

Soldier shelter

Amy Soo Leighton, Chemical Engineer at US Army Natick Soldier Research, Development and Engineering Center, reflects on the advances in rapidly deployable structures for collective protection...

The threat of Nuclear, Biological and Chemical (NBC) weapons has only increased since the United States Military first encountered them in World War I. Since then, the use of such weapons has expanded from the battlefield to sites of public terrorist attacks. Targets range from handfuls to the thousands. With this increasing threat, adequate protection must be made available to the widest number of troops as possible. Collective protection is a means of providing an environment protected from NBC warfare agents for a variety of functions. Individuals can carry out tactical functions, such as communications or medical care, without the hindrance of individual protective equipment. Collective protection also provides a clean environment for rest and relief in the battlefield. Speed and ease of deployment are critical however, particularly under the time constraints associated with potentially contaminated environments. To better serve military functions, collective protection must be rapidly deployable with minimum logistics to keep up with the mobility of military endeavours.

The goal of rapidly deployable structures for collective protection has existed for decades, but the design challenges, logistics and cost associated with such a structure have been a tremendous burden to overcome. Traditional shelters consist of heavy metal frames and separate fabric portions that require significant time and manpower to erect. Larger complexes, such as field hospitals or base camps, only magnify these logistical burdens. Although the legacy systems provide protection, the need still exists for a rapidly deployable, lightweight, low cost, soft-walled battlefield tent that can keep up with the increasing mobility demands of the Army. Many commercial quick set-up shelter options are available, yet most cannot withstand the rigorous environmental loads and durability rigors of the Military.

New advances are continually being made in structure design and collective protection materials. The US Army Natick Soldier Research Development and Engineering Center's (NSRDEC) Shelter Technology Engineering and Fabrication Directorate has a long-standing history of being in the forefront of these advances. Located in Natick, Massachusetts USA, the NSRDEC works closely with industry partners to identify, develop, and advance shelter technologies to meet the unique and unpredictable field tentage requirements of the Military.



Folding frame technology

A recent advance in durable technology for quick erect shelters and collective protection is a 'folding frame' design. The French design by Utilis has been fielded in European military applications, and current evaluations have demonstrated potential benefits for US systems. The Utilis TM series of shelters consist of a rugged, aluminium alloy frame with protective PVC outer skin and interior liner. The shelter frame has a traditional A-frame shape, with ruggedised hinges between structural members. There are few parts and interconnected pieces, minimising vulnerabilities and maintenance requirements. The outer skin and CB protective liner remain integral, deploying simultaneously via a unique pulley system. For general-purpose deployment configurations, the same design concept is used to deploy a lightweight thermal liner integral to the tent skin. Also, the system's thermal fly is efficient in reducing solar loads without requiring additional frame members.

Although simple in design, the shelter has demonstrated the level of structural integrity and durability required by US military applications. The TM tent series has successfully passed rigorous wind, driven-rain, and snow load testing at the Army Aberdeen Test Center. All of these tests were conducted on the base shelter system, without the use of additional extreme weather kits or equipment. Erect/strike test cycles on the 580ft² TM54 were conducted by four people in four minutes, without the use of any supplementary equipment. All of this is accomplished with approximately half the weight and packaged volume of the legacy shelter.



To withstand the rigors of defence environments, military shelter designs are forced to trade-off weight and set-up requirements for structural integrity. Typically, higher-echelon shelters require more time and effort to set up, but are able to withstand severe, long-term environmental loads. Forward deployed shelters, on the other hand, are rapidly deployable yet may not withstand the same environmental conditions. The Utilis™ shelter series combines a simple but strong design with a unique deployment method to provide both rapid deployability and structural strength. The combination of these capabilities makes the Utilis™ series shelters potentially beneficial to a broad range of requirements, from highly mobile to longer-term applications.

Airbeam technology

Advances in textile technology demonstrate advantageous load carrying capabilities via inflation with pressurised air. These inflatable composite structures, or airbeams, can be used to fabricate a variety of shelters from small command post and forward surgical shelters to large area hospital and maintenance shelters. Whatever the application, the unique flexibility/rigidity duality of airbeams is attractive to the rapid deployability and high mobility of the Army. Unlike typical metallic structures, air-inflated structures are designed to be lightweight and have high deployed-to-stow volume ratios that can be on the order of 100 to one. Although airbeam structures provide easy, fast deployability, they must also provide the same, if not higher, level of durability and protection that legacy military tents provide.

Inflatable structures are not a recent discovery, however, airbeam shelters of the past have been heavy, cumbersome and expensive, with poor reliability and durability. The airbeam weaknesses were due to the use of woven fabrics that were cut and shaped into beams by stitching, adhesive bonding, or thermal welding. This labour-intensive manufacturing process is expensive and structurally inferior, since seams have proven to be weak points and prone to leakage. Airbeam technology has reached the point where the structures are understood from an engineering standpoint, which takes into account not only the inflation pressure and dimensions of the airbeam, but also the individual material properties and interactions that dictate their structural performance and overall characteristics.

Vertigo, Inc., located in Lake Elsinore, CA, has specialised in the design of inflatable composite structures, airdrop systems, and other customer programmes since 1986. The NSRDEC has worked extensively with Vertigo to advance the technology of high pressure, braided, airbeam-supported structures. It has been long understood that a reduction in airbeam diameter – reducing cost, weight and bulk – requires the use of increased internal pressure. In order to advance beyond the low pressure inflatable composite structures, the technology of the airbeam had to be redesigned. Through a combination of independent research and development and joint efforts with the NSRDEC, Vertigo accomplished the development of an entirely new airbeam capable of withstanding inflation pressures more than 10 times that of previous designs.



High pressure airbeam technology has matured to demonstrate exceptional air holding capabilities, structural integrity and affordability in rapidly deployable shelters. Large-scale airbeam shelters have been made up to 85ft wide by 170ft long. The Aviation Inflatable Maintenance Shelter consists of nine 30inch diameter airbeams inflated to 80psi and can be completely set up in two days. This is far less than the week-long duration of erecting a metal frame structure of comparable size. The smaller airbeam structures, the Small Tactical Airbeam Tents (STAT), consist of 10inch diameter airbeams inflated to 40psi. The shelter is semi-cylindrical and measures 22ft wide by 21ft or 32ft long. The STAT is easily transportable due to its small packing weight and volume. This structure requires minimal personnel and effort to erect and strike because the airbeams remain integral to the shelter skin. Once the shelter is unrolled, the airbeams are inflated using a small air compressor. Once inflated, the airbeams will maintain pressure for weeks at a time. The STAT has also undergone the rigorous environmental load testing at the Army Aberdeen Test Center. The 640ft² version of the

STAT has been set up by four people in minutes. A legacy shelter of comparable size would take eight people more than 30 minutes to set up.

Conclusion

Chemical and biological contamination can occur at a moment's notice, which is why rapid deployability is critical to collective protection. Shelter designs have gone beyond the traditional heavy metal general-purpose tents of the Military's inventory. Folding rigid frames and pressurised airbeam supported shelters are relatively new, but their maturing systems have proven to reduce strike and erect requirements, as well as weight and bulk. They have also demonstrated the structural integrity to withstand the challenging environmental loads experienced across the globe. User evaluations with soldiers in the field have provided valuable feedback as to their ease of use and performance in supporting mission operations. These advances are critical in keeping up with and performing against modern warfare challenges. The NSRDEC is dedicated to remaining at the forefront of these advances and transitioning advanced shelter systems to the warfighter.



Amy Soo Leighton
Chemical Engineer
US Army Natick Soldier
Research, Development and
Engineering Center
Tel: +1 508 233 5457
AmySoo.Leighton@natick.
army.mil
www.natick.army.mil