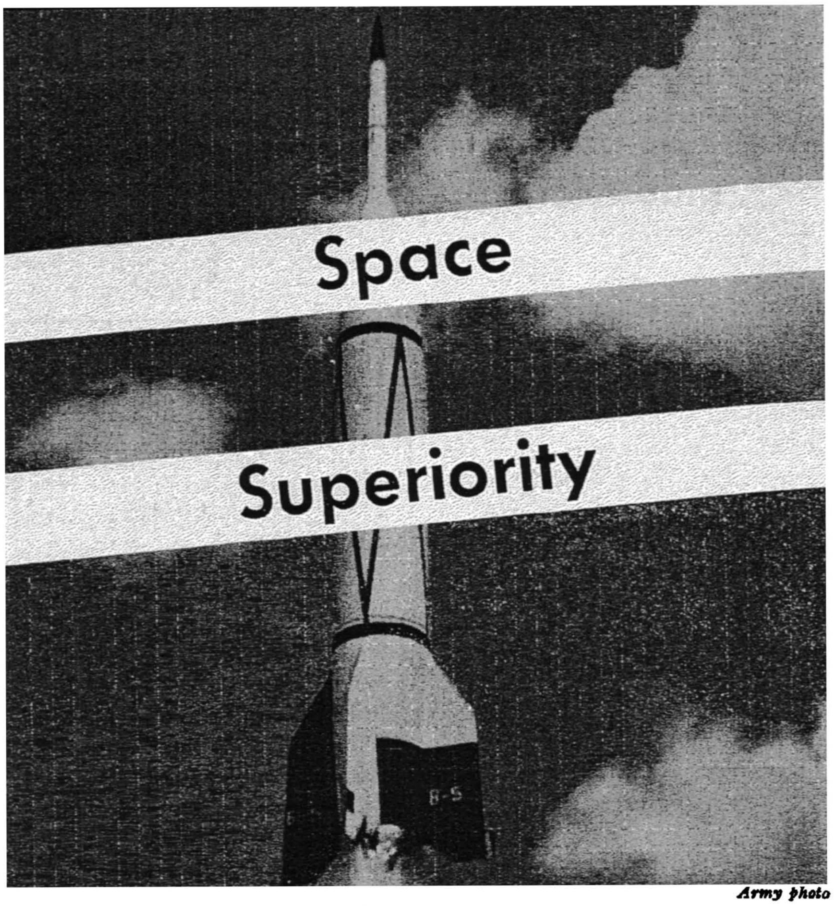


Space Superiority

Army photo

by

Dr. Wernher von Braun

THE most distinguished military thinking of our time concedes that the *only* way to win a third world war is to prevent its outbreak.

The statesmen of our country have made every conceivable effort to ease the tensions arising from the dislocation of the balance of power which followed World War II, but their labors at the conference table continue to be bitterly disappointing.

Force Necessary

The net result of all the talk is a very expensive realization that there is *only* one way in which a treaty with the dictators of the East can be made to stick; namely, to back it up with enough force to compel its observance.

Thus the West finds itself obliged to arm to the teeth in the interest of maintaining an uneasy peace in this tortured world, and the United States bears the major brunt. In rearming ourselves we face a double problem. The first is to create a *deterrent power* which shall be sufficiently effective to inhibit the East from continuing its aggressive expansion ending in all-out war.

Secondly, we must build up *fighting power* so that we may have the best prospects for success—and minimum destruction in our own and allied countries—if global war cannot be avoided. In the light of the introductory statement—credited to General Marshall—that to prevent such a war is to win it—it is only logical for the United States to give first priority and immediate, maximum attention to creating and making effective the deterrent power.

Effectiveness Uncertain

At the present time our deterrent power depends upon the combination of atom bombs and strategic bombers of long range. There is, however, considerable uncertainty as to just how much longer that combination will remain effective. The mere possession of atom bombs by the Red rulers will not render Red nerve centers and nerves less vulnerable to our bombs, but the question is whether our global bombers will be able to reach their targets when the time comes, if come it does.

We know that the Communists are vieing with us and other Western nations in the development of new and effective ground-to-air guided missiles which could make the life of a heavy bomber crew anything but a bed of roses.

The atom bomber may have been the "ultimate weapon" heretofore, but this will not be the case much longer. Like the battleship, the atom bomber will become just another weapon, capable indeed of playing an effective rôle in war, but its deterrent power is on the decline. The handwriting is on the wall.

Deterrent Power

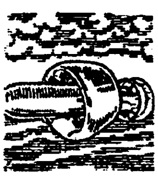
Winston Churchill thinks that the uneasy peace the world has enjoyed since 1945 has been due to the deterrent power exercised by strategic bombers with their capacity for delivering atom bombs anywhere they might be needed. It was this country's statesmen, industrialists, engineers, designers, scientists, workmen, and airmen who had the vision, the industry, and the initiative to bring that deterrent to a third World War into being. And I might include the taxpayer, without whose contribution the enormous financial requirements of the strategic-bomber concept and the atomic program could not have been met.

"Ultimate Weapon"

It is now the time, however, when we must relegate strategic bombing to a secondary position and seek a new "ultimate weapon" which shall preferably not only return to us that deciding "edge" we once had over Red aggression but likewise be kinder to the taxpayer and be able to contribute something constructive to the world whose uneasy armistice we hope it will successfully transmute into permanent peace.

It should be rather plain that there is but little use in "wildcatting" in the well-nigh exhausted oil fields of conventional armament. The deepest hole we can sink will at best bring no gusher but rather some little trickle encouraging our prospective opponent to outdo us with his totalitarian command of engineering talent and his hordes of slave labor.

We must find our deterrent to a third world war in new horizons: in a field where test drillings have already revealed a plentiful supply of the treasure we seek. Not only does it promise this but also incalculable benefits after its purpose of preventing war shall successfully have been accomplished. The field to which I refer is that of rocketry.



Rocketry is, I believe, capable of solving the world's peace problems more effectively than any other branch of science and engineering and simultaneously—that is to say, without additional expenditure—doing a great deal for the advancement of mankind. Let me give you a few highlights on what has been done in the field since some well-nigh prehistoric Chinese touched off the first primitive powder rocket. It's a far cry, indeed, from that to the German V-2 which represents the longest single stride the science has made.

Principle Well Known

In this connection, it is a mistake to think that the basic concept—either in science or technology—of the long-range liquid rocket originated in some secret German laboratory. The principle was a familiar one throughout the international technical literature long before the war. The V-2 came simply as the result of devoting sufficient practical engineering effort to the "hardware stage" of a well-known principle.

Also the V-2 and its postwar fellow rockets constitute but very modest examples of what can be accomplished with this principle along technical, scientific, and military lines. We need fear no fundamental, immovable roadblocks along the path of further development of the large liquid rocket, for the principal difficulties have already been conquered. At some distance along this path—a very attainable distance, by the way—stands the multistage, orbital rocket ship bearing a crew out beyond the stratosphere.

The first nation to launch such a rocket ship will possess, in my opinion, what may well be the long-sought "ultimate weapon." But beyond that, and once it has fully exerted its deterrent effect upon would-be aggressors, it will be capable of serving an infinitude of scientific—that is to say humanitarian—ends.

The drawing on page 772 shows a liquid rocket some 265 feet in height. Let it be 65 feet in diameter and weigh 7,000 tons—about the same as a light cruiser. The rocket's tanks will be loaded with 6,150 tons of hydrazine and nitric acid—just about half a full load for an average tank steamer.

In Three Sections

This enormous rocket ship will be made in three sections, one atop the other. The bottom section is the first booster stage. It will have 51 rocket motors giving an upward thrust of 14,000 tons. Under this thrust, the whole ship will begin to move slowly, majestically upward. When it reaches a few thousand feet, gyroscopes will actuate its controls so that the path of ascent tilts over toward, but not reaching, the horizontal. Eighty-four seconds after take-off the propellants of the first stage exhaust themselves, having brought the ship up to a velocity of 5,265 miles an hour at an altitude of 24.9 miles. The angle of climb will be 20 degrees above the horizontal.

The now empty booster stage drops off and the rockets of the second booster stage ignite, imparting to the ship a velocity of 14,364 miles an hour during the ensuing 124 seconds. The angle of climb will be down to almost the horizontal—just 2½ degrees above the latter, and the altitude will have increased to 39.8 miles. Now the second-stage propellants are exhausted and the stage is dropped.

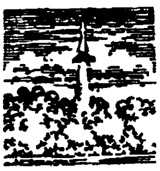
Dr. von Braun served as technical director of the German Liquid Fuel Rocket and Guided Missile Center at Peenemuende from 1937 until the end of World War II. Since that time he has been associated with the U. S. Army Ordnance Corps. At present, Dr. von Braun is technical director, guided missile development group, Redstone Arsenal, Huntsville, Ala.

18,468 Miles an Hour

The third stage—in appearance not unlike an airplane—continues under the 220 tons of thrust exerted by its 4 rocket motors and bearing cargo and crew. It reaches a velocity of 18,468 miles an hour just 84 seconds later and is in horizontal flight at an altitude of 63.3 miles.

There is still ample fuel for the motors to continue their thrust, but they are shut off by the automatic action of an integrating accelerometer—a special speed-measuring device. The rocket ship now coasts throughout the major portion of its voyage.

Since 18,468 miles an hour is somewhat higher than the so-called "circular velocity" at an altitude of 63.3 miles, the ship will recede from the earth. At "circular velocity" it would continue to circle the earth at a distance of exactly 63.3 miles—just as if it were another, smaller, much closer moon. But since there is still some air drag at this altitude (sounding rockets have already been there), the ship would lose its speed after a while and would have to glide back to earth on its wings.



In order to avoid an involuntary landing of this nature, we set the integrating accelerometer to cut off the power at a velocity somewhat higher than the circular velocity at that altitude. Thus the centrifugal force at right angles to the flight path exceeds the attraction of gravity slightly and the laws of celestial mechanics decree that the ship enter an elliptical path which carries it farther and farther out into space. After the ship has gone halfway around the earth it reaches the highest point of the ellipse—the so-called apogee—at 1,075 miles of altitude.

During this unpowered climb, which takes 51 minutes, gravity will have been working on the vessel and will have reduced the speed from 18,468 miles an hour to 14,770, which is a bit


THIRD STAGE
SECOND STAGE
FIRST STAGE
INSTRUMENT COMPARTMENT
PILOT CANOPY
PERSONNEL SPACE
CARGO SPACE
NITRIC ACID
HYDRAZINE
NITRIC ACID AND HYDRAZINE PUMPS
HYDROGEN PEROXIDE FOR PUMP TURBINES
FOUR MAIN PROPULSION MOTORS AND ONE CRUISING MOTOR
VERTICAL STABILIZERS
AILERON
RUDDER
LANDING FLAP
NITRIC ACID
HYDRAZINE
PUMPS FOR HYDRAZINE AND NITRIC ACID
HYDROGEN PEROXIDE FOR PUMP TURBINES
SWIVEL-MOUNTED ROCKET MOTORS FOR STEERING (FOUR UNITS OF THREE EACH)
PARACHUTE COMPARTMENT
22 MAIN PROPULSION ROCKET MOTORS
NITRIC ACID
HYDRAZINE
STABILIZER FIN (HORIZONTAL CONTRO
HYDROGEN PEROXIDE TANKS
STABILIZER FIN (VERTICAL CONTROL)
EXHAUST OUTLET
PUMPS FOR HYDRAZINE AND NITRIC ACID
51 PROPULSION MOTORS INCLUDING 12 SWIVEL-MOUNTED ROCKET UNITS FOR STEERING
PARACHUTE COMPARTME

less than the "circular velocity" corresponding to the apogee. If we wish the rocket ship to remain at apogee height, we must augment its speed enough to bring it up to the "circular velocity"—15,800 miles an hour. Accordingly, the rocket motors are operated long enough to make up the difference and increase the speed by 1,030 miles an hour.

Now our rocket ship will be circling the earth at a height of 1,075 miles at a speed of 15,800 miles an hour—just a little over 4 miles a second. It will take two hours to make the full circle and will require no power whatsoever. Furthermore, it will remain in this orbit indefinitely.

We have selected the orbit's plans in such a manner that its most northerly point passes over the Arctic Circle and the most southerly point just crosses the Antarctic Circle. This orbit is intermediary between an equatorial one and one which crosses the poles, and for a very good reason. The movement of the rocket ship in its orbit and the rotation of the earth so combine that there is no point on the earth's surface which cannot be observed from the rocket ship at least once every twenty-four hours—unless that point lies within the Arctic or Antarctic Circles.

Herein lies the key to military space superiority, for nothing but isolated outposts of an enemy can lie within the Arctic and Antarctic Circles, and the capabilities of rocket ships and vehicles extend far beyond mere observation, as I shall show.

36-ton Pay Load

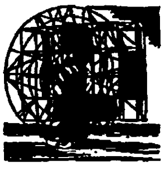
The pay load of the rocket ship we are considering is about thirty-six tons —equivalent to that of two of the new Super Constellations. During any single trip to the orbit these thirty-six tons of pay load can be discharged there and will remain circling when the plane-like third stage actuates its rocket motors and returns to the atmosphere to make a conventional airplane landing.

The two booster stages will have expelled *retarding* parachutes made of woven wire after their propellants have been exhausted and will have landed in the ocean where their empty tanks will have kept them afloat until salvaged. Thus any rocket ship can be reassembled, refueled, and relaunched an indeterminate number of times.

A modest number of such orbital rocket ships can haul into their orbit sufficient material and components to build a permanent station there—an artificial satellite.

Such an artificial satellite would preferably be built in the shape of an enormous wheel and would rotate slowly around its axle. Within its rim this rotation would generate sufficient centrifugal force to simulate the effects of gravity, rendering life far more comfortable for the inmates than if they were exposed for extended periods to the weightlessness otherwise existing in the orbit.

The satellite would be designed and built in segments of nylon-reënforced plastic. One or more segments would be loaded into a rocket ship in the uninflated condition, much as rubber life rafts are loaded into airplanes. Men in pressure suits would assemble the segments in the orbit, and, when the wheel was complete, it would be inflated from air tanks like an automobile tire.



Of course the satellite would have its own air-conditioning system which would renew the oxygen consumed by the crew and fulfill the other requirements necessary to provide them with an ample supply of healthy, breathable air. For this purpose, there would be a periodic visit by a rocket ship to provide not only oxygen, but food, water, and other necessities.

Temperature control of the interior of a space station may be obtained by regulating the ratio between heat absorption from the sun and heat radiation into space. This is easily done by "radiation shutters." Electric power for the station may be drawn from a solar reflector generating steam in a boiler tube connected to a turbogenerator. Such a solar energy plant is far more efficient in cloudless space than within the shell of the atmosphere.

We calculate that a satellite station 250 feet in diameter could accommodate a crew of between 200 and 300 men. It would weigh about 400 tons and could therefore be set up in the course of 12 to 14 rocket flights to the orbit.

Military Uses

The first and obvious military application of such a station is that of reconnaissance and observation. One or more 100-inch reflecting telescopes like that on Mount Wilson will be used. They will not be in the station itself, but will float freely in space a few hundred feet distant from it in the same orbit.

Cameras like those used in aërial surveying will automatically take reconnaissance pictures, being bracketed on their subjects by reaction flywheels radiocontrolled from the outstation. The field of view of the camera will be checked from within the station via television screen, while the camera shutter will be tripped by radio. Plate transfer will be automatic.

A single telescope can make 100 exposures during the 2 hours it takes the station to circumnavigate the earth—more than 1,000 a day. The negatives may be evaluated either in the outstation or they may be sent to earth on the weekly supply rocket ship. Immediate televising of results to earth is also within the range of possibility.

The resolving power of a 100-inch reflecting telescope at a distance of 1,075 miles is about 16 inches: that is to say, it can distinguish objects 16 inches apart at that distance. This is equivalent to the capabilities of the naked eye at a distance of 5,000 feet.

Improved Radarscope

The station would also operate improved radarscope equipment far superior to present aircraft-borne devices and thus be able to penetrate reliably the thickest cloud overcast.

An orbital reconnaissance station can pull up any iron curtain!

←

Drawing of the proposed 3-stage rocket which would be used in setting up a satellite station in space.

But reconnaissance is but the first of the military applications for our outstation in space. While we may well hope that its mere existence would seriously discourage any large-scale military moves, it has far greater potentialities. When it comes down to cases, the outstation is also a launching platform for orbital missiles against which there cannot well be countermeasures. If we fire an atom-tipped, winged rocket backward from the outstation so that its thrust diminishes its orbital velocity relative to the station by 1,070 miles an hour, it will succumb to gravity and approach the earth on an elliptical path. The speed reduction of 1,070 miles an hour is such that the missile will reënter the atmosphere tangentially at a perigeal altitude of 50 miles and halfway around the earth from its point of firing.

Controls Automatic

Upon entering the atmosphere, its automatic controls will so actuate the control surfaces as to prevent its slipping back elliptically to the apogee in the orbit, which it would otherwise do.

An application of a barometric altimeter will depress the flippers to give the wings a negative angle of attack and this will hold the missile at the perigeal altitude. Then air drag will slow it down below the local "circular velocity" so that it finally enters a supersonic glide with positive angle of attack.

The missile will reach its perigee nine minutes earlier than the outstation reaches a point directly above this perigee. This means that the missile outdistances angularly the outstation, despite having been fired backward from the latter.

Second Orbital Station

Thus, if we establish a second much smaller orbital station 2,400 miles ahead of the principal one (near which the missile is sent on its way), the missile will be within the field of observation of the second station during the whole of its supersonic glide—as will be the target somewhat later.

The second satellite station can follow the missile by radar and also correct its course by radio remote control. The target itself will enter the field of view of the controlling station some minutes before the missile reaches its objective on ground or ocean. A target line of sight will thus be established either optically or by radar. The missile-tracking radar gear will establish a second line of sight between control station and missile.

Computers in the control station similar to those used for antiaircraft guided missiles will compute the desired relationship between the two lines of sight so that the target line of sight and the missile line of sight will coincide at the moment of impact and the flight of the missile will be aërodynamically corrected by radio remote control from the station to bring this about.

> *"We need fear no immovable roadblocks along the path of further development of the large liquid rocket . . . At some distance along this path stands the multistage, orbital rocket ship bearing a crew out beyond the stratosphere. The first nation to launch such a ship will possess, in my opinion, what may well be the long-sought 'ultimate weapon'."*

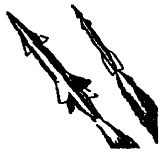
Extreme accuracy of the missile is thus assured, and it is likewise possible to detonate the atomic warhead exactly above the target and while the missile is still moving at high supersonic speed. Countermeasures appear to be wholly ineffective under those conditions.

One of the main advantages of orbital missiles is their absoluteness, so to speak. There they are in the sky—visible to the prospective enemy but unreachable by him—a sort of sidereal arsenal. We hope we won't have to use them, but we want the maximum of deterrent effect combined with the maximum destructive effect if worst comes to worst.

Millions of people all over the world would become aware of this tiny man-made constellation whipping across the skies and visible to those who knew where to look during the hours of dawn and dusk when it would glitter in the sun. For the peace-minded it would represent an ever-present guardian against war and the usurpers of power would constantly be reminded that they would sow world discord at their own peril.

Vulnerability

What about the vulnerability to attack of an artificial satellite? Are we justified in calling it a space fortress, or, as some people say, might it be destroyed from the ground at far less cost than it took to establish it in its lofty eyrie? We should remember that the same question has often been raised with respect to bombing aircraft, aircraft carriers, and tanks. In the light of my own strictures on the vulnerability of the transsonic bomber and my claims that the orbital station is the "ultimate weapon," the question of vulnerability is cogent.



There seem to be two conceivable methods of attacking an orbital station which will bear investigation of a closer nature. One of these involves firing upward a rocket which would discharge in the orbit of the station a load of shrapnellike objects into which the station would move at the rate of 15,800 miles an hour.

If it were possible to make a "hit" with such an unmanned rocket, we might well suffer a few "bullet holes" in the station. With puncture-proofing techniques such as applied in bullet-proof tires and with compartmentation we can provide some protection. Nevertheless, an interceptor rocket cannot be entirely discounted.

But let us not forget that an error in timing of the interception of one second would amount to four miles in distance, due to the velocity of the station. Even an atomic warhead on such an interceptor missile would be relatively ineffective to increase its radius of destructiveness, for the pressure wave produced by an atomic explosion is nonexistent in a vacuum.

Another possible method of attack is, of course, a manned rocket ship with rocket artillery. Any such space vessel would simply be carrying presently familiar forms of air combat out beyond the atmosphere and there is no doubt whatsoever that in such a case the victory would go to the side which made the first hit. We cannot doubt that a space station is vulnerable to such an attack, if it be presumed that the prospective enemy has been allowed to develop his rocketry at the same rate as we.

Ground Installations

In order to set up an outer station, we must first build very extensive ground installations. They will consist of elaborate take-off or launching sites, great plants for building and testing rockets, special factories for the necessary chemicals, ships for retrieving boosters, and much more. These, not the station itself, are the things to attack.

If we can get our ground establishment set up and working and establish our artificial satellite with its space-to-ground missiles ready for action, we can stop any opponent cold in his attempt to challenge our fortress in space! The space station can destroy with absolute certainty an enemy space craft prior to its launching.

But far better would it be if we could say to the enemy a determined, power-packed "No!" when he is only beginning his development of manned space craft! And still better if we can forestall his building of ground installations. I believe that there is still time for us to accomplish this, and I urge that it be done!

Scientists Dubious

There are some scientists and engineers who do not at all question the feasibility of manned space ships, yet who believe that it is too soon to tackle an all-out space program. Their explanation of this Fabian attitude is that the time is not yet ripe. They claim that the conquest of space—whether for military or scientific ends—will come as a sort of natural by-product of the many-branched development of supersonic aircraft and guided missiles which is now taking place in this country.

I do not share this point of view at all, and I want to point out that when the Manhattan Project was started a lot of people screamed that the time wasn't ripe for the atom bomb.

On the other hand, there were foresighted men who dared to take the vital step because they knew full well that, if an atom bomb could be built at all, it could never become a reality as a by-product of the academic studies on nuclear physics being carried on at various schools and colleges.

Problems Fewer

I would not be surprised if a good many readers were to consider the building of enormous, man-carrying space vessels and using them to set up a space station as somewhat on the risky side—maybe you would even call it fantastic. But let me assure you that we who advocate it are faced with far fewer basic problems than were the men who undertook the atom-bomb development back in 1940!

I am not claiming, mind you, that building a space station is as simple as putting a new automobile, or even a new jet aircraft engine into production. It is far more than that—it is one of the greatest engineering problems of the age. We must expect many a setback and many a heartbreak, but setbacks and heartbreaks are part and parcel of any courageous, far-sighted engineering effort.

Now for an estimate of the time and money required to make the effort a reality: If this project is undertaken without delay, if it is pursued resolutely, if it is pushed to the ultimate, then it can be completed far enough to have a recognizable military value within ten years and at a cost not to exceed four billion dollars.

By undertaking it without delay, I do not mean that we should immediately undertake the "hardware stage" of manned rocket ships. The first thing we ought to do is to set up a study schedule—costing at most a couple of million dollars—which will take under advisement each and every phase of the problem and present comparative studies of the various factors and elements entering into it.

Let me give an example of the sort of thing I'm talking about: If we can standardize the motors in the three stages of the ship, we shall save a great deal of time and money when we do reach the "hardware stage," and we shall cut down a great deal on the testing facilities which would otherwise be required.

Prior to designing and building manned orbital rockets, it is surely good sense to develop relatively small, multistage rockets and to fire them upward into the orbit, thus overcoming in miniature many of the practical problems which otherwise would beset the full-scale space ship.

We may take some pretty long steps in our development program without fear of their being actually reckless. When we fired the first V-2 rocket during the summer of 1942, it seemed perfectly gigantic to us alongside the kind of thing which was then common. But the step we took in building and firing that rocket was anything but reckless, as subsequent events proved.

Money Needed

With what we know today about rocketry, with the state rocket technology has reached, I see no reason whatsoever why we shouldn't take another step forward of the same order of magnitude. There's no more problem to building a "bigger" rocket than there is to building a "bigger" airplane. It just costs more money.

Editor's· Note.—This article represents the views of the author only and does not necessarily reflect the opinions or policies of the Department of the Army.

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