China Lake Propulsion Laboratories (CLPL)

NAWCWD Quick Facts
China Lake & Point Mugu, CA NAVAIR

Combustion Sciences Facilities; Ordnance, Propulsion, and Explosives Laboratories; Pearson Laboratory; Salt Wells Facilities

Mission. Navy's most comprehensive and unique center for RDAT&E of the energetic components of rockets, guided missiles, and free-fall weapons. Provide warfighters with state-of-the-art propulsion, ordnance, and fuzing systems using both in-house and contracted efforts.

Unique Features. The combination of ranges, the proximity of state-of-the-art laboratories, and the full life-cycle capability is unmatched in government and industry. Scientists and technicians can go from basic research of a new chemical to processing and testing merely by walking across the street in some instances. Mixing is conducted in sizes ranging from hand-held beakers up to 150 gallons of energetic materials. Significant spacing between facilities enables the testing of extremely large, experimental, or risky systems. The High Energy Computed Tomography system is unique within the DoD, and the Betatron radiography system is the only one of its kind in the world that is still functioning. The Propulsion Research Laboratory has the only functional combustion instability test apparatus.

Combat Support Examples. A team of scientists, engineers, and technicians working with our industrial partners supported our warfighters by producing the Hellfire "Thermobaric" warhead along with the low rate initial production of BLU-116, the Low Collateral Damage Bomb (LCDB). Highly trained specialists have refurbished fuzes for the warfighter, lent their expertise in battery technology and combustion instability, and investigated and solved failure issues in the field in real-time. Researchers are continually sought by the warfighter for quick response development of critical warfighting devices like the Jammer Effectiveness Devices (JEDs) provided in recent conflicts to preserve life and equipment when dealing with the threats of improvised explosive devices (IEDs). Many tasks are on a quick-response basis, such as providing warfighters with data on 20-mm ammunition being used in the current conflict. For past conflict examples, see the "Historical Significance" section below.

RDT&E. The CLPL area, also known as Salt Wells, is used for propulsion, warhead, and fuze testing. Propulsion grain, nozzles, and actuators are designed here. Research is conducted for explosives and propellants. Motors and warheads are processed and cast. Inspections are conducted using boroscopes as well as film and high energy computerized tomography radiography. The major test ranges are CT-1 (slow cookoff testing), CT-4 (fast cookoff testing), bullet impact, drop testing, fragment testing, T-Range (aero-heat / material testing), and Skytop (experimental to production static motor firings). Services and support include inert and energetic materials characterizations at high strain rates, experimental design, ultra-high-speed photography, ordnance support and characterization, engineering and scientific analysis, spectroscopy (time resolved), and high velocity impacts. In 1994, China Lake became the tactical lead for a program to double rocket propulsion. CLPL specialists are working on active fire-suppression systems in addition to conducting extensive work to make hypersonic weapons a reality. By studying how materials burn, researchers are developing computation models to examine reaction kinetics and species development during rocket propulsion. Using models, new ingredients can be developed and effects probed during the conceptual and early development stages.

Size / Description / Location / Scope. More than 380 employees work in more than 100 specialized labs and facilities that encompass an area of more than 7.5 square miles. Explosive T&E limits range from 200 to 500,000 pounds. This flexibility allows customers to go from concept development to full-scale prototype or to conduct research rarely available elsewhere. The area is located on China Lake's North Ranges approximately ten miles from the main gate. **Annual Test Events:** 900-1000+. **Year Opened:** 1944. **Replacement Cost:** $250M+.

Main Facilities

Salt Wells Area

In-Service Engineering Facility. This is a turn-key 10,000 SF facility for rapidly assembling and disassembling all-up-round weapon systems and small components. This facility is sited for 10,000 Net Explosive Weight (NEW) and has three secured bays.

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Mass Properties / Weapons Integration Facility. This 10,100 SF facility has five main assembly / disassembly rooms and three smaller rooms for experimental and fleet excepted ordnance items used for weapons integration and mass properties testing. It is sited for 2,000 NEW. There is also an additional 1,100 SF office space.

Fuze Test Facility. Inspections, surveillance, tests, and analysis of critical components used in safety-arming devices are conducted. Testing includes explosive train evaluations, safety critical devices under extreme environmental conditions, fuze devices exposed to the extremes of variable loads, and highly sensitive and novel energetics testing and analysis. Provides entire life-cycle support. *(See separate Fuze Test Facility Quick Facts.)*

Proximity Fuze Antenna Range Facility. The facility is used to characterize and measure antenna patterns in azimuth, elevation, and gain. One facility takes production-style measurements on existing weapons systems, and the second evaluates production and research systems. Radio frequency (RF) measurements are taken and microwave antenna systems are adaptable to many different antenna configurations. The outdoor range reduces stray reflections making it virtually noise free, and it is capable of taking measurements over a broad range of distances.

Salt Wells Processing Plant. This complex operates the following equipment: high-shear mixers from 1/4 pint to 150 gallons for mixing propellants and explosives; up to 40-gallon slurry kettles for mixing melt cast and other explosives; pellet presses; 18.1-, 45.4-, and 272-metric ton (20-, 50-, and 300- short-ton) explosive presses; complete raw material preparation in hammer mill; Sweco grinders and fluid energy mills; injection loaders for explosives; casting facilities; ovens for curing explosives and propellants; complete machining capability for rocket motors, warheads, bombs, explosives, and propellants; thrust stands, winding equipment, lasers, and laser diagnostic equipment; particle size analyzers; FTIR spectrometer, scanning electron microscope; liquid chromatography instrument; high-speed Cordin cameras; and X-ray machines.

Pearson Laboratory

- **Detonation Mechanics Laboratory.** The lab is comprised of one indoor and one outdoor bay, one gun tub, and one explosive chamber. Suited for experiments involving a NEW up to 15 pounds of explosive or propellant. The lab’s ultra-high-speed photography capability is its hallmark; it allows customers visual confirmation of very high-speed events. This lab also has a dual-head, dual-remote 300-kV flash X-ray system for orthogonal stop-action photography; the system is critical for shaped charges and explosively formed projectile design validation.
- **Shock Physics Laboratory.** The primary function is to study the shock properties of materials and shock initiation of energetics. Planar shock waves are induced into materials of interest through the use of a two-stage light gas gun. The gun can be converted to a 3-inch single-stage powder gun for lower shock pressure studies. The primary measurement modes in these studies are shock velocity, shock pressure, and particle velocity.
- **Hypervelocity Laboratory.** This confined chamber is capable of withstanding two-pound hazard Class 1.1 explosives. This facility is used to study detonation phenomena such as detonation velocity and pressure of energetic materials with guns (1/2 inch to 1 inch) and various diagnostic equipment including a 5 spot VISAR system.

Combustion Sciences

- **Combustion Diagnostics**. Research locations include Pearson Laboratory and Propulsion Research Laboratory. Combustion phenomena are studied such as flame propagation, combustion species, and flame structure using a variety of equipment to probe reactions occurring at femtoseconds and above time scales. This includes laser probing on the reaction fronts and real-time emission and absorption spectroscopy. Understanding of reaction at the micro and mesa scale provides insight into performance and allows for ingredient and manufacturing changes of a propellant to be examined in greater detail.
- **Combustion Instability.** The work performed at the Propulsion Research Laboratory examines the nature of combustion instability in solid rockets. This technology is used by technical program offices and by manufacturers to develop and diagnose rocket motors.
- **Combustion Theory and Modeling Facilities**. This research examines how materials burn and develop using computational models to examine reaction kinetics and species development during rocket propulsion. This analysis supports new ingredient development and is essential when developing highly metalized explosive warheads (thermobarics) that have large late-time combustion chemistry.
- **Small-Scale Cookoff and Hazards Facilities.** This facility includes gun tubs and a 6-inch gun site that performs small-scale slow cookoff events to study individual components and small systems so that new formulations can be developed and modified in the early stages. Larger scale experiments to study scale-up effects are also conducted.

- **Fire Science Laboratory.** This lab replicates an aircraft carrier deck as well as a burn room facility to study the effect of burning fuel fires. The goal of this research is to help understand fires so that we can design more resilient weapons systems and develop better firefighting and cooling systems and techniques. The USS *Forrestal* incident serves as a good study model for preventing future incidents. Current programs include the Joint Strike Fighter (JSF) and developing techniques for on-deck fire extinguishment. *(See separate Fire Science Laboratory Quick Facts.)*

- **Carl Schaniel Laboratory Complex.** This state-of-the-art multipurpose research facility encompasses several buildings. Here, the staff examines the synthesis of organics and metals, such as unique nano materials and coatings, for developing new propellant and explosive formulations. The facility allows researchers to mix and cast new propellant and explosive formulations concurrently. The complex also includes characterization labs that include the suite of safety, thermal, mechanical, and chemical analysis capabilities. *(See separate Explosives and Propellants Laboratory Quick Facts.)*

Unique or Historic Tests. Through the years, Salt Wells has been called upon for numerous special projects. For example, the Naval Research Laboratory used the High-Energy Computed Tomography (HECT) facility to inspect the head of a sperm whale in its study on sonar capability; technicians have also inspected “black boxes” for airlines and front-in systems for Ford. The Japanese have used Salt Wells facilities to cast their 21-inch motor and the Skytop complex to perform testing.

Recognition / Awards. China Lake has national and international technical leadership roles, including the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program and the Joint Army-Navy-NASA-Air Force (JANNAF) committee, and serves as the Navy fuzing lead for NATO. Several members are recognized leaders in the areas of fuzing, propulsion, and testing. Several Salt Wells Laboratory employees have been inducted into the Naval Air Systems Command (NAVAIR) Fellows Program and have received recognition for items ranging from patents to Navy Civilian Meritorious Awards.

Interesting Facts (Few Examples)

- **CL-20.** In 1987, China Lake invented CL‑20, which is the “most significant energetic ingredient in 50 years” because of its high performance, minimum signature, and low hazard characteristics.

- **Thermobaric Explosives.** In 2005, China Lake was issued three new patents for enhanced thermobaric explosives that have 50 to 100% higher blast energy. This new class of explosive is an example of a single event fuel-air explosive where the duration of the explosive is extended, providing increased impulsive loading for greater target effects.

- **Insensitive Munitions (IM).** Researchers at China Lake devised a way to mitigate the effects of shock to ordnance through the use of pumice, which is a naturally occurring volcanic material found on the China Lake ranges, to greatly enhance the survivability of ordnance to shock or thermal environments. The use of pumice barriers integrated into the shipping containers for weapons and ordnance devices effectively increases the number of all-up rounds that can be safely stored or shipped. An example was the design of an annular pumice ring that was designed for the Standoff Land-Attack Missile–Expanded Response (SLAM-ER) weapon system container. The ring successfully prevented the sympathetic detonation of the weapon’s warhead in the shipping configuration and is now in use by the Fleet.

- **Integrated High Payoff Rocket Propulsion (IHPRPT).** In 1994, China Lake began an ambitious tri-service / NASA / industry effort to develop revolutionary technologies to double rocket propulsion capabilities. In 2006, China Lake completed payoff studies that showed significant improvements in increasing propellant energy and motor volumetric loading, decreasing component weight and volume, and increasing component efficiency without sacrificing safety or increasing cost.

- **Joint Technical Coordinating Group on Aircraft Survivability (JTCG / AS).** Fire is a leading contributor to attrition of aircraft in combat. Active fire-suppression systems, however, can often be complex, costly, and heavy. China Lake is investigating the use of an energetic material to enhance the fire suppression powder release from inside aircraft panels in emergencies.

- **High-Speed Weapons.** China Lake has conducted extensive work in the technologies required to make such weapons a reality, including efforts in advanced air breathing propulsion systems (i.e., ramjet), blended body airframes, high-temperature materials, and ordnance package concepts. Programs such as Revolutionary Approach to Time-Critical Long-Range Strike (RATTLRS) are under way to demonstrate these technologies in flight testing.

- **Missile Airframe Technology.** NAWCWD missile airframe technology efforts provide affordable airframe structures, stable weapon flight, increased maneuverability, safe separation from launch platforms, reduced drag, improved aero-prediction and defense penetration techniques, and high-temperature airframes.

Historical Significance — Developed Non-Nuclear Components for the First Atomic Bomb. Salt Wells had a fascinating start during World War II as this amazing complex played a significant role in the Manhattan Project, developing non-nuclear explosive components for the first atomic bomb. During 1944 and 1945, non-nuclear testing for the Manhattan Project was done at four sites, including the Naval Ordnance Test Station (NOTS). The code name for work done at China Lake was Project Camel. High explosive main charges were produced at the Salt Wells Pilot Plant from the fall of 1946 through 1954.

In the 1940s, China Lake loaded and test fired the new detonators made in Pasadena, and the Salt Wells Pilot Plant also cast and machined precision high-explosive lenses that focused blast waves to create the phenomenal heat and pressure required for the plutonium core to fission. The actual nuclear components of the bomb were developed at Los Alamos, New Mexico. No nuclear components were ever developed or tested at China Lake. Due to the urgency of war, in only 115 days, the $13,000,000 plant ($243 million in today's dollars) was melting, casting, and machining explosives. Operations began just nine days after the test of the world's first nuclear weapon at Trinity Site, Socorro County, New Mexico.

Salt Wells — Post War. In 1946, the Salt Wells Pilot Plant was ordered to step up production. Because Salt Wells was the single source for high-explosive components of the fission-type bomb, no other such facility had been built. Through the mid-1950s, China Lake continued to be a major producer of certain chemical explosive components for the atomic weapons program. At the peak of its operation, the Plant had 550 employees plus 300 in support activities. Initial work at China Lake laid the groundwork for some of today's most advanced nuclear weapon systems. Today, most of the facilities have been consolidated and upgraded.

Post-War Delivery Tactics. From 1951 to 1953, the Air Development Squadron FIVE (VX-5) at China Lake was charged with developing a delivery tactic that would get the nuclear weapon on or close to the target while providing an escape envelope for the aircraft and pilot. VX-5's personnel were top caliber; the average flight time per pilot was more than 2,000 hours. These officers and about 100 enlisted men worked tirelessly, testing and perfecting bomb-delivery techniques described as "loft / toss," "over-the-shoulder," and "lay-down." These specialized maneuvers soon became the Navy way of delivering nuclear weapons from aircraft. Testing was intense and included more than 10,000 Mk 76 practice bombs.