



# Ballistic Vulnerability Reduction: Helicopter Rotor Blades



**Assessment & Analysis**  
*System Engineering and Experimentation*

Steve Polyak, (410) 278-3605  
stephen.f.polyak.civ@mail.mil

## Research Objective

Facilitate design, development, and demonstration of rotor blades with advanced technologies that:

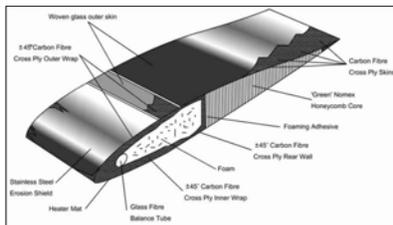
- improve operational performance
- increase tolerance to ballistic and other damage mechanisms



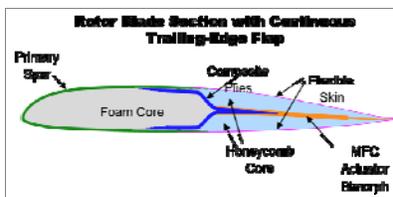
Battle damage to a main rotor blade

## Challenges

- Effective integration of damage-tolerance attributes with overriding properties required for undamaged performance
- Complex operating loads: bending, torsion and tension acting simultaneously under steady-state and cyclic conditions
- Materials that simultaneously benefit: producibility, cost, weight, control, service life, and repair, plus damage tolerance
- Blade designs with imbedded, individual active controls to optimize performance in various flight modes on tilt and compound rotors



Blade design with composite materials



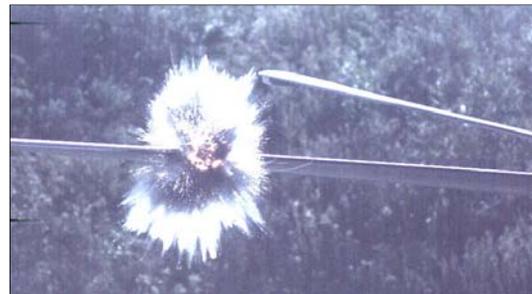
Concept for individual blade control

## ARL Facilities and Capabilities Available to Support Collaborative Research

- Live-fire test capability for all ballistic threats to rotorcraft
- High-speed video; Doppler radar; full sensor data acquisition
- Partial to complete rotor blades, with or without loads
- Unique rig to apply flight-level multi-loads to blades
- Ability to accurately hit a full blade operating at flight-representative speed and load on ground-test aircraft
- Structural test capability: ultimate strength, stiffness
- Over 30 years of experience in planning, engineering and executing live-fire tests on rotor blades for: R&D, design support and risk reduction, Army qualification, and LFT&E
- Consultation on vulnerability reduction for rotor blades
- Direct link to associated resources at ARL's Weapons & Materials Research and Vehicle Technology directorates



ARL load rig for gunfire tests on static rotor blades



Ballistic-vulnerability test on operating rotor blade by ARL

## Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Advanced composite material systems
- Damage-tolerant composite constructions
- Design and manufacturing of composite structures
- Piezoceramic actuators, active-fiber composites
- Active blade control, smart-actuation technologies