POWER UP

THE ARMY'S IMPROVED TURBINE ENGINE PROGRAM

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ITEP: POWER THE ARMY NEEDS

"We don't have the power we need." That was the warning from Maj. Gen. Michael Lundy, Commander of the U.S. Army Aviation Center of Excellence at Fort Rucker.[i]

Helicopter operations are a major pillar of the Army's new strategy for a complex world. But as the Army learned in Afghanistan and Iraq, its current fleets of Black Hawks and Apaches often don't have enough power for demanding terrain, temperatures and combat scenarios. Operating conditions have restricted missions causing crews to carry fewer Soldiers or fly without all their weapons and equipment because engines didn't produce enough power.

That's why the Army has launched a replacement engine program to transform the capability of the Black Hawk and Apache fleets. A technology demonstration phase has already produced results and will lead to the next phase of the Improved Turbine Engine Program or ITEP. The Army has asked engine makers for a 50% increase in power, 25% improvement in fuel efficiency, 35% decrease in maintenance costs, and 20% longer engine life. Under the new engine specifications, the Apache could gain an hour of extra mission time and up to 2500 lbs. of additional payload. The Black Hawk could regain the ability to carry a full load of Soldiers and equipment even in challenging scenarios involving high terrain and hot temperatures.

"We don't have the power we need."

This is the kind of transformational capability the Army needs. In October 2014, the Army released a new operating concept centered on global operations and the ability to project force even in anti-access scenarios in the Pacific and elsewhere. That means the Apaches and Black Hawks will have new challenges beyond the experience of Afghanistan and Iraq. Improved turbine engines could considerably reduce risk, enhance combat performance, and improve safety for the decades ahead.

Priority one for the Improved Turbine Engine Program is to buy back the combat utility of Black Hawk and Apache. Right now, aircrews are taking short cuts such as reducing troop loads, tasking CH-47s for air assault, or trading fuel for munitions and fire control radar of the Apache. According to the Army, ITEP is needed to end shortfalls, improve survivability for ground troops, and stop risking the ground commander's scheme of maneuver through inability to remain on station.[ii]

The tactical requirement for greater combat reach is another driver. Picture a mission in a contested environment – maybe the Pacific theater – with Soldiers prepared to take over a vital objective before adversary forces reach it. Speed is everything. Current Black Hawks could take over nine hours to accomplish the mission, according to an Army analysis. Black Hawks equipped with new engines, carrying the full load of passengers, and eliminating a fuel stop could carry out the mission in two hours and nine minutes.

The program has also attracted steady support from Congress. "The initiative to retrofit and upgrade the engines of the workhorse Black Hawk and Apache helicopter fleets via the improved turbine engine program is a testament to intelligent decision-making in the new budget era," wrote Rep. Duncan Hunter, R-California.[iii]

The Army is preparing to move toward formal engine development in 2016 and select a winning engine in 2018. "The Army has really put their money behind this program," said Colonel Thomas Todd, who was program manager for utility helicopters[iv] This analysis considers factors in the Army's decisions, including:

- Why the Army identified ITEP as a solution to combat performance shortfalls
- Tactical Impact for Black Hawk and Apache
- ITEP as Innovation for the Future Force

BACKGROUND: SHORTFALLS IN HELICOPTERS IN AFGHANISTAN AND IRAQ

"Right now, the Black Hawks can't do their stated mission in Afghanistan," said Army officials in 2004. Engine power limited range and prevented the Black Hawks from carrying the full load of combat troops in high altitudes and hot conditions without reducing the amount of fuel or payload on board.[v]

The Black Hawks simply couldn't make the weight or cover the distances as the thin, hot air degraded performance.

Crews compensated. Medevac teams removed equipment. Black Hawks carried five Soldiers, their kit and weapons, instead of 11. But that stunning conclusion signaled the Army had to find a way to close the power gap.

The Black Hawk wasn't the only fleet affected. The UH-60 Black Hawks and the AH-64 Apache share the same engine type, a 40-year old design that was no longer up to the job in operating conditions where high altitude and hot temperatures limited performance.

The Army has upgraded the current series several times and nothing is left. "If you wanted to squeeze something else out of this engine, you're only going to get maybe an extra 100 shaft horsepower, maybe one or two improvements to fuel efficiency," said Lt. Col. Roger Kuykendall, who was Army program manager of common engines.[vi]

To the Army, this was unacceptable. The solution lay with a new engine tasked to deliver 3,000 shaft horsepower. Drawing on previous research, in 2007 the Army Aviation Applied Technology Directorate began the Advanced Affordable Turbine Engine (AATE) program as the first step to develop a drop-in replacement engine to be retrofitted on both the Black Hawk and Apache.

Reaching out to industry, the Army stated "additional Black Hawk lift capability is needed for hot/high operating conditions and a significant increase in aircraft mission radius capability, up to 500 km (270 nm), is desired for both the Apache and Black Hawk helicopters."

The Army issued specific goals. The improved engines were to be 50% more powerful, and 25% more fuel-efficient with a longer lifespan and lower maintenance costs. Basic requirements included "development and qualification of a new centerline, turbo-shaft engine that is needed to support modernization requirements necessary to ensure the Apache and Black Hawk remain operationally effective well into the 21st century."

As a 6.3 technology demonstration program, AATE served as the research program to lay the technical foundation for an improved turbine engine.

"We're providing a technology foundation to achieve the better fuel efficiency metrics and better horsepower [and] more power in that same envelope," explained Gary Butler, who was engine systems team leader at the Aviation Applied Technology Directorate.[vii]

Demand continued. "Army Aviation is one of the most deployed assets in the Army," explained Lieutenant General Bill Phillips in late 2012. "Our op-tempo is very high and we are sustaining an 84-percent mission capable rate. We are now up to 5.5 million man-hours and still flying in Afghanistan. Everyone at the highest levels of the Army recognizes the value of aviation to the fight," Phillips said.[viii]

Army plans call for the Improved Turbine Engine Program to deliver engines to the Army in the early 2020s. If Army leadership is right about the future challenges, the increase in combat power won't come a moment too soon.

ARMY OPERATING CONCEPT: WIN IN A COMPLEX WORLD

Future ground forces are going to be up against adversaries with precision munitions, electronic warfare techniques and a desire to counter US advantages with novel tactics. "After more than a decade of major combat operations in Iraq and Afghanistan, the Army needs to make another transformation," explained Brig. Gen. Gary Brito, Director, U.S. Army Capabilities and Integration Center, at U.S. Army Training and Doctrine Command (TRADOC). The task was to prepare "future Army forces to support joint force freedom of movement and action through the projection of power from land across the air, maritime, space and cyberspace domains."[ix]

TRADOC released a new warfighting concept titled *Win in a Complex World* in October 2014. Known inside the Army as TRADOC Pamphlet 525-3-1, this periodic document serves as the intellectual foundation and framework for developing the force of 2025 and beyond. The concept was a bold one that emphasized maneuver and force projection, and did not shy away from high-threat, anti-access situations. While the concept drew on combat experience, it framed future Army operations to overmatch the threats and technologies of near-peer conflict.

The Army operating concept envisions soldiers deploying rapidly to conflict areas where they will fight to gain access and hold territory. Under this concept:

> Army forcible and early entry forces, protected by joint air and missile defense, achieve surprise and bypass or overcome enemy anti-access and area denial capabilities through inter-theater and intra-theater maneuver to multiple locations. Integrated special operations forces and combined arms teams dynamically task-organized for the mission conduct reconnaissance and security operations to create and preserve options for the joint force commander.[x]

The Army's new operating concept will place very high demands on the Apache and Black Hawk fleets. Achieving surprise and bypassing enemy strongpoints will be up to the combined work of Black Hawk and Apache. For example, Apaches providing forcible entry firepower and control of unmanned systems could perform much more effectively with the added range, mission duration and payload after they receive the engine upgrade.

"If we are going to fight in this complex world, if you think about being in a megacity, where you have to go into these small, tight landing zones and these urban canyons, you don't need just enough power to get in there and get out of there," Lundy said. "You need to get in there and get out of there with a lot of dynamic capability," he added.[xi]

In fact, ITEP was singled out as an important capability for Army aviation. "Improved turbine engine, drivetrain, and airfoil technologies keep legacy aircraft effective until future vertical lift fielding," stated TRADOC.[xii]

Given TRADOC's forecasts, the most important factor in the Army's decisions regarding ITEP is to what extent it can provide enhanced combat performance. The next sections consider the direct tactical impact on missions for the Black Hawk and for the Apache.

TACTICAL IMPACT: BLACK HAWK

The value of extended range may be particularly crucial for the Black Hawk. The Black Hawk is a utility helicopter used by the Army to transport and insert troops. The Black Hawk has a composite titanium and fiberglass four-bladed main rotor, is powered by two General Electric T700-GE-700 engines, and reaches speeds of over 163 mph (142 knots). Armor helps protect the Black Hawk against hits from 23 mm shells.

The stalwart Black Hawk is and will remain a mainstay for Army operations in environments ranging from combat to special operations to medical evacuation. The Army started buying Black Hawks in the late 1970s. At that time, requirements for "high/hot" operation were specified at an atmospheric condition of 4000 foot altitude/95-degree day. Helicopters have since added weight from new mission packages, and Soldier weight has increased due to the gear they carry.

In 2001, the Army began a program to upgrade over 2000 Black Hawks to the UH-60M and UH-60V configurations. New main rotor blades, a digital data bus for the cockpit avionics, multi-function displays, a stronger fuselage and advanced infrared suppression fitted the UH-60Ms for operations in tough environments. The Army also opted to buy new UH-60Ms. Including the UH-60V variant, the Black Hawk fleet will ultimately number about 2135.

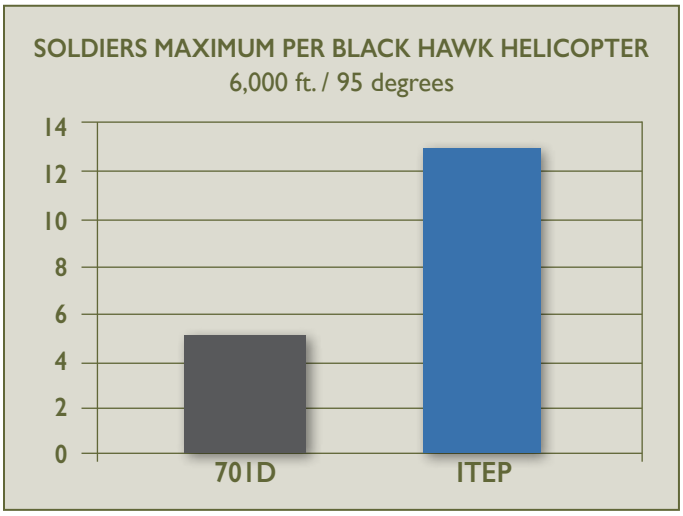
The UH-60M version soon saw service in Afghanistan. UH-60Ms included upgraded engines producing approximately 2,000 shaft horsepower, a gain of 5% over previous engines.

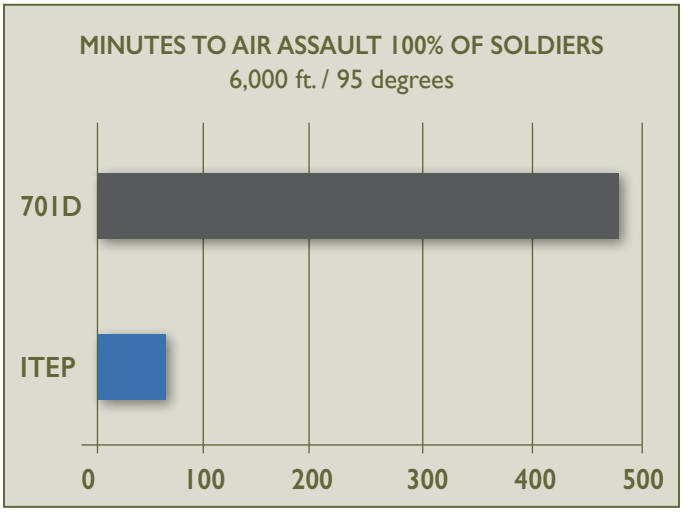
More sophisticated technology on board gave pilots multi-function digital displays for Blue Force Tracker and improved mission planning and data transfer systems. "We got great reaction from pilots," said Lt. Col. Jerry Davis of the first 12-month deployment of the UH-60M in Afghanistan. "They experienced a higher than average operational readiness rate with those aircraft in theater and they loved the technologies on board."[xiii]

But future scenarios can't get the full benefit of these upgrades without new engines. Inserting Soldiers during an air assault demands swift, decisive action. With new, ITEP engines the Black Hawk will carry the full weight equivalent of 13 Soldiers even in a high, hot environment. Altitude and temperature won't constrain tactical options.

Army plans for an air assault show the difference ITEP will make. The planning case developed by the Army calls for 130 Soldiers to conduct an air assault from a forward operating base (FOB) to an Objective 225 km distant without stopping to refuel.

Eliminating the Forward Fuel and Arming Point (FARP) in this mission profile is a transformational advantage for the Army. The FARP is a landing zone where Soldiers must clear out threats and provide security. Those Soldiers must also be resupplied, adding to the logistics requirements and potentially





constraining maneuver. While the Army trains to run a lean and agile FARP, eliminating it lessens the burdens for the mission and increases advantages. The UH-60M Black Hawk variant is at the center of the Army's long-term aviation plan and provides critical capabilities for the force over the next two decades. The Army stands to gain a true transformational capability on a conservative acquisition path with ITEP.

One reporter commenting on ITEP put it well. "The stealth Blackhawk helicopters that flew the elite members of Seal Team 6 on the mission that killed Osama bin Laden might not have had to make a refueling stop on the way back to their Afghan base if those helicopters had more powerful, fuel efficient engines."[xiv]

IMPACT ON OPERATIONS: APACHE

For the Apache, more powerful engines could significantly extend mission capability and weapons payload. The power and efficiency increase from ITEP will benefit Apaches as that fleet faces new range and loiter demands. The AH-64 Apache is highly maneuverable gunship equipped with heavy weapons, including 30 mm machine guns, Hellfire air-to-surface anti-armor missiles and in some cases, Hydra 70 rockets. The Apache first flew in 1975 and entered full service with the Army in the mid-1980s.

Armed reconnaissance is a prime Apache mission now that they are picking up the role from the OH-58 Kiowa warriors under the Army's Aviation Restructuring Initiative. Take the example of air assault. According to Army doctrine, Apaches conduct aerial reconnaissance before a planned assault. They gain

information on landing zones, survey objective areas, test air defenses, scout for artillery targets and destroy high priority targets of opportunity. On the day before the operation, known as D-1, the work of the Apaches intensifies as movement to contact sets conditions for the assault.

On D-Day, Apaches destroy located enemy forces until landing zones are confirmed clear. As Black Hawks carrying Soldiers move forward, Apaches perform attack reconnaissance along the ingress routes and out ahead as necessary. Attack helicopters then shift to overwatch of the landing zones and push supporting fires out beyond the objective.

When Soldiers are on the ground, the Apaches add new tasks to support the ground tactical phase. As the ground force moves forward and seizes its objective, Apaches may again be tasked to support the ground tactical plan. These missions include area security for forward operating bases (FOBs) and FARPs, reconnaissance of follow-on objectives, establishing screen lines, and conducting route reconnaissance and security for lines of communication (LOCs.) "Throughout all missions, the attack reconnaissance unit is prepared to conduct target/BHOs to other attack reconnaissance aviation elements, conduct CCAs, assist with C2, and provide reconnaissance information and products," says the Army.[xv]

The mission of attack helicopters shows why the extended range, mission duration and payload offered by ITEP could make a big difference in scenarios described by TRADOC.

- "Attack helicopters are offensive weapon systems. They provide commanders the means to deliver massed firepower rapidly and accurately, thus disorganizing enemy forces and allowing the friendly force to gain or maintain the initiative."
- "The mobility and flexibility of attack helicopters expand the reach of commanders to all areas of the battlefield," according to Army doctrine. "The speed with which attack helicopters can mass combat power at chosen points in the battle area allows the force commander to influence the battle to a depth that would otherwise be beyond his reach."[xvi]

As with Black Hawk, the Army has invested in the Apache to add sophisticated sensors and systems as it takes on more of the scout and reconnaissance mission. Crews use a Helmet-Mounted Display which can control the 30 mm M230 Chain Gun. Some AH-64Ds have the Ground Fire Acquisition System (GFAS) to detect and target weapons fire on the ground in a 120-degree field of regard.

The Army has a major program underway to rebuild over 600 Apaches in a configuration known as the AH-64E. With new build aircraft included the planned total number of Apaches will be 690. The program started in 2006 and is already at initial op-

erating capability. The investment is necessary because the "AH-64E Apache Remanufacture is the heavy attack helicopter of the current and the future force," according to the Army's statement in its 2013 Selected Acquisition Reports. As a network-centric platform for the Future Modular Force, the AH-64E "will provide the capability to simultaneously conduct (or quickly transition between) close combat, mobile strike, armed reconnaissance, security and vertical maneuver missions across the full spectrum of warfare from Stability and Support Operations to Major Combat Operations when required in day, night, obscured battlefield and adverse weather conditions," said the report.

Apache crews can also control unmanned aerial vehicles via datalinks which allow a Shadow or larger Grey Eagle to share a common operating picture. The UAV links will make the Apache critical for the Army's long-term transition to a manned-unmanned mix on the battlefield.

Now add the ITEP engines. Current numbers are only estimates. However, the Advanced Turbine Engine Company (ATEC), a joint venture of Honeywell and Pratt & Whitney, has estimated the ITEP engines could increase Apache mission loiter time by 48 minutes. An increase of that magnitude has tremendous tactical impact as Apache crews take on and reshape the armed scout role using manned-unmanned teaming.

Demand for Apaches heats up when conflict intensifies. Apache helicopters were deployed to assist in the fight against ISIS terrorists in Iraq and Syria. In October 2014, Apache helicopters struck four sites in a battle near Fallujah. The Apaches worked with fixed-wing aircraft together hitting two mortar sites, a large ISIL unit and two small ISIL units, according to the Pentagon. Apaches also struck tactical units and vehicles in action near Al Asad in February 2015.[xviii]

These examples shed light on how improved turbine engines could greatly increase Apache combat capability by improving on-station time. The striking Apache may have to wait as Soldiers and tactical air controllers sort out positions of friendly troops, assess collateral damage risks, and pinpoint insurgents. Extra range from more fuel efficient engines extends precious on-station time so that the Apache crews can stay on the spot to strike hard rather than having to depart the action and return to bases for fuel. Keeping the same crews in the air for extra minutes as the situation develops retains their better situation awareness of strike requirements. In addition, the extra power means the Apaches can perform missions with the full complement of equipment, munitions, and fuel aboard thereby increasing firepower and mission effectiveness.[xix]

Apache missions of the future will demand all those capabilities. Apaches are now stationed at

Fort Wainwright in Alaska where they will train with Stryker and airborne infantry units. They will also gain experience integrating with the Air Force's long-range sensors and join upcoming Red Flag Alaska exercises with joint and allied partners.

ITEP engine performance can also increase combat mission radius. Range may be especially critical as Apaches experiment with high-intensity joint missions such as launching from Navy ships.

The Apache fleet is already stretching with innovative force projection exercises. The Army conducted experiments in 2014 with Apaches extending reach and firepower from sea platforms. "One element of this could be the use of Apache and Black Hawks on ship platforms," said Gen. Vincent K. Brooks, Commander, U.S. Army Pacific.

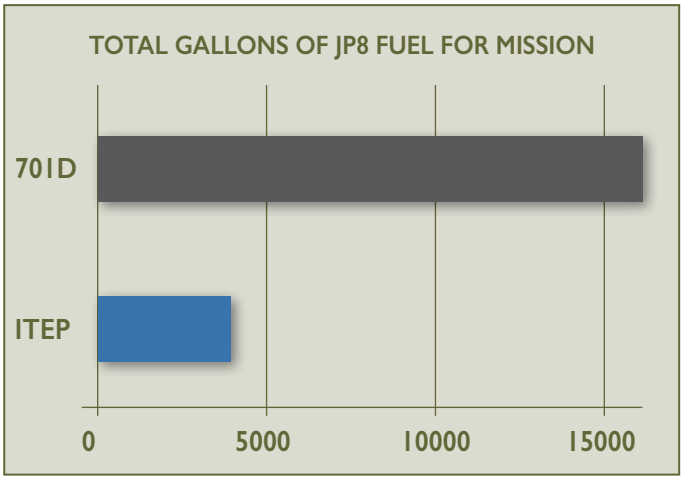
Innovation for the Future Force. The Department of Defense has goals across the military to make sure America retains a technology edge.

ITEP is an ideal fit for the Pentagon's Third Offset initiative. "I'm telling you right now our technological superiority is slipping," reiterated Deputy Secretary of Defense Robert Work in a 2015 speech at the Army War College Strategy Conference. The Pentagon launched the Defense Innovation Initiative – also called the Third Offset strategy – to stimulate investment in capabilities that will deliver strong operational advantages essential for a much more threatening environment.

There's no sign of slackening demand for lift, air assault and armed reconnaissance. "As an example, Joint Base Lewis-McChord's combat aviation brigade is preparing for assignments that would have them flying over the Pacific Ocean for the first time," noted Assistant Secretary of the Army for Acquisition, Logistics and Technology Heidi Shyu. "In the past, Army helicopter crews generally handled missions over land. This signifies important changes in how the Army will expend equipment and funds in a post-Afghanistan era," Shyu said.[xx]

An advanced, 3000 shaft horsepower engine is a transformative upgrade for Army aviation. Going forward, Black Hawks and Apaches will be at the center of the force. The combat environment of the 2020s and beyond could look very different. Picture laser weapons, more manned-unmanned teaming with helicopters and unmanned vehicles, and new hotspots across the globe. ITEP can be a driver and partner of innovation across the Army. Possibilities include:

Operational Energy. Saving fuel is a big part of ITEP. Take the Army's scenario for a 225 km air assault. Black Hawks with ITEP would use little more than one-fifth of the fuel required for the current 701D engines.



It's part of a bigger plan for innovation in operational energy to pay off in combat power. The Army's Equipment Modernization Strategy also committed the aviation portfolio to "reduce operational energy requirements and develop operationally viable alternative energy sources to reduce Soldier risk and improve sustainment." As the document pointed out, the Army "faces significant risks from outdated and inefficient energy capabilities." This applies directly to aviation systems. "Future aerial systems require greater lift, range and endurance without increasing logistical requirements," noted a special annex.

At fleet maturity, ITEP engines could save up to 50 million gallons of fuel yearly across the Apache and Black Hawk flight hours. The savings could total one billion dollars per year. Cost estimates will vary depending on spot oil prices. An even bigger variable

would be the final size of the Apache and Black Hawk fleets and their flying hour totals. However, the point is that the 25% better fuel efficiency requested by the Army returns dollar savings over the life of the program.

Directed Energy. Beyond the immediate benefits, ITEP engines will make Black Hawk and Apache more capable for future missions. For example, the Army has research underway on directed energy laser weapons with offensive and defensive applications. Mounting a laser on a helicopter is a real possibility. "The development of directed energy capabilities on mobile and fixed platforms holds promise for orders-of-magnitude increases in range, effectiveness, rate of fire, and unlimited munitions stowage," stated the Army's Operating Concept.[xxi] Power for directed energy in a fiber optic laser depends directly on engine power. Over the next few years, field testing of the ITEP engine could ascertain whether it has advantages in directed energy applications.

Future Vertical Lift. What about new helicopters? The Army's thirty-year plan is to "introduce the future vertical lift, medium utility and attack platforms while unmanned aerial systems introduce a future family of platforms with enhanced manned/unmanned teaming capabilities for operations in the networked common operating environment."[xxii] More research on future lift could begin after 2017. Future Vertical Lift may be a family of systems fielded after the mid-2030s with several exotic platforms across all the services. Work led by the Aviation and Missile Research, Development, and Engineering Center (AMRDEC) focused first on software and avionics concepts. Airframe design will come much later. When the Army moves forward with a future platform, ITEP is well-positioned to power light and possibly medium versions of FVL.[xxiii]

The reality is that hundreds of Black Hawks and Apaches will remain in the Army inventory in the 2040s and perhaps beyond. The question is whether they will deliver combat capability for Soldiers – and that answer depends on keeping ITEP on pace.

GAINING CONSENSUS

Next Steps

ITEP is the number one priority for the Army, according to Assistant Secretary of the Army Shyu. The Army wants a new turbine engine so its helicopters can fly in high and hot conditions anywhere in the world. ITEP's increased range, she said, will also save the Army in the number of helicopters it needs.[xxv] ITEP was approved by Undersecretary of Defense for Acquisition Frank Kendall in August 2015.

ITEP entered an exciting new phase with the release of requests for proposals in fall 2015. Next, the Army will select teams to go under contract to develop engines and compete for the program award. Formal competition begins in 2016.

A winner will be selected in spring 2018 to proceed to Engineering, Manufacturing and Development. Developing a production-ready engine will still require a substantial period of development and thousands of hours of engine testing to reach a military quality engine that can transition to full-rate production.

Ultimately the Army expects to buy 6,215 engines including spares.

Under current plans, the combat improvements offered by ITEP are still more than half a decade away. Any delay in the program will push back the timeline even more and leave Soldiers with less than what they need.

On Capitol Hill, Congress included funds for the competition in its 2016 budget.

Congress has recognized the technology development in ITEP can make Black Hawks and Apaches far more effective. Support has been steady – particularly from those who recognize what additional helicopter power provides for Soldiers.

The Senate Armed Services Committee has consistently expressed its support for ITEP. The Committee stated: "providing adequate and stable funding for ITEP sufficient to carry at least two engine developers over the next few years and through completion of the technology development phase is important to reduce risk, achieve appropriate technology maturity, and set the conditions for ultimate program success."[xxiv]

"The initiative to retrofit and upgrade the engines of the workhorse Black Hawk and Apache helicopter fleets via the improved turbine engine program is a testament to intelligent decision-making in the new budget era," wrote Rep. Duncan Hunter of California.[xxv]

"I want to commend the U.S. Army for establishing a firm requirement for the Improved Turbine Engine Program," said Rep. Tammy Duckworth of Illinois. Duckworth was a Black Hawk pilot who was shot down in Iraq in 2004. "What you have done to develop and integrate the engine provides a heck of a lot more engine power...a lot more fuel savings, and it is really a significant combat multiplier and good for cost savings as well," Duckworth stated.

CONCLUSION: SMART TRANSFORMATION

The Nation "must have a force that enables the Army to win in a complex world in which the future adversaries, future missions and future conditions are uncertain," noted TRADOC.

Future Army operations depend on combat reach. Pacific islands, Middle East mountain ranges, the flat plains of Africa: many potential trouble spots around the world could call on the Army to rapidly insert troops and provide armed reconnaissance and supporting fires in a joint or Coalition operation.

Tactical scenarios make a strong case. Investing in increased engine performance delivers unique and significant gains that cannot come from any other type of upgrade.

The value of ITEP rides on combat performance improvements. The Army's concepts for rapid insertion and dominant maneuver under *Win in a Complex World* will demand much from the Apaches and Black Hawks. Specific scenarios are impossible to predict. However, the performance margin for the crews – and those Soldiers who depend on them – is invaluable.

By 2040 the Army will be undergoing changes to a force that fights and wins in different ways. Yet that force will still rely on Black Hawks and Apaches. They may serve an exotic force of unmanned systems and Soldiers teamed together. Yet the missions of air assault, armed reconnaissance and strike will remain core for Soldiers. Only with ITEP can the Black Hawk and Apache deliver all that Soldiers - and the Nation - will expect of them.

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