Vanguard: The Artificial Earth Satellite

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Philippine Studies vol. 5, no. 2 (1957): 191–210

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ONE day about a decade ago the American newspapers featured in journalistic fashion with headlines, pictures and captions an event of scientific import. Scientists had directed suitable radio waves at the moon and by a receiver several hundred miles away had picked up the echoes. Though most readers considered the event newsworthy, one down-to-earth gentleman was heard to remark: "Why all the excitement? What is so remarkable about that?" One wonders whether here and there among the many people who will come to be aware of it, similar regrettable reactions may be manifested in regard to the launching of the first artificial satellite. The news is sure to find print on the front page of Philippine and American newspapers. It will be headlined in almost all parts of the world.*

Pioneering always has a contagious fascination about it. The human mind is ever in quest of what lies beyond—beyond the range of mountains, beyond the oceans, beyond the clouds. To satisfy that longing, to seek answers to the why and the how of events on this earth many nations are working shoulder to shoulder to push back the frontiers of knowledge about our planet earth. This concerted partnership among more than

* This article was ready for publication in December 1956 but was withheld for lack of space. Since then articles on the satellite have appeared in popular magazines--though not always entirely accurate.
—Editor.

forty nations begins in July 1957, runs to the end of 1958 and is known as the International Geophysical Year (IGY).[1]

Among the many and various types of research instruments which have special charm for this year the proposed earth satellites lift the imagination and inflame enthusiasm. A cherished dream of scientists, professional and amateur, came true when the United States Government gave a favorable reply to the proposal that artificial satellites be put on their course.[2] While the professionals were working out the technical details the amateur astronomers were busy getting organized for observations. When Dr. Harlow Shapley was called upon to give the astronomical highlights of 1956 he rated in the third place "the beginning of the world-wide organization of amateur astronomers for the visual tracking of the artificial satellite, the launching and study of which is one of the 'semi-astronomical' projects of the International Geophysical Year."[3]

The satellite, as a research vehicle, will make its assault on our vertical frontier. Seeking to explore the outer reaches of the earth's atmosphere it will, besides, provide information for the solution of many other geophysical problems. For these answers are not isolated but are intimately connected with one another. Unexplored as the upper regions may be, they are not entirely unknown for men have been reaching up to pull down information by all the means at their disposal. On the basis of that present knowledge the success of the first satellite flight depends.

I. PRACTICALITY

Two questions demanded affirmative answers before the earth satellite project was sponsored. The first was: is the project feasible? Unless there were assurances that the project could be securely executed the venture would never have start-

[1] J.J. Hennessey S.J. "The Planet Earth" PHILIPPINE STUDIES IV (December 1956) 535-551.

[2] "The President has approved plans by this country for going ahead with the launching of small, unmanned, earth-circling satellites." Joseph Kaplan "The IGY Program" *Proceedings of the IRE* 44 (June 1956) 741-743.

[3] *Science News Letter* 70 (3 November 1956) 277.

ed. But the experts were convinced, and were capable of convincing others, of the feasibility of the project. They were aware, too, of the expense in dollars and man power. Granted, however, that physical laws would allow of its achievement there was a second consideration. Was the essay merely theatrical like the balloon ascent of Daredevil Allen at the County Fair of 1919? Was it simply an acrobatic stunt like tight-rope walking? To allay any such fears the second consideration needed a positive affirmation. That question was: is such an expenditure in scientific talent and time worth the effort?[4] Serious geophysicists had been eagerly awaiting or rather had been pressing for just this enterprise. They had no hesitancy about guaranteeing the value of the project.

Even after its approved sponsorship the two aspects of practicality and value are still dominant. The defense of its practical feasibility must now account for such elements as (1) getting the satellite up; (2) getting the information down. If either of these two elements is missing the project ceases to be practical. Logically one might take exception to the inclusion of the second element under feasibility but more detailed consideration will show its application. That the project has value is evident from a consideration of the scientific results to be obtained by this and only by this technique. Consideration of these two aspects, practicality and value, will serve as a basis for our discussion.

GETTING IT INTO ITS ORBIT

If shooting the satellite to suitable heights were the only goal, the matter would be simple and by no means new. Already rockets have ascended vertically to altitudes comparable with the height at which the projectile will begin its career as a satellite. As a technique of investigation the earth satellite is then a logical and practical extension of the successful rocket program. It is an extension which supplements but does not suppress the rocket program.

[4] *Scientific American* 193 (September 1955) 68. "The Project is expected to cost $10 million or more."

The investigation of the upper atmosphere by rockets began after World War II in 1945 with the capture of many unassembled V-2 rockets. From 1946 to 1956 about two hundred launchings of various types of rockets have been effected. Most of these have been single stage rockets but some were tandem vehicles such as the well known Wac Corporal which was launched from the nose of a V-2 rocket when the latter's fuel was spent.[5] This second stage rocket with its own fuel then ascended to an altitude of 242.5 miles.[6] The second rocket at the end of its burnout of fuel had attained a speed of over five thousand miles an hour. Despite the fact that many experimental rockets have been fired during the past ten years, the total time of observation of the rockets amounts to about ten hours. But they have achieved what could not be done otherwise. They have raised aloft instruments which made direct observations in the upper atmosphere.

If raising the vehicle to the requisite height is a simple extension of tried and true rocket design, getting it into the orbit is neither simple nor tried and true. In rocket design the aim is to shoot the rocket as high as possible with the optimum instrumental payload. The rocket ascends vertically for tens of miles but crashes back to earth in the proximity of the launching station. The satellite has an entirely different objective. It must reach similarly great or greater heights and yet have sufficient energy of motion to continue in a curved path: not vertically out from the starting point but around the earth itself. This means practically that the vehicle must be capable of rising to about three hundred miles and when its fuel is exhausted it should be traveling at about 18,000 miles an hour. This velocity is needed to balance the earth's centripetal (gravitational) force. The sphere, if the satellite be that shape,

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[5] R.L.F. Boyd and M.J. Seaton eds. *Rocket Exploration of the Upper Atmosphere* (London 1954) p. 28. Eric Burgess *Frontier to Space* (London 1955) p. 30.

[6] The highest airplane records are at an altitude of about 24 miles; for example, the Murray flight of 16 June 1954 to 90,000 feet or about 17 miles, the highest known altitude of man at that time. Allan C. Fisher Jr. and Luis Marden "Threshold of Space" *National Geographic Magazine* 108 (August 1955) 241-278. The Bell X-2 rocket plane is reported unofficially to have flown to an altitude of 23.9 miles. *Time* 68 (1 October 1956) 72; see also *Time* 68 (12 November 1956) 76 and (19 November 1956) 68.

is not expected to crash to earth but after a long interval of cruising in its orbit it will spiral inward and slow down. As it descends further into the upper atmosphere it is finally consumed by friction with the rarefied gases. Consumption is not unlike the fate which meets the hundreds of daily meteors or "shooting stars" which enter the earth's atmosphere. Depending on the success of the launching the satellite may remain in its orbit for a few weeks or even a year or more.

The United States satellite launching project is known as "Vanguard." Though the USSR is planning the launching of satellites, Project Vanguard has been more widely publicized especially in the English journals. Hence, it is the American project that concerns us.

In size and weight the proposed satellite, the passenger on the upward trip, is quite dwarfed in comparison with the carrying vehicle. To picture the composite carrier as it is now planned, consider a long, thin cylinder tapered at the upper end or nose. Weighing about eleven tons or ten thousand kilograms, it is about seventy-two feet long and less than two feet in radius at its base, the thickest part (Figure 1). The satellite rides aboard the carrier about seventy feet above the base of the first stage. The third stage along with the satellite sphere is within the second stage just behind the nose of the vehicle.[7]

DESIGN AND FUNCTION

The design and function of each stage suggest the method of getting the sphere up and into its orbit. The first stage takes up approximately two thirds of the entire vehicle. It is a booster rocket modeled on but also improving on the Viking. Viking rockets themselves differ from rocket to rocket because performance improvement is constantly sought for. Rocket building still in the developmental class is not yet a finished art. The Viking, of which a baker's dozen have been used thus far, has an all-aluminum construction. This results in a

[7] The principal details of the planning as given in the article may be found in the Symposium on the U.S. Earth Satellite Program: Vanguard of Outer Space. *Proceedings of the IRE* 44 (June 1956) 741-767.

SATELLITE VEHICLE

WEIGHT: 10,000 KILOGRAMS
22,000 POUNDS

LENGTH: 72 FEET

BASE DIAMETER: 45 INCHES

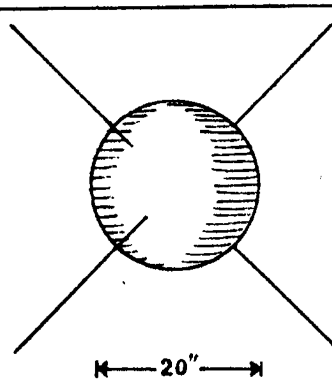
Fig. 1

PROPOSED SATELLITE

SPHERE
DIAMETER: 20 INCHES
WEIGHT: 21 LBS.
PAYLOAD: 10 LBS.

ORBIT 40° N and S
DERIGEE ALT.: 200 MILES
APOGEE ALT.: 1500 MILES
PERIOD OF
REVOLUTION: 90-100 MIN.

Fig. 2



Drawings by Roberto Rodriguez

light weight structure for the rocket which is 80 per cent propellant. For an illustration of Viking performance Viking number 7 with an initial weight of seven and one half tons attained a burnout velocity of four thousand miles per hour to reach an altitude of 136 miles.[8] Since there are no fins on the framework, steering during this interval depends on the direction of the rocket thrusts. This is determined by tipping the rocket motor in its mounting to effect each change of course. Besides, the tipping of the motor, auxiliary jet reactors govern the roll of the vessel. Fuel in the first stage burns for a little over two minutes to push the vehicle through the densest part of the atmosphere.[9] At burnout the vehicle has a velocity of over 3,600 per hour and an altitude of twenty-six miles. Throughout the course of first stage firing, the entire vehicle is guided by "sensing" mechanisms and other devices which are located in the second stage.

When the first stage has consumed its fuel supply the control mechanism in the second stage cuts off the first stage and ignites the fuel in the second. This stage, like a kangaroo mother, carries the much smaller third stage. It is located up front near the nose of the entire vehicle. A protective cone over the nose of the second stage shields the satellite sphere as the composite vehicle rises through the dense atmosphere. During the second stage burning this nose cone, no longer needed in the rarefied atmosphere, is jettisoned. The second stage belongs to the class of Aerobee rockets but taking advantage of their developmental improvements it will have marked differences. When the first contracts were let in 1946 for the Aerobee the construction called for a sounding rocket capable of carrying a 150 pound payload to an altitude of 375,000 feet. The second Aerobee fired in May 1948 reached a peak of 71 miles so that the performance of Aerobees has measured up to expectations. Both the Viking and the Aerobee

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8 The percentage of the vehicle's gross weight imparted to the propellants is known as mass ratio. The larger the value can be made the more successful the rocket is likely to be. Boyd and Seaton *Rocket Exploration of the Upper Atmosphere* p. 49.

9 At twenty-six miles 97% of the atmosphere has been encountered. Gerard P. Kuiper ed. *The Earth as a Planet* (Chicago 1954) p. 435.

use a liquid bipropellant i.e. a liquid fuel and a liquid oxidizer.[10] As in the first stage, the motor is mounted for tilting and is guided by electro-hydraulic controls. Since all the guidance for the entire vehicle is in the second stage, the elaborate designing of various sensing and controlling devices is a painstaking process. Stage number two plays the role of the commander of the vessel during the three guided periods (but only two stages) of the flight: 1) the fuel burning of the first stage, 2) the same for the second, its own stage and 3) a coasting flight of about seven hundred miles. The importance of the second stage is evident. It incorporates many features of rocket science which were untried prior to operation Vanguard. At the end of the coasting flight, the second stage has achieved two things: it has the significant remnant of the vehicle up to orbital height and has increased the net velocity to about 9,000 miles per hour. Instead of speaking about the heights reached by an object one could equally well consider the energy of position or potential energy. The higher an object is above the zero reference level, for example sea level, the more potential energy it possesss. Similarly, the speed of a given object in miles per hour might be specified for that object in terms of the kinetic energy or energy of motion. The second stage develops the requisite potential energy but not the kinetic energy for orbital flight. Having set the navigational course and imparted a spin along the longitudinal axis of the third stage, the second stage cuts off.

The third stage is a small fraction in mass and volume of the initial vessel. It accelerates blindly on course pushing the satellite sphere up to the orbital speed (Figure 1). This last stage uses a solid propellant. The final fifty percent of the orbital speed is to come from this stage. When the fuel of the third stage is exhausted the twenty-inch sphere, which is the satellite, is cut away (Figure 2).

It should be noted that there is no physical reason why the debris of the third stage should not behave as a satellite also. The first successful venture will thus result in more than

[10] J. Gordon Vaeth *200 Miles Up* (New York 1951) p. 84.

one artificial satellite but most interest will center on the one which is instrumented and designed for observation.

OTHER FLIGHT DETAILS

The above digest of the design and function of the satellite may be supplemented with some further details of the proposed launching. The site has been carefully selected at Cape Canaveral on the east coast of Florida. A glance at a map of Florida shows that this cape juts out into the ocean with no island or other inhabited land in the launching direction. The entire massive vehicle takes off in the vertical direction but gradually it bends over in a smooth curve to the east. There is a very good reason for tipping in an easterly direction. Advantage is taken of the earth's rotational velocity which gives the vehicle an additional helping speed relative to free space. Since speed is at a premium in these first attempts, the course is set to the east. It is not due east for an inclination to the equator of about forty degrees is desired in order that the satellite once on orbit may pass over more scientifically populated regions. These regions for the satellite voyage are in a belt extending forty degrees on each side of the equator. Given the orbital speed of about 18,000 miles an hour the satellite will have a period or time of revolution of about ninety to one hundred minutes. During this time the earth has rotated under the satellite so that on each revolution the satellite will cross the equator not at the same point but about twenty-three degrees to the west.

The distances and physical dimensions involved in the proposed path of the conveyor's ascent indicate the engineering problem facing the designers and planners. In the short interval of 140 seconds the first stage rising vertically and then tilting gently over has done its task of getting the vehicle to an elevation of thirty-six miles and to a speed of about 3,600 miles an hour. It speeds the remaining stages away on the journey and itself is drawn down to earth to fall along a smooth curve into the sea about 230 miles from Cape Canaveral. When the second stage starts its drive the transport is increasingly inclined away from the vertical. Though the second stage has much less fuel than the first still its gross load is of the order of one third of the initial conveyance. At burnout of the second stage the rocket has reached a speed of 11,000 miles an hour and is now at the orbital height of about three hundred miles. This guiding stage does not cut away from the third stage at once. It coasts along nearly parallel with the surface of the sea to about seven hundred miles from the starting point. During this coasting period there is a gain in potential energy but a loss in kinetic energy. The coasting run drops the speed back to about 9,000 miles an hour. This coasting period is a very critical time for the entire project. All proper directions must be set and the third stage must be given a rotation on its longitudinal axis. With these achieved the master stage rushes on to its doom back toward the earth and into the waters of the Atlantic. The third stage is fixed on its course like a rifle bullet for its target but with this difference: it constantly rushes faster and faster at speeds never before approached by any artificial object of comparable size. It must accelerate to the orbital velocity that will counteract the pull of gravity. From the zero hour of launching only ten minutes have elapsed but the traveler is fifteen hundred miles from its starting point. Having given the sphere sufficient kinetic energy the third stage separates from the instrumented satellite (Table 1). At the separation the sphere is off on its journey in an orbit which, though not a true circle, yet encircles our globe.[11]

How long will the satellite continue to go around the earth? Best hopes will be satisfied if the first satellite stays in its orbit for a good part of a year or better, but a week in orbit will be rewarding. An idea of the distance covered in such a period of time can be had by considering that the artificial satellite goes around the earth about fifteen times in a single day.

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[11] Milton W. Rosen "Placing the Satellite in Its Orbit" *Proceedings of the IRE* 44 (June 1956) 748-751. James A. Van Allen "The Artificial Satellite" *Scientific American* 195 (November 1956) 41-47. Homer E. Newell Jr. "Rockets and Satellites" *IUGG News Letter* (March 1956) 77-83.

TABLE I

Stages	Rocket Type	Propellant	Guidance By	At Cut Off		
				Expected Altitude	Expected Velocity	Elapsed Time (Approx.)
First: Burning	Viking	Liquid: Oxygen and gasoline	Second Stage	36 Miles	3,600 miles per hour	140 seconds
Second: i. Burning	Aerobee	Liquid: Nitric acid and hydrazine	Second Stage	140 miles	11,000 miles per hour	4 minutes
ii. Coasting		None	Second Stage	300 miles	9,000 miles per hour	6 minutes
Third: Burning	Solid Propellant	Solid	None	300 miles (orbital)	18,000 miles per hour	10 minutes

What keeps it from falling back to earth? Any aeroplane with all its motors gone has no chance of remaining aloft. The satellite has no motors of its own to propel it along. Is a crash inevitable and in short order? It is characteristic of a satellite that it should not have any external propulsion and should not crash back to the earth. Because of its momentum and inertia it keeps on its course. If its inertia alone is considered, it continues to move in a straight line unless some external force alters this motion. Going in a straight line it would soon escape from the earth but the earth constantly exerts a side force pulling it back toward the center of gravity of the system. The result is a circular or quasi-circular path rather than a straight course out into space. The speed necessary for orbital motion about the earth is about 18,000 miles per hour. Considerably less speed than that would result in gravitational forces pulling it down to the earth while considerably greater speeds would end in the "escape" velocity or greater where the body would leave the gravitational control of the earth.

In theory, then, once the satellite has reached orbital velocity, or circular velocity as it is sometimes called, it should continue indefinitely as a satellite. However, in the real order there are other small persistent forces acting on the satellite. There will be a drag on the satellite with its passage through the rarefied gases of the exosphere. No doubt the characteristics of the orbital regions now definitely under exploration will account for the final ruin of the first satellite. Meteors, for example, and meteoric dust will induce a slowing down process causing the satellite to spiral slowly into the more dense atmosphere of the earth. Its great speed through the more dense gaseous envelope of the earth will raise its temperature beyond the kindling point. And then the consumption process brings on its destruction without an intact return to the solid earth.

GETTING INFORMATION DOWN

From the viewpoint of acquiring information about the upper atmosphere and the vanguard to space, geophysicists would prefer to have a more ample cargo of instruments, the "payload," aboard the twenty-one pound loaded sphere. But technical conditions impose a high penalty on the payload.[12] The price to be paid has been computed in terms of the speed of the satellite. The weight penalty is critical to the orbital speed. For each additional pound of payload there is a drastic drop in obtainable speed. To be concrete, for a given propulsion system an added pound or more could mean the difference between a flight duration of half a revolution around the earth and one with manifold revolutions. Due to these severe limitations even at this late date one needs to be cautious in asserting that the payload and sphere will be as great as twenty-one pounds..[13] It is clear then that the method of getting information from the satellite back to the earth is a significant consideration of the feasibility of the project. Granted a twenty-one pound instrumented sphere various ways of getting information are available.

At the outset the first satellite cannot be expected to have aboard instruments which store the information to be salvaged from a crash. The instruments themselves will suffer the fate of the satellite: disintegration with the satellite's settling into the dense atmosphere. All information must be gleaned while the satellite is on course or going to its destruction. Suppose scientists succeed in realizing their dream of placing the satellite in its orbit, how will they follow its course? How will they read the record? The two general means are a) radio tracking and b) optical following.

Since the reading of meters plays a leading role in measurements of science, in our case telemetering (the reading of meters at a distance, or more broadly, data transmission of meter readings and comparable intelligence) is essential to the performance of the instrumented satellite.[14] In a general sense,

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[12] When a vehicle is multi-staged, the term "payload" is to be understood in its context for it may refer to various different things. The payload of the Viking stage is the Aerobee which in turn has the third stage and the satellite as *its* payload. Even the "payload" of the sphere can be spoken of, that is, the instruments within the sphere.

[13] James A. Van Allen "The Scientific Value of the Satellite Program" *Proceedings of the IRE* 44 (June 1956) 766.

[14] A. A. McKenzie and H. A. Manoogian eds. "Telemetering" *Electronics* 29 (April 1956) 153-183.

the success of telemetering depends on the radio transmitter or transmitters which can be loaded within the sphere. That these components must be as light as possible needs no comment. Sources of power to operate the instruments place exacting limitations on the loading. Every effort at miniaturization of batteries must be made. To conserve batteries, ground controlled on and off switching is contemplated. Since evident safety reasons do not allow the vehicle in its rise to pass over land areas, even at the lower altitudes of the start, receiving stations will be at a distance. Fortunately, the rocket program has provided instruments of tried and tested reliability but their weight requirements are not nearly as critical or exacting. One method of reducing the required transmitting power, or equivalently of reducing the size and weight of the transmitter without telemetering loss, is the use of new types of ground receiving antennae. These use a phase comparison technique based on the differences in signals received at properly spaced sites.[15] Under all the inherent difficulties the telemetering of the first satellite, while providing a wealth of new scientific data, will not be as complete as each category of scientists would desire. To be overly sanguine in our hopes for abundant telemetering on the first flight would be quite unrealistic. A wealth of information will remain to be uncovered by subsequent satellites.

Present plans call for radio tracking with the aid of transmitters within the satellite. The signal frequency is planned at 108.0 megacycles a second with power between 10 and 50 milliwatts. If the transmitter is of the transistor or tube type it is estimated that the total weight will be two pounds for the transistor or three pounds for the tube type. The life expectancy of this transmitter will be a little over two weeks. Not only are there weight limitations on the batteries but there are all the demands of temperature changes from 100 degrees Fahrenheit to 70 degrees below zero and also of vacuum operation. The equipment will be operating under more perfect vacuum conditions in and beyond the ionosphere than it is possible to obtain in the best laboratories.

[15] James A. Van Allen "The Artificial Satellite" *Scientific American* 195 (November 1956) 41-47.

It is to be hoped that some amateurs, "ham" radio operators, in the Philippines will join their world colleagues in detecting the flight of the satellite. Their radio receivers should be tuned to the transmitting frequency of 108.0 megacycles (subject to subsequent modification) when a passage over the Philippines is expected. Such detection along with accurate timing would benefit the international job of tracking.

Radio tracking has no limitations due to weather conditions, cloudiness, time of day or visibility conditions. Yet the satellite transmitter will be in or beyond the ionosphere. Dut to the nearness to maximum sunspot activity the density of ionization in the ionosphere will also be at or near its maximum. The radio waves from the satellite may suffer deviation and absorption in their passage through the ionized layers. This means the exact positioning of the satellite becomes more difficult. Besides the satellite will oscillate within the tropical regions and to the north and south. Over the tropics, as comparison of Baguio records with other stations shows, the ionization density is higher than in the higher latitudes. For these various reasons even a higher frequency may ultimately be used.

In this electronic and automation era it might be imagined that there would be no room in such an advanced project as an earth satellite for nineteenth century techniques. Yet it seems to the present writer that the optional method of following the first artificial moon is most likely to yield the best results. If there is an early power failure or if the batteries last for two weeks, thereafter the only means of tracking will be by watching with the naked eyes or with a small telescope. Binoculars will serve the purpose rather well.

The problem of following the satellite by visible means arises from the complexity of many elements. Only under the best seeing conditions can one hope to see the satellite passage with the naked eye. At an altitude of 300 miles, the planned satellite will present the appearance of a golf ball at a distance of about sixteen miles but moving with the speed of sound. The satellite covering will be selected to give the optimum reflection for visible observations. At the estimated speed in its orbit the satellite on each passage will be within adequate observing range for a fixed observer for only about two minutes. On an average it will be observable about once a week in any one place. Besides, because this small object is only of the magnitude of the faintest stars visible with the naked eye (the sixth magnitude it is said) it cannot be seen when the sun is pouring its light of day on the earth. Because it will be seen by reflected light from the sun (as is the natural moon, though the moon is 243,000 miles distant) it can only be seen when the sun is near the horizon. The visibility is thus limited to morning and evening twilight periods. To be sure of getting a large enough image of the satellite one might think of using a very large telescope to track this faint object in the sky. But such will not be a success. For example, the famous Yerkes telescope with its forty inch refracting objective so excellent for other purposes, will be useless for this project. The satellite moves too fast across the focal plane for the telescope to follow the object.

Is there any hope, then, that we will be able to spot the satellite in the Philippines? If the satellite does get on orbit there is very good opportunity for our seeing it. The papers and radio and news agencies will be keeping us informed about the launching. Already a staff of computers at Cambridge, Massachusetts[16] have been assigned to work out the ephemeris, or the table of positions and times of the moving moon. From these we can get an approximate expected time for the passage over our latitude in the Philippines. Fortified with binoculars or a wide-angle elbow type monocular, observers may spot the passage in the twilight hours. To time its passage to the nearest second, no small help would be a radio tuned to a station which gives constant time signals, for example JJY in Japan or WWVH in Honolulu. Such observations, if reported, will be valuable at any time. But they will be especially valuable when the satellite is spiraling down to its end. At such a time the theorists cannot predict the position of the object for the

[16] Whipple and Hynek "Optical Tracking" *Proceedings of the IRE* 44 (June 1956) 760-764.

rate of spiraling due to the atmospheric drag is an item of information being sought.

For the first satellite a lesson should be learned from the first rockets which were launched. We have no fears that events of the same type will be repeated but others of an undesirable nature can happen. Rocket science is now fairly well in possession. Yet "the V-2 was born amid destruction. The first of these rockets was fired by the Germans on 6 July 1942. After rising only three feet off the ground, it exploded, destroying the launching facilities."[17] Again in 1946 "the first Air Force V-2 was launched. It attained the majestic altitude of 300 feet, turned and headed for a crowd of about 1000 people. From then on to now we have been trying to improve that record. Incidentally, it missed the observers."[18] The first satellite is likely to have a better record.

II. WORTH

The consideration of the worth of the satellite launching must be put in focus. The incidental by-products of the research must not dominate the real objectives. Practical attainments will follow the main objective even though these are not directly aimed at. This project is not being pursued for financial recompense whether for an individual, a corporation or a nation; it is not being developed as some monster for the prosecution of devastating war. Rather it is, through devotion purely to scientific research, a contribution to the totality of human knowledge; it is a quest to acquire legitimate knowledge about the world men live in. This has been expressed by the Holy Father. Pope Pius XII in his address to the General Assembly of the International Union of Geodesy and Geophysics (IUGG) held at Rome in September 1954 said that the scientists of earlier days, such as Eratosthenes of Alexandria, Snellius of the early seventeenth century and Roger Boscovich S. J. "were in fact following the same impulses which inspire the scientists of today—intellectual curiosity divorced from self-seeking, the urge to measure certain physical

[17] J. Gordon Vaeth *200 Miles Up* p. 151.

[18] Boyd and Seaton *Rocket Exploration of the Upper Atmosphere* (London 1954) p. 1.

phenomena and then to deduce therefrom conclusions of general import."[19]

Whether the satellite is instrumented and so active, or merely passive, its value consists in its ability to do what cannot be done by any other means. Rockets have the ability to take samples of conditions in the vertical plane but they do lack duration in the upper regions that is necessary for comparative studies. Observations taken from the earth of certain characteristics aloft can be wholly erroneous since the atmosphere is a blanket for them. A very limited listing of some of the unique levels of information hoped for—surely not in one launching alone but in perhaps the twelve which are planned for IGY—may indicate how scientific knowledge will advance by the use of this new tool of research.

Though not arranged according to any hierarchy of value or precedence, some of the projects of investigation are:

1. Radiations from outside the earth. Here monitoring can be done on cosmic rays and short wave radiations such as x-rays and solar ultra-violet radiation. The satellite travels in a region beyond the barrier or blanket of the atmosphere. Observations of this kind would require instruments on board. Ionization chambers and Geiger counters can feed to miniature tape recorders their data of the varying intensities of these radiations as the satellite moves about in different geographical and solar positions. Solar flares could be studied to better advantage than ever before.

2. Meteor counts and micrometeorites. A study of interplanetary matter can be made by having impact counters record the encounters of the satellite with the tiny solid particles which impinge on it or which it overtakes in its course. An active satellite is needed for these studies.

3. Atmospheric density measurements. The effect of the air drag on the satellite will be perceptible from its varying positions in its orbit. Good location and time observations can be made on a passive satellite. In these studies amateurs in the

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[19] *IUGG News Letter* (June 1955) 278-284 carries the address in both French and English.

Philippines and around the world can contribute to the basic data for computational determination of air densities.

4. Geomagnetic field. Fluctuations of the magnetic field around the world and at various altitudes can be made in the flying laboratory. Light weight sensitive magnetometers have been designed for such observations. Perhaps definite clues may be uncovered which will account for the earth's magnetic field. Present theories are bafflingly inadequate.

5. Ionospheric studies. The upper regions of the ionosphere can be directly investigated by sampling the ionization at various altitudes on the orbit. Besides the radio transmitters on the other side of the denser electrically charged layers provide new fruitful information. Knowledge of the ionosphere is necessary for effective long distance radio communication.

6. Cloud cover over the earth. A small photoelectric cell looking now down on the earth and now out to space could be designed to register the distribution of clouds over the earth.

7. Shape of the earth. A passive satellite observed frequently through binoculars and carefully timed will improve the map making of the world and increase knowledge about the shape of the earth. The reduction of the observations to give the accurate coordinates of the place is an exacting process.

8. Chemical composition studies. There are many chemical elements in the very rarefied atmosphere such as lithium, beryllium and boron whose intensity measurements require long duration of study. The satellite alone can do this since it remains long enough in those regions to accumulate a requisite sample. Studies on other more abundant elements such as hydrogen entering from the sun are possible by the use of small proton counters.

These selected problems have been named rather than explained. Observational results from the dozen satellites to be launched during IGY are likely to fill volumes of scientific books when all the data are submitted to analysis. Some controversial theories thus far proposed to explain terrestrial phenomena may be vindicated and others rejected. New theories will arise to be submitted to further testing. But the general body of truth and knowledge of God's creation and of His loving Providence will be enlarged.

III. AND THEN!

Because of the human urge to go beyond frontiers, any discussion of satellites brings up the matter of human flight into interplanetary space. Much that is fanciful has been written on this subject. Conservatively and scientifically it is safe to say that space-flight is a thing of the future.[20] By this we understand that it is not feasible in this decade of the twentieth century. But it also means that as rocket science and engineering advances, space travel will become actual. Careful analysis now shows the magnitude of the problem. Before our dreams advance too far let us await realistically the outcome of the present project which is still beset with difficulties. But the human spirit ever leaps up for pioneering adventures. And while conservative opinion would place the future date of space travel beyond the life-time of this generation the Martin Company of Baltimore, surely pioneers of established renown in the field of rocket research, sanguinely propose that the space traveler is alive today.[21] Most of us are content to let another be the first to voyage out beyond the saving confines of our atmosphere.

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[20] Arthur C. Clarke *Interplanetary Flight: An Introduction to Astronautics* (New York: Harper and Brothers, n.d. circa 1952) p. 5 also the entire book *passim*. See also Heinz Haber "Space Satellites" *National Geographic Magazine* 109 (April 1956) 486-510.

[21] *Time* 68 (19 November 1956) 45.