



Projects & Technologies

This document provides a brief overview of some of TRI/Austin's technologies as well as current projects. The table below categorizes them according to technology area. Technologies on the following pages are listed in descending order of Technology Readiness Level (TRL) with current projects last. For a definition of Technology Readiness Levels see pg 10.

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If you are interested in discussing any of these further, please contact Azucena Overman at aoverman@tri-austin.com or 512-263-2101 extension 231.

Transitioned Technologies & Completed Projects



BondCoat for Rubber to Metal Bonding

Topic #: N1984-061, Sponsor: NAVSEA, Status: Commercially available from DepTech, www.deptechinc.com, TRL 9

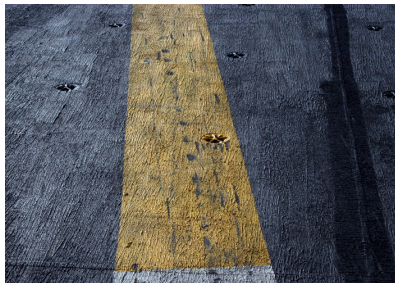
The Portsmouth connector is the most commonly used underwater connector on ballistic missile submarines (SSBNs). Due to electrical connector failures, submarines had required dry-docking as often as every two years. TRI performed shipboard inspections and laboratory connector failure analyses to identify possible failure mechanisms, and used accelerated life testing (ALT) and development of design modifications. Cathodic delamination of the rubber to

metal bond in the connector can occur when the electrical field used in cathodic hull protection systems induces hydroxide ion formation at the bond interface. TRI developed and commercialized a solution to this problem that involves a nonconductive coating (NCC) formed from a plasma spray ceramic and polymer sealer. TRI's Bond-Coat is now a fleet required standard for submarine MIL-C-24231 and MIL-C-24217 connectors. It is also used in down-hole connectors, offshore applications, and in other harsh environments that challenge rubber to metal bonds.

ecoMASS® lead replacement compounds

Topic # A1994-085, Sponsor: Army TACOM, Status: Commercially available at www.ecomass.com, TRL 9

TRI/Austin developed and tested a non-toxic replacement for lead projectiles used in practice rounds in firing ranges, where millions of dollars were being spent each year in the remediation of lead contamination. Ecomass has the same density as lead and can be molded into virtually any shape using standard high-volume production techniques. Ecomass meets or exceeds the performance of lead in terms of compatibility with current cartridge manufacturing equipment, ballistic characteristics, accuracy, and penetration.



ToughGrip™ nonskid coatings

Topic # N1998-096, Sponsor: NAVSEA, Commercially available from TRI/Austin, Inc., TRL 9

There are few environments more challenging than the surface of a Navy aircraft carrier. A non-skid coating must stand up to tail-hook impacts from landing aircraft, heavy vehicular traffic, oil, chemical and fuel spills, intense sunlight and persistent salt spray. A poorly performing non-skid coating could compromise safety on the aircraft carrier flight deck during flight operations. Cracking and spallation routinely occur due to aircraft takeoffs and landings.

That is why the Naval Sea Systems Command (NAVSEA) Carrier Program

Office and the fleet have non-skid coatings on their list of top management concerns.

In order to improve fleet readiness and lower total ownership costs, NAVSEA desires a coating that can withstand more landings and less frequent replacement. To further compound the challenge, the coating must comply with environmental regulations including the Clean Air and Water Acts, NESHAP and EPA state regulatory controls. TRI/Austin received Small Business Innovation Research (SBIR) Phase I and Phase II awards from NAVSEA to develop an improved non-skid coating that could meet these requirements. The primer system is solvent free yet has very high adhesion as measured in lap-shear tests and impact studies.

Non HAP Rubber Cement

Topic # N1998-152, Sponsor: NAVAIR, Status: Commercially available from W.W. Henry, www.wwhenry.com, TRL 9

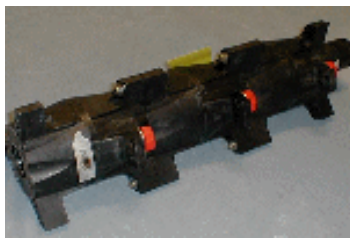
Cements used to bond rubber to metal and rubber to rubber contain large amounts of hazardous volatile organic compounds (VOCs), including methyl ethyl ketone (MEK), toluene, and methyl isobutyl ketone (MIBK). These adhesives are essential to the bonding of gaskets, door seals, bumpers, heater boots, and other applications during Naval Aircraft maintenance and assembly operations. Environmental laws and regulations require the development of new non-hazardous cements that meet or exceed the performance requirements of MMM-A-121, MMM-A-122, and MMM-A-1617. Texas Research Institute Austin, Inc. has developed and tested a new environmentally compliant, high performance cements

DeconCheck™ Decontamination Verification System

Topic #A1991-127, Sponsor: Army, Status: Phase II Completed. Transition opportunity. USP#5,670,489, TRL 9

Some hazardous materials (HazMats) are so toxic that a few drops on the skin can cause serious harm, or even death. HazMat spill responders wear special protective clothing to prevent contact with these materials. To prevent accidental exposure during suit removal, the suit must first be thoroughly cleaned (decontaminated). Previously, soap, water, and a brush were commonly used during such decontamination procedures; however, it is easy to miss spots with this method - a potentially fatal mistake. The Decon-Check™ system combines nontoxic, biodegradable cleaners and thickeners with an ultraviolet disclosing agent which shows areas on the suit which have been cleaned. This system even works with notoriously hard-to-wet materials such as Teflon™.

The system is a spray-on/scrub-off cleaner designed for use on decontaminable protective clothing. Decon-Check is not a replacement for decontamination solutions for use against chemical or biological warfare agents. The product clings to most surfaces, and its bright color shows where to scrub to ensure effective cleaning of the outer ensemble. Potential applications for this product include use in the "Personnel Decontamination Station" (PDS) at the intermediate wash point. The kit uses optimized penetrant systems to detect actual or impending defects in protective clothing and shelter materials, and thus provide a direct estimate of remaining life for CP clothing and shelters.



Composite Outboard Sensor Assembly

Funded under COSSI program. In early production

USP#7,206,265 & 7,221,623, TRL 9

Submarine Sonary systems include a towed sonar array that is deployed behind a moving submarine. The outboard sensor assembly (OSA) monitors the passage of the towed array during deployment, retrieval and relays the information to the submarine personnel. TRI/Austin used a pressure compensation system and composite materials to develop a new type of outboard sensor assembly. The system

is lower in cost, easier to manufacture in quantity, lighter weight, less likely to leak, and with a lower failure rate than conventional systems.

Assessing the Impact of Lead-free Solders on the Long-term Reliability of Weapon System Electronics.

Topic # A2001-167, Sponsor: MRDEC, Status: Phase II Completed. TRL 8

Lead based solders have been used for decades to make conductive and structural connections in electronic assemblies. Whole manufacturing technologies are based on the melt, flow and wetting characteristics of these materials and establishing new solder platforms requires substantial and pervasive changes in the industry. As industry moves away from the use of lead in electronic assemblies, the development of qualification standards and reliability models for lead free solders and conductive adhesives is needed to ensure continued performance reliability. In the proposed work, TRI/Austin has developed and validated life accelerating procedures and reliability models that can be used as a "standard of evaluation" for lead free solders, making it possible to compare them with each other and with well established tin-lead solder. Validation of these procedures and models will be obtained by accelerated life testing of materials in TRI/Austin's laboratories using multiple and variable stress factors. Standardization of a reliability test protocol to be used for existing and emerging solders and adhesives that remains valid as components, board assemblies and materials evolve. Development of a comprehensive reliability model for each specific alloy and adhesive relative to standard lead eutectic solder. Forced ranking of the best performing solders and adhesives in terms of long term reliability, based upon laboratory testing to be performed in Phase II.



Environmentally Friendly Solid Film Lubricants

Topic # N2001-153, Sponsor: NAVAIR PEO(A), Status: Phase II completed. In flight testing. Patent Pending. TRL 8

It is necessary to further reduce VOC's and eliminate lead and antimony from solid film lubricant (SFL) formulations in order to comply with environmental regulations and protect the health of personnel. SFL's are used to prevent galling, fretting and seizing in aircraft engines. These lubricants are expected to provide continuous motion lubrication for compressor and turbine disks and blade roots. NAVAIR's Technology Needs Database lists an unfulfilled need (NA807-99) for a low VOC

replacement for room temperature curing solid film lubricant, MIL-L-23398. It identifies MEK, toluene, xylene and lead as EPA-17 chemicals and targeted for reduction by NAVAIR. It also predicts that NESHAP regulations are likely to require lower VOC levels or costly control measures.

TRI/Austin, Inc. has developed a lead-free, antimony-free, VOC-free, water-based, solid film lubricant that is cured at room temperature. This SFL can withstand high pressure, has a long wear life, and provides protection against corrosion. Because of its nontoxicity, it is environmentally friendly and may potentially offer a cost advantage in packaging and transportation, especially in states with regulatory restrictions on toxic solvents. Flight testing has been completed and the formulation has been submitted for QPL listing MIL-L-23398.



LAHMP™ System for Aircraft Structural Health Monitoring

Topic # OSD1998-021 & A2002-161, & AF2006-097, Sponsors; OSD NAVAIR, Army & Air Force, Status: Two Phase IIs completed. Prototype flight tested on the F-15. Seeking transition partners. USP#7,080,555, TRL 7

The DoD is moving toward Condition Based Maintenance based on Structural Health and Usage Monitoring Systems (CBM/HUMS) to maximize useful life of components while minimizing maintenance and downtime. Applications where weight and size are critical require small, powerful embedded systems that draw low power. LAHMP fulfills these needs and can perform a variety of functions including acquiring data from various

COTS analog and digital sensors, signal conditioning, data analysis, storage, and wireless or wired communications. LAHMP is based on COTS, and is therefore highly configurable while conforming to industry and military standards. In preparation for ground and flight tests aboard an Air Force F-15 E1, TRI's Phase II SBIR team partner Boeing Phantom Works coordinated thermal, EMI/RFI, and G-force testing of LAHMP. LAHMP was operating during all tests, and none of the environmental extremes hampered LAHMP. Boeing then facilitated a ground test aboard the F-15 on 14 September 2006. LAHMP survived this test while maintaining full functionality, clearing the way for a flight test on September 26, 2006. LAHMP was fully functional throughout the flight test and collected structural health data on two bulkheads.

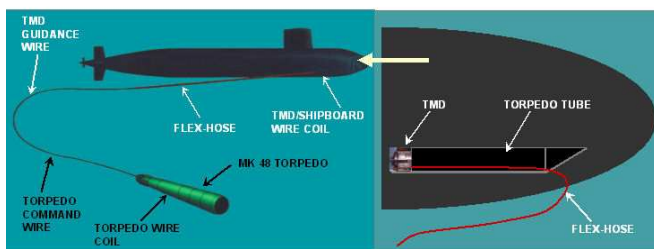
ThermaSafe™ Composites for Shipboard SMART Foundation Adapter

Topic # N2001-113, Sponsor: NAVSEA, Status: Phase II completed. Seeking projects. TRL 7

A low cost, lightweight alternative to conventional metal shipboard components is required that uses composite materials to reduce weight and cost, and can meet all of the NAVSEA requirements. During Phase I, Texas Research Institute Austin, Inc. (TRI/Austin) demonstrated the feasibility of developing a SMART reconfigurable, low cost, lightweight, fire resistant, easily accessible, composite track. The composite material is comprised of a high temperature, fire resistant resin system. The system is reinforced with high strength glass fibers that will meet MIL-STD-2031.



The TRI material passed a Full Room ISO 9705 , Fire Test conducted by NAVSEA. This test determined that the TRI , ThemaSafe low smoke composite material meets flash over requirements set by NAVSEA.



Environmentally friendly Flexible Hose Ballast

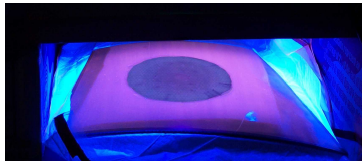
Topic # N2003-067, Sponsor: NAVSEA PEO SUB, Status: Phase II Completed. TRL 7

The Mk48 Mod 5 and Mod 6 Advanced Capability (ADCAP) Heavyweight Torpedo is a primary submarine weapon that fulfills both anti-submarine and anti-surface roles and is considered a primary weapon for the United States Navy (USN) Submarine fleet. The torpedo employs a post Launch guidance wire

communications link that provides accurate data exchange between the recently fired torpedo and the submarine. The Flex-Hose is used to position the guidance wire below the submarine's keel and clear of the propellers. A lead tape

ballast is used within the Flex-Hose to make it heavy enough so that the submarine can travel through the water at high speeds without the guidance wire entangling with its propeller. At the end of the torpedoes run the Flex-Hose is expended into the ocean.

In recognition of the serious health hazards associated with lead ingestion and the numerous sources of potential lead exposure, the Navy has established strict controls to limit both occupational and environmental exposures. While there are no existing requirements for removing the lead ballast material from the flex-hose the Navy recognizes that there are health hazards associated with ingestion of lead and that the use of lead in torpedo operations can result in an undesirable waste stream. TRI/Austin has engineered a lead encapsulated ballast to improve environmental friendliness and minimize health hazards. The ballast has been optimized for the sub-seawater environment with high hydrostatic pressure and conditions conducive to galvanic corrosion, while maintaining flexibility over a wide temperature range.



Aircraft Battle Damage Repair

Topic #: AF2000-163 & AF 2001-131, Sponsor: AF ML, Status: Both Phase II's completed. Seeking transition partners. USP#7,144,544. TRL 6.

Rapid on-aircraft repair techniques for fiberglass composite components are essential to the support of the Air Expeditionary Force concept. Field level damage repair of aircraft is critical to maintaining full force projection during combat. Current field level repair techniques for aircraft skins use thermally accelerated adhesive bonding to restore the original design strength of the composite laminate. Unfortunately, airframe structural members act as heat sinks, and make it difficult to obtain a uniform cure temperature profiles. Current resin repair systems require low temperature storage, increasing storage cost and support complexity. Texas Research Institute Austin, Inc. (TRI/Austin) has developed an ultraviolet curable glass composites system designed specifically for quick field repair of damaged aircraft. The high Tg (165 to 185°C) TRI/Austin UV cure resin and glass prepreg patches will offer a field friendly, cost effective solution to the current repair

problem. Cure times can be significantly reduced, increasing aircraft availability and reducing repair cost. The TRI/Austin aircraft field repair materials are easily applied, include a resin with a moderate viscosity, have a high glass transition temperature after cure, require no mixing, and cure in place without the addition of heat. TRI/Austin also developed a high performance, cure in place epoxy syntactic foam. Physical properties and adhesion to aircraft honeycomb have been characterized and a field application method has been developed.

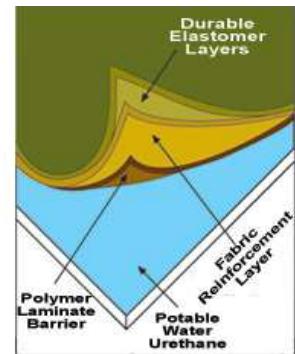
Chemical-Biological Warfare Safe Water Pouch

Topic# CBD1998-207, Sponsor: NAVAIR, Phase II Completed. Live agent testing completed with excellent results. In field testing with the Army. Patent pending. TRL 6.

Texas Research Institute Austin, Inc. (TRI/Austin) has developed a chemical-biological warfare (CBW) resistant water pouch to provide safe drinking water in contaminated environments. The water pouch is designed to fit in a variety of holding devices and interfaces with currently available mask drinkstraw systems.

A two-layer design incorporates a CBW resistant composite for the outer layer and a polyurethane inner layer for superior water potability. This configuration also gives maximum protection against leaks cuts, and tears.

The compact, hands-free, CBW resistant waterpouch is designed for the stringent requirements of military aviators and ground troops. It is also well-suited for use by DoD personnel and municipal HazMat teams involved in emergency response of CBW and hazardous materials.



Development of an Evanescent Microwave Probe Scanner for Detecting and Assessing Corrosion Beneath Painted and/or Sealed Surfaces

Topic # OSD2001-M05, Sponsor: AF, Status: Phase II completed. TRL 5

TRI/Austin, Inc. has developed a near-field RF system that can locate surface corrosion under paint. The system monitors the reflection of near-field RF energy on the skin. It is expected that the smallest detectable pit depth is 6 mils or 150 microns. It is able to detect corrosion in coatings with a thickness of up to 2 mm. It can see through most coatings

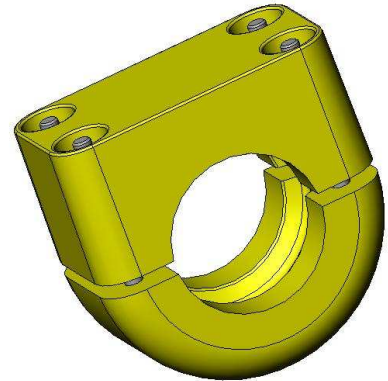
with the exception of radar absorbing materials. The system is equipped with a patent pending differential probe setup that can correct for part edges and lift off variation. Pits next to lap seams are visible because the seams are subtracted out. The exception is round geometries such as rivets. Research is planned to determine the minimum detectable pit depth around rivets. The initial configuration has been tested on Boeing's MAUS system and utilizes its software to provide a profile of the part being scanned.



Fire Resistant, Labor Saving, Reduced Weight, Pipe Coupling

Topic # N2000-040, Sponsor: NAVSEA, Status: Phase II Completed.

Conventional flange-type pipe couplings used aboard U.S. Navy surface ships and submarines typically have a large number of axially oriented bolts located around the circumference of the flange. The installation of conventional pipe couplings requires equal access to all of the bolts to ensure evenly torqued joints. The large number of bolts and accessibility difficulties with conventional pipe couplings results in a labor-intensive process for the removal and installation of these couplings. Nearby structures and equipment often have to be removed and reinstalled to gain access to the hidden bolts, or joints are inadequately tightened in cases where removal of nearby structures is not feasible. Texas Research Institute Austin, Inc. developed a low cost, lightweight, fire-resistant, easily accessible composite pipe coupling that meets the requirements of MIL-STD-777E. The use of composite materials will reduce the cost and weight of the coupling while providing a reliable, fire-resistant, corrosion-free service life in excess of 15 years.



Matrix Materials for High Performance, High Adhesion Sealants and Gap Fillers

Topic # AF 1998-193, Sponsor: AF ML, Status: Phase II Completed.

A durable one component conductive gap filler/sealant is proposed as a new material for aircraft that employ low observable (LO) technologies. This material will combine the durability of a polysulfide with the ease of use of a one component system. No mixing will be required and waste will be minimized. Conductive fillers will be investigated for incorporation into the matrix resins. Various conductive loading levels will be considered. In the proposed heat activated system, the gap-filler material is briefly heated prior to application. This initial heat activation liberates a latent curing agent, which will remain active after delivery to the substrate. Cure will continue after application to the substrate, and complete cure will be achieved in approximately 5 minutes to 24 hours depending on catalyst concentration. Density of the gap-fillers will be minimized in order to achieve weight savings on aircraft. Additionally, the functionality of the proposed system is expected to have improved bond strength to aluminum and epoxy/carbon fiber composites. Characterization of conductivity and radar observability will be determined for the candidate products.

Implosion Tests of Pressure Vessels

Topic # N2001-106, Sponsor: NAVSEA, Status: Phase II completed.

The US DoD requires cylindrical and spherical pressure resistant vessels for various applications. Each service uses pressure vessels extensively in both military vehicles and land-based systems. In some applications, these vessels need to be able to resist significant externally applied hydrostatic pressure loads without implosion. The use of composite materials for these pressure vessels offers the promise of reduced corrosion, lighter weight, and life cycle cost savings. During Phase I, and in related projects, Texas Research Institute Austin, Inc. (TRI/Austin) demonstrated the feasibility of developing low cost NDE test methods that can be adapted to the evaluation of externally pressurized composite vessels. Physical characterization of constituent materials and nondestructive evaluation (NDE) were required to determine the quality and performance characteristics of these composite pressure vessels. During Phase II, prototype composite pressure vessels were designed, constructed, and evaluated. An open ocean implosion test was carried out, and the resulting shock wave and pressure vessel remains have been analyzed. The design was modified as needed, and a final prototype article fabricated. A cost analysis for the composite pressure vessels was also prepared.

Current Projects

Polysulfide Modified Epoxy Novolac Cladding for Steel Immersion/Splash Zone Service

Topic # N2002-006, Sponsor: NAVFAC, Status: In Phase II.

Many commercial-off-the-shelf solvent-borne epoxy-based paints have been previously approved for use in submarine applications. Typically, these coatings are spray applied and the non-skid aggregate is broadcast over the paint prior to cure. Failures frequently occur and are due to poor match of thermal expansion due to the nature of the substrates, such as the submarine special hull treatment. During Phase II, TRI will formulate and test new nonskid coatings specifically designed for submarine use. Accelerated life testing will be used to characterize coating performance under simulated long-term service conditions. Repair methods and a repair kit will be developed. A field test patch will be installed on an active Navy submarine for fleet performance testing. Non-skid coating performance is also ranked among the top five issues being addressed by PEO Carriers. As part of Phase II, TRI will demonstrate that an environmentally benign, VOC free, ultra high durability (UHD) non-skid system can be scaled up for production, applied to a full aircraft carrier

landing area, and demonstrate superior performance during a full deployment. This will extend the results previously obtained via 1000 square foot test patches, and ready the nonskid coating for immediate Phase III transition into the fleet.



Composite Lube Filter Bowl

Topic # N2003-020, Sponsor: NAVAIR PMA 275, Status: In Phase II. TRL 3.

Rotary-wing aircraft use transmission systems to transfer power from the engines to the rotor system. These transmissions employ lightweight high strength metals to reduce overall aircraft weight. Despite the optimization of these materials for weight, these transmission systems still comprise up to 11 percent of the aircraft empty weight. The Navy and the helicopter industry would like to further decrease aircraft weight, as an increase in performance can be achieved for every pound of weight reduction. The Navy solicitation for this topic seeks significant gains in power/weight ratio, durability, reliability, and maintainability. It also states that, “gearbox housings currently have a high

scrap rate due to corrosion induced by the Navy’s harsh operational environment. Advanced corrosion-resistant materials would provide substantial cost benefits by reducing the rejection rate of these components. The proper material selection could also provide a substantial weight savings.”

Composites offer advantages over metals in that they resist corrosion and can achieve equal or higher strengths with less weight. The Bell V-22 tiltrotor uses higher power density transmissions than those used in conventional helicopters. Presently, commercially available carbon/epoxy composite systems have low thermal conductivity properties. The lube filter bowl was chosen as an initial candidate to mitigate the effect of low thermal conductivity on the heat rejection of the gearbox. Technical success in this component will translate to other composite components aboard the aircraft. Texas Research Institute Austin, Inc., with teaming partner Bell Helicopter Textron, Inc. is developing lightweight composite material systems that will meet design requirements to be used in a military rotorcraft transmission environment.

Improved Protective Coatings for High Strength Steels (Landing Gear)

Topic # AF2003-109, Sponsor: AF, Status: In Phase II. Patent pending.

Corrosion resistant coatings are used to protect aircraft landing gear components that are made of high-strength steel. Super-steel alloys are susceptible to corrosion and subsequent cracking when exposed to the environment. The damage rapidly diminishes the strength of the components, resulting in costly landing gear failure. The unique design of the C-17 allows it to take off and land on dirt runways that are often laden with foreign object debris (FOD). The current C-17 landing gear coating is damaged by impacting FOD, leading to weakened component conditions. In addition, the current coating system utilizes cadmium plating and a chromium containing primer. Both materials are severe human and environmental toxins and are being restricted from use in many applications. They also have large costs associated with their application and disposal. TRI/Austin is developing a completely different coating system that is resistant to the high-energy impact damage caused by FOD. The coating cures rapidly, does not contain volatile organic compounds and is non-toxic when cured. It can be easily applied or repaired in the field or maintenance depot. The combination of this impact resistant coating and a non-toxic primer will replace the poor-performing, toxic coating system currently in use.



High Temperature Matrices for Filament Wound Composites

Topic # A2003-138, Sponsor: MRDEC, Status: In Phase II.

Despite the extensive research expended on developing high Tg resins for composite filament winding applications, these resins require heated processing which limits their general acceptance in current production facilities. New filament winding matrix resins are therefore under development to overcome this limitation. TRI/Austin developed preliminary hybrid resin formulations in Phase I that are low viscosity at room temperature and have glass transitions of over 300C. In addition, it was found that thermal stability and char yield was in excess of the predicted values. This may be attributable to a synergistic char formation mechanism between the two polymers in the hybrid during decomposition. The improvement in thermal stability is potentially relevant in terms of eliminating the secondary thermal barrier coating that is sometimes necessary on rocket motor casings. The overall objective of the Phase II research effort

will be the transition of the developed resins system to a production environment. Working closely with ARC and AMCOM, TRI-Austin will fabricate and test representative pressure vessels for Phase II demonstration. These composite pressure vessels will be fabricated utilizing candidate materials, and the degree to which the resins are compatible with current processing techniques will be demonstrated.

High Damping Resin for Impregnation of Propulsion Scale Electric Machinery

Topic # N2003-211, Sponsor: NAVSEA, Status: In Phase II

In Phase I, Texas Research Institute Austin (TRI/Austin) developed a unique polymer system that exhibited excellent damping ability, with loss factors greater than 0.75 over much of the 80-120 degrees C temperature range at 120 Hz frequency. Stator modal analysis and finite element analysis verified the damping contribution of the resin. The resin also showed excellent dielectric strength and saltwater proofness under applied voltage. Based on these characterizations, it is feasible that this new epoxy-based material could be used as a VPI resin in propulsion motors to reduce the acoustic signature of the U.S. Navy's electric drive system currently in development for the new DD(X) destroyer. During the Phase II, TRI/Austin will further improve the damping resin and perform additional screening tests and FEA. Structure-borne and airborne noise and vibration measurements will be determined for a 15-20 kW motor in which the stator has been impregnated with the TRI/Austin resin, with comparisons made to a motor impregnated with a Navy-approved resin. TRI/Austin is teaming with a designer and manufacturer of Naval electric propulsion motors for the DD(X) application, and with a VPI resin manufacturer that will provide critical testing and evaluation of the resin as an addition to their product line.

Adhesives to Rapidly Attach Sensors/Demolitions to Structures

Topic # A2004-020, Sponsor: ARDEC, Status: In Phase II.

Our soldiers require new methods of attachment for munitions and sensors to unprepared and wet surfaces. Currently a variety of objects: magnets, anchors, shelves, tape, and adhesives are used in surveillance and demolition operations. All these methods of attachment have severe limitations. TRI/Austin proposes the further development of adhesives are extraordinarily insensitive to water, tolerant of unprepared surfaces, offer extremely rapid cure (20 to 30 seconds), and excellent bond strength. In Phase I the versatility of the new adhesives was demonstrated, quickly bonding three to four pound loads to unprepared concrete, aged brick, adobe, painted surfaces, aluminum, mild steel, and many others. In Phase II TRI/Austin will use an experimental design approach to optimize the Phase I adhesive compositions. We will demonstrate the adhesive performance on selected ASTM, internally developed, and supplementary adhesive testing. Testing will be conducted with as received, contaminated, and wet adherends. This is a unique new class of rapid load carrying adhesives. The Phase II will focus on optimization of the new adhesive, product scale up, thorough field application studies, and laboratory testing. This will lead to early commercialization and military deployment during Phase III. These new adhesives will provide cost savings and improved performance.

Development of High-Temperature Aircraft Camouflage Coatings

Topic # AF2004-127, Sponsor: AF, Status: In Phase II.

During the reverse thrust landing, areas of the C-17 aircraft become very hot and the current aliphatic polyurethane camouflage coating discolors and delaminates. The uncoated metal is reflective giving the C-17 a clear visual signature and mitigating survivability. In the Phase I effort TRI/Austin developed and tested novel ambient cured, high-temperature resistant, color matched, camouflage coatings for the C-17. These camouflage coatings exhibit exceptional thermal stability and color retention after high-temperature exposure. At 800oC the best new camouflage coating lost only 1.3% by weight. Phase II will focus on further formulation optimization of the unique preceramic camouflage coating and product scale up, thorough field application studies, and laboratory testing. Our preceramic camouflage coatings will exceed the thermal stability and camouflage requirements in the engine vicinity. At the one-year point in the Phase II effort we will conduct a field trial with our camouflage coating on the C-17. This will lead to early commercialization and military deployment during Phase III. These coatings will find application on the C-17 and future high-Mach aircraft. The novel high solids camouflage coatings will result in significant initial savings and life cycle supportability costs. Considerable savings can be also realized on other military and civilian aircraft.



Lightweight Durable Intumescent Coating

Topic # AF2005-118, Sponsor: AFRL ML, Status: In Phase II. Patent pending. TRL 4.

TRI/Austin, Inc. is developing innovative protective coatings that can be applied over composite structures and impart unique and vastly improved flame, smoke, and toxicity (FST) characteristics. We built on our previously successful Phase I work to further develop new preceramic coatings. This is a new and distinctive class of fire retardant intumescent coatings. Upon exposure to fire, this new coating swells into a tough, durable, insulating char that protects the underlying composite substrate. In the Phase I effort TRI/Austin developed and

tested ambient cured, VOC and HAP free, abrasion resistant, chemically resistant, fire retardant coatings. These aerospace composite coatings exhibit extended times to ignition at very high heat fluxes in cone calorimetry tests. Peak heat times up to 530 seconds have been recorded in cone testing. Phase II focused on further formulation optimization of the composite coating, product scale up, field application studies, and comprehensive laboratory testing. Extant intumescent coatings don't provide adequate heat and fire protection. The proposed preceramic coating binders are new materials, finding applications within the last five years. Improved fire and heat resistance for composite aerospace structures translates into saving warfighter and firefighter lives.

Benefits: Our new intumescent aircraft composite coatings will be directly applicable to platforms like the C-17 Globemaster, which extensively uses composites. The thermally resistant coatings could also benefit several other platforms including the JSF, F-117, and the B-2. In addition, Army tanks, Humvees, and armed forces support vehicles could immediately make use of the new coatings. NASA may have an interest in the new coatings. Commercially the coatings could be used for commercial aircraft interior coatings, infrastructure, offshore, and as steel protective coatings.

High-Temperature Integral Tank Sealant

Topic # AF2005-138, Sponsor: AF, Status: In Phase II.

The Air Force has long utilized the integral fuel tank concept in the design of the airframes for its aircraft. These airframe designs require that the tanks have a sealant that will maintain the integrity of these structures under a wide range of environmental conditions. A particular need has been identified for sealants that will perform well in long-term service at air temperatures of 350 degrees Fahrenheit and fuel temperatures of 250 degrees Fahrenheit. Sealant materials that have been developed to date include fluoropolymer types that have poor adhesion and application properties and polythioether types that do not have the thermal stability required to meet the new high temperature requirements. TRI/Austin is developing a polymer system for sealants which offers the high temperature properties of the fluoropolymers with the good adhesion and application properties of the polythioethers. The polymer system developed during the Phase I research has demonstrated the feasibility of producing the desired material combination and the performance properties of the sealants prepared using this polymer indicate that improved high temperature fuel resistance properties can be achieved.

Advanced Prognostic Health Management Technologies Using Integrated Detection Techniques with Physics of Failure Mode

Topic # AF2006-101, Sponsor: AF, Status: In Phase II.

The proportion of fatigue life that is expended during fatigue crack nucleation is significant in the materials and loading typical of aircraft structural components. The ability to measure or compute the time for fatigue damage to nucleate active fatigue cracks allows the enhanced service usage of individual aircraft components, on-condition based maintenance, and flexibility in inspection/maintenance/repair scheduling. TRI/Austin and AP/ES Inc. are developing of a structural prognostics and health management system that combines local measurements of properties of interest with the capability to model crack nucleation and growth, all integrated within a miniaturized onboard system weighing only a few pounds. The TRI team's approach is to combine multiple sensor technologies with proven physics-based modeling on a self-contained system for a complete health assessment and prognostic capability. The TRI team combines the TRI experience in developing nondestructive inspection technologies suitable for miniaturization on TRI's LAHMPT family of PHM systems with the AP/ES capability in structural modeling and prediction.

Ultra-Light Weight Energy Absorbing Armor

Topic # A2006-214, Sponsor: TARDEC, Status: In Phase I.

The U.S. Army's wheeled tactical vehicles are in need of lightweight ballistic protection that will provide sufficient defense for cargo in the open beds against ground fire and blast events. Texas Research Institute Austin Inc. (TRI/Austin) proposes a novel composite armor system that can afford this protection by dissipating the energy of the impact and/or blast while subsequently preventing penetration of projectiles. Aside from incorporating lightweight components in the armor, the proposed manufacturing process will also provide an inexpensive means to reduce the weight and also allow the panels to be molded into specific shapes. During Phase I, TRI/Austin will be working with a manufacturer of tactical vehicles for the Army who will provide technical assistance regarding incorporation of the panels onto their vehicles. Ballistics testing will be performed at an accredited facility using 7.62 x 51mm NATO ball rounds and .50 caliber fragment simulating projectiles (FSPs). Various environmental tests will be conducted based on methods outlined in MIL-STD-810 to ensure that the composite armor will maintain its effectiveness under harsh field conditions. The combination of new ballistic-protection materials and their production process will result in a lightweight, easily-installed, durable armor for military integration.

Technology Readiness Level Definitions

TRL	Level	Description
1	Basic principles observed and reported	Lowest Level of Technology Readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
2	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there is no proof or detailed analysis to support the assumptions. Examples are limited to analytical studies.
3	Analytical and experimental critical functions and/or characteristic proof of concept.	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
5	Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.
6	System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in a simulated operation environment.
7	System prototype demonstration in an operational environment.	Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment, such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.
8	Actual system completed and "flight qualified" through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9	Actual system "flight proven" through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of system development. Examples include using the system under operational mission conditions.

Source: DOD (2006), *Defense Acquisition Guidebook*