14 May 2015

INFORMATION PAPER

SUBJECT: Training and Doctrine Command's (TRADOC) Science and Technology (S&T) Technology Imperatives

1. **Purpose**. To provide an overview of TRADOC's S&T Technology Imperatives for Force 2025 and Beyond (F2025B).

2. **Facts**. S&T is a critical enabler that will help us to achieve the capabilities required for F2025B and fulfill the Army Operating Concept objective of winning in a complex world. This document establishes TRADOC's priorities and informs the efforts of the S&T community. The technology imperatives below and associated technology candidates are the result of extensive collaboration among TRADOC HQ, the TRADOC Centers of Excellence, and the S&T community. Additional input derives from presentations and analytical discussions at the most recent Mad Scientist Conference hosted by TRADOC G-2, ARCIC, and Georgetown University School of Continuing Studies. The imperatives serve to focus S&T efforts to align with future capability needs. These imperatives are largely enduring, but continue to adapt and evolve for the ever-changing operational environment and emerging Warfighter needs.

3. **Technology Imperatives for the Mid-term (present to 2025).**

a. Grow Adaptive Army Leaders, Optimize Human Performance. The Army must optimize the performance of each Soldier, Civilian, and team to meet future challenges. This will require better integration of current and maturing developments, and exploitation of emerging areas of human performance science to accelerate development; improve cognitive and physical performance; improve social and interpersonal capabilities; improve health and stamina; improve human-machine interface; and improve talent utilization. Human performance science and research in the field of naturalistic decision making can be leveraged to develop junior leaders with the judgment and "experience" of far more senior leaders, and enable them to build cohesive, resilient, effective, and ethical organizations. TRADOC assesses the following as promising in achieving this objective:

(1) Army Leadership for 2025. The Army needs innovative methods to develop leader skills in mentoring, climate setting, and strategic thinking. These technologies will optimize the capabilities of smaller units by increasing battlefield intuition, military judgment, and decisionmaking.

(2) The Future Holistic Training Environment (Live/Synthetic). Exploit immersive full-spectrum training tools that enable Soldiers to train anytime and anywhere using embedded capabilities on real equipment, allowing us to maintain "training overmatch" in a fiscally constrained environment.

(3) Sustain and Improve Cognitive Vigilance and Physical Performance. Explore approaches such as personalized medicine to exploit biomarkers, machine cognition to help compress decision cycles for human operators, and research in sleep and nutritional supplements to enable improved Soldier performance in extended operations. Example technologies include psychometric tools (e.g., physiological sensors, neuro-imaging, and neuro-sensors) to optimize human performance.

b. Maximize Demand Reduction and Improve Reliability. The demand for Army forces is expected to increase despite potential force structure and budgetary reductions. The Army must retain combat power and maximize the combat potential of its formations. Technologies that increase the reliability, maintainability, and resiliency of vehicles and other systems reduce the demand, reduce the logistical footprint, and reduce manpower requirements. These include robotic technologies which can be easily deployable, modular systems designed to augment the force and reduce support demands. TRADOC assesses the following as promising in achieving this objective:

(1) Reduction. Technologies that reduce or eliminate manpower requirements while sustaining capability will become critical. The Survey Modernization effort is a good example. This effort combines affordable systems that autonomously provide position, location, and orientation for artillery assets in a GPS-denied environment. This system could be used to eliminate a military occupational specialty, thus reducing formations by several hundred Soldiers and nearly a hundred vehicles.

(2) Robotic and Autonomous systems/Manned-Unmanned Teaming. Leveraging the success achieved with autonomous aerial platforms, these technologies offer similar opportunities for ground-based systems across all warfighting functions. Robotic and autonomous systems can be employed to augment human capabilities, enhance force structure, and mitigate risk to Soldiers. Autonomous ground-based resupply is a good example of such an application.

(3) Operational Energy. Technologies that increase the energy efficiency of our platforms, devices, and equipment will extend operational endurance and aid in reducing energy logistics requirements. Intelligent power management systems will enable leaders to monitor energy use, eliminate waste, distribute power effectively, and ensure critical systems have access to power in times of limited availability. Development of alternative power sources, energy harvesting technologies, and high-density energy storage will reduce energy transportation and distribution requirements without impacting mission requirements.

c. Maintain Overmatch. The Army requires innovative approaches that retain or improve the core operational advantages of Army forces. TRADOC assesses the following as promising in achieving this objective:

(1) Position, Navigation and Timing (PNT). Affordable technologies that ensure access to PNT information in GPS degraded or otherwise denied environments.

(2) Mobile Protected Precision Firepower. Technologies that augment the ballistic protection of combat vehicles against emerging threats, providing both soft and hard kill capability, offsetting advances in threat lethality without increasing vehicle weight, and that possess scalable precision firepower. Also critical are those technologies that will facilitate the integration of unmanned ground combat systems into manned formations (manned-unmanned teaming) to extend the operational reach and increase the capability and agility of units.

(3) Extended Range Fires. Affordable technologies such as the Low Cost Extended Range Missile that deliver increased precision and effects at extended ranges in all operational environments.

(4) Lethality and Effects. Technologies that focus on developing munitions, platforms, sensors, targeting, and mission command systems that provide the commander ability to overmatch the enemy while employing lethal and nonlethal force with precision and discrimination.

(5) Network Protection. Overmatch analysis highlights the critical importance of network protection/information assurance. Technologies contributing to a cloud-based intelligence enterprise architecture enable our ability to operate more effectively and protect the information environment by preventing adversaries from degrading, disrupting, or interdicting data.

d. Conduct Expeditionary Maneuver. Unprecedented levels of connectedness increase the speed at which events unfold and the range of their effects. Rapidly developing situations, combined with anti-access and area denial strategies require an increasingly CONUS-based Army to be capable of rapid global response. Our forces will deploy to multiple austere points of entry and pose the enemy with multiple dilemmas. The future Army must possess strategic mobility, enhanced survivability, discriminant lethality, combined arms capacity, and logistical supportability. TRADOC assesses the following as promising in achieving this objective:

(1) Extend Operational Reach and Agility. Advanced rotorcraft and strategic mobility technology initiatives to modernize the current fleet, deploy the force more rapidly, and increase operational reach and agility. These technologies must enable improved range, speed, payload, and performance in all conditions while increasing aircraft survivability and enable the employment of optionally manned aircraft and manned-unmanned teaming.

(2) Expeditionary Maneuver. Technologies that enable simultaneous force projection, entry, protection, and sustainment in austere and denied environments. This will enable us to close the seam between forcible entry and follow-on forces, ensuring sustained momentum to seize, retain, and exploit the initiative.

(3) Demand Reduction. Technologies that provide alternate sources of water and production at the point of need, such as water from air, reuse, and distribution technologies will reduce the sustainment and transportation structures required today. Improved reliability, fuel efficiency, reduced ammunition bulk, and vehicle weight reduction are other promising areas to reduce the size of the logistical footprint. Reduction of the logistical footprint is critical to improve unit self-sufficiency and operational agility, allowing redistribution of manpower.

(4) Lightweight Materials. Technologies that produce materials with improved specific strength, toughness, and ballistic resistance-to-weight ratios contribute to a more expeditionary Army by improving system performance, increasing deployability, and reducing sustainment footprints. Lighter materials will reduce Soldier burden, increase system mobility, improve system reliability, availability, and maintainability (RAM), and reduce sustainment demand of ground vehicles. These improvements include retaining or improving protection in all ground combat vehicles.

(a) Reducing Weight of Vehicle Components. Over the next decade, ground vehicle components are on track to achieve a significant reduction in weight, and in some cases volume reductions. These component weight reductions equate to moderate percent weight savings for the base vehicle before adding armor.

(b) Reducing Weight of Armor. Protective armor materials must be improved to reduce the weight of armored volumes and account for advances in adversary ballistic capabilities. These weight reductions will improve system performance and mobility; reduce deployment, employment, and sustainment footprints; increase RAM; and reduce sustainment demand. Threshold reductions for future fighting vehicles should be no less than 15-20 percent (~55 tons) with an objective reduction of 40-50 percent (~35-40 tons). Optimally this should be achieved within the next decade to enable a new start combat platform best designed for the operational demands and challenges anticipated over the 30-plus years after fielding.

(c) Reducing Total Vehicle Weight. Maximizing weight reduction of the vehicle as a system will require prioritization across component and subsystem design optimization, advanced material manufacturing and design optimization and balancing tradeoffs in weight, performance, and affordability. Advances realized in vehicle armor will also favorably impact the performance and deployment, employment, and sustainment footprints of the vast majority of the ground vehicle fleet.

e. Continuously Upgrade, Protect and Simplify the Network. A resilient, simplified and protected network, specifically resistant to cyber attacks, is critical to providing Soldiers and leaders with relevant information at the point of need at speed of war. The network must be integrated as a common operating environment across the Army. TRADOC assesses the following as promising in achieving this objective:

(1) Intelligence Enterprise Architecture. Critical enabling technologies for distributed Processing, Exploitation, and Dissemination, Plus Analysis, such as the

Intelligence Community Cloud, enable expeditionary intelligence and mission command by 2025. These technologies will also provide a single global security architecture and common operational picture for cyberspace that is essential to overcoming growing cyber threats.

(2) Cyber, Communications, Intelligence, and Electronic Warfare Convergence. Promising hardware and software technologies exist to fuse communications, intelligence, and electronic warfare capabilities into a common cyber capability enabled by upgrades to tactical networking waveforms. These technologies may allow increased network user capacity, dynamic unit re-tasking, and improved performance in spectrum-contested environments.

(3) Mission Command on the Move. Technologies that allow commanders to remain mobile without giving up mission command capability will increase the agility, speed, discrimination and effectiveness of units at all levels.

f. Medical Sciences. Critical focus areas include enhanced prosthetics, improved casualty evacuation and treatment at the point of injury, prevention and treatment of traumatic brain injury. Continued investment in medical sciences allows improved Soldier resiliency, quicker physical and mental healing, smoother integration back into society, and improved quality of life for the Soldier. TRADOC assesses the following as promising in achieving this objective:

(1) Enhanced Combat Casualty Care. This suite of advanced medical technologies improves survival from the point of injury through en-route care to life saving care, while reducing the size of the in-theater medical/trauma care footprint. Potential technology candidates include endovascular stabilizing capabilities, blood products that will be used for resuscitation, hemorrhage control; burn wound repair/scar mitigation, and a portfolio of medical equipment that will provide life support to casualties during ground and aeromedical patient evacuation.

(2) Infectious Disease Countermeasures. Infectious disease is a significant cause of hospitalization of U.S. military personnel in theater. Medical countermeasures developed to prevent infectious disease will enhance unit readiness and Soldier performance. Prevention of disease through vaccination will substantially reduce the prevalence of disease non-battle injury. Potential technology candidates include vaccine for drug resistant malaria, dengue and leishmaniasis, diarrheal diseases, and chemotherapeutic drugs and vector control measures.

(3) Optimize Health and Performance. Incorporates new technologies pushed forward on the battlefield to small units, battalion aid stations, Forward Surgical Teams, and combat Support Hospitals to enable more accurate decisions about treatment, return to duty, and evacuation for mild traumatic brain injures (mTBI) and post-traumatic stress disorder (PTSD). Included in this capability is the development of therapies, and resilience strategies, to improve recovery from TBI and PTSD. There is an ongoing development for the use of biomarkers that will provide rapid diagnosis of PTSD in

austere environments. Also included is optimizing mental acuity during continuous and sustained military operations. Potential technology capabilities include concussion dosimetry, far forward brain function assessment and diagnostics, recovery nutritional supplements, synthetic biological enhancement technologies, human performance optimization to develop physical, social and cognitive overmatch, and physiologic status monitoring and leader tools.

4. **Imperatives for Far-term (beyond 2025).** The technology imperatives above support the force of 2025 and set conditions to significantly improve the Army in the far-term. TRADOC has developed S&T lines of effort (LoEs) to provide a clear and concise articulation of the capabilities needed to fundamentally change the force in the far-term. The Army requires expeditionary technology-driven capabilities allowing rapid deployment of scalable, power projection forces on short notice. These forces must be capable of deploying to austere locations to conduct the full range of military operations immediately upon arrival, often in persistent anti-access/area denial environments against a determined and capable adversary. Below are TRADOC's recommended LoEs to guide delivery of the capabilities for this period:

a. Mobile Protected Platforms. To enable a globally-responsive force that is rapidly deployable, the Army must significantly reduce the weight and volume of combat vehicles. This can be achieved through the use of lighter materials and novel protection systems that protect against both kinetic and non-kinetic future threats. These vehicles will be augmented by unmanned vehicles and unmanned aerial systems.

b. Improved Lethality and Effects. The Army requires munitions, platforms, and mission command systems that enable detection, identification and engagement of threats with precise, scalable and tailorable effects. Army forces must be capable of delivering both kinetic and non-kinetic effects, in a contested environment and in all conditions.

c. Logistics Optimization. In order to have an expeditionary capability to fight in a contested environment, the Army must increase logistical efficiencies, increase unit self-sufficiency, and decrease logistical demand.

d. Aviation. The future Army requires aviation assets with extended reach, increased lethality and responsiveness, capable of operating in all environments and conditions. The future Army will depend on its aviation assets to rapidly deliver decisive combat power to austere points of need. This demands aviation assets with increased speed, and a significant increase in range; upgrading older platforms will not be sufficient to provide these capabilities.

e. Cyber Electromagnetic Activities. Commanders and staffs must integrate and synchronize cyberspace operations, electromagnetic spectrum management operations and related capabilities in a contested environment.

f. Accelerated Data to Decision. The future demands that our Soldiers be empowered with situational awareness and understanding to make rapid decisions by accelerating the flow of information to the point of need. This must be done without increasing the Soldier's cognitive burden; necessitating more effective user interfaces such as heads-up displays to replace traditional radios and handsets.

g. Human Performance Enhancement. The Army must maximize the return on its Soldiers. The future requires Soldiers have enhanced cognitive, physical and socio-cultural skills to be effective in the complex environment in which they will operate.

h. Robotic and Autonomous Systems. The Army needs affordable, interoperable, and autonomous unmanned systems to enable integrated manned-unmanned teaming. These systems will serve as force multipliers across all echelons and war fighting functions. Artificial intelligence capabilities will be critical to empower unmanned systems and serve as decision aids.

5. **Technology First Principles**. In the development of new technologies it is critical to ensure those technologies adhere to the following foundational principles to maximize their utility to the Warfighter:

a. Emphasize integration of technology with Soldiers and teams.

b. Simplify systems and integrate Soldier training into design.

c. Maximize reliability and reduce life cycle costs.

d. Design redundant systems that improve effectiveness under conditions of uncertainty.

e. Develop systems that degrade gracefully.

f. Maintain foundational knowledge to reduce the opportunity for surprise.

g. Reduce logistical demands.

h. Anticipate enemy countermeasures.

i. Ensure interoperability.

j. Consider scale and organizational implications.

6. **Supporting Documents.** This information paper represents an overview of the significant effort undertaken by the Capability Developer S&T community over the past 18 months to include the Mad Scientist Conference 2015. It was developed in coordination with: TRADOC's Centers of Excellence; Combined Arm's Center – Training; U.S. Army Health Readiness Center of Excellence; and the ARCIC Human

Dimension Division. Each organization developed a memorandum that articulates S&T needs and identifies technology efforts they have reviewed which begin to exemplify some of the capability desired. These are posted on an AKO site we established at https://www.us.army.mil/suite/files/44634244.