A Simple Classification of the Present and Future Stages of Manned Flight

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WHENEVER great inventions or discoveries are made, there is public concern with their potentialities and the length of time required for their full realization. This has been notably true in the application of the rocket principle of propulsion to flight. Rocket flight and space flight symbolize trips to the moon or to Mars. As long as these trips do not materialize, in the public view there is no such thing as space flight. This all-or-nothing attitude is often found in conversations, in radio and television programs, and in print.

It is true that the development of the rocket principle of propulsion is an achievement of revolutionary significance. Yet its complete exploitation will probably follow the pattern of a gradual evolution. The stages of this evolution can be understood best if we examine three factors: (1) the physiological and mechanical properties of the environment; (2) the speeds attained by rockets; (3) and distances they travel over and away from the earth.

ENVIRONMENT

It is well known that the border between the atmosphere and space, in meteorological and astrophysical terms, lies at an altitude of about 600 miles. As an environment for the flyer and the vehicle, however, the atmosphere shows conditions typical of space at much lower altitudes. We encounter within our atmosphere, beginning at 50,000 feet, a region which becomes increasingly *space-equivanent* with regard to one or more of the conditions important for manned flight. These conditions are anoxia (50,000 feet), the boiling point of body fluids (63,000 feet), the necessity for a sealed cabin (80,000 feet), meteors (75 miles), and the darkness of space (100 miles).[9]

Above 120 miles we find space-equivalent conditions in almost all respects. The atmospheric region from 50,000 feet (about 10 miles) up to 120 miles may be considered partially space-equivalent, and the region above 120 miles totally *space-equivalent,* if we ignore certain environmental effects which are caused by the solid body of the earth, its magnetic field, and its own and reflected radiation[8] (Fig. 1). Above the 120 mile level, the atmosphere is unrecognizable in manned flight. It is imperceptible to the flyer, although for the astronomer it exists up to 600 miles.

This being true, the rocket powered plane which has carried man to 90,000 feet and the rockets which have carried animals up to 36 miles,[4] have flown in a region which is space-equivalent to a high degree. A two-stage rocket,

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the WAC corporal mounted on the nose of a V-2, which attained an altitude of 250 miles, was flying under conditions of total space-equivalence even though for a few minutes only. Do not these achievements in very high altitude flying, justify the statement that we have already reached the era of space flight? From the standpoint of the environment we are at present in the partial space-equivalent phase of manned flight.

SPEED

Just as we find levels that are characteristic in the environment around the earth, so too do we find certain characteristic points in the factor of speed. They also mark distinctive stages in the development of flight (Fig. 2).

The first of these is the speed of sound (760 m.p.h. at sea level). The present record in the supersonic speed range exceeds Mach 2. In the higher range of Mach 3 or 4, in horizontal flight, centrifugal forces begin to counteract gravitation to an increasingly noticeable degree. This brings on the phenomenon of decreased weight or subgravity. Theoretically, at about 18,000 m.p.h. or 5 miles per second, in a horizontal flight the state of weightlessness, or the gravity-free state, is finally reached. This speed of 5 miles per second or 8 km. per second, where centrifugal force equals the gravitational pull of the earth, is known as the orbital, or better, circular velocity. It is the speed which will enable a craft to circle about the earth in a fixed circular orbit like an artificial satellite. At 7 miles per second or 11 km. per second, the craft breaks away from the earth's gravitational pull and escapes into the depths of interplanetary space. It is called the escape velocity.

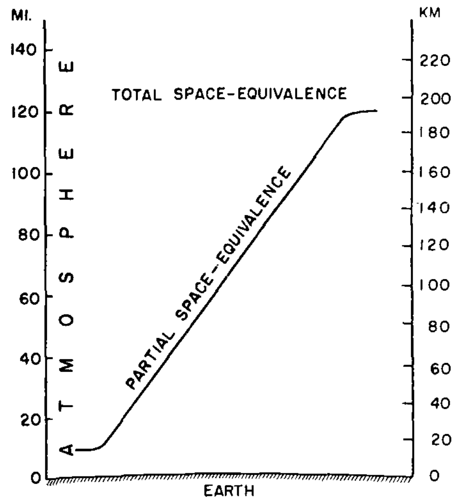

Fig. 1. The space-equivalent regions within the earth's atmosphere.

The highest speed so far attained in a two stage rocket (the WAC Corporal mounted on a V-2) is 1.4 miles per second. This is 30 per cent of the orbital and 20 per cent of the escape velocity. This is where we stand today with regard to speed. The three-stage rocket[1,5] or the atomic rocket[2,7] may bring in the remaining percentage.

DISTANCES

The various stages of flight can also be classified by the factor of the distance they cover. The craft may fly from one point on the globe to another point on the globe, in a certain distance around the globe, or far away from the globe into space.

If we combine the factors of environment, speed and distance with their characteristic levels into one picture, we see an evolutionary course in the development of manned flight that looks somewhat as follows: The long distance flights of today take us at subsonic speed, under normal gravitational conditions, in pressurized cabins through the lower regions of the atmosphere from one point on the globe to another distant point on the globe, across a number of time zones and/or across zones of different seasons in a single day. These are *global atmospheric flights*. This epoch in flying began when Lindberg crossed the Atlantic Ocean in 1927.

We are now on the threshold of the next stage. Rocket powered planes will take us at supersonic speed under subgravitational conditions and in sealed cabins through the space-equivalent regions of the atmosphere from one point on the globe to another even more distant point in a matter of hours.[3] Still bound to the earth, they will fall into the category of *global space-equivalent flight*. The precursors of this long distance *space-equivalent* space flight are seen in the short distance, short time flights of rocket powered planes and unmanned rockets of today. They can be termed *local space-equivalent flight*.

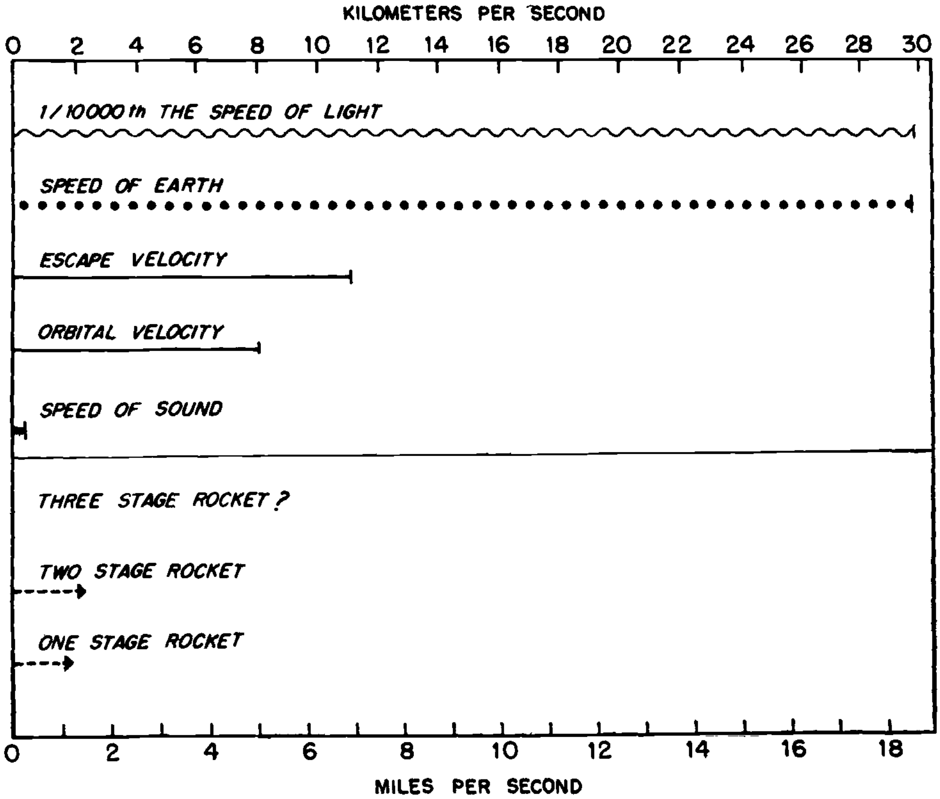

Fig. 2. Speed records in rocket flight compared to speed of sound, orbital velocity and escape velocity.

As soon as the orbital velocity (5 miles per second) is reached, flights of long duration around the globe in a satellite orbit under conditions of zero gravity and in an environment equivalent to space will become possible. But these craft still will operate within the gravitational hold of the earth and will remain within the earth's vicinity. This eventual stage may be called *circumplanetary space flight.*

The next step will follow as the escape velocity (7 miles per second) is reached. When, one day, a manned rocket leaves the earth, attains this speed and moves freely in space, then we will have arrived at *interplanetary space flight* or what we may now call "space travel."[1,5,6]

This classification (Table I) gives us, I believe, a clearly defined and realistic picture of the stage at which we stand today and of the possibilities we may expect in the future. At present we are actually in the first phase of space flight, the phase defined as *global space-equivalent flight.* Solution of the medical problems in this stage is, therefore, of immediate concern to the physiologist, the engineer, and the flyer. Incidentally, most of the medical problems involved in the final stage (space travel) are encountered in the stage of *global space-equivalent flight.*

This step by step approach to the possibilities of rocket-powered flight by human beings is perhaps more stimulating, and more fruitful for research and development, than the all-or-nothing attitude displayed by those who constantly gaze upon remote celestial bodies like the moon or Mars with a kind of space fascination. The psychological power of attraction of these objects as the final goal, however, must not be underestimated. They are extremely valuable as a background stimulus for our efforts towards advancement of human flight.

TABLE I. CLASSIFICATION OF DEVELOPMENTAL STAGES IN MANNED FLIGHT

	I Global Atmospheric Flight	II Global Space-equivalent Flight	III Circumplanetary Space Flight	IV Interplanetary Space Travel
Distance	Geographic Dimensions	Geographic Dimensions	Vicinity of Earth	Interplanetary Dimensions
Environment	Lower Atmosphere	Space-equivalent Regions of the Atmosphere	Circumplanetary Space	Interplanetary Space
Speed	Sub- and Supersonic Speed	Supersonic Speed	Orbital Velocity	Escape Velocity
Gravitational Condition	Normal Gravitation (1 g)	Subgravity	Zero Gravity	Zero Gravity

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