

Composite Transmission Components for Rotorcraft Weight Savings

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PROBLEM STATEMENT

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. Technical success in this component will translate to other composite components aboard the aircraft.

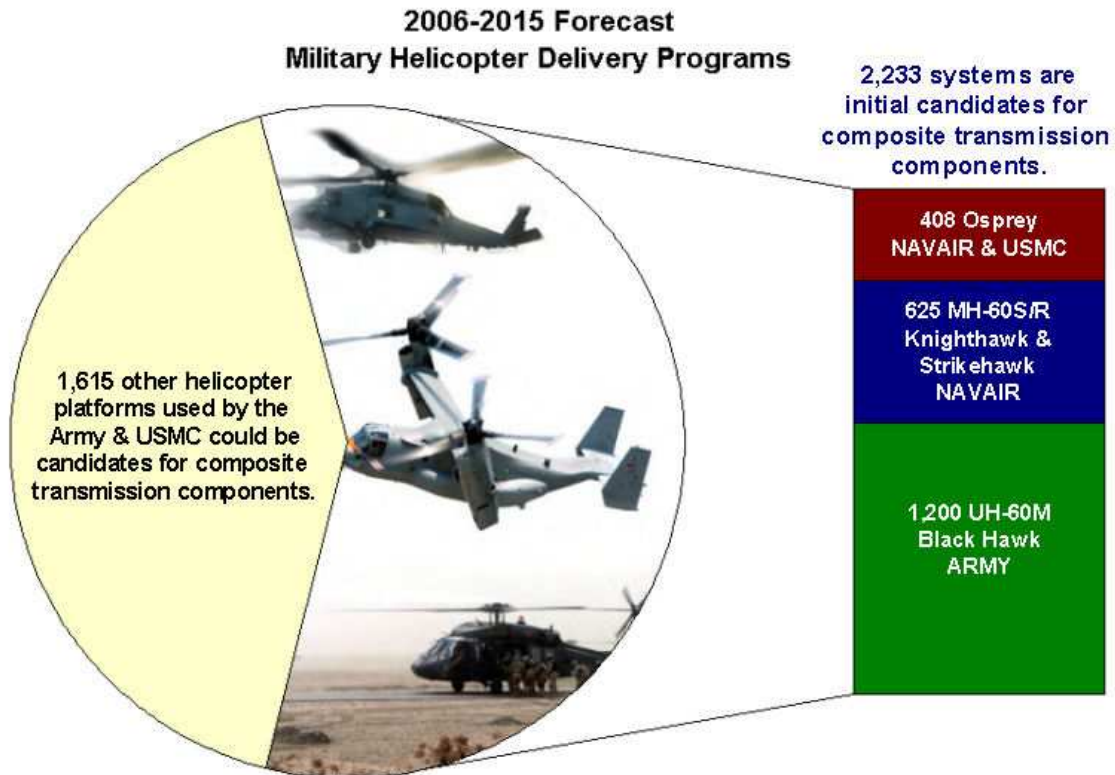
Texas Research Institute Austin, Inc., with teaming partner Bell Helicopter Textron, Inc. is developing lightweight composite material systems that will meet design requirements to be used in a military rotorcraft transmission environment.

WHO CAN BENEFIT?

The acquisition program for the V-22, PMA-275, was one of the sponsors for this work and could benefit from improved power to weight ratios. Manufacturers of rotorcraft such as Bell Textron, Boeing and Sikorsky will all benefit from lighter weight transmission components. Because the lube filter bowl is a bolt on part, once it’s qualified, it can be retrofitted into the existing fleet and new production of the V-22. There is also talk of a power upgrade effort for the

V-22 where weight savings will be especially critical and can accelerate transition of the lube filter bowl and other composite components. According to Rolls-Royce Worldwide Helicopter Demand (Figure 1), 408 V-22 Osprey systems are forecasted for NAVAIR and USMC from 2006 – 2015.

In addition to the V-22 program, the new Joint Heavy Lift helicopter would be an ideal candidate for similar composite components. Since the JHL rotorcraft is still in the concept and technology plan stage, it will also be easier to incorporate the drawing and logistics costs of the new part into the planning stage for this system. Other initial candidates include 625 Knighthawk and Strikehawk helicopters owned by NAVAIR and 1,200 Black Hawks owned by the Army.



Source: Rolls-Royce Worldwide Helicopter Demand, February 2006

Figure 1: The main candidates for the composite lube filter bowl include the Osprey V-22, the MH-60S/R Knighthawk and Strikehawk and the UH-60M Black Hawk.

In addition to the 2,233 candidate systems in Figure 1, the components are also applicable to the Sikorsky CH-53. Deliveries for a 156 helicopter order for the Sikorsky CH-53 will commence in 2015. The Bell/Augusta BA609 is a commercial tiltrotor and approximately 10-30 units per year are forecasted through 2012. Other candidates include commercial helicopters and piston & turboprop aircraft. Over 500 helicopters and 2,000 aircraft are produced worldwide each year. Composite transmission components can also benefit ground vehicles such as the HMMWV which are struggling with weight issues.

BASELINE TECHNOLOGY

The primary function of a helicopter main transmission is to take the power from the engine(s), reduce the number of revolutions per minute (rpm) (thereby increasing torque), and transfer it to the rotor system. This is usually done through several stages of reduction gearing within the transmission. The fundamental design for accomplishing this speed reduction/torque increase has remained relatively unchanged for over 30 years. The use of more advanced materials and manufacturing techniques has allowed manufacturers to improve durability and lower weight over the years, but the fundamental design concept is approaching the physical limits of improvement. Today, rotary-wing aircraft transmission systems comprise up to 11-percent of the aircraft empty weight. Newer, more advanced materials and designs are required to achieve significant gains in power/weight ratio, durability, reliability, and maintainability.

TECHNOLOGY DESCRIPTION

The bowl is a carbon/epoxy composite and is secondary bonded to the aluminum components. An epoxy material has been selected for cost, hot/wet mechanical properties, RTM processibility, and fatigue resistance. The material properties are unaffected by Jet Fuel or Turbine Engine Lube after 90 day soak. A standard modulus carbon fiber has also been selected for strength, fatigue resistance, low weight, and relatively low cost (compared to other fibers). The use of composites allows a weight reduction of 26% over the current lube filter bowl.

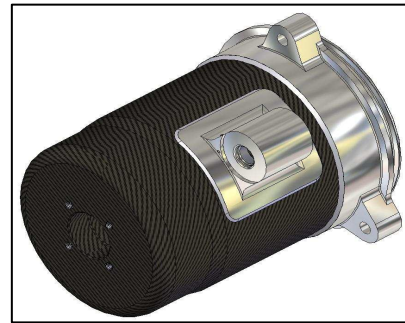


Figure 2: Lube Filter Bowl.

CURRENT STATE OF DEVELOPMENT

Initial prototypes have been fabricated. The test plan is being formed and the number of initial prototypes required is being determined. Part of the test plan review includes determining which tests can be run in parallel and which can be done by similarity. Once the results from the test plan have been reviewed, it will be determined if it is necessary to also conduct a flight test of the part or if the bench tests are sufficient for qualification.

Table 1: Phase II Milestones and TRL's				
Milestone	TRL	Risk	Measure of Success	TRL Date
Deliver prototypes	3	Low	Internal tests and tests at Bell.	Q1 2007
Envelope drawing and engineering documents	3	Low	Complete engineering portion of changes to get as a Class II part in the Bell system during Phase II.	Q4 2007
Qualification	6	Moderate	Passing of bench tests in a relevant environment. Results show that the part is similar to the existing lube filter bowl.	Q4 2007

TECHNOLOGY AVAILABILITY

The lube filter bowl will be available for flight tests in early 2008. Bell Helicopter, the prime contractor on the V-22 has provided technical requirements and is assisting in developing a plan for technology insertion.

TRL	Required Test and Demos	Target Date	Funding Required
7	Flight Test	Q2 2008	TBD*
8	Logistics, spare parts, manual modifications.	Q2 2008	\$60-\$100k

*A flight test may not be required for qualification if initial test results establish similarity.

TRI/Austin seeks PMA-275 Program Office support for test and evaluation in Phase III. The option to obtain matching SBIR funds for transition will also be explored.

REFERENCES

TRI/Austin is working with the Naval Air Warfare Center Division Newport and Bell Textron Helicopter, a prime contractor on the V-22.

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Additional references from TRI/Austin's other transitioned products are available upon request.

ABOUT THE COMPANY

Founded in 1975 by Dr. J. Scott Thornton, TRI/Austin is a complete materials science and development company specializing in the challenges of harsh environments on land, in air, at sea, undersea and even "down-hole". Our advanced materials and composite expertise covers the entire product life cycle including development, testing and characterization, qualification, manufacturing, nondestructive evaluation, health monitoring, problem identification and problem resolution. We pride ourselves on our ability to find the best solution for our customers' materials problems whether it is through our in-house expertise or with the assistance of one of our many teaming partners. Our objective is to develop, characterize and transition innovative materials and material monitoring systems that address the critical needs of the Armed Forces.

Our products include Bond-Coat to protect Naval submarine connectors from cathodic delamination, Tough-Grip® non-skid coatings for Naval ships, and environmentally friendly Ecomass® compounds to replace lead in Army practice rounds.



Figure 4: TRI/Austin's Tough-Grip™ non-skid coating deployed aboard the USS Truman.



Figure 5: BondCoat coating commercialized by TRI/Austin, Inc. for submarine connectors.