ATEC ADVANCED TURBINE ENGINE COMPANY

A JOINT VENTURE OF

Honeywell Pratt & Whitney A United Technologies Company

WHY TWO SPOOLS ARE BETTER THAN ONE:

EQUIPPING OUR MILITARY WITH THE BEST TECHNOLOGY FOR EXISTING AND EMERGING THREATS

SUPERIOR TECHNOLOGY: ATEC's HPW3000 is the superior option to serve as the new engine to power the Army's Apache and Black Hawk helicopter fleets, meeting or exceeding the performance and energy efficiency requirements of the Army's Improved Turbine Engine Program (ITEP).

The reason is because of the major technical difference between the ATEC engine and its competitors – the HPW3000 incorporates what is known as dual-spool architecture, while other engine companies continue to rely on single-spool architectures for applications such as this.

The term "dual spool" refers to the number of rotating assemblies within the helicopter engine. Each spool is comprised of a turbine-compressor combination. The dual-spool architecture excels in several areas:

First, because the engine has two assemblies, the design does not have the aerodynamic compromise and diminution in engine performance associated with single-spool designs. In a dual-spool architecture, each spool operates at its most efficient design point, which eliminates the need for making unnecessary tradeoffs, such as for speed and power that a single-spool engine would have to make.

Second, the design point efficiency of the two spools directly results in improved fuel efficiency as well. The fuel savings of the HPW3000 is at least 3 percent to 4 percent greater than that provided by any single-spool engine. When considering what the Army spends on fuel for its helicopter fleets, that savings – to our government and taxpayers – is dramatic.

All told, when factoring in savings from diminished fuel consumption and lowered operating and support costs, ATEC officials estimate that, compared with the current T700 engine in the Black Hawk and Apache fleets, the HPW3000 will accrue yearly savings of $1 billion.

Third, the dual-spool design means better overall helicopter handling and flight characteristics. In part, that's because dual spools result in reduced "rotor droop" – or low rotor RPMs – which occurs when the engine cannot drive the blades at sufficient RPMs to ensure good helicopter performance. In addition, the dual-spool architecture provides a major benefit in engine starting over single spool.

Fourth, as threats and concerns move to different regions of the world – many in the Middle East's desert climate – dual spools improve overall engine performance, particularly in hot and sandy environments. This is crucial, especially given that improved performance in these types of environments is a chief goal of Army leaders following U.S. involvement in conflicts in Iraq and Afghanistan. Because there are two rotating assemblies that can vary in speed, the engine is more capable and better at handling sand ingestion than a single spool engine, which would incur much greater degradation to engine components. As a result, a dual-spool design fosters greater time-on-wing and less down time for maintenance.

Fifth, dual-spool engines can scale into new, future engine developments by the government – with no need to add exotic or unfamiliar materials or technologies. Plus, the fuel savings and performance advantages of the dual-spool architecture would also extend to a new helicopter program currently in its early stages. The Army is sponsoring research on a family of helicopters known as Future Vertical Lift. Fitting these aircraft with the HPW3000 or a more powerful derivative would provide greater economies of scale, in addition to the fuel savings and ability to meet the Army's expanded performance requirements.

DEEP EXPERIENCE, PROVEN APPROACH: The dual-spool architecture has been a proven and standard feature of engines powering fixed-wing propeller and jet aircraft since the 1950s. The ATEC team, a joint venture between Honeywell and

Pratt & Whitney, has a half century of experience developing engines for the military incorporating the proven dual-spool architecture.

Today, Pratt & Whitney leadership in the design, manufacture and servicing of aircraft engines – including dual-spool engines for front line military aircraft – continues with the F100 powering the F-15 Eagle and F-16 Fighting Falcon, as well as the F117 for the workhorse C-17 mobility fleet, and the PW4062 for the KC-46 tanker. The company also pioneered the development and fielding of the world's only fifth generation fighter engines, the F119 for the F-22 Raptor, and the F135 powering the F-35 Lightning II.

Honeywell has more than 45 years of engine development experience and has fielded 65,000 propulsion systems with more than 241 million service hours. The company has demonstrated success with its T55 engine on the CH-47 Chinook, AGT-1500 TIGER program for the Abrams tank, and through its extended aftermarket partnership with the Army.

The incorporation of the superior dual-spool architecture into the HPW3000 is indicative of the expertise that the ATEC partners have developing engines to power fighter and mobility aircraft, helicopters, turboprops and tanks for the U.S. military.

The extensive history and the engineering experience underpinning the dual-spool approach of the HPW3000 provides Army leaders with confidence. That's because in order for variations on the single-spool architecture to meet the Army's demanding requirements, the manufacturer must wring every ounce of remaining potential by using unproven and exotic materials. That in turn results in higher risk for the Army and warfighters who fly and depend upon the Apache and Black Hawk fleets.

REAL WORLD NEED FOR DUAL-SPOOL DESIGN: As the most versatile Army helicopter, the Black Hawk is used for missions as diverse as air assault and troop transportation. But the capabilities of the current engine are limiting to the missions in critical ways. For example, "today, when an 11-person squad is assigned to carry out a mission 150 miles away, two Black Hawks are needed to transport the troops, and the aircraft would have to stop halfway through the

flight" for fuel and ammunition, according to reports from National Defense magazine.

In other words, Black Hawk and Apache crews must make payload tradeoffs because of engine limitations. But that will change should the Army select the HPW3000 engine as a replacement.

Under the Improved Turbine Engine Program, the Army is seeking an engine that is approximately the same size as the T700 but is 50 percent more powerful and 25 percent more fuel-efficient. These improvements will multiply the battlefield capabilities of aviators and their crews and, in the process, save soldiers' lives.

The ATEC team has built and tested two demonstration HPW3000 engines, and the preliminary data indicates that the HPW3000 will double the Black Hawk's range and the number of troops that it can carry. The HPW3000 will also significantly improve the aircraft's performance in high altitude and hot weather environments, the types of environments encountered in recent conflicts and potentially in the future. Testing results show that the HPW3000 will give Apaches an extra 48 to 66 minutes of loiter time and an increase of 3,330 pounds in lift capacity. These improvements will allow the aircraft to carry a full load of personnel, fuel and weapons.

ALIGNS WITH DOD ENERGY, COST GOALS: The development of the dual-spool HPW3000 engine aligns directly with the Department of Defense's energy strategy, which calls for improving fighting ability and lowering costs by a focus on systems requiring less fuel.

In its energy strategy released in 2011, the Department of Defense called for "more fight, less fuel" by reducing demand for energy in military operations.

"Today's military missions require large and growing amounts of energy with supply lines that can be costly, vulnerable to disruption, and a burden on warfighters," the military's energy strategy says. "The Department needs to: reduce the overall demand for operational energy; improve the efficiency of military energy use in order to enhance combat effectiveness; and reduce military mission risks and costs." Operational energy is defined as "energy required for

training, moving, and sustaining military forces and weapons platforms for military operations."

In April 2013, the Secretary of the Army identified operational energy as a "critical enabler for the range of military operational capabilities from the individual soldier to strategic levels."

The view is echoed by Marine Corps Gen. John Allen, former Commander of the International Security Assistance Force and U.S. Forces Afghanistan. Allen said that "operational energy equates exactly to operational capability."

When it is installed in the Army's Black Hawk and Apache fleets, the HPW3000 will be a fundamental factor in fighting and winning battlefield engagements. It will boost operational capability, reduce demand for operational energy, improve the efficiency of helicopters and their combat effectiveness, and save lives.