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THE WHITE HOUSE

WASHINGTON

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MEMORANDUM FOR THE PRESIDENT

I inclose a brief summary of information which has been obtained by the four earth satellites we have placed in orbit. One of the most significant findings is the unexpectedly high radiation intensities at altitudes greater than 620 miles.

The "air" temperature has not yet been directly measured, but there are reports on satellite surface temperatures. These have varied from $-13^{o}F$ to $167^{o}F$.

It is interesting to note that the air density at sea level is 92 billion times greater than at 230 miles altitude.

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1 Incl: Notes on U.S.
Satellite Measurements

NOTES ON U. S. SATELLITE MEASUREMENTS

1. The U. S. has successfully placed in orbit four earth satellites (Explorers I, III and IV, and Vanguard I). All except Explorer III are still in orbit. Explorer III, because of its low altitude perigee (118 miles) and the resulting relatively high air resistance, remained in orbit for only three months. Some pertinent information about these satellites is contained in the following table:

Satellite	Launching Date	Expected Life-Time (Years)	Perigee (Miles)	Apogee (Miles)	Payload (Pounds)
Explorer I	Jan. 31, 1958	3-5	224	1573	30.8
Vanguard I	Mar. 17, 1958	200	404	2465	3.3
Explorer III	Mar. 26, 1958	.25	118	1740	31.0
Explorer IV	July 26, 1958	.7-1	157	1380	38.4

2. The most extensive scientific measurements that have been conducted with the satellites have been in the area of cosmic radiation. In addition, measurements have been made of micrometeorite impact and the temperatures reached by the satellites. The measurement of the path of the satellite, which has been done by both electronic and optical means, has also allowed a determination of the air density at various altitudes.

3. Cosmic radiation measurements have been made with Explorers I, III and IV. New and unexpected results have been obtained from these measurements. Explorers I and III each carried a single Geiger-Mueller counter. These counters indicated radiation intensities as expected up to about 620 miles. This information correlates with data obtained in previous rocket tests.

At altitudes greater than 620 miles, however, unexpectedly high radiation intensities were measured which exceeded the measuring capacity of the counters.

Explorer IV carried more extensive instrumentation which in addition to measuring the radiation intensities, also allows insight as to the type and characteristics of the particles causing the high measurements. Preliminary results from Explorer IV indicate substantiation of the estimates made from the Explorers I and III data. The radiation intensity increases by a factor of several thousand between 180 and 1000 miles. The intensity continues to rise to 1500 miles, the maximum altitude for which data is currently available. At 1000 miles the exposure level would be 2 roentgens per hour, as compared to the permissible human rate of approximately .002 roentgens per hour. This does not necessarily preclude manned space travel, but does make imperative proper shielding. In addition, the high radiation levels need to be considered in relation to the heating of the high atmosphere, the amount of visible light, radio noise and ionization produced.

4. Temperature measurements have been made on Explorers I and III, and in addition have been derived from transmitter frequency changes on the Vanguard satellite. The measurements have been made on the surface or within the satellites themselves, using "thermometers" whose electrical resistance changes with temperature. No attempt has been made as of yet

to measure the "air" temperature in space. The temperature measurements on the satellites have been made during the early state of satellite operations for engineering rather than scientific purposes. The purpose of the measurements was to ascertain the reliability of the method used to control the temperature of the satellite and therefore the internal electronic components.

In order to operate properly, these electronic components must be maintained within certain temperature limits, hence the concern over the temperature of the satellites. The temperature of the satellite will be determined by the quantity of heat transferred to it by means of conduction, convection or radiation. Since there is no body in contact with the satellite, there is no heat transferred by conduction. Convective or frictional heating resulting from the satellite passing through the "air" is negligible. It is not meant to imply that the "air" temperature is negligible, but that the heat transferred from the "air" to the satellite is negligible. This is because the heat transfer rate is dependent upon the <u>density</u> of the air, and the density at these altitudes is extremely small. Consequently, the predominating heat transfer process will be radiation. This radiation will be from the sun, either directly or reflected from the earth, and infrared radiations from the earth. A relatively small amount of heat is also generated within the satellite due to dissipation of power, but the temperature effects of this source of heat are small compared to the radiative heat transfer. The radiative heat transfer <u>rate</u> is directly affected by the emissivity of the surface of the satellite. Consequently, by proper choice of surface material and finish the heat transfer rate, and thereby the temperature, can be controlled. For the Explorers, the stainless steel surface was partially covered by eight equally spaced aluminum oxide strips running longitudinally along the cone-cylinder body. Calculations indicated that the resulting average emissivity would result in maintaining the electronic components between the desired 23°F and 113°F. The success of the method used is indicated by the measured temperatures in the transmitter which varied from 32°F to 97°F. The satellite surface temperature varied from -13°F to 167°F. The temperature variation results from the fact that part of the time the satellite is in the shadow and therefore not subject to direct radiation from the sun, resulting in a cyclic temperature history. The smaller variations in temperature in the components, as compared to the satellite surface, result from the fact that the rate of heat transferred from the satellite surface to the internal electronic components is retarded by the use of insulators between the surface and the internal components.

5. Explorers I and III carried wire grids for the detection of micrometeorite impacts. Explorer I also carried a microphone for micrometeorite detection. In one thirty-two day period the wire grid registered only a single impact, whereas the microphone detected seven hits. Taking into account the sensitivity of the instrument, the average influx of particles 4 ten-thousandths of an inch in diameter or greater was 8 per square foot

per twenty-four hour day, whereas the average influx of particles 1.6 ten-thousandths of an inch in diameter or greater was 80 per square foot per day. These values are in fair agreement with previous predictions, but are too limited for statistical analysis. While the probability of micrometeorite impacts of a size large enough to do structural damage is extremely small, the sand blasting effect of small particles over long periods of time could affect the satellite's surface condition. Surface conditions are important for temperature reasons as indicated previously, and in addition solar battery "windows" may be sensitive to surface conditions.

6. The density of the air determines the air resistance to the satellite, and in turn affects its path and orbital characteristics. Conversely, a knowledge of the change in orbital characteristics will allow the density of the air to be derived. All the satellites are tracked electronically and optically, and from these measurements various investigators have derived values of air density in the altitude range of 110 to 230 miles. Previous measurements with vertical sounding rockets extended up to 135 miles. Above this altitude estimates of density were obtained from the observation of meteors. The satellite density data falls roughly between the measurements obtained with these two methods, and varied from 4170×10^{-14} pounds per cubic foot at 110 miles altitude to 88×10^{-14} pounds per cubic foot at 230 miles altitude. The air density at sea level, therefore, is 92 billion times greater than at 230 miles altitude.

The data is quite sketchy at this time, but as tracking techniques improve and data is accumulated, the satellites will provide a powerful tool for the accurate determination of density over a wide range of latitude, altitude and time.