

The logo for the Army Research Laboratory (ARL) features the letters 'ARL' in a bold, white, sans-serif font. The 'A' is stylized with a yellow and black graphic element above it. The logo is set against a black background that is part of a larger, curved, yellow and black graphic element on the left side of the page.

ARL

**Army Research Laboratory
Technical Strategy
2015-2035**

EXECUTIVE SUMMARY

The Army Research Laboratory (ARL) has developed an overarching technical strategy, envisioned to support Strategic Land Power Dominance for the Army of 2030 and beyond, which is based on eight subordinate S&T campaigns; namely, *Extramural Basic Research*, *Computational Sciences*, *Materials Research*, *Sciences-for-Maneuver*, *Information Sciences*, *Sciences-for-Lethality and Protection*, *Human Sciences*, and *Assessment and Analysis*. These subordinate campaigns are structured to foster discovery, innovation, and transition of technologies leading to Power Projection Superiority, Information Supremacy, Lethality and Protection Superiority, and Soldier Performance Augmentation for Strategic Land Power Dominance.

In concept, *focused campaigns* – in Sciences-for-Maneuver, Information Sciences, Sciences-for-Lethality and Protection, and Human Sciences – act in concert with cross-cutting campaigns to provide a robust S&T framework that is geared towards overcoming the technological challenges to the future Army's Strategic Land Power Dominance. Each of these focused campaigns is centered around technical emphasis areas which concentrate on the systematic application of knowledge to develop useful materials, devices, systems, methods, or analyses; thereby translating promising basic research and knowledge into solutions. These emphasis areas were specifically chosen to focus on critical challenges that arise in the extreme operational and threat environment in which the Army performs. Simultaneous with the generation of technological products, knowledge and understanding gleaned in these emphasized areas are used to improve assessment and analysis methodologies and leveraged to help influence requirements for future Army systems.

Knowledge products and technologies generated as a result of ARL's Technical Strategy will enable revolutionary capabilities available to the commanders of the Army of 2030 and that offer the Commander-in-Chief options across the geopolitical landscape.

The Army Research Laboratory's Technical Strategy Leading to Strategic Land Power Dominance for the Army of 2030 and Beyond

The United States Army of 2030 will operate in a rapidly changing environment, hitherto unparalleled in complexity. Developing trends and the dynamics of the Army's future operational environment suggest that the Army's land power dominance will demand an increased speed of responsiveness, mechanisms to mitigate or wholly eliminate tactical surprise, a capability to effectively accommodate changing alliances and partnerships, and proficiencies across a myriad of functional domains. Strategic land power dominance will be critical to the U. S. Army's capability to conduct prompt, sustained, and synchronized operations with a force customized to the mission and poised to prosecute both combat and noncombat missions in all functional domains – air, ground, maritime, space, and cyberspace.

Future land power dominance will heavily rely on significant science and technology (S&T) advances. Particularly in support of Power Projection Superiority, Information Supremacy, Lethality and Protection Superiority, and Soldier Performance Augmentation, as these areas will serve as the technological cornerstones that ensure the Army's control of the battlespace. Exploitation of emerging S&T discoveries, innovations, and transition of developments in these critical areas will enable *a ready, robust, regionally engaged, expeditionary, globally responsive, and mission-tailored Army force that is uniquely positioned to shape events in peace, prevent, and rapidly end conflict at the speed at which it unfolds*. Through preventing conflict, shaping the operational environment, and winning the nation's wars, the future Army – America's principal land force – will provide future commanders with decisive land power across the range of military operations in the homeland and abroad.

Power Projection Superiority, Information Supremacy, Lethality and Protection Superiority, and Soldier Performance Augmentation are essential to the future Army's strategic land power dominance. Additionally, S&T advances in these areas will be critical in helping to streamline today's Army into an agile, adaptable, lethal, and resilient force with a greatly reduced tooth-to-tail structure possessing capabilities far superior to those of today's force.

Power Projection Superiority, *focused on agile deployment and positioning of Army forces to ensure global responsiveness, will*

- Increase the number of platform options available to future commanders.
- Restore the strategic responsiveness to deter conflict.

Information Supremacy, *focused on limiting tactical surprise and improving situational awareness, will*

- Enable decentralized and distributed information and systems to fully facilitate mission command.
- Enable greater situational understanding and decision superiority.
- Enable decisive offensive cyber domain operations at the tactical edge.

Lethality and Protection Superiority, *focused on substantial improvements in firepower and efficient protection systems, will*

- Provide precision fires that overcome anti-access and area denial threats.
- Provide renewable directed energy weapons with limitless munition availability.
- Provide lightweight, cost effective protection for vehicles and the dismounted warfighter.

Soldier Performance Augmentation, *focused on substantial enhancements to warfighter physical, cognitive, and perceptual performance, will*

- Greatly shorten the time required to grow leaders.
- Accelerate knowledge, judgment, and experience transfer to empower junior leaders.
- Enable over match through increased cognitive capacity that turns data into decisions faster.

The U. S. Army Research Laboratory (ARL) – the Army’s corporate research laboratory – is pursuing discoveries, innovations, and transition of technological developments that are geared towards acting upon opportunities in power projection, information, lethality and protection, and Soldier performance. As a guide towards the technological possibilities in these areas, ARL has developed eight S&T campaigns, depicted in figure 1; namely, Extramural Basic Research, Computational Sciences, Materials Research, Sciences-for-Maneuver, Information Sciences, Sciences-for-Lethality and Protection, Human Sciences, and Assessment and Analysis. Each of these campaigns is designed to explore, better understand, mature, and exploit S&T developments leading to Power Projection Superiority, Information Supremacy, Lethality and Protection Superiority, and Soldier Performance Augmentation that are essential to the future Army.

Extramural Basic Research is focused on steering and oversight of systematic studies to increase fundamental knowledge and understanding in the Physical Sciences, Information Sciences, Life Sciences, and Engineering Sciences related to long-term national security needs.

Computational Sciences is focused on advancing the fundamentals of Predictive Simulation Sciences, Data Intensive Sciences, Computing Sciences, and emerging Computing Architectures to transform the future of complex Army applications.

Materials Research is focused on fundamental research for scientific discovery and innovative problem-solving to provide superior materials and devices needed to achieve lasting strategic land power dominance through Structural Materials, Electronics, Photonics, Energy and Power, Biotechnology and Bioinspired, High Strain and Ballistic Materials, and Manufacturing Science, Processing and Sustainment.

Sciences-for-Maneuver is focused on gaining a greater fundamental understanding of advanced mobility systems and their supporting architectures – critical to the future Army’s movement, sustainment, and maneuverability through Energy and Propulsion, Platform Mechanics, Platform Intelligence, and Logistics and Sustainability.

Information Sciences is focused on gaining a greater understanding of emerging technology opportunities that support intelligent information systems that perform acquisition, analysis, reasoning, decision-making, collaborative communication, and assurance of information and knowledge through Sensing and Effecting, System Intelligence and Intelligent Systems, Human and Information Interaction, Networks and Communications, and Cyber Security.

Sciences-for-Lethality and Protection is focused on gaining a greater understanding of emerging technologies that support weapon systems, protection systems, and the mechanisms

of injury affecting the warfighter through Lethality Research for Soldiers and Army Platforms, Protection Research for Soldiers and Army Platforms, and Battlefield Injury Mechanisms.

Human Sciences is focused on gaining a greater understanding of individual physical, perceptual, and cognitive performance through Human-Physical Interface, Human-Human Interface, and Human-Technology Interface.

Assessment and Analysis is focused on supporting evaluators, PMs, and decision makers; modernizing the Army's capabilities in engineering-level analyses of technologies and systems; and leveraging those strengths to create fundamentally new capabilities through Assessment of Science and Technology, Science and Technology of Assessment, Assessing Mission Capability of Material, and Material Capable of Assessing Mission Capability.

Conceptually, the tandem arrangement of Extramural Basic Research, Computational Sciences, and Materials Research – working in conjunction – provides ARL with a strong foundation from which the research directions of the Sciences-for-Maneuver; Information Sciences; Sciences-for-Lethality and Protection; and Human Sciences Campaigns are guided.

The *Sciences-for-Maneuver; Information Sciences; Sciences-for-Lethality and Protection; and Human Sciences* Campaigns are each focused around technical emphasis areas which concentrate on the systematic application of knowledge to develop useful materials, devices, systems, or methods; thereby translating promising basic research into solutions for broadly defined Army needs, short of system development. These emphasis areas were specifically chosen to focus on critical challenges that arise in the extreme operational and threat environment in which the Army operates. Simultaneous with the generation of technological products from these emphasis areas, knowledge and understanding gleaned in these emphasized areas is used to improve our Assessment and Analysis capabilities.

ARL's focused campaigns – in *Sciences-for-Maneuver, Information Sciences, Sciences-for-Lethality and Protection, and Human Sciences* – act in concert with our cross-cutting campaigns to provide a robust S&T framework that is geared towards overcoming the technological challenges to the Army's Strategic Land Power Dominance.

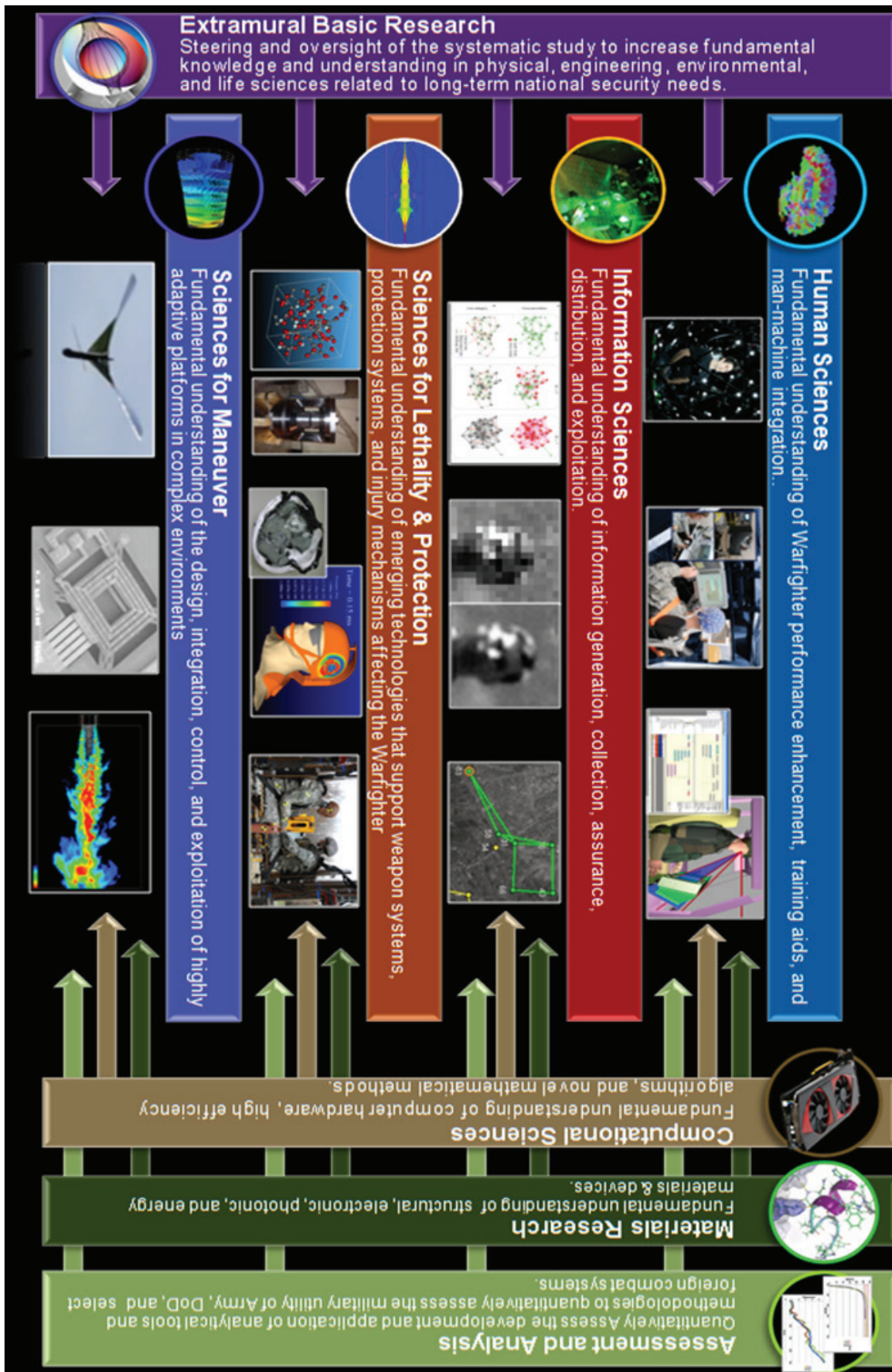


Figure 1. ARL's S&T Campaign Framework for Strategic Land Power Dominance in the Army of 2030 and beyond. Extramural Basic Research, Computational Sciences, Materials Research, and Assessment and Analysis, ARL's four cross-cutting campaigns, act in concert with four focused campaigns in Human Sciences, Information Sciences, Sciences-for-Lethality and Protection, and Sciences-for-Maneuver leading to knowledge products and technologies that facilitate the U. S. Army's Strategic Land Power Dominance in 2030 and beyond.

EXTRAMURAL BASIC RESEARCH CAMPAIGN

ARL's Extramural Basic Research Campaign is focused on identifying, forming, driving, and transitioning innovative research discoveries in the Physical Sciences, Information Sciences, Life Sciences, and Engineering Sciences that are critical to the U.S. Army's future technological superiority. This campaign concentrates on high-risk and high-payoff transformational basic research that is expected to have revolutionary impacts on the Army's warfighting capabilities. In addition to significantly improving the Army's existing warfighting capabilities, it creates disruptive and game-changing new technologies for the Army, while also preventing technological surprises from potential adversaries.

VISION: Discoveries and innovations made with our academic and industrial partners are infused into the Army's S&T laboratory portfolio to provide a robust foundation for technical advances ensuring the Army's technological edge. High relevance discoveries and innovations are strongly leveraged by the Army's S&T laboratory enterprise to achieve capabilities far beyond the state-of-the-art. Discoveries and innovations made through collaborative efforts are essential in maintaining the land power dominance of the Army of 2030 and beyond.

MISSION: To steer and oversee Army-relevant technical programs executed by ARL's academic and corporate partners in the engineering, physical, information and life sciences; and develop and exploit innovative advances to ensure the Nation's technological superiority. Discoveries and innovations generated through these programs – primarily embodied as knowledge products – are leveraged as the foundation for future Army technologies.

The Extramural Basic Research Campaign provides critical underpinning support to all of the other ARL Campaigns, feeding new ideas and concepts into those campaigns, and also providing key connections with world-class extramural researchers to perform collaborative research with ARL's scientists and engineers. Additionally, when unique and important opportunities exist, research is also supported with industry partners, not-for profit organizations, other research organizations, and international researchers.

This campaign utilizes a set of complementary instruments to optimally engage and collaborate with the extramural research community. The principal vehicles are the Single Investigator (SI) program, the Multidisciplinary University Research Initiative (MURI), Collaborative Technology/Research Alliances (CTAs/CRAs), and University Affiliated Research Centers (UARCs). Explicitly,

- The SI program provides modest-sized grants to individual university faculty focused on highly innovative new concepts; one-third of these grants are re-competed annually, resulting in an agile and responsive program to exploit high promise, new concepts.
- The MURI program supports 5-year research efforts on topics that have the potential for accelerated advancement from a focused and cohesive multidisciplinary approach.
- The CTA/CRA research consortia – *composed of ARL, other Army Laboratories, industry, and academia* – are focused on the rapid transition of innovative technologies to address evolving warfighter needs and supported by large-sized investments for potentially longer periods.
- The UARCs are large, sustained investments in several highly focused fundamental research areas that are expected to have major and direct impacts on Army technologies. These programs are designed to provide a critical number of personnel in each area; and provide dedicated facilities that are shared between the academic partners and ARL researchers ensuring close collaborations while assisting in the transition of technology developments.

ARL's Extramural Basic Research Campaign is focused on the Physical Sciences, Information Sciences, Life Sciences, and Engineering Sciences. External research efforts in these areas are strongly linked to ARL's in-house research portfolio through the myriad of transition vehicles, including collaborative research in many cases. Discoveries and innovations made in extramural basic research will exert a significant impact on the Army of the future.

Physical Sciences is focused on basic research to discover, understand, and exploit physical phenomena which are expected to create revolutionary capabilities for the Army of 2030 and beyond. Discoveries in this area are expected to lead to capabilities in communications and materials well beyond classical limits that restrict the performance of current Army systems.

Life Sciences is focused on basic research to discover, understand, and exploit biological systems that are expected to create revolutionary capabilities for the Army of 2030 and beyond. Discoveries in this area are expected to lead to capabilities in materials and Soldier performance augmentation, well beyond the limits facing today's Army.

Information Sciences is focused on basic research to discover, understand, and exploit the mathematical, computational, and algorithmic foundations that are expected to create revolutionary capabilities for the Army of 2030 and beyond. Discoveries in this area are expected to lead to capabilities in materials, the information domain, and Soldier performance augmentation, well beyond the limits facing today's Army.

Engineering Sciences is focused on basic research to discover, understand, and exploit new material systems, mechanical systems, electronics, and photonics that are expected to create revolutionary capabilities for the Army of 2030 and beyond. Discoveries in this area are expected to lead to capabilities in materials, the sciences for maneuver, the information domain, the sciences of lethality and protection, and Soldier performance augmentation, well beyond the limits facing today's Army.

Discoveries and innovations leading to technologies that support and help to shape Land Power Dominance in the Army of 2030 and beyond will transition via two principal pathways. Primarily, promising technologies will transition to the warfighter through the Army S&T laboratory enterprise including the Army Research Laboratory (ARL) and its Army Research, Development, and Engineering Center (RDEC) partners within the Army Research, Development, and Engineering Command (RDECOM) including Communications-Electronics Research, Development, and Engineering Center (CERDEC); Natick Soldier Research, Development, and Engineering Center (NSRDEC); Tank Automotive Research, Development, and Engineering Center (TARDEC); Aviation and Missile Research, Development, and Engineering Center (AMRDEC); Armaments Research, Development, and Engineering Center (ARDEC); and Edgewood Chemical Biological Center (ECBC). Integrated technology solutions matured through these partnerships will transition to the Army of 2030 via our stakeholders.

In addition, promising technologies will transition to the warfighter through our industrial partnerships whereby novel concepts are embodied as field-ready materiel solutions, and also through transitions through the countries' other R&D organizations.

COMPUTATIONAL SCIENCES CAMPAIGN

ARL's S&T investments in Computational Sciences are focused on advancing the fundamentals of predictive simulation sciences, data intensive sciences, computing sciences, and emerging computing architectures to transform the future of complex Army applications. Gains made through these underpinning multidisciplinary research efforts and exploiting emerging advanced computing systems will lead to scientific breakthroughs that are expected to have significant impact on Army materiel systems. Technologies resulting from this multidisciplinary research collaboratively with other ARL S&T campaign innovations will have a significant impact on Power Projection Superiority, Information Supremacy, Lethality and Protection Superiority, and Soldier Performance Augmentation for the Army of 2030.

VISION: Computational science and the applications of advanced computing technologies will accelerate the United States Army's strategic land power dominance through critical research developments. Strategic and transformative developments in Computational Science will poise the Army of 2030 and beyond as the world's dominant land force. The desired end state is to leverage the full range of S&T enablers to position the Army to excel in distributed operations and increasingly complex operational environments.

MISSION: To discover, innovate, and transition S&T capabilities that (1) harness the potential of computational sciences and emerging high-performance computers (HPC) to maintain the superiority of Army materiel systems through predictive modeling and simulation technologies; (2) facilitate information dominance, distributed maneuver operations, and human sciences through computational data intensive sciences; and (3) significantly increase and tailor advanced computing architectures and computing sciences technologies on the forefront to enable land power dominance.

Computational Sciences uses advanced computing to understand and overcome complex fundamental challenges simultaneous to improving approaches of importance to the Army including weapon systems design; materials-by-design; information dominated and networked battle command applications; system-of-systems analyses; human performance modeling; platform maneuverability; and tactical supercomputers. There are natural synergies among the challenges facing Computational Sciences and ARL's other S&T campaigns. Synergistic advances across all campaigns are expected to enable next generation scientific breakthroughs. The Computational Sciences Campaign heavily relies on ARL's research expertise and facilities devoted to emerging advanced computing architectures, mobile High Performance Computing (HPC), multi-scale and interdisciplinary predictive simulation sciences, multi-dimensional distributed data analytics, and computing sciences. Discoveries and innovations made in this area will exert a significant impact on the Army of the future.

ARL's Computational Sciences Campaign builds on fundamental pillars of mathematics, computer engineering, computer science, electronics engineering, algorithm engineering, and software design to conduct research in areas including *Advanced Computing Architectures; Advanced Algorithms; and Modeling and Simulation Technology.*

Disruptive discoveries leading to new Army capabilities are facilitated by key enablers. Key enablers which foster discovery within ARL's Computational Sciences Campaign include scalable algorithms; model order reduction techniques; data intensive computing; and adaptive

visual analytics. Recent discoveries in these technical areas are instrumental in charting the course of future research at ARL.

These foundational pillars and key enablers strongly support the Computational Sciences Campaign to provide an adaptive, agile, and Army-relevant program devoted to addressing significant S&T challenges for Army critical applications. The areas of emphasis include Predictive Simulation Sciences; Data Intensive Sciences; Computing Architectures; and Computing Sciences.

Predictive Simulation Sciences concentrates on understanding and exploiting the fundamental aspects of verified and validated computational simulations that predict the response of complex Army systems and guide Army materiel design, particularly in cases where routine experimental tests are extremely difficult to conduct or not feasible.

Data Intensive Sciences focuses on understanding and exploiting the fundamental aspects of large-scale, multi-dimensional data analytics. Experiments, observations, and numerical simulations are on the verge of generating petabyte-quantities of data. These massive amounts of data are distributed across disparate locations and pose a challenge in providing real-time analytics that support U. S. military operations.

Computing Architectures concentrates on understanding and exploiting the fundamental aspects of hardware and associated system software for emergent and future computing architectures for mobile, scientific, and data intensive applications. Computing systems include both mobile and fixed/virtual architectures optimized for fast communications, low power consumption, large hierarchical memory, novel and robust algorithms, high resiliency, and HPC networking.

Computing Sciences concentrates on understanding and exploiting the fundamental aspects of computer science research related to ease of programming, computing environments, languages, and reusable programming models for Army specific applications.

Discoveries and innovations leading to technologies that underpin US Army of 2030 Strategic Land Power Dominance and beyond will transition from ARL via two principal pathways. Primarily, promising technologies will transition to the warfighter through our Army Research, Development, and Engineering Center (RDEC) partners within the Army Research, Development, and Engineering Command (RDECOM) including Natick Soldier Research, Development, and Engineering Center (NSRDEC); Aviation and Missile Research, Development, and Engineering Center (AMRDEC); Armaments Research, Development, and Engineering Center (ARDEC); Tank Automotive Research, Development, and Engineering Center (TARDEC); Edgewood Chemical and Biological Command (ECBC); and Communications-Electronics Research, Development, and Engineering Center (CERDEC). Integrated technology solutions matured through these partnerships will transition to the Army of 2030 via our stakeholders including PEO Soldier; PEO Ground Combat Systems (GCS); PEO Aviation; and PEO Combat Support and Combat Service Support (CS&CSS).

In addition, promising technologies will transition to the warfighter through our industrial partnerships whereby novel concepts are embodied as field-ready materiel solutions.

MATERIALS RESEARCH CAMPAIGN

The Materials Research Campaign focuses on fundamental research for scientific discovery and innovative problem-solving to provide superior materials and devices needed to achieve lasting strategic land power dominance. Materials research cross-cuts ARL's four focused S&T campaigns by providing materials with superior properties to address emerging requirements and capabilities for all Army platforms, with emphasis on Structural Materials; Electronics; Photonics; Energy and Power; Biological and Bio-inspired Materials; Lethality and Protection Materials; and Manufacturing Science, Processing and Sustainment.

VISION: Discovery and unparalleled innovation of devices and Materials By-Design and On-Demand across all Army domains. Understand, exploit, and demonstrate diverse material sets with exceptional quality and capabilities relevant to the Army of 2030 via advances in manufacturing science. The desired end state is to enable the Army of 2030 to succeed in distributed operations and increasingly complex environments through realization of superior materials.

MISSION: Perform fundamental interdisciplinary research in materials and manufacturing science to ensure rapid and affordable development of materials, from discovery to delivery, critical to the Army of 2030.

The Army of 2030 will require materials with unprecedented capabilities that can be rapidly grown or synthesized, and processed cost-effectively to enable Army platforms that are highly mobile, information reliant, lethal, and protected. The Materials Research Campaign addresses the future Army's need to rapidly respond to emerging threats and to eliminate tactical surprise – *caused by the proliferation of advanced technology to our adversaries* – by creating a materials by-design and on-demand enterprise; and a manufacturing science engine to ensure rapid progression from materials discovery to delivery, with the goal of producing materials in greatly reduced timeframes and at a fraction of the cost compared to today.

ARL's Materials Research Campaign builds on fundamental pillars of materials science, physics, mathematics, computational chemistry, synthetic chemistry, biology, and engineering to conduct research in areas including *Advanced Experimental Techniques; Modeling and Simulation; Bridging the Scales* – a Materials-by-Design paradigm; *Material Property Characterization* to measure materials properties and performance to inform the research community across the scales; and *Growth or Synthesis and Processing* – a Materials-on-Demand paradigm.

Key enablers are emphasized which are expected to lead to disruptive discoveries yielding new Army capabilities. Discovery enablers include biological and bio-inspired materials; metamaterials; two-dimensional and nanoscale materials; and multi-functional and hierarchical materials. Recent scientific emphasis areas that promise disruptive capabilities include quantum science – *to alter time, space, and information processing*; coupling energy fields to matter – *to create new materials and selectable system responses with vast performance improvements*; and interfacial science – *from which many key Army capabilities are enabled*. Recent discoveries in these scientific areas are setting the course of future ARL research.

Strongly supported by these foundational pillars and key enablers, the Materials Research Campaign is flexible, agile, and Army-relevant, striving to address cross-cutting S&T challenges for Army critical applications. The areas of emphasis include Structural Materials; Electronics; Photonics; Energy and Power; Biotechnology and Bio-Inspired; Lethality and Protection; and Manufacturing Science, Processing, and Sustainment.

Structural Materials is focused on novel and specialized materials to enhance the structural efficiency and systems performance of advanced platform structures while maintaining the same or greater levels of protection compared to today's platforms.

Electronics is focused on specialized electronic materials and devices to achieve Army dominance over the entire electromagnetic spectrum, particularly in contested environments. The two primary thrusts of this area are Energy Efficient Electronics and Hybrid Electronics. Energy Efficient Electronics is focused on low-power-demand electronic components having increased performance capabilities; and Hybrid Electronics focuses on high performance, conformable, and flexible electronics for advanced sensors and processors.

Photonics is focused on materials and devices for photonic sensors and sources; scalable high energy lasers; secure communications via quantum networking; and protection of sensors and human eyes against high power and short pulse laser threats.

Energy and Power is focused on materials and devices for more efficient power generation; energy storage; energy harvesting; fuel processing; micropower; and novel alternative energy solutions at lower cost.

Biotechnology and Bio-Inspired is focused on new biological materials derived through synthetic biology as well as classical approaches. Novel biological materials are combined with inorganic devices to sense chemical and biological agents; generate power from organic sources; and produce materials to create new protection designs inspired by nature.

High Strain Rate and Ballistic Materials is focused on novel and specialized materials to enhance the performance and efficiency of Army weapons and protection systems including lightweight, extreme performance materials; novel energetic materials; and energy absorbing materials.

Manufacturing Science, Processing, and Sustainment is focused on discovery, innovation, and maturation of manufacturing innovations to facilitate agile, adaptive, mobile processing and manufacturing capabilities to enable superior performance and implementation of cost reduction methodologies. Sustainability is focused on understanding material properties and degradation mechanisms to improve durability of Army systems in extreme environments.

Discoveries and innovations leading to technologies that support and help to shape Land Power Dominance in the Army of 2030 and beyond will transition from ARL via two principal pathways. Primarily, promising technologies will transition to the warfighter through our Army Research, Development, and Engineering Center (RDEC) partners within the Army Research, Development, and Engineering Command (RDECOM) including Natick Soldier Research, Development, and Engineering Center (NSRDEC); Aviation and Missile Research, Development, and Engineering Center (AMRDEC); Tank Automotive Research, Development, and Engineering Center (TARDEC); and Communications-Electronics Research, Development, and Engineering Center (CERDEC); and Edgewood Chemical Biological Center (ECBC). Integrated technology solutions matured through these partnerships will transition to the Army of 2030 via our stakeholders including PEO Soldier; PEO Ground Combat Systems (GCS); PEO Aviation; PEO Combat Support and Combat Service Support (CS&CSS); and the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD).

In addition, promising technologies will transition to the warfighter through our industrial partnerships whereby novel concepts are embodied as field-ready materiel solutions.

SCIENCES-FOR-MANEUVER CAMPAIGN

ARL's S&T investments in Sciences-for-Maneuver are focused on gaining a greater fundamental understanding of advanced mobility systems and their supporting architectures – critical to the future Army's movement, sustainment, and maneuverability. Knowledge gained through these research efforts will lead to technological developments that make it possible to design, fabricate, integrate, control, and support platforms which will have a direct impact on Power Projection Superiority for the Army of 2030.

VISION: Air and ground platforms available to commanders of the Army of 2030 are designed and built that make it possible to rapidly respond to emerging conflicts at any location around the globe. Based on vastly improved materials, logistical support needs of the fighting force are greatly reduced. A globally responsive, lethal, and resilient force serves as a significant deterrent to rising conflict. The desired end state is to leverage the full range of S&T enablers to prepare forces to succeed in distributed operations and increasingly complex environments.

MISSION: To discover, innovate, and transition S&T enabled capabilities that significantly increase the force effectiveness and global responsiveness of the Army - America's primary ground force.

ARL's Sciences-for-Maneuver Campaign builds on fundamental pillars of physics, mechanical engineering, and electronics engineering to conduct research in areas including *Robotics; Intelligent Platforms; and Collaborative Autonomy.*

Key enablers are emphasized which are expected to lead to disruptive discoveries yielding new Army maneuver capabilities. Discovery enablers include adaptable mobile platforms; advanced world view technologies; and advanced peer-to-peer communication architectures. Recent discoveries in these scientific areas are setting the course of future ARL research.

The Sciences-for-Maneuver Campaign is strongly supported by these foundational pillars and key enablers to provide a flexible and adaptive approach which is geared towards addressing S&T challenges to Army Power Projection Superiority. The emphasis areas include Energy and Propulsion; Platform Mechanics; Platform Intelligence; and Logistics and Sustainability.

Energy and Propulsion concentrates on understanding and exploiting the applications of energy generation, storage, conversion, and management. The goal of this research is to provide energy and power applications to enhance Army operational effectiveness, improve efficiency, and accelerate development of critical military platform systems ensuring Army Power Projection superiority.

Platform Mechanics focuses on fundamental research that enables the development of the highly maneuverable platforms for the Army of the future.

Platform Intelligence focuses upon fundamental research that enables effective teaming of Soldiers and robots to conduct maneuver and military missions. ARL's activities are centered upon enhancing the autonomous capabilities of unmanned systems.

Logistics and Sustainability focuses on fundamental research to enable the rapid and reliable assessment of future Army platform reliability, health, and usage.

Knowledge gained in the Energy and Propulsion; Platform Mechanics; Platform Intelligence; and Logistics and Sustainability emphasis areas are expected to impact a wide array of vehicle systems including the ground, air, and maritime domains, across a wide range of platform sizes – from micro- to macro-scales.

Discoveries and innovations leading to technologies that support and help to shape Power Projection Superiority in the Army of 2030 and beyond will transition from ARL via two principal pathways. Primarily, promising technologies will transition to the warfighter through our Army Research, Development, and Engineering Center (RDEC) partners within the Army Research, Development, and Engineering Command (RDECOM) including Natick Soldier Research, Development, and Engineering Center (NSRDEC); Aviation and Missile Research, Development, and Engineering Center (AMRDEC); Tank Automotive Research, Development, and Engineering Center (TARDEC); and Communications-Electronics Research, Development, and Engineering Center (CERDEC). Integrated technology solutions matured through these partnerships will transition to the Army of 2030 via our stakeholders including PEO Soldier; PEO Ground Combat Systems (GCS); PEO Aviation; and PEO Combat Support and Combat Service Support (CS&CSS).

In addition, promising technologies will transition to the warfighter through our industrial partnerships whereby novel concepts are embodied as field-ready materiel solutions.

INFORMATION SCIENCES CAMPAIGN

ARL's S&T investments in Information Sciences are focused on gaining a greater understanding of emerging technology opportunities that support intelligent information systems that perform acquisition, analysis, reasoning, decision-making, collaborative communication, and assurance of information and knowledge. Understanding gained through these research efforts will lead to technological developments that make it possible to manage and utilize information flows in the battlespace. Technologies resulting from these efforts will have a direct impact on the Information Supremacy of the Army of 2030.

VISION: Intelligent information systems available to the Army of 2030 provide reliable, timely, valuable, and trustworthy information and knowledge at the most appropriate force echelon, especially to the tactical edge – significantly mitigating tactical surprise. Army offensive information systems significantly limit the adversary's command-and-control capabilities. Intelligent information systems support and team with the force, forming an underlying socio-technical base for all things in the battlespace, from munitions targeting to maneuver to command-and-control. The desired end state is to leverage the range of S&T enablers to prepare forces to succeed in distributed operations and increasingly complex environments where information plays an ever increasing role.

MISSION: To discover, innovate, and transition S&T capabilities that (1) facilitate the availability and effective use of high assurance and high quality information and knowledge at the tactical edge in a timely manner; and (2) facilitate the development of offensive information systems to limit adversary command-and-control capabilities.

ARL's Information Sciences Campaign builds on fundamental pillars of networks; advanced decision support aids; modeling and simulation of complex environments; and high performance computing to conduct research in areas including *Intelligent Agents; Enhanced Tactical Networks; Effective Decision Support Aids; Knowledge Exploitation; and Cyber Defense and Forensics.*

Key enablers are emphasized which are expected to lead to disruptive discoveries yielding new Army capabilities. Discovery enablers include Quantum Information Science; non-linear control theory; and advanced mobile computing architectures. Discoveries in these scientific areas will substantially impact the course of future ARL research.

The Information Sciences Campaign is strongly supported by these foundational pillars and key enablers to provide a flexible, adaptive, and Army-relevant approach which is geared towards addressing S&T challenges to Army information supremacy. The emphasis areas include Sensing and Effecting; System Intelligence and Intelligent Systems; Human and Information Interaction; Networks and Communications; and Cyber Security.

Sensing and Effecting research concentrates on understanding and exploiting information gained through sensing and exploiting data to drive effectors. Both sensing and effecting necessitate detailed understanding of corresponding physical behaviors

that generate and utilize data, as well as effective means for storage, retrieval, and manipulation of data.

System Intelligence and Intelligent Systems research concentrates on understanding and exploiting interactions between information and intelligent systems, such as robots and software agents, wherein information is transformed between different levels of abstraction and roles within the intelligent system's cognitive processes – recognition, reasoning, predictions, and decision-making.

Human and Information Interaction research concentrates on understanding and exploiting interactions between information and humans, which involves complex mixed-initiative processes of information acquisition, transformation between levels of abstraction and relevance, comprehension, negotiation, and interactive tasking – mutually between humans and Army information systems.

Networks and Communications research concentrates on understanding and exploiting information's interactions with socio-technical networks, particularly communications, and command and control networks, both formal and social. Such interactions are heavily influenced by complex channels and protocols requiring complex analyses to understand and predict emergent behaviors of networks.

Cyber Security research concentrates on understanding and exploiting interactions of information with cyber attackers – human and/or intelligent agents. These interactions involve friendly operations against adversary information systems and networks, defense of friendly information systems and networks, and assurance of persistent information support to Soldiers even when parts of the friendly systems and networks are compromised.

Discoveries and innovations leading to technologies that support and that are expected to help to shape Information Supremacy in the Army of 2030 and beyond will transition from ARL via two principal pathways. Primarily, promising technologies will transition to the warfighter through our Army Research, Development, and Engineering Center (RDEC) partners within the Army Research, Development, and Engineering Command (RDECOM) including Communications-Electronics Research, Development, and Engineering Center (CERDEC); Natick Soldier Research, Development, and Engineering Center (NSRDEC); Tank Automotive Research, Development, and Engineering Center (TARDEC); and Aviation and Missile Research, Development, and Engineering Center (AMRDEC).

Integrated technology solutions matured through these partnerships will transition to the Army of 2030 via our stakeholders including PEO Soldier; PEO Enterprise Information Systems (EIS); PEO Ground Combat Systems (GCS); PEO Intelligence Electronic Warfare and Sensors (IEW&S); and PEO Missiles and Space; PEO Command, Control and Communications-Tactical (C3T). In addition, promising technologies will transition to the warfighter through our industrial partnerships whereby novel concepts are embodied as field-ready materiel solutions.

SCIENCES-FOR-LETHALITY AND PROTECTION CAMPAIGN

ARL's S&T investments in Sciences-for-Lethality and Protection are focused on gaining a greater understanding of emerging technologies that support weapon systems, protection systems, and the mechanisms of injury affecting the warfighter. Knowledge gained through these research efforts will lead to technological developments that make it possible to develop a broad array of lethality systems as well as resilient vehicle protection systems. In addition, knowledge gained from understanding injury mechanisms will be leveraged to develop robust systems. Technologies resulting from these efforts will have significant impact on the Lethality and Protection Superiority of the Army of 2030.

VISION: Lethality systems available to commanders of the Army of 2030 are precise, long range, and highly mobile. Protection systems are light weight, low burden, affordable, and resilient towards a broad array of threats. A fundamental understanding of injury mechanisms is exploited for a safer, more effective force. A globally responsive, lethal, and resilient force serves as a significant deterrent to rising conflict. The desired end state is to leverage the range of S&T enablers to provide forces with the right lethality at any place and time without increased warfighter risk and warfighter protection against the continuum of threats without degrading combat power.

MISSION: To discover, innovate, and transition S&T capabilities that (1) facilitate the development of discriminant lethality across a broad range of missions; (2) facilitate the development of protection systems that are effective, fieldable, and affordable against a broad array of threats; and (3) enable robust technical tools and methodologies for evaluation and combat decision aids.

Fundamental research efforts in the Sciences-for-Lethality and Protection Campaign are targeted at achieving seven overriding functional goals including

- *Mobile protected fire power for expeditionary forces.*
- *Desired effects at standoff ranges for moving targets in access denied environments.*
- *Soldier protection with zero impact on effectiveness.*
- *Adaptive weapon systems empowering the Soldier/Squad to focus on the fight.*
- *Completely reversible human effects in any situation.*
- *Robust, reliable weapons/platform evaluation at significantly reduced cost.*
- *Robust tools for battle damage assessment and combat decision aids.*

These goals are strongly supported by research in technology areas – containing fundamental building blocks and scientific advances through which innovation is realized. Combinations of existing and innovative technologies are brought together through partnerships to realize disruptive system advances. All of these advances are driven by overcoming key learning and technical challenges required to enable disruption for the Army of 2030. Some challenges are:

- Understanding the interaction of extreme fields with matter.
- Understanding the controlling mechanisms of human ballistic injury and performance.
- Understanding the relationship between aerodynamics and algorithms for navigation and environment constraints including measurement/processing/flight time/GPS denied.
- Understanding robust, reliable, and recoverable non-lethal mechanisms to shut down or dissuade humans.

- Understanding the coupling of physical phenomena – mechanical, electro-magnetic, and biological – across the range of military interest.
- Understanding and discovery of very high energy storage mechanisms and controlled release on desired timescales.
- Understanding the fundamental aspects of frequency agile, high-energy, and short pulse laser interaction with organic, biological, and inorganic materials.

The Sciences-for-Lethality and Protection area is focused on gaining a fundamental understanding of armor, under body, scalable effects, electronic warfare, and human injury mechanisms. This area heavily relies on ARL's research expertise and facilities in terminal effects; impact physics; weapons physics, guidance and aerodynamics; and ballistic vulnerability. Discoveries and innovations in this campaign are expected to exert a significant impact on the Army of the future by greatly enhancing lethality, protection, and commensurately mission effectiveness.

The Sciences-for-Lethality and Protection technical emphasis areas include Lethality Research for Soldiers and Army Platforms; Protection Research for Soldiers and Army Platforms; and Battlefield Injury Mechanics.

Lethality Research for Soldiers and Army Platforms concentrates on understanding and exploiting the fundamental aspects of launch and control; electronic attack; directed energy mechanisms; and target effects.

Protection Research for Soldiers and Army Platforms concentrates on understanding and exploiting the fundamental aspects of protection against ballistic threats; directed energy threats; and CBRNE threats.

Battlefield Injury Mechanics concentrates on understanding and exploiting the fundamental aspects of human combat injury mechanisms.

Discoveries and innovations leading to technologies that support and help to shape Lethality and Protection Superiority in the Army of 2030 and beyond will transition from ARL via two principal pathways. Primarily, promising technologies will transition to the warfighter through our Army Research, Development, and Engineering Center (RDEC) partners within the Army Research, Development, and Engineering Command (RDECOM) including Armaments Research, Development, and Engineering Center (ARDEC); Natick Soldier Research, Development, and Engineering Center (NSRDEC); Aviation and Missile Research, Development, and Engineering Center (AMRDEC); Tank Automotive Research, Development, and Engineering Center (TARDEC); Communications-Electronics Research, Development, and Engineering Center (CERDEC); and Edgewood Chemical Biological Center (ECBC). Integrated technology solutions matured through these partnerships will transition to the Army of 2030 via our stakeholders including PEO Soldier; PEO Missiles and Space; PEO Ground Combat Systems (GCS); PEO Intelligence Electronic Warfare and Sensors (IEW&S); and PEO Ammunition (Ammo).

In addition, promising technologies will transition to the warfighter through our industrial partnerships whereby novel concepts are embodied as field-ready materiel solutions.

HUMAN SCIENCES CAMPAIGN

ARL's S&T investments in Human Sciences are focused on gaining a greater understanding of individual physical, perceptual, and cognitive performance in the context of interface with the environment; other individuals and groups; technology; and information. Additionally, the behavior of groups – ranging in scale from small teams to societies and cultures – is of particular interest. Understanding gained through these efforts will lead to technological developments that are expected to vastly improve Soldier-system performance and training effectiveness.

VISION: The Army of 2030 maximizes the effectiveness of Soldiers physically, perceptually, and cognitively. Small units are capable of operating effectively and efficiently in social-cultural contexts around the globe. The desired end state is to leverage the full range of S&T enablers to poise forces to succeed in distributed operations and increasingly complex environments.

MISSION: To discover, innovate, and transition S&T capabilities to (1) understand and improve individual and small unit performance across the full range of military operations; (2) empower leaders with enhanced cognitive capabilities to make sound decisions quickly; and (3) enable expeditionary forces to use knowledge of societal and cultural issues and social cognitive networks to shape the operational environment.

Human sciences are those scientific disciplines whose central objects of study are the phenomena that cause, shape, or result from the behaviors of humans, including their actions, their interactions with each other, and their interactions with the physical world. The Human Sciences Campaign is focused on humans as part of a larger, dynamic system and how humans *interface* with other elements of the system. Elemental *interfaces* of particular interest are the physical environment – including the brain/body relationship within the individual; other humans through one-to-many and one-to-one dynamics; and technology including materiel and information.

Innovations developed as part of the Human Sciences Campaign are expected to enhance warfighter physical capabilities by balancing load, improving protection, and enhancing performance. Further, aided and augmented sensory systems matched to individual capabilities and tuned to the operational environment are expected to significantly impact warfighter situational awareness. In addition, knowledge gained in this campaign is expected to facilitate the efficient management of warfighter cognitive load to ensure high proficiency in Army-relevant environments. Warfighter interactions with intelligent systems will be guided by principles derived from brain and behavior fundamental research – a cornerstone of the Human Sciences Campaign. More, applications of these technologies and methodologies in the full range of social and cultural environments – *based on an understanding of networked communications, relationships, and dynamics across diverse social structures* – are expected to be important in poising the Army of 2030 to quickly shape its operational environment.

ARL's Human Sciences Campaign builds on fundamental pillars of sociology, biology, physiology, and psychology to conduct research in areas including *Trust and Influence; Small Unit Dynamics and Performance; and Learning and Training Technology.*

Key enablers are emphasized which are expected to lead to disruptive discoveries yielding new Soldier Physical, Perceptual, and Cognitive capabilities. Discovery enablers

include adaptive training modules; realistic virtual human avatars; and mobile brain imaging. Discoveries in these scientific areas will substantially impact the course of future ARL research.

Strongly supported by these foundational pillars and key enablers, the Human Sciences Campaign is flexible and agile with an eye towards addressing S&T challenges for Army critical applications. The areas of emphasis include Human-Physical Interface; Human-Human Interface; and Human-Technology Interface.

Human-Physical Interface fundamental research focuses on better understanding the relationship between the brain and the body, and interactions with the physical environment. Fundamental understanding gained in genetics and genomics; molecular biology; and human biochemistry and their impacts on brain structure-function coupling are expected to be essential in augmenting warfighter performance. Physical-cognitive interactions – especially in the operational environment – are expected to influence warfighter behavior; learning and decision making; and multisensory perception.

Human-Human Interface fundamental research is focused on better understanding one-to-one, one-to-many, and many-to-many interactions. The focus of this area is on providing and evaluating effective personnel training, leader development, and team building through fundamental understanding and enhancement of motivation, physical resilience, cognitive resilience, and trust. Understanding and exploitation of the fundamental aspects of social networks dynamics; organizational structure optimization; and ethics, values, trust, social-cultural, economic, and geopolitical effects are expected to be critical in influencing group dynamics and performance.

Human-Technology Interface fundamental research is focused on understanding how humans interact with materiel and information. Fundamental research areas of interest include ergonomics and biomechanics to increase Soldier performance while simultaneously minimizing injury probability; physical augmentation to improve physical load management; wearable and implantable systems and devices for protection and for medical applications; and brain-computer interactions dedicated to understanding and enhancing cognitive performance and protection against cognitive harm.

Discoveries and innovations leading to technologies that support and help to shape Soldier Performance Augmentation in the Army of 2030 and beyond will transition from ARL via two principal pathways. Primarily, promising technologies will transition to the warfighter through our Army Research, Development, and Engineering Center (RDEC) partners within the Army Research, Development, and Engineering Command (RDECOM) including Natick Soldier Research, Development, and Engineering Center (NSRDEC); Aviation and Missile Research, Development, and Engineering Center (AMRDEC); Tank Automotive Research, Development, and Engineering Center (TARDEC); Communications-Electronics Research, Development, and Engineering Center (CERDEC); Armaments Research, Development, and Engineering Center (ARDEC); and Edgewood Chemical Biological Center (ECBC). Integrated technology solutions matured through these partnerships will transition to the Army of 2030 via our stakeholders including Office of the Deputy Chief of Staff for Personnel (G-1); PEO Soldier; PEO Simulation; Training and Instrumentation (STRI); PEO Enterprise Information Systems (EIS); the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI); and the U.S. Army Medical Research and Materiel Command (USAMRMC).

In addition, promising technologies will transition to the warfighter through our industrial partnerships whereby novel concepts are embodied as field-ready materiel solutions.

ASSESSMENT AND ANALYSIS CAMPAIGN

ARL's investments in Assessment and Analysis have three aims – supporting evaluators, Program Managers (PMs), and decision makers; modernizing Army's capabilities for the laboratory's historic strengths in engineering-level analyses of technologies and systems; and leveraging those strengths to create fundamentally new capabilities. Accomplishing these aims will position ARL to lead the Army to the RDT&E solutions that will be demanded by technological and strategic realities, the evolution of which will only continue to accelerate.

VISION: Army decisions about technology investments, weapon systems acquisition, and operational employment are founded on rigorous, transparent technical bases that take account of the full DOTMLPF spectrum, the breadth of adversaries' potential actions and countermeasures, and the ultimate consequences in terms of our forces' effectiveness in completing their missions. The desired end state is that comparable analytical capabilities are built into materiel and fielded to operational units, allowing Soldiers to employ swiftly and decisively emerging Army systems.

MISSION: To discover, innovate, and transition S&T capabilities that (1) improve the technologies being developed to meet critical and Army-unique needs; (2) provide decision makers and Soldiers with accurate and detailed awareness of materiel's capabilities; and (3) link the institutional and operational forces by means of a powerful shared toolset that simplifies and improves their decision making.

ARL's Assessment and Analysis Campaign is focused on guiding the development and integration of technologies, substantially broadening the range of issues that can be addressed with analytical rigor, improving the throughput and responsiveness of the analytical processes, and developing ruggedized and ready-to-employ applications that make the full power of the laboratory's internal analysis capabilities available directly to the Army's operational force. This campaign builds on fundamental pillars of physics, materials science, mechanical engineering, mathematics, and chemistry to conduct analyses in areas including *Ballistic Susceptibility; Electronic Warfare; and Materiel Failure*.

Key enablers are emphasized which are expected to lead to disruptive analytical methods to support development of new Army materiel capabilities. Enablers include intelligent systems; cyber security; information sciences; human sciences; materials; and lethality and protection.

Strongly supported by these foundational pillars and key enablers, the Assessment and Analysis Campaign is highly rigorous with a focus on addressing vulnerability and susceptibility challenges to development of Army-critical materiel systems. The areas of emphasis include Assessment of Science and Technology; Science and Technology of Assessment; Assessing Mission Capability of Materiel; and Material Capable of Assessing Mission Capability.

Assessment of Science and Technology concentrates on understanding the costs and benefits of R&D efforts, their readiness levels, risks, potential payoffs, and integration challenges.

Science and Technology of Assessment concentrates on understanding the key types of analytical problems likely to confront the Army of 2030, exploiting the latest

developments by our academic and industrial partners, and performing basic and applied research to develop the powerful new tools required.

Assessing Mission Capability of Materiel concentrates on understanding and exploiting systems' technologies, design, and employment together with current – and likely future – state of the art developments to optimize future designs and to inform evaluation and acquisition decisions with analyses that are both technically sound and practically efficient. Key to this effort, are methodologies to integrate technical assessments into the science and engineering domain with considerations of mission effectiveness for the materiel's operational user.

Materiel Capable of Assessing Mission Capability concentrates on understanding and exploiting developments in the other S&T campaigns to evolve assessment and analysis itself from a laboratory service to a technology that we transition to the warfighter.

The transitions from ARL arising from the Assessment and Analysis Campaign occupy several distinct value chains. Assessments and analyses performed as a laboratory service will transition to our stakeholders and partners including Office of Secretary of Defense (DOT&E and ASD(DT&E)), Department of Army (ASA(ALT), DUSA(TE)), Army Test and Evaluation Command (ATEC), Army Materiel Systems Analysis Activity (AMSAA), TRADOC Analysis Center (TRAC), and all Army PEOs; as well as through our Army Research, Development, and Engineering Center (RDEC) partners within the Army Research, Development, and Engineering Command (RDECOM) including Natick Soldier Research, Development, and Engineering Center (NSRDEC); Armaments Research, Development, and Engineering Center (ARDEC); Aviation and Missile Research, Development, and Engineering Center (AMRDEC); Tank Automotive Research, Development, and Engineering Center (TARDEC); Edgewood Chemical and Biological Command (ECBC); and Communications-Electronics Research, Development, and Engineering Center (CERDEC).

Assessment technologies and capabilities that are developed into ready-to-employ products are expected to transition to the RDECs as well as partners in the Army analysis community (AMSAA, ATEC, TRAC, and the Center for Army Analysis). Technologies and the associated methodologies that enable systems to reason about their mission capabilities will be transitioned to all of the relevant RDECs and to the warfighter through our industrial partnerships whereby novel concepts are embodied as field-ready materiel solutions.

SUMMARY

The U.S. Army Research Laboratory (ARL) – the Army’s corporate research laboratory – traces its lineage back to the Watertown Arsenal, established in 1820 as the Army’s first scientific research facility. As the Army Materiel Command’s (AMC) single corporate laboratory and the Army Research, Development, and Engineering Command’s (RDECOM) fundamental research laboratory, ARL concentrates on scientific discovery, innovation, and transition of technological developments. The S&T program is building on this proud legacy by driving the discoveries and innovations which will be critical to realizing new capabilities for the Army of 2030 and beyond.

The overarching goal of the ARL Technical Strategy is to provide the vision, key technical focus areas, and principal transition pathways which are essential in assuring the continued strategic land power dominance of the United States Army. This technical strategy is focused on exploring, better understanding, maturing, and exploiting S&T developments leading to Power Projection Superiority, Information Supremacy, Lethality and Protection Superiority, and Soldier Performance Augmentation –*the technological cornerstones that will ensure the future Army’s dominance of its operational environment.*

ARL’s Technical Strategy highlights a coordinated and synchronized S&T campaign framework guiding the essential S&T efforts that will provide the future Army with the capabilities to conduct prompt, sustained, and synchronized operations with a force customized to the mission and poised to prosecute both combat and noncombat missions in all functional domains – air, ground, maritime, space, and cyberspace. Central to this construct are eight S&T campaigns focused on:

- ***Extramural Basic Research***
- ***Computational Sciences***
- ***Materials Research***
- ***Sciences-for-Maneuver***
- ***Information Sciences***
- ***Sciences-for-Lethality and Protection***
- ***Human Sciences***
- ***Assessment and Analysis***

As a capstone document, the ARL Technical Strategy provides a top-level view of high-impact S&T areas. Additional detail on the S&T campaigns can be found in the Army Research Laboratory S&T Campaign Plans.



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