

# Synthetic Multifunctional Materials Research Initiatives

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**Research, Development, and  
Demonstration of multifunctional  
materials and structures to realize  
improved, new, or unique systems for  
military and civil use**

# Objectives

**The objectives of the Synthetic Multifunctional Materials (SMFM) project are threefold:**

- (1) to develop and demonstrate synthetic multifunctional materials utilizing compositional and morphological arrangements to perform at least one additional function,**
- (2) to establish rules for their design, and**
- (3) to develop tools for their incorporation into structures.**

# Focus - Multifunctions

1. **Structural Capability + Power (Energy Generation)**
2. **Structural Capability + Self Repair**
3. **Structural Capability + Sensing**
4. **Structural Capability + Ballistic and/or Blast Protection**

# Program Elements

- 1. Developing novel materials**
- 2. Developing new materials processing techniques**
- 3. Mathematical models**
- 4. Fabrication strategies**
- 5. Lower cost**
- 6. Increase performance**
- 7. Enable new missions for military systems**
- 8. Smart materials and actuators**
- 9. Improving logistics**
- 10. Techniques for assessing damage evolution and predicting future performance through physics-based models and interrogative tools**

# Functional Materials for Structural Applications

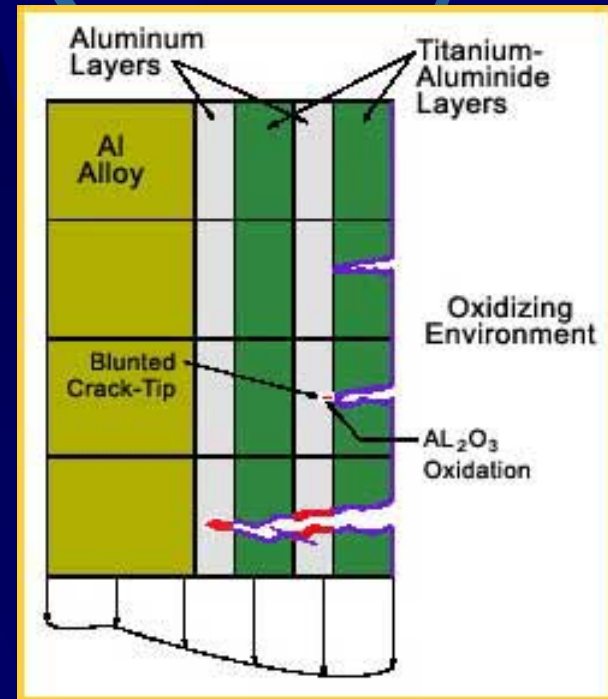
1. Identifying revolutionary and promising new armor
2. Steel/polymer composite hybrid armor
3. Novel Thermoelectric materials that offer revolutionary improvements in cooling and power generation using thermo-photo-voltaic systems
4. Developing high strength and high stiffness super carbon fibers  
Using carbon nano-tubes technology.

# Synthetic metallic-intermetallic laminate

The synthesis of metallic-intermetallic laminate (MIL) composites using metal foil starting materials can be used to design superior structural materials.

2. Through-thickness wires will be used in the MIL composites to allow strain/damage, temperature, and electrical/magnetic field sensing, while improving through-thickness strength.

3. Tailored layer structural stiffness and acoustic impedance through variations in density and modulus will be incorporated into the MIL composites for controlled, tunable acoustic sensing and vibration mitigation, while reducing density and not sacrificing structural performance.



# Multifunctional Material Systems: The First Generation

Leo Christodoulou and John D. Venable

Table I. Comparison of Carbon Nanotube Fibers

Fiber Type	Ultimate Tensile Strength (GPa)	Modulus (GPa)	Toughness (J/g)
Carbon fiber	2.27	483	12
E glass	3.44	72	15–30
S glass	2.60	80	15–30
Kevlar 29	2.70	42	33
Kevlar 49	2.7	90	27
UTD-spun SWCNT fibers (drawn to 450%)*	3.9	85	600

\* UTD = University of Texas at Dallas; SWCNT = single-wall nanotubes

# Northrop Grumman Interests

- Real comparison of Metal and Composites performance
- Steel, aluminum, fiber glass, carbon composites

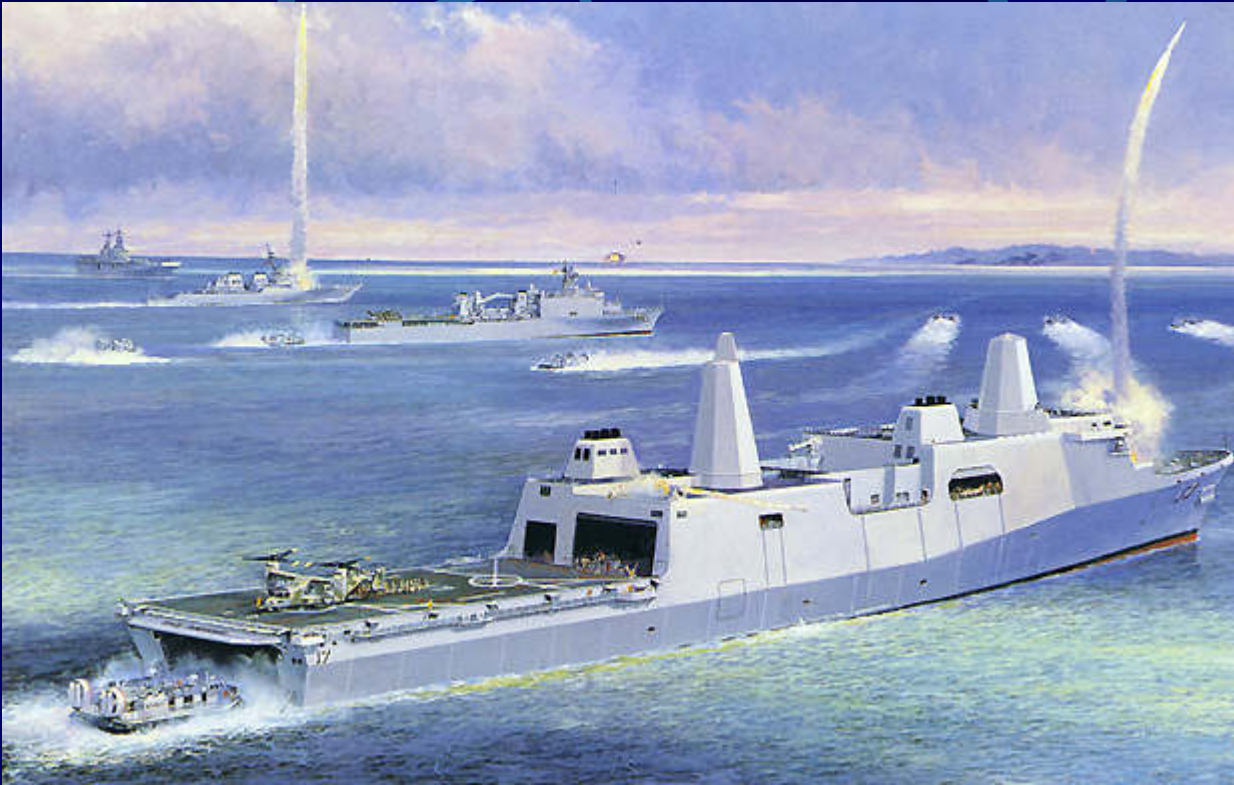
# Northrop Grumman Interests

- 1. Ballistic slightly more important than Blast
- 2. Residual strength of panels (after blast or ballistic impact) under mechanical loads
- 3. Vibration minimization
- Does composites damp out the vibrations

# Northrop Grumman Interests

- Composites Advantages over steel
  - Survivability (ship not sink, not broken)
  - Protection (of personnel from casualty)
- 
- Steel Advantages
  - Cost of repair lower (Smaller area of damage or smaller holes),

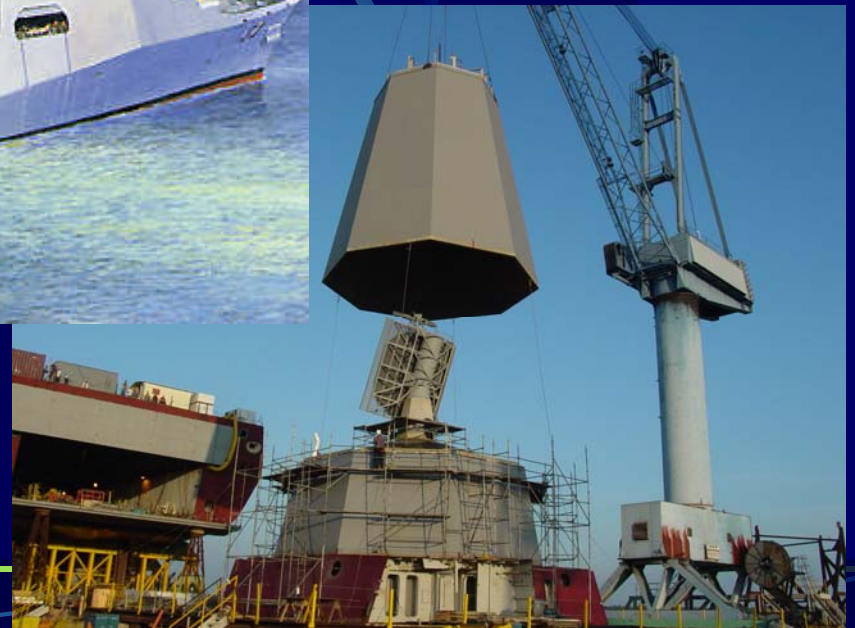
# Hydrodynamic Shock of Composite Materials

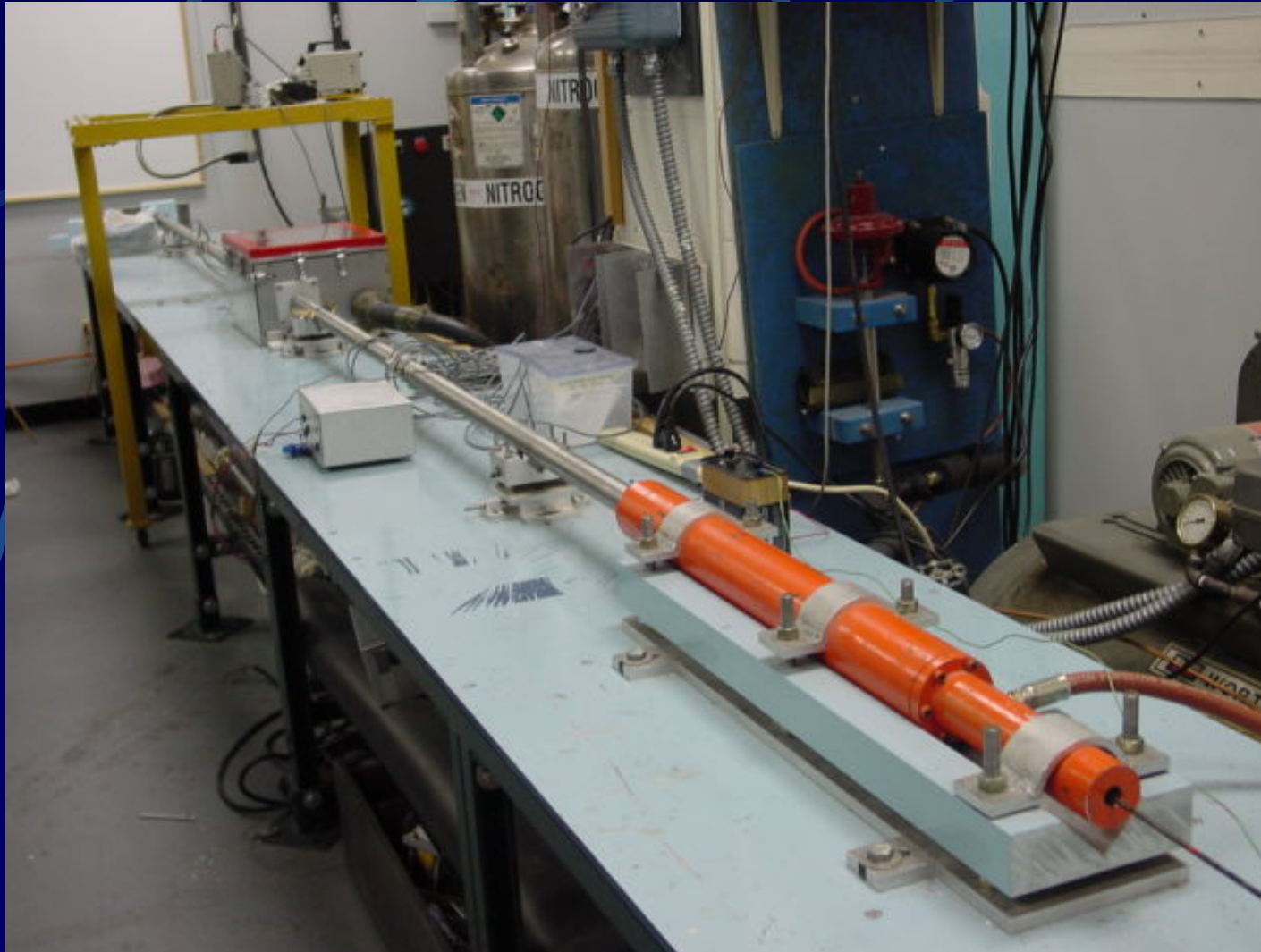


Literature  
Review,  
Team Building  
Phase



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# Obtaining Use of Equipment

Currently investigating possibility of using Avondale light weight shock test machine.

Question of who is cognizant authority over machine

Obtaining authorization to use machine



# Experiment Design

- Applied force (Pressure, Pure Shock, Brisance)
- Sample (Shape, Aspect Ratio)
- Materials (Matrix, Fiber, Special Treatment)
- Fixture (Boundary Conditions, Preloading, Hydrostatic Pressure)