U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND

SUPPORT TO ARMY MODERNIZATION

2018 EDITION

TABLE OF CONTENTS

CCDC MISSION & VISION

INTRODUCTION

The U.S. Army Combat Capabilities Development Command (CCDC) has almost 14,000 scientists, engineers and other professionals working worldwide on a strategic portfolio that balances near-, mid-, and far-term modernization with the development of technologies that will become the capabilities the Army needs to maintain decisive overmatch.

Headquartered at Aberdeen Proving Ground, Maryland, CCDC comprises eight major science and technology competency domains and three international centers. The command maintains more than 500 active domestic and international partnerships within a global science and technology network, including agreements with domestic and international academic institutions, small business, industry and other government agencies.

These relationships, combined with its workforce, give the command the reach, position, scale and technical expertise to ensure decisive capabilities for today's Soldiers and the future Army, as well as foundational capabilities for the Joint Warfighter. They also allow CCDC to partner closely with the requirements community of the Training and Doctrine Command, which defines future Army needs, and the Assistant Secretary of the Army (Acquisition, Logistics and Technology) Program Manager community, which brings those capabilities to the field.

CCDC leads the development of the technologies needed for Army modernization by performing research, development and engineering deemed too risky or too Army-specific for industry or academia. The organization's technological expertise, systems engineering discipline, analytical capabilities and collaborative reach give the Army an organic research and development capability on the cutting-edge of technology across the full spectrum of operations. With scientists stationed around the globe, CCDC actively explores international collaborative opportunities to close capability gaps for the Warfighter. The command's tight integration with the Army and deep understanding of Soldier needs gives it unmatched insight into capability development.

In 2018, the U.S. Army established Army Futures Command (AFC), marking the most significant Army reorganization effort since 1973. AFC is tasked with driving the Army into the future to achieve clear overmatch in future conflicts. In January 2019, the U.S. Army Research, Development and Engineering Command was moved from the U.S. Army Materiel Command to the Army Futures Command and renamed the Combat Capabilities Development Command (CCDC). Under AFC's strategic vision, CCDC will continue to solve the Army's toughest technological challenges, today and tomorrow. Leading the Army's largest talent pool of scientists and engineers, it will discover, develop, deliver and analyze the capabilities future Soldiers need to fight out nation's wars and come home safely.

VISION

To be the Army's enabling command in the development and delivery of capabilities that empower, unburden and protect the Warfighter.

MISSION

Provide innovative research, development and engineering to produce capabilities for decisive overmatch to the Army against the complexities of the current and future operating environments in support of the Joint Warfighter and the Nation.

CCDC COMPETENCY AREAS

ARMAMENTS — Picatinny, NJ
The CCDC Armaments Center is the Army's home for lethality, with a mission to lead research, development and engineering of systems solutions to arm those who defend the nation against all current and future threats, at home and abroad.

AVIATION & MISSILE — Huntsville, AL
The CCDC Aviation & Missile Center is the Army's focal point for providing research, development and engineering technology and services for aviation and missile platforms across the life cycle.

C5ISR — Aberdeen Proving Ground, MD
The CCDC C5ISR Center advances Soldier capabilities that enable situational awareness and understanding, establish and secure communications, and protect Soldiers from surprise attack.

CHEMICAL BIOLOGICAL — Aberdeen Proving Ground, MD
The CCDC Chemical Biological Center integrates life cycle science, engineering and operations capabilities to counter chemical, biological, radiological, nuclear and high-yield explosive (CBRNE) threats to Soldiers, Joint Warfighters and the Nation.

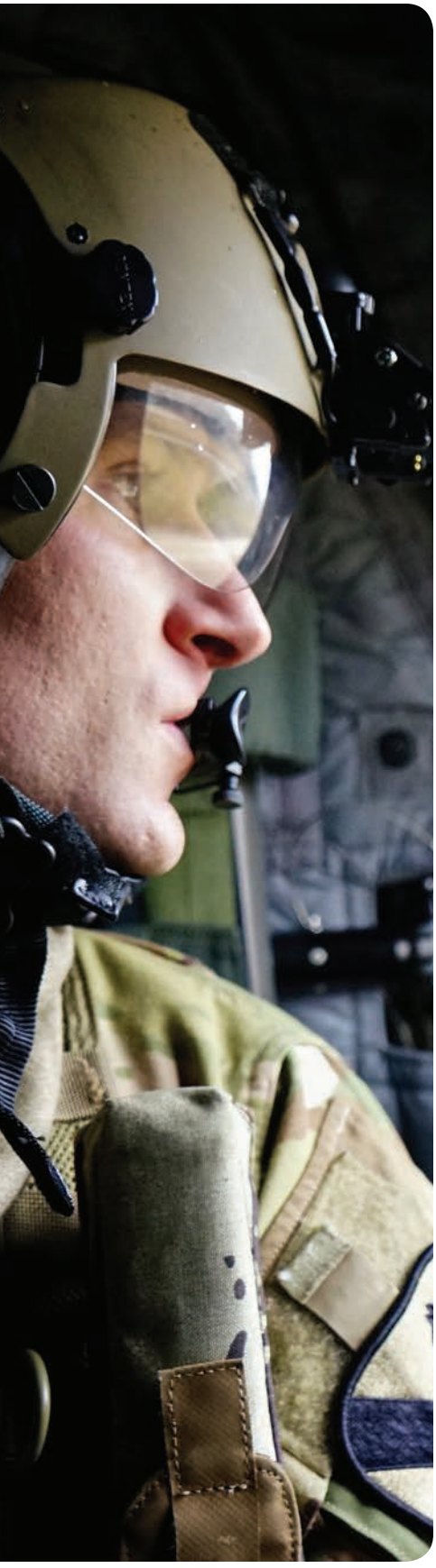
DATA & ANALYSIS — Aberdeen Proving Ground, MD
The CCDC Data & Analysis Center provides agile, timely, and integrated item/system level performance and effectiveness, vulnerability/

lethality, and human systems integration analytical products, data, and experimentation to ensure Army modernization decisions are underpinned by sound evidence.

GROUND VEHICLE SYSTEMS — Warren, MI
The CCDC Ground Vehicle Systems Center develops, integrates and sustains technology solutions for all manned and unmanned DOD ground systems and combat support systems to improve current force effectiveness, provide superior capabilities for the future force, and ensure decisive overmatch capabilities for unified land operations to empower Soldiers and the Joint Warfighter.

RESEARCH LABORATORY — Adelphi, MD
The CCDC Army Research Laboratory is focused on unifying researchers from across the globe to address the Army's top enduring science and technology challenges, with a mission to discover, innovate and transition technology to ensure dominant military land power.

SOLDIER — Natick, MA
The CCDC Soldier Center provides the Army with innovative Science & Technology solutions to optimize Soldier/team performance and improve combat readiness by incorporating the latest innovations to maximize Soldier/squad performance optimization and the Warfighter's lethality, combat readiness, survivability, sustainability, mobility and combat effectiveness.



KEEPING PACE WITH THE CHANGING CHARACTER OF WAR

> "I'm not interested in a linear progression into the future. That will end up in defeat on a future battlefield. What I'm talking about is a significant — call it '10x,' call it 'leap ahead,' all those types of terms — a very significant, radical improvement in current capabilities."
>
> — U.S. Army Chief of Staff Gen. Mark Milley

Technology is evolving faster than ever before and becoming a global commodity that empowers and emboldens the full spectrum of our nation's adversaries. In 2018, this idea moved beyond insight and conventional wisdom into the realm of institutional change.

War has moved more deeply into the information age, and the weapons in the fight are increasingly available as the digital world has minimized our adversaries' capability gaps. The second- and third-order effects of this change have been outlined, but not thoroughly understood; the nature and velocity of change means the challenge evolves as we study it. Our adversaries see our strengths and actions and move to create opportunities to act, which demands a new level of responsiveness and agility. Our Warfighters have long succeeded under these conditions, and exploiting short-lived windows of opportunity is a core concept of Multi-Domain Operations. Our institutions now face a similar task.

Army leaders recognized the need for disruptive institutional change and have created a new Army Command for the first time in more than 40 years. Army Futures Command, or AFC, will modernize the Army for the future, integrating the future operational environment, threat, and technologies to develop and deliver future force requirements, designing future force organizations, and delivering materiel capabilities.

CCDC has embraced this reality both institutionally and throughout our workforce. As we tackle the twin challenges of letting go of the old processes and understanding the new challenges, we have not lost focus on our mission: to discover, develop and deliver the capabilities Soldiers

will need on the complex future battlefields where our nation's future will be decided. Our understanding of fundamental scientific truths continues to inform Army requirements, and the skill of our workforce continues to bring new systems from concept to design to fielded capabilities. As we moved closer to integrating into AFC in 2018, we focused on tangible technology transitions, and an equally essential yet intangible item: effective partnerships with the other AFC and Army elements, our sister services and industry partners.

Soldier capabilities depend on output from those partnerships, and the character of these outputs must mirror the changing character of war. In the age of industrial-scale war, output was measured in the delivery of tangible objects. The information age brought forth less tangible outputs, as leaders began to see the impact of having the right information at the right time — an impact that could create or close off opportunities as effectively as weapons that outmatched the adversary. Today, CCDC scientists are setting the conditions for future types of warfare as-yet untested, such as algorithmic warfare conducted through the medium of artificial intelligence. The command's scientists and engineers are creating and delivering intangible innovations such as new data sets, testing procedures, development processes, machine learning code and delivery systems. These outputs will become part of AI systems that turn information Soldiers have yet to fully perceive into the knowledge they need to exploit or close a window of opportunity. These systems will then need to adapt to the changing conditions of engagement in ways unlike any Army system has ever done before.

These new systems will not stand alone, but must be integrated with industrial-age systems that still define the physical reality of the battlefield. Integration is a CCDC chartered mission, one that has expanded as access to commoditized technological capabilities has made the operational environment more complex. Threat-informed development tells us that adversaries will exploit this complexity and contest the dominance of U.S. forces across all domains to achieve their objectives, sometimes without resorting to armed conflict. This will complicate the mission of deterrence and drive further demand for responsiveness and agility across the Science & Technology community. CCDC's ability to create, integrate and upgrade systems at the speed of relevancy is a competitive advantage over adversaries who simply buy and use technology, but who lack the sophisticated S&T team that CCDC represents. The command's extensive network of international and domestic partnerships with academia, industry, military partners and other government agencies is a competitive advantage over adversaries who lack this vital access to the global intellectual, industrial, and military communities.

CCDC is already working to address these challenges, wrapping up the first year of a thorough campaign to increase the transparency and effective use of our resources and core competencies in order to achieve the agility required to support the Army in today's contested spaces. Our Campaign Plan addresses integrated technology development and the core requirements that make it possible: people, infrastructure, business practices and communication. This plan enabled the command to

quickly pivot to realigning its efforts to support the Army Modernization Priorities by restructuring portfolios, eliminating ineffective programs and spearheading new initiatives with new partners, such as the AFC Cross Functional Teams.

At the same time, CCDC understands it is the Army's steward of technologies that will become capabilities the future force requires. Therefore, we must operate across multiple time horizons. Yesterday's basic research is the foundation of the capabilities we deliver today, just as the partnerships we foster now will become the bedrock out of which we will carve capabilities for Soldiers of the future. For that reason, CCDC is working to maintain a balance between supporting the modernization priorities that will make the force of 2028 the most lethal in the world, and conducting the research necessary to develop technologies that will empower the force of 2040 and beyond.

The examples that follow are weighted toward the Modernization Priorities because those needs are of immediate importance to our nation's Soldiers, our partners and stakeholders. The most advanced capabilities require a long development process, and we will report on these success as we move scientific discovery from a technology under development to a capability that empowers, unburdens and protects Soldiers.

SUPPORT TO ARMY MODERNIZATION & READINESS

In 2018, CCDC aligned its Science & Technology investments to the Army Modernization Priorities by restructuring portfolios, eliminating ineffective programs and spearheading new initiatives where capability gaps demanded. The command also solidified how it supports the new Cross Functional Teams charged with executing those modernization efforts.

ARMY MODERNIZATION PRIORITIES

- LONG RANGE PRECISION FIRES
- NEXT GENERATION COMBAT VEHICLE
- FUTURE VERTICAL LIFT
- NETWORK
- SOLDIER LETHALITY
- AIR & MISSILE DEFENSE

From scientific discoveries and intangible algorithms driving future advancements, prototypes and software transitioning to PEOs for acquisition and fielding, and cost savings/avoidance redirecting resources to better support Army Readiness and Modernization, CCDC's accomplishments in 2018 are as diverse as the expertise of the command's scientists and engineers.

LONG-RANGE PRECISION FIRES

Long-Range Precision Fires, or LRPF, provides the Army with long-range and deep-strike capability. It is the Army's number one modernization priority and critical to winning in a fight against a peer adversary.

The Army must provide commanders with surface-to-surface fires that are precise, responsive, effective, and adaptable. Army LRPF must be able to penetrate through the enemy force's defensive capabilities within the operational environments by synchronizing effects across multiple domains.

The CCDC Armaments Center leads the command's support to Army LRPF modernization efforts and the LRPF Cross Functional Team, with additional support from the command's Army Research Laboratory, and C5ISR and Aviation & Missile centers.

The Tail Controlled Guided Multiple Launch Rocket System demonstrates a concept to increase the range of effects of the system and adds maneuverability for future missions.

Tail Control Guided S&T for GMLRS-Extended Range

After six years of extensive research, engineers at the CCDC Aviation & Missile Center conducted two successful test flights of the advanced tailed controlled missile system in FY2018 at White Sands Missile Range, New Mexico. The Tail Controlled Guided, or TCG, Multiple Launch Rocket System maximizes the range of the Guided Multiple Launch Rocket System, or GMLRS, that entered production in 2003 as the Army's primary precision strike artillery weapon.

The Tail Controlled GMLRS is a partnership between CCDC Aviation & Missile Center and Program Executive Office Missile & Space, to extend the current range of the GMLRS from 70km to upwards of 130km. The successful flight tests demonstrated the feasibility of doubling the range of the current production and fielded GMLRS, and adds cross-range maneuverability for future missions.

VALUE TO THE ARMY

- Addresses overmatch of MLRS-class foreign rocket systems that either meet or exceed the maximum range of existing GLMRS.
- Provides capability to engage targets at extended ranges.
- Proof of concept to double range of GMLRS with vertical impact capability.

KEY TAKE AWAYS

- TCG technology demonstration was the 'Pathfinder" that informed GMLRS-Extended Range Program of Record.
- Two successful flight tests of TCG in FY2018 at White Sands, New Mexico demonstrated the feasibility of doubling the range of the current production and fielded GMLRS, and adds cross-range maneuverability for future missions.
- During FY18 flight test, TCG missile demonstrator reached a distance of 112.9 km/70 miles. During the second flight test it reached a distance of 139.2 km.
- The S&T program provides government owned technical data which allows the Army to retain rights to the data at a potential cost savings.

PATH FORWARD

- TCG test bed airframe will be utilized for continued flight testing of UTAH Sensor S&T efforts in FY19.

Obscuration for Long Range Precision Fires

CCDC Chemical Biological Center hosted a production management review and field demonstration in April 2018 for DoD pyrotechnics experts and production managers to review the progress of a program to replace HC smoke with the less toxic HX smoke in 155mm M116A1 Smoke artillery projectiles currently used to create battlefield obscuration for training by U.S. Army forces in Europe.

CCDC Chemical Biological Center engineers and pyrotechnicians developed HX smoke to replace the legacy zinc-hexachloroethane based HC smoke used to create smoke screens on the battlefield. HC is an irritant and potentially toxic to unmasked Warfighters. It is also toxic to the environment as an aquatic pollutant. M116A1 projectiles with HC payload were last produced in the 1980s.

HX smoke produces efficient white visual pyrotechnic smoke equivalent in performance to HC smoke, while being less toxic and less hazardous.

A demonstration shows the concealing power of a new, less toxic HX artillery smoke payload at a production review held at the CCDC Chemical Biological Center April 25, 2018.

VALUE TO THE ARMY

- Provides the Warfighter the next generation of obscuration replacing the obsolete and prohibited HC.
- Lower hazard, lower toxicity white visual smoke for multiple uses: artillery, hand smoke grenade.

KEY TAKE AWAYS

- In both cost and performance HX is similar to the original HC smoke formulation, while being less toxic.
- Multiple potential uses: M116 155mm round, AN-M8 replacement, 'nonlethal' mine fill, etc.

PATH FORWARD

- The CCDC Chemical Biological Center will continue to evaluate HX smoke as an HC replacement for the M116 155mm round and HX smoke as a fill for the AN-M8 smoke grenade.

Additional Long-Range Precision Fires Modernization Support

EXTENDED RANGE CANNON ARTILLERY

The CCDC Armaments Center successfully achieved several successes in key subsystems of the Extend Range Cannon Artillery Program. The center successfully and safely test-fired the XM907 cannon, the XM1113 warhead with rocket, and the XM654 Supercharge. These combined successes achieved ballistic range of more than 60km. Moving forward, the center will conduct Field Artillery Demonstrations of the M109A7ER (Extended Range) and Self Propelled Howitzer AutoLoader.

NEW ENERGETIC MATERIAL: BIS-OXADIAZOLE DINITRATE

The CCDC Army Research Laboratory discovered a novel energetic material demonstrating superior explosive and propellant performance compared to TNT, while also being less toxic. The compound, known as bis-oxadiazole dinitrate, represents a feat in the chemistry behind explosives: designing a material that would detonate with more force while being stable enough to melt-cast. Stable compounds generally make for poor explosives, but that stability allows the Army to melt down the compound for molds and shells to make bombs.

NAVAL STRIKE MISSILE FOREIGN COMPARATIVE TESTING

In partnership with U.S. Pacific Command, U.S. Army Pacific, the U.S. Pacific Fleet, Raytheon and the Norwegian Company Kongsberg, CCDC Aviation & Missile Center successfully mounted the off the shelf Norwegian Naval Strike Missile on a Heavy Expanded Mobility Tactical Truck to fill a capability gap. The system demonstrated cross-domain capability to engage a maritime target during SINKEX in July 2018, which is a significant part of RIMPAC 2018.

STRATEGIC LONG RANGE CANNON

The CCDC Army Research Laboratory conducted a comprehensive identification and evaluation of S&T required to enable a lethal extended range cannon. The lab designed a propellant formulation to drive cannon design requirements and identified materiel compositions to improve high temperature, pressure and wear conditions for cannon and flight body. All knowledge was transferred to the LRPF Cross Functional Team as a foundation to strategic long-range cannon requirements.


40

NEXT GENERATION COMBAT VEHICLE

Soldiers must have a next generation combat vehicle that provides increased survivability, mobility and lethality at a reduced weight, to close with and destroy peer threats through maneuver, firepower, and shock-effect.

The Next Generation of Combat Vehicles, or NGCV, allows the Army to achieve combat vehicle overmatch in close combat against the pacing threat. It delivers decisive lethality with manned and unmanned teaming as part of a combined arms team in the future operating environment.

The CCDC Ground Vehicle Systems Center leads the command's support to Army NGCV modernization efforts and the NGCV Cross Functional Team, with additional support from the command's Army Research Laboratory, and Armaments, C5ISR, and Aviation & Missile centers.

The Operational Test results of the Mission-Enabling Technologies Demonstrator (MET-D) will be released in early 2019. The results and the MET-D vehicles themselves will transition into future system designs of the NGCV Experimental Prototype.

Mission-Enabling Technologies – Demonstrator

The CCDC Ground Vehicle Systems Center conducted squad and platoon level maneuvers using the fire team vehicle approach in an operational demonstration in 2018, and gained user feedback on the utility and capability of the enhancements and the fire team vehicle concept of operations.

The enhancements to the vehicles include, optimized situational awareness between vehicles and fire teams, improved closed hatch operations with focus on driving and target engagement, reduced crew task loading incorporating cooperative crew station design, autonomous functionality and a Bradley turret reconfigured into an unmanned, remotely operated weapon system.

VALUE TO THE ARMY

- Provides the Army/Cross Functional Team with flexibility in infantry fighting vehicle concept of operations, leveraging split squads and the potential for Manned Unmanned Teaming in Infantry Fighting Vehicle formations.
- Leveraged value of system level experimental prototyping with soldier operational testing to better inform development of system requirements.

KEY TAKE AWAYS

- Demonstrated how integrating sensor technologies and a remote turret enables smaller and lighter vehicles, optimizes the Warfighter Machine Interface, and improves closed-hatch performance.
- Shows how to use sensors, networked vehicles, and the Warfighter Machine Interface to improve crew to dismount communication and situational awareness.

PATH FORWARD

- MET-D Phase 0 Completed the Operational Testing in September 2018. The analysis is ongoing and results will be published in a report early in 2019. The test results and the MET-D vehicles themselves will transition into future system designs of the NGCV Experimental Prototype.

Expedient Leader Follower/ Autonomous Ground Resupply

The CCDC Ground Vehicle Systems Center is supporting Expedient Leader Follower, or ExLF, and Autonomous Ground Resupply, or AGR, efforts through several programs.

ExLF is accelerating delivery of robotic capability to Soldiers by building and integrating Leader Follower systems and issuing to two Palletized Load System Truck Companies under the Leader Follower Directed Requirement. ExLF systems are currently being built and integrated for engineering testing in preparation for Army Test and Evaluation Command, or ATEC, testing starting in April 2019. The systems for the Operational Technical Demonstration will be built and integrated starting in March 2019 and to be issued to Soldiers starting in September 2019.

AGR is increasing leader-follower capability through software, hardware and architecture improvements. Systems will begin Engineering and Evaluation Testing in June 2019, with ATEC safety testing in August 2019 and Solder Experimentation in September 2019. All products from AGR Increment II will transition to the PEO Combat Support & Combat Service Support; Next Generation Combat Vehicle Cross Functional Team; and the Training and Doctrine Command before the end of 2019. With the final transition on Increment III before the end of 2021.

Autonomous Ground Resupply systems will begin engineering and evaluation testing in June 2019, with ATEC safety testing to follow in August 2019 and Soldier experimentation in September 2019.

VALUE TO THE ARMY

- Accelerates delivery of robotic capability to Soldiers.
- First step toward integrating large vehicle robotics into Army formations.
- Increases force protection and sustainment throughput of convoy operations.

KEY TAKE AWAYS

- Direct output of an S&T program (AGR 6.2/6.3) and transitioned to a limited production and year-long Soldier demonstration through ExLF (6.4).
- Informs Leader Follower requirements and transitions to Program of Record.
- Developing the foundational architecture and behaviors for NGCV.

PATH FORWARD

- Integrate Leader Follower systems on PLS A1's and issue to Soldiers at Ft. Polk (4QFY19) and Ft. Sill (2Q FY20) transition to LF Program of Record (FY21).

Additional Next Generation Combat Vehicle Modernization Support

ADVANCED LETHALITY AND ACCURACY SYSTEM FOR MEDIUM CALIBER

The CCDC Armaments Center is developing the next generation medium caliber armament system to maximize lethality against Next Generation Combat Vehicle, or NGCV, target sets at extended ranges. It will serve as an accurate medium caliber armament system for stationary and fire on the move capability with turret/vehicle integration. The S&T program will continue to mature and test XM913 weapon system, ammo handling, ammunition suite, and fire control through FY19 to optimize lethality for NGCV and culminate in an integrated TRL6 demonstration that will engage NGCV Targets to 3000m.

NGCV EXPERIMENTAL PROTOTYPE

The CCDC Ground Vehicle Systems Center has developed a set of platform-level experiments of new technologies over time phased at the direction of the NGCV Cross Functional Team. It will integrate technologies into a platoon set of ground combat vehicles, analyzing the impact and receiving Soldier feedback to improve overall effectiveness in direct support of next generation combat vehicles.

MODULAR ACTIVE PROTECTION SYSTEMS (MAPS)

The CCDC Ground Vehicle Systems Center demonstrated soft-kill active protection systems in 2018 that are compliant with a modular approach. Through three successful virtual demonstrations, the Ground Vehicle Systems Center was able to prove modularity and MAF verification for these systems that will defeat Anti-Tank Guided Missiles.

M3 EXPLOSIVE REACTIVE ARMOR (FRONTAL)

The CCDC Army Research Laboratory conducted a demonstration of effective, light weight, low cost, and universal explosive reactive armor configuration for use on front glacis of U.S. combat vehicles. The new tile design and Tech Data Package applicable to several vehicles across the fleet including the Army Modernization Priority for NGCV, and can provide near-term savings for PM-Armored Multi-Purpose Vehicle.

CVP SURVIVE

The CCDC Ground Vehicle Systems Center demonstrated leap-ahead blast protection in a clean design utilizing advanced active and passive soldier protection technologies. It designed, developed and demonstrated state-of-the-art ballistic protection, blast mitigation, and advanced material technologies to influence the next-generation of infantry fighting vehicles.


N280BH
V-280
VALOR

FUTURE VERTICAL LIFT

Future Vertical Lift, or FVL, is an Army-led multi-service initiative, focused on enhancing vertical lift dominance through the development of next generation capabilities. It increases reach, protection, lethality, agility and mission flexibility to successfully dominate in highly contested and complex airspace against known and emerging threats.

FVL's lethality, autonomy, reach, agility and protection attributes, teamed with future unmanned systems, extends Army Aviation's interoperability to get there, stay there, and dominate in Multi-Domain Battle. It enables the joint force to seize, retain, and exploit the initiative giving the ground force commander an asymmetric advantage against peer and near-peer adversaries.

The CCDC Aviation & Missile Center leads the command's support to Army Future Vertical Lift modernization efforts and the FVL Cross Functional Team, with support from the command's Armaments and C5ISR centers, as well as the Army Research Laboratory.

Bell Helicopter's Air Vehicle Concept Demonstrator aircraft, funded under the Joint Multi-Role Technology Demonstration program, was flown for the first time by an Army pilot Feb. 7, 2018 in Amarillo, Texas.

Joint Multi-Role Technology Demonstration

CCDC Aviation & Missile Center personnel have been fully involved in the Joint Multi-Role Technology Demonstration, or JMR TD, effort, including integration of experimental test pilots and flight test engineers into the mixed flight test team.

Led by the CCDC Aviation & Missile Center, JMR TD is an Army science & technology effort designed to develop, expand and demonstrate new capabilities in vertical lift technology.

JMR TD has two components: Air Vehicle Demo and Missions Systems Architecture Demo. The Air Vehicle Demo focuses on advanced rotary-wing configurations and enabling technologies that are needed to achieve the combination of performance (range, speed, payload, etc.) survivability, reliability, and affordability for emerging Future Vertical Lift, or FVL, requirements and missions. Missions Systems Architecture Demo, or MSAD, explores the advanced tools and techniques needed to develop and analyze requirements to minimize life-cycle costs required by increasingly complex missions systems.

VALUE TO THE ARMY

- Advanced vertical lift capabilities provide the future joint force ground commander with flexibility and asymmetric opportunities required in the future Multi-Domain Battle.
- JMR TD demonstrates those transformational vertical lift capabilities to prepare for FVL programs.

KEY TAKE AWAYS

- Completed more than 100 hours of ground and flight testing for JMR TD.
- Released solicitation for Mission Systems Architecture Capstone.

PATH FORWARD

- One of the flying demonstrators is in active flight test and the other is scheduled to start flight testing in early 2019. Both should be complete with the JMR TD flight testing by the end of 2019.
- The final major demo of the MSAD has begun and will be complete in 2020. The FVL acquisition program of record for Capability Set 3 is utilizing the JMR TD knowledge base robustly in the Analysis of Alternatives and acquisition planning.
- A follow on S&T managed effort similar to JMR TD has begun and will continue through 2023 for the FVL Capability Set 1 capability.

Gray Eagle Engine

CCDC Army Research Laboratory scientists identified a combustion chamber material failure mechanism within the Gray Eagle Engine and demonstrated an alternative path to a 200-hp engine.

VALUE TO THE ARMY

- Identified failure mechanism for cylinder wall delamination that cost the Army $12 million.
- Identified a course of action to address combustion chamber failures to extend operation of the GE aircraft from 1,500 to 2,500 flight hours.
- **Provided an alternative path for a 200-hp GE engine, potentially saving the Army more than $1 billion.**

KEY TAKE AWAYS

- Identified material solutions to prevent combustion chamber failure, avoid further loss of aircraft, and extend flight hours.
- Optimized GE engine calibration resulting in power and efficiency increases and representing substantial future cost savings for the Army.

PATH FORWARD

- Transition to AFC AAL HALO program to solicit industry and academia to develop a new wear-resistant and thermal barrier coatings.
- PM Unmanned Aerial Systems will make a decision by late 2018 on their path forward on the 200 hp Gray Eagle Engine.

CCDC Army Research Laboratory scientists identified a combustion chamber material failure mechanism within the Gray Eagle engine, potentially saving the Army more than $1 billion.

Additional Future Vertical Lift Modernization Support

AUTOMATED/AIDED TARGET RECOGNITION

The CCDC C5ISR Center developed, evaluated and demonstrated computer vision algorithm components and real-time embedded processing techniques to improve state-of-the-art infrared aided target recognition on Soldier and Next Generation Combat Vehicle platforms. Automated or aided target detection and recognition will be used on manned platforms to help reduce Soldier workload, improve situational awareness, and reduce response times. On unmanned ground platforms, automated target detection and recognition become a fundamental enabling technology for autonomous operation and mission execution.

TRANSPARENT CERAMIC ARMOR FOREIGN COMPARATIVE TESTING

The CCDC Global Technology Office is executing OSD's Foreign Comparative Testing (FCT) funds with the CCDC Army Research Laboratory to evaluate transparent material from a German supplier that has the potential to significantly reduce the weight and thickness of windshields yet provide the ability to defeat higher caliber threats. The CCDC Army Research Laboratory will work with PM Cargo to transition this capability that also provide 30 percent lower cost product while also enhancing the current capability of air platforms.

NETWORK

The Army's new network modernization strategy is designed to enable the Army to "fight tonight" while also actively seeking next-generation solutions to stay ahead of potential adversaries. This strategy is a fundamental change in the Army's approach to tactical network modernization, which is aimed at keeping pace with threats in the near-term and developing a future network through rapid insertion of new technology and focused science and technology efforts.

The Army is committed to delivering a tactical network that guarantees that the Army can prepare for war and fight and win against any adversary. The Network Cross Functional Team is focused on integration, speed and precision to ensure the Army's capability development process is adaptable and flexible enough to keep pace with the rate of change in technology.

The CCDC C5ISR Center leads the command's support to Army Network modernization efforts and the Network/Command, Control, Communications, Intelligence Cross Functional Team, with additional support from the command's Army Research Laboratory, and Aviation & Missile and Soldier centers.

The Ultra Light Command Post vehicle is designed to support airborne and air assault forces with an initial entry CP node. UL CPN enables units to rapidly establish unit-tailorable mission command capability at the local objective area and over the horizon.

Expeditionary Mission Command Technology Demonstration

The CCDC C5ISR Center hosted the Expeditionary Mission Command Science and Technology Objective-Demonstration, or EMC STO-D, Capstone event in 2018, culminating a three-year initiative that produced Soldier-vetted capabilities with all of the goodness of traditional command posts, plus, made them mobile.

The demonstration served as a display of the CCDC C5ISR Center's efforts to make tactical command posts more mobile and survivable, supporting a major priority line of effort of the Army's network modernization strategy.

VALUE TO THE ARMY

- Enhanced command post survivability versus near peer threats.
- Decreased logistics burden and complexity.
- Improved combat effectiveness by new solutions for combat training centers.

KEY TAKE AWAYS

- EMC STO improved combat effectiveness and survivability of current and future force.
- Reduced Tactical Command Post setup/teardown time by 50 percent. Reduced fuel consumption by 22 percent.

PATH FORWARD

- Transitioned eleven ground breaking technologies to CCDC Soldier Center, PEO Command, Control, Communications-Tactical; PEO Simulation, Training, and Instrumentation; PEO Combat Support & Combat Service Support; and U.S. Marine Corps, shaping the future expeditionary mission command.
- EMC STO Final Report to be released in Q1FY19.

CHIMERA

The CCDC C5ISR Center has developed the DoD's only cross-vendor National Security Agency, or NSA, type 1 encryptor manager that is government developed and owned, and given free to all services and three letter agencies.

The Common HAIPE Interoperable Manager for Efficient Remote Administration, or CHIMERA, allows for remote configuration, management, software update and cryptographic key loading of multiple modern Inline Network Encryptors from the three major device vendors currently deployed within the Army inventory.

Currently, Army management must be done from multiple hosts, each running on its own unique vendor management software. By creating and using universal software, CHIMERA offers the potential to save the Army time, money and manpower.

CHIMERA, developed by the CCDC C5ISR Center, will be fielded Army-wide in FY19, as the DoD's only cross-vendor NSA type 1 encryptor manager.

VALUE TO THE ARMY

- Research in support of future force and national priorities.

KEY TAKE AWAYS

- Keeps Soldiers out of hostile/dangerous/remote environments and allows them to perform their maintenance and keying remotely.
- Allows Soldiers to identify problems prior to outages occurring.
- **Saved $3.1 million in maintenance hours in FY18.**
- Successful pilot fielding both CONUS and OCONUS.

PATH FORWARD

- CHIMERA will be fielded Army-wide in FY19.
- Maj. Gen. Bassett (PEO-Command, Control, Communications-Tactical) signed Acquisition Decision Memorandum Aug. 17, 2018.
- Maj. Gen. Baker (Network Enterprise Technology Command) signed Enterprise fielding decision Oct. 1, 2018.

Additional Network Modernization Support

NETWORK VULNERABILITY ASSESSMENT

The CCDC C5ISR Center conducted a risk-based assessment of current network against enemy threats to drive realignment of Science & Technology efforts to address gaps and risk areas for future fights. This effort resulted in halting nine S&T efforts, pivoting 10 S&T efforts, and three new S&T efforts to counter threats.

RF METAFERRITE DEVICES

The CCDC Army Research Laboratory developed MetaFerrite engineered materials for the creation of ultra-thin, conformal, and wideband directional antennas and other RF devices, and successfully tested a one-inch thick broadband UHF/VHF antenna, compared to a conventional antenna equivalent approximately 13 inches thick. The ultra-thin antennas for radar/EW applications have no obvious visible signature or protrusion from platform, without resulting in performance degradation.


PULL TO
OPEN

SOLDIER LETHALITY

Soldiers and squads are the foundation of the decisive force. They must be organized, equipped, and trained with superior lethality, situational awareness, mobility and protection that provides the overmatch required to defeat capable and determined adversaries in complex operating environments. Soldier Lethality, or SL, spans all fundamentals: shooting, moving and communicating, protecting, sustaining and training. The Army's fundamental responsibility is to equip, train and field Soldiers with the tools and resources to engage with and destroy the enemy.

The battlefield of tomorrow will be more lethal, and the Army must change with that in mind. To ensure overmatch, the Army must modernize, train, and structure the force to build land-power capability against near-peer threats. This will be accomplished by providing them with next generation capabilities to increase lethality, mobility and survivability, while countering emerging threats.

The CCDC Soldier Center leads the command's support to the SL Cross Functional Team Army modernization efforts focused on SL, with additional support from the command's Army Research Laboratory, and Armaments and C5ISR centers.

Water-based lithium ion battery deliver high energy density while being flexible, conformable and non-flammable.

Flexible Aqueous Lithium Ion Batteries

The CCDC Army Research Laboratory is developing prototypes of the first water-based lithium ion battery that delivers high energy density while being flexible, conformable and non-flammable.

The first-of-its-kind battery reaches the 4.0 volt mark desired for household electronics, such as laptop computers, without the fire and explosive risks associated with some commercially available non-aqueous lithium-ion batteries.

VALUE TO THE ARMY

- Non-flammable battery (minimal safety concern).
- Reduced weight burden for Soldier.
- Low-profile, flexible & conformal shapes.
- Order of magnitude faster recharge times (3V flex aqueous battery).

KEY TAKE AWAYS

- Deliver higher energy density while removing the risk of fire and the limitations of normal battery packaging.
- Top candidate for Soldier-worn energy to power next-gen equipment and integration into unmanned and manned vehicles.

PATH FORWARD

- The CCDC Army Research Laboratory will deliver 30 3-volt flexible aqueous battery prototypes at the end of FY19 and 30 4-volt high energy flexible aqueous batteries by the end of FY20. These batteries will undergo spec testing by the CCDC C5ISR Center and field testing by the CCDC Soldier Center. PM Soldier Warrior, PEO Soldier, PM Air Warrior, Special Operations Command, and Naval Surface Warfare Center-Carderock have all expressed interest.

Next Generation Combat Ration

The CCDC Soldier Center is developing a nutrient-dense Close Combat Assault Ration (CCAR) with reduced weight and cube for semi-independent operation of small units.

The Soldier Center aims to develop new rations that meet the challenges of Warfighters operating semi-independently on a multi-domain battlefield. The CCAR will be a lightweight, low volume, shelf-stable, daily combat assault ration that provides small units nutrient dense components to be consumed by grazing and will require no heating or field preparation. The ration is intended to support small units, for up to seven days, across a spectrum of future operating environments in a complex and ambiguous battle space to increase readiness, sustainability and lethality.

The CCAR is designed to feed Warfighters in the field for an entire day, unlike MREs which require three per day. The CCAR is similar to the First Strike Ration, first fielded about 10 years ago, but the CCAR will be even smaller and lighter to carry.

The CCAR will leverage emerging technologies in food preservation and compression to provide shelf stable, nutrient dense food that retain their original flavor but are reduced in weight and volume by up to 50%. In addition, these technologies allow for the inclusion of more fruits and vegetables in rations.

The prototype Close Combat Assault Ration on display at the Pentagon May 24, 2018 includes a tart cherry nut bar, cheddar cheese bar, mocha desert bar, vacuum-dried strawberries and trail mix of fruit and nuts, among other items that were vacuum microwave dried.

VALUE TO THE ARMY

- Enables sustainment of small units up to 7 days without resupply.
- Optimizes Warfighter physical and cognitive performance and recovery.

KEY TAKE AWAY

- Integrated ration development approach which includes maturation of nutrition, packaging and food protection technologies to improve Warfighter performance, mobility and survivability on the future battlefield.

PATH FORWARD

- Transition weight and volume reductions to TRL 6 in FY20.
- Transition nutrition stability and retention to TRL 6 by FY21.
- Continue maturation efforts in caloric densification, packaging, and food protection technologies for the Joint Services through FY22.

A CCDC Chemical Biological Center scientist, in full chemical/biological suit protection, outfits Porton Man with sensors prior to a test. Porton Man is a carbon fiber, fully-articulated mannequin used to test the effectiveness of chemical and biological protective suit systems.

Porton Man Capability

The CCDC Chemical Biological Center conducted the validation of Porton Man System-Level Chemical Protective Ensemble Test Fixture in 2018. Porton Man is a carbon fiber, fully-articulated mannequin used to test the effectiveness of chemical and biological protective suit systems.

Covered with several hundred ports for sensors, the mannequin is used to test chemical and biological protective suit systems with live chemical warfare agent. Porton Man allows for real-time data, showing the ranges of motion, orientations, actions or time increments at which a protective suit performed well or poorly.

In June 2018, Porton Man was endorsed by the Army, which allows data derived from Porton Man to be used for acquisition programs. Porton Man is also validated as an official test method for the U.S. Chemical Biological Defense Program.

VALUE TO THE ARMY

- Only system-level test asset measuring effect of motion on Warfighter protection using live chemical agent.
- Real-time breakthrough measured based on Warfighter motions.
- Links breakthrough to toxicological impact.
- Leverages validated capability with no sustainment cost.

KEY TAKE AWAYS

- Informs fielding decisions for next generation chemical protective ensembles.
- Data used to update operational TTPs.
- Operationally-relevant chemical protective test.
- First internationally accredited chemical/biological capability.
- Transition completed in less than one year (planning testing validation transition).

PATH FORWARD

- Cooperative Test and Evaluation Program Agreement drafted with UK in support of Acquisition Program testing.
- Planned additional validation for liquid agent threat to supplement vapor testing.

Additional Soldier Lethality Modernization Support

LIGHTWEIGHT STANDALONE XSAPI PLATES

The RDECOM Soldier Center completed the design and developed prototypes for Next Generation X-Small Arms Protective Inserts, or XSAPI, component development in 2018. The prototypes demonstrated potential for weight reduction in body armor with ballistic protection equal to currently fielded systems.

T-11 RESERVE AUTOMATIC ACTIVATION DEVICE

The CCDC Soldier Center is conducting tests of a prototype T11RAAD on dummy payloads. Occasionally (near once/year) a static line paratrooper encounters an issue with their main T-11 parachute but also loses situational awareness and does not deploy the T-11 reserve parachute in time to ensure it inflates and lowers the paratroopers rate of descent appropriately prior to landing on the drop zone. More typical fielded Automatic Opening Devices (AOD) for Military Free Fall (MFF) are not capable of determining an issue with a T-11 main parachute in time due to the relatively low T-11 jump altitudes. The T11RAAD consists of a set of sensors and a machine learning algorithm (Software) that has been tested in many pre-rigged malfunction scenarios. Both the hardware and software (source code) are Government-owned to help reduce anticipated future life-cycle costs. The T11RAAD testing will continue into 1QFY20 and the results will continue to be briefed to the Army Airborne Board. Currently T11RAAD requirements are being drafted by the Maneuver Center of Excellence (MCOE) for a potential FY20 program of record to be led by PM Soldier, Clothing and Individual Equipment.

EXOSKELETONS

The CCDC Soldier Center advanced & demonstrated the exoskeleton boot (i.e. "Exoboot") system, reducing physical work for Soldiers performing Infantry tasks. Understanding Man/Machine interface and user validation are critical components of a larger Exoskeleton S&T acceleration program. The potential impact of exoskeletons to improve Soldier Lethality (Warfighter reach and ability to carry fight-ending capabilities), Extend Area of Influence (carry more water, food, ammo, less re-supply), and to improve Mission Readiness (improve recovery times, reduce acute and chronic injuries), is very high.

NEXT GENERATION SQUAD WEAPON TECHNOLOGY

The CCDC Armaments Center developed a prototype cased-telescoped cartridge and weapon to increase lethality as well as increasing accuracy and shortening engagement times as part of the Next Generation Squad Weapon program, a Science & Technology effort to develop an automatic rifle and ammunition as a system with significant increase in performance using lightweight cartridge materials. This effort focuses on a higher pressure system with 6.8mm projectiles, cased telescoped cartridge, muzzle devices, and an integration kit for generation four fire control.

AIR & MISSILE DEFENSE

Air and Missile Defense is one of the Army's top modernization priorities and critical to winning in a fight against a "near-power" adversary. Air and Missile Defense, or AMD, systems will include the ability to defeat missile threats against the U.S., the deployed forces and the allies and partners.

Army AMD efforts and initiatives must continue balancing modernization with competing operational demand in order to maintain overmatch against potential adversaries. The Army AMD force is globally deployed and regionally engaged as a key strategic enabler for the joint force and the nation.

The CCDC Aviation & Missile Center leads the command's support to Army AMD modernization efforts and the AMD Cross Functional Team, with additional support from the command's Army Research Laboratory, and Armaments and C5ISR centers.

The Ballistic Low Altitude Drone Engagement system detects, tracks and defeats enemy unmanned aerial systems using an organic, low cost, low collateral damage solution.

Ballistic Low Altitude Drone Engagement

After successful demonstrations at multiple exercises, the CCDC Armaments Center is transitioning component technologies from the Ballistic Low Altitude Drone Engagement, or BLADE, to PdM Counter Rocket Artillery and Mortar's Mobile Low Slow Small Unmanned Aerial System, or UAS, Integrated Defeat System in support of a U.S. Central Command joint urgent operational need.

BLADE detects, tracks and defeats enemy unmanned aerial systems using an organic, low cost, low collateral damage solution.

VALUE TO THE ARMY

- Provides the capability to accurately detect, track, and defeat enemy UAS using a fielded weapon system.
- Provides an organic, low cost Counter UAS capability.

KEY TAKE AWAYS

- Components of the BLADE System were developed and demonstrated, using radar assets within the Counter-Rocket, Artillery and Mortar architecture.
- At multiple exercises BLADE demonstrated defeating maneuvering fixed wing and quad rotor UASs.

PATH FORWARD

- BLADE component technologies as part of MLIDS Inc 1 would go through Record Test early next year; limited rapid fielding would follow the Record Test. The BLADE STO will have a demo in Q4FY19.

Additional Air & Missile Defense Modernization Support

TUNABLE PYROTECHNICS

The CCDC Armaments Center developed and integrated technologies of nano, reactive, and advanced materials to create customizable or "tunable" family of expendable aircraft countermeasures, with a significant increase in survivability of Warfighters, aviation assets, and crew members to current and next generation missile threats. These technologies have developed and demonstrated reactive energetic technologies to replace existing products that will keep Warfighter teams safer against emerging future priority threats.

LOW-COST EXTENDED RANGE AIR DEFENSE

The CCDC Aviation & Missile Center is in the process of developing and demonstrating an air defense interceptor that is smaller and more affordable than Patriot to address proliferating threat of Subsonic Cruise Missiles and Tactical/Lethal Unmanned Aerial Systems, or UAS. The CCDC Aviation & Missile Center's efforts will provide the Army with an affordable defense against saturating raids of Cruise Missiles and Tactical/Lethal UAS, aligned to the Army's Air and Missile Defense Modernization Priority. Major technical accomplishments this year included tower testing of the interceptor seeker to verify performance in representative conditions, and successful Launch Test Vehicle flight tests to verify operation of the launcher testbed and validate predictive dynamic models. Moving forward, the center plans to conduct a Ballistic Test Vehicle flight test which will evaluate propulsion, mission computer, power system, data link, and launch control.

AERIAL THREAT DEFEAT COALITION WARFARE PROGRAM

Through the CCDC Global Technology Office, the command has partnered with the Republic of Korea to characterize Low, Slow, and Small, or LSS, aerial systems; develop an optimized warhead against LSS aerial systems; develop detection and tracking algorithms; and demonstrate the integration of the algorithms for detection and tracking into a launcher that can fire a warhead optimized to defeat the LSS aerial systems. The Warfighter will benefit from a capability that currently does not exist for detecting, tracking, exploiting and/or destroying LSS Unmanned Aerial Systems.

SCIENTIFIC DISCOVERY

CCDC maintains a keen awareness, and informing of, the current/future operating environment and associated challenges in order to provide pertinent modernized, innovative, and threat-informed technology development and engineering. The Army Science & Technology community, transitions and delivers relevant and innovative technology that enables modernized capabilities aligned with Army priorities.

As the Army's corporate laboratory, the CCDC Army Research Laboratory focuses on scientific discovery, technological innovation, and transition of knowledge products that inform and enable technology and capability development for the Warfighter.

Directed Evolution

Professor Frances Arnold won a 2018 Nobel Prize in Chemistry for research initially funded by the U.S. Army in new enzyme production that led to the commercial, cost-effective synthesis of biofuels tested on the U.S. Army Black Hawk helicopters in 2013, and are now approved by the aviation standards body for use in commercial aviation.

With a modest single investigator grant from the CCDC Army Research Laboratory in the 1990s, Arnold demonstrated the ability to modify an enzyme that provided robust native activity but at higher temperatures. Through a process of protein sequence alteration and selection, directed evolution stretches the boundaries of enzyme activity and function beyond what nature provides.

The CCDC Army Research Laboratory helped nurture this ground-breaking research, which has provided valuable tools for enhancing the creativity of biologists and engineers within the Army research enterprise and the research community at-large. The exciting Army-impactful industrial biofuel transition further validates CCDC's basic research investments.

VALUE TO THE ARMY

- New field of directed evolution creates novel enzymes producing new materials (e.g., bio-fuels, coatings, therapeutics).
- Smart decision-making by machine learning tools enables synthesis of Army-relevant chemicals.

KEY TAKE AWAYS

- Basic research program recognized by 2018 Nobel Prize in Chemistry to Prof. Frances Arnold, validating basic research investments for long-term payoff.
- New method creates enzymes to enable and control manufacturing at previously unattainable speed and precision.

PATH FORWARD

- Researchers have used this method to create biofuels tested in Blackhawk helicopters; now approved for commercial aircraft and next steps are further transitions to CCDC Aviation & Missile Center for large-scale integration in Army air assets.

Additional Scientific Discovery

HUMAN-IN-THE-LOOP REINFORCEMENT LEARNING

The CCDC Army Research Laboratory has achieved significant advances in human-in-the-loop reinforcement learning. These advancements have drastically reduced the number of examples needed for a machine learning system to learn.

This class of machine learning algorithms, loosely inspired by the brain work, provide a robot the ability to learn how to perform tasks by viewing video streams in a short amount of time with a human trainer. A human provides real-time feedback in the form of critique i.e., "good job" or "bad job" — similar to the way a person might train a dog to do a trick.

The CCDC Army Research Laboratory extended earlier work in this field to enable this type of training for robots or computer programs that currently see the world through images, which is an important first step in designing learning agents that can operate in the real world.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DIRECT SUPPORT TO ARMY READINESS

Technology is moving at a fast pace. U.S. Army scientists and engineers work hard not only to provide today's Soldiers with the latest technologies but also to anticipate what Soldiers in the future will need in a world where battles will be fought very differently.

Army Research and Development, or R&D, personnel contribute to Soldier readiness by having the scientific and technological expertise; the collaborative reach; the position within the greater science and technology community; and the organizational scale necessary to harness the R&D process and meet the Army's needs. Using these tools, the Army's R&D contributions flow along two intertwined paths: scientific and technological expertise and organizational collaboration and support.

Designed to detect the vapors emitted by chemical weapon agents, the JCAD had to be modified so that it could detect explosives — which have low vapor pressures — without losing its original functionality.

JCAD-Chemical Explosives Detector Transition

The CCDC Chemical Biological Center improved the existing Joint Chemical Agent Detector, or JCAD, in 2018, creating a modification that allows it to be used for explosives, low volatility chemicals and opioid detection.

In use for over 10 years, and with tens of thousands in service, the JCAD has long been a critical aid to the Warfighter for detecting chemical warfare agents. However, as chemical biological threats evolved the Army needed the capability to detect homemade explosives and unknown bulk explosives.

As a solution, Scientists designed a separate JCAD accessory to detect explosives which consisted of add-on pieces: a cradle with a probe swab, and an inlet. When inserted into the cradle, the JCAD is considered an M4A1 JCAD Chemical Explosives Detector, known as JCAD-CED. The JCAD-CED will also be able to detect nonexplosive compounds and pharmaceutical-based analogs — including illegal and dangerous drugs.

For now, the M4A1 JCAD-CED is a prototype. Development is ongoing with additional funding from the Joint Project Manager for Nuclear, Biological and Chemical Contamination Avoidance.

VALUE TO THE ARMY

- Adds significant new threat detection capability to the Warfighters' existing equipment.
- Reduced logistics and training burden for CBRNE Soldiers.

KEY TAKE AWAYS

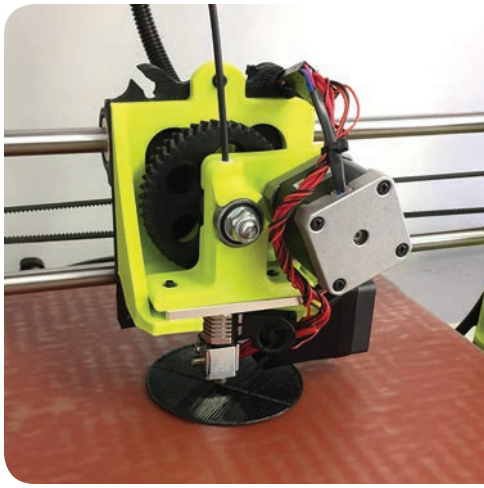
- Developed an integrated Chemical Warfare Agent and Explosives detection capability with only software upgrades and a sampling inlet adapter that can be implemented to retrofit 56,000 existing JCADs.
- Improves detection capabilities, while minimizing the logistics and training burden on the Soldier.

PATH FORWARD

- The JCAD-CED is fulfilling U.S. Special Operations Command chemical explosives detection requirements.
- The JCAD-CED will replace a legacy explosives detector with improved reliability and footprint as the units already have the JCAD vapor detector in their inventory.

Rapid Fabrication via Additive Manufacturing on the Battlefield

In 2018, the CCDC Armaments Center completed delivery of the Rapid Fabrication via Additive Manufacturing on the Battlefield, or R-FAB, system to Korea on schedule and is now conducting an operational assessment through August 2019. R-FAB is a mobile system to demonstrate emerging additive manufacturing technologies for expeditionary point-of-need use. The system was previously studied during the JWA 18.1 in Germany in May 2018, and CCDC Armaments Center engineers completed the Pacific Pathways 17.3 in Thailand and Japan in August and September 2017.



The Rapid Fabrication via Additive Manufacturing on the Battlefield (R-FAB) mobile system demonstrates the ability to use additive manufacturing for expeditionary point-of-need use.

VALUE TO THE ARMY

- Operationalizes CCDC by bringing together all CCDC elements to provide additive manufacturing technology for Warfighters at the point of need.
- Enabling 2nd Infantry Division to maintain a high readiness status, getting temporary critical parts made in hours or days instead of waiting weeks for the supply system.
- Informs Army Additive Manufacturing, or AM, Campaign Plan and future system requirements.

KEY TAKE AWAY

- Completed on scheduled delivery of R-FAB to Korea.
- Demonstrated to meet demand of printing multiple different parts simultaneously.
- Demonstrated ability to return equipment to full readiness state in hours.

PATH FORWARD

- Capability Production Document update to require expeditionary AM system.
- Continue Operational Assessment in U.S. Forces Korea to August 2019.
- Support digital thread through RAPTOR.
- Continual improvement through insertion of emerging AM technologies (polymers, metal cold spray, metal, circuit boards, energetics, etc.).

The CCDC Armaments Center received a Defense Department Value Engineering Award in June 2018 for their accomplishments in cost savings/avoidance for the Army.

Cost Savings and Avoidance through Value Engineering

Value engineering conducted by the CCDC Armaments Center resulted in $26.9M in savings/cost avoidance in 2018 for the U.S. Army.

These cost savings were realized through several programs, including the harvesting of 19-perf JA2 propellant from the M829A1 stockpile and recycling it for the production of M1028 canister rounds; modifying the 105mm M774 and M833 kinetic energy cartridges; and redesigning the meltable lifting plug to reduce the number of process steps and labor required. The Armaments Center was awarded a DoD Value Engineering award in June 2018 for its efforts.

VALUE TO THE ARMY

- The CCDC Armaments Center manages JPEO Armaments & Ammunition and Armaments Center Value Engineering program.
- Has a $10 million annual savings goal; reducing overall cost of Army materiel.
- The CCDC Armaments Center received a DoD Value Engineering award in June 2018.

KEY TAKE AWAYS

- 19-perf JA2 propellant was harvested from the M829A1 stockpile and recycled for the production of the M1028 canister rounds resulting in **$10,305,630** cost savings.
- M148A1B1 steel cartridge case is no longer in production 105mm M774 and M833 Kinetic Energy (KE) cartridges, The modified cases successfully passed all required testing to validate performance resulting in **$10,406,008** in cost savings.
- The meltable lifting plug has been redesigned reducing the number of process steps and labor required resulting in **$6,182,240.66** in cost savings.

PATH FORWARD

- The CCDC Armaments Center will continue to conduct its Value Engineering program in support of the Joint Program Executive Office Armaments & Ammunition.

Other Army Readiness Support

BATTERY SHORTAGE RESOLUTION

In 2018, CCDC C5ISR Center engineers help resolve critical shortage of Type-90 non-rechargeable and rechargeable batteries. The Type-90 series batteries are used to power over 50 different Army C5ISR and other weapon systems. CCDC C5ISR Center engineers engaged the Communications-Electronics Command and Defense Logistics Agency, or DLA, to cut more than six months off the process to requalify the BA-5590 battery, and accelerated production of the BB-2590 rechargeable and BA-5390 non-rechargeable batteries to restore DLA stocks that fell to critically low levels.

CONVERSION OF ENERGETICS TO BIOFUEL

The CCDC Armaments Center developed a process for the chemical destruction of propellant followed by recycling of constituents into biofuel by algae. The center closed a capability gap by implementing a robust, cost-effective, environmentally sound demilitarization capability to replace open burn disposal for a wide variety of propellants.

DETECTION AND AERIAL THREAT DEFEAT – COUNTER UNMANNED AERIAL SYSTEM

The CCDC Armaments Center conducted several successfully demonstrations of a Counter-Unmanned Aerial System to meet an identified capability gap of easily detecting small and high flying unmanned aerial vehicles, or UAVs, and defeating them in a cost-effective manner, as evident by the crash of an inexpensive UAV flown by North Korean that traveled undetected to southern parts of the peninsula. The CCDC Armaments Center developed an integrated systems that will demonstrate the full kill chain of detection, tracking, slewing, launch, and defeat of the low, slow and small unmanned aerial system threat. It provides an improved capability in defending an area of interest with minimal manning and equipment against UAV.

GLOBALLY ENGAGED

The U.S. Army is aware that the U.S. is no longer the sole-leader in the advancement of Science & Technology, or S&T. CCDC's forward presence allows the command to effectively build and maintain key international partnerships, Through these partnerships, the Army is able to leverage the advances of foreign, friendly nations thereby ensuring that the U.S. Army retains its decisive technological advantage on the battlefield even as S&T advancements become more widespread.

CCDC's Global Technology Office is the focal point for leading the command's global presence and ensuring its contributions are advancing the U.S. Army's S&T posture. Through this effort, CCDC maintains a direct connection between its eight major science and technology domains and three international centers, and the Combatant Commands, Army Service Component Commands, and our Foreign Allies.

The CCDC Global Technology Office leverages several mechanisms to build and maintain key international partnerships. These programs include international agreements that enable cooperative research; foreign comparative testing programs that discover and evaluate game-changing foreign technologies; engineer and scientist exchange programs that increase international cooperation among allies; and embedding science and technology advisors within commands.

These efforts keep the command and its workforce informed about technology development across the globe which ensures that the U.S. Army retains its decisive technological advantage on the battlefield even as S&T advancements become more widespread.

Impacts of International Presence

QUICK RELEASE BLAST ATTENUATION DEVICE SCIENCE ADVISOR SUPPORT

The CCDC Science Advisors in Germany identified a limitation to U.S. capabilities and through the Field Assistance in Science and Technology Request for Information process, CCDC Armament Center, developed a M121 Quick Release Blast Attenuation Device, or QRBAD, which reduces the blast effects on the mortar crew when firing the mortar in mounted mode. This re-design shortens removal time of the BAD, improves the crew's ability to shoot and move, and reduces exposure to incoming fires. Members of the U.S. Army 7th Army Training Command participated in the designs with CCDC and will be an integral part of the April 2019 field assessment.

TRUSTED OPERATION OF A ROBOTIC VEHICLE IN A CONTESTED ENVIRONMENT PROJECT AGREEMENT

CCDC and Australia have brought together their engineers to improve capabilities in the area of unmanned autonomous ground vehicles as part of a project agreement entitled Trusted Operation of a Robot Vehicle in a Contented Environment, or TORVICE. Work conducted as part of the TORVICE Project Agreement will increase the: reliability of autonomous Unmanned Ground Vehicles, or UGVs, Warfighter's confidence of UGV performance to complete mission objectives, and ability to defeat enemy UGVs which are becoming increasingly common on the battlefield.

INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE INTEROPERABILITY PROJECT AGREEMENT AND COALITION WARFARE PROGRAM

CCDC has partnered with Canadian counterparts in a project agreement and coalition warfare program focused on Intelligence, Surveillance and Reconnaissance, or ISR, Interoperability. This partnership will develop software for an open agile architecture that is based on existing constructs to allow interoperability of disparate U.S. and Canadian ISR assets to communicate and interoperate in a coalition environment. Development and testing of an open standard architecture will allow autonomous "plug-and-play" interoperability of fixed and mobile coalition ISR assets enabling the Commander for more flexible ISR options.

SOLDIER BORNE SENSOR SYSTEM FOREIGN COMPARATIVE TESTING

CCDC, PEO Soldier, and Norway are working together to assess a Soldier and Small Unit organic capability that provides a rapidly deployable sensor from a tactical position to gain actionable situational awareness and understanding. The objective is determine the effectiveness of a miniature unmanned aerial sensor for detectability and reducing risks to Soldiers while increasing overmatch.

LOOKING BEYOND 2028

The Army has charged CCDC with the critical mission to discover and innovate for Soldiers today and tomorrow. The command supports the entire materiel lifecycle; basic research feeds into our applied research and technology development that is later transitioned into capability with our acquisition community and sustained with our Life Cycle Management Commands.

As the Army looks to Army Futures Command to achieve its modernization priorities by 2028, CCDC maintains a stable balance of Science & Technology, or S&T, investments across the near, mid and far time horizons, supporting readiness now while developing technologies for the future Army.

The command works internally with other Army command and across the sister services, as well as externally with valued industry, academia and international partners. These partnerships leverage unlike minds and untapped innovation, to enhance Army capability now and into the future.

The command will continue to develop a robust method of global technology scanning to increase worldwide collaboration and research. The value of international capabilities will be enhanced to better influence opportunities for Army overmatch against adaptive adversaries. The Army will leverage its armament community, science advisors, and researchers to develop robust collaborative partnerships with foreign universities, governments and industries to ensure a balanced global posture that strengthens our alliances, assist in humanitarian efforts, and bolsters economic prosperity.

To maintain a strategic technological advantage against our adversaries we must continue our focus on basic research. A balance of S&T investments and strategic partnerships enable CCDC to keep the technology pipeline full, from initial discoveries to upgrades for equipment already in the field.

The past year has seen many changes for CCDC, and more will come, but the fundamentals of how the command supports the U.S. Warfighter will not change. The Army will continue to need people to dig into science to find the answers to the problems it faces — and CCDC will continue to discover and develop the capabilities that empower, unburden and protect U.S. Soldiers.

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