ITEM 1
Complete Rocket and UAV Systems

Complete Rocket and UAV Systems

Complete rocket systems (including ballistic missile systems, space launch vehicles and sounding rockets) and unmanned air vehicle systems (including cruise missile systems, target drones and reconnaissance drones) capable of delivering at least a 500 kg payload to a range of at least 300 km as well as the specially designed "production facilities" for these systems.

Produced by companies in

- Brazil
- China
- Egypt
- France
- India
- Iran
- Iraq
- Israel
- Italy
- Japan
- Libya
- North Korea
- Pakistan
- Russia
- South Korea
- Spain
- Syria
- Ukraine
- United Kingdom
- United States

Rocket Systems

Nature and Purpose: Rocket systems are self-contained flight vehicles, which carry their fuel and oxidizer internally and boost their payloads to high velocity. After burnout, the payload continues on an unpowered, ballistic trajectory either into orbit or to a target on earth. Depending on its range and trajectory, a rocket may or may not leave the atmosphere. Rocket systems normally consist of four elements: 1) the payload, or warhead; 2) a propulsion system, which provides the energy to accelerate the payload to the required velocity; 3) a guidance and control system, which guides the rocket along a preprogrammed trajectory to its destination (not all rockets are guided, however); and 4) an overall structure that holds everything together.

Method of Operation: Before launch, rocket subsystems are checked for operational readiness, and the flight plan or trajectory is programmed into the guidance computer. On ignition, liquid or solid propellants generate the thrust to launch the rocket. If the rocket has multiple stages, each stage terminates its thrust when its fuel is expended or almost expended and is separated from the rest of the rocket, and the next stage is ignited. The guidance and control system guides and steers the rocket in order to maintain the proper trajectory. After the final stage terminates its thrust, the payload is usually released on its final trajectory. In some systems, the payload remains attached to the missile body as it reenters the atmosphere.

Typical Missile-Related Uses: Complete rocket systems controlled under the MTCR as Category I are capable of delivering a payload of 500 kg or more to a ground range of 300 km or more. Rocket systems capable of delivering a payload of less than 500 kg to a ground range of 300 km or more are controlled as Category II items and are described in Item 19 of this handbook. Space launch vehicles and sounding rockets are used to place satellites in orbit or to gather scientific data in the upper atmosphere, respectively. The main difference between them and offensive ballistic missiles is their payload and intended use. With the addition of a weapons payload and different guidance algorithms, space launch vehicles and sounding rockets can be used as ballistic missiles. In fact, many commonly used space launch vehicles have been developed from, and share components with, former and currently operational ballistic missiles.

Other Uses: N/A

Figure 1-1: A solid propellant SRBM.

Appearance (as manufactured): Complete rocket systems are large, long, narrow cylinders. When assembled, rocket systems controlled by Item 1 typically have dimensions of at least 8 m in length, 0.8 m in diameter, and 5,000 kg in weight, with a full load of propellant. Some representative photos of rocket systems are shown in Figures 1-1, 1-2, 1-4, and 1-5. See Figure 1-3 pullout diagram for an exploded view of a ballistic missile. The forward end, or nose, typically has a conical, elliptical, or bulbous fairing that houses the payload, and joins to the cylindrical body in which the propellants are located as shown in Figure 1-3. The blunt aft end is straight, flared, or symmetrically finned for stability during launch and atmospheric flight. The body of the missile houses the rocket motor(s), which supplies the thrust. The missile surface is usually made of metallic or composite materials with heat-absorbing materials or protective coatings. Depending on their intended use, some surfaces may be unfinished.

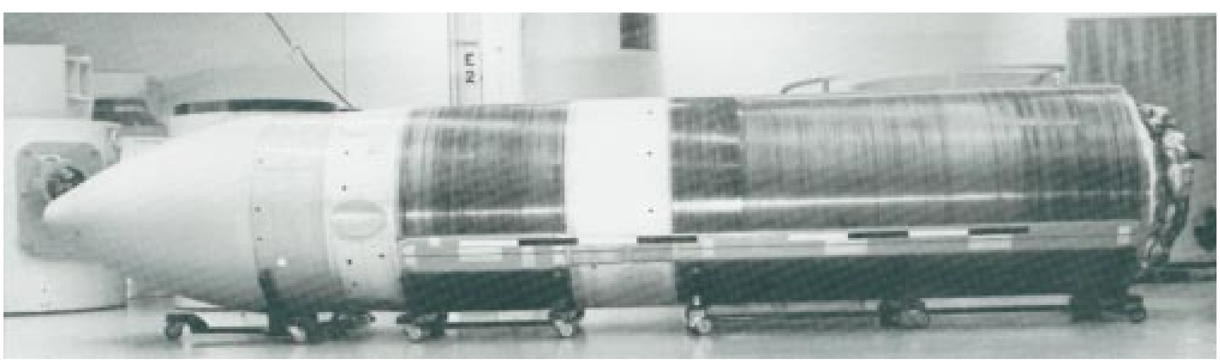

Figure 1-2: A solid propellant, submarine launched ballistic missile.

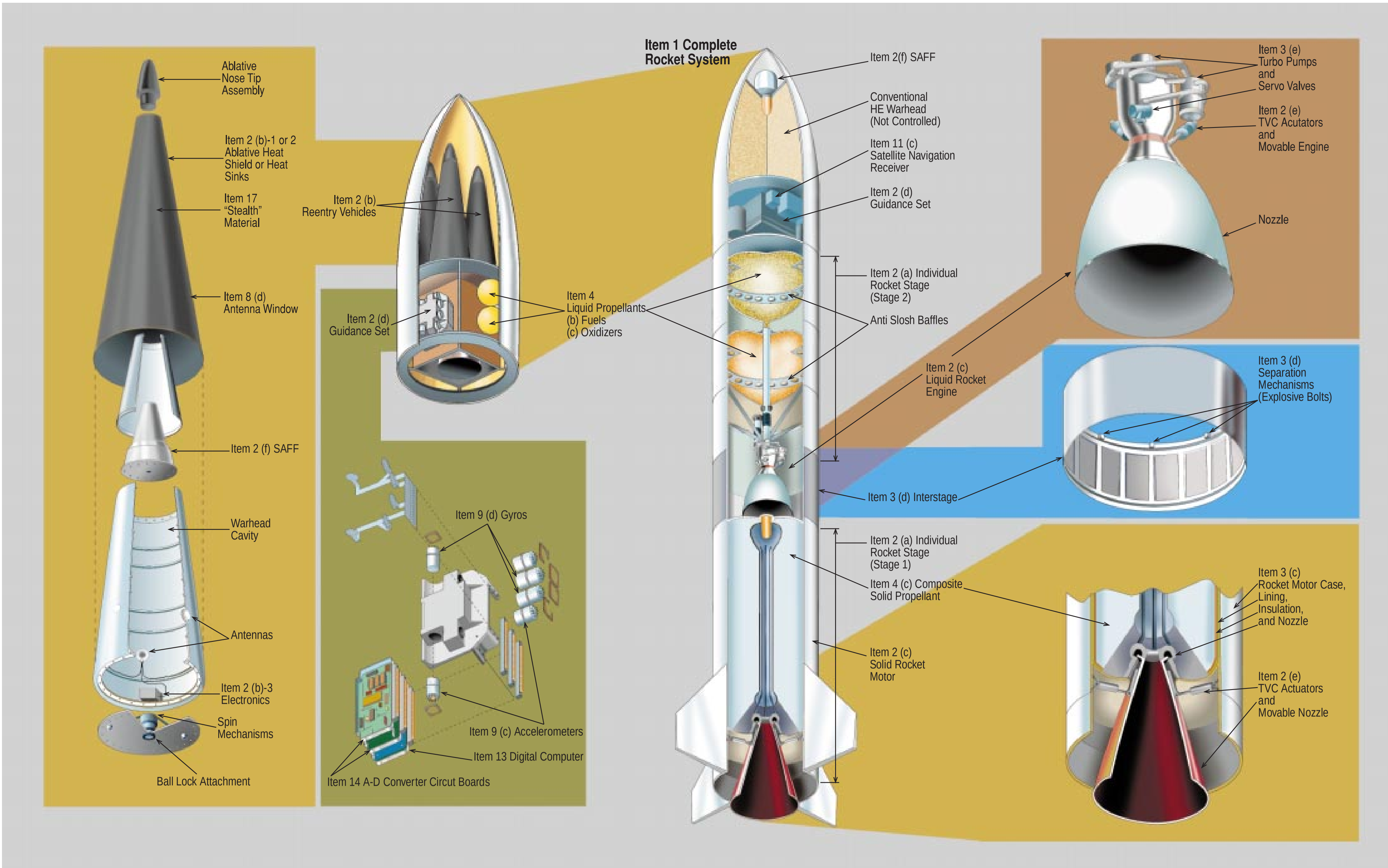

Figure 1-3: Exploded view of MTCR Annex items used in a ballistic missile.

Figure 1-4: A short range liquid fueled ballistic missile.

Photo Credit: AlliedSignal Aerospace

Figure 1-5: A space launch vehicle.

Appearance (as packaged): Because rocket systems controlled under the MTCR are large, a complete rocket system is seldom packaged as a fully assembled unit for shipment from the manufacturer to its point of use or storage. Instead, the major subsystems are shipped in crates or sealed metal containers to an assembly facility near the launch location, where they are assembled, tested for their operational state, and erected for vertical launch. Exceptions include mobile ballistic missiles, which are fully assembled and stored in a horizontal position in a mobile transporter-erector-launcher and moved to the launch point when needed. These packaging and shipping methods are described more fully in later sections of this handbook.

Unmanned Air Vehicles, including Cruise Missiles, Target Drones, and Reconnaissance Drones

Nature and Purpose: Unmanned air vehicles (UAVs) are typically air-breathing vehicles which use aerodynamic lift to fly and thereby perform

Produced by companies in

- Australia
- China
- Israel
- Russia
- United States

their entire mission within the earth's atmosphere. The most common mission for UAVs is reconnaissance. They are usually powered by small turbine or piston engines that drive either free or ducted propellers. UAVs tend to fly at relatively slow speeds of 360 to 540 km / hr, usually for several hours. Cruise missiles are distinguished from other UAVs by their use in weapons delivery and by flight trajectories that often minimize their vulnerability to defenses. Cruise missiles can fly at almost any speed, but they are usually powered by small jet engines, which typically operate at high subsonic speeds (less than 900 km / hr). UAVs, including cruise missiles, can fly at altitudes ranging from very low, nap-of-the-earth trajectories to very high altitudes.

Method of Operation: UAVs are launched from many platforms, typically trucks, aircraft, and ships. They may fly autonomous preplanned routes and / or routes controlled by a human operator. After their mission is completed, they usually return to base to be used again. Cruise missiles are frequently carried and launched by aircraft as well as trucks, ships, or submarines. Land- and sea-based cruise missiles usually use a small rocket booster to accelerate them to flying speed. Cruise missiles usually fly preplanned missions specifically designed to defeat defenses by means of terrain masking or defense avoidance, and increasingly by use of stealth technology. Most cruise missiles contain a sensor system that guides them towards their targets by using terrain features or target signatures. Cruise missiles increasingly use inertial navigation systems, updated by satellite navigation receivers in addition to, or instead of, terrain-aided navigation systems to guide them to the vicinity of the target. Once there a terminal sensor is activated to home in on the target. Various types of sensors are used to detect distinctive target signatures or to match preprogrammed scenes of the target area. Once at the target, the cruise missile either detonates the warhead or, if so equipped, dispenses submunitions.

Typical Missile-Related Uses: UAVs are most typically used as reconnaissance platforms and thus carry electronic, video, or photographic payloads to gather or monitor data over unfriendly territory. They are designed to optimize time on station, which, for some systems, can be more than 24 hours. Because of their long range, flexible payload, ease of acquisition, and reasonable cost, UAVs are potential delivery vehicles for weapons. UAVs are also used as target drones, platforms for agricultural monitoring and spraying, scientific data gathering, relaying communications, or electronic warfare. UAVs are becoming more popular for monitoring borders and natural or manmade disasters. Cruise missiles typically deliver weapons payloads weighing 200 to 500 kg to a distance of between 300 and 5,000 km.

Other Uses: N / A.

Appearance (as manufactured): UAVs, including target and reconnaissance drones, often look like airplanes without cockpits for pilots. They vary in appearance because their role-specific designs differ, but many have prominent wings and complex antennae, windows, or domes on the body. Although some UAVs are large enough to have human pilots, most are somewhat smaller. Cruise missiles are UAVs designed or modified for use as weapon delivery systems. Reconnaissance drones usually have long slender wings suited for extended missions at medium-to-high altitude, or they can look more like missiles. An example of the former type is shown in Figure 1-6; notice that it is as large as a manned fighter. Figure 1-7 depicts a jet powered UAV used for reconnaissance missions, sitting on its launcher.

Cruise missiles usually have a cylindrical or box-like cross-section and a fineness ratio (ratio of length to diameter) between 8 to 1 and 10 to 1. They all have a lifting surface, or wings, and most use control fins at the tail (some have ailerons on the wings and / or canards), although the shape and size of these surfaces depends greatly on the intended flight regime and payload. Most of these features of a typical cruise missile are shown in Figure 1-8. Most cruise missiles have a dull finish or coating to make them harder to detect, and ad-

Photo Credit: Teledyne Ryan Aeronautical

Figure 1-6: A large Category I UAV.

Figure 1-7: A jet powered reconnaissance UAV sitting on its launcher.

Figure 1-8:
A land attack cruise missile in flight showing its entire control surfaces and engine inlet.

vanced designs have unique geometric surfaces to reduce radar reflections. These features are shown in Figure 1-9. See Figure 1-10 pullout diagram for an exploded view of a UAV.

Appearance (as packaged): UAVs, including cruise missiles, typically are manufactured in components or sections at different locations and assembled at a military site or a civilian production facility. These sections may vary in size from less than 10 kg and 0.03 cubic meters to 150 kg and 0.1 to 1 m^3. The smaller sections can be shipped in heavy cardboard containers; medium-size sections require heavy wooden crates. However, most modern cruise missiles are shipped fully assembled in environmentally sealed metal canisters, which can also serve as launching tubes. Their wings are folded either within or on top of the missile body, and the tail fins are often folded on longitudinal hinges in order to fit within the launch canister and open after launch to control the missile. The wings of large UAVs are detached from the fuselage, and each section is crated separately for shipping by truck, rail, or cargo aircraft.

Figure 1-9:
An operational cruise missile on its checkout stand showing its nose cone modified to lower radar returns and enhance aerodynamic performance.

Additional Information: A Category I UAV can be as large as an airplane, as shown in Figure 1-6. In fact, any airplane with the necessary range-payload capability can serve as a UAV if outfitted with the appropriate guidance package or remote piloting equipment.

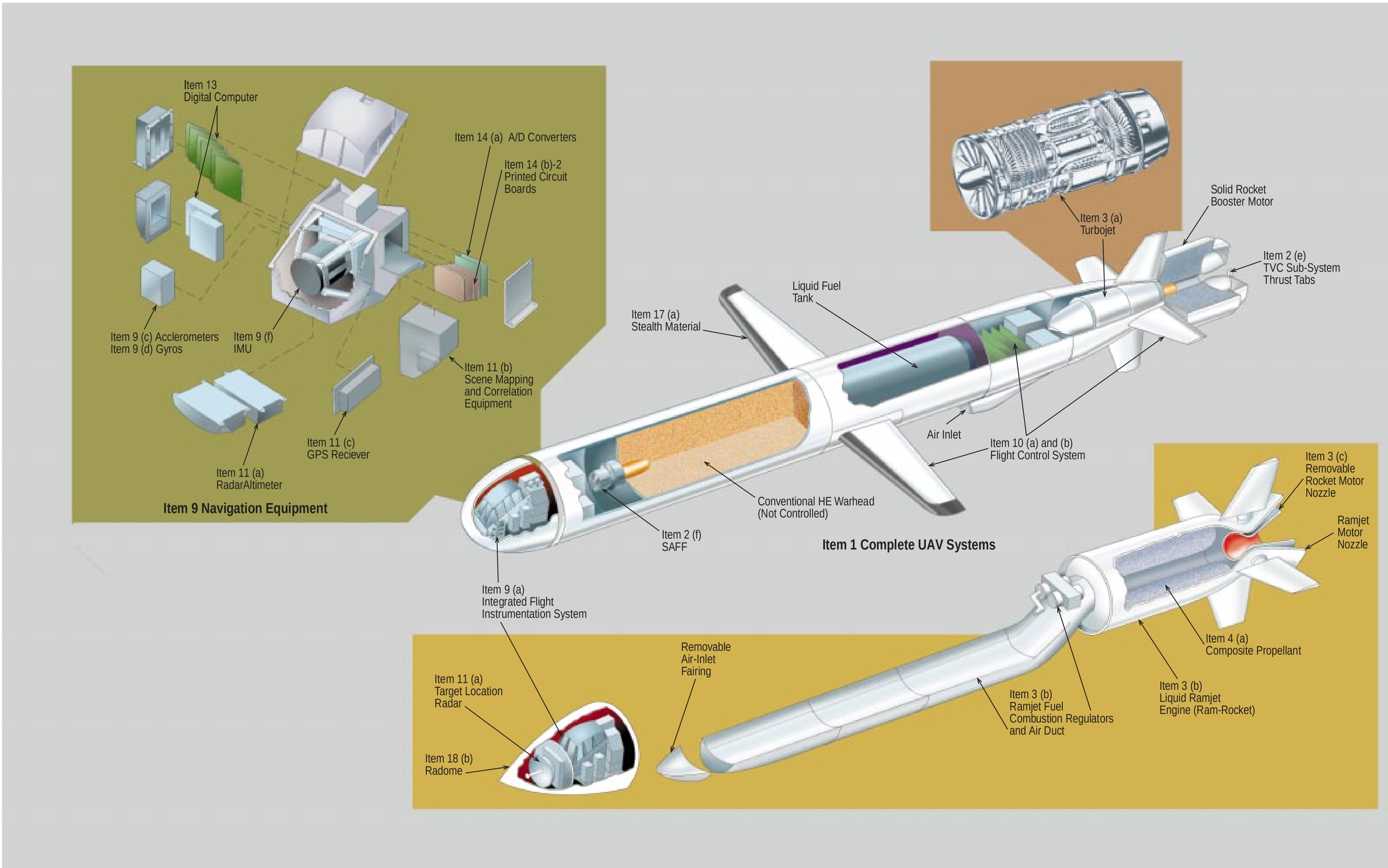

Figure 1-6: Exploded view of MTCR Annex items used in a notional cruise missile (UAV).

Specially Designed Production Facilities and Equipment for the Systems in Item I

Nature and Purpose: Specially designed production facilities include all the special equipment used for the production of complete rocket systems and UAVs. There are many different kinds of specially designed production equipment for such missiles which, when integrated into installations, are considered production facilities. Some of the largest, most important, and most distinctive such equipment are the jigs and fixtures used to ensure proper alignment of individual missile components during assembly of missiles.

Method of Operation: Jigs and fixtures are used to receive, support, align, and assemble individual missile components such as fuel and oxidizer tanks, motor cases, and engine assemblies. Overhead cranes are used to move the missile components from their shipping containers and dollies onto the assembly jig. Laser alignment instruments are sometimes built into fixtures in order to ensure precision fitting, and electrical and electronic test equipment for functional and operational testing are used as necessary during the assembly process.

Typical Missile-Related Uses: Production facilities are used to assemble a complete missile system from its subassemblies and component parts. At the end of each production step, mechanical and electrical fit and function tests are performed to verify that the assembly is ready for the next step. After the missile is assembled and passes all production tests, it is disassembled at prescribed body break points. These separated missile components are loaded into individual containers or crates for shipment to a facility for long-term storage or to the operational launch point for final reassembly and use. However, cruise missiles are typically shipped fully assembled to operational units (depending on the type of launch platform) or for long-term storage.

Other Uses: Assembly jigs and fixtures are usually single-application items designed to produce one type of rocket system or UAV. It is usually not practical to modify them for other uses.

Appearance (as manufactured): Assembly jigs and fixtures used in the production of rocket systems are usually large and heavy structures. Their overall length and width are roughly 20 to 30 percent larger than the missile system that they are designed to assemble. Their weight may total hundreds or even thousands of pounds as shown in Figures 1-11, 1-12, and 1-13.

Appearance (as packaged): Assembly jigs and fixtures for large missiles are often too large and heavy to be packaged and shipped to the production plant as complete units. Instead, component parts are shipped separately in large crates or protected on pallets for assembly onsite. They will be securely fastened to the crate to forestall any movement. Smaller jigs may be individually crated or palletized for shipment.

Figure 1-11:
Solid rocket motor assembly jig for an ICBM.

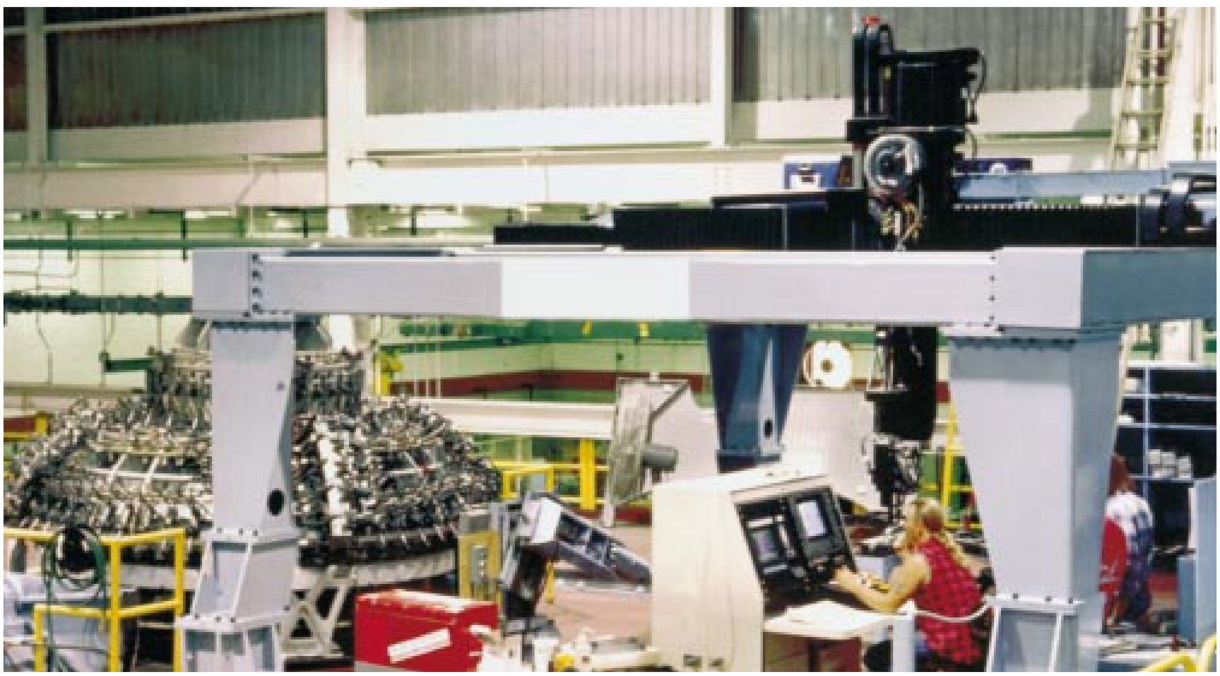

Photo Credit: Sciaky, Inc.

Figure 1-12:
On the left, a very precise hydraulically adjustable welding fixture for a liquid propellant tank end dome; its seven-axis gantry robot welder is on the right.

Additional Information: Assembly jigs and fixtures built to receive and assemble missile components in a horizontal attitude require contoured surface pads or rollers to support the cylindrical body parts with minimal deformation. Rocket assembly systems, which build the rocket in a vertical attitude, require fewer body support fixtures but must allow a high overhead clearance within the building to stack the components and move a fully assembled missile. The primary components of assembly jigs and fixtures are standard structural steel members. Their size and strength are dictated by the requirement to support and maintain alignment of the large and heavy missile components during missile assembly.

Jigs and fixtures are usually assembled by welding or bolting large steel plates and I-beams or tubular members together on the floor of the missile assembly building. In some cases, these fixtures are built on floating pads, not bolted to the floor; such pads isolate the structure from vibration, which might otherwise cause misalignment of their precision reference points. Precision survey devices are used to ensure correct alignment.

Figure 1-13: Modular jig supporting a cruise missile in final assembly.