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Shelter Technology, Engineering, and Fabrication Directorate

TECHNOLOGIES OVERVIEW

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Shelter Technology, Engineering, and Fabrication Directorate (STEFD)

This brochure contains information on STEFD's current and new technologies which are being researched, tested, prototyped, and utilized.

STEFD provides shelter systems for today's Soldier in various types of environments. The team focuses on providing several shelter systems, which satisfy an abundance of purposes in conflict situations. The standard family of tactical shelters includes rigid wall, soft wall, and hybrid. All teams work with the PM Force Sustainment Systems Office as well as for external customers for the development and fielding of shelter systems. Each of these teams focuses on different types of shelter systems.

STEFD strives to develop concepts and technologies to support Collective Protection by providing technical management and engineering support for the Army, Department of Defense and applicable customers in assigned areas as well as industry, academia and foreign governments. Furthermore, STEFD is constantly conducting basic and applied research, technology development, demonstration, and engineering support. The Directorate works with soft, hybrid, and rigid wall mobile/tactical shelters, including tactical command post systems, CB protected mobile shelter systems, and camouflage concealment and detection technology for mobile shelters.

Although the well-known requirements of tactical mobility, lightweight shelters, and ease of erecting/striking have always been important in the shelter technology area, the recent emphasis is "Logistics Transformation." Shelter technology efforts are underway to improve the survivability, mobility and sustainability of Soldiers through the development of rapidly deployable shelters that are lightweight, low cube, energy efficient and require minimal manpower to erect; improved Chemical and Biological (CB) resistant fabrics, closures and airlocks, and transitioning technology to the commercial sector to make the cost of a capability needed by the Army more affordable. Additional shelter technology efforts are focused on the need for Camouflage, Concealment, and Deception (CCD), ballistic protection, CB protection, and commercial partnering opportunities in novel structural supports, such as lightweight, High Pressure Air Beams. Future efforts are focused on the need to develop new generations of hybrid shelters, which incorporate the best features of rigid wall and soft wall shelter technology.

For More Information

Shelters Technology, Engineering & Fabrication
PHONE: COMM (508) 233-4347, DSN 256-4347
E-MAIL: NATI-AMSRD-NSC-AD-B@CONUS.army.mil

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Solid State Lighting for Shelters I

- NSRDEC and Techshot are developing a solid state lighting system using LED luminaries. LEDs have the advantage of producing an efficient, lightweight, rugged lighting system that is integral to shelter systems. The Techshot Shelter Lighting System (SLS) provides lighting intensity and uniformity required for battlefield or other temporary military structures. The SLS is an adjustable illumination assembly for battlefield shelters in a package that is robust, transportable and reliable. Unlike existing fluorescent lighting systems, the SLS is shatterproof, containing no fragile components subject to early failure or fault. The SLS is an ideal system for deployed Medical or Command and Control structures requiring high intensity and uniform lighting. This system can operate from a wide range of AC or DC input power including solar (photovoltaic), AC generator, vehicular, stationary, fuel cell or battery. In addition, the system is designed to provide uninterruptible power via an internal secondary battery backup circuit.

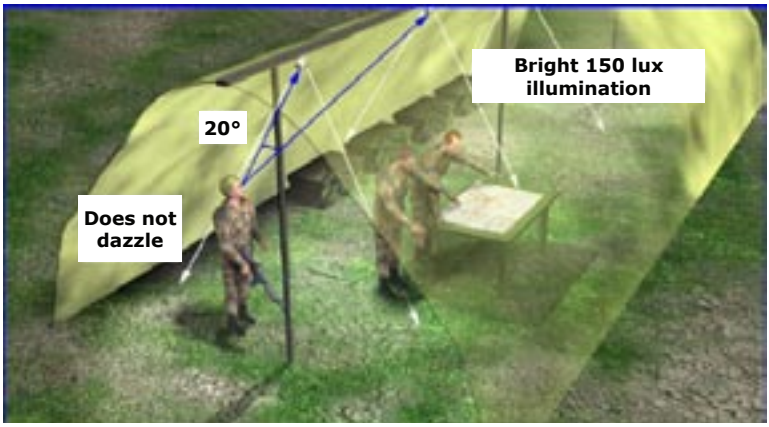
Light Module Assemblies (LMAs) string test set-up

- The SLS consists of a power controller unit and a Flexible Illuminator Assembly (FIA). The FIA is a string of light module assemblies (LMAs) that house multiple LEDs and their driving electronics. The FIAs not only provide superb lighting but can also be stored and transported within the structure, eliminating the substantial logistical issues common with the fragile fluorescent systems. For those applications not requiring a 700 lumen light source, the FIA can be constructed to support lower intensity general purpose needs, or the SLS can provide dimming capabilities. The FIA can also be configured as a drop-in replacement for permanent, removable, underwater, and other mission critical fixtures.

Solid State Lighting for Shelters II

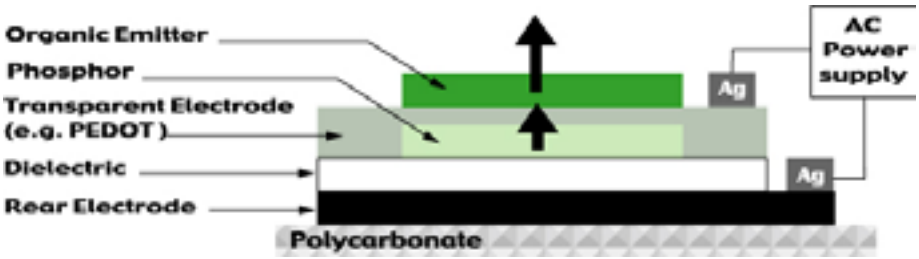
SOSIL with control unit

- NSRDEC and Physical Optics Corporation (POC) are developing a solid state lighting system using LED luminaries. LEDs have the advantage of producing an efficient, lightweight, rugged lighting system that is integral to shelter systems.
- The POC Solid State Illumination System (SOSIL) comprises of an array of single light fixture assemblies, each with a high-brightness white LED with a proprietary POC non-imaging beamformer (NIB). Each array of 16 light fixtures will evenly illuminate 1400 square feet of shelter. SOSIL is designed to illuminate an area without glare or dazzle, even when a light fixture is viewed directly, and the power supply will allow the lights to be dimmed. The SOSIL fixtures will be permanently integrated with the shelter so that it is transportable and deployable as part of the shelter. Unlike current systems, the SOSIL will be safe and reliable, with no fragile vacuum tubes or bulbs that contain mercury. SOSIL will be powered from 120 VAC, 60 Hz power line and will automatically switch to a battery upon power line failure. The 100,000 hour LED lifetime projects to a 15 year operating period, which exceeds the lifetime of shelter systems.



Polymer Based Lighting

- NSRDEC and Crosslink are developing a flexible electroluminescent (EL) polymer lighting system for field shelters. The EL lighting system consists of a number of flexible light panels designed to fold with the shelter walls/ ceiling upon strike and erect as a semi-permanent part of the shelter. As a result, the EL lighting system will reduce logistics and deployment time for shelter systems while providing high quality white light.



Basic EL panel layers.
Substrate is not exclusive to Polycarbonate.

A Crosslink EL panel demonstrates flexibility in gelbo flex test

Crosslink white light NSRDEC Prototype

An Overview of Flexible Photovoltaics (PV) Technology:

- Traditional power sources are heavy, expendable, detectable, not directly integratable into Warrior Systems, and do not have sufficient density for extended missions
- Conversely, photovoltaics (PV) convert light energy into electricity with no noise, moving parts, fuel consumption, or pollutant emissions
- Significant recent advancements allow PV modules that are flexible and lightweight

More on PV Technology: The photovoltaic (PV) integrated shelter products utilize amorphous silicon (a-Si) technology on polyimide (i.e. plastic) substrate. The benefits of this combination are a lighter weight product than similar a-Si PV on stainless steel, and lower cost of the PV resulting from on-going improvements such as roll to roll processing, and multi-beam laser etching of the film during manufacture. Once the PV module is fabricated, it is positioned on a polyvinyl chloride (PVC) coated mesh or cloth material and roll laminated under both heat and pressure to bond the PV module to the substrate itself. When this lamination process has cooled, the physical bond of the module to the substrate is extremely strong and designed to survive the stress of wind induced flexing experienced by fabric shelters.

Ultra Lightweight Flexible Photovoltaics for the Individual Soldier

- This program seeks to maximize an opportunity in creating a very low maintenance system for the individual soldier by using solar modules which are carried in, mountable on, or integrated into gear which is already typically worn or carried. This is expected to reduce the level of excess batteries that need to be carried and can make the individual Soldier more self-sufficient. There currently is a wide range of equipment requiring electrical power which this program can positively impact, including communication gear, Global Positioning System (GPS) equipment, night vision gear, weapon sights, etc. Future equipment which will require even more electrical power includes health monitoring systems, digital mapping displays, and computer-based information systems.

- In some instances the solar module will need to be deployed in order to get adequate charging current; in others, charging may occur continuously from exposed solar modules during the Soldier's other activities.

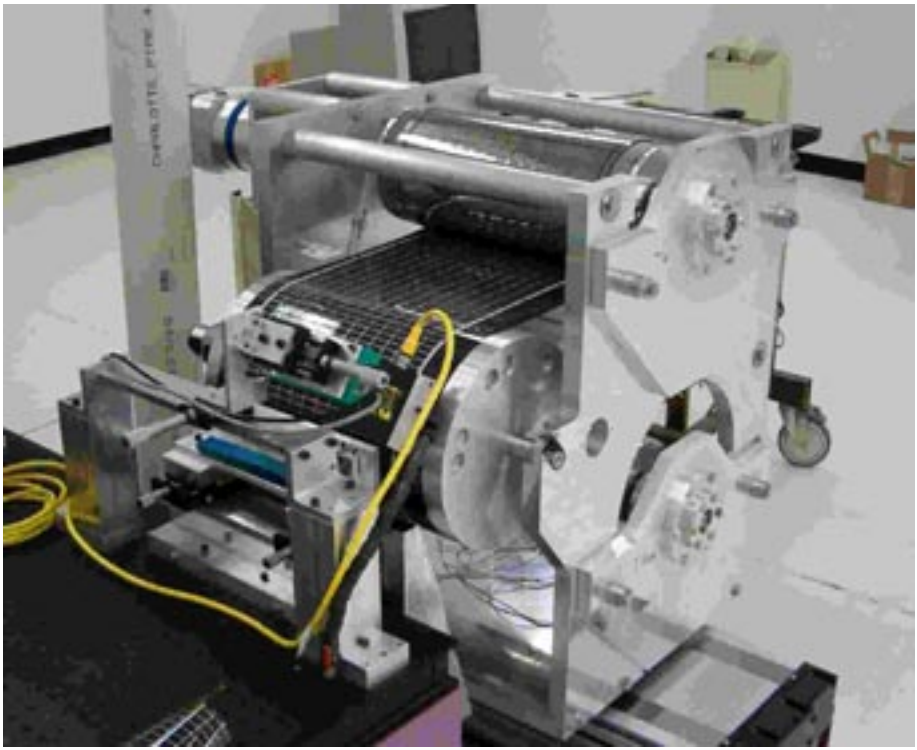
Status: Initial results indicate that PV panels integrated with the assault pack of the dismounted Soldier may provide sufficient power to charge batteries stored in that pack while the Soldier is on the move.

PV Stowed (left) and PV Deployed (right)

Flexible Photovoltaics (PV) Manufacturing Improvements and Low Light Devices

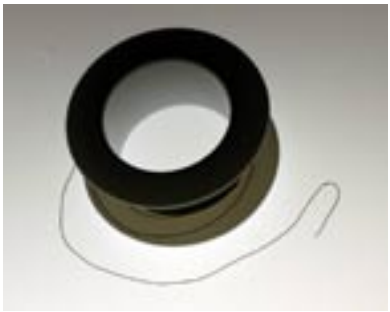
- This program seeks to continue the past successes of the NSRDEC Flexible PV program by improving the root enabling technology in terms of materials, manufacturing throughput, production quality assurance, module conversion efficiency, and increasing the breadth of the light spectrum able to be converted to electrical power.

Status: Progress is already being made in the areas of automated buss bar tabbing of the PV modules, development of thermoplastic urethane (TPU) as a higher quality replacement for the adhesive layer in the module stack, investigating an optical monitoring system for the metal deposition step in the manufacturing process, and looking at a textured polyimide web for use in refracting light as a potential way to increase conversion efficiency.



OSD funded SOCOM Technology Transition Initiative (TTI)

- This project involves the investigation and development of methodology of allowing PV to work in concealed conformal objects; development of visual coatings with light transmission capabilities for such conformal objects; investigation into very small PV power sources for use in tagging, tracking, and locating (TTL) applications; research and development of power producing materials with inherent camouflage patterns, and research and development of a PV fiber.



Status: The program funded production of 1000 PowerFilm® AA battery chargers as well as questionnaire development and staff from NSRDEC to provide NET and evaluation data collection in the field. Results from this field evaluation show application of PV technology providing positive returns when used in long duration (36+ hours) mission scenarios. Working PV fiber has been delivered with low conversion efficiency (<1%), with work continuing on increasing yield, durability and efficiency of that fiber. Weaving trials have been started to examine the effect of inert fibers on the performance of the PV fibers when integrated in a traditional textile.

Flexible Photovoltaics for Fabric Structures

- This program responds to a rising demand for electrical power in off-grid and temporary shelter installations, particularly with Command & Control and medical operations. This technology looks to fabricate and install a significant number of PV integrated shelter components and structures in order to improve performance and manufacturing aspects of the shelter integrated photovoltaic product, combating the logistical burdens of traditional fossil fuel based power generation systems. PowerFilm® Inc. will manufacture a significant number of PV integrated shelter units to be made available and tested in a CONUS field environment by military personnel. This will serve as an efficient way for soldiers to get acquainted with the capability of PV and provide feedback so that optimum methods of use and improvements in future iterations of the technology can be implemented. The field environment testing will be done in a sequence of steps which include planning, delivery, and evaluation phases.
- A "Balance of Systems" (BOS) was developed and produced as a complementary piece to the PV integrated items. The BOS includes twin HMMWV storage batteries, a charge controller which controls the flow of power from the shelter PV to the batteries as well as monitoring power drawn from the batteries, and a DC to AC inverter which converts the 12 volts DC from the battery / PV to 115 Volts, 60 Hz, AC power. The charge controller, battery, and inverter are conveniently packaged in a rugged aluminum case with handles for a four man carry for ease of transport and installation.

Status: The PV has been successfully integrated into solar shades for the TEMPER tent and other shelters. Systems ranging from 750 W to 2 kW have been demonstrated and undergone technical and user testing. Prototypes are currently being evaluated in an operational environment through the Rapid Equipping Force.

Flexible Photovoltaics Improvements and Applications

- This effort focuses on examining the production methods and materials of manufacturing amorphous silicon based photovoltaics (PV) on a flexible polyimide substrate to realize an increase in process yield, eventually leading to a decrease in cost of the final product. Prior work has identified silicon deposition as an area needing improvement. Adding the relatively slow rate of the silicon deposition process to the high cost of silicon machines makes silicon deposition the dominant cost factor in current manufacturing of flexible PV on polymer substrate. This program is addressing a number of major issues which have resulted in throughput improvement in the silicon process and at the same time improved performance of the PV devices produced. The throughput improvement in silicon deposition included both machine design improvements and process improvements. Taking advantage of newer DC magnetron cathode technology has both increased deposition rate and improved target material utilization. Efforts are also currently underway at PowerFilm® Inc. to increase efficiency by improving the PV device's ability to collect more light at the red end of the spectrum.
- Following the Department of Defense call for a reduction in demand on electrical grid power in March of 2001, there has been an increasing effort and number of projects aimed at installing long term PV on military bases. As the efficiency and cost effectiveness of PV improves, it becomes more and more cost advantageous to install PV in permanent structures. The lightweight flexible PV developed to date in industry has been aimed at applications requiring lifetimes of three to five years with very little work being done on longer lifetime applications. Part of this program is focused on identification of potential weaknesses impacting long-term lifetime, correcting weaknesses found, and having appropriate testing done to verify the extended lifetime.

Status: The program is already displaying potential benefits that may increase yield from the manufacturing process and increased efficiency of the PV material. Optical monitoring systems are allowing PowerFilm® Inc. to more fully understand the affects of manufacturing variables, and have resulted in the implementation of manufacturing processes that are producing consistently higher yield material.

Photovoltaic (PV) BB2590/BB390 Intelligent Battery Charger

- In the area of Solar Battery charger units, the implementation and testing of the BB-2590/BB-390 solar chargers and other battery charger options will be accelerated by building a number of test units which may be sent out for evaluation and comments in order to provide feedback for improvement. These units for the mainstay batteries along with test units for other various applications will be provided to NSRDEC for evaluation and demonstration purposes.

Status: PowerFilm® Inc. continues to work toward the design of a BB2590 / BB390 intelligent battery charger incorporating a full array of features including power tracking, optimum charging efficiency, state of the art battery protection algorithms and DC-DC converter for use with a wide array of modules. On a parallel path, PowerFilm® has fabricated sixteen cell modules specifically for a twenty volt (20V) fold up array. These arrays are designed to work with existing chargers for the BB 2590 made by McDowell, Brentronics and Patco.

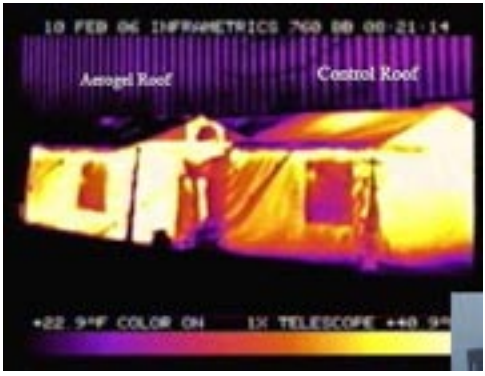
(Left) Initial Revision Showing Battery in Charging Position and Charger Faceplate Without Battery

(Below) Final Revision (concept drawings)

High Performance Shelter Insulation

The military use of rapidly deployable shelters calls for high performance in very extreme conditions, which is a tall task for the thermal insulation layers of these shelters. Current methods that use stagnant air gaps are effective only in moderate environments. Shelter systems in extreme environments use a multi-layer insulation made of polyester batting and metallized film for thermal protection. While this composite insulation provides the required performance, reducing the weight and cube of these insulation systems will reduce shelter strike and erect times, will improve troop mobility, and will also reduce the storage area needed that could be used for additional troop supplies. This program looks to make these improvements by utilizing the outstanding properties of aerogel material in developing effective and flexible military shelters.

Aerogels are a nano-porous silica material with the lowest thermal conductivity of any known solid, yet are inherently brittle and expensive to manufacture. Through a Small Business Innovation Research (SBIR) effort with Aspen Aerogels, Inc. the unique thermal properties of aerogel material has been incorporated into a flexible, durable insulation for military shelters. Aspen has also developed low cost manufacturing techniques that enable this amazing material to be commercially viable. This high performance shelter insulation has demonstrated a 40% improvement in thermal resistance while not affecting the packing configuration of the tent and increasing the weight by only 3%. In addition to the high thermal performance, the aerogel material provides infrared signature and acoustic suppression to further enhance the tent performance. Aspen partnered with Outdoor Venture Corp., manufacturer of currently fielded tents, to fabricate aerogel insulation for the Tent Extendable Modular Personnel (TEMPER) and the Modular Command Post (MCP) tents.



AIRBEAM TECHNOLOGY

Overview: A novel textile technology has been developed that enables the use of inflatable arches or "airbeams" as structural support members in shelters. Airbeams replace current metal-frames in fabric structures offering significant deployment time, weight and cube savings for highly mobile military shelters. This new airbeam technology offers increased structural carrying capacity, improved durability, and excellent air holding when compared to currently available inflatable technology.

Description: Airbeam technology was developed through Army science and technology (S&T) funding, the Small Business Innovation Research program as well as congressionally directed funding. Investments were also made by the Logistics Transformation Agency and the Army Medical Research and Materiel Command who recognized the high payoff potential of this new shelter technology. The strategy used to develop the technology included early fabrication of prototypes concurrent with the development of the manufacturing technology as well as determination of the structural performance of these unique textile structures. User evaluations and technical testing on prototypes enabled the technology, shelter design and system configuration to mature to a production-representative level.

In FY06, 20 foot wide by 32 foot long Small Tactical Airbeam Tents (STAT) were successfully fabricated for the PM FSS Force Provider Team and compared to commercially available shelters, ranked highest. The key performance demonstration occurred at Ft. Lee in July 2006. A timed deployment trial was conducted with Quartermaster General, BG Bellini and PEO Combat Service Support, MG Bartley in attendance. The STAT based 150-soldier camp was fully operational in less than 4 hours including air conditioned bunk space, field kitchen, laundry,

latrines, and showers. The current 600 soldier camp takes about three weeks and 70 soldiers to deploy. Besides the order or magnitude reduction in total set up time, FP ELSS fits on a single C17 and can be complexed to form larger camps as required. Senior Army leadership endorsed the plan to insert airbeam technology into the Force provider system and environmental testing conducted by the Aberdeen Test Center fully confirmed technical performance.

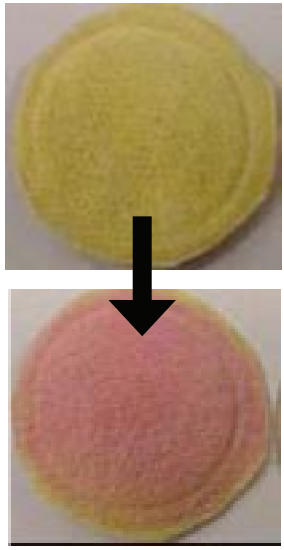
The primary advantage of the airbeam shelter is the 80% reduction in deployment time (to fully operation state including liners, lights and power) from one hour and forty minutes for the current TEMPER tent to twenty minutes for the airbeam shelter. Also, personnel requirements can be reduced 20%, requiring 8 personnel versus 10. Added to this is a 30% reduction in cube. These savings result in a new base camp that offers a completely self-contained soldier support camp that can be entirely deployed and operational within hours. This achievement of accelerating transition of a new technology directly into production will result in immediate pay-off for sustainment of the Soldier.

Status: The Small Tactical Airbeam Tent has been successfully transitioned to PM Force Sustainment Systems and adopted into the TEMPER family of standard tents. Now called the Air Supported TEMPER, this shelter is the standard tent for the Expeditionary Force Provider Modules.

Agent Indicating Shelter Material

- Collective protection shelters have historically been heavy, cumbersome, carried high logistical burden, and above all been very expensive. Through the years, advances like flouropolymer coatings and low temperature processible flouropolymers have been made in barrier materials to improve the protective capabilities of collective protection shelters; yet each of these thrust areas have their own technical challenges and associated investments to mature the technologies. A revolutionary new approach which offers a long-term solution to these problems is thus desirable. This approach would require improving existing lightweight, flexible, flame resistant, chemical biological (CB) textile barrier materials via incorporating visible detection and self-decontamination capabilities in to the materials. Detection would involve an interior color change that indicates chemical agent levels greater than acceptable concentration control levels.
- The improved material will be used in military shelters possibly integrated into currently fielded chemical and biological liners or integrated directly into the skin of the shelter. Lynntech proposed to develop a self-decontaminating smart textile that uses catalytic reactivity of nanoparticles to decontaminate chemical agents. The chemical reaction for decontamination is used to aid in the reaction to exhibit a visible warning when the barrier is compromised. This material will be integrated with the existing CB barrier materials to produce a composite shelter material that offers enhanced CB protection as well as allows for a visible indicator of exposure due to breach in the barrier material.

Status: During the Phase I, Lynntech has developed a self decontaminating smart textile material that uses catalytic reactivity of nano particles to decontaminate chemical agents while this reaction is used to exhibit a visible warning when the barrier is compromised. This material has been integrated with the existing CB barrier materials to produce a composite shelter material. During Phase II Lynntech is further advancing the technology and scaling up with fabrication process to produce a multi-layer shelter material with improved barrier properties, self decontaminating characteristics and color indicating capabilities against CWAs. A full scale prototype tent will be fabricated using this material.



Material showing color change after testing

Integrated Collective Protection Shelter Systems: Impermeable Barriers and Self-Decontaminating Reactive Materials

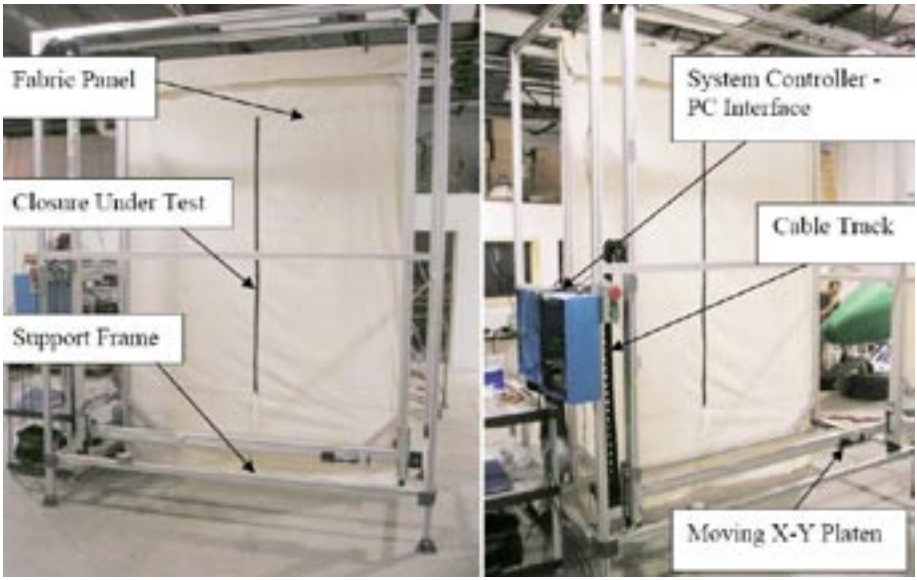
- The Fabric Structures Team has successfully managed the technology development for a first generation, single layer tent laminate and manufactured a product which delivers Chemical-biological protection at a lower mass of 10.5 oz, as compare to the Chemical and Biological protective single layer laminates (12-14oz).
- High performance barrier films under went live chemical agent testing (HD/GB) at the Edgewood Chemical Biological Center and were then incorporated into a laminate for further studies in flex fold, abrasion, blackout and durability. The marrying of substrate, barrier films, topcoats, back-coats, flame resistance and each process step were analyzed and engineered for optimization to meet MIL-PRF 44103 and Chemical & Biological Protective Shelter performance specifications. Structural heat seal seams were achieved with development of a Chemical and Biological heat seal tape that is compatible with industry standards.
- Options for a blackout system were tested at NSRDEC with a passing system. Other integrated components of the Chemical and Biological laminate system include: flooring laminate with an added nylon substrate for durability and bias laminate load patches for hardware attachment points.
- An active chemistry delivery system was also demonstrated as part of the laminate system. Active chemistry attachment density targets were achieved and chlorine charge levels were also demonstrated. The BA-1 hydantoin chemistry solution provided to Warwick Mills by Tyndall Air Force Base is still undergoing evaluation for effectiveness.

Status: This program has transitioned individual components and lab coupons, to pathfinder processes, pilot runs, full width manufacturing and are ready to transition to the Joint Expeditionary Collective engineering development program. Each selected component of the laminate underwent rigorous testing to contribute to the overall system performance. The reactive option for this fabric to detoxify fugitive agents is currently being evaluated to determine its efficacy against traditional chemical and biological agents.

Novel Closure Test Methodology

- There currently is no formal military specification or user's requirement document, which defines the operational performance requirements or test methods to evaluate the performance of Chemical Biological Radiological Nuclear (CBRN) closure systems for Collective Protection (COLPRO) shelters. This problem is further exacerbated by the fact that depending on the shelter type, mission, and level of protection required, system requirements and hence potential solutions may vary.
- This project managed by the Fabric Structures Team designs standardized test fixtures and methods for technical testing, functional evaluation and chemical simulant/live agent testing of novel CB Closures. The functional evaluation test fixtures are designed to quantify mechanical performance, user 'friendliness' and utility under military operational conditions.

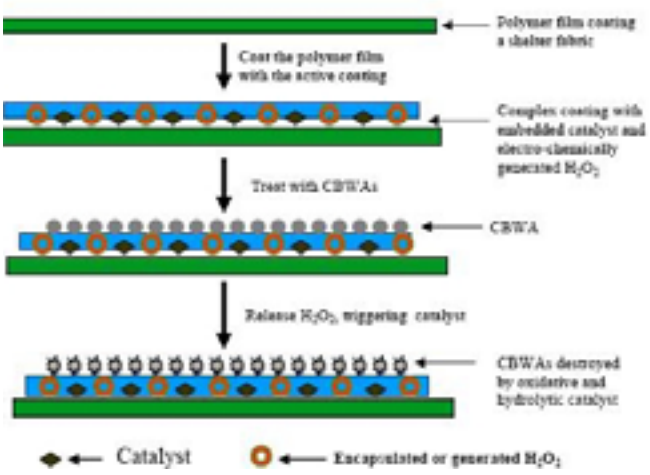
Status: Currently, test fixtures have been constructed to evaluate the mechanical integrity of closure systems as well as evaluate their durability. A chemical test fixture has been built by Technical Products, Inc. which has been transitioned to Dugway Proving Grounds for evaluations. These test fixtures and test methods are utilized to evaluate potential closure solutions for the Joint Expeditionary Collective engineering development program.



Self-Decontaminating Polymer Systems for Chemical and Biological Warfare Agents

- This program's mission is to develop a self-decontaminating, smart polymer-coating for collective protection (COLPRO) shelter materials and other textiles that rapidly and efficiently reacts with and destroys chemical and biological warfare agents (CBWAs). A self-decontaminating coating will be developed for collective protection materials, comprised of an active layer that generates hydrogen peroxide which reacts with and destroys CBWAs. The hydrogen peroxide will be generated in situ by electrochemical reactions that uses air and water thus, providing a continuously-regenerated supply of peroxide. The hydrogen peroxide reactivity will be enhanced and controlled by catalysts. Triggering of the active response will be accomplished by coupling to currently fielded CBWA sensors. Initially the program had a focus on the development of the basis of the electrochemical components of the material, including the anode and cathode, these components are still being further optimized. Testing is being conducted to prove the in situ generated amounts of hydrogen peroxide will react with and destroy both surrogate chemical and biological agents. In situ generation of hydrogen peroxide has been proven and is being optimized. Self-decontaminating materials reduce logistical burdens by eliminating the need for decontamination following a CBWA attack. NSRDEC is providing engineering support for this program. This includes system integration and technical expertise. When the material is fully optimized and passes all military testing it will be transitioned to the Soldier.

Status: Research has proven in-situ generation of hydrogen peroxide. Development has moved to coating currently fielded non-chemical or biologically protective tentage materials with the current configuration. The materials have shown decontamination, in surrogate agent testing.

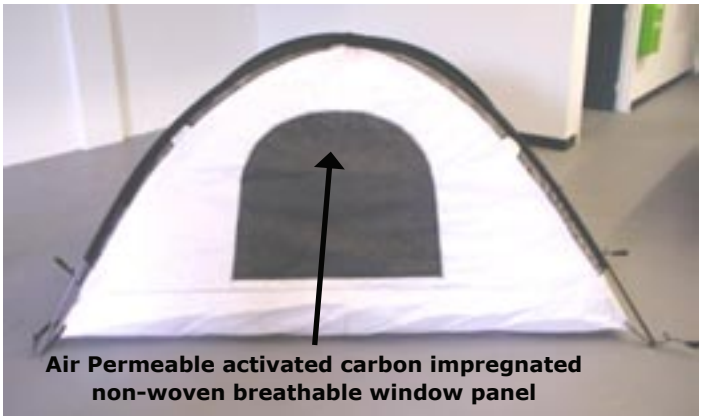


Passive Chemical and Biological Protection for Crew Tents

- This Small Business Innovation Research program is looking to develop Chemical, Biological, Radiological, and Nuclear (CBRN) protective shelters that will require no electrical power or overpressure to keep occupants protected. The shelter keeps the Warfighter protected through a system of carbon windows integrated into an impermeable fabric shelter skin. Providing CBRN protection through this method gives the Warfighter increased protection capabilities while reducing both logistical and power burdens. Primary challenges to this approach include the need to provide satisfactory air quality to participants and ensure the shelter is hermetically sealed. Triton is focusing their efforts on developing small (two and five man) shelters that will contain replaceable media panels. Triton is currently working with Production Products Manufacturing on determining the must suitable carbon media and method of integration into their prototype shelters. The shelters will also include the ability to remove and replace the carbon filters through a simplistic interface design. The NSRDEC is actively involved in managing the product development. NSRDEC is also providing expertise in Chemical and Biological textiles and access to testing facilities and strategic partners.

Status: Triton Systems Inc. is currently in Year 2 of their Phase II Small Business Innovation Research contract. They have previously completed a Phase I and Phase I plus-up. In the first year of Phase II of their program, Triton has developed a computer modeling program which allows the user to approximate air quality and Chemical Warfare Agent (CWA) levels inside a passive tent. Additionally, they are investigating various carbon loadings in their filtration media as well as innovative methods for attaching/detaching the filtration panels through the use of CB closures. Triton plans to deliver a working prototype shelter with replaceable filtration panels in the next month or two to evaluate the system. Furthermore, Triton has also begun CWA testing on

prospective barrier materials for the shelter; there are plans for use of a thin but durable barrier material to reduce system weight and cube, in effect making the shelter system highly transportable. Triton plans to transition the technology to both military and commercial sectors. In this early stage of development, Triton proposes to target first responders, the military and the Federal Bureau of Investigation with their technology. Triton is also working on a potential partnership with Production Products, which would result in improved manufacturing capabilities and reduce product development and transition times.



Prototype small crew tent with showing air permeable window panel

Prototype small crew tent with camouflage wind/rain over protective fly

Self-Decontaminating Barrier Material Incorporating Catalytically Reactive Membranes for Individual and Collective Protection on a Chemically/Biologically Contaminated Battlefield

Research in this area is geared towards developing suitable self-decontaminating barrier coatings for General Purpose (GP) shelter fabric. The program has a three-pronged mission:

1. Develop improved GP Fabric Coating Formulations;
2. Develop improved Singlet Oxygen CB Decontamination Photocatalysts & Storage Systems;
3. Integrate Photocatalyst into improved GP Fabric Coatings Formulation.

1. Development of Improved GP Fabric Coating Formulations: Ventana is developing self-decontaminating coatings for hardening GP shelter fabric. This entails deposition of three different coatings upon GP fabric. First a urethane primer coating is deposited onto the fabric, followed by a polyvinyl alcohol (PVOH) CB barrier film. Finally, a heat sealable, thermoplastic polyurethane or polyurethane-urea is then applied as a topcoat upon the PVOH to protect it from abrasion and humidity which would otherwise degrade its barrier properties. Significant efforts up to this point have been devoted towards evaluating various commercially available polyurethanes & urethane-ureas (PU) as candidate topcoat materials. Initial work was done using Cydrothane HP-1035, a waterborne urethane emulsion, but this material was discounted due to its tendency towards swelling. Other versions of polyurethane coatings were then evaluated. These coatings differed from the former in that they were two component, 100% solids liquid resins which had reasonably low viscosities such that they could be readily deposited upon the fabric and subsequently thermally cured to tough PU coatings. Several different types of PU resin chemistries were evaluated by Ventana. Aromatic PU resin coatings manufactured by Air Products Inc. were found to be highly resistant towards 2-chloroethyl ethyl sulfide (CEES) swelling. The resins were somewhat similar in chemical composition to established Chemical Agent Resistant Coating (CARC) type paint and were found to readily adhere upon PVOH film but had little wetting upon GP fabric. This indicated that the resin could be used as a topcoat for the self-decontaminating fabric composition but would be unsuitable as a replacement for the Cydrothane HP-1035 PVOH primer layer. These PU resins also cure to form reasonably humidity resistant films and are promising topcoats for the self-decontaminating fabric system. Work is underway to evaluate their heat sealability and joinability.

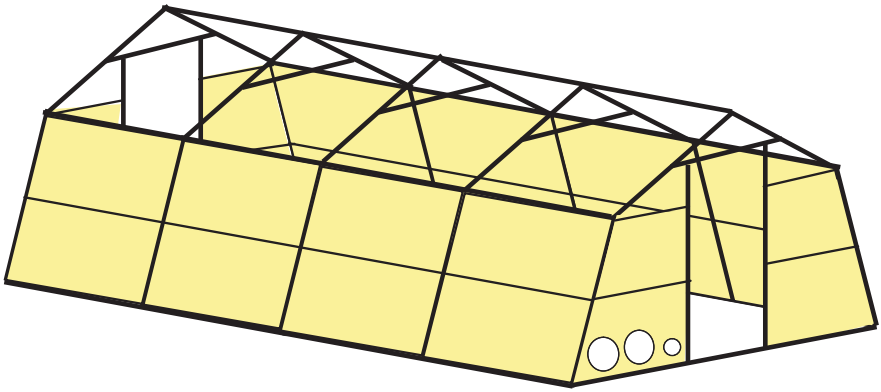
2. Development of Improved Singlet Oxygen CB Decontamination Photocatalysts & Storage Systems: Besides developing GP fabric

coatings, efforts have also been made to develop better singlet oxygen photosensitizer/storage compositions as well as devising means for supporting them upon the self-decontaminating fabric surface. Ventana has been working in conjunction with entities at Worcester Polytechnic Institute on this research area. In particular, several promising visible light activated phthalocyanine and porphyrin based photosensitizers have been synthesized by both groups. These materials are efficient singlet oxygen photogenerators. In addition, pyridone based moieties have been covalently attached to these photosensitizers and have been found to efficiently reversibly trap (store) and release singlet oxygen upon standing at room temperature. Since the trapping and releasing of singlet oxygen is a thermally rather than photochemically driven process, it is has been shown that these materials are capable of decontaminating CEES in both light and dark situations. This expands the utility of this shelter fabric decontamination system towards operating during both day and night. Efforts have also been most recently directed at evaluating other reactive singlet oxygen storage compounds including furans and maleated polybutadiene oligomers. Preliminary results suggest that both of these compounds are highly reactive towards singlet oxygen and may be capable of generating peracids upon standing which are also known for their CB decontamination properties.

3. Integration of Photocatalyst into Improved GP Fabric Coatings Formulation: Work has been undertaken to adhere and heterogeneously support these singlet oxygen decontamination photocatalysts onto the above PU resin fabric coatings. Much of this work has involved pretreating montmorillonite clay surfaces with the photocatalyst followed by blending the treated clay with the urethane resin. Clay was selected on the basis of its chemical inertness towards singlet oxygen coupled with its ability for its platelets to become oriented into smooth, flat layers during fabric coating operations. At present, Ventana has successfully prepared a clay/resin dispersions and cured coatings derived from these compositions.

Modular Ballistic Protection System

- The Modular Ballistic Protection System (MBPS) is a rapidly deployable ballistic panel and attachment system that protects Warfighters in tents against small arms and small fragmentation threats. The MBPS improves expeditionary Warfighter survivability by providing ballistic protection. NSRDEC developed the MBPS in partnership with the University of Maine.
- The MBPS is intended to provide immediate protection to troops at the beginning of a deployment before sandbags and concrete barriers are erected. As a mobile and reusable system, MBPS can also protect units on the move, i.e. units who would not be at a location long enough to install concrete barriers and sandbags. In these two scenarios, troops often have no protection in the tents in which they work, eat and live. The MBPS is a first step in meeting this deficiency.
- The MBPS stands apart from other ballistic panels in terms of weight, deployment time, system integration, and cost. A single ballistic panel weighs four (4) pounds per square foot. The first generation of the MBPS was designed to directly integrate into a TEMPER tent frame without special tools or equipment. The MBPS can be deployed into a 32-foot long TEMPER tent by four Warfighters in one hour. The system includes sliding ballistic doors on the endwalls for easy access and pass-through entries for HVAC and power.
- This program also includes NSRDEC and University of Maine modeling programs. First-order analysis developed by NSRDEC ballistic experts enable the MBPS team to quickly assess the ballistic performance of different panel materials based on V50 results. NSRDEC's Integrated Casualty Estimation Methodology (ICEM) models assess personnel injury in specific base camp configurations, with and without the present of ballistic protection. The University of Maine has also developed a casualty prediction model based on Monte Carlo simulations. Preliminary casualty models predict that fortifying base



Schematic of the MBPS

camp shelters with the MBPS has the potential to significantly reduce the number of serious injuries resulting from small fragmentating munitions.

- The MBPS has undergone extensive testing to verify its blast and ballistic protection capabilities. Arena testing has shown that a single panel can protect against a majority of fragments from small fragmenting munitions. Blast testing has proven that the MBPS, as installed in a TEMPER, meets UFC 4-010-02 Standards for Expeditionary and Temporary Structures — Inhabited Structures. The MBPS composite ballistic panel materials have undergone Right Circular Cylinder (RCC) testing to simulate fragmentation threats as well as firearms testing; MBPS panels meet NIJ IIIA standards for ballistic protection

Status: MBPS has been integrated into the TEMPER tent and successfully undergone technical and operational testing. A full scale prototype is being evaluated in theater through the Rapid Equipping Force. A prototype MBPS system has been designed and demonstrated for the Air Supported TEMPER, rigid shelters and mobile kitchens and is currently being evaluated. MBPS has successfully transitioned to PM Force Sustainment Systems and achieved Milestone A.

More on Modular Ballistic Protection System (MBPS) Technology:

The MBPS stands apart from other ballistic panels in terms of weight, deployment time, system integration, and cost. A single ballistic panel weighs four (4) pounds per square foot. The first generation of the MBPS was designed to directly integrate into an aluminum TEMPER tent frame without special tools or equipment. The MBPS can be deployed into a 32-foot long TEMPER tent by four Warfighters in one hour. The system includes sliding ballistic doors on the endwalls for easy access and pass-through entries for HVAC and power.

The MBPS is intended to provide immediate protection to troops at the beginning of a deployment before sandbags and concrete barriers are erected. As a mobile and reusable system, MBPS can also protect units on the move, i.e. units who would not be at a location long enough to install concrete barriers and sandbags. In these two scenarios, troops often have no protection in the tents in which they work, eat and live. The MBPS is a first step in meeting this deficiency.

MBPS Installed in a TEMPER Shelter

Blast Testing the MBPS

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THE SCIENCE BEHIND THE WARRIOR:
YESTERDAY, TODAY AND TOMORROW.

US ARMY NATICK SOLDIER
RESEARCH, DEVELOPMENT & ENGINEERING CENTER

Kansas Street, Natick, MA 01760

BUSINESS INQUIRIES:

(508) 233-4184, nati-amsrd-nsc-ad-b@conus.army.mi

MEDIA INQUIRIES:

(508) 233-6938

ON THE WEB:

nsrdec.natick.army.mil

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