HISTORICAL BRIEFING

USAF R&D ORGANIZATION, 1960-1962

Though its ballistic missile program had been eminently successful, the Air Force through the 1950's continued to wrestle with the vital problem of promptly exploiting scientific and technological advances so as to create superior weapons systems as rapidly as possible. To speed up the process, new doctrines of weapon acquisition had been adopted in the '50s. One of the more far-reaching of these was known as "concurrency," a concept that provided for developing all aspects of a weapon system simultaneously, including research and development, procurement, testing, production, logistics and training systems, and ground equipment and installations.

Air Force organization had not kept pace with these new acquisition techniques, however. The result was that as time passed the adherence to the concurrency doctrine led to a blurring of the boundaries between ARDC's responsibilities for research and development and AMC's for procurement and production.

In May 1959, therefore, General Curtis E. LeMay, the Air Force Vice Chief of Staff, formed a Weapon Systems Study Group to review acquisition policies and procedures and determine an Air Force structure best suited to rapidly obtaining complex missile and space age weapon systems in the current environment. Included in the study group were several high-ranking commanders and members of the Air Staff, including General S. E. Anderson (chairman), AMC Commander, General Schriever, ARDC Commander, and General Mark E. Bradley, USAF DCS/Materiel.

The eventual result of the group's studies and deliberations was the presentation of three proposals to the Air Force Chief and Vice Chief of Staff, Generals White and LeMay, on 2 June 1960. A plan proposed by General Anderson called for a recombining of AMC and ARDC into a single command. One proposed by General Schriever called for the retention of two separate commands but a reorganization that would expand ARDC responsibilities to include procurement, testing, and production of major weapon systems. A third plan, proposed by General Bradley, called for no organizational changes but for improving the acquisition systems through changes in policy and procedures.

General White rejected the Anderson and Schriever proposals in favor of the Bradley plan, modified to include other possible steps "short of major reorganization." The study group thereupon set to work developing concrete proposals along the lines suggested by General White. The group's final report was submitted to General LeMay on 26 August, and by 1 September Air Force headquarters was in the process of implementing several of the study group's recommendations for changes in policy and procedure.

Meanwhile, General Schriever was becoming increasingly concerned over the Air Force space program. Soviet progress in producing space boosters and satellites had persuaded Schriever that the U. S. space program in 1960 was in a position similar to that of the missile program in 1954--in dire need of a maximum, concentrated, and coordinated effort to enable the U. S. to match and exceed the capabilities of the Russians.

In the fall of 1960, the R&D effort for Air Force space projects was the responsibility of ARDC's Air Force Ballistic Missile Division (AFBMD) in Los Angeles. AFBMD's most urgent mission in 1960, however, was to work with AMC's collocated Ballistic Missiles Center (BMC) to bring to operational status an intercontinental ballistic missile force. In the fall of 1960 this program was approaching quantity production and deployment status, and new responsibilities for site activation, installation, and checkout were being assigned to the complex. Added to this sharp rise in ballistic missile activity was an expansion of the increasingly-important space program.

The result as General Schriever saw it was that two national programs--ballistic missiles and space--were competing for management attention and resources within a single R&D organization. This led to serious organizational tensions that were aggravated further by a shortage of working space. The overall result, Schriever said, was that the AFBMD/BMC complex was losing its earlier cohesiveness and singleness of purpose, and was becoming so large and cumbersome that neither ballistic missile nor space programs were being managed with proper effectiveness.

On 23 September 1960 General Schriever communicated this concern, particularly his concern for the space program, to General White. Stating that the Air Force was the major contributor to the nation's space effort, he pointed out that the service nonetheless had no well-defined space program, and no nationally recognized operating agency oriented toward the exploitation of space technology (partly, Schriever knew, because the Secretary of Defense had not yet assigned the space mission to a specific service). These deficiencies General Schriever described as comprising one of the most pressing problems facing the Air Force, and one that had to be solved soon.

As a partial solution, Schriever recommended the movement of the ballistic missile operation to Norton AFB. The site activation activities should be moved immediately, he said, and the current ballistic missile programs should be moved on a phased basis as they proceeded into advanced development stages (and were thus freed from the need for the close technological support available only in Los Angeles). The Inglewood complex would then become identified with, and the focal point for, the Air Force space program.

When General White replied on 10 October 1960 he substantially agreed with General Schriever's position. He approved the immediate move to Norton of the site activation activity, and the move of the Atlas, Titan, and Minuteman offices as they progressed into the final stages of development. He also approved the concentration of the space activity in Los Angeles.

Meanwhile, General Schriever had not relinquished his conviction that the current weapon systems acquisition environment demanded a major overhauling of the Air Force acquisition system, particularly a broadening of ARDC's scope to include procurement, testing, and production responsibilities for major systems. And, though rejected by General White, General Schriever's proposals had found receptive listeners elsewhere in the government/industrial complex. Among those convinced of Schriever's correctness was Mr. Roswell L. Gilpatric, Chairman of the Board of the newly-formed Aerospace Corporation.

When the Kennedy Administration assumed power in January 1961, Mr. Gilpatric became Deputy Secretary of Defense in the new administration. That same month Mr. Gilpatric told General White that the Air Force could have its long-sought space mission provided the service adopt a reorganization plan based on the proposal made earlier by Schriever. General White agreed to do so.

Schriever thereupon formed a task force to draft a reorganization plan that would be acceptable to higher echelons. Chairman of the task force, apparently at General White's suggestion, was Major General Howell M. Estes, Jr., who was then Assistant DCS/Operations in Air Force headquarters. A plan was quickly formulated, approved by Generals Schriever and White and Secretary of the Air Force Zuckert, then coordinated with the Army because of its Corps of Engineers' involvement in missile site activation. The proposed reorganization was then presented to Defense Secretary Robert S. McNamara.

On 6 March 1961 Secretary McNamara assigned to the Air Force sole responsibility for the development of military space programs, and on 17 March announced the Air Force reorganization, which would take place on 1 April 1961. Three new commands would be formed from ARDC and AMC--AFLC, AFSC, and the Office of Aerospace Research. Three AMC centers--Ballistic Missiles Center, Aeronautical Systems Center, and Electronic Systems Center--were taken over by AFSC and combined with the former Ballistic Missile Division, Wright Air Development Division, and Command and Control Development Division. Out of the combined AFBMD/BMC organization in Los Angeles was created a Space Systems Division and Ballistic Systems Division. Over these two divisions was placed a Los Angeles-located Deputy Commander (AFSC) for Aerospace Systems. Commanded by General Estes, who gained his third star from the assignment, the DCAS organization was a temporary expedient designed to provide on-the-spot decisions and insure management responsiveness while it was supervising the creation of SSD and BSD out of BMC/AFBMD.

Meanwhile, the phased move to Norton of elements of the ballistic missile complex was proceeding about on schedule. By early 1961, site activation activities plus most of the Atlas office had moved.

Some adjusting took place after the reorganization of 1 April 1961, and a new plan was presented to Air Force headquarters on 22 May 1961. This plan proposed a gradual move of all BSD elements to Norton, with key ballistic missile program offices remaining in Los Angeles only until their projects passed beyond their greatest dependence on the technical competence available only in the Los Angeles area. According to this schedule, the Titan I office would move by fall 1961, the Titan II office by December 1962, and the

Minuteman office by July 1963.

Secretary Zuckert approved this plan on 8 June 1961, but asked that a special effort be made to advance the Titan II and Minuteman movement dates. By late summer 1961, the Atlas and Titan I program offices, the site activation establishment, and some BSD staff support agencies were in place at Norton.

But by the fall of 1961 the planned move seemed to be bogging down. For one thing, General Estes had indicated to General Schriever that he considered the DCAS organization a permanent arrangement. This was not only contrary to General Schriever's view but also was basically in conflict with the idea of moving BSD to Norton, since BSD's move would make a retention of the DCAS structure highly unlikely. Secondly, a new movement plan published in October 1961 considerably stretched out the Zuckert-approved plan, calling for the move of various headquarters elements and the Titan II SPO in July 1963 instead of December 1962 or earlier. And this later plan made no provision whatever for the movement of the Minuteman SPO or other BSD organizational elements, which comprised more than half of the BSD force.

Besides the question of DCAS and the BSD movement problem, the Los Angeles complex in the fall of 1961 was presenting General Schriever with a manpower dilemma as well. Schriever had committed himself to saving a considerable number of manpower spaces through the reorganization of April 1961. These manpower savings had not materialized.

These several difficulties prompted General Schriever in

November 1961 to direct an inspection and survey of the DCAS organization to evaluate the effectiveness of DCAS' use of manpower in carrying out its mission responsibilities. The team was to recommend organizational changes or new procedures that might lead to a more effective and economical operation in Los Angeles.

Led by Brigadier General William E. Leonhard, a member of the AFSC staff, the inspection team carried out its survey between 13 November and 9 December 1961. It found many serious deficiencies in the organization from both efficiency and manpower standpoints.

Foremost was the fact that the DCAS element was not functioning as intended. The DCAS himself had been given directive authority over BSD and SSD, but the DCAS staff was supposed to act only in an advisory capacity to the DCAS, not as an operating element interposing itself between the two divisions and AFSC headquarters. Contrary to this intention, however, the DCAS staff had established itself as a complete operating staff at a command level one echelon higher than the two divisions. In this capacity it was issuing instructions to the division staffs, requiring reports of them, and reviewing specific programs being managed by them. The net effect was to insert an unnecessary additional command element between AFSC headquarters and the two divisions, a procedure that lengthened and complicated communications and delayed the decision process for vital programs.

The Leonhard team also found that manpower was being wasted because of duplication of staff support functions. DCAS through a support wing provided special and general staff support to the two divisions. But a division commander could not request this support directly, he had to request it through the DCAS. For this and perhaps other reasons, each division took to creating within its own organization staff support elements that essentially duplicated those maintained for them by DCAS.

The team found further that manpower was being wasted by an unfortunate but unavoidable geographical dispersion of elements within the Los Angeles complex caused by a shortage of facilities. And more manpower was wasted by the splitting of the BSD operation between Los Angeles and Norton. The team pointed out that operations became costly and extremely inefficient when program offices were separated from their division headquarters, as was the case with the Atlas and Titan I SPOs. The team also found, however, that a SPO should not be separated too soon from its source of technical support, such as STL or Aerospace Corp. A general rule outlined by the team was that a SPO needed particularly to be near its technical support during the early stages of a stystem's R&D cycle, and near its division headquarters during the later stages.

Manpower was also being wasted, the Leonhard team said, through a tendency within the DCAS organization to overmanage, through an inflexibility within the organization that led to offices being retained past their periods of usefulness, and through higher headquarters indecisiveness, a problem contributed to by the interposition of an additional staff element between the two divisions and AFSC.

The Leonhard team made the following key recommendations:

1. That the DCAS element be eliminated.

2. That BSD and SSD be elevated to true division status.

3. That the central staff support operation be rescinded except for non-mission housekeeping, administration, and some comptroller functions, which could be assigned to an SSD base support wing for collocated elements of the two divisions.

4. That the DCAS staff plus its extensions in the support wing be reassigned to the appropriate divisions so as to make the divisions autonomous in mission functions.

5. That the phased move of BSD to Norton be expedited in order to improve management and provide better utilization of manpower resources. If possible, this was to be done without establishing another R&D center at Norton but also without depriving newer programs of necessary technical support.

6. That Aerospace/STL personnel be collocated as much as possible with their Air Force counterparts.

If the DCAS arrangement were retained, however, and major elements of BSD remained in Los Angeles, the team recommended:

1. That the DCAS organization return to the operational concept originally established, with the DCAS himself having directive authority but with his staff retaining an advisory capacity only.

2. That DCAS be limited to broad policy guidance and direction, with detailed program management responsibility assigned to the divisions.

3. That the DCAS staff be reduced.

4. That special staff functions now in the divisions be centralized in the support wing.

The Leonhard report apparently put an end to speculation that

DCAS would become a permanent organization, and it got the BSD move to Norton back on the track. Soon after the report's submission, General Estes began to phase down his DCAS operation, and by May 1962 the two divisions had been officially given their own staff support functions such as information, comptroller, and personnel. By June, BSD and SSD were completely autonomous.

An AFSC movement order of 30 April 1962 directed that BSD complete its move to Norton between 1 May and 30 September 1962. By June, BSD was ready to move, and it completed its move between July and September on schedule. DCAS was discontinued accordingly on 10 October 1962.

[redacted]

UNCLASSIFIED

BALLISTIC MISSILES, SATELLITES

AND SPACE VEHICLES

1956 to 1976

["Ely" Report]

[redacted]

DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

UNCLASSIFIED

[redacted]

WDTL 56-40

CONFIDENTIAL

This document contains information affecting the national defense of the United States within [redacted] of the Espionage Laws, Title 18, U.S.C., Section 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

BALLISTIC MISSILES, SATELLITES AND SPACE VEHICLES 1956 to 1976

OCT 3 1956

INTRODUCTION

1. Many different organizations have made feasibility studies covering various types of satellites and space vehicles to be used for specific objectives. Estimates of development time schedules have been made by individual authors for their particular projects. While these studies are important contributions to the overall knowledge in this area, their value is directly related to the background of the author and the material available to him. As the situation stands today, we have a series of more or less isolated studies covering various facets of the entire field. No one has made an attempt to collate the results of these studies and to integrate these results into a correlated survey of all of the advanced systems that may come into being during the next 20-year period.

2. This paper makes a brief survey of the entire field of future ballistic missiles, satellites and space vehicles and points up the need for a detailed survey. The results of the various studies that have been made have been considered in the light of our present ballistic missile and satellite programs. Estimates of the technical developments that may be expected as logical extensions of our present ballistic missile and satellite programs have been made. With this information in mind, estimates of the development time schedules of all of the advanced systems expected during the next 20 years have been made. In addition, comments, conclusions, and recommendations are made regarding required

action in connection with the applied research, research facilities, and research management necessary, if these developments are to be timely and obtained at minimum cost.

3. A general discussion of the above points is included in the following paragraphs. Detailed information and examples are attached in the following Tabs:

a. Tab A, in conjunction with Figures 1 and 2, considers briefly the current state-of-the-art, the rapid strides that have been made in the past, and a discussion of the performance that appears technically feasible during the next 20-year period.

b. Tab B, in conjunction with Figure 3, considers the types of systems progression that may logically develop from our present ballistic missile and satellite programs during the 1956 to 1976 period.

c. Tab C, in conjunction with Figure 4, discusses and estimates future development schedules for the systems of Tab B.

d. Tab D covers examples of lag in the development of applied research facilities.

e. Tab E contains estimates of the applied research, research facilities, and development and test facilities considered necessary to support future ballistic missile, satellite, and space vehicle programs.

DISCUSSION

4. In Tabs A, B, and C, an attempt is made to present a rough idea of what might be expected during the next 20-year period. However, it must be strongly emphasized that these developments and the associated

schedules are realistic only if adequate design information is available, or applied research to obtain the information is underway prior to the start of the development program. It should be apparent from our brief look into the future in Tabs A, B, and C that a large amount of applied research is necessary to support these programs. Vigorous action must be taken immediately to insure that a well-thought-out program, properly emphasized with funds, personnel, and priority is prepared, initiated, and properly monitored.

5. Past Air Force research and development history indicates that the research progress in each technical area has lagged woefully far behind the requirements of the aeronautical design engineer. One trouble seems to be that a development project or system has to be approved before the necessary supporting research can be approved and started, thus automatically delaying the project until the information is available. The alternative usually occurs, that is, proceeding with the project on the basis of available, though inadequate, data and then delaying later due to extensive modification and retrofit programs. The research facilities necessary to obtain the design information have not kept up with requirements for this information. It takes time to obtain research facilities, and Air Force planners to date have not been eminently successful in selling large research programs or research facilities unless they could be identified with specific projects. Scientists' thinking has, in general, kept far ahead of the technical facilities that have been provided.

6. In instances where facilities have been started that were not related to specific projects or systems, there is usually so much lag in the development that the need is much less urgent by the time the facility is completed; the difficulties having been solved by "trial and error" engineering. Some examples of this are contained in Tab D. No criticism is intended of the concept of AEDC or the High Temperature Structural Testing Facility at WADC, but only of the delay in getting these facilities started. Another example closer at hand is our lack of adequate nose cone design information for our current ballistic missile programs. Data was needed at Mach 23.5, but we are battling against time now to obtain a variety of re-entry data at Mach 15. Shock tubes had to be constructed and a re-entry test vehicle program initiated on a crash basis in order to obtain data. In lieu of adequate data, a conservative nose cone design must be utilized until full-scale flights have confirmed that the design is too conservative. Perhaps the reason that it is difficult to get applied research projects and facilities started is that under the present system, many people at many levels of management, have to be convinced that such research is necessary or that the approach is the "right way". It is inevitable that persons in this management chain do not have the proper technical background to have an appreciation for the requirement. Thus, a considerable amount of time is lost in overcoming this initial inertia. People do not readily accept new ideas. Whittle, as an example, had considerable trouble in advancing his ideas for jet propulsion.

Ballistic Missiles, Satellites, and Space Vehicles 1956 to 1976

Consider the various phases through which a project progresses prior to completion, e.g.:

a. Determination of feasibility.

b. Initiation of project.

(1) Recheck of initial feasibility study.

(2) Determination of requirements.

(3) Availability of funds.

(4) Selling program to higher authority.

c. Acquisition of design information.

d. Design, engineering, construction, and test.

One is forced to conclude on the basis of past experience that b and c are the really long lead time items. It is believed that the time to initiate a project can be considerably shortened and the acquisition of design data can be accomplished in a more timely fashion if one ARDC agency was given the mission of looking into the future and determining the applied research that is necessary to support future ballistic missile, satellite, and space vehicle programs.

7. This review and evaluation of required applied research should be made considering the requirements of a future program in its entirety rather than by considering individual proposals by themselves. The obvious first step is to make some approximations as to the scope of future systems programs. If we accept a program such as presented earlier as within the realm of possibility for the future, then we must also accept the fact that a considerable amount of design information is

required and certain types of applied research programs must be started immediately. There are many areas of weaknesses where little or nothing is underway for support of future programs. Many different industrial, research, and educational organizations have recognized some of the problems and have made studies and proposals. Many ARDC centers and other government agencies have studied various future problems and have made recommendations. Many committees have been established to investigate various aspects of high speed and high temperature problems and have made recommendations.

8. As a result of reviewing many studies, reports, proposals, and recommendations, estimates can be made of certain types of research that must be accomplished in the immediate future, and the types of research, development, and test facilities necessary to support future systems. This information is contained in Tab E. It should be pointed out that as one looks farther and farther into the future, it becomes more and more difficult to define the applied research necessary; because we do not know what all of the problems will be until after initial space programs are started.

9. The scope of the effort required to identify systems programs and supporting research for future ballistic missiles and space vehicles requires the attention of a special organization within ARDC. This responsibility should come under the mission of the Space Center presently being studied by the Headquarters ARDC, "Ballistic Missiles and Space Vehicle" Committee. However, it is highly unlikely that a

Space Center could be operational in time to be effective for improved ballistic missiles and satellites and perhaps not even in time for early work required in connection with a lunar test instrument carrier. There are many areas where work must be initiated immediately if we are to obtain timely design information for the future.

10. It is recognized that the Office of Scientific Research has a mission of sponsoring basic and fundamental research in various fields of interest to the Air Force. Some of this, of course, applies to the ballistic missile and space vehicle fields, but the activities of the Office of Scientific Research are not aimed at the solution of the rather specific areas of technical difficulties within a system that we have been talking about.

11. The present mission of WDD is to provide operational ballistic missiles at the earliest possible date. In accomplishing this mission, WDD has been faced with a rather formidable set of technical problems. In solving these problems, WDD has been continually confronted with new and related problems whose solutions are not necessary to perform the immediate mission, but which do apply to ballistic missiles, satellites, and space vehicles of the future. Thus, by the very nature of its work, WDD is uniquely qualified to identify the requirements for future research. WDD is now successfully executing its responsibility for bringing two ICBM systems and an IRBM system into existence on an unprecedented time schedule. This is being accomplished by a special management team of WDD-R-W-BMO. By virtue of this experience, WDD is

uniquely qualified to organize, direct, and utilize the results of this basic research.

CONCLUSIONS

12. It is concluded that we will have improved ballistic missiles, improved satellites, and various types of space vehicles within the foreseeable future, if applied research facilities of a suitable nature are provided with sufficient lead time.

13. It is concluded that the Air Force must vigorously support various means of obtaining basic design information which will result in design criteria that will reduce the number of aerodynamic, dynamic, structural, guidance, and propulsion deficiencies that will occur in the future missile, satellite, and space vehicle programs.

14. It is concluded that some organization within Headquarters ARDC must be given the responsibility immediately to identify the future requirements for applied research and research facilities needed to support the ballistic missile, satellite, and space vehicle programs of the future. This responsibility should ultimately belong to the ARDC Space Center but an interim agency needs to be designated until the Space Center comes into being.

15. It is concluded that WDD is in a unique position to identify these requirements for applied research and research facilities and to initiate action as a logical extension of the present mission.

16. It is further concluded that it is vitally important for the future of the Nation that adequate funds, priorties, and authority be

Ballistic Missiles, Satellites, and Space Vehicles 1956 to 1976

provided to support the responsibility outlined above.

RECOMMENDATIONS

17. It is recommended that the mission of the Western Development Division, ARDC be expanded to cover the following. These recommendations are considered an interim measure and are to be phased into the activities of the ARDC Space Center when this Center becomes operational.

a. Make initial estimates of future ballistic missile, satellite, and space vehicle programs based on current experience, and other information available from all sources.

b. Continuously revise these estimates to keep the future programs apace with systems requirements and technical feasibility.

c. Identify the areas of technological weaknesses and areas where major break-throughs are required.

d. Define the objectives in the areas where applied research, research facilities, and general development are required.

e. Determine the priority of the various research programs

by fitting the programs to system development programs & considering the required lead times,

f. Make cost estimates and present justification to cover the above.

g. Initiate and supervise the properly identified and approved projects in support of the future Air Force ballistic missile, satellite, and space vehicle program.

LAWRENCE D. ELY
Colonel, USAF
Asst for Technical Groups
Technical Operations, WDD

STATE-OF-THE-ART
(Tab A)

1. First let us review very briefly what appears to be technically feasible during this period. In order to illustrate the rapid strides that are being taken in advancing the state-of-the-art and technical developments and what is possible for the future, reference is made to Figure 1. This Figure is broken up into 3 areas; the first is for surface to surface missiles, the next is for artificial earth satellites, and the last is for true space flight vehicles. Missile range, orbital altitude, and distance from the earth is plotted against actual booster burn-out velocities necessary to achieve these distances. It should be noted that 3,000 ft/sec was a high projectile velocity in 1943. By 1946 to 1947, this had climbed to 4,000-5,000 ft/sec. By early 1956, test missiles were achieving 6,000-7,000 ft/sec, and now we are in the range of 12,000-15,000 ft/sec with our re-entry test vehicle flights. By 1958 to 1959, our ballistic missile velocities will be in the region of 23,500 ft/sec. It is apparent that big jumps are now being taken in performance, and it is easy to see that the vehicles that are capable of travelling great distances over the surface of the earth do not require much increase in booster burn-out velocity in order to reach a velocity that enables them to orbit around the earth as artificial satellites. After one gets into this area, relatively slight increases in booster burn-out velocities enables one to set vehicles on orbital paths farther and farther away from the earth, until finally the orbit is sufficiently large so that a trajectory can be chosen that will intersect the orbit of other large celestial bodies, such as the Moon, Venus, or Mars.

State-of-the-Art

2. All of the booster burn-out velocities and corresponding distances shown on Figure 1 are based on minimum energy trajectories. In order to get much farther out into space than Venus and Mars, it would require excessively long periods of time on this basis. (See Figure 2.) However, before this era is reached, it is expected that nuclear propulsion or other forms of power will be perfected that will permit other than minimum energy trajectories. The curve drawn through Mars illustrates the changes in orbital flight time that are possible by using other than minimum energy trajectories. The present concept of nuclear power will probably not be the ultimate power solution. Some efficient system utilizing the principle of exhausting small masses at extremely high velocity will probably come into being for other than minimum energy trajectories. Our initial efforts at true space flight during the 20-year period beyond improved ballistic missiles and satellites should be concentrated on a means of traversing the distance to the Moon (240,000 miles). This experience could then be utilized for the next large jump to Mars or Venus (35,000,000 miles at closest point).

3. Plans are already underway for satellites for different purposes, using hardware currently under development. The International Geophysical Year Satellite will utilize the Viking-Aerobee-solid propellant combination, and the Advanced Reconnaisance System Satellite will utilize the SM 65 with an added stage replacing the SM 65 nose cone. Studies have been made which indicate that it is feasible to get to the moon carrying test instruments and using propulsive and guidance components presently

under development. One promising study by RAND proposes the SM 65B with the advanced GE guidance system, less nose cone, plus the second stage Vanguard. It should also be noted that Soviet literature as reported by the Air Technical Intelligence Center is replete with instances of Soviet thinking on lunar and satellite vehicles. These range from scientific articles sponsored by the Academy of Sciences to the science fiction variety, but indicate a high level of interest in various forms of space travel.

**ESTIMATES OF DEVELOPMENTS
FROM
PRESENT BALLISTIC MISSILE PROGRAM
(Tab B)**

1. The logical development fall-outs that can be expected from our present ballistic missile and satellite programs are presented in Figure 4.

a. Our present ballistic missile program emphasizes early operational capability rather than optimum design. Therefore, many improvements can be expected after flight experience is accumulated. These improvements will be dictated by requirements but may be quite varied in nature. Missiles of greater range can be expected due to improvements in propulsive units, fuels, structure, and warheads. Greater accuracy can be expected due to improvements in the guidance and control system and increased knowledge of winds and other geophysical aspects at launch and target. A variety of nose cones can be expected with varying performance objectives and with varying trade-offs between total nose cone weight, warhead weight, vulnerability, accuracy, heating, and impact velocity. There will also be similar trade-offs from the standpoint of the entire missile between gross weight, warhead weight, warhead yield, range accuracy, vulnerability, propulsive weight, and so forth. With the advent of nuclear propulsion, major redesigns can be expected.

b. During the evolution of military ballistic missiles, attention will be directed to the use of this means of transportation for other than warheads. Experimental mail will likely be considered first due to weight limitations, and then perhaps military logistics for the transport of highly strategic materiel. Last to be considered will be air freight. Finally, attention will be directed to the transportation of personnel as the first step in space travel by man. Entirely new configurations will no doubt be developed with some consideration being given to glide missiles. Glide missiles might also be used for fly-over reconnaisance. Major problem areas would be the development of a satisfactory landing technique and the comfort and safety of passengers in flight and would probably include the development of capsules dropped by parachute.

c. Recoverable satellites would be the next step beyond our present satellite program. RAND studies indicate that recovering these vehicles in predetermined areas by retrefiring rockets is feasible. At 150 s.m. altitude, a relative rearward velocity of 2,000 ft/sec will bring the satellite to earth in 2,000 n. miles. The error in range due to a ± 100 ft/sec error in rearward velocity would amount to a ± 50 nautical miles. The error in timing of the retrofiring rockets could account for a ± 50 n.m. additional, which would mean that the satellite could be landed in an area of 100 n.m. in length and no more than 40 n.m. in width. Feasibility studies have also been conducted involving the recovery of re-entry bodies weighing up to 3,000 lb., using a 100 ft diameter parachute with double layer fiberglass capable of withstanding 1100° F. and test instrument canisters that can withstand up to 700° F. Developments from both the satellite programs and transport missile programs would feed into the next logical step, a man-carrying satellite or space platform. Early development of nuclear propulsion would permit the early development of a man-carrying satellite.

d. With hardware presently under development and supporting research, it would be possible now to devise a vehicle that would be capable of taking test instruments to the moon. An SM 65B ballistic missile could be used plus a new 4400 lb nose cone which would include the second stage Vanguard. This combination would have a gross weight of 243,665 lbs. This would be capable of putting a 1,160 lb. mass on a free flight trajectory. The 4,400 lb. nose cone would be composed of the following weights:

Working Space-Vehicle (Instrument and Communications Package Included)		320 lbs.
Last Expended Booster Stage		840 "
Structure	60	
Power Plant and Residuals	530	
Guidance and Control	250	
Usable Fuel		3,240 "
		4,400 lbs

The above weights assume destructive impact and instruments that could still operate after impact. It is believed that retrofiring rockets weighing about 240 lbs. could be used, which would allow instruments to be landed at near zero G. In this case, however, the weight of instruments and communications equipment that could be carried would be only 50 lbs. It is estimated that the guidance accuracy with the advanced G.E. guidance system would be such as to impact within an area of 50,000 sq. miles which is about 1/80 of the available area. Additional details covering tracking, communications, guidance, control, landing technique, meteor encounters, etc., can be obtained from RAND Research Memorandum, RM-1720, "General Report on the Lunar Instrument Carrier (U)", dated May 28, 1956.

e. As soon as the success of a test instrument carrier is assured, then attention will be focused upon space vehicles for military usages, and then a man-carrying lunar vehicle. Military usages cannot be determined until scientific data has been obtained, but advanced communications methods are bound to be among them. A very brief summary of some of the scientific data that could be obtained by landing test instruments on the moon is listed below:

Satellites
Global weather phenomena
Observation of astronomical bodies without obscuration & distortion by earths atmosphere
Reconnaissance
Communications
Cosmic radiation outside atmosphere.

(1) Magnetic field of moon.

(2) Mass of moon by observation of trajectory.

(3) Atmosphere of moon.

(4) Radio-propagation characteristics. We would have a one-way stable source with no reflection from the ionosphere.

(5) Electrostatic field of the moon.

(6) Determination of crustal composition and characteristics of the lunar crust.

(7) Temperature and temperature distribution.

(8) Frequency of meteoric impacts.

(9) Cosmic ray intensity.

(10) Lunar vibration rate

(11) Lunar orbital velocity.

Estimates of Developments from Present Ballistic Missile Program

Some of these data are already on hand, in rather a crude fashion, but the information could be refined considerably by landing instruments on the moon rather than relying on instruments placed on the earth. The lunar vibration rate, for example, can be determined much more accurately by a point source located on the moon, rather than relying on information from broad lunar geographical characteristics.

NOTE: Technical data presented in connection with the lunar test instrument carrier and recoverable satellites were obtained from the RAND Corporation.

ESTIMATE OF FUTURE DEVELOPMENT SCHEDULES
(Tab G)

1. In Figure 3, an attempt has been made to estimate development schedules for possible future ballistic missile, satellite, and space vehicle programs. Although, the present ballistic missile program will gradually phase into an initial operational capability, and there will be no sharp end to the development, mid-calendar year 1959 seems to be a fairly realistic termination point. Prior to this, some work on improved ballistic missiles will surely start. In fact, as a result of the present development work, many ideas for improvement have come to mind, and it is only the concentration on an early flight vehicle that has prevented improvements from being instituted.

2. Sometime during this period of improvement on ballistic missiles, it is estimated that work will start on transport missiles for experimental mail, air freight, and military logistics purposes. Once we have determined that we can land this material safely, then we will embark upon a transport missile program for personnel. This will without doubt be a rather lengthy program, possibly longer than a man-carrying lunar vehicle program due to the fact that the latter will only carry test engineers and scientific personnel.

3. The IGY satellite program as presently visualized is a very short development program imposed by the necessity to get the satellites flying before the end of the International Geophysical Year. Development of the Advanced Reconnaisance System has been extended over a considerable period due to the low priority assigned to the program at

present. Before we are very far along on this program, improvements will be apparent and development work will be accomplished on recoverable satellites and other work which when combined with the effort on transport missiles will develop into a program to carry man in a satellite or space platform.

4. Development work on the lunar test instrument carrier could be started now if SM 65B missiles could be made available at an early date. Due to the allocation of these early missiles to captive tests and flight tests for checking propulsion, guidance, nose cones, and overall reliability, it is anticipated that we will be well into the SM 65 test program before any of these vehicles can be diverted for use in the development of a lunar test instrument carrier. It is estimated that this will be a comparatively short development program, but that near the end of it a man-carrying vehicle will be designed and built; the first vehicles to circle the moon and return, later to land on the moon. The next step beyond this would be the lunar vehicle for military purposes, early usages would no doubt be for reconnaisance and communications. The next step beyond this would be vehicles to travel to other planets from the earth or from planet to planet.

UNCLA[redacted] C[redacted]AL

EXAMPLES OF DELAY IN PROVIDING RESEARCH FACILITIES
(Tab D)

1. AEDC

The initial effort on this huge complex of engine and aerodynamic test facilities was started in 1946. The German BMW was disassembled and shipped to the U.S. in 1947 where it was stored at Alameda until 1950. The first $30,000,000 was not appropriated until 1949. The prime purpose of this complex was to provide the Air Force with research facilities that would enable them to attain and maintain a position of world supremacy in the fields of aerodynamic and propulsion research. Today, even though the original concept has been reduced in magnitude, this complex is not yet finished due primarily to budget limitations. The hypersonic, 40 inch tunnel of the Gas Dynamics Facility, for example, is not estimated to be completed before 1959, 13 years after the idea was taken from the actual German design made during WWII (Kochel M-10). These facilities are inadequate for our future space vehicle needs, both from the aerodynamic and propulsion standpoints.

2. High Temperature Structural Test Facility - WADC

This facility was started several years ago and is to be constructed in three phases. The pilot plant to obtain design criteria and to check operating techniques is in operation now. The interim plant will not come into being until '57 or '58, and the full-scale plant, not until '59 or '60. The thinking that went into its design was based on satisfying the requirements for high temperature testing of Mach 3 aircraft. It does not have the capability for the high rates of heating

Examples of Delay in Providing Research Facilities

or the high temperatures required for missile design or test.

3. AEDC and the High Temperature Test Facility are not being constructed even in time to adequately take care of aircraft requirements. The Air Force now spends tens of millions of dollars annually on modification and retrofit programs to correct aerodynamic, dynamic, structural, and other deficiencies discovered only after the aircraft has been put into service. Other millions can be attributed annually to loss of aircraft and delays in production due to inadequate design information. The inevitable loss of life cannot be measured in dollars. It should be possible to cut down on this additional cost by spending only a small proportion of this amount on a well-rounded and well-integrated research and development program designed to continuously replenish the fund of design information in order to keep the level of knowledge sufficiently high to attain and maintain air technical supremacy.

UNCLAS[redacted] CO[redacted]TIAL

ESTIMATES OF APPLIED RESEARCH, RESEARCH FACILITIES AND DEVELOPMENT AND TEST FACILITIES
(Tab E)

Following is an outline of areas of applied research and research facilities considered necessary to support ballistic missile, satellite, and space vehicle programs during the next 20 years. An estimate is also made of some of the component development work and the development and test facilities that will be required to prove the adequacy of components. This information has been compiled from preliminary surveys and estimates made by Holmes and Narver, Inc., RAND Corp., Ramo-Wooldridge Corp., Western Development Division, ARDC, Wright Air Development Center, and others. More emphasis has been placed on the aerothermodynamics area than specifically on propulsion, guidance, aeromedicine, and communications as it is believed that these latter fields are covered in considerable detail by special ARDC Long Range Planning Committees. A much more detailed and continuing evaluation and review is necessary of everything comprising the 20 year program, as indicated in the conclusions and recommendations.

UNCLASSIFIED[redacted]AL

[redacted]

WDTL 56-40

UNCLASSIFIED [redacted] [redacted]AL

AEROTHERMODYNAMICS, GUIDA[redacted]ND PROPULSION

Exploratory Research Leading to Detailed Design Information Required in Areas Listed Below	Added Research Facilities Required to Obtain Information	Development and Test Facilities Required
Transition	Improved Shock Tubes	Full scale, high temperature, high rate of heating, dynamic structural testing facility
Boundary Layer	Electromagnetic Accelerators	Centrifuges
Chemical Kinetics of Gases at High Temperature	Light Gas Guns	Shakers
Radiation Characteristics of Gases at High Temperature	Atomic H Gun (Use preheated H to cause dissociation)	Hazard Stands including Toxic Gas Facilities
Heat Transfer	High Velocity Gun - Spark Discharge	Captive Test Stands
Stability	High Temperature Hypersonic Wind Tunnel (Wave Super Heater - Cornell) (Pebblebed Heater Type - RPI) (H_2-O_2 Burner Type)	Rocket Sled Tracks
Materials Characteristics at High and Low Temperatures	Evacuated Ballistic Ranges	Environmental Simulators (all inclusive, temperature, pressure, vibration, etc.)
Cooling Techniques	Shaped Charge Jets	Hypersonic Test Vehicles
Vibration	Large Solar Furnaces	Vertical Test Ranges
Flutter	Flash X-ray Equipment for Meteoric Impact.	Space Ranges - Ground and Satellite Stations
Structural Integrity		
Radio Propagation		
Flame Attenuation		
Nuclear Radiation Effects		
Meteoric Impact Effects		
Cosmic Radiation Effects		
Space Physics		

[redacted]AL

UNCLASSIFIED SECRET

WDTL 56-40

SPECIAL AREAS OF INVESTIGATION AND DEVELOPMENT

Aerothermodynamics, Guidance, Control, Navigation, and Propulsion

Optimum Method of Reentry Body Attitude Stabilization.

Methods for Recovering Reentry Bodies.

Methods for Recovering Satellites.

Improved Data Recovery Methods (All types of data on reentry body, propulsion, and guidance)

TV Data System.

Improved Telemetry Systems.

Improved High Speed Photographic Techniques - Gound and Vehicle Borne.

Improved Methods for Handling Aerodynamic Heating - Thorough investigation of radiation heat absorption, insulation, ablation, transpiration cooling, and film cooling.

Microwave Techniques for Measuring High Speed Impact Velocities.

Complete Environmental Simulation for Equipment and Components.

Magnetohydrodynamics Techniques.

Long Range Tracking Systems.

Advanced Communications Equipment.

Radiation Resistant Electronic Components.

Improved Reaction Controls.

Advanced Counter Countermeasures.

Space Navigation Devices. — Corrections of gyro drift.

Space Instrumentation.

Braking Rocket Systems - Tied to appropriate instrumentation for altitude, velocity, or acceleration.

Improved Propellants - Higher Specific Impulse, Solid Propellants.

Improved Propulsive Systems, Nuclear Propulsion, High Velocity Exhaust.

Special Areas of Investigation and Development - Aerothermodynamics, Guidance, Control, Navigation, and Propulsion

Solar Energy and other approaches to auxiliary power capable of withstanding long operational life and high transient power drainage.

Production Techniques (Machining and Fabrication) for various types of materials.

SPACE-MEDICINE

Effect of Cosmic Rays on Personnel

Crew Survival - safety, comfort, psychology, and sociology.

Nutrition

Disposal of Sewage

Air Conditioning

Environmental Simulation for Personnel

These are but a very few of the problems to be investigated in the space-medicine area.

UNCLASSIFIED

[redacted]

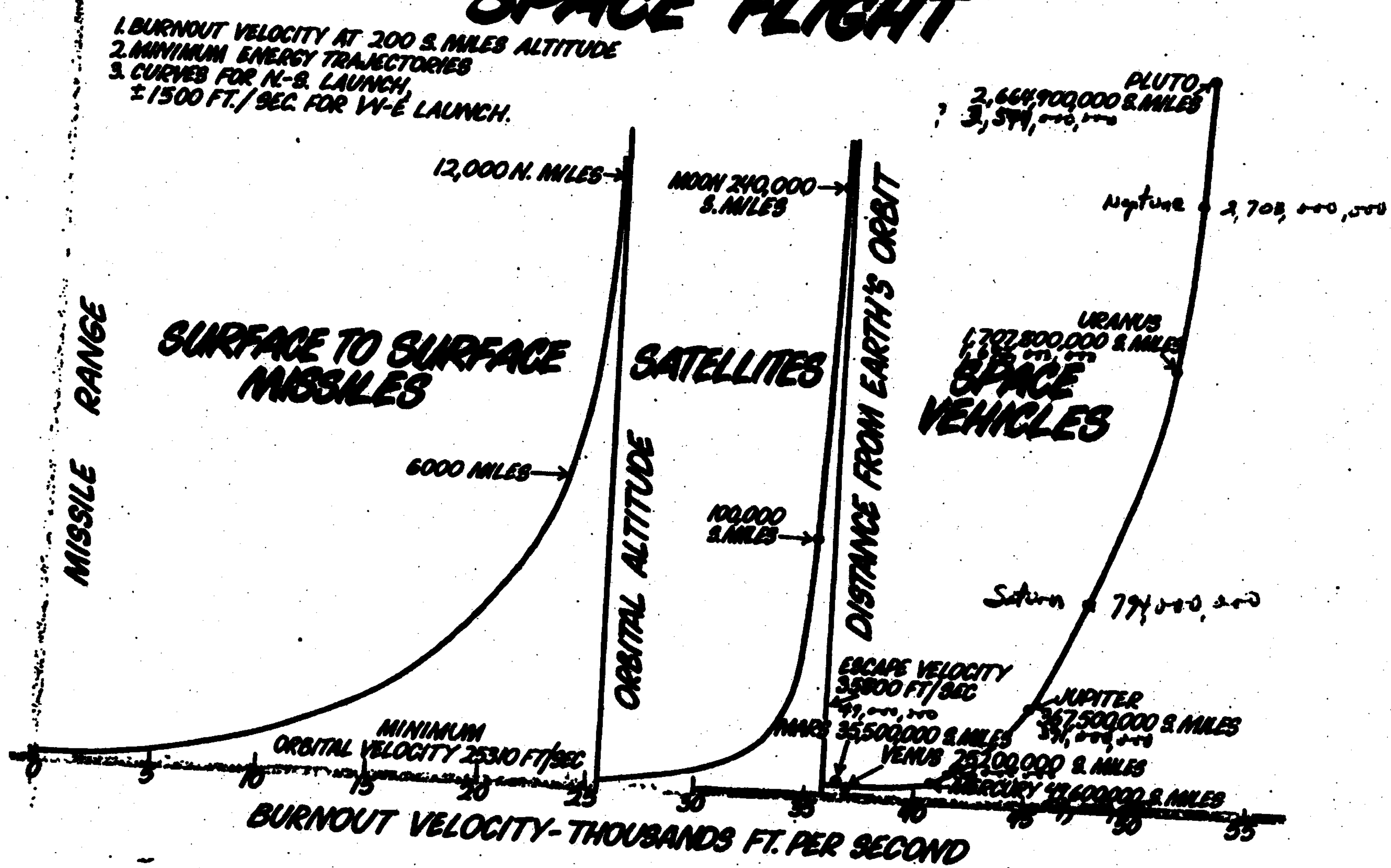
BALLISTIC MISSILES AND SPACE VEHICLES THE NEXT 20 YEARS

UNCLASSIFIED [redacted]

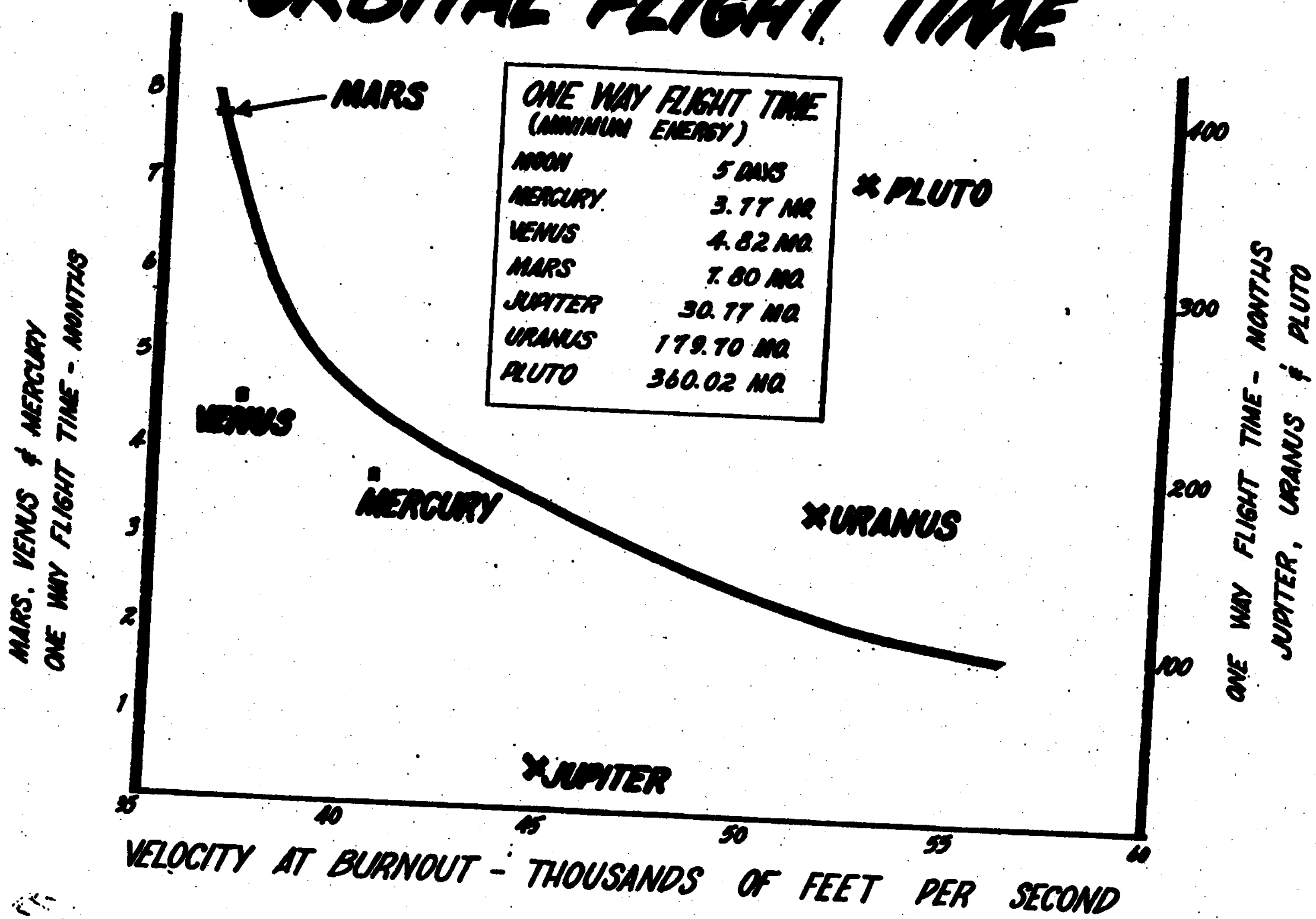
WDGP 56-0676

56 1392-1L7

SPACE FLIGHT



ORBITAL FLIGHT TIME

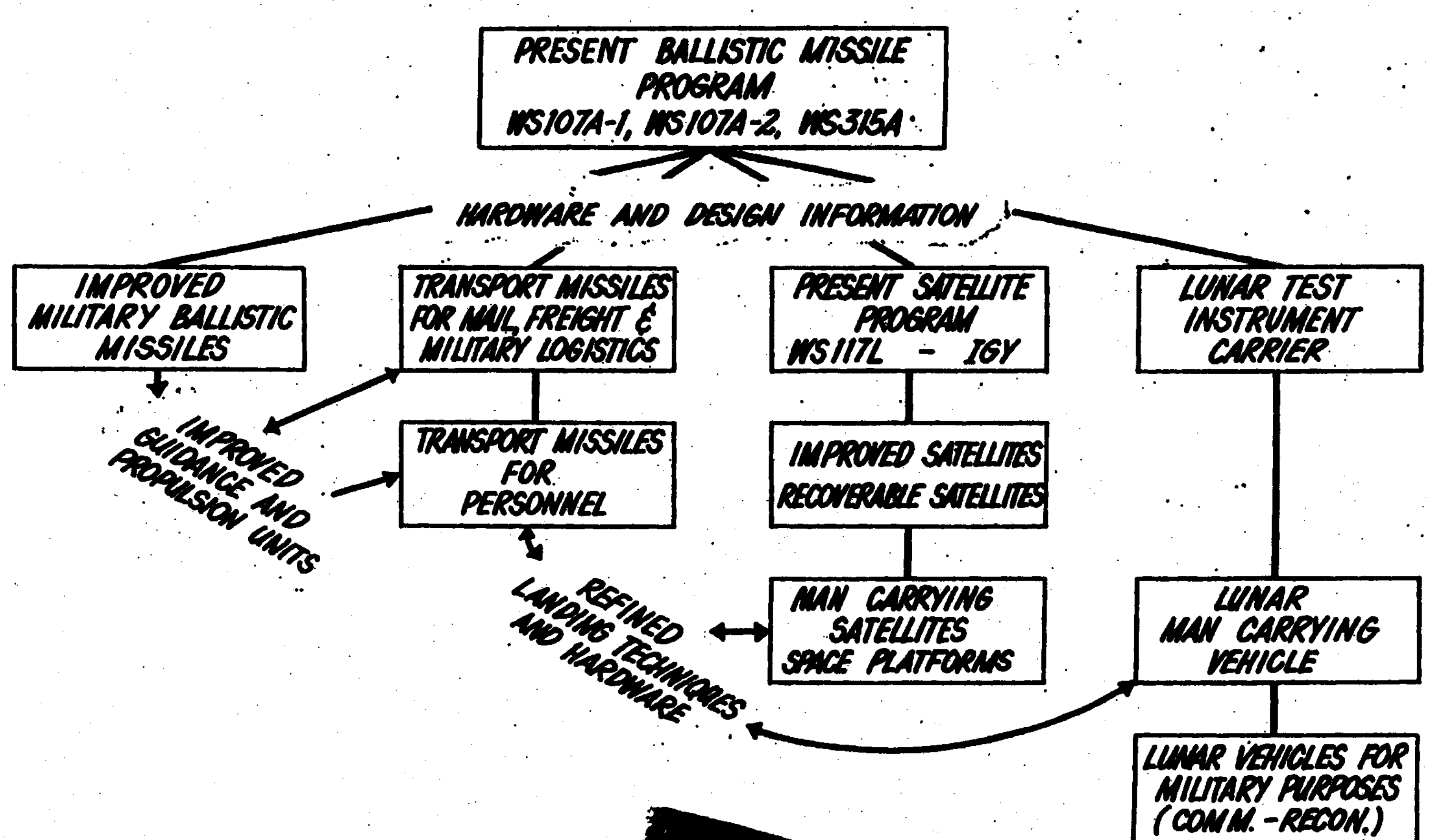


56 1388-TL-6 R1

UNCLASSIFIED [redacted]

SPACE TRAVEL

DEVELOPMENTS FROM BALLISTIC MISSILE PROGRAM

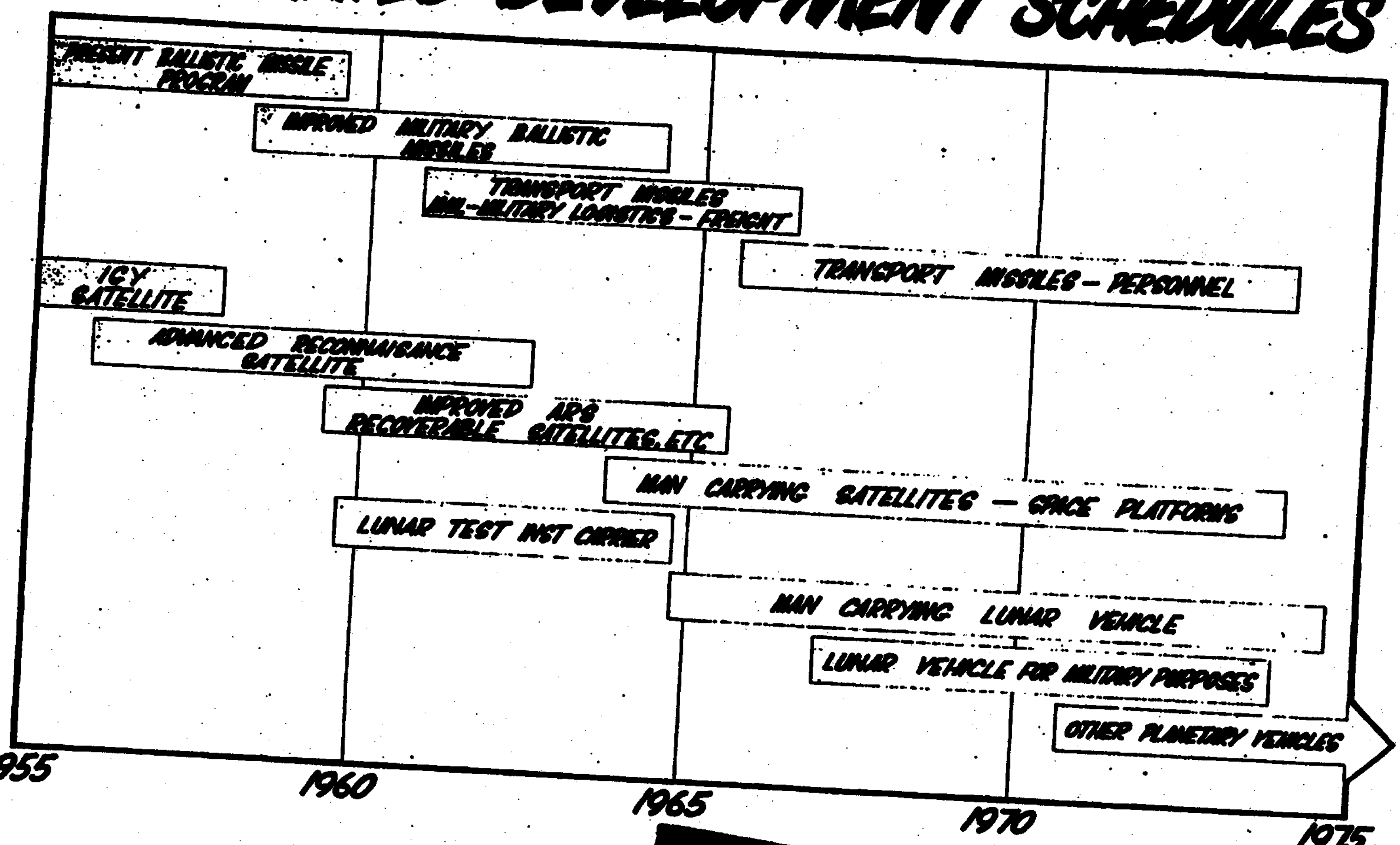


56 1216-DTL-2

[redacted]
UNCLASSIFIED

UNCLASSIFIED [redacted]ENTIAL

SPACE TRAVEL ESTIMATED DEVELOPMENT SCHEDULES



56 1223-DTL4

[redacted]

[redacted] UNCLASSIFIED