THE SIGNIFICANCE OF THE DISCOVERER PROGRAM

1. The DISCOVERER program is providing vital technical and scientific advances to the whole of aerospace technology. While many of the results of the DISCOVERER program are directed primarily toward applications in the SAMOS and MIDAS programs, the long term benefits of DISCOVERER are serving to increase significantly man's knowledge of the spatial environment, to enhance his skills and techniques in space operations, and to provide experience in the development and operation of a reliable space vehicle. Many difficulties, some self-imposed due to the nature of the experiment, have been met and solved in the DISCOVERER program. In general, most of these problems are common to both SAMOS and MIDAS. Problems have been found and solved in a relatively inexpensive system prior to their occurence in the latter vastly more complex and expensive programs. From this viewpoint DISCOVERER is a "test bed" for space programs.

2. From inception to the present, the DISCOVERER program has demonstrated constant technical growth in improved hardware methods, reliability, techniques, and new discoveries. The significant features of the program to date can be summarized as follows: (a) development of a reliable workable and versatile satellite airframe - AGENA, (b) adoption, modification and improvement of an existing rocket engine for reliable space vehicle application, (c) demonstration of the ability to achieve repeatedly a pre-determined orbit with good precision, (d) demonstration of on-orbit stabilization of a satellite vehicle in such a manner that its orientation relative to the earth's local vertical remains constant, (e) development of a complex ground environment permitting high precision in vehicle position determination and forecasting in orgit, (f) command and monitoring of functions within the orbiting vehicle, either by pre-programming or by instructions from the ground, (g) collection of new and significant information on the spatial environment, (h) determination of the environment within the vehicle, particularly local temperatures and pressures, and the development of techniques for the prediction of the environment with alternative equipments and alternative types of orbits, (i) development of recovery tehhniques.

3. <u>System Considerations</u> - In the remarks to follow, major emphasis has been placed on those aspects of DISCOVERER which are most pertinent to SAMOS and MIDAS and those which have overall scientific importance.

4. <u>Launch to Orbit Injection</u> - The AGENA vehicle has been designed for use with both the THOR and ATLAS boosters. In either combination the ascent technique used by the AGENA vehicle is substantially the same; however, there are significant differences in the method of utilizing the booster. In the DISCOVERER program, in order to conserve weight, the THOR booster follows a pre-programmed trajectory using only its autopilot. Further, the THOR thrust is not cut off by command at a pre-determined velocity, but its fuel burns to near exhaustion. This relatively inaccurate booster performance, compared with the ATLAS boosted AGENA, and coupled with lower altitude of DISCOVERER orbits, imposes severe orbital injection requirements. Specifically these

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requirements are such that at an injection altitude of 120 statute miles (typical) an angular error of plus or minus 1.1 degrees or a velocity deficit of only 100 feet per second below the value for a circular orbit will result in a failure to complete the first orbit. To insure an optimum payload weight in relation to high probability of achieving orbital injection, the DISCOVERER program successfully undertook a re-exploration of the problem of rocket engine performance prediction for the AGENA engine. This study led to new theories and the improvement of existing ones to assist in the determination of: (1) sea level engine performance, (2) methods of extrapolation to vacuum performance, (3) degree of anticipated performance deviation in flight, (4) vehicle propellant loading and weighing techniques, and (5) determination of the proper level of conservatism in flight performance prediction. The outgrowth of this effort was improved performance prediction and, based on numerous simulated altitude firings at Bell and AEDC, a revision in the mehod of estimating vacuum engine performance from ground tests. This effort, then, is responsible for resolution of a problem area that could have plagued both the SAMOS and MIDAS program with failures to orbit. Numerous advances and redesigns of the myriad valves and regulation of the system have also been made and will continue to be made as improvements to the system because of DISCOVERER sponsored ground and flight tests. As a result of DISCOVERER developments, it has been possible to repeatedly inject DISCOVERER vehicles into orbit with an injection angle error not exceeding 0.4 degrees. The precision components and techniques developed in this aspect of DISCOVERER are directly applicable to SAMOS, MIDAS, and programs with a man-in-space application.

5. Orbital Operations - Precise Position Determination and Forecasting In Orbit - DISCOVERER tracking and orbital computation techniques have been developed to a high order of precision. Data from each orbitalpass are used to refine the vehicle ephemeris so that the exact location of the vehicle is known at all times. This precision has become routine. The orbital parameters of DISCOVERER XI were known after the first pass with sufficient accuracy to predict the time of arrival at subsequent tracking points with an accuracy of the order of a second. On the same flight, the final signal initiating the recovery sequence on the seventeenth pass was given within five seconds of its planned time, after a total orbiting time of approximately 100000 seconds - 1 part in 20000. The procedures, equipments, and techniques responsible for such results are applicable to all space operations.

6. On-Orbit Stabilization - The DISCOVERER on-orbit stabilization system, as the point of departure for similar SAMOS and MIDAS systems, demonstrated the first earth-center stabilized vehicle. This system has been perfected to the point that the DISCOVERER vehicle attitude errors are of the order of 10 in pitch, 0.5 degrees in roll, and 1.5 degrees in yaw.

7. Atmospheric Density - New and scientifically important information on the density in the upper atmosphere has resulted from the DISCOVERER program. Atmospheric density data derived from the orbital decay of DISCOVERER vehicles and other satellites have invalidated the altitude density curve recommended by the ARDC model atmosphere panel in 1959. Also, much new evidence on atomspheric density changes with diurnal, seasonal, and altitude variations has been

accumulated. These data are being furnished to the scientific community.

8. Vehicle Internal Pressures - The DISCOVERER program has produced new data relating to satellite internal pressure conditions which have had a significant affect on environmental testing concepts and added new knowledge on the spatial environment. The ambient pressure of the typical DISCOVERER orbit at the averate height of 200 miles is 10^{-7} mm of mercury. It was determined from DISCOVERER data that at the end of the first orbit, internal vehicle pressures were usually about 10^{-3} mm, and after 25 orbits (38 hours) the pressure had not fallen below about 10^{-5} mm of mercury. This effect has = been determined to be the result of outgassing from surfaces exposed to a vacuum. The above condition is of significance when related to our ability to simulate orbital conditions in environmental test chambers for relatively short term orbital operations.

9. Vehicle Temperatures - The DISCOVERER program has brought to light new information, revising previous theories and experimental procedures, on the maintenance of the desired thermal balance within near-earth orbiting satellites. Using accepted practices for the maintenance of the required internal satellite temperatures on the early DISCOVERER satellites, it was soon learned that these methods were inadequate and erroneous. Modification of previously accepted techniques and the installation of heating devices raised the observed low internal satellite temperatures to a proper temperature. These data are of particular significance to man-in-space, SAMOS, and MIDAS programs.

10. Recovery - The problem of recovering a DISCOVERER capsule from orbit is extremely complicated because, in addition to the relatively straightforward process of putting the satellite on orbit, the following four processes must be completed successfully: (1) a recovery team must be located so that one of the satellite orbits passes over it, (2) the recovery capsule must be related from the parent satellite at the correct time within quite narrow limits. Each second of timing error represents five miles displacement of the recovery point, (3) the capsule retro-velocity vector must be within 10 degrees of the desired direction in order that the capsule will re-enter within the recovery area, (4) following the deceleration and heating phase, the capsule must be further slowed by a parachute, (5) in the final phase, the capsule must be recovered from the air or from the sea. The first two of these processes have been satisfactorily accomplished on several flights. The last two processes, parachute deceleration and pick-up, have been also satisfactorily demonstrated in tests on many occasions, using capsules dropped from high-altitude balloons. The third item, the provision of the correct retro-velocity in the desired direction has been a major problem. It is the purpose of the presently proposed diagnostic flight to solve this problem.

11. Subsystems - Air Frame - Weight is a major consideration in satellite design. The objective is to provide maximum strength with minimum weight. This result was achieved in the AGENA by the use of the new material magthorium which possessed the qualities of light weight, strength, and favorable

high temperature characteristics. Methods of fabricating this new material were developed and subsequent flight results have verified the structural integrity of the resulting air frame. In like manner, novel techniques were employed in the fabrication of the propellant tanks. A scheme was devised wherein spun aluminum was turned and tapered to provide tankage of minimum weight with the required structural integrity. The MIDAS and SAMOS satellites are the identical basic air frame and tank configuration developed in DISCOVERER with those necessary provisions to carry the appropriate payloads.

12. AGENA Engine Development - (a) Model 8048 - This Engine, which is a significant improvement over the basic 8001 Hustler, was flown successfully in seven DISCOVERERS before its first use in MIDAS. Its reliability performance characteristics and capabilities were well established facts which permitted MIDAS to launch with a high degree of confidence that the expensive and complex payload equipment would indeed go into orbit with a high probability of performance. Before the first SAMOS launch, using this same engine, at least three additional DISCOVERER launches will have taken place.

13. Auxiliary Power - Power system components for use generally in satellite systems, and specfically in SAMOS and MIDAS, have been designed, developed, and tested in the DISCOVERER program. Chief among such components are static electronic inverters to covert battery energy into the various A/C voltages required by the other subsystems. The first static inverters ever flown were aboard DISCOVERER vehicles. They are considered essential system elements since they halve the weight and double the efficiency of their rotary counterparts, and it is not likely that the long lifetimes required in other programs can be achieved with rotary units. The DISCOVERER power system incorporates a silver-perioxide-zinc primary battery as a prime energy source. This battery has been developed specifically for satellite operations and incorporates refinements for high efficiency and performance in zero gravity environmental conditions. An advance in silver-peroxide-zinc battery design was necessary in this development to increase the energy-to-weight efficiency. Much has been learned in the DISCOVERER program regarding internal and external circuit design to enhance inverter performance and reliability, and to permit survival of inverters under a wide variety of malfunctions or overloads. Design features have been evolved to minimize standby power losses so that efficiency can be maintained at a high level even under fluctuating loads. Inverter development history has been, and continues to be, marked by high failure rates in system checkouts on the ground; many failure causes involving procedures, design, and quality control, have been isolated and corrected in the DISCOVERER program.

14. Guidance and Control - Major elements of the AGENA guidance and control system which are common to SAMOS, MIDAS, and NASA programs have been tested during DISCOVERER operations. Some of these guidance elements are: The S/S"D" timer and the Minneapolis Honeywell inertial reference package, which will be used on all SAMOS and MIDAS flights; the DISCOVERER gas control system, which is providing the basic experience leading to improved SAMOS and MIDAS

systems; and the DISCOVERER horizon Scanner, which will be on the early SAMOS and MIDAS flights. In addition, DISCOVERER will test the new engine fuel driven hydraulic pump which will be used on all SAMOS and MIDAS flights. It is anticipated that the NASA AGENA guidance and control system will also lean heavily on DISCOVERER experience. Within the DISCOVERER program itself the techniques of earth centered stabilization and gyro compass satellite yaw control were accomplished for the first time.

15. Recovery Techniques - Solving the recovery problem is important to the DISCOVERER program and science in general because many biomedical experiments and scientific measurements depend on recovery; however, in addition to the man-in-space and scientific aspects and DISCOVERER recovery effort has many direct applications to the SAMOS recovery program. The SAMOS recovery program will use the DISCOVERER experience in the following areas: (1) Ablation phenomena. (2) Recovery capsule detection. (3) Recovery force deployment and operations. (4) Aerial pick-up technique. The aerial pick-up techniques will be identical except that a larger winch will be used for the SAMOS recoveries. These techniques have been continuously improved under the DISCOVERER program. The SAMOS recovery force may be deployed over land but it is expected that the procedures will be outgrowths of the DISCOVERER operation. The DISCOVERER experience was largely responsible for the selection of a crystal controlled recovery beacon for SAMOS, dye marker and flashing light detection aids will be the same. The ablation phenomena studies, which will be accomplished on the next DISCOVERER flight will be of general interest but are particularly pertinent to SAMOS and MERCURY which have the shallow angle, long heat pulse, re-entry trajector.

16. Future goals - The basic AGENA vehicle and the AGENA-B follow-on version are develppment and testing products of the DISCOVERER program. These products are major advances in all fields of space technology which have been achieved in a minimum time at a relatively low cost. The DISCOVERER program is providing, on a broad front, tested hardware for the R and D versions of SAMOS and MIDAS. Also, because of the experience and success achieved in theDISCOVERER the NASA cancelled the VEGA program in favor of the AGENA-B vehicle. This action was taken because it was apparent to NASA management that a reliable relatively inexpensive vehicle was available from DISCOVERER. The development of the dual-burn AGENA-B vehicle in DISCOVERER has drastically cut the development time required to deliver a tested satellite vehicle for subsequent SAMOS and MIDAS operational programs.

17. The immediate future goals for DISCOVERER include the following: (1) Achieve successful orbital recovery. (2) Successfully recover bio-medical specimens from orbit. (3) Demonstrate the design integrity and operation of the AGENA-B version. (4) continue component development leading to overall improved reliability, (5) Conduct geophysical and astro-physical experiments in order to gain new knowledge of the earth and the near spatial environment. Examples of specific future goals within selected subsystems include: (a) Propulsion - Model 8096 - This model will provide an improved injector, an uncooled nozzle extension to the 45:1 area ratio, and pumo inducers and a restart capability. This development adds