Pencil-slim Minuteman lifts off Cape Canaveral launch pad February 1, 1961, at start of a perfect flight in which all stages and systems were tested.

The countdown hits zero. This missile rises strai and true with the roar that heralds solid-propel rocket power. Here's a firsthand look at how Minu man, our second-generation ICBM now near operational readiness, grew from the study ph in 1955 to become today's new lean breed nuclear weaponry . . .

America's Strategic

ACE IN THE HOLE

By Flint DuPre

OFFICIAL US AIR FORCE PHOTOS

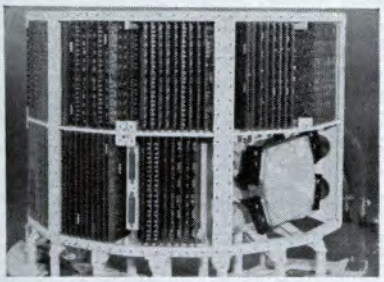
1961 was the year of truth for the Air Force's Minuteman intercontinental ballistic missile. Minuteman took giant steps toward the combat operational capability it is shortly scheduled to achieve. Retracing those steps makes it possible to place this new lean breed of nuclear weaponry in proper perspective in terms of what it will add to our strategic strength. The speed with which Minuteman has been developed—from a study phase of 1955 to a production decision in 1958 and the first successful launch in February 1961—is most reassuring.

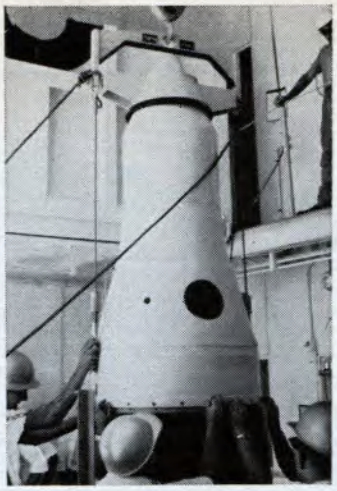
For a firsthand look at just how all this was accomplished, you must travel from the sand and scru Florida's Cape Canaveral to sprawling aerospace comple Los Angeles, then up to Va berg AFB, and on up the Coast to Sacramento and Se across the top of the contine Montana, down to the salt fla Utah, and on across the nati the industrial East. Cover thous of miles and still you won't s the places and activities co uting to Minuteman. But you get a fast look at the wonde modern aerospace technology

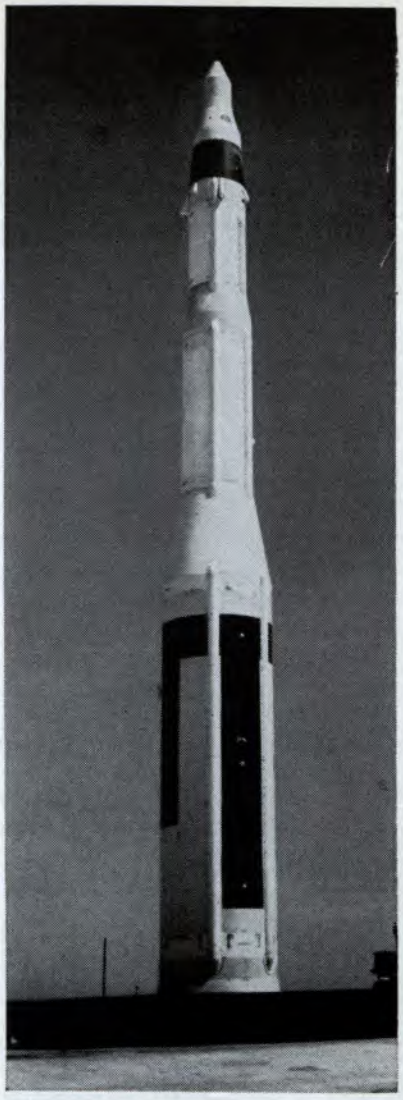
You'll see Minuteman's components being made, th search and development test fi

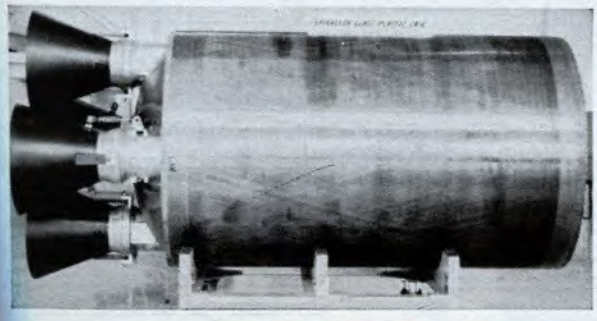
(*Continued on page 46*)

Far right, Minuteman. Right, reentry vehicle. Below, the solid-stage digital computer used in Minuteman guidance.

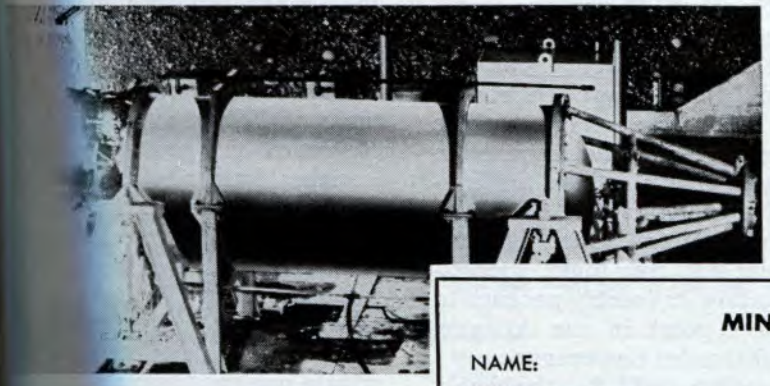


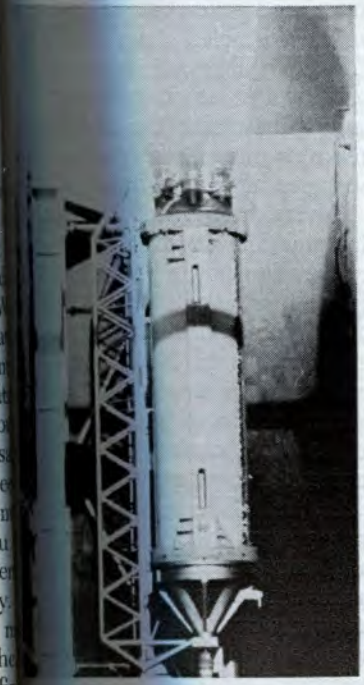






At left, Minuteman's 3d stage, built by Hercules. Below, "hot" firing of Aerojet 2d stage. Beneath is Thiokol 1st-stage engine being static-test-fired in inverted vertical position.





MINUTEMAN FACT SHEET

NAME:	Minuteman (SM-80) (WS-133A)
TYPE:	Intercontinental ballistic missile (ICBM)
SPEED:	Over 16,000 mph
RANGE:	Over 6,300 statute miles
APOGEE:	Not announced
HEIGHT:	About 54 feet
DIAMETER:	About 6 feet
LAUNCH WEIGHT:	In 60,000-to-70,000-pound class
MAJOR ASSOCIATE CONTRACTOR:	Boeing Co.
POWER SYSTEM:	Solid-propellant rocket engines in each of three stages
FIRST STAGE:	Thiokol Chemical Corp.
SECOND STAGE:	Aerojet-General Corp.
THIRD STAGE:	Hercules Powder Co.
GUIDANCE SYSTEM:	All inertial
GUIDANCE:	Autonetics Div. of North American Aviation
WARHEAD:	Nuclear
REENTRY VEHICLE:	AVCO Corp.
PROGRAM MANAGEMENT:	AF Ballistic Systems Division (AFSC)
SYSTEMS ENGINEERING AND TECHNICAL DIRECTION:	Space Technology Laboratories, Inc. (STL)

November 17, 1961: Minuteman is fired successfully from silo at Cape Canaveral and races some 3,400 miles downrange.

the building of launch pads and silo holes for the training of combat crews, the construction of plant and assembly facilities, and site-activation construction for initial operational deployment.

The starting point is Cape Canaveral where the Air Force Missile Test Center and the Atlantic Missile Range, stretching more than 5,000 miles down into the South Atlantic, have become symbols of our nation's strength in the rapidly advancing art of missilry.

The morning of last February 1 was bright with Florida sunshine. A pencil-slim Minuteman took the sun's rays on its launch pad as Col. (now brigadier general) Sam Phillips, director of the Minuteman program since its inception, sat before the launch consoles in the nearby blockhouse to monitor a historic test.

Shortly after 9:00 a.m. the countdown hit zero, and the missile rose straight and true with a roar that heralded solid-propelled rocket power. The three-stage missile operated perfectly, the first time in our history that all stages and systems of a major missile had been tested in an initial launch. Minuteman went into free flight, successfully sending its reentry package to an impact point in the Atlantic, some 4,600 miles downrange.

"Minuteman will be the backbone of our ICBM force," Gen. Thomas D. White said on hearing the test results. "The successful firing of all three stages and the flawless operation of the guidance system the first time we launched the Minuteman is a long step toward the early attainment of this remarkable weapon," he added. The recently retired Chief of Staff's expression is significant since he, along with Gen. Curtis E. LeMay, the present Chief of Staff, and Gen. Bernard A. Schriever, Commander of the Air Force Systems Command, provided full support to the accelerated development of this missile in the face of some powerful detractors.

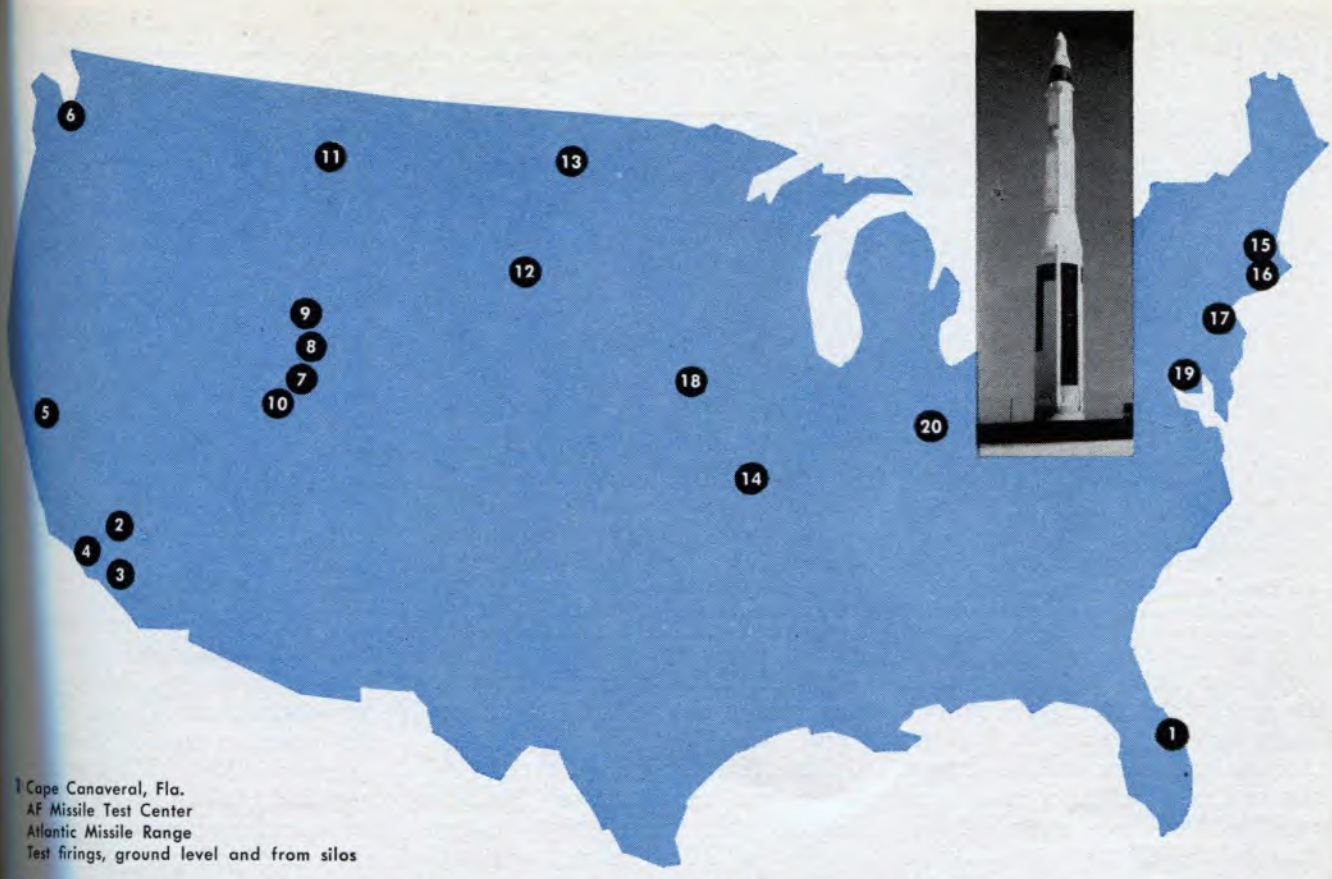
As that test was logged on Minuteman's permanent record, other pads at Cape Canaveral were bei readied for additional tests, a holes were being dug for t below-ground silo testing so imp tant to the missile, which is desig to be positioned underground p manently, launched from bene the surface of the earth if the ala ever goes off.

Other above-ground missiles w fired in May and July of 1961. B were generally successful. By l August the first silo test was ma As the missile emerged from t ground, its second stage fired p maturely, causing the test vehi to explode.

Then on November 17 Minu man scored a perfect launch fr a steel-and-concrete test hole at t Cape. In a major milestone of t development program, the reen vehicle raced more than 3,400 mi downrange. General Phillips cal the launch from the ninety-fo deep silo "totally successful."

Before the August malfunctio Minuteman had been tested eig times at Edwards AFB, Calif., controlled and partially simulat launches from silos, but the N vember flight was the first succe ful below-ground, operational-ty shot. The military-industry te responsible for Minuteman w heartened by performance d obtained from this silo launch. T missile was progressing handily the second-generation follow-on the liquid-fueled Atlas and Ti ICBMs, which are larger, m costly, and more complicat though they have the same 6,3 mile-plus range and general p formance as Minuteman.

Moving from Florida to Cali nia, you find in the Los Ange area, at Downey, a production l for the inertial-guidance and flig control equipment in the Au netics plant of North Americ Aviation. This associate prime c tractor produces a system t guides and controls the mis during flight, yet remains opera while the ICBM is sealed in a s for perhaps years. To accomp this, Autonetics has had to deve transistors, resistors, diodes, a capacitors up to one hundred ti more reliable than any previou available.



1 Cape Canaveral, Fla.
AF Missile Test Center
Atlantic Missile Range
Test firings, ground level and from silos

2 Edwards AFB, Calif.
AF Flight Test Center
Controlled and partially simulated launches from silos

3 Downey, Calif.
North American Aviation—Autonetics
Production of inertial-guidance and flight-control equipment

4 Vandenberg AFB, Calif.
1st Strategic Aerospace Missile Division
Training program for SAC combat crews

5 Sacramento, Calif.
Aerojet-General Corp.
Production of second-stage rocket engine

6 Seattle, Wash.
Boeing Co.
Assembly and test of complete weapon system
Development of ground-support equipment

7 Hill AFB, Utah
Ogden Air Materiel Area
Assembly and maintenance facility

8 Plant 77
Boeing Co.
Assembly, overhaul, repair, maintenance

9 Plant 78
Thiokol Chemical Corp.
Test and production of first-stage engine

10 Plant 81
Hercules Powder Co.
Production of third-stage engine

11 Malmstrom AFB, Mont.
341st Strategic Missile Wing
Construction for three squadrons, 150 missiles, 15 control centers

12 Ellsworth AFB, S. D.
Minuteman missile wing under construction

13 Minot AFB, N. D.
Minuteman wing scheduled

14 Whiteman AFB, Mo.
Minuteman wing scheduled

15 Boston, Mass., area
AVCO Corp.
Production of reentry vehicles

16 Boston, Mass., area
American Machine & Foundry Co.
Production of launch-site mechanisms

17 New Jersey
Hercules Powder Co.
Curtiss-Wright Corp.
Production of cases for Minuteman engines

18 Offutt AFB, Neb.
Hq. Strategic Air Command

19 Andrews AFB, Md.
Hq. Air Force Systems Command

20 Wright-Patterson AFB, Ohio
Hq. Air Force Logistics Command

Map shows the major sites and facilities contributing to the near-operational readiness of Minuteman ICBM. The tour starts at Florida's Cape Canaveral, runs to the sprawling aerospace complex of the West Coast, up to Sacramento and Seattle, down to the Utah missile hub, back up to Montana and the launch sites, then across to the industrial East.

About 165 miles north of Los Angeles is Vandenberg AFB where Strategic Air Command combat crews are beginning a training program. After learning to fire the missile in a number of test launches, they will be assigned to the base complexes where Minuteman will be deployed. Vandenberg is a combination training and operational missile base, located on ranch land once used by the US Army but now converted to expensive missile facilities for use of the 1st Strategic Aerospace Missile Division. Launch pads jut along the shore line, with the Pacific and its attendant range providing the shooting gallery for the frequent launches. The below-ground launch facilities for Minuteman are under construction; 1962 should be a full year for the training of SAC crews at this base.

Continuing north to Sacramento, you see being made what it takes to send Minuteman from one part of the world to another. Here the second-stage rocket engine was developed and is being produced at the Aerojet-General Corporation's plant, a 20,000-acre site in the foothills of the Sierra Nevada range.

(Continued on following page)

Air Force's Brig. Gen. Samuel P. Phillips, who has been director of the Minuteman program since its inception.

Col. Harry E. Goldsworthy, USAF, who is Commander of the Minuteman Site Activation Task Force at Malmstrom AFB.

More than 2,000 persons work on the problems of inert parts, propellants, and fabrication in facilities that include some of the largest cast and cure buildings in the free world. Test firing to perfect and improve the engine take place in rock and gravel trenches formed when the rugged land was dredged for gold.

On up the coast line to Seattle, Wash., are the extensive facilities that the Boeing Company devotes to this project in its responsibility for the assembly and test of the complete weapon system. Located in a restricted area of the plant, in the heart of the city, is a simulated launcher network consisting of launch-support building, launch-control center, and a full-size silo with a missile in it. These facilities are used as models for similar structures in the field where Minuteman will be permanently stationed underground.

In this off-limits area a trim Texan, E. H. Boullioun, Boeing's installations project officer for Minuteman, takes authorized visitors into a building where a large tractor-trailer combination called a transporter-erector is being fitted with a full-scale test missile. Designed to travel over all types of roads—sometime this year it will face its severest test on the rugged terrain of Montana—the sixty-three-foot-long combination, with a loaded weight of 108,000 pounds, will transport missiles from landing strips to their permanent launch sites. "The missiles will be airlifted by C-133 transports from the assembly point in Utah to the support bases," Mr. Boullioun says. "Then this baby takes over."

In another part of the vast Boeing plant are mockups and cutaways of Minuteman fixed facilities. Other company responsibilities include development of a major portion of the ground-support equipment in the launch site and launch-control center, the instrumentation systems, and the interstage structures connecting the engines and guidance system. Nearby are full-scale railway cars for the mobile Minuteman program, deferred last March in the interest of getting more fixed sites more rapidly. The mobile program was dropped in mid-December as Defense Secretary McNamara recommended funds for an increased number of Minutemen in silos.

From Seattle you go to Utah where you'll see some of the modern plants which produce the first- and third-stage engines, as well as the assembly and maintenance facility at Hill AFB, six miles south of Ogden, hub for the entire Minuteman program. Proudly calling itself the "Missile Center of the West," Hill is also the home of the Ogden Air Materiel Area and Air Procurement district.

There are three principal Air Force-industry plants in this area. One, Plant 77, located in the West Area of Hill AFB, is a series of many buildings to be operated by Boeing for assembly of Minuteman, as well as for overhaul, repair, and maintenance when the IC[BM] comes operational. The pl[ant] cupies 790 acres. The Air Fo[rce] Boeing are completing the [con]sion of more than sixty [new] buildings once used as an [Army] ordnance depot. When the [plant] becomes fully operational so[metime] this year, the outlay will re[ach] about $11 million.

About sixty miles north[west] Brigham City, is Plant 78, th[e] kol Chemical Corporation's [fac]ity for test and production [of] first-stage engine. Sprawling [on] 11,000-acre tract in rugge[d] lated land are dozens o[f] buildings and test facilities, [in] ful pastels to contrast wit[h] bleak surroundings. This com[plex] for administration, productio[n] static test of engines, for the [mix]ing of solid fuels, for nozzle m[ak]ing, and for curing ovens f[or] large engine cases. Near this [area] of modern technology—at Pr[omon]tory, Utah—earlier history was [made] when in 1869 the golden spik[e] driven to join the Central P[acific] and Union Pacific railroads a[s] nation's first transcontinental [line].

For Minuteman, Thiokol b[egan] development of the first-stag[e] gine in August 1958 and perf[ected] the nation's largest solid-prope[llant] engine within the twenty-s[ix] months allotted under the cont[ract].

About fifty miles south of [Hill] AFB and Ogden, near Bacch[us], Plant 81 being built for Her[cules] Powder Company for assembly [and] production of the third-stage [en]gine, which was designed and [de]veloped at the company's ne[w] Bacchus Works.

All three stages are sent to [the] Boeing facility at Hill AFB [for] final assembly.

"This is the business end of M[in]uteman," Col. Harry Goldswo[rthy] will tell you when you reach M[al]strom AFB in Montana, a few m[iles] from the city of Great Falls. As [Site] Activation Commander here, C[ol]nel Goldsworthy directs const[ruc]tion for the complex of three sq[uad]rons of the first missile wing, [des]signated the 341st. He stands [be]fore an unusual map on which [red] colored lights burn and flicker. [It's] relief map of the wing's area co[ver]

(*Continued on page 51*)

plot larger than the state of Rhode Island.

Colonel Goldsworthy and his deputy, Col. Art Lahlum of the Army Corps of Engineers, use this map to check progress as the silos and control centers take form. The map is divided into three sections, one for each squadron comprising the wing. The squadrons are broken down into flights of ten missiles each and one control center. A Minuteman wing has 150 missiles and fifteen control centers.

When a light goes out or flickers disturbingly, this means trouble. Within minutes one of the colonels or Clair Popejoy, Boeing manager on the spot, will likely board an on-alert helicopter and fly to the trouble spot. This close attention to detail goes far toward keeping the Malmstrom construction ahead of schedule. Late last year the Corps of Engineers had completed its work on the first flight, and Boeing began the assembly and checkout of equipment necessary to make Minuteman operational, with a target date before the end of this year for the first flight.

A visit to each of the 165 Malmstrom sites (silos and control centers) would take weeks by car, many days by helicopter. Traveling from one to another, and covering all locations, you would travel about 3,000 miles. The cabling being placed several feet underground to furnish communications between the control centers and the missile silos will total about 2,200 miles when completed. To link the sites it is necessary to tunnel the cable under about thirty river beds and seventy railroad and car roadbeds.

These cables will relay complex coded communications data necessary to launch the missiles. This feature of Minuteman construction has caused some writers to suggest that an animal might touch off a nuclear war by gnawing into the cable and causing a missile to fire. The men responsible for setting the cable and for its eventual operation say this simply could not happen. Air Force Secretary Eugene Zuckert recently pointed out that an accidental launching would be impossible because of a complicated system of mechanical and manual controls. If an animal should get its teeth into the buried cable, an alarm would go off, causing automatic shutdown of the system. The same would occur if a person tampered with the cable.

Because it is the first and most advanced of the four Minuteman support bases under construction, Malmstrom lends itself to close examination of what an operational Minuteman facility in the field will look like. The launch-control centers are the nerve centers of the missiles. Each is an underground command post, consisting of a launcher-support building and a concrete capsule, with a tunnel connecting them. Squadron personnel will man the control centers, which contain electronic monitoring equipment such as TV consoles as well as diesel engines, batteries, environmental equipment, and facilities to feed and shelter the men at the center.

Each center is at least six miles from the silos under its jurisdiction, and the missiles are dispersed from one another by at least that same distance. The silo hole is an eighty-foot reinforced-concrete launch tube. A metal liner goes into the hole first. Then the missile is lowered into it. Each missile has its own underground support building, a prefabricated insulated-metal structure that rests on a concrete foundation, with the top flush with the ground. This building will contain electric generators and air-conditioning equipment for environmental control of the missile.

The launch tube will have a horizontal concrete-and-steel sliding cover. The area close to the tube will be paved and equipped with rail tracks so the transporter-erector can move the missile up to the opening for lowering into the silo. This operation can be repeated in reverse if it should be necessary to remove the missile from the silo for checkout or repair.

Each missile site will not only be hardened to withstand all but a direct hit but will also occupy a fenced-in three-acre plot of ground not easy to distinguish from the air.

There are three other Minuteman support bases beside Malmstrom. Construction for the wing near Ellsworth AFB, S. D., is well along. Ground has been broken for the third and fourth wings at Minot AFB, N. D., and Whiteman AFB, Mo., respectively. These four wings will have 600 Minuteman missiles underground by the mid-1960s.

Your Minuteman trip ends in the industrial East. Near Boston, AVCO is manufacturing the reentry vehicles, or nose cones, on an assembly line. In the same area the American Machine & Foundry Company produces launch-site mechanisms. In New Jersey both Hercules and Curtiss-Wright Corporation are turning out cases for Minuteman engines.

The fifty-four-foot Minuteman has many things in its favor. It represents a breakthrough in economy; it is a missile our country can afford to buy in quantity, giving the USSR that many more targets to worry about.

The test program so far indicates good accuracy and reliability. Maintenance cost is low, as the missile will be on site in its hole unattended for long periods of time, yet can still be sent off in a matter of seconds.

Minuteman holds another distinction unique in the history of weapons. Although it can duplicate the speed—more than 16,000 miles per hour—and the intercontinental range of Atlas and Titan, it will cost only about one-third of the estimated $2-million-each price tag of the larger missiles. This is especially encouraging since historically new models of weapons usually cost more than their predecessors.

AFSC's General Schriever sums up the Minuteman weapon system this way: "It provides added depth to our national deterrent posture and imposes complications on our adversaries. Minuteman rates a degree of respect that cannot be matched by other modern weapon systems."

Which is one way of saying that Minuteman is indeed America's ace in the hole.—END

Mr. DuPre, a previous contributor to AIR FORCE *Magazine, visited the principal Minuteman locations described in this story as part of his duties as an information officer for Hq. USAF.*