Defense Technologies

Report Series by Defense Ventures

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Report 1:
DARPA and DARPA Developed Technologies

Overview

Although a number of agencies conduct or are involved in defense research related initiatives, the Defense Advanced Research Projects Agency (DARPA) acts as the central research and development arm of the Department of Defense (DOD). In this capacity, DARPA manages and directs selected basic and applied defense research and development projects where both risks and potential rewards are high and where future success may lead to revolutionary defense technology breakthroughs. Moreover, almost all of these defense research projects are long term efforts with those that come to fruition often not being used by the military until many years after the initial development was started.

Hence, since its formation in 1958 in response to the Soviet's launch of Sputnik, DARPA has been responsible for funding numerous technologies or underlying technologies that have significantly advanced US military capabilities. These technologies include night vision, Saturn Five Rocket surveillance satellites, guided munitions, stealth technology, unmanned aerial vehicles (UAVs), and body armor. Moreover, some DARPA developed technologies, such as the Global Positioning System (GPS) and ARPANET (the predecessor of the Internet), have moved beyond military use to impact the world as a whole.

To achieve such breakthroughs, DARPA has long operated more like an investment firm with its small, flexible, and flat organizational structure and a core team of technologically outstanding and entrepreneurial program managers. Furthermore, DARPA is independent of the defense research and development establishment - falling under the jurisdiction of the of the Director for Defense Research and Engineering.

DARPA Strategic Thrusts

Currently, DARPA is structured into five program offices handling a portfolio of research and development initiatives and strategic thrusts:

- The Defense Sciences Office (DSO) is the most scientifically diverse DARPA office with no limits on the range of scientific and engineering ideas it pursues. Key strategic thrusts include the Physical Sciences, Materials, Mathematics, Training and Human Effectiveness, Biological Warfare Defense, and Biology.

- The mission of the Information Processing Techniques Office (IPTO) is to develop and bring the most advanced information technology capabilities to the war fighter. Key strategic thrusts include Cognitive Systems, Command & Control, High Productivity Computing, Language Processing, Sensors & Processing, and Emerging Technologies.

- The Microsystems Technology Office (MTO) leads pioneering research into Integrated Microelectronics in order to revolutionize the performance and functionality of future DOD systems. Key strategic thrusts include Electronics, Photonics, Microelectromechanical Systems (MEMs), Architectures, and Algorithms.

- The Strategic Technology Office (STO) was formed in 2006 by a merger of the Special Projects Office (SPO) and Advanced Technology Office (ATO). Key strategic thrusts include Space Systems, Satellites, and Near Space Sensors; Strategic & Tactical Networks; Information Assurance; Underground Facility Detection & Characterization; Chemical, Biological and Radiological Defense; Maritime Operations; and Small Unit Operations.

- The Tactical Technology Office (TTO) develops advanced defense systems with a particular focus on the development of Aerospace Systems and Tactical Multipliers. Key strategic thrusts include Directed Energy Systems, Precision Strike, Space Operations, Unmanned Systems, and Air/Space/Land/Sea Platforms.

Selected DARPA Research Initiatives

Some active or recently active DARPA funded research projects or initiatives worth noting include the following:

- Developed by the TTO and defense contractor BBN Technologies Corp., the Boomerang is an acoustic gunshot detection system designed to be used on mobile combat vehicles such as the HMMWV. Its development grew out of a program begun in late 2003 as US troops in Iraq began to be confronted by a growing insurgency and experienced difficulty in determining where gunshots targeting Humvees were coming from until after someone was hit. In 65 days, DARPA developed a prototype that will detect a bullet's muzzle blast and supersonic shockwave and then indicate on computer a shooter's range, elevation, and azimuth. In July of 2008, BBN was awarded a US$73.8 million contract for 8,131 Boomerang systems, spare systems, and training services.

- Managed by the TTO, the High Energy Liquid Laser Area Defense System (HELLADS) program aims to develop a high-energy laser weapon system that

will be capable of shooting down tactical targets such as surface-to-air missiles. The HELLADS system is being designed so that it can be integrated onto tactical aircraft; and thus, significantly increasing engagement ranges compared to ground-based systems. Although still largely in the design and demonstration phase, defense contractor General Atomics will build the HELLADs while Lockheed-Martin will design the tracking system.

- Developed by the DSO, the Wasp micro air vehicle is a half-pound UAV with a 14-inch wingspan designed for front-line reconnaissance and surveillance over land or sea. The Wasp is capable of staying aloft for one hour at 35 miles per hour and shares a common ground control station with the Raven, Pointer, and Puma UAVs. Currently, the Wasp family of UAVs include a number of variants now used by the Air Force and Marines.

- Managed by the STO, the Very High Efficiency Solar Cell (VHESC) program seeks to develop affordable portable solar cell battery chargers with a solar cell efficiency of 50% from sunlight at standard weather conditions. Such a breakthrough will dramatically both reduce the battery logistics pipeline and reduce the amount of battery weight (nearly 20 pounds on average for a three day supply) carried by individual soldiers to power common battlefield devices. DARPA has already begun the next phase of the program by creating the DuPont-University of Delaware VHESC Consortium to transition lab work into a prototype model with the goal of production by 2010.

- Managed by the STO, the WolfPack program seeks to develop technologies to prevent enemy use of communication and radar equipment on the battlefield via ground based monitors and jammers that are linked to avoid disruption of non-enemy communication systems. Currently, DARPA and the Army are developing long-term plans for WolfPack deployment via airborne and deep launch devices. In addition, DARPA is working with the Air Force to develop an enemy air defense suppression strategy and is discussing plans with the Navy for force protection missions.

The above examples represent just a fraction of the diverse range of defense research related initiatives undertaken or being undertaken by DARPA that will not only improve the capabilities of US fighting forces but may also lead to breakthrough technologies for wider non-military uses.

Report 2:
Air Force Technology

Major Aerospace Systems & Platforms

Major aerospace systems or platforms currently under development for the Air Force include the following:

- The Pentagon's overall program to develop the Next Generation Unmanned Aerial System (NG UAS) or unmanned aerial vehicles (UAVs) promises to be a major leap forward for aerial warfare and ground support and a boon to smaller aerospace and defense contractors who have traditionally dominated this market.

  Major Air Force UAV programs or aircraft include small or micro UAVs such as the Battlefield Air Targeting Micro Air Vehicle or BATMAV (developed by defense contractor Aerovironment, Inc.) and the Desert Hawk Small Unmanned Aircraft System (developed by defense contractor Lockheed Martin); medium altitude and long endurance (MALE) UAVs such as the MQ-1 Predator and the MQ-9 Reaper (both developed by defense contractor General Atomics Aeronautical Systems); high altitude, long endurance, and conventional UAVs or HALE UAVs such as the RQ-4 Global Hawk (developed by defense contractors Northrop Grumman, Raytheon, and L3 Comm); and high altitude, long endurance, and low-observable UAV included the RQ-3 DarkStar (developed by defense contractors Lockheed Martin and Boeing. Its development was terminated; however, there are reports that it is still in development as a so-called "black project.")

- The Lockheed Martin F-35 Lightning II, a product of the Joint Strike Fighter (JSF) program, is a stealth capable multi-role strike fighter utilizing the latest in aircraft technology. The F-35 has three variants: the F-35A with conventional takeoff and landing capabilities, the F-35B with short takeoff and vertical landing capabilities, and the F-35C for carrier based operations. All three variants are derived from a common design sharing 80% of the same parts and should resolve the traditional inability to communicate with various platforms used by allies and different military services. In fact, the F-35 is expected to replace at least 13 types of aircraft for 11 nations.

  Lockheed Martin is the lead contractor with Northrop Grumman and BAE Systems involved in a supporting role. In addition, the USA is the primary

customer and financier while Australia, Canada, Denmark, Italy, the Netherlands, Norway, Turkey, and the United Kingdom have contributed US$4.4 to the US$40 billion plus in total development costs.

- In February of 2008, the Pentagon awarded a US$35 billion contract for the KC-45 next generation of refueling tankers to Northrop Grumman in partnership with the European Aeronautic Defense and Space Company (EADS). The contract for 179 refueling tankers would be the first of three deals worth up to US$100 billion to replace the Air Force's entire tanker fleet over the next 30 years.

  However, Boeing (the maker of the KC-135 Stratotanker that has been in service since 1957) protested the contract's award to Northrop Grumman's and challenged the Air Force's technical and cost evaluations, conduct of discussions, and source selection decision. Furthermore, the contract's partial award to a European firm at a time when the US economy is struggling drew additional political scrutiny. Ultimately, a review by the congressional Government Accountability Office (GAO) concluded that Boeing's proposal for the contract did not undergo a fair review and in June of 2008, the Pentagon cancelled the awarded KC-45 contract.

Advanced Air Force Technology & Defense Research Programs

Formed in 1997 by the consolidation of four research laboratories and the Air Force Office of Scientific Research, the United States Air Force Research Laboratory (AFRL) operates under the Air Force Material Command and is responsible for the development of Air Force technologies and defense equipment for use by the US military. The AFRL employs approximately 1,400 military and 4,400 civilian personnel and is responsible for the Air Force's technology and science budget of almost US$2 billion while an additional US$1.7 billion comes from AFRL customers.

The AFRL develops Air Force technologies through the following nine technology directorates scattered throughout the country:

- Headquartered at Wright-Patterson AFB (Ohio), the Air Vehicles Directorate is responsible for the development of defense technologies for military aerospace vehicles that will provide future capabilities in areas such as UAVs and space access. Core defense technology areas of focus include the aeronautical sciences, control sciences, structures, and integration.

- Headquartered at Kirtland AFB (New Mexico), the Directed Energy Directorate develops directed energy technologies for high power microwaves, lasers (including semiconductor, gas, chemical and solid-state lasers), adaptive optics, imaging, and effects. In addition, the Directorate's Starfire Optical Range conducts research in advanced tracking, adaptive optics, atmospheric physics,

and imaging of objects in space using large ground-based telescopes.

- Headquartered at Wright-Patterson AFB (Ohio), the 711th Human Performance Wing consolidates research, education, and operational consultation in the areas of aerospace medicine, science and technology, and human systems integration.

- Headquartered in Rome (New York), the Information Directorate develops aerospace command and control information technologies for use in air, space, and ground systems. This includes information fusion and exploitation, communications and networking, collaborative environments, modeling and simulation, defensive information warfare, and intelligent information systems technologies.

- Headquartered at Wright-Patterson AFB (Ohio), the Materials and Manufacturing Directorate develops new materials, processes, and manufacturing technologies for use in aerospace applications. This includes aircraft, spacecraft, missiles, rockets, and ground-based systems and their structural, electronic, and optical components.

- Headquartered at Eglin AFB (Florida), the Munitions Directorate develops defense technologies for air-launched munitions that are designed to defeat fixed, mobile, air, and space targets.

- Headquartered at Wright-Patterson AFB (Ohio), the Propulsion Directorate develops air and space vehicle propulsion and power technologies such as turbine and rocket engines, advanced propulsion systems, and associated fuels and propellants for propulsion systems. The Directorate is considered to be one of the nation's leaders in the field of power technology.

- Headquartered at Wright-Patterson AFB (Ohio), the Sensors Directorate develops technologies for radar, active and passive electro-optical targeting systems, navigation aids, automatic target recognition, sensor fusion, threat warning, and threat countermeasures. These technologies are then incorporated into air and space reconnaissance, surveillance, precision engagement, and electronic warfare systems.

- Headquartered at Kirtland AFB (New Mexico), the Space Vehicles Directorate develops defense technologies for radiation hardened electronics, space power, space structures and control, space based sensing, space environmental effects, autonomous maneuvering, and balloon and satellite flight experiments.

In addition, the AFRL manages the following defense research and development related programs based at the Wright-Patterson AFB (Ohio):

- The Air Force Independent Research & Development Program is responsible for creating dialogue between the Air Force and the private sector.

- The Air Force Science Fair Program supports education efforts in science and math and encourages students who are conducting research in areas of interest to the Air Force.

- The Air Force Small Business Innovation Research Program encourages technology research by small businesses through a three phase process:
  - Phase I: Technology feasibility is determined and contracts of up to US$100,000 lasting from six to nine months are awarded.
  - Phase II: Successful Phase I contract winners receive awards of up to US$750,000 to accomplish the primary research effort. These awards will typically last for 2 years.
  - Phase III: Private sector or federal agency funding is used to commercialize the defense technology.

- The Air Force Technology Transfer Program promotes the transfer of Air Force technology with academia, industry, and state and local governments.

- The AFRL Technology Milestones Program highlights AFRL success stories and keeps key decision makers informed about significant Air Force technology advances.

Key Agencies & Research Institutes

Other key government agencies directly or indirectly involved in the development of Air Force technology include the following:

- Formed in 1958 in response to the Soviet's launch of Sputnik, the National Aeronautics and Space Administration (NASA) is the lead federal agency for aerospace related R&D activities. NASA partners with academia, industry, and other federal, state, regional, and local entities to conduct research and develop new defense technologies into commercially viable products. These research related activities are spread across several research centers, namely the Ames Research Center, the Jet Propulsion Laboratory, the Goddard Institute for Space Studies, the Goddard Space Flight Center, the John H. Glenn Research Center at Lewis Field, and the Langley Research Center.

- Established in 1950 as an independent federal agency, the National Science Foundation (NSF) supports research and education in all the non-medical fields of engineering and science. With an annual budget of approximately US$6.06 billion, the NSF is the funding source for roughly 20% of all federally supported basic research activities conducted by America's colleges and universities. These

research and education support activities are organized into seven directorates encompassing several disciplines, specifically: Biological Sciences; Computer and Information Science and Engineering; Engineering; Geosciences; Mathematical and Physical Sciences; Social, Behavioral, and Economic Sciences; and Education and Human Resources.

- Formed in 1970, the National Oceanic & Atmospheric Administration (NOAA) is an agency under the Department of Commerce (DOC) that supports research work involving space weather, the environment, and weather satellites. In addition, the NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) operates and manages various environmental satellite programs while the http://www.oar.noaa.gov/ conducts research on various environmental and weather related phenomena and develops related technologies and observations systems.

- With is origins dating back to the 1920s, the Federal Aviation Administration (FAA) is an agency under the Department of Transportation (DOT). In addition to regulating and overseeing all aspects of civil aviation, the FAA develops and operates air traffic control and navigation systems for both civil and military aircraft and is involved in researching and developing the National Airspace System.

Key private sector research institutes involved in aerospace related R&D that are worth noting include the following:

- In early 2008, Lockheed Martin and Rice University partnered to create the Lockheed Martin Advanced Nanotechnology Center of Excellence at Rice University (LANCER) based at Rice's Richard E. Smalley Institute for Nanoscale Science and Technology - one of the largest nanotechnology facilities in the US. LANCER pairs researchers from Lockheed Martin with Rice experts in areas such as carbon nanotechnology, photonics, and plasmonics. With US$3 million in funding for three years, LANCER will fund up to half a dozen projects per year with priority given to projects that can either be brought to market quickly or will dramatically improve upon existing technologies. Applications being pursued include high-strength lightweight coatings and composites, sensitive sensors that have wider operating environments, energetics for missiles, nanocomputing technologies, and nanoelectronics.

- Formed in 1941 by Lockheed Martin, the Skunk Works has been responsible for developing some of the most well known military aircraft such as the U-2 and the F-22 Raptor. In more recent years, the Skunk Works' largest projects have included the F-35 Lightening II and various unmanned aerial vehicles (UAV) and related defense systems.

Report 3:
Missile and Space Technology

Star Wars

Today's Strategic Defense Initiative or so-called "Son of Star Wars" program is far less ambitious in scale than the impenetrable shield envisioned by the Reagan administration that would have put defensive weapons in space. Rather, today's Star Wars proponents see the program as a way to provide security against accidental launches, the actions of rogue nations, and an answer to the growing space capabilities of China.

Currently, plans calls for an early warning system of communication and detection technology acting in combination with satellites in space that will provide warnings of incoming missiles. These in turn will be destroyed by sophisticated interceptors and other missile technology based in the USA. In addition, a multinational defense system would be created that would cover as many countries who want to sign up. However, a bigger area to defend also creates a much bigger technical challenge to ensure that such a defense system will work. Hence, the missile technology developed for the system will need to incorporate new weapon technologies such as those being developed by the Army for Terminal High Altitude Area Defense (THAAD) - a project to develop a system to shoot down short and medium-range missiles using hit-to-kill kinetic energy weapons that do not have warheads.

In February of 2008, Star Wars received a boost when the Pentagon performed a US$30 million successful Star Wars-style space interception when it used a SM-3 missile (developed as part of the "Son of Star Wars" program) to destroy a faulty 5,000 pound satellite roughly the size of a school bus that was falling out of control from space. The interception was considered a success and sent a clear message that the US intends to counter any new developments in space technologies by China.

Despite this successful interception, a comprehensive US missile defense program remain controversial with some lawmakers believing that missile defense funds would be better spent on securing the nation's borders and infrastructure against another 9/11 style attack. Furthermore, with a new administration set to take office amidst an economic downturn, the future of so-called "Son of Star Wars" missile defense programs remain uncertain at this time.

Chinese Space & Defense Technologies

China's military modernization and development of new space and defense technologies has given political ammunition to US military hawks and advocates of Star Wars type defense systems. For starters, its latest defense white papers have contained lofty military modernization goals and a particular focus on high-tech information warfare. Moreover, China's development of the Jian-10 fighter-bomber jet (which is said to be superior to its Russian counterparts) has placed China at the cutting edge of military aviation.

Even more worrisome to defense planners is China's development of new space technologies. In the summer of 2006, China demonstrated its space technology to be more powerful than suspected when it used a ground-based laser to paint a US Satellite. Then on January 11, 2007, China launched the first successful test of anti-satellite technology in 20 years by using a ground-based medium-range ballistic missile to destroy an aging weather satellite. The test made China one of only 3 countries (the USA and the former Soviet Union) to prove their abilities to shoot down objects in space - thus elevating it to the top ranks of space warfare technology.

Furthermore, the latest annual report on China's military power prepared in early 2008 by the Defense Department for Congress noted that China has developed a range of weapons technology and high powered lasers that have the potential of jamming and destroying satellites. The report also noted that China will be constructing a new launch complex on Hainan Island while the People's Liberation Army (PLA) was improving its own satellite capability to the point where China is expected to replace all foreign-produced satellites with Chinese made ones by 2010.

These developments have served as a wake-up call to US defense planners as they clearly show that the PLA, the world's largest military with nearly 3 million members, is moving away from being a fighting force based on sheer size towards one based on quality with the capability to wage a high-tech, short-duration, and high-intensity conflict.

Report 4:
Army Technology

Future Combat Systems (*) & Vehicle Technology

*(*editor's note: despite the apparent demise of FCS, I chose to include its description because the technology requirements still exist, even if the program is dead.)*

Officially starting in 2003, the Future Combat Systems (FCS) program is a US$160 billion Army modernization program that promises to move the Army away from the division-centric structure of the past making it more deployable with faster response times. Co-managed by Boeing and Science Applications International Corp (SAIC) and involving more than 550 defense contractors and subcontractors throughout the USA, the FCS program focuses on defense systems and weapons technology in the following core areas:

- Individual Soldiers - Envisions the use of nanotechnology, artificial powered exoskeletons, and magnetorheological fluid ("smart fluid") based body armor to create fully networked and integrated infantry combat systems. However, initial development focus will be on defense technologies that will reduce an infantry soldier's fighting load and power requirements.

- Communications Network - Includes the creation of a completely interconnected and layered system of computers and software, radios, and sensors into a so-called Brigade Combat Team (BCT) Network. The BCT Network will include 5 layers (a Sensor/Platform Layer, Application Layer, Services Layer, Transport Layer, and a Standards Layer) that will connect various FCS platforms to every command level and integrate communications with other military branches and allies.

- Manned Ground Vehicles (MGVs) - Including the XM1204 Non-Line-of-Sight Mortar (NLOS-M), XM1203 Non-Line-of-Sight Cannon (NLOS-C), XM1202 Mounted Combat System (MCS), XM1207 and XM1208 Medical Vehicles (MVs), XM1205 Recovery and Maintenance Vehicle (FRMV), XM1201 Reconnaissance and Surveillance Vehicle (RSV), XM1206 Infantry Carrier Vehicle (ICV), and the XM1209 Command and Control Vehicle (C2V).

- Unmanned Ground Vehicles (MGVs) - Including the XM1217 Transport Multifunctional Utility/Logistics and Equipment (MULE) Vehicle (MULE-T), XM1218 Countermine MULE Vehicle (MULE-CM), XM1219 Armed Robotic Vehicle-Assualt-Light (ARV-A-L), and the AND XM1216 Small Unmanned Ground

Vehicle (SUGV).

- Unmanned Aerial Vehicles (UAV) - Including the XM156 Class I UAV and the XM157
  Class IV UAV.

- Unattended Ground Sensors - Includes the AN/GSR-9 (V) 1 AN/GSR-10 (V) 1 Unattended Ground Sensors (UGS).

- Non Line of Sight-Launch System (NLOS-LS) - Includes the XM501 Non Line of Sight - Launch System (NLOS-LS).

With initial production starting in 2013, the first fully equipped FCS brigade is set for deployment in 2015 with full production beginning in 2017 to fully equip 15 brigades by 2030.

However, to pay for increased FCS technology funding, the army has reduced funding for its Abrams, Stryker, and Bradley vehicle technology programs - leaving them with limited funds for research, development, testing, and evaluation. Then in the middle of 2008, the Army shifted the initial focus of the FCS program away from armored brigades with heavy vehicles to focus on the operational and survivability needs of infantry foot soldiers. These changes have lead to members of the Top House Armed Services Committee (HASC) to express concern that the Army is investing to much in the FCS program at the expense of manned ground vehicle technology programs without knowing the likelihood of the FCS program being able to deliver manned ground vehicle technology on schedule.

Nevertheless, there are currently 75 FCS related tests occurring while planned program Spin Outs will deliver FCS equipment and technology to the battlefield as it becomes available. In fact, FCS has already delivered new defense technologies (such battlefield sensors) into the hands of soldiers and hence, the program has largely moved from just a concept towards reality.

Battery Technology

Currently, the average American soldier carries a pack with nearly 100 pounds of gear and equipment with nearly 20 pounds of this consisting of a three-day supply of batteries needed to power their gear. Hence, much of the initial focus of the Army's Future Combat Systems (FCS) program emphasizes technologies that will reduce this fighting load and power requirements. Moreover, with a variety of sensors forming the foundation of the information network to enable fully equipped FCS brigades to function, battery and fuel cell technology advances will be vital.

For example, the FCS information network will rely heavily on two battery powered

Unattended Ground Sensors (UGS) - a tactical sensor (said to be roughly a foot in length and a few inches in diameter) and an urban sensor (said to be roughly the size of a cigarette pack) that can be carried by individual soldiers. Although current battery operating time for both sensors is classified, tactical sensors are said to have batteries that are capable of lasting for weeks while urban sensors are said to have batteries that can last for days. However, sensors are also being developed that are capable of handling multiple battery packs that can be chained together and buried - giving sensors much longer lives but not a solution towards reducing a soldiers' fighting load.

Hence, the Army's venture capital arm (OnPoint Technologies) has focused much of its budget towards investments in companies that are developing new and longer lasting power sources. These include investment in A123 Systems (the developers of advanced Lithium-Ion based cells for rechargeable battery packs), Atraverda (the developers of advanced bi-polar battery electrodes for rechargeable batteries), IFCT (the developers of next generation fuel cell systems for portable devices), PowerGenix (the developers of next-generation rechargeable batteries), Power Precise (the specializing in battery management devices), Ultra Cell (the developers of integrated fuel cell systems), Zinc Matrix Power (the developers of high-performance rechargeable alkaline battery technology for commercial and military markets), Akermin (the developers of portable fuel cells based on its proprietary "Stabilized Enzyme Biofuel Cell" SEBC™ technology); and Superprotonic (the developers of solid acid fuel cell or "SAFC" technology).

In addition, the Very High Efficiency Solar Cell (VHESC) program of the Defense Advanced Research Projects Agency (DARPA) seeks to develop affordable portable solar cell battery chargers with a solar cell efficiency of 50% from sunlight at standard weather conditions. DARPA has already begun the next phase of the program by creating the DuPont-University of Delaware VHESC Consortium to transition lab work into a prototype model with the goal of production by 2010.

Such investments by OnPoint and DARPA will not only produce new power technologies to address the battlefield needs of individual foot soldiers, but will likely produce new products that will also meet the needs of commercial markets (and more than pay for the cost of development). Hence, there is a good possibility that at some point in the future, the next big breakthrough in alternative energy will come as a result of dual-use technologies initially invested in and developed for the Army - a win-win scenario for both the military and the private sector.

Report 5:
Navy Technology

Advances in Ship Technology

Previously known as the DD(X) program, the Zumwalt-class destroyer was designed to be the cornerstone for future surface combat ships using the latest in advanced navy technology. With a low radar profile and a wave-piercing "tumblehome" hull with sides sloping inward from the waterline, the Zumwalt-class was designed to reduce the radar cross-section and to utilize less energy than traditionally designed naval ships. Furthermore, the Zumwalt-class will be packed with advanced navy technologies and have a Total Ship Computing Environment Infrastructure (TSCEI) and hence, require a much smaller crew complement of 142 and be less expensive to operate than traditional destroyers.

However, the Zumwalt-class program has been plagued by controversies over cost and design. Originally pegged by the Navy at a cost of US$3.3 billion each with subsequent ships costing US$2.2 billion each, the Congressional Budget Office later predicted that the first two ships would cost US$5 billion apiece with subsequent ships costing US$3.6 billion each. Furthermore, several design issues have been raised, namely:

- The stability of tumblehome designs in rough seas has been questioned.
- Although the Zumwalt-class has improved air defenses, a top navy official testified before lawmakers on July 31, 2008 and stated that the Zumwalt-class "cannot successfully employ the Standard Missile-2, SM-3 or SM-6 missile" - the Navy's primary air defense weapons and the latest in missile technology.
- The long range fire support capability of the Zumwalt-class has also been called into question given that most of the shells carried have a smaller war head and a shorter range.
- The Zumwalt-class is designed with a substantially large deckhouse containing all major sensors and detection technologies; however, there are reports that defense contractor Northrop Grumman has had problems in guaranteeing the seals between its construction panels.

Hence, the original plan to build 32 ships for the class has since been cut down to 2 (with one of the ships to be built by General Dynamics and the other by Northrop Grumman while Raytheon will supply the ships' combat systems). However in September of 2008, the Defense Department signaled that it will be changing its position on building the class - including whether or not to even build the first two

ships.

Long Range Engagement

As part of the Navy's Innovative Naval Prototype (INP) program to develop big-ticket, high-risk, and high-payoff items with low technology-readiness levels (TRLs), the Electromagnetic Railgun (EMRG) will launch projectiles using electricity rather than chemical propellants. This will enable the gun to fire projectiles in all-weather conditions at ranges in excess of 200 nautical miles (230 miles) - more than 20 times the current range of the MK 45 5-inch Naval gun. Since the EMRG requires no propellant or warhead (damage is caused by thousands of fragments traveling at lethal velocities), storage requirements are reduced and magazine capacity is increased ten-fold. This, combined with the much greater stand-off distance gained from the EMRG's increased range, will greatly improve ship board safety.

Furthermore, the EMRG will greatly increase the combat capabilities of the Navy and the Marines as its GPS-guided projectiles will be accurate to within 5 meters of the target. Thus, the chances of collateral damage will be reduced. In addition, the EMRG has the capability to mass persistent volume fire into a specific land engagement while its high trajectory angle will enable it to hit targets on reverse slopes.

In January of 2008, the Navy tested its first EMRG; however, it is estimated that it will take another 15 years (by 2020-2025) before a viable EMRG weapon technology is ready for naval deployment. Currently, BAE Systems and General Atomics are under contract with the Office of Naval Research (ONR) to develop EMRG weapon technologies through to technology maturation. Other partners involved in EMRG development include Boeing, Charles Stark Draper Lab, Inc., Department of Energy (Lawrence Livermore National Laboratory), US Naval Academy, Naval Postgraduate School, Naval Sea Systems Command (PMS 500), NAWC Rhode Island, NSWC Carderock, and the NSWC Dahlgren.

Report 6:
Other Military Technology

Simulation Technology

Developed by Alameda California based Total Immersion Software and funded by the Defense Advanced Research Projects Agency (DARPA), the RealWorld program is a set of simulation technology tools that allows anyone with a laptop computer to quickly create mission-specific simulations in computerized 3-D worlds. Consisting of air, ground, and maritime combat components, the RealWorld program allows not-so-technically adept users to recreate an actual battlefield event that accurately represents the terrain, buildings (both inside and outside), and vehicles confronted in the field or to easily create a new battlefield scenario from government collected data.

One such example of the capabilities of this new simulator technology is the RealWorld Air Combat Environment or RealWorld ACE simulator which uses data from a wide variety of government databases (such as elevation data, aeronautical charts, and imagery from the National Geospatial Intelligence Agency) to create accurate training scenarios that can incorporate everything from signal recognition training to in-flight "rangeless" electronic warfare training. Moreover, in the same manner that commercial games allow multiple players to play the same game scenario at the same time, the RealWorld ACE simulator allows up to 10 students at a time to fly in the same battle space as if they were in combat reacting and responding to battlefield threats.

In addition to the above training benefits delivered by the RealWorld program, defense contractor Total Immersion who is developing RealWorld for a token sum. In turn, Total Immersion will not only have its R&D paid for, it will also be able to keep the building tools it is creating for RealWorld that will in turn be used to create commercially viable tools and platforms. Moreover, as a government funded and owned simulation, RealWorld programs can be used at any military base where they can be of use without paying licensing fees associated with commercial off the shelf products. Hence, RealWorld's development is a win-win scenario for both the military and its private sector defense contractor and should serve as a model for future defense and private sector collaboration and cooperation.

Global Information Grid (GIG)

Envisioned in late 1999 and officially mandated by the Deputy Secretary of Defense on September 19, 2002, the Global Information Grid (GIG) will integrate nearly all of the Department of Defense's (DOD) information systems, services, and applications into one seamless and secure internet-like communications network. Designed to be less dependent on fixed or ground-based systems and equipment, the GIG will instead rely on space-based and mobile systems to transmit and route data. It will also form the primary technical framework for network-centric warfare operations - linking all advanced weapons platforms, sensor systems, and command and control centers. Thus, the GIG will create an environment where users can access data on demand from any location with such data coming from any number of sources - ranging from weapons systems belonging to other military services to space based satellites.

To build a core GIG capability, the DOD plans to spend at least US$21 billion through 2010; however, its creation faces several management, operational, and technical hurdles as outlined in a 2004 GAO report. These include:

- Management and investment challenges include deciding what capabilities to fund and enforcing such decisions across thousands of systems and the various military services.

- Operational challenges include deciding when, what, and how much information to include on the network as well as convincing data owners to share data and trust the network enough to post their data.

- Technical Challenges include developing new technologies on schedule, assuring common technical and information specifications, and developing the means to protect the system and its data.

Furthermore, implementing the full GIG vision will require the development of new information sharing technology applications and capabilities. Hence, as development of the GIG moves forward, increased collaboration with industry will be key to achieving and successfully implementing the full GIG vision.

Report 7:
Unmanned Aerial Vehicles (UAVs)

Unmanned aerial vehicles (UAVs), also known as unmanned aircraft systems (UAVs), are unpiloted aircraft that can be flown via remote control or on pre-programmed flight plans. Although UAVs have existed since World War I, interest in them only began to take off in the 1980s and 1990s with the development and miniaturization of appropriate technologies such as smaller computers and Global Positioning System (GPS) devices.

Today, UAVs are now regularly deployed to perform a variety of critical battlefield functions, including:

- Reconnaissance and remote sensing using electromagnetic spectrum, biological, and or chemical sensors.
- Transportation of payloads - either internally or externally.
- Precision air strikes of ground targets - especially those located in sensitive areas.
- Search and rescue type operations.

Thus, each armed service sees a potential battlefield use for UAVs; however, their development has also led to bitter battles between the various armed services (most notably between the Army and the Air Force) as each service feels threatened if another service were to be in complete control of them. In principal, the Army has recognized that the Air Force has both the responsibility and a requirement for strategic level UAVs while the Air Force has recognized that the Army has a need for more tactical level UAVs. Furthermore, it is generally recognized that there is a need for common ground stations, common training standards, and common hand-off procedures and thus, the two services are looking at ways to merge and accelerate their respective UAV programs.

UAV Programs or Aircraft

A number of UAVs with different characteristics and intended uses have already been developed and produced for or are under development for each of the armed services. Examples of Air Force UAV programs or aircraft by intended usage include the following:

- Small or micro UAVs include the Battlefield Air Targeting Micro Air Vehicle or BATMAV developed by defense contractor AeroVironment, Inc. and the Desert

Hawk Small Unmanned Aircraft System developed by defense contractor Lockheed Martin.

- Medium altitude and long endurance (MALE) UAVs include the MQ-1 Predator and the MQ-9 Reaper both developed by defense contractor General Atomics Aeronautical Systems (GA-ASI).
- High altitude, long endurance, and conventional UAVs or HALE UAVs include the RQ-4 Global Hawk developed by defense contractors Northrop Grumman, Raytheon, and L3 Comm.
- High altitude, long endurance, and low-observable UAV included the RQ-3 DarkStar developed by defense contractors Lockheed Martin and Boeing. Its development was terminated (however, there are reports that it is still in development as a so-called "black project.")

Examples of Marine Corps UAV programs or aircraft by intended usage include the following:

- Small or micro UAVs include the Wasp III developed by defense contractor AeroVironment, Inc. and the Defense Advanced Research Projects Agency (DARPA).
- Low altitude and long endurance UAVs include the Dragon Eye and the Raven B developed by defense contractor AeroVironment, Inc.
- Medium altitude and long endurance (MALE) UAVs include the ScanEagle developed by defense contractors Boeing and Insitu.
- Medium ranged tactical UAVs included the Pioneer UAV originally developed by Israel Aircraft Industries (IAI) more than two decades ago. In July of 2007, the Marine Corps announced that it will retire its aging Pioneer fleet and transition to the Shadow Tactical Unmanned Aircraft System developed by defense contractor AAI Corporation.

Examples of Army UAV programs or aircraft by intended usage include the following:

- Low altitude and long endurance UAVs include the Raven B developed by defense contractor AeroVironment, Inc.
- Short Range Tactical UAVs include the RQ-7A/B Shadow 200 developed by defense contractor AAI Corporation.
- Medium range tactical UAVs include the Hunter RQ-5A / MQ-5A/B originally developed by defense contractor TRW (now Northrop Grumman) and Israeli Aircraft Industries (IAI) and the IGNAT-ER Long Endurance Unmanned Vehicle developed by defense contractor General Atomics Aeronautical Systems Inc. (GA-ASI). However, the Army is currently transitioning to the MQ-1C Warrior (an upgraded version of the MQ-1 Predator) developed by GA-ASI and funded by the Army.

Examples of Navy UAV programs or aircraft by intended usage include the following:

- The Fire Scout Vertical Takeoff UAV developed by defense contractor Northrop Grumman are designed to take off and land vertically from any aviation-capable warship.
- High altitude UAVs include the RQ-4A Global Hawk Maritime Demonstration system developed by Northrop Grumman.

Major UAV Defense Contractors

Defense contractors involved in the development of UAVs or technology for UAVs include the traditional defense and aerospace heavyweights such as Boeing, Lockheed Martin, Northrop Grumman, Raytheon, and Honeywell. However, defense contractor heavyweights have traditionally seen UAVs to have low profit margins compared as they tend to be ordered in small batches and are relatively inexpensive when compared with manned aircraft. Thus, the development of UAVs has also been a boon for smaller or lesser known aerospace and defense contractors who have largely taken the lead in their development and production. Hence, the industry remains largely fragmented (much like the early days of the aircraft or auto industries) with at least 50 US companies, government agencies, or academic institutions (plus additional developers overseas) who have developed UAV designs or prototypes or have UAVs ready for production or are already in production.

The following defense contractors are worth noting as they have established UAV platforms and systems:

- Established in 1953 five years after the creation of Israel, the Israeli Aircraft Industries (IAI) is a global aerospace and defense contractor and a leading developer of UAV technology and systems with 34 UAV customers on four continents. Major UAV systems developed by IAI include the Heron, I-View, Naval Rotary Unmanned Air Vehicle (NRUAV), Searcher Mk.II, Bird Eye 400, Bird Eye 600, Mosquito, Ranger, Hunter, Scout, and the Pioneer. In addition, IAI develops airborne and ground data terminals for UAV communications.

- Founded in 1950 and currently an operating unit of Textron Systems Corporation, AAI Corporation is a global developer of aerospace and defense technologies including tactical UAV systems, training and simulation systems, automated aircraft test and maintenance equipment, armament systems, aviation ground support equipment, and logistical, engineering, and supply chain management services. AAI is the creator of the Shadow Tactical Unmanned Aircraft Systems (TUAS) and is a subcontractor on Honeywell's Micro Air Vehicle program. In addition, AAI has developed several common ground control systems including the Army's One System Ground Control Station, the One

System Portable Ground Control Station, and the One System Remote Video Terminal.

- Founded in 1971, AeroVironment, Inc. is a vehicle systems pioneer having developed more than 30 groundbreaking vehicle systems such as the Solar Challenger, the Sunraycer, and the General Motors Impact. Since 1986, AeroVironment has developed UAV systems including the Pointer (the first micro UAV for military use), Raven, Dragon Eye, Puma AE, Wasp, and so-called Stratospheric Persistent UASs (extreme-endurance stratospheric aircraft). In addition, AeroVironment has also developed a common compact and portable ground control systems for its series of UAVs.

- An affiliate of General Atomics, General Atomics Aeronautical Systems (GA-ASI) is the developer of the groundbreaking Predator - a UAV series that has logged over 435,000 flight hours with over 80% of them in combat. GA-ASI is also the developer of the I-GNAT, I-GNAT ER/Sky Warrior Alpha, Sky Warrior, and the Predator B UAVs. In addition, the defense contractor has developed a series of ground control stations and sensor systems and provides field operations support for UAVs.

- Founded in 1994 to develop micro robotic aircraft for offshore weather reconnaissance, Insitu specializes in the design, development, and manufacturing of UAV systems. Insitu is the developer of the ScanEagle (developed in partnership with Boeing), Insight, GeoRanger, and Integrator UAV platforms.

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