MAN AT THE THRESHOLD OF SPACE FLIGHT

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All development takes place in steps; for the most part in gradual invisible steps; occasionally in distinctly recognizable steps, but once in a great while - a century or so - in the radical step of a revolutionary impact. Such far reaching events have been, for instance, the invention of the printing press, the discovery of electricity, the invention of the steam engine and the combustion motor and their application to ground, sea, and air transportation and the invention of wireless communication. They all indicate a threshold to a new era in human culture and civilization. Today we are witnessing a similar step with the development of the rocket and its application to human flight. This invention has brought us to the threshold of space flight.

The rocket is a self-contained propulsion device - the only kind which we know - independent of an external medium both dynamically and chemically. Dynamically, because to attain propulsion it does not require an atmospheric medium to "push against." In fact, it is more efficient in the thinner higher regions of the atmosphere and most efficient in a vacuum. Chemically, because it carries its own oxygen or other forms of oxidizers for burning the fuel, in contrast to the jet engines which makes use of the atmosphereic oxygen in this respect. Furthermore, the powerful thrust of a rocket exceeds by far all other propulsion methods. These unique features enable a rocket to fly beyond the atmosphere and operate in space. In fact, since air is a hindrance to the rocket, its natural habitat is outside the atmosphere. With regard to its preferred environment, the rocket is a spacecraft.

In contrast, propeller planes and jet planes, while "wing supported" and "air supported" can operate only inside the atmosphere. With regard to the environment they are both aircraft. But the jet plane is the transitional stage to the rocket.

The altitude ceiling for air supported planes and air breathing engines is maximally around 20 miles or about 30 kilometers, the limiting factor being the density of the atmosphere. In contrast, the rocket has practically no limitation in altitude whatsoever; its vertical operational range is determined exclusively by the fuel.

In the realm of rocket flight the concept of height above the earth's surface blends into that of "distance" xx

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from the earth. The rocket alone has really conquered the third or vertical dimension in flight. It has opened a new frontier: the "vertical frontier" - a challenge for research and adventures.

The element of speed also reveals the specific nature of things to come. Jet propelled planes may reach velocities somewhat beyond three times the speed of sound. For rockets this speed unit is irrelevant because they approach the speed of meteorites.

The form of motion in conventional planes is governed by the steadily acting power of propulsion; in rocket flight, we deal with the laws of ballistics and even with those that govern the movement of celestial bodies, as expressed in the three laws of planetary motion by Johann von Kepler. During these flight conditions an environmental factor - ever present on earth, namely, weight, is eliminated.

Summarizing: These two facts - one, that the environment in rocket powered flight has the properties, not of the atmosphere, but rather - more or less - those of free space and, second, that the rocket craft itself, with regard to its motion - behaves like a celestial body - indicates that we have entered a novel, revolutionary phase in the development of flight.

We are at the threshold of space flight. This is, of course, of tremendous importance to the Air Force.

A special Department of Space Medicine was established in 1949 at the USAF School of Aviation Medicine at Randolph AFB, Texas, by Major General Harry G. Armstrong, Commandant of the School at that time. The mission of this department is to study the human factors involved in flight beyond the atmosphere. The Aeromedical Laboratory at Wright-Patterson Field, Ohio, under the late Brig. General Edward J. Kendricks, began the preparation for physiological animal experiments in rockets at about the same time. Since 1951 the Air Force has a Space Biological Branch at the Aeromedical Field Laboratory at Holloman Air Force Base, New Mexico, under the supervision of Colonel John P. Stapp and Major David G. Simons.

The Soviet Union has an Institute for Astrobiology, for the study of the ecological aspects on other planets. Similar studies are going on at the School of Aviation Medicine.

The first symposium on problems of Space Medicine was called by General Armstrong at the School of Aviation Medicine USAF in 1948. A second symposium on the "Physics and Medicine of the Upper Atmosphere" - with emphasis upon Space - was organized by Dr. Clayton S. White, Lovelace Foundation, Albuquerque, New Mexico, and

Brigadier General Otis O. Benson, then Commandant of the School, and held at the White Plaza Hotel in San Antonio Texas, at that time.

In 1950, at a meeting of the Aero Medical Association in Chicago, a Space Medicine Branch of that organization was founded which now holds regular sessions each year during the annual meeting of the Aero Medical Association.

Space medical topics are also found on the programs of various related technical societies. Such societies, variously called "space research societies", "rocket societies", "astronautical societies" and "interplanetary societies" are found in more than twenty countries. These national organizations are all members of the International Astronautical Federation (I.A.F.).

Ten years ago the word "space medicine" did not exist, and its mention would have sounded strange indeed to our ears. Today, this new field of medical science is considered an indispensible part of any discussion or meeting which deals with flight into the upper atmosphere and space.

Before we discuss the problems of space medicine, one point should be clarified. When the concept of flight first became associated with the word "space", it was under the term "space travel." This magic phrase has intrigued the mind of the public, who immediately visualized trips to the Moon or Mars. In this sense, space travel has become a main topic of delightful and sometimes fascinating stories in publications, on the radio and on television. The word "travel" usually refers to long distances. According to Webster it means a "journey to distant and unfamiliar places" and it generally covers weeks or months or years. For trips to distant and unfamiliar celestial bodies "space travel" indeed would be the appropriate term. The full realization of this final goal, however, will follow the course of a step by step evolution. For the preliminary stages "space flight" is a more suitable term, because "flight" could refer to a trip of short and long duration. If we prefer no specification the more general term "space operations" is indicated. So much for the general and historical remarks about Space Medicine.

The medical problems encountered in space operations arise from the environment per se, namely, from the physical and chemical properties of the new millieu: Space, and from the process of movement through this environment which results in the state of weightlessness. Of special interest to us is, where or at what altitudes the characteristics of space operations begin, and consequently protective measures must be provided. One of the most important of these is human engineering of the cabin.

Other medical problems encountered are high accelerations during launching and decelerations during reentry into the atmosphere, visual problems in closed systems, psycho-physiological problems in closed systems, day-night cycling in an environment where there is no sequence of day and night, selection of the crew, toxicity of rocket fuel, etc. It is too early to discuss all of these problems in the present stage of development. We shall, therefore, confine our discussion to

1) The environmental and motional conditions in space operations and where above the earth surface they begin.

2) The various kinds of space operations

3) Human engineering of the space cabin and

4) The state of weightlessness

First, what are the differences between the atmosphere and space, from the standpoint of manned flight? The most important are:

1. The atmosphere contains a rather high concentration of oxygen which we need for respiration - in Space there is no oxygen;

2. The atmosphere exerts upon us, a certain barometric pressure that maintains our body fluids in the liquid state - in Space no barometric pressure exists;

3. Up to a certain altitude the atmosphere can be used for the pressurization of the cabin - in the emptiness of space there is no ambient air available;

4. In the lower zones of the atmosphere we are protected against the intense cosmic radiation by the atmosphere's filter function - in space no such natural protection can be anticipated;

5. This same situation holds true for the ultraviolet part of the solar spectrum;

6. The protective filter function of the atmosphere also applies to meteorites;

7. In the atmosphere, light is scattered by the air molecules; producing the so-called skylight. Space is permanently in a mysterious state of darkness.

8. The atmosphere transmits sound waves - in space there is no medium for sound propagation, therefore it is totally silent.

9. The atmosphere provides mechanical support or lift to the moving craft. In the vacuum of space, no such support can be expected - a fact which leads to the permanent occurrence of weightlessness.

10. And finally - the atmosphere with its tightly packed molecules contains and transfers heat, a factor which results in the phenomenon of heat barrier in fast

flying vehicles. In space, the carrier and transmitter of heat is exclusively solar radiation.

These ten points represent the principal differences between our atmosphere and space - as an environment for manned flight, and reflect the specific nature of space operations.

Now, in order to get a clear picture of where we stand today in Space Flight and Space Medicine, we must examine where - between the atmosphere and space - the aforementioned functions of the atmosphere come to an end and the space flight characteristics begin.

As you know, the atmosphere extends to an altitude of about 600 miles above the earth's surface. This estimate is based upon the occurrence of collisions between the molecules. Only so long as intermolecular collisions occur can the air be considered a material continuum or a continuous medium. Above 600 miles the free path of the particles become so large, that such collisions are very rare, instead the particles move freely with velocities acquired by the last collision. Those particles with velocities less than the escape velocity of 7 mps, after describing an elliptic path, fall back to the atmosphere; those moving with escape velocities, mainly hydrogen and helium, escape into space. Therefore, above the escape level we observe a kind of spray zone. This fringe zone of the atmosphere, called exosphere or dissipation sphere, gradually thins out into the vacuum of Space.

The 600 mile level is the border or limit of the atmosphere, with regard to its geographic vertical material extension or the material limit of the atmosphere. It is the border between atmosphere and space in terms of astrophysics. From the standpoint of manned flight, the story is different. The actual material termination of the atmosphere is not what counts - rather, it is the cessation of the functions that the atmosphere offers for manned flight. And these functions, as we have just seen, are manifold, however, they do not terminate at the material limit nor altogether at the same level; rather, as we shall see later, they come to an end at different altitudes; some even well within the stratosphere. The levels where these functions cease are called the functional borders between the atmosphere and Space or the functional limits of the atmosphere. At these functional borders, and above them we encounter space-like or space equivalent conditions with regard to the particular function in question.

We shall use these two terms "functional borders or limits" of the atmosphere, and "space equivalence" within the atmosphere, as basis for our discussion. Now, returning to our 10 points more in detail.