U.S. ARMY

WHITE SANDS MISSILE RANGE
BIRTHPLACE OF AMERICA'S MISSILE & SPACE ACTIVITY

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MISSILE RANGE NEW MEXICO

2046 STRATEGIC PLAN

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Cover: (main) The Indirect Fire Protection Capability Multi-Mission launcher fires an AIM-9X Sidewinder missile during a test at White Sands Missile Range. IFPC is a system in development that will allow the use of many different missile systems from one launcher, allowing a Soldier to select the right weapon for the target, and will also be integrated with Army Integrated Air and Missile Defense allowing the system to be directly controlled through a single unified air defense network. (Credit: WSMR PAO); (bottom, left to right) Soldier with the 82nd Airborne 2nd Brigade Combat Team, participates in Network Integration Evaluation 16.1 exercises at White Sands Space Harbor, Sept. 2015 (Credit: WSMR PAO); Air Launch Cruise Missile testing at the High Altitude Electromagnetic Pulse (HEMP) Facility Dec. 2015 (Credit: WSMR PAO); WSMR Rancher's Day guests visit Mastodon Site, Sept. 2014 (Credit: WSMR PAO).

Inside Cover: (front) A tactical vehicle with the 82nd Airborne, 2nd Brigade Combat Team, involved in Network Integration Evaluation 16.1 exercises at White Sands Space Harbor, Sept. 2015 (Credit: WSMR PAO); (back) Soldiers participating in NIE 16.2 exercises near Ft. Bliss, Apr/May 2016 (Credit: WSMR PAO).

WSMR 2016-2046 STRATEGIC PLAN

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LETTER FROM LEADERSHIP

DELIVERING TOMORROW'S READINESS

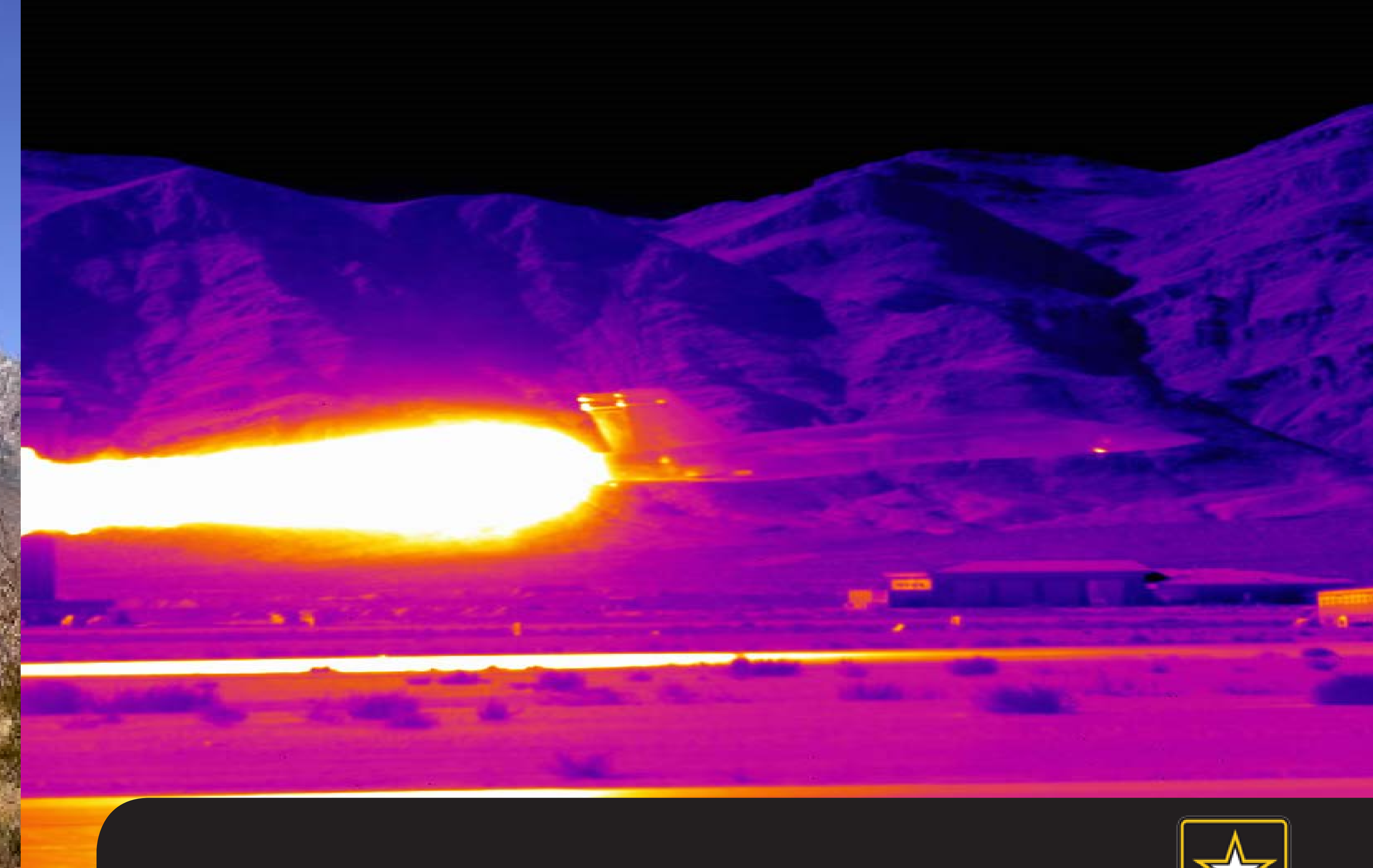
Every day, I see the men and women of White Sands Missile Range do amazing things to provide our joint warfighters with a decisive edge wherever they serve. The professionalism, commitment and dedication of our workforce to the military, civilians, and their families bearing the burdens of war are truly impressive. We are proud that during the last decade of conflict, WSMR has done more for the test/training arena than at any time since its inception sixty-five years ago.

The United States faces a rapidly changing global security environment that is volatile, unstable and increasingly threatening to our interests. We are entering a new era of evolving threats and advancing technologies that are on par with our existing warfighter capabilities. DoD is developing Third Offset Strategies to maintain the competitive edge over our adversaries while sustaining a leaner, more agile Army, Navy and Air Force. These changes in strategic technologies, concepts and guidance; along with continued reduced resources will mandate various adjustments in our operations and infrastructure. It is time for WSMR to closely scrutinize and reexamine how we do business and how to adapt to face future challenges within this dynamic environment. This plan will help guide our command in its pursuit of that objective.

The plan starts with a "Vision Vignette" to show and excite the reader on how the Range will function in 2046, followed by an "Executive Summary" and my "Commander's Assessment." The assessment identifies the drivers/requirements for the desired end state in 2046, and battlespace of today. The section titled "Future State, Recommended Actions and Roadmaps" lays out the future state of each goal/action and a roadmap to reach the future state. Finally, the document concludes with a top-level "Concept of Operations for Execution of Strategic Plan," the way to implement the strategies described. Additional information on many of these sections can be found in the digital appendices hosted on the WSMR public website.

This Strategic Plan will help reshape the way we do business now and set the foundation for monthly reviews to measure our progress. The Plan is a living document and will be updated periodically to reflect changing conditions. Your comments for improvement will also be included as we move forward. Deliberate change is essential if our command is to do its part in ensuring that the Military Services remain the most capable force that the world has ever known. This plan guides WSMR to deliver tomorrow's readiness.

Timothy R. Coffin
Brigadier General, U.S. Army
Commanding General



WSMR VISION VIGNETTE

At dawn October 1, 2046, the sleek, autonomous, hypersonic air defense missile screamed from its launcher and streaked into the heavens. Within seconds, the weapon acquired the swarm of targets from off-board sensors communicating through the satellite network. This missile was designed for extreme lethality to any intruder: airplane, drone, hypersonic strike weapon, nap-of-the-earth cruise missile, short- or long-range ballistic missile, surface combatants and space threats. This morning, Artificial Intelligence (AI) Central Processing Unit dispatched its warhead in a process called "MIE'ing" (Multiple Intercept Engagements), exterminating a swarm of ten drones, but not before the swarm made an unexpected maneuver during the final phase of the flight that, in turn, prompted an associated action in the missile prior to warhead release.

The swarm control drone had been confused when a blackbody radiator on the side of Salinas Peak coincided with solar glint, causing it to execute the automated ground-to-air missile avoidance maneuver. By merging meteorological data with advanced digital terrain elevation data (DTED), our Environmental Data Group provided information that confirmed the source of confusion. This sequence of events showed that WSMR's environment data characterization, along with other range information, was critical for our customers' decision-making processes and validation of their models and simulations.

The expansive gypsum dunes of nearby White Sands National Monument were momentarily illuminated in the predawn semi-darkness, from ten small bursts as the swarm targets were destroyed. Having been prepared and monitored by an extraordinary team, the hypersonic air defense system exceeded expectations. At White Sands Missile Range, this complex orchestration of threats, advanced AI interceptor and data collection instrumentation, is just another day at the office here at the world's most sophisticated open-air test facility.

More impressive than the outcome of the test, was how rapidly and easily the demanding scenario was planned and executed. The week prior, our customer delivered illustrated specs of their requirements via three-dimensional holographic messaging, clearly communicating their primary test objectives to the test office. Using automated systems, WSMR test personnel executed all the required test preparations and the Master Planning system almost instantaneously reserved airspace, land space, routed resources and de-conflicted the necessary electromagnetic spectrum for the event. Our system pre-coordinated evacuations and roadblocks, contacted our regional partners to ensure situational awareness, and ultimately helped ensure greater safety for all. USAF training operations at Holloman AFB, Virgin Galactic launches and landings, Ft. Bliss maneuver training, and WSTF space activities were all updated of changes immediately in real-time. Our dy-

Cox Range Control Center, WSMR. (Photo: WSMR PAO)

namic planning modules analyzed all vehicle characteristics and illustrated the risk contours for the scheduling system; all personnel at pertinent geographic locations were accounted for by satellite to verify their safety. Roadblocks, air blocks and spectrum requirements were established automatically via geo-fences, and full compliance was monitored in real-time by smart (learning) systems with visual and IR recognition capabilities.

The evening prior, and in the hours leading up to the predawn test, unmanned ground and air vehicles had been deployed from their maintenance sheds throughout WSMR's Main Post, as well as from satellite locations around the Tularosa Basin. These unmanned units placed themselves at operationally advantageous locations in order to acquire the best 'view' and gather high fidelity test data. These assets self-navigated via their embedded redundant navigation systems, which self-activate in the event GPS is unreliable. The mission at hand was a particularly long-range test, so Unmanned Ground Vehicles (UGVs) dispersed along highways to public and private lands, even hundreds of miles from the intercept region on WSMR. Unmanned Aerial Vehicles (UAV's) dropped radiosondes on inaccessible mountain peaks along the flight path to gather any telemetry data not picked up by satellites and the HALE-type (High Altitude, Long Endurance) UAVs overhead.

Our remote tracking and data collection systems exist independent of external power systems and are completely autonomous in regards to operation. Advances in black silicon solar panels and high energy density batteries allow these robot data gatherers to remain on station for weeks, as may be required during a long test series or long-duration tests. Microwave and satellite data links enabled immediate data delivery to our customer, even as these data-gathering vehicles navigated the roadways back to their shelters for minor maintenance and hardware updates. In jamming and GPS-denied environments, these robots automatically find a node along our extensive fiber-optic network. While connected to the network, all data is transmitted to the customer's terminal instantly, even when no other radio frequency or light-based signal in the region can arrive in intelligible form. While the customer's communicators were degraded Thursday, October 1, 2046, WSMR delivered the raw test data and the preprocessed reduced data into information usable for communication degradation analysis. Throughout the comprehensive jamming environment, the data gatherers located outside WSMR utilized the latest quantum entanglement communication systems to transport separate, classified, non-test data back to WSMR's Range Control Center. Their googol-byte onboard memory capacity is sufficient to retain all the original, raw data in the event of a lost link or garbled transmission.

Orchestrating this mission was the most qualified and competent team of any range in the world. The 'average' WSMR Test Officer holds a PhD in a critical technical field. Through WSMR's cooperative research and internship partnerships with local universities, these Test Officers developed hands-on, technical expertise in this type of work. The workforce is adaptive and they are continually learning at an extraordinary rate. Special-skill employees are acquired via an expedited seventh-generation HR system; typically, the best-quality candidates are hired within two days. Contractor alternatives (to complement the Government) can be hired within hours. Each team member enjoys the benefits of pay-for-performance, provided by the highly-efficient ACQDemo system. Our teammates are happy, collaborative and personify excellence on a massive scale.

Immediately after the event completed a swift range restoral process commenced. The test data already in the customer's hands, WSMR's Master Planning system began reconfiguring the range for the next customer. Just another exceptional, productive day at White Sands in our quest for National Security, delivering tomorrow's readiness.

EXECUTIVE SUMMARY

This 2016/2046 Strategic Plan contains our Commanding General's future vision for the Range, presenting an assessment of the current and foreseen capabilities, facilities, requirements and operations that will guide our efforts to move WSMR to its future state as a premier Major Range Test Facility Base (MRTFB). This Plan will keep the Range focused on its mission of providing world-class test and evaluation services in support of our Armed Forces acquisition systems. It also describes how we plan to improve every aspect of what we do, now and in the future.

As an enduring and living document, WSMR's G5 will conduct periodic status reviews using sets of pre-established metrics to measure progress. The Plan will be amended to support new and complex requirements of our customers, Military Services, and the test and evaluation community. Where no roadmaps have been identified, G5 will suggest the creation of Subject Matter Expert (SME) teams to develop them. New versions will be published when the leadership deems that conditions exist for updates.

Our Strategic Planning team reviewed over 350 source and reference documents and conducted more than fifty-five interviews with WSMR and WSTC management, as well as tenants, customers and neighboring groups, agencies and installations; ATEC leadership; DoD agencies pertinent to our mission, including the OSD and Test Resources Management Center (TRMC); and members of the national Test & Evaluation (T&E) community. From this foundation, informal roadmaps were established to help U.S. meet future requirements, including revised processes that will set the conditions to support change.

The identified needs and associated corrective recommendations include:

Human Capital: The Range must address long-standing human resource issues related to its Government and contractor workforce. We will seek to gain direct-hire authority to strengthen our ability to recruit and retain top-of-class team members. To stabilize the workforce, we will (1) examine workload sharing with other ATEC ranges, Holloman AFB, NM, Ft. Bliss, TX, and Kirtland AFB, NM; (2) suggest a simplified tasking approach to allow contractors to temporarily surge their workforce as needed to support tests and missions; (3) encourage mentoring, phased retirement and recruitment of more part-time workers; and (4) adjust position descriptions to increase flexibility of assignments. We will seek pay-for-performance for the Government workforce; develop better knowledge management and retention processes; and support leadership development, STEM, GEMS and other programs that promote the local growth of a skilled workforce.

Test Facilities and Instrumentation: We must address future systems under test and obsolescence issues of existing test facilities, instrumentation, tools and processes.

The bulk of our current equipment is technologically obsolete and contain serious shortcomings, including; expired life-cycles, workforce intensity, limited mobility, and inadequate net-centric operations. We will plan to examine (1) the expansion of long range corridors for tests; (2) implementation of better, faster Flight Termination Systems, barriers and geo-fences; (3) acquisition of new range radars after RULE program completes; (4) preparation for Advanced Range Tracking and Imaging System (ARTIS) implementation; (5) installation of fly-along instrumentation packages and telemetry software and transponders; (6) plans to test autonomous systems; (7) preparations for urban and electronic warfare environments; and (8) installation of out-of-band lasers and sensor systems.

Infrastructure: WSMR has not had a T&E approved MILCON since 1999. With infrastructure valued at more than $2 billion, using the normal Army MILCON process to sustain the T&E infrastructure of the Range will not work. Specific needs: (1) the vast majority of our buildings (more than 90 percent) are at the end of their useful life, and need to be replaced or refurbished to more adaptable, technologically-advanced research and training structures; (2) all range roads will require improvement before 2046; (3) installation security enhancements, including replacement or upgrading of the main gates, IDS systems, and border fences; (4) improvement of Garrison operational support; (5) enhancement of quality of life; (6) improvement of water resources and, to a lesser extent, increased use of renewable energy; (7) better management of off-range sites; and (8) better communications systems.

Partnerships: An enhanced framework of excellent customer relations and enduring partnerships will be critical for WSMR by 2046. The Range will set the conditions so that our customers will view U.S. as a true teammate in their acquisition process. We will endeavor to work with them early in the test definition process to help outline test objectives and see them through to mission readiness, providing true "cradle-to-grave" project support.

WSMR's external regional partners consist of federal and state agencies, civic communities and organizations, and private landowners and businesses. The future success of WSMR is based on the continuous development and enhancement of enduring partnerships with its stakeholders. The details of these relationships vary depending on their mission, but as with any relationship, constant, actionable and accurate communication will be key.

We will foster a more symbiotic, collaborative relationship with ATEC Headquarters and other ATEC test centers. We will accomplish this by using the digital platforms and channels of communication ATEC Command has provided in order to realize a more efficient, needs-based method of matching test system personnel with mission schedule requirements.

Processes: Efficient and cost-effective business processes are fundamental to future WSMR operations. It is not within the scope of this strategic plan to predict in detail what future changes will look like, but the Plan aims to lay out several core requirements: (1) Continue to examine how MRTFBs are funded. Navy processes, for example, are aligned with keeping facilities and capabilities viable, whereas WSMR operates on the ATEC Direct Labor Hour (DLH) model; (2) Identify "core" infrastructure and workforce needed to preserve capability and keep the doors open. Deploy an independent team to validate the results of the determination; (3) Allocate remaining "core" funding toward Test Center efficiencies to continue to reduce institutional costs. Efficiencies can be measured as improvements in capabilities or reductions in institutional costs; (4) Cost containment: Identify areas to minimize cost to customers while maximizing data collection; (5) Provide accurate, detailed cost estimates to customers, broken down to the branch level. Standardize a process to be followed by all groups and validate the quality of the estimates on completion of tests; (6) Follow current instructions and regulations that require test officers to notify the customer of changes to the cost of their tests. Promote stronger communication between the test officer, the customer and the support staff when changes to a test program occur. Receive customer concurrence.

Budgetary constraints will persist and we will work diligently towards reducing costs. Furthermore, we will make a distinction between controlling expenses and managing investments: between trimming capability and eliminating waste. Reduction of costs does not mean reduction of capacity to support WSMR's very important mission, or reduction of our commitment to our people; or an indication that we will always opt for the lowest bidder. It means working smartly to find ways to eliminate non value-added tasks, while simultaneously developing means to ensure the workforce is highly trained in the skills and techniques that will be required of them.

In addition to the budgetary uncertainties mentioned above, WSMR will continue to face the day-to-day demands of facilities modernization and sustainment, workforce stability issues, and unanticipated new programs and the emerging technologies associated with them. These demands will continue to place increasing pressure on the leadership to acquire and retain the capabilities and needed readiness to deal with them. This Plan aims to the provide overall guidance and support to realize our main objective, of achieving our future state as a premier MRTFB in support the T&E community and the needs of their acquisition programs.

AGM-158 Joint Air-to-Surface Standoff Missile (Photo: Department of the Air Force)

Commanders, assisted by their staffs and subordinate commanders, along with interagency and multinational partners and other stakeholders, will continuously assess the battlespace and the progress of the operation toward the desired end state in the timeframe desired. [...] An assessment is a key component of the commander's decision cycle, helping to determine the results of tactical actions in the context of overall mission objectives and providing potential recommendations for the refinement of future plans. Assessments provide the commander with the current state of the operational environment, the progress of the campaign or operation, and recommendations to account for discrepancies between the actual and predicted progress. Commanders then compare the assessment against their vision and intent and adjust operations to ensure objectives are met and the military end state is achieved.

--COMMANDER'S HANDBOOK FOR ASSESSMENT PLANNING AND EXECUTION, 2011[1]

COMMANDER'S ASSESSMENT

U.S.ARMY

Third Offset Strategy at WSMR

To provide context and understanding of why it is vital to prepare WSMR for the future, an examination of the National Security offset strategies is warranted. In a November 2014 speech to the Reagan National Defense Forum, U.S. Secretary of Defense Chuck Hagel announced the creation of a Pentagon initiative to develop new military technologies and operational concepts to counter growing threats to U.S. military supremacy. He noted U.S. capabilities could no longer dominate the battlefield. The Pentagon was in a severely constrained fiscal environment and thus a new approach was needed. Hagel proposed a "game-changing third 'offset' strategy" be developed that would allow the United States to remain the world's dominant military power.

The two previous United States' offset strategies were implemented during the Cold War. The first, during the 1950s, relied on the vast size of the U.S. nuclear arsenal to offset the Soviet Union's enormous numerical superiority in conventional forces. The second offset strategy was needed in 1970, when the Soviets approached nuclear parity with the United States. The U.S. military was still smaller than the Soviet forces, having contracted considerably after the end of the Vietnam War. American defense planners turned to advanced technology as a way to uneven the playing field.

WSMR tested a significant number of second offset technologies, including Precision Guided Munitions (PGM), Search and Destroy Armor (SADARM), Tactical Missile System (TACMS), and Brilliant Anti-Tank (BAT). Follow-on advances included Stealth technologies and Small Diameter Bomb (SDM). A very significant 1982 WSMR test used aircraft cueing of surface-to-surface ballistic missiles with anti-armor sub-munitions. The Soviets were watching, and the implications of that single test gave them pause.

A third game-changing strategy is emerging. Again, this strategy relies on advanced technologies. The current view of the Third Offset Strategy contains five common technological components:

- Deep-Learning and Autonomous Learning Systems: Machines and applications that require faster-than-human reaction times used for indications and warnings in cyber defense, electronic warfare, and large density missile raids. Also used for Big Data analytics.
- Human-Machine Collaborative Decision Making: Exploiting the advantages of both humans and machines for better and faster human decisions (Human strategic guidance combined with the tactical acuity of a computer).
- Human-Machine Combat Teaming: The above collaborative decision-making helps humans make better decisions whereas human-machine combat teaming actually works with the unmanned systems to perform

> **DoD's responsibilities are to be prepared to address a broad range of contingencies and unpredictable crises well into the future. That means we must prepare our defense enterprise for the challenges of that uncertain future. We face the rise of new technologies, national powers, and non-state actors; sophisticated, deadly and often asymmetric emerging threats, ranging from cyberattacks to transnational criminal networks; as well as persistent, volatile threats.**
>
> **--CHUCK HAGEL**
> **DEFENSE SECRETARY, 2014[2]**

operation. For example, the Perdix mini-drone can be launched from a UAV and fly in close proximity to many identical drones, maintaining constant communication with them. (Swarm operations and tactics).

- Assisted Human Operations: These operational components will include wearable electronics, combat apps, heads-up displays, exoskeletons and other systems that will assist the warfighter in all possible contingencies. For example, the USAF Research Laboratory is developing skin biosensors (applied as a Band-Aid) that will read all sorts of biodata.
- Network-Enabled, Cyber-Hardened Weapons: The priority here is to enhance cyber-security. Every weapon and system of the future will be subject to cyber-attacks like, for example, GPS and communications-denied environments.

As WSMR prepares for 2046, the Range will likely see a new collaboration model that accelerates the development and fielding of third offset capabilities. A new way of doing business will emerge, requiring the collaboration of the military, aerospace, defense contractors and academia, with industry. This new model must address such things as intellectual property and cost sharing, and acknowledge the need to be expeditious. Tests aimed at linking these new and legacy capabilities and enhancing their effectiveness will no doubt be undertaken. As with the second offset strategy, WSMR must be prepared to test these technologies and advanced sensor systems. The enemies of U.S. will be watching and the implications of the testing must again give them pause.

Human Capital

I cannot be prouder of our excellent workforce, both Government and contractors. They perform challenging missions heroically and professionally, day in and day out. However, a commander should not rely on heroics. An honest assessment finds areas of concern that must be addressed if WSMR is to be successful in 2046.
Areas of Concern:

- Future workforce knowledge and skill level: Running a test range requires unique skills; however, universities do not offer engineering degrees in test and evaluation. Realistically, most of our workforce learn the skills they need from on-the-job training. Considering WSMR's aging labor demographics, there looms the potential loss of considerable institutional knowledge. Federal Government succession planning is poor and this makes the loss of knowledge even more pronounced.
- Skill mismatch: With advancing technologies and constant innovation, the skills needed for T&E can change rapidly.
- How to acquire the needed talent quickly is a problem: There is intensified competition for quality talent in a marketplace that current DoD budgetary constraints make it difficult to be competitive in. High-quality talent is difficult to attract to this area in general, therefore we must grow our own talent locally and make WSMR a more attractive place to work and play. A lengthy hiring process only compounds the problem.
- Data Support Limitations: Most missions currently supported have Data Support Limitations (DSLs), primarily due to a drawdown in personnel over the past several years. The instruments exist, but cannot be adequately staffed. This is not a sustainable situation, and adds risk to the customers' time schedules as well as Test Center data collection.
- WSMR personnel needs are uneven and unbalanced: Large tests require the support of 500 or more people, generating necessary short-term surges of personnel. This creates peaks and valleys in workforce activity on the WSMR calendar. Identifying a cost-effective way to keep this large number of skilled personnel working on reimbursable tasks, or on-call, is its own challenge.

Test Facilities and Instrumentation

My assessment here is broken into two main categories: The "Current and Enhanced Capabilities" of the Range's test and instrumentation facilities that will be required due to advances in threats and future systems. I refer to the second category as "Obsolescence," based upon the lack of spare parts, additional skillsets demanded of our labor force, and incompatibility of our existing tools and facilities.

Current and Enhanced Capabilities:

Understanding emerging technologies is critical to preparing WSMR for future testing support. Although predicting them is problematic and often inaccurate, understanding new and advanced technological threats can enable better decision-making today, reduce unanticipated events, and help manage future uncertainty.

My staff used two methods to explore possible emerging technologies: The methods were Scenario Planning and Trend Analysis. Scenario Planning entails the use of a description of a possible future state-of-affairs or development, and the corresponding possible consequences emanating therefrom. Trend Analysis involves the use of historical data to produce a forecast of technology characteristics and their resulting impact on WSMR testing support. A drawback to this method, however, is that it tends to miss "leap ahead" technologies. To minimize this, several known leap ahead technologies are discussed in what follows; the examples are only intended to be representative of future technologies and certainly not meant to be exhaustive.

The table below contains a list of global scenarios, with an assessment of their implications, an analysis, and anticipated impact on WSMR operations.

Global Scenarios and Assessments

The strong conclusions of the Scenario Planning method indicate that; the Range lacks a mega-city, is not prepared for autonomous system testing, and needs to lower costs.

To a lesser extent WSMR is not prepared to test Intelligence, Surveillance and Reconnaissance (ISR) systems, and needs to improve its Internet, cyber protection and firewalls. WSMR is in better shape on renewable energy and encroachment.

Trend Analysis: This analysis was based upon weapon and sensor performance of today. Future impact was determined by increasing or decreasing system performance by a factor of two. The analysis was grouped by system type: weapons, sensors, other systems.

The analysis of weapons included directed and kinetic energy systems, sensors and seeker validation, targeting algorithms, lethality, performance (range and flight profile including speed, altitude, and maneuverability), accuracy, and environment, including jamming and clutter.

Kinetic Energy Weapons

Presently WSMR can handle multiple Mach targets and weapons. Doubling of weapon speeds to hypersonic levels (Mach 5-10) may require more range area, particularly for high altitude and turning systems. High slew rates optics, and better and faster Flight Termination Systems (FTS) will be needed. In addition, a Regional Sound Policy may be required to deal with sonic booms.

Higher altitude weapon systems (~20 miles and above) will have no impact on instrumentation; however FTS and safety footprints may require more range area.

Global Scenario	Implication and Assessment	What it means for WSMR	WSMR Impact
Climate Change	Population displacement Opening of the Artic Lower emissions	Continued focus on WSMR to use renewable energy Testing of renewable energy for the battlefield	Low: JLUS, ACUB and IMCOM renewable energy efforts are protecting/preparing WSMR for renewable energy. WSMR ready to test renewable energy systems.
Population Growth	Mega-cities	Urban Battlefields	High: DoD needs a mega-city test and training environment. Failure of JUTC was programmatically driven vs. need driven. DoD/WSMR will push for an effort in this area.
Inequality Growth	Conflict, terrorism, poverty	Small unit engagements, ISR	Medium: WSMR prepare to test ISR systems. Enhancement may include mega-city, role-playing personnel, bomb-making facilities, etc.
Technology Acceleration	More can be done by fewer people, i.e. 3d printing, nano, bio tech, etc.	Autonomous systems Terror threat more capable Fewer WSMR employees	High: WSMR is not prepared to test Autonomous systems or run its support systems with less people.
World knowledge on the internet	Internet learning Change faster and more global Big data	WSMR employees/systems on the Internet Cyberattacks, Cyber-Terrorism Systems tested must access the Internet	Medium: WSMR needs to enhance its internet for customers and employees. Cyber capabilities maybe important.
Energy Demand Growing	Energy sharing between countries Energy wars Energy transport	SunZia like encroachment Defense/offensive systems for energy generation and transport	Low: JLUS and ACUB efforts are protecting/preparing WSMR against encroachment. WSMR ready to test energy off/def. systems.
Globalization	Multinational corporations	Contractors global	Medium: Better "firewalls" needed.
US Debt Increases	Cuts in defense spending	Less institutional funding	High: WSMR needs to continue to explore lower cost approaches to support customers such as automation.

Lower flight altitudes will have no impact on WSMR instrumentation. However minimizing manmade structures in the central flight path of the range would enhance range usability for customers.

Increased range (distance) of weapon systems will impact WSMR. This will drive customers to use racetrack profiles, or only test the end game events. More off range corridors and additional mobile instrumentation will enhance range usability for customers.

Smaller weapons will necessitate smaller FTS, and telemetry transponders systems. Size will impact WSMR's ability to track (Weibel radars can track very small (BB sized) targets, but not at range).

Increased accuracy will only have a minor impact for WSMR. Improvements to best estimate of trajectory may be required.

Threats systems (targets, bunkers, etc.) and test environments (jamming, manmade clutter, urbans, etc.) will require continuous updating to remain current for customers.

Tests associated with multiple objects/warheads will impact WSMR, particularly if the number of tracked objects exceeds ten. In combination with decreased size, WSMR range instrumentation may be a limiting factor. Fly-along packages, airborne sensors, higher frequency, phased array radars may be required to accomplish future testing.

In the past, WSMR has tested weapons with special warheads, including pressure and thermal, directed energy and kinetic energy combinations. Doubling the size will have no impact on WSMR support. Biological, chemical or nuclear weapons were not considered in this analysis.

Directed Energy Weapons

- Lasers: Doubling of power levels would not drive new range instrumentation. MET equipment can support these systems and should be persevered. More accurate range instrumentation may be required to validate weapon accuracy. Natural and manmade obstruction in and around HELSTF would be a complicating factor and should be avoided. Lasers operating in different frequencies will require additional instrumentation support within and out of band of the new frequencies.
- High Power Microwaves (HPM): Doubling of power levels and increasing repetition rates may drive new range instrumentation. More accurate and additional range instrumentation may be required to validate weapon accuracy and threat simulation. HPM's operating in different frequencies and power will require additional instrumentation support within and out of band.
- Electronic Warfare (EW): This is a catchall category for future electronic warfare systems that may come to test at WSMR. WSMR's existing capabilities may be able to support such tests, but instrumentation from other ranges may be required to provide the required data products. In the 1990s, WSMR had substantial capability in EW with the integration of the Big Crow system that was part of the Directorate for Applied Technology, Test and Simulation (DATTS). DATTS became the Survivability, Vulnerability and Assessment (SVA) in FY00 and still has some minor EW capability with our Joint Directed Energy Test Site (JDETS). Currently, WSMR has limited EW, but expects more in the future.

Sensors

Active and passive sensors deal with frequencies associated with ultraviolet (and higher) light, lasers, microwave, infrared, lower bands, and EW. To be competitive in the sensor-testing area, WSMR will need to provide electronic warfare, frequency jamming and an assortment of other signal clutter sources capable of simulating real-world scenarios.

Unmanned aerial system repairers from Company F, 227th Aviation Regiment, 40th Combat Aviation Brigade, based out of Fort Hood, TX, inspect an MQ-1C Gray Eagle in the Middle East, Jan. 2016. Company F Gray Eagles provide armed aerial reconnaissance for stability operations. (Photo: I. Kummer)

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- Frequencies: Ultraviolet (UV) radiation is actively being pursued as a means for future communications systems by the U.S. Army Research Laboratory. Ultraviolet radiation has a relatively short path length through the atmosphere because of high attenuation; however, it is this property that makes UV radiation ideal for short-range propagation (i.e., signal detection beyond the useful range would be highly improbable). In addition, using UV transmitters and receivers with overlapping beam cones, non-line-of-sight (non-LOS) transmissions would be possible. If the issue of understanding and compensating for UV scattering from atmospheric molecules is resolved, this technology could make a sudden appearance on the communications scene. WSMR has limited capabilities in this area, and new detectors and sources would be required to participate and support this technology.
- Light: WSMR is a prime location for laser testing. The doubling of power levels to operate these tests would not drive new range instrumentation. More accurate range instrumentation may be required to validate sensor accuracy. Natural and manmade sources emitting specific frequencies would be a complicating factor. Jamming and Clutter sources may be required. As well, WSMR is a good location for long distance active infrared (IR) sensor testing. Doubling of power levels would not drive new range instrumentation. More accurate range instrumentation may be required to validate sensor accuracy. Natural and manmade sources emitting specific IR frequencies would be a complicating factor. Jamming and clutter sources may be required.
- Microwaves: WSMR is also a good location for active microwave sensor testing of lower bands; including microwaves and radars. Doubling of power levels would not drive new range instrumentation. Phased array radars do not have a dummy load capability, thus a large range can accommodate their testing needs. Doubling of power levels will not drive new range instrumentation, however this may require the availability of on-site power. More accurate range instrumentation may be required to validate sensor accuracy. Natural and manmade sources of interference should be minimized. Additional EW, jamming and clutter sources would enhance test range utility for customers.
- Electronic Warfare: WSMR is a great location for high-power EW testing. This is particularly true for frequencies that are dangerous to test in the national airspace or near populated areas. Doubling of power levels will not require additional range area. Additional range instrumentation may be required to validate sensor capabilities. Natural and manmade sources of interference should be minimized. Additional EW sources and targets would enhance test range utility for the customer.
- UV and higher passive sensor: WSMR has limited capabilities in this area. New detectors and sources would be required. Natural and manmade sources such as power lines would be a complicating factor.
- Light (optics and laser detectors): Natural and manmade sources at specific frequencies would be a complicating factor. Jamming and clutter sources may be required. Natural and manmade sources at specific IR frequencies would be a complicating factor. Jamming and clutter sources may be required. Lower bands (microwaves and radars), natural and manmade sources at specific frequencies would be a complicating factor. Additional EW, jamming and clutter sources would enhance test range utility for the customer.
- Passive EW testing: Additional range instrumentation may be required to validate sensor capabilities. Natural and manmade sources of interference should be minimized. Additional EW sources and targets would enhance test range usability for customers.
- Active Seismic detection on a

A radar systems specialist with the 49th Communications Squadron adjusts a peak power analyzer in May 2012 near Holloman AFB, NM. The analyzer allows signal and power input from a primary surveillance radar to determine any necessary or recommended adjustments to signal strength or maintenance procedures. (Photo: Holloman AFB PAO)

COMMANDER'S ASSESSMENT
WSMR 2046

WSMR Optics Kineto Tracking Mounts on display at Holloman AFB, NM. (Photo: G. Palombit)

small scale: Presently, WSMR would be a good location for seismic testing, depending on soil type. Additional range instrumentation may be required to validate sensor capabilities. Natural and manmade sources of interference should be minimized.

- Sounds: Presently, WSMR is a good location for sound detection sensors with its remote location and canyon features being very useful to testers. Additional range instrumentation may be required to validate sensor capabilities in the future. Natural and manmade sources of interference should be minimized. Urban terrain would enhance test range utility for the customer.
- Magnetic: Active magnetic field sensor that works on a small scale. Presently, WSMR is no better a location than other ranges. Remoteness and canyon features may be useful to testers. Additional range instrumentation may be required to validate sensor capabilities in the future. Urban terrain would enhance test range utility for customers.

Hypersonics

The operational speed of these systems can vary depending on altitude. However, even at very high speeds, such as Mach 10, WSMR instrumentation is not overly stressed. Nevertheless, this technology will have a profound impact on WSMR. Off-range corridors will be needed to increase the size of the range. Investment will be required to install new instrumentation and FTS to prevent public risk over these longer corridors. This effort is aligned with Kinetic Energy Weapon, stated above.

Autonomous Systems

Artificial intelligence and similar advances will revolutionize the concept of autonomy. Future systems will be better able to react to their environment and perform more situational-dependent tasks, as well as synchronized and integrated functions with other autonomous systems. Weapons, sensors and other systems will be enhanced with automation. Testing at WSMR will most likely involve subjecting systems to varying inputs, situational-dependent tasks, and integration elements to ensure they make the correct "decision." Algorithms that use fuzzy logic would require additional training events, in addition to testing events.

Impact of these systems on WSMR is twofold. There would be a large increase in the number of test events on the range. In keeping with the axiom that "to err is human, but to really foul things up you need a computer," smart or autonomous systems will require much more testing to prevent catastrophic events from occurring. Because current autonomous systems are more difficult to adjust, extensive testing of these systems will be necessary. The second impact is the need to achieve a correct understanding of the "truth" data of the test environment. When the autonomous system algorithms make an error, the range must be instrumented enough to figure out how the error occurred. Detailed pre-test and post-test data collection, supported by associated new instrumentation designed to collect the correct information will be required.

Command and Control Systems

There is a strong trend for many systems in DoD to work in conjunction with other systems on the battlefield. Good examples of this are the Network Evaluation Integration (NIE) and Army Integrated Air Missile Defense (AIAMD) programs. These test efforts required large areas and elevated numbers of diverse assets to accomplish their test objectives. Each asset, its location, and the data flow between them needs to be collected.

Future Command and Control system of systems testing will have more components and partners (communication networks, Internet connections, the Global Integration Grid (GIG), Army, Navy Air Force, foreign systems, "white" forces, etc.) This type of test program will place pressure on the WSMR range schedule, IA policies, spectrum management, frequency deconfliction and overall range instrumentation.

Urban Environment

This is not a new concept, but an immediate environment is needed to support both developmental and operational testing (see Scenario Planning Analysis at the beginning of this section). The 2006 and 2010 Quadrennial Defense Reviews identified the ability to operate in urban terrain as a critical requirement for Military Services. Realistic urban environments ranging from small rural villages to modern metropolises pose challenges to air, ground, maritime and system of systems, as demonstrated in the Iraq conflict. The DoD does not presently have an environment to adequately test acquisition systems in an operationally representative urban setting. Retired USASC LTC Frank Prautzsch said that, "Without realistic urban environmental test data, the acquisition community cannot measure system performance, leaving warfighters not fully understanding the capabilities and limitations of fielded systems. This can lead to degradation of system performance during combat operations, threatening the lives of our warfighters."[3] It is projected that an urban capability will be developed at a MRTFB, most likely WSMR.

WSMR's DES Building after the 2009 windstorm.

Acquisition, Sustainment and Modernization

Keeping WSMR's instrumentation systems current and proficient hinges on the ability to acquire new capabilities, to sustain existing capabilities and to modernize these capabilities in a continual, timely and efficient manner. The current process for acquisition, sustainment and modernization is mired by inefficiencies and ineffectiveness. To implement the changes deemed necessary in this plan, leadership will need to develop new approaches for executing all three activities.

Obsolescence

The backbone of the WSMR open-air test support is the data collection instrumentation (radars, optics and telemetry systems), used to produce the highly precise truth data required for evaluation and analysis of current weapons systems and space hardware performance. While the existing radars, optics and telemetry systems are capable of meeting most current requirements, the equipment is by and large, technologically obsolete and contain serious shortcomings; e.g., some instrumentation is over fifty years old, manpower intensive, lacks mobility, and limited in net-centric operations. Equipment upgrades and replacement programs are required to rectify these issues.

In addition to the open-air data collection instrumentation, the Range operates a number of other laboratory test facilities, such as Electromagnetic Radiation Effects (EMRE); Nuclear/Radiation Effects; Transient Electromagnetic Directed Energy (HPM sources), Applied Environmental Testing; Large Blast Thermal Simulator (LBTS); and High Energy Laser Systems Test Facility (HELSTF). Some of these laboratory facilities will require new test buildings to house and operate their new instrumentation systems. They require modern test control and data acquisition systems to minimize labor costs and operate in a net-centric data processing and distribution approach.

Infrastructure

Without a strong and sustainable infrastructure, the installation simply cannot accomplish current missions nor adapt quickly and cost-effectively to new ones. Another major concern is WSMR has not received a Test and Evaluation MILCON since 1999 (Phase 1 Launch Complex Revitalization brought in approximately $6.9 million). With over $11 billion in test and evaluation infrastructure, the Range cannot remain viable on MILCON funding at 0.06 percent every 17 years. Without a new approach, or additional capital investment, safety, security test missions and personnel are at risk. The roof blowing off the installation's DES building during the windstorm of December 8, 2009, was clear evidence of this problem.

My assessment includes the following areas of concern:

- Lack of adaptable, technologically advanced research and training infrastructure.
- Needed improvement of range roads.
- Needed enhancements to installation security: main gates, IDS systems, borders, etc.
- Development of needed efficien-

cies and improved, better-value responsive operational support for installation customers and assigned military units.

- Enhanced quality of life for service members, civilians and family members that live and work at WSMR.
- Greater use of renewable energy technologies and an enhanced use of water resources.
- Better management of off-range sites.
- Improved communications systems.

Partnerships and Regional Growth

WSMR's mission requirements will become more complex, bringing about increased competition for limited resources, driven by the continuing need to push our existing boundaries and current off-range launch site capabilities. Partnerships between external agencies, communities and our internal stakeholders will be key to our collective success in the future. An enhanced framework of enduring partnerships will be critical for WSMR in 2046.

Our partnership with ATEC is vital to our future success. Our command group must reach out to the staff and leadership of ATEC in order to maintain communication as well as synchronize our combined paths forward regarding infrastructure, instrumentation and program requirements.

Processes

WSMR has numerous processes that have not changed in many years, yet will need to change to meet the challenges of 2046. To focus the workforce, my areas of concern are limited to three wide-ranging process areas: The institutional funding model, other command support arrangements, and handling of cost estimates and change management.

The ATEC Institutional Funding Model: This model allocates additional institutional funding to ranges that have higher Direct Labor Hours (DLH). The thought process was that busy Test Centers with more customers would require more institutional funding. In practice, this makes no business sense.

Unfortunately, the model drives Test Centers to "generate" as many DLHs as possible. There is no measure of the "value" of the DLHs in the ATEC model. Test Centers have very few choices to increase DLHs; most choices/options are bad for the Army and the American taxpayer. Test Centers can generate more DLHs by "putting more people on test programs." More people will generate more DLH. Test Centers can increase DLHs by moving functions to contractors' versus using other Army organizations, because contractor generated DLHs count towards a Test Center total, while other Army organizations DLHs do not. Finally, a Test Center can increase DLHs by landing more work. This drives Test Centers into a competition with other Test Centers and service providers. Landing the work is valued regardless of where, or which Test Center is the right, or best place for the test effort.

The negative consequences of this funding model are widespread and harmful. No efforts to find efficiencies in Government or contractor labor will be successful without first addressing this funding model. It can be stated with confidence that the ATEC allocation model for Test Center institutional funding is essentially flawed, myopic, and counterproductive to Army goals. This process must be corrected in order for WSMR to get where our Nation needs U.S. to be in 2046. I have included recommendations in this plan to fix this process (see "Business Model," Roadmap).

Other command support arrangements: Test support has become more and more interdependent. WSMR leverages WSMR Garrison, Logistical Readiness Command, ARL, Navy, Mission and Installation Contracting Command, and a host of other groups to accomplish a test. This will increase greatly by 2046. The support WSMR receives from these groups has deteriorated due to budget pressures over previous years. Budget uncertainties and pressures will likely continue. A new way to manage support relationships is called for if WSMR is to be ready for the 2046 timeframe.

Cost Communication: Customer surveys over the last nine years confirm that the processes used by WSMR to handle cost estimates, change management, and cost accounting are the number one complaint about WSMR test support. Each of these sub processes must be corrected to position WSMR for 2046.

Mobile TRACS van operations during a mission at White Sands.

FUTURE STATE, RECOMMENDED ACTIONS & ROADMAPS

U.S.ARMY

Human Capital

Future State: The Range will possess a quality workforce. The brightest talent from across the country will seek out WSMR for employment opportunities. The workforce will have a desire for personal growth and new challenges. We will provide many opportunities for individuals to pursue self-improvement including trainings, advanced education, plus developmental and exchange assignments to enhance their skills. Our organization will have the dedication and adaptability to support our test and evaluation mission, minimize costs while continuing to exceed the expectations of our customer.

Roadmaps:

Working under the current fiscal constraints, WSMR will explore creation of an adaptive talent pool that examines adjustments to position descriptions to increase flexibility of the Government's workforce. Support contracts will provide ability to "surge" for labor-intensive tests. Approaches to study are:

- improving the workforce mix between contractor/Government
- cross-training employees to accommodate lulls and surges in workload
- workload sharing between all ATEC ranges
- workload sharing between Holloman AFB, Kirtland AFB and other regional interests
- increasing the number of part-time workers
- requesting changes to federal law
- encouraging phased retirement

WSMR will encourage and facilitate knowledge management and succession planning as Standard Operating Procedure (SOP). With early planning, the efforts made will ensure our mission will continue without degrading at periods of transition. Through our partnership with the New Mexico Congressional delegation, in 2016 we sought to gain direct hiring authority. At present, WSMR is awaiting US Senate approval of NDAA FY2017, specifically Sections 1102 and 1103, which would provide direct hire mechanisms, incentive and retention allowances, plus developmental budgets for all Major Range Test Facility Bases (MRTFB). With passage of NDAA FY2017, WSMR will be able to better position itself towards the goal of becoming a more desirable, talent-attracting workplace.

In order to achieve a dynamic alignment of our workforce, leadership and management must be committed to shared goals. We must construct a plan that establishes clear WSMR-specific goals, structures and accountabilities that will drive the performance of the entire WSMR Team. We must empower employees to execute on strategy through flexible and participative systems, processes, tools and resources. An effective way to do this is by having individual directorates (Teams) build standardized

***Leadership Development Programs at WSMR:** WSMR offers two unique programs: Reaching New Heights (RNH) and the Executive Development Program (EDP). Program objectives are to:*

- *Familiarize and teach participants the principles of leadership*
- *Develop team building*
- *Building personal leadership skills*
- *Expanded knowledge of Team WSMR organizations and missions*

Leadership for the programs is provided by an Executive Committee comprised of the Executive Director, the Deputy Garrison Commander, and the Materiel Test Directorate Deputy Director and Training Coordinator. A three-member Steering Committee provides day-to-day guidance for program participants.

The RNH focuses on building career management and personal leadership skills, and encourages participants to become responsible for creating and fulfilling self-development goals. Its target audience is Team WSMR GS-12s and below, but also invites WG and NAF employees.

EDP provides leadership skills training to employees who show a potential for advancement. It does this in order to prepare for vacancies in key leadership positions that will no doubt arise at some point in the future. Its target audience is Team WSMR GS-13/14s (or equivalent pay band/current permanent supervisors or high-performing GS-12s). RNH is a prerequisite for participation in the EDP.

roadmaps. By working together, each team can define a set of objectives and actions that they will work to achieve in rolling quarterly or six-month cycles.

Team roadmaps should offer a sense of focus and direction for each cycle. These roadmaps should be shared and made public among the directorates (server-based platforms provide a good option for sharing workspaces and are currently utilized by most DoD organizations, including WSMR). Putting a name next to an action fosters a sense of individual responsibility and accountability for each team member's contributions. Holding regular meetings to review progress will create a sense of productivity, unity and accomplishment.

Test Facilities and Instrumentation

Understanding emerging technologies is critical to prepare WSMR for future testing. We will continue to be alert and aware of all technological developments that may have an impact on our test and evaluation operations. The following sections provide a detailed assessment of the future status and capabilities of our instruments, facilities, tools, and technical processes, with indication of the planned, suggested and/or recommended road maps to get there.

Radars

Future State:

By 2046, the WSMR instrumentation radar suite will be almost unrecognizable, both in terms of appearance and performance capabilities, when compared to the AN/FPS-16 and AN/MPS-39 (Multi-Object Tracking Radar, MOTR). All future radars will not only be mobile, but will be autonomous, self-driving units capable of performing pre-mission calibrations, orientations and operations automatically. Future radar units may not be exclusively located on ground, but rather could also be installed onboard unmanned aircraft to provide aerial coverage of autonomous vehicles moving in orderly formation or in swarms.

The precision of Time-Space-Position-Information (TSPI) collected from future radars will exceed those attainable from their contemporary counterparts. Ground clutter, which limit radar performance at low elevation angles today, will be vastly mitigated through the utilization of high-resolution terrain maps that allow these spurious effects to be subtracted from the radar return signal. These radars will seamlessly link with other data collection assets and computers, via high-speed fiber optics networks, to share TSPI and other tracking information on a global scale and to provide the customer with near-instantaneous knowledge of test article performance upon completion of the mission.

In addition to a self-driving capability, radars in 2046 will possess the capability to perform self-diagnostics to ensure their mission worthiness prior to the start of customer tests. Further, these units will also have the capability for some level of self-repair; however, there will still be situations where technicians may have to make on-site repairs in the case of serious malfunctions.

There will be a greater variety of radars supporting future tests at WSMR. Instrumentation having ultra-high slewing capability will be used in the Close-In zone (e.g., near a launch site) and high power units will operate in the Fly-Out zone. Other radars with multiple small beams will have been developed to track dense swarms of autonomous vehicles and sub-munitions dispensed from warheads. These test articles will require a higher resolution tracking capability than is attainable in present-day radars.

Mobility will be a universal feature of instrumentation in the future state. Inasmuch as the Range envisions a continuing role in off-range and safari test support, the capability to relocate assets quickly to any location in the world dictates a requirement for mobility.

Finally, the cost to operate radars of the future will be dramatically less than that required for their contemporary counterparts. In contrast to the AN/FPS-16 and AN/FPS-39 radar systems that require multiple operational personnel in each unit, future instrumentation will be either autonomously operated or controlled by one or two individuals located at a central facility. In addition, radars in 2046 will have been developed using improvements in life-cycle maintenance to lower operational costs.

Roadmap:

The starting point for achieving the future state described above is the formation of a WSMR team comprised of radar, computer and other Subject Matter Experts (SME) to develop a Radar Roadmap that identifies the key steps required to reach the future state.

Secretary of the Army, the Hon. Eric Fanning, center, and White Sands Missile Range Commander Brig. Gen. Timothy Coffin, center, pose for a photo with WSMR leaders in front of the Cox Range Control Center, July 2016. (Photo: WSMR PAO)

The roadmap will start with an assessment of the current state of the radar suite and upgrade/modernization programs currently in place; these programs include the Radar Utilization Life Extension (RULE) for the AN/FPS-16s and the MOTR-4 Range Integration Program for the AN/FPS-39s.[4] These programs are projected to extend the useful service life of the Range radars through 2026 and enable customer test support up to this time.

The next step is to complete implementation of a program to replace the current radar instrumentation suite by 2026. A Range Radar Replacement Program POM 18-22 (2 February 2016), with a projected Initial Operation Capability (IOC) in mid-2022, is currently a work in progress with Headquarters, Department of the Army Staff. This program will include the key provisions of mobility, net-centric operations and improvements in life-cycle maintenance; radars designed to operate in both Close-In and Fly-Out zones. Based on experiences with previous programs having remote operations requirements, coordination and partnership with both cyber and physical security organizations will be required to implement unmanned, remoter radar operations.

For planning radar capabilities beyond 2026, future WSMR teams will refine and enhance the Radar Roadmap to take advantage of technological innovations, many of which cannot be foreseen at present. Analogous to this Strategic Plan, the Radar Roadmap must be a living document to ensure success in reaching the future state discussed above. Evaluation of technology maturity for future planning will include:

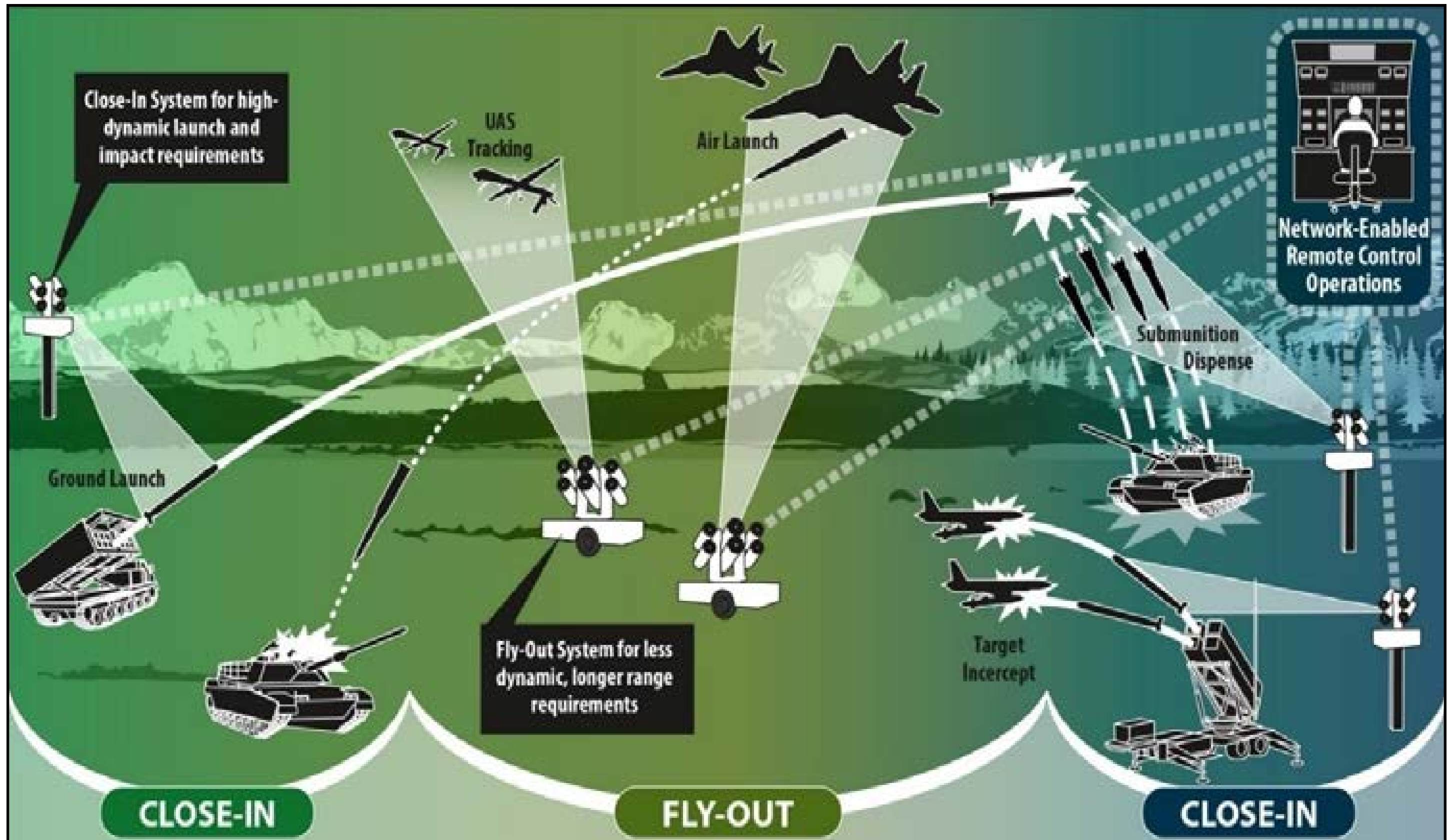
- Improve mobility, including the goal of a self-driving capability for transporting precision instrumentation on paved and unimproved roads.
- Implement remote classified operations, with a goal of implementing Artificial Intelligence and other computational techniques to achieve autonomous setup, calibration/orientation and operation of radar instrumentation.
- Provide systems capable of state-of-the-art self-diagnostics assessments and self-repair capability.
- Installation of non-GPS timing, position and navigation equipment in the mobile radar systems.
- Develop a multiple object tracking capability for closely spaced objects (a new capability required for autonomous systems testing)
- Provide support for C-Band Pulsed Transponder Tracking.
- Perform systems design that minimize the cost to operate and maintain future radar systems.
- Restoration of lost measurement capabilities.
- Identification of technical shortfalls in the instrumentation before they impact support of customer requirements.
- Adaptation to new and emerging customer support requirements.
- Implementation of a program to continuously analyze methods to lower operational costs.

Optics

Future State:

Optics instrumentation, similar to its radar and telemetry counterparts, will be vastly different from the contemporary instrumentation systems of 2016, both in physical appearance and capability. Similar to the features projected for radar systems (such as being mobile, self-driving units with

FUTURE STATE
WSMR 2046



ARTIS Concept of Operations

autonomous set up), optics units will feature self-orientation/calibration and operation of in 2046. In addition, future optics systems will likely have the capability to perform self-diagnostics and even perform self-repair at a highly independent level. Like radars, optics systems will have separate instrumentation for optimal Close-In and Fly-Out zone data collection.

Optics systems of the future will be net-centric units linked with other data collection assets and computers by high-speed fiber-optic networks, able to receive extremely precise TSPI for continuous, nearly loss-free tracking of small, dynamic test articles such as hypersonic velocity projectiles. All optics data collected during a test will be transferred almost instantaneously via network connection to a control center for immediate processing by high-performance computers. The customer will receive the data in the form of information and knowledge immediately upon test completion.

Optics systems in 2046 will have the capability to record data in the ultraviolet, visible and infrared (both mid- and short-wavelengths) portions of the spectrum. This capability will enable the Range to record optics data from a wide variety of test articles (e.g., autonomous systems, missiles, etc.) as well as a wide assortment of lasers used either as directed energy weapons or to designate/illuminate targets. Digital recorders used to collect optics data will greatly exceed the resolution and framerates found in today's units. They will also be more rugged and have a longer service life.

The quality of future optics data will far exceed that of data currently recorded in the field. Optical compensation and computational techniques will be used to eliminate the effects of atmospheric turbulence, precisely correct for refraction errors and compensate for any distortions caused by the optics system itself.

The cost to operate optics systems of the future will be far less than the cost required to operate today's instruments. The net-centric capability along with autonomous operation will require significantly fewer personnel to operate the entire system, in stark contrast to today's operational requirement for multiple operators assigned to each optics units. Improvements in life-cycle maintenance to lower operational costs will also result in savings to the customer.

Roadmap:

The roadmap for optics will follow a route similar to that for the reaching the future state of radar and telemetry systems. A team of WSMR optics, computer and other SMEs will be formed to produce an Optics Roadmap that will identify specific steps to proceed from the present to the future state. This roadmap will be a living document, updated periodically.

The first step will be to assess the current state of WSMR optics assets along with programs in place designed to move the instrumentation systems into the future. Implementation of the Advanced Range Tracking & Imaging System (ARTIS) currently underway is projected to deliver three Close-In and two Fly-Out systems by mid-2019. Additional systems are scheduled to be delivered through 2023.[5] The ARTIS instrumentation systems are anticipated to provide optics support to Range customers through 2046. These gimbal systems should serve the Range a minimum of 30 years.

An important consideration for the roadmap team is to ensure that the Range can provide optics data collection for the spectral regions utilized by emerging weapons systems, especially those planned for use in directed energy weapons. The delivery of a shortwave infrared (SWIR) capability under ARTIS will fill a critical gap in the Range's capability to support solid-state laser weapons systems; obtaining SWIR capability to supplement the mid-infrared wavelength IR sensors will be a near-term upcoming requirement. As new laser weapons and designators are developed and tested at WSMR, optics instrumentation capable of collecting data in new regions of the spectrum will likely be required. Under its current design, ARTIS will likely not be a mobile, self-driving system or autonomous set up candidate, but radically new technology over the next three decades could change that.

As is true for radar and telemetry, planning optics capabilities beyond 2030 will require future WSMR teams to upgrade, refine and enhance the roadmap based upon technological innovations in optics and computer sciences, many of which cannot be reliably predicted. Analogous to this Strategic Plan, the Optics Roadmap must be a living document to ensure success in reaching the future state discussed above. Evaluation of technology maturity for future planning should include the elements found in the WSMR "Radar Roadmap" section.

Telemetry

Future State:

Telemetry instrumentation systems will undergo significant transformations, both in physical appearance and capability by 2046. Operational capabilities projected for radar and optics systems, such as self-driving, along with autonomous setup, orientation/calibration and operation will be an attribute of the telemetry systems in 2046. In addition, future telemetry systems will have the capability to perform self-diagnostics and a high level of self-repair.

Telemetry systems in 2046 will be net-centric field units linked with other data collection assets and computers, via high-speed fiber optics or wireless networks, to both transmit and receive TSPI for nearly loss-free signal tracking, as well as providing critical information from real-time telemetry streams directly to customers and other Range assets. All telemetry data collected during the test will be transmitted, via the network, to a control center for final data processing, using High Performance Computers, and immediate delivery to the customer in the form of information and knowledge.

Future telemetry systems will handle telemetry data transmission rates that vastly exceed the current capability. Additionally, these telemetry systems will utilize real-time frequency switching and other techniques to compensate for any encroachment or intrusions (accidental or deliberate) occurring in the assigned bands. The quality of future telemetry data collected from advanced weapons systems will far exceed that being recorded and processed from current test articles.

Analogous to the case for radar and optics, the cost to operate telemetry systems in the future will be far less than for today's instrumentation. The net-centric capability, along with autonomous operations, will require significantly less personnel to operate the entire system, in contrast with today's operational requirement for multiple operators assigned to each telemetry van. Improvements in life-cycle maintenance to lower operational costs throughout the service life of the instrumentation will also result in savings to the customer.

Roadmap:

The roadmap for telemetry will be similar to that developed for optics and radar systems. A team of WSMR telemetry, computer and other experts will be formed to produce a Telemetry Roadmap that will identify specific actions required to proceed from the present to the future

Mobile TTS system during a routine checkout in the WSMR Tech Area. (Photo: G. Palombit)

One of the two electromagnetic railgun prototypes on display aboard the joint high speed vessel USS Millinocket (JHSV 3) in port at Naval Base San Diego (Photo: K. Kirsop)

state.

The roadmap development effort will begin with assessing the upgrades to be delivered as part of the Mobile Telemetry Acquisition Systems (MTAS) program currently being implemented.[6] This program will provide the capability to support 20 Megabit per second (Mps) data rates, will utilize a net-centric capability to decrease operational personnel required in situ, and will provide for data stream transmission over the network using Internet Protocol (IP). Additionally, this program will provide advanced telemetry simulators to perform better pre-test checks along with modifications to increase post test data processing reliability.

The MTAS upgrade program is projected to provide a Range telemetry system capable of supporting customer requirements through 2026. To plan beyond 2026, future WSMR teams will be required to update the roadmap, based upon technological innovations in telemetry and computer sciences that currently cannot be reliably envisioned. Analogous to the Strategic Plan itself, the Telemetry Roadmap must be a living document to ensure success in reaching the future state discussed above. Evaluation of technology maturity for future planning should include the elements found in the Radar Roadmap outline.

Kinetic Energy Weapons/Hypersonics

Future State:

Weapon systems will require increased ranges (distances) to test, which WSMR will accommodate using off-range sites and long-range corridors. Customers will commonly be looking to use racetrack profiles, or only test the end-game events. Range customers will schedule tests requiring simultaneous tracking of multiple objects/warheads, perhaps putting upwards of 10 test articles in flight at once. Some weapons will steadily decrease in physical size and our customers will need support from fly-along packages, airborne sensors, combined with high-frequency phased array radars to accomplish this testing.

Roadmap:

Presently WSMR can handle tests involving multiple Mach targets and weapons. Doubling of weapon speeds to hypersonic levels (Mach 5-10) will require more range area, particularly for high altitude and turning systems. The WSMR Test Center will look to strengthen its existing partnerships with remote launch/impact sites such as Green River, UT, and Ft. Wingate, NM, while transitioning to increasingly modular and mobile instrumentation. (See Appendices, "Extended Range and Safari Operations.") Higher slew rate optics, and better, faster Flight Termination Systems (FTS) will be needed. In addition, negotiating a Regional Sound Policy will be necessary to accommodate sonic booms.

More off-range corridors and additional mobile instrumentation will enhance range usability for customers. However, investment will be required to install new instrumentation and FTS to prevent public risk over these longer distances. Additionally, smaller weapons will necessitate smaller FTS telemetry transponder systems. Decreased size may affect WSMR's ability to track items (Weibel radars can track very small, even BB-sized targets, but not successfully at great distances). Present Range instrumentation may soon be a limiting factor, if not upgraded.

Threats systems (targets, bunkers, etc.) and test environments (jamming, manmade clutter-white noise, urban, etc.) will require continuous updating to remain current for customers.

Related to testing of kinetic and directed energy weapons, WSMR's focus will be the reduction of cost of the facilities via a reduction in the number of operational personnel required, and an enhancement of the pulse width and duration of the radiation exposure.

Directed Energy (DE): Weapons and Testing

Future State:

There is broad agreement that weaponized High Energy Laser (HEL) and High-Power Microwave (HPM) systems will be Third Offset Strategy game changers. For example, the Navy has estimated that high-energy lasers can be fired for roughly one dollar per shot, versus $25,000 for conventional weapons. With rapid-fire, lasers can engage salvos of enemy threats, and they reach their target at the speed of light, which at roughly a million times the speed of sound will be critical for countering hyper-velocity threats. Lasers will also vastly reduce the logistics tail of manufacturing, transporting, and storing explosive munitions.

WSMR will continue to be a prime choice for testing Directed Energy Weapons such as lasers, HPM and other electronic warfare related systems. The High Energy Laser Systems Test Facility (HELSTF) located at WSMR, is designated as the DoD's dedicated joint-Service test range for Directed Energy Weapons. Customers will appreciate WSMR's extensive controlled airspace and large mountain backstops as critical elements for HEL engagements of rockets, artillery, mortars (RAM), and low/high altitude missile and UAV targets.

In 2046, WSMR will be evaluating portable electromagnetic rail guns and directed energy weapon systems which have advanced to second and third generation technology. Larger systems will be routinely used on naval platforms and permanent land bases. These systems reversed the cost exchange ratio when defending against missile attacks. Solid-state lasers are ubiquitous, and counter-sensor weapons utilizing directed energy are commonplace. High-powered microwave transmitters are small enough to be mounted on virtually all airborne platforms, and can be instantaneously directed to disrupt enemy electronics. HELSTF is using particle beam weapons and ultra-short pulsed lasers in the picosecond to femtosecond range to evaluate laser hardening of combat equipment. HELSTF is the center for high-energy laser testing in the United States.

The Army's High Energy Laser Mobile Demonstrator successfully engaged 90 mortars and several UAVs during tests at White Sands Missile Range, NM. (Photo: Courtesy graphic)


Electromagnetic Pulse (EMP) Test Facility at WSMR.

Similar to lasers, WSMR will continue to serve as a prime location for HPM testing, including threat characterization, material validation and system vulnerability assessments. In the future, doubling of HPM power levels and increasing repetition rates will drive the creation of new and more accurate instrumentation as customers push to validate weapon accuracy and threat simulation to even greater levels of precision. WSMR will operate HPMs in different frequencies and at different power levels to provide needed test support. To operate its HPM resources both within and out of band, WSMR will require additional instrumentation beyond today's capabilities.

Customers will see WSMR as a great location for high-power electronic warfare (EW) testing. This is particularly true for systems emitting frequencies too dangerous to test in the national airspace or near populated areas. The emergence of megacities and force engagement on increasingly urban battlefields will likely drive interest in EW tactics and non-lethal systems. As EW systems become smaller, more practical and more effective, many customers will seek out WSMR as a test bed due to its advantages of controlled airspace and large, secure areas to recover targets. The increased reliance on autonomous systems, networks and technology in general will put emphasis on finding and exploiting hardware vulnerabilities. Assuming no significant investment or upgrade to WSMR's existing EW test capabilities occurs, the Test Center will look to collaborate with other ranges in order to bring in the needed instrumentation required to provide data products that meet customers' needs.

This beam director was used for the Mobile Tactical High Energy Laser and has been reformatted to support the Solid State Laser Testbed Experiment at High Energy Laser Systems Test Facility at White Sands Missile Range, NM. (U.S. Army photo)

Roadmap:

For nearly fifty years, the running joke in the nuclear power industry has been that "Nuclear fusion is the energy source of the future…and always will be." The corollary in the laser weapons field has been that these systems are always "five years away" from being ready to field. Unlike fusion power, recent developments in solid-state lasers that derive their energy from electrical power, have led experts in the DoD to conclude that High Energy Laser (HEL) technologies are ready.[7]

The core aspects of HEL system evaluation such as laser output characterization, adaptive optics, beam control, pointing/tracking performance, optical figure, optical coatings, and static/dynamic lethality assessments should not change significantly in the upcoming decades, and at present WSMR has the ability to test all of these aspects of a HEL system.

As HEL systems move from the laboratory to the field, they will need to be tested. That testing requires controlled airspace, long distances, isolation from populated areas, and realistic airborne and ground-based threat scenarios. WSMR offers all of the above, as well as a 30-plus year track record of testing HEL systems at HELSTF. Citing land mass, remote location, controlled airspace, mountain backdrops (to geographically intercept beam propagation) and recent advances in solid-state laser technology, WSMR anticipates directed energy will be an emerging area of growth for the next several decades.

Objectives for tactical laser systems look for a one-megawatt system, with a weight to power ratio of five kilograms per kilowatt. A 150-kilowatt laser mounted aboard a Predator drone is already undergoing testing at WSMR, so it seems almost certain that HEL systems will play a major role in future WSMR testing.[8]

WSMR will work to keep its status as the DoD's primary joint-Service test range for Directed Energy Weapons, and will more aggressively promote the Range's controlled airspace and large mountain backstops as critical requirements for HEL testing to our military and industry interests. The Test Center currently boasts significant technical expertise working with HEL systems and possesses a unique instrumentation suite not available elsewhere. By being proactive in knowledge transfer, process documentation, succession and retention, WSMR will be able to maintain this advantage.

Central Test and Evaluation Investment Program (CTEIP) previously invested in WSMR's HPM Test Facility and may be a possible funding source going forward as new, increasingly-capable technology upgrades are required. Funding categories under CTEIP include Joint Improvement and Modernization (JIM) projects, Resource Enhancement Project (REP) and Threat Systems (TS) projects; all of these represent potential instrumentation acquisition mechanisms to help WSMR retain its ability to test Directed Energy Weapons. The Directed Energy Test and Evaluation Capability (DETEC) project assisted WSMR's HPM Facility in their efforts to obtain seven narrowband and wideband sources; DETEC-2 is a follow-on effort that may be able to provide similar guidance and assistance as needs evolve at the facility in the coming years.

In recent years, investments in HPM technologies have been more significant than those in HEL. However, both HPM and HEL are projected to get budget increases based on renewed interest in DE defense. In the upcoming years, DE technologies will focus on ballistic missile defense, precision strike capabilities (including adversary infrastructure) and anti-unmanned aerial vehicle weapons.

WSMR will require new measurement technologies to characterize HEL beams incident on targets, target response (including electronics), and beam control system performance. Likewise, future HPM testing will require development of new instrumentation sites to accommodate longer range testing. In a broader context, safety and test planning tools, atmospheric characterization and compensation, and a means of scoring HEL engagements need to be developed. WSMR will also require the ability to emulate threat DE and non-DE systems.

White Sands Missile Range will work closely with the TRMC and, more specifically, the Directed Energy Test Technology Area (DETTA) working groups, to both assist in the development of these test technologies and to ensure those technologies are deployed to WSMR. Early and frequent coordination between the technology developers, users, and Program Managers (PMs) is vital to ensure the required testing capabilities are ready when the programs need them. In addition, there are numerous Directed Energy working groups and professional societies that WSMR will participate in to stay up to date on emerging technologies, and to form working collaborations with other DE testers/developers. Examples are the Range Commanders Council (RCC) and Directed Energy Professional Society (DEPS).

Sensors

Future State:

In addition to the traditional sensing capabilities, a number of other types of sensors will complement WSMR's sensor suite by 2046. White Sands Missile Range will continue to be a good location for long distance active infrared (IR) sensor testing. Even an effective doubling of the power levels used today would not prompt a need for new range instrumentation.

WSMR will remain a preferred option for active microwave sensor testing of lower bands, including microwaves and radars. Phased array radars do not feature dummy load capabilities, therefore large ranges are needed to accommodate this type of radar testing.

The Test Center will work to increase its capacity to test a variety of sensor types beyond those typically associated with WSMR (laser, IR, microwave, etc.). Acoustic, magnetic and seismic instruments will see increased support on the Range. Geographically, WSMR is a good location for acoustic detection sensor testing due to its remote location, various canyon features, and the Aerial Cable Range facility. Testers will continue to find these resources worthwhile. Urban terrain will likewise enhance test range function for customers interesting in assessing acoustic and RF equipment.

By providing additional electronic warfare-related assets, such as frequency jamming and clutter sources, WSMR will be able to help maximize value for our customers' mission dollars, regardless of what type of sensor is under study.

Roadmap:

As stated, WSMR will need to provide electronic warfare, frequency jamming and an assortment of other signal clutter sources capable of simulating real-world use-case scenarios in order to be competitive in the sensor-testing arena. Procuring additional equipment and performing instrumentation upgrades will likely follow from any push to increase our capabilities here, but even before that, WSMR needs to better understand the current landscape of sensor testing and make informed choices about what upgrades and technologies will best fit with long-term industry (and research) trends.

The US Army Research Laboratory (ARL) is actively pursuing ultraviolet (UV) radiation as a means for future communications systems.[9] However, WSMR has limited capabilities in this area and new detectors and UV generation sources would be required to participate, support, or assist development of this technology. Opening a dialogue with ARL to discuss their anticipated needs in this area would be a first step towards addressing what might be possible.

Even though WSMR is a good location for testing long-distance infrared sensors, a focus group should initiate a more detailed investigation to make sure that unexpected sources of natural or manmade IR frequencies do not exist on the Range, ones that might create unwanted interference or produce undesirable effects. A similar characterization strategy to rule out unwanted acoustic, magnetic and seismic sources would also be a good idea. With seismic sensor testing, some study of the impact of soil types on the Range will be requisite.

For phased array radar testing, WSMR will need to be able to deliver adequate power to the units. A significant increase in radar electrical consumption may stimulate requirements for furnishing increased stable power at Range locations used for tests. White Sands Missile Range Directorate of Public Works (DPW) and other stakeholders need to assess ways to ensure more sites have reliable, safe firm power, the long-term result of which will be a greater flexibility to accommodate large-scale, power-hungry tests, as well as being a more environmentally friendly and an economical alternative to generator power.

White Sands Missile Range is on par with other test ranges when it comes to magnetic sensor testing. Remoteness and canyon features may be useful to testers in the future, but credible electromagnetic assets or advantages specific to WSMR have not yet emerged or been identified.

Long Endurance Small Unmanned Aircraft Systems from AFRL.

Coalition soldiers practice urban operations in the Besmaya Range Complex, Iraq, June 2016. (Photo: J. Hamby)

Command and Control Systems

Future State:

The concept of Battle Command has advanced to include multiple tiers of participants. Some are largely "man-in-the-loop," some are "passive," some are "robotic," and some are "semi" or "fully autonomous." Intelligent systems plan and execute wargame exercises that involve joint-Service and foreign entities. These test exercises require large areas, numerous diverse assets, representative threat systems and environments, and a combination of live, virtual, and constructive entities to accomplish the test objectives. Information associated with each asset, its location, its behavior and performance, and the interactive data flow between them needs to be collected.

Roadmap:

There is a strong trend for many DoD systems to work in conjunction with other systems on the battlefield. Recent examples are the Network Integration Evaluation (NIE), Army Warfare Assessment (AWA), and Army Integrated Air and Missile Defense (AIAMD) programs. To facilitate WSMR's ability to test future Command and Control system-of-systems, the Range must prepare to host complex exercises and be able to adapt to an ever-increasing number of test entities and active participants who need to share information in real-time across multiple platforms. Command and Control capabilities already encompass wired and wireless communication networks, internet connections, the Global Information Grid (GIG), and mobile devices. This type of test program will place simultaneous pressure on WSMR's range schedule, IA policies, spectrum management, frequency de-confliction and overall range instrumentation. Moving forward, examining customer feedback from previous NIE exercises and adopting appropriate corrective measures will help identify existing shortfalls. Staying abreast of other large-scale military test events will be a good way to anticipate shifts in Command and Control testing requirements. Recent tests facilitated through ATEC's Joint Test Element include:

- Joint Counter Low, Slow, Small Unmanned Aircraft System
- Joint Deployable Integrated Air and Missile Defense
- Joint Advanced Capability Employment
- Unmanned Aircraft Systems – Airspace Integration

As UAV and swarm technologies mature, major industry players should also be considered as they may have similar test requirements.

Urban Environment

Future State:

The Range offers multiple realistic urban test environments, which range from small rural villages to modern metropolises. The tailored urban terrain will provide representative environments, particularly with regard to radio frequency communications and line-of-sight visibility. Examples of simulated urban environment features include buildings, bridges, tunnels, subways systems, airports, energy and water distribution systems, and communication facilities. Situational environments will be provided to facilitate training in areas of ISR, Command and Control Systems, Electronic Warfare (EW) (e.g., intense jamming and GPS denied environments), and Freedom of Movement, all with realistic and representative human/cultural components.

Roadmap:

DoD test requirements include an immediate need to support both developmental and operational testing in urban environments. It is projected that an urban capability will be developed at a MRTFB, most likely WSMR. Developing an urban environment test capability is a major undertaking that will require significant planning, preparation, funding and support. A WSMR team of experts needs to form in order to examine this roadmap in detail.

High Speed / Hypersonics

Future State:

In 2046, WSMR will be positioned at the forefront of hypersonics testing through development and/or acquisition of mobile telemetry stations, space-based telemetry, high-speed trackers (radar and non-radar), new risk analysis tools, and state-of-the-art modeling and simulation tools. In cooperation with landowners and other Government agencies such as the BLM, states, and the Forest Service, WSMR and DoD will establish off-range launch sites at various distances up to 1000 miles from the Range itself and Spaceport America landing/impact sites. These corridors will be cleared of all other air and space traffic if necessary, or flights can continue under the hypersonic test vehicle if the safety analysis shows sufficiently low risk.

High-speed camera image of the Office of Naval Research Electromagnetic Railgun located at the Naval Surface Warfare Center Dahlgren Division, firing a world-record setting 33 mega-joule shot in December 2010. (Photo: US Navy)

Roadmap:

High Speed/Hypersonic (HS/H) weapons testing at WSMR and other test ranges will significantly exceed the existing land area, as well as the capabilities of instrumentation assets, necessary to meet known test requirements. Included are hypersonic cruise missile simulators, scramjet testbeds, long-range strike weapons, hypersonic cruise missiles (Mach 4-8), hypersonic interceptor (Mach 8-12) and space access (Mach 7-15).

Some of the challenges posed by such testing are:[10]

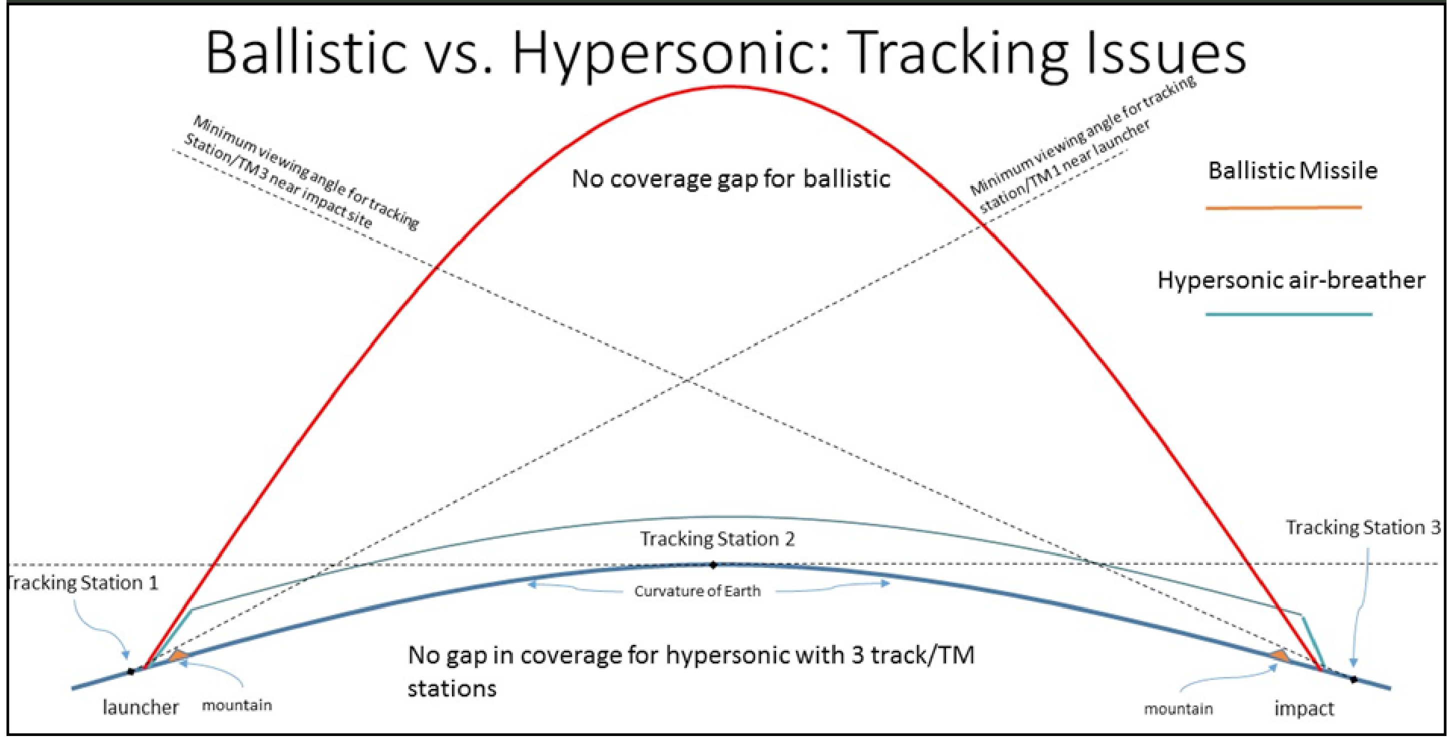
- Flight corridors with lengths exceeding five hundred miles or more will be required for full performance testing.
- Air corridors that include overland ranges to recover components from advanced research vehicles must be provided.
- Off-range launch sites will be needed (See Appendices, "Extended Range and Safari Operations.")
- Time-Space-Position-Information will be required throughout the corridor area.
- Vehicle speeds of Mach 12 and greater are projected to occur at altitudes of 20 m and higher, thus challenging data collection capabilities.
- Plasma envelopes are expected to form around the vehicle during flight will likely impede telemetry signals and command destruct signals.
- Overland flight corridors will involve an elevated risk to civilian population centers.

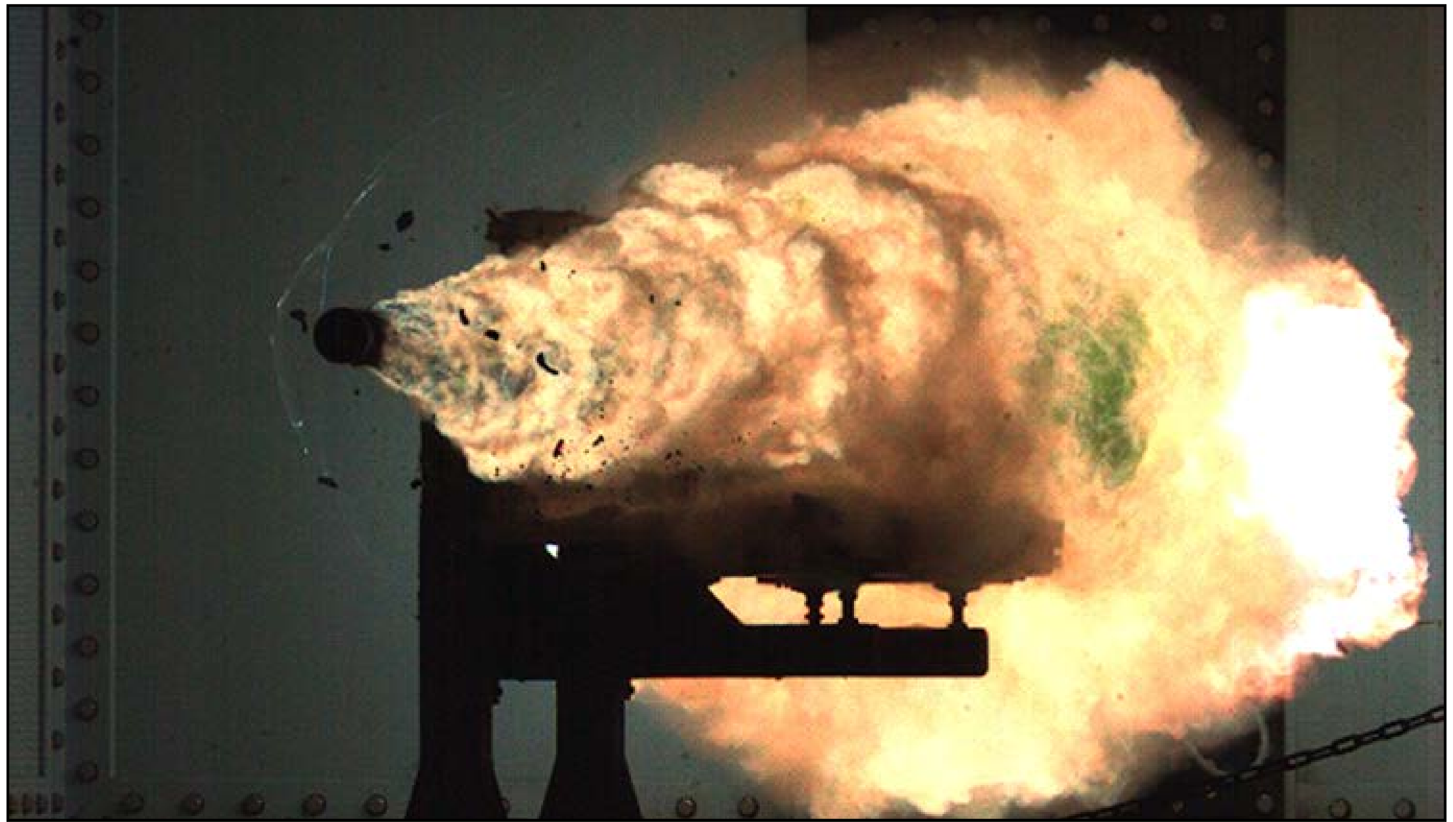
WSMR will be required to acquire and test instrumentation capabilities to support HS/H weapons testing. Off-range launch sites, detailed risk analyses, and possibly evacuation agreements will be required to support these types of vehicles. Overland testing of hypersonic vehicles is preferred by most customers because of the wealth of details that can be derived from examining components after a mission to determine how the materials fared at high temperatures during the flight. Most US programs to date (such as X-51) have been tested over water and suffered vehicle loss in the ocean at the end of the flight. WSMR will be well positioned to conduct this overland flight testing if test facilities are provided.

The High Speed/Hypersonics T&E Infrastructure Capabilities Study provides several references to the critical need for and the technology gap perceived in M&S capability.[11] The High Speed/Hypersonics (HS/H) project identification of M&S requirements ranges from the development of simulation techniques for the prediction of on-set hypersonic flight phenomena (e.g., plasma formation), telemetry antenna patterns, electromagnetic interference, and methodologies leading to mission effectiveness determinations.

Hypersonic testing adds several twists to the type of missile testing that has traditionally been performed at WSMR. Missiles, sounding rockets, and ballistic missile simulators (HERA, STORM, PAAT, ARAV) which fly a predictable, mostly exo-atmospheric path, need only two columns of restricted airspace/space in which to operate. There is

This diagram shows tracking an object with three tracking stations.





Photograph taken from a high-speed video camera during a record-setting firing of an electromagnetic railgun (EMRG) at Naval Surface Warfare Center, Dahlgren, VA, in January 2008. (Photo: US Navy)

no conflict with air traffic because there is no atmospheric flight between the two restricted airspace blocks. Ballistic vehicles climb nearly vertically and drop their lower stages near the launcher in the launch hazard area. They coast through space and reenter the atmosphere over the target area. Their predicted impact points [Instantaneous Impact Prediction (IIP)] move so rapidly from the launch hazard area to the target zone that there is very little risk exposure to the public. From burnout to impact, which comprises 80-90 percent of the flight time, the vehicle is coasting and its IIP stays in the target area. The unpowered, exo-atmospheric vehicle cannot maneuver; therefore, it cannot threaten people or facilities outside the target area.

Hypersonic air vehicles, on the other hand, are air-breathers and even at 60,000-foot elevations, are sharing airspace with unmanned and possibly manned aircraft. Air corridors must be coordinated with the FAA. (See Appendices, "Extended Range and Safari Operations.") The possible impact point travels much more slowly across the ground, even at Mach 10, which increases the risk exposure on the ground. More importantly, as atmospheric vehicles using wing lift and aerodynamic flight controls, hypersonic vehicles retain maneuverability throughout their entire flight from launch until landing or impact. This drastically widens the footprint of the affected area on the ground, complicating risk analyses, evacuations, and community outreach.

Tracking and telemetry are complicated by the distances involved (>1,000 miles) as well as the terrain masking which occurs when a vehicle is flying at low altitude. The diagram on pg. 27 illustrates a long-range scenario requiring three tracking stations to provide full range coverage. Although the diagram is not to scale, one can readily see there is a gap in coverage for more than half the distance of the hypersonic trajectory aggravated by the terrain masking from the mountains.

As with the Mach 10 Sprint missile tested at WSMR in the 1960s, the plasma sheath around the vehicle will block most radio transmissions to or from the test article. New techniques must be developed to communicate through the plasma. The maneuverability of the vehicles will necessitate automated ground-based autodestruct or on-board autodestruct systems that can react far faster than a human to terminate an errant flight. The performance dynamics of HS/H vehicles will require a paradigm shift in flight termination systems used at participating test ranges. Development of auto-destruct algorithms, based on Artificial Intelligence (AI) and similar processes will be required to perform decision-making tasks that, based upon predicted flight corridor violations, would possibly require vehicle termination action. Additionally, Over-The-Horizon (OTH) capabilities for termination action will also have to be developed in order to compensate for sudden corridor departure by high speed vehicles. Given that a significant portion of the flight corridor is over civilian population centers, the development of advanced flight safety tools to support the HS/H tests is a critical requirement.

Through cooperative agreements between WSMR and other DoD installations, overland test corridors meeting hypersonic test requirements will be established. Traditional (radar, optics, telemetry) and non-traditional (low earth orbit satellites) data collection methodologies must be implemented to meet HS/H TSPI and other data collection objectives. Corridors between two or more test ranges, such as WSMR to/from China Lake or WSMR to/from Utah Test and Training Range, will have to be cooperatively developed to meet the cruise distance requirements of five hundred miles or greater. (See "Partnerships and Regional Growth" subsection "Alliances and Partnerships Beyond New Mexico.") Note, however, that providing complete TSPI coverage from ground-based instrumentation along such long corridors may not be feasible, given the extreme length of the flight path and the costs to acquire and implement the required data collection capability. Solutions for addressing this technology gap include the use of Unmanned Aerial Vehicles and low earth orbit satellites to provide the required position and telemetry data from on-board instrumentation. Another approach is the possible use of high-speed chase aircraft to follow the hypersonic vehicle during portions of the flight to perform data collection operations. Any test of HS/H vehicles will require the use of non-traditional data collection instrumentation and platforms for measuring test performance.

FUTURE STATE
WSMR 2046

Soldiers with 2nd Brigade 1st Armored Division, inspect the Technical Unmanned Aerial System (Shadow) after the UAV lands on the flight line during the Network Integration Evaluation event in White Sands Missile Range. (Photo: Spc. S. Rosario)

Unmanned, Autonomous Systems

Future State:

Artificial intelligence and similar developments are only beginning to revolutionize our weapons, instrumentation and sensor systems. The impact of autonomous systems at WSMR is twofold:

First, there will likely be a large increase in the number of test events on the range. Part of this increase will stem from adaptive systems having to experience a wide variety of both stimuli and environmental experiences in order to acquire a 'memory' of what can possibly occur. The more tests an autonomous system undergoes to increase its knowledge base for decision-making, the better the probability for making intelligent choices in autonomous operations (this is akin to the learning process for humans).

Second, the need to understand the "truth" data of the test environment will increase, as will the amount of data collected during a test. When the autonomous system algorithms make an error, WSMR must have sufficient instrumentation to determine how and why an incorrect action occurred. Detailed pre-test and post-test data collection, supported by associated new instrumentation designed to collect the correct information, along with input from the system designers, will be required.

One of the most significant challenges facing WSMR over the next 30 years will be testing the rapidly developing class of autonomous weapons systems. Classical test approaches emphasize real-time support (e.g., computational), communications, networking, along with command and control that continue to be developed and optimized to satisfy new customer requirements. Current test methodologies will no longer be applicable due to expanding system interdependencies and increasing complexity, among other factors. An autonomous system, when compared to a traditional system, will have multiple interactions between many onboard components (e.g., computers) that can result in non-deterministic behavior during tests.

The recognition that autonomous systems represent a new type of technology is key to development of a test capability that can address the many challenges these complex weapons systems will pose. Traditional weapons systems perform predictable tasks in bounded environments, designed with such constraints in mind. A complex (autonomous) weapons system, on the other hand, will function and operate in an open-type environment and oftentimes in a non-deterministic manner. Complex systems are composed of interconnected parts (i.e., system of systems),

FUTURE STATE
WSMR 2046

A UAV with a camera mounted onboard flies during Remote Operated Video Enhanced Receiver (ROVER) demonstration. (Photo: U.S. Air Force photo/D. Rogers)

each having one or more behavioral characteristics. As a result, a total system response is based on the combination of possible actions of the individual components. The complex system capability is always greater than the sum of its parts. In the case of an autonomous system, the complexities of human interaction, multi-system operation, knowledge frameworks, sophisticated behavior models, collaboration, and expanding mobility all combine to create developments that leads to even more complex adaptive behavior.

Autonomous systems will produce revolutionary new testing paradigms at WSMR. Testing will be more fluid and coupled with a component of uncertainty (and risk) more commonly referred to as "chaos" variables. Testing an autonomous system cannot be limited to the physical domain aspects of the individual system, but must consider systemic factors of the entire collaborating unit: humans, systems, and mission scenario. The manner in which these systems respond to and interact with the world environment introduces additional complications. For example, most systems will employ onboard sensors to guide locomotion or to reconnoiter their surroundings. If an infrared sensor is used, the scene will appear different to what a human sees, and the system response to sensor stimuli may lie completely outside logical human expectations. This is an example of a possible non-deterministic behavior based upon autonomous decision-making built upon a stimulus-response event.

Roadmap:

The task of developing and implementing an autonomous systems test capability at WSMR will be one of the most challenging projects ever undertaken by Range personnel. It is projected that an autonomous system test capability to support benign aerial and ground vehicles with current Range instrumentation assets (radars, optics and telemetry) will need to be operational at WSMR by 2020, and test support capabilities for weaponized autonomous systems under simulated battlespace conditions must be established by 2026.

The Range will need to form an interdisciplinary task group consisting of instrumentation and computer specialists, WSMR SMEs, along with consultants from industry and academia to begin developing the capability for testing autonomous systems (certainly for aerial and ground vehicles, and likely space vehicles). There are a number of steps to initiate the conceptual capability described:

- Survey resources and identify potential partnerships with DoD, academic and industrial research facilities currently researching autonomous systems technology to determine what types of autonomous systems are being developed and what future test requirements will look like.
- Develop and acquire new Range instrumentation, based upon liaisons with autonomous system developers, to meet TSPI and other data collection requirements.
- Acquire inexpensive surrogate vehicles to develop techniques and test the capability of current and acquired instrumentation to obtain TSPI and other performance data.
- Develop and implement new flight safety tools designed to protect military and civilian assets outside the test arena.
- Collaborate with ARL to develop autonomous system access to micro-meteorological conditions.

Follow-on activities for the task group will consist of formulating plans for addressing some of the more complex issues associated with autonomous systems testing. For example, a high-performance computer operating on AI and other advanced computer software will ultimately control swarms and amalgamations of autonomous systems in order to replicate anticipated battlespace scenarios in a realistic manner.

Another task for the group will be to acquire or developed instrumentation to perform detailed terrain mapping of test arenas, covering the visual, IR. microwave and other electromagnetic spectrum bands used by sensors onboard the test articles. This mapping requirement addresses the need to create test courses for evaluating various capabilities of autonomous systems that can be understood in terms of the autonomous systems' sensor perception, and to serve as a diagnostic tool for system performance evaluation (both for real-time and post-test analysis).

The development of test arenas required to evaluate the performance of autonomous systems will pose significant instrumentation challenges for WSMR. Initially, these systems will require a considerable amount of human control in order to effect performance features, such as initiation of flight or ground locomotion; predictably, humans and test articles will be in close proximity to each other on the Range during live missions. As onboard intelligence systems evolve, the degree of human control and intervention will decrease to the point where the systems become autonomous (humans may still provide a goal or task to be performed). Autonomous systems testing will require new methodologies to prevent the test article from leaving its arena (e.g., use of an electronic geo-fence may be required). This confinement system will need to provide a safe means for ensuring test termination in the event an autonomous system under test attempts to leave the test area.

Swarms of autonomous vehicles require special attention because their similar appearance and potentially small size will require suitable instrumentation to support testing. One option for WSMR is to acquire an advanced multi-object radar, or other tracking instrumentation with suitable beam size characteristics that can resolve and track individual articles.[12] Another option would be to utilize UAVs with wide-angle fields-of-view to record optic or electronic data from above the formation, then merging this data with data collected from ground instrumentation (optics or electronic), to form a three-dimensional temporal presentation of the swarm. The virtual representation could be produced for performance evaluation, again both in real-time or for post-test analysis.

The use of Modeling and Simulation (M&S) procedures in the analysis of autonomous systems test results will be a critical tool for visualizing and assessing the performance of complex systems. One particular area for the application of M&S techniques will be for postmortem analyses of failures that occur during testing.

Another requirement for autonomous system testing will be accessibility to local meteorological data, applicable to both ground and aerial vehicles, for intelligent decision making during the test. One use of atmospheric measurements, in a specific locale, will be for autonomous airborne systems to adjust their flight paths in order to avoid strong winds or identify thermal lift regions to gain altitude more efficiently (i.e., an imitation of hawks in flight). For autonomous ground systems, local weather conditions could be used to determine safe terrain negotiations (e.g., avoidance of gullies if a storm is occurring or anticipated).

Timing and Navigation – GPS

Future State:

Current and future requirements call for testing in a GPS-denied environment. (There are concrete examples of this denial activity having already been invoked by at least one of this Nation's potential adversaries.)[13] This drives a need for critical timing and position information to be derived from alternative sources.

Large Blast Thermal Simulator facility in late 2015.

Roadmap:

WSMR timing systems must support extended periods (the full duration of customer test scenarios) without re-synchronization via the GPS satellite constellation. This can be accomplished by ensuring that WSMR master timing units include disciplined oscillators, which can then feed distributed timing units throughout WSMR via either RF or network communication links. (IEEE 1588 is the current protocol for precise network timing.)

Collection of precision position information on WSMR test articles during GPS-denied test environments can be achieved through remote sensing or on-board instrumentation. (See discussion in this section on "Radars", "Optics", and "Telemetry"). A breakthrough anticipated during the next five to 10 years is a miniaturized electronics package that will provide near-GPS quality position, navigation and timing information for weapons systems.[14] Future devices of this sort will support Range instrumentation requirements, including challenges associated with hypersonic vehicle and autonomous system testing. WSMR will implement plans to acquire these systems subject to pending test requirements and available funding.

Large Blast Thermal Simulator (LBTS)

Future State:

Although the core capability (generating synthesized blast waves and thermal pulse environments) remains largely unchanged, WSMR will have implemented significant enhancements to facility sustainability and streamlined the processes for mission planning, execution, and data reduction. As a result, test throughput will increase while at the same time customer test costs will decline.

Roadmap:

After a multi-year hiatus, the LBTS facility is in the preliminary planning stages of reactivation. The Defense Threat Reduction Agency (DTRA) has expressed a strong desire to use the facility for roughly the next 10 years, beginning in 2018. Requirements beyond 2028 are uncertain at this time.

In March of 2016, several sub-systems at the LBTS underwent evaluation. The results are available in the appendix to this document. In summary, the control system and tunnel instrumentation systems need to be replaced, the Thermal Radiation Simulator (TRS) needs to be refurbished, the Rarefaction Wave Eliminator needs a new assessment, and a new process for modelling desired blast wave characteristics needs to be established. Notably, an analysis of alternatives that revisits the possibility of using large compressors to establish the required pressures in the driver tubes versus resurrecting the cryogenic system is recommended. (Known potential failure mode/safety concerns with the pebble bed heaters will require an extensive "Fitness for Service" analysis before reactivation of the entire facility.)

A new CONOPS for the LBTS is also currently under consideration. WSMR may elect to condense the annual window for testing down to roughly three months to reduce overall sustainment/staffing costs. Past operations also involved multiple contractors for pretest blast wave modelling, facility operations, instrumentation and data collection, and TRS operations. A new team that addresses all of these areas will be established.

Ultimately, all upgrades and enhancements to LBTS need to focus on safety, sustainability, and efficient test conductibility to meet customer requirements. Finding effective ways to cross-utilize the LBTS operations staff during non-test periods also warrants consideration.

Aerial Cable Range

Future State:

The Aerial Cable Range (ACR) operates as a semi-autonomous facility. Small, strategically located high speed and tower-mounted optical trackers provide optimum viewing angles for the highly constrained ACR test corridors. Dedicated assets avoid repetitive transportation, setup, and calibration costs associated with repositioning and staffing core WSMR assets. Directed energy testing is routine, and ACR instrumentation is tailored to provide high resolution position and imagery data products. The high operational throughput and opportunity to conduct tests at approximately 1/8 the cost of conventional flight tests are a constant draw for new Acquisition Programs.

Roadmap:

Short-term objectives include all-weather surveillance cameras to facilitate operations, extension of the fiber and wireless networks to the remaining ACR launch and instrumentation sites, and erection of the two fixed towers that are already on site.

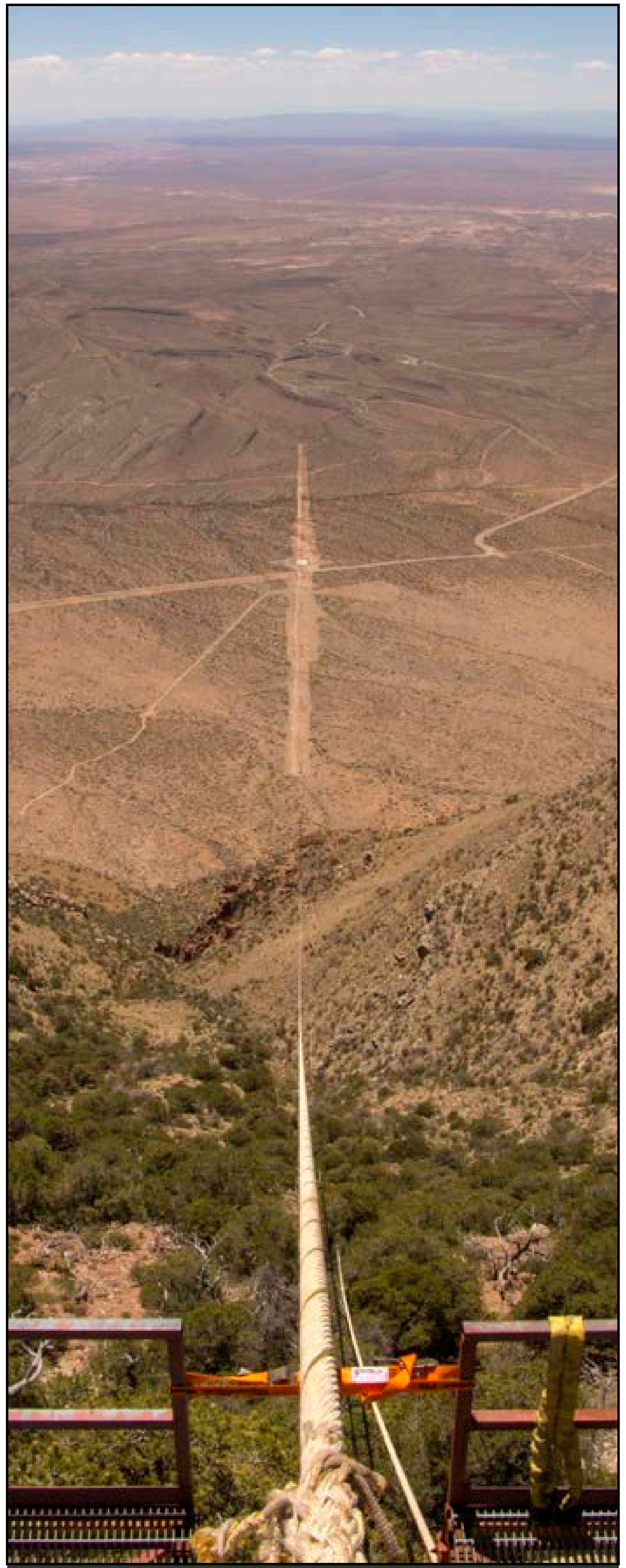
A study/assessment of optimum site locations and dedicated ACR instrumentation requirements is critical. Historic workloads suggest a review of the ACR CONOPS may also be warranted, in concert with the LBTS CONOPS development, with regard to cross-utilization of personnel. As with other WSMR test facilities, the ACR roadmap must focus on cost-effective ways to meet future ACR test requirements that involve higher velocity test articles and increased directed energy testing.

Space-Based Operations (Launch, Recovery, Sensing, Tracking)

Future State:

White Sands Missile Range will utilize its current and future instrumentation and launch assets to support future tests of the NASA Orion Crew Escape Vehicle and other manned and unmanned space systems. In addition, WSMR will participate in tracking NASA's manned flights in orbit and provide assets, both instrumentation and runway support, at the Space Harbor for routine or emergency spacecraft landing (similar to the support provided to the NASA Space Shuttle Program). The Range will also participate in global data transmission and relay operations in support of orbital missions (e.g., NASA Orion flights).

The location of the New Mexico Spaceport facility adjacent to the western boundary of the Range will provide additional opportunities for space-based operations in support of the commercial sector. As this facility expands its launch capabilities beyond the initial Virgin Galactic enterprise, the Range will provide technical and instrumentation support, as needed, to ensure that safe and efficient Spaceport operations flourish.


Aerial Cable Range's 3-mile span of test line during a periodic cable replacement, June 2016. (Photo: G. Palombit)


New Mexico Spaceport is located adjacent to WSMR.

Through collaborative efforts with our allies and the implementation of the Global Surveillance and Strike Network, we will provide support to DoD operations that ensure the protection of our Nation's space capabilities and to provide a capacity to deny utilization of these assets to potential adversaries.

Roadmap:

For WSMR to arrive at the 2046 future state described, the Range must make progress in three key areas:

- Provide future instrumentation and ground facilities to support manned orbital space flight programs, such as the NASA Orion spacecraft.
- Form stronger partnerships with NM Spaceport America, NASA and other regional non-military facilities to provide technical and instrumentation to support commercial spaceflight activities.
- Form new partnerships with DoD organizations supporting space operations (the Operational Responsive Space Command at Kirtland AFB, for example) to find ways to expand the Range's role in future space-based activities.

Missiles

Future State:

Future weapon systems will be globally expeditionary, with greater strategic and tactical mobility through lighter, more capable, and more survivable platforms. Systems will be equipped with a wide array of overmatching, long-range capabilities that enable soldiers to detect, identify, and defeat enemy surface and air combatants and systems. The ability to employ and synchronize Army, Joint, and Unified Action Partners' future weapon systems will facilitate delivery of tailorable effects to achieve military objectives while preventing friendly-fire incidents and minimizing collateral damage.[15]

White Sands will test weapon systems having the ability to engage the full range of targets, in all conditions, and in all domains (e.g. land, sea, air, space, & cyberspace). Expanded and refined use of the electromagnetic spectrum through employment of kinetic energy, directed energy, and hypervelocity munitions will enhance many systems' ability to deliver desired effects on target. Improved accuracy and range will enable scalable and precise ground-based effects on surface and aerial targets in all conditions. Our future instrumentation systems will need to acquire data on missiles and projectiles that will be technologically upgraded to improve their performance attributes, such as precision of impact location, increased standoff distance, capability to withstand enhanced adversarial cyber countermeasures, and delivery of more lethality on target. White Sands Missile Range will test the long-range strike weapon using the off-range launch sites, air/space corridors, and distributed, automated instrumentation discussed elsewhere in this section.

Roadmap:

Missile testing will continue to be a primary WSMR function through 2046. Test Engineers at WSMR coordinate with program managers and TRMC to identify test require-


An Isreali-made Tamir missile is fired from the IFPC Multi-Mission Launcher during a 2016 test

ments in an increasingly timely and efficient manner. Fundamental activities for Test Engineers will be:

- Anticipating the performance parameters of future missile systems coming to WSMR and having an awareness of their timeframe of arrival.
- Understanding what data products Program Managers of missile projects will need in order to meet their acquisition milestones.
- Making determinations to ensure WSMR's existing instrumentation and infrastructure will meet customer requirements; coordination with instrumentation SMEs will be necessary to ensure instrumentation capability matches test article performance capability.
- Identifying what additional WSMR assets are required, if any, and subsequently supplying the customer a preliminary cost estimate and rough procurement schedule necessary to obtain the needed resources.

Special Use Airspace, Airborne Systems

Future State:

The Range workload comprised of testing and training missions will increase dramatically by 2046. One of the reasons for this increase will be attributed to the Range having divided its airspace vertically into multiple layers and improved real-time scheduling, through automation techniques, to allow for more sharing of airspace and faster replacements for cancelled or delayed missions. White Sands Missile Range will have maintained complete control of the airspace over the range and range extensions, and will have in place flexible agreements for blocks of airspace adjacent to WSMR for large-scale tests and space operations.

The Range will also have temporary restricted areas from surface to infinity leading from Ft. Wingate, NM; Green River, UT; Dugway Proving Grounds, UT; the Gulf of Mexico and several other launch sites to support long-range programs. Very long-range programs such as HS/H will launch over water in the Gulf of Mexico and fly into WSMR for recovery on land.


In many remote areas where Soldiers operate, service members radio over-the-horizon communication from the field to higher headquarters like the brigade is nonexistent. Army scientists and researchers built the SMDC-ONE nanosatellite as an innovative technology solution. (Photo: U.S. Army illustration)

Improved automation of the Range Scheduling function and updates of contemporary Missile Flight Safety parameters and Operating Procedures will be in place to ensure optimal use of Range assets (time, land area) along with minimal risk resulting from errant test articles.

The Range's vast land and air spaces will permit testing of unproven Unmanned Aerial Systems (UASs) in a way that no other land range can match. Weaponized UAS and Unmanned Combat Aerial Vehicles (UCAV) will test at WSMR safely. These combined features will attract numerous advanced weapons systems developers, plus the option to test or operate explosive or hazardous UASs will not exist at most other UAS test sites.

Leading up to 2046, WSMR will be considered a good choice for UAS testing because of its advantages in restricted airspace, land space, favorable weather, relative RF quiet, airfields, technical expertise, and corporate knowledge with a wide range of UAS.

Roadmap:

The Range will continue participation throughout the next 30 years with the Joint Land Use Study (JLUS) group to facilitate agreements with the surrounding counties and communities to protect Military Training Routes (MTRs).[16]

White Sands Missile Range will maintain and upgrade, if required, an UAV Safety Policy to give customers advance notice of operational restrictions based on size, maturity, or built-in avoidance capabilities of UASs. The Range will maintain cognizance of future policies written and circulated by the FAA.

White Sands Missile Range will enhance its capabilities in the areas of miniaturized Flight Termination System (FTS) systems, use of multiple object tracking radars, improved RF and fiber optic networks, complete characterization of operating environment (especially terrain for evaluation of autonomous and intelligent systems) and airspace management. WSMR will at the same time look to market more aggressively its assets of restricted airspace and land space for the testing airborne systems.

The Range will seek out and enter into agreements with other continental DoD test facilities (e.g., Dugway Proving Ground) to establish restricted airspace for tests requiring long-range corridors. (See Appendices, "Extended Range and Safari Operations.")

Nanotechnology

Future State:

Throughout the next 30 years, nanotechnology promises the ability to produce entirely new high-performance materials; e.g., additive manufacturing (3-D printing) will dramatically shrink the barriers between design concepts and reality.[17] By manipulating materials at the molecular level, industry will develop a wide range of applications and new platforms that will be both stronger and lighter, contributing to both greater speed and longer range. Future weapons systems will include new nano-coating or nano-shielding that allows for self-repair or stealth abilities by deflecting signals in various bands. Such breakthrough technologies will have significant implications for the air-breathing and space platforms that are expected to be tested at WSMR through 2046 and beyond.[18]

Roadmap:

Currently, WSMR can provide electromagnetic, nuclear radiation and climatics exposures. However, in the future, customer requirements will necessitate that WSMR physically examine nanomaterials immediately after exposure, to determine if there was material damage resulting from the tests. These tests will require WSMR to utilize its scanning electron microscope and acquire additional laboratory instrumentation to perform the inspection task. In addition, WSMR will likely test systems composed of self-healing materials; inspections after exposure to radiation or extreme climatics would ascertain whether the self-healing process was degraded during the exposure process.

Natural and Manmade Environments

Future State:

In 2046 WSMR will be a premier testing range for harsh environments, both natural and manmade. Natural environments including extreme heat and cold, humidity, low pressure, wind, dust, sand, salt fog, vibration, and solar radiation will not have changed significantly in the last 30 years but the fidelity of data collected will have improved dramatically. Conversely, the labor required for a test will have dropped significantly. Many environments will no longer require a fixed laboratory as portable equipment will have become standard.

Real growth will occurred in the area of manmade environments. WSMR will be equipped to expose test articles to every wavelength of electromagnetic radiation known to man at power levels that are classified. WSMR will retain the only nuclear reactor in the Army. This, in addition to other sources, will produce every type of ionizing radiation that exists to ensure that warfighters have hardened equipment that will not fail in a post-nuclear environment.

Roadmap:

The TRMC's 2016 Strategic Plan predicts growth for nuclear and electromagnetic test capabilities. (See page 36.) White Sands' facilities, installations and capabilities include Applied Environmental Testing, the Vacuum Test System at HELSTF, the Electromagnetic, Directed Energy and Nuclear Effects facilities and the Aerial Cable Range. All will require different levels of upgrade and modernization. The existing climatic testing capabilities will require attention as they become obsolete, unreliable, inefficient, or do not meet customer test requirements. Some of the climatic test equipment dates back to the 1990s and is approaching end of life. WSMR will require modern test control and data acquisition systems for net-centric data processing and distribution. To those ends, facility and test equipment improvements will be necessary in the following areas:

Solar: WSMR requires new full-spectrum solar light systems that are configurable to test item geometry for the large chamber testing at the Temperature Test Facility.

Testing a Patriot missile system in WSMR's cold chamber, 2015. (Photo: G. Palombit)

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The DoD must develop new tactics, techniques and procedures to avoid, assess, and mitigate attacks on U.S. space assets. The next step is a study to identify the threat environments, current T&E capabilities and resource and infrastructure shortfalls. Due to the current and future world political situation(s) and potential global economic situation(s), the utilization of electromagnetic and nuclear/radiation threats are on the rise and to ensure that our country's forces can meet these current and future threats, they must be adequately assessed to clearly understand our Warfighter's abilities and limitations to effectively fight.

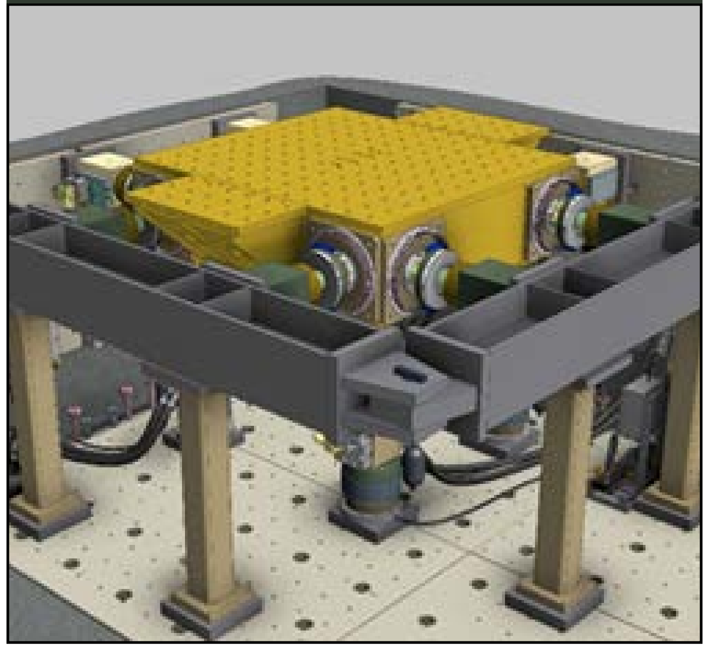
--TRMC's 2016 STRATEGIC PLAN, predicting growth for nuclear and electromagnetic test capabilities.

Sand and Dust: A new sand and dust chamber, having a large cross sectional area (approximately 20 ft. x 20 ft.) will allow testing to meet most customer requirements. The chamber will meet air temperature and velocity, relative humidity, and particle density requirements defined in MIL-STD-810.

Rain and Wind: A new rain and wind chamber, having a large cross sectional area (approximately 20 ft. x 20 ft.) to meet most customer requirements will produce repeatable standard test conditions. The chamber needs to produce hurricane gusts up to 100 mph.

Field Climatic Conditioning: Transportable hot and cold temperature conditioning systems are needed to provide pre-fire temperature conditioning support at remote missile firing locations. Systems will need to attain temperature extremes of -65 to +160 degrees F and have the ability to control humidity.

Six Degrees of Freedom Vibration Test System at SVAD.



Humidity and Salt Fog: WSMR requires new chambers to test large explosive items in humid and salt fog corrosive environments.

Dynamic Environments Testing: Multi-degree of freedom (2-DOF, 3-DOF and 6-DOF) test systems will be required to simulate the fatigue effects created during materiel transport, handling, and service use for current and future military systems. Vibration systems such as the one depicted below will reduce test times and provide a more realistic stimulus for test articles. WSMR will require new test buildings to house and operate these new systems.

Non-Destructive Testing: WSMR needs improvements in X-ray testing capability and the processing of the data. WSMR requires high-resolution, three-dimensional digital X-ray imaging (e.g., computed tomography) systems using low and high-energy X-rays for examining both small and large missiles, cartridges, fuses, and their internal explosive components in order to better detect serious flaws. Facilities may require improved radiation shielding methodology to protect personnel from harmful radiation. WSMR needs ruggedized portable high-energy X-ray systems to assess explosive items at remote test range locations. This equipment is essential when performing X-ray inspections of suspect, damaged or partially functioned missiles, missile components, and other ordnance items that cannot safely transport to the radiographic test facility.

Launcher Dynamics Instrumentation and Data Acquisition: As the mission of the open-air range expands to support a broader array of materiel for developmental testing in addition to systems involved in training and operational testing, the requirements to provide instrumentation, data acquisition and analysis will also require modernization and tailoring to meet those mission requirements. As technology increases, developmental test mission instrumentation systems must be modernized to improve sensor, data transmission, recording, data analysis and data distribution. These improvements will help ensure WSMR customers get quality, timely and cost-effective data to characterize the systems under test. Operational testing and training missions will require systems that can measure and record dynamic data on a non-interference basis over long periods. To accomplish this, WSMR will need micro- and nano-sensors, compact data recording and data transmission systems. Large volumes of data collected over extended periods will require automated intelligent processing systems to extract and analyze critical data sets.

Electromagnetic Effects: In the future, Electromagnetic Environmental Effects (E3) testing will increase as reliance on electronics and autonomous systems become ubiquitous throughout the majority of military systems. Enhancements to our E3 facilities for the future will focus on waveform (i.e. pulse width, spectrum width, etc.) vice the power level or frequency range. This is a result of WSMR recently integrating new and upgraded equipment and infrastructure through the Army Major E3 Modernization effort. The Army Major will renovate many of WSMR's E3 capabilities with equipment having an approximate life-cycle between 15 to 20 years. Due to the dynamics of the E3 environment, additional and modified capabilities may be required to simulate future E3 threats and to adequately meet DoD's testing requirements before 2030. Areas of consideration are:

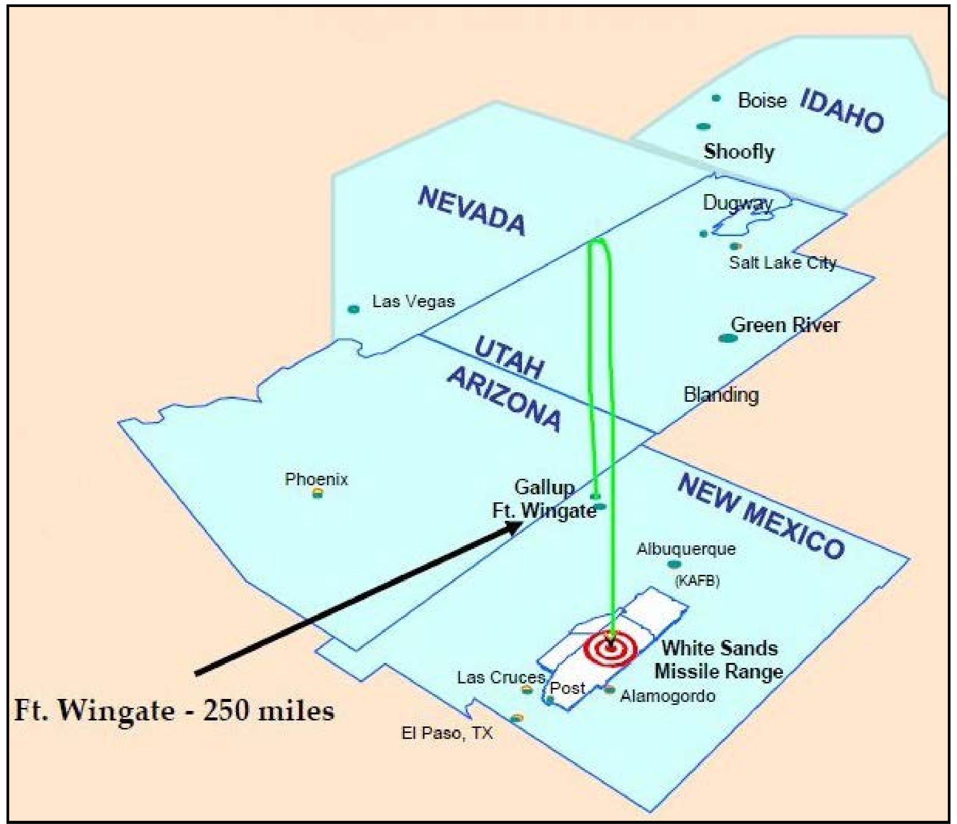
- Enhanced External RF EMRE Safari Capability
- Improved capability to conduct all E3 testing at the Line Replaceable Unit (LRU) or Line Replaceable Module (LRM) level
- Viable Direct Strike Lightning Capability
- Re-Vitalization of Mobile HEMP Capability
- Urban E3 Environment Testing Capability
- Mode Stir/Electromagnetic Reverberation Chamber
- Substantially Improved Anechoic System-Level Chamber
- Obtaining Equipment/Capabilities to meet the power and frequency dynamics across the Electromagnetic Spectrum and Threats
- Electromagnetic Compatibility (EMC) enhancements for the future will focus on resolution, full-system measurement and measurement accuracy
- The Electronic Attack (EA) team will need to stay abreast of threat developments and be able to respond to rapid changes. Processes successfully used in the past such as teaming with ARL and CCM should be enhanced and solidified via Inter-Service Support Agreement (ISSA).

Nuclear/Radiation Modernization: Over the last year, WSMR has been integrating new and upgraded equipment and infrastructure through the Army Major Nuclear Modernization effort. Additionally, the Pulsed Neutron Environment CTEIP project is evaluating the viability of developing a Low Enriched Uranium (LEU) Reactor and Dense Plasma Focus (DPF) capabilities to replace the current FBR. The Army Major will renovate many of WSMR's nuclear/radiation capabilities with an approximate life-cycle of 10 to 15 years, or approximately year 2025. Again, due to the dynamics of the nuclear/radiation environment requirements, additional and modified capabilities may be required to simulate future threats and adequately meet the DoD's testing needs. The upgrades and procedure changes that will be required are:

- Construct replacement LEU core by 2019 to ensure no significant impact on our Strategic Missile and Support Systems upgrade programs.
- Adequately shape PNE CTEIP on LEU / DPF to ensure that these capabilities will meet total DoD and government requirements.
- Obtain new technology Flash X-Ray by 2020 to mitigate obsolescence issues with current PI-538 and to increase capability.
- Obtain new technology in a Nuclear Thermal Simulator to reduce sustainment costs from White Sands Solar Furnace and increase capabilities.
- Upgrade linear accelerator to 45 Mev by 2018 to better support the complete DoD requirements for gamma dose rate testing.
- Establish a semiconductor technology roadmap to quantify future testing requirements and infrastructure adequately.
- Develop improved speed and accuracy on radiation metrology technologies and processes.
- Develop processes and procedures to reduce testing costs, but still ensure high confidence in nuclear/radiation performance and survivability.

A Soldier works on Warfighter Information Network-Tactical Increment 1 equipment during the NIE 11.1 at White Sands Missile Range, N.M. in July 2011. (Photo: C. Schwerin)

FUTURE STATE
WSMR 2046



Off-Range Missile Launch Sites and Flight Corridors.

Extended Range and Safari Operations

Future State:

In the next 30 years, WSMR will support long-range missile tests (>100 miles) which will exceed the extensive airspace and land area of this installation. In many cases, the terminal end of a long-range flight will be the most hazardous, due to debris impact; thus, the optimal flight safety option will be to launch off-range, have the missile's ground track pass over low population-density areas, and then impact on WSMR. Scheduled for the early 2020 timeframe, are the lower-tier project missions, with target support out of Ft. Wingate, that exemplify the WSMR long-range missions just described.

In addition to these operations, longer distance, overland missile flights will also be part of WSMR's future. Examples of other longer off-range launch areas, in addition to those listed above, are Green River, UT and Shoofly, ID (see figure). Other off-range launch sites, with impact on WSMR, could include locations in Canada and the Gulf of Mexico. In addition to conventional missile flights, WSMR will likely be required to support HS/H tests having requirements for corridors ranging from 600 to over 1000 miles, with full TSPI (optics, radar and telemetry) coverage along the entire route (see subsection High Speed / Hypersonics). With vehicle speeds attaining Mach 10 and higher, flight altitudes reaching 100,000 feet, along with flight paths over civilian population areas, meeting data collection and flight safety requirements will pose significant challenges which surpass the current capability of all test ranges.

White Sands Missile Range will continue to implement their innovative safari concept which can support tests across the globe. Because of its vast land area, WSMR implemented an instrumentation approach that was oriented toward mobility; in the future, all of its data collection instruments will be mobile (see Radars, Optics and Telemetry subsections). This mobile capability came to the fore when the Missile Defense Agency requested support for Pacific Ocean tests and the Range's instrumentation, which was already designed to be deployed to remote locations over the 2.2-million acre range in the southern New Mexico desert, was successfully utilized.

Some examples of near future WSMR safari support are as follows: Electron Rocket, safari location Mahia, New Zealand, August-October 2016; PAC-3 MSE vs Janus Target, Kwajalein, Reagan Test Center, July 2017, FY-18 and FY-2021.

As a necessary adjunct to mobile data collection instrumentation, WSMR also deploys a control van to provide range control, flight safety and data collection/reduction support using its deployed assets. The future evolution of range control vans will see a decrease, both in the size of the equipment enclosure and the number of personnel required to operate and maintain the range support system. In addition to gains from smaller computers and electronic enclosures, exploitation of future advancements in AI and other computational techniques will result in significant operational functionality transferred from human to machine execution. As 2046 approaches, this evolution could result in a control van that fits into the cargo area of a family-size SUV, with at most one operator required to perform the range control and safety functions. The ultimate goal is for an operator located at WSMR to remotely operate the control van of the, which has been prepositioned near the test site.

Roadmap:

The following tasks must be accomplished in order for WSMR to enhance its long-range corridor and safari support over the next 30 years:

- To provide the required flight paths for long-range missiles and/or HS/H testing, WSMR, in coordination with the FAA, must develop new flight corridors over land that minimize overflight of populated areas. As part of this effort, WSMR must pursue the environmental, airspace, and infrastructure concepts to allow longer-range corridors to be set up quickly for future customers.
- Future operations, having flight paths over population centers, will require advanced flight safety capabilities in order to guarantee the maximum level of safety for the public and to private property. The Range will have to develop both hardware systems and software tools to implement this enhanced capability.
- White Sands Missile Range must seek additional opportunities to expand its safari support to locations and facilities not previously utilized. Safari efforts will provide WSMR an opportunity to optimally employ its personnel and field underutilized equipment to maximize the use of its test resources. In turn, safari exercises can remove the need of other installations to acquire, operate, and maintain expensive range control and safety systems that already exist at WSMR, and are available on short notice.
- White Sands Missile Range must continue to design data collection instrumentation that is mobile and can be easily deployed to off-Range sites. In addition, design improvements to control vans that utilize advanced computational hardware and software to provide range control, flight safety and other support capabilities, must also take place.
- WSMR will need to conduct a far reaching National Environmental Policy Act (NEPA) Environmental Impact Statement to direct this effort and inform the public.

Networks, Wireless Connectivity and Peer-to-Peer Models

Future State:

The WSMR network of the future will be a combination fiber optics and wireless enterprise system having the capability to support both test articles and data collection instrumentation that generate orders of magnitude more data than currently produced by contemporary range assets. The features of the future WSMR network are as follows:

- Bandwidths thousands of times greater than presently attainable.
- Data throughput latency that is negligible, relative to WSMR's current capability. Data from instrumentation and the test article will be immediately available upon test completion.
- Open-restricted access capability for attached devices that enable a broad range of authorized instrumentation and customer asset support.
- The capacity to handle the large volumes of data produced by autonomous systems by using advanced computational techniques (i.e., Big Data and data mining analytics).
- A real-time capability will be in place that ensures the non-intrusive monitoring, troubleshooting, and resolution of network configuration issues and concerns (e.g., self-adaptation) as well as an inherent network capability to provide a total, complete, deterministic and well-controlled cyber operational and assessment environment.
- A capability to perform comprehensive network diagnostics prior to tests, including identification of potential network failures, and provide verification that only authorized devices are connected.
- A developmental cyber environment capability will exist that ensures a non-competing, non-intrusive and continuous integrated open-air range.
- A fully networked operational and institutional communications system throughout the Range to all direct and indirect T&E mission stakeholders.
- A data throughput capacity that provides real-time transmission of all data collected during tests (e.g., no dependence on the use of 'hand-carried' optical media to provide all optics data collected during testing).

A Soldier, from the Army Reserve 392nd Expeditionary Signal Battalion, helps validate the unit's newly enhanced Warfighter Information Network-Tactical Increment 1 network equipment on Fort Eustis, Va., Nov. 2015. (Photo: A. Walker)

The Army's next generation high-bandwidth Secure Internet Protocol Router/Non-secure Internet Protocol Router Access Point, or SNAP, ground satellite terminals will include military satellite and secure Colorless Core capability. The SNAP shown here was part of NIE 13.1 at WSMR. (Photo: A. Walker)

- A network capability that supports all levels of secure information transmission through TOP SECRET.
- A means so that all upgrades and other programs to eliminate network deficiencies can be directly carried over to the IRCC to improve its capabilities as well.
- Easier access of the appropriate parts of the network for commercial and foreign customers.

In order to achieve the future enhances listed above, networks will be designed and implemented using advanced technological concepts. For example, an approach such as the "Process-in-Network" (PIN) concept which is defined as a capability to processes data or information as it is being transmitted through the network would be a possible methodology (details of this architecture and what it could potentially offer to WSMR and its customers are discussed in the Appendix).

The future WSMR network will provide the maximum amount interoperability for instrumentation and test articles. In the future, access to networks involving numerous flavors of interfaces will be the rule. Future instrumentation will be configured with the proper interface technology to ensure the equipment is 'always best connected' while seamlessly ensuring continuity. In terms of protocols, IP will have progressively increased its footprint by steady migration and integration into the WSMR infrastructure. As an example, upon completion by 2020, the new Mobile Telemetry Acquisition Systems (discussed in the "Telemetry" section) will transmit data using IP protocol. Interface solutions will bridge old instrumentation protocols to new network standards, thus avoiding the requirement to discard expensive instrumentation due to network interface incompatibility.

Instrumentation (particularly optics and telemetry), autonomous systems and virtual collaborative environments will represent the bulk of traffic on network bandwidth. Networks will undergo continuous upgrades to provide increased throughput and performance to handle data volumes that will eventually exceed capacity. In addition, impacts to spectrum and energy demands will manifest themselves as constraints to any future network architecture. As a guiding principle, the future approach will have always strived to have a network system in place that exceeded the data requirements imposed by all devices connected to the system.

The application of robust cybersecurity procedures and techniques will be integral to all future network technology implemented at WSMR as discussed elsewhere in this document. The Range will implement cybersecurity policies in such a way that imposition of procedures to protect the network will not interfere with users having maximum access and freedom when using the network.

Wireless connectivity will have evolved to where most communications, including voice, instrumentation and weapon systems testing will be utilizing it. Wireless will be used initially with the in-situ fiber optics in the current WSMR network (i.e., the Test Support Network). As technology develops and higher throughput rates and smaller bandwidths in wireless occur, coupled with the achievement of more effective cyber-security technology, the wireless communications system at WSMR will continue to grow in size and criticality over the next 30 years.

Several applications where wireless connectivity will be a vital test asset are as follows:

- NIE testing, which will continue to grow at WSMR, focuses on testing wireless communication systems to determine their suitability for battlespaces.
- Future autonomous systems will rely heavily (if not totally) on wireless communications during testing.
- As data collection instrumentation systems become more automated and eventually autonomous, they will utilize wireless communications for performing such functions as self-driving, remote setup, orientation, and calibration at their preassigned positions on the Range.

Wireless technology will remain the only viable means of communication in the modern battlespace.[19] In order to replicate these conditions realistically during T&E operations, a robust, high-performance capability for wireless communications will be in place at WSMR and other test facilities, wireless and fiber networks working in tandem.

Roadmap:

To move into the future, WSMR will look to take the following steps to upgrade and enhance its test network, wireless connectivity and peer-to-peer capabilities:

- Increase the number of access points on the Range to enable more instrumentation to connect directly to the existing network.
- Install state-of-the-art technology to increase the bandwidth and decrease the latency of the network.
- Implement an open-restricted network for authorized users to replace the closed-restricted network.
- Implement robust cybersecurity protection for the networks that allow authorized devices to operate with minimum interference from security software
- Increase the bandwidth, throughput and secure transmission capability to enable all test data to be transmitted to a central collection point using only the network (i.e., eliminate the requirement for 'human data delivery' procedures).
- Upgrade the network to support Raman and thulium-doped amplifiers, expanding the Dense Wavelength-Division Multiplexing (DWDM) to L Band. This will provide for each type of instrumentation system (i.e., optics (Close-In, Fly-Out), radar (Close-In, Fly-Out), GPS, telemetry, etc.) to have their own wavelengths sharing the same fibers within the TSN with data rates around an Exabyte-per-second.

Plans to better implement wireless technology at WSMR in the future are as follows:

- Increase the number of wireless network radio poles and overall wireless data throughput capability across the Range. This effort should include raising the height of the poles from 50 to 200 feet, and populating the WSMR grid with sufficient coverage to eliminate dead zones in data and voice communications.
- Develop a wireless capability (similar to the fiber-optic network) that enables transmission of all instrumentation data (e.g. high-speed, high definition video) to a central collection in real-time.
- Implement modulation schemes that upgrade from 256 Quadrature Adaptive Multiplexing (QAM) to 1024 QAM. This will increase the number of channels and their bandwidths by a factor of 2 million, enabling a higher number of frequency channels for utilization with less spectrum required and with narrower bands, as well as provide higher data throughput.
- Boost commercial cellphone coverage (even if only one vendor) throughout the Range.
- Implement technology that will enable radios and smart devices used to control Range activities to operate within any automated frequency authorization and spectrum monitoring program. In the future, employ technology that allows each IP radio to have preassigned credentials with biometric logon capability. Establish procedures to make maximum use of available spectrum and to identify unauthorized users (including the location of the unauthorized device) and frequency encroached.
- Design and implement a capability for each WSMR IP radio assigned frequency and bandwidth to update the Frequency Area Coordinator's (FAC) servers automatically with the Radio Frequency Allocations (RFAs) and credentials scheduled for use that specific day.
- Implement procedures to connect to public domain

A Soldier monitors input from the tactical operations center at the Early Infantry Brigade Combat Team Limited User Test at White Sands Missile Range, N.M., in July 2011. (Photo: US Army)

services through a series of Radium servers similar to using a cross-domain solution. This will provide the required security for connections between WSMR and commercial networks.

Information Security

Future State:

Data collected from future testing at WSMR will pose significantly new challenges for protecting classified, sensitive or proprietary information. These challenges will arise from the extremely large volume of data captured from instrumentation and test articles, as well as considerably increased use of electronic test information reporting, in lieu of hard copy or optical media. The basic levels of security, TOP SECRET, SECRET and CONFIDENTIAL, along with declassification and special handling instructions are expected to apply into the foreseeable future. In addition, protection of classified and other types of restricted data will still be required. The use of security containers will diminish and increased reliance placed on secure server storage will occur (see subsection "Big Data, Data Mining and Augmented Reality").

JUNO target missile launch from Ft. Wingate, NM, December 2015. (Photo: G. Palombit)

Moving into the future, the volume of test data and information content generated during Range operations will grow almost exponentially, especially as autonomous systems and System of Systems are tested at WSMR. The amount of classified and unclassified test data that will result during this data explosion will likely exceed the capability of personnel. At which point, reliance will be placed on intelligent computational processes to analyze test data; this will entail utilizing heuristic rule-based Expert Systems and other Artificial Intelligence processes to automatically apply the correct security classification levels (and perform the other associated procedures) that are currently performed by humans.

As more information is collected and stored electronically, WSMR will have the opportunity to apply knowledge-based processing techniques (e.g., Big Data, Data Mining) to provide customers with an analysis of a wide range of test article performance data. One of the main challenges for future server storage will be to provide sufficient server storage capacity to handle extended data retention. For long-term retention (i.e., years), the potential amount of data that could be collected by WSMR in the next 30 years would require a server storage capacity of an Exabyte or more.

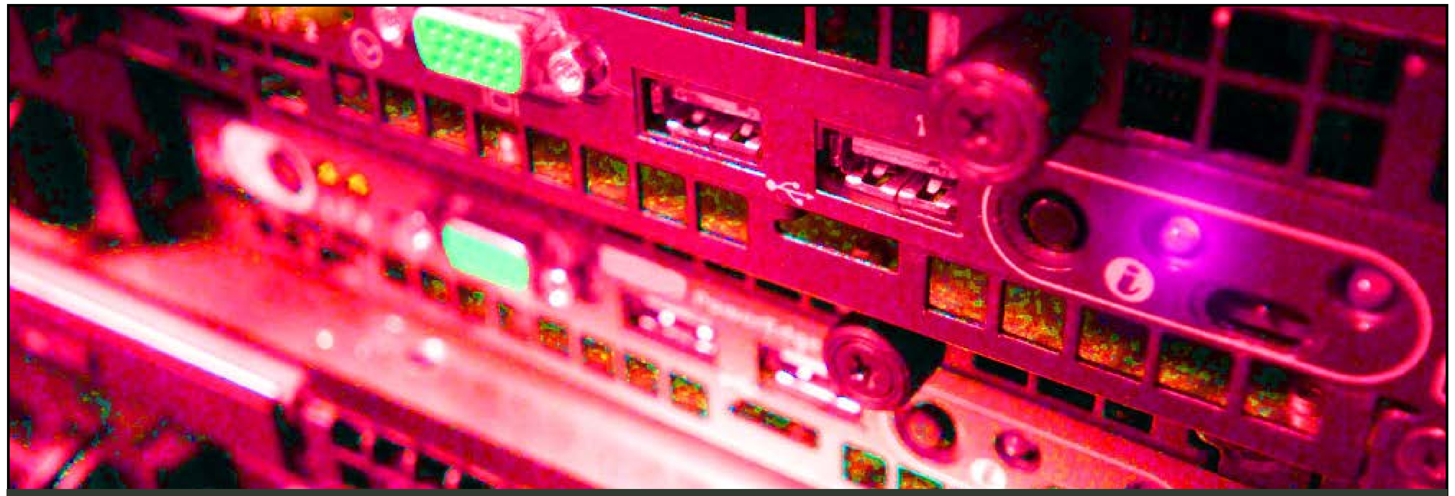
The release and transfer of data (both classified and unclassified) increasingly moves toward a purely electronic form, as it does, the methods will change for ensuring that only the intended recipient receives the information. The encryption of classified data for electronic transfer will be mandatory. Where humans are involved in the electronic transfer of classified data (e.g., data exchange via smart devices), reliance will be placed on biometric technology to establish positive identification to ensure a secure exchange of information. Where the transfer of classified data does not involve humans directly (machine-to-machine), the unique identifiers of humans is no longer applicable. In the future, classified machine-to-machine data transfers will utilize a BIOS-metric (analogous to a biometric marker) or other device implanted in computational processors to establish unique identifications.

Storage of classified material in approved secure containers (i.e., safes) and so called 'open data storage area' will also continue to be a requirement for the next 30 years. These storage arrangements will be modernized to provide continuous electronic monitoring and surveillance to increase the level of classified data protection and reduce security violations.

Roadmap:

WSMR will not create security regulations; rather, the Range will have to provide innovative solutions for the secure handling, storage and transfer of large volumes of electronic classified information in accordance with any new Government security regulations and procedures.

Based upon the growth requirements in the amount of and length of retention for test data storage, WSMR will augment existing and/or acquire new server systems to provide the required storage capacity.



Defense Secretary Leon E. Panetta spelled out in detail the Defense Department's responsibility in cybersecurity during a speech to the Business Executives for National Security meeting in New York, October 2012. (Photo: C. T. Lopez)

The Range will acquire new classified storage containers (safes) to satisfy future security requirements and provide more efficient hard copy storage. Open storage areas will be upgraded to integrate technologically-advanced intrusion alarms and other hardware that ensure the highest degree of protection for classified information stored in these areas.

Form a study group to generate the specific roadmap for WSMR information security. Roadmap should address large data storage, automated security classification, big data mining tools, use of BIOS as well as better and more automated security containers.

Cyber Test and Evaluation

Future State:

Moving towards year 2046, DoD systems will increasingly depend upon complex, interconnected information technology environments. This dependence will grow steadily, both in terms of size and as a potential threat attack vector. Cyber environments are inherently vulnerable, providing opportunities for adversaries to exploit systems, steal data or negatively impact missions. Potential cyber vulnerabilities, when combined with a determined and capable threat, pose a significant security problem for the DoD and its warfighters. Cybersecurity test and evaluation will assist in the development and fielding of more secure, resilient systems in response to this problem.

Roadmap:

The National Cyber Range (created by DARPA and subsequently transferred to TRMC) provides assistance to test facilities, such as WSMR, to address cybersecurity issues on a continual basis.[20] In addition, another cyber-focused resource WSMR has available locally is the ARL's Survivability/Lethality Analysis Directorate (SLAD), which currently serves as the "Army Acquisition Blue Team." Additionally, WSMR will seek out other DoD resources to help secure its existing cyber systems as well as assist in the creation of high-fidelity, mission-representative cyberspace environments for T&E.[21] In order for WSMR to maintain up-to-the-minute awareness of cybersecurity and cyber T&E advances, WSMR leadership must bring together a multi-directorate group to create a roadmap forward.

Big Data, Data Mining and Augmented Reality

Future State:

In the future, the growth of test data stored by the Range is expected to grow dramatically (perhaps nearly exponentially). Almost all of this data will be stored digitally on servers at different locations on WSMR. Advanced methodologies to effectively search and retrieve stored information will have been implemented to enable utilization of this vast amount of data, and to provide customers with information and knowledge based on analyses of test results. Two of the current software tools that will continue to be employed for this purpose are Big Data and Data Mining.

White Sands Missile Range will not develop the fundamental tools used for Big Data and Data Mining operations; rather, the Range will leverage the myriad of tools and techniques available, or to be developed by industry (e.g., Google) and Government agencies (e.g., National Security Agency) and will tailor these methodologies to the Range's unique requirements.

Roadmap:

Continue the implementation efforts for Big Data and Data Mining Analytics, begun in 2014 with the acquisition of WSMR's Thunderbird Hadoop/Storm Big Data system and the Ryleh Big Data development system. Acquire a third Hadoop/Storm Big Data system planned for Q4 2016 to enhance the current Big Data capability.

Proceed to adapt and tailor the tools available for these systems to further develop and expand the capability to provide Big Data and Data Mining services to both customers and WSMR organizations in the future.

Continue to maintain awareness of new developments in this area by DARPA, Government Laboratories, commercial sources and academia to effect technology transfers to address WSMR requirements.

Survey future customer requirements for implemen-

FUTURE STATE
WSMR 2046

A virtual reality system on exhibit by Space and Naval Warfare Systems Center (SSC) Pacific's Battle Space Exploitation of Mixed Reality (BEMR) lab at WEST 2016. The BEMR lab specializes in evaluating and integrating augmented and virtual reality applications for the Navy to help save costs on training and maintenance systems. (Photo: K. Jackson)

tation of Augmented Reality and other advanced concepts in computer sciences to supplement the Range's current and future capabilities in Big Data and Data Mining. Work with study group on information security (see Roadmap in subsection "Cyber Test and Evaluation"), to develop detailed roadmap.

Spectrum Monitoring, Frequency Surveillance and Allocation

Future State:

Over the next 30 years, WSMR will acquire the capability to continuously monitor 100 percent of the electromagnetic spectrum present at any given time on the Range, and will be able to identify the locations and frequencies of all emission sources, taking immediate action to mitigate any interference from unauthorized sources. Frequency monitoring systems deployed at the Range by 2046 will have the capability to combine local monitoring with larger regional and ultimately national frequency surveillance and monitoring systems.

By 2046, WSMR will also have the capability to:

- monitor and control interference automatically
- identify signals emanating from all authorized and unauthorized (rogue) sources of radiation throughout the Range
- view complex scenarios of frequency power and time at a glance
- collect and present evidence of Radio Frequency Interference (RFI), noise floor or signals of interest
- map Radio Frequency Interference (RFI) sources from mobile or multiple fixed sites
- geo-locate intermittent signals in real-time

In the future state, WSMR will have the capability to reallocate frequency resources automatically, in an optimal manner, and to adjust the needs of weapon systems testing to compensate for the transfer of any parts of the RF spectrum to or from commercial activities. Dynamic frequency allocation will bring an automatic ability to distribute frequency assignments for weapons systems tests on the Range running concurrently.

The capability to monitor a far greater breadth of frequency bands will emerge in the coming years. For example, WSMR will be able to collect and monitor bands above 15 GHz because of ongoing pressure applied to the T&E community to reduce or abandon the radio spectrum below 7 GHz. In addition, the Range will be able to monitor optical bands as well.

Roadmap:

To start the process, White Sands Missile Range will develop a comprehensive spectrum monitoring capabilities roadmap that defines capability enhancements, cost estimates and timelines to get from our current state to the future state outlined above. We will survey all spectrum monitoring systems across ATEC, AF, and Navy MRTFBs to determine current DoD capabilities. We will leverage existing capabilities including the present WSMR spectrum monitoring system, the US Army Electronic Proving Ground's Multi-spectrum Ambient Noise Collection and Analysis Tool (MANCAT), and encouraging tactical RF monitoring/direction-finding systems in development. The WSMR future state vision is a quantum leap from its current state and, minus radical advances in the associated technology, will involve incremental improvements over the next 10-30 years. There will be challenges with technology, process implementation, personnel resources, skill sets, and affordability. These elements must all be roadmap components.

In conjunction with the above analysis and research, there are also numerous agencies and studies that will inform our future state requirements and solutions. WSMR will be a key player in initiatives to ensure that our requirements are captured and that possible funding avenues are explored. WSMR will actively continue implementing the recommendations of the DoD Electromagnetic Spectrum (EMS) Roadmap and Action Plan.[22] This plan will start in 2017 to collect spectrum usage data through at least one-half of all test and training activities by the year 2021. The objective is to review and analyze frequency spectrum requirements and identify where the system can be simplified to provide timely information to support DoD studies, and to promote and defend DoD spectrum requirements.

WSMR will also continue to support the Frequency Management Group and RCC to ensure established practices and procedures are followed, and to stay abreast of common trends and technology advances at other test ranges.

The Range will continue to work with the TRMC, the International Telemetering Conference Community and the National Advanced Spectrum and Communications Test Network to facilitate identification and adoption of spectrum-efficient technologies. In addition, WSMR will actively participate in studies to determine the possibility of minimizing the use of radio spectrum frequencies and the feasibility of using optical bands for telemetry operations.

The Range will collaborate with the TRMC to promote the fielding of existing advanced T&E communication technologies to improve overall EMS support for weapon system development and assessment. WSMR will investigate technologies such as Advanced Range Telemetry "Tier 1" and "Tier 2" transmitters, integrated iNET system capability, and Common Range Integrated Instrumentation System (CRIIS) for potential utilization at WSMR.

Secure Communications / Quantum Entanglement

Future State:

Future test programs will have advanced communications systems. Enhancements to Frequency Hopping Spread Spectrum (FHSS), Direct Sequence Spread Spectrum (DSSS), Time Hopping Spread Spectrum (THSS), Chirp Spread Spectrum (CSS), and combinations of these techniques will form future communication technologies. The main objectives of these techniques are to make communications resistant to jamming, and/or to conceal communications that are taking place, the latter sometimes called Low Probability of Intercept (LPI). More advanced radio transmissions such as Ultra-Wideband (UWB) will also be available. UWB transmits information by generating radio energy at specific time intervals and occupying a large bandwidth, thus enabling pulse-position or time modulation.

Roadmap:

White Sands Missile Range will closely monitor the DoD efforts to explore the use of quantum entanglement and quantum communications as the ultimate means to achieve secure communications. This methodology uses entangled photon pairs to provide unconditionally secure, instantaneous communication between two points. Upon maturity, WSMR will incorporate this technology into its networks and communications systems.

In order to support future spread spectrum technologies, secure communications and quantum entanglement, WSMR will need the latest radios available for customer testing needs. The Range will acquire these systems upon technology maturity, subject to budgetary constraints imposed in the future.

Soldiers use Nett Warrior to plan a raid during NIE 13.2. The brigade conducts tactical operations in an operational environment during Network Integration Evaluations at Fort Bliss, TX, and White Sands, NM, to evaluate and provide feedback on the tactical network and other equipment under tough, realistic conditions against a thinking, adaptive enemy. (Photo: D. Bague)

The Army's new Rapid Vehicle Provisioning System (RVPS) reduces the time it takes to provision an entire brigade's worth of networked vehicles from six weeks to less than five days. The Army conducted a demonstration of RVPS in late February 2016 at Fort Bliss. (Photo: A. Walker)

Adaptable and Flexible Battlespace Environments

Future State:

Standardized net-centric operations will provide the vehicle for extending operational or test environments by employing interoperability between assorted tactical, live, virtual, and constructive (LVC) systems, locally and distributed from Army and joint installations. This leverages maturing infrastructure, software, and test procedures that (1) facilitate the stimulation of test articles using fielded and simulated systems, and (2) enable immersing a test article in a much broader battlespace, including threat representations and joint, interagency, and multi-national system interactions. As time progresses, the application of AI and other advanced computational and LVC techniques will extend this capability to more sophisticated scenarios, such as those involving multiple autonomous systems in swarms or federated groups. The future battlespaces created by LVC techniques will support, throughout the full acquisition cycle, all requirements of materiel developers testing at the Range.

WSMR has developed and will continue to develop advanced M&S capabilities to meet the challenges posed by future weapons systems tests. Among other benefits, the implementation and use of effective M&S skills will enable testers to reduce the number of live tests required to validate an article's performance. During periods of budget uncertainties, White Sands' M&S techniques will be critical to the eventual fielding of advanced weapons systems.

Roadmap:

A growing joint community is in place today and will only continue to grow in the future. The Range must continue the development of more sophisticated battlespaces, using LVC techniques, to ensure that it can meet the requirements for emerging weapons systems testing. As an important component, the Range must endeavor to safeguard the secure and uninterrupted availability and reliability of its information systems. We must be prepared in order to accommodate all tests associated with ever-changing modern battlespace dynamics. As such, we will must overcome the growing information assurance and cybersecurity challenges of utilizing long-haul communications for distributed test operations at WSMR.

The HS/H T&E Infrastructure Capabilities Study, discussed in the "High Speed/Hypersonics" section, gives several references related to critical needs and perceived technology gaps in M&S capabilities.[23] The identified M&S requirements vary from development of simulation techniques for predicting the onset of hypersonic flight phenomena (e.g., plasma formation), to telemetry antenna patterns, electromagnetic interference, and methodologies leading to mission effectiveness determinations. The study also points out that testing of this particular weapon system is expensive in the extreme and that effective use of M&S is one of the methods predicted to reduce costs to the program. (Cost drivers include not only the live open-air test, but also experimentation carried out in wind tunnels, high-speed test tracks and other facilities that are cost-intensive to operate.) Based upon broad identification of the requirements for the HS/H project's M&S developments, those areas pertaining to T&E of this weapon system, with regard to the Range's mission (TSPI, Flight Termination Systems, etc.), should receive strong emphasis when drafting a more detailed roadmap towards 2046.

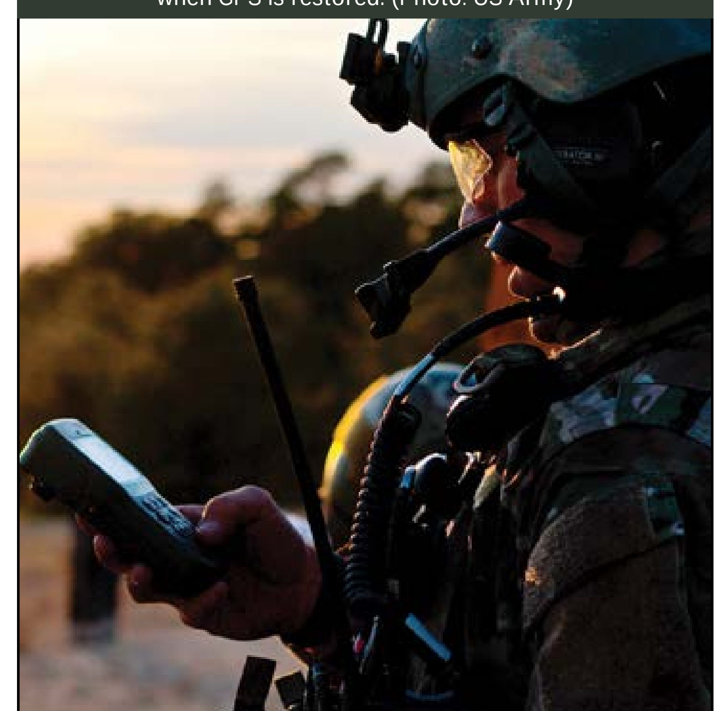
The use of M&S procedures in the arena of autonomous systems (see "Unmanned, Autonomous Systems") will be essential. Utilization of M&S will extend down to the initial design of the vehicle or platform, providing a basis for analyzing the expected behavior and interaction of sensors, control processors, power systems and locomotion/flight control, in order to pre-assess performance objectives. During test planning, M&S will be used to analyze and provide critical information required for assigning areas (ground and/or airspace) in which the autonomous systems will be able to safely test. (This facet takes on a critical importance with weaponized autonomous systems.) In addition, M&S will be used to define test activities for autonomous systems that produce stressful performance conditions for all critical parts of the test article (e.g., sensors, power system, control processor(s), etc.). Modeling and Simulation procedures will be used to analyze the test article post-test as well, to arrive at sound conclusions for failures during field exercises. This diagnostic capability will be critical to testing autonomous systems in order to pinpoint causes of failure as well as in safety investigations.

The Range must also continue to develop advanced M&S methodologies and techniques to support tests of emerging weapons systems with advanced capabilities. In particular, an M&S capability to support HS/H and autonomous systems programs will play a critical role in reducing test costs for Range customers during times of budgetary shortfalls.

Finally, WSMR will develop a capability for utilizing Design of Experiments (DoE) for developing future tests. DoE will provide a scientific test design methodology to deliver statistically significant data to customers, and potentially reduce the number of operations required to achieve results. The Range will develop a team of DoE-qualified personnel, either through hiring university-trained personnel or by way of in-house training development programs, to achieve the payoffs in improved test and analysis processes that DoE has demonstrated.

A detailed roadmap will first examine enhancements to WSMR's battlespace. Subsequent issues to explore are customer needs, the more specific roles of M&S and DoE, and above all, safety factors.

GPS satellite receivers are vulnerable to conditions that impede the signal transmission. The chip-scale atomic clock provides Soldiers a backup source of accurate time and a quicker recovery when GPS is restored. (Photo: US Army)



Interfaces

Human to Machine Interfaces (H2M)

Future State:

H2M interfaces are in place and have been implemented with a wide range of entities, including standalone computers; manufacturing; most categories of electromechanical tools and equipment; home environmental controls; and system of systems.

We have a number of useful applications for advanced H2M devices for different Range applications. For example, in the area of environmental testing where simultaneous tests occur (e.g., cold temperature soaking and sand storm simulations), all operations are computer controlled. They are enabled and provided with an advanced H2M controller, and multiple functions are performed by a single operator.

As well, the control of multiple autonomous systems is conducted by a single operator. When these systems made their initial debut for testing, they were not fully autonomous; rather they evolved from significant human intervention to nearly full autonomy. An intelligent H2M interface is utilized to provide a scenario where multiple devices are required to be simultaneously tested. This feature is of seminal importance for the warfighter; multiple autonomous systems designed to perform different functions like, for example intelligence, surveillance and reconnaissance, and nuclear radiation detection are controlled by one individual.

Roadmap:

Future interface developments will not only deliver more intelligence, but also the capability for control to become almost totally net-centric and enabled through cloud processing. One of the most significant challenges posed by this mode of operation is cybersecurity. One solution proposed is to provide control functions via cloud processing using encrypted data, with the end device having the capability to decrypt the control data sent to it. In addition, the H2M interface controllers are expected to evolve into wearable devices. This advance would enable the warfighter to utilize the device in a 'hands-free' manner (e.g., voice control), thus minimizing the encumbrance of having to hold onto a controller while simultaneously operating a weapon system.

The design and development of sophisticated and effective H2M interfaces will be vitally important for con-

An explosive ordinance disposal technician briefs visitors on the capabilities of one of their robots during a tour of Wright-Patterson Air Force Base, Ohio, July 2016. (Photo: J. Farnsworth)

ensure that the highest level of cybersecurity is attained to protect the critical assets networked through the M2M interfaces.

During the next 10 years, M2M connectivity will become almost ubiquitous, as wireless communications achieve greater bandwidth and throughput speeds, and utilization of cloud computing continues to develop. This advance will not be without the occurrence of some potentially significant issues insofar as WSMR and other DoD installations are concerned. The benefits that will gained from the increased capability and sophistication of M2M technology using wireless networks will require larger bandwidths and utilize more of the electromagnetic spectrum; however, the commercial sector will, simultaneously, be demanding more of the same spectrum, and this could constrain future military wireless applications. As was the case for H2M interfaces, cybersecurity for M2M connectivity will be a significant challenge.

One example of a possible future application of intelligent M2M interfaces will be to control autonomous systems. As discussed in the Appendix "Modernization and Development Philosophy", a high degree of Artificial Intelligence will be required to control autonomous systems being tested under simulated combat conditions. The HPC system will have numerous M2M interfaces linking the central control system to multiple complex test articles to produce the required warfighting scenario. These interfaces will need to have high communication throughput speeds, and will have to be cyber-protected in order to ensure that safe, reliable control of the test articles can be maintained. Especially true if the articles are weaponized.

A second example of the use of M2M connectivity is the remote control of Range data collection instrumentation. During the 2030s, it is expected that Range instrumentation will be mobile and automated, to allow for self-driving, and autonomous setup, while calibration/orientation and test operations can be controlled by a central processor, utilizing AI, to carry out mission support with minimal human intervention. By 2046, the capability for M2M interfaces to become self-adapting and achieve the capability to be operated on different computer platforms without human modifications will be the established modus operandi.

As was the case for the H2M interfaces, M2M interfaces will be key components of weapons systems in the future, and must be included as part of system evaluation exercises in the future. WSMR will monitor M2M developments for application to WSMR-specific problems.

Robotics and Warfighter Systems Interface

Future State:

Robotics is employed to mitigate risks, increase awareness and augment human capabilities by providing additional power and endurance, in a variety of activities, including warfare.

We have developed affordable, interoperable and increasingly autonomous Unmanned Ground Systems (UGS) and Unmanned Air Systems (UAS) in order to enhance the endurance, reconnaissance, security, persistence and protection of Soldiers and units across the range of military operations.

Roadmap:

During the next 30 years, WSMR will be required to test various robotics systems that will assist in providing this Nation's warfighter with an overwhelming capability on the battlefield. The robotic systems to be tested will utilize multiple WSMR assets, e.g., climatics laboratories, autonomous arenas, etc., and will feature many of the systems already identified, such as the H2M and M2M interfaces.

Human-machine relationships with autonomous vehicles like UAVs and UGVs are explored for future research.

Robotics provides an excellent example of how a WSMR 'one-stop' approach to providing comprehensive services to support future missions will make this installation the 'go-to' place for testing.

The goal in the mid-term is for robotics to deploy as force multipliers at all echelons from the squad to the Battalion Combat Team (BCT), and across all war fighting functions. This achievement will decrease physical and cognitive workloads on the warfighter, while increasing their combat capabilities. The long-term goal is an Army equipped with affordable, interoperable, autonomous unmanned systems enabling integrated manned/unmanned teaming for improved movement and maneuverability, protection, intelligence and sustainment. Increases in autonomy will enable robotic wingmen, robots as squad members, nano and micro robots used for situational awareness, autonomous appliqué kits, exoskeletons, etc. Each will increase levels of autonomy that further mitigate risk, and increase speed, reduce burden, both cognitive and physical.

WSMR will form a study group to develop a detailed roadmap for robotic test support. The group will investigate and identify safety, customer data requirements, pretest and posttest needs, and what environments are required.

Infrastructure

Future State:

White Sands Missile Range is a premier Research, Development, Testing and Evaluation installation with adaptable, technologically advanced research and training infrastructure that meets the evolving needs of our customers and partners. WSMR provides a safe, attractive community and high quality of life for Service Members, Civilians, and their Families. By 2046 there will be a thriving community of families who call WSMR home, composed of our military and civilian workforce. For those who do not walk to work and even for those who do, there are regular shuttles between facilities and out to the neighboring communities, and car parks.

Outside the boundaries of our main offices and living community are the test facilities and launch sites, which enable WSMR personnel to meet dynamic customer requirements and various missions. Our modern and adaptable buildings provide a flexible interior space which can be renovated to support multiple uses. The multi-story structures, allow for more square footage to accommodate a wider range of users. Columns and load-bearing walls have been minimized, and open floor plans with flexible furniture are standard. WSMR has decades of experience with launches, and understands the massive coordination and technology required to achieve success. We utilize the most modern technology, which eases storage, transport and preparation for a launch.

The Range provides state of the art communications capabilities, including networking, telephone, mobile networks, and fiber optic connectivity. WSMR's vast network of roadways, spanning into remote locations of our expansive range, is well maintained and includes edge lined rumble strips to alert drivers should they drift off the road. We provide reliable utilities to key, high-use areas of the range while also minimizing visual clutter. Through extensive planning and partnership agreements, we have ensured a safe, functional buffer zone that has kept new construction and frequency interference from encroaching on airspace and range capabilities.

> ***We [as a nation] are consuming more energy and have an aging infrastructure, it is the responsibility of the Army to help reduce the stress and strain on those power lines and we do this in partnership with the utilities. The power lines end here. There's no better support from the community than here at White Sands and New Mexico. You have a lot of natural resources that contribute to the future of this state.***
>
> *--Katherine Hammack, 2013*
> *Assistant Secretary of the Army for Installations Energy and Environment at dedication ceremony for WSMR's 42-acre solar array*

Roadmap:

WSMR is postured for growth and development. In preparing for future range needs, the U.S. Army Garrison Directorate of Public Works (DPW) initiated an intensive, comprehensive and installation-wide planning effort beginning in 2015. To accomplish this task, the Garrison DPW invited all the installation's stakeholders to form a "team of teams." After a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, the "team of teams" established a clear future vision for the real property management of the installation:

Based on this vision, the team created four Real Property Planning Goals to guide the development process:

- Provide adaptable, technologically advanced infrastructure that supports the evolving testing, training, research, and development needs of joint partners and customers.
- Provide a safe and secure community and work environment by ensuring safety standards are met, expanding communication capabilities, and improving infrastructure.
- Create an attractive environment that provides a cohesive identity through the design of living and working spaces that are inviting, functional and reflect the cultural and natural heritage of WSMR.


Solar pannels comprising WSMR's 42-acre solar arrary. (Photo: WSMR PAO)

- Provide quality of life through access to services and amenities that meet the daily needs of our community.

The teams then developed specific sub-goals for each planning goal, braking the installation down into seven planning districts, to facilitate narrowing the focus of their objectives and creating specific Area Development Plans (ADP). Six of the seven ADPs are either complete or in draft, with the final ADP planning session scheduled for early FY 17. These are the detailed roadmaps for WSMR infrastructure.

This vision for the future is compelling and while current resources are limited, it provides a well thought out and through vision for both the planned future, and the unplanned one. WSMR needs to explore as part of the Roadmap different/better methods to resource infrastructure needs.

Partnerships and Regional Growth

Future State:

In 2046, partnerships will remain just as important as our most valuable resource, which is our workforce. Successful partnerships between our external stakeholders, internal stakeholders and the ATEC community will depend upon a mutual trust that can only occur through the human dimension. Agencies, organizations, and communities cannot achieve efficient partnerships without the committed relationships between the staff and leadership of the parties involved. Our future state will consist of "self-healing" partnerships–namely, relations improve without any outside intervention–and will exist through the dedicated outreach, communication, and listening of the WSMR workforce. Leadership will establish conditions to allow for complete trust and situational awareness amongst our partners so that they know their concerns are being addressed in a collaborative environment consistent with our mission objectives. When all issues and concerns between our partners and WSMR's mission are resolved, at all levels, it will constitute a measure of success.

Roadmap:

Our Customer: The Ultimate Partner: Ultimately, our most important partnership is the acquisition community who provide needed capabilities to our warfighters. Our focus going forward will be to create conditions so that any customer will view us as a true acquisition teammate. We can achieve these conditions by leading a cultural change, a feeling prevalent amongst many in the MRTFB. We must also continue to work with customers early in the test definition process to define the main objectives clearly. In many cases, test customers come requesting expensive instrumentation resources that may or may not be the optimal solution. WSMR has subject matter experts to help work out initial test designs as well as find solutions when things go wrong, which is the most important service we provide. In some cases, finding outside support or suggesting another range is the best solution for the customer. We must be willing to coordinate and lead that support, mindful of the customer's objectives (see the "Safari" and "CONOPS" sections). Our desired future state is one where customers view WSMR as a comprehensive, solution-oriented organization able to meet their life-cycle testing needs.

The remainder of this section focuses on our constant efforts to enable our partners to allow us to support our ultimate partner, the Customer. In the following sections we (1) discuss the regional partnerships we hold within New Mexico; (2) identify and recognize our internal WSMR team members; and (3) explore other partnerships and resources outside of the State, to include a number of contemporary partner-identifying tools available to the Test Center. Bottom line, all of our partnerships, those existing today and those still yet to be formed, are important to WSMR's future and ultimately to our Nation's security.

Regional Partners within New Mexico

WSMR has approximately 2.2 million acres comprising over 17 percent of the Army's land holdings in the United States. Federal lands, state lands and private land holdings surround WSMR. We have key partnerships with these various landowners, especially in our Northern and Western Call Up Areas (NCUA and WCUA). These areas provide an additional 1.5 million acres to execute critical RDTE efforts. The vast majority of the NCUA and WCUA fall within our restricted airspace, which is controlled by WSMR under an agreement that is unique from other DoD properties. This airspace not only allows us to conduct more complex missions, but also requires the situational awareness and support of our neighbors that own the land below. Our ability to continue current and future missions will depend on maintain and fostering key relationships with these partners adjoining our installation.

WSMR's external regional partners, however, extend beyond lands adjacent to the facility and consist of federal and state agencies, civic communities and organizations, private landowners and businesses. Key WSMR partners include:[24]

FEDERAL PARTNERS	STATE PARTNERS	LOCAL PARTNERS
FAA	Los Alamos National Labs	County Commissions
US Department of Energy	Sandia National Labs	City Councils
Bureau of Land Management	NMSU	Las Cruces Military Affairs Committee
National Park Service	NM Tech	Alamogordo Committee of Fifty & Forum
Lincoln National Forest	UNM	MEVDA
Cibola National Forest	UTEP	Private Landowners and Businesses
US Fish and Wildlife	NMCRDC	Local Law Enforcement
ARMs committee	State Governor & Executive Branch	
US Forest Service	NM State Legislature	
Bureau of Reclamation	State Law Enforcement	
Federal Tribes	NM Military Base Planning Director	
New Mexico National Guard	NM State Land Office	
Border Patrol	New Mexico Game and Fish	
Federal law Enforcement	State Historic Preservation Office	
Cannon Air Force Base	NM Environmental Improvement Division	
Holloman Air Force Base		
Kirtland Air Force Base		
Ft. Bliss		
Corps of Engineers		
Senators, Representatives & Congressional Staffers		

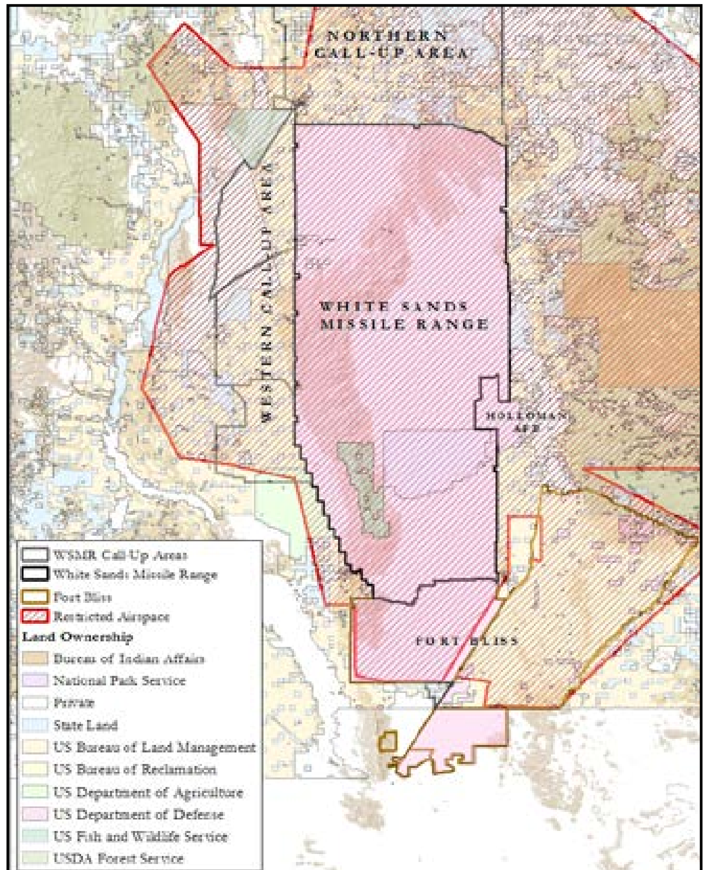
As with any relationship, whether personal or professional, there is a commitment of time and resources. Thus our partnerships will require continual nurturing, through personal face-to-face interactions to be successful; and the time to build them is not when WSMR has a crisis. Our first interaction with a potential partner or stakeholder should not be when we are asking for something. WSMR must be proactive to identify future partners and to maintain current relationships.

Landholders around WSMR consists of the Department of Interior, the Department of Agriculture, other military installations (Ft. Bliss and Holloman Air Force Base), the State Land Office and private citizens.

Each group of stakeholders mentioned above requires a different approach for successful collaboration, and each has the potential to positively–or negatively–influence our future military test and training efforts. It will be important for WSMR leadership to understand these various potential impacts for the navigation and prioritizing of effective solution sets.

Going forward, WSMR leadership will continue to think creatively and look in all directions and levels to resource and achieve effective regional partnerships. An excellent example of a foundational regional partnership is the Joint Land Use Study (JLUS), funded by OSD's Office of Economic Adjustment and completed in early 2015.[25] This study effectively linked leadership from the cities, counties, state and federal agencies immediately surrounding WSMR, Ft. Bliss and HAFB. The Southern New Mexico and El Paso (SNMEP) JLUS identified over 130 strategic initiatives for collaboration that will foster economic growth consistent with the future needs of our military test and training communities.[26]

A key positive outcome of this study was the consensual agreement by the surrounding city, state and federal agencies to transition the study team into a collaborative Implementation Committee (IC). Since forming, the IC has divided responsibilities for the 16 most important JLUS initiatives into four workgroups: airspace, communications, energy projects, and plans/ordinances. In addition, OSD's Office of Economic Adjustment recently funded a second grant to the SNMEP region to assist the IC's implementation of key initiatives. WSMR's continued support of this effort is paramount. The IC



WSMR Airspace, Surrounding Land Ownership and Northern/ Western Call-Up areas.[27]

allows the surrounding state and local Governments and federal agencies a forum to work with WSMR and limit encroachment on each other's mission. This forum has provided and will continue to provide, an effective path for issues and conflicts to be resolved.

Landowners and Business

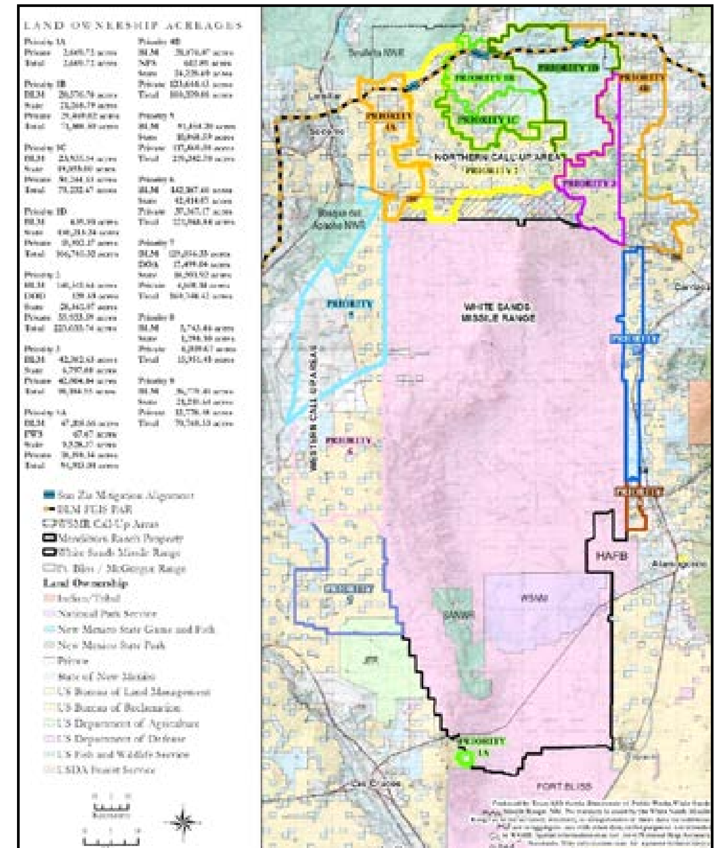
White Sands Proving Ground was created in the early 1940s primarily from the ranching community who were told that this was just a temporary need for our Nation's war effort. Most of these displaced landowners moved to areas surrounding WSMR now known as our NCUA and WCUA (see above figure). In the early 1960s, the Army came back and initiated condemnation proceedings for all of this land in support of critical Pershing Missile testing. These condemnation proceedings were only halted after three years of fighting a united ranching, state Government and NM Congressional team. When the Army conceded that they did not have to own the land, as long as the resident landowners agreed to evacuate when requested by the military, an agreement was forged and the Call Up Areas came to exist. This commitment is documented in an agreement between each landowner and WSMR, which has been in place for over 50 years. These compensatory agreements for the inconvenience and disruption to their operations are renewed every five years. This arrangement is essential to WSMR's future, as it effectively doubles the size of WSMRs operational area to support complex and long-range missions that cannot fit within our range boundary. The need for these call-up areas will continue to increase; and the ability for the DoD to gain over 1.5 million acres of additional battlespace when needed for less than a dollar per acre/per year is simply an outstanding bargain.

Strong partnerships with these surrounding landowners and businesses will become more critical each year to ensure successful regional growth and limit encroachment to our mission. Private land ownership has the most dynamic potential to influence the military missions, as landowners have a constitutional right to sell, conduct, construct, and radiate almost anything on their property. This sense of self-determination is very strong in rural New Mexico, and attempts to dictate what landowners can do with their property, or how they should conduct themselves on it, sometimes meet with staunch resistance. WSMR is extremely fortunate, in that most of the private land ownership in our most critical future mission growth areas of the NCUA and WCUA, is almost exclusively comprised of ranchers. Their job of raising cattle on large tracts of land has little, to no interference with our ongoing missions. In fact, it is very compatible and beneficial, with landowners routinely out on our northern and western borders, alerting WSMR to any suspicious activities.

Going forward, it is essential to not only maintain strong relationships with our call-up area community; but to put in place long-term processes and instruments to limit development that would be incompatible with our mission, and support uses that are; such as grazing, hunting, and hiking. To do this, WSMR initiated an Army Community of Buffer (ACUB) proposal in 2016. This program provides funding to third parties and will create relationships, agreements, and compensation to limit unwanted development. For example, if a rancher no longer wanted to ranch, he or she could sell their property at fair value to a consortium that would keep it in compatible use and prevent unwanted development (housing, hospitals, industrial complexes, towers, etc.). In addition, for those ranchers who want to continue ranching, they could sell any development rights that might prove incompatible to WSMR's ongoing mission. The rancher could continue to ranch and hold evacuation agreements with us, but they would not be permitted to develop or sell to a corporation any right deemed incompatible with WSMR's mission. The ACUB process will start in FY17 and will take many years to completely achieve the listed priorities shown on page 53. The objective 30 years into the future; have in place binding agreements covering all -and consensual with -private land ownership in the NCUA and WCUA and other areas along our border, which perpetually preclude incompatible development to our military missions.

Federal Agencies

Federal lands surround the majority of WSMR's perimeter. These federal partners consist of the Bureau of Land Management (BLM), Ft Bliss, Holloman AFB, Department of Agriculture's Jornada Experimental Range, US Fish and Wildlife, Sevilleta Wildlife Refuge and, within our borders, the San Andreas Wildlife Refuge and White Sands National Monument, operated by the National Park Service. In addition, WSMR operates many off-range launch or instrumen-



WSMR ACUB All Priorities Map, 2016.[28]

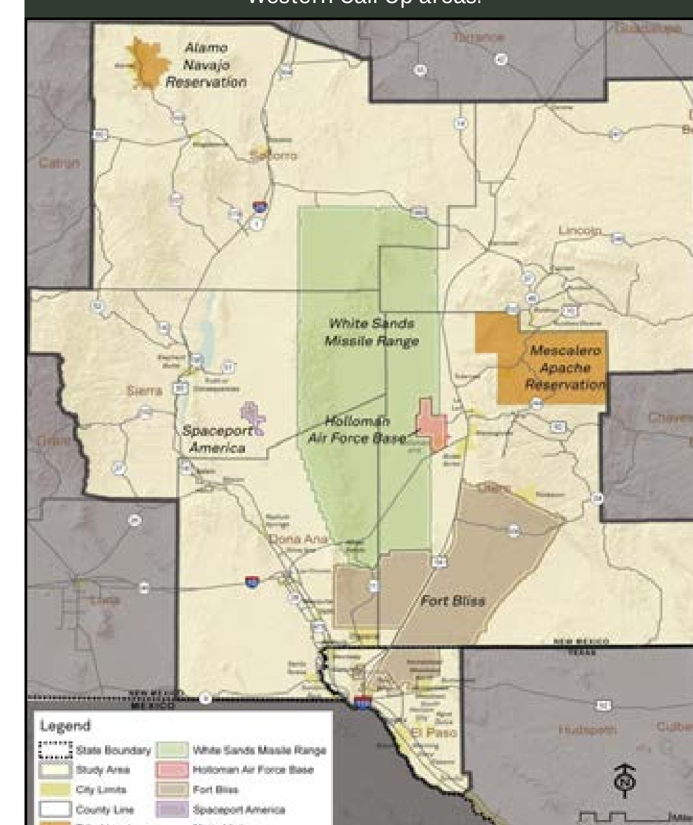
tation sites within several National Forests (Lincoln, Cibola, Gila, etc.). Each of these federal agencies have separate missions, which at times can create conflict and affect our mission. Each has a different path for collaboration and partnership.

The BLM's mission is to manage public lands for multiple uses in the best interest of our Nation. BLM has several districts that interface directly with WSMR; the Las Cruces, Socorro, Albuquerque and Roswell Districts. These districts have Resource Management Plans (RMPs) that are updated on a periodic basis and define processes for use, limitations, land designations, and disposal. BLM has many land management practices that will limit development such as; care for the natural environment, protecting view sheds, identifying and supporting monuments. These practices are very compatible with our desire to limit development in areas that would impact our mission. However, BLM is required to consider projects through the NEPA process on public lands that may not be in the best interests of WSMR's military mission. Going forward, it is important for WSMR to continually request Cooperating Agency status for all RMPs, as well as for projects that have the potential for negative impact to our mission. This will allow WSMR leadership to support the decision-making process of the BLM and provide the necessary information for the best possible outcome.

The Forest Service has a mission similar to the BLM in that they are chartered to manage our National Forest's for multiple uses (hiking, logging, camping, hunting, etc.) while adhering to conservation principles and keeping our National Forest viable and protected for future generations. WSMR has several key instrumentation and test support sites in the Lincoln National Forest, that directly support activities within our range boundaries. WSMR also has similar sites in the Cibola National Forest to support long-range and off-range missions - to include a booster drop zone in the Magdalena Ranger District. Each of these forests, and those not listed here specifically, have land use plans that are periodically updated through meetings with the public to discuss/define multiple use. It is imperative that WSMR review these documents as a cooperating agent and attend the public meetings to discuss our mission - and ultimately protect our required sites. Going forward, WSMR will provide liaisons to each Forest Service public meeting and provide the necessary information/ support as Forest Service managers listen to the public and make appropriate land use decisions.

The Wildlife Refuges, the Jornada Experimental Range and White Sands National Monument each have various land use plans and processes to define their mission, vision and path forward. These deal with the multiple public uses such as; research, experimentation, recreation, conservation, protection, commercial activities, etc. WSMR has sites and conducts activities that can directly impact their missions and plans, just as their activities can impact ours. As with the BLM, WSMR must continually requested Cooperating Agency status on land use plans and other projects as necessary. Going forward, WSMR will assign full-time individuals with each of the federal agencies. These individuals will be responsible for education, information, and

WSMR Airspace, Surrounding Land Ownership and Northern/ Western Call Up areas.[29]



> ***It does take a large village of communities, not just the WSMR community, but our communities around us to work together and take care of this national treasure.***
>
> ***--Brig. Gen. Timothy R. Coffin 2014 at WSMR Assumption of Command Ceremony***

ensuring situational awareness of our leadership for any activities that require collaboration or resolution. This will enable a future state of trust and mutual support for each other's mission.

Fort Bliss is an Army installation that has primarily a training and readiness mission. Holloman Air Force Base is an Air Force installation that has both a training/readiness mission and a significant test capability. WSMR, Bliss and HAFB entered into a TRIAD relationship endorsed by OSD to manage issues and concerns within the airspace, land space and frequency domains of the three bases.[30] This partnership was formed to ensure the three bases had a local forum to resolve conflicts at the lowest level possible, although in rare cases involvement from the three base commanders has been required. The utility of this forum is to allow for information flow and inputs into the decision matrix of each base commander. In a constrained fiscal environment with decreasing budgets, it is imperative that the three bases work together to find synergies and interdependences. The TRIAD can be highly beneficial to the region, but will only be successful if resourced with talented personnel chartered to define and propose actionable COAs for the installation leadership.

In addition to the TRIAD partners, New Mexico has Kirtland AFB, Cannon AFB and the NM National Guard. Kirtland has multiple organizations from various federal agencies, which span across the with RDTE and Training sector. Cannon AFB has primarily an Air Force special operations readiness/training mission for the 27th SOW. The NM National Guard has Army and Air Force capabilities across the state. Each of these partners have organizations/units that have utilized WSMR capabilities and have the potential to increase their usage. WSMR and the NM Military Base Planning Director initiated a summit of all Military bases in New Mexico to ensure that situational awareness of missions, capabilities and needs were being socialized at the leadership level. This summit has allowed key discussions to occur between the leadership and staffs that would not normally occur. Several successful arrangements have already developed from this summit, including the 58th SOW from Kirtland expanding/paving the runway at Stallion Army Airfield. This is a key example of two organizations partnering together to get a capability that neither Service base could afford on their own. The NM Military Summit can be highly beneficial to the region, but will only be successful if resourced with talented personnel chartered to define and propose actionable COAs for the Summit leadership. Going forward WSMR will facilitate and support both the TRIAD and the NM Military Summit.

Our NM Congressional Legislatures are always key partners in our mission success. They have historically provided critical support to our mission when emergencies warranted legislative action (e.g. when a windstorm destroyed our Directorate of Emergency Services bldg., or for land buffer action surrounding our NRO/NASA site). In addition, they have exceptional field office representatives in our local community that continually provide assistance, information and great support to our installation. A key example of this support is the Southern New Mexico Economic Sustainability and Compatibility Workgroup (SNMESCW) that was conceived and is hosted monthly by our two Senator's Las Cruces field representatives. In addition to the Senate staff, this workgroup consists of leadership from WSMR, Ft. Bliss, HAFB and the NM Spaceport. Its mission is to develop, prioritize, and assist in implementing strategies that ensure the viability of current and potential mission sets. This group has been instrumental in keeping the military bases linked with legislative action and other federal actions that could influence the mission set of WSMR, such as the Organ Mountain and Desert Peaks Monument proclamation and possible legislation. In addition, the group conceived, developed, and supported, along with the NM Base Planning Director, the highly successful JLUS study grant from OSD. The group is important for the continued strong relationship with our Congressional delegation, which has obvious benefits. Going forward, WSMR will continue to support the SNMESCW monthly meetings and set up an actionable database of tasks from all future meetings.

WSMR Commader BG Ferrari welcomes Senator Udall to White Sands in 2011. (Photo: WSMR PAO)

Senator Heinrich visits 2E Soldiers and facilities at White Sands Missile Range, April 2013. (Photo: US Army)

Congressman Pierce and other distinguished visitors are welcomed by BG Coffin to HELSTF in September 2014. (Photo: WSMR PAO)

Governor Martinez is welcomed by LTC Balyoz on her visit to 2E facilites at WSMR, December 2011 (Photo: WSMR PAO)

State and Local Governments, Native Americans and Organizations

Six counties, five cities, several state agencies and various other organizations surround or interface with WSMR. Each of these entities have various levels of jurisdiction, oversight, interests and desire to support WSMR. The path forward to developing enduring partnerships with these stakeholders will vary depending on their mission, but as with any relationship, constant, actionable and accurate communication will be key.

The surrounding counties include Socorro, Sierra, Dona Ana, Otero, Lincoln, and El Paso County in Texas. In addition to these, there are other counties in the state that are directly impacted because of launch/instrumentation sites, or due to low level military flight routes that encompass much of the state. Each of these counties has different resolutions and covenants. A five-person commission guides some counties, while some have only three commissioners. Some counties actively support things like zoning; others have very little desire to see any restrictions. The county commissions have an important role to play when establishing guidelines for growth and permitting. It is important to educate and network with the commissioners on a routine basis, so they understand our mission and any possible impacts that their decisions may have on our activities. There are several large cities (Las Cruces, Alamogordo, El Paso) and numerous smaller cities (Socorro, Truth or Consequences, Tularosa, Ruidoso, Gallup, Chaparral, Cloudcroft, etc.) that are directly impacted by WSMR missions and represent where most of our workforce live. The city councils pass ordinances, codes and permit various activities that can directly influence our activities. As with the county commissions, it is important to educate the council members on a routine basis of our activities for successful and compatible economic growth in the region. Going forward, WSMR will develop a routine schedule so that each commission and council will be visited/briefed, at least once a year on WSMR activities, and more often if there is potential direct impact from a specific test or event. In addition, WSMR will provide a tour for the leadership of every surrounding local Government. These actions will help set the conditions for mutual trust.

The NM State Land Office (SLO) manages approximately a third of the land in the NCUA and various locations in our WCUA. The SLO has a mission of generating revenue on state lands for the State Land Trust, which primarily supports NM schools and hospitals. They are a key partner in protecting our long-term interests, particularly in the NCUA. Going forward, WSMR will continue to examine all types of MOAs, and Limited Use Restrictive Conditions (LURC), Business Agreements, etc., for collaborating with the SLO. The right partnership will depend on if the use is temporary for a mission, or if is long-term protection from development that could limit our mission. Our near term priority is to limit the development of state land in the NCUA. This is critical for current missions and equally important for future missions, as the NCUA is within our restricted airspace and necessary to protect various low-flying threats, target launches, and impact areas. Going forward, our goal is to lock in the SLO land restrictions that will prevent incompatible development on all SLO land surrounding WSMR.

WSMR is fortunate to have several top quality academia partners in the region. These consist of New Mexico State University, University of New Mexico, New Mexico

Sandia National Laboratories expressed interest in conducting long-duration UAV flights; they were looking to develop a launching point for extended high-altitude missions. Their interest for these high-altitude tests included having worldwide command and control facility.

Tech, and University of Texas in El Paso. These academia partners are the main source of our current and future workforce (see "Human Capital" section). In addition, we have technology challenges that can be supported by a dedicated team of leading research professors and their students. Many times, our universities/research institutions are better able to develop flexible, innovative solutions to some of our technical challenges, partly due to schools having greater ease of access to the latest research methods and cutting-edge technology. Initiating four seed projects in order to help in our various instrumentation challenges, WSMR has started technology assistance programs with our local and regional universities, each bring different subject matter experts and interests. UNM has special Nuclear Engineering expertise, pertinent to our fast burst reactor. UTEP has a first-rate 3D printing lab and has previously expressed interest in working with WSMR's fabrication needs. NMSU and its Physical Science Lab has long been a partner with WSMR's instrumentation, and recently with the UAV technologies/challenges. The additional advantage this provides to WSMR, is the ability to groom and attract top engineers, scientists, and mathematicians from the local universities. They get to work on exciting challenges and see a potential career path that provides a professionally stimulating and rewarding work environment. It is strategically important to continue relationships on all fronts with these partners. Going forward, our goal is to expand this program into a sustainable pipeline of educated, excited and exceptional interns, who will one day join our workforce and having developed the needed skillsets. SVAD is eager re-establish programs and relationships with New Mexico Tech in Socorro, NM.[31]

Expanding on our academia partnerships is the New Mexico Collaborative Research and Development Council (NMCRDC). The NMCRDC was established by NM's Congressional Senators (Udall & Heinrich) to link our National Labs (Sandia and Los Alamos) with the regional academia and the military installation. The purpose of this group is to provide a collaborative forum of our regional technology capabilities. The long-term vision of this group is to

Mescalero tribal members removing an agave plant. The CRM Program partnered with Mescalero to identify and gather plants of traditional importance to the tribe at WSMR.

establish a technology corridor that can take advantage of NM's unique resources for the benefit of NM's and our Nation's economy. Each member in this NCRDC has various strengths and capabilities in common areas to WSMR, such as Big Data and analytics, Directed Energy concepts and research, UAV programs and challenges. At a recent Development Council meeting, major partners identified their short-term interests and needs as related to UAV testing within the state's technology "cluster":

- Sandia National Laboratories expressed interest in conducting long-duration UAV flights; they were looking to develop a launching point for extended high-altitude missions. Their interest for these high-altitude tests included having worldwide command and control facility.
- The NMSU Flight Test Center was working on building additional infrastructure as well as working with WSMR and the Space Port to coordinate and support their launches. Their major issues included Big Data processing and miniaturization. They felt that airspace was becoming increasingly crowded with the addition of small, low-altitude personal UAVs. For NMSU, data backhaul and processing of sensor data has emerged as a hot topic.
- The UNM has interest in Big Data processing and building a better offload infrastructure. The offload infrastructure they envision would be in addition to UAV command and control. In addition, UNM expressed a need for an agnostic framework for workflows.

New Mexico State University's Flight Test Center was working on building additional infrastructure as well as working with WSMR and the Space Port to coordinate and support their launches. Their major issues included Big Data processing and miniaturization.

UNM has interest in Big Data processing and building a better offload infrastructure. The offload infrastructure they envision would be in addition to UAV command and control. In addition, UNM expressed a need for an agnostic framework for workflows.

Working with the NMCRDC, White Sands has opened a dialogue with local industry and educational groups to identify areas of mutual interest and benefit. Going forward, WSMR will continue to develop and enhance this partnership with talented staff and resources.

Along WSMR's borders, is America's Spaceport that was designed, funded and built by NM tax dollars for the express purpose of supporting our Nation's burgeoning commercial space industry. The location of this is Spaceport is strategic for its ability to use WSMR's air/land space for the safe launch and operations of commercial space platforms, and is also discussed in "Space-Based Operations" section. This is a symbiotic relationship with WSMR, as we are able to provide mission support with our instrumentation and we have a space launch partner to support DoD organizations (i.e. Operational Responsive Space at KAFB). The relationship is in its infancy, but in 2046 a strong commercial spaceport will support the commercial space industry and also specific DoD space operations; with the assistance of WSMR's range capabilities and its internal partners (e.g.NASA). Going forward, WSMR will continue to develop and enhance the NM Spaceport partnership to ensure our future missions remain compatible and symbiotic.

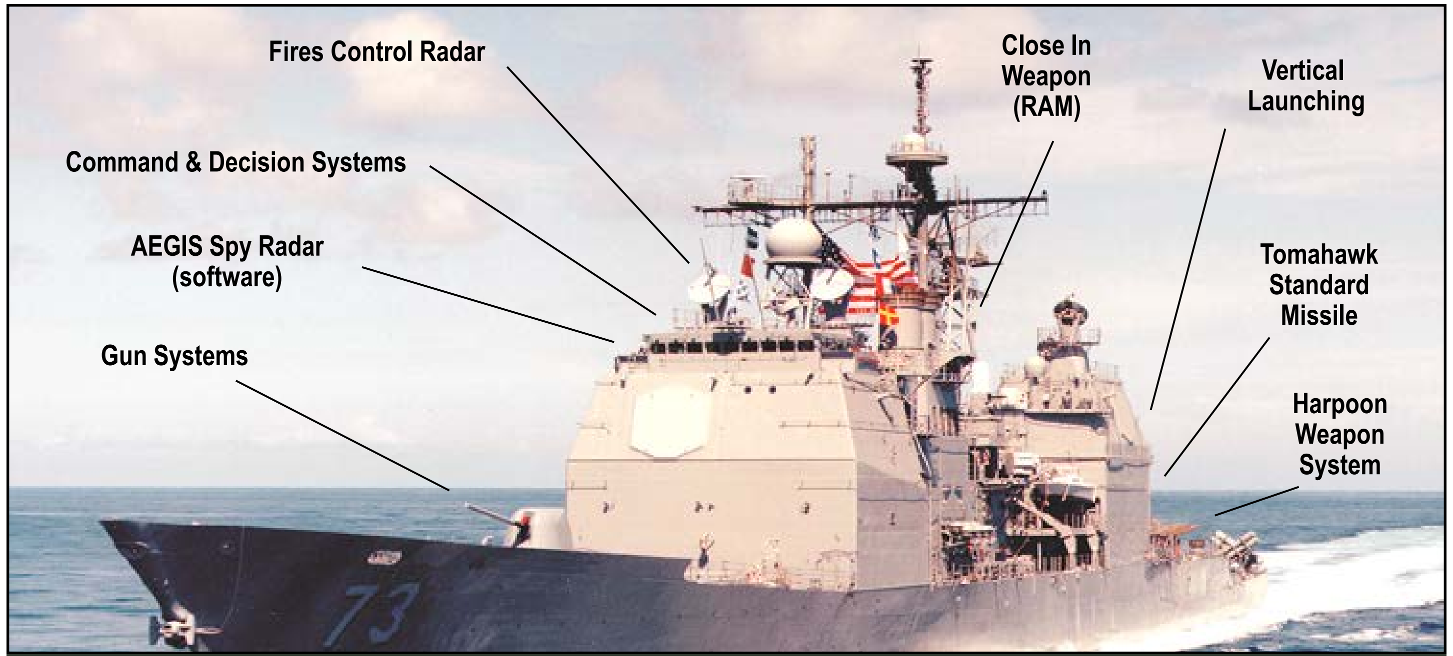
Even before the ranchers arrived in this region, our Native Americans lived and worked in all of what WSMR considers their operational areas. There are numerous cultural sites and areas of significance throughout NM, and within WSMR that have ancestral ties to the 22 NM Pueblos and the Mescalero Apache and Navajo Nations. Our regional Native Americans are very patriotic and supportive or our mission and many have nobly served in our Armed Services. In addition to their support, these partners have legal standing for various cultural sites within our boundaries and under our multiple low level flight paths throughout the state. It is important to maintain an open dialogue for continued support and trust. Going forward, Range staff will consult with the CG (at least once during his/her tenure) regarding tribes affected by WSMR missions.

Civic organizations such as the Las Cruces Military Affairs Committee, the Alamogordo Committee of Fifty and Forum, and the ARMs committee provide outstanding support to WSMR. These local military support groups have an intense desire to support our military and civilians, and achieve results that are second to none in the country. Our military members continue to proclaim that WSMR's community support is the best they have ever witnessed. Numerous other organizations, from law enforcement agencies, to economic (MEVDA) and business, provide abundant opportunities and responsibilities for partnership. In some cases these partnerships must be maintained for compliance, such as with the NM Environmental Department and the NM State Historic Preservation Office. It is important that open and frequent communication continue to enhance these partnerships. WSMR cannot accomplish the critical missions within our borders, without the help and support of civilians, communities, and agencies outside our borders. Going forward WSMR will continue to staff these partnerships with dedicated and talented staff.

WSMR Internal Partners

WSMR is home to numerous branch locations each representing their federal parent organization. These WSMR teammates perform core, mission-critical research and testing for outfits such as NASA, ARL, DTRA and others. While each serves a unique purpose, their continued success is directly linked to WSMR's land, airspace and frequency domains. WSMR proactively identify and anticipate changes in requirements relative to each tenant organization's mission. Knowing that each faction at WSMR is

A rocket launches from White Sands Missile Range taking a scientific payload over 100 miles up before returning safely. (Photo: J Hamilton)



Navy Surface Systems Tested at WSMR.

feeling continual budget pressures and looking for efficiencies, working together will help develop partnerships that are better for the warfighter and taxpayer. Going forward, WSMR will set up an Executive Director-led forum that periodically examines these partnerships to increase, enhance and support and more effectively support our customers.

"The Department of Defense is facing . . . pressures demand[ing] a cultural adaptation which values and rewards sound, innovative thought, facilitated by partnering with experts outside our traditional ecosystem, in order to improve the speed of our problem solving ability and enhance capability implementation."[32]

Navy

As the sponsor of all naval tests conducted on the Range, the Navy Detachment operates many unique facilities. A key WSMR partner, their organization provides numerous capabilities including support of surface-to-air and surface-to-ground weapons testing launch complexes, missile assembly facilities, suborbital rockets, a mobile launcher and advanced gun systems. Navy customers historically comprise 20 percent to 30 percent of our annual test workload.

In addition, the Navy team at WSMR has developed a suite of highly capable Tactical Ballistic Missile (TBM) targets that support both test and training needs. This capability effectively allows WSMR to offer more comprehensive service and support at significant savings.

Going forward, the forum led by the Executive Director will periodically examine the needs of WSMR's Navy Detachment with the aim of enhancing our support.

Air Force

The Air Force Detachment and the USAF 96th Test Group sponsor all test programs at WSMR. Their capabilities include the 746th Test Squadron and GPS jamming, the 846th Test Squadron, the Holloman High Speed Test Track (HHSTT), the National Radar Cross Section (RCS) Test Facility, the 586th Flight test Squadron with modified AT-38B and C-12J aircraft, and the Operating Location (OL-AA) at Kirtland Air Force Base with its related laser test facilities. Currently 20 to 30 percent of WSMR's test workload comes from Air Force customers.

Going forward, the forum led by the Executive Director will periodically examine the needs of the Air Force Detachment with the aim of enhancing our support.

National Aeronautics and Space Administration (NASA)

NASA operates two major organizations at WSMR, the White Sands Test Facility (WSTF) that reports to the Johnson Space Center, and the Tracking and Data Relay Satellite System (TDRSS) that reports to the Goddard Space Flight Center. Each of these organizations has numerous capabilities and facilities at WSMR including:

- Launch Complex 35 East (LC-35E) devoted to sounding rocket launches.
- A hypervelocity gun to examine extreme high-speed impacts on various materials.

WSMR Executive Director Paul Mann, right, greets Chief of Naval Operations (CNO) Adm. Jonathan Greenert. Greenert was at White Sands Missile Range March 25, 2015 to visit the Navy operations. (Photo: M. Rodriguez)

- Numerous rocket stands to test hypergolic propellants and motors in a space environment.
- Multiple tracking and data systems to communicate with the International Space Station.

With a view towards 2030 and beyond, NASA characterizes missions into three types, progressing chronologically: Earth Reliant (to 2021), Proving Ground (the 2020s) and Earth Independent (2030 and later). Looking at the mid-21st century, NASA has publically expressed a number of high-level objectives and missions that WSMR can position itself to support.

The U.S. will embark on a manned mission to Mars and will require significant use of facilities at WSMR, WSTF and NASA for testing of spacecraft and the associated systems. Directly related to visiting Mars, development of nuclear rockets may resume in the future; testing capabilities for these rocket engines will follow. Likewise, there will be a continuing, expanding reliance on private industry for routine access to space. The DoD will need to consider the stance private industry has on risk, processes and proprietary information if they expect to partner with industry in upcoming decades.[33]

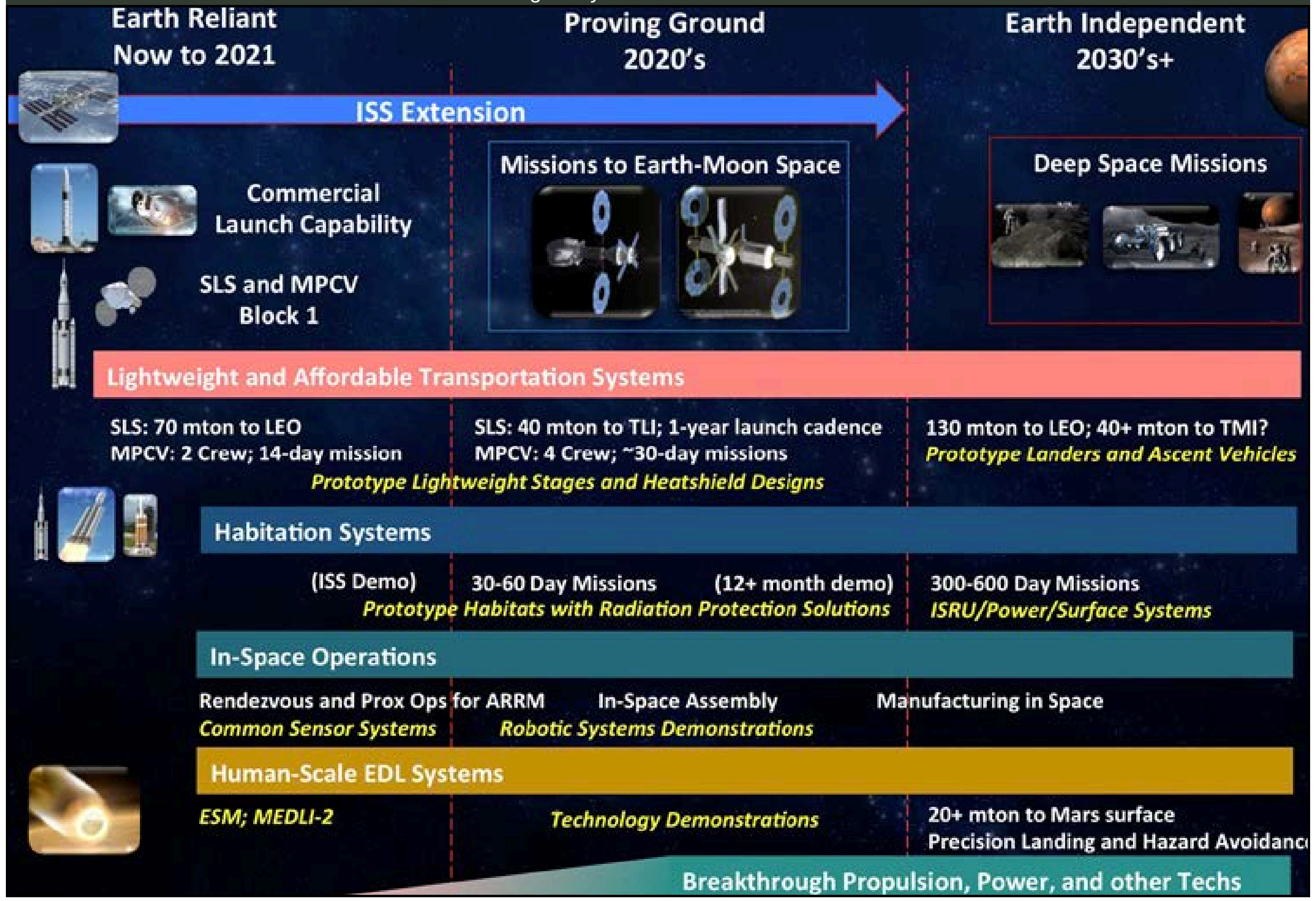
NASA is interested in exploring commercial launch capabilities, finding lightweight transport vehicles, applying robotic systems, and investigating radiation-resistant habitats, among many other topics. In-Space assembly and manufacturing are ongoing technological goals for the agency when it comes to Space Operations, as are the related areas of In-Space propellant resupply and space-based depots. WSMR will assess how and where it might fit into testing these technologies and better support customers with similar needs, in particular our Defense space industry and requirements. Going forward, WSMR will establish a mission partnership MOA with NASA to continually collaborate and examine our collective workloads and capabilities for effective an efficient partnerships.

National Reconnaissance Office

The National Reconnaissance Office (NRO), the country's eyes and ears in space, is currently working towards producing value-added information without increasing volumes of data. The NRO is developing ways to manage systems as a single, integrated architecture, focused on multidisciplinary solutions to intelligence problems.[34] WSMR NRO collaborates closely with numerous entities spanning the DoD, including the National Security Agency and the U.S. Strategic Forces Command.

The NRO has potential to integrate into "system of systems" tests at WSMR. Going forward, WSMR leadership

NASA's Science, Technology, Engineering and Design (STED) roadmap showing parallel lines of effort for the next 20-plus years, including many areas relevant to WSMR.[35]



will examine potential programs and efforts that make sense to support with NRO's capabilities.

Training and Doctrine Command (TRADOC) Analysis Center (TRAC)

TRAC at White Sands Missile Range (TRAC-WSMR) conducts a wide variety of analyses, studies and simulations and for DoD agencies and beyond. TRAC-WSMR is responsible for the ongoing analysis of brigade operations and for developing life-cycle costs of new equipment. The command also develops, maintains, validates, and exports a suite of combat models and simulations to provide evaluations of battlefield functional areas and weapon systems.[36]

Over the next 30 years, TRAC-WSMR will look to advance their modeling capabilities. The unit is uniquely located at WSMR and the possibility exists to integrate their modeling and analysis support directly into test efforts. Going forward, WSMR will develop an MOA with TRAC to explore and establish 'model-test-model' and 'test-model-test' support concepts.

Defense Threat Reduction Agency

DTRA is a combat support agency of the DoD responsible for safeguarding the United States and its allies from weapons of mass destruction (WMDs). DTRA Research and Development Enterprise's primary testing location is WSMR, where it maintains a broad spectrum of target types on its testbeds. Additionally, the DTRA Counter Weapons of Mass Destruction Technologies Directorate Test Support Division of the Research and Development Enterprise is located at nearby Kirtland Air Force Base in Albuquerque, NM. At present, DTRA enjoys a significant partnership with the Joint Improvised-Threat Defeat Agency. DTRA is a critical partner in our threat-representative target support area, as they construct, operate, and maintain numerous target complexes for precision-guided munition testing. These complexes cover a wide variety of threats including deeply buried bunkers, tunnel complexes and structures made with specific concrete/materials representative of our adversaries' constructions. Going forward, WSMR will examine how to assist DTRA in their support of our customers. Key future steps include establishing a contract vehicle that provides increased flexibility to support our North Range operations and includes developing prefabricated target structures designed for multiple users.

Army Research Laboratory

ARL is the Army's primary source of fundamental and applied research. Elements of two ARL organizations are located at WSMR: the Information and Electronic Protection Division (IEPD) of SLAD, and the Computational and Information Sciences Directorate (CISD) Battlefield Environment (BE) Division. SLAD is a unique bridge between the Army's research, development, test and evaluation (RDT&E) communities, providing value throughout the acquisition life-cycle.[37]

In addition, our local ARL team is taking a leading role in a congressional/OSD/HQDA initiative to conduct system cyber vulnerability assessments. HQDA is slated to conduct Cyber Vulnerability Assessments on more than 50 systems (some fielded, some still in acquisition T&E process, and some fielded and in acquisition T&E process). This is a key partnership going forward as most Range customers will requires this support. The ARL team also boasts an accomplished atmospheric sciences division. These experts will be helpful to our future customers who require high-fidelity temperature/environmental data during testing and analysis of the next generation of sensors. Going forward, WSMR will develop a mission support MOA with ARL to provide these cyber and atmospheric science services and continually examine other opportunities for partnership (e.g. the anechoic chamber shown above).

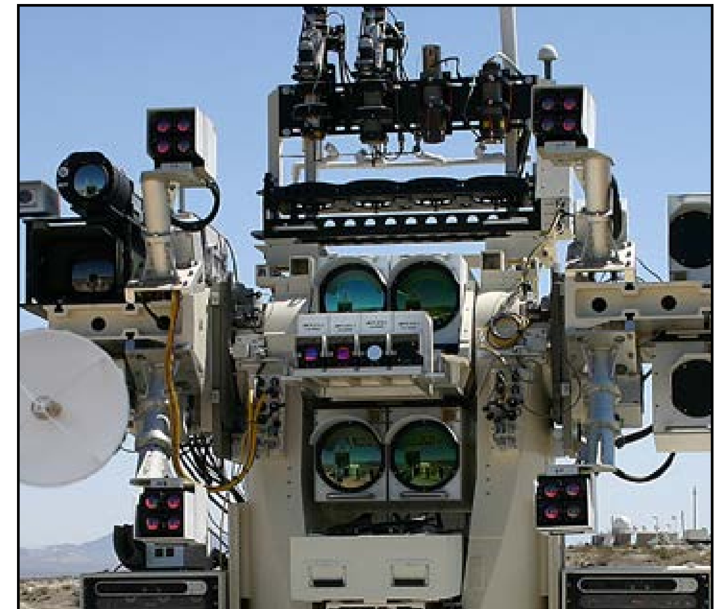
Center for Countermeasures (CCM)

CCM-WSMR CCM is a "joint activity that directs, coordinates, supports, and conducts independent countermeasure/counter-countermeasure test and evaluation activities of U.S. and foreign weapon systems, subsystems, sensors, and related components." CCM testing and analysis directly support evaluation of the operational effectiveness and suitability of the military's countermeasure systems.[38]

In line with the CCM's overarching strategic plan and ongoing mission, CCM-WSMR can expect increased workload at the Aerial Cable Range, and the ACR facility represents an excellent opportunity to build relations. Going forward, WSMR will develop an MOA for operation of the ACR that allows increased and efficient support to our customer.

National Geospatial Intelligence Agency (NGA)

Testing in the main ARL test chamber in the Electromagnetic Vulnerability Assessment Facility. The main chamber can be used for testing everything from computer networks to small aircraft.



CCM's Joint Mobile IRCM Test System is a mobile, self-contained, ground-based, open-air missile simulator.

NGA's mission is "to provide accurate and timely expert analysis of worldwide gravity, satellite and positional information including imagery and mapping control for navigation, safety, intelligence, positioning and targeting in support of national security objectives." At White Sands, the NGA Support Team "furnishes precise geodetic and geophysical survey information to WSMR mission partners and other DoD customers."[39] The NGA will be a critical associate looking towards 2046 as they have the capability to understand our terrain and provide high-fidelity DTED data. Future customers will demand an absolute understanding of the environment at resolutions not possible today. Similar to the frequency topics discussed herein, we will need better understanding of WSMR's terrain topography to support data analysis and failure modes of complex systems. These future systems will be equipped with artificial intelligence and operate autonomously. For example, WSMR must be ready to provide the environmental data that can help explain why a swarm of UAVs suddenly deviated from their preset flightpath through a canyon and discern if the deviation was due to glint from a reflective surface below. If so, our customer will be looking to WSMR talent for ways to reprogram the devices correctly and recreate the test conditions. Going forward, WSMR will develop a support MOA with NGA to fully characterize the Range's terrain.

Alliances and Partnerships beyond New Mexico

Army Test and Evaluation Command

ATEC is WSMR's higher headquarters. ATEC plans, integrates, and conducts experiments, developmental testing, independent operational testing, and independent evaluations and assessments for acquisition decision makers and commanders. ATEC's 9,000 military, civilian and contract employees are highly skilled test officers, engineers, scientists, technicians, researchers and evaluators that are involved in over 1,100 tests daily.

Located at 29 locations in 17 states, and an annual budget exceeding a half billion dollars. ATEC is an important source of support and has numerous capabilities and skills to leverage. In the future, as budgets shrink, WSMR will need to share highly precise instrumentation with other ATEC ranges, leveraging our facilities and other ATEC facilities and instrumentation to maximize our effectiveness. Going forward, White Sands should take the lead in establishing a more efficient, need-based means of matching test system personnel with mission schedule requirements across all of ATEC's test locations.

TEO, TRMC, and DOTE

Various organizations provide oversight and support requirements to WSMR. The Army's Test and Evaluation Office, the Test Resource Management Center and the Director of Operation Test and Evaluation are some key organizations that are critical to our future success. They work closely with our ATEC headquarters, establish policy, define test requirements, and validate/resource our infrastructure/personnel needs. It is imperative that the WSMR team, at all levels, continues to reach out to the staff and leadership of these organizations. Communication and synchronization of our collective paths forward for infrastructure, instrumentation, and program requirements must occur frequently and accurately. Going forward, in conjunction with ATEC staff, WSMR will set conditions to have increased dialogue and status reviews. The future objective is that the leadership of these organizations will always know about, and be supportive of, all ongoing initiatives and efforts at WSMR.

Western Regional Partnership

The Western Regional Partnership provides a proactive and collaborative framework for senior policy level Federal, State and Tribal leadership to develop solutions that provide for reliable outcomes for America's Defense, Energy and Environment in the West. (See page 62.)

Goals of the WRP:

- Serve as a catalyst for improved regional coordination among State, Federal and Tribal agencies.
- Provide a forum for information exchange, identification of issues, problem solving and recommendations across the WRP region.
- At annual Principals' meeting, adopt strategic priorities to complete in the subsequent year.
- Work to leverage existing resources and linking of efforts to better support key projects
- Provide a GIS Sustainability Decision Support Tool that integrates appropriate Federal, Tribal, State and other available data source, for use in regional planning by WRP Partners.

The Western Regional Partnership will be a significant resource to proactively identify and address common goals and emerging issues, and to develop solutions that support our mission. This has already occurred with some of our off-range launch sites such as Green River Launch Complex in Utah. Because of our support, and involvement with this association, the BLM new exactly who

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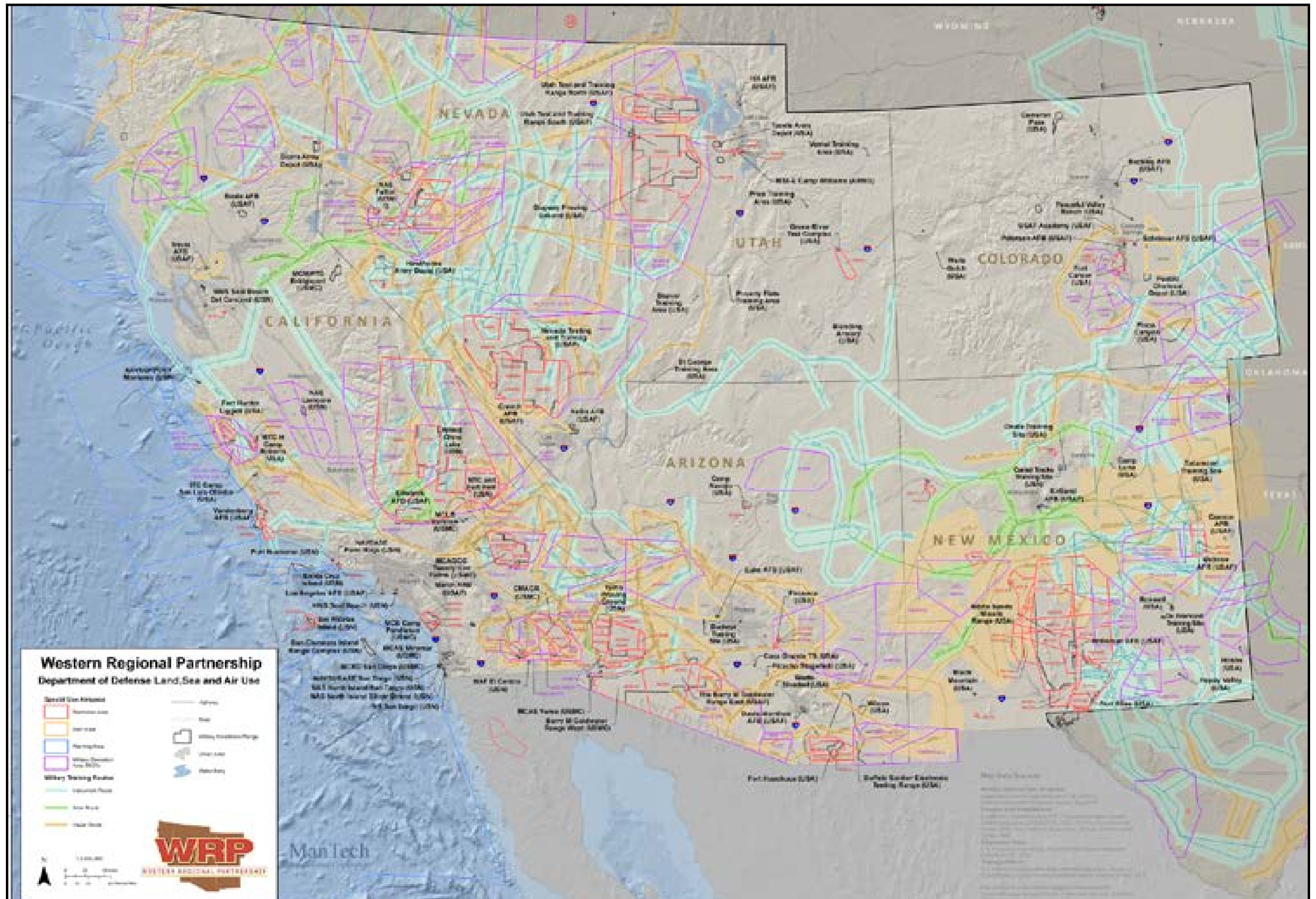


Western Regional Partnerships map.

to call and coordinate with for a pending gas line project, which was projected to go through the complex. The relationships through this forum become more important as WSMR looks to the Western states for additional off-range sites and corridors. Going forward, WSMR leadership will continue to support and provide the necessary staff to the relevant committees.

Processes

Our current Business Model and associated processes, fundamental to WSMR operations, need improvement. Such shortcomings have been identified via interviews, customer survey data, and higher headquarter inputs. As with other process improvement areas, it is not within the scope of this strategic plan to develop a detailed roadmap. However, the plan does aim to layout several core requirements the new processes will exhibit and provides general suggestions for possible improvements.

Business Model

Future State:

WSMR will adopt a more comprehensive, agile approach to how problems are solved for customers and internal directorates. Improvements will be made to WSMR's legitimate attractiveness as a test facility to entice industry customers. The new Business Model's core requirements will represent a re-envisioning of the current ATEC funding model, as identified by a collaborative ATEC/Test Center process improvement team.

Requirements of the new model:

- Institutional core funding will keep needed facilities "operating" at an Army selected level, regardless of customer workload. This would be a shift from the present ATEC funding model that does not allocate funding to do this. An example of the proposed model would be sizing WSMR optics, radars, TM, etc., to support a Patriot/AIAMD "6-on-6" engagement test.
- Meet Congressional stated purpose of Institutional core funding.
- The new model will encourage labor efficiencies at the Test Centers, especially if the Army, DoD and U.S. Government budgets are stretched thin. Every effort will be made to find efficiencies in operating costs, and the model will encourage this at the Test Centers and at ATEC headquarters.

Roadmap:

WSMR will work with ATEC to establish a new funding allocation model. This may be the most strategically important process, as it supports all other efficiency improvements at the Range.


US Army members work in the administrative shelter of the expeditionary combat outpost at White Sands Missile Range, N.M., May 2013. (Photo: J. Dean)

The ATEC/Test Center Team should examine how the Navy MRTFB are funded. WSMR learned through conducting primary interviews, that the Navy process is aligned more strongly to keeping required facilities/capabilities viable versus the ATEC DLH model. If required capacities are more utilized (i.e. reimbursable), it gets less institutional funding. Less utilized capabilities that are required get more funding. The approach for institutional funding allocation is to provide funds towards "capabilities" that keep a level of service. This bottom-up analysis will establish the "required" funding for the T&E enterprise. Test Centers could make prioritized lists of facilities/capabilities, although an ATEC enterprise level list is even better. Institutional funding would go to top priority capabilities. A side advantage of this funding approach, is if funding shrinks, Army and ATEC leaders will quickly understand what capabilities will be lost as they are on the bottom of the list.

To make this approach work, an honest determination of the service level funding is needed. A possible process is:

- Identify "core" infrastructure and workforce needed to preserve the level of service. This would be done based on today's needs, cost of maintaining a capability and future work projections. "Core" funding would be the lowest acceptable amount based on future needs and risk analysis. Example: A needed, but low use facility may look at "shutdown" periods, or sharing labor with other facilities to minimize costs. This is presently being done at the ACR and LBTS facilities.
- An independent team will validate the results of the determination.
- The remaining institutional funding would be allocated toward Test Center efficiencies, improvement projects, and T&E initiatives, thus further reducing institutional costs. Efficiencies would be measured as improvements in capabilities or reductions in institutional costs. For example, reducing three person operations to only two person operations would be an improvement in efficiency.

The proposed process will allow the Army leadership to understand impacts of funding reductions. Many aspects of WSMR's proposed 30-year evolution, such as making the improvements that would create the ideal range we would like to operate, will hinge on correcting this funding model.

Cost Estimation, Containment

Future State:

WSMR will charge appropriate, competitive costs for test services. Services will be in line with customers' expectations. Test Officers and WSMR personnel will identify areas to minimize cost to customers, while maximizing data collection. Cost accounting will be actuate and timely.

Roadmap:

To reach the future state, three processes require improvement; Cost estimation, cost change management, and cost accounting.

Cost Estimation: Although there is a WSMR SOP on how to generate cost estimates, many groups do not follow the SOP. Additionally, the SOP allows multiple groups to submit bids for test work with no measure of the quality of the bid.

An accurate, detailed bid ensures that the customer is aware of costs, and provides a clear reference point, when additional support requirements are requested. In the near term, WSMR will improve the cost estimation process to:

- Provide an accurate, detailed cost estimate to the customer. Detail of the cost estimate should be down to the branch level. This will enable improvement in the change management and cost accounting sections.
- Provide a uniform process followed by all groups, or only permit one group will provide estimates.
- Verify the quality of the estimates.
- Track the accuracy of cost estimates against the actual test costs, to encourage improvements to estimating process.

Everything starts with a well-done, detailed, cost estimate. The G5 and SV cost estimates which, follow the existing WSMR SOP, are good examples of the detail and quality needed. The whole of WSMR needs to follow these two groups' example, or have G5 and SV do the estimates for all test programs. Following the WSMR SOP will ensure cost estimates meet the accuracy, quality, and accountability requirements described above.

Following the WSMR SOP will require developing the estimate with the Test Officer and the various service provider's inputs. This is important, because then the customer, test officer and support groups have a clear understanding of the basis of the cost estimate. When change occurs to the test, everyone will be cognizant of the change. This is where the cost change management process will begin.

Cost Change Management: WSMR instructions and ATEC regulations require notifying the customer of changes to the cost of their tests; however, this is not the standard practice. The new process will:

On March 18, 2015, during a briefing to the House Armed Services Committee (HASC), Secretary of Defense Ashton Carter emphasized that budgeting must follow strategy: "The Defense Department needs your [HASC] support for this budget, which is driven by strategy, not the other way around."[40]

- Provide an incentive to the WSMR Test Team to advise customers of cost/growth changes. This incentive should apply to all service support managers and the Test Officer.
- Receive customer concurrence.
- Accuracy of cost growth is not as important as receiving customer acknowledgement/acceptance of changes. Process should work to prevent "sticker shock." For example, the new process should notify the customer if the additional optics requested will increase test costs by 25 percent. If actual costs turn out to be lower, the customer will be more understanding than if costs are greater.

The new process must incentivize the WSMR Test Team to inform customers of test cost changes, this will begin with a different approach to funds allocation. When the WBS is set up for a test program, sections of that WBS are subdivided to each branch or directorate. Managers of those subdivided units, the branches or directorates, will be responsible and accountable to manage to the cost estimate they provide.

If the customer requests a change to the test, and that change results in more or less cost to the branch or directorate, the branch/directorate must notify the Test Officer of the increase or decrease in additional funds. If this notification does not happen, the branch/directorate must absorb the additional cost with their institutional funding. This new process provides a strong incentive to the WSMR Test Team to inform customers of test cost changes.

Cost Accounting: WSMR instructions and ATEC regulations require employees to fill out their timecard accurately. Then, timecards are reviewed and approved by management. However, the present system is filled with errors. New process will:

- Hold managers/employees more accountable for accurate timecard charges against test programs.
- Hold managers more accountable to meet their provided cost estimate.
- Ensure stronger communication between the Test Officer, Customers, and support provided when changes to a test program occur.

These proposed process improvements will also address cost accounting problems. Managers will want to ensure the accuracy of timecards relative to a test program, since the managers themselves will need to justify requests for additional resources. Managers will be responsible for the cost estimate they provide. The result of this effort will be better communication between the Test Officer, customers, and support branch/directorate.

Support from other Organizations

Future State:

A more responsive and aligned work process with support organizations.

Roadmap:

The current process for external and internal support to WSMR test missions has an unhealthy feedback loops. External examples include; Civilian Personnel Advisory Center, Mission and Installation Contracting Command, Logistical Readiness Command, and garrison (Installation Management Command). An internal example might include G staff personnel. Problems arise when these support organizations receive funding cuts that result in a reduction of service. In the past, some support organizations have discontinued service, or reduced quality of service to below acceptable levels.

The reduction in service typically results in WSMR requesting the parent organization to restore funding, or shadow/contractor workaround solutions are developed at the Test Mission's expense.

A feedback loop, where "lack of performance" leads to additional funding, is very unhealthy. Every effort will be made to perform through the use of efficiency improvements or reprioritization of efforts, prior to receiving additional funding. As with other process improvement areas, it is not within the scope of this strategic plan to invent the new process. However, the plan can layout core requirements for the new process.

Multiple HIMARS launch at WSMR, 2008.

Generate a new process with healthy feedback loops. Requirements to be examined are:

- Feedback loops for performance reduction should reward properly selected priorities, good leadership/management, and productive processes or productive employees.
- Feedback loops for organizations that have truly tried their best may include additional funding requests.

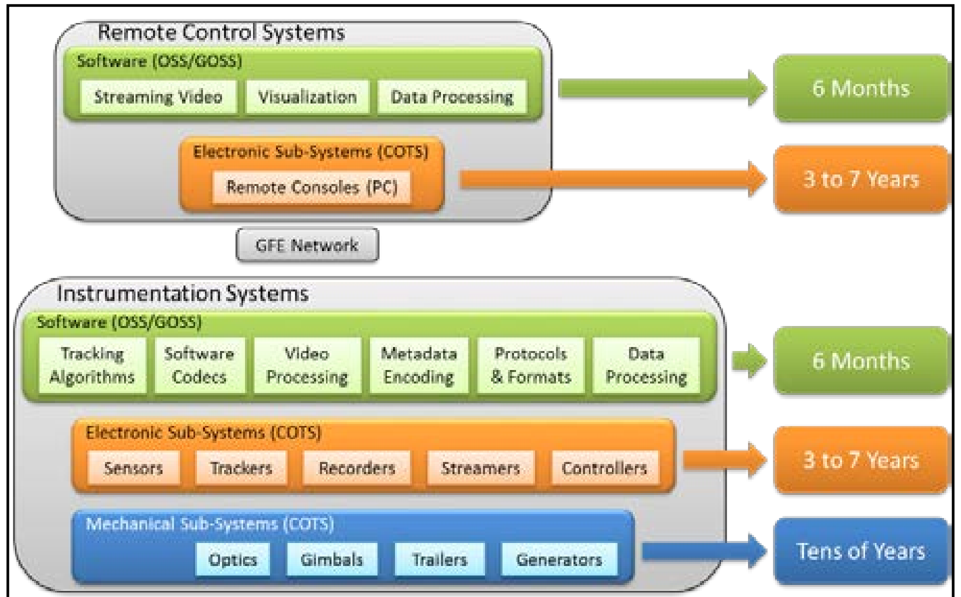
To ensure all sensible efforts have been made to accomplish the service before an external service is reduced or removed may require a detailed investigation be performed by an outside group such as Lean Six Sigma, the Inspector General, or the newly established Quarterly Assurance group. The outside group must first look for a better process or better management of the process, before requesting additional funding. This new approach would eliminate unproductive processes, leadership, or employees. In addition, the approach should reward high-performing organizations that need additional resources.

Suggested approach for internal organizations is very similar. Before reducing or removing internal services, a detailed investigation will be performed at the group's supervisory level. The investigation will focus on whether all sensible efforts have been made to accomplish the service, before they are reduced or removed.

Acquisition Sustainment and Modernization

Future State:

WSMR acquires, sustains and modernizes its testing capabilities in an efficient, timely and effective manner. Hardware systems leverage standardized interfaces and are upgraded or replaced in a simple "plug 'n' play" manner. Vendor "lock-in", due to proprietary interfaces and software, is a thing of the past. Software systems and capabilities are shared among multiple ranges, thereby achieving developmental efficiencies across the MRTFB. Due to the Government open source nature of most software, IA processes are streamlined and efficient. Updates are scheduled on a regular six-month interval. Software systems and algorithm development are coordinated amongst all developers, through a shared and common development network.



Life-cycle periods for various range architecture components.

Roadmap:

The Range instrumentation architecture will move from predominately proprietary systems, to more shared systems. Many current systems feature proprietary interfaces, protocols and formats. As an example, current KTM optical systems might have five different cameras/recorder combinations from five different vendors, and each unit might generate a different file format. This places a significant burden on processing and data handling requirements.

Primary requirements for acquisition, sustainment, and modernization include the following:

- A process that provides for efficient and effective system and sub-system evolution.
- A process that provides for efficient and effective software sustainment.
- Eliminate or reduce single vendor lock-in on systems and sub-systems.
- Minimize non-value added operations due to IA requirements

The process of sustainment and modernization is directly impacted by the life-cycle of system and sub-system architectures. It is important to recognize how the life-cycle varies across different types of components within a system. The above figure shows typical life-cycle periods for many of the common systems that are in use at WSMR.

Given these time frames, a strategy can be developed that places focus at WSMR on those items that require frequent and fast turnaround times. This places an emphasis on system and sub-system components that rely heavily on software. Items that have longer life-cycle times tend to represent the electronics and mechanical hardware within range instrumentation systems. The primary strategy with electronic systems, is to focus on standardized architectures. Opportunities for standardization include; operating system, physical format and mounting, external interfaces, control protocols, data streaming formats, and file formats.

Moving forward, the software development strategy needs to initially focus on the creation of a WSMR range-wide developer's network, which is separate from the Army admin network and the TSN. Policy dictates that software development not occur on a production network. As such, a separate network is needed. The many stand-alone developer net-

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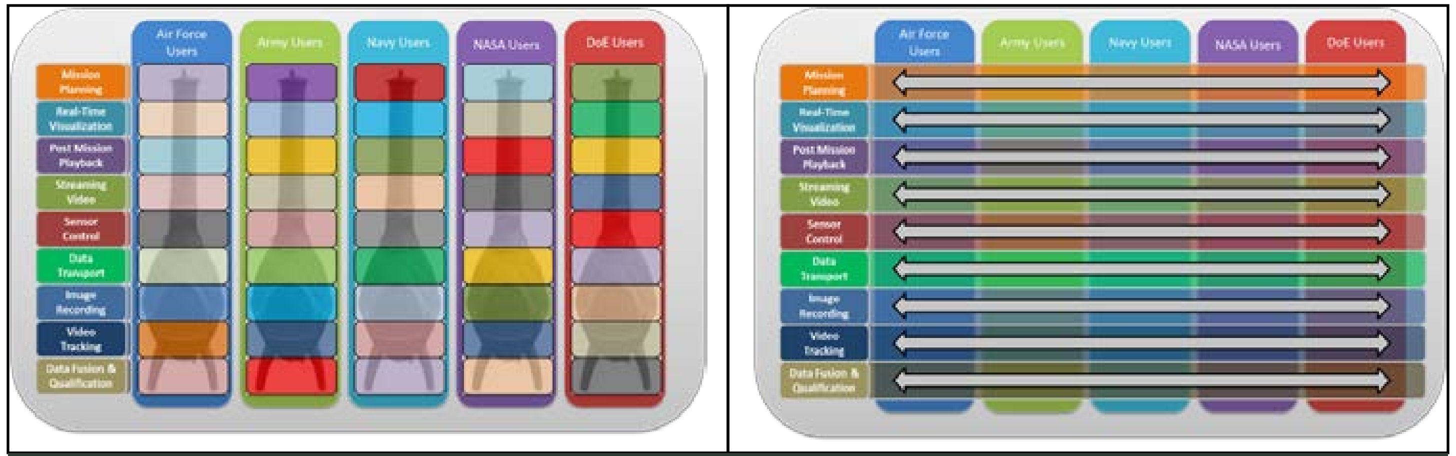


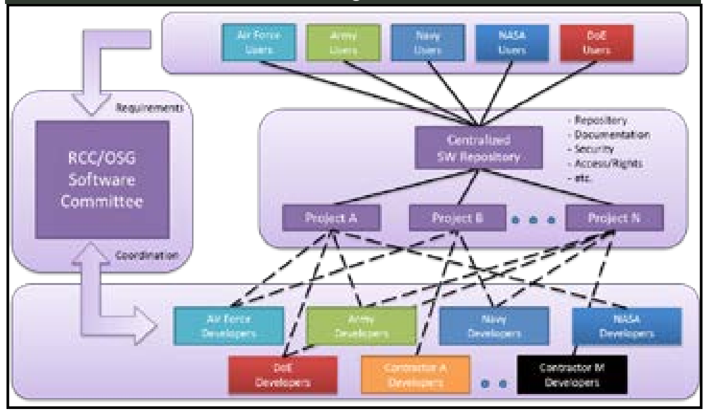
Moving from current stove-piped solutions (left) to common, collaborative solutions (right).

works that currently reside on WSMR need to be consolidated and tied to a common software repository.

Once software systems in this new paradigm are matured and standardized, interfaces have been defined, future large system acquisition efforts can focus on the long-term life-cycle components, such as optical gimbals and lenses. These longer life-cycle components can then be integrated into the existing capability without having to divest in all of the prior investments in software and other sub-systems.

A key to successfully implementing this strategy is the long-term investment in STEM capabilities within the WSMR workforce. To support this philosophy, a continuous flow of investment dollars to the Range is needed. For collaborative development, software and other sustainment efforts should be coordinated across all ranges where common and similar requirements dictate, to achieve maximum efficiencies. Examples include data fusion, video streaming, video tracking, data reduction, calibration algorithms, 3D graphics, etc. The right shows the current state on the left and the desired future state on the right. The figure is simple and basic but fundamentally shows how there are a large number of opportunities for achieving significant efficiencies if only the ranges choose to adopt this future state. Below shows some of the mechanics for how this type of sustainment model is envisioned through active efforts that have recently been initiated by WSMR, in coordination with the RCC and TRMC.

An approach for collaborative software development across the ranges.



Mission Execution Model

Future State:

A range customer comes to WSMR and meets with a test officer and range engineer. After describing desired testing parameters, a 3D visualization system is used to select and enter launch and impact or intercept locations, build a trajectory, select instrumentation options, and view what potential data products might look like at different launch time windows. A mission cost estimate based on choices and selections is provided allowing for examination of trade space in sensor coverage. Within a few hours, many of the mission parameters have been determined, saved to a file, and the customer leaves happy, knowing that his testing requirements will be met at an expected price.

The test officer and the range engineer hold a requirements review with WSMR stakeholders, and an evaluation and assessment of the mission requirements is performed. This review provides an opportunity for mission operators, data reduction analysts, etc., to perform a sanity check on the mission objectives, and recommend changes based on past experience and results of similar efforts. This review is part of a comprehensive evaluation process that is carried out at each major stage of a mission. The primary stages for each mission include:

- Requirements capture
- Mission planning/budgeting/scheduling
- Mission set-up/execution/teardown
- Data analysis & product generation

The review process provides two primary quality related functions. First, it allows for identifying mistakes and errors, before they are propagated through the mission process. Second, it allows for building a history of mission execution configurations and results for all phases of the mission. Traceability of issues and determination of root cause is streamlined, due to the rigorous process of capturing and storing mission process phase details. Page 68 captures the approach of layering evaluation and assessment on top of the mission execution process.

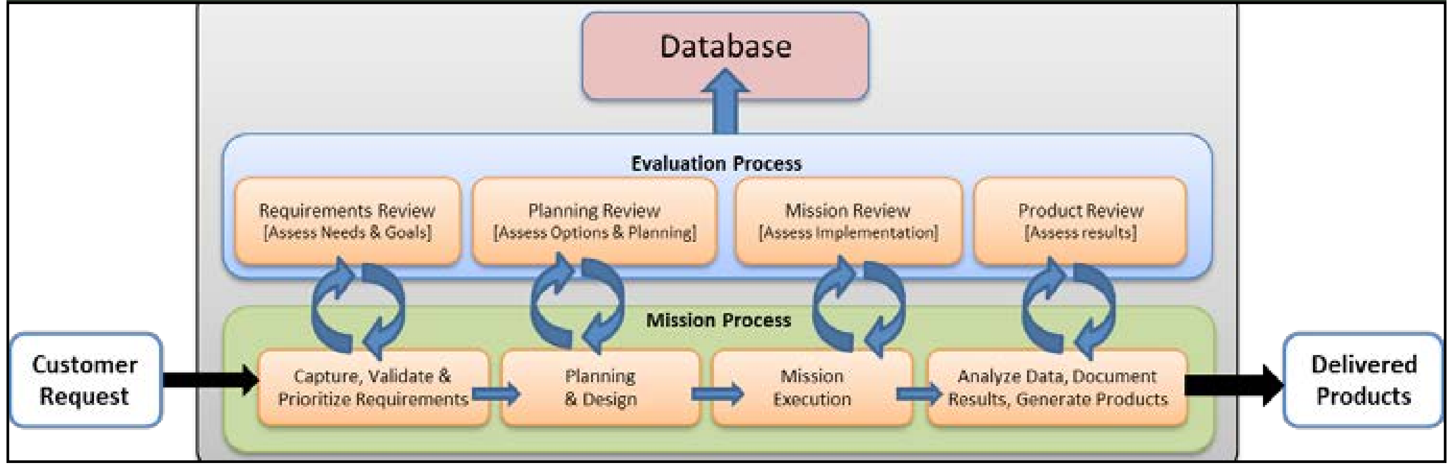
The 3D graphics system forms a core component of the "Mission Execution Toolset." The toolset provides an integrated end to end suite of software for executing missions. Requirements capture, mission planning and estimating, mission execution and the visualization of data products are all components of the toolset. In addition, machine readable files and a database form key components of the system that allow for continuous process improvement. This is a key feature of the system. While the review process may capture context and qualitative information about a mission through interaction with the workforce, automation tools that are built into the software at every phase of a mission allows for the collection, storage, and display of quantitative performance metrics. This is a key feature, in that data is harvested automatically on each and every mission. Dashboards that are tailored to each mission component are made available to managers and supervisors, so they can address any negative trends that start to show on their dashboards. In addition, dashboards are examined when reviewing TDAP requests to determine where the most "bang for the buck" can be achieved with investment decisions. the figure below shows the detailed process-flow of the Mission Execution Toolset concept, and the individual layers of graphics, automation, and continuous improvement that are embedded within the capability.

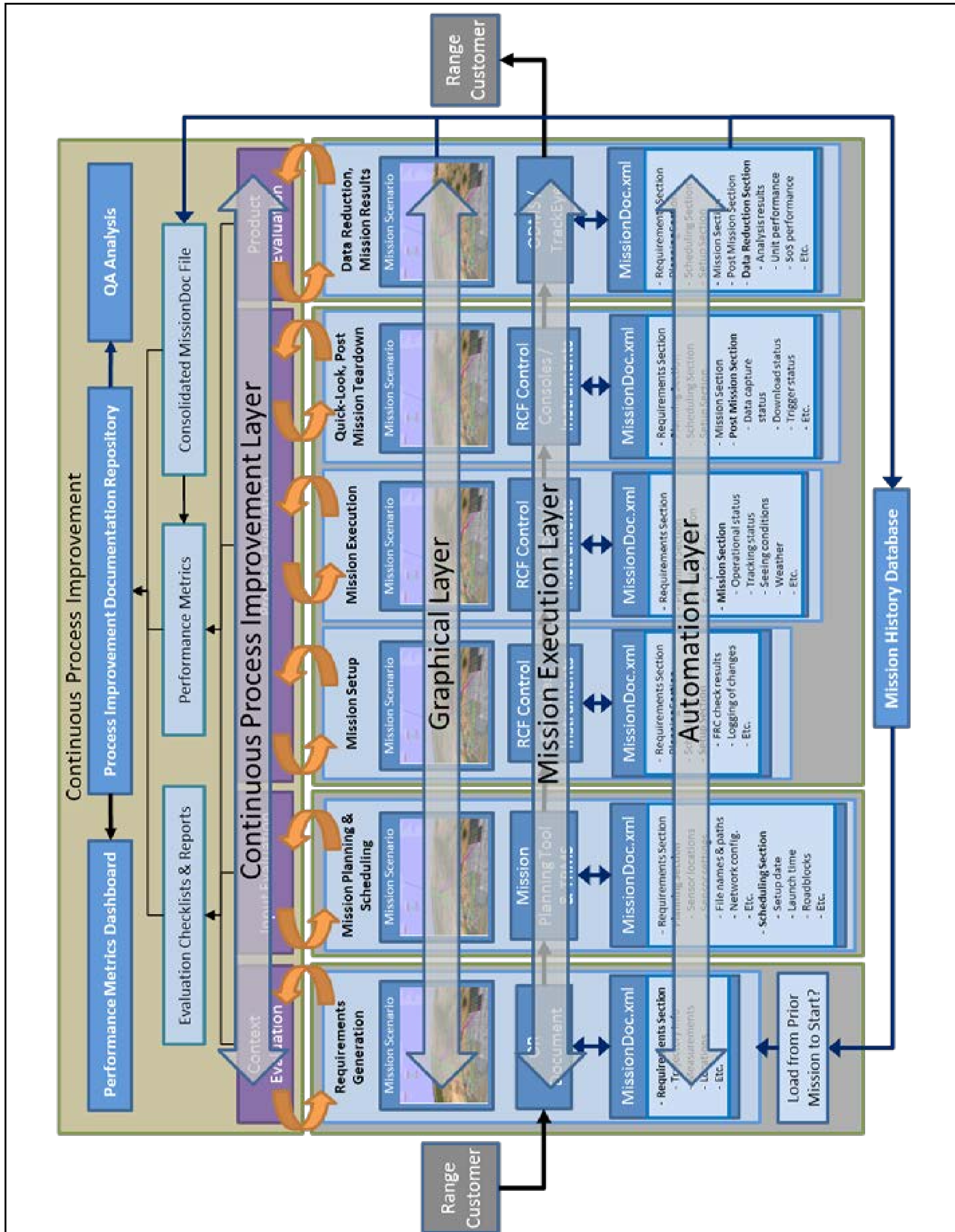
Roadmap:

The key to the development of the Mission Execution Toolset is the integration of software tools within the WSMR mission execution process. The graphics, metrics database, dashboards, and automation layers, are all straightforward technology implementations that are high TRL solutions, readily available and only require integration.

MEADS launch, WSMR, November 2012.

Integrated mission process evaluation and assessment.





The Mission Execution Process.

CONCEPT OF OPERATIONS FOR EXECUTION OF STRATEGIC PLAN

Implementation of the WSMR 2046 Strategic Plan requires focused efforts on five critical goals, along with numerous roadmap actions to achieve the future state as discussed throughout these pages.

Action teams will address specific roadmap actions listed for each of these goals. In this manner, by focusing on specific bounded tasks, WSMR leadership will be able to track progress more readily and score quick wins that could have significant payoffs. Piece by piece, action teams will be able to progress through each of the goals by building on prior successes and WSMR will eventually establish a healthy battle rhythm.

The identified action items represent small, manageable steps along the way towards achieving WSMR's larger, long-term objectives. These action items will be Specific, Measurable, Achievable, Relevant, and Time-Bound (SMART). An assigned Action Team Leader will be responsible for managing advancement towards accomplishing action items and helping to ensure their timely execution.

The WSMR G5 will lead the strategic plan implementation process with monthly status reviews to track progress towards completion of each action item. The G5 will facilitate priority recommendations to directors and Test Center/Garrison commanders, based upon the status reviews and budget constraints. They will make recommendations to the Commanding General/Executive Director (CG/ED). The CG/ED will host yearly meetings during the FY's third quarter to ensure progress and provide course corrections based upon changing conditions as necessary. As discussed throughout, the objective for WSMR is to remain flexible, adaptable, and responsive to the needs of our warfighter, preparing them for the dynamic and complex environments of tomorrow.

Many studies have examined different ways of how to implement change successfully in industry. The five-step process shown below represents one of the best strategies to accomplish change:

- Step 1: Establish urgency. Inform the workforce why it is important to make the strategic changes needed for the future.
- Step 2: Personal Action. Assign by name a single, dedicated action officer to lead improvement actions. Must be a SMART action.
- Step 3: Measure progress. At quarterly intervals, measure the progress made. Hold personnel accountable for completion of actions.
- Step 4: Tools. Leadership must provide the tools and resources needed to accomplish an action (e.g., new computers, appropriate personnel, dedicated time, software, etc.).
- Step 5: Rewards. Reward action officers and team members for successfully accomplishing tasks.

Urgency → Personal Action → Measures → Tools → Rewards

From John P. Kotter, Harvard Business School; adapted from a six-step process.[41]

WSMR has traditionally struggled with the implementation of recommended actions in past strategic plans. While the reasons behind this repeated lack of follow through are no doubt complex, it is possible to identify four basic (and related) causes:

- Lack of Resourcing: In the recent past, WSMR lacked the needed people, funding and tools due to budget constraints and drawdown. Leadership must commit to resourcing the goals and tasks to achieve the future state.
- Lack of Accountability: Lack of accountability is a notable problem at WSMR, as expressed recently by the Executive Director.[42] Previous strategic plans have failed to hold personnel accountable for completion of their assigned action items. Addressing accountability problems at the outset of the strategic plan's implementation will help alleviate numerous issues that plagued past WSMR efforts.
- Lack of Priority: Often times other urgent projects or tasks arise and divert management's attention away from working to achieve the longer-term, collective strategic goals. Aggressively holding goal leaders accountable for results will help prevent permanent shifts in attention that can derail strategic plan progress.
- Too Big: Strategic plans have multiple parts, all of which require senior leadership involvement to bring about real change. By focusing on five critical areas, and through implementation of a manageable number of tasks in an area at one time, the overall execution of the plan remains governable.

This Strategic Plan differs from its predecessors in several significant ways that should make it more effective. First, thanks to today's increased search power for information, this plan will build from a meta-analysis-like survey of similar documents WSMR had published going back several decades, a luxury most previous efforts did not have. By looking backwards as well as forwards, the Plan better identifies which areas have been historically difficult for WSMR to implement change. Secondly, the intent behind this document is that it not be static. By creating a living document and opening it up to WSMR's stakeholders for comment and adaptation, the strategy and end goals herein will better adapt and change as WSMR's needs change. Lastly, by looking at discreet areas and assigning specific tasks to individuals accountable for their implementation, this concept of operations will guide WSMR into 2046.

Cox Range Control Center, Bldg. 335, White Sands Missile Range, NM. (Photo: WSMR PAO)

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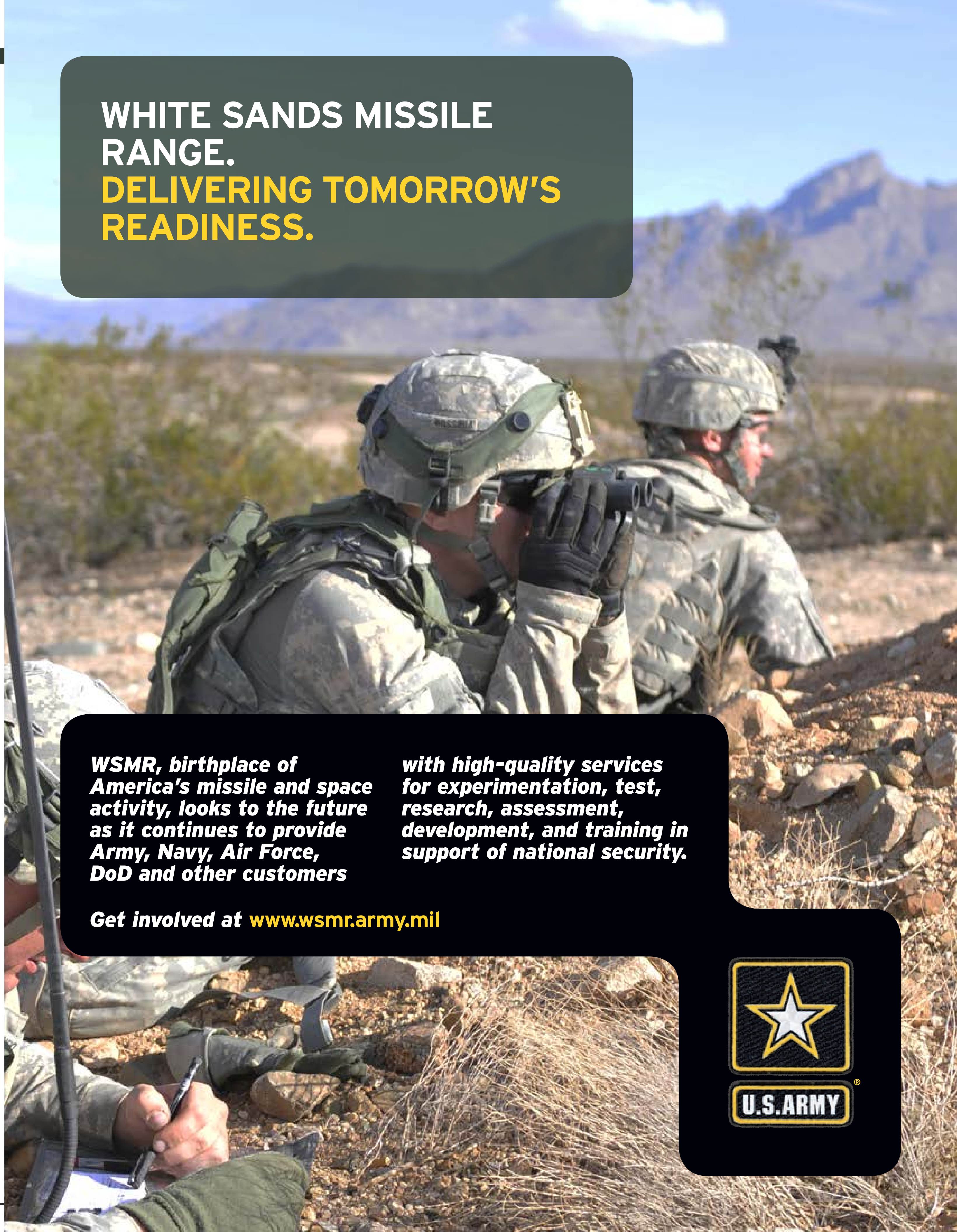
ACRONYMS
WSMR 2046

Acronyms

A2/AD – Anti-Access Area Denial
ACR – Aerial Cable Range
ACUB – Army Compatible Use Buffer
ADC – Association of Defense Communities
ADP – Area Development Plans
ADP – Area Development Plans
ADS-B – Automatic Dependent Surveillance-Broadcast
ADSS – ATEC Decision Support System
AFB – Air Force Base
AFRL – Air Force Research Laboratory
AGATCS – Army Ground Aerial Target Control System
AHW – Advanced Hypersonic Weapon
AI – Artificial Intelligence
AIAMD – Army Integrated Air Missile Defense
AirPA- Airborne Telemetry Phased Array
AN/FPS – Army Navy Fixed, Radar, Search
APT – Advanced Pointer Tracker
ARAV – Army Aviation
ARL – Army Research Laboratories
ARTIS – Advanced Range Tracking and Imaging System
ARTM – Advanced Range Telemetry
ASCM – Air to Surface Cruise Missile
ASD(R&E) – Assistant Secretary of Defense for Research and Engineering
ASR – Air Surveillance Radar
ASTERS – Autonomous Systems Test and Evaluation Requirements Study
ASVS – Airborne Separation Video System
AT/FP – Anti-Terrorism/Force Protection
ATC - Aberdeen Test Center, Aberdeen Proving Ground, Maryland
ATEC – Army Test and Evaluation Command
ATM – Aeronautical Telemetry
AUTM – Association of University Technology Managers
AWACS – Airborne Warning and Control System
BAT – Brilliant Anti-Tank
BCT – Brigade Combat Teams
BDFA – Big Data Framework Architecture
BE – Battlefield Environment
BEAR – Beam Experiments Aboard Rocket
BFV – Bradley Fight Vehicle
BLM – Bureau of Land Management
BMC – Brigade Modernization Command
BMD – Ballistic Missile Defense
BSAF – Beam Shaping Assembly
Facility
C2 – Command and Control
C3IM – Command, Control & Communication Information Management
C4RS – Command, Control, Communications, Computers, Reconnaissance and Surveillance
CAC – Common Access Card
CCM – Counter-Counter Measures
CE – Conducted Emissions
CIPAC – Critical Infrastructure Partnership Advisory Council
CISD – Computational Information Sciences Directorate
CM – Counter Measures
CND – Computer Network Defense
CO2 – Carbon Dioxide
COA – Certificate of Authorization
CoE – Center of Excellence
COE – Common Operating Environment
CONOPS – Concept of Operations
COOPs – Continuity of Operations Plans
COTS – Commercial Off-The-Self
CRAM – Counter Rockets, Artillery and Mortars
CRCC – Cox Range Control Center
CRIIS – Common Range Integrated Instrumentation System
CS – Conducted Susceptibilities
CSBA - Center for Strategic and Budgetary Assessments
CSP – Cloud Service Providers
CSS – Chirp Spread Spectrum
CTEIP – Central Test and Evaluation Investment Program
CTSF –Central Test Support Facility
CW – Continuous Wave
DA – Department of the Army
DAR – Data At Rest
DARPA – Defense Advanced Research Projects Agency
DASD – Deputy Assistant Secretary of Defense
DE – Directed Energy
DEPS – Directed Energy Professional Society
DETEC – Directed Energy Test and Evaluation Capability
DETTA – Directed Energy Test Technology Area
DHS – Department of Homeland Security
DLH – Direct Labor Hours
DLWS – Demonstrator Laser Weapon System
DMSMS – Diminishing Manufacturing Source and Material Shortages
DoE – Design of Experiments
DOF – Degrees Of Freedom
DOT&E – Director, Operational Test & Evaluation
DOTLM-PF – Doctrine, Organization, Training, Leadership, Material Education, Personnel and Facilities
DPF – Dense Plasma Focus
DPG – Dugway Proving Ground, Utah
DPW – Directorate of Public Works
DREN/S – Defense Engineering and Research Network System
DSL – Data Support Limitations
DSSS – Direct Sequence Spread Spectrum
DT – Development Test
DT&E – Developmental Test & Evaluation
DTED - Digital Terrain Elevation Data
DTRA – Defense Threat Reduction Agency
DWDM – Dense Wavelength-Division Multiplexing
E3 – Electromagnetic Environmental Effects
EA – Electronic Attack
ELDRS – Enhanced Low Dose Rate Sensitivity
EMC – Electromagnetic Compatibility
EMI – Electromagnetic Interference
EMR – Electromagnetic Radiation
EMRE – Electromagnetic Radiation Effects
EMRH – Electromagnetic Radiation Hazard
EMRO – Electromagnetic Radiation Operational
EMS – Electromagnetic Spectrum
EPAF - European Participating Air Forces
EPG - Electronic Proving Ground, Ft. Huachuca, Arizona
ESD – Electrostatic Discharge
ETS – Experimental test Site
EW – Electromagnetic Warfare
FAA – Federal Aviation Administration
FAC – Frequency Area Coordinator
FBR – Fast Burst Reactor
FHSS – Frequency Hopping Spread Spectrum
FLC – Federal Laboratory Consortium
FLEX – Force Level Execution System
FORSCOM – United States Army Forces Command
FRIC – Federal Partnership for Interoperable Communications
FTS – Flight Termination System
GDOP – Geometric Dilution of Precision
GEODSS – Ground-based Electro-Optical Deep Space Surveillance
GIG – Global Information Grid
GPS – Geographic Positioning System
GRF – Gamma Radiation Facility
GSA – General Services Administration
GSS – Global Surveillance and Strike
GTIM – Ground Target Irradiance Measurement
H2M – Human to Machine
HA – High Availability
HAZMAT – Hazard Material
HD – High Definition
HEL – High Energy Laser
HELMD – High Energy Laser Mobile Demonstrator
HELSTF – High Energy Laser Systems Test Facility
HEMP – High Altitude Electromagnetic Pulse
HERA – High Explosive Rocket Assisted
HERF – Hazards of Electromagnetic Radiation to Fuel
HERO – Hazards of Electromagnetic Radiation to Ordnance
HERP – Hazards of Electromagnetic Radiation to Personnel
HESD – Helicopter Electrostatic Discharge
HHSTT – Holloman High Speed Test Track
HITRAC – Homeland Infrastructure Threat Risk Analysis Center
HPC – High Performance Computing
HPM – High Power Microwave
HQDA – Headquarters Department of the Army
HR – Human Resources
HS/H – High Speed/Hypersonic
HST – High Speed Transports
HTA – Hazardous Test Area
HVP – Hyper Velocity Projectile
IA – Information Assurance
IAW – In Accordance With
IC – Implementation Committee
ICBM – Intercontinental Ballistic Missiles
IED – Improvised Explosive Device
IEPD – Information and Electronic Protection Division
IEW – Information Engineering Workbench
IFF – Image File Format
IG – Inspector General
IIP – Instantaneous Impact Prediction
IMU - Inertial Measurement Units
INR – Initial Nuclear Radiation
IoT – Internet of Things
IP – Internet Protocol
IPS – Installation Property Standards
IR – Infrared
IRCC – Inter-Range Control Center
IRI – Industrial Research Institute
ISR - Intelligence, Surveillance and Reconnaissance
ISSA – Inter-Service Support Agreement
IT – Information Technology
JAMD – Joint Air Missile Defense
JHPSSL – Joint High Power Solid State Laser
JIDA – Joint Improvised-Threat Defeat Agency
JIM – Joint Improvement and Modernization
JLUS – Joint Land Use Study
JPME – Joint Professional Military Education
JTAMD – Joint Theater Air and Missile Defense
JUTC – Joint Urban Test Capability
KTM – Kineto Tracking Mounts
LACM – Land Attack Cruise Missile
LaWS – Laser Weapon System
LBTS – Large Blast Thermal Simulator
LC-35E – Launch Complex 35 East
LEED - Leadership in Energy and Environmental Design
LEU – Low Enriched Uranium
LID – Low Impact Development
LIDARS – Light Detection and Ranging
LINAC – Linear Accelerator
LMR – Land Mobile Radio
LMR – Land Mobile Radio
LPI – Low Probability of Intercept
LRM – Line Replacement Module
LRU – Line Replacement Unit
LSS – Logistics Support System
LTE – Long Term Evolution
LVC – Live, Virtual, Constructive
LWIR – Long Wavelength Infrared
M&S – Models and Simulations
M2M – Machine to Machine
MANCAT – Multi-Spectrum Ambient Noise, Collection and Analysis Tool
MBDA – Minority Business Development Agency
MCA – Military Construction – Army
MDA – Missile Defense Agency
METL – Mission Essential Task List
MILCON – Military Construction
MIMO – Multiple In/Multiple Out
MIRACL – Mid Infrared Advanced Chemical Laser
MOP – Massive Ordnance Penetrator
MOTR – Multi-Object Tracking Radar
MRBM – Medium Range Ballistic Missiles
MRTFB – Major Range Test Facility Base
MSE – Multiple Simultaneous Engagements
MS-ISAC – Multi-State Information Sharing and Analysis Center's
MTAS – Mobile Telemetry Acquisition Systems
MTHEL – Mobile Tactical High Energy Testbed
MTR – Military Training Routes
MUPS – Mobile Uninterruptible Power System
NARUC – National Association for Regulator Utility Commissioners
NASA – National Aeronautics and Space Administration
NCIRP – National Cyber Incident Response Plan
NCR – National Cyber Range
NCUA – Northern Call-UP Area
NDAA – National Defense Authorization Act
NDT – Non-Destructive Testing
NEA – North Expansion Area
NEC – Network Enterprise Center
NEI – Network Evaluation Integration
NEV – Neighborhood Electric Vehicles
NGA – National Geospatial-Intelligence Agency
NIE – Network Integration Exercise
NIFC-CA – Naval Integrated Fire Control – Counter Air
NIPR – Non-Secure Internet Protocol Router
NIR – Near Infrared
NM Tech – New Mexico Technical College
NMCRDC – New Mexico Collaborative Research and Development Council
NMSU – New Mexico State University
Non-DE – Non Directed Energy
NRO – National Reconnaissance Office
NTTR – Nevada Test and Training Range
OA – Operating Area
OAR – Open Air Range
OCO – Offensive Cyberspace Operations
OEM – Original Equipment Manufacturer
OMF – Optical Maintenance Facility
OPTEMPO – Operating/Operations

Tempo
OT – Operational Testing
OTAs – Operation Test Agencies
OTC – Operational Test Command, Ft. Hood, Texas
OTH – Over-The-Horizon
OTP – Outline Test Plans
P2P – Peer to Peer
P3 – Public Private Partnerships
PAAT – Passive Acoustic
PCII – Protected Critical Infrastructure Information
PCIS – Partnership for Critical Infrastructure Security
PESD – Personnel Electrostatic Discharge
PGM – Precision Guided Munitions
PIN – Process In Network
PLVTS – Pulsed Laser Vulnerability Test System
PM – Program Manager
PMG – Precision Guided Munitions
PNT – Positioning, Navigation and Timing
POC – Point of Contact
POR – Programs of Record
PRST – Pacific Range Support Team
PS – Precipitation Static
QA – Quality Assurance
QAM – Quadrature Adaptive Multiplexing
QD – Quantity Distance
RAM – Rockets, Artilleries and Mortars
RCC – Range Commanders Council
RCCC – Regional Consortium Coordinating Council
RCL – Radiation Correlation Facility
RDAS – Remote Data Acquisition System
RE – Radiated Emissions
REP – Resource Enhancement Project
RF – Radio Frequencies
RFA – Radio Frequency Allocations
RML – Radiation Metrology Laboratory
RMR – Electromagnetic Environments
ROCS – Real-Time Operations Control
ROE – Rules of Engagement
RPMP – Real Property Master Plan
RPPB – Real Property Planning Board
RRL – Rapid Response Laboratory
RRRP – Range Radar Replacement Program
RS – Radiated Susceptibilities
RT – Radiation Tolerance
RTASSC – Radiation Tolerance Assured Supply and Support Center
RTC – Redstone Test Center, Redstone Arsenal, Alabama
S&T – Science & Technology
SADARM – Search and Destroy Armor
SBIR – Small Business Innovation Research
SCMM – Signal Collection, Monitoring and Measuring
SDB – Small Diameter Bombs
SET – Spectrum Efficient Technologies
SIPR – Secure Internet Protocol Router
SLAD – Survivability/Lethality Analysis Directorate
SLBD – Sea Lite Beam Director
SLTTGCC – State, Local, Tribal and Territorial Government Coordinating Council
SMART - Specific, Measurable, Achievable, Relevant, and Time-Bound
SME – Subject Matter Expert
SoAF – Status of Action File
SoS – System of Systems
SoSA – System of System Analysis
SoSE&I – System of Systems Engineering and Integration
SPIE – Society of PhotoOptical Instrumentation Engineers
SSA Space Situational Awareness
SSL – Solid State Laser Weapon System
SSN – Space Surveillance Network
SSTI – State Science & Technology Institute
STAR – System Threat Assessment Report
STEM – Science, Technology, Engineering and Mathematics
STL – Semiconductor test Laboratory
STORM – Simulation Testing Operations Rehearsal Model
SUT – System Under Test
SV – Survivability/Vulnerability
SVAD – Survivability, Vulnerability, Assessment Directorate
SW – Small Wideband
SWICs – Statewide Interoperability Coordinators
SWIR – Short-Wavelength Infrared
SWOT – Strengths, Weaknesses, Opportunities, and Threats
T&E – Test and Evaluation
TACMS – Tactical Missile System
TBD – To be Determined
TBM – Tactical Ballistic Missile
TDRSS – Tracking and Data Relay Satellite System
THEL – Tactical High Energy Laser
THSS – Time Hopping Spread Spectrum
TM – Telemetry
TMV – Telemetry Mobile Vans
TOW – Tube-launched Optically-tracked Wire-guided missile
TRAC – TRADOC Analysis Center
TRACS - Transportable Range Augmentation and Control System
TRADOC – Training and Doctrine Command
TREE – Transient Radiation Effects on Electronics
TREM – Target Reflected Energy Measurement
TRIAD – Ft. Bliss, Holloman Air Force Base, White Sands Missile Range
TRMC – Test Resource Management Center
TSN – Test Support Network
TSPI – Time-Space-Position-Information
T-SS – Tri-Service Study
TSTS – THEL Static Test Site
TTA – Test Technology Area
TTARS – Transportable Telemetry Acquisition Relay System
TTAS – Transportable Telemetry Acquisition System
TTS – Telemetry Tracking System
TWG – Test Working Group
UAE – United Arab Emirates
UAS – Unmanned Aerial System
UAV – Unmanned Aerial Vehicle
UCAV – Unmanned Combat Aerial Vehicles
UNM – University of New Mexico
USAG – United States Army Garrison
USG – Unmanned Ground Systems
UTEP – University of Texas El Paso
UTTR – Utah Test and Training Range
UV – Ultraviolet
UWB – Ultra Wideband
VDC – Volts Direct Current
VoIP – Voice over Internet Protocol
VPG – Virtual Proving Ground
VTS – Vacuum Test System
WB – Wideband
WCUA – Western Call-Up Area
WMD – Weapons of Mass Destruction
WSMR - White sands Missile Range
WSSF – White Sands Solar Furnace
WSTF – White Sands Test Facility
WTM – Wireless Test Network
YPG – Yuma Proving Ground, Arizona
ZB – Zettabyte











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