April 2015

Trip to Washington DC

ACC Web Site: www.arnoldcommunitycouncil.com

2015

Arnold Community Council

Executive Summary

The Arnold Community Council (ACC) has been a long-time advocate of policy change in lieu of requests for budget authority to solve problems at Arnold Engineering Development Complex (AEDC), Arnold AFB, Tennessee. Such an approach can save precious federal tax dollars by eliminating unintended, negative consequences of legislation or regulation. Because of recent budget cuts and additional workloads placed on the DoD, the need for such policy change and subsequent administrative flexibility in the field is more important than ever. Consequently, the ACC will be advocating four initiatives this year. Three of the initiatives are general issues that will be presented to the members of the Congressional Range and Testing Center Caucus (CRTCC). The final initiative is one that is unique to AEDC.

As indicated in the attached appendices, first generation hypersonic weapons are a direct threat to U.S. military capabilities. The U.S. needs to ensure rapid investment in test facilities and the research necessary to build hypersonic systems for the Nation in order to counter game changing attributes of global reach, rapid response and asymmetric advantage, obtained through the use of hypersonic technologies.

Additionally, the need for acquisition streamlining has reached a critical mass; the DoD can no longer afford to acquire systems in a traditional manner that adds excessive cost and schedule when funds are more constrained than ever before. Therefore the ACC fully supports and asks the CRTCC to support the NDIA study that identifies practical, acceptable and truly streamlined methods for the DoD acquisition process. The NDIA Study may be found at Appendix 1.

TAB 1 - GENERAL INITIATIVES:

- Further populating the Congressional Range and Testing Center Caucus (CRTCC) with new members; establishing a related network of all community groups for military bases in districts of the CRTCC members; and highlighting to the caucus cross-cutting initiatives that would better support the DoD test and evaluation community.

- Enhancing the opportunity to accept new tenants at CRTCC ranges and test centers, specifically, streamlining the Enhanced Use Lease (EUL) regulations to support future requests for a quick lease of government land. A model for this initiative may be the State of Tennessee's "Select Tennessee" program which ensures sites, facilities and buildings are ready for rapid use by potential commercial customers.

- The National Defense Industrial Association (NDIA) completed a report recently with recommendations for streamlining the Defense acquisition process. The ACC supports the conclusions from this report.

TAB 2 - UNIQUE AEDC INITIATIVE:

- Providing a leading and cost-saving role for AEDC within the 2013 NDAA directed hypersonic study.

TAB 3 - ACC PARTICIPANTS IN THE APRIL 2015 TRIP TO WASHINGTON DC

- Spreadsheet of participants with affiliation and contact information

TAB 4 – GENERAL AEDC INFORMATION:

- 2014 Economic Impact of AEDC and AEDC General Fact Sheet

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TAB 1

2015

The Congressional Range and Test Center Caucus

In 2013, Major Range and Test Facility Base (MRTFB) community support groups worked with Congressional Representatives to form an MRTFB Caucus. The purpose of the proposed caucus was to educate members of Congress on the strategic value of Department of Defense ranges and test centers, showing the unusually high return on investment captured by those facilities and supporting their operations. On January 22, 2013, the Congressional Range and Test Center Caucus (CRTCC) was established. Congressmen Diane Black (R-TN-06) and Tulsi Gabbard (D-HI-02) are the co-chairs and there are 22 Congressional members. Also during 2013, the CRTCC was highlighted to the test and evaluation community through an article in the ITEA Journal and with Congressman Black as an invited speaker at the ITEA International Symposium and was broadly acclaimed as a much needed support group for the MRTFB.

The ACC supports the mission of the CRTCC which seeks to educate Members of Congress about the strategic value of ranges and testing centers and to promote their role in the Department of Defense's Testing and Evaluation (T&E) mission.

The goals of the ACC continue to be: 1) Support stable budget authority/flexibility for long-term investment in major range and test facility base infrastructure; 2) Provide recommendations for greater flexibility in supporting government and commercial customers (see attached NDIA initiative paper at Appendix 1); and 3) Ensure understanding of the importance of MRTFBs in the reduction of cost and risk in developing, fielding and maintaining DoD weapon systems. The ACC will bring forth initiatives supporting these goals to the CRTCC for support.

A strong effort to link the civilian community groups of the CRTCC members must be nurtured. The Test Resource Management Center has produced a short DVD covering all of the MRTFB sites which may be viewed at the following link http://www.acq.osd.mil/dte-trmc/index.html (use the QR Code below to go to the link). The CRTCC Chairmen should pass this link to the CRTCC membership and interested community groups. This video provides baseline understanding for the community of MRTFB advocates which will allow joint issues of national importance to be identified to the caucus. The CRTCC's ability to respond to such issues of National Strategic Importance, the awareness of local communities across the country of CRTCC responses, and the communication of these successes on national websites will attract new members to the caucus and make it a natural target for Senatorial interest.

For 2015, the Arnold Community Council (ACC) has as an initiative to strengthen the CRTCC. This initiative has five parts: 1) Connect the civilian community groups of all the CRTCC Congressional members and bring joint issues before the caucus; 2) Encourage more Congressional members to join the caucus; 3) Update the CRTCC web page to represent more of the member's bases; 4) Start pursuing Senatorial caucus membership and 5) Set up visits by the CRTCC membership to the Hypervelocity Wind Tunnel 9 at White Oak MD, the Aberdeen Proving Ground at Aberdeen MD and the Patuxent River Naval Air Station at Patuxent River MD to see three of DoD's MRTFB capabilities.

Recommend that the CRTCC support the ACC in accomplishing its 5-part initiative for strengthening the caucus. It is also recommended that the CRTCC support the other broad initiatives that the ACC is pursuing in 2015: streamlining of the Enhanced Use Lease process and streamlining the defense acquisition process. Finally, supporting the AEDC unique initiative on hypersonic Test and Evaluation capabilities is requested.

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Streamlining the Enhanced Use Lease Process

Use of excess Federal land by industrial and commercial entities offers huge benefits to both the Federal Government and the private entities. In the past, there have been two separate transfers of excess AEDC Reservation property to local government entities demonstrate the potential for mutual benefit. The first transfer was the sale of 125 contiguous acres to the City of Tullahoma in 1975 for use in the development of an industrial park. The second was the sale of 795 acres, which was separated from the AEDC Reservation by the construction of Interstate Highway 24, to Coffee County in 1977 – also for the development of an industrial park. Today, there are 492 employees in the Tullahoma Industrial Park and 2,841 in the Coffee County Interstate Park. This is an economic impact to the region that is similar in size to the AEDC primary mission's economic impact. It brings diversity to the region's employment base, providing beneficial competition among AEDC vendors and suppliers. At the same time, AEDC benefits through improved educational, transportation, healthcare, and cultural infrastructure. Future transactions of this nature can be implemented as Enhanced Use Leases (EULs) and will then bring revenue to AEDC through lease payments.

Prospective tenants interested in EULs at AEDC want to be able to finalize a land lease quickly – within three to four months. This requires an aggressive schedule that could be possible through either of the following scenarios: 1) fast tracking is supported by the Secretary of the Air Force-Installations, Environment and Logistics (SAF/IE), Chief of Staff of the Air Force (CSAF), and Federal Congressional members; or, 2) an option is developed under which excess land could be leased (EUL) to a public entity such as an Industrial Development Board; and then, be made available to prospective tenants through subleases. Recently AEDC requested that a parcel of land be included in the "Select Tennessee" program where the state Economic and Community Development Commission markets businesses to choose sites in the state, but was turned down because of many issues with the land (not cleared; contamination; no water & sewer; lease vs. buy). However, the state suggested the site would be best utilized for large, heavy manufacturing operations.

One example of the second option is the Community Reuse Organization of East Tennessee which is an economic development organization whose purpose is to assist the private sector in creating quality jobs in the region by using the underutilized Federal land, facilities, equipment, personnel and technology available at the Department of Energy (DOE) Oak Ridge complex. This project currently has 17 corporate residents who have provided hundreds of jobs and millions of dollars in capital investment. The transfer of property from the DoE to the Community Reuse Organization of East Tennessee was accomplished in accordance with sub-clause 770 of the Atomic Energy Act and included over 600 acres of land and resulted in over 100 leases. Another example is the use of Tennessee Valley Authority (TVA) land for Industrial projects in Anderson County Tennessee.

The ACC will pursue Air Force approval of EUL process streamlining through the two options above to allow AEDC to grant land leases more quickly. Similar streamlining is already in place within NASA and DOE.

Streamlining the EUL processes across the DoD would provide more opportunities for leasing available land. All of the DoD ranges and test centers own vast amounts of land and are looking for opportunities to lease excess land to offset operating expenses. These opportunities should be vigorously pursued as long as the lease does not in any way encroach on the DoD's mission performance or functional efficiency at the site.

Recommend that the CRTCC encourage the DoD and Services to develop a streamlined Enhanced Use Lease program.

2015

"Pathway to Transformation"

The National Defense Industrial Association (NDIA) completed a report in November 2014 titled "Pathway to Transformation"(http://www.ndia.org/Advocacy/AcquisitionReformInitiative/Documents/NDIAPathwaytoTransformationAcquisitionReport.pdf) which caps off nearly eight months of research into the Defense acquisition process. It concludes that meaningful improvement to the acquisition process requires sustained effort as there is no "once and for all" solution to cost and schedule growth. The report groups its recommendations into three primary areas: authority and accountability, matching requirements to resources, and evidence based decision making. NDIA's POC for this report is Mr. Will Goodman, Vice President for Policy, wgoodman@ndia.org, 703-247-2595.

Authority and Accountability. The report aims to restore the time-honored principles of the Packard Commission by providing broad authority to acquisition decision makers, clarifying and shortening their chains of command, centralizing acquisition authority and responsibility, and holding those responsible, accountable. The report recommends a Defense Streamlined Programs Pilot authority, which would add managerial judgment and flexibility to the acquisition process. It recommends tasking the Service Chiefs to link and streamline the requirements, acquisition, and budget processes, and holding them accountable for requirements validation, rather than the Joint Requirements Oversight Council, a multi-service committee. It recommends identifying and expanding the use of commercial "state of the practice" subsystems, measuring value beyond individual transactions to incentivize and reward creative acquisition strategies, streamlining the process for commercial item determinations, and facilitating government and industry collaboration on the path forward for intellectual property rights. Last, it recommends empowering and rewarding government employees to bolster the essential dialog with industry.

Matching Requirements to Resources. NDIA strongly supports limiting the requirements levied on the acquisition system to the resources provided to it, and making sure that any remaining essential requirements are properly resourced. The report recommends a process for sunsetting new and existing acquisition requirements in statute, or alternatively convening an expert panel to review and reduce the requirements in the current body of acquisition law. The report recommends several approaches to improving the management of both the civilian and military acquisition workforces by making workforce management more strategic, fully funding the Defense Acquisition Workforce Development Fund on a stable basis, and making the acquisition profession more attractive to capable and talented military personnel. The report recommends more collaboration between government auditors and the vendors they audit and close oversight of that process by Congress. And it recommends raising the small business reserve under the Simplified Acquisition Threshold to $250,000 and raising the Threshold to $500,000 for all businesses.

Evidence-Based Decision Making. During the research process, NDIA members raised several acquisition processes as problematic, but data to substantiate those concerns has not been collected and analyzed. Therefore, NDIA recommends having GAO study complex systemic acquisition problems, such as the possible abuse of the bid protest process by contract incumbents, the impact on innovation of the LPTA source selection method and IDIQ MACs, and the future utility of a management reserve account if applied strategically to certain acquisition programs. Further, NDIA recommends taking full advantage of "big data" advances in automated information collection and analysis to improve the quality and reduce the manual burden of acquisition program reporting requirements. Last, the report endorses an ongoing Department initiative, Technology Domain Awareness, as a way to increase the efficiency of public and private research and development through incentives rather than mandates.

The ACC recommends that the Congressional Range and Testing Center Caucus (CRTCC) support the conclusions found in the NDIA report for streamlining the Defense acquisition process.

TAB 2

Arnold Community Council 2015 Critical Issue

Maintaining Military Superiority: Revitalization of Hypersonic Testing Capabilities

Hypersonic capabilities that operate at speeds greater than Mach 5 (five times the speed of sound, or about 3800 mph at sea level) are widely viewed as military game changers. We are competing with potential adversaries to be the first to field advanced hypersonic systems.

- *Speed is the new stealth - The Economist, 1 June 2013*

Hypersonics capabilities are prioritized in

multiple national policy documents

OMB-OSTP FY16 Priority

Advantages: responsiveness, survivability, cost effective (max

r"
4

50 cruise missile systems are required to cover the same area in 15 minutes

Every Hypersonic System developed by the DoD is tested at the Air Force's Arnold Engineering Development Complex (AEDC) at its Tennessee and

NASA effectively ceded leadership in hypersonics to the DoD when it eliminated hypersonic aeronautics

Congress, in its National Defense Authorization Act for Fiscal Year 2013, noted that the state of the Nation's hypersonic ground test and evaluation facilities and workforce have not received adequate attention over the years facing both threats of divesture as well as gradual decay

Congress must recognize that the DoD has the lead for hypersonic systems development including ground testing and support the sustainment and improvement of the national resources at AEDC

- **Recommendations from Congressionally directed report on Hypersonic T&E Infrastructure (NDAA 2013) should be implemented**

- **Hypersonic capabilities include both the test infrastructure and workforce expertise and both must be enhanced and sustained – *a new hypersonic propulsion facility for the nation should be built at AEDC***
- **AEDC's Tennessee and Maryland sites are strongly supported in both research and workforce development by The University of Tennessee Space Institute (UTSI) and the University of Maryland**

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2015 Hypersonic Ground Testing at AEDC

The "Third Offset Strategy" is a new initiative by the Secretary of Defense to harness technological innovations to preserve America's military primacy in the future. The initiative is not a comprehensive national defense strategy let alone a national security strategy. It will focus more narrowly on restoring and sustaining our conventional power projection capability and capacity, which is the bedrock of deterrence. The strategy will tailor itself to the more concrete goal set out in the Defense Strategic Guidance document of defeating the anti-access/area denial (A2/AD) challenges and China's A2/AD capabilities in general. The wide expanses of distances in the Asia-Pacific region, the growing A2/AD threat which requires greater stand-off distances, and the increasing need in modern warfare for fast response times for time-critical targeting are all challenges to meeting the strategy and must be addressed. It points to the need for the Department to invest in high-speed weapon and platform technologies. Speed is the attribute that will enable this power projection, including hypersonic flight, which is greater than five times the speed of sound. The USAF and DARPA have invested millions of dollars in hypersonic technologies and believe that a hypersonic program of record could begin as early as 2020. In addition, the Chinese and other competitor nations are pushing toward military parity with the U.S.; and in some cases, as in hypersonic vehicle development, they appear to be leaping ahead. Allowing nations in the Asia-Pacific region that do not share our respect for free and open avenues of commerce to gain a strategic advantage over the U.S. and her allies only brings more instability to the world.

Congress, in its National Defense Authorization Act for Fiscal Year 2013, noted that the state of the Nation's hypersonic ground test and evaluation facilities and workforce have not received adequate attention over the years facing both threats of divesture as well as gradual decay, and is concerned that the broad developmental hypersonic RDT&E community needs renewed attention. With only a few exceptions, the nation's significant hypersonic aeronautical and propulsion ground-test capabilities are a part of the Air Force's Arnold Engineering Development Complex (AEDC) at its Tennessee and Maryland sites. The Act called for the DoD and Office of Science and Technology Policy to conduct a study and provide a report to the Congress on this issue. That report was delivered to Congress in March 2015.

The DoD needs to make sure that AEDC is central to any plans coming from the NDAA requested report. AEDC should play a major role in managing and coordinating the nation's hypersonic aeronautical and propulsion ground testing, leading the development of new advanced hypersonic ground test capabilities (this includes siting of a new hypersonic propulsion test facility at AEDC) and assuring that the expertise of the nation's hypersonic ground test workforce is developed and

sustained, all supporting the ability to project power with speed. Given the existing ground test facilities and accompanying workforce, AEDC's Tennessee and Maryland sites are ideal to play these roles. The University of Tennessee Space Institute (UTSI) and the University of Maryland, both in close proximity to the AEDC sites, would support the sites by providing a focused educational program on High Speed Systems to assure that the expertise to achieve the nation's hypersonic goals are met. NASA has made the decision that it will no longer be in the business of supporting hypersonic aeronautical research. **Recommend Congress recognize that DoD has the lead for hypersonic systems development including ground testing and support increased funding for the expansion and improvement of the national ground test assets already in place at AEDC. This action will be a key part of implementing the expected recommendations of the NDAA requested report.**

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Should America Fear China's "Carrier-Killer" Missile?

Robert Farley, The National Interest, 22 September 2014

The DF-21D anti-ship ballistic missile (ASBM) has generated a tremendous amount of interest over the past five years. If it works, it poses a very serious threat to U.S. Navy (USN) carriers, as well as to the other advanced warships of the USN, of the Japanese Maritime Self Defense Force, and others. An anti-ship ballistic missile is more than just a missile; it requires a broad, sophisticated support system. Unlike a missile launched at static targets, a carrier-killing ASBM requires terminal guidance, as it must revise its flight path after reentering the atmosphere. From launch to strike, the flight of an ASBM can take fifteen or so minutes, at which time the carrier in question will have more than likely moved its position on the open ocean. The missile thus needs to be adjusted remotely or needs to have the capacity to identify the carrier on its own. Both of these processes depend on the operation of a sophisticated set of sensors, as well as a communication system capable of integrating these sensors and transmitting information to shooters. As Andrew Erickson emphasizes, "the successful achievement of high-quality, real-time satellite imagery and target-locating data and fusion as well as reliable indigenous satellite navigation and positioning would facilitate holding enemy vessels at risk via devastating multi-axis strikes." The USN is very concerned about the DF-21D, which is one reason it's working so hard on ship-borne anti-ballistic missile (ABM) technology. The USN is also working on other countermeasures, including strikes on DF-21 launch sites at the onset of war (potentially delivered from nuclear cruise missile submarines (SSGNs), and electronic warfare. This is why it's so important to emphasize the importance of the ancillary ISR and communication system that make the DF-21D possible. The US doesn't need to destroy ever launcher, or shoot down every missile in flight. Both of those represent important capabilities, but the key task is to disrupt the system that supports the missile, making it hard for China to identify, target, and strike US carrier groups. No one knows what would happen if the Second Artillery launched a salvo of DF-21Ds at a US carrier battle group. Some percentage (depending on reliability) would invariably go astray without US help. US escorts would shoot down some percentage with ship-board systems. Electronic disruption would cause some to plunge harmlessly into the ocean. And finally, some might hit a carrier, or hit carrier escorts. A successful hit will almost certainly result in at least a "mission kill," disabling a US carrier for the remainder of the conflict.

Anti-Access System of System

It bears emphasis that Chinese carrier-killing capabilities constitute a system of systems, not dependent upon any particular weapon. The rest of China's system of systems includes nuclear and conventional submarines, medium and long range strike aircraft, surface warships, and land-based cruise missile installations. These platforms can launch a wide array of weapons, most importantly China's vast arsenal of cruise missiles. In sufficient numbers, all of these can threaten to kill a carrier. In a shooting war we could expect China to use all of these systems, or to graduate their use depending on political and military developments. Some of these are more easily countered than others, while some pose greater costs to the Chinese. For example, any surface ship launching a cruise missile at a USN carrier group can likely expect quick destruction. Similarly, both aircraft and submarines would face a high rate of attrition while making attacks on US ships and installations. ASBMs have some obvious advantages over these other systems. Operating from land bases, the DF-21D can strike carrier groups at greater range (1000+ miles) than any cruise missile. US air defense systems were designed to defend against Soviet cruise missile attacks, but a ballistic missile attack is a different prospect entirely. While the US can strike land bases, China can defend these targets more heavily through active and passive measures that it can protect relatively fragile ships and aircraft.

US Responses

The development of the DF-21D may have contributed to the USN's decision to focus on air defense ships (such as the Arleigh Burke Flight III) capable of ballistic missile interception, at the expense of such platforms at the Littoral Combat Ship and the DDG-1000. But as suggested earlier, the United States has also looked into other options, including SSGN launched cruise missiles and hypersonic strike vehicles designed to attack Chinese bases before the Second Artillery can launch

the missiles. The United States is also, presumably, working on cyber, electronic, and physical means of disrupting China's recon and communications systems.

Nevertheless, some have suggested that the DF-21D has rendered the supercarrier obsolete. While it depends on how we use the term "obsolete," it's probably too early to make that claim. China has expended vast time and resources determining how to kill US carriers, which suggests that the Chinese military takes carrier capabilities seriously. Moreover, the number of countries with both the interest and technical capability to develop the system of systems necessary to operate an ASBM is probably limited to two for the foreseeable future, with only Russia joining China. Still, efforts to diversify US capabilities surely make some sense. SSGNs, equipped with land attack cruise missiles, can pick up a great deal of the slack while remaining relatively safe from attack. Amphibious assault ships, the term the USN uses for its light carrier fleet, can ably carry out much of the "strategic influence" mission that the supercarriers currently provide.

Strategic Relevance

Just because China has ASBMs doesn't mean that it will use them, even in a shooting war. The point of the "system of systems" is not to use it, but instead to deter the US from going to war. Failing that, it is to deter the USN from aggressively using its carrier groups in combat. Sinking a carrier could kill 6000 Americans in a few minutes, the prospect of which could make the US President reconsider intervention in any dispute with China. Moreover, ASBMs and the other assorted systems would make USN admirals very leery about sailing its primary assets into danger. Aircraft carriers don't just symbolically represent national power, they ARE national power, and the loss of two or three would dramatically cut US capability to intervene anywhere in the world.

However, the DF-21D will suffer from the same problem as the variety of global strike weapons that the United States and others have considered over the years. A credible threat to kill a US carrier at range is great, but no one has any idea what will happen when the Second Artillery first lets loose with a salvo of ASBMs. Any medium range ballistic missiles (MRBM) launched could carry a nuclear warhead, targeted either at a carrier or some other target. Chinese leadership will have to count on very cool heads in Washington for the fifteen minutes between launch and impact. Much will depend on the extent of contact between Beijing and Washington during the process of escalation; if this process has involved multiple misunderstandings, then launching a missile could lead to a degree of escalation that China has not prepared for. At the extreme, launching at a US carrier represents an enormous risk, because it could start a decision-process that would bring full nuclear retaliation from the United States. That China still lacks a secure second strike capability against the US (and would struggle, in context of a conflict, to safely deploy its ballistic missile submarines) makes the situation even less stable, because the Americans might suspect the PLA of engaging in "use it or lose it" thinking. Even if the US correctly assesses the nature and purpose of the attack, the destruction of a carrier could serve to commit the United States, rather than scare it off. The United States also faces escalatory problems. Air-Sea Battle, the emerging "operational toolkit" that has dominated much discussion of US Pacific strategy, apparently envisions pre-emptive strikes against Chinese land-based missile installations. Such strikes, which make a great deal of sense from an operational perspective, represent a grave danger of strategic escalation. Again, China must recognize the intent behind US attacks, and refrain from reacting inappropriately, a problem exacerbated by China's nuclear deficit.

Conclusion

The ASBM is essentially a sea denial/anti-access weapon, not a sea-control weapon. It cannot prevent the USN from killing Chinese ships, only change the method by which the Americans do so. The use of such a weapon in anger would carry the potential for grave escalatory consequences on both sides. It's difficult to imagine what, besides Taiwan, China and the United States might be willing to tolerate such risk for. As such, it's not entirely clear how transformative the weapon really is. It certainly marks an important contribution to China's arsenal, and a harbinger of China's growing power. Its impact, however, is more incremental than revolutionary, especially in context of the steady growth of China's other anti-access options. One implication of the development of this system is the need for establishing a reliable crisis hotline between the US and Chinese governments, along with norms about how leadership will handle such communication in a crisis setting. This may prove a tall order for a pair of governments that remain committed to the public position that war is extremely unlikely.

Hypersonic missiles
Speed is the new stealth
Hypersonic weapons: Building vehicles that fly at five times the speed of sound is amazingly hard, but researchers are trying

Jun 1st 2013 | *The Economist*

ON AUGUST 20th 1998 Bill Clinton ordered American warships in the Arabian Sea to fire a volley of more than 60 Tomahawk cruise missiles at suspected terrorist training camps near the town of Khost in eastern Afghanistan. The missiles, flying north at about 880kph (550mph), took two hours to reach their target. Several people were killed, but the main target of the attack, Osama bin Laden, left the area shortly before the missiles struck. American spies located the al-Qaeda leader on two other occasions as he moved around Afghanistan in September 2000. But the United States had no weapons able to reach him fast enough. After the terrorist attacks of September 11th 2001, American officials decided that they needed to obtain a "prompt global strike" capability, able to deliver conventional explosives anywhere on Earth within an hour or two. One way to do this would be to take existing intercontinental ballistic missiles (ICBMs) and replace the nuclear warheads with standard explosives. The hitch is that ballistic missiles are usually armed with nuclear warheads. A launch could therefore be misconstrued as the start of a nuclear strike, says Arun Prakash, a former Chief of the Naval Staff, the top job in India's navy. Moreover, ICBMs carrying conventional explosives towards targets in Asia or the Middle East would at first be indistinguishable from those aimed at China or Russia, according to a paper issued by the Congressional Research Service, an American government-research body. This uncertainty might provoke a full-scale nuclear counterattack. In the years after 2001 funding for non-nuclear ballistic missiles was repeatedly cut by Congress, until military planners eventually gave up on the idea. Instead, they have now pinned their hopes on an alternative approach: superfast or "hypersonic" unmanned vehicles that can strike quickly by flying through the atmosphere, and cannot be mistaken for a nuclear missile. These hypersonic vehicles are not rockets, as ICBMs are, but work in a fundamentally different way. Rockets carry their own fuel, which includes the oxygen needed for combustion in airless space. This fuel is heavy, making rockets practical only for short, vertical flights into space. So engineers are trying to develop lightweight, "air breathing" hypersonic vehicles that can travel at rocket-like speeds while taking oxygen from the atmosphere, as a jet engine does, rather than having to carry it in the form of fuel oxidants. The term hypersonic technically refers to speeds faster than five times the speed of sound, or Mach 5, equivalent to around 6,200kph at sea level and 5,300kph at high altitudes (where the colder, thinner air means the speed of sound is lower). Being able to sustain flight in the atmosphere at such speeds would have many benefits. Hypersonic vehicles would not be subject to existing treaties on ballistic-missile arsenals, for one thing. It is easier to maneuver in air than it is in space, making it more feasible to dodge interceptors or change trajectory if a target moves. And by cutting the cost of flying into the upper reaches of the atmosphere, the technology could also help reduce the expense of military and civilian access to space.

All this, however, requires a totally different design from the turbofan and turbojet engines that power airliners and fighter jets, few of which can operate beyond speeds of about Mach 2. At higher speeds the jet engines' assemblies of spinning blades can no longer slow incoming air to the subsonic velocities needed for combustion. Faster propulsion relies instead on engines without moving parts. One type, called a ramjet, slows incoming air to subsonic speeds using a carefully shaped inlet to compress and thereby slow the airstream. Ramjets power France's new, nuclear-

tipped ASMPA missiles. Carried by Rafael and Mirage fighter jets, they are thought to be able to fly for about 500km at Mach 3, or around 3,700kph.

It's not rocket science but reaching hypersonic speeds of Mach 5 and above with an air- breathing engine means getting combustion to happen in a stream of supersonic air. Engines that do this are called supersonic-combustion ramjets, or scramjets. They also use a specially shaped inlet to slow the flow of incoming air, but it does not slow down enough to become subsonic. This leaves engineers with a big problem: injecting and igniting fuel in a supersonic airstream is like "lighting a match in a hurricane and keeping it lit," says Russell Cummings, a hypersonic propulsion expert at California Polytechnic State University. One way to do it is to use fuel injectors that protrude, at an angle, into the supersonic airstream. They generate small shock waves that mix oxygen with fuel as soon as it is injected. This mixture can be ignited using the energy of bigger shock waves entering the combustion chamber. Another approach is being developed at the Australian Defense Force Academy. In a process known as "cascade ionization", laser blasts lasting just a few nanoseconds rip electrons off passing molecules, creating pockets of hot plasma in the combustion chamber that serve as sparks. Scramjet fuel must also be kept away from the wall of the combustion chamber. Otherwise, it might "pre-ignite" before mixing properly, blowing up the vehicle, says Clinton Groth, an engineer at the University of Toronto who is currently doing research at Cambridge University in England (and who has consulted for Pratt & Whitney and Rolls-Royce, two engine-makers). To complicate matters further, scramjets move too fast for their internal temperature and air pressure to be controlled mechanically by adjusting the air intake. Instead, as scramjets accelerate, they must ascend into thinner air at a precise rate to prevent rising heat and pressure from quickening the fuel burn and blowing up the combustion chamber. In other words, igniting a scramjet is difficult, and keeping it going without exploding is harder still. Moreover scramjets, like ramjets, cannot begin flight on their own power. Because they need to be moving quickly to compress air for combustion, scramjets must first be accelerated by piggybacking on a jet plane or rocket. There are, in short, formidable obstacles to the construction of a scramjet vehicle. Even though the idea has been around since the 1950s, it was not until the 1990s that a scramjet was successfully flight-tested by Russian researchers, working in conjunction with French and American scientists—and some experts doubt that those tests achieved fully supersonic combustion. The next step forward came in July 2002, when a scramjet vehicle was successfully flown in Australia by researchers at the University of Queensland. The HyShot scramjet flew at Mach 7.6 for six seconds. But this was not controlled flight of a scramjet vehicle: instead the HyShot was launched on a rocket into space, and its engine was then ignited as it fell, nose pointing downwards, at hypersonic speed back towards the ground. More recently America's space agency, NASA, has made progress with two experimental scramjet vehicles, both of which are dropped from a carrier plane and then accelerated using a rocket booster. The unmanned, hydrogen-fuelled X-43A scramjet accelerated to a record Mach 9.68 in November 2004. This was the first fully controlled flight of a scramjet-powered vehicle, though it lasted only ten seconds. NASA is now concentrating on another test vehicle, the X-51A Waverider. In its first test, carried out in May 2010, the X-51A reached Mach 5, but not a hoped-for Mach 6, during a flight lasting roughly 200 seconds. Subsequent tests in June 2011 and August 2012 both failed. In a test flight on May 1st 2013, however, the X-51A maintained a speed of Mach 5.1 for four minutes, in the longest scramjet flight on record. In 2010 the head of America's Pacific Command, Admiral Robert Willard, said that a Chinese program to convert a

nuclear ballistic missile into an aircraft-carrier killer, by packing it with conventional explosives, had reached “initial operational capability”. The DF-21D, as it is called, is designed to descend from space at

hypersonic speed and strike ships in the Western Pacific. Even though the accuracy of the DF-21D’s guidance system is unknown, the missile is already altering the balance of power within its range, says Eric McVadon, a consultant on East Asian security and a former US Navy rear-admiral. “America is slowly losing the strategic advantage that its stealth warplanes have long provided.” Having ruled out such systems due to the “nuclear ambiguity” a launch would cause, and with powered hypersonic vehicles descended from the X-51A still years away, America has begun testing yet another approach. As part of an effort called Project Falcon, the US Air Force and DARPA, the research arm of America’s armed forces, have developed hypersonic “boost-glide” vehicles that piggyback on a modified ICBM and achieve hypersonic speeds simply by falling from a high altitude, rather than using a scramjet. The “hypersonic cruise vehicle” (pictured on previous page), is carried on an ICBM into the lower reaches of space where it separates, and, rather than following an arching ballistic trajectory, glides back to Earth at more than 20,000kph. The first vehicle, tested in April 2010, successfully separated from its ICBM, but about nine minutes later contact was lost. “They were getting good data and then the skin peeled off and it went boom,” says Brian Weeden, a former air-force captain and nuclear-missile launch officer stationed in Montana. A test in 2011 also failed. In spite of such setbacks, research into hypersonic weapons will continue. Building a vehicle capable of gliding at Mach 16 is difficult, but not impossible. America’s space shuttle used to re-enter the atmosphere at Mach 25, so fast that friction heated air molecules into a layer of plasma around the craft that radio signals could not penetrate. New “ceramic matrix composites” show great heat-shielding promise, says Sankar Sambasivan, the boss of Applied Thin Films, a company in Illinois that makes parts for military aircraft. Testing equipment is also improving. Heat and pressure sensors, and even video cameras, can be embedded in vehicles to gather data as they fly, providing “a level of detail and fidelity that we’ve never had before,” says Ken Anderson, head of hypersonic air vehicles at Australia’s Defense Science and Technology Organization. Better wind tunnels help, too. The one at Belgium’s Von Karman Institute for Fluid Dynamics can generate short blasts of air at Mach 14. This is done by cooling the test chamber, reducing the speed of sound and thereby increasing the Mach number of air forced in with a piston. Last year a DARPA statement noted that America is gradually losing the “strategic advantage” that its stealth warplanes have long provided, as other countries’ stealth and counter-stealth capabilities continue to improve. Instead, DARPA suggested, America will need “the new stealth” of hypersonic vehicles. Similarly, Russia’s deputy prime minister, Dmitry Rogozin, remarked last year that the design of hypersonic missiles had become a priority for the country. Getting anything to work at all under hypersonic conditions is extraordinarily difficult—but the effort continues even so.

TAB 3

TAB 4

AEDC

Arnold Engineering Development Complex
Arnold Air Force Base, Tenn. 37389
An Air Force Materiel Command Test Facility

Test Before Flight

www.arnold.af.mil

AEDC's economic impact $620.9 million in FY14

Arnold Engineering Development Complex's (AEDC) economic impact – which includes AEDC and its remote operating locations the Hypervelocity Tunnel 9 at White Oak in Silver Spring, Md., and the National Full-Scale Aerodynamics Complex at Moffett Field, Calif. – was $620.9 million in Fiscal Year 2014.

Each local impact: the local areas through payroll, secondary jobs, created through local spending, and other expenditures for supplies, utilities, fuel and services and the spin-off impact of those purchases.

AEDC employed a mixture of active duty military personnel from the Air Force and Navy, Department of Defense civilians; and contractor personnel, which totaled 2,310 personnel in fiscal 2014. Of the 2,310 personnel, 52 were active-duty military; two Air Force Reserve and National Guard; 251 appropriated fund civilian employees (includes general schedule, federal wage board and other military branches); 60 government non-appropriated fund employees; 30 other civilians (credit union, Base Exchange and commissary tenants); and 1,875 contractor and sub contractor employees.

Additionally, using the Tennessee Valley Authority economic impact model methodology, AEDC estimated that more than 1,640 secondary jobs were created in the local area, for a total of 3,950 jobs directly related to AEDC. Examples of secondary jobs include those created by home construction and at local supermarkets, car dealerships and department stores.

During fiscal 2014, the payroll cost for AEDC government and contractor personnel was $304.4 million. AEDC's direct expenditures – which include utility costs, service contracts with outside vendors and military health insurance paid to local doctors and hospitals – was $117 million. Furthermore, the indirect spin-off impact of these direct expenditures is approximately $198 million.

The overall economic impact figure does not include more than $102 million paid to the approximately 4,554 retired military personnel living in the local area.

Fiscal Year 2014
Work Force Impact Data

TVA Model Estimates for AEDC
As of Sept. 30, 2014

Direct Employment at AEDC	
Military	54
DoD Civilian	294
Non-appropriated Fund	60
ATA	1,875
Other	30
Base Exchange, Commissary, Ascend Federal Credit Union, tenant organizations, other contractors	
Total	2,310
Secondary Jobs Created	1,640
Total Employment Impact	3,950

In total, this retired pay group generates more than $150 million, including the spin-off effect.

The economic impact data and secondary employment estimates represent AEDC's economic impact during fiscal 2014, which runs from Oct. 1, 2013 to Sept. 30, 2014.

AEDC operates the world's largest complex of ground test facilities with a replacement value of more than $12.2 billion.

AEDC Public Affairs • 100 Kindel Drive, Suite A-242 • Arnold AFB, TN
(931) 454-4204 • DSN 340-4204
For information on AEDC visit our website at www.arnold.af.mil

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ACC Web Site: www.arnoldcommunitycouncil.com

Arnold Engineering Development Complex

Air Force Test Center

General Fact Sheet

- Established in 1951 to “make U.S. air power the best in the world and keep it the best in the world” (President Truman @ AEDC dedication)
- World’s most advanced and largest aerospace ground test complex – 28 active facilities of which 19 are unique in the U.S. and 14 are unique in the world
- National asset capable of duplicating, emulating and simulating sea level through space flight conditions to reduce the cost and risk of developing and fielding aerospace systems
- $12.2 billion facility value; $620.9 million annual economic impact
- Vital to military and economic defense of the U.S.
- Played a key role in the fielding of every U.S. weapon system flying today
- Key reducer of cost, risk and schedule for U.S. aerospace acquisition programs
- Sole provider of most aerospace ground test services for DoD
- Major provider of ground test services for industry and NASA
- Helped develop all manned NASA spacecraft
- Provides aeropropulsion test and analysis for jet engines, gas turbine engines, SCRAM jet engines
- Provides hypersonic testing for re-entry vehicles, rocket staging and ballistic impacts
- Provides altitude testing for large rocket motors
- Provides thermal vacuum testing for manned and unmanned spacecraft, subsystems and sensors
- Provides aerodynamic testing for performance characterization, weapons separation, and engine-inlet compatibility
- Provides computational modeling, instrumentation design/fabrication and facility design/ development
- High quality, high tech, highly educated, highly specialized workforce
- Bench marked as the model for outsourcing for the DoD
- Principally located in rural Tennessee with access to ample TVA power and water
- Low risk of encroachment - 40,000 acres for growth/safety
- Remote sites in White Oak, MD and Sunnyvale, CA

- Alliances with academia, industry and other government agencies
- Provider of multiple spin-off businesses (such as Micro Craft in Tullahoma, TN)
- Key component of U.S. aerospace industry's positive balance of trade

ACC Web Site: www.arnoldcommunitycouncil.com