NAWCWD *Quick Facts*

China Lake & Point Mugu, California (March 2008)

Providing Daily Support to our Warfighters Around the World
Supporting Naval Aviation and Warfighter Requirements Since 1943

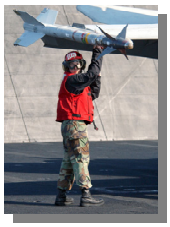
Naval Air Warfare Center Weapons Division (NAWCWD)
Center of Excellence for Weapons and Armaments
www.nawcwd.navy.mil

Mission: To provide Navy and Marine Corps warriors with effective, affordable, integrated warfare systems, and life-cycle support to ensure battlespace dominance.

Research, Development, Acquisition, Test, and Evaluation (RDA, T&E)

- Provide logistics and in-service support for guided missiles, free-fall weapons, targets, support equipment, crew systems, and electronic warfare
- Operate the Navy's Land and Sea Ranges using state-of-the-art Network-Centric Warfare, modeling and simulation, and full-scale and sub-scale targets
- Conduct joint live-fire survivability testing
- Test explosives and propellants up to 500,000 pounds

Ranked Highest In Military Value
Recent DoD studies highly ranked several NAVAIR sites. WD, once again, was ranked number one by the Navy for overall military value.



Center of Excellence for Weapons and Armaments and Live-Fire Survivability Testing

Direct Conflict Involvement. Played significant role in every U.S. military crisis since WWII.

World Leader in RDA, T&E of guided missiles, advanced weapons and systems, complex software integration on tactical aircraft, energetic materials and subsystems – proven through 50 years of unparalleled products.

Aircraft Weapons Integration. AH-1, AV-8B, EA-18G, EP-3E, F/A-18G, JSF, UAS, F-22 (USAF).

Geographic Diversity. Few areas in the world offer ocean, deep water ports, protected islands, mountains, deserts, canyons, and forests—all in close proximity. Developed

- Sidewinder missile, the world's premiere aerial combat weapon – sold to 31 countries.
- Warfighter Response Center provides subject matter experts internationally.
- Unique world class facilities and test ranges for weapon system solutions.
- Optimal test environment – 360 clear days per year.

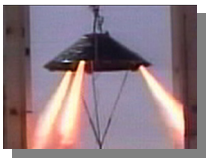
Weapons. Advanced Medium-Range Air-to-Air Missile (AMRAAM), Advanced Antiradiation Guided Missile (AARGM), Evolved SeaSparrow Missile (ESSM), General Purpose Bombs, High-Speed Anti-Radiation Missile (HARM), Harpoon, Hellfire, Joint Direct Attack Munition (JDAM), Joint Standoff Weapon (JSOW), Laser Guided Bombs, Low Collateral Damage Bomb, Maverick, Phoenix, Rolling Airframe Missile (RAM), Spike, Standoff Land-Attack Missile (SLAM), SLAM-ER (Expanded Response), Sidewinder, Sparrow, Standard Missile, Tomahawk, Trident, Vertical Launch ASROC (Anti-submarine Rocket), Walleye

Programs/Projects/Systems (Examples). Active Electronically Scanned Array (AESA), Anti-Swimmer Grenade (ASG), Counter Improvised Explosive Devices, Digital Precision Strike Suite (DPSS), Digital Ground-Based Threat Detection System (DGTDS), Electronic Warfare Systems, Joint Helmet Mounted Cueing System (JHMCS), High Speed Weapons, Infrared and Electronic Countermeasures, Intrepid Tiger Pod, Link-16, Low-cost Guided Imaging Rocket (LOGIR), Multifunctional Information Distribution System (MIDS), Precision Strike Suite for Special Operations Forces (PSS-SOF), Rapid Attack Information Dissemination and Execution Relay (RAIDER), Shared Reconnaissance Pod (SHARP), Tactical Aircraft Electronic Warfare, TOPSCENE, Unmanned Aerial Systems, Weapon System Support Activities

Technology Transfer (Examples).

- Stop-action video
- Chemiluminescent light sticks
- Auto air-bag sensors (worldwide)

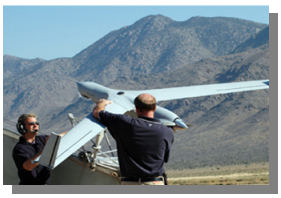
Mars Lander 2004. Designed, built, and installed the zylon bridle system onto each spacecraft; jointly developed, with JPL, the descent rate limiter, and radar system; tested the retro-rocket systems, and conducted multi-body tests.

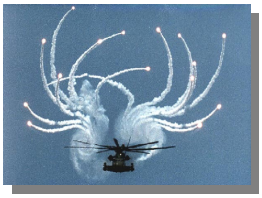


Developed and Fielded First

- Air-to-air guided missile in combat – Sidewinder
- Polaris Missile concept
- U.S. precision-guided air-to-surface weapon – Walleye
- Real-time night display of targets
- Plastic bonded explosives
- Anti-radar missile – Shrike/HARM

Future. Network-Centric Warfare, Energetics, High-Speed Weapons, Unmanned Aviation Systems, Homeland Defense, Counter Terrorism, Time-Critical Long Range Strike.





NAVAIR Naval Air Systems Command						
Weapons Division	China Lake, CA Point Mugu, CA	**Aircraft Division**	Patuxent River, MD Lakehurst, NJ Orlando, FL	**Depots**	North Island, CA Jacksonville, FL Cherry Point, NC

Scope of Operations (March 2008)

Annual Funding FY07	$1.09 billion
Contracts (all supplies & services)	$603,000,000
WD Personnel	
• Civil Service	4,051
• Military (NAWS/NAWC)	802
• Contractor work years	1,774
• **Total**	**6,627**
(NAVAIR Personnel at all 8 sites)	*23,000+*
Annual Test Events	1,800
Training Sorties	3,192
Major Training	30

- **Fleet Battle Experiments** Empire Challenge 06 and 07
- **Fleet Exercises -** RIMPAC 06
- **Major Exercises -** conducted on the SeaRange, Land Range, Superior Valley, and Electronic Combat Range. Top Gun training.

Land 1.1 mil acres (larger than Rhode Island)

- Navy's largest single landholding
- 85% of Navy's RDA, T&E Lands
- 36% Navy lands worldwide
- 95% lands left completely undisturbed

Sea 36,000 square miles, expandable to 125,000

Air R2508 is 12% of California's total airspace

Annual Visitors 38,000+ **Foreign Visits** 2,500+

Facilities and Ranges

The Naval Region Southwest proudly hosts NAWCWD on its premiere facilities at China Lake and Point Mugu, California

Plant replacement value	$3 billion
Major facilities: (40) Buildings:	3,000+
Airfields:	2

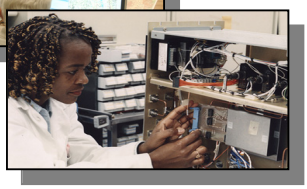
Customers & Partners (Partial List)

Government. Army, DARPA, DOT, DTRA, FAA, FBI, ONR, MDA, NASA, NAVSEA, NIMA, NRO, NTSB, SPAWAR, SF, USAF

Foreign. Australia, Canada, Croatia, Denmark, Egypt, Finland, France, Germany, Greece, Israel, Italy, Japan, Korea, Norway, Netherlands, New Zealand, Spain, Switzerland, Thailand, UK.

Industry. BAE Systems, Boeing, Lockheed Martin, Raytheon, Northrop-Grumman, General Atomics

Teaming. DoD, other agencies, academia, and industry. Cooperative R&D and Commercial Service Agreements, Navy Potential Contractor Program and Patent License Agreements



Developmental Testing
WD Tenant Commands
VX-31 (China Lake)
VX-30 (Point Mugu)

Operational Testing
VX-9 (COMOPTEVFOR)
Marine Aviation Detachment (MAD)

History

China Lake. Established in WWII to test rockets developed by the California Institute of Technology.
Point Mugu. Established in 1946 as the Navy's first instrumented missile-test sea range.

AIAA Historic Aerospace Sites. Both China Lake and Point Mugu have received this prestigious national recognition by the American Institute of Aeronautics and Astronautics.

Location

China Lake Location 150 miles NE of Los Angeles (desert)
Point Mugu Location 50 miles N of Los Angeles (coast)

BDO/WTM/0408

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Overview

Arming The Fleet

Fleet Progress On Many Fronts

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OVERVIEW

The Naval Air Systems Command (NAVAIR) delivers weapon systems to warriors for Navy and Marine Corps missions. Products and services include fixed and rotary wing aircraft, avionics, air- and surface-launched weapons, electronic warfare systems, cruise missiles, unmanned aerial vehicles, launch and arresting gear, and training systems.

NAVAIR encompasses eight sites across the country. The Aircraft Division has sites at Patuxent River, Maryland; Lakehurst, New Jersey; and Orlando, Florida. NAVAIR depots are located at North Island, California; Jacksonville, Florida; and Cherry Point, North Carolina. The Weapons Division (WD) includes sites at China Lake and Point Mugu, California. The entire NAVAIR organization has made significant contributions to the Fleet by providing total life cycle support: research, design, development, and engineering; acquisition; test and evaluation; repair and modification; and in-service engineering and logistics support.

Many NAVAIR publications have documented significant contributions to the Fleet in support of naval aviation and warfighter requirements. This document, produced by the NAVAIR Weapons Division, focuses specifically on the weapons and systems Research, Development, Test and Evaluation (RDT&E) contributions made at China Lake and Point Mugu since 1943. During every United States military crises since World War II, RDT&E work at China Lake and Point Mugu has played a significant role: developing and testing weapons and systems that work.

Firsts. WD provides direct Fleet support for naval aviation and is recognized for a number of significant "firsts." WD has extensive experience in developing, perfecting, and testing military components and subsystems that also have direct application to space missions. Although work for other government agencies represents only a very small fraction of the total workload, the Division is occasionally called upon by NASA to lend expertise to projects of national importance. Lessons learned from joint projects help WD find solutions to naval aviation problems. China Lake and Point Mugu are recognized for several space related and earlier undersea "firsts."

Technical Expertise

- Test and evaluation
- Technology transfer
- Modeling and simulation
- Image and signal processing
- Laser and optical components
- Electro-optics/infrared systems
- Fuzing components and devices
- Interoperability of warfare systems
- Energetic materials and subsystems
- Advanced weapons and guided missiles
- Radar systems, including synthetic aperture
- Complex weapon system/software integration

Firsts

- Air-to-air guided missile ever used in combat–Sidewinder
- X-ray video system to see inside rocket motors while firing
- To develop and test the concept for the Polaris missile
- U.S. precision-guided air-to-surface weapon–Walleye
- U.S. manned submersible to descend 2,000 feet
- Technology to photograph the back side of the moon
- Mars and Lunar Landings–subsystem RDT&E
- Atomic bombs–non-nuclear components
- Reprogrammable self-protection jammer
- Successful antiradar missile–Shrike
- Real-time night display of targets
- U.S. satellite launch–NOTSNIK
- Plastic-bonded explosives
- U.S. aircraft rockets

Guided Missile Development. China Lake has made significant contributions to every aspect of guided missile technology and development. WD expertise has had a significant impact in the arsenal of U.S. air-, surface-, and subsurface-launched weapons that cover virtually every threat, from enemy aircraft, to surface and sub-surface combatants, to radar systems, to hardened ground targets.

A Unique Place for Unencroached RDT&E of Weapons and Weapons Related Technology. WD is home to the largest and most diverse test range in the world, with a wide variety of features—mountains, ocean, deep-water ports, protected islands, deserts, canyons, and forests—in close proximity and all highly instrumented. The Land Ranges are larger than the state of Rhode Island, and the Sea Range is the Navy's largest test and evaluation (T&E) facility. The Division has outstanding weather for testing and training and conducts more than 1,800 events each year. WD is a billion dollar per year operation with more than 6,500 employees and 40 major facilities, many of which are not duplicated anywhere else in the world.

Since the 1940s, China Lake and Point Mugu have earned a strong reputation as pioneers in experimentation. WD has contributed to more than 50 major weapon systems, including the Sidewinder missile, Joint Standoff Weapon (JSOW), and Joint Direct Attack Munition (JDAM), and the Division is now working on weapons of the future.

Location. China Lake is located 150 miles northeast of Los Angeles on the western edge of California's Mojave Desert. Point Mugu is located on the Pacific Coast about 65 miles northwest of downtown Los Angeles, near the cities of Camarillo and Oxnard.

Visitors and Guests. Both sites at WD host more than 35,000 official visitors and more than 3,000 foreign military guests each year. More than 8,000 community passes are issued for people to come on base and use our many facilities. [170]

National Center of Excellence. The recent BRAC commission determined that China Lake was once again ranked number one in military value for Naval weapons work. As a result, they recommended that China Lake become one of three Centers of Excellence for Weapons and Armaments research and development activities in the country. The two other weapons centers are the Air Force's Eglin Air Force Base and the Army's Redstone Arsenal.[170]

Ranked Highest in Military Value

2005 BRAC

The 2005 Base Realignment and Closure Commission concluded that the Navy should consolidate their air-to-air, air-to-ground, and surface-launched missile research, development, acquisition, test and evaluation activities into a single site for a more efficient, integrated capability. This recommendation was approved to establish a Naval Integrated Weapons and Armament RDAT&E Center at China Lake which moves designated equipment and personnel from Point Mugu; Port Hueneme; the Naval Weapons Station, Seal Beach, California; the Naval Surface Warfare Center, Crane, Indiana; the Naval Surface Warfare Center, Indian Head, Maryland; Naval Air Warfare Center Aircraft Division, Patuxent River, Maryland; and the Naval Air Warfare Center, Dahlgren, Virginia. [170]

1995 BRAC. During the 1995 BRAC studies, the top three naval technical activities were all NAVAIR sites. Secretary of the Navy John Dalton, on June 14, stated: "…China Lake and Point Mugu [rate] number 1 and 2 in military value among all Navy activities…"

Military value includes physical and community assets and environmental and human resource factors. WD has advanced physical facilities, strong community support, low encroachment, excellent human resources, and broad mission capabilities. For example, 70 Technical Centers across the Navy were asked to carefully document their level of work involvement in 34 specific common support functions. Final results showed that no Center was involved in more than eight functions—except China Lake, which had significant documented work in 23 different functions. Point Mugu was involved in eight.

New Facility

New Fixed Wing Live-Fire Test and Evaluation Center. Following BRAC recommendations, China Lake built this new center that moves live-fire test and evaluation from Wright-Patterson Air Force Base in Ohio to the China Lake Weapons Survivability Complex. The new 22,000 square foot building is planned for completion in 2008. This new lab will be a Joint-Service Test Arena supporting all Air Force and Navy fixed-wing aircraft. [170]

121 Advanced Sensor Laboratory

China Lake has recently completed a new six-story, $18 million dollar Advanced Sensor Integration Facility. This lab will help our scientists and engineers to integrate some of the many complex sensors and systems in our premiere F/A-18 tactical aircraft we use in the Navy. [170]

BRAC—Additional Work Requirements Demand Additional Hiring. To ensure adequate workload staffing, WD recruiters regularly visit more than 25 colleges and universities across the country, and advertise nationally in employment websites and major newspapers, publications, and journals. In addition recruiting specialists regularly attend job fairs, seminars, and conferences nationwide.

Evolution of Modern Weapons.

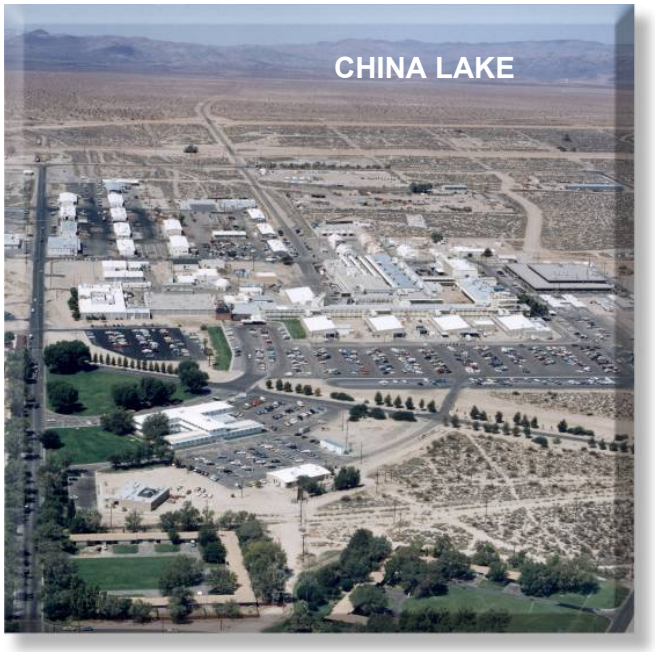
In WWII, China Lake and Point Mugu contributed extensively to several product lines that are still in use and being upgraded today, including aircraft rockets, antisubmarine weapons, guided missiles, and general purpose bombs. During the Korean Conflict, folding-fin aircraft rockets (FFARs), specialized antitank weapons, and fire-control systems were developed. By the end of the Vietnam War, efforts also encompassed laser-guided weapons and other "smart bombs," air-to-air and air-to-surface guided missiles, dispenser munitions, antiradar missiles, fuel-air explosives (FAEs), advanced antiship weapons, ship-launched guided missiles and projectiles, strategic weapons, aircraft guns, and swimmer/SEAL (Sea-Air-Land) weapons.

Later, improvements were made in aircraft electronic warfare, avionics, and software, and by Operation Desert Shield/Storm, China Lake and Point Mugu technology had made a significant impact on nearly every aircraft and weapon system used, including Sidewinder, High-Speed Antiradiation Missile (HARM), Tomahawk, Rockeye, Sparrow, and Harpoon—along with the avionics to integrate and operate the weapons. The Bosnian war made use of the Advanced Medium-Range Air-to-Air Missile (AMRAAM), cluster bomb unit (CBU)-87, and CBU-99. JSOW and JDAM made their debut in Desert Fox. WD contributed significantly to these weapons. In Afghanistan and Operation Iraqi Freedom, U.S. and allied forces have relied heavily on many of these weapons and technologies. And Sidewinder still remains the world's premiere air-to-air missile.

WD Contributed to 50 Major Fleet Weapon Systems.

Through the years, WD and its predecessor organizations developed and contributed to more than 50 major weapon systems and pioneered technologies that support the Fleet today.

HISTORY



China Lake. In the midst of World War II, the Navy established China Lake as the Naval Ordnance Test Station (NOTS) for testing and evaluating rockets being developed by the California Institute of Technology (Caltech). The formal mission statement for NOTS in 1943 identified "research, development and test of weapons" as the Station's primary purpose. This mission remains today. The first weapons included rockets and early missiles such as Mighty Mouse, Zuni, Sidewinder, and Shrike. In the 1950s, NOTS scientists and engineers developed the air intercept missile AIM-9 Sidewinder air-to-air missile, which has become the world's most used and most copied air-to-air missile. In 1967, China Lake combined with the Naval Ordnance Laboratory at Corona to form the newly created Naval Weapons Center (NWC). In 1979, the National Parachute Test Range (NPTR) at El Centro, California, also merged with NWC. In 1992, NWC China Lake joined the NAVAIR units at Point Mugu, California, and White Sands in Albuquerque, New Mexico, to become part of the Naval Air Warfare Center Weapons Division (NAWCWD). Today, WD is headquartered at China Lake and is a tenant of the Navy Region Southwest.

On May 12, 2000, the U.S. Naval Museum of Armament and Technology was officially established at China Lake when the Secretary of the Navy signed the establishing memo, culminating a 10-year effort.

Testimonial – VIP Involvement

"China Lake's notable accomplishments and famous desert culture have created an esprit de corps perhaps unequalled in the Navy's far-flung organization."

—Dr. William S. Dudley
Director of Naval History

US Naval Museum of Armament and Technology

The Museum contains one of the finest publicly accessible collections of tactical air weaponry and technology anywhere.

Point Mugu. The first Navy presence at Point Mugu occurred in 1946 when Seabees from Port Hueneme put down a Marsden Mat runway as the first airstrip. That same year, Point Mugu became the Naval Air Missile Test Center (NAMTC), the U.S. Navy's first instrumented missile-test sea range. NAMTC developed and tested missiles and drones, including the Gorgon, Gargoyle, Lark, and Little Joe. The Pacific Missile Range (PMR), headquartered at Point Mugu, was established in 1958. In 1959, NAMTC became the Naval Missile Center (NMC). Point Mugu, already home to the F-14 Tomcat System Integration Test Station, became host to the Software Support Activity for the Tomcat in 1971. As the As the Harpoon, Tomahawk, Trident, and Standard Missile were under test in 1975, the Navy merged PMR and NMC into the Pacific Missile Test Center (PMTC). In 1992, PMTC, NWC China Lake, and NAVAIR units at White Sands and Albuquerque, New Mexico, combined to form the NAWCWD.

American Institute of Aeronautics and Astronautics (AIAA)**.** For more than 75 years AIAA has been the principal technical society devoted to continuing contributions and global leadership in the aerospace profession. The institute has more than 35,000 members, both professionals and students, and conducts many national technical conferences each year and publishes many textbooks, technical journals, and short courses annually. The AIAA Board of Directors established the historic Aerospace Sites Committee in 1999 to recognize and preserve significant contributions made in both aeronautics and astronautics to culture and technology. Advances and discoveries in the aerospace field have significantly affected the lives of people the world over.

On November 14, 2003, the Naval Base Ventura County at Point Mugu was formally named an American Institute of Aeronautics and Astronautics (AIAA) historic site. Their citation reads as follows:

Award
Point Mugu—AIAA Citation

Established in 1946 to provide a comprehensive test and evaluation site for tactical missiles, Point Mugu has been instrumental in the development, test, evaluation and inservice support of systems including Regulus, Sparrow, Phoenix, Bullpup, Harpoon, SLAM, Tomahawk, Standard, and Rolling Airframe Missile. The first missile launch from an operational submarine was also accomplished at Point Mugu.

The institute designation placed it in the company of 20 other historic spots, including Kitty Hawk, N.C.; Dutch Flats, the San Diego airport where Charles Lindbergh's Spirit of St. Louis was tested; the Air Force Flight Test Center at Edwards Air Force Base, home of legendary test pilots and fledgling astronauts; and the Pasadena plant site where scientists for Aerojet Engineering invented rocket fuel in the 1940s.

AIAA China Lake Historic Aerospace Site

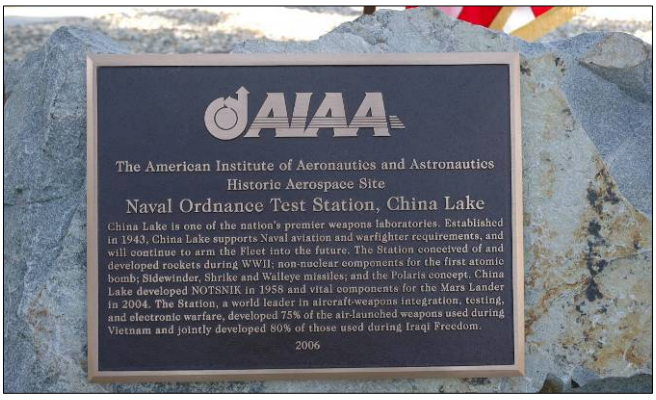
In 2006, China Lake was also chosen an AIAA Historic Aerospace Site, along with the NASA Johnson Space Center, Houston, Texas. The bronze plaque was unveiled by Rear Admiral Walter Skinner at a formal public dedication held at the U.S. Naval Museum of Armament and Technology. The citation reads as follows:

Award
China Lake—AIAA Citation

China Lake is one of the nation's premiere weapons laboratories. Established in 1943, China Lake supports Naval aviation and warfighter requirements, and will continue to arm the Fleet into the future. The Station conceived and developed rockets during WWII; non-nuclear components for the first atomic bomb; Sidewinder, Shrike, and Walleye missiles; and the Polaris concept. China Lake developed NOTSNIK in 1958 and vital components for the Mars Lander in 2004. The Station, a world leader in aircraft-weapons integration, testing, and electronic warfare, developed 75% of the air-launched weapons used during Vietnam and jointly developed 80% of those used during Iraqi Freedom.

Three bronze plaques will be mounted at China Lake—at the museum park, in front of Michelson Laboratory, and at the official Visitor's Center.

As part of the ceremonies, the U.S. Naval Museum of Armament and Technology restored and unveiled two new exhibits including the Mark IV, Fleet version of the "Fat Man," and the Caleb, the follow-on to NOTSNIK, part of China Lake's early satellite program.[171]



Dynamic Work Force. Today, more than 6,500 unique individuals continue the WD tradition. Approximately 4,500 federal employees work side-by-side with more than 2,000 contractors, and military personnel, and 74% of the work force work in RDT&E. WD is an efficient organization. Scientists, engineers, physicists, and mathematicians work on complex issues vital to national defense.

Innovative Management. July 2002 marked the 21st anniversary of the Navy's Joint Personnel Demonstration Project, which supports pay-for-performance rather than longevity. China Lake was one of two sites to test this new approach to management. The Demo project has been scrutinized and was so successful that Congress extended it twice. The Demo now serves as a model for 16 other federal personnel projects.

Testimonials – VIP Involvement

"I think we have some of the answers to that, Mr. Chairman, in the experiments that have already been conducted, thanks to the discretion the Congress has given us in the past. And I think that record shows that at key installations like China Lake where we have, perhaps, one of the best civilian work forces any country could ever have—private sector or government. It's produced some of the most remarkable technological breakthroughs. I think that flexibility in management has improved the capability of that civilian work force—and has allowed us to keep the very best people around."

—Paul Wolfowitz, Deputy Secretary of Defense
From his testimony before the HASC during a hearing on May 1, 2003, on the Defense Department's proposed legislation to revamp the personnel system.

Engineer and Scientist Development Program (ESDP) and Journeyman Hiring. WD recruiters search for science and engineering students from among more than 25 colleges across the country and since 2000 have been successful at hiring more than 400 graduates. Responding to recent BRAC developments and nationwide workload shifts, new work from more than seven bases nationwide is planned to come to WD. In 2008, WD is tasked to hire more than 800 graduates in high tech fields. In addition WD is tasked with hiring many journeymen with specialized skills needed in critical technology areas.[170]

Enormous Ranges. WD's land, sea, and airspace are unique natural assets and are used for training and T&E. WD encompasses more than 1.1 million acres. The Land Range at China Lake is the Navy's largest single land holding with 38% of all Navy land worldwide and 85% of the Navy's RDT&E land. The R-2508 restricted airspace, 12% of California's total airspace, includes more than 17,000 square miles over land. The Sea Range at Point Mugu includes 36,000 square miles of ocean (expandable to 196,000 square miles, from Big Sur south to the U.S./Mexico border). The R-2508 is jointly managed by the Navy (China Lake), the Air Force (Edwards Air Force Base), and the Army (Fort Irwin). The Ranges are interconnected. For example, a unique FAA-approved restricted corridor (IR-200) connects the Sea Range with the Land Range to the north. This allows the launch of long-range Tomahawk cruise missiles from the Sea Range to targets on the Land Range, thereby allowing the Navy

to test all operational aspects of the weapon system. Missiles are continuously monitored and tracked. They contain inert warheads, and chase planes can take control at any time.

Facilities and Laboratories. WD has more than 40 major facilities, including three airfields, with a replacement value of close to $3 billion. More than 2,000 buildings encompass six million square feet. Many facilities are not duplicated anywhere else.

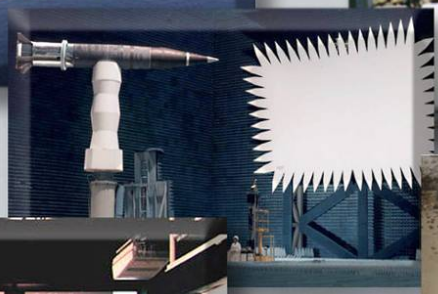
The Sea Range off the coast of Point Mugu is the largest and most heavily instrumented sea and air range in the U.S. The Range Operations Center is capable of hosting and monitoring complex full battle group Fleet exercises involving aircraft, surface ships, and

submarines. San Nicolas Island (SNI), 60 miles offshore, is used for littoral warfare training, including theater warfare exercises. SNI includes launching facilities and a 10,000-foot runway. At Point Mugu the Radar Reflectivity Laboratory (RRL) is the Navy's largest indoor radar reflectivity chamber, designated as a national asset. For more than 35 years, the RRL has helped determine what a target looks like to radar. The F-14 Weapons System Integration Laboratory supports software and avionics integration for the F-14A Tomcat aircraft and Phoenix missile systems. The Missile Systems Evaluation Laboratory is a $45-million facility with 123,000 square feet of special-purpose laboratories. This targets complex is the only facility to provide full life-cycle support for all Navy aerial and surface targets. The Surface Craft Division at Port Hueneme operates target boats and hulks and provides range surveillance and target recovery. Point Mugu's electronic warfare (EW) capability is a core area of expertise and supports the electronic attack EA-6B, the stand-off jammer aircraft for the Navy and the Air Force. It is the only dedicated tactical EW platform in the U.S. inventory.

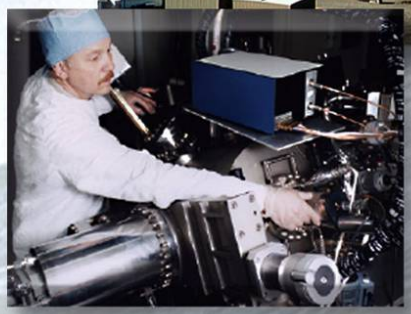
At China Lake, the fighter/attack F/A-18 Advanced Weapons Laboratory (AWL) and the AV-8B AWL rank in the top of the world's software developers. The Propulsion Laboratory is the Navy's one-stop shop for R&D of missile propulsion, ordnance, and fuzing. The Integrated Battlespace Arena (IBAR) includes nine modeling and simulation (M&S) laboratories, with secure links worldwide. The Missile Engagement Simulation Arena (MESA) hangs full-size jets like puppets, weighing up to 25,000 pounds, when testing missile fuzes. It is the only facility of its kind. The Skytop facility tests Trident and other massive rocket motors with up to one million pounds of thrust as well as rocket motors that produce only ounces of thrust. The Electronic Combat Range (ECR) realistically simulates combat threats. China Lake's Geothermal Plant turns a natural asset, volcanic steam, into usable electricity that helps power the base. And the Etcheron Valley Range, with mountains high in iron content, provides a perfect veil for testing high-powered GPS jamming; the Supersonic Naval Ordnance Research Track (SNORT) is a four-mile-long, dual-rail track, capable of propelling test items up to four times the speed of sound; and the new Live Fire Survivability Complex is the largest facility of its kind in the country.

Laboratories & Facilities








Aircrew Safety and Survivability. Since the 1950s, aircrew safety and survivability have been central to the technical mission of the National Parachute Test Range (NPTR) that was relocated to China Lake in 1979. It was here that the rocket-assisted personal ejection catapult (RAPEC) was designed, developed, tested, and released. RAPEC and subsequent systems have saved the lives of hundreds of aircrew members.

Systems such as the Navy Aircrew Common Ejection Seat (NACES) and China Lake developed and produced Thin-Pack Parachute (now deployed in Fleet patrol (P-3 Orion aircraft) are of incalculable value in increasing the survivability of military aircrew members. Related efforts conducted at state-of-the-art survivability facilities have led to major improvements in the ability of U.S. aircraft to survive the harsh environment of air combat and bring their crews safely home.

Following the *Challenger* disaster in 1986, China Lake worked with NASA in the evaluation of an emergency escape system for the Space Shuttle. Military test parachutists tested the system from a specially modified Convair-240 aircraft. Scientists and engineers assisted NASA's Pathfinder team by testing the rocket-assisted deceleration (RAD) system as well as designing and fabricating the actual tether system between the RAD and the landing package that was used in the successful Pathfinder landing on Mars in 1997.

During the Mars Exploration Rover (MER) mission in 2004, China Lake designed, built, and assisted in installing the bridle system onto both spacecraft; designed the descent rate limiters (joint effort with JPL); tested the radar systems that were used in timing airbag deployment and retro-rocket ignition; tested the retro-rockets that slowed both landers descent; and conducted multi-body tests involving the parachutes, backshells, and landers.

Avionics. Avionics integrate a weapon-delivery platform—the aircraft—with its weapons and sensors. From development of the FLIR system, which produced the first-ever 24-hour attack capability, to today's cutting-edge avionics on the F/A-18E/F Super Hornet, WD has played a central role in making avionics one of the chief reasons for U.S. supremacy over its adversaries.

Complex Weapon System Integration. Key aircraft platforms in the current war include the F/A-18, EA-6B, and AV-8B. WD has Weapon System Support Facilities for F/A-18, EA-6B, AV-8B, and the AH-1 helicopter. In 2007, VX-31 took delivery of the first EF-18G test-bed aircraft. WD also integrates the mission avionics for the special missions EP-3E, supports development of the Joint Strike Fighter (JSF), and supports the Air Force F-22 in Sidewinder weapons integration. WD supports the system design and development phase of the JSF and staff provides systems and software engineering and integration, primarily in the mission systems (avionics) and weapons integrations areas. WD also performs JSF live fire testing, integrated test force, verification, and survivability activities.

WD has been a world leader in integrating highly complex weapon systems, including the avionics and EW equipment, into naval aircraft. As an example, the F/A-18, the Navy's strike fighter, forms the core of the Navy's air warfare capability. F/A-18s use numerous mission computers with more than 10,000,000 words of code in more than 40 processors. The F/A18-E/F Super Hornet now has 11 weapon stations and increases weapons carriage, fuel load and range, growth space, and survivability.

The Advanced Weapons Laboratory (AWL) at China Lake is responsible for integrating the weapons, avionics, sensors, EW systems, FLIR, software, and radars into the F/A-18. This laboratory reached the Software Engineering Institute's (SEI) Level 4. This prestigious rating puts AWL in the top 9% of the world's software developers. Weapons integrated include free-fall bombs (Mk 80 series), foreign and domestic short-range missiles (ASRAAM, Python, AIM-9 series to include AIM-9X), AMRAAM, Sparrow, JSOW, JDAM, SLAM-ER, Maverick (EO and IR), HARM (to include Block 3A/5/6 and the QuickBolt and AARGM series), and the M-60 gun.

In September 2002 the AV-8B Joint System Support Activity (JSSA) achieved the SEI Software Capability Maturity Model (SW-CMM) Level 4 – top 9% of all organizations assessed. In 2004 the P-3C software support activity achieved SEI Level 4, and the EA-6B IPT achieved Level 3 certification.

The SEI at Carnegie Mellon University has carefully scrutinized the advanced software practices of more than 1,100 private and government agencies, including Boeing, Raytheon, and Warner Robbins AFB. In an exhaustive process involving more than 4,300 pages of documentation, more than 30 in-depth interviews and five days of on-site assessment, companies are ranked in several areas of technical expertise, including software product engineering, quantitative control processes, software quality processes, and organizational process focus and definition.

Weapon Platform Integration

Electronic Warfare. The EA-6B Systems Integration Facility is the only existing Airborne Electronic Attack (AEA) facility of its kind. Point Mugu has been the center of AEA research, design, and test since 1968.

Point Mugu has eight specialized laboratories. The Prowler's radar and communications-jamming capabilities continue to lead the way in neutralizing enemy air-defense systems in the early days of battle, allowing U.S. fighters free use of the skies. Since 1990, most strike groups insist on the protection of an AEA umbrella. The EA-6B provides cover for the entire strike group, allowing offensive craft to penetrate safely within lethal range of ground missiles and radar. Also at Point Mugu is the Radar Reflectivity Laboratory, the Navy's largest indoor radar reflectivity chamber. Engineers develop, test, and integrate radar warning systems, jammers, decoys, and software. In addition, WD designs, fabricates, and tests the aerodynamic, mechanical, electrical, and structural interfaces.

Award

In October 2006, Point Mugu received a Congressional Record Acknowledgement from the Honorable Elton Gallegly in tribute to the Electronic Warfare Center of Excellence, and its past and current contributions to our national defense. [172]

EA-18G Replaces EA-6B

In 2007, VX-31 took delivery of China Lake's first EF-18G test bed. The multimission aircraft with electronic attack capability will replace the EA-6B Prowler and will be the cornerstone of the Naval airborne electronic attack mission. With Advanced Electronically Scanned Array (AESA) radar, the Growler will have self-protection capabilities and be effective for target identification and prosecution. The multi-mission Growler will counter enemy defenses using both reactive and pre-emptive jamming techniques. In 2007 the aircraft completed a successful Low Rate Initial Production (LRIP) milestone. This new version of the F/A-18 Super Hornet is planned to enter the Fleet inventory in 2009. [170] [172]

EW facilities at China Lake include the ECR, the Navy's principal open-air range for T&E of airborne electronic combat. In realistic training just short of actual combat, pilots can fly against simulated air-to-air threats, and surface-to-air threats and complete an air-to-ground strike all in a single mission. The Etcheron Valley Range provides a perfect venue for testing directed energy weapons technology and GPS packages in jamming environments without disturbing commercial or military aircraft.

Energetic Materials. NAVAIR maintains a full-spectrum energetics RDT&E capability to support the development and acquisition of Navy weapon systems. NAVAIR attracts top-ranked people and maintains a world-class energetics capability while partnering with industry and academia. Examples of recent technology include CL-20, a molecule that enables the world's most powerful explosive currently available, and hypersonic propulsion systems for weapons that will exceed Mach 4. The NAVAIR energetics business base includes Navy air- and surface-launched weapons and other service and Defense Agency programs. Energetics constitutes over $100 million and 800+ workyears at NAVAIR WD annually including basic research in combustion sciences, firefighting technology, insensitive munitions, energetic materials, ordnance, and propulsion. Explosives RDT&E has included developing explosives, warheads, shaped charges, and castable explosives; ordnance safety; ordnance-pollution abatement; and characterization of metals under explosive loading. China Lake was the first to develop plastic bonded explosives (PBX).

Propellant RDT&E began with a concentration on double-base propellants and expanded into work on liquid, smokeless, and alternative solid propellants; combustion instability; manufacturing and storage applications; material and system safety; and liquid, solid, ramjet, and hybrid propulsion systems. China Lake propellant work has also found application in space programs, weather modification, and ejection systems. China Lake was the first to synthesize the CL-20 energetic molecule, one of the most significant energetic ingredients in the past 50 years.

Thrust-vector-control technology developments have provided the foundations for numerous weapon applications, including vertically launched weapons, and highly maneuverable air intercept weapons. China Lake also refined and developed advanced processes and technologies for explosive forming and welding of metals that revolutionized the industry.

Full-Spectrum Fleet Support. WD is intimately involved with a product from cradle to grave—from concept formulation through research, development, manufacturing support, Fleet support, weapon retirement from service; and environmentally compatible system demilitarization.

Fuzing. Advances in fuzing technology at China Lake and its predecessor organization at Corona, California, provided the Navy with a world-class design capability in target-detecting devices (TDDs), contact sensors, electro-mechanical safety and arming (S-A) devices, and fuze antennas, with hundreds of designs and components in Fleet use. Highly advanced fuze documentation is in widespread use by many North Atlantic Treaty Organization (NATO) countries. Guided-missile warhead fuzes cause the weapon to detonate at the point where the explosion will do the most damage. Fuzes are critical to weapon success.

Fuzes—Key Elements of War. Since post-WWII, when the U.S. Joint Chiefs of Staff listed the atomic bomb, radar, and the proximity fuze as the three most significant developments of the war, China Lake has been developing fuzes and components.

Concerning safety and arming (S-A) devices, China Lake has nearly three quarter of a million devices in the Fleet with an outstanding safety record. S-A devices are in use in all Navy guided missiles. Development began in 1953 and continues today. China Lake developed a universal arming and firing device to remotely safe and arm rocket motor ignition devices. S-A devices ensure safety in missile handling, shipping, storage, and launch. The S-A device is a fuze component that isolates the detonator from the warhead booster charge until the launched weapon has achieved a safe distance.

Award
Presidential Citation

On December 16, 1964, President Lyndon Johnson presented a citation to a team of China Lake/ Corona engineers for greatly improving the efficiency/ economy of S-A devices by improving operation and reliability and reducing their weight, size, and cost. The new S-A was adapted to almost all Navy missiles.

Cost Savings – Best Business Practices
Costs savings for the first procurement exceeded 20 million dollars, and the cost savings since then has far exceeded one billion dollars.

Continuous-slot antennas optimize warhead burst time while also improving countermeasures. The Mk 45 TDD for Standard Missile, an example of this expertise, is considered by many to be the world's premier missile fuze.

Free-fall weapon fuzing work includes the fuze munitions unit (FMU)-140/Bdispenser proximity fuze, the DSU-30/B TDD and the FMU-139/B electronic bomb fuze, which increased the reliability of bomb fuzes up to 97% versus 75%. Between 1980 and 1990 more than one million of these fuzes were delivered.[8] In 2005, WD began working on a spiral development that will result in extended operational time, expanded arm/delay time options, improved weapon interface, as well as a significant increase in reliability. The FMU-139C/B is the first phase of this progression and two contracts are in place. The next phase, FMU-139X/B will be an in-line fuze with 1760 data interface that will increase reliability from 95% to 98% while increasing the suite of arm and delay times. The first contracts were in 2006. [172]

Edge-detection was developed in the mid-1960s and is now used in most Navy anti-air missiles. Edge detection increases the probability of detonating the warhead while the target is within its lethal range, in contrast to a simple timed detonation.

Fore-and-aft adaptive-logic was developed at China Lake and used in long-range missiles. This extension of edge detection uses two beams instead of one. As the missile approaches a target, it size changes from a dot to an extended shape, and the two beams help determine the target size and the optimum time to detonate the warhead.

Pseudorandom-noise modulation was applied to TDD designs to take advantage of spread spectrum techniques in which the transmitted signal is spread over a wide frequency band, providing a lower-density signal than conventional signals. For fuzing applications, it makes the signal difficult to detect, while providing a high-resolution target-detection capability.

Active-optical fuzing, is now used in TDDs for anti-air and anti-surface missiles. TDDs use an active source, usually a laser, to detect the target. The active optical TDD provides high-range resolution information and narrow-beam control, improving the ability to place the warhead fragments on the target. During Vietnam, a crash program was begun in 1968 to develop an active optical TDD; China Lake produced the DSU-10/B in eight months.

Laser and Optical Components. China Lake developed component polishing and coating techniques, optics evaluation and instrumentation, surface-absorption measurement, and surface-damage characterization. Accomplishments in laser research range from early development of a night search-and-rescue system that grew out of dye-laser research to the development of the diode laser. Developments also include the interferometric surface scanner; bowl-feed polishing, ultra-high-vacuum deposition, and ultra-clean sputter-deposition optical-film-production techniques; and a portable CO_2 laser.

Modeling and Simulation (M&S)

WD's earliest use of M&S was in the creation of analog and digital simulations for weapon systems. Weapon System Support Activity (WSSA) laboratories integrate advanced weapons and components into a total weapon system onboard naval aircraft platforms. M&S plays a major role in this integration process allowing continuous design assessment throughout the process. In the past, live fire testing had been exclusively used to evaluate how a missile system functions. WD pioneered simulation based acquisition (SBA).

Cost Savings – Best Business Practices

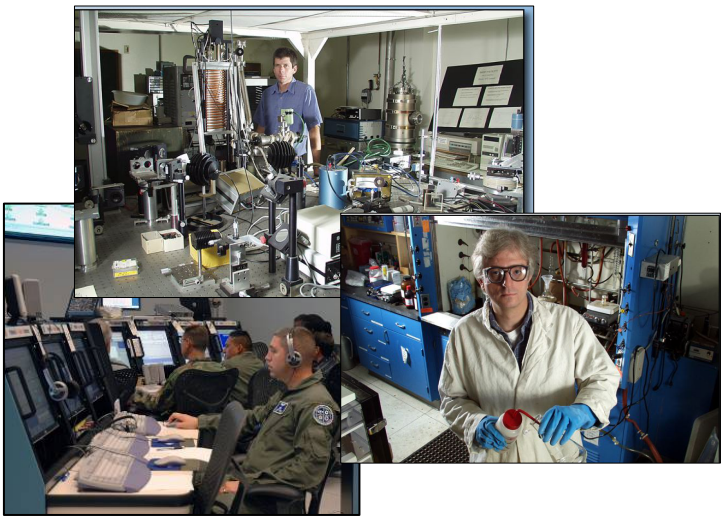
The use of M&S during development has saved tens of millions of dollars over the years. Using hardware-in-the-loop (HWIL), WD integrates part of the missile hardware, such as the seeker or control section, into the simulation, running in real time. Part of the missile functions in the laboratory as though it were in actual flight. During the 1970s and 1980s, HWIL reduced the number of live firings required to field Sidewinder, Sparrow, and RAM. In the 1960s the AIM-9D required 129 live firings to prove out its performance. By 1981 the AIM-9M required only 35 live firings. Total acquisition risk was also significantly reduced because extensive use of HWIL simulations solved design problems early in the developmental cycle when they could be fixed at a much lower cost with less schedule impact.

During the 1990s WD developed signal-processor-in-the-loop (SPIL) advanced simulations made possible by high performance computers and custom digital processors. SPIL creates very complex target scenes, including a detailed model of the seeker front end, and then injects the seeker sensor output directly into the real missile signal processing hardware. SPIL significantly contributed to the Sidewinder, Sparrow, RAM, and SLAM programs. Simulations also allow engineers to better understand threat missile systems, particularly the man portable air defense systems (MANPADS), against our own aircraft.

Today, WD uses advanced simulation technology to link geographically separated facilities such as the Integrated Battlespace Arena (IBAR), global positioning system (GPS) Laboratory, and F/A-18 Advanced Weapons Laboratory (AWL) at China Lake; the Interoperability Test and Evaluation Complex (ITEC) at Point Mugu; and the Air Combat Environment Test and Evaluation Facility (ACETEF) at Patuxent River into a total "virtual" battlespace.

Research, Science and Technology

The Weapons Division maintains a strong research, science and technology base and these efforts are at the forefront of new weapons and systems development. Extensive research is conducted annually in a wide range of topics including combustion sciences, firefighting, insensitive munitions, energetic materials, ordnance and propulsion, and laser and optical components. WD often partners with other national and international government research agencies such as the Defense Advanced Research Projects Agency (DARPA), the Office of Naval Research (ONR), the National Aeronautics and Space Administration (NASA), and the North Atlantic Treaty Organization (NATO). WD also partners with private industry in joint research projects, many are described in the technology transfer sections and other places throughout this book.



Test, Evaluation and Training. Each year WD conducts more than 1,800 test events, hundreds of major training events, and about 3,000 training sorties. WD evaluates weapons, components, and systems in realistic environments; conducts full-scale, joint-live-fire survivability testing; and tests guns and ammunition, explosives, and propellants. WD can safely detonate up to 500,000-pounds of explosives without public complaints. Other testing activities include GPS jamming, high power microwave, and fire-fighting agents and devices. WD maintains the world's largest collection of "shootable" anti-radiation missile targets for test activities. WD conducts extensive modeling and simulation in numerous specialized facilities; and China Lake served as the National Parachute Test Range (NPTR) from 1979 until 2005.

Clear Weather for Testing. Both the Point Mugu Sea Range and China Lake Land Range airfields consistently enjoy great flying weather. Point Mugu is VMC (visual meteorological conditions) 85% of the time and China Lake is VMC 99.5% of the time—in other words, more than 360 clear days per year. Even Palm Springs, California, cannot match WD's meteorological statistics.

Training the Fleet. WD also helps train the Fleet—from simple to complex. WD can support anything from one aircraft on one target to complex battlespace scenarios involving multiple sites and multiple players. Fleet Training Exercises, and Fleet Battle Experiments, FBEs, are becoming increasingly complex, and WD is becoming more involved. Each year, the Division conducts complex "what if" battle group scenarios to see how well all the weapons systems play out in real time. The goal is to see what works and what doesn't. In 2002, WD completed the Millennium Challenge, named FBE-Juliet. The Sea and Land Ranges were the site of live action by joint forces. Efforts were orchestrated from the Interoperability Test and Experimentation Center at Point Mugu, and the Integrated Battlespace Arena at China Lake.

Each year, allied customers from many nations send hundreds of troops to train for conflict and test weapons on WD's ranges. Allies include Australia, Canada, Great Britain, Switzerland, Italy, and Norway. The Japanese are one of WD's largest customers on the Sea Range.

At Superior Valley, WD has tactical targets and automatic weapon scoring systems where WD trains pilots, including F/A-18 squadrons from Lemoore. WD also conducts search-and-rescue training and helicopter mobile assault training. And on the Electronic Combat Range, pilots can fly against actual threat radar systems. They can fly HARM missions, practice tactics, and use countermeasures.

Warheads Design. Since the 1950s, China Lake has served as the warhead design agent for most Navy missiles and free-fall weapons, providing quick response production. Examples include **Anti-surface weapons:** Harpoon, Tomahawk, Penguin, Maverick, Condor Shrike, HARM, Standard Antiradiation Missile (ARM), SLAM-ER, Air Launched Tacit Rainbow, Ground Launched Tacit Rainbow, and Zuni 5.0-Inch Rocket. **Free Fall Weapons:** Bombs, Skipper, Walleye, Rockeye, APAM, Fuel Air Explosive (FAE), and FAE II. **Anti-Air Weapons:** Rolling Airframe Missile (RAM), Sparrow, Sidewinder, and AMRAAM.

Weapons Development. WD expertise has been applied in the majority of the U.S. family of air-, surface-, and sub-surface-launched weapons. The current family includes AMRAAM, JDAM, JSOW, Sidewinder, HARM, Trident, Tomahawk, RAM, Standoff Land-Attack Missile–Expanded Response (SLAM-ER), and ESSM. Through the years, WD has played every role in weapon development. Currently WD is working directly or indirectly on 25 different weapons and weapons systems for the Fleet. WD is the primary technical lead for 15 systems, and we provide other engineering or T&E support to dozens of other weapons, projects, and programs.

Weapons Development. Pioneered Technologies That Influence Today's Military Arsenal.

- Precision guidance in IR–Sidewinder missile. Invented and developed the Sidewinder missile.
- Antiradar (passive RF) guidance– Shrike, HARM, AARGM. China Lake developed Shrike, which begat HARM. Developed the HARM low-cost seeker.
- TV guidance. China Lake developed Walleye, the archetype of all modern TV-guided weapons.
- Technologies for proximity fuzing, warheads, solid rocket propulsion, and thrust vector control (TVC).
- TVC is currently used on SeaSparrow, Tomahawk, VLA, AIM-9X Sidewinder, and Standard Missile.
- A systems approach to weapon integration on naval platforms versus integrating weapons as an "afterthought."

NAVAIR AIRSPEED. COST SAVINGS AND BEST BUSINESS PRACTICES

The AIRSpeed program began in 2004 to reduce the cost of doing business, improve productivity, and increase customer satisfaction using Lean and Six Sigma methodologies, and position for Fleet recapitalization. Also known as Continuous Process Improvement (CPI), the program consists of completing projects by a variety of trained individuals from full-time improvement experts (Black Belts) to part-time improvement experts (Green Belts) to the general workforce/team members (Yellow Belts) and project sponsors. The National program has trained approximately 200 Black Belts, 1500 Green Belts and thousands of Yellow Belts who are now working throughout the entire NAVAIR organization. CPI is everyone's responsibility.

As of February 2008, $81M in NAVAIR benefits have been identified. [200] The pilot test of AIRSpeed, hosted by the Business/Financial Management Competency, reduced processing time for funding documents from four weeks, to four days!

Our leaders as well as our front line employees have all engaged in AIRSpeed projects. VADM Wally Massenburg, a trained Green Belt, former NAVAIR Commander, has saved more than $476,000 by developing a rigorous tracking system for depot-level repairable parts at North Island, California.

At WD, Rear Admiral Mark Skinner, former WD Commander and AIRSpeed champion, identified an accounting structure problem causing approval delays up to six months. His team worked the Lean Six Sigma Define-Measure-Analyze-Improve-Control methodology, and cut the approval time in half.

One Kaizen project led by the employees in the Radio Frequency Branch, resulted in $106,000 savings. A labor adjustment process within the competency achieved a 66% reduction in defects with a savings of more that $200,000. A contract closeout project saved $81,000 with a potential future savings of $170,000. A billing process project improved morale and increased efficiencies, and another project hopes to save 1.5M annually in equipment inventory. These are just a few representative examples of NAVAIR AIRSpeed efforts where teams of individuals successfully used the methods of Lean and Six Sigma.

In 2007, Vice Admiral David J. Venlet, Commander, presented the Commander's National Award to five outstanding teams across NAVAIR: 1. Acquisition: simplified acquisition procedures saving $4.5M over 5 years; 2. Logistics/Industrial: reduced work-order costs by 50% and saved more than $1M; 3. Program Management: restructured and revitalized every aspect of its acquisition program; 4. Quality of Service: AIRSpeed deployment NAVAIR-wide; and 5. RDT&E: reduced aircraft risk – Airwake Analysis. WD contributed many members and leaders to these teams. [201]

Smart Buyer. To be most effective, the "smart buyer" function requires active, hands-on involvement by laboratory personnel. For example, to prosecute the war on terrorism, U.S. warfighters needed a hard-target penetrating warhead. The contractor for the BLU-116A/B changed its initial proposal, offering to produce only 250 (rather than the original 420) for $29 million. The Defense Threat Reduction Agency turned to China Lake, which ended up with a $25 million contract to redesign and produce a minimum of 370 of the warheads. And when the contractor-designed FMU-159A/B hard-target smart fuze (HTSF) for the BLU-116 could not be produced with the desired reliability under a tight delivery schedule, China Lake was asked to solve the problem with an alternate fuze—a modified FMU-143—that was qualified for use in the new warhead.

Again, when the Harpoon antiship missile twice failed OPEVAL in 1976, China Lake was tasked to correct the problems. Civil-service engineers conducted a thorough review of production processes and then put together a comprehensive support plan involving integrated factory testing, product assurance upgrades, package validation, physical audits, and construction of a factory-equivalent test facility. The payoff began to show in the following year. Costs dropped, factory acceptance yields climbed, and the maintenance due date was extended from two to three years. There was not a single free-flight failure of a Harpoon seeker built after the corrective actions.

Testimonials – VIP Involvement

"China Lake is a jewel in our crown. We have depended on it to help in leading us into second sourcing. It shows the value of keeping a good base of development going outside of industry and inside of the services."

—Hon. John Lehman Secretary of the Navy
Before the House Armed Service Committee,
March 5, 1986

In 1971 when severe quality problems were plaguing the AIM-7F Sparrow missile, China Lake found a solution. In-house engineers took custody of the baseline documentation from the single Sparrow contractor and set up an in-house missile subassembly test capability. They invoked stringent production-assurance processes and began opening competition to a second source. The baseline for both contractors was rigidly controlled with configuration audits and technical and documentation reviews. The result was that a program out of control in terms of cost and quality was, over a period of three years, brought back into line. Mean time between failures soared, and over the next 10 years, the cost for the guidance-and-control section dropped from $300 thousand per unit to less than $100 thousand. [10]

DEVELOPMENTAL AND OPERATIONAL TEST AND EVALUATION

Developmental Test and Evaluation

Air Test and Evaluation Squadrons (VX-30) at Point Mugu and (VX-31) at China Lake operate under the command of the Naval Test Wing Pacific who reports to the Commander, Naval Air Warfare Center, Weapons Division. Both squadrons perform aircraft and weapons developmental testing (DT) and provide aircraft, aviators, and aircrew to support the RDT&E mission on NAVAIR's Sea and Land Test Ranges on the West Coast. They fly the F/A-18 Hornet, FA-18G Growler, AV-8B Harrier, attack helicopter AH-1 Cobra, and the UH-1 Huey in support of weapon systems integration and sustainment. They also fly the P-3 Orion, C-130 Hercules, and the T-39 Saberliner in support of "systems under test" on NAVAIR's test ranges. In addition, they fly the SA-227 Metroliner in support of the NAWCWD inter-site shuttle mission and HH-1 and SH-60 helicopters providing the sole search and rescue (SAR) mission in the R-2508 complex. Squadron pilots log more than 7,800 hours of testing and training missions annually. [173] [174]

Operational Test and Evaluation

Air Test and Evaluation Squadron Nine (VX-9) conducts operational test and evaluation of all air-to-ground weapons, air-to-air weapons, sensors, electronic warfare systems and mission software upgrades to aircraft and weapon systems. More than 350 VX-9 Vampires maintain and fly a diverse fleet of approximately 20 aircraft used in the demanding and dynamic role of operational flight test, supporting both the Navy and Marine Corps tactical aviation. VX-9 currently operates and tests the FA-18E/F Super Hornet, FA-18C/D Hornet, AV-8B Harrier, EA-18G Growler, as well as the AH-1W/Z Cobra and UH-1Y helicopters. The squadron is headquartered at China Lake. VX-5 moved to China Lake from Moffet Field in 1956, and merged with VX-4 from Point Mugu to become VX-9 in 1995 under the Commander, Operational Test and Evaluation Force (COMOPTEVFOR)." [175]

Marine Aviation Detachment (MAD) provides project management, aviation support, and technical expertise for assigned Marine Corps weapons systems, subsystems, and mission planning at both China Lake and Point Mugu. Marines assigned to the MAD support multiple RDT&E missions, to include VX-31, and operational test and evaluation at VX-9. The MAD is headquartered at China Lake and was established in 1988, but Marines have been stationed at China Lake since 1943. The MAD operates under the command of the Aviation Department, Headquarters, Marine Corps. [176]

MAJOR ACHIEVEMENTS BY CONFLICT
QUICK-RESPONSE EXAMPLES

Operation Iraqi Freedom. WD serves the needs of our warfighters in quick-response fashion everyday in some way. This book attempts to capture the most significant accomplishments. Below is a quick summary of a few of the topics. For detailed information on each topic, please see the next section entitled "Operation Iraqi Freedom (OIF) Direct Warfighter Support and Quick Response Achievement."

A few notable quick-response topics include: CH-53E, Cobra Dos, Collateral Damage Bomb (LCDB), Electronic Warfare Database Support (EWDS), GBU-24E/B Laser Guided Bomb, Improvised Explosive Devices (IED) countermeasures, Intrepid Tiger Pod, Jammer Technique Optimization (JATO), JDAM, MANPADS, MH-60R, Precision Strike Suite for Special Operations Forces (PSS-SOF), P-3C direct search capability, RAIDER, Shared Reconnaissance Pod (SHARP), and TOPSCENE.

Battle of Fallujah

For example three quick-response WD programs including the Tactical Dissemination Module (TDM), the Digital Precision Strike Suite (DPSS), and the GBU-38 were all critical in helping warfighters win the Battle of Fallujah. And the Warfighter Response Center is manned around the clock, providing engineering and logistics support to our warfighters in the field.

Baghdad International Airport

During OIF, as coalition forces captured Baghdad International Airport, the Forward Dissemination Element (FDE) was immediately relocated there for the duration of the conflict. TDM supplied more than 900 target packages to coalition bombers and is still forward-deployed. TDM was installed on six U.S. Navy ships in FY04.

Operation Enduring Freedom (OEF). JDAM and JSOW refinements and upgrades were accelerated as F-14B OFPs, F/A-18 software block upgrades, and new electronic warfare (EW) suites. In addition, range testing and training activities were accelerated, involving the Tomahawk, Hellfire, AMRAAM, JSOW, and Harpoon. Point Mugu provided round-the-clock support with the EA-6B Prowler Program. China Lake also invented and developed the Tactical Dissemination Module (TDM), a revolutionary new portable computer/radio system that creates customized real-time-targeting strike packages for specific aircraft. For example, a special operations force identifies a time-critical target. Next, they digitally photograph the target, determine the approximate global positioning system (GPS) coordinates, and then transmit the data back to Central Command (CENTCOM), who decides which weapon is currently available (target weapon pairing), in order to make the call for fire (CFF). TDM received a deployment order in 2002 and has supported OIF ever since.

Kosovo. In Kosovo, China Lake and Point Mugu influenced HARM, JDAM, JSOW, and Tomahawk weapons. Navy, Air Force, and allied aircraft fired more than 1,000 HARMs during the air campaign in Kosovo. A HARM Tiger Team from WD deployed to Italy to support forward-deployed forces. The team reloaded up-to-date missile software in more than 400 missiles in 36 days. HARM subject matter experts provided on-site training and technical support. When additional mission scenario data was needed, to allow HARM to attack new threats, WD accelerated development and deployed it to the Kosovo Theater in less than four weeks.

Desert Fox. A rapid response was provided to deployed forces onboard *USS Nimitz* in the Persian Gulf. The response provided military technicians with new maintenance tools designed and built by F/A-18 Facilities Task Team personnel. In addition, Carrier Air Groups (CAGs) deployed in support of Operation Desert Fox urgently requested some of the first-production JSOW air-to-ground missile (AGM)-154A assets in support of operations. WD studied the feasibility, identified software incompatibilities, prescribed a fix, and conducted testing in the F/A-18 AWL at China Lake. WD quick-response team was formed and traveled to McAlester Army Ammunition Plant, Oklahoma, and reprogrammed JSOWs with software compatible with the deployed system.

Desert Storm/Desert Shield. During Desert Shield and Desert Storm, China Lake re-invented the FAE weapon to help clear minefields for the Marines. China Lake and Point Mugu responded with quick-reaction, on-demand requests to support operating forces and troops in the Persian Gulf. Engineers modified, improved, tested, and validated various aspects of the Sidewinder, Tomahawk, FAE, HARM, and Shrike weapon systems. Point Mugu also developed EW system upgrades, developed and hand-delivered OFP upgrades, and developed and fielded weapon-integration and weapon-targeting software for combat aircraft.

Vietnam Conflict. The Center conceived and developed the Sidewinder missile, the world's most accurate, reliable, and successful dogfight missile, along with Walleye, Shrike, FAE weapons, FFARs, forward-looking infrared (FLIR) technology, and the "Eye" series of free-fall weapons.

During the Vietnam Conflict, an immediate need arose for a specialized TDD for the Standard ARM (anti-radiation missile). In only eight months, China Lake/Corona developed and fielded a new active-optical TDD, the DSU-10/B. In addition, through the Vietnam Laboratory Assistance Program (VLAP), China Lake provided scientific/technical advisors to the Fleet and the Marines tasks were of a quick-response nature: quick fixes, typically inexpensive, to emergent problems. Some 50 tasks were addressed by China Lake personnel. Included were a small beacon for use by ground troops in identifying themselves to A-6 attack aircraft (1968), map illuminators (1969), hand-emplaced FAE canisters for mine clearance (1970), and a lightweight gun pod for the Marines. China Lake also

provided direct support to the Special Forces community with custom explosives and devices, night-vision signals and devices, and specialized weapons and grenades, communications gear, and unique support equipment.

Cuban Missile Crisis. In 1962 the Soviets had set up medium-range nuclear missiles in Cuba with complicated arrays of radar defending missile sites. The U.S. had no antiradar missile, but Shrike was under development at China Lake. An urgent message was received to provide Shrike missiles at once, even though the development program was not completed. Two hundred missiles were built, about half produced in-house at China Lake.

Korean War. During the Korean War an urgent request came from the field for a weapon to defeat 13-inch tank armor. Within 29 days China Lake produced and developed a shaped-charge warhead to match with the five-inch high-velocity aircraft rocket (HVAR) motor and produced RAM, a 6.5-inch Antitank Aircraft Rocket (ATAR). The Michelson Laboratory hall was turned into a crash production facility for RAM fuzes. RAM was designed, tested, documented, and produced at China Lake, and put in service in Korea.

WWII. In WWII China Lake, working as part of a Cal-Tech team, was known as "Rocket-Town" and engineers created an entire family of highly effective rockets on a quick-response basis. For example, "Holy Moses" was one of the most effective and widely used U.S. rockets of war. In addition, China Lake developed, tested, and trained pilots and crews to fire the aircraft rockets and bombardment rockets that affected the outcome of the war.


Iraqi Freedom
2004
Desert Shield/
Storm
1991
Enduring Freedom
2001
Vietnam
1956-1975
Kosovo
1999
Arming The Fleet
Korea
1950-1953
Desert
Fox
1998
WWII
Bosnia
1992-1995
1941-1945


CAPTURED

OPERATION IRAQI FREEDOM (OIF)

DIRECT WARFIGHTER SUPPORT AND QUICK-RESPONSE ACHIEVEMENTS

Operation Iraqi Freedom (OIF).

80% Weapons—WD Influenced

WD supported the integration and development of more than 80% of the weapons used in theater during Operation Iraqi Freedom. Weapons included JSOW, JDAM, HARM, Tomahawk, SLAM-ER, LGB/GBUs, and AMRAAM.

Weapons and Weapon Systems

Digital Ground-Based Threat Detection System (DGTDS). Man portable air defense systems (MANPADS) underscore the asymmetric nature of modern warfare—one person toting a $25,000, IR-guided missile can, in theory, destroy a military aircraft. With the unsuccessful but dramatic missile attack on an Israeli airliner in Kenya in 2002, officials in Washington became very interested in this counter-terrorism device.

Quick-Response

In 2003 WD was given only 90 days to conduct a study on the most feasible means of non-tactical, large body aircraft in military use. Two options were considered. One option was to install a robust detection and countermeasure system on every aircraft, or use a ground-based system to protect the airfield, thereby protecting all aircraft at that airport. The ground-based approach was chosen and development continued.

In 2006, WD began DT on 2-node and 4-node systems and fired combinations of MANPADS and rockets to determine launch detection performance.

Testimonials – VIP Involvement

Early in 2006, the DGTDS team successfully demonstrated the system's capabilities in a series of live-fire demonstrations for visiting officials including the Office of Under Secretary of Defense, and the Department of Homeland Security.

Award

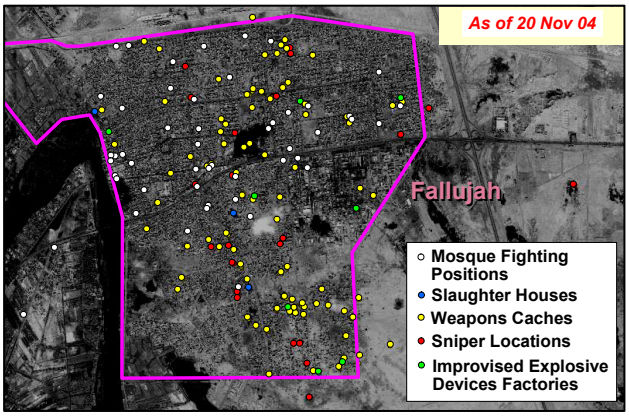
The DGTDS team, led by Mallory Boyd, received a Commander's Award for their outstanding efforts.

Thanks to the innovation and dedication of the DGTDS team, in the near future large aircraft supporting military operations may fly into uncertain or hostile environments more safely. [172] [177]

Digital Precision Strike Suite (DPSS). DPSS provides a brand-new capability for the Fleet. It is a self-contained laptop system that increases the success for first-pass attacks with smart weapons. The computer correlates real-time target images from various sensors with existing geographical database imagery and assigns a latitude, longitude, and elevation to any part of the target. These targeting data are then transmitted to the aircraft and weapon. And it's all done by one operator, using a laptop computer, in less than a minute. Already tested in operations in the field, DPSS revolutionizes strike warfare. [55]

In the battle for Fallujah, DPSS improved our targeting capabilities in terms of accuracy and timelines, and kept incidents of collateral damage to a minimum. It rapidly became the targeting method of choice. In 2006, DPSS-SM evolved with precision fire image, and was urgently requested by the U.S. Marine Corps and the U.S. Army. The high effectiveness and field portability of this system adds thousands of Special Operations and Army users to the targeting community. Multiple joint exercises involving Precision Fire Images (PFI) were planned for 2007. [170] [172]

Fallujah. Weapons Division Weapons and Systems That Helped Win the Battle. TDM, DPSS, GBU-38. One of the fiercest battles in Iraq involved the city of Fallujah. The mission was to defeat two to three thousand armed militants in a stronghold. After roughly 70% of the 300,000 residents evacuated, the battle was fought street-by-street, building-by-building, and room-by-room.



According to Captain Dan Lee, "The Digital Precision Strike Suite (DPSS) improved our targeting capabilities in terms of accuracy and timelines, and kept incidents of collateral damage to a minimum. It rapidly became the targeting method of choice. In addition, the insurgents were using a mosque as a command center. This is where the GBU-38 proved its worth. U.S. forces were able to remove the outer wall without damaging the mosque, allowing ground forces to achieve their objective. Our forces have never had to execute urban warfare like this before. It was incredibly difficult with high risks. Our forces prevailed, killing an estimated 1,600 insurgents with relatively small losses. Unfortunately, 83 American's gave the ultimate sacrifice to free Fallujah." [170]

Quick-Response

GBU-24E/B Laser Guided Bomb. In 2004, WD completed operational testing (OT). Two key launches of the GBU-24G/B Laser Guided Bomb from F/A-18C/D aircraft against realistic targets confirmed precision and effectiveness. In a quick turn-around effort, China Lake completed and delivered 143 tactical and 21 inert trainer BLU-116A/B bombs in short order. In addition, in an unprecedented successful test, eight GBU-38s, 500-pound JDAMs, were released from an F/A-18 aircraft and all weapons hit their targets. [172]

Hellfire. New MAC Warhead. In support of OIF, WD designed, developed, and built a new metal augmented charge warhead that inflicted great damage to multi-room structures during the war. The effects of the warhead are formidable.

Testimonials – VIP Involvement

"– can take out the first floor of a building without damaging the floors above, and is capable of reaching around corners, into niches and behind walls to strike enemy forces hiding in caves, bunkers and hardened multi-room complexes. It went from development to deployment in less than a year."

—Donald Rumsfeld, Secretary of Defense
Speaking on the AGM-114N Metal Augmented Charge Hellfire

"The weapons were employed the first night of [the war] with great success." Sewell also quoted the Marine Corps aviator who was the first to use the new Hellfire warhead in combat. '"That thing was awesome,' the Marine said. 'I thought it was a 2,000-pound JDAM going off.'"

—LCDR Donald Sewell, Pentagon spokesman
As reported in *Defense Week*

The new MAC warhead technology has its roots at China Lake where, as early as the 1960s, Navy scientists were conducting basic research into fuel-air explosives (FAEs). Concepts were turned into tactical weapons: surface-launched FAE (SLU-FAE) and the CBU-55/72 FAE family. In the 1990s, WD developed nonliquid FAEs containing aluminum particles. The goal was a solid FAE with a greater impulse (pressure over time) than conventional explosives. Their work received a classified U.S. Patent and was the basis for the MAC warhead. Unlike conventional warheads, which have a sharp pressure spike that decays rapidly, the MAC has a sustained pressure wave.

Quick-Response

"Thirteen months from funding to fielding," noted the project's systems engineer. "That was total design, development, assembly, explosive loading, integration into the missile armament section, and testing. Normally, that would be about a three-year project." [54]

In 2003 China Lake became the Technical Design Agent for the PBXN-112/MAC warhead which was integrated into the Hellfire II missile. WD designed, manufactured, tested, qualified, and manufactured 100 warheads that proved formidable in the urban warfighter field. In 2004 130 MAC warheads were converted into AGM-114 missiles improving the lethality against a wide range of non-traditional targets. In 2005, WD manufactured 400 warheads while the program successfully transitioned from WD to industry by qualifying Alliant Techsystems, Inc. (ATK) as the commercial manufacturer

Hellfire. Thermobaric AGM-114N. During 2005 WD celebrated the completion of the AGM-114N Thermobaric Hellfire missile OPEVAL (OT-IIIA) with the best possible grade of Operationally Effective and Operationally Suitable. This upgrade provides significant lethality

improvement over the AGM-114 Blast Frag Hellfire variants against a wide range of non-traditional, Military Operations in Urban Terrain (MOUT) and maritime targets. [172] [178]

Hellfire Packs a Greater Punch. Marine assault units engaged in OIF are using Hellfire missiles equipped with a new metal-augmented-charge (MAC) warhead. The new warhead—designed, developed and built at China Lake, with support from the Marine Corps, White Sands Missile Range, Eglin Air Force Base Open Air Range, NAVSEA Indian Head, and Redstone Technical Test Center—inflicts greater damage in multi-room structures than the AGM-114M Hellfire warhead. The effects of the Hellfire MAC warhead are formidable. Unlike conventional warheads, which have a sharp pressure spike that decays rapidly, the MAC has a sustained pressure wave. That pressure propagates throughout a structure to extend the lethal effects of the warhead detonation. In 2002, the Defense Threat Reduction Agency (DTRA) tasked NAVAIR to develop a new Hellfire warhead. That hard work paid off in OIF. [54]

In 2006, working with the Army at Redstone Arsenal, WD continued to improve the Hellfire's effectiveness against Military Operations in Urban Terrain (MOUT) targets, and improved trajectory shaping software was used to improve and enhance performance. The goal of trajectory shaping was to flatten the end-game trajectory impact to improve penetration. Test results proved the new technology successful and 200 PBXN-112/metal augmented charge (MAC) warheads were produced by WD for the Army's Joint Attack Munitions Systems (JAMS) Program Office. [172]

Hellfire Missile – New Mac Warhead. In 2006, working with the Army at Redstone Arsenal, WD continued to improve the Hellfire's effectiveness against MOUT targets, and improved trajectory shaping software was used to improve enhance performance. The goal of trajectory shaping was to flatten the end-game trajectory impact to improve penetration. Test results proved the new technology successful and 200 PBXN-112/metal augmented charge (MAC) warheads were produced by WD for the Army's Joint Attack Munitions Systems (JAMS) Program Office. [172]

Quick-Response
Improvised Explosive Devices (IED) Neutralization
Terrorism has created its own specialized arsenal of hand-made or improvised bombs. These devices, although often crude in nature, are very inexpensive to build and very deadly to our warfighters. In fact, they are the primary source of U.S. casualties. In 2005 the SECDEF directed the establishment of the Joint Improvised Explosive Device Defeat Organization (JIEDDO). In September, 2006 JIEDDO then directed China Lake to begin developing the Joint Counter IED Facility (JCIF). This quick-response effort involved building a specialized facility dedicated entirely to the research and development of anti-IED tactics and technologies.

The fiberoptics installation contract, and infrastructure procurements required more than 500 separate contracts involving more than $52M and an additional $22M is allocated for jammers, threats, tactical vehicles and money to support external agencies. This counter-IED effort is a combined Joint Service, interagency, multi-national program. The enemy is adaptive, innovative and flexible, and unfortunately, there is no "silver bullet" to defeating IEDs. Rather, JIEDDO has a three-part strategy: attack the network, defeat the device, and train the force. In 2007 alone, JCIF conducted 898 test events.

New Facility and Testimonials – VIP Involvement
Joint Counter IED Facility Opens at China Lake. Dr. Delores Etter, Assistant Secretary of the Navy for Research, Development and Acquisition, joined Congressmen Kevin McCarthy, NAVAIR Commander Vice Adm. David Venlet and WD Commander Rear Admiral Mark Skinner at the opening of the Joint Counter IED Facility at China Lake. Etter pushed the button to detonate the ribbon, signaling the official opening of the facility. [177]

Quick-Response

JDAM. Quick Recovery. JDAM has been used extensively throughout the OIF conflict and supplies can not always meet demand. In a quick turn-around effort, Marine Forces requested that 630 additional JDAM tail kits be readied for immediate use. Working with Eglin AFB, the WD team provided the necessary I-level maintenance at Crane Army Depot over a 3-week period and got the job done.

JDAM. One-Hour Fix. In addition, WD received an urgent request for assistance in regard to JDAM IBIT reprogramming from deployed Marine forces. Upon receipt, WD analyzed the problem, recommended a work around, copied and sent JDAM replacement software to OCONUS via the FWST representative in one hour!

Costs Savings – Best Business Practices

JDAM. The team tested each tail kit, reloaded software, replaced minor parts and performed corrosion control procedures, inspected and returned the tail kits in record time, avoiding $500K in shipping, handling and contractor depot maintenance costs. This is an excellent example of a tri-service cooperative quick response effort to place JDAMs back into the hands of the Warfighter. [172]

JDAM. 6,500 Dropped. Navy and Marine Corps carrier-based aircraft flew nearly 8,000 missions in the first three weeks of the Operation. F-14, F/A-18 (the F/A-18E Super Hornet in its maiden combat deployment), and AV-8 aircraft dropped more than 6,000 precision-guided weapons—including 2,400 JDAMs—during battlefield interdiction missions, strikes against command and control targets, and close air support operations. Overall, 6,500 JDAMs were dropped and over 800 Tomahawk cruise missiles were launched. [55]

Quick-Response

Low Collateral Damage Bomb (LCDB). BLU-126B. As in previous Middle East conflicts, the current Iraq war requires military operations within an urban environment. Damage to historic and religious structures and injury to non-combatants is unacceptable. Since there was no existing Navy weapon system having all the performance characteristics necessary to neutralize this threat given the urban scenario, in rapid response, WD answered the call. WD developed and qualified a LCDB for use with precision guidance kits in only 15 months.

The new design reduces fragment quantity by 90% and reduces lethal radius by 50% to minimize collateral damage. The LCDB (BLU-126B) fitted to the JDAM or LGB guidance kits provides repeatable precision delivery, in some cases to less than 10 feet. WD developed the BLU-126B by modifying the existing BLU-111 500-pound class bomb. BLU-111, the smallest bomb available for fixed-wing aircraft required significant engineering to maintain the same mass properties, meet the collateral damage requirement and assure the explosive component initiation reliability was not degraded. This was the key feature in compressing a normal 36-48 month RDT&E effort into 15 months. The BLU-111 can eliminate enemy personnel within semi-hardened buildings with minimal damage to surrounding buildings or injury to non-combatants. The new "LoCo" bomb will be compatible with BLU-111 configurations including JDAM, LGB, and Dual-Mode LGB (DMLGB).

On July 27th, 2007 the first LoCo was dropped against an enemy target and performed successfully as designed and on August 12th a second successful drop took out an enemy van loaded with weapons. [170] [172] [179]

Award and Quick-Response

LCDB—NAVAIR Engineers Win Top Honors. Forty NAVAIR engineers from both Patuxent River and China Lake won the Navy's "Top Navy Scientists and Engineers of the Year Award" during a ceremony held May 2, 2007 at the Pentagon. The BLU-126B bomb went from concept to deployment in less than 16 months and fulfilled a Fleet need for a weapon that is both combat effective and adheres to U.S. Central Command's Collateral Damage Rules of Engagement.

The BLU-126B is externally identical to the 500-pound BLU-111, but contains less explosive mass producing a reduced fragmentation pattern and blast radius for use in situations where friendly forces are close to the target. The new LCDB can be used with the same guidance kits as the BLU-111 and since it is a modification of an existing weapon, the program is highly cost effective, can be produced at the same cost as the BLU-111, and requires no unique support costs. [177]

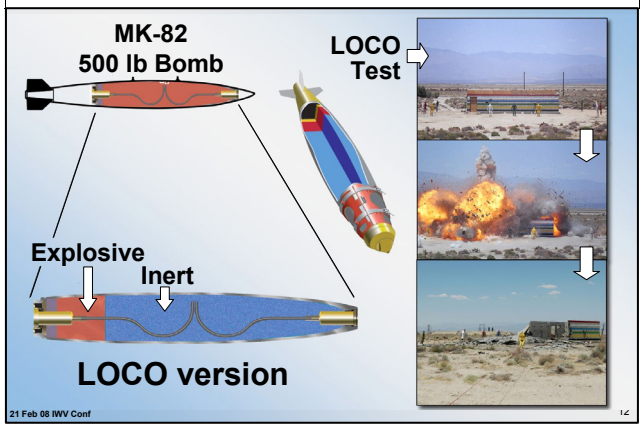
Testimonials – VIP Involvement

"This weapon allows us to target and destroy the enemy without causing damage we didn't want to inflict. It's exactly what we need in current combat environments where the enemy hides among the civilian population."

—VX-31 Test Pilot

"Our primary mission is to deliver required capabilities to the Fleet on cost and on schedule. In this case, the program swiftly responded to the need to have an effective weapon that limits damage outside the intended target and which the warfighter will find easy to employ. I consider this a huge success, demonstrating acquisition agility in rapidly fielding an effective combat solution."

—Rear Admiral Timothy Heely
Program Executive Office for Strike Weapons
and Unmanned Aviation



Mobil Laser Evaluation System Development. The requirement for real-time evaluation of the position and relative energy of a tactical airborne laser system led to the development of the Mobil Laser Evaluation System. Using this device, the operator can detect a laser spot on any type of tactical or non-tactical target by using an infrared imaging unit. The laser spot data are processed to give the relative position of the center of the spot relative to the center of the target by time-tagging the position using GPS time stamping and then saving the data in a text file. These data are transferred real time to Range Control for project engineers to evaluate. This is the only system of its kind in the Navy and can be rapidly deployed in 30 minutes or less. Edwards Air Force Base has used it for a series of tests involving the F-16's Sniper targeting pod, and Nellis Air Force Base is considering using the new technology. In 2005 WD developed a remote site-controlled pan-and-tilt mount and laser spot imager for moving targets. In addition, tests were conducted for LGTR, Dual Mode Guided Bomb, Predator, and F/A-18 software evaluations using the ATFLIR targeting pod. [172]

Quick-Response

P-3C Direct Search Capability for Mark 46 Torpedoes Developed in only 3 ½ Months. Directed Search is a new search mode used by torpedoes to seek and destroy a target. It requires the software to allow the operator to choose one of two search options and then to calculate a release point based on torpedo type and mode selected. Due to a delay time for the torpedo to be programmed after the mode is selected, an additional Weapon Fly-To-Point was also added to aid the Pilot in steering the aircraft for optimum weapon release based on time torpedo release is initiated, time of actual physical release, and projected position of the target when the weapon will hit the water. Software Engineering personnel persevered, and engineered an elegant integrated hardware and software solution. This effort increased ASW effectiveness by a giant leap. [172]

P-3C Cutting Edge Aircraft Systems Delivered. Working with industry, WD teams performed installation and training on several new and updated P-3C aircraft systems. The team received a BRAVO ZULU naval message as follows:

Testimonial – VIP Involvement

"This outstanding team ensured that cutting-edge technology and modifications to numerous AIP aircraft systems were installed and tested in time to deploy these critical assets into combat zones, where they will significantly enhance capability and reliability for theater commanders, aircrew, and maintainers. This talented and motivated group selflessly worked long hours into night-check and on weekends to ensure tasks were accomplished with minimum impact to ongoing operations." [172]

—COMPATRECONWING TWO
Kaneohe Bay, Hawaii

Patriot Radar Range Finder Team Recognized for Quick-Response Effort

Award

The WD-led Patriot radar range finder team was nominated for the prestigious David Packard Excellence in Acquisition Award. WD and the Naval Undersea Warfare Center (NUWC) at Newport, Rhode Island worked closely together in developing a miniature, collision-avoidance and situation-awareness radar system usable by the entire attack submarine fleet. The need for this radar was realized after a Los Angeles class submarine collided with the Japanese fisheries research ship, the Ehime Maru, off the island of Oahu in February, 2001. The CNO and Commander, Submarines, Pacific (COMSUBPAC) determined that an existing proposal from WD could help avoid a repeat incident by developing a smaller, mast-mounted radar. A team was formed from Government Laboratories, Canadian-based Amphitech International, WaveBand Corporation, and Sperry Marine.

Quick-Response

The radar was developed and at-sea demonstrations conducted all within 13 months. Requirements demanded the new radar fit atop the submarine mast in a space no larger than a two-pound coffee can, without extra wiring or disrupting existing parts. The radar performed as designed, and received rave reviews from crews familiar with its capabilities. This breakthrough brings precise situational awareness performance to the submarine, a benefit never before enjoyed by a submerged platform. The new radar, now in high-rate production, is providing a unique ability to each fleet attack submarine. Spiral engineering techniques are being used to improve the first design, while Phase B of the radar enters development at WD. [177]

Precision Strike Suite for Special Operations Forces (PSS-SOF). PSS is in use extensively in Afghanistan and Iraq supporting ground combat engagements. It has been the system of choice to target both GPS and laser guided weapons for close air support missions, Troops in Contact (TIC) missions, and time sensitive missions. It is a specialized DPSS program that allows Special Operations Forces Joint Terminal Attack Controller (JTAC), Joint Fire Observers and other trained users to provide highly accurate eyes-on-precision target coordinates to any other target planning system or available weapons delivery system. Increased precision allows greater speed in target destruction, fewer and smaller weapons, fewer civilian and military casualties, less collateral damage, and the use of fewer delivery platforms, resulting in lowered costs. These WD developed tools have now moved beyond the tactical aviation community as a force multiplier to the Army artillery community. PSS-SOF is being taught in theater by U.S. CENTCOM and NSAWC and has been formally integrated into schoolhouses from all services, including the Army Artillery Schoolhouse at Ft. Sill, Oklahoma. [172]

Testimonial – VIP Involvement

"The ability of a joint terminal attack controller (JTAC) to generate a precision target location is one of the most significant force multipliers for the fires community to emerge in many years."

—Marine Corps Gazette, Digital Targeting May 2005

"By combining PSS-SOF with precision munitions, the service brings precision fires to the *pointy end of the spear*. In addition to the munitions peace, the Artillery school at Ft. Sill also started an operational warfare class and a course to train joint fire observers."

—Major General David Ralston
Fort Sill, Oklahoma Commanding General
Chief of Army Artillery

In 2007-2008 a Pocket-Sized Forward Entry Device (PFED) was introduced in a collaborative effort between the Army, Joint Forces Command and China Lake.

Rapid Attack Information Dissemination and Execution Relay (RAIDER). Ground Mobile Gateway (GMG) (RAIDER-GMG). RAIDER-GMG significantly improves the Dynamic Targeting (DT) timeline by providing machine-to-machine digital communications for the major data link systems currently fielded. RAIDER-GMG operators are able to receive an air support request, build the retasking message, and transmit it over the appropriate data link directly to the attacking aircraft or controlling platform. In 2003, RAIDER was forward deployed to Iraq.

In 2004, 29 reservists were deployed to Stuttgart, Germany for the JXF program supporting the European

Operations Plans Center; Republic of Korea supporting RAIDER and 7th Air Force operations; and Qatar and Iraq supporting the Tactical Dissemination Module for Central Command. In supporting Korean operations, the WD Weapons Response Center coordinated lifecycle support with the Naval Air Logistics Office for a HMMWV deployment from China Lake to Osan, Korea. [172]

During the Joint Expeditionary Force Exercise-06 a RAIDER-GMG concept car demonstrated initial capabilities and new future enabling technologies such as tactical targeting networking (TTNT); common data link (CDL); and securable, tactical cellular telephones. RAIDER-GMG has formally transitioned to the Objective Gateway Program at ESC Hanscom Air Force Base. In 2007 three RAIDER systems were deployed in Iraq/Afghanistan and WD civilian engineers have supported them in theater.

The RAIDER team participated in a JFCOM sponsored exercise known as Bold Quest. Bold Quest was a blue force tracking event in which the RAIDER unit was used, in a coalition environment, to disseminate both blue force position and strike information. The WD RAIDER program has been working with the Air Force Objective Gateway to solidify acquisition plans for a 2011 IOC of the Ground Mobile Gateway. WD is currently working with United States Air Forces Europe (USAFE) on the delivery and support. [172] [180]

Quick-Response

When the RAIDER group received an urgent request from the *USS Harry S. Truman* Battle Group for Link-16 imagery capability, China Lake installed a system, based on the RAIDER-GMG design, on the aircraft carrier. Within 1 week the system was supporting operations in the CENTCOM area. [172]

Shared Reconnaissance Pod (SHARP) for F/A-18F

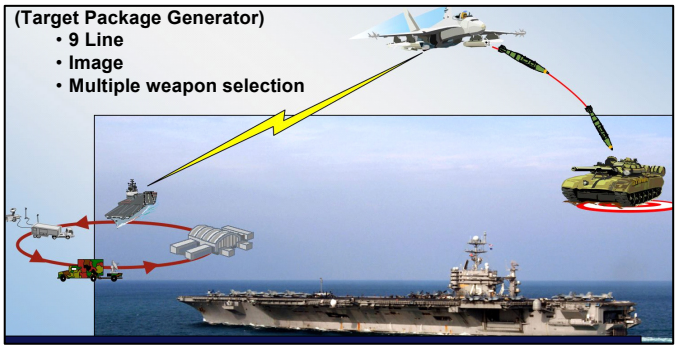
The NAVAIR developed SHARP POD provides a reconnaissance capability for the F/A-18E/F Super Hornet and was approved for early deployment. This is a multi-function pod and is capable of simultaneous airborne and ground screening, giving us the opportunity to bring real-time high-resolution images to ground forces in Northern Iraq. Through a tremendous effort on the part of the SHARP's test team, the Fleet was able to put the Pod's imaging capability to good use, only three months after SHARP's first flight. Later, in 2005 SHARP completed OPEVAL and urgent testing for IED detection at Yuma Proving Ground, Arizona was completed.

Quick-Response

In 2007, the SHARP pod met an urgent operational need to download imagery from the F/A-18s SHARP Pod to *USS Lincoln's* main computer network. This allowed the ship's computer networks to convert imagery to weapons targeting coordinates.

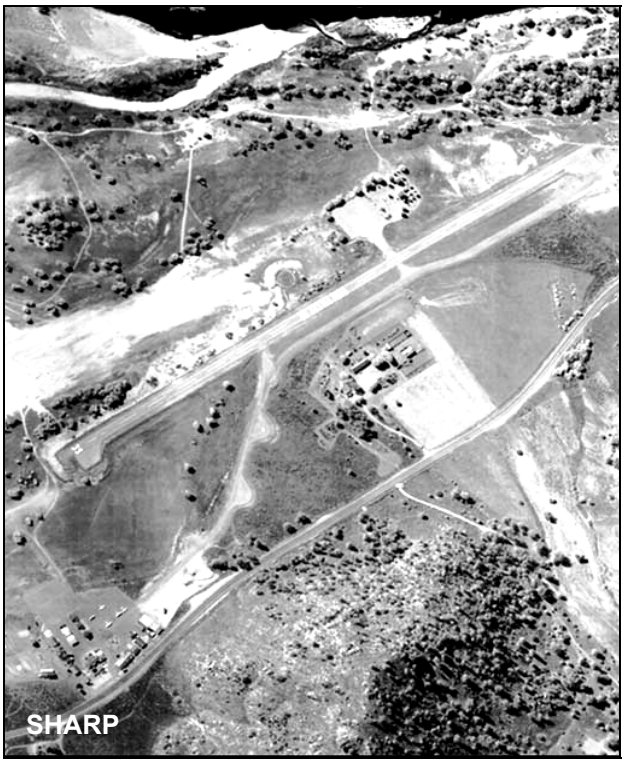
Testimonials – VIP Involvement

The SHARP team received praise from RDML Scott Vanbuskirk for their outstanding work on the *USS Lincoln*. The Admiral reported great success during three separate drills where a targeting support product was produced in 30 minutes or less, an improvement over the previous best time of 90 minutes.



Quick-Response

Shared Reconnaissance Pod (SHARP). Developed by NAVAIR and Scheduled for Early Deployment. "The Fleet is going to love it," shouted an enthusiastic pilot who was describing SHARP. The pod provides a reconnaissance capability for the F/A-18E/F Super Hornet, and was approved for early deployment. Through a tremendous effort on the part of the SHARP's test team, the Fleet will be able to put the Pod's imaging capability to good use, only three months after SHARP's first flight. The Advanced Weapons Laboratory's (AWL's) project lead, praised the team, referring to their Herculean efforts to get this capability to the Fleet. During its first flight, SHARP collected visible and infrared wavelength imagery from station six of a Super Hornet for two hours as the aircraft flew over the ranges at China Lake. According to developers, SHARP will be more reliable, day/night capable, with a near-real-time data link capability and near-instantaneous image processing. NAVAIR's AWL led the software development and integration, which will allow SHARP to function while installed on the F/A-18. In 2005 SHARP completed OPEVAL and urgent testing for IED detection at Yuma Proving Ground, Arizona was completed. [55] [172]



Tactical Dissemination Module (TDM). China Lake invented and developed TDM, a revolutionary new portable computer/radio system that creates customized real-time-targeting strike packages for specific aircraft. For example, a special operations force identifies a time-critical target. Next, they digitally photograph the target, determine the approximate GPS coordinates, and then transmit the data back to Central Command (CENTCOM), who decides which weapon is currently available (target weapon pairing), in order to make the call for fire (CFF). When TDM receives the CFF over a secure network, the target-package generator automatically fills in the fields on a computerized worksheet and then automatically formats the information into a standard nine-line message specific to the launch aircraft. Reconnaissance images, as well as pre-existing satellite imagery, are chipped (re-sized and oriented for pilot ease of use). In addition, the location of friendly forces or enemy surface-to-air threats is identified. These funnel-feature navigation aids are used to lead the aircraft and weapon to the target. Sequential images get progressively larger in scale as the target approaches. This package is sent through a secure network to the Forward Dissemination Element (FDE), portable computer/radio field equipment), then is transmitted directly into the cockpit of the strike aircraft by means of one of numerous RF data links. In conflict, the rules of engagement require positive target identification before weapon release. TDM delivers this capability.

TDM work began at China Lake in 1993, and the Navy's first system was demonstrated in 1994. Through the 1990s, development efforts were part of the Rapid Precision Targeting System (RPTS) project. RPTS was deployed in NATO Bosnia/Kosovo operations. In late 2002, RPTS—now called TDM—was deployed to the Persian Gulf during Operation Southern Watch. Later, during Operation Iraqi Freedom, as coalition forces captured Baghdad International Airport, the FDE was immediately relocated there for the duration of the conflict. TDM supplied more than 900 target packages to coalition bombers and is still forward-deployed. TDM was installed on six U.S. Navy ships in FY04. Using satellite and relay aircraft, designers will extend TDM range from the current 180-mile limitation to virtually anywhere in the world. [60] [170]

Combined Air Operations Center
Prince Sultan Air Base, Saudi Arabia

Weapon Platform Integration

H-1W. The AH-1W has been the Marine Corps primary attack helicopter throughout OEF and OIF. In 2008, 150+ helicopters in Iraq and Afghanistan support ground troops. They carry TOW Hellfire missiles, 5-inch Zuni rockets, 2.75 hydra rockets, 25mm guns, 7.63 mm guns. The H-1 is in the heat of all battles. Each helicopter has a 2-man crew.

At WD, the H-1 Weapon System Support Activity (WSSA) performs full life-cycle system and software engineering for the AH-1W, UH-1Y, and AH-1Z helicopters. In 2007, the team successfully completed an extremely aggressive, high visibility, Fleet-critical developmental test program for the UH-1Y and AH-1Z. The program was crucial in keeping the program on track to deliver the UH-1Y, major upgrade, to the Fleet in 2008. In parallel, the team translated complex code for the AH-1W software to resolve GWOT Fleet requirements.

Quick-Response

In addition, the H-1 WSSA's efforts were accomplished in record time. The DT-IIC-2 test program, originally planned as an eight-month effort, was executed successfully in only four. The test program required integration of multiple, highly complex subsystems including a Helmet Mounted Sight Display, a Target Sight Sensor, and a complete, integrated avionics software suite. System test objectives required executing more than 170 flight test sorties and four detachments, including two shipboard detachments. In the four-month test period, the team planned, executed, and formally reported on a total of 256 flight test hours, 41 ground test hours, and 635 lab test hours.

Equally noteworthy, the AH-1W team successfully translated code in the Cobra 3 Project. The AH-1W aircraft, circa 1970 technology, is a federated system whose functionality relies on 386 processors. The team faced the daunting challenge of translating the existing Communication, Display, Navigation Unit (CDNU) software code from one programming language to another while also implementing new functionality. The team accomplished the goal on time and on budget. [181]

C-130. Old 'Flying Taco Stand' Not Too Worn to Do the Trick. "It's been an adventure, no question about it," said Cmdr. Steve Gasporovich, the executive officer of VX-30, a Navy air test and evaluation squadron based at Point Mugu. The orders given Gasporovich and Maj. Robert W. Baxter of the Air Force Reserve the first week of March were simple: Fly the C-130 more than 9,000 miles from California to a desert base, and prepare the airplane to launch five jet-powered drone aircraft toward Baghdad. The aging C-130 was dubbed the Flying Taco Stand because of its unique color scheme. The objective of the mission was to trick Iraqi air defense gunners into firing at "ghost" planes before the waves of coalition aircraft struck. The two veteran aviators left California on March 11 and arrived at the desert base on March 18, the day before the war began with the "decapitation" bomb-and-missile strike aimed at Saddam Hussein's bunker in Baghdad. Changing pilots in-flight and stopping only to rest the 11-man crew, the C-130 was in the air for 32 hours in four days. After they arrived, the crew worked quickly to mount the cargo, five jet-powered drones, to pylons beneath the wings. Each drone carries six canisters loaded with 96 shotgun-shell-sized charges of chaff, which are fired remotely. The crew launched three Firebees programmed to fly to Baghdad, on to Tikrit—Saddam's hometown and his power base—then back to Baghdad, making multiple passes dispensing chaff over the Iraqi capital. [69]

Quick-Response

F-14 Upgrade to 'Bombcat,' Navy Earns Hill Plaudits

To give the venerable F-14 Tomcat fighter jet a bigger role in the war against Iraq, NAVAIR rushed a newly developed software upgrade to all 30 "D model" aircraft in the war zone, enabling them to drop the most devastating, satellite-guided, bunker buster bombs on targets in Iraq last week. This effort quickly drew praise from aides to House Armed Services Chairman Hunter and other lawmakers. All 30 F-14D fighters participating in the war were modified five to six months ahead of schedule after accelerated testing of a software upgrade, said Denise Deon, a NAVAIR spokeswoman. Upgrades and training of 90 aircrew and maintenance personnel were completed within 17 days.

JDAMs and cruise missiles have been the primary weapons in the so-called "shock and awe" campaign against fixed targets in Baghdad, Basra, and elsewhere in Iraq. A Navy F-14D from *USS Constellation* gave the upgrade its first "operational" test on March 1 when it destroyed a ground target while patrolling the southern no-fly zone over Iraq. The F-14, featured in the hit movie "Top Gun" with its

distinctive twin engines, supersonic speed, and variable sweep wings, entered the Navy fleet in 1973. The most advanced model, the F-14D, was last delivered in May 1992 and will be replaced by F/A-18E, F, and G Super Hornets in about five years. [61]

Quick-Response

All 30 F-14D fighters aboard the aircraft carriers *USS Theodore Roosevelt*, *USS Abraham Lincoln,* and *USS Constellation* were modified approximately six months ahead of schedule to carry the D04 after accelerated testing of D04 was deemed low risk by COMOPTEVFOR (Commander, Operational Test and Evaluation Force).

On February 2, 2003, the Navy transported an upgrade support team of F-14D IPT personnel to *USS Roosevelt* to make the required changes to aircraft, and software. The team formed two sub-teams to accomplish the accelerated schedule concurrently on *USS Lincoln* and *USS Constellation*. The upgrades to all forward-deployed F-14Ds and the training of 90 aircrew and numerous maintenance personnel were completed within 17 days. A Navy's F-14D from *USS Constellation* provided the first operational JDAM strike on March 1, 2003, when it destroyed a ground target over Iraq in support of Operation Southern Watch. The Navy's F-14D with JDAMs was used extensively with pinpoint accuracy to eliminate high-priority targets in OIF. [57]

Quick-Response

F-16 JDAM Test Shows Joint Quick-Response Capability. Nothing accelerates the tempo of military support operations like a war. That was demonstrated in a marathon fix-test-field project that involved Edwards Air Force Base, the Land Range, and nearly a score of other organizations. The problem, which had shown up on the opening day of OIF involving Block 30 F-16s operating in the Iraqi theater, affected JDAM. The software glitch was soon fixed, but the F-16 JDAM software had to be tested quickly on the China Lake ranges before it could be sent back to Iraq. Elapsed time from first call until the software was on its way to Iraq was 30 hours. "It was absolutely amazing how much we got accomplished in such a short period of time," said the 416th project pilot. "The same effort normally takes weeks." And apparently the Block 30 F-16s and their JDAMs are doing the job in Iraq. "The field hasn't come back with any complaints." [55]

Test and Evaluation

Empire Challenge 2006.

In 2006, China Lake hosted more than 700 people from Great Britain, Canada, and Australia who brought a large-scale multi-national military force to China Lake that included aircraft, sensors, equipment, and personnel. The team set up a command center, forward operating ground stations, aircraft, and aircrews for the numerous exercises. The goal was to demonstrate and evaluate intelligence gathering techniques and joint and coalition war fighting operations. Two key WD assets were used extensively and included the Airspace Surveillance Center (ASC) and the Range Signal Density Enhancement Team at the Electronic Combat Range (ECR). [172]

Empire Challenge 2007.

China Lake hosted the largest Empire Challenge 2007 in July with about 1,400 civilian and military personnel participating in the two-week exercise led by the National Geospatial-Intelligence Agency (NGA), partnering with the National Reconnaissance Office (NRO) and the Joint Forces Command (JFCOM). The exercise demonstrated joint and coalition interoperability among intelligence, surveillance, and reconnaissance (ISR) platforms, sensors and systems. The idea of the exercise was developed after combat operations in Iraq and Afghanistan identified technical issues with the sharing of ISR information with allied countries. This was the largest and most complex series of ISR system tests and technology in that it combined real-time surveillance with pre-planned and non-traditional reconnaissance using a worldwide network to reach back and collaborate with allies in Australia, Canada, Great Britain and the NATO C3 Agency. Ground operations tested manpower and equipment simulating real-life situations in theater including convoy attacks by opposing forces, small arms fire and improvised explosive

devices. 110 sorties were flown during the 9-day event. Imagery intelligence and ground moving target indicator data were data-linked real-time. The data were screened and relayed via a Global Broadcast System uplink to receiving stations at RAF Marham in England, the Defense Imagery and Geospatial Office in Canberra, Australia, and the Canadian Forces Defense Headquarters in Ottawa, Canada. Analyzed and exploited intelligence data products were sent from those long distance locations back to China Lake on a secure network.

Testimonials – VIP Involvement

More than 100 congressional staffers, senior executives, flag officers and distinguished visitors from coalition and NATO countries, the Office of the Secretary of Defense, the Joint Staff, JFCOM, Army, Air Force and Navy components received briefings and observed activities in real time in the JTF C2 Center, the ground station complex at Armitage Airfield and on the South Range during two days of visits.

Empire Challenge is scheduled to continue through fiscal 2011 under JFCOM sponsorship, returning to China Lake to continue the work necessary to review new technology and improve coalition interoperability in the future.

New Facility

Explosive Ordnance Training Facility (EOTF). In 2006, China Lake opened a new tactical combat training facility set up to train Navy expeditionary forces before deployment to the war zone. This explosive ordnance training facility replicates the type of environment our troops face in Iraq. Forces sharpen their combat skills and soldiers learn how to conduct house-to-house searches, identify sniper threats, and how to deal with the climate and terrain. The range consists of pistol and rifle ranges, a 2.5-mile crew-served weapons and demolition range, a combat convoy course and tactical driving range, and a mock "town" where troops are trained to use weapons and tools such as unmanned aerial vehicles, robotics, night vision, lasers, and other high-tech warfighting equipment. China Lake supported 400-500 military personnel the first year with a capacity for up to 1,000 per year. In 2007, more than 800 deploying EOD technicians trained at this facility in direct support of OIF. Operations are managed by the Explosive Ordnance Disposal Training and Evaluation Unit One Detachment (EODTEU 1), China Lake. [170] [182]

Developmental Test and Evaluation

VX-30 Air Test and Evaluation Squadron THREE ZERO. The VX-30 "Bloodhounds" operate a diverse inventory of instrumented Navy Range support aircraft and support many developmental programs including the F-22 Raptor, Sidewinder AIM-9X, EA-6B Prowler, Tactical Tomahawk Land Attack Missile, AMRAAM, HARM, and SLAM-ER. VX-30 also supports high-profile scientific and strategic customers such as NASA, MDA, and United States Air Force Intercontinental Ballistic Missile (ICBM) improvement programs.

In 2004, VX-30 operated additional aircraft including the F-18A/B Hornet, F-14A/B/D Tomcat, QF-4N/S Phantom, LC-130F, DC-130A, and KC130 Hercules. OT included the Improved Tactical Air Launched Decoy II (ITALD II), F/A-22 Raptor, and Side-winder AIM-9X. The squadron supported a myriad of other programs as well. The final VX-30 flight of the F-14 Tomcat took place marking an end to an era, and the final QF-4 flight took place as Bloodhound 145 was flown to NAS North Island to become a display the *USS Midway* museum in San Diego.

In 2005, the squadron supported the Carrier Strike Group (CSG) exercises, Japan Self-Defense Force (JSDF) and the British Royal Navy. One of the most significant events was the transition of the F-14's to F/A-18's.

In 2006, twelve VX-30 personnel were deployed to Iraq, Afghanistan, and the Horn of Africa as Individual Augmentees (IA). More than 2,100 sorties were flown and VX-30 supported multiple SLAM-ER, Tomahawk, AMRAAM, and Phalanx test flights as well as Sea Harrier, ATFLIR, and several other projects with VX-30 F/A-18s. VX-30 Hornets flew in support of the *USS Abraham Lincoln*, *USS Carl Vinson*, *USS Nimitz*, *USS Ronald Reagan*, *USS Peleliu,* and Tarawa ESG.

In 2007, aircrews conducted RD&E operating out of the Reagan Test Site on Kwajalein and the Pacific Missile Range in Hawaii. Programs during the year included the Aegis Ballistic Missile Defense, THAAD, and numerous foreign military programs. The F/A-18 Hornet supported SLAM-ER, Tomahawk, AMRAAM, and Phalanx test flights. [173]

VX-31 Air Test and Evaluation Squadron THREE ONE. In 2004, VX-31 operated 18 FA-18A-F Hornet/Super Hornet aircraft, 5 AV-8B Harriers, 3 HH-1N Hueys, 1 AH-1W Cobra, 1 T-39 Saberliner, and 2 SA-227 Metroliner aircraft. A variety of war-fighting improvement programs were supported on all platforms. VX-31 flew 2787 total sorties, 4802 flight hours supporting aircraft and weapons programs.

In 2005, the APG-79 AESA radar for the F/A-18E/F was one of the major programs supported and OPEVAL began. The squadron returned to flight mission duty for the Space Shuttle Discovery and one VX-31 crew staged a Huey at Edwards AFB in support of its return. In addition, VX-31 provided range support and T&E for a revolutionary new network centric warfare tool called the Tactical Targeting Network Technology (TTNT). TTNT is designed to enable all entities in the battle space to provide near-real time information, including video, to the AOR Commander to reduce the kill chain reaction time. In September 2005, 140 personnel from the Navy, Air Force, and DOD civilian and contractor communities descended on China Lake to test the new wireless system. More than 500 VX-31 man hours and 25 flight hours were dedicated to this project. In 2006 VX-31 welcomed the arrival of the AH-1Z Cobra and the UH-1Y and the squadron supported 35 separate developmental T&E projects.

During 2006, the squadron continued developmental test of our current and future combat aircraft, weapons, and

associated weapons systems and provided enhanced combat capabilities for the F/A-18A-F Hornet, AV-8B Harrier and the AH-1W Cobra. The APG-79 Advanced Electronically Scanned Array (AESA) Radar for the F/A-18E/F has transitioned from developmental test into operational test while future capabilities were explored with new software builds and continued to be a major test program. Continued AV-8B Harrier testing has provided the fleet with new war fighting capability upgrades. VX-31 welcomed the arrival of the AH-1Z Cobra and UH-1Y and the EA-18G Growler. At the close of 2006, VX-31 was actively supporting 35 separate developmental test and evaluation projects for weapons, aircraft, and associated systems.

During 2007, the "Dust Devils" supported the Active Electronically Scanned Array (AESA) Radar Program and AESA passed its full rate production milestone and Fleet Aircrews began training with the system. The EA-18G Growler arrived at VX-31 for an intensive test period and the test team achieved a successful Low Rate Initial Production (LRIP) milestone.

Aircrew and civilians alike spent many hours traveling throughout the world in support of deployed squadrons, providing training on the latest updates to mission computer software, weapons, and sensor upgrades so that they may more effectively execute their missions. And the H-1 WSSA added two new helicopters and entered a very robust developmental test period with anticipated fleet introduction in 2008. [174]

Award

VX-31 Receives Meritorious Unit Commendation

On Monday, February 6, 2006 members of VX-31 were recognized for superior performance by the Secretary of the Navy with the presentation of the Navy's Meritorious Unit Commendation award signed by the Honorable Gordon England. [177]

Testimonials – VIP Involvement

"The personnel of VX-31 raised the benchmark for superior performance across the entire test community within the Navy. Deploying personnel to conduct combat operations and accelerating delivery of vital weapon systems for wartime use, the squadron demonstrated the highest levels of professionalism in their execution of mission accomplishment during Operation Iraqi Freedom."

—Honorable Gordan England
Secretary of the Navy

Operational Test and Evaluation

VX-9.

Quick-Response

During OEF in late 2001, VX-9 performed a quick-reaction assessment (QRA) for the GBU-32 1000lb JDAM. Eight test missions were conducted and VX-9 efforts resulted in rapid fielding. Testing on the GBU-38, or the 500lb JDAM, made this highly useful weapon available to the fleet and has supported troops on the ground in close proximity to the enemy, even through poor weather and visibility. In addition, the testing on ISR programs such as SHARP, ATFLIR, and LITENING II have given Navy and Marine Corps platforms an increased capability to counter IEDs and support troops in enemy-controlled territory. Also during OEF, VX-9 finished Hellfire quick reaction testing in four weeks – a normal four months or more operation.

Other programs that VX-9 contributed to in recent times include the GBU-24 EB/GB testing, SLAM-ER upgrades and SLAM-ER ATA, Laser JDAM, EA-6B systems, and Digital Comm Suite (DCS). VX-9 provided OT for the F/A-18 Software Block Upgrade (15C) with more than 100 requirements – a $120 million dollar program that included the JSOW, AIM-9X, JHMCS, MIDS and requirements from six Foreign Military Sales customers. [172] [175]

Marine Aviation Detachment (MAD). The mission of MAD is to provide project management, aviation support, technical expertise, fleet support for assigned Marine Corps weapons systems, and related devices throughout the weapons systems life cycle. We accomplish this by supporting developmental and OT at VX-31, VX-9 and elsewhere and by providing war fighter input to the engineers and support personnel of WD through our Marines who are based at China Lake and Point Mugu.

The detachment works diligently to ensure that those who go into harm's way receive nothing but the most reliable and effective weapons systems available in support of the Global War on Terrorism and to be ready for any major regional contingency. MAD responds to fleet needs as the operating forces continually refine tactics, techniques, and procedures to increase mission effectiveness and enhance force protection against an evolving set of threats.

Highlights of capability developed or fielded for 2007 with strong Marine influence include completion of OPEVAL Phase I for H-1 Upgrades, OPEVAL of Hornet OFP 20X, OPEVAL of Harrier OFP H4.0, trajectory shaping the AGM-114N Thermobaric Hellfire, fielding of BLU-126B Low Collateral Damage Bomb (LCDB), fielding of Intrepid Tiger (IT) Pod, fielding of Technical Control and Analysis Center (TCAC) Remote Analysis Workstation (RAWS) used by Radio Battalions forward deployed today, development of Dual Mode Laser Guided Bomb (DMLGB), development of Joint Helmet Mounted Cueing System (JHMCS), and improvement in Aircraft Survivability Equipment. [184]

Electronic Warfare

AN/ALR-67(V)2. Radar Warning Receiver. Forward deployed RAAF combat troops needed immediate support for the (V)3 system. Multiple requests were received for UDF updates. Working with Raytheon, WD engineers immediately went to work on the AN/ALR-67(V)2 and generated UDFs W8 and WA. In short order. [172]

Communications Jamming. Integrated Product Team Supports OIF. The EA-6B IPT at Point Mugu was recognized for a job well done in quickly fixing a software problem that was concerning warfighters flying EA-6B Prowlers in support of missions in Iraq. The EA-6B communications jamming weapons system, USQ-113, had been locking up for no known reason.

Quick-Response

The technical lead and software programmer for the USQ-113 correctly identified the root cause of the problem (a memory leak) and was able to rapidly write a software patch to fix the problem. His efforts from the time he read the first post-mission report to the release of a software patch were just under four months. As a result, the Fleet was able to load this patch prior to OIF, where it was used in combat. [55]

In 2005, Trident Warrior, a multi-service exercise, was conducted to demonstrate the ability of the VDC-500 SATCOM radio to provide USQ-113 tactical information to an "over-the-horizon participant. In 2005 two OFPs were released. [172]

Quick-Response

Electronic Warfare Database Support (EWDS). The EWDS laboratory provided continual quick reaction support to OIF. During 2004 EWDS provided 124,000 database updates, 44 rapid reaction files to support active combat operations, and the lab established a new record time for data push (from request to cockpit in less than 1 hour). The WD lab provides a sensor-engineered operational database containing order of battle, characteristics and performance, electronic intelligence (ELINT), weapon system library, and tactical data. This information is fused into a single relational database host. During 2005 and 2006, the EWDS team produced more than 800 ICAP3 I-Files and updated 300,000+ database records, and responded to more than 6,000 fleet help desk requests. [172]

Electronic Warfare Tactical Information and Report Management System (ETIRMS). ETIRMS provides a wealth of Electronic Warfare information, in an easy-to-understand form, to both training and operational Tri-Service Aviation squadrons. ETIRMS is used by Fleet Intelligence Centers, Advanced Electronic Warfare Schools, and National Analysis Centers. WD teams have supported ETIRMS 24/7/365 throughout the OIF conflict. For example, during 2004, WD teams completed 5 builds, designed and implemented order of battle support, delivered 2 fielded releases, put together a successful proposal to build the EA-18G Mission Planner ($13 million dollar effort), and completed Software Requirements Review (SRR) for the EA-18G. In 2005 six major ETIRMS releases were delivered. [172]

E-2C. **Software Updates.** The Product Support Activity developed software for the aircraft's Mission Computer, supporting OIF. In 2004, the PSA delivered Block 2 software for the Mission Information and Software Transfer system (improving functionality for mission planning and reconstruction) and launched a SIPRNET website to support the reporting of problems and rapid distribution of software data-files to and from operating forces. [172]

ICAP-III Electronic Attack Aircraft. During 2004, ICAP-III provided a quantum leap in capability and effectiveness. The WD IPT provided crucial software build support and technical expertise during both Developmental and Operational Test phases. The IPT also provided vital software database support for the mission planning system (TEAMS V7/8), which included a critical library summary and post flight analysis tools. In 2005 three block development efforts were conducted and a special OFP was released to the Fleet in direct support of the war. Initial operational capability was achieved with the deployment of VAQ-139. In 2006, the ICAP III Block 2 was released to the Fleet. [172]

Award

In 2006, the EA-6B ICAP III and the EA-18G Tactical Aircraft Programs, as a result of their teamwork synergies were awarded the 2006 David Packard Excellence in Acquisition Award. This award recognizes exemplary innovation and best acquisition practices. [172]

Quick-Response

Intrepid Tiger Pod. A quick reaction capability program, the Intrepid Tiger Pod (CH-53E), was successfully completed at WD after only one year of development, test, and production efforts. This airborne communication Jammer pod is now being used in theater by the Marine Corps on F/A-18D and AV-8B platforms. In addition, during 2006, the WD Tiger Pod team collected air-to-air infrared signature measurements on various aircraft including the UC-35D, AH-1Z and UH-1Y and completed ground-to-air testing for the MV-22 for enhancing future countermeasure systems.

Award

Point Mugu team members were honored with the Edward Heinemann Award for design and modification.

Quick-Response

Jammer Technique Optimization (JATO). The JATO team continues to develop and deploy new EA-6B quick-response capabilities for combating the GWOT. The JATO team also provides detailed Jammer Technique Analysis and Tactics (JTATs) documents that provide technical guidance for optimum utilization of Electronic Attack weapon systems in Theater. In 2005 and 2006, numerous operational exercises were completed and new capabilities implemented. [172]

Award

JATO Team Plays Major Role in Counter Terror Success. The JATO Team at Point Mugu earned the Marine Corps' "Semper Fi" award for fielding an essential new jamming capability for the Marine Corps. The award states, "The JATO team designed, developed, tested, and fielded a unique and extremely critical electronic warfare capability that had an immediate and powerful impact on both the tactical situation on the ground and the overall strategic condition of the global war on terror." The team brings years of hands-on expertise to get the job done. In the Operator's Advisory Group (where the Fleet decides on their most important requirements), JATO is consistently ranked in the top five programs in importance. Although busy around the clock supporting EA-6B EA, the JATO team is also actively transitioning the jamming mission to the EA-18G Growler. [177]

Low Band Transmitter (LBT). In 2004 WDs IPT developed the software and hardware that increased jamming effectiveness. In 2005 the OFP team produced software for the ICAP II Block 3 Fleet release so support urgent fleet combat needs. [172]

Operational Flight Programs. In 2004, two OFPs for two separate weapon system versions of the EA-6B were released and added a significant signal processing enhancement for emitters. The detection and classification success rate increased to over 98%. In addition, the AEA/EA-6B IPT was chosen to provide engineering, and test and integration support for the EA-18G electronic attack system. The IPT was also selected to be the developer of the AEA Unique Planning Component (UPC) for the Navy Joint Mission Planning System (JMPS) that will support the EA-6B and EA-18G. As a result, the EA-18G Systems Integration Laboratory (SIL) was built at Point Mugu. [172]

Quick-Response

Also in 2004, in a quick response effort, a WD team installed the "Cobra Dos" software and hardware mods on more than 50 AH-1W helicopters, deployed to Afghanistan and Iraq, in less than one month. These dynamic Comm/Nav upgrades included installing a new OFP and a Night Targeting System pre-point switch modification which brought the fleet to a single hardware configuration, added close air support functionality; and improved navigation, target acquisition, mission planning and encryption. This intensive upgrade culminated a two-year software development.

Radar Warning Receiver – AN/ALR-67(V)2. Forward deployed RAAF combat troops needed immediate support for the (V)3 system. Multiple requests were received for UDF updates. Working with Raytheon, WD engineers immediately went to work on the AN/ALR-67(V)2 and generated UDFs in short order. [172]

Modeling and Simulation

TOPSCENE is a computerized mission rehearsal system that allows mission planners, aircrew, and ground crews, the ability to plan and rehearse a given mission on a 3D database prior to manning their aircraft or beginning troop movements. TOPSCENE provides 3D visualization of the battlespace, real-world imagery, high fidelity and accurately modeled three-dimensional tactical data for a realistic representation of the battlespace environment. With TOPSCENE the user can change environmental factors within the scene, display the Heads Up Display (HUD), attach a joystick controller, incorporate the Joint Mission Planning System (JMPS) as a moving map display, display a terrain grid, provide a playback function, display 3D models (aircraft, buildings, road signs, etc.), record rehearsals in .avi (movie) and .jpg (picture) formats, establish two point mensuration, and share scenes over LAN connections. TOPSCENE was the first of its kind and has provided a multitude of by-products ranging from scene generation engines, re-configurable trainers, to full up weapon system trainers, and a standardized multi-force database for use in many different imagery display tools. TOPSCENE is currently used by all four services and is deployed aboard all naval aircraft carriers, a few AMPHIB ships, and aboard most major air stations and forward deployed troops to Iraq and Afghanistan.

The TOPSCENE system has gone from a multi rack 1400 pound UNIX driven system, to a simple software module that can be stand alone or be integrated with the JMPS and is now able to function on a standard graphics laptop computer. The program has directly supported OEF, OIF, GWOT, and Operation Desert Storm. TOPSCENE has also supported other special events from providing homeport security planning to supporting the summer Olympic Games. Point Mugu has been the sole logistics and support activity for TOPSCENE. This includes R&D logistics, testing, documentation, and installation. [185]

Quick-Response

Responding to urgent warfighter requests, WD deployed TOPSCENE personnel to forward bases in Iraq and Afghanistan and aboard each of the naval vessels. Deployed personnel provided quick turnaround database updates making it possible to fly a SORTIE at 09:00, then brief for the 16:00 SORTIE showing the battle damage of preceding operation.

Direct Fleet Support

Quick-Response

In 2004, WD provided rapid-fire support for transporting MH-60R aircraft within a USAF C-141 to support Fleet exercises; provided major quick turnaround modifications of a P-3 bomb bay to support VX-20 and a federal intelligence agency; designed a ramp door restraint device for the CH-53E with completed units being sent directly to Iraq; conducted rapid design modifications of machine gun mounts for the CH-53E. WD installed several new avionic systems into two Special Project's P-3 supporting the War effort. Additional work involved the ALE-47, countermeasure dispensing system, the AAR-47 Missile Detection System and the IR Strobe. Engineers worked long hours including weekends and holidays to meet the schedule. [172]

Computer Aided Design (CAD). WD used several CAD software packages to design and develop prototypes through production (level 1, 2, & 3) drawing/data packages used to manufacture parts, modify aircraft, support flight clearance requirements and document changes to aircraft configuration. WD then produces documents, such as structural analyses, electrical load analyses, weight and balance analyses necessary to satisfy flight clearance requirements.

Fleet Weapons Support Teams (FWST). WD's FWST played a significant role in the success of deployed forces during OIF. Professionals ensured that weapons were capable of performing their mission. FWST representatives also provided essential real-time training to ordnance personnel and aircrews, as well as serving as the corporate connection back to weapons program managers who could identify and correct logistics deficiencies on the battlefield. [55]

Below, are a few examples of work conducted during OIF.

- **FWST. AIM-9X.** Conducted inspections and modifications to all AIM-9X and CATM-9X assets aboard several aircraft carriers.
- **Bombs/Weapons/Guns.** Tested and fixed hundreds of GBU-12 bombs, Sidewinder weapons systems, and AN/AWM-102/103 test sets at the Al-Asad Air Base in Iraq and provided depot level repair on the Intermediate Level 20mm Turret Test Console. Also fixed MK-122 safety switches.
- **Boresight.** Identified problems and an FWST member designed an Advanced Boresight that was so effective that it was approved and 40 units were delivered. In addition, the team member went on to lead a fabrication team and participated in several technical manual, hardware, and firmware reviews. The new design has increased Fleet utilization, improved alignment, and automatically calculates rocket launcher lug, HUD bolt, and shim adjustments.

- **Documentation.** The FWST provided updated versions of all gun, launcher, and rocket manuals to *USS Saipan's* Aviation Intermediate Maintenance Depot. They provided Support Equipment Change documentation for their common rack and launcher test sets. [55]
- **First Marine Expeditionary Force (IMEF).** FWST provided "in theater" weapons/weapons systems assistance, ashore and afloat, as well as supporting the Third Marine Aircraft Wing (3rd MAW). [55]
- **GBU-12 Crisis Response Team.** WD teams, working with the Joint Reserve Base (Dallas, Texas) and the Naval Air Station Lemoore tested and repaired hundreds of units which were then re-issued to the Fleet for training applications.

Quick-Response

Jams. Investigated problems on the AH-1 that was experiencing 20MM feed system jams. The problem was identified as an incorrect alignment to the feeder stripper. An FWST member designed a gauge to verify proper alignment. The quick response design was approved and 180 gauges were procured and delivered to Marine Squadrons.

- **JDAM.** WD's FWST assisted Marine Air Logistics Squadron Eleven (MALS-11) with buildup of Mk 83 bombs to JDAM units and assisted Carrier Air Wing Five (CVW-5) Ordnance regarding fuze function delay options for GBU-32/35. [55] In addition, FWST personnel were deployed on-board *USS Kitty Hawk* to provide training and support for CVW-5 during their initial JDAM captive flight training. [55]
- **JSOW.** The FWST assisted forward deployed forces with Airborne Weapons Bulletins (AWBs) concerning software configuration of certain weapons. [55]
- **Laser Guided Bomb (LGB).** The FWST assisted fixed-wing munitions personnel and aircraft operators in determining the cause of failure of several LGB weapons. [55]
- **LAU-116A/A Missile Launcher.** The FWST assisted MALS-31 with troubleshooting and repairing an electrical problem they encountered while conducting electrical checks on the Common Rack and Launcher Test Set (CRALTS). [55]
- **Sidewinder.** The FWST provided forward-deployed support on 32 AIM-9M Sidewinder missiles and technical assistance to Marine Aviation Logistics Squadron (MALS)-31 Ordnance personnel on implementing Air Weapons Bulletin (AWB)-405 on 13 Sidewinder missiles that they had received. The FWST assisted *USS Harry S. Truman* (CVN-75) in troubleshooting and fixing an F/A-18 AIM-9 squadron wing tip station problem. [55]
- **SLAM-ER.** In 2005-2006, teams continued work to complete the final test phase of a revolutionary capability for prosecuting a moving target using data-linked information while exploiting the SLAM-ERs tremendous standoff range. In 2005, twelve captive flights were conducted, three of which used an Air Force JSTARS aircraft as the targeting platform. WD upgraded missile software in 3 SLAM-ER missiles aboard three participating aircraft carriers. Part of Operation Valiant Shield. [172]
- ***USS Nimitz.*** China Lake engineers traveled to *USS Nimitz* during a Composite Training Unit Exercise on the Sea Range, part of final preparation of the *Nimitz* for the Persian Gulf. Engineers trained operators to develop target packages on the Precision Targeting Workstation and pass them to the Digital Camera Receiving System. From there, the packages can be sent to airborne F/A-18s equipped with the Fast Tactical Imagery (FTI) system. Engineers also investigated problems with the FTI link between the ship and the aircraft. Engineers fixed the problem, allowing voice and imagery transmissions and generated a user's manual for the staff. [55]

Warfighter Response Center (WRC) Links Warfighters to Engineers. During OIF WD's WRC was manned 24/7 resolving difficult issues for warfighters from the Navy, Marine Corps, Army and Air Force. WRC has four SIPRNET terminals with secure e-mail and VTC services and full support for recall, logistic, and deployment of reservists. The WRC also teamed up with NAVSEA for expanded services. As part of NAVAIR's response network, the WRC helped with questions or data calls on OEF and Operation Noble Eagle. The WRC is linked to the Force Protection Condition command and control and the Emergency Operation Center. Fleet help desks and call centers are at NAVAIR's national level of attention and are directly linked to the Navy's Integrated Call Center located in Norfolk, Virginia.

Quick-Response

For example, an Air Force pilot experienced some problems dropping a particular weapon in theater. Within hours, WD engineers were testing the proposed solution on the Land Range. By the end of the same day, the fix was on its way to Iraq.

Just before the conflict in Iraq began, pilots flying over Baghdad observed oil-filled ditches all around the city and were concerned that if the oil was ignited, the smoke would affect the accuracy of the precision laser-guided munitions they were going to use. Before the day was out, WD engineers had consulted their subject matter experts, developed tactics for weapons employment, and had the solution to pilots in theater.

Quick-Response

Another call came from an Air Force pilot who experienced problems dropping a particular weapon in theater. WD engineers were contacted via our neighbor, Edwards Air Force Base, requesting a software update for that weapon. Again, WD was able to identify the problem and come up with a solution that was tested on the Land Range to make sure it worked. In short, in a little more than a 24-hour period, WD identified and fixed the problem, tested it, and had the new fix in theater for the pilots to use. [55]

WRC Provides Direct OIF Support. The WRC manages the combat deployment of two NAVAIR prototype systems: the Tactical Dissemination Module/ Rapid Precision Targeting System (TDM/RPTS), and the Digital Precision Strike Suite (DPSS).

Quick-Response

The forward-deployed WD team, civilian and contractors, transported and set-up the TDM/RPTS system at Prince Sultan AFB Saudi Arabia and Ali Al Salem Kuwait. The WD team quickly integrated the system into the Combined Air Operations Center and it became operational in just one month.

WRC coordinated TDM training, provided pre-deployment protective uniforms and gear, and assisted with medical screening/vaccination/prescriptions to meet CENTCOM-specific requirements. During OIF TDM/RPTS successfully executed more than 1,000 combat missions to multiple aircraft. The WRC has also conducted more than 300 Situational Awareness (SA) missions, providing ground forces with SA imagery products to identify and locate improvised explosive devices.

The DPSS system was also in direct response to warfighter needs generating targeting quality coordinates. The United States Joint Forces Command partnered with WD to refine this existing capability and formalize DPSS training for all Joint Terminal Attack Controllers (JTACs). DPSS is currently fielded in numerous warfighter units, including SEAL teams on both coasts, the 720th Special Tactics Group (AFSOC), West Coast Marine Units (IMEF), and selected U.S. Army Special Forces.[168]

Weapons Loading Standardization Team (WLST). Throughout OIF the WLST has provided direct support to the Fleet. For example, in 2005, the team issued 45 Interim Rapid Action Changes (IRAC) and subsequently incorporated 35 of these into formal updates to publications. Reviewed, researched, and answered 121 Technical Publication Deficiency Reports. Overall in this one year they updated more than 221 publications. In 2006 the WLST completed testing, validation, verification, and production of high priority ALE-47 system upgrades to deploying helicopters supporting OIF. [172]

Awards

Warfighter awards were given in 2005 to a diverse number of teams representing the Hellfire missile, the Machine Shop, ordnance and project support groups, the Supersonic Naval Ordnance Research Track (SNORT), DPSS/PSS-SOF, TDM, and WRC. [172]

Testimonials –VIP Involvement and Quick-Response

An Air Force pilot experienced some problems dropping a weapon in theater. Within hours WD engineers were testing a proposed solution on the Land Range. That same day, the fix was on its way. "And as F-16s flying missions in OIF were having problems delivering their munitions, experts at Hill AFB, Utah; Edwards AFB; and China Lake, worked together and found a fix an amazing 30 hours later. That's the kind of warfighter support our Air Force wants, needs, and continues to get."

—General Greg Martin
Commander, Air Force Reserve Command
Wright Patterson AFB, Ohio

In 2005 the WRC classified portal received more than 75,000 visits from more than 12,000 customers and the unclassified portal received 225,000 visits from 90,000 customers. [172]

Weapons Loading Standardization Team (WLST). In 2004 WD completed testing, validation/verification, and production of high priority ALE-47 system upgrades to deploying helicopters supporting OIF. This evolution was started and completed for AH-1, UH-1, CH-53, and CH-46 in less than 6 weeks from start to furnishing production checklists to the deploying units. C-130 was also done later in the year for the same upgrade to ALE-47.

Special Weapons and Projects

Library—Technical Library Provides Warfighter Support. The Library serves the warfighter in combat regions and aboard ship. For example, a request was sent to the Library by a USMC Cobra squadron based in Iraq. Critical software documentation was necessary for flight clearance. The Library used its extensive resources and provided the documentation quickly. The Library was called upon by sailors onboard ship in the Persian Gulf and the Mediterranean for numerous requirements, including software, instructions, and handbooks.

In 2006, the library provided 1,865 individually tailored current awareness "alerts," keeping analysts, scientists, and engineers regularly informed of news and literature updates in their specific fields of interest. [172]

Presidential Helicopter – HMX-1. A WD specialized workforce provides aircraft structural modification and reconfiguration services for the HMX-1. These multi-trade artisans are skilled at problem solving and can design and build hardware in a way that expedites normal design and production processes. During 2004, the shop continued support for the HMX-1 Presidential Squadron to maintain a fleet of nine Versatile Huffer Units (VHU). This unit provides the H-60 Presidential Helicopter with more versatile starting capability. VHU Units were also fabricated and assembled for the Arm Special 160th OPS, Fort Campbell. It involved retrofitting old units to fully functional units supporting the Army's Special Operations immediate need supporting OIF. In addition, WD provided a major fabrication role in modification and prototype install of the NSH-60F Presidential test bed platform, and conducted a major modification on an H-3 engine exhaust Nacelle Mod, T-58 Engine prototype design and install. (Photo reference [199])

White House photo by Susan Sterner

WD WEAPONS

Table of WD-Influenced Weapons in Conflict

During every major U.S. military crisis since WWII, RDT&E work at China Lake and Point Mugu, has played a significant role: developing and testing weapons and systems that work!

✓ = Active Fleet Inventory
◯ = Used in Combat

	Iraqi Freedom (2003-Present)	Enduring Freedom (2001-Present)	Kosovo (1999)	Desert Fox (1998)	Bosnian Conflict (1992-1995)	Desert Storm (1991)	Vietnam Conflict (1956-1975)	Korean War (1950-1953)	World War II (1941-1945)
AMRAAM	✓	✓	◯	◯	◯	✓			
ASROC / VLA	✓	✓	✓	✓	✓	✓	✓		
Atomic Weapon Non-nuclear components									◯
FAE	✓	✓	✓	✓	✓	◯	◯		
Fleet Ballistic Missiles	✓	✓	✓	✓	✓	✓	✓		
Gator		✓	✓	◯	✓	◯			
General Purpose Bombs	◯	◯	◯	◯	◯	◯	◯	◯	◯
HARM	◯	◯	◯	◯	◯	◯			
Harpoon, SLAM, SLAM-ER	◯	◯	◯	✓	✓	◯			
Hellfire	◯	◯	◯	◯	◯	◯			
JDAM	◯	◯	◯						
JSOW	◯	◯	✓	✓					
Laser Guided Bombs	◯	◯	◯	◯	◯	◯	◯		
Maverick	◯	◯	◯	◯	◯	◯	◯		
Phalanx	✓	✓	✓	✓	✓	✓			
Phoenix	✓	✓	✓	✓	✓	✓			
Rockets	◯	◯	◯	◯	◯	◯	◯	◯	◯
RAM	✓	✓	✓	✓	✓				
Shrike	✓	✓	✓	✓	✓	◯	◯		
Sidewinder	✓	✓	✓	✓	◯	◯	◯		
Skipper						◯			
Sparrow, Sea Sparrow, ESSM	✓	✓	✓	◯	✓	◯	◯		
Standard Missile	✓	✓	✓	✓	✓	✓	◯		
Tomahawk	◯	◯	◯	◯	◯	◯			
Walleye	✓	✓	✓	✓	✓	◯	◯		

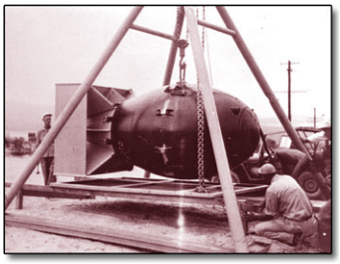
NOTE: Middle East and Falklands, Iran/Iraq War, Cuban Missile Crisis - Although direct combat involvement by U.S. Navy forces was either minimal or advisory, many of the weapons and systems developed and tested by China Lake and Point Mugu and deployed by the Fleet were used as deterrents during these conflicts. [11]

WD-INFLUENCED WEAPONS

AMRAAM. The AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM) is an all-weather, beyond-visual-range, supersonic aerial-intercept guided missile that uses active radar target tracking and target detection and proportional navigation guidance. During Operation Iraqi Freedom, Point Mugu teams reprogrammed AMRAAMs with updated software.

ASROC. The Antisubmarine Rocket (ASROC) is a quick-reaction, all-weather, intermediate-range, Antisubmarine Warfare (ASW) weapon launched from surface ships. ASROC consists of a torpedo, a double-base propellant rocket motor, an ignition separation assembly, and a dome-shaped plastic nose cap that protects the torpedo's transducer assembly as the weapon enters the water.

Vertical Launch ASROC (VLA) is an improved rocket-propelled, ASW weapon designed for deployment on ships equipped with the Mk 41 Vertical Launching System. In 1978, a major milestone was achieved at China Lake when the first vertically-launch-controlled ASROC airframe was launched from a prototype of the Mk 41 Vertical Launching System. Several years later the formal VLA Development Program was initiated, and VLA missiles were introduced into the Fleet in March 1993.



Atomic Weapons. Of all the "weapons that win wars," the ones that can best lay claim to this title are the first atomic bombs, Fat Man and Little Boy, which ended World War II. China Lake was a major contributor to the success of those weapons. An atomic bomb is essentially a conventional bomb with a nuclear core. The China Lake/California Institute of Technology (Caltech) Team, experts at conventional explosives, was tasked to develop the non-nuclear explosive components of the atomic bomb.

FAE. Fuel air explosives (FAE) weapons use an explosive charge to disperse liquid fuel into the air, which creates an aerosol fuel/air cloud. When the cloud reaches an optimized mixture, it is ignited by a detonator, creating a shock wave front that is useful against soft targets such as minefields, personnel, aircraft in the open, and bunkers. FAE has also been used for creating clearings in forests and jungles. Since 1960, China Lake has developed FAE weapons and devices, including two 550-pound weapons, the CBU-55 and CBU-72 cluster bombs, both containing three FAE submunitions loaded with ethylene oxide liquid fuel.

Fleet Ballistic Missiles. Fleet ballistic missiles are large, long-range, submarine-launched missiles equipped with nuclear warheads. Although never fired in combat during more than 40 years of service, Fleet ballistic missiles have played a central role in the U.S. policy of strategic deterrence. China Lake's work on, Polaris, Poseidon, and Trident have advanced the state of the art in thrust-vector-control systems, propellant efficiency and safety, and large rocket-motor technology. Work has included basic research, engineering and advanced-development efforts, support for operational systems, and technical advice. China Lake's greatest efforts have been in propellant hazard evaluation and aging characterization, as well as testing and evaluating propulsion systems. The early China Lake studies had a profound effect in shaping the country's strategic deterrence policies, which contributed to international stability. In November 2003 WD was given a Trident Command Flag commemorating the 20th anniversary of Trident I missile launches at Point Mugu.

Gator. Gator is an aircraft delivered, unguided, target-actuated triservice anti-personnel and anti-tank munitions (land-mine) delivery system. It is used primarily against area targets such as tanks, armored vehicles, trucks, radar installations, surface-to-air-missile (SAM) sites, parked aircraft, and other materiel. The Gator system was originally developed by China Lake as part of the "eye" series of free-fall weapons.

The free-fall weapon program was initiated at China Lake in 1959 to develop new free-fall bombs and systems that would improve the Navy's air-attack.

General Purpose Bombs. The Mk 80 weapons are air-to-surface, free-fall, non-guided, general purpose (GP) bombs, including the 250-pound (Mk 81), 500-pound (Mk 82), 1,000-pound (Mk 83), and 2,000-pound (Mk 84) versions. The Mk 80 series was developed in the 1950s in response to the need for bombs possessing less aerodynamic drag, for operation on jet aircraft. Bombs are fitted with either a nose or tail fuze to meet specific tactical needs such as fragmentation, blast, cratering, or penetration. They can also be used for land or sea mines. Later versions, including the Mk 82/83/84, can be modified with a high drag tail assembly for low-altitude delivery. China Lake and Point Mugu have been actively involved with RDT&E of bombs since WWII.

HARM. The High-Speed Antiradiation Missile (HARM) is an air-to-surface guided missile used to seek out and destroy enemy radar systems. HARM was conceived at China Lake and became a joint Navy-Air Force project. China Lake pioneered antiradar (passive RF) guidance for the Shrike missile, which evolved into HARM to meet Fleet needs for a wide-frequency coverage high-speed anti-radiation missile. The basic overall design, including seeker, warhead, and fuze, were developed at China Lake, which also developed a procurement package for a second-source competition. China Lake, as lead laboratory, provided technical management to prove the concept and to establish feasible performance specifications. During Operation Iraqi Freedom, Point Mugu responded to more than 100 Fleet requests concerning EW data, and generated electronic intelligence files enabling HARMs to defeat new threat radars.

Harpoon. The AGM/RGM/UGM-84 Harpoon is an autonomous, all-weather, over-the-horizon, antiship missile system providing the Navy and Air Force with a common missile for air, ship, and submarine launches. Developed in the early 1970s, Harpoon is one of the most widely exported Navy weapon systems, with more than 30 nations fielding the system. The first missile was delivered in November 1988, and was test fired at Point Mugu.

SLAM. In the late 1980s, the Navy needed a land-attack missile. Rather than design one from scratch, the Navy took everything from Harpoon except the guidance and seeker sections, added a GPS receiver, a Walleye optical guidance system, and a Maverick data-link to create SLAM. SLAM is an intermediate-range system, effective against high-value land targets and ships in port.

SLAM-ER. SLAM-ER is a significant improvement over SLAM. It is a day/night, adverse-weather, over-the-horizon, precision strike missile addressing the Navy's requirements for a precision-guided Standoff Outside of Area Defense weapon.

Hellfire. The helicopter launched AGM-114 Hellfire missile is an air-to-ground missile that provides heavy antiarmor capability to attack helicopters. The first three generations of Hellfire use a laser seeker. The fourth generation, Longbow Hellfire, uses a radar frequency seeker. The first generation Hellfire was the main armament of the Army's AH-64 Apache. The second and third generations of Hellfire, the AGM-114B/K, are the main armament of the Marine Corps' AH-1W Super Cobra. Laser Hellfire homes on a laser spot that can be projected from ground forces, other aircraft, or the launch aircraft itself, enabling the system to be used in a variety of modes. Hellfire is effective against armored vehicles and concrete bunkers. During 2000-2001, WD provided systems engineering support and testing. Tests included developmental, insensitive munitions, safety and safe-separation, flight, and warhead performance. WD also investigated fixed-wing requirements, used advanced simulations to study proposed concepts, and provided survivability assessments and personnel training. In support of Operation Iraqi Freedom, WD also designed, developed, and built a new metal augmented charge (MAC) warhead for the Hellfire Missile that went from development to deployment in less than a year. The effects were formidable.

JDAM. The Joint Direct Attack Munition (JDAM) is a low-cost, inertial guidance kit that is attached to an unguided free-fall bomb, converting it to an accurately guided "smart" weapon. This strap-on Global Positioning System (GPS)/inertial navigation system (INS) guidance kit improves the accuracy of general-purpose bombs. JDAM was developed to meet the need for an adverse-weather, accurate-strike capability in response to lessons learned during Desert Storm. JDAM is a joint Air Force/Navy weapon system. The Air Force serves as the

lead, and WD serves as the Navy's technical agent for JDAM. WD provides Fleet technical support as well as support for contractor testing, mission planning and development, and logistics.

JSOW. The Joint Stand-Off Weapon (JSOW) is an air-to-surface, unpowered, guided glide weapon. JSOW is a launch-and-leave weapon that uses GPS/INS and is capable of day/night and adverse weather operations. Aircrews have the ability to attack multiple targets in a single sortie. JSOW is delivered in three variants: baseline, antiarmor, and unitary (penetrator). WD played a significant role in the successful delivery of the first JSOW, overseeing development and preparing the Fleet for its introduction. The first flight test took place in December 1994 from an F/A-18C Hornet at China Lake. JSOW is a joint Navy-Air Force weapon program, with the Navy as the lead service. WD is the Navy's Technical Agent for joint development.

Laser Guided Bombs. Laser guided bombs (LGBs) are air-to-surface general-purpose bombs modified with laser-guidance kits. LGBs are used for precision attacks on surface targets. An airborne or surface designator illuminates or "tags" the target with a laser, and the weapon homes in on the reflected laser energy. LGBs are excellent performers in dive deliveries from medium altitudes. Laser guided technology has greatly enhanced the effectiveness of general purpose bombs. For example, in WWII it would take thousands of bombs to hit a target the size of an aircraft shelter. In Vietnam, 300. Today, it can be done with one laser guided bomb. WD continues its role as the Navy production and in-service engineering agent for Laser Guided Bombs.

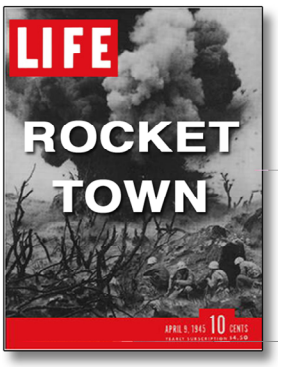
Maverick. Maverick is an air-to-surface tactical missile designed for close air support, interdiction, and defense suppression. It provides stand-off capability and high probability of kill against a wide variety of tactical targets, including air defenses, ships, ground transportation, armor, and fuel storage facilities. Guidance systems used by Maverick include infrared, laser and TV. Maverick is exported to more than 25 countries. Maverick was originally developed for the Air Force beginning in the mid 1960s, and the first deliveries were made in 1972. Subsequently, China Lake became heavily involved in modifications and refinements to the system.

Phalanx. The Mk 15 Phalanx Close-In Weapon System (CIWS) is a fast-reaction, computer-controlled rapid-fire 20-millimeter gun system providing U.S. Navy ships with a terminal defense against antiship missiles that have penetrated other Fleet defenses. It is designed to engage antiship cruise missiles and fixed-wing aircraft at short range. with integrated forward-looking infrared (FLIR), Phalanx automatically performs search, detecting, tracking, threat evaluation, firing, and kill assessments of targets. WD's involvement with Phalanx has been in the area of test and evaluation. Phalanx has tested on the Land Range since the late 1970s.

Phoenix. Phoenix is a long-range, all-weather, radar-guided air-to-air missile carried on the Grumman F-14 Tomcat. Phoenix, the Navy's only long-range air-to-air missile, is mated with either the AWG-9 or AWG-17 radar/fire-control system, which can track up to six Phoenix missiles fired against separate targets simultaneously. The improved Phoenix, the AIM-54C, was designed to counter projected threat tactical aircraft and cruise missiles. WD's involvement with Phoenix has been in the area of test and evaluation and extensive technical and design support. Point Mugu's F-14 Weapons Systems Integration Laboratory supports software and avionics integration for the F-14 Tomcat and Phoenix missile systems.

RAM. The RIM-116A Rolling Airframe Missile (RAM) is a lightweight quick-reaction high-fire-power surface-to-air weapon designed to counter antiship missiles. There are more than 100,000 in the world's inventory today. RAM is a joint U.S. and German venture to design an effective, low-cost, ship self-defense system. RAM is a 5-inch passive dual-mode radio frequency (RF) and infrared (IR) fire-and-forget missile that uses Sidewinder technology for the warhead and rocket motor. Because of its high-tech guidance system, RAM requires no shipboard support after the missile is launched. RAM is effective against a wide spectrum of threats and it supplements Phalanx and SeaSparrow in the ship's defensive arsenal. RAM is currently installed, or

planned for installation, on more than 80 U.S. Navy, 28 German Navy, and three Korean ships. China Lake was the U.S. government's lead technical agent for the development of the RAM. Initial development began in 1974, and production was initiated in 1987.



Rockets. Rockets are air- and surface-launched, unguided, rocket-propelled ballistic trajectory weapons. In 1941, Pearl Harbor drove home a hard lesson in naval air strike warfare: there was a great need for superior aircraft weapons. China Lake (then known as the Naval Ordnance Test Station (NOTS)) was established as a proving ground for developmental rockets. Early rockets developed by the California Institute of Technology (Caltech)/China Lake team included the 2.75-, 3.5-, and 5.0-inch aircraft rockets; the 5.0-inch High-Velocity Aircraft Rocket (HVAR) Holy Moses; and the 11.75-inch Tiny Tim. The 3.5-inch fixed-fin rocket was the first forward-firing aircraft rocket used by American troops during World War II. Early rocket work laid the foundation for China Lake's later efforts in rockets, missiles, propellants, warheads, launchers, and fire-control systems. By the end of World War II, China Lake/NOTS had conducted more than 1,000 projects, and the base was well on its way to becoming the largest Navy-built, Navy-managed community. It had emerged as the Navy's lead laboratory, with the most completely instrumented ranges in the nation for rocket and midrange, guided-missile testing.

Shrike. AGM-45 Shrike is a passive-homing air-to-ground missile whose mission is to home on and destroy radar transmitters used by the enemy to direct ground antiaircraft batteries and surface-to-air missiles. Shrike was the first missile to be mass-produced specifically for the U.S. antiradar mission. Shrike-On-Board was a quick-reaction program during Vietnam to put Shrike on destroyers. Beginning in 1958, China Lake conceived, developed, and tested Shrike, the world's first successful antiradar missile, as a direct response to Fleet needs. China Lake pioneered antiradar (passive RF) guidance for Shrike, the High-Speed Antiradiation Missile (HARM), and the Advanced Antiradiation Guided Missile (AARGM). China Lake first developed Shrike, which begat HARM.

Sidewinder. Sidewinder is a supersonic, heat-seeking, air-to-air, guided missile carried by fighter aircraft. It has a high-explosive warhead and a passive infrared guidance system. It is carried by many types of aircraft, both fixed wing and helicopters. With more than 200,000 produced for 46 nations excluding the U.S., the AIM-9 is one of the oldest, least expensive, and most successful missiles in the entire U.S. weapons inventory. China Lake conceived, designed, and developed the Sidewinder in the early 1950s. For the AIM-9M, WD serves as the design agent, providing production support, data management, design changes, modeling and simulation, and logistics. For the AIM-9X, WD is providing system engineering, system performance specifications, threat models and analysis, developmental testing, signal processor in the loop (SPIL) facility, and logistics.

Skipper. The AGM-123 Skipper II is a short-range precision-attack missile, consisting of a modified Paveway II laser guidance system and a Mk 78 Shrike motor attached to a Mk 83 1,000-pound general-purpose bomb. It is a standoff antiship missile based on existing missile and bomb components. The rocket motor was derived from the AGM-45 Shrike antiradar missile. China Lake designed and developed Skipper II as a powerful modification to the Paveway II family of guided bombs.

Sparrow. The AIM/RIM-7 Sparrow is a highly maneuverable, medium-range, semi-active, air-to-air (AIM-7), and surface-to-air (RIM-7) missile. Sparrow is controlled by four delta wings and propelled by a dual-thrust solid-propellant rocket motor. In air-intercept applications, the launch aircraft illuminates the target with its radar throughout the missile's flight, as does the ship in a surface-launch engagement. At intercept, an active radio-frequency fuze detonates the high-explosive warhead. Sparrow is an all-weather missile that can attack high-performance aircraft and missiles. Sparrow I began in 1946 and made the first U.S. kill of an airborne target in 1952 at Point Mugu.

SeaSparrow. The SeaSparrow surface-to-air missile system can destroy hostile aircraft and antiship missiles. The first Sea Sparrow shipboard launch took place in 1972. A vertical-launch system was tested in 1981, and SeaSparrow RIM-7M, along with the AIM-7M Air Sparrow, entered service in 1983. The AIM/RIM-7M missile upgrade (from the AIM-7F) has an inverse monopulse semiactive radar

seeker, improved electronic counter-countermeasures, digital microprocessing, a new warhead, and active radar fuze. AIM/RIM-7P began development in 1987, and deliveries of the –7P missile began in 1991. The –7P has a low-altitude guidance system that is effective against very low sea-skimming cruise missiles.

Evolved SeaSparrow Missile (ESSM). By 1995 the Engineering and Manufacturing Development of the ESSM had begun. The RIM-162 is a kinematic improvement to the RIM-7 SeaSparrow missile with a primary mission of destroying low altitude highly maneuverable anti-ship cruise missiles. The missile incorporates the use of midcourse data links in order to provide ship based corrections during flight. The ESSM is an international, cooperative, major upgrade of the RIM-7 NATO SeaSparrow missile. During 2000 and 2003, WD completed development and operational testing of the ESSM, supported transition to low-rate initial production, and assisted in developing a six-degree-of-freedom simulation model. WD has provided Sparrow technical support to 20 countries through the years.

Standard Missile. Standard Missile (SM) is the Navy's primary surface-to-air Fleet defense weapon and is widely deployed on Navy ships. It is the descendant of an earlier missile project known as "Bumblebee," which included Terrier, Tartar, Talos, and Typhon. The newer SM concept minimized compatibility changes and was modular in design for ease of upgrade. SM, one of the most reliable weapons in the Navy's inventory, began development in 1964, entered service in 1968, and has steadily evolved. The three main sub-types include SM-1, Standard ARM, and SM-2. China Lake was both the design agent and technical direction agent for all SM fuzing (TDD, S-A device, and fuze contact device) and portions of the flight-termination system in the SM-1 and SM-2.

The China Lake-developed Mk 45 TDD for SM is considered by many to be the world's premier missile fuze.

WD is the technical direction agent of NAVSEA for the Mk 45 Mods 9, 10, and 14 TDDs and the technical direction and design agent for the S-A device, arming-firing device, and fuze contact device. WD will aid in development planning and contract formulation for the SM-6 program, scheduled to begin in 2004.

Tomahawk. Tomahawk is a long-range, surface-to-surface, guided, subsonic cruise missile used for land attack from submarines, and surface ships. Tomahawk flies at extremely low altitudes at high sub-sonic speeds and over evasive routes for increased survivability. Targets are often high-value land assets in high-threat areas. Radar detection of the Tomahawk is difficult because of the missile's low radar cross-section and low-altitude flight. Infrared detection is difficult because the turbofan engine emits little heat. Tomahawk has inertial and terrain contour-matching radar guidance that uses a stored map reference on board to compare with the actual terrain to determine the missile's position. Surface-launched cruise missile development began in 1972. Tomahawk's first developmental flight tests and simulations were conducted at Point Mugu in the mid 1970s, and in 1978 the first submarine launch was made off Point Mugu. Tomahawk Initial Operating Capability came in 1983. During 2000 and 2001, WD supported three major efforts, including the Penetrator Variant for deep targets, Tactical Tomahawk, and Block II/III.

China Lake is the Navy's Principal Support Activity for the Tomahawk, the Acquisition Engineering Agent for the all-up round, the Software Engineering Agent and the Engineering Design Agent for the Tactical Tomahawk Penetrator Variant Warhead.

Walleye. The AGM-62 Walleye is a precision-guided (television) air-to-surface glide weapon. It is used primarily against targets such as fuel tanks, tunnels, bridges, radar sites, port facilities, and ammunition depots. Walleye I and II are linear shaped charge warheads fitted with a TV seeker head, a set of aerodynamic control surfaces, and a tail-mounted datalink. The weapon has evolved into numerous versions, including the original Walleye I Extended Range Data Link (ERDL), Walleye II, and the Walleye II ERDL. China Lake conceived, designed, developed, and tested Walleye—the first precision-guided air-to-surface weapon. China Lake was the lead laboratory for the entire development, from concept to production.

FLEET PROGRESS ON MANY FRONTS

FUTURE WARS – FUTURE WEAPONS

Future Ordnance Systems

WD is now working on the weapons of tomorrow. Future ordnance systems will include improved reactive composite cases and impulsive energy weapons with flux compression, very high velocity directional fragments, and electromagnetic pulse (EMP). New explosive fills in development contain reactive metal enhancement, super brisant, and thermobaric qualities; and directional, super/hyper sonic, and mission responsive weapons are also in development. Conventional improvements will involve internal blast, battle damage assessment (BDA), initiation systems, multi-mode, miniature ESAD, sensors, submunition dispensing, penetration materials, and pyrophoric/fire start. Ordnance effectiveness will be enhanced via predictive model simulation and thermobaric modeling. Aircraft, guns, and ammunition of the future will include lead-free, medium-caliber ammunition primers and heat and water resistant "green" gun barrels. Aqueous based parts cleaning solvents will be used to meet modern environmental regulations.

High-Speed Weapons. High-speed supersonic and hypersonic weapons can provide dramatic improvements in platform and weapons survivability and in the ability to engage time-critical targets, and to penetrate hardened and deeply buried targets. WD has conducted extensive work in the enabling technologies required to make such weapons a reality, including efforts in advanced airbreathing propulsion systems, blended body airframes, high-temperature materials, and ordnance package concepts. Programs are under way to demonstrate these technologies in flight testing.

CNO NAVAL POWER 21. FUTURE GOALS AND NAVAIR WD ACHIEVEMENTS

The Chief of Naval Operations (CNO) has outlined his operational vision for the 21st century in his plan, "Sea-Power 21: Sea Strike, Sea Shield, and Sea Basing." NAVAIR will serve as the lead Systems Command for Sea Strike. Key areas include persistent Intelligence, Surveillance, and Reconnaissance (ISR); time sensitive strike; information operations; and ship-to-objective maneuvers. Below are a few examples of how NAVAIR WD is meeting the challenge.

CNO Goal: Acquire mobile targets more quickly and deliver an increasingly persistent and decisive volume of timely fire. In partnership with the Defense Advanced Research Projects Agency (DARPA), Office of Naval Research (ONR), and National Aeronautics and Space Administration (NASA), NAVAIR WD has conducted ground tests of full-scale ramjet engines for supersonic strike weapons. WD has established partnerships with Lockheed Martin in a Solid Fuel Ramjet Technology prototype for hypersonic strike weapons. In the area of guidance and control WD has directly supported Tactical Tomahawk (TACTOM), Tactical Dissemination Module (TDM), Digital Precision Strike Suite (DPSS), rapid precision targeting, Advanced Antiradiation Guided Missile (AARGM), Quick Bolt, and HARM Precision Navigation Upgrade (PNU) first flights, in addition to JSOW-C Unitary sled tests for deeply buried target destruction. WD is also developing and evaluating concepts for directed energy weapons, including high-power microwave (HPM) weapons and high-energy lasers.

CNO Goal: Develop unmanned platforms for combat and reconnaissance in the air. In partnership with Northrop Grumman, WD has conducted the first flight of the Fire Scout UAV. In addition, WD has sup-ported high-speed taxi and first flight tests of Northrop Grumman's X-47A Pegasus naval unmanned combat air vehicle (UCAV-N). WD also tested the weaponization of Predator for Operation Enduring Freedom.

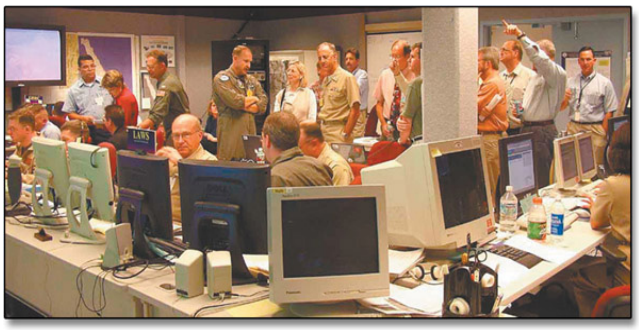
Autonomous Operations

CNO Goal: Sea Shield—Develop defenses against ballistic and cruise missiles. As the acquisition engineering agent for RAM, NAVAIR is developing afloat weapons. WD provided highly successful command-and-control and imagery support that resulted in a critical milestone in delivering a ballistic missile defense capability to the Fleet. NAVAIR's VX-30 provided testing support. In October 2002 NAVAIR WD successfully demonstrated a composite case solid rocket motor in support of the Missile Defense Agency's (MDA) kinetic-energy boost-phase intercept program. MDA has requested that NAVAIR be the flight-safety authority for launches from the Kodiak Launch Complex. In 2002 five Aegis ships fired on a single MA-31 precision guided target, the most surface combatants ever lined up to shoot at a supersonic skimming target. NAVAIR ranges supported the tests that made this possible.

CNO Goal: Develop better defense against small boats. WD is currently developing a concept for a small, low-cost, shoulder-launched, fire-and-forget missile called Spike. Spike will service the critical firepower needs of the U.S. Marine Corps and the Special Warfare community, and has application to the CNO's goal of developing better defense against small boats.

CNO Goal: Extend the persistence and staying power of our forward-deployed naval force. NAVAIR currently has TDM personnel in theater to provide advanced ground-to-air data links in support of Operation Enduring Freedom. In addition, NAVAIR's Engineering and Fleet Weapons Support Teams (FWSTs) are providing worldwide, on-site technical and training assistance to operational forces both ashore and afloat. Though it may be relatively invisible, WD developed technology that is helping to keep our ships at sea. Calcification-prevention tablets reduce calcium build-up in ship plumbing thereby reducing maintenance time and cost.

CNO Goal: Put intelligence, surveillance, and reconnaissance systems into one network. During Millennium Challenge 2002, DARPA developed unattended ground sensors at Superior Valley relayed intelligence on tracked vehicle traffic to a Predator UAV, which transmitted the data to the Strike Warfare Command Center at China Lake. From that location, the Carrier Air Wing Commander controlled Tactical Aircraft strikes using developmental systems that synthesize intelligence feeds. This revolutionary capability provided the commander with the common operational picture, enabling real-time re-tasking of airborne assets. Throughout this exercise, NAVAIR ranges were networked with other Army, Air Force, and Marine ranges. As a result of these successful efforts, the Joint Forces Command (JFCOM) designated NAVAIR Point Mugu as the Joint National Training Center (JNTC) regional hub for future joint experimentation.[38]



JOINT SERVICE

Teamwork is the cornerstone of NAVAIR's success. Each and every activity that China Lake and Point Mugu participate in—every test event, training mission, and laboratory experiment—is a team effort. Teamwork binds together the network of highly trained scientific, technical, and administrative personnel (military, civilian, and contractor) who carry out the NAVAIR mission.

Teamwork extends far beyond the geographic and organizational borders of NAVAIR. Customers from throughout the Navy bring their problems to China Lake and Point Mugu, expecting and finding the solutions that help to make the Navy the central element of the national defense structure.

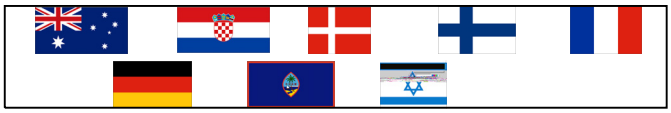
And teamwork reaches across service boundaries to the Marine Corps, Army, Air Force, Coast Guard, and Homeland Defense Department. NAVAIR is at the forefront of joint-service activity: joint training, joint testing, joint experimentation, joint research, joint development, and joint acquisition.

Among the many joint ventures on which China Lake and Point Mugu have embarked with the sister services is establishment of a Warfare Response Network and a Homeland Defense Response Team. NAVAIR's western-most bases have made major developmental, test, and training contributions to the Department of Defense's (DOD) top weapon systems. The Land Range, Sea Range, and Electronic Combat Range (ECR) have hosted virtually every combatant aircraft in the DOD inventory, ranging from Air Force fighters and bombers and Army helicopters to developmental aircraft (e.g., the F-22 and Joint Strike Fighter (JSF) to joint-service UAVs). Special Forces units have roamed the deserts hills of Superior Valley, and Marine light armored vehicles have raced across the dry flats of Airport Lake during live-fire exercises. The ranges and laboratories have played principal roles in the Nation's largest joint-service battle experiments, and Point Mugu has been selected as the site of the U.S. Joint Forces Command's Regional Joint National Training Center.

Joint Activities/Partnerships

For a complete list of our partners including the Marine Corps, Air Force, Army, Coast Guard, other DOD agencies, international partners, industry partners, and educational institutions, please see *Joint Activities/Partnerships* in the index.

INTERNATIONAL SERVICE



The country's international partners benefit from the same principle of teamwork. The first Tomahawk firing from a British submarine took place on the Sea Range, and the Japanese Defense Force conducts annual training and missile-development exercises there. The Italian Air Force trains with HARM on the Land Range, and the Royal Danish Navy has participated in Evolved SeaSparrow Missile (ESSM) launches on the NAVAIR Ranges. Many countries send representatives to the F/A-18 AWL, and all North Atlantic Treaty Organization (NATO) countries benefit from NAVAIR-developed improvements to the Mk 82 series bombs. NAVAIR explosive ordnance disposal (EOD) units train with counterparts from Croatia to Thailand, and the Joint Tunnel Warfare Center welcomes representatives from many U.S. allies.

NATIONAL AND INTERNATIONAL FORUMS

WD has historically provided a leadership role in many professional societies. WD is on the Executive Committee of the Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee (JANNAF); active in the American Institute of Aeronautics and Astronautics (AIAA), and chaired the 2000 Missile Sciences Conference; serves on the Missile Sciences Committee; chairs sessions for the Military Sensor Symposia (MSS) on Active Systems, and the MSS National/International conferences; and co-chairs sessions for the National Fire Control Symposium.

Awards

Internationally, WD is active in NATO and Technical Cooperation Program affairs, and chairs a panel on second generation military laser systems. For more than 20 years, this group introduced and investigated new laser systems that have been successfully produced. During three years (1996, 1998, 2001) the group conducted highly successful field trials and generated high quality reports on laser performance under severe atmospheric turbulence. In 2002 this group won the NATO Research and Technology Organization scientific achievement award over a field of 150 other NATO groups. This work has had positive impact. For example, the joint Army/Navy Foreign Comparative Test program evaluated a German LADAR obstacle avoidance system for helicopters which is now in production for special operations command platforms. In addition, activities in 3-D imaging LADAR, support the Cruise Missile Real-Time Retargeting (CMRTR) program.

WD also serves on the steering committee of the NATO Insensitive Munitions Information Center with representatives from the United Kingdom, Australia, and New Zealand. WD has also led several panels in propulsion, warheads, guidance, control, and fuzing. [40]

TECHNOLOGY TRANSFER

The Federal Laboratory Consortium (FLC), the primary national Federal technology transfer group, consists of more than 700 federal laboratories and centers and their parent departments and agencies. The FLC, originally established by China Lake in 1971 as the DOD Technology Laboratory Consortium for Technology Transfer, grew from 11 original laboratories in 1971 to 200 laboratories in 1975 under China Lake leadership. The FLC promotes and strengthens technology transfer nationwide. Through the years, thousands of government patents have been awarded with numerous applications to warfighting systems, a key means of staying ahead of U.S. adversaries.

WD transfer programs have included telecommunications on radar systems, video frequency data conversions, data displays, test facilities, and a design for an airport firefighting system for short takeoff and landing airports for the Federal Aviation Administration (FAA). Work was done in low-light-level television, voice scramblers, patrol car tracking, and personnel communication links for the Law Enforcement Assistance Administration. Biomedical ideas have been brought to life for the National Institute of Health, and an air-quality-control monitoring program conducted mapping of aerosols for the State of California. Other significant WD contributions resulted from investigations into wind, solar, and geothermal energy; solid waste conversion to clean burning fuel; and aircraft survivability. An explosive device was developed to clear fire lines for the Forest Service. [41]

CL-20. Most Significant Energetic Material in 50 Years. China Lake developed the most significant energetic ingredient in 50 years. CL-20 was a breakthrough in energetic materials with higher performance, minimum signature, and reduced-hazard characteristics. CL-20 has numerous military and commercial applications. Following the invention of CL-20, China Lake chemists have now developed an environmentally cleaner approach to this important product that could avoid the use of heavy metals and precious metal catalysts in the production process as well as using a less expensive starting material. A patent application has been filed for the new process. [192]

Automotive Air-Bag Sensors. A tiny micro-machined digital accelerometer designed by WD engineers as a guided-missile component is today at the heart of a life-saving system used throughout the world. In 1994, the Navy needed a means to accurately measure the distance traveled by the missile after launch—a computation necessary for arming the warhead-firing device at a safe distance from the launch aircraft. A China Lake engineer conceived of a precision, extremely robust, micro-machined, miniature accelerometer, which at the time did not exist. Working with a Small Business Innovation Research contractor, WD oversaw development of an accelerometer using microelectronic fabrication techniques (to ensure ease of manufacture and thus low per-unit cost) and operating with a single power supply. The device was also designed to be resistant to variations in supply voltage. The resulting accelerometer was incorporated into several warhead safe-arm devices. It was subsequently transitioned into millions of automobile crash-sensor air-bag-initiation systems by major foreign and domestic automobile manufacturers. The device, also used for hundreds of other consumer and industrial applications, is now marketed and sold internationally.[42]

Geophysical Warfare "Rainmakers." During the Vietnam Conflict, U.S. warfighters needed a way to interdict enemy traffic on the Ho Chi Minh Trail. "Project Popeye" helped answer the call. China Lake adapted its cloud-seeding technologies to enhance rainfall, thereby significantly deterring enemy activity on the trail. This highly successful China Lake technology was also used in hurricane abatement, fog control, and drought relief.

Ultrasonic Scanning. During Vietnam, China Lake pioneered logarithmic amplifiers for radar signal processing applications. In 1971 this technology was transferred to the Mayo Clinic and led to the development of the first ultrasonic body scanning equipment.

Stop-Action Video. China Lake invented the electro-mechanical shuttered video camera to provide non-smeared stop-action images of weapon test events. Today, this technology is used for commercial stop-action sports broadcasting. Since WWII, China Lake has been one of the most accomplished developers of range instrumentation. Other examples include real-time continuous x-ray systems, high-speed photography, and encrypted telemetry.

Chemiluminescent Light Sticks During the Vietnam Conflict, U.S. warfighters needed emergency lighting for life rafts, downed flyer beacons, map reading, and damage evaluation. China Lake scientists answered the call with a chemiluminescent light stick. Today this technology is used commercially worldwide for novelty items, commercial fishing lures, and illumination sticks for emergency kits.

Geothermal Energy. China Lake is practically energy independent. This world-class resource ranks among the top 10 in total power output. While California and much of the nation have been in an energy crisis, China Lake has remained nearly energy independent since 1987. In 1964, geological engineers at China Lake first discovered the enormous geothermal potential on the northwest portion of the base. In the 1980s, wells were drilled and contracts were established with Southern California Edison to tap this valuable resource. Total energy savings since that time are on the order of $36 million. The Navy will save in excess of $500 million during the life of the contract. WD was assigned the lead role for all Navy geothermal effort, not geographically limited to China Lake. Two test wells have been drilled and the technical results are now being evaluated. Future energy potential is enormous. In addition, China Lake is the DOD lead laboratory for solar energy and has about one megawatt of photovoltaic (PV) systems installed, including the largest PV/diesel/battery hybrid in the world. The Energy Program Office has assisted with other PV installations for the Marines, Army, and Air Force.

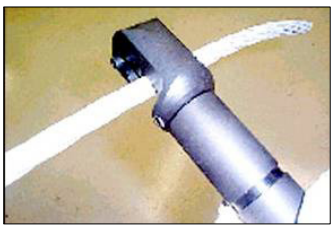
Calcification-Prevention Tablets. Virtually every ship in the U.S. Navy today carries and uses a product invented by researchers at China Lake. The product isn't very big or expensive, but it saves the Navy more than $4 million dollars each year and is used by cruise ships, freighters, and other navies. For decades, the Navy dealt with the problem of calcium buildup in the sewer systems aboard ships. When urinals are flushed with sea water (which is well saturated with calcium), uric acid and other acid components cause precipitation of calcium carbonate, which builds up on the inside of the ship's plumbing. The traditional cure for pipes clogged by calcium deposits is expensive and time-consuming hydroblasting. China Lake scientists developed inexpensive, environmentally friendly, water-soluble polymers that are placed in the urinals in tablet form and release citric acid to bind the calcium in the flush water.

Award

This invention won the Office of Naval Research's Vice Admiral Harold G. Bowen Award in 1996. More than 1.5 million tablets per year are used by the Navy and trouble calls on the high seas have dropped by 90%.

HazMat Containers. Point Mugu has also been actively involved in helping develop new technologies for hazardous materials containers. More than 60 different types of containers are now in use at Navy/Army/Air Force facilities around the world. They are also now available on commercial carriers. [41]

Actuated Cable Cutters. In the early 1950s the Navy developed a blank, explosive, cartridge-actuated, cable cutter for emergency cable cutting for ship tow/transfer lines, helicopter supply lines, etc. In 1990, this technology transferred to private industry. Today,



companies such as CACT CO and Hi-Shear Technologies, of Torrance, California, have developed advanced cartridge-actuated cutting tools that are used nationwide, as well as by many countries throughout the world by the police, sheriffs, SWAT teams, and fire departments, for cutting security bars, chains, and locks. These tools are also highly effective "jaws of life" for cutting through steering wheels and break pedals. The electric power line industry across the U. S. and in some foreign countries is now using cutters for cutting lines, bolts, and ground rods. These extremely portable devices are also indispensable for emergency relief during earthquakes, explosions, and other disasters. Cutters can also be remotely activated. Rescue workers use these devices for cutting rebar and other steel bars. For example, in the Oklahoma bombing, cutters were used by the fire department to rescue individuals. [8]

New Directions in Technology Transfer. As our adversaries have adopted increasingly innovative tactics to disable coalition forces and impede their mission, the DoD has turned to one of its greatest assets, R&D, to counter these threats. WD has begun to exploit Cooperative Research and Development Agreements (CRADAs), as mission extenders, to leverage the capabilities of private industry, in many cases, small businesses, in this endeavor. Several of the CRADAs recently executed in conjunction with this initiative are addressing specific force protection requirements. Through a series of CRADAs with different manufacturers, WD is investigating use of lightweight armor materials to protect the occupants of High-Mobility Multipurpose Wheeled Vehicles (HMMWV), while preserving their durability and off-road performance. One recently-executed CRADA is investigating the feasibility of using directed energy to disable the electronic triggering mechanisms of improvised explosive devices (IEDs). The subject technology may also have potential for stand-off detection of IED command wires. A CRADA that is presently under negotiation will explore the feasibility of achieving stand-off detection of sniper scopes and optical surveillance equipment. [193]

PARTNERING WITH INDUSTRY AND ACADEMIA FLEET BENEFITS

Commercial Research and Development Agreements (CRADAs). Since the early 1990s, the number of CRADAs at WD has continued to climb. Through 2007, WD has executed 176 CRADAs with industry partners that generated revenues in excess of $20M, and represent a potential cost avoidance to the Navy of $66M. Most agreements involve military-related technology, however some CRADAs involve commercial and educational projects. For example, a recently-executed CRADA with the University of California, Santa Barbara (UCSB) will enable the transfer of specialized radar technology from UCSB to the Navy for the purpose of mapping ocean surface currents and wave heights in the vicinity of the Pacific Test Range. Another interesting CRADA effort, in which WD has teamed with a local medical research entity, will explore the use of Navy-developed data mining and machine learning capabilities for medical diagnostic applications. Significant CRADAs over the past 5 years include a "TERM" Ball Joint Seeker, Integrated Weapon System Simulation, F-16/HARM Missile Integration, Evolved SeaSparrow Missile Composite, Virtual Flight Testing, Block IV Fuze Modification, Guided Zuni Rocket Study, Digital Precision Strike Suite, Anti-Swimmer Grenade Development, Counter-MANPADS Research, and Thermal Battery Research. [193]

Commercial Service Agreements (CSAs). WD enters into Commercial Service Agreements (CSAs) to conduct "fee for service" work efforts for private industry and academia under the three federal statutes that authorize such work including Title 10 USC 2539b, 2681, and 2563. WD is one of the few DOD laboratories able to provide services under all three statutes. CSAs are one-sided agreements wherein the government laboratory conducts the work and the non-government customer pays the government laboratory all direct and indirect costs incurred to accomplish the work. Since 1997, the number of CSAs at WD has continued to climb. Through 2007, WD has managed 255 CSAs with industry partners that generated approximately $80M. In the performance of its military mission, WD has acquired and developed specialized equipment and many one-of-a-kind facilities. WD's resident scientists and engineers constitute a significant scientific resource. Significant CSAs over the past 5 years include work efforts completed for Lockheed Martin, The Boeing Company, Northrop Grumman, and Raytheon.

Educational Partnership Agreements (EPAs). Legislation encourages EPAs, and WD is proactively working with a variety of institutions. These relationships foster an open exchange of technical ideas and provide a synergy that is of great value to both communities. EPAs allow scientists, engineers, teachers, university professors, and students to collaborate and share ideas, equipment, and facilities in the pursuit of scientific research and education. WD has ongoing EPAs with Sierra Sands Unified School District, Cerro Coso Community College, and with California State Polytechnic University, Pomona, California. [43]

Patents With Commercial Potential. From 1959 to 2007, more than 1,500 patents have been issued at WD (1,105 at China Lake and 584 at Point Mugu). Some inventors hold more than 20 patents. During 2003 China Lake wrote 29 patent disclosures, 24 new patent applications, and 18 new patents were issued. Point Mugu wrote 26 patent disclosures, 19 new patent applications, and 19 new patents were issued.

Since the 1940s, scientists and engineers have created hundreds of inventions to solve technical problems associated with weapon development. The Web sites below include lists of patents that are licensable and those that have reverted to the public domain.

ENVIRONMENTAL LEADERSHIP

From the stunning Native American rock art of China Lake's Coso Range to the rare Island Night Lizards of San Nicolas Island, WD's resources constitute an extraordinary national treasure. For more than 50 years, WD has exercised responsible, proactive stewardship.

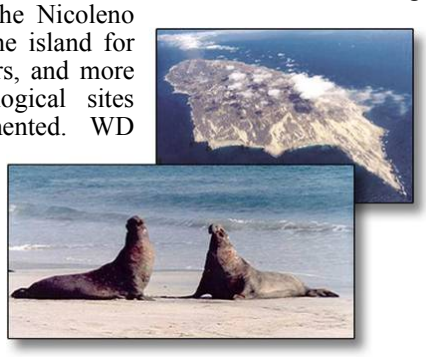
Unencroached with Room to Grow. Encroachment is a fact, to varying degrees, at all military installations. As the population grows, the issue naturally intensifies and many bases today are greatly affected by adjacent urban sprawl. However, of all DOD facilities, China Lake, located in a remote portion of the Mojave Desert, has the least potential to disturb the neighbors—more than one million acres, larger than the state of Rhode Island. Military activities impact less than 10% of the total land area. And the Sea Range, encompassing 36,000 square miles, is the Navy's largest test and evaluation facility. Business opportunities at WD have room to grow. In addition, WD is close to completing an Environmental Impact Statement (EIS) at China Lake. One EIS is already in place for the Sea Range. These studies will streamline the environmental approval process. WD RDT&E activities meet or exceed all state and federal clean air act, hazardous materials, and permitting requirements—opening the doors for new business.

Minimal 10% Impact. The vast majority of China Lake's land is a safety and security buffer and remains in a mostly pristine natural state. Locations for new facilities and specialized test events are carefully selected to minimize impact, and the staff scrutinizes virtually every mission-related activity to ensure that it complies with natural-resources laws and regulations. Ongoing formal cultural-resource inventories to identify archaeological, historical, and traditional properties have been conducted on more than 11,000 acres to date.

Dedicated Staff. Long-range resource planning, as well as day-to-day oversight, of scores of WD environmental projects, is carried out by a team of civil service professionals, ranging from archaeologists and ecologists to environmental engineers and augmented as needed by contract specialists. Community involvement is also encouraged. For example, the Friends of China Lake Archaeology, a self-help group of volunteers, logged more than 900 hours of work in the first half of 2003 to establish a federal curation facility on base.

Petrogylphs. China Lake protects the largest concentration of ancient rock art in the world. This area, 100 square miles of rugged mountain canyons inside the base boundaries, is a National Registered Historic Landmark. As a result of WD's unique stewardship, China Lake won the Governor's Award for Historic Preservation in 2003. Despite heightened security since the 2001 terrorist attacks, China Lake continues to provide public tours of the Coso petroglyphs.

San Nicolas Island. On WD's San Nicolas Island (SNI), 65 miles off the California coast, isolation has resulted in the evolution of distinct and unique taxa. The island is the largest breeding site in the world for California Sea Lions. Annually, more than 23,000 Elephant Seals, 100,000 California Sea Lions, and 500 Harbor Seals use the island beaches. WD has broken ground on an approved $12 million-dollar military-construction project to build a special pier to meet operational requirements. In addition, the pier will keep boats from beach landings that could disturb sensitive wildlife. SNI also has an outstanding cultural heritage. The Nicoleno Indians inhabited the island for at least 10,000 years, and more than 500 archaeological sites have been documented. WD protects and preserves the resources at SNI in the context of an Integrated Natural Resources Management Plan.



Management. During the last three years, WD developed aggressive management plans for preserving endangered species such as the Mojave Tui Chub, the Island Night Lizard, the Desert Tortoise, Mojave Ground Squirrel, the California Inyo Towheether, the Western Snowy Plover, California Brown Pelican, and the San Nicolas Island Fox. Plans protect birds from aircraft strike hazards, ravens from overpopulation, and pinnipeds from the impact of nearby missile launches. Wild horses and burros, potentially at risk on runways, are rounded up annually and adopted out in a formal program in coordination with the Bureau of Land Management. China Lake cleared more than 100 acres of non-native vegetation that was depleting wildlife water sources and developed a Geographic Information System-based photographic database for identifying and protecting its 122 natural desert water sources.

Environmental Awards. In 2003 the Governor's Award for Historic Preservation was presented to China Lake for its long-standing heritage program that combines scientific, historic, recreation, and Native American values. No other military installation has been the recipient of such a prestigious award. In 2002, WD won the Chief of Naval Operations Environmental Award. The citation read in part, "Through your resourceful Natural Resource Program, you continue to effectively balance mission support with wildlife and land management through conservation education and conscientious environmental stewardship." [44]

SPACE PROJECTS—FLEET BENEFITS
Human Systems

China Lake is involved in numerous programs related to aircrew survival equipment, primarily in the area of parachute systems and components. Division expertise in parachute technology, one of only two government labs to retain this capability, has also drawn customers from the National Academy of Science's National Research Council, NASA Johnson Space Center, NASA Dryden Flight Test Center, and the Jet Propulsion Laboratory (JPL) to China Lake. Some of these programs include the X-37 Crew Return Vehicle (CRV), Mars Exploration Rover, Mars Science Laboratory (MSL), and the Orion Crew Exploration Vehicle.

X-37 Crew Return Vehicle (CRV). China Lake was tasked to develop and test a collapsible drogue parachute for NASA's X-37 CRV test program. The B-52 aircraft flew to 45,000 ft. and released the CRV test vehicle, which conducted practice maneuvers and eventually landed at Edwards AFB. To ensure that the CRV did not inadvertently recontact the B-52 after release, China Lake developed a drogue parachute separation system that released from the CRV seconds after separation from the B-52. Due to the high altitude test requirements and the direction of prevailing winds at that altitude, a drogue chute collapse mechanism was needed to prevent the drogue drifting into Los Angeles International Airport's air corridor. This collapse mechanism consisted of ultra-low-temperature-capable silicone bands inside a Teflon cloth sleeve. This collapsible drogue system was tested at China Lake's HIVAS facility and worked quite well. Future testing will be conducted.

Mars Science Laboratory (MSL) Wind Tunnel Testing and RF Pyrotechnic Line Cutter. The Jet Propulsion Laboratory (JPL) is funding China Lake to provide parachute expertise in the design and testing of the new MSL parachute, as well as development and testing of a new RF pyrotechnic line cutter device used for testing parachutes in the Ames Wind Tunnel Facility. MSL is a Mars Lander developed by JPL that is much larger than the 2004 rovers and is designed to conduct a multitude of science experiments on the surface of Mars. The parachute is being tested in the Ames Wind Tunnel Facility, and one of the test requirements is for the parachute to be disreefed several times once the wind tunnel airflow has reached test velocity. Since this time is always different, the standard fixed time delay line cutters could not be used. China Lake developed an RF-triggered line cutter that allows the line cutter to be fired after the wind tunnel has come up to speed. The device is revolutionary in the parachute industry, and will help immensely in other parachute programs.

Orion Crew Exploration Vehicle (CEV). China Lake was asked to provide parachute design expertise and testing facilities for the Orion CEV, part of the Constellation Program which is scheduled to replace the Space Shuttle in several years. The parachute system has currently undergone 14 parachute tests, ranging from a test of a single 10-foot diameter pilot chute up to a system test of two 24-foot drogue parachutes, three pilot parachutes, and a cluster of three 116-foot diameter final recovery parachutes.


Final Recovery Chute Cluster

New Parachute For Navy Targets. In 2006, a new parachute was needed for a Navy target. Increases in the weight of the target had caused an increase in landing damage due to the higher rate of descent under the old recovery chute. The requirement was for a parachute with twice the drag area of the old one with the same volume available for stowage. Even using new high strength, low volume materials, the parachute had to be packed using a hydraulic ram at forces up to 45,000 lbs. Under forces that high, metal components bend and break, causing damage to the parachute system. Based on the collapsible drogue parachute work done for the X-37 system, a new method of attaching the reefing line using fabric instead of the conventional steel reefing rings was used, allowing the new parachute to be packed in the same small volume as the old chute. The new system was successfully tested at China Lake and has completed its first successful mission at White Sands Missile Range (WSMR).


Orion Crew Exploration Vehicle

SPACE PROJECTS—FLEET BENEFITS
Mars Exploration Rover (MER) 2004

WD provides direct Fleet support for Naval aviation and has extensive experience in developing, perfecting, and testing military components and subsystems that have direct application to space missions. Although work for other government agencies represents only a very small fraction of the total workload, the Division is occasionally called upon by NASA to lend expertise to projects of national importance. Lessons learned from joint projects are mutually beneficial. WD's experience includes rocket motors (deceleration and stabilization of spacecraft), jet vane and thrust vector control systems (precision guidance and landing control), and radar systems (determining distances from landing surfaces). Since 1979, China Lake has been home to the National Parachute Test Range (NPTR). Any Federal agency can take advantage of the unique combination of assets and technical skills at NPTR. For example, the Forestry Service (airborne fire fighters), Special Forces, Air Force, Army, and Marines have all tested on NPTR. WD has proven experience in parachute RDT&E, and emergency escape systems (manned sea landing/recovery). WD maintains the Land Range, where all types of Navy test equipment (as well as Lunar and Mars vehicles) are evaluated.

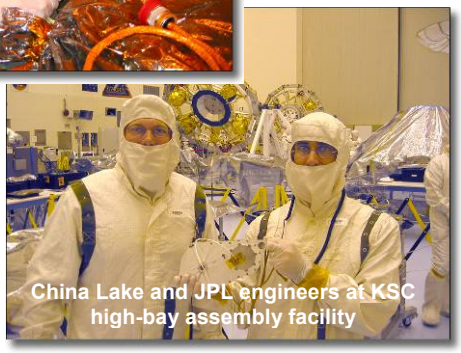
Fleet Benefits. WD's relationship with NASA is mutually beneficial. Lessons learned from joint projects help WD find solutions to Naval aviation problems. Lessons learned from the 2004 missions include developing the Zylon bridle that will allow increased deployment velocities and decreased weight and volume for future Naval aviation parachute systems. Zylon lines may one day replace heavy, cumbersome aircraft tie-downs on carrier decks. The radar altimeter may be considered for high-altitude, low opening (HALO) parachute systems. Also, the descent rate limiter is being considered for use in reusable reefing systems for Army cargo and Navy special forces parachute systems.

Mars Exploration Rover (MER) 2004. Continuing a 61-year relationship with the California Institute of Technology (Caltech) and a long-time relationship with NASA and the Jet Propulsion Laboratory (JPL, a division of Caltech), China Lake was asked to assist on the 2004 missions. (China Lake was established in 1943 as a place to test and evaluate Caltech rockets during World War II.) The success of *Spirit*, the Rover that landed on January 4, and *Opportunity*, that landed January 24, can be attributed in part to the innovation and technical expertise of China Lake. The team has applied their extensive Navy parachute and egress expertise to assist NASA and JPL Mars missions for the past 10 years.

Zylon Bridle. China Lake designed, built, and assisted in the installation of the bridle system onto each spacecraft. The bridle connects the MER backshell to the Lander. Zylon, a new ultra-high-strength fiber, was subjected to strength and environmental testing, and the required joints were designed and tested. Prototypes were fabricated, qualification tests conducted, and finally three flight-quality units were fabricated at China Lake to support the two missions plus a "flight spare." Each bridle contained 22 digital communication wires, allowing each Lander to command the retro-rockets. The bridles worked perfectly and now remain on the surface of Mars.

Descent Rate Limiter (DRL). China Lake and JPL jointly developed the DRL. In addition, China Lake tested and qualified the mechanism, and installed it on each spacecraft at Cape Canaveral's Kennedy Space Center. The DRL allows the Lander to slowly drop to the end of the bridle. Initial tests were conducted at China Lake's Crew Systems drop tower, but results were unsatisfactory. Late in the program, JPL chose to abandon that design and, with China Lake's assistance, designed a totally new device. This design proved suitable, and several flight-quality units were qualified.


China Lake engineer installing DRL on Lander at the Kennedy Space Center


China Lake and JPL engineers at KSC high-bay assembly facility

Radar Systems. JPL adapted the radar altimeter from a Harpoon missile, and WD engineers built a test vehicle to deploy the radar system from a helicopter that made terrain-approaches over several types of geologic features. Then a series of drop tests was conducted to capture terrain-approach data at realistic speeds. The radar altimeter supplies the descending spacecraft with altitude and velocity data for use in timing airbag deployment and retro-rocket ignition.

Retro-Rocket Systems. WD conducted several motor-burn tests at its Weapons Survivability Laboratory. The flight-spare backshell was suspended from a test tower and restrained by the bridle. The retro-rockets were ignited to determine thrust and structural reactions. Follow-on tests

were conducted with other motors to study and compensate for wind, proper separation of environmental covers, and inadvertent torque effects. Retro-rockets slow the Lander down from 200 mph until it hovers above the planet surface, ready for the airbag landing.


Retro-rocket testing at China Lake's Weapons Survivability Laboratory

Multi-Body Tests. Weapons Division tested the system. During descent, the parachute, backshell, and Lander are connected by lines and bridles into a three-body system. JPL was very interested in the dynamics that would result during the descent to Mars. So China Lake's Crew Systems built a simulated three-body test item and dropped it from a helicopter. On-board and ground-based instruments and video captured the response.

Six Minutes Of Terror. Entry, Descent, and Landing (EDL) on Mars requires perfect timing. More than half of all missions to Mars have failed. Landing entails getting a one-ton spacecraft traveling at 12,000 mph to safely stop within six nail-biting minutes. In the first four minutes, atmospheric friction slows the spacecraft to 1,000 mph and raises the temperature of the heat shield to about 2,600°F. With only 100 seconds left, a parachute slows the spacecraft to 200 mph; 20 seconds later, the heat shield is jettisoned, exposing the Lander inside; 10 seconds later, the backshell, still attached to the parachute, begins lowering the Lander on the bridle. A radar system then begins measuring altitude. Eight seconds before touchdown, gas generators inflate the Lander's airbags; two seconds later, the three main deceleration rockets on the backshell ignite, and one or two (of a set of three) small transverse rockets may be fired for stabilization if needed. Three seconds later, when the Lander is about 49 feet above ground, the bridle is cut and the Lander free-falls, cocooned in airbags, hitting the surface at 30 to 50 mph. The Lander then bounces as many as 30 times and rolls up to a mile before stopping. If it hits a sharp rock, the mission could be over—Mars is plagued with jagged boulders, massive craters, cliffs, and high winds.

Perfect Navigation and Control. After traveling more than 300 million miles for seven months, *Spirit* made a perfect landing. "My hat is off to the navigation team because they did a fantastic job of getting us right where we wanted to be," said Dr. Steve Squyres of Cornell University, Ithaca, N.Y., Principal Investigator for the science payload. "This is our new neighborhood. We wanted someplace where the wind had cleared off the rocks for us. What we're seeing is a section of surface that is remarkably devoid of big boulders, at least in our immediate vicinity." Three weeks later, *Opportunity,* an identical twin to *Spirit,* also made a near-perfect landing halfway around the planet from where *Spirit* landed. JPL's Pete Theisinger, project manager for the rovers said, "We are two for two." And Dr. Steve Squyres, proclaimed, "We have scored a 300-million mile interplanetary hole in one." WD tested the rocket motors that helped ensure both of these precision landings. In addition, WD engineers were part of the team that evaluated the landing performance of *Spirit* in preparation for the *Opportunity* landing.

JPL, NASA, Navy, Industry Partners. According to Dr. Charles Elachi, director of NASA's JPL, President George W. Bush called to congratulate the MER flight team for reconfirming the American spirit of exploration, stating that "…We have assembled the best team of young women and men this country can put together." In addition, people from around the world share a special connection to this mission. The Landers each carry a DVD containing millions of names collected during a "Send Your Name to Mars" campaign. Images from this mission have the highest-resolution, more than three times that of the 1997 Mars Pathfinder. Only two weeks after the landing, NASA's Web portal received more than two billion hits, and users downloaded 154 million Web pages worldwide.


Spacecraft separation test at China Lake's MESA facility

2008 Update. In 2008, amazingly, both rovers are still functional. *Spirit* has driven 4.5 miles and sent back more than 102,000 images, and *Opportunity* has driven 7.2 miles and sent back more than 94,000 images. This is fantastic, considering that their planned operational period was three months.

WD has been testing Entry-Descent-Landing concepts for the next generation Mars lander. WD has been working with the Jet Propulsion Laboratory in developing a ground based test bed to include a sophisticated multi-degree of freedom dynamic simulator capable of full size (1000kb) vehicle testing as well as fabricating a test facility to conduct Touchdown Dynamic Tests (TDT). The next generation of smart landers are under development. The next mission is planned for 2009.[172] [194]


White House Photo Eric Draper

"Congratulations for reconfirming the American spirit of exploration."

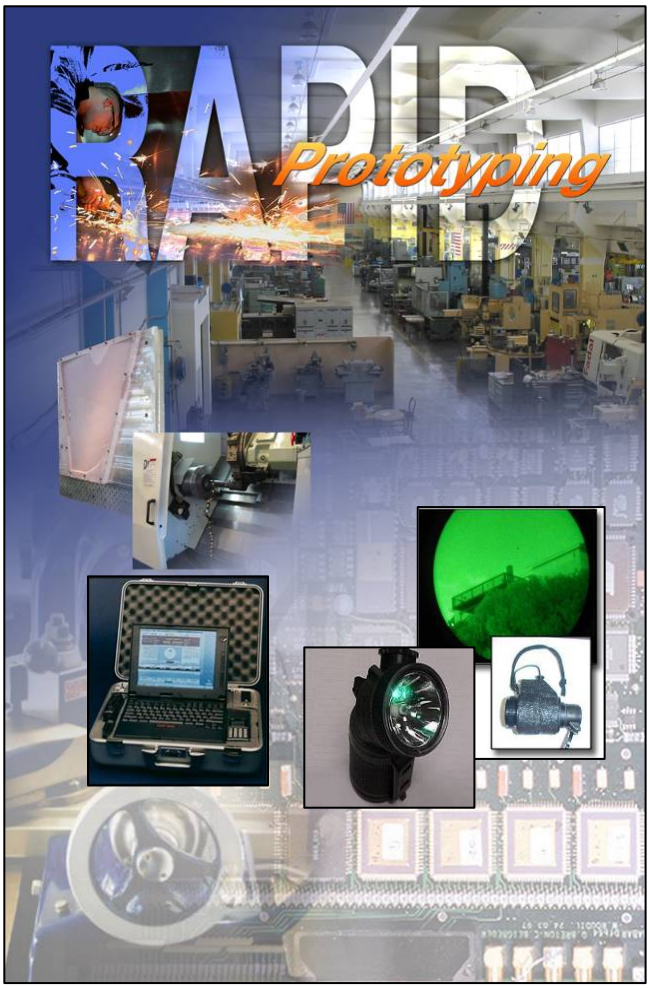
—President George W. Bush

Movies/Animation. Additional information is available from JPL at http://marsrovers.jpl.nasa.gov; from Cornell University at http://athena.cornell.edu; and from NASA at http://marsrovers.nasa.gov. Numerous animations clearly illustrate the mission, see: Entry, Descent, and Landing (EDL).[168]

RAPID PROTOTYPING FOR QUICK-FIX FLEET SOLUTIONS

Quick-Response

The Fleet Support Initiative (FSI) is an effort to identify small, quick-fix problems at the working level in the Fleet and to find a solution.



Weapons Prototype Division provides products that meet customer defined requirements in support of RDT&E. Prototype mechanical and electronic components and systems are supplied on a quick-reaction basis in small quantities. Those products are fully documented with appropriate technical data to support future production and to fully characterize developmental test articles. The established quality systems including ISO9001:2000 certification ensures product integrity for project and warfighter customers alike.

The Prototype Division, working with other WD teams, supports the Office of Naval Research (ONR) Tech Solutions process, established to receive and respond to Fleet requests. The concept is to focus and communicate actively with Sailors and Marines to determine what went wrong on their last deployment and what future capabilities are needed.

One of the goals is to identify and select tasks that can be accomplished in a year or less. Among the FSI projects are efforts to provide a low-cost "Link-16" for legacy platforms, a thermal-imaging maritime surveillance system, a small, lightweight night-vision device for aircrew survival vests, and a night-vision goggle-compatible flash-light. Several of these simple, inexpensive solutions can make the difference in whether or not an aircraft or the lives of aircrew survive an emergency. Tech Solution requests for support, include improved helo ballistic pro-tection, line-of-sight communications, covert ejection seat beacons, and portable solar panels.

Since the Vietnam War, China Lake and Point Mugu have participated in the Vietnam Laboratory Assistance Program (VLAP) and the subsequent Navy Science Assistance Pro-gram (NSAP), providing quick, low-cost, solutions to important Fleet problems throughout the world. NSAP is now the ONR Naval Fleet Force Technology Innovation Office.

WD Fleet Weapon Support Teams (FWSTs) also provide on-site technical and training assistance to operational forces worldwide. For the war on terrorism, WD has outfitted unmanned aerial vehicles (UAVs) with specialized sensors and instrumentation required for Coast Guard and Homeland Defense missions. WD has accel-erated periscope radar development to increase submarine safety in littoral waters, and is developing special tunnel-warfare weapons and technology, as well as Spike, a low-cost guided missile that fits neatly in a Marine and Navy Seal commando backpack.

WD has historically provided customized direct support for special warfare systems. Examples include nonirritating face paint sticks, night-vision devices, map illuminators, liquid explosives, small personal identification beacons, hand-emplaced fuel-air explosion (FAE) canisters for mine clearance, lightweight gun pods, a lead-computing gun sight for aircraft, luminous wristwatch dials, auto-inflatable life preservers, 20-mm gun pods, and the Limpet Assembly Modular (LAM) swimmer-emplaced mine.

WD also provides direct support to the Special Operations Forces with custom explosives, grenades, specialized weapons, communications gear, air and ground reconnais-sance technology, thin-pack parachutes, portable targeting systems, and other unique support equipment. [52]

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