**China Lake Weapons Digest**

**50 Years of Providing the Fleet with the Tools of the Trade**

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Source: Naval Air Warfare Center Weapons Division
http://www.nawcwpns.navy.mil/~bronkhor/clmf/weapdig.html

(Originally prepared for the 50th anniversary edition of The Rocketeer, China Lake's in-house newspaper, 4 Nov. 1993.)

"When given a certain amount of freedom within an atmosphere of technical expertise, available facilities for basic RDT&E, and close operating relationships with the military community, the individual and corporate creativity characteristic of the laboratory community can arise to resolve operational problems and meet military needs and to lay the groundwork for further developments. . . ."

ROCKETS

Aircraft rockets were China Lake's raison d'etre at its establishment. The early forward-firing aircraft rockets developed by the Caltech-NOTS team included the 3.5- and 5.0-Inch Aircraft Rockets; the 5.0-Inch High-Velocity Aircraft Rocket, Holy Moses; and the 11.75-inch Tiny Tim. Early China Lake products also included spin-stabilized bombardment rockets and special-purpose rockets that were used for everything from propelling line charges to sampling atomic clouds. Folding-fin aircraft rockets (FFARs) are another highly successful China Lake product; literally millions of the 2.75-inch Mighty Mouse and 5.0-inch Zuni have been fired in combat. Related work by China Lake includes the development of the BOMROC system and several rocket-assisted projectiles (RAPs); work on RAPs evolved over the years to include extended-range guided projectiles, such as the Antiradiation Projectile (ARP). China Lake's rocketry expertise--propulsion, warheads, airframes, aerodynamics, ballistics, launchers, fire-control, etc.--was also instrumental in establishing its guided missile programs.

FREE-FALL WEAPONS

The "Eye" Series of free-fall weapons (originally targeted with an "iron bombsite and a Mk 1 eyeball") began with a late-'50s China Lake study that showed the need for improved conventional weapons. NOTS developed a family of weapons during the 1960s that included the well-known Snakeye fin-retarded bomb (Mk 81 and Mk 82 GP bombs) and the Rockeye II antitank/material cluster weapon Mk 20, which has provided the basis for other dispenser weapons such as the current Gator mine-delivery system. The Eye series also included the Sadeye, Rockeye I, and Gladeye dispenser weapons; Fireye gelled-fuel weapon; Briteye balloon-borne flare; and Deneye antitank mine-dispenser system--as well as some special-purpose weapons, submunitions, fuses, launchers, and supporting systems. Follow-on work included design and development for the Advanced Bomb Family. China Lake also developed and applied the technology of Fuel-Air Explosive (FAE) Weapons, from grenades to 2,000-pound FAE II bombs (BLU-96/B). FAE I (CBU-55/72) was deployed in 1970, and further developments have included surface-launched mine-clearing systems (SLU-FAE and CATFAE)

GUIDED MISSILES

Nearly every guided missile in the U.S. Inventory today owes a major debt to China Lake R&D efforts in sensors, guidance, control, fuzing, propulsion, warheads, and materials technology. China Lake has made significant contributions to every aspect of guided missile technology and development. Sidewinder is certainly China Lake's best-known success, although far from being its only one. Although guided missiles were originally outside of the Station's charter, Sidewinder was developed by China Lake beginning with a 1949 feasibility study that begat the "heat-homing rocket" that became Sidewinder. Fielded in 1956 and combat proven in 1958, AIM-9A through AIM-9M versions of the deadly little heat-seeker have served the Fleet for over 35 years. Developed and modernized with the principles of simplicity, reliability, and producibility in mind, the AIM-9 family of missiles has proven to be the world's most accurate, reliable, and successful dogfight missile--a missile adopted and copied by friend and foe alike. During the '70s NWC pursued Agile (XAIM-95), an advanced dogfight missile combining China Lake technology advancements in thrust-vector control, guidance, and targeting. China Lake demonstrated the technology and hardware for the next-generation long-range air-to-air missile with its Advanced Common Intercept Missile Demonstration (ACIMD), which incorporated advanced guidance, ramjet-propulsion, warhead, and airframe technologies.

Shrike (AGM-45) is another China Lake development demanded directly by the Fleet; the first successful antiradar missile, Shrike has become one of the most-fired guided missiles in history since its 1965 combat debut. Along with Shrike developments, China Lake antiradar technology programs (such as ERASE and its products and by-products, like the Antiradiation Projectile) provided the foundations for the next generation of antiradar missiles, including HARM (AGM-88). With the Walleye (AGM-62) TV-guided glide bomb, China Lake designed and developed the first precision-guided anti-surface weapon. An outgrowth of in-house technology efforts, Walleye was fielded in 1967 and proved its unsurpassed accuracy in combat. Related to Walleye but cancelled before completion was Condor (AGM-53), a rocket-powered TV-guided missile. Extended-range data links have also been developed for Walleye. China Lake also developed Bulldog (AGM-83), the first successful laser-guided missile, which was approved for service use in 1974 but cancelled in favor of the Air Force Maverick.

Missile improvement and support projects have been conducted by China Lake for a variety of Navy missile systems, notably Sparrow (AIM/RIM-7), Maverick (AGM-65), Harpoon (A/R/UGM-84), and Tomahawk (BGM-109). China Lake provided the engineering, documentation, and production disciplines to get these programs back on track when they ran into trouble and followed support efforts with improvement projects for components and systems.

ANTISUBMARINE WEAPONS

Antisubmarine warfare (ASW) was at one time a major area of endeavor for NOTS; the Pasadena Annex was the focus of ASW work, which included technology development, submarine-detection systems, torpedoes, fire control, and delivery systems. China Lake and Pasadena developed a variety of ASW rockets, including the 12.75-inch "Weapon A" rocket-propelled depth bomb and launcher system; the Rocket-Assisted Torpedo (RAT); and ASROC, which superseded RAT and went to the Fleet in 1960. ASROC versions are still in service, including Vertical-Launch ASROC.

NOTS Pasadena developed or participated in the development of the Mk 32 Mod 2, Mk 42, Mk 43, Mk 44, and Mk 46 torpedoes. NOTS also developed devices like the Mk 40 Torpedo Test Vehicle for RDT&E, and programs such as Project SWISH studies of torpedo hydrodynamic noise and RETORC--the Research Torpedo Configuration--laid the groundwork for further developments in ASW weapons, including the Mk 48 torpedo.

SPECIAL WEAPONS

China Lake work on special weapons--nuclear weapons--began with Project Camel, part of the Manhattan Project, to develop and produce non-nuclear explosive bomb components (for which the Salt Wells Pilot Plant was built) and test bomb shapes. China Lake did not work on nuclear warheads, but supported a number of special weapon programs during the 1950s, when the military's focus was largely on nuclear weapons, with safety evaluations, component and shape testing, and component development. China Lake redesigned the Elsie (TX 8/TX 11) penetrator weapon and developed the Bombardment Aircraft Rocket (BOAR), one of the earliest rockets designed to carry a nuclear warhead. NOTS also demonstrated in 1957 a submarine-launched bombardment missile called Marlin.

One of China Lake's most significant areas of accomplishment is in Fleet ballistic missile support, especially with regard to Polaris. The Polaris Studies conducted by China Lake were instrumental in the development of the concept and the weapon system, and China Lake played a crucial role in rocket motor testing (Skytop) and underwater-launch testing (Pop-Up). The T&E role continues to be significant, as witnessed by the huge Trident II motor test facilities opened in 1986.

AIRCRAFT SYSTEMS

China Lake has throughout its history been involved with the complete weapon system, which includes the necessary fire-control, interfaces, launchers, and (more recently) software. Beginning in the '40s, China Lake developed bomb directors such as the Mk 6 Mod 3, Mk 10, and the EX-1--the most accurate of its day for single-seat attack aircraft; the bomb-director set AN/ASB-8; and fire-control systems Mk 8, Mk 16, and EX-16--a high-performance system using a revolutionary computing technique. China Lake was involved in the early development of TV-based avionics, and following its early work on FLIR technology, China Lake was the lead in integrating FLIR systems into aircraft. China Lake targeting and fire-control projects also include the CP-741/841 weapons computer, Navy Pave Knife laser designator, and the Angle-Rate Bombing System (ARBS).

As an outgrowth of its fire-control work, China Lake became involved with avionics and software development and weapons integration for the A-7 aircraft, and as a result of the great success of the A-7 project China Lake was designated the Weapon System Support Activity (WSSA) for the AH-1, A-4M, A-6E, A-7E, AV-8B, and F/A-18 aircraft and has performed integration and avionics tasks for a variety of other Fleet and developmental aircraft. Aircraft weapons integration and avionics, including the development and testing of operational flight programs (OFPs) has become one of the major areas of endeavor at China Lake. The Weapon System Support Facility at Armitage Field houses simulation and development laboratories that support every aspect of avionics hardware and software integration, development, and T&E.

Outgrowths of China Lake's work in aircraft systems have included such support devices as the Memory Loader/Verifier and the development of the Versatile Training System/Versatile Computing System, which became the standard readiness-squadron training-support system and the basis for other training systems.

FUZING SYSTEMS

China Lake has been developing fuzing components and devices for its ordnance products since it began developing rockets during World War II, and the 1967 merging of NOL Corona with NOTS China Lake to form NWC brought to China Lake decades of fuzing, safety-arming device, target-detecting device, and related technology experience and expertise. Guided missile fuzing technologies developed and successfully exploited by Corona and China Lake include edge-detection, developed in the mid-1960s and employed in all Navy antiair missiles; fore-and-aft adaptive-logic, a flexible, adaptive, and effective scheme used in long-range missiles; pseudorandom-noise modulation, which combines the advantages of two other technologies while avoiding their major shortcomings; and active-optical, first investigated in the '50s and now applied to a number of antiair and anti-surface missiles. Continuous-slot antenna development has been one of the most significant contributions to fuse-antenna development; based on an earlier French patent, China Lake refinements, developments, and new fabrication techniques have been applied to a variety of missiles. The Mk 45 target-detecting device/shroud assembly (TDD/SA) for Standard Missile is an example of the application of this fuzing expertise. Considered by many to be the world's premier missile fuse, the Mk 45 is a sophisticated device that combines several advanced technologies. Free-fall weapon fuzing, too, has been pursued by China Lake. China Lake has had significant involvement in the development of such devices as the FMU-139/B electronic bomb fuse, FMU-140/B dispenser proximity fuse, and DSU-30/B target-detecting device.

Safety and arming (S-A) devices is another area in which China Lake holds unqualified leadership, with well over 400,000 devices in the Fleet with a perfect safety record. The basic acceleration-driven S-A device was developed in the mid-'50s by Corona, and the pneumatic-driven S-A device was developed in the early-'60s for Walleye.

AIRCREW SAFETY

China Lake has been significantly involved in aircrew safety RDT&E since the 1950s when it developed the Rocket-Assisted Personnel Ejection Catapult (RAPEC). RAPEC was developed as an outgrowth of China Lake expertise in propulsion systems and was widely fielded. Another ejection seat based on China Lake propulsion-system expertise was the Vertical-Seeking Subsystem (VSS) for the Maximum-Performance Ejection Seat; although the overall program was cancelled in 1982, China Lake had developed and demonstrated the thrust-vector-control and MICRAD attitude-reference systems that allowed safe ejection at low altitude and in adverse attitude--even upside-down. Realistic, high-speed testing of ejection systems has also been a major area of T&E work at China Lake, especially using the SNORT dual-rail supersonic track, which was the test facility for most of the Navy's aircraft-ejection systems, as well as for several Air Force aircraft and the Gemini spacecraft. The 1979 incorporation of the National Parachute Test Range mission into NWC brought long experience and unparalleled expertise in parachute systems RDT&E to China Lake. Recent projects in aircrew safety and parachute systems have included the Seawater-Activated Release System (SEAWARS); the Space Shuttle Emergency Egress System; and T&E programs for special-forces parachutes, the Galileo Jupiter probe parachute system, and the recovery system for the Shuttle boosters.

TECHNOLOGICAL ADVANCEMENT

The maintenance of a technology base program that includes basic and applied research in the physical sciences has been a cornerstone of China Lake's success--and essential to the full-spectrum RDT&E of weapon systems for the Navy. China Lake has been for a large part of its 50 years a world leader in the synthesis, formulation, process development, scale-up, and evaluation of new and improved energetic materials for use in advanced weapons and propulsion systems. Explosives RDT&E has included the development of explosives, warheads, shaped charges, and castable explosives; ordnance safety; ordnance-pollution abatement; and characterization of metals under explosive loading. Further, the majority of plastic-bonded explosives (PBXs) in service use were formulated at China Lake. Propellant RDT&E began with a concentration on double-base propellants and expanded into work on liquid, smokeless, ramjet, 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. Thrust-vector-control technology developments by China Lake have provided the foundations for numerous applications, including vertical-launching systems.

Beginning with independent and exploratory development work in 1962, China Lake developed the technology and hardware to provide the Fleet with an effective night-attack capability using forward-looking infrared (FLIR) devices. An early success was the development of the ADAM search set and ADAM FLIR display system, which demonstrated the first real-time IR night display of targets; the technology evolving from this early effort lead to China Lake involvement in the development of the Night-Attack System, the Night Observation Gunship (NOGS), and the A-6E TRAM and A-7E FLIR targeting systems. Early work in IR target detection also lead to China Lake's development of the FOCUS series of air-to-ground missiles using modified Sidewinder components.

Laser and optical components technology is another area of significant accomplishment. China Lake has been a leader in the development of new optical-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. China Lake developments also include the interferometric surface scanner; bowl-feed polishing, ultrahigh-vacuum deposition, and ultra-clean sputter deposition optical-film-production techniques; and a portable CO2 laser. China Lake has also provided invaluable support to a variety of high-energy-laser research and development programs.

Weather modification was another area of China Lake preeminence. Between 1949 and 1978 China Lake developed concepts, techniques, and hardware that were successfully used in hurricane abatement, fog control, and drought relief. Military application of this technology was demonstrated in 1966 when Project Popeye was conducted to enhance rainfall to help interdict traffic on the Ho Chi Minh Trail. China Lake developments and improvements in chemiluminescent (chemical-light) compounds and devices have seen widespread application for military and civilian uses. Manufacturing and related technologies are also areas of unparalleled China Lake accomplishment. China Lake established itself as the Government and industry leader in soldering technology with the development of state-of-the-art systems and techniques through its experience in full-spectrum weapon systems development and support. Success in this area is well illustrated by the phenomenally successful Soldering Technology Seminars and soldering training programs and by the establishment of the DOD Electronics Manufacturing Productivity Facility at China Lake.

TECHNOLOGY APPLICATIONS

China Lake has applied its technological and developmental expertise over the years to a wider variety of projects and products than weapon systems. For example, in the wake of the Soviet Sputnik launch, China Lake developed the quick-response NOTS Project, also known as "NOTSNIK," and built a vehicle to put a satellite in orbit from a tactical aircraft--which may have launched one of the first U.S. satellites. Outgrowths from this work included the Caleb airborne satellite/probe launching system; the Microlock portable satellite-tracking stations, which were deployed around the world; and the early-'60s demonstration of concept and hardware for SIP, a developmental satellite-killer. China Lake also participated in early strategic-defense and space-research projects with the development of probes, propulsion systems, and sensors in projects such as HITAB and TERASCA. Drawing upon its propulsion expertise, China Lake built and demonstrated the Soft-Landing Vehicle, a prototype Moon lander. China Lake undersea research ranged from the development of submarines to research into the nature of the sea itself. Submarines developed by China Lake and the Pasadena Annex during the 1960s included Moray, a two-man deep-diving submarine that was the research prototype for a sort of underwater fighter plane; Deep Jeep, the first U.S. manned submersible to descend over 2,000 feet; and CURV, a remote-controlled diving vehicle designed to recover torpedoes and used in 1966 to recover a lost nuclear weapon in deep water off the coast of Spain. NOTS was also talking to dolphins in those days--"Notty" was the first of these--and studying the way fish swim.

OPERATIONAL SUPPORT

Operations analysis in support of the weapons-development program has been a significant and very productive area of endeavor at China Lake since shortly after its establishment. R&D requirements, weapon system requirements, operations, intelligence, foreign-material exploitation, systems effectiveness, aircraft survivability, mission-area analysis, and systems alternatives studies have all been pursued. The Polaris Studies and the Free-Fall Weapon Studies are examples of analyses with significant Navy-wide impact. China Lake has also made extensive contributions to Joint Technical Coordinating Groups, Joint Munitions Effectiveness Manuals, and projects such as the Tactical Air Armament Study (TAAS). For example, as a result of TAAS, China Lake developed the Navy and Marine Corps Ordnance Requirements (NAVMOR) and the Soviet Ship Vulnerability Program for the Navy. One of the more significant pieces of analysis conducted by China Lake was the investigation of the 1973 munitions-train explosions at Roseville, Calif., and Benson, Ariz.; the Roseville-Benson Studies not only saved the Government $50,000,000 to $90,000,000 in damage claims, they established that Navy ordnance was, indeed, safe to ship by rail.

Throughout the Vietnam war, China Lake supported the operators through the Vietnam Laboratory Assistance Program (VLAP), providing analyses, weapons, support equipment, and operational support--including sending China Lake civilian personnel to provide immediate, on-sight consulting and liaison. China Lake provided customized direct support for the Special Forces community with special-warfare systems and swimmer weapons--everything from non-irritating face-paint sticks to plastic wrap to specialized weapon systems, night-vision devices, and liquid explosives. China Lake also developed major systems for special warfare, such as the Mk IX swimmer-delivery vehicle, the Underwater Explosive Unit, and the Actuation Mine Simulator.

The quick-response capability of the in-house laboratory has proven to be one of China Lake's most significant contributions to the Navy and to the Nation over the years. Things like Project Ram, which developed, produced, and delivered the 6.5-inch tank-killing rocket to Korea in just 28 days in 1950; the ESE ("Easy") program that produced preproduction Shrikes for possible use during the Cuban Missile Crisis; literally hundreds of rush projects carried out under VLAP; development of a specialized TDD for Standard ARM; deployment of the Sea Chaparral and Shrike-on-Board systems for ship self-protection during Vietnam; development of the ICWD radar-warning device during the Iran crisis; and dozens of projects--large and small--in support of operations in Desert Shield and Storm.