Modular Solutions for Mobile Hospitals

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1 Abstract

The requirement for rapidly deployable medical capabilities, such as mobile hospitals, has been recognized from the time of the US Civil war to more recent occasions (Hoyle, 2004, Mohr et al, 2005) for military and non-military requirements. Hoyle (2004) describes the conversion of a semi-trailer to support readiness outside of Cincinnati, Ohio in the 1960s and Mohr et al., (2005, p. 91) describe a more modern and robust MED-1 which "is the nation's first fully equipped mobile surgical hospital and consists of two 53-foot tractor trailers, one of which stores equipment and the other a fully functional patient care facility. The facility center morphs into a 1,000-square-foot workspace featuring a two-bed shock–resuscitation and surgical unit and a 12-bed critical and emergency care unit. MED-1 also includes materials for a climate-controlled tented area holding 130 additional beds".

While effective in local and regional circumstances due to mounting on tractor trailers, they are currently less mobile if desired to support non-contiguous requirements, for instance during the recent Haiti earthquake, which required mobile military hospitals to be utilized (Pape et al., 2010, Kreiss et al., 2010). The ability to rapidly move a standardized and scalable medical package, capable of rapid expansion and replenishment is critical. Potential barriers to adoption by Military-civilian and Humanitarian organizations are discussed. Future research opportunities are identified.

2 Introduction

Hospitals are a vital part of healthcare provision to a population. Hospitals may be either fixed facilities, used regularly by a population at risk, or hospital capabilities can be mobile. These mobile capabilities can be used to provide a higher level of care in a regularly underserved population, such as many rural areas, or they may be used in contingency operations. The latter is the main focus of this research, as those facilities must often move rapidly and efficiently in a constrained logistics environment.

Often, the requirement for a hospital in a given location is unknown until a short time before the requirement (Kovacs and Spens, 2009). In some cases, such as hurricane Sandy along the East Coast of the United States in 2011, onshore destruction was highly anticipated within a span of approximately 7 days. The unknown however was the extent of the damage in the location at which the damage would occur. Likewise, the severe destruction caused by hurricane Katrina in the New Orleans, Louisiana area of the United States stopped services entirely at many fixed

facility hospitals. Earthquakes in Pakistan, tsunamis in Japan, and other threats to life occur regularly. Often, help is requested from outside organizations, and some responders, such as a military organization, are uniquely equipped to respond.

Research by the Fritz Institute (Thomas, 2003) has identified several key challenges to humanitarian organization response to disasters. Likewise, military responses are often guided by the political realities within their government, or overarching homeland requirements.

3 Unplanned Hospital Employment

3.1 Humanitarian

The goal of a humanitarian operation is to bring relief to those who are suffering. The suffering can be caused through environmental changes or through civil or military unrest. Often, the result is a reduction or destruction of critical infrastructure performance. The provision of healthcare is a critical part of most infrastructure designs. Some events can be forecast. These may result from environmental effects that have long cycles or civil and military unrest that has occurred for greater than a short period of time.

Often, the permission of a government must be obtained or a request received from the government in order to move humanitarian aid to support an effected population. The required permission is a complication for those tasked with providing logistics to support the move of a hospital. Affected infrastructure may include roads, airports, and seaports as well as warehousing and cross docking facilities. Therefore, shipments with the smallest weight and most efficient use of cube will take the most advantage of limited and constrained resources.

3.2 Contingency

Contingency use in this paper will refer to the short-term requirement of a military force to deploy hospital medical assets. Militaries of various countries around the world maintain different postures based on requirements of their government and ability to provide appropriate material. To this end, some countries have small defensive forces which are designed to remain within the political boundaries of their home nation. Other countries have forces which may be considered more expeditionary and nature (Pettit and Beresford, 2005).

Expeditionary forces may be used to project military capabilities over great distances. These may be within a region, within a hemisphere, or globally. Countries that have the capability to project a military force globally often also have the required C and airlift to move those assets. There may be limitations and bottlenecks based on force requirements and the situation to which the military force is responding. Additional constraints may include available funding for the operation as well as country clearances and force availability.

3.3 Preparedness

Requirements for hospitals to support preparedness in the context of this paper, include a mobile hospital facility that resides in storage to support an unplanned or planned closure or repair of a facility or to maintain the civil capability to respond rapidly in the event of an outage of critical local infrastructure. Additionally, hospital systems may purchase, store, and maintain the capability to deploy in the event one of its facilities has degraded capabilities. This use is generally outside the scope of this research at this time.

4 Hospital History

4.1 US Civil War

Early healthcare systems provided rudimentary care to patients who presented themselves to personnel working as doctors. During the pre-Civil War time, there was little standardized care provided. The United States Civil War (1863 to 1865) was witness to terrible carnage inflicted by both sides of the conflict. The surgeon general of the northern forces, Surgeon General Hammond, was frustrated by the lack of capability to remove the wounded from the battlefield and it eventually comes to medical care. The result of this frustration was the formation of a standard Ambulance Corps, developed by Letterman.

Letterman's Ambulance Corps was seen as a very successful innovation to battlefield care. One of the most remarkable demonstrations of the capabilities of a trained, staffed, and equal force occurred during the battle of Antietam. Antietam is the bloodiest single day of fighting in United States military history. Over 22,000 soldiers were casualties that day. Of the approximately 17,000 who were injured, it is estimated that one in seven would die from their wounds. The Ambulance Corps evacuated over 9,400 wounded from the battlefield in one day. Figure 1 illustrates the 57th New York Ambulance Corps removing wounded from the battlefield after the Battle of Fredericksburg in December of 1862.

Figure 1: 57th NY Ambulance Corps removes wounded from the battlefield 1862

4.2 World War II

Some of the most challenging terrain in which to conduct healthcare occurred across the Pacific theater. For the United States, the large fixed hospitals that were capable of seeing hundreds of patients at a single time or impractical to move, set up, and sustained across the vast reaches of the Pacific Ocean. To solve this problem, US Army Col. Percy J. Carol developed a concept of modularity, which effectively shrank the capabilities, size, and manning requirements. His development contained 25 beds, 29 staff, was able to be carried entirely by the staff and could conduct basic procedures. Its size restricted its capability to operate as a fully functional hospital Greenwood, 2009). This concept remains in use in modern day with specialized surgical facilities far forward on a contemporary battlefield.

4.3 The 1950s

Although designed to pick up and move patients from the point of injury to the point of care, prior to the 1950s ambulances served no further purpose. Innovation occurred, as is often the case, following a disaster. Healthcare providers realized that more lives could have been saved with the provision of en-route care to those who were wounded. The particular incident is referred to as the

Harrow and Wealdstone train disaster, which occurred in 1952 in the United Kingdom (BBC, 2005). Following this event, more hospital like capabilities were introduced onto the ambulance platform which was previously sparse, as depicted in Figure 2. This mobile healthcare capability, combined with emergency medical treatment training, remains in effect currently.

Figure 2: Typical 1950s British Ambulance

4.4 Modern Day

The ability of technology, combined with the skills of a physician at a remote location using standardized telecommunications devices and protocols enabled the first remote-controlled toy surgery in 2001. The patient, who required their gallbladder to be operated on, was in Strasbourg, France. The surgeons, were in New York city. This operation, popularly referred to as "the Lindbergh operation", named after the famed solo Atlantic flyer, provided proof that the technological advances could yield great benefits. This technique of telemedicine has stretched to more efficient use of time, leveraging of capabilities in different time zones, as well as efficient reach back capability for specialized diagnoses and conferencing.

Hyperconnected telecommunications are available in most any region through the use of sophisticated equipment and a robust infrastructure (Howden, 2009). The challenge is to effectively move the hospital facility where needed efficiently and in enough time to treat the wounded.

5 Speed/Material Velocity

Research conducted by the Fritz Institute (Thomas, 2003) “whose mission is to strengthen the infrastructures of humanitarian relief organizations by mobilizing logistics and technology expertise and resources”. This mobilization of resources to move to the affected area, may occur as soon as 2-3 days after the event and last the duration of the mobilization as shown in Figure 3. The 1952 UK incident emphasizes the importance of rapid movement to the wounded. Likewise, military contingencies are closely tied to prior planning for a certain area of the world where armed conflict may erupt.

Once the order is given, rapid, efficient and effective movement of much materiel begins to flow. Synchronization and deconfliction with other materiel, humanitarian aid providers and transportation is under constant assessment. This operation serves as the essential bridge between Readiness and Response and requires extensive pre-planning to be successful. While a military may be properly staffed to plan and uses a common language to communicate, HROs often lack the requisite skill sets and experience to optomize operations.

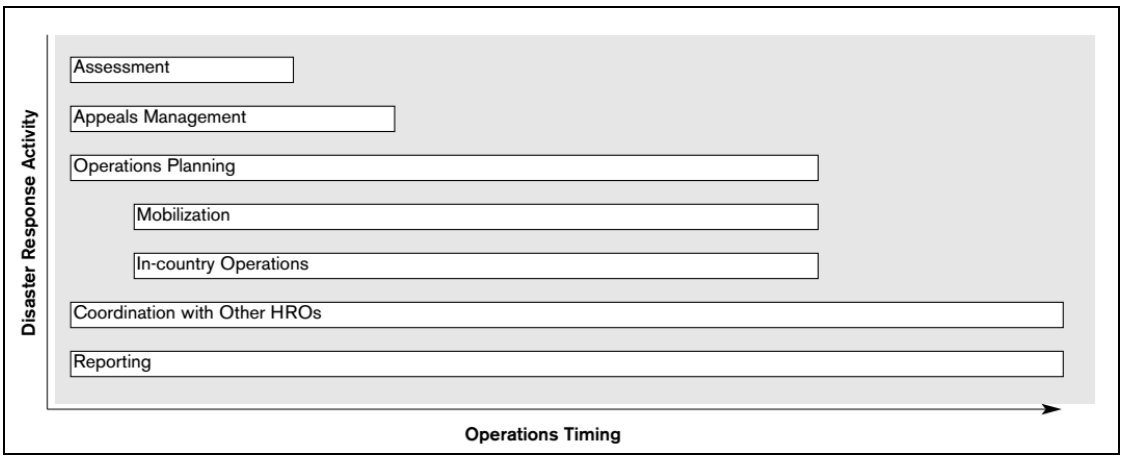

Figure 3: Major Activities within a Disaster Response Operation

6 Pain Points

Five Pain Points were identified by Fritz researchers (Thomas, 2003) as impacting a Humanitarian Relief Organizations' ability to respond effectively. 1) Donor scrutiny of funding flow emphasizes direct aid to the affected, not systems and preparedness, 2) Organizational culture and turnover such as a mismatch between roles in logistics and actual logistics experience, leading to eventual short tenures, 3) Lack of institutional learning driven by turnover rates as high as 80% in some organizations, 4) Little pre-event coordination which leads to inefficient redundancies, no coordinated efforts or standardized practices and 5) Ineffective technology leverage which is caused by funding restrictions and culture barriers such as the available ERPs lacks flexibility for material donations and rapid non-standard data inclusion.

7 Challenges

A hospital consists of over ten thousand unique items of varying sizes. The number of manufacturers involved in supplying this equipment can be several hundred, depending on the size and specialty of the hospital. There is no current incentive for manufacturers to change the design and engineering of products to improve handling.

There is very little cross-talk within the HRO community about methods to best store, organize and ship hospital capability to affected regions. When considering military and civil requirements, there is virtually no interconnectivity and cross-talk. Lack of technology innovation hampers the ability to effectively design and structure PI configured loads.

The nature of the logistics requirement to deliver healthcare assets to a area with potentially compromised infrastructure under sub-optimal conditions seems to support PI principle implementation to drive improvements.

8 Conclusion

Capabilities to deliver healthcare on a large scale to impacted populations has greatly improved since the earliest Ambulance Corps use. However, current delivery methods for mobile and

modular hospitals remain inconsistent among hospital users. Military, civilian and NGOs spend little time in discussion about how to configure their equipment for shipment. Recent reports emphasize the military availability of hospitals (Rand, 2010), but assume adequate lift will be made available to move the material to a required location with little regard to ultimate efficiencies within the shipping container.

Continued research is warranted in the areas of personel capability and knowledge, qualitative research with key enablers to better and more fully understand the scope of the current challenges across key disaster and contingency mobile hospital providers, to include manufacturers identified in other PI research. Leverage use of technology to identify and explain the benefits of PI principle usage to stakeholders to encourage change.

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