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Development of a Humanitarian Engineering Course For Future Military Officers

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Development of a Humanitarian Engineering Course For the Future Military Officer

Abstract

Military involvement in humanitarian assistance roles is well established. Efforts have ranged from managing large scale operations such as the Berlin airlift in World War II to supporting homeland natural disaster relief efforts in concert with federal, state and local authorities during Hurricane Katrina and the Covid-19 pandemic to international involvement in disaster recovery such as Operation Tomodachi following the 9.0 earthquake off the coast of Honshu, Japan and Operation Unified Assistance following an earthquake and tsunami in the vicinity of Indonesia, Sri Lanka, India and Thailand. These efforts highlight the continued presence and need for military personnel in humanitarian missions to save lives, establish effective partner relationships, and improve international relations. Students at military and civilian institutions who will commission as military officers can benefit from a further understanding of global, national, and local level policies and efforts to address humanitarian challenges and needs as these students will be at the forefront of facing these challenges around the world. Additionally, it is critical that a set of students understands the engineering challenges behind the humanitarian efforts that are undertaken. In order to increase the knowledge of students, a humanitarian engineering elective course was developed and implemented that incorporates the use of engineering principles to address humanitarian events and crises. Through a tiered approach that increases student knowledge of humanitarian and disaster relief doctrine and guidance, addresses fundamental engineering challenges facing many international communities, and provides students with a technical understanding of disaster relief structures through the use of engineering programs like STAAD (Structural Analysis And Design), an effective course has been developed for future military officers. This paper details the course outcomes, structure and content and provides recommendations and guidance for implementing a humanitarian engineering course for future military officers.

Introduction

From 1970 to 2000, 68 percent of all U.S. naval operations were categorized as Humanitarian Assistance and Disaster Response (HA/DR) efforts [1]. In 2007, the Navy added HA/DR to their maritime strategy [2]. At the United States Naval Academy (USNA), students will be commissioned as Navy and Marine Corps officers, and as junior officers many of them will be involved in HA/DR operations. However, at the junior officer level, there is almost no prior education in college preparing them to lead Sailors or Marines in an HA/DR response or to grasp the complexities and challenges of a humanitarian response. To address this, a course in humanitarian engineering was created at USNA for engineering students to understand the humanitarian ecosystem when it comes to a response and to engineer technical solutions that understand the context and constraints of the problem.

The overwhelming majority of the students in the humanitarian engineering class are senior engineers who are majoring in Mechanical Engineering. Students from Nuclear Engineering, Ocean Engineering, and General Engineering also took the course. Students from these majors complete pre-requisite course work, specifically a mechanics of materials class and a fluid mechanics class, that supports their ability to assess the technical efficacy of engineering solutions specific to shelter and water. The students generally come into the course with a desire to understand the tie between their engineering expertise and the humanitarian roles they will play as junior officers.

Having established this course at USNA to support engineering students commissioning as military officers in a wide range of Navy and Marine Corps disciplines, it is now desired to share these efforts and promote further education of future military members on humanitarian response and the engineering challenges associated with both small-scale and large-scale operations. These operations can occur at any location throughout the world and involve cooperation and coordination with various international government organizations, aid organizations, national and local governments and, most importantly, the people of the affected area. The goal of this paper is to educate the reader on the humanitarian ecosystem, the role of the military in operating within the ecosystem, and to provide a sample course outline in humanitarian engineering that can be tailored and used to educate both future and current military officers. The paper will mimic the course structure used at USNA to provide the reader an insight into the methodology that enables effective learning about humanitarian engineering, within a military construct, by students.

Course Development

The impetus for designing this course stemmed from the author's research interest in developing deployable structures for use in HA/DR. In order to design effective structural solutions, the author investigated the operational context of HA/DR which led to a pivotal collaboration with the Naval War College's (NWC) Civilian-Military Humanitarian Response Program. This partnership provided deep practical insights, involvement in working groups dedicated to HA/DR curriculum and research development, mentorship of student shelter capstone projects, and facilitation of student participation in a disaster simulation.

A key takeaway from discussions with NWC leadership was the need for earlier HA/DR education for future officers who often encounter these challenges in the Fleet before receiving formal instruction. Identifying this gap in the USNA Curriculum, the author developed a framework of course outcomes based on primary research, engagement with humanitarian organizations, and pedagogical tools from the USNA Center for Teaching and Learning. By the end of the course, students are able to:

- Describe the roles and coordination of the United Nations (UN), foreign governments and militaries, and non-governmental organizations (NGO) in the HA/DR ecosystem.
- Detail the standards required to maintain human dignity in shelter and settlement, and water design.
- Apply human dignity standards as engineering constraints.
- Determine the engineering challenges associated with the construction of shelter and water solutions for HA/DR.
- Validate existing shelter solutions using simple analytical, physical and computer modeling.
- Evaluate existing humanitarian solutions through case studies.

- Design a low-tech solution for shelter or water needs for HA/DR.

To evaluate student mastery of the course outcomes, assessment methods were developed by mapping course outcomes to Bloom's Taxonomy [3] and ABET outcomes [4]. This alignment ensures the course remains consistent with the USNA Mechanical and Nuclear Engineering Department's assessment process. The humanitarian engineering curriculum is designed to address the following four ABET outcomes:

- Outcome 2: An ability to apply engineering design to produce solutions that meet specific needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors.
- Outcome 3: An ability to communicate effectively with a range of audiences.
- Outcome 4: An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of the engineering solutions in global, economic, environmental and societal contexts.
- Outcome 6: An ability to develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgement to draw conclusions.

Table 1 maps the course outcomes to Bloom's Taxonomy and to ABET student outcomes, and lists examples of assessments used and discussed in this paper. Additional methods of assessment drew from contemporary primary sources, such as the International Monetary Fund podcasts and UN policy documents, to ensure the grounding of theoretical concepts with real-world applications. As the term progressed, the curriculum remained adaptive, with content modified to reflect current global events.

Table 1 Mapping of Course Outcomes

Course Outcome	Bloom's Taxonomy Level	ABET Student Outcome	Examples of Method of Assessment
Describe the roles of the UN, NGOs, and militaries in the HA/DR ecosystem.	Understand	3 & 4	Individual homework: researching and presenting the interaction between specific response entities.
Detail the standards required to maintain human dignity in shelter and settlement, and water design.	Understand	2 & 3	Individual homework: Summarize Sphere Handbook shelter and settlement's quantitative "Key Indicators" and their use in real-world applications.
Apply human dignity standards as engineering constraints.	Apply	2 & 4	In-class group assignment: design and sketch out a shelter settlement for class participants located on campus.
Determine engineering challenges associated with shelter and water solutions for HA/DR.	Analyze/Evaluate	2 & 3	Individual homework: select a technology from the Global WASH Portal and evaluate its use in a case study.
Validate existing shelter solutions using simple analytical, physical and computer modeling.	Analyze/Evaluate	6	Final Project: perform computer and physical modeling of an existing shelter used in a real-world application.
Evaluate existing humanitarian solutions through case studies.	Analyze/Evaluate	6	Final Project: complete a written technical critique of a past or existing shelter and water solution.
Design a low-tech solution for shelter or water needs for HA/DR.	Create	2 & 6	Final Project: perform structural analysis of existing shelter using building code.

Course Structure

The humanitarian engineering course is taught as a three credit-hour, elective engineering course in a 16-week semester. The course content is broken down into a series of five modules.

- Module 1 (Humanitarian Engineering, International Development) focuses on defining humanitarian engineering, gaining an understanding of the direct and indirect roles that engineers play in humanitarian operations, and defining development and the role that development organizations play.
- Module 2 (The International Humanitarian Ecosystem) introduces students to the humanitarian ecosystem starting with an overview of how humanitarian response works and an introduction to the UN cluster system that supports a more effective and organized response to humanitarian disasters. Students then gain an understanding of all organizations involved in humanitarian response with a particular focus on the response role that the U.S. Navy and Marine Corps team plays and how organizations and teams of engineers work together to respond.
- Module 3 (Human Dignity and Humanitarian Standards in HA/DR) provides students with a core understanding of international standards on dignity that should inform both the actual response and the engagement with people during the response to a humanitarian crisis. This includes defining dignity and associated guidance on how to maintain dignity for certain humanitarian efforts.
- Module 4 (Shelter and Water) focuses on two specific UN clusters to support an in-depth analysis and understanding of the technologies used for responding to casualties that require shelter and water, and the use of local resources for response. This module was the most in-depth module and provided the students with the tools and knowledge to evaluate case studies for their overall effectiveness and to support a final project that challenged them to select a structure, complete an overall engineering analysis and consider adherence to humanitarian guidance.
- Module 5 (The Domestic Humanitarian Ecosystem), provides students with knowledge on U.S. specific disaster response organizations, how they coordinate response, and the role of engineers in this humanitarian ecosystem.

This paper will provide details on Modules 2 through 4. While Modules 1 and 5 provide outstanding context and background information, these items need to be covered on any course focused on humanitarian engineering and are not specific to a course being taught to future military officers. Modules 2 through 4 provide the bulk of the coursework and focus on the fundamental engineering aspects and the role played by the military and will be covered in detail.

The Humanitarian Ecosystem and the Role of the Military in Humanitarian Response (Module 2)

The following section is to provide the reader with a basic overview of how international humanitarian response works and how the U.S. and foreign militaries are involved. This basic understanding informed the structure of the Humanitarian Engineering course at USNA.

The humanitarian ecosystem (Figure 1 [5]) is extremely complex, involving multiple entities including: governments, NGOs, individual philanthropists, international organizations, and militaries. For every single disaster responded to, this ecosystem looks, reacts and adapts differently. The overarching framework of how to do it is the same, but because the needs are specific to any particular disaster, the ecosystem will flex and adapt.

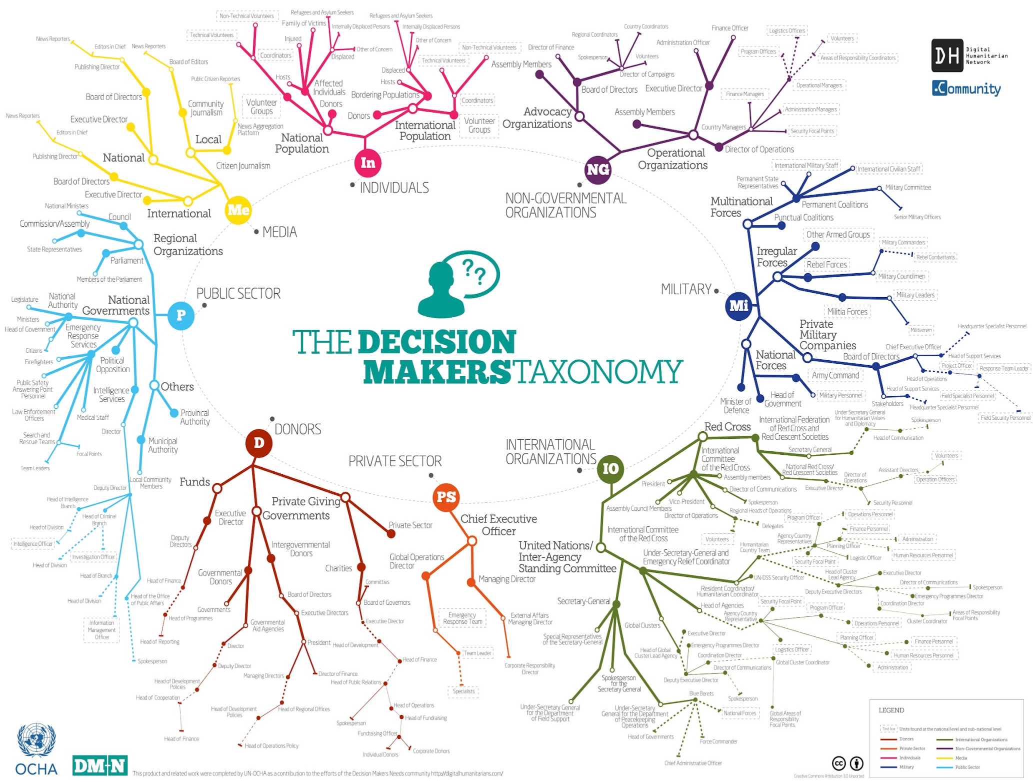

Figure 1 - The Humanitarian Ecosystem detailed [5].

Figure 2 provides a 'cleaner' version of the ecosystem [6]. At the very center are the affected communities of every humanitarian event. The blue circles highlight entities whose primary mandate is humanitarian work. The entities circled in gold, like the military, are important entities, but they are not humanitarian in nature; they will support humanitarian entities.

If an event happens, the affected state is responsible for dealing with humanitarian responses internal to borders. Most countries have a national disaster management office, for the U.S. that is the Federal Emergency Management Agency (FEMA). However, when the magnitude and severity of the event is too much, the affected communities will extend an invitation for support, mostly to the UN, and the international communities will respond through the coordination of the UN [7].

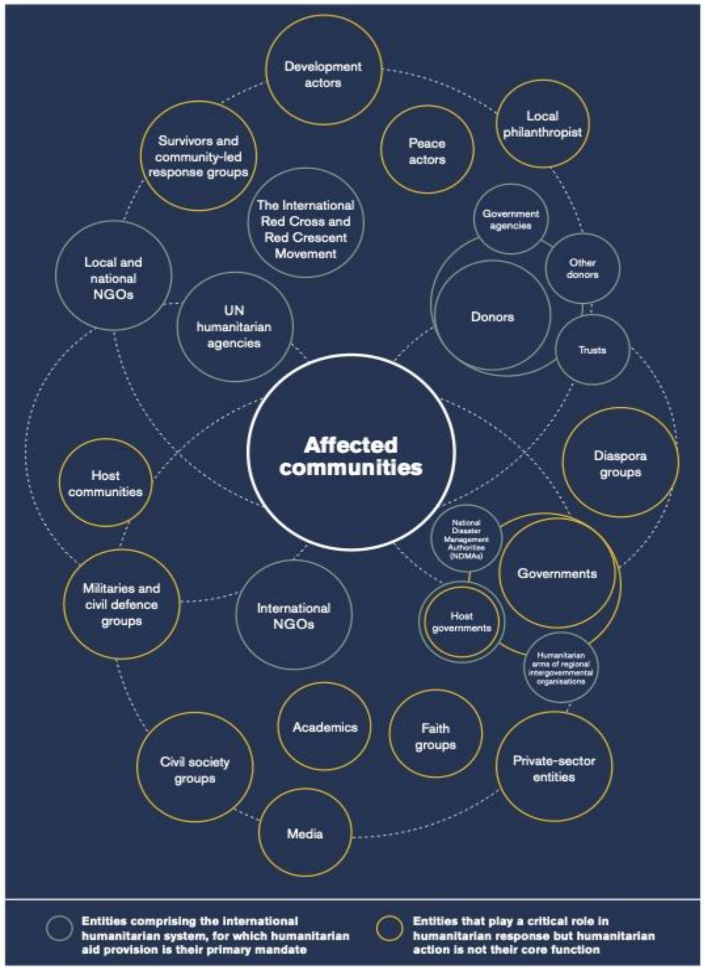

Figure 2 - The Humanitarian Ecosystem summarized [6].

The coordination of a global response is done through the UN Office for the Coordination of Humanitarian Affairs (OCHA). The Cluster System (Figure 3) is OCHA's coordination mechanism [7, 8]. A 'cluster' groups all humanitarian organizations working in a specific sector – functional areas that are required in a response to keep people alive and alleviate their suffering. The 11 clusters are: Water, Sanitation and Hygiene (WASH), Shelter, Protection, Nutrition, Logistics, Health, Food Security, Emergency Telecommunications, Education, Early Recovery, and Camp Coordination and Camp Management. The person in the middle of this coordination mechanism is the Humanitarian and Emergency Relief Coordinator, essentially the conductor of this orchestra of clusters. The clusters will have individual meetings, led by single or multiple organizations. For example, the WASH cluster is led by the United Nations Children's Fund (UNICEF), and the Shelter Cluster is jointly led by the International Federation of the Red Cross and Red Crescent Society (IFRC) and the United Nations High Commissioner for Refugees (UNHCR). The 'conductor' brings the cluster leaders together and formulates a response plan, all in support of what the affected country wants done.

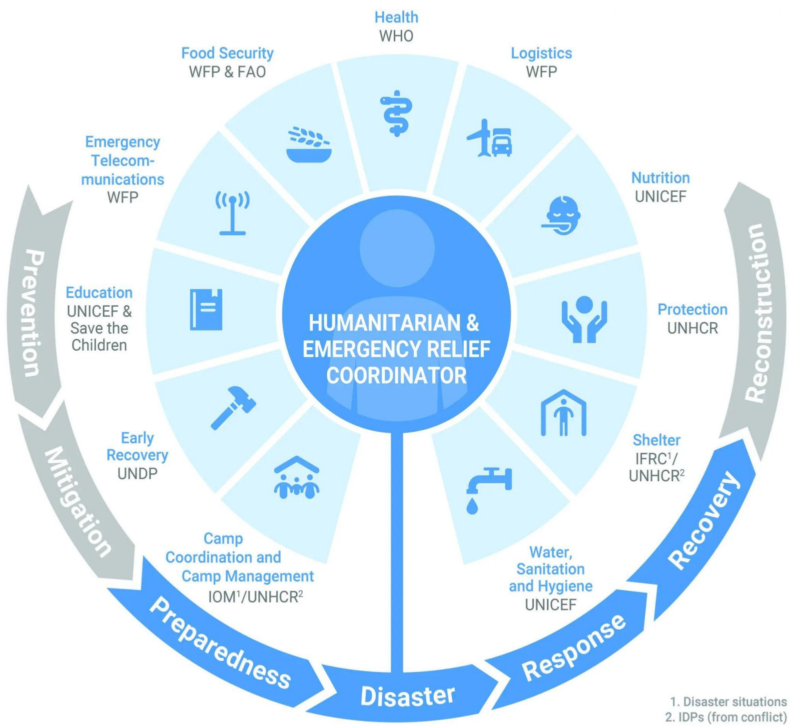

Figure 3 The UN OCHA Cluster System [8].

In the most dire circumstances, there is one more responder and that is the military. The military efforts are at the initial emergency response level, and they are needed for their unique capabilities and assets (logistics, ships, aircraft, etc.). Asking the military for assistance is often a last resort, meaning the need they fulfill cannot be met with available civilian assets. Figure 4 provides an example of the foreign military assets used for HA/DR in the Philippines as of December 2013. Militaries will coordinate through a Multinational Military Coordination Center (MMCC) hosted by the affected state's military. The coordination between the MMCC and the UN is done through the UN Civil-Military Coordination (UN-CMCoord). The key elements of this coordination are information sharing, task division and joint planning [8].

The students at USNA are all going to serve as officers in the Navy and Marine Corps and every single one is going to support a wide mission set that may very well include responding to a humanitarian disaster. Additionally, approximately a third of the graduating class each year will graduate with an engineering degree. The tie between their role as officers and as individuals with engineering knowledge can be an important asset in humanitarian response. One of the goals of this course was to not just focus on the mission set of the U.S. military as it relates to HA/DR, but to encourage student learning and understanding of the fundamental engineering principles that must be part of leadership decisions as operations related to HA/DR unfold. While the entire scope of all engineering aspects of HA/DR was too broad to be covered in a one semester course, by selecting a few UN clusters, a more thorough analysis of both the humanitarian needs and the engineering challenges related to the specific cluster could prompt better learning.

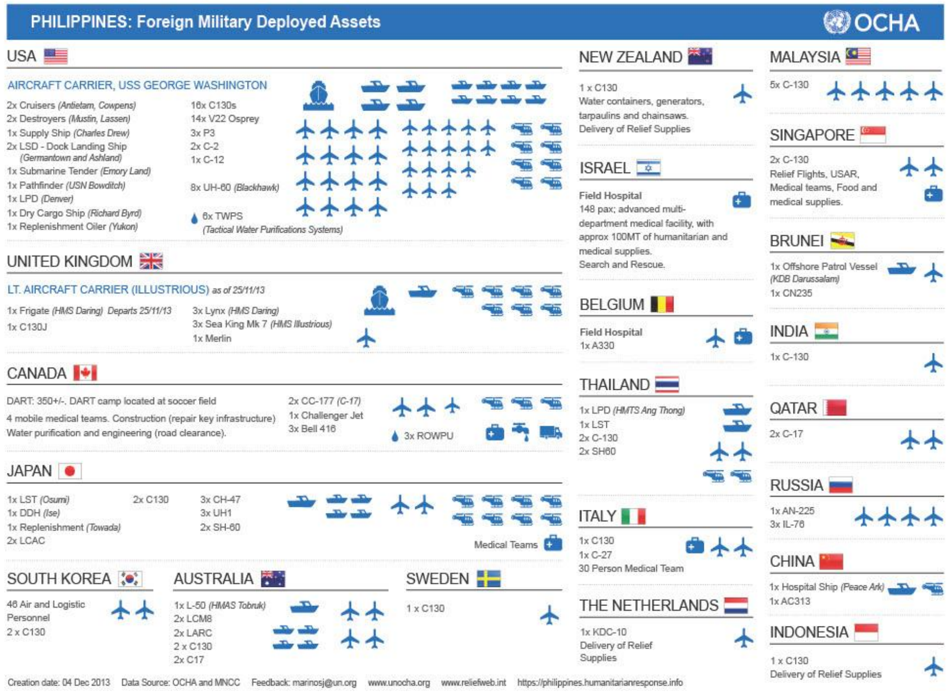

Figure 4 Foreign Military Assets used in Philippines as of 04 December 2013 [8].

Human Dignity and Humanitarian Standards in HA/DR (Module 3)

The USNA course was structured around engineering solutions for two of the clusters: WASH and Shelter, leveraging the instructor's background in structural engineering and the students' academic disciplines. The curriculum is adaptable and the framework is inherently modular; relocating the course to a different department would allow for an emphasis on clusters more aligned with those fields, such as Logistics (Systems Engineering), Health (Biomedical Engineering), or Emergency Telecommunications (Electrical Engineering).

Students learned about existing WASH and Shelter solutions via case studies, agency manuals and current events. They also assessed the solutions' technical efficacies by using analytical, computer and physical modeling. However, as is done prior to any good engineering solution, students needed to understand what was required, what was adequate and how it was quantified. This is where the Sphere Handbook comes into play and becomes an integral part of understanding HA/DR.

The Sphere Handbook provides a set of principles and the minimum humanitarian standards in four technical areas of humanitarian response: WASH, Food Security and Nutrition, Shelter and Settlement, and Health [9]. The Sphere Handbook was established in reaction to the poor, and damaging humanitarian response seen in the Rwanda Genocide. In 1996, a Joint Evaluation of Emergency Assistance to Rwanda concluded that "more than 200 aid groups operated in a 'policy vacuum', without strong coordination" and deaths could have been avoided [10].

It is important to distinguish that the Sphere Handbook is not giving standards that are the bare minimum to survive, but working to answer the question of what are the minimum requirements for a life of dignity. It was important to educate students about the concept of dignity and what that truly means before tackling the challenges of responding, both operationally and with an engineering mindset, to a humanitarian casualty event.

On December 10, 1948 the General Assembly of the UN adopted the Universal Declaration of Human Rights as a common standard of achievement for all people and nations. The declaration's first article proclaims "All human beings are born free and equal in dignity and rights" [11]. Humanitarian assistance is generally accepted to mean "the aid and action designed to save lives, alleviate suffering and maintain and protect human dignity during and in the aftermath of man-made crises and natural disasters..." [12].

How 'dignity' is quantified is where the Sphere Handbook comes in. The Sphere Handbook takes qualitative standards and measures them quantitatively by what are called "key indicators". For example, a Sphere Handbook WASH standard is "People have equitable and affordable access to a sufficient quantity of safe water to meet their drinking and domestic needs" [9]. This one qualitative standard translates into multiple quantifiable standards, including:

- 15 liters of water per person per day;
- 250 people per tap (based on a flow rate of 7.5 liters/minute);
- less than 500 meters from any household to the nearest waterpoint;
- less than 30 minutes queuing time at a water source.

For Shelters, an example of a standard is: "People have access to living spaces that are safe and adequate, enabling essential household and livelihood activities to be undertaken with dignity" [9]. This one qualitative standard also translates into multiple quantifiable standards, including:

- 3.5 m^2 of living space per person, excluding cooking space, bathing area and sanitation facility;
- 4.5 m^2 to 5.5 m^2 per person in cold climates or urban settings where internal cooking space and bathing and/or sanitation facilities are included;
- minimum of 2 m floor-to-ceiling height at the highest point (2.6 m in hot climates).

Taking time to understand the Sphere Handbook qualitative standards and how they are transitioned into quantitative standards is a critical step in educating students and future military officers and cautioning them about not going into a problem and trying to solve it without knowledge of standards. While officers could enter into a humanitarian crisis and begin providing aid by supporting movement of supplies, building temporary structures, and other efforts, a better understanding of the basic needs of the communities, at a personal level, is essential to make the effort effective and gather the full support of the entire impacted community. This understanding of standards allowed the transition to the largest modules of the course that focused on shelters and WASH and supported student understanding of how to evaluate the effectiveness of humanitarian responses based on both the engineering design aspects and the standards in place through the Sphere Handbook.

Shelters (Module 4a)

The shelter module focused on educating the students on the types of shelters, the many factors engineers have to balance for a successful shelter design, the process to apply building codes, and the use of a structural analysis and design software STAAD (Structural Analysis And Design) by Bentley Systems [13]. This background knowledge allowed students to then structurally analyze and evaluate adherence to humanitarian guidance for real-world case studies both as a group and individually in a final project.

Students were first instructed on how to perform a structural analysis. They were taught about how to classify the structure’s lifespan, function, and location so the right loads can be determined from the building code. These loads can then be put on the designed structure and a verification is conducted to ensure the structure satisfies strength, stiffness and stability requirements by the building code.

Shelter classification was covered to ensure all students understood the variation in structure types for HA/DR. Shelters are classified based on the duration of their use - ranging from an Emergency Shelter, the most basic shelter that can be provided immediately after the disaster, to Core Shelters, a permanent solution that has been planned and designed. Figure 5 illustrates the different shelter types [14].

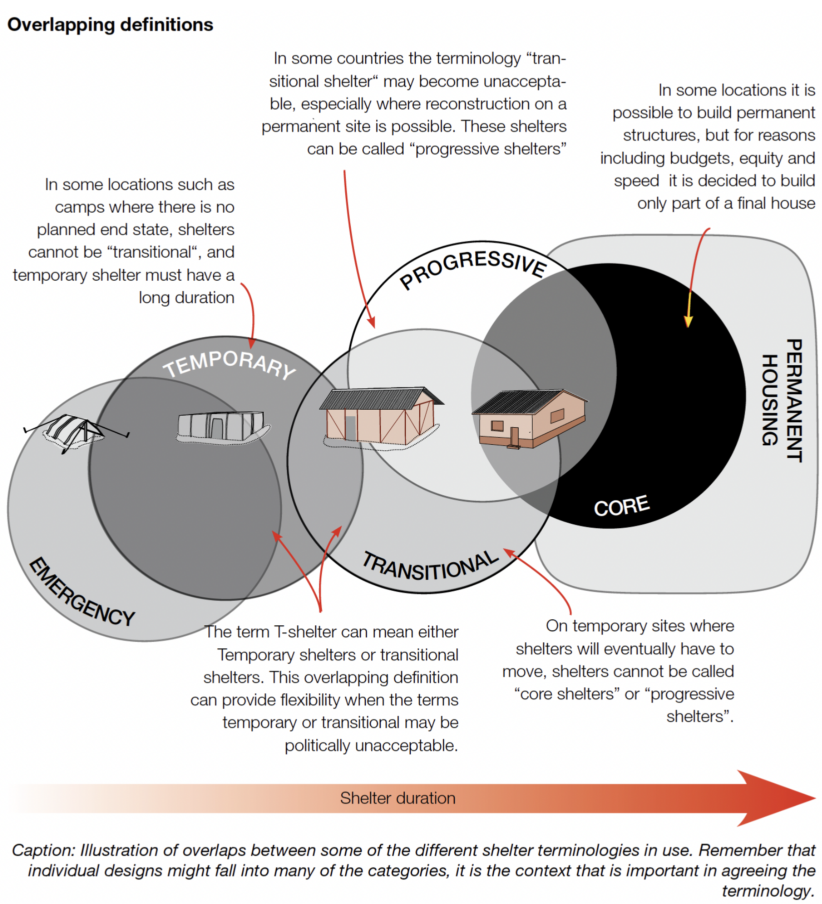

Figure 5 - Shelter types classified by the shelter duration [14].

In the course, the focus was on temporary and transitional structures, which presented a challenge when applying building codes meant for permanent structures to short-term structures. To navigate this, the course followed the approach used by structural engineers that reviewed shelter designs by the IFRC [14,15]. The structural engineers applied the requirements contained in the International Building Code (IBC) with modifications. The IBC standards are based on a 50-year lifespan, making them ill-suited for post-disaster structures that are usually only meant to last for 2 years [16]. Because of this difference, the IFRC structural engineers adjusted the load requirements to fit a shorter, operational life. For example, the IBC mandates a 1.9 kPa live load for permanent dwellings, which is excessive for the post-disaster contexts addressed here. Consequently, floors were analyzed using a 1.0 kPa load, a value consistent with IBC specifications for attic spaces. Students gained an understanding of the reasons for the modifications and applied the IFRC modified standards when conducting shelter analysis in the course.

Students were also educated in this module about the relationship of building codes to environmental hazards. Building codes also use the location of a shelter to determine the type and magnitude of environmental hazards and their loadings - flood, snow, wind, and earthquakes. Shelters are designed to avoid increasing the risk of death or injury, meaning shelters are to be designed such that if they fail in a future disaster they are less likely to kill people. For example, following an earthquake, timber shelters are used more than masonry structures because timber is lightweight and less likely to cause fatalities than collapsing masonry structures from future earthquakes. However, lightweight structures are more sensitive to wind loading; this highlights the need to consider a wide range of factors in the decision-making process for shelter construction.

Students gained an understanding of risk management for temporary shelters used in HA/DR as well. Because the IBC is meant for permanent structures, the environmental loads can be reduced for the temporary shelters because the risk of a "worst-case" event is much smaller over a shorter time period. Since the IBC has no protocol for this, the IFRC used ASCE 37-02 (Design Loads on Structures During Construction) construction load standards to calculate the necessary reductions for these temporary buildings [17]. For example, wind loads for structures with a 1 to 2-year life span were reduced by 15%. Students quickly grasped the reason for these modifications as they aligned closely with operational risk management training that is a fundamental part of military operational planning.

Having established the loading requirements, and data on shelter dimensions and materials, students completed a case study of a past and/or existing shelter as a final project. It included a formal report, a structural analysis using STAAD and the construction of a 1:24 physical model of their selected shelter. Students assessed the structural performance of the shelter's original design and proposed and assessed design changes to improve the structural performance. For example, their changes included resizing members, changing the structural layout, material or member cross-section geometry, all while balancing other design constraints like budget, material availability, future maintenance, upgrade expectations, and cultural appropriateness. The physical models were used to give the students a better understanding of construction feasibility, scale and aesthetics.

Students also evaluated their shelter's adherence to humanitarian guidance given in the Sphere Handbook and other manuals like the IFRC Shelter Safety handbook [18], which gives information on how to build safer. This includes good practices like: avoiding shelter designs in strong wind areas that have short roof eaves (no more than 45 cm), as large overhangs act like "umbrellas" that the wind can catch and rip off; designing for firebreaks between shelters with a minimum of 2 m between individual shelters, and larger firebreaks of 6 m to 10 m between blocks of shelters.

Overall, this portion of Module 4 on shelters explored the engineering challenges of selecting, designing, building and maintaining the right shelters for a humanitarian assistance event. The students gained an understanding of the difficulties associated with designing and building temporary versus permanent structures, and the unique nature of engineering in an unfamiliar area to many of the responders and an area that had been significantly impacted by a casualty.

Water, Sanitation and Hygiene (Module 4b)

Similar to the Shelter Module section, the WASH Module section introduced the key requirements and basic needs for WASH and then challenged students to think about and analyze the implementation of these items as a responder to a humanitarian crisis. Students first learned about the UN declaration of human right to water and sanitation [19] which explicitly recognized that clean drinking water and sanitation are essential human rights and the government has a legal and moral obligation to ensure its citizens have access to both. The USNA course focused on the 'Water' in WASH, based on water being the first need to support satisfaction of the remainder of the WASH attributes, time limitations on the course and the overall expertise needed to branch into the other attributes.

The "Emergency WASH Knowledge Portal" [20] by the Global WASH Cluster was used to educate students on the technologies and solutions for water supply in emergencies. The portal shares specialized knowledge and technical contributions from a wide range of global experts and agencies across both the humanitarian and development sectors in WASH. The knowledge portal reviews a total of 68 technologies and solutions from identifying the water source, the intake, the abstraction and treatment, the distribution, to the household water treatment and safe storage options. Figure 6 lists all the technologies reviewed for source, intake, abstraction, treatment, distribution and storage [20].

The water supply technologies can be filtered by the response phase, the application level (scale), the management level, the local availability of technology and components, the technical complexity, and the maturity level of the technology. For this course, the focus was on the acute response phase (immediately following a disaster) and a low technical complexity (only minimal technical skills and simple tools are required to implement, operate and maintain).

Students were given an assignment where they studied and presented a technology from each of the categories: water source, intake, abstraction, treatment, distribution, and household treatment and storage. Some examples of the technologies include:

- water source – rain water, rivers and streams, groundwater

- intake - rainwater harvesting, riverbank filtration
- abstraction - hydraulic ram (impulse) pump, deep well progressive cavity pump
- Treatment - roughing filtration, chlorination
- Distribution - water vendor cart, water kiosk
- Household water treatment and storage - ceramic filtration, boiling, solar disinfection

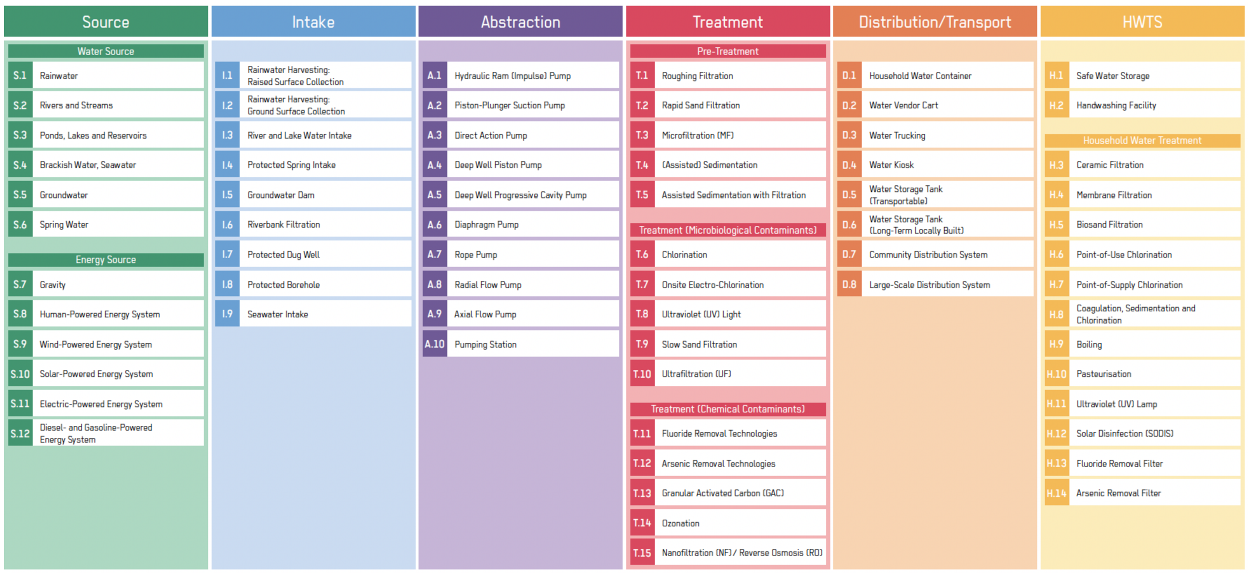

Figure 6 - General technology overview for water supply technologies [20].

Students explained the purpose, function and key features of their assigned technology. They also analyzed the advantages and disadvantages to their selected technologies in terms of efficiency, cost, ease of deployment, suitability for different types of emergencies, and scale. For their final project case study on the shelter, they also researched the water supply technology that was being used in their camps. These efforts on WASH allowed students to gain a robust understanding of the complexities related to one of the most important UN clusters – one that dictates the success of both immediate life-saving interventions by international responders and the long-term capacity of local communities to rebuild and sustain recovery.

Conclusions

Humanitarian engineering in the context of HA/DR is a critical role for future naval officers, who will lead Sailors and Marines in a high-stakes environment. By bridging the gap between humanitarian doctrine and fundamental engineering challenges, this curriculum enhances officer readiness to operate alongside international organizations and local communities. Through a structured pedagogical model that balances doctrine guidance with a technical analysis of disaster relief structures and water supply technologies, an effective educational foundation has been established for future military leaders.

While developed for military students, this framework could be adapted to civilian institutions. Following two successful semesters and formal approval as a permanent course at USNA, the value of this interdisciplinary approach is clearly recognized. Though this course focused on two

UN clusters based on the instructor's expertise in structural engineering, the modular design allows for future tailoring to other technical disciplines and relevant humanitarian sectors.

Looking forward, efforts to refine the course include the incorporation of response simulations and the latest U.S. humanitarian policies to ensure continued relevance for future Navy and Marine Corps officers. The primary objective remains the improvement of student learning through a rigorous focus on actual humanitarian disasters and project-based assignments that ensure the practical application of engineering principles to complex HA/DR events.

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