atlas missile

The Weapon System—The Atlas (SM-65) is America's first intercontinental ballistic missile. With associated ground equipment it comprises the Air Force weapon system WS 107A-1. The missile has been developed in a flight-test program that began in mid-1957. It is in production at San Diego by Convair (Astronautics) Division, General Dynamics Corporation.

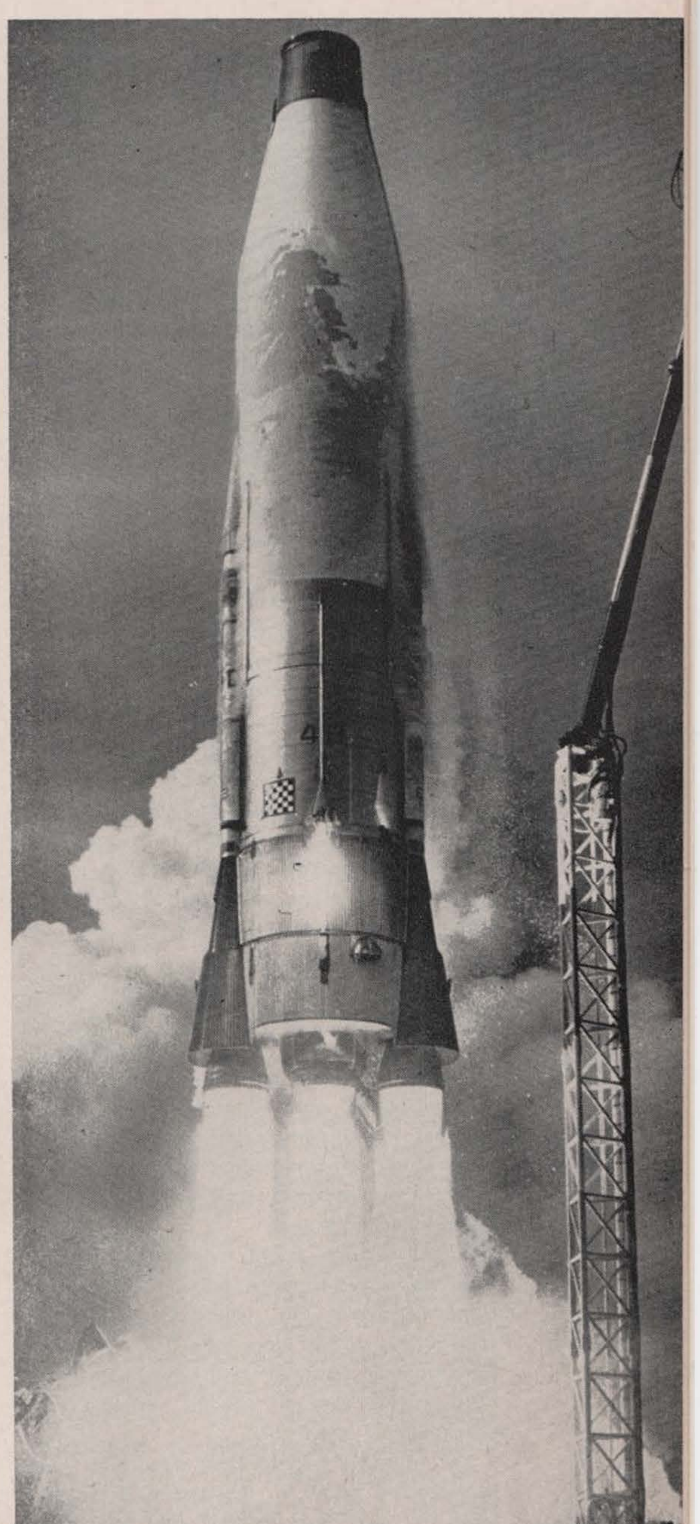
Atlas was the first missile to lift itself into orbit without extra rocket stages, and is being used in a number of pioneer space projects.

The Missile—The Atlas is designed to deliver a thermonuclear warhead more than 6,000 statute miles (5,500 nautical miles). It is powered by liquid propellant rockets—two large boosters, one large sustainer and a pair of small "vernier" rockets. All burn liquid oxygen and RP-1, a kerosene-like hydrocarbon. Takeoff thrust is approximately 360,000 pounds. Takeoff weight is about 260,000 pounds. The missile is 75 feet long and 10 feet in diameter. Some flight versions with a pointed nose are 82 feet long.

The unique Atlas propellant tank is made of tough, lightweight stainless steel, thinner than a dime. The tank, measuring about 60 feet in length, has no internal framework. It is kept under pressure to retain its shape. This results in a tremendous weight saving. A special cold-rolled austenitic steel (AISI grade 301) was perfected for the Atlas, and Convair worked with the welding industry to develop new welding techniques and equipment for fabrication. Skin gages vary throughout the structure, being tailored to meet local stresses. The heaviest gage is less than 40-thousandths of an inch. The thinnest wall section meets a specification for minimum tensile strength of 200,000 pounds per square inch.

The missile contains more than 40,000 parts (not counting subsystems supplied by associate contractors—engines, nose cone, guidance, etc.)

In a unique staging version originated by Convair, all five rockets are ignited prior to launching. After a few minutes of flight, during which the missile is lifted well into its trajectory, the booster engines and associated



ATLAS STARTS LONG TRIP—Pouring a torrent of fire from its three rocket engines, an Atlas intercontinental ballistic missile rises from its launch pad at the Air Force Missile Test Center at Cape Canaveral, Fla. Photo shows the start of the successful flight of Aug. 2.

equipment are jettisoned to lighten the load. The sustainer engine continues to accelerate the missile until it has attained a velocity on the order of 16,000 statute miles per hour. Then the sustainer is shut off, and the small vernier rockets are used (if needed) to "trim" velocity to the exact value required.

After vernier shutdown, when the missile is following a purely ballistic (unguided) course, the nose cone is separated from the rocket structure by firing small retarding or "retro" rockets. Nose cone and tankage travel in a high arc through outer space until the atmosphere is re-entered. Then the tank structure is destroyed by frictional heating.

(Conventional long-range missiles consist of two or more rockets, one mounted on another. The bottom or booster rocket furnishes all power until it burns out. Then it is dropped and the next stage is ignited. The Atlas system, with its unique "one and one-half" staging, differs from the other modern missiles in having two sets of engines but only one fuel tank structure. This permits igniting all engines, including the upper-stage (sustainer) engine, on the ground. There is no risk that the missile will abort through failure to achieve ignition of a second stage many miles in the air. This achieves a remarkable improvement in missile reliability. The "one and one-half" principle was first advocated by Convair in a report to the Air Force in May 1949.)

During powered flight the course and speed of Atlas are governed by the guidance system. The missile employs radio-inertial guidance (requiring a station on the ground) through the period of early operational use, then changes to all-inertial (self-contained) guidance. Using self-contained guidance, the missiles can be fired in a single salvo, instead of being launched in series.

Flight Testing—Flight missiles are shipped from the factory to the Atlantic Missile Range, Cape Canaveral, Fla., where Convair maintains a field staff of more than 1,000 persons. Here Convair, as agent of the Air Force, puts each missile through ground testing, final checkout and test flight.

During a flight, data from more than 150 instrumented points in the missile is telemetered (radioed) back to AMR over nearly 50 channels. This information—recorded on some 10 miles of magnetic tape—includes temperatures, vibrations, accelerations, liquid flow rates, etc. From this information, engineers can reconstruct an Atlas flight in detail.

Flights to Date—Atlas flight testing started at Cape Canaveral in June 1957, using Series A missiles fitted with booster engines only and having dummy nose cones. The range for these flights was limited to approximately 600 miles. In eight such flights, the missile never failed to launch smoothly and retain complete stability during vertical rise.

On the first two flights (June 11 and Sept. 25, 1957) the missiles malfunctioned after starting pitchover into trajectory and were destroyed by the range safety officer. Successful flights followed Dec. 17 and Jan. 10.

Testing of the complete missile, having both sustainer engine and separable nose cone, started in the summer of 1958. A control system "random failure"* caused the first three-engine Series 8 Atlas to break up in flight July 19. The second was launched successfully on Aug. 2, attaining a range of more than 2,500 miles. Successful longer-range flights followed Aug. 28 and Sept. 14, and a full-range flight of well over 6,000 statute miles was made Nov. 28. Missile 10-8 was fired into orbit Dec. 18. The first Series C Atlas was launched Dec. 23. Series D testing started in the spring of 1959, and the first fully successful flight was made June 20.

Ground Testing—Atlas missiles assigned to ground testing are sent to two California facilities, Sycamore Canyon, near San Diego, and the Missile Static Test Site (formerly Edwards Rocket Base), to be expended in a rigorous and exhaustive program of captive testing.

History—The Air Force in 1946 awarded Convair the first research and development contract in a program to develop a missile capable of carrying a warhead 5,000 miles. (At that time the only long-range rocket was the 200-mile German V-2.)

Convair designers under Karel J. Bossart (later technical director of Astronautics)* conceived and developed the MX-774 research

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* A random failure is comparable to having a flat tire on a modern automobile. One expects to make hundreds of trips without tire trouble—but there is always the possibility of having a flat on the next trip out.

* Bossart was awarded the Exceptional Civilian Service Award by Air Force Secy. James H. Douglas in 1958.

rocket. This introduced three innovations which have since become part of the universal art of rocketry:

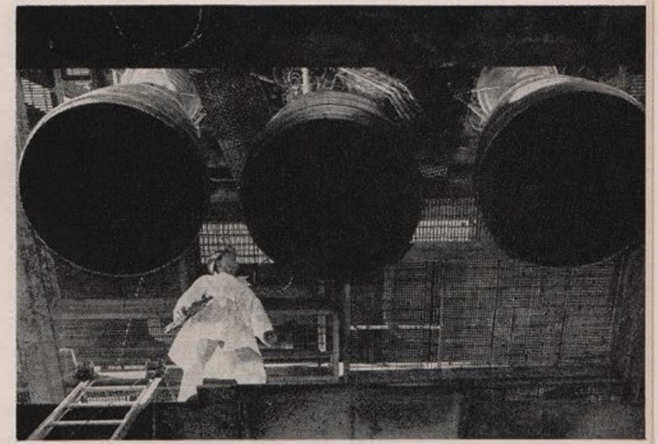
1. First swiveling of engines for directional control. (The Germans controlled the V-2 with rudderlike graphite vanes placed in the jet stream.)
2. First "integral" tanks—the skin of the missile serving also as the wall of the propellant tanks, thus achieving a tremendous weight saving. (The Germans used separate internal tanks.)
3. First separable nose cone. (The Germans re-entered the complete rocket structure.)**

Defense Department economy cutbacks in 1947 led to shelving of ICBM development, but unexpended and supplementary MX-774 funds enabled Convair to complete 3 of the 10 MX-774's under construction, conduct the first captive firing in November 1947, and launch the completed rockets at White Sands Proving Ground in 1948. From then until early 1951, the company continued limited ICBM studies with its own funds.

The Air Force renewed ICBM work on a conservative scale in January 1951, giving Convair a study and development contract.

The program was named "Atlas" that fall. By 1953 Convair had developed essentially the present Atlas design—pressurized stainless steel tanks, one and one-half staging, vernier trim rockets, gimbaling engines, radio-inertial guidance, etc.—and construction of the first test tank started that winter.

In this original version, the Atlas was to be equipped with five main engines developing takeoff thrust of more than 600,000 pounds. North American Aviation, which had worked on Atlas propulsion as a subcontractor, was made a full associate contractor of the Air Force in 1954.



This is the Atlas intercontinental ballistic missile propulsion system, generating 360,000 pounds of thrust. In long-range flight tests, this engine has hurled the Atlas over 6325 miles from the launching pad at Cope Canaveral, Florida. Made by Rocketdyne, a division of North American Aviation, Inc., the primary units are composed of a twin-chambered booster at left and right, a sustainer in the center, shown here being inspected by Al Smith, Rocketdyne Field Service representative. The propulsion system also includes two small vernier, or stabilizing engines, mounted on the missile frame to prevent roll.

During 1954, successful testing of small nuclear devices (Operation Castle) led the Air Force to accelerate the ICBM program. The present Air Force Ballistic Missile Division was created to manage it. Atlas was redesigned to the present three-engine configuration by December, and Convair received a production contract in January 1955.

Atlas fabrication began in San Diego in 1955. First engine tests were conducted at Edwards in June 1956; the first completed missiles were delivered to Sycamore and Cape Canaveral that fall.

Associtaes—As systems integrator for Project Atlas, Convair builds the airframe, the autopilot system and various components; assembles and checks out the missiles; conducts both captive and flight tests for the Air Force; activates new Atlas bases under direction of the Air Force Ballistic Missile Division, and trains Air Force personnel.

Associate contractors, in addition to Rocketdyne, include General Electric Company and the Burroughs Corporation, radio-inertial guidance (to be followed by American Bosch Arma Corporation, all-inertial guidance); and General Electric Company and Avco, nose cones.

Research and development phases of Proj-

** Over the years there have been other major Convair innovations. Two that should be noted:

Tracking—A unique electronic tracking/guidance system was conceived by Convair in 1946, in connection with MX-774; when missile work stopped, the Air Force continued support of this development, called the Azusa system. It became the range tracking system at Cape Canaveral, now used on all missiles launched there.

Verniers—When powered flight ends, ballistic missiles must have the exact velocity required for a given trajectory. Convair evolved the techniques now in general use: After shutdown of main engines, small accessory rockets ("verniers") are employed for precise adjustment of velocity.

ect Atlas have been directed since mid-1954 by the Ballistic Missile Division, ARDC, Inglewood, Calif., now commanded by Maj. Gen. Osmond J. Ritland. At Cape Canaveral, Convair launching complexes and assembly/checkout buildings are part of the Atlantic Missile Range, ARDC, commanded by Maj. Gen. Donald N. Yates, with headquarters at nearby Patrick Air Force Base.

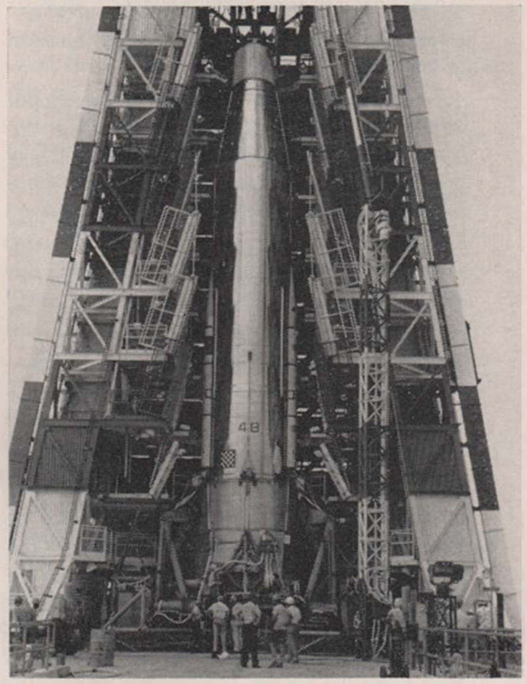
Looking Ahead—The Atlas is achieving operational capability in 1959. The operational force will be part of the Strategic Air Command, commanded by Gen. Thomas S. Power. SAC's 1st Ballistic Missile Division, commanded by Maj. Gen. David Wade, has headquarters at Vandenberg Air Force Base, Lompoc, Calif., a combined operational and training base. The first SAC-launched Atlas was fired from Vandenberg by the 576th Strategic Missile Squadron on Sept. 9, 1959.

Work is well advanced on two of the three complexes planned for Francis E. Warren Air Force Base, Cheyenne, Wyo. Other Atlas bases will be situated at Offutt AFB, Omaha, Neb.; Fairchild AFB, Spokane, Wash.; Forbes AFB, Topeka, Kan.; Schilling AFB, Salina, Kan., and Lincoln AFB, Lincoln, Neb. Convair is assisting the Air Force in the installation of training facilities at Sheppard AFB, Texas, and Chanute AFB, Ill. Atlas squadrons at Vandenberg, Warren and Fairchild are assigned to the 15th Air Force (March AFB, Calif.); those in Kansas and Nebraska, to the 2nd Air Force (Barksdale AFB, La.). Each squadron will have 10 missiles.

Convair is responsible to AFBMD for establishing technical criteria for Atlas complexes, for integrating the installation of ground support equipment, for checking out complexes, and for activating them and turning them over to the Air Force in operational condition. The company began training Air Force operational instructors at San Diego in June 1958.

As the first extensively tested ICBM, and the first to launch itself into orbit, Atlas has become the sturdy wheelhorse of the Early Space Age. Missions announced to date, and now under way, include:

1. *To boost the first U.S. manned capsule into orbit.* (This is Project Mercury.)
2. *To boost an instrumented probe into space.* (This is Atlas-Able 4, one of the Air Force "Able" shots, combining Atlas with three upper stages.)
3. *To boost the first heavy satellites into polar orbit.* (Projects Midas and Samos.)
4. *To boost the first "medium energy" vehicles into high orbit.* (This is Vega, combining the ICBM with a Convair-built second stage, and a storable propellant third stage. Early missions are expected to include scientific earth satellites, moon probes and planetary probes; later missions may include two-man space capsules, television surveys of the moon, and lunar satellites.)
5. *To boost the first "high energy" vehicles into distant orbits.* (This is Atlas-Centaur, combining the ICBM with Convair-built second stage, the latter having the first liquid hydrogen rockets. A storable propellant third stage, as in Vega, can be added when necessary. Initial capabilities will include soft-landing a half-ton payload on the moon.)



ATLAS IN TOWER—The huge Atlas intercontinental ballistic missile is shown here in a test stand at the Air Force Missile Test Center in Florida. The missile stands as tall as a seven-story building. This view shows an Atlas at AFMTC before the successful launching of Aug. 2. Work platforms have been folded up to permit withdrawal of the mobile steel gantry tower.

ATLAS ON LAUNCH PAD—Towering some 75 feet above the elevated launch platform, an Atlas intercontinental ballistic missile is readied for test flight at Cape Canaveral, Fla. The massive steel service tower has been withdrawn from the pad. The slender gooseneck boom carrying power and instrument lines to the nose cone swings away shortly before launch.

Since 1952—Convair began space studies in 1952. The first report on satellite capabilities of the Atlas was published as a classified document in May 1953. That fall Convair proposed use of the Atlas to place a TV-equipped military reconnaissance satelite in polar orbit. Space studies continued under the leadership of Krafft A. Ehricke, who joined Convair in 1954. In 1957, after Russia's launching of the first satellite stirred strong U.S. interest in space, Convair was able to present a comprehensive satellite and space development program to government agencies. (One recommendation was for development of an upper-stage rocket powered with liquid hydrogen. Such a program is now under way in Project Centaur.)

Talking Satellite—In a project sponsored by the Advanced Research Projects Agency, Atlas Missile 10-B was launched into orbit from Cape Canaveral at 6:02 p.m. Dec. 18, 1958. Fewer than 100 persons knew of the project until President Eisenhower announced two hours later that Atlas was circling the earth.

The 122-pound payload, installed by the Army Signal Corps, consisted largely of duplicate communications relay equipment, designed to tape-record radioed voice or code messages and rebroadcast them upon command from the ground. The first words broadcast from space were:

"This is the President of the United States speaking. Through the marvels of scientific advance, my voice is coming to you from a satellite circling in outer space. My message is a simple one. Through this unique means I convey to you and to all mankind America's wish for peace on earth and good will toward men everywhere."

Successful experiments continued for the life of the batteries, through December. The satellite is believed to have re-enterd the atmosphere and burned on Jan. 21.

Key data (all miles statute) included: Takeoff weight approximately 245,000 lb.; booster package jettisoned normally; sustainer shutdown after some 4½ min. of flight, when velocity was 25,394 ft. per sec. (17,314 mph) relative to earth's surface. Initial estimates of satellite weight (8,700 to 8,800 lb.) were refined to "not more than 8,661 lb." after detailed analysis. (The weight of residual propellants cannot be determined precisely.) Orbital data: initial perigee 110.6 mi., apogee 911 mi., period 101 min., inclination 32.3°.

Project Mercury—Initiated by the National Aeronautics and Space Administration in October 1958, this is a program to put the first U.S. manned capsule in orbit—"an arm-stretching, mind-stretching undertaking that thrills everyone of us," Administrator T. Keith Glennan has said.

The capsule, to be boosted into orbit by the Series D Atlas, is under development by McDonnell Aircraft Corp. Roughly conical in shape, it is approximately 7 feet across the base and 10 feet high. A boom carrying emergency escape rockets is fitted atop the capsule during launching but is jettisoned once the capsule is safely in orbit. A special couch-like seat will support the pilot during takeoff acceleration and again at re-entry (when the capsule will come into the atmosphere base-first).

Launched from the Atlantic Missile Range, the capsule will circle the earth at an altitude of 100 to 150 miles, for up to 24 hours, before descent is initiated by firing retarding rockets. After the vehicle has been slowed by aerodynamic drag, parachutes will lower it to the surface, and a fleet of recovery ships will rendezvous to pick it out of the water.

An extensive test program, including experimental launchings with smaller rockets, is

planned during 1959. The first "Big Joe" flight was made with on Atlas Sept. 9. Meantime, a team of seven Air Force, Navy and Morine volunteers is receiving "the most extensive course of training ever offered to a party of prospective explorers." One flier will be picked to make the trip just before the first manned launch.

The capsule flights will lead eventually to establishment of a permanent manned satellite, NASA hod said.

Project Vega—A multi-stage rocket, Vega will be the first U.S. space vehicle in the "medium energy" class—capable of putting a 5,800-lb. weather satellite in orbit 300 miles above the earth. Vega can be used as a two- or three-stage vehicle as required. This program is directed by NASA.

The first two stages will consist of the Series D Atlas topped by another Convair-built vehicle. Jet Propulsion Laboratory, operated under contract to NASA by California Institute of Technology, will supply a third stage and will have technical direction of the Vega program.

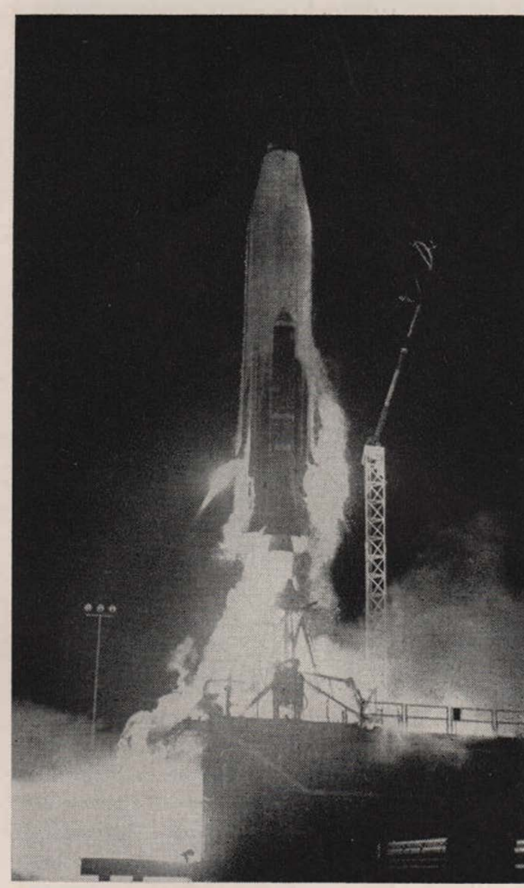
The second stage will be powered by a modified version of the General Electric Company's Vanguard power plant (liquid oxygen and kerosene), developing a thrust of 35,000 pounds. Modifications made by GE will include development of a system permitting the engine to be stopped and restarted in space, so that a precise orbit can be established at high altitudes.

The third stage will be powered by a 6,000-pound-thrust storable-propellant engine, now under development by JPL.

In the three-stage configuration, NASA Administrator Glennan has said, Vega will have the potential to put a 740-pound experimental communication relay into the 22,000-mile or "24-hour" orbit.

At this altitude, the speed of a satellite fired eastward along the equator just matches the rotation of the earth; the orbiting body appears to remain stationary in the sky.

Using such satellites as radio or TV relay points, the U.S. could conduct worldwide commercial and military communication, or beam television programs abroad. (It hos been estimated that U.S. overseas messages will climb from the 1.5 million of 1950 to 3 million by

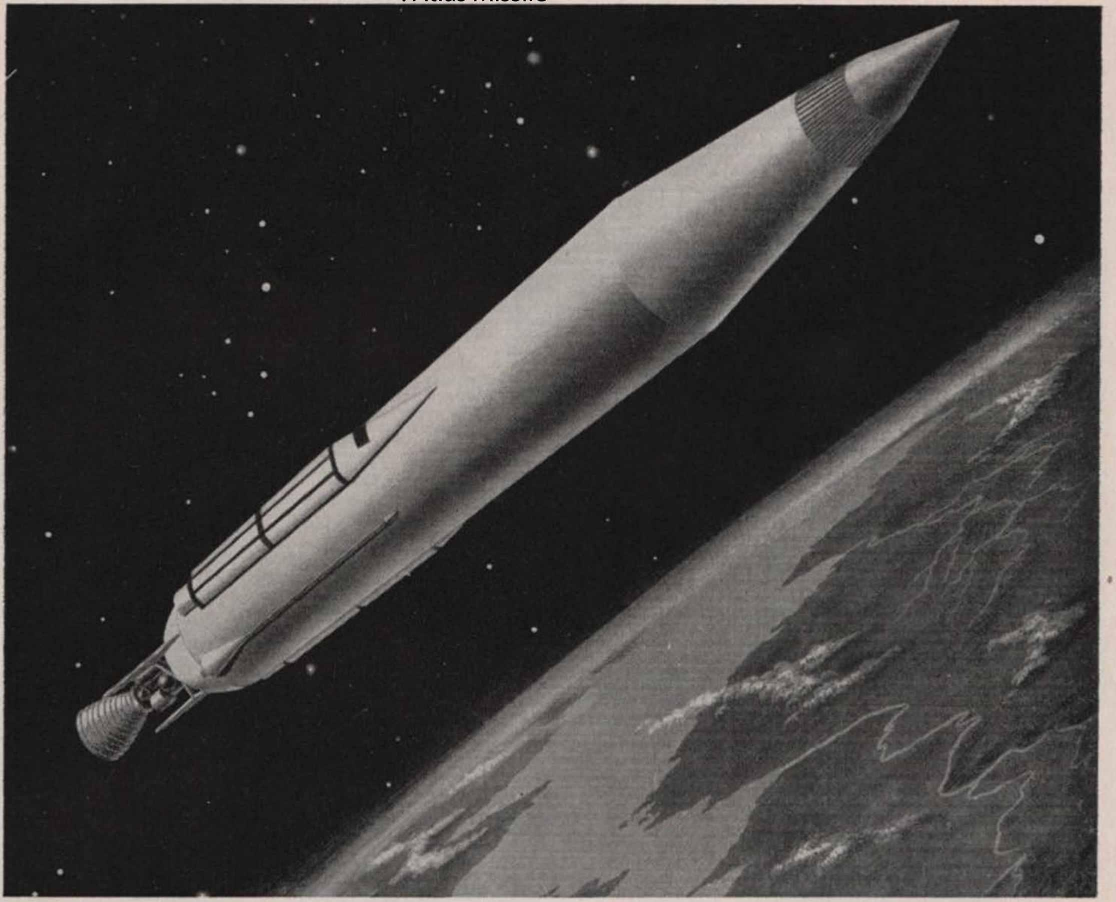


ORBITAL ATLAS BEGINS HISTORICAL FLIGHT—An Air Force Atlas intercontinental ballistic missile rises from a launching pad at the Cape Canaveral, Flo., Atlantic Missile Range, to begin a journey that covered millions of miles through space. This was Atlas 10B, placed into orbit Dec. 18, 1958, the only rocket in the Free World capable of propelling and guiding itself into a satellite path around the earth. The entire 82-foot missile, minus its jettisoned booster engine package, remained in orbit 33½ days, to become the largest satellite launched by any western nation. Lifted by approximately 360,000 pounds of thrust from its five rocket engines, the Atlas had achieved its earth-circling ellipse approximately 4½ minutes after this photo was taken. It made 500 revolutions before re-entering the atmosphere and burning up on Jan. 21, 1959.

1960; and if facilities are available, to some 20 million by 1970.)

NASA hos contracted with Convoir for eight Vega flight vehicles and one engineering evaluation vehicle, at a cost of $33,500,000 (not including the Atlas boosters or the GE engines. The boosters will be procured out of Air Force-allotted missiles.)

Project Centaur—The first U.S. space vehicle in the "high energy" class, Centaur will be capable initially of putting heavy (4 ½-ton)



ARTIST'S CONCEPTION OF ATLAS IN ORBIT—The Atlas intercontinental ballistic missile launched into orbit December 18, 1958, is shown high above the earth in this drawing by an artist of the Convair Division of General Dynamics Corporation, builders of the Atlas. The 82-foot missile, produced at San Diego, Calif., by Convair-Astronautics, is the only rocket in the western world capable of propelling itself into orbit around the earth. At left, still attached to the missile, is one of the three main engines which power the Atlas. Two additional "booster" engines were dropped at a lower altitude.

payloads into satellite orbit, or sending large instrumented probes deep into space.

Centaur will employ the Atlas as booster and a Convair-built upper stage of Atlas-type construction, powered by the first U.S. liquid hydrogen engines. If needed, the Vega third stage can be added for additional capability.

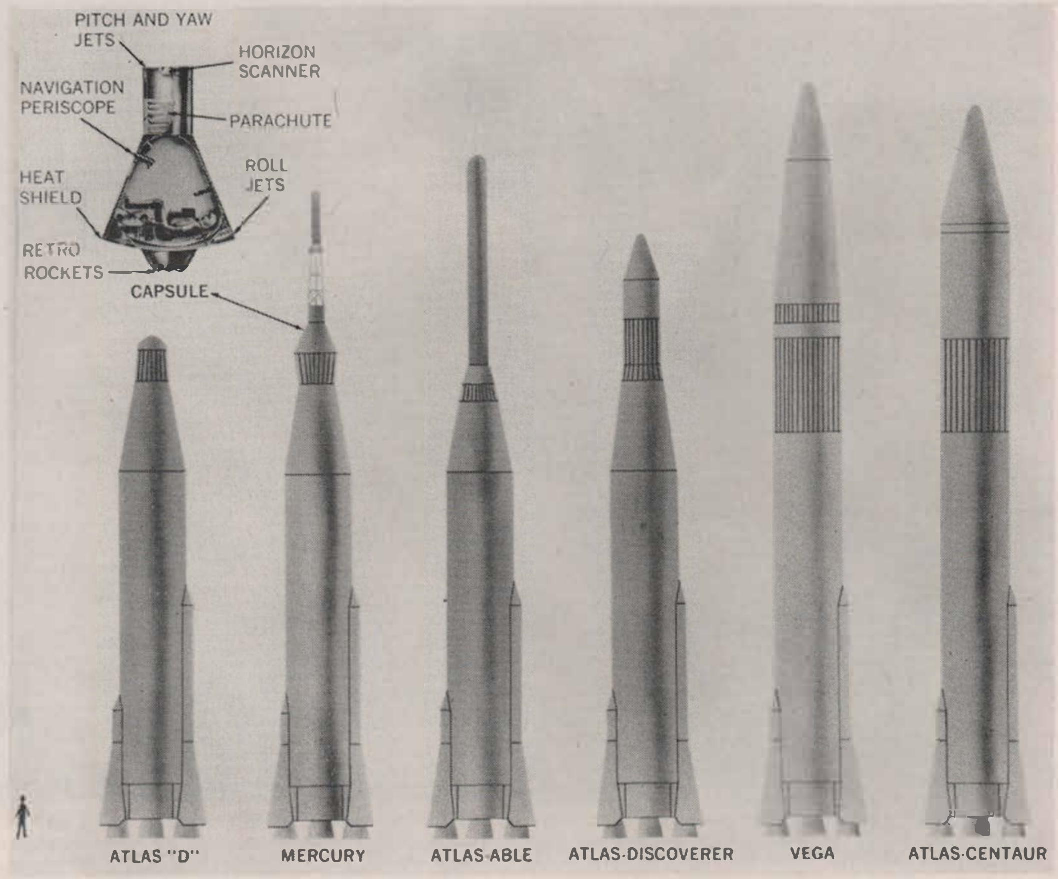
Contracts originally were awarded Convair and Pratt & Whitney Aircraft (a pioneer in liquid hydrogen propulsion) by the USAF Air Research and Development Command, as agent for the Advanced Research Projects Agency. The Centaur program was transferred from ARPA to NASA on July 1, 1959.

Krafft A. Ehricke, the noted space authority, is director of Convair's work on the Vega and Centaur programs.

Both programs rely heavily on Atlas technology, with resultant savings. In each case, the Atlas booster is being modified by building a tank of uniform 10-foot diameter (instead of tapering the forward end, as is done in the ballistic missile). Matching second stages are built of thin-gage stainless steel with Atlas tooling and welding equipment. New or modified Atlas complexes at Cape Canaveral will be used for launching both spacecraft.

Projects Midas, Samos—These are military satellite projects employing the Atlas booster and a Lockheed Aircraft upper stage powered by the Bell Aircraft "Hustler" engine. Both programs are sponsored by ARPA and directed by AFBMD. Lockheed is principal contractor, and Convair is responsible for conducting launchings from Atlas-type complexes.

Midas is a program to develop an early-warning system against enemy ballistic missile attacks. It is based on the use of satellites carrying infra-red sensors, to detect ICBM's immediately after launching. Samos (formerly



Sentry) is an advanced satellite reconnaissance system.

Atlas-Able 4—Atlas will serve as booster of this four-stage rocket, to be fired into space from Cape Canaveral. This is another in the series of Air Force "Able" shots, which are directed by AFBMD for NASA.

The second stage rocket is Aerojet liquid propellant (fuming nitric acid and UDMH); third stage, Allegany Ballistics Laboratory (spin-stabilized solid propellant, same as Vanguard third stage); and fourth stage, a Space Technology Laboratories vehicle having vernier control plus injection rocket. STL is program manager and associate contractor to AFBMD. Convair is responsible for the booster and its adapter section and for conducting the launching.

Future Application—The next generation of space boosters, to come into use in NASA programs of the 1960's, will provide thrusts on the order of 1 to 1.5 million pounds.

These include Saturn, a cluster of Atlas-type Rocketdyne engines, now under development for the Army Ballistic Missile Agency; and a 1.5-million-pound single chamber engine, also a Rocketdyne product (to be clustered in a super-booster known as Herax).

Centaur has been picked by the Advanced Research Projects Agency to serve as third (payload) stage of the Saturn vehicle.

Space Electronics—Convair's Azusa rocket tracking system, used for all ballistic missiles launched from Cape Canaveral, employs phase-comparison techniques for correctly positioning missiles with an accuracy of one-tenth of a foot at distances of 300 miles.

The system can be designed for handling deep-space communications at distances up to 200 million miles.