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FUTURE MANNED EARTH ORBITAL ACTIVITIES

It is a pleasure to have this opportunity of discussing some of the near-future manned earth orbital activities that are presently under serious consideration within NASA. Development and maintenance of an unexcelled capability to conduct manned earth orbital operations at will is one of the most fundamental aims of our overall space program, and such a capability is a requirement if U. S. world leadership in space operations is to be assured. Our earth orbital space station plans are primarily oriented around the peaceful exploitation of space with the principal objectives being: The direct promotion of human welfare; the expansion of man's knowledge in science and technology; the advancement of our national capability for undertaking space travel; and the enhancement of national security through NASA R&D support. Most of you will recognize that these objectives are an inherent part of the space act mandate which established the NASA. The Mercury flights and the planned Gemini/Apollo earth orbital flights will supply valuable experience related to these objectives, and will provide a hardware basis for timely implementation of a near earth manned station program which can more fully achieve these humane objectives.

This talk today concerns space stations which carry man as an integral part of the spaceborne facility. For perspective, it is germane to observe that, in a true sense, there are no totally unmanned space programs since man is always somewhere in the loop. However, the question sometimes arises as to why the man should be physically within the space station, in contrast to being remotely coupled from the ground. Those of us who have experienced difficulties in designing and obtaining reliable remote operation of necessarily complex spaceborne equipments that are required to measure new and as yet only partially understood phenomena no longer ask this question. The desirability of having the human hand and brain directly involved in a complex spaceborne experiment is now fully appreciated by us. Man's capability to exercise selectivity in acquiring and transmitting data, in removing the need for a complex pre-programmed command and control system, and his ability to simplify equipment calibration and adjustment and increase operating reliability amply illustrates the beneficial impact of man. Additional and more scientific type benefits accrue through having a properly trained individual in the space facility who can make on-site observations and modifications of experiments, and who as a flexible and intelligent scientific operator has the capability to observe and capitalize on unforeseen events. In other words, the space station facility would utilize man in the same way as in ground research laboratories. Automated or unmanned activities in every day life have been developed only after man has had sufficient experience to know what and how to automate. There is no reason to believe that a spaceborne research activity is basically different.

Basically a space station operates in zero gravity and in a vacuum environment. Thus, information transfer must occur through either the gravitational or electromagnetic fields. While some specialized information concerning the earth's geometry is obtainable via the gravitational field, all other information must be obtained through use of multiple sensors in the electromagnetic spectrum. In theory, an unlimited amount of information can be obtained by appropriate electromagnetic sensors, since any given combination of atoms and molecules may be uniquely identified by selectively measuring their overall electromagnetic reflection and absorption characteristics. This feature, in conjunction with the unique geometrical positions obtainable in earth orbit, constitute the starting point for identifying potentially useful applications of space stations.

A key factor in successful exploitation of space is the biomedical and behavioral reaction of man to zero gravity and long-term spaceborne confinement in a limited volume. Our limited flight experience to date indicates that any deleterious effects of space flight can be controlled, but man's reaction to long-duration space missions is not yet quantitatively understood. Thus, the biomedical and behavioral areas must receive major attention in the earlier extended duration earth orbital flights. Current planning includes the heavy scheduling of various cardiovascular, respiratory, hematological, musculoskeletal, metabolic, fluid and electrolyte balance, neurological, digestive, psychomotor function and adaptation experiments. In addition, hematological and cardiovascular evaluations are presently planned for all earth orbital missions because of the Mercury data which suggests some degradation in this area. It is planned to use this experimental data to develop and test remedial and preventative measures for use on later operational flights.

From the behavioral standpoint, the operation of man in space differs from that of earth primarily by the absence of the normal proprioceptive cues and motor restraints occasioned by gravity. To ensure that man becomes able to operate the spacecraft and associated subsystems properly, training is required in the space environment to assure that man may learn to compensate or substitute for the missing cues normally provided by gravity. Emphasis in planned experiments has been placed upon maintenance and repair techniques, operational problems such as the transferal of fluids, assembly and fastening methods, and extravehicular activity.

Proposed experiments in the space science area encompass astronomy, bioscience, physics and chemistry. In the astronomy/astrophysics area an observatory associated with a space station would not be subjected to the rather severe limitations imposed by the earth's atmosphere. The atmosphere absorbs some of the more interesting radiation from celestial bodies, and it limits optical resolution. The spectral transparency and operational flexibility offered by a spaceborne manned facility therefore offers unusual opportunity to extend our knowledge in this vital area. A modified OAO type 38" telescope is planned for the earlier flights. This wide-band instrument would have both a spectrophotometric and an imaging mode. In the first mode, the spectral range would probably extend from 1,000 Å to 10,000 Å with a resolution of 0.2 Å. In the second mode, the field would be approximately 4 arc-deg, with a 0.1 arc-sec resolution. Thus both the infrared and the ultraviolet regions have some coverage, in addition to the full optical spectrum. A complementing radiotelescope, up to 30 feet in diameter, is planned, since identification of radio sources and their correlation with optically visable objects has assumed increasing importance in astrophysics. Due to the importance of the sun's radiation, a solar coronagraph would also be part of the planned observatory. Because of man's unique ability to adjust and operate these sensitive scientific instruments, it appears feasible to ultimately use a manned spaceborne telescope up to 120 inches in diameter. Such telescopes, along with complementing radio observations, can greatly extend the size and detail knowledge of the known universe.

In the bioscience area, experimentation and research is planned with tissue regeneration and healing, bacteriology, germination, embryology, andcellular physiology. Such experiments in a zero gravity environment should significantly enhance our understanding, both from the standpoint of manned space flight and pure science.

Experiments in the physics and chemistry area would include the study of basic physical processes such as surface tension effects, liquid/vapor interfaces and behavior in zero gravity, fracture mechanics and the effects of long-term exposure of materials to the space environment. In addition, chemical reactions would be examined to observe the effects of zero gravity and a vacuum environment on the formation of compounds, combustion, surface chemistry, etc. These physics and chemistry experiments are expected to aid the development of future spacecraft in addition to furthering human knowledge.

One of the areas that shows great promise in providing directly beneficial returns to humanity is research and observation of meteorology from a manned spacecraft. Recent advances in meteorological theories indicate that a synoptic, or overall, view of cloud cover and knowledge of the interaction between extraterrestrial phenomena and the atmosphere can significantly aid in the prediction of weather.

The unique viewing position of a space station, using appropriate sensors, can achieve the necessary world wide synoptic coverage, and can assist meteorologists in developing a more complete theory. It is anticipated that through the gradual improvement in knowledge of the basic weather processes it will be possible to utilize "trigger mechanisms" whereby small energy expenditures at the right place can be made to yield large effects, thus opening the way to eventual weather modification, as well as more accurate prediction.

For meteorological research a multi-sensor capability would be provided. The correlated sensor outputs would provide a synoptic coverage of meteorologically significant events and parameters. The actual equipment would include a multispectral camera with adjustable filters and film combinations for imaging in different bands to determine spectral characteristics and structure of earth's albedo, cloud cover, and ground characteristics. Associated with the camera would be an IR scann imaging device to measure atmospheric and earth surface spectral characteristics, and a multi-frequency radar to observe cloud formations and localized storms. In addition, a solar radiation telescope would be used to measure the solar flux and the type of energetic particles above the atmosphere. A manually controlled spectrometer could determine the spectrum of reflected, emitted and scattered radiation at various viewing angles selected on the basis of existing meteorological conditions.

Another broad area that holds great promise of major direct benefit is that of earth mapping and survey. Subcategories now being studied under this broad area include geology, hydrology, agriculture and forestry, oceanography, and bio-geography. A few examples will serve to indicate the useful payoffs that may be achieved.

Many underground streams, important in water resource management, if not too deep, clearly show up in infrared photography. This is due to the temperature differential between the ground above the stream and the surrounding area. Similarly, in oceanography icebergs can be identified, and ocean currents such as the Gulf Stream can be accurately located. This latter type of information is useful in a number of ways, such as helping to increase the world fish catch, which constitutes an important source of food. In the agricultural area, appropriate combinations of infrared and chromatic optical sensors can indicate the state of health and the potential yield of crops in advance of the time they are ready for harvest. This is important both for advance planning and as an economic indicator.

The U. S. expenditure for these types of resource management was $6 billion in 1960, with upwards of $20 billion projected for 1980. For research in more efficient methods of management we spent $0.5 billion in 1960 and are expected to spend $1.5 billion in 1980, for an expected total of $20 billion in this 20-year period. Of primary importance to resource management is the ability to obtain reliable and timely information as to the particular phenomena which affect the resources. A space platform provides an excellent means for timely survey functions because of its large and repetitive coverage. The key research problem in effectively using the space facility for this purpose is development and validation of appropriate sensors. A manned space testbed appears to be the most effective means to develop the techniques whereby these sensors are brought to bear upon areas of interest, are adjusted, and are interchanged in response to varying weather conditions and other phenomena. New techniques and principles will evolve with usage. Thus, a continuing program of technique and sensor improvements is forecast. The types of sensors frequently contemplated include a multispectral camera, infrared imagery, and a side-looking radar with at least a 3-frequency operating capability. These equipments, operated in conjunction with a microwave radiometer, can provide correlated outputs which contain the information needed for effective resource survey and management.

Some other areas where an earth orbiting facility appears to offer promise of unique benefits are communications, arms control, and navigation and air traffic control. These, and other areas, which may be effectively supported by a manned space station are currently being examined so that a more quantitative understanding of suitable manned space station missions can be developed.

The contemplated multiple applications and missions discussed earlier indicate space station deployments into various orbits. A low inclination, approximately 30°, orbit below the Van Allen belt would provide the most economical deployment for uses insensitive to spacecraft position. Zero gravity observations and basic science and technology experiments are examples of potential applications in this orbit. A low altitude polar orbit is indicated for obtaining complete scanning of the earth's surface. Examples of possible uses for polar orbits include meteorological experiments and multispectral earth observations. A 24-hour synchronous orbit, possibly utilizing three cooperating stations, provides for uninterrupted earth observations, and could be useful in astronomy and astrophysics investigations, advanced meteorological observations, navigation, air traffic control, commercial communications, etc. A fourth deployment into highly elliptic orbits is currently under study. Such orbits, periodically returning to near earth every 7-30 days, would provide a low risk opportunity for simulation of future deep space travel programs.

Near earth orbital durations of up to 90 days are possible from simple extensions of the lunar Apollo Command and Service Modules, used in conjunction with a LEM ascent stage. These missions could carry either two or three men, and up to 5,000 lbs of experimental equipment. Earth orbital missions using this type of spacecraft could be initiated perhaps as early as 1968 without reducing the probabilities of a U. S. manned lunar landing in this decade, and without significant impact on planned unmanned programs. Thus, NASA is giving serious consideration to the use of this lunar Apollo hardware as a logical precursor to both a more complete and long-duration space station and as a forerunner of extended manned space flights.

Our studies indicate that the next major phase in manned earth orbital operations should be a space station with a 6-9 man capacity. This would be specifically designed for long-duration earth orbital flights and would directly further the routine exploitation of near earth space for peaceful purposes. The studies on this concept have shown that the basic station module should have a useable total volume in the order of 8,000 cubic feet with continuous "floor" areas of not less than 300 square feet. Periodic resupply every 120 days is currently planned, and logistics ferry vehicles of various types are under study. The ballistic type vehicle requires the least new development and appears satisfactory for early station support. However, its low L/D ratio results in limited reentry maneuverability and relatively high reentry deceleration forces. For this reason, higher L/D vehicles are also under consideration. With their greater reentry maneuverability, deployment of recovery forces can be minimized, and deceleration forces can be limited to about 1.5 times that of earth gravity.

In conclusion, I hope this brief exposure to some of NASA's thinking on potential future manned earth orbital activities has provided some additional insight into the possibilities of using near earth space for peaceful and beneficial applications.