Rapid-response architecture: Redeployable trauma centres for post-disaster response

In the wake of global disaster, there is a strong need for post-trauma emergency structures. A research project from South Carolina’s Clemson University seeks to inject some architectural integrity into current models of operationalised healthcare facilities able to be quickly deployed to disaster strike zones and set up within hours. In this regard, the World Health Organization (WHO) advocates research and development in innovative, sustainable responses to disasters, including rapid-response architecture. This, in a world where more communities and regions are now increasingly susceptible to the deleterious outcomes of life-altering events of cataclysmic scale and intensity.

Background and recent history

The earliest portable building was generally considered to be the yurt, an ancient thatched hut that could be assembled/dismantled and transported from place to place using carts drawn by mules, oxen or horses. Variants on this basic freestanding building type evolved through the centuries in response to local culture as well as climatic factors, locally available materials, fabrication techniques and site conditions such as mountainous terrain versus low-lying coastal sites.

Currently, modern redeployable trauma centres, or RTCs, are called for, able to be transported and operationalised quickly in the aftermath of man-made and early disasters. Globally, effective, sustainable RTCs can fill a critical void in a community or region to launch a healthcare infrastructure. During the first world war, innovations in military hospitals were introduced on the battlefield. New, nomadic systems for healthcare delivery were highly efficient, mobile and relatively lightweight. Lessons had been learned from the American Civil War: tent hospitals in the aftermath of man-made and natural events of cataclysmic scale and intensity.

More recently, the US military developed its DEPMED (Deployable Medical) centres, transportable systems whose modules were designed to be quickly deployable in a 16- to 256-bed capacity. DEPMEDS, however, are far less mobile than their MASH precursors. For this reason, they are not positioned in direct proximity to front line combat zones. DEPMED/CSH RTCs have performed rather admirably during the Iraq and Afghanistan Wars, saving thousands of lives.

Mobile vehicles developed during this period include advanced ambulances, and mobile vehicular clinics-on-wheels for use by governmental and NGO healthcare organisations, and a wide array of public health agencies. These include Ian M. Smith’s CARE Mobile Medical Clinics, deployed in India in the late 1950s and early 1960s (Figures 2a and 2b), the government of Cuba’s deployment of 36 multi-phasic mobile medical units (Figure 3a), and a fleet of 42 mobile health screening units deployed throughout the Republic of Congo in the 1980s (Figure 2b). Not ironically, the hospital bed itself remains that most mobile of devices, and this portability alone provides enticing opportunities for innovative applications in RTC settings.

Recent disasters and RTCs

At the present time, a complex and often contradictory set of six superordinate dimensions generally shape current
The Haitian earthquake of 2010 was a catastrophic magnitude 7.0 disaster event, with an epicentre near the town of Léogâne, approximately 25km (16 miles) west of Port-au-Prince, Haiti’s capital city. An estimated three million people were impacted by the quake, with 316,000 lives lost, 300,000 were injured and more than one million persons instantly became homeless IDPs. The Haitian government estimated that 25,000 residences and 30,000 commercial buildings collapsed or were severely damaged.

Makeshift, zombie-like tent cities sprang up literally overnight everywhere in the days and weeks following the catastrophe. Golf courses, vacant lots, parking lots – in short, anywhere with open space became encampments. They each ranged in size from a few dozen families to thousands of families each. One of the hundreds of temporary-permanent encampments was set up in Coral, eight miles north of the centre of Port-au-Prince. Within days of the earthquake, thousands of refugees had agreed to relocate to this formerly remote, barren place. RTCs set up in the aftermath of the earthquake included an advanced portable hospital sent over by the Israeli government (The Israel Defense Forces Medical Corps-EMC), Field Hospital, International Red Cross open-air tent hospitals, the ad hoc conversion of schools into makeshift trauma treatment centres, and various container clinics set up by a handful of NGOs deployed from various countries.

The earthquake and tsunami off the Pacific coast of Tohoku in 2011 was a magnitude 9.0 undersea mega-thrust event. It was the most powerful known earthquake ever recorded and one of the five most powerful earthquakes in the world overall since modern record keeping began in 1900. Its triggered powerful tsunami waves that reached heights of 40.5 metres in Iwate Prefecture, and which travelled 10km (6 miles) inland in the Sendai Region. In 2011, the NHK News Service in Japan reported that in addition to the loss of 15,800 lives, 5,950 injuries, 3,600 missing persons, and the total destruction of 45,000 buildings, damage to an additional 140,000 buildings, and massive relocation of infrastructure amenities, the tsunami itself inflicted multiple nuclear accidents. These accidents centred on an ongoing Level 7 meltdown at three reactors within the Fukushima 1 Nuclear Power Plant complex, with associated evacuation zones upgarding to 20km west and 40km north of the most costly global disaster on record.

Right after the earthquake, one Japanese architectural firm, Yasutaka Yoshimura Architects, published a report that it had developed an advanced container shelter, the Ex-Container Project, for persons and families displaced by the disaster. These modular units were extremely generic and minimalist and are adaptable for use as clinics. Their proportions were virtually identical to standard intermodal shipping containers. They are all white on the exterior, with windows and openings sparingly carved out from these “shoetboxes.” The modular units can be stacked on top on one another up to four levels in height. They are currently in mass production and a total of 50,000 have been purchased by the Japanese government to date, for deployment across the post-disaster strike zone on newly acquired land parcels. RTCs deployed in this strike zone have to date consisted of International Red Cross and Red Crescent tent hospitals, airlifts to urban medical centres, and Japanese defence force portable field clinics.

Global prototyping
On the evening of 20 April 2010, a massive explosion occurred in the Gulf of Mexico 60 miles off the coast of Louisiana. An immense ball of fire erupted high into the clear night sky as 11 men lost their lives. An over-budget, problem-plagued deepwater oil exploration platform had imploded – the BP Deepwater Horizon. The limitations of extreme engineering technology were laid bare for the world to witness as this rig fell 150 metres to the ocean floor in less than 30 seconds.

The unprecedented damage inflicted upon the region’s delicate aquatic ecosystems, its seafood industry, tourism, and the communities directly impacted, garnered extensive media attention and scrutiny by global environmental advocacy organisations. Governmental agencies with supposed regulatory oversight of the US deepwater drilling industry were caught completely unprepared. In response to this and other on-shore and offshore disasters, a prototype RTC was developed within the Graduate Program in Architecture + Health at Clemson University in the US, by Team 898. This system is modular and can be set up on water by a buoyant aperture, configured up to 75 modules, or on dry land. It was developed in response to the specific scenarios of the recent BP disaster, the Tohoku earthquake, and recent strife in the Mediterranean off the coast of Libya (Figures 3-7). This system’s modules feature photovoltaic panels, lightweight shell fabrication based on techniques perfected by the automobile industry, and a thermoplastic polymer exterior skin. (Figure 7). Ryan Ramsey co-lead the design of this innovative prototype (with the author). The RTC’s configurations can be pre-set to be expandsable to a single modular unit to as many as 75 or more modules on a single site. (Figure 5). The most aptancy of these systems afford a high degree of flexibility from a site-planning standpoint. Reconfigurability options yield pinpoint response modalities in settings that can range from dense urban, open shoreline, irregularly shaped sites, to remote rural sites. In terms of design, Vectors and installation factors, modular systems, lift- pack systems and hybrid systems combining elements of both, are most feasible at this time. Hybrid fixed container systems likely afford the most amenity and flexibility in most field settings. In Israel, two large urban
hospitals recently opened, each with a below-grade parking deck that can rapidly re-deploy or reconfigure to house pop-up portable trauma centres (Figure 8). This strategy is one that warrants significant further research and field testing.

It would appear logical to surmise that the global demand for ecologically sustainable and health-promoting RTCs has never been greater. Of course, challenges and opportunities associated with RTCs are many, as are the various methods available for their funding, designing, prototyping and manufacture. An RTC can function as a freestanding entity or as an adjunct to a fixed, immobile healthcare infrastructure, including as kit-of-parts, highly flexible appendages to conventional, fixed-site clinics, hospitals and medical centres. Why aren’t more architects engaged in responding to the challenge? Why is it that so few off-the-shelf prototypes of genuine architectural integrity are readily available for first-responder implementation? Where is private industry? Why have most healthcare architects remained indifferent to this call for action? The following are perhaps a few reasons why significant architectural design/technical advancements in this field remain so few and far between.

The dominance of the engineers: Transnational engineering firms dominate the industry as the provider of first choice in emergency and offsite shelter. An emphasis on bare bones functionality and logistical expediency has usurped any attention to anything that might be equated with the broader, classically based Vitruvian principles of architecture (commodity, firmness and delight). The largest US federal contracts are held by a relatively small handful of very large engineering corporations. These politically connected corporations tend to dismiss anything that aspires to achieve more than bare functionality: “We don’t have time for architects (or architecture) and they are (it is) a needless expense anyway that just slows us down.”

Architects’ traditional disdain for bureaucracy: Many architects are disinclined to communicate with engineers and politicians in a truly collaborative spirit. It is this fact that perhaps holds the profession back from making further inroads in achieving higher healthcare design quality with respect to pre-manufactured RTCs. This might account for the disaster industry’s unfortunate yet continued overreliance on prosaic, uncreative and excessively minimalist shipping-container-based systems, nearly all of which are placeless, ephemeral and wholly generic in relation to the timeless Vitruvian principles of commodity, firmness and delight.

Lack of professional training and preparation: The culture within most academic schools of architecture does not foster a genuine appreciation for or attitude of social engagement among the students—in terms of inculcating the personal initiative, sense of compassion and indefatigable perseverance so necessary to respond quickly and adroitly to healthcare needs in the aftermath of disaster. It is not an overstatement to say that, while in school, most architects are not trained in the realm of healthcare, nor with governmental ministries of health. The status quo in this regard must change, and change quickly.

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References

Figure 6: Internal configurations can be adjusted according to need—from surgery space to staff housing

Figure 7: An exploded diagram of the RTC prototype

Figure 8: Israel RTC deployment within medical centre parking deck

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