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Quick Deployment Disaster Shelters: Building Community Through Design

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Abstract

By understanding the experience of disaster victims, we can design product solutions that mitigate the effects and speed the pace of disaster recovery. In major disasters, temporary tent shelters can become semi-permanent. They need to provide protection from the elements, a refuge, comfort, security, and a sense of community.

UNIT^E is an innovative tent designed for disasters. Its hard shell container provides lockable storage within the tent when erected. Pictograms, colour coding and simple twist and lock mechanisms allow easy construction by one person on solid or soft ground providing a 12 sq m footprint, or zipped together for family accommodation. The design eliminates the trip hazard of protruding guy ropes. The roof design allows for clearing of ash and snow loads and the ability to collect and store rainwater. Replaceable groundsheets provide a fresh unused floor for each deployment. An identity pack for each tent makes it easier to identify and locate people from a group within the shelter community.

UNIT^E was developed through an iterative design process. Initial research fueled idea generation, producing 320 concepts. These were grouped by subject matter into eleven distinct areas. Groups were screened against developed criteria, combined and developed through critique and focused prototype testing.

The UNIT^E design takes into account the storage, deployment and refreshment of the product through out its life cycle. UNIT^E provides shelter that aids recovery from disasters by facilitating community and empowering disaster survivors.

Keywords: Community, Human Centred, Utility, Design

Introduction

The annual number of reported natural disasters has dramatically increased over the last hundred years. The rate of increase has been significant and sustained since the1950s, with a 21-fold increase in reported disasters between 1950 and 2006. Through the same period there has been a major reduction in deaths attributed to disasters (EM-DAT 2008).

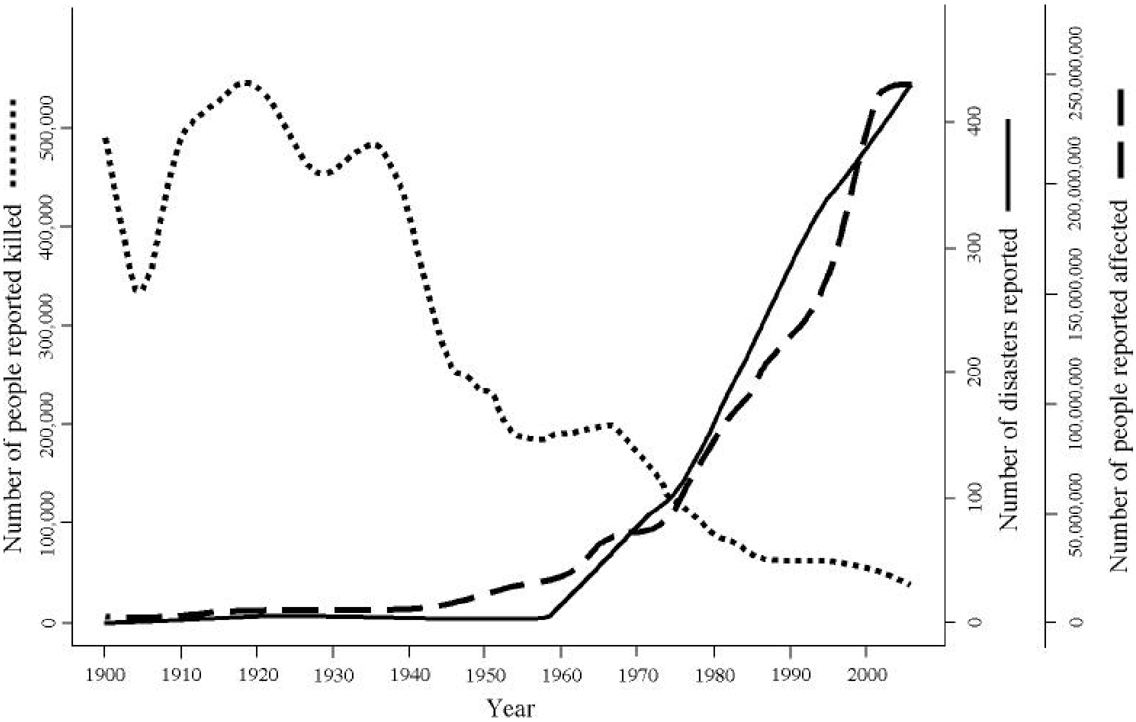

Fig. 1. Natural disaster summary 1900-2006 (linear-interpolated smoothed lines).

The reduction in mortality is attributable to a range of factors, which include: speedy response by authorities and organisations tasked with mitigating the effects of disaster; improvements in medical technology; better transportation infrastructure; developments in communication technologies; improvements in building science and civil engineering; increasing public awareness; scientific monitoring and prediction. While the ability to survive a disaster is enhanced, population increases mean that the number of people now affected by disasters has, like the number of reported disasters, increased nearly 50 fold during the same period (1950-2006). In 2007 the number of people affected by disasters was approximately 197 million (UN/ISDR 2008).

Economic Impact

Disasters have a significant economic impact arising from factors such as infrastructural damage, loss of economic production, loss of life and livelihood. Damage estimates for Hurricane Katrina in 2005 are in excess of $US 200 billion; for the 1995 Kobe Earthquake in excess of $US 150 billion (EM-DAT 2008).

The economic cost of the 2004 Indian Ocean Boxing Day Tsunami has been estimated at over $US 15 billion (Harcourt 2005). With international donations of aid in the region of $US 1.34 billion, and with 1.7 million people affected by the disaster (Inderfurth, Fabrycky & Cohen 2005), the spending per head was in approximately $US 788 per person affected. This amount of spending per head is exceptional. By contrast, in 2000, spending on disasters in North Korea, Somalia, Tajikistan, Uganda and Guinea-Bissau was less than $US 10 per affected person (Guha-Sapir, Hargitt and Hoyois 2004).

The Role of Design

Cooper (2001) identifies two leading factors: delivering unique benefits and superior value to the customer; and a market driven and customer focused development process as critical to success in product development.

The sustained rise in the number of disasters, and the humanitarian and economic scale of these disasters, has prompted governments and NGOs to plan, predict, train, and resource themselves to respond effectively. In many cases, products that have been developed for the military and leisure sectors are used in response to disasters. Those involved in disaster reconstruction are in a position to demand better-designed products, and they should, because products that are designed for the particular needs of people affected by disasters and those assisting them will provide more effective solutions and advance the road to speedy recovery from disaster. The scale of disaster recovery expenditure indicates that a significant unmet market exists for the development of products and services specifically designed to help mitigate the effects of disasters.

Such products and services cover a broad range of categories, among them products that assist or prepare families to survive a disaster, for example water storage products and systems for emergency water supply; products that provide direct support for those affected by disaster, such as tents, cookers, generators; and products that assist those involved in search and rescue and assistance, such as backpacks, stretchers, portable communications, tools and equipment.

Preliminary Incursions Into Disaster Response Design

The development of the UNIT^{E} disaster tent, one among 320 disaster product concepts, is underpinned by research and investigation that started in Christchurch New Zealand, in November 2005, when AFFECT The Centre for Affective Design at Massey University held a two-day product innovation workshop with the theme *Natural Disaster Solutions.*

The theme was selected in the context of two significant natural disasters, the 2004 Boxing Day Tsunami and Hurricane Katrina in 2005. *Natural Disaster Solutions* was considered an industry neutral subject, allowing participant companies to work together creatively and collaboratively, free of concerns that they would be compromising commercial interests.

Senior design and product planning personnel from South Island companies worked with industrial design staff and students from the Institute of Design for Industry and Environment at Massey University. Twenty-three participants completed the workshop.

Participants noted that the design and development of products for consumer markets generally assumes that the infrastructure we take for granted in our daily lives, such as reticulated water and electrical supply and telecommunications and transportation networks, can be relied on to support the product’s functioning. Disaster scenarios strip away these systems and provide a challenging and very different context to the usual product design projects, which deal with first world consumer markets.

Workshop outcomes included ideation (the visualisation of ideas), concept generation and the construction of card & foam prototypes of a range of solutions for disaster applications. Academic staff made a commitment to explore further design possibilities in relation to the disaster environment.

Research Method

This exploration involved research and investigation which occurred in two sequential twelve week projects within the undergraduate Industrial Design programme at Massey University. The first project involved third year students and the second, fourth year students. An iterative design method of analysis, design and evaluation was used to investigate the disaster context.

The first project, *Research and Concept Generation*, completed in 2006, focused on generating knowledge and understanding of the disaster context in order to drive ideation and concept generation. The focus was to generate a large amount of relevant ideas for students to develop in the *Development* project, which was completed in 2007.

Research and Concept Generation project outcomes.

This produced information related to specific disasters (volcanic eruption, landslide, tsunami, flooding and earthquake); human needs (shelter, nutrition and the experiences of those affected by disasters); and agencies responding to disasters (emergency response agencies, civil defence, communications). In addition 320 concepts were generated, from which 39 ideas were developed through to a basic concept and form model.

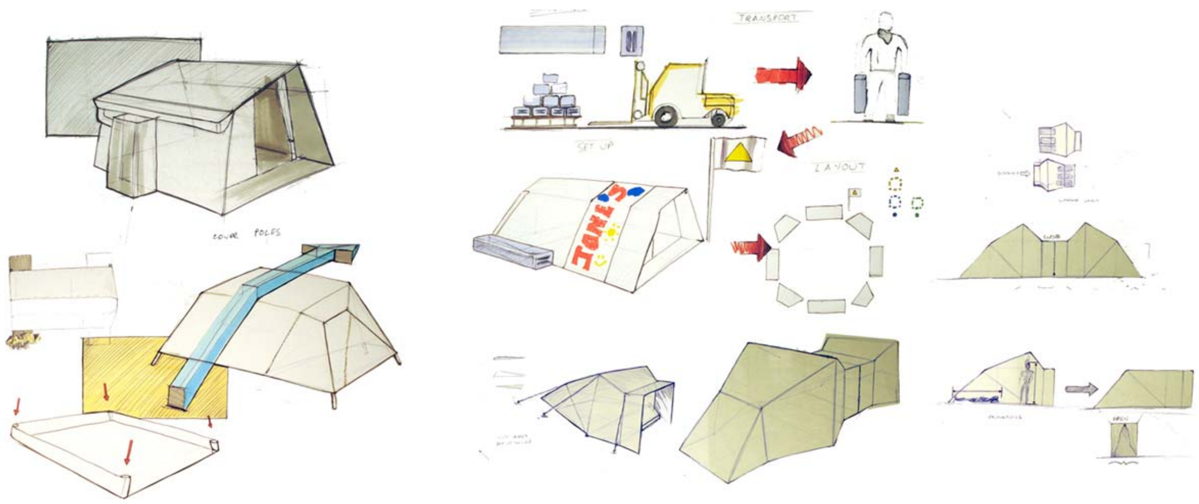

Fig. 2. Concept generation: Tent shelter.

Development project outcomes.

Work completed in the *Research and Concept Generation* project was grouped into common areas and reviewed. A matrix screening process was used to select specific product areas for further design development. The areas selected were: human registration system; rescue backpack; stretcher; domestic water conservation; personal communication device; electronic positioning emergency radio beacon (EPERB); water collection device; quick deploy temporary shelter; rescuer tools; medical nebulizer; emergency toilet.

The quick deploy emergency shelter product UNIT^{E} was one of the outcomes of this project. Details of its development are presented in the following sections of this paper.

Fig. 3. Prototype test UNIT^{E}: Size and accommodation of activities.

Tents and Temporary Shelters

Natural disasters can demolish buildings and render people's homes unsafe and uninhabitable. In this scenario people either flee to the homes of friends or families outside the disaster zone, or live in makeshift shelter homes and mass community shelter areas, often tent camps, until the damage is cleared and homes rebuilt. People who seek refuge in tent camps often end up staying for much longer periods of time than intended.

More than 250,000 people required temporary shelter and 380,000 buildings were damaged or destroyed in the 1999 earthquake that devastated Turkey. Tents were provided as an immediate response to the disaster. The following winter saw 135,000 people accommodated in tent camps in the affected areas (Johnson 2002).

Twelve months after the 2004 Boxing Day Tsunami that wreaked havoc around the Indian Ocean, tens of thousands of the 1.7 million people displaced by the disaster remained in deteriorating tent camps, with hundreds of thousands more in other temporary shelter. Tents were still being supplied, upgraded or replaced at the end of this period. Approximately 64,000 tents had been supplied in total, including 9,000 replaced with weather resistant models and a further 20,000 family tents ordered to replenish supplies (IFRCS 2005).

Designing for Stress

People who have survived a disaster are subject to stress brought about by a range of physical, psychological and sociological stressors. These include: cold/heat, noise, motion, hunger, fatigue, sickness, disease, loneliness, fear/anxiety, uncertainty, lack of belonging, poverty, lack of status, and degradation of housing conditions. The effects of these stressors degrade our cognitive and motor abilities. Nilsen & Bjelland (2006) recommend when designing for stressful situations that designers should accommodate the reduced performance of those stressed and design accordingly. This includes: avoiding making demands on physical accuracy or quick responses; reducing physically demanding tasks; reducing the number of inputs; simplifying every task, and making tasks intuitive; using existing conventions; giving the user control; making contact surfaces non-slip; giving precise chronological instructions.

The UNIT^E Quick Deploy Disaster Shelter

The shelter solution presented here is intended for the transitional period between immediate response and more developed, structured, semi permanent housing. Its design addresses not only the needs of the disaster-affected end user but also the needs of the people and organizations storing, transporting, erecting and refreshing the product.

Johnson (2002) says that appropriate temporary accommodation is of particular concern after a disaster. It can be a key factor in providing a safe and supportive environment from which families can re-establish daily routines, assisting the overall recovery of a region as a whole.

Affective qualities of design are of particular importance in designing appropriate accommodation to provide those affected by disaster with a sense of comfort, a place to rest and recover, privacy, security and community from which they can rebuild their lives.

UNIT^E is derived from simple Euclidian forms and is the most logical shape for strength and space efficiency. It is space efficient, easy to erect and dismantle and structurally sound. UNIT^E has a footprint of 3 x 4m and varies in height from 1.8m to 2.2m due to the innovative ‘popping' roof design. The size exceeds the minimum specifications of 3.5 m^2
per person of shelter set out in the Sphere Project's *Humanitarian charter and minimum standards in disaster response project handbook 2004*. The shelter is designed to house three adults and has a collapsible awning - good for use in the sun, or strapped down for extra support in extreme weather. For larger groups, UNIT^E is modular and can zip up where the two awnings meet to form a 6-person shelter. In this case the entry point changes from the front to the side. The result is a shelter with two rooms and a meeting area at the entry point.

Distribution and the formation of community

UNIT^E is packed into a moulded recyclable plastic case which provides more efficient stacking, transport and storage than the traditional ‘tent bag'. Once UNIT^E is in place the container provides a lockable storage safe within the tent. Sixteen interlocking containers stack onto a forklift pallet, making it easy to transport in large numbers. The pallets can be crane or fork lifted onto trucks, ships or planes and rapidly conveyed to the relief effort.
The sixteen shelters, once at their destination, form a neighborhood-sized community for approximately 40-50 people. On arrival at the campsite, one person can carry the shelter, which weighs approximately 40kg with the case.

In a sea of identical tents it is hard to identify friends and families homes. UNIT^E comes with a coloured flag and village layout plan with every pallet. This gives displaced people a sense of community and helps them navigate through a maze of shelters. Each shelter comes with an identity pack, which includes a number on waterproof plastic paper, waterproof markers (to personalise the number and flag) and a watertight sleeve on the shelter to hold the number.

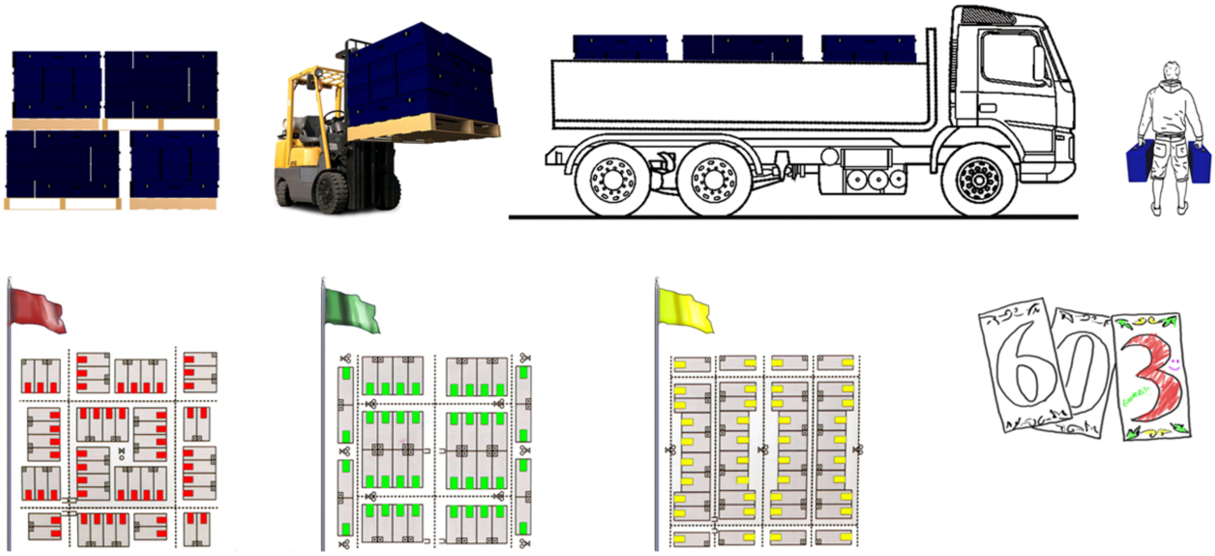

Fig. 4. Storage, transportation, community planning and personalisation.

UNIT^{E}: Basic Structure

The structure is comprised of several components:

- Flat pack feet that simply twist and lock into position. They can be fixed to the ground with 15cm ‘easy stomp’ pins that provide ample grip, or sandbagged in place. This allows the shelter to be erected with no protruding guy ropes, reducing trip accidents.

- The spaceframe structure is made of a combination of cast and extruded aluminium poles (extruded light T6 – 7001 ALLOY tubing). The poles come in two parts that are connected by elastic rope and lock into each other with sprung brass pins. Colour coding reduces confusion about what goes where. The corner pieces hold the poles in place with a sprung brass pin system (like that commonly used on crutches). They have an over moulded rubber sleeve into which the flexible carbon rods of the roof component are slotted.

- Carbon fibre rods, flexible, light and very strong, hold up the roof. The rods are used as tension springs. This allows the ‘popping roof’ design to work.

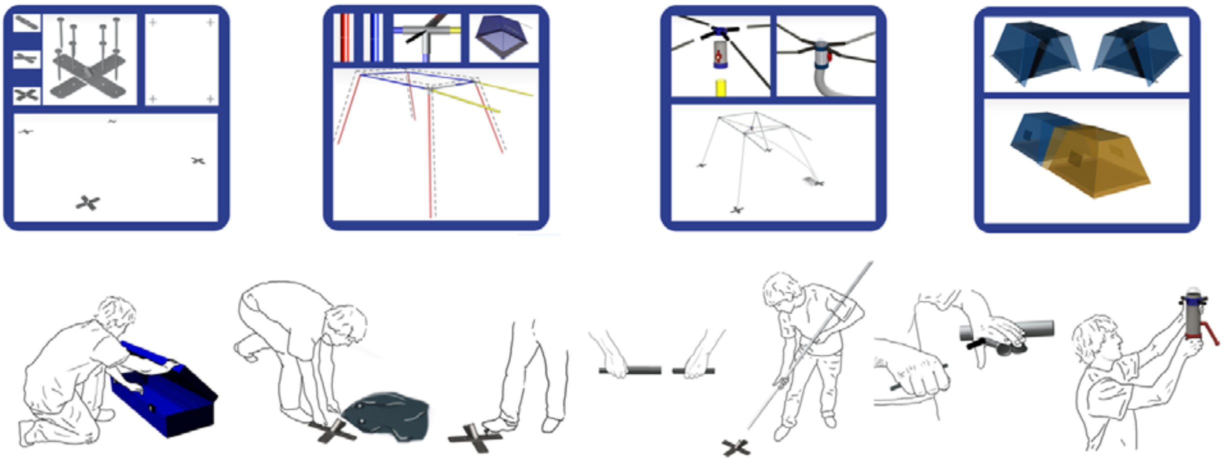

Fig. 5. Assembly uses easy-to-follow pictograms to avoid language and literacy issues.

UNIT^{E}: Water Catchment System and 'Popping' Roof Features

The innovative roof design allows for the clearing of snow or volcanic ash and the collection of rainwater. A central hub connected to the frame by tensioned carbon rods allows a section of the central roof to sit in one of two positions. By pushing and pulling the hub the central section pops up and down, displacing roof contents (much as an umbrella is pumped to shake off excess water prior to being collapsed). Roof angles prevent initial build up of snow but when the weight gets too great, the roof simply pops down, alerting the user to clear it. A quick vigorous pumping action and it's cleared.

For water collection the roof is popped down to a height of 1.8m (standard height is 2.2m) inverting the top of the tent and funneling rainwater into an easy to carry flexible bladder (with external overflow). Standard plumbing fittings are used for easy repair and maintenance. A switch valve at the top allows disconnection of the system when there is no rain, and ventilation on hot days. The solid container UNIT^{E} comes in provides a lockable storage compartment for the shelter dweller, and can also house the two water collection carry bags that come with the package. The two water bags screw directly onto the downpipe of the water catchment systems; they are easily removed to transport once filled.

Fig. 6. Details of foot, frame connections and water catchment device.

Ground Sheet and Cover Sheet

The UNIT^E shelter deals with the cover sheet and the ground sheet in an innovative way; the two pieces of material are separate. When the shelter is no longer needed and the disaster affected can move on, it can be cleaned or recycled and reused for another situation.

When a shelter has been in use for a long time no other part of it suffers as much wear and tear as the ground sheet, which comes under extraordinary abrasion through contact with the ground, especially when occupants are moving about inside the tent. That's why Unite's ground sheet is replaceable.

The cover sheet is made of materials that are nutrients to the technical manufacturing life cycle (Mc Donough and Braungart 2002). These materials can be recycled or 'upcycled' if the material is beyond repair or cleaning. The cover sheet is made up of a three layer system comprising of a nylon layer, an aluminised PE film layer and a further tight weave nylon layer on the inside. This means the fabric can be waterproof, fire retardant, wind and rip resistant, thermally reflective, and suitable for any weather condition.

Each time UNIT^E is dispatched to a new situation it comes with a fresh, unused ground sheet. This gives the feeling of a new tent; one the stressed and tired disaster affected can make their own. The ground sheet system is made of materials that are nutrients to the biological life cycle (Mc Donough and Braungart 2002). The sheet itself is made of a biocomposite material that is impact resistant, cut resistant, heat insulating, recyclable, compostable and waterproof.

The fittings and clips that hold it in place are made from biodegradable polymers. The entire groundsheet can be thrown in the compost after use and biodegrade after its intended lifespan (approx 2 years in composting conditions). The groundsheet extends 20cm up the side of the tent and is clipped into place at the corners and Velcro sealed along the edges.

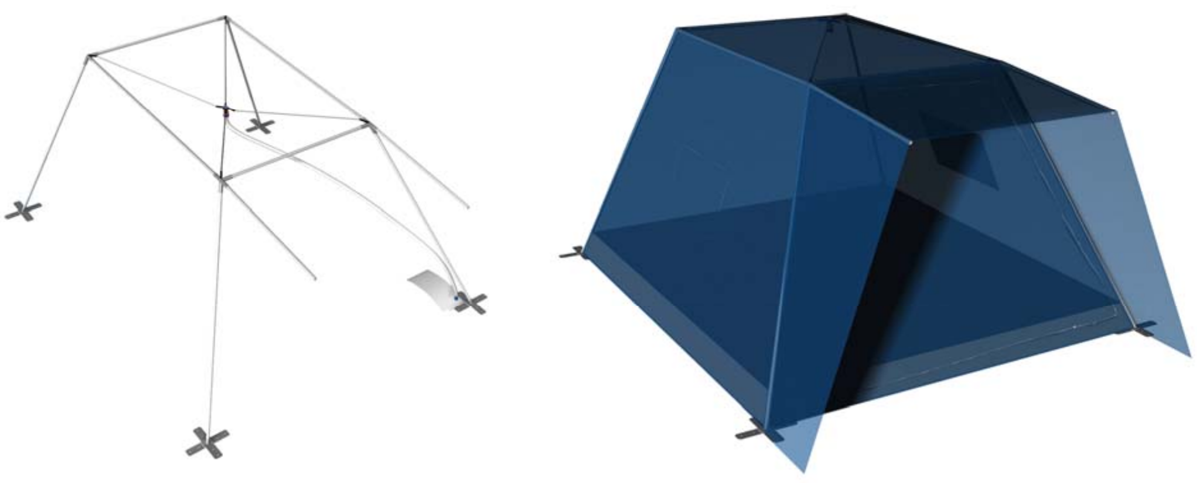

Fig. 7. Frame with water catchment and storage, and fully assembled tent shelter.

Conclusion

UNIT^E seeks to aid the road to recovery from disaster by facilitating the rebuilding of community early on in the recovery process. Its design addresses the full life cycle of the product. Features have been developed to deliver clear benefits to all of the stakeholders involved with the storage, deployment, erection, use, and refreshment of the product. Innovative features such as the 'popping' roof and water catchment system require further testing. Prototyping at full size for user trials and further developing material qualities and specifications to address high wind and winter conditions needs to be completed to further advance the design.

UNIT^E is one example that illustrates how design can help those involved, from the organizations directing and coordinating the reconstruction effort to those using the designed products and services, to deal more effectively with disaster reconstruction.

References

Cooper, Robert G. (2001) *Winning at New Products - Accelerating the Process from Idea to Launch,* Third edition, Perseus Publishers. Cambridge; Mass.

EM-DAT: Emergency Events Database (2008). *World 1900-2006: Combined trend for events.* Belgium. Center on Epidemiology of Disasters (CRED). http://www.emdat.be/Database/Trends/NaturalDisasters/natdis_trend1_05.html accessed 12 February 2008.

EM-DAT: Emergency Events Database (2008). *World 1900-2006: Damage estimates.* Belgium. Center on Epidemiology of Disasters (CRED). http://www.emdat.be/Database/Trends/NaturalDisasters/natdis_trend1_04.html accessed 12 February 2008.

Guha-Sapir, D., Hargitt D., and Hoyois P. (2004). *Thirty years of natural disasters 1974-2003: The numbers.* P50-52. Belgium. Center on Epidemiology of Disasters (CRED). http://www.emdat.be/Publications/publications.html accessed 10 February 2008.

Harcourt, Tim (22 December 2005). *Recovery and reconstruction – the Indian Ocean Tsunami one year on*. Sydney: Australian Government. Austrade. http://www.austrade.gov.au/The-Indian-Ocean-Tsunami-one-year-on/default.aspx accessed 13 February 2008.

IFRCS: The International Federation of Red Cross and Red Crescent Societies (15 December 2005). *Tsunami – Facts and figures.* Geneva: IFRCS. http://www.ifrc.org/docs/pubs/Updates/tsunami_facts151205.pdf#xml=http://search.ifrc.org/cgi/texis.exe/webinator/search/pdfhi.txt?query=tents&pr=english&prox=page&rorder=500&rprox=500&rdfreq=500&rwfreq=500&rlead=500&sufs=0&order=r&cq=&id=43d50a69b2 accessed 10 February 2008.

Inderfurth, Karl F., Fabrycky, David and Cohen, Stephen P. (December 2005). *The tsunami report card.* FP Foreign Policy: Carnegie Endowment for International Peace. Washington DC: http://www.foreignpolicy.com/story/cms.php?story_id=3314 accessed 12 February 2008.

Johnson, Cassidy (2002). *What's the big deal about temporary housing? Types of temporary accommodation after disasters: example of the 1999 Turkish earthquake.* TIEMS conference. 2002, May 14-17. University of Waterloo, Canada.

Mc Donough, William., and Braungart, Michael. (2002). *Cradle to cradle: Remaking the way we make things*. First edition, North Point Press. New York.

Nilsen, Kjetil L. and Bjelland, Hans. (2006) *Unpleasant emotions: Designing for stress The need for guidelines when developing products or systems for use in stressful situations.* Design & Emotion Conference. 2006, September 27-29. Göteborg.

The Sphere Project. (2004) *Humanitarian charter and minimum standards in disaster response.* p17. The Sphere Project. Geneva: http://www.sphereproject.org/component/option,com_docman/task,cat_view/gid,17/Itemid,26/lang,English/ accessed 10 February 2008.

United Nations. International Strategy for Disaster Reduction (18 Jan 20008). *Disaster figures for 2007*. Geneva: UN/ISDR. http://www.unisdr.org/eng/media-room/press-release/2008/pr-2000-01-disaster-figures-2007.pdf accessed 14 February 2008.