AIR FORCE RESEARCH LABORATORY

The only Air Force organization wholly dedicated to leading the discovery, development, and integration of warfighting technologies for the nation’s air, space, and cyberspace forces.

2017 DOD LAB DAY

Our commitment to innovation gives us the drive to constantly push the envelope and deliver the technology that keeps us prepared for the future. We invite you to explore some of the exciting developments that will pave the way for a stronger tomorrow.
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Advancing Biosensor and Material Development Using Synthetic Biology Approaches</td>
</tr>
<tr>
<td>6</td>
<td>24/7 Combat Fitness System Technology</td>
</tr>
<tr>
<td>8</td>
<td>Military Applications of Gene Editing Technology</td>
</tr>
<tr>
<td>10</td>
<td>Machine Learning on a Neuromorphic Computer with Truenorth Processors</td>
</tr>
<tr>
<td>12</td>
<td>WARTAK for Tactical Communications</td>
</tr>
<tr>
<td>14</td>
<td>Spartan</td>
</tr>
<tr>
<td>16</td>
<td>The Ninja Counter — sUAS System</td>
</tr>
<tr>
<td>18</td>
<td>Precision Navigation and Timing</td>
</tr>
<tr>
<td>20</td>
<td>Navigation Technology Satellite-3 (NTS-3)</td>
</tr>
<tr>
<td>22</td>
<td>Low Cost Attribute Aircraft Technology (LCAAT)</td>
</tr>
<tr>
<td>24</td>
<td>Advance Ordnance Technologies</td>
</tr>
<tr>
<td>26</td>
<td>Hypersonic International Flight Research Experimentation (HIFiRE)</td>
</tr>
<tr>
<td>28</td>
<td>Liquid Metal Antennas</td>
</tr>
<tr>
<td>30</td>
<td>Add New Link 16 to MQ-95 with Conformal Antennas</td>
</tr>
<tr>
<td>32</td>
<td>Self-Protect High Energy Laser Demonstrator (SHIELD)</td>
</tr>
<tr>
<td>34</td>
<td>Remote Access Non-Destructive Evaluation (RANDE)</td>
</tr>
</tbody>
</table>
THE CHALLENGE

Often times warfighters, civilians, and the infrastructure in which they depend are exposed to dangers. Relying on human detection of potential dangers, such as explosives and toxins is not always effectively monitored for threat mitigation. We have focused our efforts on enhancing stand-off detection by advancing biosensor development using synthetic biology, in order to protect humans and the environments that they inhabit.

THE SOLUTION

Nature offers an extraordinary template of specificity, controlled response, and exceptional signal amplification to detect and track items of interest. Molecular switches are a good example of how nature can bind molecules with specificity and then produce a signal output.

Synthetic biology’s mission is to hone this ability by designing and constructing a specific biological system for a targeted purpose. In this case, we are utilizing synthetic biology as a tool to develop sensors that will detect chemicals, such as explosives (stand-off detection) and/or biomarkers. Engineering natural systems as novel sensors is an important technical capability for protecting the United States Air Force.
ADVANCING BIOSENSOR AND MATERIAL DEVELOPMENT USING SYNTHETIC BIOLOGY APPROACHES

HOW IT WORKS
We train bacteria to detect explosives, or biomarkers, by exploiting the cell’s ability to sense small molecules in complex backgrounds, amplify reporting signals, and self-replicate. This allows the bacteria to develop cell-based sensors for detection of chemical and biological targets. An example reaction would be a fluorescent glow (from a protein) which can then be analyzed with an electronic readout, a protein readout, and the specific reaction that occurred.

WHY IT MATTERS
Identifying suspicious and harmful materials/chemicals is a challenge to the naked eye. Currently, we rely on the human assessment and electronic sensors. But biosensors can be trained to detect multiple materials/chemicals at the same time. This will not only reduce detection time and cost to the Air Force but will also help protect our warfighters and civilians exposed to harmful materials.

IMPACT FOR THE FUTURE
Detection is the first step to the bio-sensors ability but offering a mitigating response is the natural future direction of this technology. We are looking to continually improve the biological sensors so they may work in complex environments. Additionally, we are exploring the opportunity to detect stress hormones in humans and then activate a pathway to make an anti-stress molecule, like serotonin. Yet another vision for our future and further protecting our warfighters.
THE CHALLENGE

High performing athletes and special operations personnel expose themselves to extreme conditions as part of their grueling training. These physical demands increase the risk of injury and impede the ability to perform at peak conditions. The 24/7 Combat Fitness System Technology provides athletes, special operations personnel, trainers, and commanding officers with the information they need in order to keep performance optimal and determine proper recovery times.

THE SOLUTION

Using proprietary technologies and off-the-shelf wearable sensors, The 24/7 Combat Fitness System Technology has been developed to assess recovery needs, recovery status, and paths to peak performance of high performing athletes and special operations personnel.
HOW IT WORKS
Multiple sensors (hydration sensors, heart monitors, etc.) are worn during training to monitor athletes and special operations personnel. The system uses algorithms developed by AFRL to provide individualized assessments of recovery needs and recovery status. The data collected is available in real-time, so peak performance can be monitored as the individual trains.

WHY IT MATTERS
Keeping special operations personnel mission-ready is an important advantage. And understanding how to maintain peak performance with recovery needs reduces downtime, saves money, enhances readiness, and can help prevent serious injuries.

IMPACT FOR THE FUTURE
As the 24/7 Combat Fitness System Technology advances, standards, and baseline measurements will be in place. These standards can drive the development of sensors that can be worn during training and missions so personnel’s physical conditions can be monitored in real time.
**THE CHALLENGE**

Being exposed to harmful chemical, biological or environmental agents is a hazard many warfighters face. Exposure to these agents can cause genetic and epigenetic alterations that have both short-term and significant long-term effects. How can we remove a virus or disease caused by these harmful exposures?

**THE SOLUTION**

Military Applications of Gene Editing Technology is a unique technology that enables geneticists and medical researchers to edit parts of the genome by removing, adding or altering sections of the DNA sequence with exquisite precision. In other words, this technology addresses what went wrong on the human cell level and is able to revert it to a normal state.
MILITARY APPLICATIONS OF GENE EDITING TECHNOLOGY

HOW IT WORKS

This technology harnesses a bacterial defense mechanism to ablate deleterious sequences (like pathogens) or restore gene function site specifically. Once an individual is diagnosed as having been impacted by a harmful exposure a review of the individual’s genome and epigenome occurs. Next, the editing process is initiated by introducing “guide RNA” that directs a nuclease to the intended target in the genome which allows repair at the intended target to occur using host repair functions and the corrective template. This individualized treatment targets the harmful genetic information and replaces it with appropriate, “good” information. Or, in some cases, the editing can be performed on stem cells to allow an influx of good cells to overcome the impaired cells.

WHY IT MATTERS

Before the arrival of technology to edit and correct the genetic change leading to an adverse effect it was only possible to at best treat the symptoms and decrease their severity. Site specific gene editing allows fixing the cause with individualized precision.

IMPACT FOR THE FUTURE

While still in the early stages of testing, this technology allows one to imagine a future where we do not have to live with the burden of inherited diseases and can reverse the harm from exposure to diverse agents (chemical, biological and environmental) that is an inevitable part of the life of a warfighter. Human cell-based models will continue to be tested to ensure accuracy in treating targeted, affected areas as we continue to make this vision a reality.
THE CHALLENGE

Losing network connection, human control, or access to a ground station in contested areas can lead to mission failure. A warfighter’s potential inability to identify targets on synthetic aperture radar (SAR) images is a major disadvantage. This opens a need for a technology that can detect targets and operate without external dependencies.

THE SOLUTION

AFRL has combined machine learning, Neuromorphic Computing technologies, and the IBM TrueNorth processor in order to meet and reduce the dependency on external factors (networks, ground stations, etc.). The result of combining these technologies is a deep neural network (DNN) application that achieves over 90% accuracy and is 20 times more energy efficient.
MACHINE LEARNING ON A NEUROMORPHIC COMPUTER
WITH TRUENORTH PROCESSORS

HOW IT WORKS

Machine Learning is a type of artificial intelligence that is able to learn from data and then execute cognitive functions without being explicitly programmed. Using a neuromorphic computer inspired by the working mechanisms of the human brain with sixteen IBM TrueNorth Processors, the machine is able to process EO/IR/RF images and videos while detecting targets that can then be classified.

WHY IT MATTERS

This technology will provide warfighters with new capabilities — enhanced big data analytics, faster target/event recognition, and improved situational awareness. The goal is for more prompt and robust decision making. Applied to unmanned aerial systems (UASs) in contested areas, this tool offers up to a hundred times better energy efficiencies that enable size-weight-and-power (SWaP), intelligent at-the-edge processing, analytics, and decisions, as well as autonomous intelligence, surveillance, and reconnaissance capabilities when human-out-of-the-loop situations occur.

IMPACT FOR THE FUTURE

As this technology advances, we will be able to implement smaller computers into aircraft without losing data processing capabilities. Future applications include attaching these computers to multiple platforms to further enhance capabilities when a network connection is lost or access to a ground station in contested areas is limited.
THE CHALLENGE

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HOW IT WORKS

WaRTAK starts with the ATAK (Android Tactical Assault Kit) application that the Air Force Research Lab (AFRL) developed for Special Operations Forces. Based on a shared moving map, ATAK allows everyone to see where every node exist every second, while offering a suite of tools and overlays for augmenting situational awareness. The ATAK app is a powerful, precise, and intuitive human-machine interface based on Android phones and tablets. Next, an advanced, high-bandwidth, mobile ad-hoc network (MANET) built using radios from Persistent Systems is established as the line of sight network infrastructure. Finally, beyond line of sight communication is established via supplemental Internet-over-cellular/SATCOM connections. Every moving or tower-mounted WaRTAK node expands the network to other nodes creating a vast, secure, private network that exposes the common situational awareness picture to WaRTAK nodes in buildings, trucks, air vehicles, and dismounted troops anywhere, worldwide.

WHY IT MATTERS

WaRTAK is a robust tool that is rewriting the thought process for the military’s approach to communications. WaRTAK effectively, efficiently, and at relatively low cost, allows users to track friendlies and easily share points of interest (or enemies) in the battlespace. Information is instantly relayed to all equally, forming a Common Operating Picture to ensure synchronous operations.

IMPACT FOR THE FUTURE

Today’s missions are rarely static operations. Future missions will require ever-faster, more accurate, and synchronized coordination and situational awareness. WaRTAK enables the highest commanders down to individual warfighters to share Unity of Command, coordinate Surprise, improve Maneuver, keep information Secure, and enable Surprise, using common standards. WaRTAK is the enabler of future warfare.
THE CHALLENGE

As small unmanned autonomous systems (sUAS) technologies become more sophisticated, so do their military application. The challenge is the unbalanced ratio of machine to human used to operate sUAS for intelligence, surveillance, and reconnaissance mission support. Further, it becomes more difficult for one operator to manage plans for multiple sUAS. Other challenges are introduced when the sUAS loses GPS signals used for navigation. How do we create an intelligent and autonomous system of sUAS, capable of decentralized decision making?

THE SOLUTION

Spartan is implementing technologies into small quadcopters (450-1000mm) that allow for decentralized decision making by the agents (quadcopters). This technology currently allows for four to five agents to negotiate between themselves to cover paths determined by an operator while minimizing latency.
HOW IT WORKS

The agents will provide a plan to be approved by the operator. The operator remains out of the loop with the exception of adding or removing new task and adjusting the plan as needed. The agents are free to handle the paths and react to environmental effects such as wind, pop-up threats, no fly areas, etc - dynamically planning and replanning along the way. Essentially the drones are negotiating on who should complete the task between themselves.

WHY IT MATTERS

We are in situations where we can leverage the power of autonomy. Spartan arms us with the ability to move away from the traditional person to aircraft ratio which previously required three people to one quadcopter. When one person is trying to control multiple agents it can get overwhelming. Having agents do this themselves will be helpful in reducing turnaround time in decision making to complete missions.

IMPACT FOR THE FUTURE

The next phase for Spartan is scaling up the demonstration and developing a framework around the program. The technology has been tested on multiple types of drones and the system can currently manage around four to five but the ultimate goal is to be able to work with up to thirty agents. The end result of these efforts will be a decentralized sUAS system capable of carrying out intelligence, reconnaissance, and surveillance missions.
THE CHALLENGE

Non-state actors threaten personnel, equipment, and facilities around the world using commercial unmanned aircraft systems (UAS). These weaponized drones are modified to carry improvised explosives and data collecting technologies that seriously endanger our security. How do we prepare our warfighters to deal with this threat and how can we determine whether sUAS in the vicinity of DoD operations are friend or a foe?

THE SOLUTION

The NINJA Counter—sUAS System is rapidly developing solutions to identify drones, determine the source, and offer a counter measure when necessary. The system combines off-the-shelf technology with Air Force developed technology to create a solution that can actively keep up with the ever changing commercial drone market.
HOW IT WORKS
Using a combination of hardware, software, and advanced algorithms, the NINJA counter UAS system can detect drones in DoD established restricted operating zones. Once detected, a signature is created and the system will determine if the drone is friendly or foe. If the drone is identified as an enemy, measures are taken to mitigate the threat. These can be electrical disruptions or mechanical disruptions depending on the specific situation.

WHY IT MATTERS
The pace of commercial development is extremely rapid and as technology advances, the threat to our military evolves as well. The NINJA solution has been developed to match this pace and keep warfighters safe.

IMPACT FOR THE FUTURE
This concept has been tested, showcased at official government events, and can be deployed quickly and utilized in the near future. Currently a framework is in place and use cases already exist. The NINJA system will be able to collect data on drones flying near restricted airspace, and can be used as patrol around facilities, as well as play a critical role in defending all of our military personnel.
THE CHALLENGE

GPS is a revolutionary technology that delivers precision positioning and timing to a vast array of military and civil users. The benefits of GPS are so great that many systems are designed to rely on it as the sole source of positioning, navigation, and timing (PNT). Our dependence on GPS has become a weakness that can be exploited by adversaries through jamming and spoofing attacks. What solutions exist to provide trusted and assured PNT when we need it most?

THE SOLUTION

AFRL has developed an open architecture for PNT systems that allow for affordable, rapid reconfiguration when operating in GPS-denied environments. Termed Alternative Navigation, or Alt-Nav, the system can be used to complement or backup the GPS. Unlike GPS, Alt-Nav does not have a one-size fits all solution and must be adapted to the environment, the mission, and the platform. Alt-Nav fuses information from multiple sensors (inertial, air data, camera, lidar, magnetic, signal of opportunity, synthetic aperture radar) to overcome GPS’s vulnerabilities.
HOW IT WORKS
The display consists of a small sensor pod plug and play navigation system containing an inertial measurement unit, camera, magnetometer, and GNSS (Global Navigation Satellite System) receiver. Sensor measurements are processed in real-time by an adaptable estimator that calculates an Alt-Nav PNT solution. Results from both the real-time adaptable estimator and data playback of previous flight test will be presented.

WHY IT MATTERS
Alt-Nav will protect warfighters, aircraft, and weapons from situations or areas where GPS may not be available rendering them ineffective. An open architecture for PNT is the only cost effective way to implement Alt-Nav sensor packages and algorithms that must be customized to the mission.

IMPACT FOR THE FUTURE
The next step is to integrate an open PNT architecture into the next generation of traditional GPS/inertial aircraft navigation units. This will allow for Alt-Nav sensors to compliment or backup GPS-based PNT information provided to aircraft systems. These efforts, among others, will reduce warfighter vulnerability and mitigate the risk of depending on GPS as the sole source of navigation.
THE CHALLENGE

Many United States weapons systems and personnel, along with the Nation’s critical infrastructure, rely heavily on Satellite Navigation (SatNav) for Positioning, Navigation and Timing (PNT) services. Today’s Global Positioning System (GPS) provides continuous, highly accurate PNT services to commercial, civilian and military users. However, the increasingly contested space domain, and congested radio frequency (RF) domain requires advancement in PNT capabilities to assure continued reliable, robust, and resilient access for users. How does the Air Force guarantee resiliency and prevent spoofing and interference?

THE SOLUTION

The Navigation Technology Satellite-3 program (NTS-3), managed by the Air Force Research Laboratory Space Vehicles Directorate, will experiment with advanced techniques and technologies to detect and mitigate interference to PNT signals from space, thus increasing SatNav system resiliency for commercial, civilian, and military users.
HOW IT WORKS
SatNav has three main segments: spacecraft, ground control system, and user equipment. NTS-3 will integrate multiple advanced technologies, explore new concepts of operations, and experiment with novel techniques, tactics, and procedures. Advanced technologies that will be demonstrated on NTS-3 include atomic clocks, antennas, amplifiers, reprogrammable digital waveform generators, new signals, automation, use of commercial assets, cybersecurity, and software defined user equipment.

WHY IT MATTERS
GPS was designed for a world when space was uncontested and uncongested. The NTS-3 efforts will provide warfighters with a more resilient PNT capability. These advancements seek to mitigate interference, improve accuracy and integrity, and enable the overall SatNav system to become agile and flexible to meet the needs of the warfighter.

IMPACT FOR THE FUTURE
As the NTS-3 technology matures through space experimentation and prototyping, the knowledge gained from NTS-3 is expected to transition to future generations of GPS. Ultimately, these efforts will offer a more resilient form of PNT.
THE CHALLENGE

“In the year 2054, the entire defense budget will purchase just one aircraft.” - Norman Augustine. Today the class of Unmanned Aircraft Systems (UAS) is built on a commercial model centered on longevity, safety, and reliability. But as Air Force aircraft cost continues to rise their requirements for engagement also increases. Taking an approach that reduces cost, and balances the design and quality requirements will enable quicker and lower cost production.

THE SOLUTION

In order to mend the two, we must focus on designing an aircraft to augment manned systems as force multipliers and make them more capable as a system of systems. This forces a cost imposition strategy on near-peer adversaries. The Low-Cost Attritable Aircraft Technology (LCAAT) Program looks to introduce an Unmanned Aerial Vehicle system that will support the warfighter, have lower cost, and meet the capability needs for support in contested areas.
LOW COST ATTRITABLE AIRCRAFT TECHNOLOGY PROGRAM (LCAAT)

HOW IT WORKS

LCAAT Program is exploring a wide range of technology innovations that will enable a new genre of low-cost Unmanned Aerial Vehicles (UAVs) with long range capability, in environments where forward basing is difficult or prohibited. Due to their low cost, different classes of UAVs will augment manned weapon systems and have highly optimized roles for specific mission activities including: weapons delivery, finding and locating targets, or communications.

WHY IT MATTERS

These UAVs can be manufactured at a high-rate reducing touch labor and ultimately reducing cost. Since it is being designed for a narrow requirement suite, production can move quicker and addresses the necessary operations stage. Knowing these UAVs are not built for longevity and at a much lower cost, the acceptance criteria should become more relaxed which results in a quicker production to air timeline, and permit quicker technology refresh as requirements change with time.

IMPACT FOR THE FUTURE

Establishing a defined design criteria that will address the ideal cost to quality ratio is the next step. The lower production cost will reduce the impact if a UAV is lost. Deployment time of the UAVs will be decreased. Additionally, UAVs can fly into highly contested areas ahead of a manned craft. The manned aircraft will thus be supported by UAVs increasing the engagement abilities in contested areas.
THE CHALLENGE

The future Air Force will demand fewer and smaller platforms. As a result, compatible weapons with the same effectiveness of larger weapons will become a necessity. Furthermore, weapons will be more frequently carried within aircraft to maintain stealth abilities. The challenge becomes, how do we get the same or more energy from smaller weapons?

THE SOLUTION

To address this challenge, the Munitions Directorate is developing a suite of technologies that will allow for smaller, more effective, and more durable weapons. These technologies include reactive structural materials that utilize energy from the structure of the weapon, nanoenergetics—providing a faster release of energy compared to traditional energetics, Distributed Embedded Fuze Systems to increase weapon reliability, and Additive Manufacturing resulting in optimized structures and fast customization of weapons.
HOW IT WORKS

The goal of reactive structural materials is to replace inert weapon materials with material that can enhance or increase the energy released. This reduces the size and produces more energy per unit volume in the weapon. The composition of nanoenergetic formulations results in a faster release than traditional energetics, thus increasing lethality. Next, the Distributed Embedded Fuze Systems alter the location of firesets within the explosives. The new fusing architecture allowing for distributed functions enables a critical component of the fuze to be protected, leading to fewer malfunctions. Finally, Additive Manufacturing uses 3D printing to rapidly produce prototypes, optimize designs, and open the trade space that leads to innovative weapon designs.

WHY IT MATTERS

This suite of technologies will allow for smaller, more effective, more survivable weapons that support Air Force aircraft development while maintaining stealth capabilities. Further, though there is a reduction in the size of the weapons, there is no sacrificing of the effectiveness of the weapons.

IMPACT FOR THE FUTURE

In the long run, efforts will continue to research and develop smaller lethal weapons to meet the challenges in Air Force platforms and to support the Warfighter. These advancements will require a shift in thinking and challenge current paradigms which will lead to reduced volumes without sacrificing weapon effectiveness.
THE CHALLENGE

Hypersonic flight research provides the Air Force with a competitive advantage on understanding and tapping into this complex phenomena. It will transform the future of aviation but in order to properly execute in this field, we must have access to the most accurate data. How can this be done affordably?

THE SOLUTION

The goal of the Hypersonic International Flight Research Experimentation (HIFiRE) program is to advance the understanding of complex hypersonic phenomena and multidisciplinary physical interactions through affordable flight experiments. HIFiRE has been jointly established by the Australian Defense Science and Technology Group (DSTG) and the US Air Force Research Laboratory (AFRL).

The data gathered from these efforts will allow us to make careful inferences for new capabilities in the hypersonic flight domain. HIFiRE is focused on the fundamental research; trying to reveal what we don’t understand about hypersonic flight in order to address issues and conceptualize future design.
HOW IT WORKS
HIFiRE provides an innovative flight test approach described as "a wind tunnel in the sky", enabling affordable in-flight measurements of boundary layer transition, material survivability in extreme environments, scramjet engine mode transition and operability, and adaptive guidance and control, as well as high fidelity instrumentation and sensors. Additionally, HIFiRE provides the opportunity to build and sustain a core competency in flight testing by engaging more personnel, both government, and industry, in test events. HIFiRE is not a technology—each experiment (flight) are technology focused and look to gather informative data.

WHY IT MATTERS
Accurate and usable data requires access to actual flight conditions. HIFiRE uses cost effective in-flight testing to gather reliable and comprehensive performance data that ground test facilities strain to simulate. The data collected will reduce uncertainty in future system designs, advance maturity of key technologies, and validate instrumentation and flight test methodology.

IMPACT FOR THE FUTURE
This research will be used to further understand hypersonic flight. Personnel and expertise will be developed to enhance hypersonic technology. The HIFiRE experiments will help transition hypersonic flight into a real Air Force capability.
THE CHALLENGE

With a diverse range of missions, aircraft require the reconfiguration of antennas to perform multiple functionalities. However, the space for antennas on aircraft is limited and the integration of antennas onto the airframe can result in compromising its structural integrity or increasing drag and fuel consumption. How do we ensure the latest technologies can be used without compromising the performance of our aircraft?

THE SOLUTION

Instead of using solid metals for some components, we are using a liquid metal alloy that can be moved around to meet specific needs and is embedded in the aircraft structure, without compromising the structural properties. The liquid state allows for the antennas to be reconfigured to provide tunable frequency and directional operation and go so far as being multi-operational. These liquid metal antennas reduce the structural alteration to the craft.
LIQUID METAL ANTENNAS

HOW IT WORKS
Using gallium, and other metals, a liquid metal alloy is formed. This is then placed within the structure of the aircraft through channels confined within the skin of the airframe providing superior aerodynamic performance. The liquid metal is integrated into aerospace grade epoxy composites with additive manufacturing and is physically reconfigured to provide tunable frequency and directional operation. Because it is liquid it becomes possible to reconfigure and change the antenna for mission specific systems.

WHY IT MATTERS
This is a revolutionary technology and a novel approach to tunable and reconfigurable radio frequency (RF) antennas. It allows for cost savings through flexible/integrated electronics, multi-functional components, and damage resistant electronics. Further, the structural integrity of the aircraft is not compromised with this advancement in technology.

IMPACT FOR THE FUTURE
As the liquid metal technology advances, it will be integrated into more electronic processes and the ability to reconfigure antennas based on missions will increase. Next steps for furthering this technology include chemically altering the reactions when the liquid metal comes in contact with other metals as well as impeding the liquid from solidifying at high altitudes.
ADD NEW LINK 16 TO MQ-9S WITH CONFORMAL ANTENNAS

THE CHALLENGE

As technology continues to advance, adding new function to an aircraft may mean significant modifications. For new antennas it may be necessary for the antenna to stick out of the fuselage, which requires holes to be drilled that could result in a weakening of the aircraft’s structure. How can we avoid this from happening?

THE SOLUTION

As opposed to drilling into the fuselage to add an antenna, parts of the aircraft that are removable can be printed on by using additive manufacturing technologies. Conformal antennas use 3D printing technology to print the part and install it seamlessly onto the aircraft. These techniques have been developed over years by AFRL.
AIR FORCE RESEARCH LABORATORY

ADD NEW LINK 16 TO MQ-9S WITH CONFORMAL ANTENNAS

HOW IT WORKS
3D printing uses a nozzle that heats up materials with plasma and prints the antenna directly on the aircraft part. With this process, the aircraft becomes a canvas and the antenna is directly added onto its surface.

WHY IT MATTERS
Conformal antennas allow us to utilize the existing structure of the aircraft without impacting the aircraft structure and reduces the need for air worthiness testing. This helps us focus on integrating new technologies onto existing aircraft, faster and at less cost to the Air Force.

IMPACT FOR THE FUTURE
The technology, in this case, is not the antenna, it is the printing capabilities. We are developing new materials to further evolve this unique printing process to address the growing communications needs of our Airmen.
THE CHALLENGE

Fighter on Fighter engagement superiority has been key to air-dominance, and subsequently battlespace dominance, since World War II. Technologies have pushed aircraft and missile speeds, ranges, and agilities, so that technologically capable tactical platforms have distinct advantages when such confrontations occur. Survival in such circumstances can depend on weapons speed, accuracy, and effectiveness. Imagine an energy beam which can effectively travel at light speed, precisely target an aimpoint on a threat, and in seconds negate that threat. Laser weapon systems are approaching compact sizes with sufficient power on target to accomplish such missions, without restricting the fighter operational agility, and with ability to re-charge in flight using pints of aircraft fuel. The objective of the SHiELD program is to demonstrate the ability to mount a powered laser system onto an aircraft, in a pod.

THE SOLUTION

The Self-Protect High Energy Laser Demonstrator Advanced Technology Demonstrator (SHiELD) is an effort to integrate an agile, compact, high power laser system, with its associated power, cooling, and battle management systems onto a tactical aircraft to demonstrate self-protection in contested environments. With this technology, the military aircraft can boast advanced self-defense capability against highly sophisticated missile threats. SHiELD will help demonstrate the maturity of integrated laser systems in a complex flight environment, improve situational awareness, and enhance survivability.
HOW IT WORKS
To produce a lasting material effect, the laser must stay engaged on the target aimpoint for a specific minimum amount of time as the target absorbs incident laser energy. The onboard beam control system manages this interaction. It initially acquires the target, tracks it, selects and maintains the aimpoint as the laser is fired at the threat. This beam control system will also correct for aero-effects disturbances and aircraft motion throughout the target engagement. Batteries will help keep the lasers powered through energy storage paired with cooling systems that will prevent components from overheating.

WHY IT MATTERS
SHIELD will allow warfighters to better handle dangerous engagements and take on greater challenges. It will provide quick response times in determining whether an incoming object is a friend or foe and impacts the way warfighters approach situations. Because the laser is rechargeable, its use is unrestricted, as long as the aircraft can afford the fuel to keep it energized. Ammunition (photons) are generated onboard electrically, so re-arming will require only a small amount of fuel.

IMPACT FOR THE FUTURE
SHIELD is currently planned as a two phase demonstration. First to develop a lower power system to demonstrate aero-effects mitigation and aimpoint maintenance. Second, to augment the phase I system with a high power laser to demonstrate performance in flight against threats. These developments are graduated to develop a laser system that can protect our warfighters, and reduce dependency on finite ammunition stores.
THE CHALLENGE

Robotics are now fully integrated into aircraft manufacturing to meet competitive needs for production speed and accuracy. However, maintaining an aircraft is specific to each airplane’s condition (how it was flown, where it was based, how old it is), and the work is both manually intensive and constricting. Although the aircraft’s interiors are large, they are also tightly arranged with detailed structures. For example, a wing box may be several feet across, but bolts in the far corner are arranged in a pattern separated by fractions of an inch. This limited access often necessitates structural disassembly for ASIP-required inspections or requires inspectors to work in constrained spaces.

THE SOLUTION

Remote Access Non-Destructive Evaluation, or RANDE, enables efficient access to confined areas for inspections, increased awareness of internal conditions, and improved sensor positioning. The robotic arm provides remote inspection without sending personnel into difficult, hazardous conditions and eliminates the need to tear down internal cavity structures. Ultimately saving time and significantly cutting costs.
HOW IT WORKS

RANDE is a robotic snake arm with an integrated operator control module and non-destructive inspection sensors for internal cavity inspection. The wiring bundles in the robot arm communicate with the base unit and operations computer. It works intuitively and applies a leader/follower motion approach for snake arm. RANDE has the ability to cover a large area while remaining dexterous enough to inspect bolt patterns. The tool is both small and highly adaptable while being strong and highly accurate. Integrating motion safety systems and establishing human trust in the robot to “do no harm” is a top requirement.

WHY IT MATTERS

Reliable inspection tools for limited-access areas are needed to accelerate aircraft structural integrity inspections, returning aircraft to flying status in support of national defense. Advances in robotics are allowing the AF to apply technology in maintenance that has not been considered before, tapping a market with large potential benefit in maintenance efficiencies. RANDE is the first step in eliminating expensive teardown for structural repairs.

IMPACT FOR THE FUTURE

Integrating the robot with the emerging generation of inspection sensors that are used in AF aircraft maintenance is an important next step. There is a long, costly investment in tool sets, workforce training, and technical instructions that all have to work together to achieve a new inspection capability. Although this prototype was tested on one AF aircraft, significant additional development will be a stepping stone to address many other AF fleet challenges.