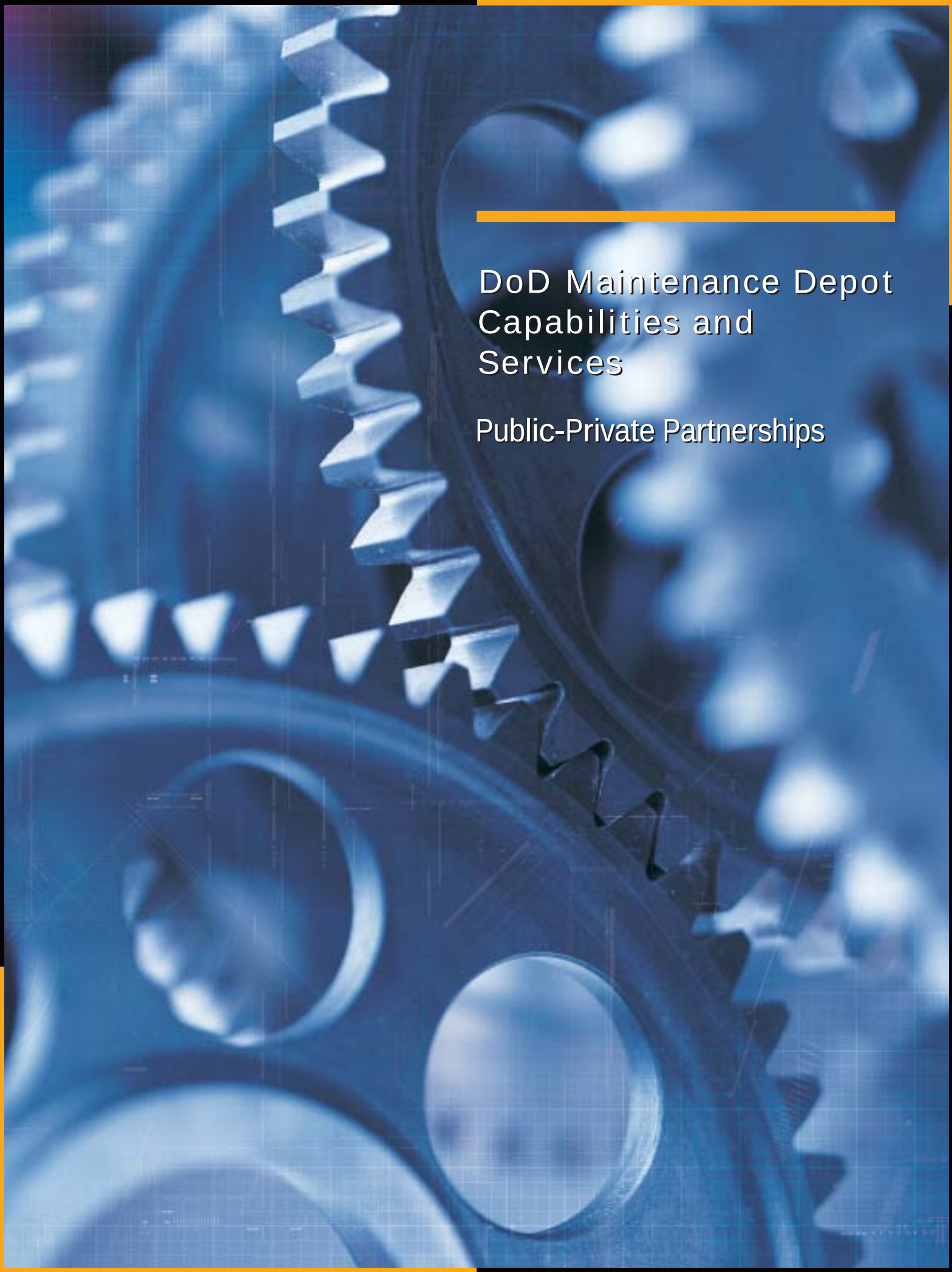

DoD Maintenance Depot Capabilities and Services

Public-Private Partnerships

A message from the Deputy Under Secretary of Defense for Logistics and Materiel Readiness

I welcome this opportunity to provide information about the extensive repair, remanufacturing, and testing capabilities possessed by the depot maintenance activities of the Department of Defense.

Congress has enacted legislation that allows DoD's maintenance depots to enter into partnership agreements with commercial and defense-sector firms. Partnering is a key component of the Future Logistics Enterprise, a set of initiatives designed to transform DoD logistics for the 21st century. Partnering permits depot maintenance activities to provide goods and services to the private sector, thus creating unique opportunities benefiting both the government and the participating firms.

This brochure highlights some of the outstanding capabilities at DoD's maintenance depots that may be of interest to industry. Aircraft composite repair, stereolithography, numerically controlled manufacturing and repair, laser automated decoating, and aluminum ivadizing are among the processes highlighted in the following pages.

I am personally aware of the tremendous capability—provided in large part by our superb DoD personnel—of our depot maintenance activities. I consider our ability to offer authorized goods and services to private-sector firms a win-win situation for both sectors, and I am pleased to make the enclosed information available for your review. I encourage your interest and look forward to exploring areas of mutual benefit.

Diane K. Morales
Deputy Under Secretary of Defense
(Logistics and Materiel Readiness)

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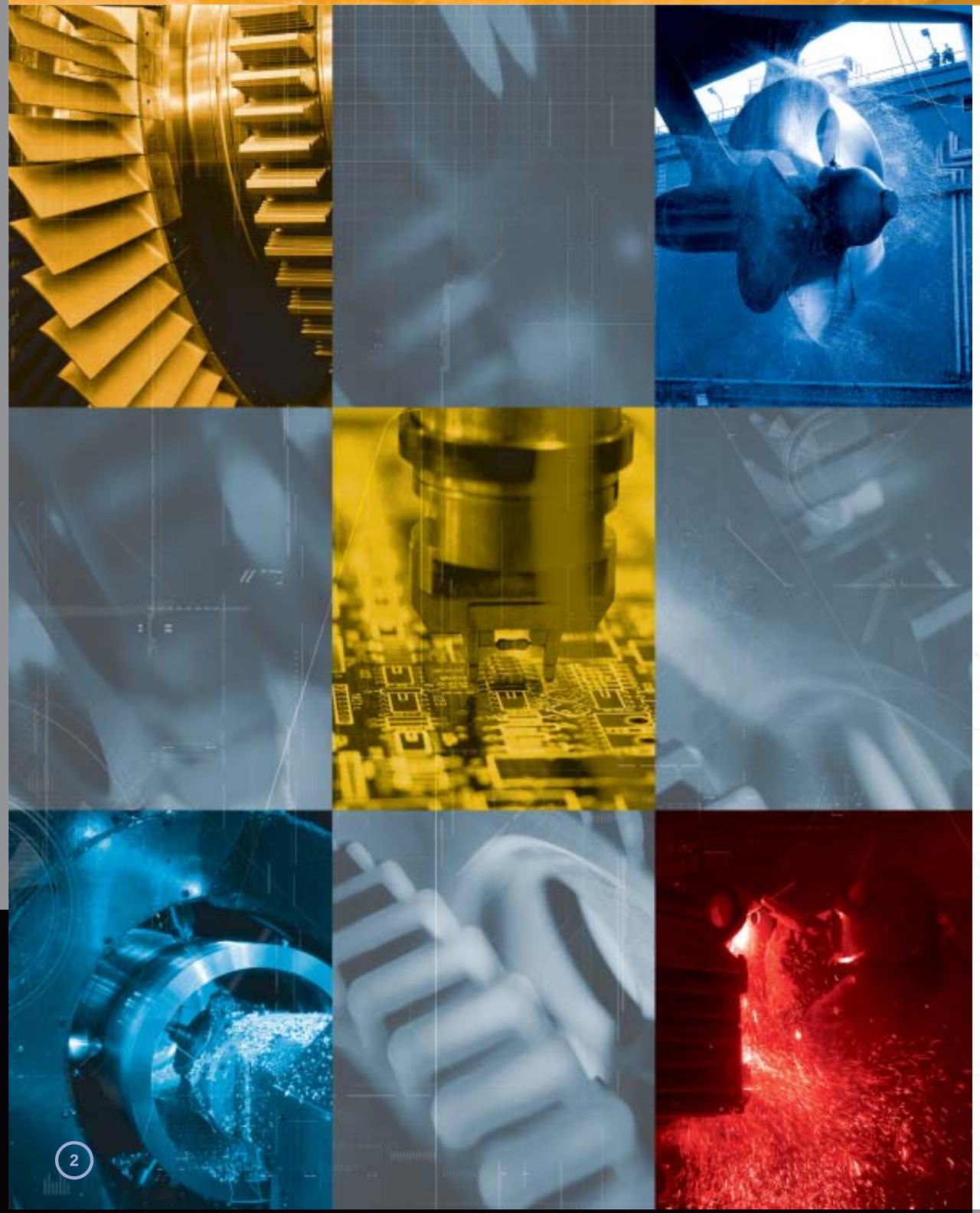


Overview

The Department of Defense operates 20 major depot maintenance activities that possess some of the most extensive repair, testing, and remanufacturing capabilities in the world. Congress has enacted legislation that allows DoD's maintenance depots to enter into partnership agreements with private-sector firms. Following are depot capabilities that can be covered by such agreements:

- *Manufacturing:* fabrication of parts, assembly of components, and final assembly and painting of end-use items
- *Repair:* diagnostics, refurbishment, overhaul and rebuild
- *Technical services:* testing and analysis, repair-process design, and in-service engineering.

This brochure highlights both the range and depth of DoD's depot maintenance capabilities. It illustrates how these resources can be used to meet private-sector requirements.

What Types of Partnering Are There?

Arrangements for utilizing the capabilities of a depot maintenance activity can take numerous forms:

- *Teaming or work sharing*—Work sharing incorporates a combination of depot and contractor facilities and employees to produce or repair weapons systems, equipment, and components.
- *Purchasing*—Private-sector firms can purchase articles or services from DoD's depots. This applies to goods or services that end up in products sold to the U.S. government or friendly foreign governments.
- *Leasing*—Private-sector firms can lease facilities at maintenance depots and install their own equipment, or they can lease facilities and depot-owned equipment. The leased facilities and equipment can then be used by private-sector firms to produce goods and services for either government or commercial customers.

Partnering agreements can even include bartering and "in kind" arrangements. In addition, weapon system program offices may permit access by defense contractors to depot facilities and equipment as government-furnished property.

What Are the Potential Benefits to Industrial Firms?

With partnership agreements a firm can to gain access to

- economical manufacturing and repair capabilities;
- a motivated and skilled workforce and a management team with extensive repair and manufacturing expertise;
- processes that otherwise would require special use permits (coating removal, plating, etc.);
- facilities already covered by hazardous materials licenses; and
- laboratories, centers, ranges, or other facilities at maintenance depots for the testing of materials, equipment, models, computer software, and other items.

Firms often find partnering with a maintenance depot to be financially attractive because they can avoid investment in new capabilities; however, firms may find that longer-term agreements justify the investment in their own capabilities at a DoD depot.

Aeronautical

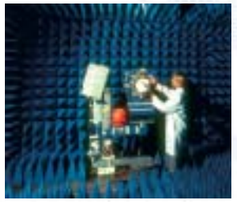
DoD has a wide range of repair, testing, and manufacturing facilities that can be useful to aerospace and aviation industry firms. Salient capabilities include

- aircraft composites,
- gas turbine engines, and
- component fabrication and repair.

Aircraft Composites

Several facilities have complete repair, remanufacture, and modification facilities for aircraft and non-aircraft bonded-honeycomb and advanced-composite-structures and components.

- *Advanced composites:* the manufacture and repair of parts and components that utilize advanced composite materials.
  - Composite repair to metallic structures on and off aircraft
    - fatigue cracks
    - corrosion grind-outs
    - structural enhancements
  - Aluminum surface preparation on and off the aircraft
    - phosphoric acid anodizing
    - grit blast silane
    - grit blast sol gel.
- *Bonded covers, panels, and surfaces:* the manufacture and repair operations for parts and component covers, panels, and surfaces that require high-strength bonding. Depots typically support a complete workflow in which an item is received, inspected, disassembled (if necessary), repaired, reassembled, inspected, painted, and returned to the customer. If manufacturing is required, the item can be manufactured from drawings or from a sample item.
  - Bonded honeycomb—DoD aviation depots can mill honeycomb to specified shapes from computer files. Items with dimensions of up to 10x20x3 feet can be cut with multiple contours.
  - Boron repair—DoD depots can repair advanced composite material (such as boron) through an advanced laboratory technology that has developed into an industrial repair capability.
- *Plastics:* the manufacture and repair operations (including injection molding, resin transfer molding, vacuum forming, and



fiberglass lay-up) for plastic and fiberglass parts and components.

The depots also have numerous autoclaves in a variety of sizes and capabilities to perform composite repair and manufacturing. Much of the autoclave equipment is computer-controlled, with nitrogen-purge, temperature, and pressure capabilities for both thermoset and thermoplastic composites. This equipment can process most current aircraft composite components, including entire wings. The autoclaves range in size from 3x4 feet to 15x55 feet (the newest autoclave), and can provide temperatures over 750°F and pressures greater than 200 psi.

Gas Turbine Engines

DoD has state-of-the-art engine repair and testing capabilities. Repair capabilities include jet engine blade and vane repairs and refurbishment of jet and gas turbine engine bearings with overhaul and testing of jet fuel controls. Additional component repair capabilities include

- jet fuel and air turbine starters;
- auxiliary drives and power take-off shafts; and
- specialized tooling for gearbox repair and assembly.

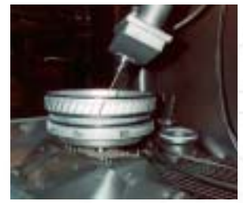
Turbine engine test cells can test the full range of turbojet and turbofan engines for military or commercial aircraft. Some cells can evaluate jet engines with up to 100,000 pounds of thrust, a mass airflow of 500 pounds per second, and fuel flow of 100,000 pounds per hour. These cells possess real-time data-acquisition-and-control systems that enable production testing for many military and commercial derivative engines.

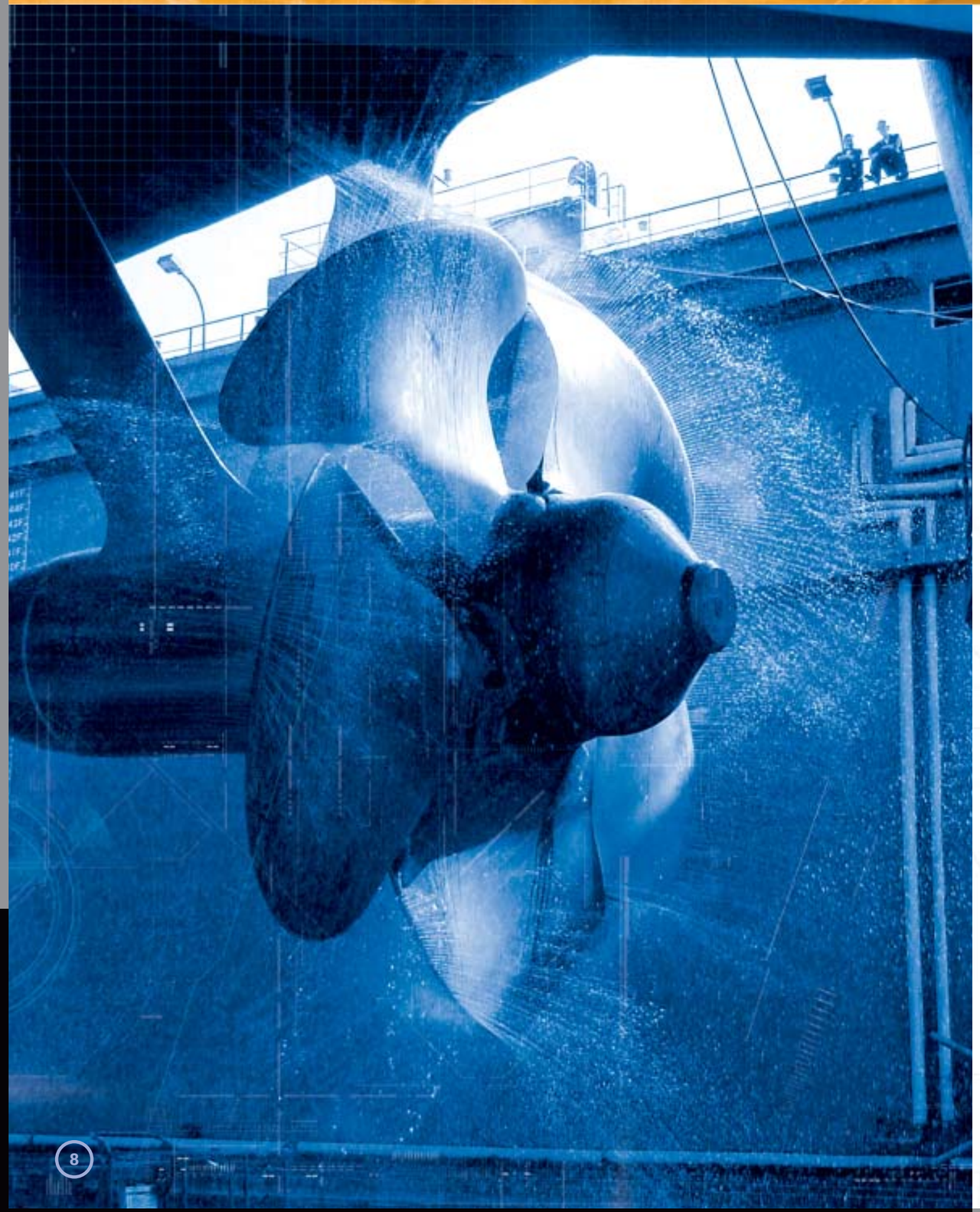
Several depots also have engine testing acoustical enclosures (known as hush houses). Hush houses permit the testing of aircraft-mounted turbofan turbojet engines up to maximum power in an afterburner, and keep noise within acceptable levels for nearby communities.

Component Fabrication and Repair

DoD's aeronautical depots also have extensive fabrication, overhaul, and testing resources for metallic components and accessories.

- *Cable manufacturing and repair:* the repair and manufacture of aircraft cables and harness assemblies, employing special skills and technologies. Depots have unique capability in the areas of laser marking, labeling, wire terminating, terminal molding, harness braiding, and wire testing.
- *Precision peening and automatic lance shot-peening:* performing precision peening to increase the resistance of metal against fatigue. The specialized automatic lance peening, for example, involves the use of a lance extension to get at difficult to reach places, such as jet engine dovetails.
- *Pneumatic accessories:* extensive overhaul and testing capabilities for all types of air-driven accessories, including test cells capable of
  - simulating aircraft flight conditions and sustaining heated compressed air to 300 psi, 850°F, and 400 pounds-per-minute flow;
  - attaining process air conditions of 800 psi, 1,400°F, and 1,400 pounds-per-minute flow;
  - fuel component testing using Stoddard solvent and process air conditions of 600 psi, 700°F, and 100 pounds-per-minute flow; and
  - simulating aircraft cabin-to-atmospheric conditions to 100,000 feet.





Marine

The U.S. Navy shipyards possess a wide array of industrial capabilities, including

- engineering, testing, and measurement;
- manufacturing;
- ship construction and repair; and
- marine equipment repair.

Engineering, Testing, and Measurement

The Navy's shipyards provide the full range of marine engineering services—from design and analysis for shipboard electrical and electronic systems and mechanical marine equipment to structural and naval architectural services.

- *Marine engineering services:* engineering measurement services that support the predictive maintenance of marine equipment, such as trend analysis for repair scheduling. Marine engineering services can monitor the vibration of equipment to evaluate the condition of bearings, shaft alignment, rotor balance, gear mesh and alignment, and pump and impeller wear.
- *Heat detection:* infrared scanning of equipment motor controllers, electrical relays, and switch panels to detect high-resistance connections, ineffective insulation, unequal load phases, and imminent component failure.
- *Theodolite measuring:* precise industrial measurement through the use of laser-guided electronic theodolites for precise hull location measurements. The use of electronic theodolites is valuable for large-scale measurements and within small confined spaces. The greatest draws for these systems are their prefabrication, repeatability, and first-time quality. These capabilities are available both on and off yard.
- *Metals testing:* comprehensive metallurgic material engineering testing facilities that have a mechanical testing capacity up to 400,000 pounds and can test hardness in the lab and on site.

Testing includes

- metallographic micro-structural examinations;
- metallurgic sample preparation;
- electron microscopy, energy dispersive scanning, and spectroscopy from 5 to 250,000 times magnification;
- failure analysis; and
- field investigations.

Manufacturing

The naval shipyards also offer highly developed manufacturing capabilities.

- *Automated manufacturing:* a fully integrated automated manufacturing facility—the fastener manufacturing cell (FMC)—that contains
  - a turning, drilling, milling, threading, and deburring center with automatic bar-feed capability; and
  - an automated engraving system for traceability.

  Innovative features of the FMC include in-process quality inspection and statistical process-control capabilities that allow on-line computer-controlled error compensation during manufacturing. The cell significantly reduces the time required to manufacture fasteners. Conventional methods require 1–3 hours per fastener at multiple machine stations; the FMC does the same work in only 10–30 minutes.
- *Propeller fabrication:* can accommodate ferrous castings up to 40,000 pounds; nonferrous castings up to 235,000 pounds. Specially designed multi-axis CNC profilers provide the ability to machine propellers in excess of 30 feet in diameter.
- *Propulsion shaft refurbishment:* the refurbishment of all types of propulsion shafts—some shaft lathes have a 60-inch swing and can handle an 85-foot shaft that weighs up to 70 tons—with full computer numerically controlled (CNC) capability. Automatic wire-feed welding, state-of-the-art heat treating equipment, and a full complement of specialized tooling and equipment minimize shaft handling and facilitate the heating and installation of bearing sleeves.

Ship Construction and Repair

The shipyards can perform a wide array of structural construction and repairs. They can manufacture, forge, bend, cut, and heat-treat almost any metal. The shipyards also have metal fabrication experience with ferrous and nonferrous metals.

- *Bow dome maintenance:* the replacing of existing bow domes with booted bow domes or repair of existing domes. Shipyards can perform all necessary repairs on both steel and glass-reinforced plastic bow domes and adjacent hull structures. Environmentally controlled bow dome booting facilities enable the shipyards to install new rubber dome boots for either repairs or newly manufactured domes. The plastics and rubber shop facilities and personnel are regularly involved in research and development projects, and are constantly improving their processes.
- *Welding and cutting technologies:* the welding and cutting of a wide variety of metals using some of the latest techniques, including laser technology for welding and cladding of ship components. Shipyards have significant experience
  - welding a variety of metals—alloys, stainless steel, aluminum, brass, bronze, CuNi, Inconel, NiCu, and titanium; and
  - cutting metal by employing different capabilities—CNC plasma cutting, CNC thermal cutting (including air carbon arc, plasma arc, and oxygen lance), and automated cutting tables.

Marine Equipment Repair

Naval shipyards have extensive experience repairing shipboard mechanical and electrical equipment and machinery.

- *Mechanical systems:* the repair, testing, and troubleshooting of all types of mechanical systems, including
  - steam, water, gas, oil and air pumps;
  - valves;
  - elevators;
  - diesel engines;
  - forced air blowers; and
  - injectors.
- *Electrical systems:* the electrical repair capability for electrical machinery repair (for example, modern motor or generator (MG) set refurbishment, servicing, and test facilities). Facilities can perform all required repairs and full-load testing (including full instrumentation) on both AC and DC ends of the MG set. Naval facilities are certified to perform equalizer winding encapsulation on 500 kW armatures. Vacuum and pressure impregnation of insulating resin is also available for components up to 5 feet in diameter. Both stators and rotors can be processed, and a team of experienced, highly trained, and certified motor/generator personnel work with on-site engineering support to ensure high-quality results.

- *Antenna restoration facilities:* unique, stand-alone facilities that are certified for depot-level repair of underwater antennas. For example, one facility can restore and upgrade antennas, towed buoys, and control units for submersible communications systems. It has its own electrostatic discharge– controlled work area, a controlled access transmitter room, hydrostatic pressure vessels, a variable lift antenna test stand with integrated ground plane, and its own machinist area for the manufacture of parts.

Automotive

Depot facilities operated by the Army and Marine Corps can repair, remanufacture, and test a wide array of automotive vehicle systems and components. Specific capabilities include

- manufacturing,
- gas turbine and reciprocating engines, and
- vehicle repair, testing and calibration.

Manufacturing

The Army and Marine Corps have decades of experience operating industrial facilities to maintain land-based combat and support vehicles. Over the years they have developed capabilities to manufacture parts and components for a wide variety of automotive vehicles.

- *Flexible computer-integrated manufacturing (FCIM):* capabilities that provide a means to manufacture vehicle parts on demand. For technical data package development, FCIM offers computer numerically controlled machine tool programming, computer-aided design and manufacturing, and reverse engineering.
- *Rubber fabrication facility:* state-of-the-art facilities equipped with systems, equipment, tooling, and material handling that can perform injection and compression modeling of component items, and can fabricate and mold small rubber component items, such as bushings, grommets, boots, bumpers, covers, and skids. One depot possesses a 126,000-square-foot facility to rebuild or remanufacture track shoes and road wheels and a 12,800-square-foot building to rebuild pneumatic and radial tires.

Machine shops can also fabricate molds and special production machinery, allowing quicker reaction to satisfy low-volume orders quickly and inexpensively. Facilities include a rubber laboratory with skilled chemical technicians and rubber specialists capable of performing physical property tests.

Gas Turbine and Reciprocating Engines

Several Army and Marine Corps depots repair, reclaim, and overhaul complete engines, as well as their associated components. Gas turbines and vehicular and marine diesel engines can be rebuilt to the original manufacturer's performance specifications, at a fraction of a new engine's cost. For example, depots have a variety of dynamometers for vehicle testing. These include three- and four-axle chassis dynamometers, engine test dynamometers from 250–5,000-horsepower engines, in-line dynamometers for conventional transmissions, and 250–1,800-horsepower cross-drive dynamometers for tracked vehicle transmissions.

Vehicle Repair, Testing, and Calibration

Land-based combat system maintenance depot capabilities include the complete maintenance, testing, and repair of all tracked and wheeled vehicles.

- *Wheeled and tracked vehicle repair:* maintenance on a wide variety of automotive and ordnance equipment. Depot expertise includes the full range of vehicle inspection, repair, rebuilding, and testing.
- *Welding, sheet metal, and machining:* an extensive range of welding, sheet metal, and machining capabilities. Employed technology includes tungsten inert gas, metal inert gas, pulse-metal inert gas (armor plating repair), oxygen or acetylene, submerged arc (for amphibious assault vehicle road wheel repair), heat treating, and automated flame shape cutting. Sheet metal and machining functions use CNC machines, which reduce time and save material during repetitive operations. Sheet metal work includes vehicle body repair, shelter repair, and equipment for shearing, bending, and hole punching. Machining equipment includes micro-precision drilling machines and CNC milling machines and turning centers.
- *Vehicle test tracks:* test facilities that incorporate paved and dirt test tracks, test ponds, natural terrain, and a test slope (30 and 60 percent grades) for testing hill-climbing ability, fuel systems, braking, and other essential wheeled and tracked vehicle functions.

Electronics

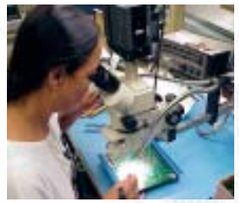
DoD enjoys a wide range of resident electronics qualifications across its depots. DoD depots provide a full-spectrum of ground, airborne, navigational, and satellite systems support, including

- systems and equipment repair,
- technology application, and
- antenna measurement facilities.

Systems and Equipment Repair

- *Avionics and instrumentation equipment:* the repair and overhaul of cockpit instrumentation, communication systems, and navigation equipment, such as indicators, gyros, Doppler navigation systems, GPS (Global Positioning System) navigation systems, and countermeasure equipment (including radar and infrared detectors and jammers). Some of the available facilities and equipment include class 1,000, 10,000, and 100,000 clean rooms; rate tables flight motion tables; north-seeking gyro test ranges; and burn-in test stands. Among the avionics and instrumentation resources are
  - electro-optical alignments and subassembly repair,
  - laser bore sight repair and calibration,
  - radio frequency (RF) interrogator adjustment and repair,
  - infrared detector repair and alignment,
  - photometric measurement, and
  - radiometric characterization (heat measurement at specific wavelengths).
- *Radars:* the complete repair, overhaul, and testing for a variety of radar, including ground control approach (GCA), target acquisition, surveillance, and interrogator (identification: friend or foe). Radar test sites permit the testing of complete systems using actual aircraft making an approach on a virtual runway 300 feet above the ground.
- *Satellite communications (SATCOM):* specialized facilities and equipment that can support Cesium/Rubidium time standards,







perform high-frequency repair up to 44GHz, support satellite antennas up to 60 feet in diameter, repair phased-array antenna panels, and perform precision alignment and test surface accuracy of antennas. Military depots have extensive qualifications to test, repair, and overhaul various SATCOM systems and subsystems. Other SATCOM facilities include satellite communications antenna test pads, digital communications satellite subsystem, facilities, and extremely high-frequency antenna support.

- *Automated Information Systems:* the repair, testing, modification, and integration of computerized equipment and peripherals, including test measurement and diagnostic equipment and automated test equipment. Technicians repair, calibrate, modify and align these highly complex systems at both the depot and the customer's site.

Technology Application

- *Technology insertion engineering (TIE):* a full range of advanced technologies that can be inserted into operational systems with minimal risk and maximum supportability. Support projects range from analysis and design to prototyping, testing, and production. TIE encompasses three major capabilities:

  - *Microelectronics*—The most advanced microelectronic technologies are available for low-risk, high-functionality, high-reliability use in a variety of systems. These technologies include hybrids, multiple-chip modules, ASIC, VHSIC, VLSI, gallium arsenide, and MIMIC.
  - *Electro-optics*—Electro-optics technology combines microelectronics and photonics to transmit information as light. Expertise includes lasers, fiber optics, thermal imaging, and infrared technology.
  - *System technology and integration*—The coordination of different elements of a system (with the capability to modernize electronic components and software design, streamline integration, and provide an extendable migration path) ensures flexibility in future technology insertion.

- *Flexible computer integrated manufacturing:* equipment that offers customers rapid manufacturing capabilities for electronic assemblies. The Rapid Acquisition of Manufactured Parts system, a sophisticated software system, controls all operations in the FCIM facility. FCIM begins with the manufacturing engineering data capture system, which uses the Internet to download drawings, technical information, or digital data from customers. A micro-process program runs production equipment, including a computer-directed assembly, a conformal coating system, a robotic tinning system, an in-line cleaning system, and a wave soldering system. All FCIM programs are developed on computer-aided engineering systems, and all equipment is fully integrated with electronic data exchange.
- *Infrared circuit card diagnostics and inspection:* a new electronics diagnostics process, in which circuit cards are tested using infrared imagining. Circuit card subcomponents have infrared "signatures" during different modes of operation. Circuit cards can be mapped and recorded via computer infrared imaging. When faulty circuit cards are examined with this process, a diagnostic comparison can be

made using these unique infrared signatures. The faulty subcomponents are then quickly isolated and replaced. The electronics infrared diagnostics are fast and accurate, which results in faster repair turnaround for electronic equipment.

Antenna Measurement Facilities

State-of-the-art compact antenna range test facilities and radome test facilities can perform pulsed radio frequency measurements or continuous-wave RF measurements from 0.5 to 40 GHz. With the depots' antenna electrical testing and qualifications, they can test side-lobe levels, beam width, gain, and bore sight for 8–18 GHz antennas up to 4 feet in diameter. Specific capabilities include

- RF and digital testing of radar receivers;
- test facilities, including antenna chambers, radar ranges, and radomes;
- testing of high-voltage power supplies used in electronic transmitters;
- thermal analysis; and
- rheology and mechanical testing.

- *Anechoic chambers:* chambers that support various antennas and testing requirements. These chambers vary in size and capabilities. For example, the chamber at one depot measures 28x16x16 feet, has an 18-foot path, and a quiet-zone reflectivity range (33 dB at 500 MHz to 50 dB at 18 GHz).

- *Vertical planar scanners:* systems ideal for measuring large arrays or reflector antennas. Utilizing state-of-the-art antenna measurement instrumentation, these systems provide automatic setup of scans based on measurement parameters and desired output. Measured data can be processed for far-field or holographic patterns yielding complete characterization of the antenna's performance.

- *Radar measurement facilities:* antenna test pattern ranges (including GCA Farfield Ranges) that operationally test and align the antennas, and atmospheric radar test facilities that house Digital Ionospheric Sounding System equipment.

Processes

The depot maintenance facilities possess superb cutting-edge technology capabilities for manufacturing and repair processes, including

- manufacturing,
- metalworking and finishing,
- paint and protective coating application and removal, and
- nondestructive testing and failure analysis.

Many of these processes, laboratories, and testing facilities are applicable to multiple weapons platforms as well as many commercial industrial applications.

Manufacturing

DoD's maintenance depots have facilities that can manufacture high-quality parts from ferrous and nonferrous metal in all sizes.

- *Rapid prototyping:* the capability to produce prototypes in hours rather than weeks. These industrial facilities can produce models and castings using stereolithography and other state-of-the-art manufacturing techniques.
  - Rapid prototyping speeds the development of new products. Resin models produced directly from a computer-aided design (CAD) data file can be used for form, fit, or function testing. In addition, a quick-cast model can be produced to build a casting mold for the part. Using this combination of technologies, a new product can be modeled in resin then manufactured in metal by creating the casting pattern and casting and machining the part.
  - Pattern making facilities utilize laminated object manufacturing to create steel castings.
- *Computer-aided design and manufacturing:* numerically controlled programming that interfaces with CAD systems. These are another example of DoD's flexible manufacturing capabilities, with software applications generating tool paths with minimal user input. Further enhancements for this capability include the capture of a knowledge base from experienced CNC programmers and machinists. Time savings in CNC programming development can be 30 to 90 percent.

- *Rapid parts manufacturing (RPM):* technologies that permit the creation of physical objects from digital data without manually generated numerical control programs or tooling. Through the Rapid Prototype Technology Advancement program facilitated by the National Center for Manufacturing Sciences, several industry partners have benefited from RPM implementation at DoD facilities. Benefits include reduced down time, lead-time for needed parts, and program cost.
- *Laminated flex cable:* capabilities that provide a wide range of services, primarily the repair and manufacture of laminated flex cable harnesses. Depots typically work with AWGs (American Wire Gauge) of 4 to 30; however, specialized capability is available for as small as 50 AWGs wire. For this fine work, the shops perform microminiature soldering and employ 2MCF-certified personnel. Shops can also repair a variety of circuit card assemblies and have some manufacturing capability.
- *Foundries:* DoD industrial facilities that can manufacture from ferrous and nonferrous metal high-quality parts in all sizes. Several DoD facilities have pattern-making units that create
  - high-alloy steel and stainless steel castings up to 6,000 pounds;
  - austempered ductile iron, brass, and bronze castings up to 1,000 pounds; and
  - aluminum castings up to 500 pounds.

  For intricate shapes, a precision unit produces investment castings to high tolerances. High-alloy steel castings up to 50 pounds can be manufactured, as can brass and bronze castings up to 50 pounds and aluminum castings up to 30 pounds.

Metalworking and Finishing

DoD's maintenance depots possess a wide variety of metalworking and finishing processes.

Metalworking

- *Electron beam welding:* precision welding that uses extremely high energy density to minimize the impact of the heat by producing a small heat-affected zone. CNC capability allows precise repeatability, and weld contamination is minimized because the process occurs in a vacuum chamber.
- *Heads-up-display (HUD) welding:* the real-time analysis of the welding process using Weld Signature™ analysis. Information about the quality of the weld is provided as instant feedback to a heads-up display in the operators' helmet. The HUD welding system reduces costly repairs and rework of welds, reduces costs associated with analyzing weld data, and increases weld reliability.
- *Laser metalworking:* the combined application of industrial lasers, galvanometric imaging systems, and computer control to provide a unique combination of precision, speed, and versatility that cannot be matched by any other metalworking technique.
  - *Laser cutting and drilling*—Laser cutting and drilling provides a smoother edge and better accuracy than plasma or oxy-fuel cutting, and at much higher speeds than water-jet cutting, machining, or routers, with no tool wear.
  - *Laser cladding*—Laser cladding deposits surface materials onto a substrate using laser energy delivered through fiber optics. With the laser cladding process, repairs can be made on expensive aluminum components that cannot be repaired using more conventional processes. Even materials that cannot be welded, such as K-monel, can be clad by laser.
  - *Laser welding*—Industrial lasers can achieve high-speed welding of carbon steel, stainless steel, aluminum, titanium, and dissimilar metals.

- *Near-dry machining and drilling:* a process that enables the machining and drilling of metal structures in a near-dry manufacturing environment. This near-dry process reduces the volume of lubricant, reduces industrial waste disposal, and speeds processing time.
- *Fluid cell press for sheet metal forming:* a fluid cell press that can form extremely thin material—0.008 to 0.375 inches thick. Some presses have two 157.5x63x14.2-inch trays and can produce forming pressure as high as 22,000 psi.
- *Water jet cutting:* the making of clean precision cuts through various manufacturing materials —titanium, aluminum, stainless-steel alloys, glass, ultra-dense plastic, and composite materials—without delamination. Water jets cut through materials without generating localized heat on cutting surfaces; as a result, they avoid thermal distortion and structural changes. Because the metallurgic structure of the material is undisturbed, fewer downstream manufacturing operations are required for the final product.
- *Wire electrical discharge machining:* the precision machining of titanium and other hard metals, which provides the required finer surface finishes for weapon systems components. This cutting-edge precision machining technology is also useful to the medical and tooling industries.
- *High-velocity electromagnetic metal forming (EMF):* the application of electromagnetic forces to form metal—for both radial forming and sheet forming. Radial forming can be done either on a die to give a tube a more complex shape, or on a smaller tube to swage the two tubes together. With sheet forming, a metal sheet is forced against a die to give it a more complex shape. EMF can generate high cost savings by eliminating one or more processing steps, combining assembly or joining operations, and eliminating the need for welding (especially in aluminum alloys).
- *Tube bending:* the use of a laser coordinate measurement machine (CMM) to duplicate existing tubes on CNC tube benders. Some shops can bend tubes up to 4 inches in diameter. The laser CMM can also be used to reverse-engineer from an existing part to produce an exact duplicate.

Metal Finishing

- *Advanced metal finishing:* metal finishing capabilities that support manufacturing or reclaim damaged or worn parts. Current depot process capabilities include
  - chrome, nickel, cadmium, silver, and gold plating;
  - anodizing of titanium and aluminum;
  - conversion coatings for aluminum and cadmium;
  - stainless steel passivation;
  - black oxide coating;
  - manganese phosphate finishing;
  - chromic processes for magnesium;
  - and aluminum vapor deposition.
- *Aluminum ivadizing:* the application of an aluminum coating (approximately 0.5–1 mil thick) by IVD systems. The IVD systems have ample capacity for all parts, from small bolt-sized pieces to 3x10-foot components.
- *Allison electrophoretic process:* an aluminum alloy coating process used for nickel-base or cobalt-base turbine blades and vanes, as well as for oxidation protection in turbine engine environments above 1,900ºF.
- *Physical vapor deposition sputter coating process:* application of coatings to compressor or turbine

section blades and vanes for surface protection. Sputter coatings produced under vacuum deposit very thin layers with very high quality and adherence. Reactive gases, such as nitrogen, may be added inside the coating chamber to create a TiN coating system.

- *Thermal spray coatings:* processes that use thermal and kinetic energy to deposit a raw material onto the surface of a component. There are five primary thermal spray techniques:
  - *Cold gas spray* coating uses no thermal energy and a tremendous amount of kinetic energy to deposit metallic and plastic materials. Because there is an absence of thermal energy, the cold spray eliminates oxide formation in the subsequent coating, and coatings can approach densities of 100 percent. The advantages of cold gas spray are its superior surface coverage, superior surface hardness, and tendency toward less corrosion.
  - With *flame spray* the raw material (a powder or wire) is fed into a flame where it is melted, formed into molten droplets, and then blown toward the substrate. The flame spray process can be advantageous because it is very inexpensive and can deposit certain ceramics.
  - When two electrically charged and continuously fed wires of opposite polarity are brought together, they are melted by the resultant *electric arc*. The electric arc process is valuable because it is very inexpensive, the density of the coatings is superior to flame spray coatings, and the deposition rate can be upwards of a 100 pounds of material per hour.
  - *Plasma spraying* uses ionized gases to create high-temperature plasma. The plasma spray process can produce coating densities that approach 98 percent, and any material that has a melting point can be plasma sprayed. The main advantage of the plasma spray process is that it can deposit materials with high melting points (such as ceramics) with excellent physical properties. *Low-pressure* (vacuum) *plasma spray* coatings are applied to turbine section components for superior surface protection compared to traditional thermal sprayed coatings.
  - The *high-velocity oxy-fuel* (HVOF) process for machinery repair sprays a powder onto machine parts at a high velocity and a high temperature. HVOF yields shorter application times, higher bond strength, lower porosity, and better wear resistance than other thermal spray processes.
- *Powder coatings:* the application of high-performance fluoropolymer coatings in powder form, which reduces VOC emissions and negates oven capacity limitations. Thermoplastic powder coatings comply with environmental regulations; exhibit excellent

resistance to chemicals, solvents, and regents; show excellent abrasion resistance; and form good barriers against corrosion.

- *CNC robotic shot peening system:* equipment that shot peens parts using steel media of various sizes. Some machines consist of a 6-axis top-mount robot with an ID peening lance, an indexing and continuous rotating turntable, a rotary blast lance, a pressure engine blasting system, a dual media reclaim system, and other support components. The systems also include a versatile shuttle conveyor loading system for automatically loading and unloading blast booths.

Paint and Coating Application and Removal

Defense depots possess an extensive array of environmentally friendly techniques used to apply and remove coatings from land, sea, air, and space vehicles.

Application

- *Appliqué coatings:* one of the few alternative paint coating technologies currently available. An appliqué is a plastic adhesive film and that provides effective topcoat performance. The use of appliqué as a paint substitute can provide substantial cost savings because it reduces painting requirements, repair time (when compared to touch-up painting), maintenance requirements, and hazardous waste.
- *One-coat topcoat paint systems:* self-priming topcoats applied to many surfaces. Topcoat systems eliminate 50 percent of the required volume of paint, comply with VOC emissions regulations, lower costs, shorten drying times, reduce pot life, and reduce surface imperfections (such as orange peel).

Removal

- *Laser depainting or decoating:* a non-intrusive and low-kinetic energy ablating process for the removal of paint or coatings. The depainting process requires minimal surface preparation or post-process activities, and laser paint removal is efficient and generates less disposable waste than the initial volume of applied paint. With laser depainting, a pulsed beam of light energy strikes a surface and volatilizes the surface coating. Some depots use a similar process, the Laser Automated Decoating System, to remove coatings—without damage—from composite, thermoplastic, or metal-substrate aircraft components.
- *Abrasive media blasting:* the use of abrasive media—soda, carbon dioxide, walnut hull, wheat starch, plastic bead, and steel bead—to wear the coating off surfaces with a scouring action. Select depots use abrasive media technology to remove paint from aluminum and composite aircraft skins and other structures.
- *Water jet blasting:* an alternative to traditional cleaning solvents that can be used to remove silicone rubber, abradable coatings, paint coatings, and corrosion. Several shipyards also use a closed-loop ultrahigh-pressure water jet blast for removing paint, rust, or other hull coatings from a ship's outer hull surfaces. The remotely operated equipment strips coatings with water at pressures as high as 40,000 psi and captures the coatings and water for separation and recycling.

- *Ultrahigh-pressure water jet stripper:* a process used by depots to remove thermal spray coatings. The system utilizes a 55,000-psi intensifier pump, a six-axis pedestal robot, and sophisticated nozzle technology and software to strip coatings with water. Tenacious coatings (such as RTV, abradable rubber, sealants, and metal spray) can be removed in minutes using only water, which is recycled through an integral water reclamation system. Hazardous waste is limited to what is removed from the part being stripped.
- *Cryogenic degreasing and decoating:* technologies that employ extremely cold temperatures to cause coatings to become more friable and induce differential contraction for debondment of the coatings from surfaces. This process provides for a more through cleaning and decoating process.
- *FlashJet depainting:* a specifically developed solution to the problem of removing paint and specialty coatings from aircraft and aircraft components. The Flashjet process employs pulsed light energy to pyrolyze an organic coating while a stream of CO^2 particles cools the substrate and removes the coating residue. FlashJet offers high strip rates, damage-free coating removal, precision process control, and significant reductions in maintenance labor-hours, stripping cycle time, and stripping costs.

Nondestructive Testing and Failure Analysis

Many of the defense depots are unmatched in terms of nondestructive testing capabilities and failure analysis.

- *Nondestructive test and inspection:* inspection capabilities that do not require the destruction or dismantling of the component. These depot capabilities span the entire spectrum of inspections and include the most advanced technologies and methods.
  - Neutron radiography capable of pinpointing minute amounts of moisture and corrosion inside inspected parts, assemblies, or aircraft
  - Totally maneuverable film and digital information for both the neutron and x-ray inspection systems
  - Laser ultrasonic inspection systems
  - C-Scan inspection facilities with scanning envelopes up to 15x40 feet
  - Real-time x-ray bays for component inspections
  - Both on- and off-aircraft eddy current, dye penetrant, magnetic particle, x-ray, and magnetic rubber inspection systems
  - Overhead programmable robots used for inspecting intact aircraft in real time or on film
  - Computerized tomography, a powerful x-ray imaging method that overcomes many of the limitations inherent to radiographic inspections
  - Standard nondestructive techniques for aircraft undergoing detailed structural inspections.
- *Failure analysis:* the investigation of all manner of material failures, including metals, composites, polymerics, and ceramics, through the use of scanning electron microscopy, metallographic analysis, material analysis, mechanical testing, and fractographic analysis. DoD has material test and evaluation laboratories capable of conducting complete failure investigations and analyses.

Laboratories and Testing Facilities

DoD has numerous laboratories at its maintenance depots around the United States. These facilities perform testing and analysis of metals, composites, chemicals, and the environment.

- *Science and engineering laboratories:* full-service technical laboratories that provide engineering consulting and testing services to a wide variety of customers worldwide. Engineers (chemical, materials, mechanical, electronic, and welding) and scientists (physicists and chemists) supported by engineering technicians have developed the technical knowledge and skills necessary to provide complete, integrated engineering and scientific solutions to support industrial repair and manufacturing processes. These processes include cleaning, plating, advanced composites, adhesive bonding, metal joining, foundry operations, and heat treatment. Science and engineering laboratories provide the following capabilities:
  - Certified chemical analysis that permits critical evaluations of water and hazardous materials, as well as oils, hydraulic fluids, breathing air and other gases, and metals
  - Mechanical and fatigue testing
  - Corrosion testing
  - Metallographic examination
  - Structural and electronic failure analysis.
- *Materials laboratories:* laboratories that can perform mechanical testing of metal alloys and polymeric materials; quantitative and qualitative analyses of metal alloys and polymeric materials; plating and surface finishing; cleaning; and corrosion prevention processes. DoD material laboratories can ensure compliance with military and industry standards and specifications. Analytical procedures, techniques, and equipment identify metal alloying elements and polymeric materials, evaluation and characterization of thermal properties, and maintenance and monitoring of industrial shop processes and industrial water quality.
- *Test ranges:* ranges where DoD can test whatever it repairs, produces, or remanufactures. Land, sea, and air ranges—coupled with an extensive array of laboratories and test facilities—are among the unparalleled resources of DoD's depots.

Location of DoD's Maintenance Depots

Legend

AD	Army Depot
ALC	Air Logistics Center (Air Force)
AMARC	Aerospace Maintenance and Regeneration Center (Air Force)
IMF	Intermediate Maintenance Facility
MCLB	Marine Corps Logistics Base
NADEP	Naval Air Depot
NSWC	Naval Surface Warfare Center
NSY	Naval Shipyard
NUWC	Naval Undersea Warfare Center

Sources for Further Information

CAPABILITY CATEGORY	DEPOT				
	Army Depots	Naval Air Depots	Naval Shipyards & Warfare Centers	Air Force Logistics Centers	Marine Corps Logistics Bases
Aeronautical					
Aircraft Composites		●		●	
Gas Turbine Engines	●	●		●	
Component Fabrication and Repair	●	●		●	
Marine					
Engineering, Testing, and Measurement			●		
Manufacturing			●		
Ship Construction and Repair			●		
Marine Equipment Repair			●		●
Automotive					
Manufacturing	●				●
Gas Turbine and Reciprocating Engines	●				●
Vehicle Repair, Testing, and Calibration	●				●
Electronics					
Systems and Equipment Repair	●	●		●	●
Technology Application	●	●		●	●
Antenna Measurement Facilities	●	●		●	●
Processes					
Manufacturing	●	●	●	●	●
Metalworking and Finishing	●	●	●	●	●
Paint and Protective Coating Application and Removal	●	●	●	●	●
Nondestructive Testing and Failure Analysis	●	●	●	●	●
Laboratories and Testing Facilities	●	●	●	●	●

For information about specific capabilities at a particular depot, call the following telephone numbers:

Army Depots
703-614-3936

Naval Air Depots
301-757-3046

Naval Shipyards and Warfare Centers
202-781-3312

Air Force Logistics Centers
937-904-1220

Marine Corps Logistics Bases
800-952-3352

For Information about other capabilities call:
937-656-2741


Depot Maintenance
Public-Private Partnerships