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USAF
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QUARTERLY
REVIEW

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The USAF Research and Development Quarterly Review is published to inform responsible personnel of recent accomplishments and trends in the Air Force research and development program. Its dissemination should be limited to personnel having an official requirement for this type of information.

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[redacted]

Highlights

Powered flight tests of the GAM-72 (Quail) commenced in August 1958. Indications are that scheduled flight test completion will be realized by August 1959. The current operational availability is visualized as May 1960. (WS-122A) [redacted]

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Development programming of the GAM-77 (Hound Dog) was initiated in August 1957. The first of these missiles was delivered in January 1959 with testing to commence in March 1959. Barring unusual flight test difficulties, operational availability by May 1960 is realistic. (WS-131B) [redacted]

•

The results of an engine study to determine the relative merits of incorporating the J-58 engine in the F-108/B-70 were presented to USAF on January 1959. This Headquarters has recommended that the J-93 engine be continued as the power plant for the systems. (System 202A) [redacted]

•

The Convair Model "B" supersonic ejection seat has proven technically feasible and the development objectives have been attained. Convair is preparing a proposal for production incorporation in the F-106 A/B aircraft. (WS-201B) (U)

•

A major milestone has been achieved in the F-106/GAR-3 Weapon System. Two missiles were salvo launched from an F-106 test aircraft and guided to direct hits on the target. (WS-208A) [redacted]

•

In November 1958 the IM-99A Bomarc installation at Santa Rosa Island and Field 9 APGC was accepted as a functioning guided missile base. This is the first base in the IM-99A program and will be used for Category II and III testing and the ADC Unit Training Program. (WS-200A) [redacted]

•

On December 1958 the XV-3 successfully performed full conversion from helicopter flight to fixed wing flight and reconversion to helicopter flight for vertical landing. (System 602A) (U)

•

Boeing and North American presented the results of their coordinated efforts to date in determining and defining compatibility problems between the B-70 and KC-135A. Based on the data obtained and presented by the Contractors, the B-70 is capable of beingrefueledby the KC-135A for accomplishment of its projected mission. (System 422L) (U)

•

A new world record of 117,900 pounds cargo airlift was established by Military Air Transport Service utilizing a C-133A airplane on 15 December 1958 at Dover AFB, Delaware. The cargo was carried at the design take-off gross weight of 275,000 pounds. The take-off distance was less than 5,000 feet and the duration of the flight was one (1) hour. (System 402L) (U)

[redacted]

[redacted]

RESEARCH AND DEVELOPMENT QUARTERLY REVIEW

To meet the needs of rocket and hypersonic airframe designers, a class of metals known as refractory metals hold potential for greatly extending present melting point temperature limitations. Four of these refractory metals have melting points exceeding 4400° F. (U)

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One approach to the oxidation problem of the refractory metals is through the use of protective coatings. The flame spray coating technique which employs an arc plasma jet is considered by many as an outstanding metallurgical achievement of 1958. With further development, many significant Air Force weapon applications are anticipated. (U)

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During 1958, a milestone was reached in the ARDC plastics development program. Glass fiber reinforcing material was produced, on a laboratory scale, with almost double the modulus of elasticity of current glass fibers. (U)

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The Hurrican Balloon feasibility study has been extended through the 1959 hurricane season. If instrumented balloons can be maintained within the "eye" of severe tropical disturbances, the development of an operational device for the tracking of such storms over great distances will be feasible. (U)

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The latest development in pressure suits has been the quick-donning, short term, emergency, CSU-4/P garment. Successful tests have been completed in the low altitude chamber at WADC. (U)

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In October 1958 construction was completed on the new 84-foot radio telescope of the Propagation Sciences Laboratory, Electronics Research Directorate, AFCRC. This telescope, located near Hamilton, Massachusetts, will become a basic tool in the EDR growing space research program. (U)

*

The 6th Annual ARDC Science and Engineering Symposium will be conducted at the Shoreham Hotel, Washington, D.C., on 1 and 2 October 1959.

[redacted]

RESEARCH AND DEVELOPMENT QUARTERLY REVIEW

USAF R&D BRIEFS

(U) The following pages tabulate action during the past quarter on the USAF research and development program. This section is broken down in terms of the ARDC Headquarters organization and concept under major headings WEAPON SYSTEMS and TECHNICAL DEVELOPMENTS. Each in turn is broken down by subheading indicating the responsible Headquarters organization. All systems are identified by number and title or name, project number, responsible center, report numbers; and other identification is included in order to associate R&D Briefs with other ARDC documents. Security classifications of pages, paragraphs, and titles are indicated in conformance with AFR 205-1. The Quarterly Review presents a survey of major R&D activity within this section in order to show current program status. Test results, anticipated progress, slippage, projected operational dates, completion deadlines, cancellation possibilities, requirements decisions, transfers of responsibility, joint action with Army or Navy, and other pertinent information is published for the edification of Air Force technical staff personnel with a need-to-know the full R&D status of the whole program or some of its components.

Strategic Systems

(U) B-58 HUSTLER (WS 102A)

(U) As of 31 December 1958 the fifteen B-58s currently on flight status had performed 496 flights totaling 964 hours. Over 83 hours of supersonic flight time have been logged.

[redacted] Initial SAC operational Air Crew training will be accomplished primarily at Carswell by the B-58 Test Force. A twelve week course is planned and the training includes ground school, B-58 simulator experience, TF-102 and B-58 flights. Instructor crew training will be accomplished during the flight test program in CY-1959. SAC Operational Crews are to start training in December 1959 with a number of the test aircraft and a number of the first inventory airplanes. Initial training for the B&N crew member will be accomplished at Mather Air Force Base to prepare the member for subsequent integrated crew training at Carswell. The Defensive Systems Operator will receive initial training at Keesler Air Force Base with integrated crew training also at Carswell.

[redacted] The significance of simulator devices in crew training is much greater than in the past since these equipments will provide the only means by which crew standardization can be monitored. This training program provides the minimum support required for the first operational unit.

[redacted] Necessary administrative action was initiated to procure ten (10) YJ-79-GE-9 engines for Research, Development and Test purposes. The GE-9 engine is one of the SAC recommended changes which will be incorporated in B-58 Weapon System. The ten (10) engines will fulfill the following existing test requirements:

a. Two (2) engines for simulated altitude evaluation (AEDC)

b. Two (2) engines for extreme temperature evaluation (APGC)

c. One (1) engine for icing tests (Mt. Washington)

d. Two (2) engines for sea level static tests (WADC)

e. Three (3) engines for flight test. (General Electric, Edwards AFB)

[redacted] Since there is no longer an operational requirement for the RB-58 Photo Reconnaissance Pod, the responsibility for all air and ground equipment associated with this sub-system will be transferred to the Aerial Reconnaissance Laboratory at WADC. A letter has been sent to Hq USAF stating that all testing of the electronic reconnaissance pod is deferred until late 1959 or early 1960 and that consideration is being given to turn over the ferret equipment developed under this program to the RB-47 reconnaissance program at SAC (RB-47H's).

(U) Initial flight tests with YJ 79-GE-5 engines installed on B-58 airplanes Nos. 7 and 10 resulted in poorer than predicted performance in terms of engine specific fuel consumption. Investigation has resulted in the identification of a number of causes for this reduced airplane performance. Interim changes to the engine and nacelle are being made. Basically, the nacelle inlets are increased in size, the spike positioning schedule has been changed, the engine RPM schedule is being varied to provide for overspeeded engine capability, and several other lesser changes are being incorporated. The evaluation of the performance capabilities of airplane #7 which incorporates these changes will be completed by Mid-January 1959.

(U) B-52 (WS 101)

(U) There have been a number of incidents in B-52 aircraft operation where water in the fuel has caused engine fuel starvation. Investigation revealed that a serious basic deficiency in quality control of JP-4 exists since no one agency has the overall responsibility. The fuel is procured by the Navy, delivered by AMC, stored on base by the Base Air Installations and delivered to the aircraft by organizational fuel trucks. In addition to the problem of excess water in the fuel prior to insertion into the aircraft is the precipitation of solution water inherent in aviation fuels and consequent formation of ice. Solution of the problem in time for the 1958-1959 winter season is not possible. It is planned that fuel heaters will be installed prior to the 1959-1960 winter season.

[redacted] Proposals were forwarded by the Weapon System Contractor to modify the B-52 aircraft with turbo-fan engines. The proposals were reviewed with considerable interest by the using command and a subsequent position was established by Hq USAF that it is their intent to support a program to incorporate new turbo-fan engines in the B-52 in the event a follow-on FY 60 buy is approved. In addition, it is desired to include turbo-fan engines in as much as possible of the FY 59 B-52 program on a production installation basis. No modification to existing engines on aircraft is contemplated.

[redacted] A study is being made to identify all significant technical and management problems in [redacted] each being an individual weapon system or major subsystem. The modification schedule for penetration aids has been exercised by OCAMA, SAC, Hq USAF and AMC Aeronautical Systems Center. The Hq USAF was requested to establish a policy to be followed in the event one or more of the penetration aids is not available at the proper time. The established policy is, the penetration aids modification of the B-52 aircraft is considered a "true package" for Group "A" (basic provisions) installation. Group "B" (black boxes) will be installed during normal downtime insofar as practical. In the event of Group "B" nonavailability, installation will be performed by using base and/or field team personnel as required.

[redacted] The Flight Test Program for the AN/ALQ-27 was definitized to the point where the radar requirements were specified as well as the location and schedules. First flight tests were accomplished at Rome Air Development Center utilizing a C-47 against [redacted] installed. Later flights included operating against both single and multiple installations of a mixed variety, i.e., search, tracking, and height finding radars. Procurement authorization was granted to proceed with the procurement of ten (10) each AN/ALQ-27 DECM subsystems for service test. Funding was increased by $26,557,000 from $31,500,000 to $58,057,000 for this purpose. An additional $6.89 million procurement authorization was forwarded for the required B-52 prototype engineering with a first flight test date set for October 1959.

(U) Following a series of accidents wherein the stabilizer trim system was suspected of being a major contributing factor, an exhaustive investigation was undertaken to determine what corrective action was needed. The investigation will cover:

1. Re-evaluation of the B-52 stabilizer trim system for possible improvement or corrections for eliminating the inherent inability of the pilot to detect nose down

attitudes in sufficient time for application of appropriate corrective means.

2. Re-evaluation of the B-52 performance characteristics particularly during light-weight take-offs and accelerations thereafter.

3. Re-evaluation of techniques as specified in pilot's handbook.

(U) Evidence of fatigue cracks in the lower wing skin trailing edge area and the flap track rib was discovered on operational aircraft. This resulted in placing the aircraft on an exceptional release status with a maximum of six days permitted to accomplish the desired inspections.

(U) WS 123A - SM-73, Goose

[redacted] Hq USAF directed termination of the SM-73 Goose surface-to-surface long range decoy missile on 12 December 1958. During this quarter certain derivatives of the program, such as [redacted] useful application to other weapons. The program was dropped because of severe operational disadvantages in strike reaction timing compounded by overall USAF funding problems.

(U) WS 112A - GAM-63, Rascal

(U) By direction of Hq USAF the GAM-63, Rascal program was terminated 29 November 1958. The system capability, although useful, did not justify an inventory build-up. However it served its purpose in the advancement of ASM technology and as a forerunner to the Hound Dog and follow-on air to surface missiles of increasing performance.

(U) WS 103A - SM-62, Snark

[redacted] Developmental testing was completed in September 1958, however, the ARDC evaluation finds overall missile system reliability low with further improvements indicated in certain subsystems and components. Accordingly additional Category II (AFR 80-14) testing has been approved with 3 full range SAC launched test missiles to be flown this spring. One soft site, fixed base operational Snark squadron is being activated at Presque Isle, Maine.

(U) WS 122A - GAM-72, Quail

[redacted] The current operational availability date for the GAM-72 is visualized as May 1960. More than a year's slippage has accrued to this program due to developmental difficulties with the J-85 engine. Accordingly powered flight tests did not commence until August 1958.

[redacted] At this writing aerodynamic testing has covered 67% of the altitude regimes and 75% of the required speed regimes. Although the J-85 seven stage engine performs satisfactorily in free flight, there is considerable difficulty in getting stable engine operations in the captive condition. The r.p.m. spread between engine idle and blow-out has been raised from 700 to 3,000 r.p.m. satisfactorily and the indications are that scheduled flight test completion by August 1959 will be realized.

(U) WS 131B - GAM-77, Hound Dog

[redacted] Development "go ahead" on this program was in August 1957. In this quarter the program passed its mid-point time wise fully on schedule. The first of 35 missiles for powered flight test was delivered January 1959 with testing to commence in March 1959 on the AFMTC range. Maximum program compression was achieved through full overlap of production and development. Barring unusual difficulties in flight test, operational availability by May 1960 is realistic.

(U) B-70-WS 110A

(U) The XSM-64 Navaho "Fly Seven" program in support of the B-70 R&D effort was cancelled by direction of Hq USAF. Decision to terminate was the result of two unsuccessful firings coupled with an evaluation conducted by the Weapon System Contractor. The evaluation revealed that as a result of the failures, the probability of obtaining sufficient successful full-duration instrumented flights to accomplish the objectives had become extremely low.

[redacted] In October the B-70 program was redirected by Hq USAF stating that the redirection was to be implemented as follows:

a. The currently planned first flight date of January 1962 is to be maintained.

[redacted]

b. A minimum of the first three test aircraft to be accepted at the rate of one per quarter.

c. The first operational wing to be equipped at least one year later than originally planned, i.e., not earlier than August 1965.

d. Budget/planning ceilings for P-100 series funds, including total engine development costs but exclusive of industrial facilities as follows:

FY 1959 - 195 Million
FY 1960 - 320 Million
FY 1961 - 439 Million

The technological advancement represented by the B-70 requires that considerable applied research and component development be undertaken. Success in these undertakings must be assured before the components are engineered into the weapon system. Consequently the development reschedule will enable the B-70 to benefit from the experience of other weapon systems such as the F-108.

e. The B-70 engine program was placed under close scrutiny and Hq ARDC was directed to compile and have available for presentation to Hq USAF a complete presentation comparing the J-93 and J-58 engine development programs as applicable to the B-70. It was planned to present the results of this comparative study to the Secretary of the Air Force during January 1959.

(U) DYNA SOAR (System 464L)

[redacted] The objective of the Dyna Soar program is to develop a manned military weapon system capable of operating in hypersonic, high altitude, sub-orbital flight regimes. The program is divided into two stages, Dyna Soar I, which is a joint AF-NASA program to develop military test systems and Dyna Soar Studies which is a joint AF-ARPA program covering the follow-on weapon system studies. Over-all technical control of the project rests with the Air Force.

[redacted] Boeing Airplane Company and Martin Company are the two contractors in competition on this program. The present schedule calls for source selection procedures to select one of these contractors to carry the Dyna Soar I program to completion. This selection will take place early in 1959. Mock-up is scheduled for early 1960 and the first unmanned flight in mid 1961. First manned powered flight is scheduled for mid 1962 with first global demonstration in late 1963.

(U) During December 1958, the Dyna Soar Weapon Systems office conducted a Development Engineering Inspection on this program. The DEI team, consisting of personnel from Hq ARDC, WADC, AMC, NASA, AFCRC, SAC, AFFTC, AFBMD and Rand, visited Boeing Airplane Company on 8-9 December 1958 and Martin Company on 11-12 December 1958.

(U) STRATEGIC SYSTEM STUDIES

(U) In the Strategic Systems Planning area (Program Structure 199A, Project 7990), there are several feasibility studies being pursued. These are designed to investigate potential strategic weapon systems in an effort to identify possible and logical replacements for current and planned inventory systems. These studies will determine the technical, economic and operational feasibility and desirability of improved weapon systems incorporating new advances in science or technology. These basic studies are performed primarily by civilian contractors under the supervision of ARDC, and later analyzed and evaluated by ARDC with the assistance of the Strategic Air Command. Weapon system studies of this type may be completed within one fiscal year; however, for advanced types of systems, several years of effort may be required with annual or periodic reviews, evaluation and reorientation of the work. The current Strategic System Studies are as follows:

(U) Hypersonic Boost Glide Bombardment/Reconnaissance Studies

[redacted] Studies have established the feasibility of a boost-glide bombardment/reconnaissance weapon system. Efforts are continuing to study the potential of this concept to more clearly define the weapon system, subsystem requirements, operational concepts, possible development and production schedules, and those areas in which technical difficulty might be encountered.

[redacted]

(U) Recoverable Booster Study

[redacted] A requirement exists for a comprehensive design and operation analysis study of recoverable boosters. This work is including considerations and comparisons of recovery methods from single parachute recovery to air breathing and rocket propelled carrier aircraft to launch payloads such as orbital devices, hypersonic gliders and space probes. It is placing special emphasis on the recovery of 1,500,000 booster systems. Overall economy of the complete orbital system is a primary design objective; therefore, cost, schedules, maintainability, facility requirements, number of launches required to make recoverable boosters economically feasible are being considered. Also, the feasibility of utilizing booster aircraft for ferry purposes as well as for launching vehicles into unique orbits is being studied. Studies on SR 126, ROBO, showed that recovering of boosters was desirable if Dyna Soar and future space systems are to be kept at the lowest possible cost. As a result of this and other previous work, ARDC started the preliminary work on recoverable boosters in August 1958. A letter from the DCS/Development, dated 23 September 1958, requested that ARDC brief ARPA on a comprehensive program to investigate all conceivable approaches to booster recovery. This program was given to ARPA.

(U) Intercontinental Boost Glide Missile

[redacted] This study is to aid in determining the advisability of developing a boost-glide intercontinental missile. This concept might provide a means of obtaining ranges in excess of 8,000 NM and payloads in excess of 10,000 lbs. at an overall reduction in gross weights when compared to present day missiles. Work will be completed by July 1959, at which time a decision will be made as to whether or not to continue this work.

(U) ANP Rocket System Studies

[redacted] These studies will support, from the complete weapon system standpoint, Air Force, AEC and NASA studies and development in the reactor-power plant area. Increased payload ICBM's are of the most immediate interest but other military applications are being considered and the feasibility and military worth determined. Ranges and/or payloads in excess of those associated with WS 107A are being investigated.

(U) Extended Range High Speed Strategic Bomber Study

[redacted] The requirement will exist for a manned, bombardment aircraft system in the post-1970 period. Forecasts of target identification and discrimination problems demonstrate clearly that the target pre-selection that is necessary for missile warfare will limit both the active and deterrent capability of a missile force, even with optimum performance (guidance, survivability, etc.) of such a force. The ability (accuracy, reconnaissance, command, etc.) of satellite or space systems to provide the indicated hunter-killer capability is by no means assured.

[redacted] Years of study have preceded the development of previous and existing generations of manned bomber systems. The B-52, B-58, and B-70 are examples. This study is investigating the feasibility of a manned bombardment/reconnaissance aircraft system capable of delivering high-yield nuclear warheads at a combat radius of 5,500 NM or more without refueling but with speed less than those required for the boost glide circumnavigation concept, Mach 4.0 to 8.0 desired. This bomber study as a system includes consideration of methods of launch, dispersal and hardening, "turn-around" concepts, type of pro-[redacted] pressed requirement for unrefueled long range capability has yet to be satisfied.

[redacted] This is the only ARDC study effort being conducted on a strategic aircraft weapon system with the capabilities outlined above. GOR 81 for a Piloted Nuclear Powered Intercontinental Strategic Bombardment Weapon System, unsatisfied to date, may well be met or exceeded with an all supersonic nuclear mission capability as a result of this study.

(U) Strategic Orbital System

[redacted] This task is considering an integrated earth orbital concept designed to define promising concepts of operation. This includes the relationships of potential offensive, defensive, reconnaissance, deterrence, and support sys-

[redacted]

tems. In considering military application in the earth orbital area, contractors are being asked to consider both conventional and radical concepts. This includes potential methods of offense and defense using other than nuclear bombs. The investigation will include manned or unmanned, reconnaissance, satellite inspector vehicles, command stations and stored weapons. The studies will produce recommendations for other studies, basic research, technical development, and weapon system feasibility and operational dates for GOR's 173 and 174.

(U) Strategic Lunar System

[redacted] The objective of this study is to develop integrated concepts for military operation in lunar and cis-lunar space and to outline the research and development program required before these concepts can be implemented. All available information indicates that the Russians have developed a high level of competence in technical fields which are associated with any type of space operations. The United States cannot afford to allow Russia to attain a strategic advantage. Therefore, this study is of vital importance to the national security of the U. S. The scope of the problem is so broad that the initial period of the study will not adequately explore all the possibilities for military operation or thoroughly investigate the various technical problems which must be satisfied before these operations become feasible. It is intended to continue this study with such re-direction as may be necessary to take advantage of information as it becomes available from the present efforts. Preliminary results indicate that this follow-up study will consider such items as active defense measures for lunar or cis-lunar stations, methods by which the moon can be used as the base for striking targets on earth, and possible methods of nullifying any hostile sources operating in lunar or cis-lunar space. This work is in support of GOR 173.

(U) Advanced Strategic Communications System

[redacted] This study is to determine parameters and feasibility for an aircraft communication system to provide extended range communications when used in conjunction with high altitude relay stations. It is desired to clearly define the capability and limitation of this system to fill the communication requirements for control of the strategic strike force. As the elapsed time becomes less between the initial warning of attack and the launching of the alert force the problems of communications to insure constant contact and control are constantly increasing. The Strategic Air Command has strongly supported requirements for advanced systems to provide this communication capability.

(U) Penetration Aids for Manned Bomber

[redacted] This is a study to determine the feasibility of developing an integrated penetration aid system for the B-70. This work will consider feasibility of aids to simulate radar reflectivity, infra-red radiation and provide the necessary confusion techniques to give the B-70 a high probability for successfully completing its bombing mission. Work started December 1958 and will be completed by approximately 1 July 1959.

(U) Advanced Ballistic Missile Weapon System Study

[redacted] This study will determine feasibility of a quick reaction ICBM from hardened sites to complement the Minute Man. Range 8,500 NM or more. Payload with and without terminal guidance and other penetration aids, 10,000 lbs. and larger to include 100,000 lbs. or more.

[redacted] As the Strategic Air Command phases missiles into the inventory and replaces the air- [redacted] rapidly. [redacted] missiles [redacted] numbers. Based on this, targets to be destroyed, and other factors, there appears to be a require- [redacted]

[redacted] Preliminary work has indicated that it is [redacted] The Advanced ICBM study is designed to prove feasibility and provide realistic operational dates for the above stated requirement.

[redacted]

[redacted]

Air Defense Systems

(U) F-108 (System 202A)

[redacted] During this reporting period many subcontractor selections have been made. Some of these are as follows: Central Air Data computer from Air Research Division, Garrett Corporation, Air Induction Control System by Marquardt Aircraft Company, and Autonetics Division of North American for the automatic flight control system.

(U) The initial meeting of the F-108 flight test task force was held early in December 1958. The group completed organizational plans and established a course of action. The Air Force Flight Test Center has been designated as the flight test site for Categories I and II testing of the F-108.

(U) The first full scale development rocket motor for the GAR-9 was successfully fired by Aerojet on 8 December 1958 at -65°F. The PFRT motor has been officially designated the XM-59.

(U) A development engineering inspection was conducted on the mocked-up F-108 during the week of 5 January 1959 preliminary to the formal Mock-Up Board.

(U) Two briefings were given to the Scientific Advisory Board Guidance and Control Panel. On 21 January at Wright Patterson AFB the subject was the mission and traffic control subsystem. At North American Aviation on 22 January 1959 the presentation reflected qualitative and quantitative target and GAR-9 missile requirements.

[redacted] Hq USAF has directed a stretchout of the F-108 Weapon System to conform with dollar ceilings imposed on the program for fiscal years 1959, 60 and 61. The following guidelines accompanied the Hq USAF redirection of the program:

1. First flight date of the F-108A delayed two months, i.e., April 1961.
2. Inventory test aircraft decreased from 31 to 20.
3. First operational squadron equipped one year later, i.e., June 1964.

[redacted] The results of an engine study to determine the relative merits of incorporating the J-93 or the J-58 engine in the F-108/B-70 were presented to USAF on 16 January 1959. This Headquarters recommended that the J-93 engine be continued as the power plant for the systems.

[redacted] The GAR-9 Warhead Phase II Feasibility Study was reopened on 21 January 1959, to con- [redacted] desired to make new warhead proposals in light [redacted] The Air Force conclusion remains the same as before i.e., [redacted] the only [redacted] that will meet the weapon system requirements.

(U) The F-108 official Mock-Up Board was held 26-29 January 1959.

(U) F-106 - WS 201B

(U) The initial goals of the flight test program are designed to prove out the airframe engine combination functional adequacy, the flight control system characteristics, the aircraft weapon control system through all of its operating modes except automatic attack and navigation, and the MB-1 and GAR-3 armament capability. Progress in these areas is outlined as follows:

[redacted] Airframe Engine Combination

[redacted] The contractor has demonstrated satisfactory performance, flutter and subsystem operating characteristics throughout the specification speed altitude envelope. The flight loads program has progressed through the 80% limit load data flights, and there is no indication of any problem which would preclude 100% structural clearance by July 1959.

[redacted] An extensive program has been conducted to explore the yaw buzz characteristics of the aircraft, and there still remains some work in this area to insure that no tactical limitations

[redacted]

result from inlet buzz conditions encountered at the performance extremes of the aircraft. A major problem was uncovered in the fuel system involving the main transfer fuel line and its associated wiggins couplings. The required inspection and replacement of faulty parts in all test aircraft resulted in flight test program delays averaging three weeks. Further flight testing of the fuel transfer system, the increased internal fuel capacity, and the external fuel usage is presently under way.

[redacted] The Air Force Phase IV tests by AFFTC have begun on the F-106B, and early results indicate that the specified performance will be met easily by the F-106B with the improvements associated with the J75-P-17 engine incorporated. The F-106A Phase IV activity has been limited to an evaluation of the basic stability characteristics of the Case XIV wing compared to those of the Case XXIX wing in order to establish the validity of the data obtained in the stability and control test to all F-106 aircraft. The applicability of Phase IV results obtained on the Case XIV aircraft to all F-106's has been established in detail. The Phase IV performance program will commence on the F-106A in the very near future. Category II functional evaluation of the aircraft subsystems is under way, but has not progressed sufficiently to define specific problem areas, if any.

[redacted] Flight Control System

[redacted] As a result of the loss of F-106A, S/N 57-242, from the Category II program because of hydraulic system partial failure, steps have been taken to insure against the repetition of the same condition. All aircraft have been inspected and faulty HEP valves replaced or repaired. Convair is conducting a flight test program to determine the exact environment of these valves and to evaluate the effectiveness of several fixes to increase the system reliability. The stability derivatives flight test program is practically complete, and the data is being furnished to Hughes Aircraft Company to be used in programming the "B" computer for automatic mode operation. The pilot assist mode has been flight tested by Hughes. A previous informal evaluation by WADC pilots revealed certain deficiencies which have been corrected. The pilot assist modes will incorporate bank hold, pitch or altitude hold, and optional heading hold and will be available for operational use in all tactical aircraft. The basic stability augmentation system of the aircraft has proven satisfactory and at present is satisfactory for conducting manual co-altitude attacks. This conclusion is based on concurring reports of contractor, AAD, and Category II tests to date.

[redacted] Aircraft Weapon Control System

[redacted] The major effort in MA-1 system flight test has been centered in the AWCS, armament development (AAD) program at Holloman AFB. Progress has been limited by a series of airframe, instrumentation, and MA-1 system malfunctions causing the slippage of the beginning of the MB-1 firing program from September to December 1958. The MA-1 performance has been characterized by a lack of consistency. Some results have been excellent, while others have not been good enough to warrant the commencement of firings of MB-1's at manned targets.

[redacted] To date, the only problem which appears to involve any system changes not already known by the contractor is associated with transient effects on the system which cause firing signals to be given at random times during the attack phase. A temporary fix has been developed to provide safety for the test operation, and a fix for the basic deficiency is under development so that no extended effect on the test program or operational employment is anticipated. MA-1 operation in the Category II aircraft has been limited by the lack of adequate spares support, which has been corrected, and by the recent aircraft grounding because of fuel and flight control systems T/O compliance. On most of the flights conducted with the MA-1 operating, the Category II results appeared very satisfactory. More conclusive results as to the MA-1 functional suitability will be obtained during the next reporting period.

[redacted] MB-1 and GAR-3 Armament Capability

[redacted] Convair has satisfactorily demonstrated the MB-1 launch capability throughout the performance envelope up to speeds of M = 2.0. A change was accomplished in the missile bay baffling to correct an MB-1 pitch-up problem at high speeds, and no difficulty is anticipated in

[redacted]

completing the firing program throughout the performance envelope. Results from the contractor firing program have indicated very close agreement with analytical MB-1 ballistics data to be used in the MA-1 computer making a reduction in the magnitude of this program possible.

[redacted] An active program is being conducted to determine the effects of missile bay vibrational environment on the GAR-3. This program has produced data defining the environment and evaluation of certain modifications to the bay and launcher configurations. The problem is to determine the degradation in missile performance experienced as a result of repeated exposure to the open bay conditions and to resolve what feasible changes can be made to the airframe and/or missile to improve the situation. At present, it is estimated that the GAR-3 experiences a 25% loss of hit probability after eleven exposures to the most severe high "Q" environment obtainable in the F-106A. This program is being flight tested.

(U) The loss of an F-106B on 5 January 1959 at Holloman AFB will delay approximately two months the armament separation and ballistics programs until another aircraft can be instrumented to carry the task. This will delay clearance of the F-106B in other test programs and in operation until about May 1959 for MB-1 and July 1959 for GAR-3's.

(U) It has been determined that the Convair Model "B" supersonic ejection seat, whose development was under control of the Industry Crew Escape System Committee, had proven technically feasible and the development objectives have been attained. Convair is preparing a proposal for production incorporation in F-106A/B aircraft.

(U) Problems have been encountered with fuel feeding of the F-106A fuselage tank. The regulator manufacturer has a new design which will not allow fuel to leak into the regulator. This will be installed as soon as available. A fuselage tank emergency pressurization system to supply air pressure directly to the tank will be incorporated effective the first tactical aircraft. The final fix will be a boost pump installed in the fuselage tank. This will require a depot level retrofit program for service aircraft.

[redacted] A D.E.I. was conducted on the [redacted] The most difficult problem encountered was the lack of pilot's helmet clearance when utilizing the optical sight due to interference between the stand-[redacted] ECP will be submitted to relocate [redacted] It was also decided [redacted] must be installed in the F-106B and inspected by the Air Force since the Mock-up observed included only the F-106A.

(U) F-101B - WS 217A

(U) The initial goals of the flight test program are designed to prove out the airframe engine combination functional adequacy, the flight control system characteristics, the aircraft weapon control system thru all of its operating modes, and the MB-1 and GAR-1D/2A capability. Progress in these areas is outlined as follows:

[redacted] Airframe Engine Combustion

[redacted] The contractor has demonstrated the following:

1. Satisfactory structural integrity at a designed gross weight of 39,800 lbs. with load factors of negative 2.8 to positive 6.8 "G's" (Design goal for the F-101B aircraft).

2. Acceptable flutter speeds to 700 KIAS or Mach true = 1.71 whichever is less.

3. A panel vibration limitation of 600 KIAS below 25,000 feet and Mach = 1.71 for altitudes above 25,000 feet. The restriction, due to panel vibration will be removed with incorporation of ECPs which have received engineering approval. An extensive program has been conducted to investigate the inlet duct and J-57-P-55 engine incompatibility. An interim and final fix configuration has been decided upon. The interim fix is the utilization of a second turning vane added to the inlet duct. The final fix is a 7° ramp configuration in the inlet duct. It was also discovered that the rotation of the armament door caused a stall problem and the final fix for this problem is the installation of flow fences on either side of the armament door.

[redacted]

[redacted]

[redacted] A major problem was uncovered in the fuel system involving the Marman coupling. A final meeting of the group investigating the Marman coupling problem was held on 18 November 1958 after an extensive service test of the coupling and safety device configuration. It was decided that the CF-17B coupling with safety device would be used on all F-101 aircraft. The MA-9 fuel air combustion starter has experienced the following problems:

1. Early in the program turbine failures were experienced due to a defective weld area which required more extensive inspection on the part of the contractor and Air Force quality control personnel.

2. Failures experienced in the air regulator has caused an operating restriction of 2,000 p.s.i. to be effected on the starters. This problem has been solved and with the incorporation of an ECP on all starters the 2,000 p.s.i. restriction will be removed. The F-101A had an undesirable airframe buffet in the high cruise region (Mach 0.85 to 0.95). This problem was first identified in September 1955. This condition also existed with the F-101B and was solved by installing stainless steel afterburner nozzle tabs.

(U) The excessive tire failures and blowouts experienced primarily at AFFTC during the Phase IV and Phase VI operation of the F-101A in the Spring and Summer of 1956 resulted in an extensive investigation and redesign of the wheel and tire configuration for the F-101B due to the heavier gross weight of this aircraft. The new wheel and tire configuration is 31 x 11.50 x 16 tubeless type with effectivity on the eighteenth (18) F-101B aircraft delivered to the using command.

(U) An electrical terminal block problem was discovered early in October. It was noted that electrical continuity through the circular terminal block P/N 20-76077 was disturbed or interrupted as a result of loosening of the screws holding the terminals in place. Interruptions have caused hardover yaw damper conditions and loss of flight instruments. This deficiency has the potential capability of affecting all electrical connections channeling into the cockpit area. A T.O., 1F-101-766, dated 24 December 1958, has been published which establishes required corrective action to be completed within ten (10) days after receipt of kits.

[redacted] Flight Control System

[redacted] The MB-5 automatic flight control system has not completed its environmental qualification testing.

[redacted] An evaluation by Air Force pilots early in November indicated that it is an acceptable basic autopilot system and automatic instrument landing approach system. The primary problem with the basic system is in the altitude hold mode. An evaluation of changes involving the redesign of the pitch, attitude and altitude error time constant networks is currently under way. Preliminary results and pilot evaluation indicated that this new configuration shows considerable promise for eliminating the objectionable long period pitch oscillations experienced previously. A qualified basic autopilot system is anticipated by 1 March 1959. The pilot assist modes are cleared for operational use during the Category III testing which began on 1 January 1959.

[redacted] The basic stability augmentation system of the aircraft has proven satisfactory and is satisfactory for manual co-altitude and snap-up attacks. This conclusion is based on reports from the contractor, joint test program and the "Little David" operation.

(U) The automatic attack program is currently under way by the contractor, however, progress to date is not sufficient to be commented upon. The first Air Force testing of the automatic attack mode will occur in July 1959 as part of the joint test program at Holloman.

[redacted]ire Control System/Armament System

[redacted] To date, the effort expended flight testing this system has been performed by the contractor and the joint test program at Holloman.

[redacted] In the early stages of the development program conducted by the contractor, rocket separation problems were experienced. The solution to the rocket pitch problem was the utilization of a six inch lanyard with zero time delay rocket initiator and the separation problem

[redacted]

[redacted]

between the two rockets was solved with the incorporation of an aft spoiler and separator with nylon surfaces in conjunction with a forward post. The MG-13 firings to date have been characterized by a fair amount of consistency. This was demonstrated both in the "Little David" operation as well as the joint test program.

[redacted] With respect to the Category II Test Program, there has been no MG-13/MB-1 experience other than the firings conducted during the fire power demonstration. The GAR-1D/2A test program to date has been conducted only by the contractor. The joint test program is expected to start the GAR firing test in April 1959. During the contractor's test, a crossover problem was experienced with the alternate door which fires three (3) GAR missiles per side. This problem was solved by incorporating a ripple firing technique. This crossover problem also occurred on the primary armament door which fires two (2) GAR missiles and this problem was solved by increasing the time delay between the firings of the Number One and Two missile from .030 seconds to .050 seconds.

(U) Survival Kit Provisions

(U) The F-101B will be equipped with a "get-me-down" type survival kit instead of the fire-well type kit. This was brought about by the acceptance of the Air Defense Command of a 15 to 20 minute "get-me-down" capability. This kit eliminates costly aircraft plumbing changes and utilizes items currently available in Air Force stock.

(U) The F-101B is currently in an intensive flight test stage. Besides the contractor Category I flight test program, the following programs are under way: The Category I SAGE testing with the aircraft based at Otis AFB utilizing the experimental Boston Air Defense SAGE Sector, the joint Accelerated Development program at Holloman AFB, Category II tests at Eglin AFB, and stability and performance at Edwards AFB. Soon to be initiated is the Category III test program at Otis AFB, Massachusetts.

[redacted] The contractor armament firing program to date has been successfully demonstrated at the following representative conditions.

a. Falcon program.

1g	40,000 feet	1.13 - 1.68 Mach
1g	51,000 feet	0.93 Mach
3g	41,000 feet	1.26 Mach

b. MB-1

-1g	40,000 feet	1.66 Mach
-1 to 3g	12-42,000 feet	1.2-1.72 Mach

[redacted] WS 208A - Falcon

[redacted] A total of six XGAR-11 missiles have now been launched against a variety of targets in both co-altitude and snap-up attacks. All missiles guided well within the design lethal radius with one scoring a direct hit. First firing of the prototype XGAR-11 is scheduled for March 1959.

[redacted] A major mile-stone has been achieved in the F-106/GAR-3 Weapon System with two missiles being salvo launched from an F-106 test aircraft. This was the first time that a guided GAR-3 had been launched from the interceptor which is the intended missile carrier. Both the missiles guided to direct hits on the target.

[redacted] WS 200A - Bomarc, IM-99

[redacted] During the fourth quarter of 1958, flight testing of the IM-99A continued at the AFMTC. A total of six flight tests were conducted utilizing the SAGE experimental computer at Kingston, N. Y. for control. Several firsts were achieved during these tests; two missiles were launched simultaneously against two targets; the X-10 was utilized as a target; and the target was redesignated after missile launch. In each instance the flights would have achieved at least carrier kill and in one case the vertical stabilizer was sheared from the drone.

[redacted] In November the IM-99A installation at Santa Rosa Island and Field 9 APGC was accepted as a functioning guided missile base. This is the first base in the IM-99A program and will be used for Category II and III testing and the ADC Unit training program.

[redacted]

[redacted]

AIR DEFENSE STUDIES (299A)

(U) Optimum Interceptor Study

[redacted] This study is to determine the general characteristics of the best system for the interception of advanced targets of the 1970-75 time period. Both manned and unmanned systems are to be considered and their respective advantages and disadvantages against all hostile targets, except ballistic missiles, are to be compared. In considering a manned system, trade-off data leading to a conclusion as to the optimum division of performance in altitude, speed, maneuverability and range between the aircraft and its armament system are to be developed. Results of this study will aid in determining the type and rough performance characteristics of the ideal interceptor for 1970-75. The planned completion date is May 1959, with the evaluation being planned for June 1959.

[redacted] Aircraft for Arming the DEW Line

[redacted] This study will provide the necessary information to determine the appropriate aircraft to be based along the DEW Line to provide a search and trail capability. The System Requirement is scheduled for release in early March.

[redacted] Means for Arming the DEW Line Extension

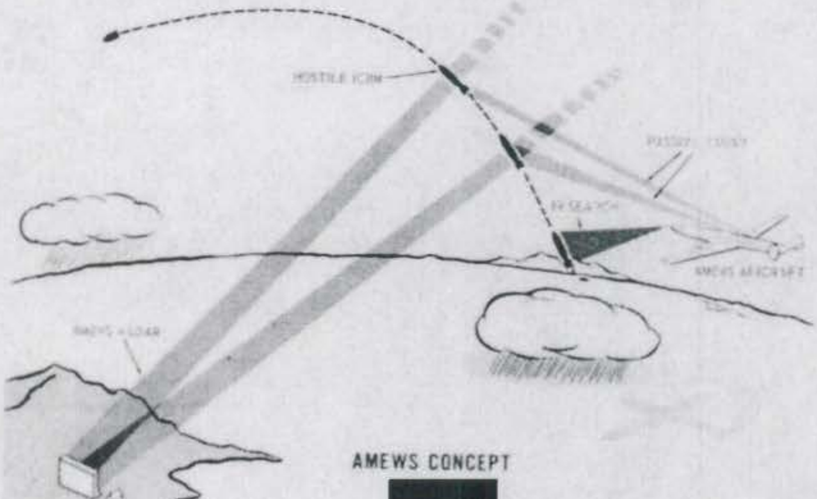
[redacted] This study will determine the feasibility of providing a search and trail capability for the AEW extensions of the DEW Line. The System Requirement is scheduled for release in early April.

(U) Satellite Interceptor

[redacted] This study will provide the necessary investigations leading toward satisfying GOR 170 for a defense system which will have the capability of detecting, identifying, tracking, cataloging and destroying earth satellites, which pose a threat to the security of the United States. The evaluation of this study will begin in February 1959.

(U) Advance Defense Concepts

[redacted] This is a study of new means of obtaining early warning, tracking, trajectory or orbit prediction, mission assessment, cataloging and ultimate destruction of space vehicles, satellites, ICBM's, IRBM's and boost-glide vehicles. Present studies are investigating particular problems posed by individual hostile systems, e.g. AICBM and anti-satellite studies, which will provide inputs to this task. The feasibility of an environmental system, capable of handling all hostile targets and providing necessary support to friendly space systems will be investigated. A final report on AMEWS (Airborne, Missile Early Warning System), a study under this task, is expected to be submitted in February 1959. *See Diagram A Below.*



AMEWS CONCEPT

[redacted]

[redacted]

Tactical Systems

(U) WEAPON SYSTEM 303A

(U) F-104/J79 Oil Starvation

(U) This problem became extremely apparent after the loss of an aircraft and the fatal injury of the Commander of the 56th FIS on 11 December 1958 at Wright-Patterson AFB. This accident and two others were all attributed to failure of the No. 2 bearing due to lack of lubrication to the bearing. At least 5 or 6 incidents have occurred where an extremely large amount of oil was consumed in less than an hour's flight time. Oil dipstick and airframe mounted oil servicing pump which are incorporated on all F-104/C/D series aircraft are being retrofit on all F-104A/B aircraft. A priority oil system incorporating a low oil level warning light in the cockpit, and a stand-pipe in the oil tank, was approved for production in the last 27 F-104C/D series aircraft. This system will provide sufficient oil for lubrication and allow sustained engine operation in the event the hydraulic portion of the oil system should deplete the oil supply. Retrofit action is being expedited by SMAMA. SMAMA has also issued instructions to the field to impound any F-104's which exhibits large oil loss during any one flight. Impounded aircraft and engine will be thoroughly investigated by a team of engine experts from SMAMA, OCAMA, General Electric, Lockheed, and WADC Propulsion Laboratory.

[redacted] Flight Envelope

[redacted] Lockheed has succeeded in extending the flight envelope of the F/104B aircraft. The first extension occurred at 34,000 feet where a Mach number of 2.056 was obtained. At 63,000 feet the envelope was extended to 2.071 Mach number.

(U) F-104/J79 Fuel Line Hose Rupture

(U) The ADC experienced two (2) fuel line ruptures on the Jonah Able project. As a result, ADC grounded their fleet on 15 January, pending a fix. A T.O. 1F-104-648 was published on 17 January describing an inspection and cyclic pressure check prior to reinstallation of the fuel hose. ADC has been experiencing better than 50% rejection of the fuel hose as a result of T.O. 648. On 22 January, ADC again grounded their F-104 fleet pending a T.O. for inspection of all the fuel lines on the J79 engines. A revised T.O. 648 was issued on 24 January 1959 calling for inspection and pressure test of the majority of fuel hoses incorporated in the J79-3 and -3A engine. The allowable creep tolerance was also changed to a more realistic value.

[redacted] WS 309A - MACE, TM-76A/B

[redacted] The operational concept of the Mace Weapon System was changed from one of limited mobility with dispersed, soft launch sites to one of dispersed hardened launch sites having a rapid fire launch capability. The USAFE, PACAF, TAC, AMC and ARDC were acquainted with the new operational concept during the worldwide Tactical Missile Conference held at Hq USAF 3-5 September 1958. Subsequent to this meeting, Hq USAF issued directives which officially converted the Mace program to the new operational concept. GOR-37 dated 12 October 1954 was revised 23 December 1958 to reflect the new concept.

[redacted] The new operational concept requires the design, test and construction of shelters for the Mace and its associated ground support equipment. The newly required rapid force launch capability requires design, development and production of new GSE. Initial deployment of the TM-76A in April 1959 will be in the soft configuration pending availability of hardened shelters.

[redacted] BULLPUP - GAM - 83 WEAPON SYSTEM 321A

[redacted] Funds were released in December 1958 for modification under AFR 80-4 of one wing of Tactical Air Command F-100 aircraft to provide an operational capability with Bullpup (GAM-83) missiles. Funds subsequently were provided for procurement of 715 GAM-83 missiles by MIPR from the Navy.

[redacted]

[redacted]

(U) VTOL FIGHTER-BOMBER WEAPON SYSTEM 318A

[redacted] The Department of the Navy, by Memorandum dated 17 November 1958, officially replied to the Department of the Air Force Memorandum of 3 September 1958, which requested clarification of the Navy position concerning the Bell V/STOL Fighter-Bomber. The Navy, in their reply, declared that due to budgetary considerations the BUAER would not be able to continue financial support following Phase I completion in February 1959.

[redacted] On 1 December 1958, Hq USAF requested Hq ARDC and Hq AMC to forward as soon as possible an abbreviated Development Plan offering a solution to GOR 169, taking into account the FY 59 and 60 budget programs and the above outlined Navy withdrawal. In a wire to Hq USAF dated 5 December 1958, Hq ARDC stated the following position:

[redacted] The present System 318A program at Bell, if properly funded is the only approach that could meet the 1963-64 operational date.

[redacted] The present FY 59-60 budget funding falls some $80 million short of the funds required to place System 318A in the inventory at an early date.

[redacted] In view of the implied later operational date resulting from these budgetary considerations, a Source Selection should be implemented for a tactical V/STOL Fighter-Bomber having capabilities commensurate with the 1965 plus time period.

(U) At an early date, Hq ARDC would submit an Abbreviated Development Plan documenting this course of action.

[redacted] On 19 December 1958, Hq USAF directed Hq ARDC to assume management responsibility for the previous joint Navy-Air Force Program and to continue the Bell development as a stripped prototype test vehicle program. A development plan, including funding requirements, was to be submitted as soon as possible.

[redacted] An Abbreviated System Development plan for two prototype Bell V/STOL aircraft, dated 1 January 1959, was forwarded by Hq ARDC to Hq USAF via letter of transmittal dated 7 January 1959. This letter also stated ARDC's objections to procuring two prototype vehicles which did not include a complete weapon system programming concept and which could only result in two experimental type test vehicles showing no improvement in the state-of-the art. Hq ARDC is actively pursuing the directed program however, complete programming is proving difficult due to the lack of adequate funds. Bell has been provided funds to carry them through the month of February. To date no funds have been applied to provide a V/STOL version of the J85 engine required for use in the Bell aircraft.

(U) Further action is pending a meeting of Hq USAF, Hq ARDC, Hq AMC and Hq TAC on 9 February 1959.

(U) A development Engineering Inspection of the complete system concluding the Phase I program, will be held jointly with the Navy at Bell Aircraft Corporation, Niagara Falls, New York on 17-19 February 1959. This inspection will be the final Navy action in connection with this program.

(U) F-104 (WS 303A)

(U) F-104C/TX-28 Capability

(U) The F-104C/TX-28/M-1C program at APGC got under way on 5 January 1959. The program was granted an overriding Test Priority for the duration of the testing. The final Nuclear Weapon Safety study on the F-104C/TX-28 combination was conducted at AFSWC the week of 19 January 1959. Disagreement among the board members existed regarding the adequacy or inadequacy of the nuclear store lock/release system to provide the proper safety against inadvertent drops of the store. The point of disagreement has been referred to Hq USAF for resolution.

(U) F-104 Tubeless Tires

(U) In November, Hq Air Defense Command directed using organizations to stand-down all F-104 aircraft equipped with the tubed tires because T.O. limits indicate the tubed tire to be incapable of speeds over 174 knots. Normal

[redacted]

lift-off speed of the F-104 is 175 knots. The tubed tires were pressed into service due to the scarcity of tubeless tires brought about by the requirements of Project Jonah Able. The tubeless tires are capable of speeds up to 239 knots. As a result of laboratory tests conducted by WADC, tubed tires produced by Firestone, Goodyear and U. S. Rubber were approved for 180 knots, at a maximum gross weight of 20,500 pounds and for Afterburner take-offs only. (This provides for all take-off configurations except external tanks.)

(U) Escape Capability, Upward Ejection

(U) Early track testing of the upward ejection seat indicated poor separation of pilot from the seat after a successful ejection had been completed. Seat/dummy separation was therefore facilitated by a new positive separation device. The device incorporates straps upon which the pilot sits, a thruster and an initiator. The initiator fires at the same time the lap belt initiator fires. This in turn actuates the thruster which exerts a force in tension of 800 pounds on the straps in 0.2 seconds. The pilot is forced out of the seat by the straps being pulled taut across the seat. The third upward seat ejection sled test was successfully completed on 20 January 1959. Speed of the test was slightly greater than 500 knots. All items of the system performed as designed, including the positive separation device. Maximum altitude of the seat was approximately fifty (50) feet, parachute on the dummy was completely opened and the dummy was undamaged. The 1 and 0 parachute initiator timing was connected for the test; however, only one (1) panel of the parachute was ripped. Retrofit of the upward ejection system is scheduled to begin at the contractors in April and at SMAMA in May.

(U) Flight Loads Tests

(U) The F-104A 100% flight loads tests with external stores and the F-104B 80% loads tests have been completed.

(U) GE-J79 Compressor Corrosion

(U) Project Jonah Able reported corrosion problems with the inlet guide vanes (IGV) and the compressor blades of the GE-J79 engine. The General Electric Company had similar experience with this problem. Gunfire had blackened the compressor blades of a J79-3 engine installed in an APGC assigned aircraft and erosion was found after the carbon was removed. The engine blades were cleaned with a solvent, smoothed out with crocus cloth, and the engine was returned to service. A like operation was performed at the Jonah Able project, and the engines affected were returned to operational service. A report that the corrosion contributed to performance loss was erroneous. Actually, cause of performance loss was due to the temperature amplifier circuit being 40°C low in its Military Power rating. An adjustment to the correct value of 585°C restored the engine to its proper specification limits.

(U) F-104C J79-7 Engine Vibration

(U) Severe vibration has been encountered at medium altitudes and low cruise power conditions. A test program has been instituted to determine the cause and corrective action required. Based on data thus far, the possibility that this phenomenon is one of airframe-engine compatibility appears to have been eliminated. Further testing of a known deficient engine is being undertaken by the respective contractors at AFFTC.

(U) F-104 Main Wheel Assembly

(U) APGC submitted an emergency U. R. as a result of a broken wheel while taxiing. Maintenance procedures and rough taxiing were considered to be contributing factors. Tests were completed on a modified wheel which will provide a better life capability and upgrade the wheel to its specification requirement of 10,000 pounds. A 10,000 pound wheel is satisfactory for F-104 gross weights of approximately 23,000 pounds. Since a safety-of-flight supplement was issued cautioning against high speed taxi turns, and the checking of maintenance procedures by OOAMA, no further incidents due to wheels have been reported. Future spare wheels, due for procurement in FY-60, will be completely qualified for maximum airplane gross weights.

[redacted]

(U) APGC F-104A/M-61 Gun Test

(U) A final report on the APGC F-104/M-61 gun test indicates excellent results with no evidence of major problems requiring further development effort.

(U) AFFTC Category II Tests

(U) Category II tests were completed by AFFTC on 21 November 1958. The 4 test aircraft accumulated a total of 312 hours in approximately 71 days test span.

(U) F-105, WEAPON SYSTEM 306A

[redacted] A great deal of difficulty has been incurred in the production scheduling of all series of F-105 aircraft. A total of 75 F-105B aircraft will be produced, however, the initial deliveries of aircraft to the Tactical Air Command for use in Category III testing have slipped to the extent that TAC will not have a complete squadron until approximately June 1959. As a result of Republic Aviation Corporation's production difficulties, the Aeronautical Systems Center conducted a survey at the contractor's facilities on 10-12 December 1958. The survey team consisted of ARDC-AMC WSPO personnel as well as TAC personnel. Hq USAF approved Republic's revised production schedule for the "B" aircraft. (See WA59-1.)

[redacted] The F-105D/E production was also amended in light of reduced funds available for the FY 59 program. The total production of "D" aircraft has been reduced from 383 to 373 aircraft and the "E" production has likewise been reduced from 89 to 83 aircraft. Program Summaries for the D/E aircraft are as follows:

	FY 58	FY 59	FY 60	FY 61	FY 62	Total
F-105D	20	58	104	136	55	373
F-105E	8	10	24	33	8	83

(U) Other areas of interest are as follows: F-105B/J-75-P-3 Engine Performance Report: This report received the AFFTC Commander's approval and has been published. As a result of WSPO coordination with AFFTC on this report, it was agreed that the WSPO reply letter to the report be attached and distributed at the same time and with the report by AFFTC. It is hoped that distribution made in this manner will reduce some of the normal panics that generally result when a flight test report is issued. Since this report was on the "B" aircraft utilizing the P-3 engine the WSPO letter also emphasizes the fact that the report was not representative of tactically configured F-105B's.

(U) ANTI-SKID BRAKE SYSTEM

(U) Air Force evaluation of the anti-skid system was delayed for a period of time due to a requirement to replace the landing gear struts on the test aircraft. These struts were of the old configuration, and they were found to have fatigue cracks in the trunnion blocks. Further delay was incurred due to an inadvertant retraction of the landing gear on the test aircraft (aircraft was not in motion at the time and damage was minor). AFFTC completed evaluation of the Goodyear anti-skid system the last part of December and gave their approval. Production and retrofit installation will be made of the approved system in all F-105 aircraft. This item is closed.

(C) F-105 BRIEFING TEAM

(U) The team's purpose was to acquaint USAFE personnel with the F-105 and its particular requirements. The team, composed of representatives of the F-105 Weapons Phasing Group with representatives from AMC, ARDC, TAC, MOAMA and Republic Aviation Corporation, visited USAFE in November 1958. The formal briefing was presented in five parts: Development Status, Operational Status including fire control system, System Programming, Supply and Maintenance programs and Serviceability and Maintainability. With each briefing, a set of four volumes of data covering essentially what is known of the F-105D/E aircraft was left for guidance and study toward the planning necessary to accomplish conversion. This team will make the same presentation at the PACAF Weapon System Phasing Group meeting on 9-10 February 1959 at Hickam AFB.

(U) STATIC TEST FAILURE OF LEADING EDGE FLAP

(U) The failure of the leading edge flap attachment occurred at 88% ultimate load of negative

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[redacted]

"g" quantities and was identified 1 December 1958. A Flight Safety Supplement was issued limiting use of full leading edge flaps to positive "g" loads and speeds below 520 KIAS. 30% Leading Edge Flaps are unrestricted and are the normal cruise and maneuver position. Action was taken to delete the 100% Leading Edge Flap position on the flap selector quadrant. This action however, provides full flaps for the normal takeoff and landing which were the initial design points. This item closed.

(U) J-75-P-19 ENGINE/F-105 AIRFRAME

(U) Both Republic Aviation Corporation and AFFTC have flown the referenced combination and feel that there appears to be no unusual problems for the combination. AFFTC was authorized by the WSPO to uptrim their P-5 engine to the P-19 ratings for a continuation of their Phase IV performance evaluation. AFFTC estimated that their performance flight test program utilizing P-19 engine ratings would be completed by January 1959.

(U) ROLL-COUPLING INVESTIGATION

(U) Description: Computer studies by AFFTC indicated a possible coupling tendency during rolls at 1.8 Mach and negative "g". The preliminary indication obtained on the AFFTC computer instruments and a review of the recordings made at the same time by WSPO and RAC personnel indicate an incompatibility between the paper record and pilot's instruments. Republic has completed some flight tests to demonstrate rolls at high speed under negative "g" conditions. These tests show close correlation to Republic computer studies completed in 1956 which indicated no problem would exist under the noted conditions. The AFFTC Phase IV stability airplane is being bailed to Republic for continuation of the low speed roll-coupling investigation.

(U) PHASE V TESTS IN ALASKA

(U) Information from the Phase V tests indicate cold test temperatures were continuous enough to provide cold soaking at -49°F and take-off ground temperatures of -36°F. Upon completion of the Alaska tests the Phase V aircraft successfully completed a nonstop flight from Alaska to Eglin AFB on the 22 of January. No difficulties were encountered on the flight and the aircraft has been returned to WPAFB for continuation of WADC testing.

(U) SPIN TESTS

(U) Five spin entries and spins from one half to three turns have been completed from an erect entry to date. The following preliminary comments have been received. As the aircraft approaches the stall the spin will develop in the direction of directional trim with the aircraft yawing into the trim and full opposite rudder will not correct the yaw. Use of full rudder opposite the rotation and full lateral control with the rotation effects recovery quite rapidly. If the lateral control is held too long, it will cause about one half turn in opposite direction after neutralizing lateral control.

(U) FAILURE THIRD STAGE COMPRESSOR DISC J75-P-5

(U) T.O. 1F-1-555 was issued 29 August 1958 to restrict operation of J75 engines to 25 hours until the third stage disc was replaced in accordance with T.O. 2J-J75-551. The rework has been under way at OCAMA and Pratt-Whitney. On 28 January 1959 it was reported that failures have been discovered at less than 25 hours. With full coordination of SAAMA and WSPO an urgent action one day T.O. was issued to restrict unmodified engines to five hours. This T.O. had no effect on the F-105 test aircraft as modified engines are installed. Category III aircraft assigned to TAC, however, require engine support from SAAMA.

(U) F-100C/D/F, WEAPON SYSTEM 305C

[redacted] In accordance with agreements between Hq ARDC, Det #1, and the Wright Air Development Center, responsibility and authority incident to the ARDC management of the F-100 WSPO was transferred from the Directorate of Systems Management, RDZSTF, to the ARDC Engineering Representative at Sacramento Air Material Area, effective 1 December 1958.

(U) A USAF Procurement Authorization for $416,000 was received by AMC to conduct a service test of the F-100 Zero Length Launch for

[redacted]

[redacted]

Hardened Shelters. ARDC has also provided funds in the amount of $70,000 to the program. The hardsite program has been made to include the TM-76. Planning and programming for both weapon systems is being monitored by the TM-76 WSPO.

[redacted] LIGHT WEIGHT NAVS SYSTEM RETROFIT

[redacted] A meeting was held at Hq USAF on 12 November 1958, at the direction of AFDRQ, to review ASN-9 and ASN-25 test data and production NAVS status for computer selection for the retrofit program. As a result of this meeting it was determined that the ASN-9 does not meet TAC requirements and the ASN-25 will not be available in an acceptable time period. Further action was to be held in abeyance pending further direction from AFDRQ.

Support Systems

(U) WS 429L - Q-2A Drone

(U) Project William Tell, the worldwide weapons meet held at Tyndall AFB, came to a very successful close on 30 October 1958. This was the first weapons meet in which the Q-2A target drone was used rather than tow targets. The attacking force was composed of 12 Air Defense teams consisting of 4 teams flying the F-102 aircraft firing GAR-1 guided missiles, 3 teams flying the F-89J aircraft firing the MB-1 Genie rockets and 5 teams flying the F-86L aircraft firing 2.75 folding fin rockets.

(U) Wing tip pods were used to provide the necessary augmentation for the Q-2A. The flight test evaluation of the prototype radar augmentation and wing tip pods was first initiated in February 1958 and completed in June 1958. Scoring was provided by the PARAMI miss distance indicator system for both the MB-1 rockets and GAR-1 missiles. The TRAID 500 camera was used to score the 2.75 rockets. The Air Force developmental tests of the prototype PARAMI system did not begin until February 1958. Considering the short time allowed for procurement of the scoring equipment which was designed and fabricated to commercial standards, its performance was satisfactory in that there were 2 failures in 31 missions. There have been no camera failures reported to date. Of the 78 missions performed, 65 were succesful target presentations. Only four missions were aborted due to drone malfunction. The following were the causes of mission aborts:

1. 3 Tracking beacon failures
2. 2 Personnel errors
3. 2 PARAMI failures
4. 4 Drone control malfunctions
5. 2 Other

[redacted] Considering the dual launch system of the GB-26, the reliability of target presentation of the Q-2A drone system during the meet was 83.3%. The 2.75 rockets hit fourteen drones out of 83 passes, resulting in 10 drone expenditures. The GAR-1 missiles hit the Q-2A eleven times out of 62 passes resulting in 10 drone expenditures. The MB-1 rockets had 2 probable direct hits out of 39 passes resulting in 2 drone expenditures. 3 drones were expended as a result of failure in the recovery system.

(U) The H-21 helicopter was used very successfully for drone retrieval from the water with the exception of a few drones which were recovered approximately 40 miles off shore, recovery of the drones was accomplished within a few minutes after they landed in the water, thereby minimizing salt water corrosion of the drone. As a result of this experience, the WSPO does not consider salt water corrosion a major problem.

(U) While the Q-2A used as a target for Project William Tell is a significant improvement over targets used in earlier competitions, the augmentation and scoring is considered to be an interim development of the equipment to be used in the XQ-2C now in progress. In addition to improved radar and IR augmentation and scoring, the Q-2C will have improved speed and altitude capability. Flight test evaluation of the XQ-2C is scheduled to begin in November 1958.

(U) Northrop N-156F MAP Fighter (System 420A)

(U) The USAF Development Directive for this system dated 14 March 1958 stated no

[redacted]

[redacted]

money would be committed or expended until notified. Program funding will be determined after receipt and approval of a development plan.

(U) ARDC responded with an Abbreviated System Development Plan for a MAP Fighter Weapon System, N-156F (System 420A) dated 20 June 1958 which was transmitted by letter dated 24 June 1958. Attention was invited to the following problem areas (among others) in the development of this system:

[redacted] This weapon system, as proposed by the contractor, involves the use of SARAH missiles in a forward hemisphere attack at differential altitudes. This is an entirely new use of Sidewinder type missiles and is considered to be a high-risk development program, which, if successful, will provide a system with a low probability of kill.

[redacted] A further missile development program must be undertaken to make the Navy-developed SARAH missile compatible with the N-156F aircraft. This program would consist of changing the navigation constant of the missile and probably the structural characteristics of the missile.

(U) The contractor's availability dates for GFAE equipment have been optimistic and in all cases have been earlier than those given by the Air Force. This is probably true of CFE also but due to numerous equipment changes made by the contractor during the time the plan was written, evaluation for scheduling purposes was precluded.

(U) This aircraft is not expected to be any easier to maintain than current century series fighter aircraft performing similar type missions.

(U) The 1st indorsement from USAF on the 24 June letter was dated 21 August 1958 and stated:

[redacted] "It is the intent of this Hq to issue a General Operational Requirement for a MAP weapon system that will permit a survey of existing and proposed weapon systems within the aircraft industry to fulfill the requirement. For this reason, Headquarters' actions concerning the Development Plan . . . , is held in abeyance."

[redacted] "Further actions by ARDC on the MAP Fighter Weapon System (420A) will not be required until issuance of this GOR; issue date is expected in mid-October 1958."

(U) To date the GOR has not been received. The Deputy Secretary of Defense directed the Air Force on 26 August 1958 to make arrangements with Northrop to continue their N-156F Program at the minimum possible cost to the government from 22 August 1958 until 1 October 1958. One million dollars was made available which was the maximum amount to be used for a study to determine the suitability of the N-156F aircraft as a combat weapon system for use by NATO-MAP countries.

(U) By message dated 27 November 1958 USAF requested ARDC participation to support [redacted] tractor had also been furnished the questions and after several meetings to establish engine and other equipment schedules he made up a draft reply. Hq ARDC by letter dated 5 January 1959 furnished USAF comments on the proposed answers. The following four items were specifically pointed out in the letter as critical:

[redacted] "The most critical aspect of the program under consideration is the availability of qualified engines in adequate numbers. The J-85 series engines have been programmed for T-38, and GAM 72, and are also under consideration for Q-4, VTOL and several civil aircraft. The N-156 production line, without priority, cannot receive J-85 engines until 1961. Pratt & Whitney JT-12 engines have not been fully developed, and since essentially no effort has been channeled to JT-12 afterburner design, these engines could not be qualified and delivered in production quantities until 1961 (if placed on contract now). The JT-12 is estimated to weigh 100 pounds more than the J-85, and would require extensive airframe changes for size and weight and balance. Neither J-85 nor JT-12 engines for the MARK II version of the N-156 can be produced without a very expensive product improvement program. Funds of this nature have not been programmed by the Air Force."

[redacted] "A considerable difference of opinion appears to exist regarding the degree of complexity, and therefore the limits of performance, to be designed into the fire control system. As re-

[redacted]

[redacted]

quested by the Deputy Director of Requirements, Hq USAF, the FCS should have relatively simple parameters. As proposed by Northrop, the N-156 will have terrain avoidance, air search, track, attack illumination, ground mapping and contour mapping. This involves a complexity similar to that of F-105 aircraft, which may well be beyond the technical support and maintenance capabilities in MAP countries."

[redacted] "Load factor design for 5.76g does not meet standard USAF criteria of 8.67g at combat weight with full internal fuel. With such a low design factor, overstress may occur frequently and cause significant reduction in fatigue life. This lower strength may be considered adequate by the Netherlands, but is not recommended.

[redacted] "Northrop has proposed a forward hemisphere differential attack capability utilizing a modified Sidewinder 1C. This might be achieved through a high risk development program not presently planned or funded. The first 1C optimized for rear hemisphere attack will not be test fired until 1960; for forward hemisphere attack, the 1C would have to be further developed and could not be expected for inventory in less than four years."

[redacted] USAF TWX AFDRD-TA 55451, dated 23 January 1959 directed implementation of the program authorizing design, development, and fabrication of three flight and one static test articles. The fire control, bombing navigation system is to be unsophisticated and comprised of available, proven components to provide:

a. Computing sight for gunnery, rocket firing or pursuit attacks for air-to-air missiles of the GAR-8 type.

b. Delivery of conventional bomb.

c. Delivery of special weapons by LABS and Toss Bombing methods.

[redacted] The above fire control/bombing configuration is not to be considered the final type for all N-156 aircraft; this will be handled on a user country basis, as the above is for the three aircraft authorized to permit a comprehensive and realistic flight test program.

[redacted] With regard to this direction the WSPO has determined the following problems exist:

1. Northrop has authorized vendors to proceed with the development and production of components such as FCS, and cancellation of these efforts in favor of any USAF preferred components may be costly to the MAP in terms of dollars and time.

2. Engine availability is not known at this time but priority requirements for Q-4 missiles will probably cause slippage of the second and third N-156F aircraft from December 1959 and February 1960 to June and August 1960. First N-156F can fly July 1959, with non-afterburning engines, if current YJ-85-1 stall problem corrective action proves to be adequate.

(U) USAF is being requested to provide necessary guidance on the above problems.

(U) T-39 UTILITY JET TRAINER (UT-X) (SYSTEM 452L)

(U) North American Aviation was announced the winner in the UT-X competition. Procurement of seven (7) aircraft is anticipated in FY-59.

(U) A Program Planning Conference was held at North American Aviation on 4, 5, and 6 November 1958 for the purpose of establishing a configuration, a basis for a Detail Model Specification and Logistics Support planning. A board was appointed and mock-up inspection procedures were employed. A total of 86 Request for Alteration forms (RFA's) were submitted to the Board for review. Of these RFA's, 54 were placed in Category I, 3 in Category III, 12 in Category IV and 17 in Category V. All Category I RFA's will be made a part of the Detail Model Specification or incorporated in the production airplane at no change in the base price. The Category III and IV RFA's presented some problem areas which are discussed below.

(U) Navigator's Station

(U) Amendment Nr 1 to GOR 132 defines that space and weight provisions be made for a Navigator's Station to perform "dead reckoning," radio and celestial navigation for proficiency purposes. No such provisions have been made.

[redacted]

[redacted]

A study will be made by the Contractor so that a detailed proposal could be developed and submitted for the incorporation of these provisions.

(U) Electronic Equipment

(U) The Contractor generally had selected commercial airline equipment. The Air Force has stated a requirement for TACAN, IFF, and standard UHF equipment.

(U) Instrument Panel Layout

(U) The cockpit of the UTX was generally good. Commercial airline quality instruments have been used along with a Collins Integrated Flight Director System. The Air Force Crew Station group recommended a complete revision of the panel with standard Air Force instruments with integral lighting. The group requested permission to study this matter with the Contractor with a view toward providing a panel more suited to Air Force operations and support.

(U) Range

(U) North American has not made structural provisions for the slipper tank configuration they proposed. These tanks are necessary to meet the 1500 nautical mile range requirement of GOR 132. The tanks may require some additional beef-up in wing structure and landing gear.

(U) Wing and Empennage Anti-Icing

(U) The Contractor has deleted the anti-icing provisions from the wing and empennage. The CAA will not certify the airplane for all-weather operation in icing conditions without these provisions.

(U) C-130 BLC TEST BED (SYSTEM 400N)

(U) In response to the Abbreviated System Development Plan submitted to Hq USAF to satisfy GOR 130 Revised, title: (U) Troop Carrier/Assault (Fixed Wing) Support Aircraft, a Development Directive 106 was issued on 23 December 1958. This action was followed by the publication of an ARDC System Directive 400N.

[redacted] This directive initiated the development, modification and test of a single test bed C-130B aircraft into a configuration incorporating a boundary layer control system. Blowing air will be furnished by two pod-mounted T-56 engines with load compressors. It is anticipated that this test bed aircraft will furnish engineering, manufacturing, and performance information applicable to a proposed C-130 boundary layer control production program now under consideration in Hq USAF.

[redacted] Production funds of $2.75 million have been directed for this program by Hq USAF. If a decision is made to go ahead with a production program, funds will be made available for engine development, initial engineering, tooling, and pre-production items.

(U) H-40 HELICOPTER (SYSTEM 443L)

(U) The Army Designation of this helicopter is HU-1A.

(U) The overhaul life of the dynamic components of the YH-40 and HU-1 helicopters has been increased from 150 to 200 hours. The engine in the Army Fort Rucker Logistics Evaluation Flight Test aircraft will be flown to 300 hours in an attempt to extend the engine overhaul life.

(U) The initial flights of the No. 3 YH-40 helicopter in the Adverse Weather Flight Test Program were made at WADC. This aircraft was then shipped to Ottawa, Canada, on 13 November 1958 for spray rig tests to determine the capabilities of the helicopter in icing conditions. These have been completed. Ideal icing conditions were encountered. Heavy icing on the main and tail rotor blades resulted in moderate vibration of the helicopter. Only light icing was accumulated on the upper circumference of the engine intake screen. This aircraft was returned to WADC for continuation of the Adverse Weather Flight Test Program.

(U) T-37 JET TRAINER (SYSTEM 424L)

(U) Operationally the noise level of this aircraft is considered excessive. The following paragraphs briefly outline the status of the noise problem.

[redacted]

(U) The objectionable noise of the J69 engine is generated by the compressor and is a high frequency, pure tone. The engine contractor has attempted to reduce this noise at the source by redesign of several engine components. These efforts have been unsuccessful. Engine noise reduction investigation by Continental is continuing. An outgrowth of the Continental noise reduction investigations was a sound absorbing inlet duct which showed merit. This concept is being investigated in a T-37A installation. It is estimated that the test of the sound absorbing inlet duct will indicate the feasibility of this approach in February 1959.

(U) The removal of personnel from the high noise level area will reduce the impact of this problem on the Air Training Command operation. This result will be obtained by the use of the nickel-cadmium battery in the T-37A. Engine starting will be accomplished by using the aircraft battery instead of a ground power unit. Ground power unit operators will be removed from the high noise level area close to the aircraft. The change to the nickel-cadmium battery in production aircraft will be made in June 1959.

(U) In April 1957, a piece of ground support equipment was proposed to the Air Training Command as one method for suppressing noise. At that time the Air Training Command rejected the use of this type of equipment because it was operationally objectionable. In November 1958, Air Training Command representatives expressed interest in the engine noise suppressor. A proposal for development of this equipment is being evaluated. It is anticipated that this program will be placed on contract shortly and that prototype equipment will be available for evaluation in mid 1959.

(U) KC-135 JET STRATOTANKER (SYSTEM 422L)

(U) At a meeting held at W-PAFB on 7 October 1958, Boeing and North American presented the results of their coordinated efforts to date in determining and defining compatibility problems between the B-70 and KC-135A. The data were presented to representatives of both project offices, WADC and Hq SAC. Based on the data obtained and presented by the Contractors, the B-70 is capable of being refueled by the KC-135A for accomplishment of its projected mission. It was agreed, however, that modifications to the KC-135A boom to permit refueling at the present placard speed of the airplane are almost essential for more reasonable assurance in performing the mission satisfactorily. Boeing and North American will continue their close coordination however during the development period of the B-70 to further assure that any new problems are immediately recognized as they may arise.

(U) The vertical fin flutter problem has been solved by a combination of rudder cable tension increase from 100 pounds to 150 pounds and removal of the rudder cable idler pulleys. Cable tension increase to 150 pounds was also being considered in order to alleviate cable slack which occurs at low temperatures in arctic operation. It was found that the late October flight tests on the 83rd airplane with idler pulleys removed were unsatisfactory in damping because the normal 100 pounds tension in the cables had deteriorated to approximately 60 pounds. Indications are that cable tensions should be more than 125 pounds, measured at 70°F temperature, but that a tension of more than 150 pounds does not provide any appreciable improvement over the 150 pounds setting. Changes are expected to be made in airplanes currently being delivered and the Mach placard of .85 will be raised to .90 as soon as the exact configuration and effectiveness of the fix has been confirmed by official correspondence. Two problems now remain in regard to this item:

(U) First, maintenance procedures may require a change to provide more frequent checks of cable tensions because of deterioration of tension with time.

(U) Second, removal of the idler pulleys reopens the problem of chafing of the cables against structure, this being the reason for the installation of the pulleys in the first place.

(U) The autopilot stabilizer trim system malfunctions have been thoroughly investigated and failures have all been attributed to the shaft and shaft bearings in the magnetic clutch assembly of the auto-pilot stabilizer trim servo actuator. All failures have occurred in clutches of the type used before a nitrided clutch bearing was incorporated in approximately the 127th production airplane and on. To further increase reliability of the servo actuator, a ball bearing clutch shaft configuration is being incorporated in lieu of the former journal bearing, the gear attachment is being added to the former cantilevered gear shaft. Action is being taken to rework all units prior to the nitrided shaft installation. Present estimate for availability of first rework kits is 15 May 1959.

(U) H-43 LOCAL BASE RESCUE HELICOPTER

(U) A conference was held on 29 September 1958 to discuss replacement of the Lycoming STU/5A impingement starter with an electric starter-generator system in the H-43B helicopter. All pertinent AMC and ARDC personnel concerned with engineering and procurement of both type starter systems were in attendance.

(U) At the conclusion of the conference the decision was made to replace the impingement starting system with the electric starting system. This decision was based on the following factors.

a. The impingement starter is still considered to be in the development stage. Qualification of the starter was scheduled for completion in May 1958 but as yet has not been accomplished.

b. Compatibility of the engine-starter has not been established. The specification requires that the starter must accelerate the engine to 25 percent r.p.m. within 78 seconds. This is the engine self-sustaining speed. If the engine is not self-sustaining within 78 seconds the starter air-fuel supply is exhausted. At low temperatures the starting times have exceeded the specification requirements thereby requiring redesign of the starter air-fuel supply system.

c. Maintainability of the impingement starting system is questioned due to the complicated nature of the device.

d. The impingement starter costs per aircraft are approximately five (5) times the cost of an electric starting system.

e. Modified to operate at -65°F the impingement starter system will weigh slightly more than the electric starting system.

f. The Department of the Army has deleted the impingement starting system from the FY'58, '59 procurement of HU-1A aircraft.

(U) The Development Engineering Inspection on the T-53 powered H-43B helicopter was held at Kaman Aircraft Corp., Bloomfield, Connecticut on 30-31 October 1958. There were 73 RFA's submitted and of these there were no safety of flight items.

(U) On 8 December 1958, the fifty (50) hour tie-down test of the H-43B was completed. A team consisting of representatives from the SSPO and the WADC witnessed the tear-down inspection of the aircraft and reported satisfactory results.

(U) C-133 CARGOMASTER (SYSTEM 402L)

(U) A Military Air Transport Service C-133A airplane successfully demonstrated its capability to airlift WS-107A-2, Titan Stage I and Stage II, from Denver, Colorado to Patrick Air Force Base, Florida on 20 November 1958.

(U) The delivery of ten (10) converted T-34 engines per month starting in October 1958 from San Antonio Air Materiel Area (SAAMA) to support the C-133A Modification Program at the Douglas Aircraft Company has not materialized. The ARDC representative at SAAMA has indicated that deficiencies in the engine test cells and vibration equipment are rejecting converted T-34 engines due to excessive engine vibration. Cognizant WADC laboratories, Pratt & Whitney Aircraft Division and Curtiss-Wright Corporation representatives are closely monitoring and assisting SAAMA progress towards a solution for the engine vibration problem experienced in the test cells. Impact of continued slippage in the delivery of converted T-34 engines beyond 15 December 1958 will result in the readjustment of deliveries of modified C-133A Aircraft to Military Air Transport Service.

(U) A new world record for cargo airlift was established by Military Air Transport Service utilizing a C-133A Airplane on 15 December 1958 at Dover AFB, Delaware. 117,900 pounds of cargo was carried at the design take-off gross weight of 275,000 pounds. The take-off distance was less than 5,000 feet and the duration of the flight was one (1) hour.

(U) C-130 HERCULES (SYSTEM 400L)

(U) The C-130B made its initial flight 20 November 1958. Flight time was 1 hour and 15 minutes. The purpose of the flight was to conduct aircraft systems shakedown, check-out flight test instrumentation, and obtain preliminary flying qualities evaluation. Maximum airspeed attained was 250 knots and maximum altitude was 12,500 feet. Noise level in flight station and cargo compartment indicates much improvement over the C-130A. Additional structures stiffness throughout the airplane is evident in flight and lends a good "solid" feel to the airplane.

(U) Hamilton Standard Propeller Qualification: The 150 hour qualification test on the Hamilton Standard propeller was completed on 23 December 1958. The propeller failed to qualify completely as the result of brush block wear and clutch slippage during throttle "burst and chop" tests. The propellers scheduled for installation on TAC airplanes will be of the same configuration as the WADC qualification test article. Restrictions will be placed on the propeller until a qualified article is available. Restrictions are as follows:

1. Throttle movements in the "burst-chop" sequence will require stabilized propeller r.p.m. below 103 percent during electronic governing.

2. Inspection of propeller brush-blocks at 75 hour intervals.

(U) T-38 (System 420L)

[redacted] "Talon" was selected as the popular name for the T-38A aircraft by Air Training Command contest.

(U) Engine problems have plagued the program to date. The first ground run YJ85-GE-1 was delivered to Northrop on 3 September 1958. Difficulties were encountered in instrumentation and engine performance throughout the ground run test schedule. As a result only twenty-five percent of the required ground running was completed in 35:52 hours of test time. The compressor of the engine failed on 21 November 1958.

(U) The delivery of the second ground run engine was delayed until December 1958.

(U) A (Safety of Flight) development engineering inspection was held 9-11 December with ground run engines installed.

(U) Two supposed flight-rated engines were shipped in December to Northrop. All three of the engines delivered in December have encountered stall problems.

(U) Due to the failure of the first ground run engine in November, the second ground run engine was slated to complete the remaining 75% safety of flight tests programmed prior to release of the YT-38 for first flight. Continued stalls of a random nature made this engine useless for completion of the ground test program.

(U) The first flyable engine stalled during deceleration while installed in the left hand duct of the YT-38. This was an instrumental engine and data reduction indicated the contributing factors of duct distortion on this stall were minor.

(U) The second flyable engine (uninstrumented) was run in the right hand duct. Fluctuating tailpipe temperature was evident after approximately two minutes and stall occurred upon retardation of the throttle.

(U) Coordinated action is being taken to attempt to resolve these problems. First flight date will slip from January until possibly April because of the problem.

(U) There has been informal information received to the effect that the requirement for an Integrated Instrument System might be cancelled. To date firm guidance has not been received.

(U) Data from a high speed sled run of the canopy system revealed that a stiffening of the canopy was required due to breakup immediately following release. Verification of the fix incorporated will be made during sled runs at AFFTC in March 1959.

(U) The requirement for a cartridge starting

[redacted]

system on the J-85 engines in T-38 aircraft has been cancelled stopping the development program.

(U) After considerable delay the FY 59 facilities funds were released to provide G.E. with facilities needed to expand the monthly production rate of the J85-5 engine to meet requirements.

Research Systems

(U) AVRO VERTICAL TAKE-OFF AIRCRAFT (SYSTEM 606A)

[redacted] In March of 1958, ARDC recommended a joint AF/Army Program for the AVRO-VTOL System. During the same month, Hq USAF directed implementation of this program, which is a joint effort to develop the AVROCAR subsonic research vehicle. Funding from the concurrent AF-sponsored study, to explore potential Air Force applications of the AVRO concept was at that time transferred to the AVROCAR program. The Air Force is also providing program management, facilities, engines and other GFAE as a part of its contribution to the integrated effort.

[redacted] The AVROCAR vehicle is scheduled for first flight in June 1959, to demonstrate the basic unknowns of this type of aircraft, i.e., hover, transition, ground effect, stability and control.

[redacted] Confidence in the AVRO work has now increased to the point where the supersonic capabilities appear attractive. The Hq USAF has recently approved the use of $600,000 for FY 59 studies.

[redacted] Additional emphasis has recently been given this program by the Canadians. A [redacted] requirement for a strike reconnaissance aircraft for 1963 to 1968 similar to the USAF supersonic AVRO system. [redacted] during 1952 a [redacted] mately one-half million in the program and was preparing to allot funds during FY 59, 60 and 61 for limited support of a joint program with the USAF.

(U) XV-3 CONVERTIPLANE (SYSTEM 602A)

(U) During flight tests the XV-3 rotor displayed aeroelastic instability which resulted in suspension of flight activity. For this reason this research vehicle was installed in the NASA Ames Laboratory 40 x 80 wind tunnel on 7 October 1958 for flight simulation.

(U) As a result of rotor system modifications the NASA tests indicated that the aeroelastic instability of the rotor had been eliminated within and beyond the entire operational range of rotor speeds, at air speeds up to 140 knots. Stiffening of the cyclic control system was the major single factor responsible for solution of this problem. Concurrent with rotor modifications, aircraft configuration changes were investigated. One of the major items in this category was the incorporation of half span wing flaps to reduce the wing stalling speed and to improve the hovering performance of the vehicle.

(U) Flight tests at the Bell facility at Ft. Worth, Texas were resumed in December. On 18 December 1958 the XV-3 successfully performed full conversion from helicopter flight to fixed wing flight and reconversion to helicopter flight for vertical landing.

(U) X-15 - Research System 605A

(U) B-52 X-15 Mating

(U) The mating of the X-15 to the B-52 was accomplished satisfactorily. No problems were encountered in the wiring connections, plumbing or mechanical attachments.

(U) Flutter

(U) Shake tests of the X-15/B-52 revealed that the pylon side bending frequency was considerably less than anticipated. The data was reviewed with NAA, Boeing Aircraft Company and WADC on 12 January 1959. It was concluded that the reduced pylon stiffness will not compromise any of the planned flight profiles. X-15

[redacted]

stabilizer flutter margins are presently being reviewed using the latest tunnel tests, weight figures and measured stiffnesses.

(U) Pressure Suit

(U) Mr. A. S. Crossfield, North American Aviation pilot, received a new full pressure suit with face seal helmet from Aero-Medical Laboratory and David Clark Company. Nitrogen contamination tests were conducted by Aero-Medical Laboratory on 19 December 1958. Nitrogen leakage was negligible. A blast test was satisfactorily conducted on the electrical visor to be used on neck seal suits on 22 December 1958.

(U) Stability Augmentation

(U) Service life testing of the stability augmentation system has completed 529 simulated flights. Several equipment modifications brought about by this testing have improved equipment reliability.

(U) Propulsion

(U) An engineering inspection of the XLR-99-RM-1 engine was held on the morning of 18 November 1958. Of the 14 change requests all were put in approved status except one which was for study. Plans to conduct a training program on the XLR-99 engine have been tentatively established. The school will be held at the contractor's facility and will be conducted under the sponsorship of the Air Training Command. It is currently planned that the PFRT test will start on 15 February 1959.

(U) Inertial Flight Data System

(U) The first stable platform system including all indicators and the ground check-out equipment console has been delivered to NAA flight test at Edwards Air Force Base.

(U) Ejection Seat Sled Tests

(U) The fifth X-15 dynamic sled test was fired 21 November 1958 at the AFFTC track. This seat included the trailing boom modification, but did not include the shock-wave generator. The booms added stability in the pitch and yaw axes, but it rolled approximately 270° at the time of dummy separation. The maximum rate of roll was approximately 1 rev/sec. Four of the sled rockets failed to fire resulting in 800 p.s.f. "q" rather than the planned 1,500 p.s.f. One sled rocket on both sled runs 19 and 31 December 1958 failed to fire and the pressure sensing device did not allow the seat to eject at the lower velocity.

(U) AFFTC has now obtained sled booster rockets from Holloman and testing will be resumed shortly. Glide flights have been released as far as seat stability is concerned on the basis of information available on sled tests within the envelope as tested; Mach .377-195 p.s.f. "q" and Mach .72-715 p.s.f. "q".

(U) X-18 Tilt-Wing VTOL (System 607A)

(U) The X-18 research vehicle program is progressing in accordance with programmed funding. This project with Hiller Aircraft, Inc., was initiated to provide a demonstration of the feasibility of VTOL flight using a tilt-wing/propeller configuration and to provide data for evaluation of the tilt-wing concept as a VTOL and a STOL vehicle.

(U) The test vehicle utilizes an existing airframe (Chase, YC-122-C) two Allison turboprops (YT-40-A-14) and one Westinghouse (J-34-WE-36).

X-18 Characteristics:

Length	63 feet
Height	24.7 feet
Span	60 feet
Design Weight	33,000 lbs.
Propeller	Curtiss, 6-Blade (dual rotation)
Range NM	172
Cruise Kts	219
Hovering Endurance S.L. out of ground effect	30 min. @33,000 lbs.

(U) The vehicle has been moved from the Hiller facility to Moffett Field, Naval Air Station for subsystem checkouts and initial runups. The aircraft is scheduled to be moved to Air Force Flight Test Center in May 1959 where the flight test program will be conducted. Completion of the program is estimated to be June 1960.

Directorate of Aeronautics

(U) APPLIED RESEARCH IN MATERIALS

(U) Military events of the past few years have focused sharp attention on the limitations of aeronautical materials of construction. Therefore, the prime objective of the ARDC Applied Research Program in Materials is to provide the leadership necessary to significantly extend the useful range of application of aeronautical materials. The purpose of these briefs is thus to give you an indication of the scope of this Program. They discuss metals, plastics and other synthetics, coating techniques, and unique methods for developing new materials.

(U) REFRACTORY METALS

(U) To meet the needs of rocket and hypersonic airframe designers, new metallic materials are required. This is primarily because of severe temperature extremes extending from below - 400°F to over 5,000°F. The superalloys composed of such elements as nickel and cobalt give satisfactory long time service (hours) to near 1,700°F; but at temperatures over 2,000°F, only several minutes of useful life can be expected. A class of metals known as the REFRACTORY METALS hold potential for greatly extending this temperature limitation.

(U) Four of these refractory metals are shown in Figure 1. All have melting points exceeding 4,400°F. The potential useful temperature of these metals has been estimated and is shown in the last column. Unfortunately, these refractory metals are subject to severe oxidation at elevated temperature and are brittle. The ARDC applied research program is attempting to overcome these problems. If successfully developed, these metals will find wide application in hypersonic leading edge applications, rocket engine exhaust nozzles and jetavators.

(U) COATING TECHNIQUES

(U) One approach to the oxidation problem of the refractory metals is through the use of protective coatings. Such coatings must be impervious, resist thermal shock, and withstand a highly corrosive and erosive environment. The technique of applying such coatings is highly significant since uniformity and adhesion are particularly important. Figure 2 indicates a number of these coating techniques. The enameling and oxyacetylene flame spray have been successfully used by the Air Force; for example, for wear resistance on reciprocating engine parts and on combustion cans in jet engines.

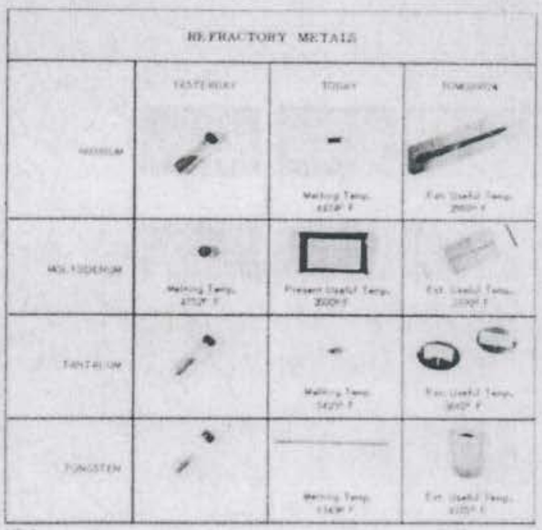


FIG. 1

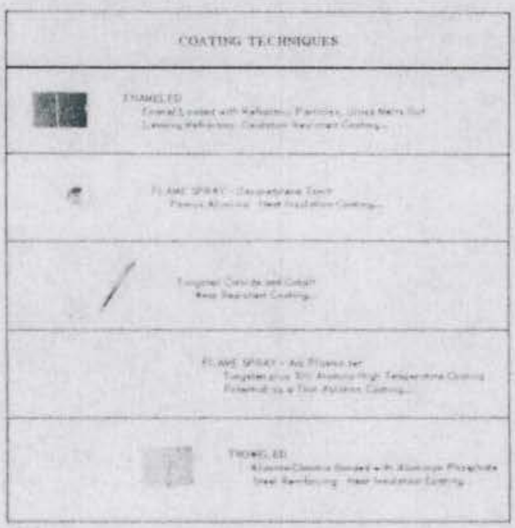


FIG. 2

(U) The flame spray technique which employs an arc plasma jet is considered by many as an outstanding metallurgical achievement of 1958. The temperature generated by an arc jet is so intense (15,000+ °F) that it can vaporize the highest melting materials known. These materials can then be condensed as a coating on the component requiring protection. The potential of this arc plasma jet coating technique has yet to be fully exploited. With further development, many significant Air Force weapon applications are anticipated. For example, ablation protection of nose cones and hypersonic leading edges may be greatly facilitated.

(U) A direct development from the AF's program has been the "TROWELED" coating technique. By this procedure, the life of ramjet tailpipes has been extended several fold under temperature conditions approaching 3,000°F. These heat insulating coatings are laid up by hand troweling of the ceramic material over a steel wire reinforcement.

(U) The ARDC is continuing its coating development effort to afford thermal protection for the refractory metals and graphite at temperatures up to and beyond 5,000°F.

(U) BERYLLIUM MATERIALS

(U) Beryllium has many outstanding properties which make it an exceedingly attractive air weapon material. As indicated in Figure 3, it is lighter than aluminum yet stiffer than steel. It is one of the best heat sink materials known.

(U) Several of the most promising applications for beryllium are depicted in the figure. In guidance systems, a very light and strong material which is dimensionally stable over a wide temperature range is required. Beryllium has provided the answer at a significant increase in performance as well as weight savings over its steel predecessor.

(U) For applications employing the heat sink principle, beryllium offers significant weight savings. For example, a 13 lb. beryllium nose cone has the same heat sink capability as a copper cone weighing 100 lb. Beryllium or some beryllium compounds offer potential as leading edge material for air weapons exposed to severe aerodynamic heating. This exceptional ability to absorb and store heat may save hundreds of pounds of weight in future aircraft braking systems.

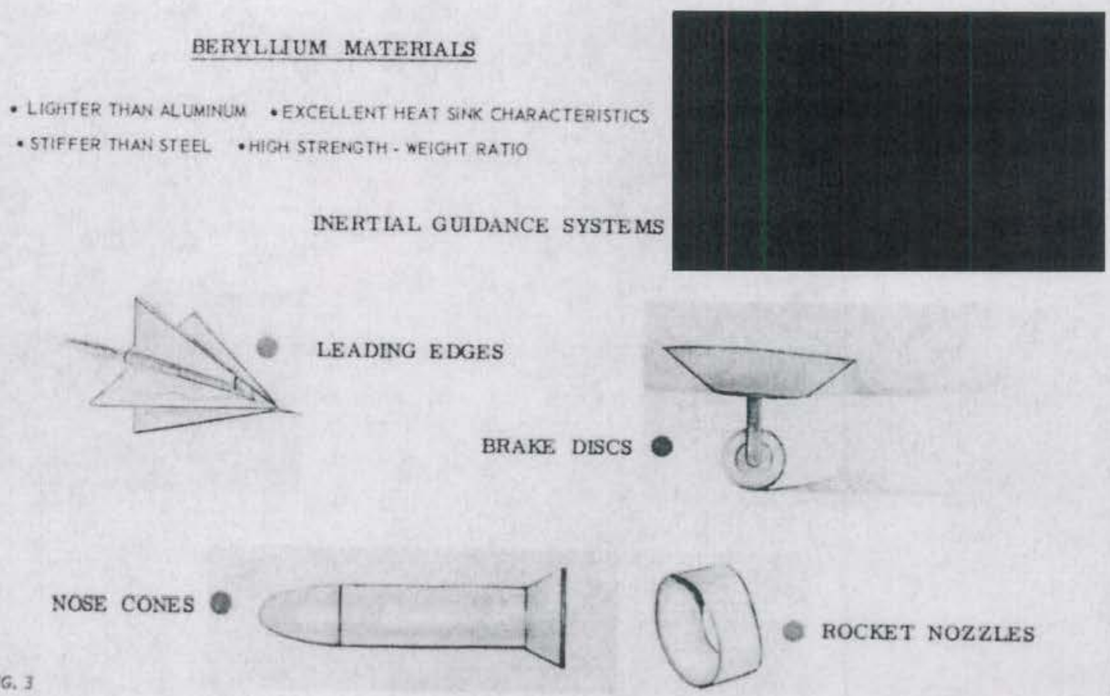


FIG. 3

(U) But why hasn't this potential of beryllium been exploited? Unfortunately, beryllium is a brittle material which has been avoided because of its scarcity, cost and toxicity. Techniques for joining (welding, brazing) have also been lacking. The ARDC has inaugurated a concentrated program to overcome these disadvantages of beryllium. With successful development of a ductile beryllium alloy and/or composite, a superior material will be available for air weapon designers. Furthermore, because of this metal's exceptional strength to weight ratio, it should find application in satellite and space weapons in which weight savings are at a premium.

(U) PLASTIC MATERIALS

(U) Plastics have solved many Air Force problems. Their substitution for glass in aircraft gave significant weight savings; their radome applications contributed significantly to airborne radar. These uses are dwarfed by the potential of plastics in future air weapons. Many of these possibilities are illustrated in Figure 4.

PLASTIC MATERIAL

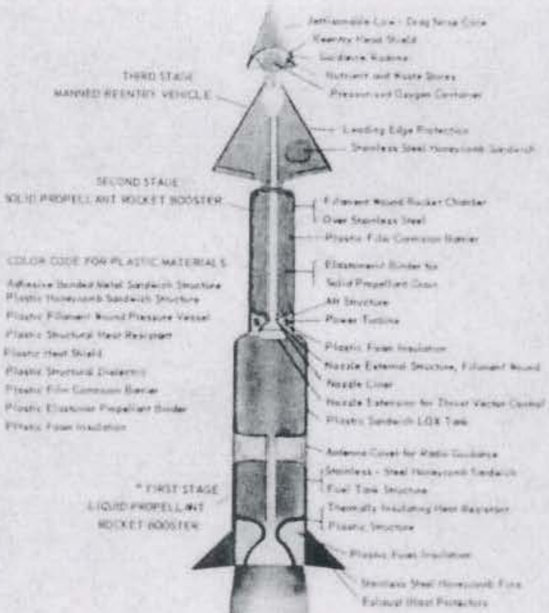


FIG. 4

(U) Plastics are practical as nose cone material because of their outstanding ablation characteristics. In simulated reentry environments such as rocket blast and the plasma arc, reinforced plastic materials have shown superior performance to ceramics and high temperature metals.

(U) While the original polyester plastics were limited to structural applications below 200°F, the development of heat resistant silicone and phenolic resins has extended the maximum long time operating temperature to 700-800°F. This temperature capability combined with the excellent strength to weight properties of plastics has provided the air weapon designer with a highly versatile structural material from which rocket chambers, pressure vessels, and sandwich structures can be built.

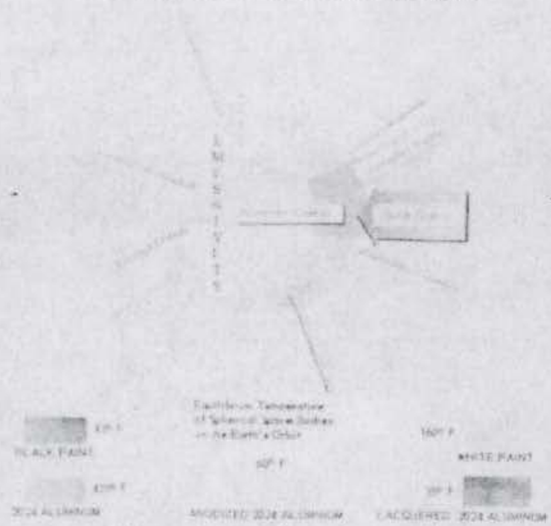
(U) The current Air Force Program on reinforced plastics is directed toward significant extension of the temperature range of application of plastics with a concurrent improvement in strength properties. During 1958, a milestone was reached in the ARDC plastics development program when we produced, on a laboratory scale, glass fiber reinforcing material with almost double the modulus of elasticity of current glass fibers. There is every reason to believe that this laboratory development can be translated into production quantities.

(U) EMISSIVITY COATINGS

(U) Many Air Force weapons of the future will not enjoy the natural protection of the earth's atmosphere. They will be exposed to the total radiant energy of the sun. Temperature control of such vehicles will be highly dependent upon the materials of construction. The balance reached between absorbed solar energy and re-emitted infrared radiation will determine the skin temperature. Figure 5 illustrates this heat balance process. It should be noted that the materials' properties known as emissivity, absorptivity, and reflectivity are vitally important to this heat balance. To illustrate, consider the following: Metals are normally excellent reflectors but poor emitters of long wave length radiation (infrared) while paints are generally poor reflectors but good infrared emitters. What this boils down to—and verified by actual measurement—is that the equilibrium skin

FIG. 5 EMISSIVITY COATINGS

FACTORS THAT DETERMINE THE TEMPERATURE OF BODIES IN SPACE



temperature of painted surfaces will be much lower than polished metal surfaces. An optimum selection of satellite and other spacecraft surface material must then be based on an accurate evaluation of the emissivity, reflectivity, and absorptivity properties of materials.

(U) Since little effort in the past has been devoted to the collection of such property data, a portion of the ARDC's materials program has been directed toward collecting such fundamental data. Some results are shown in Figure 5. These equilibrium temperatures are calculated for a spatial environment with the suns spectral intensity based on a black body radiating at approximately 5,500°K.

(U) Although it appears that careful selection of coating material can provide good temperature control, several other considerations introduce an element of caution into such a conclusion. First, these temperature calculations ignore internal heat; and, second, abrasion or other surface attack may drastically alter the material properties of emissivity, absorptivity, and reflectivity. For example, just 10 watts/ft.^{2} of internal heating can raise the skin temperature of polished aluminum to over 600°F, and that of aluminum paint from 35°F to almost 140°F. The effects of surface abrasion are theorized to bring about equally significant changes. Pinpointing these effects is included in the ARDC coating materials program. Development of coating materials stable in the spatial environment is also a goal of this program.

(U) MATERIAL SYSTEM

(U) Material system is another way of defining a composite such as sandwich construction. It was due to the foresight of the AF's people in the Materials Laboratory at Wright Field that adhesives were available that solved many of the problems of the riveted B-36. A more recent testimonial to the ARDC's composite materials program is the B-58. The major portion of its structure is sandwich construction. The plastic adhesive and core material for the aluminum sandwich and the brazing processes for the stainless steel sandwich were developments of the ARDC's Materials Program. These sandwiches may satisfy Mach 3 flight requirements, but the goal of the materials program is a satisfactory composite for hypersonic leading edges as well as other hot spot areas. Boost glide systems will need such material composites.

(U) Pictured in Figure 6 is a composite material system composed of quartz plus foamed quartz insulation attached to stainless steel sandwich by a ceramic adhesive. Such a system has potential to over 2,200°F service. Part of our material system applied research program is being devoted to the design and evaluation of such composites. Emphasis is also being placed

MATERIALS SYSTEM

A COMPOSITE MATERIALS SYSTEM FOR LEADING EDGE APPLICATION

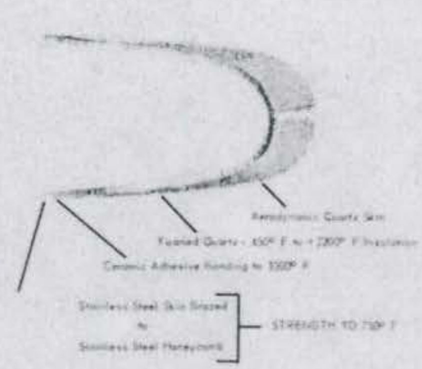


FIG. 6

on the development of a ceramic or inorganic adhesive with temperature capability far in excess of the 1,000°F. It was only in 1958 that laboratory quantities of the 1,000°F ceramic adhesive were developed—a significant plateau, but well below the future goal which has been set. Without these more temperature resistant materials, excessive weight penalties for coolant and cooling equipment will be required—seriously detracting from payload carrying capability.

(U) TAILORING MATERIALS

(U) Gone are the days when the empirical approach of "cut and try" could be relied on to yield improved materials. Furthermore, the inherent qualities of natural materials such as rubbers and greases are inadequate for advanced weapon designs. Therefore the trend to synthetically tailored materials has been greatly accelerated. The AF's materials program has pioneered in molecular engineering through its plastics and elastomeric (synthetic rubber) applied research efforts. Figure 7 illustrates the tailoring of materials to produce silicones which have found wide application as rubbers, lubricants, and plastic resins.

TAILORING MATERIALS

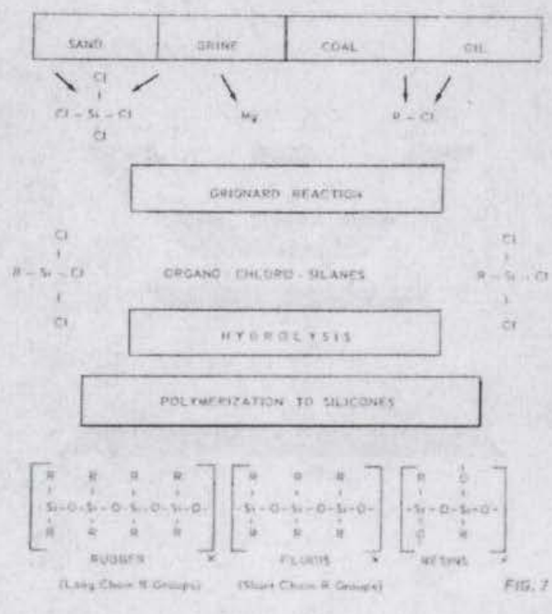


FIG. 7

(U) The fluorinated silicones for heat resistant applications resulted directly from the ARDC materials program. Even these materials have only modest temperature capability and very limited nuclear radiation resistance. As an approach to significant improvement on these limitations, Air Force materials engineers are attempting to tailor (polymerize) rubber-like materials which employ a metallic constituent such as tin or boron. Some laboratory investigations of 1958 indicated thermal stability of these types of combinations approaching 800°F—almost double the capability of the best available synthetics. The low temperature properties are not being overlooked—serviceability below -400°F is the goal.

(U) Another urgent Air Force objective is compatibility of seals, gasket, and hose materials with high energy fuels. Hydrazine, for example, seriously degrades the best available elastomers. Applied research is therefore being directed toward tailoring elastomeric materials which will be compatible with new Air Force propellants.

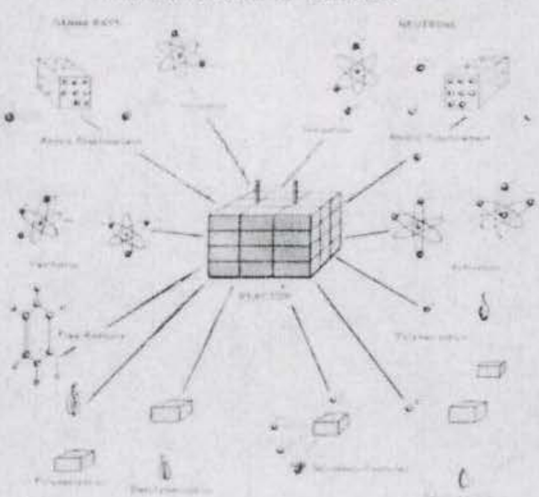
(U) RADIATION DAMAGE OF MATERIALS

(U) Engineering materials for future Air Force weapons must be capable of survival in a nuclear environment, not only where nuclear power plants may be employed but also where exposure to cosmic radiation is anticipated. Irradiation studies of components, such as radio receivers, motors, capacitors, have shown that resultant damage is a direct function of the materials of construction.

(U) Gamma rays and fast neutrons are the prime triggers of radiation effects in materials. Figure 8 illustrates some of the reactions which occur when materials are exposed to gammas and neutrons. Atomic displacement and ionization takes place in metals which generally results in an increase in strength and hardness but lowers the ductility. This is not considered serious. The exception to this conclusion is the semi-conductor elements such as germanium. In such devices even slight atomic disturbance cannot be tolerated.

(U) The non-crystalline materials such as rubbers, lubricants, and adhesives: nuclear radiations, even in small doses, drastically alter

RADIATION DAMAGE OF MATERIALS



these type materials. The chemical bonds which bind atoms of these materials are quickly destroyed or changed. Greases may turn to gums; adhesives and rubbers may harden and crumble. In such cases, the radiation is actually polymerizing or depolymerizing the materials.

(U) Therefore, the nuclear environmental effects on Air Force materials are not being overlooked in the applied research program. For example, not only are temperature and corrosion resistance goals in the program to develop inorganic polymers, but significantly improved radiation resistance is a part of this objective. It may also be possible to develop additives for lubricants and polymers which will raise their radiation tolerances to acceptable levels. Such materials have been labelled "anti-rad" additives. Concurrent with these development efforts, an extensive testing program is in progress to study and evaluate the effects of a nuclear environment on all classes of air weapon materials.

(U) LABORATORY MATERIALS

(U) It has been recognized in the materials applied research program that product improvement alone cannot provide the significant strides forward that are required. For orders of magnitude improvement, some work must be undertaken which has limited chance of success yet whose potential payoff is great. Figure 9 pictorially describes one such venture. Fine filament materials which have been termed "whiskers" exhibit phenomenal strengths compared to the same material in bulk form. For example, iron whiskers are almost 50 times stronger than bulk material; graphite whiskers are nearly 800 times stronger. The utilization of even a part of this potential in a practical Air Force material is our objective. Possibly an early application of such fine filaments may be in electrical and electronic miniaturized devices. Therefore, one part of the whisker effort is the collection of physical as well as mechanical properties of these filaments. New testing equipment and techniques must be devised to accomplish this job primarily because of the size of these whiskers.

(U) A significant contribution to the understanding of fatigue and creep of materials may also result from the study of fine filaments. This is the subject of an in-house effort at the Materials Laboratory, WADC.

LABORATORY MATERIALS

WHISKERS

GRAPHITE WHISKERS MAGNIFIED 100 TIMES (APPROX.)

		WHISKERS	BULK MATERIALS
IRON	TENSILE STRENGTH	1,900,000 psi (2.5 cm x 15 MICRONS)	45,000 psi
GRAPHITE	TENSILE STRENGTH ELASTIC MODULUS	2,900,000 psi 150,000,000 psi (3 cm x 2.7 to 5 MICRONS)	3,500 psi 1,500,000 psi

FIG. 9

(U) Sonic Fatigue Testing Facility

(U) A Sonic Fatigue Testing Facility is being planned at WADC to:

a. Obtain knowledge, through research, of the fragility levels (i.e., noise levels at which specimens sustain sonic fatigue damage) of structural designs now in use or proposed for future flight vehicles.

b. Develop structures having the proper balance between the weights of structural elements in a given design in order to optimize fatigue life of the design.

c. To develop new materials and structural designs having improved tolerance to imposed acoustic loads at less weight.

d. Evaluate the ability of structural designs of future flight vehicles to withstand sonic loads imposed during their service lives. In order to accomplish the purpose of this facility, knowledge gained therefrom must be published in handbooks of design criteria and practices and made available to structural designers during the initial design stages. Although designed primarily for sonic fatigue testing of flight vehicle structures, this facility can also be applied in a similar fashion to the testing of large equipment packages; e.g., guidance systems.

(U) Sonic fatigue damage to present aircraft structure has become of paramount importance to the Air Force through: (a) vast costs and structural weight increases for its correction; (b) delays in delivery of aircraft while fixes are being installed; (c) maintenance time required to repair damage to operational aircraft, and loss of combat readiness. Since propulsion devices of future flight vehicles will produce tremendous increases in power, thrusts, and speeds over those now obtained in aircraft, the noise energy available for producing sonic damage will increase commensurately.

(U) The first large costs for fixing sonic fatigue were encountered in 1955 in connection with the B-52. These have continued as newer aircraft with higher thrust power plants have been developed. These costs have averaged over ten million dollars per year and were $29,000,000 in 1958. In addition to these actual dollar costs much flying time has been lost while service aircraft are being repaired and a great maintenance burden has been imposed on using services. Even delays in delivery have been encountered. These intangible costs, though difficult to reduce to dollar values, are potentially more important to the nation than the actual dollar costs for engineering changes. As sonic fatigue failures are corrected the structural modifications increase the structural weights and correspondingly reduce payload. For example, 1,000 lbs. of structure have been added to the KC-135 to compensate for sonic damage. It is expected that the research and development enabled by this facility will make possible lighter weight fatigue resistant structures than the "patched up" designs which result when aircraft are fixed or "beefed up" to take the service encountered sonic pressures.

(U) Sonic Fatigue is recognized as a critical problem in the KC-135, B-58 and B-52G all of which will be in operational status for at least 5 years. Sonic damage is recognized as an important problem in electronic equipment. Therefore large equipment packages in missiles should be tested for possible malfunction in intense noise fields. Although contractors for both the foregoing aircraft and for missiles are making great efforts to compensate for this damage, the history of the problem indicates that testing carried out on small specimens in presently available facilities cannot assure adequate structural or equipment tolerance to intense noise. In addition the application of the Zero Launch concept to present aircraft will pose severe sonic fatigue problems. Service fixes for these remaining difficulties will result from knowledge obtained through use of this facility.

(U) For vehicles under design or to be designed in the future, the increased powers necessary guarantee an increase in the noise produced. To a certain extent the effects of this increased noise on structure is alleviated by selection of optimum configuration for the vehicle; however, the degree of alleviation by this means is limited and the structural design problem remains for reuseable vehicles in the following classes: high speed, high thrust aircraft; other weapon systems of the future which will use the sensible atmosphere in some degree during their flight mission, air to surface or air to air missiles which are carried for repeated flights before being expended. In the case of the Snark Missile, sonic induced vibration produced damage to equipment in the original design; thus, even for single shot missiles, sonic damage to electronic equipment is expected to cause major problems.

(U) Zero Time Delay Immediate Parachute Deployment Lanyard

(U) A survey of the use of the ARDC-developed zero time delay lanyard covering the period from 1 January 1958 through 30 September 1958 shows that there were 69 emergency ejections from USAF aircraft where the zero second deployment lanyard was available. In 24 of these ejections, the lanyard was attached at the time of the ejection. In this group, at least four fatalities were prevented by its use. Of these four, one was a successful ejection from an altitude of less than 100 feet. Another was a successful ejection at 450 feet from an aircraft diving at a speed of 390 knots. Of the total of 69 ejections, the lanyard was not hooked up in 45 cases. In this group, there were eight fatalities due to low altitude at the time of ejection. The majority of these, if not all, would have been saved had the lanyard been used.

(U) Aerodynamic Parameter Study

(U) The AEDC has recently completed an aerodynamic parameter study of various sphere-cone-cylinder-flare configurations for re-entry vehicles. This study was intended to provide useful design information on the advantages and disadvantages of various types of bodies, thereby aiding the vehicle designer in the choice of aerodynamic configuration. The successful attainment of this goal has been indicated by a letter from General Electric commenting upon the great contribution of this study to the aerodynamic design of the Mark 3 re-entry vehicle configuration and recommending more such studies in order to aid the rapid development of new weapon systems.

(U) RUNWAY OVERRUN BARRIERS

(U) Air Force activity in the Runway Overrun Barrier Program has resulted in the following changes:

a. The priority of the Runway Overrun Barrier Program has been increased from priority 1-B to 1-A.

b. The following aircraft are to be prototyped with an emergency arrester hook and flight tested to determine the acceptability of the hook installation and the performance degradation: F-106, F-102, F-101-B, F-100, F-105, F-101-A and C, F-86, F-84, T-33 and F-89. It has been emphasized that the hook installation should be light weight and simple in operation, and should impose minimum performance penalty. The acceptability of the installation on those aircraft programmed to remain in the inventory subsequent to the second quarter of FY-61 will be modified in order of priority as listed above. This has been designated a safety or flight modification (Class IV) by Hq USAF.

c. All existing MA-1A Chain Barriers are to be modified to provide the dual capability of an engaging aircraft by means of the MA-1A webbing adapter, and the hook and cable assembly, essentially in accordance with Navy Technical Order AER-SI-221 dated 27 August 1956. This modification will be performed at base level and will not require procurement of modification kits.

d. A quantity of 50 All American Model 340D water squeezer-type Energy Absorbers are to be procured using FY-59 funds. Installation at bases within the ZI will be accomplished by the supplying contractor. This energy absorber has been declared tentative standard by Hq USAF. These energy absorbers will be procured with rope retrieving systems and have the dual engagement device capability as described in c. above. The MA-1A chain energy absorber has been declared limited standard by Hq USAF and will no longer be procured.

e. A development program is under way in ARDC to test and evaluate the following energy absorbers:

1. E. W. Bliss Model 200D
2. Van Zelm Metal Bender
3. The improved MB-1 barrier
4. The improved AAE Model 340D water squeezer.

At the conclusion of this program, a final Air Force energy absorber will be chosen for quantity procurement on a competitive basis. This program is expected to be completed during FY-60.

(U) PROPULSION DIVISION

(U) Interservice Group for Flight Vehicle Power

(U) Late in 1957 the Ad Hoc Group on Guided Missiles Auxiliary Power Systems (Office of the Assistant Secretary of Defense - Research and Engineering) recommended the establishment of a joint service group at the project level to "foster the interchange of (secondary or auxiliary power) technical information, to eliminate undesirable duplication, to assure coverage of technical developments, and to direct development so as to lead to the formulation of standards." As a result of this recommendation and subsequent discussion among Army, Navy and Air Force representatives associated with the power program, planning meetings were held at the U. S. Army Ordnance Missile Command, Redstone Arsenal, Alabama, on 24-25 June 1958, at the Naval Research Laboratory, Washington, D. C., on 15-16 July 1958, and at Hq. Air Research and Development Command, Andrews Air Force Base, Maryland, on 15-16 October 1958. Representatives of the Army (USAOMC, ABMA, USASRDL, ARGMA), Navy (NRL, BuAer, BuOrd), Air Force (Hq ARDC, WADC, AFCRC, AFBMD), Department of Defense (OSD-GM, OASD/R&E, DCS/D) and the National Aeronautics and Space Administration (Washington, D. C., Hq) participated.

(U) At these three meetings, the organization and method of operation of a group to be known as the Interservice Group for Flight Vehicle Power were formulated and an agreement to formally establish the IGFVP was finalized. This agreement has now been coordinated and approved by the Office of the Secretary of Defense and the Departments of the Army, Navy and Air Force, and is currently being signed by the chiefs of research and development of each of the three military services.

(U) The objective of the IGFVP is to effect an informal exchange of information among the three services at a technical level for the purpose of improving non-propulsive flight vehicle power systems. The scope of the Group encompasses "all power required for a flight vehicle except propulsive power," including storage, extraction, conversion and delivery of this power.

(U) Implementation of the IGFVP objective will be effected by the Steering Group, which will establish, modify or discontinue Working Groups as required, prescribe Working Group objectives, recommend tasks and monitor Working Group activities. In addition, the IGFVP will foster symposia and encourage the adoption of joint technical requirements and standards by the three military services.

(U) The Steering Group has established Working Groups for chemical combustion, batteries, nuclear conversion, solar conversion, mechanical processes, electrical processes, and advanced methods to exchange information on all phases of power research, development, systems, and engineering. These Working Groups will collate such information at scheduled meetings, and informally between individuals at other times. They will also prepare periodical summaries outlining the national governmentally sponsored flight power efforts.

(U) Membership of the Steering Group will consist of nine members; three appointed by each of the military services. Working Groups will consist of the minimum number of members from the Army, Navy and Air Force, and other Government agencies, necessary to encompass the activities in the pertinent areas. Government observers and industry representatives may participate on an individual basis.

(U) The next meeting of the Steering Group is scheduled for April 1959. Steering Group contact members are as follows:

Air Force:
Major William G. Alexander (Chairman)
Hq Air Research and Development Command
Andrews Air Force Base
Washington 25, D. C.

Navy: Mr. Burton J. Wilson
Naval Research Laboratory
Washington 25, D. C.

Army: Mr. Arthur F. Daniel
U. S. Army Signal R&D Laboratory
Fort Monmouth, New Jersey

[redacted]

(U) Each Working Group is planning its first meeting during the period from January to March 1959. The Groups' initial objective is the compilation of a summary outlining the national governmentally sponsored research and development effort within each area, indicating type, nature, and objective of work, the sponsor, cognizant engineers or scientists, size of effort, and other pertinent remarks. Working Group Chairmen are indicated below:

Advanced Methods Working Group:

Mr. Edwin J. Callan
Wright Air Development Center
Wright-Patterson Air Force Base
Ohio

Batteries Working Group:

Mr. Charles H. Clark
U. S. Army Signal R&D Laboratory
Fort Monmouth, New Jersey

Chemical Combustion Working Group:

Mr. Joseph L. Browning
Naval Propellant Plant
Indian Head, Maryland

Electrical Working Group:

Mr. Burton J. Wilson
Naval Research Laboratory
Department of the Navy
Washington 25, D. C.

Mechanical Working Group:

Mr. John S. Keeler
Wright Air Development Center
Wright-Patterson Air Force Base
Ohio

Nuclear Working Group:

Dr. Russell D. Shelton
Army Ballistic Missile Agency
Redstone Arsenal, Alabama

Solar Working Group:

Dr. Norman Rosenberg
Air Force Cambridge Research Center
L. G. Hanscom Field
Bedford, Massachusetts

Directorate of Weapons and Guidance

[redacted] NUCLEAR APPLICATIONS DIVISION

(U) PROGRESS

(U) Applied Research Program During a Nuclear Test Moratorium

[redacted] The nuclear test moratorium presents the problem of improving the atomic capabilities of the Air Force without the benefit of full-scale tests. A vigorous program involving theoretical studies, laboratory experiments and field simulation tests has been initiated to fill the gap imposed by the test moratorium. In addition, plans for full-scale tests are being continued on the assumption that test operations may be resumed at some future date. The ARDC program is primarily concerned with weapon effects and applications, since the Atomic Energy Commission is responsible for the development of atomic weapons.

[redacted] Prior to the test moratorium, preparations for future test operations were already in the planning stage. [redacted] was scheduled for the Nevada Test Site in spring 1959, and [redacted] for the Eniwetok Proving Ground in spring 1960. The weapon effects test program for Operation [redacted] has already been approved by the Department of Defense. Formal proposals for the Weapon Effects Program for Operation [redacted] have been sent to the Armed Forces Special Weapons Project. The complete Weapons Effects package for [redacted] presented to the DOD for approval in early 1959. These test programs will be maintained as ready-to-go test packages during the test moratorium.

[redacted] The Applied Research Program during the moratorium will consist of an extension of the applied research normally conducted by ARDC in the Nuclear Warfare area. In addition to this vigorous theoretical program, a substitute must be added for the verification normally

[redacted]

provided by full test participation. It must be [redacted] field simulation experiments will be subject to certain limitations, since they will provide only a partial duplication of the nuclear environment, and the combined effects of all energies emitted from the nuclear detonation cannot be investigated. Recognizing these limitations a program covering the major areas normally investigated during full-scale test has been initiated. The [redacted]

[redacted] The Research Program outlined above will require an annual funding level of $10 million as compared to FY-59 funding of $4.7 million. These funds are exclusive of the cost of preparations for full-scale test participation or the cost of additional equipment and field simulation experiments which will be recommended as part of this program.

(U) Air Sampling Techniques

[redacted] In the past the AEC and Hq USAF have asked ARDC to develop air sampling equipment. To date ARDC has been successful in satisfying the operational requirements for both the AEC and Hq USAF because of the relatively low speeds and altitude capabilities of the aircraft involved. However, the ARDC does not now have the capability to satisfy air sampling requirements for future Air Force vehicles. To establish the technical feasibility and capability for accomplishing air sampling requirements with future Air Force vehicles, ARDC has initiated an applied research program.

[redacted] The Wright Air Development Center is studying new techniques and developing test components that may be applicable to accomplishing sampling of nuclear bomb debris under extreme environmental conditions and operational situations. The developmental program at WADC will be co-ordinated with the other governmental agencies conducting air sampling programs. The new ARDC research will result in an integrated and co-ordinated program that will improve future Air Force capabilities to accomplish sampling of nuclear bomb debris.

(U) Radiac Instruments

(U) A technical personnel dosimeter is being developed for use by selected Air Force workers in conjunction with work on nuclear powered aircraft or ground nuclear powered stations. It will be used to provide administrative control over individuals operating in the presence of nuclear radiation on a more or less routine basis to preclude excessive cumulative exposure. Delivery of a dosimeter that will read integrated doses of gamma radiation up to 5 roentgens is expected by 1960.

(U) The DT-60/PD phosphor glass dosimeter and the CP-95-A/PD computer indicator were developed to provide an emergency instrument to assist Air Force commanders to evaluate their casualties as a result of nuclear radiation from nuclear weapons. The technique is considered suitable for this purpose although research and development efforts are continuing to improve the present instrument reader combination. The Navy has completed a research program which has resulted in the recommendation for major modifications of the present DT-60/PD, and the replacement of the CP-95-A reader with a lighter weight, battery operated unit. It is anticipated that the AFSWC evaluation of the Navy recommendations will be completed by the latter part of 1959.

(U) A survival rate meter is being developed for use by air crew members who have been "downed" in a radioactive field. The dosimeter will provide information on the radiation hazard that will assist the air crew member to escape from enemy territory or to return to duty if downed in friendly territory. Delivery of a satisfactory instrument which will read up to 200 roentgens per hour is expected in 1960. If the accuracy is sufficiently good and the production costs low, this rate meter may be considered as a possible replacement for the AN/PDR-39 gamma meter.

(U) Nuclear-Bomb Propelled Space Vehicle

[redacted] On 1 July 1958, ARDC contracted with General Atomic Division of General Dynamics [redacted]

[redacted] The idea of using nuclear bombs as a means of propulsion for space vehicles or rockets was conceived at the Los Alamos Scientific Laboratory several years ago. Initial studies of the idea showed it was not feasible because there was no known method for the vehicle to absorb the tremendous energy from the bomb in a reasonably smooth, structurally tolerable pulse.

[redacted] Dr. T. B. Taylor, et al., of General Atomic conceived the idea of [redacted] tem as a means of transmitting the bomb pulse to the vehicle as a structurally tolerable impulse. Preliminary studies were made of this idea under a no-cost contract with the AEC. No insurmountable difficulties arose during this preliminary study, so General Atomic approached ARPA to request funds with which to continue and accelerate the feasibility study.

[redacted] The present concept of the nuclear bomb propelled vehicle is roughly as follows: [redacted] which are stored in the vehicle, are fired period- [redacted]

[redacted] The total mass of the vehicle including [redacted]

(U) The present study contract with General Atomic is due to terminate 30 April 1959. Whether or not the contract is extended depends on the results of the present contract. To date, no insurmountable technical difficulties have arisen.

(U) Atomic Test Proposals

[redacted] The technical program for [redacted] resentatives of Hq USAF, Hq ARDC, AFSWC, WADC, AFCRC, AFMDC, and the E. H. Plesset Associates, Inc., who are under contract to Hq ARDC, for the purpose of designing atomic test experiments.

[redacted] In general, the atomic test proposals were designed to obtain information [redacted] experiments were proposed for [redacted] quire approximately $72,000,000 of AFSWP funds, and were sent to Hq USAF by Hq ARDC letter, subject: (U) Project Proposals [redacted] Titles of the specific test proposals are as follows:

[redacted]

[redacted]

[redacted]

(U) SOUNDING ROCKET, [redacted]

[redacted] On the basis of certain atomic tests held in 1958, to confirm a theory [redacted] it was found necessary to [redacted] occurring. A five-staged solid propelled sounding rocket [redacted] capable of [redacted] was proposed by the AFSWC. Six firings are planned from Wallops Island, Virginia.

(U) The Air Material Command has received procurement authority for the program. Upon completion of arrangements with NASA for the use of the Wallops Island range, as well as for technical assistance of NASA, the rockets will be fired at the rate of one each month starting in June 1959.

(U) Conference on Electromagnetic Blackout

[redacted] A conference was held at AFCRC on 20-21 November 1958 to brief Air Force agencies and contractors on latest results of high altitude tests conducted during [redacted] The presentations were directed towards the system implications of high altitude nuclear detonations. These briefings covered nuclear effects on electronic systems, blackout theory, summary of project results and future test plans. The information provided Air Force contractors with inputs required to proceed with an evaluation of the impact of these effects on electronic systems.

(U) Bomb Alarm Network

[redacted] Hq USAF has directed Hq ARDC to proceed with all action necessary to establish a bomb alarm network so as to meet a target date for an operational bomb alarm system within the United States by 1 July 1960. At a meeting in Hq USAF on 22 January 1959, it was determined that Hq USAF would prepare a communications plan incorporating the locations of Bomb Alarm detector sites and central display units. Before detailed planning and cost estimates can be accomplished by ARDC a communications plan must be accomplished.

[redacted] Briefly, the bomb alarm network that is being considered by Hq ARDC consists of several nuclear bomb detectors located around primary target areas connected by wire and radio communication nets to several central display units. When installed, the bomb alarm network will be capable of furnishing, within seconds, unequivocal evidence that nuclear weapons have been detonated on or near specific target areas within the United States. It is important to point out that this network cannot be used to evaluate bomb damage, since the communication networks will undoubtedly be destroyed by the initial nuclear detonations.

[redacted] In conjunction with the installation of a bomb alarm network within the United States, a feasibility study will be conducted to determine the applicability of establishing a world-wide bomb alarm net.

(U) RESULTS

(U) [redacted]

[redacted]

(U) B-52 Participation [redacted]

[redacted]

(U) Simulated High Altitude Test

[redacted]

(U) Representatives of all the participating [redacted]

[redacted]

(U) Alpha Contamination Meter

(U) Hq USAF has established an Operational Support Requirement for an Alpha contamination meter, since the AN/PDR-10 Alpha counter was not satisfactory for Air Force use because of difficult maintenance and unreliability.

[redacted]

[redacted]

[redacted]

[redacted]

(U) Explosive Ordnance Disposal (EOD)

(U) The first Air Force Navy Explosive Ordnance Disposal (EOD) Management Review Conference was held on 4 November 1958. This meeting was set up by the Bureau of Ordnance, Department of the Navy, to aid in establishing policies to better support their DOD EOD R&D and training responsibilities. There were representatives from Hq USAF, Hq AMC, Ogden Air Force Base, EOD Tech Center and EOD School (Navy), and Hq ARDC.

(U) This was the first time ARDC has been called into this area since AFR 136-10 assigned EOD R&D responsibilities to the ARDC. Requirements are to be generated by the AMC which has the responsibility of providing EOD teams, world wide, to handle specific Air Force incidents. The Navy EOD Tech Center is extremely interested in working out a point in munition developments (nuclear, non-nuclear, and missiles), whereby they can develop EOD procedures and tools by the time items go into stockpile.

[redacted]

[redacted]

[redacted]

ARDC is initiating a product improvement program to incorporate an anti-materiel Mabfrag munition into the Mabfrag Weapon System. This new bomblet will be interchangeable with the present standard M-132 Mabfrag bomblet, is estimated to be up to 12 times more effective than existing anti-materiel munitions, is relatively simple and inexpensive and can be completed in one year at a cost of approximately $160,000.

(U) 20mm Ammunition

[redacted] The production of quality 20mm HEI ammunition by the Ordnance Corps has been at a virtual standstill because their inability to meet specifications. As a result, Hq USAF directed a review of quality control procedures and specifications to determine the waiver action which could be granted to increase the production of quality ammunition in the event of wartime expenditures. A meeting was held in the Office of the Chief of Ordnance with representatives from USAF, ARDC, AMC and the Ordnance Corps in attendance. Based upon test firing of ammunition produced since resumption of production through selective assembly, and based upon reduced effectiveness that could result from accepting ammunition that does not meet specifications relative to prematures, duds, accuracy, pressure and velocity the following conclusions were reached: A. A satisfactory round is presently being produced and the capability to continue to produce satisfactory ammunition is now considered to exist; B. The Air Force quality assurance program will show the unsatisfactory lot or lots that may be manufactured; C. Blanket waivers of the specifications or quality control procedures would not necessarily increase the production of quality ammunition in the event of wartime expenditures; D. A procedure for as soon as possible processing waiver consideration or individual lots (approximately 50,000 rounds), that do not meet specifications has been agreed to with the Ordnance Corps. The Ordnance Ammunition Command will forward data on such lots to OOAMA with information copy to the APGC; E. Continuity of production will enhance the quality of the final product.

(U) Self-Destruct Fuze for 2.75" FFAR

[redacted] The requirement for a self-destruct fuze for the 2.75" Aircraft Rocket was recently cancelled. This action was based on recent difficulties encountered in obtaining a satisfactory fuze in the time period required. Even the simplest approach to obtain a "fix" eliminating the difficulties would not place the item in stockpile prior to the time the using aircraft phase out of inventory.

(U) Radiation Weapons

(U) The Advanced Weapons Division initiated a Radiation Weapons program during the quarter to determine the lethal effects of coherent electromagnetic radiation. A new technical requirement, TR 254-58, has been published with the Rome Air Development Center designated as the responsible Center.

[redacted]

(U) PROGRESS

(U) Defensive Anti-Missile System (DAMS)

[redacted] As the threat to strategic aircraft shifted

[redacted]

[redacted]

from gun and rocket firing interceptors to missile firing interceptors, with their increased standoff range, it was determined that a new concept for actively defending an airborne vehicle was necessary. The result was a development known as the Defensive Anti-Missile System (DAMS), which was intended to destroy AAM and SAM rather than the platforms from which they were launched. The Crosely Division of AVCO has been working on this concept for approximately eighteen months and has completed Phase II of a planned development program. The progress of this program was reviewed by Command representatives at Hq ARDC on 2 and 3 December 1958.

[redacted]

[redacted]

[redacted]

(U) Computer

A digital computer weighing 850 pounds

(U) System

System total weight would be 10,000 pounds

P_k (against a single attacker) = .95

(U) Study and Investigation of Matched Filter Techniques

[redacted] This program which is being conducted by the Air Arm Division of Westinghouse Electric Corporation consists of study, analysis, and experimentation to determine the applicability of matched filter pulse expansion-compression techniques to airborne interceptor radar. It is expected that the techniques will provide a significant improvement in detection and interception capabilities against supersonic airframes of small radar cross sectional area.

[redacted]

[redacted] All of the circuits required, but the time circuits, to incorporate the MTI feature in the system have been completed and initial unit tests have been made.

(U) High Altitude Radar Performance Tests

(U) Photographs of a conventional plan position indicator radar presentation, depicting topographical and cultural characteristics, of the earth's surface were taken from an altitude of 97,000 feet during December 1958. This function was accomplished by means of an instrumented pressure sealed gondola attached to an unmanned two million cubic feet free balloon vehicle. Preliminary analyses of these radar presentation photographs has extended the limited knowledge of radar characteristics at altitudes considerably above the current operational level.

(U) Stratosphere flights of this nature will be continued on a limited scale to obtain factual data descriptive of low power, "X" band radar capabilities required for future radar map-matching operation. Applied Research radar map matching effort is being conducted within the 730D Navigation and Guidance area under Project 4144, Airborne Radar Guidance Techniques.

[redacted]

[redacted]

(U) All-Mechanical Flight Control System

(U) As aircraft technology has advanced rapidly in the past few years the mechanical flight control system has been replaced first by electrical and then hydraulic control systems. This progression was a direct result of the increased size, weight, power, and response requirements imposed upon the flight control system.

(U) An unsolicited proposal submitted by Curtis-Wright Corporation has resulted in a contract for a new approach to the mechanical flight control system problem. The proposed system should answer many of our current and future environmental problems in addition to being smaller, lighter, more reliable, and possessing increased response when compared with our present systems.

(U) The proposed system operates on the principle of transmitting power through high r.p.m. and low torque. It incorporates a mechanical servo (using spring clutches), light weight high r.p.m.-low torque shafts, and epicyclic gear actuators. Components of this system can be used, with comparative savings in size, weight and increased reliability, in other aircraft subsystems; such as, landing gear, flaps, and speed brakes.

[redacted]

(U) THE ARGONNE LAW POWER REACTOR (ALPR)

(U) A 200 KW electrical output boiling water reactor power plant, is currently operating at

[redacted]

[redacted]

the Idaho Testing Station. This nuclear power plant is a prototype of stations for DEW line application.

[redacted]

(U) GROUND SUPPORT AND FACILITIES

[redacted]

[redacted]

[redacted] STATUS: On 31 October 1958 Convair and Lockheed submitted competitive proposals for two developmental aircraft that would be proto- [redacted] source selection evaluation was conducted and the results presented to the Air Staff. As of this date no announcement of the selected contractor

[redacted]

has been made. The current program consists primarily of propulsion system development with a small effort devoted to nuclear research and aircraft design studies. In event of a decision to develop an aircraft, the airframe contractor could have the aircraft ready to fly 30 months after go-ahead. All components of the CAMAL system for which ARDC is responsible could be developed so as to yield an operational system in 1967.

Directorate of Geophysics

(U) APPLIED RESEARCH IN METEOROLOGY

(U) General Circulation of the Earth's Atmosphere

(U) Considerable effort has been devoted in recent years to the study of the general circulation of the earth's atmosphere. The aim of these studies is to develop a theory which would provide a complete description and explanation of the global distributions of the meteorologically significant atmospheric properties.

(U) The equations which express the fundamental laws for fluid systems such as the atmosphere are extremely complicated and cannot be solved analytically without drastic simplifications. High speed electronic computers have recently made it possible to solve such systems of equations by finite difference numerical methods.

(U) Through work done under Project 8626 the first successful solution of this kind has now been accomplished. It has shown that the gross features of the global circulation can be deduced from the fundamental laws given only crude representations of the essential physical parameters. In addition, it has confirmed some basic observations concerning the role of the large-scale eddies in maintaining atmospheric motion against friction and in satisfying the atmospheric balance requirements of heat and momentum. This initial "theory" is being refined, eliminating some of the arbitrary constraints and improving the manner of representing the basic physical parameters. A complete theory of the general circulation is not yet available, but progress has been made.

(U) Numerical Weather Prediction

(U) It has been the aim of workers in the field of numerical weather prediction to successfully solve the primitive equations by numerical methods.

(U) The primitive equations are the three equations of motion, the equation of continuity, the First Law of Thermodynamics, and the equation of state. The first five equations are first order partial differential equations, the last is an algebraic equation. First order partial differential equations are in principle simpler to solve than equations of higher order. The primitive equations contain as solutions, motions, such as gravity and sound waves, which are meteorologically unimportant. Until recently these non-meteorological motions tended to obscure the meteorological motions when numerical computations were made. Therefore, many ingenious filters, such as the geostrophic and hydrostatic approximations, were introduced into the equations to eliminate the non-meteorological motions. These filters made it possible to obtain meteorological motions from the equations, without taxing the capacities of the machines then in existence. The price paid for this success was that the governing equations became third order. These equations carried their own numerical problems with them, and much of the work during the last ten years has been concerned with various modifications of these higher order equations in order to yield more correct meteorological motions.

(U) Very recently, under Project 8628, contract with Professor Heinklemann, it was found by the Numerical Weather Prediction Group of the German Weather Service that the numerical solution of the primitive equations is very sensitive to the type of finite-difference scheme used. It is all important that the finite-difference equations resemble the differential equations as closely as possible. For example, since the differential equations of motion express the conservation of momentum, so should the finite-difference equations. When the finite-difference equations were set up in such a way that momentum was conserved, successful predictions from the primitive equations followed. Of course, small time steps were used in order to guarantee stability, but this no longer involved storage problems, since machines have increased tremendously in capacity.

(U) The way has now been opened up for investigation of many meteorological problems by means of the relatively simple primitive differential equations. This appears to be a very significant advance in the field of meteorological research.

(U) Hurricane Balloon Program

(U) The Hurricane Balloon feasibility study, Project 7776, Task 67642, has been extended through the 1959 hurricane season. The analysis of tests conducted during the 1958 hurricane season provided a promising but inconclusive assessment of the theory. The program objective is to determine the feasibility of maintaining an instrumented balloon within the "eye" of severe tropical weather disturbances. If balloons can be maintained within these storms, the development of an operational device for the tracking of such storms over great distances will be feasible.

(U) The testing involves the release of suitable instrumented balloons within the "eye" of hurricanes. The balloon launcher is delivered to the eye center by aircraft, dropped, and the release proceeds. The balloon launching and release is performed automatically using a device containing the balloon, instrumentation payload, lifting gas source, and the necessary timing and inflation controls. Upon inflation, the balloon seeks an equilibrium altitude. The position of the balloon is determined at intervals using aircraft borne UHF direction finding equipment in conjunction with the balloon-borne transmitter. At the same time the parameters affecting balloon flight are measured, telemetered, and recorded by aircraft borne instruments.

(U) A minimum of six aerial drop tests in hurricanes are planned for the 1959 hurricane season.

Directorate of Installations

(U) P-341 Minor Construction Program

(U) Hq USAF made available $1,100,000 for the accomplishment of FY-59 P-341 Minor Construction Projects. Thirty-nine (39) P-341 Minor Construction Projects have been approved for accomplishment and funded in the amount of $562,000. Twenty-nine (29) additional P-341 Minor Construction Projects estimated to cost $977,000 have been recognized as operational requirements and are in various stages of preparation for approval, making a total program of $1,539,000. This constitutes a program twenty-five percent larger than funds presently available, which is normal.

(U) FY 59 Military Construction Program

(U) During this quarter funds were apportioned for construction of 21 ARDC projects valued at $16,631,000 and 12 tenant command projects valued at $3,532,000 at the various ARDC installations.

(U) FY 60 Military Construction Program

(U) At the beginning of this quarter, the Air Force forwarded its FY 60 MCP request to Department of Defense. The defense reviews are essentially complete and it appears that the ARDC portion of the FY 60 MCP will be essentially as follows:

CENTER	NO. OF ITEMS	COST ($,000)
AEDC	7	7,178
AFFTC	6	3,323
APGC	2	382
AFMDC	9	7,742
AFSWC	3	797
AFCRC	8	2,615
AFMTC	8	2,462
WADC	3	9,840
RADC	0	0
Totals	46	34,339

(U) Master Planning

(U) During the past quarter, work progressed on the Master Plans for Edwards AFB, L. G. Hanscom Field and Arnold Engineering Development Center.

(U) The first phase of the Load Evaluation Tests of Rogers Dry Lake, Edwards AFB was completed. This phase consisted of test borings, test pits and laboratory tests.

(U) X-1 Test Stand - Edwards AFB

(U) Edwards AFB. Construction of test stand facilities for the X-15 were completed during October 1958 after a seven month construction period. The responsibility for both design and construction was assigned to ARDC.

(U) AFMTC - Azusa Requirements at Eluthera and Cape Canaveral

(U) On 17 November 1958, Hq USAF directed termination of construction of the Azusa facility at Eleuthera, Patrick Aux #4. Further, on 3 December 1958, Hq USAF approved for design a 6,512 sq. ft. Mark II Azusa facility at Cape Canaveral, with existing Eleuthera plans to be site adapted to Cape Canaveral. These two actions were taken in compliance with ARDC request. Design is being expedited on the Cape Canaveral Azusa.

(U) AFMTC - Submarine Cable Extension to Antigua

(U) Status of the Project is as follows:

a. A contract with Western Electric Co. was signed 17 November 1958, providing for design, engineering and development as necessary to extend cable communications from Puerto Rico to Antigua. This contract does not include provision of hardware, cable or installation and totals $516,447.

b. The Range Contractor has been directed to proceed with the hydrographic survey of the cable route. Two survey crews are at work locating geodetic control, cable landing sites and LORAC sites. The Range Contractors work is estimated at $185,000. The U. S. Navy Hydrographic Office has estimated the cost of their participation at $54,000.

c. Preliminary design criteria for the cable terminal buildings, at Antigua and Puerto Rico, have been prepared and are in the process of coordination with Western Electric.

(U) APGC - Model III Bomarc Launcher Shelter

(U) Construction of this facility at Santa Rosa Island, Eglin AFB, is substantially completed except for certain modifications which have been requested and for which a sum of $15,000 has been cited by Hq USAF.

(U) Facilities for Frequency Diversity Radars Operational Service Test Sites

(U) FPS-24 Radar Equipment Building, Eufaula, Alabama. Construction of equipment building 30% complete as of 10 December 1958 (Beneficial Occupancy Date scheduled 1 January 1959.)

(U) FPS-35 Radar Tower, Thomasville, Alabama. Construction 13% complete as of 3 December 1958. (Beneficial Occupancy Date scheduled 1 May 1959.)

(U) FPS-28 Radar Equipment Building, Houma, Louisiana. Design nearing completion. Construction scheduled to commence 1 February 1959. (Beneficial Occupancy Date scheduled 1 June 1959.)

Directorate of Life Sciences

(U) USAF Uniform Assemblies

(U) The Shade 193 Silver-Tan summer service uniform will continue as the required uniform for officers in 1959 and 1960. Industry and all other interested parties will be advised in December 1959 if any change in the summer uniform is intended for the summer of 1961. Meanwhile, the Shade 84 Tropical weight uniform continues in service test status and may be worn only on such a basis.

(U) Drug Control of Cardiac Failure During Cold Water Immersion

(U) Results of extensive past research on the use of various drugs for the control and prevention of cardiac failure which may be induced by emergency immersion of Air Force crew members have been summarized. They are being prepared for publication as a technical report. A total of over 30 compounds of widely differing types (antimalarials, antihistaminics, and glycosides) have been evaluated in tests involving over 500 experimental animals. By using a quantitative assessment method for determining each drug's effectiveness and applying statistical methods for screening the potentially useful compounds, three promising protective drugs have been revealed. These are methapyrilene, chloromethapyrilene, and antazoline. Further studies of the relative protection provided by these compounds during rewarming as well as during immersion cooling are in progress.

(U) Human Tolerance to Transient High Temperatures

(U) Individuals in summer flying clothing have been exposed to a series of thermal transient conditions, the most severe having a peak wall temperature of 432°F. These conditions produced only moderate stress in the subjects. Waveform of the transients consists of a 100°F per minute rise to peak temperature, followed by an exponential decay with initial slope on the order of 75°F per minute. Air within the 4-foot-cube test section is heated by the walls through natural convection with a peak temperature above 300°F.

(U) Work is continuing with the objective of establishing limits useful in the design of vehicle cabin emergency cooling systems, where appreciable savings in weight may result.

(U) Trainer, Flight Simulator, B/RB-58A Aircraft, Type MB-32

(U) A contract was awarded on 15 April 1958 to Link Aviation, Inc., Binghamton, New York, for design, development, and prototype production of an RB-58A Aircraft Flight Simulator.

(U) This simulator is considered unique in that (1) the flight simulator will be capable of being functionally interconnected to the B-58 Bomb-Nav and Defense Operator Station Trainers, thus providing the first integrated Bomber Crew Trainer, (2) for the first time in production design of U. S. Air Force Aircraft Flight Simulators, a computer and function generator are being designed into the equipment using analog to digital, digital, digital analog techniques for simulation of engines of the B-58 Aircraft.

(U) The use of digital function generators to be utilized in this simulation will permit the Air Force to exploit in a limited degree the advantages of digital computation in flight simulation. The digital function generators to be utilized in this simulation will permit new data to be easily stored so that changes in functions to be simulated may be accomplished in a routine, simple manner requiring no design changes. The digital computer will perform linear interpolations between stored coordinates of functions of one, two, or three variables. The coordinates of these points for every engine function to be generated will be stored on a magnetic drum.

(U) At the present, the contractor is proceeding with this system, limited to engine simulation, in the B-58 Flight Simulator. It is anticipated that the flight simulator will be completed during the last quarter of 1959. Procurement of the simulator has recently been modified so that follow-on procurement will be Category I as will procurement of the Defense Operator Station Trainers and Bomb-Nav

Trainers. This change was deemed desirable in order to insure compatible interconnected operation of the Flight Simulator Bomb-Nav and Defense Operator Station Trainers.

(U) Development of Training Design Guide

(U) The timely and appropriate establishment of training provisions (procedures, materials, devices, facilities) during weapon system development has been a problem for some time. Recently, the development of a guide was undertaken at WADC for a twofold purpose. First, an effective methodology for applying the scientific principles of training to weapon system design needed to be established. Second, guidance to weapon system designers for applying these principles was necessary.

(U) The guide is based on the premise that weapon and/or supporting systems fulfill their mission as a result of proper performance by man and machine. Hence, an optimum system design must be based on man and machine characteristics as design parameters. Also, if an efficient system is to be created, the development process must allow training provisions and operational system design mutually to influence each other. It is anticipated that as a result of the guide, the capability for providing future weapon systems with trained personnel will be very much improved, since full advantage will be taken of the state-of-the-art. The guide will become available as a WADC Technical Report during the latter part of 1959.

(U) A System for Classifying Tasks

(U) A scheme, or possibly alternative schemes, for classifying tasks and relatively homogeneous segments of job activities is now under development. The classification is intended as an aid to organizing information on training conditions. Since rules or principles of learning may apply in one kind of task situation but not in another, it is desirable to organize tasks accordingly. As a result, both decisions on further training research and application of specific training principles can be more efficiently made. The task classification may also suggest a useful rubric for the analysis of job activities.

(U) This work is being performed both in-house and on a contract monitored by the Training Psychology Branch, Behavioral Sciences Division, Aero Medical Laboratory, Wright Air Development Center. Professor Lawrence M. Stolurow, a former Air Force psychologist now at the University of Illinois, is the Principal Investigator on the contract.

(U) Man-Machine Systems Design Methodology

(U) Under high traffic loads in a Radar Approach Control Center (RAPCON), two or more operators may be assigned parallel functions which are carried out simultaneously. In such instances how should the job be divided between the two paralleled operators? In WADC TR 58-473, "Load Balancing and Procedural Flexibility in a Two-Man Radar Approach Control Team," J. S. Kidd and J. J. Hooper report a study (carried out on the Ohio State University electronic radar simulator) in which performance was evaluated under three methods of aircraft assignment and two levels of restraint on the option of exchanging control responsibility during the approach. The three assignment methods were (a) Sector Control (assignment on the basis of point of entry into the system), (b) rotation control (one operator takes the first aircraft, the other operator takes the second, etc.), and (c) destination control (aircraft bound for one of the two available landing fields were always given to the same controller).

(U) Restraint conditions were (a) partial (control of aircraft could be exchanged only after traversing the first 30 miles of the 50 mile radius control zone), and (b) no restraint on exchange of control of a given aircraft.

(U) Results indicate that destination assignment (all aircraft for a given airfield always handled by the same controller) and freedom to transfer control responsibility at any time or place in the control zone yielded superior system performance.

(U) Man-Machine Systems Design Methodology

(U) Are two heads better than one in the accomplishment of a complex, decision-making task? Is two-man coordinative behavior distractive or does it help to prevent errors? Kinkade and Kidd have attempted to answer these questions using an operational game based on air traffic control. WADC Technical Report 58-474, recently received from The Ohio State University Research Foundation, gives details of the experiment. The three conditions investigated were (1) one operator working alone, (2) two operators working together without communication, and (3) two operators working together with communication. Over-all task load was the same for all conditions.

(U) Results show that: (1) a two-man team required significantly less time to complete the problem than did a man working alone, (2) no significant difference exists between the number of separation errors (collisions) made by individuals and two-man teams. When a comparison is made on an individual basis (performance divided by the number of team members) the person working alone is substantially superior. Increasing the number of workers in a complex task does not result in a proportional increase in performance. The explanation proposed is that the nature of the task is changed by adding team members in that each member is required to divide his time and attention between the primary demands of the task and coordination with other team members.

(U) Quick-Donning Pressure Suit

(U) The history of pressure suit development in the USAF has been one of requirements demanding physiological protection at higher altitudes for longer periods of time. In conjunction with this, the necessity of mobility and comfort has taken on more importance. The accomplishment of both of these features in one garment has been extremely difficult.

(U) The latest development in pressure suits has been the quick-donning, short term, emergency, CSU-4/P garment. This get-me-down garment is designed to provide physiological protection at 70,000 feet for 5 minutes. Successful tests have been completed in the low pressure altitude chamber at the Wright Air Development Center which show the garment fulfills these design requirements.

(U) The CSU-4/P is a full bladder garment,

incorporating the following advantages:

a. Quick donning. This is made possible by way of a single, front opening zipper.

b. Minimal bulk in the unpressurized state (see pictures).

c. Loose fitting (see pictures). Increased comfort is a result of the loose fit. This feature permits an eight-size range which will accommodate the Air Force flying population.

(U) Ordinarily a lightweight flying suit would be worn under this garment. The CSU-3/P anti-g-suit may be worn under this suit if required.

(U) A service test quantity of 50 garments will be purchased with money being reprogrammed by Hq USAF. These garments will be sent to SAC units at Carswell AFB, Texas as well as ADC and TAC organizations for testing.

(U) Parachute Jump Testing

(U) Parachute jump testing is an integral part of the standardization procedure in the development of many items of personal equipment for pilots and other aircrew members. Static line jumps and free fall delay jumps are both performed depending upon the type of information desired.

(U) During 1958 a total of 57 jumps were performed by experimental test jumpers within the Aero Medical Laboratory at Wright Air Development Center. These jumps included 21 static line jumps, 27 free falls over land, and nine free falls over water. Items jump-tested included experimental flying boots, contractor furnished survival kits, MH-1 back pack life rafts, experimental flying helmets, partial pressure suits, experimental life preservers, and experimental pneumatic kidney pads.

(U) Each jumper is required to complete a jump test form wherein he reports on the equipment jump-tested. As a result of this procedure the project engineer has a written record of the jumpers' recommendations in order that he can take appropriate action.

Directorate of Physical Sciences

(U) RESEARCH ON CRYSTAL GROWTH

(U) Advances in Crystal Growth

(U) Dr. Dan Trivich of Wayne State University, while working on an AFOSR contract, has succeeded in growing single crystals of cuprous oxide, 1 to 15 mils thick and around 1" x 1-1/2" in size. This was accomplished by annealing polycrystalline sheets formed by oxidizing thin sheets of copper. These single crystals should prove of value in the study of oxide-type semiconductors, since they will permit a separation of the properties dependent on the inherent nature of the oxide crystal. The techniques of preparation of these thin sheet crystals should be useful to researchers who need such crystals for catalysis, adsorption and similar surface chemical studies.

(U) Whisker Research Proves Importance of Surface Smoothness

(U) A typical iron "whisker" is four microns in diameter and about one centimeter long. Filamentary crystals or whiskers have been of scientific interest during the last two hundred years, but only in recent years was it recognized that they possess unusual strength and magnetic properties. Renewed interest followed the discovery in 1952 that tin whiskers were found to have tensile strengths close to that predicted for perfect crystals. Since that fundamental discovery much work has been carried out studying the growth and properties of whiskers with hope that more of the theoretical strength could be realized in structural metals.

(U) Recently basic research in the Materials Laboratory, WADC, has made a major contribution to the understanding of the part the surface plays in the phenomenal strength of these filaments. By coating iron whiskers with a nickel layer about 10 atoms thick, tensile strength was increased by a factor of two. These studies indicate that the extremely high strengths of whiskers result not only from a decrease in dislocation density but also from surface effects, a point previously in question. Technologically it is of importance to know the basis of whisker strength, for only through an understanding of the solid state properties involved is there hope for realizing these high strengths in larger samples and ultimately in structures.

(U) New Furnace Advances Silicon Carbide Research

(U) Dr. George Smiltons, Materials Sciences Laboratory, AFCRC, has developed a new furnace for growing single crystals of silicon carbide. Silicon carbide has shown promise for use in semiconducting devices which theoretically should operate at temperatures as high at 700° C. Special problems are associated with the growth of ultrapure silicon carbide single crystals. Foremost among these are vaporization and decomposition of the material. The new furnace developed in the laboratories of AFCRC has special heat shielding which provides a uniform and stable temperature gradient over the heat zone. This furnace will permit the growth of larger single crystals than is presently possible, and is a substantial contribution to silicon carbide technology.

(U) Synthesis of Silanes Made Safer

(U) In 1955 the Chemistry Department of the Aeronautical Research Laboratory, WADC, reported the synthesis of a new class of silicon-containing polymers. Chemically, they are named perarylated silanes and contain only silicon atoms and aromatic rings. These compounds are more than a scientific curiosity because they have a high degree of thermal stability and inherent resistance to nuclear radiation through internal resonance. These two attributes make this class of inorganic polymer a likely candidate for further development into materials for use as power transmission fluids, lubricants, and possibly as dielectric coatings. The laboratory methods first used in synthesizing these compounds were extremely dangerous because of the likelihood of explosion and fire. Recently the synthesis method has been modified and made safer by using different solvents and extraction processes. Pilot plant quantities have been produced. The availability of this new synthesis method should stimulate applied research on these unusual compounds and speed the day when they are used in components and future weapons systems.

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(U) AN INFORMATION SYSTEM FOR CURRENT ARDC TECHNICAL EFFORTS

(U) The ARDC Management Council has recently approved an information system for active ARDC technical efforts. This system is designed to furnish information to the ARDC staff offices, the centers, governmental agencies, universities, industry and other qualified users of current ARDC technical efforts within hours after receipt of a request. Because of the enormous size and complexity of the ARDC R&D program, the job of identifying, reporting, storing and retrieving information is overwhelming. Within the approximately 9,000 contracts in our R&D effort, 15,000 or more current technical efforts exist. Unfortunately, very little of this information is readily available, and the effort currently involved in locating it is costly in terms of manpower, time and money.

(U) Behind each completed weapon system is a large fund of scientific efforts and even larger quantities will precede each future weapon. The ability to make maximum use of our scientific knowledge will greatly aid our program and help keep us ahead in the race for technical superiority. Technical information is also a necessary part of the intelligence used to completely evaluate and resolve management problems. In the Research Program, the Office of Primary Responsibility (OPR) maintains files of R&D technical efforts which are kept up to date and furnish the source for current data needed in making management decisions. However, many man hours are necessary to maintain these files, and unless the location of this knowledge is known and requested, the information is available only to that one office. In the Development Program, on the other hand, not all of the technical efforts are closely monitored. This is because such efforts are contained in prime contracts, subcontracts, sub-sub contracts, and sub-sub-sub-..... etc. It is physically impossible for the Development Program staff to keep cognizant of the entire technical effort. A good example was the recently cancelled Navaho program in which about $300,000,000 was spent on 280 projects on state-of-the-art development in the areas of propulsion, aeronautics, flight control, guidance, automatic systems and materials. Unfortunately, only a small percentage of this program was easily available to ARDC scientists.

(U) The technical information system to be put into use in the near future will provide for each research or exploratory effort by a scientist to be reported and stored within a five-day period. Requests for information will be handled on a fast-retrieval basis; that is, the request will be filled within a one-to-eight hour period depending upon its complexity. The operation of the system involves identifying the technical effort, reporting the information, electronic data processing, and, finally, retrieving the information.

(U) The identification is to be done by the chief scientist actually performing the technical effort. He will prepare a brief, coded description of the primary and the related technical efforts using the technical areas and words contained in a specially prepared and furnished ARDC scientific vocabulary. This information plus the chief scientist's name, the number of assistants, the contractor's name and the contract number will be entered on a data record card preprinted in accordance with ARDC instructions. This record will be mailed to the electronic data processing system (EDPS) at Hq ARDC. The EDPS will process the information for storage and forward the record to the OPR in Hq ARDC, who will review the record for correctness and return it to the EDPS for filing. The retrieval cycle in the EDPS will be initiated by a request from the user (Hq ARDC, Centers, Government agencies, industry, etc.) to the OPR at Hq ARDC who, after approval, will forward it to the EDPS for data processing. After the request is processed, the output result or answer, in printed form, will be sent directly to the user.

(U) GEOPHYSICS (804A)

(U) NEW RADIO TELESCOPE COMPLETED

(U) Construction was completed in October on the new 84-foot radio telescope of the Propagation Sciences Laboratory, Electronics Research Directorate, AFCRC. This telescope, located at Sagamore Hill, near Hamilton, Mass., is one of the largest such telescopes in the country, and will become a basic tool in ERD's growing space research program. Studies of immediate interest concern an investigation of earth-moon-earth communications, atmospheric refraction and regions of galactic noise. (Galactic noise represents the background against which ICBM's must be detected and could represent a limiting factor in ICBM detection.) The telescope is similar in design to the 84-foot radio telescope recently placed in operation by the Naval Research Laboratory. It is equatorially-mounted, which means that the rotation mechanism is geared to the apparent once-a-day revolution of all the stars about the North Star. The apparent rotation rate of all stars is therefore constant; once the antenna is fixed on a given star, the telescope will continue to track that star. Although operation was originally scheduled to begin in November, design and construction problems have resulted in a two month's slippage in the program.

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BASIC RESEARCH on PROPULSION

By Captain R. S. Berrier, USAF

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(U) The purpose of this article is to review the basic research program in the Propulsion Area, 801A, although some space will be devoted to a brief discussion of the entire Basic Research Program.

(U) The program in the propulsion area is divided among 10 projects and some 190 contracts, in addition to which there are 15 internal efforts at various centers. It is the policy of the Air Force to do basic research where the capability for research exists. Most of the funds in the propulsion area go to the Office of Scientific Research which monitors research contracts. The centers that do in-house research are also allotted funds in order that they may supplement their in-house work with contract research.

(U) In the basic research program, the counterparts of the Technical Program Planning Documents (TPPD's) are the Research Planning Objectives (RPO's) for the six basic research program areas. These differ somewhat from the TPPD's, in that they are in no way directive but instead attempt to provide guidance to Air Force, university and other scientists for planning research of interest to the Air Force. The RPO's were prepared by leading scientists from the various ARDC Centers who were working in the fields covered by the RPO's, so that the guidance which is provided represents the best technical judgment available within the command. These documents are revised as necessary at inter-center coordination meetings held for the respective areas annually. Two of these meetings have already been conducted, and it might be construed as a tribute to the authors of the original documents that there so far have been no real changes proposed. In the form of a brochure, "Basic Research in the Air Force," 10,000 of these RPO's have been distributed to universities, independent research organizations, industrial concerns—anyone that we feel has a capability to do basic research.

(U) Before going any further, I might try to define "basic research." A purist would probably define it as "A search for knowledge—just for the job of knowing something that had not been understood before without necessarily having any application in mind." In practice though, anything we do in the Air Force has to be justified to somebody, usually several somebodies. Ordinarily, these people want to know how the knowledge that may be gained could be put to use to produce or to improve an Air Force weapons system. Because of this bias toward practicality or applicability, the basic research program is divided into six areas named Propulsion, Materials, Electronics, Geophysics, Biosciences, and Mechanics; instead of being divided into the scientific disciplines such as physics, nuclear physics, mathematics, chemistry, and others. Of course, each of these basic research program areas can be and is subdivided into such scientific disciplines. Our largest effort is in the area of combustion dynamics, which might be expected from a propulsion program. The study of propulsion embraces many scientific disciplines, and some of these divisions represent combinations of the others.

(U) The RPO divides the propulsion area into

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four scientific areas of interest to the Air Force, i.e., energy sources, energy release and transformation, energy conversion, and experimental and theoretical techniques. Each of these areas comprise efforts in the various scientific disciplines. Let's now discuss each of these areas of interest in turn.

(U) Energy Sources

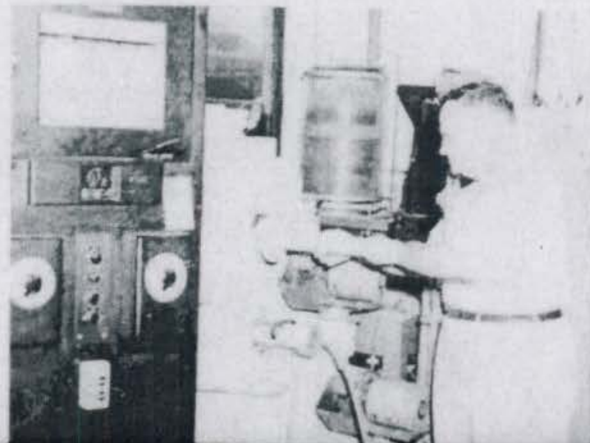
(U) Research on energy sources must provide knowledge needed for the exploitation of known sources of energy; e.g., the sun is an almost inexhaustible source of energy—but how can it be used for propulsion? New sources of energy must be discovered. For example, can we get energy from the magnetic field of the earth? (Actually this is a poor example of new sources of energy—we know it's there.) Some thirty years ago we didn't know that it was feasible to derive energy from atoms splitting up into little atoms: namely, the fission process. At that time this would have represented a new energy source. Under energy sources, we are studying high energy chemical bonds. Chemical energy is a familiar example to all of us—a match represents a source of energy: its energy is stored as chemical energy. Another example of chemical energy is the energy stored in the gasoline in our automobile tanks. The need here is to find chemical sources that will yield us more energy per pound than these sources that we already know about. In this line, studies of reactions in the high temperature arc at the Vitro Laboratories have yielded basic information leading to possible new and improved methods for the synthesis of high energy fuels. Vitro believes that they have succeeded in producing decaborane (a very high energy fuel in energy per pound) by suddenly quenching a very high temperature stream of vaporized boron in an atmosphere of hydrogen. This represents a much cheaper, safer way to produce fuels from boron than the present method. In the way of new energy sources, Vitro proposes the possibility of quenching a high temperature beam of ions composed of seven hydrogen atoms attached to one lithium atom. If this is possible, we will have a chemical fuel of unheard of energy per pound. It doesn't do as much good to get high energy fuels if we can't contain them, if they eat through their containers, or if they are too thick to flow through our plumbing or if they blow up when you look at them. So, we have to undertake to find out what are the properties of our present and proposed energy sources.

(U) Since a fusion reaction produces some one-to-ten million times the energy that a chemical reaction produces and a fission reaction produces many times the energy of a chemical reaction, we are studying fusion and fission reactions as a means of propelling vehicles. Also, in the nuclear field we are studying the structure of matter in general in order to understand the complex interactions necessary to change energy from one form to another; namely, from an unusable form to a usable form.

(U) Energy Release and Transformation

(U) A gallon of gasoline, the sun, a chunk of uranium, or the magnetic field of the earth, as such, are not effective for propulsion unless we can first release their stored energy. For the gallon of gasoline, this is easy—all we have to do is to light a match to it and its chemical energy is released in the form of heat. Other energy sources are a little more difficult to deal with. For example, we know that if we could make 2 hydrogen atoms combine into 1 helium atom that a lot of energy would be released; but how do we do this and avoid having a hydrogen bomb? Another type of energy available to us for propulsion is the energy of the sun: it's there, but what do we do with it? An example of the work that has been done in this area is the research at WADC which resulted in the development of a CdS photovoltaic cell (see figure 1). This cell

FIG. 1 Research is conducted in the Aeronautical Research Laboratory, WADC, on the growth, optical and electrical properties of CdS crystals. Very large single crystals of CdS have been grown in this apparatus.



transforms solar energy to electrical energy with an efficiency up to 6.5%. This probably can be increased by producing CdS crystals of greater purity. Solar generators made from silicon crystals have attained efficiencies as high as 10%, but they poop out if heated to temperatures of 300° or greater while the CdS solar generator cells work up to 750°F. WADC is continuing this work through contracts with Harshaw Chemical Company and Eagle-Picher Company who are trying to make purer crystals by different methods. As an indication of how worthwhile research into the field of solar energy might be, consider this--each square meter of the earth's surface exposed to the sun's radiation receives one kilowatt of power. Over the entire earth's surface this is about 100,000 billion kilowatts--a million times as much as all the electrical power produced throughout the world. In a few days the sun supplies as much energy as can be recovered from all known coal and oil reserves accumulated over billions of years. In the propulsion area we are spending $321,000 on solar energy studies, although money is also being spent in several other areas for solar energy research—for example, materials and electronics. Also, in a very closely allied program area, secondary propulsion, the expenditure of some one million dollars is planned in the near future.

(U) Energy Conversion

(U) After we have a source of energy and have put it into a usable form, the final conversion must take place. In propulsion the objective is to move something from one place to another; therefore, we have to get our energy translated into motion somehow or other. There are several forms of conversion that we know of --some of which are rather commonplace and some are rather exotic. An example of the commonplace is the conversion of heat energy to mechanical energy (the kind we often want in propulsion). In an internal combustion engine we release the chemical energy of gasoline by igniting it to produce heat energy which expands the combustion products and pushes a piston, thus converting chemical energy to mechanical energy. Another type of conversion is electromechanical – exemplified by ion propulsion and/or plasma propulsion. This is not quite commonplace, but it is rapidly approaching the hardware stage. This method of conversion needs a lot of basic research before it will really approach being a practical method of propulsion, but it obviously is not a dream. An example of a rather exotic method of conversion is magneto-mechanical conversion; namely, the changing of the energy of a magnetic field to the kinetic energy of a body. From your own experience you have seen a magnetized piece of metal move from a state of rest to align itself to magnetic north under the influence of the earth's magnetic field. Under ordinary conditions it has not been possible to realize any work from this effect, but why shouldn't it be possible to use some of the enormous amount of energy available in the earth's magnetic field to produce motion in a man-made device which we would like to move from place to place. Another rather exotic mode of conversion is termed photomechanical. As you all know, visual light and other forms of electromagnetic radiation has particle-like characteristics as well as wave-like properties. Particles of light don't weigh much, but they go awfully fast and they have momentum, since momentum is equal to a mass times velocity. Since every action produces an equal and opposite reaction, it might be possible to shoot particles of light out the back end of a vehicle and make it go forward if there were not much resistance to the vehicle's forward motion. This condition of very little resistance is found in the extremities of our atmosphere; i.e., in what might be termed space.

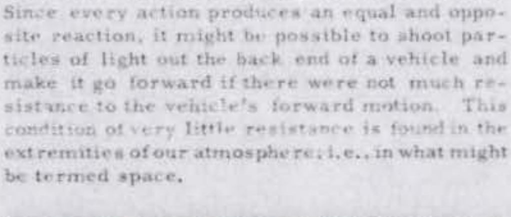


FIG. 2 The irregular blobs of light show the energy released by the recombination of atmospheric oxygen atoms caused by the release of nitric acid from an Aerobee rocket at various altitudes. The streaked lines are caused by stars.

(U) An example of the work that has been done in the past in this area of energy conversion is that of Dr. Harteck of Rensselaer Polytechnic Institute who has made a study of ways to cause the oxygen atoms in the upper atmosphere to recombine producing the heat energy to expand gases and produce motion in a missile (see figure 2). He found that a gold surface will cause these oxygen atoms to combine and made oxygen molecules, giving up a lot of energy in the process. The heat from this recombination could be used to give other molecules kinetic energy, thus producing motion. The techniques of doing this are now being studied by Dr. Harteck under an applied research contract with Air Force Cambridge Research Center.

(U) Theoretical and Experimental Techniques

(U) The fourth and last scientific area of interest in the propulsion area is theoretical and experimental techniques. Some years ago we departed from the philosophical approach to problem solving and changed to the experimental or pragmatic approach. The philosopher says that if a frog jumps half the distance between where he is and where he wants to go every jump, that he never will get there. The pragmaticist will tell you that the frog does get there because he tried it, and the mathematician will prove to you that he did, or could by the theory of limits or some such thing. Well, the point of this is that to back up our theories—our supposed explanation for why things happen—we need to try out these explanations and see if they work. The trouble is that it is usually not very practical to try out the full-scale event because of expense and the difficulty in measuring what happened. For example, it is a lot cheaper to build a model X-15 and fly it in a wind tunnel to find its lift characteristics, its drag forces, regions of instability and other things than it would be to build an X-15, fly it with no previous information and take tremendous chances on destroying it before we get the information. Of course, it would be still easier and cheaper if we had ways to predict the things we want to know from theoretical considerations. It would be quite worthwhile to be able to say that if a body were shaped this way it would have these drag and lift forces at these speeds. Well, this is what we're after in this area—means of predicting and providing what will happen under various circumstances to various things.

(U) In conclusion, basic research in the propulsion area is aimed at uncovering new knowledge from which to evolve advanced methods of storing, releasing, and converting energy in a predictable and controllable manner suitable for practical application.

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ELECTROMAGNETIC

PROJECT PARAMI

By William R. Killion, 1st Lt, USAF
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(U) Since the inception of the Air Defense Command Project "William Tell" there has existed a need for a complete miss-distance indicator capable of providing immediate missile miss-distance information for competitive scoring of the various fighter organizations of ADC. To accomplish such a task, Hq ARDC, Det #1 directed the Q-2 Flight Test Section, Q-2 Test Branch at Holloman to conduct the following development test programs required for operation "William Tell" to be completed prior to October 1958.

1. Determine the scoring capabilities of the prototype PARAMI system using the GAR-1D/F-102 weapon system.
2. Determination of the operational performance characteristics of "William Tell" configuration Q-2 drone.
3. Evaluation of the bistatic radar-pod characteristics for GAR-1D missile and the F-102 fire control system.
4. Evaluation of the monostatic radar-pod characteristics for the F-89J fire control system.
5. Determine scoring capabilities of production model PARAMI system using the GAR-1D/F-102 and MB-1/F-89J weapon systems.

(U) The activity of the Q-2 Flight-Test Section was geared to a high pitch. The morale of the airmen was high because each one knew the importance of the task ahead; each one knew he had a definite part to play toward the success of project "William Tell." From 13 February 1958 to 17 October 1958, a total of 119 Q-2A flights were scheduled.

(U) The first phase of testing was the Parson PARAMI Miss-Distance Indicator to be used as a scorer for the following: GAR-1D/F-102 weapon system and MB-1/F-89J weapon system. Working in conjunction with the Fighter-Missile-Test Branch at Holloman, and the units of the Air Defense Command, the Q-2 Flight-Test Section prepared the Q-2 drone flight patterns and attack angles of the F-102 and F-89J missile-launch aircraft to meet the requirement and simulate actual flight condition of project "William Tell." With the Q-2A drone flying a race-track pattern the F-102 missile-launch aircraft would fly various attack geometries. Each attack would be accompanied by the firing of GAR-1D or MB-1 missiles, either singularly or in salvos, depending upon the type of pass required. Electronic instruments located in the GAR-1D and MB-1 missiles and the Q-2 drone would provide the needed data which was recorded at the PARAMI ground station at Holloman.

(U) Upon compiling data and comparing with the ground optics report, the results were considered satisfactory by the testing activity and were approved for "William Tell." Operational characteristics of the Q-2 drone were excellent all through the test program, resulting in 90% drone reliability during the evaluation flights.

(U) Receipt of the production-type model of PARAMI proved more challenging for here was the test of the PARAMI gear right off the assembly line. The production accuracy test program has not been completed at AFMDC because of the inability to obtain ground optical coverage.

(U) Besides testing the PARAMI scoring capabilities for the GAR-1D and MB-1 missiles, it was equally as important to determine the bistatic radar-pod characteristics for the GAR-1 missile system and the monostatic radar-pod characteristics for the F-102 and F-89J fire control systems. The difference between the bistatic and the monostatic radar reflector pod lies in the intensity and direction of signal return. The energy from the fire control system source is reflected off the monostatic pod in a narrow beam at relatively large strength back to the illuminating radar. This enables the fire control system to lock on at a greater distance. The energy reflected off the bistatic pod is reflected at different angles at relatively low strength compared to the monostatic pod. The reflected energy covers a large area enabling the missile to seek and track the target. After the F-102 and F-89J missile-launch aircraft completed the prescribed number of passes the results indicated the radar-pod characteristics of both bistatic and monostatic reflectors would provide satisfactory coverage.

(U) The PARAMI system was used at Tyndall AFB for the "William Tell" operation with great success.

Language TRANSLATION

By George A. Shiner

(U) A report[1] of the Science Advisory Committee appointed by President Eisenhower contains the statement: "The reason scientific information has become a major problem, particularly since World War II, is that the rapid rate of scientific progress has multiplied the volume of scientific information to a point where it can no longer be published and handled within the framework of existing methods. When one considers, too, that much of what is significant in science is being published in unfamiliar languages, it is clear that the working scientist is faced with almost insuperable problems in attempting to keep himself informed on what he needs to know."

Mr. George A. Shiner received a B.E.E. from the University of Akron in 1954. During summer vacations he was engaged in flight test instrumentation work at the U.S. Naval Air Test Center, Patuxent River, Maryland. He was with Engineering and Research Corporation, engaged in analog computation and simulation for military aircraft until December 1954. Since then he has been associated with the Intelligence Laboratory, Rome Air Development Center, New York, working on automatic reading of information, machine translation of languages, and automatic semanticgraphic composing techniques.

(U) Language difficulty is reflected in the fact that Russian language publications are estimated to account for a tenth or more of all the scientific literature being published in the world today. It has been estimated at 20,000 publications annually, containing about 120,000 articles of significance for some branch of research and engineering in the physical and life sciences. This total is second only to the English total. It is expected that by 1979 Russian language publications will increase to at least twenty percent of the world's output.

(U) Machine translation of languages, evolved over a long period of time, (Warren Weaver, 1949) has been investigated on a number of separate fronts. However, efforts have been handicapped by lack of adequate research tools and sufficient funds with which to support really effective remedies.

(U) Universities and commercial firms in the United States, England, and Italy are doing basic and applied research on actual mechanical systems for language translation. The United States Air Force and the National Science Foundation have supported research and development to the extent that available funds have permitted.

(U) International Business Machines, Mohansic Laboratory, Yorktown, New York, supported by RADC, are developing actual hardware for machine translation of languages. This is the only hardware development in existence, the initial effort having been started in 1956 at International Telemeter Corporation, Los Angeles, California, and at the University of Washington, Seattle, Washington. Dr. Gilbert King, when at International Telemeter Corporation (1955-1957) designed and developed for the Air Force an extremely fast and large capacity photoscopic memory that is capable of storing a 500,000 word Russian-English dictionary and of looking up English equivalents at a minimum rate of twenty words per second. Linguists and engineers at the University of Washington prepared a 500,000 word Russian-English dictionary of 31 scientific fields to be coded on the photoscopic memory. This lexicon is expected to be completed in February 1959. A setback occurred in the program in the summer of 1957 when funds for the program were not available. Contract work did not resume until May 1958 when IBM, with Dr. Gilbert King as principal investigator, did further research and development on the fast, large-capacity photoscopic memory.

(U) Demonstration of the photoscopic memory device as an automatic dictionary is expected in May 1959. At that time development of additional hardware and methods for processing the English equivalents and semantic and syntactical data from the photoscopic memory dictionary into an intelligible translation will begin, with an esti-

[1] President's Science Advisory Committee, Improving the Availability of Scientific and Technical Information in the United States, December 1958.

mated completion date of August 1960 for the demonstration of a completely automatic language translation complex.

(U) RADC is also sponsoring preliminary observations of language technology which at the moment suffers—and very much so--from an insufficient realization of the basic mass phenomena of language which must be considered in any attempt at mechanization.

(U) Various linguistic studies constitute parts of one project. Different ends require different means and different logical structures. A new branch of linguistics (machine) has to constantly compare its own logical structures with those already recognized. New techniques are important in any branch of science; knowing how and how not to use them is more important. Let us mention just a few new developments in language technology which follow along the above lines.

(U) Cambridge Language Research Unit, England - Research to develop a mechanical thesauris; continuation of research toward the formulation of a general methodology of machine translation via a formalized lattice theory and the thesaurus. The Unit is exploring the possibility of constructing general mechanical translation programs to be used with the USAF photoscopic store, rather than devising restricted translation programs applicable to single pairs of languages only. Many-to-one translations can be handled by a mechanical thesaurus proper to the output language. "Thesaurus" means an organization of word-use according to idea content of which a mathematical model can be made. The construction of this model has made possible the taking of word segments, words and phrases as elements of a lattice and using the mathematical properties of lattices to resolve the numerous semantic problems involved in translation.

(U) Harvard University, Cambridge, Massachusetts - Finalization of empirical techniques to prepare technical dictionaries by automatic means; syntactical research in Russian-English machine translation.

(U) University of Milan, Italy - Psycholinguistic research for attaining Russian-English machine translation via correlation matrices; preliminary research in automatic abstracting. The research is based on the original findings of the Italian Operational School regarding the nature of human cognition. The approach to the solution of translation problems is based on the central role of the correlators in the language system; the resolution of the apparent meaning of a group of words is operationally effected by means of correlation matrices. This research combines the facets of psychology, logic, and linguistics. It can be postulated, on the basis of valid evidence[2], that the solution to the problems of translation (machine and human) can be achieved more fully within the domain of psychology-plus-linguistics than within the linguistic facet alone.

(U) University of Washington, Seattle, Washington - Formulation of operational rules of syntax to improve the present word-by-word machine translation output; formulation of transformation rules to achieve the correct synthesis of the English output. The University of Washington research is geared to the resolution of syntactic-semantic problems within the confines of standard linguistic rules. Operationally, the program is constructed for use with the USAF photoscopic store.

(U) Experiments conducted in the United States and the Soviet Union on the translation from a given language (source language) into another language (target language) and vice versa have been based on a conscientious limitation of the type of text (narrowly technical), its dictionary capacity (only up to 8000 words), phraseology (the absence of units with a figurative meaning, idioms, etc.), and the polysemantics of a word and other language phenomena. It is quite natural that a formalization of the rules for bi-linguistic conformities in such narrow margins could be after a definite preliminary study, applied to the appropriate program in the form of a command for an arithmetic electronic computer.

(U) In principle, these translations can hardly produce an economical or practical solution, when considering the general overall automatic language translation problems. However, the linguistic research effort performed in previous publicized machine translation experiments is commendable, insofar as it provides precise English technical correspondents for the Russian technical terms in the technical field being translated. The discrepancy, in this respect, is in the fact that the limited technical glossary stored in the memory of the machine conforms

[2] Russell, Bertrand, Brain, Mind, Perception and Science, Philosophical Library, New York, 1951, and Miller, George, Language and Communication, McGraw-Hill Book Company, New York, 1951

only to the lexical requirements of the technical theory being translated and enough to limit, in certain cases, its applicability to other branches of the technical subject. For instance, the Russian word IMPUL'S in "Theoretical Chemistry" is translated consistently as "MOMENTUM" which is entirely correct in the particular contexts, but could not possibly apply in other instances where the word would have to be translated as "IMPULSE" or "PULSE" as in "Applied Chemistry." This problem also occurs in physics and mathematics.

(U) In many approaches, the electronic memory will never have a fast enough or large enough memory (dictionary) to be capable of distinguishing between different technical fields; for instance, "TOK" can be translated in electrical engineering context as "CURRENT" or in biology as "MATING PLACE."

(U) Along with the major problem of semantics is the secondary problem of sentence structure. From the automation viewpoint, there is no identity between sentence structures in different languages. It is easy to find examples of sentences which have one and the same structure, but in correct translation, sentences having entirely different structures will correspond to them. Examples exist where no solution has yet been found to properly translate a given sentence, out of context, into another language.

(U) Inadequate hardware or test equipment for studying machine translation of languages has compelled researchers to create highly complex logical structures within non-logical (arithmetic) operations. The unusual relation between the translation program and the dictionary (assignment of control codes directly to words which are in the dictionary) artificially limits the possibility of a practical and simple translation and hampers the solution of the problem.

(U) The Air Force approach contains the hypothesis that one of the greatest technical advances in language automation will be in the development of special methods and hardware. Special importance is attached to non-arithmetic (logical) operations to proceed automatically with one or the other sequence of operations. With the above approach, the following principles are being used:

- Separation of the dictionary from the logical operations, making it possible to expand the dictionary easily without changing the logical operations,
- Placement of words in the dictionary in complete form, which allows the simple logical composition of a sentence to generally known rules of English grammar,
- Inclusion in the dictionary of idiomatic and grammatical indices of constant grammatical characteristics of words,
- Utilization of an extremely fast (20 words per second), large capacity (500,000 words) memory as an automatic dictionary,
- Utilization of a polytechnical vocabulary, making it possible to study the utilization of micro-glossary techniques and values of polysemantic words according to context from many technical fields instead of only one at a time.

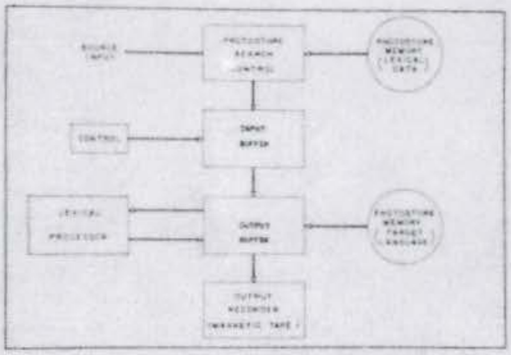
The above rules on which translation automatization is based are sufficiently clear to carry on further work on a broad scale.

(U) The use of an extremely fast automatic dictionary and a general purpose language processor is not only economical but offers the possibility of going beyond the limits of one sentence and into a much greater perspective; namely, introducing the text into the machine in full paragraphs.

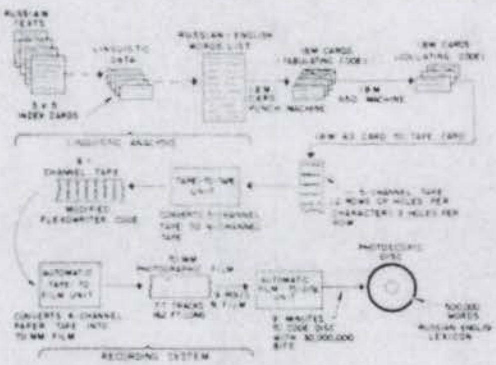
(U) The rate of searching for words in dictionaries to a great extent determines the rate of the entire translation process. Therefore, special attention is devoted to the problem of accelerating this part of the work in the Air Force automatic language translation project. A pertinent factor in using optical memories is its great economy. It is estimated that the cost of translating one Russian word, using only one photoscopic memory device will be five-hundredths of a cent, compared to one-fourth of a cent per word when magnetic tapes are used.[3]

(U) To summarize, the USAF Automatic Language Translation Program has been geared to

[3] Appendix "A" Machine Translation of Languages, Ramo-Wooldridge Corporation, Contract AF30(635)-2847, March 1957.



FUTURE MECHANICAL TRANSLATING SYSTEM

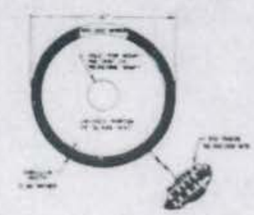


Method for converting source data into the Photoscopic Memory

develop a fast-access, large-capacity memory, corresponding to an up-to-date dictionary. Such a memory will permit extreme flexibility in the use of already existing data processors and should within a reasonable time permit an efficient, economical solution to the machine translation of languages.

(U) The memory device, invented by Dr. Gilbert King, is capable of storing thirty million bits of digital information with a nominal access time of fifty milliseconds and has a scanning rate of one million bits per second. The acutal area for storing the thirty million bits is only ten square inches. Thus, the memory has a density of three million bits per square inch.

Photograph of a completed disc



The Photoscopic Memory

(U) From a technical standpoint, the perfection of a simple practical machine for language translation is proceeding at a rate commensurate with the availability of funds.

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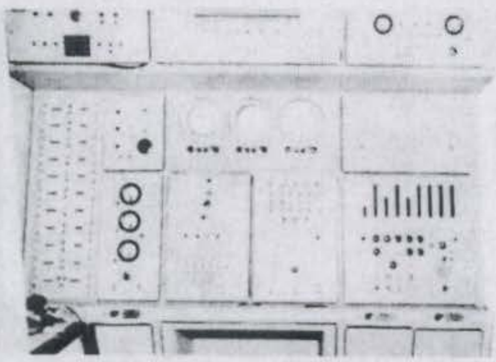

Preflight inertial guidance ground support equipment for the SM-62 (SNARK) missile.

[redacted]

Preflight Ground Support Equipment

FOR AN INERTIAL GUIDANCE SYSTEM

By Welby T. Risler

The author served three years in the United States Army Signal Corps as a radar and communications technician during World War II. Afterward, he attended Emory University where he received an A.B. degree in Physics in 1949. He accepted a research assistantship from the Physics Department at the University of Florida where he received his M.S. degree in 1952. He is a member of the Sigma Pi Sigma Physics Honor Society and Triangle Engineering Fraternity.

Mr. Risler has been employed at AFMTC for six and one-half years. His experience during this time includes research in radar and CW propagation errors, airborne microwave refractometer, communications, and cruise missile inertial guidance systems. He presently is Chief of the Guidance Section, Engineering Analysis Branch, Directorate of Test Engineering.

(U) Technical publications have emphasized the design problems associated with the development of inertial guidance systems with very little attention being given to the development of preflight ground support equipment. The preflight ground support equipment must be able to rapidly checkout, program, and align an inertial guidance system. This is not an easy task since inertial guidance systems are a complex maze of electrical and mechanical gear - the greater part of which are closed loops. In developing guidance support equipment, a decision must be made on the balance between the automatic and human operations involved. (Picture of guidance support equipment.) Generally, the more operations performed automatically by the ground support equipment, the less the time of operation; however, the more complex and less reliable the ground support equipment. Another decision must be made on how much assistance should be given to the maintenance of the guidance system. It is not feasible to replace the complete guidance system in the event of a red "no-go" light during checkout, but neither does time permit locating a system difficulty down to the electronic or mechanical component level.

[redacted] The Air Force now has tactical type inertial guidance ground support equipment for the SM-62 (SNARK) missile at AFMTC. The functions of this equipment are divided into two areas: (1) aligning and programming the guidance system; and (2) operation analysis of the guidance system. Programming and aligning of the guidance system consists of slewing the gyro-stabilized platform, zeroing the outputs of integrators, clearing and coding computers, etc. Most of these operations are initiated and supervised by the equipment operator. Operation analysis of the guidance system is divided into a finite number of subsystem tests. The operator can test any particular guidance subsystem by means of a selector switch on the analyzer's front panel. Once initiated, the test is completely automatic with colored lights indicating the results of the test. A green light for no equipment failures and a red "no-go" light for a test failure, together with a red light over the module or modules name plates which failed in the subsystem. Flight line maintenance is reduced to replacing these modules with spares.

[redacted] The heart of the guidance analyzer is the "voltage comparator." The voltage comparator determines if the various voltage points monitored throughout the guidance system are within specified tolerances. The voltage comparator is divided into two channels; one channel to test voltages for exceeding an upper limit value and the other channel to test for voltages going below a lower limit value. Should the tested voltage not be within these limits, the voltage comparator will stop the subsystem test and turn on the appropriate red lights. Also, a white light will

[redacted]

come on over the appropriate upper or lower voltage limit exceeded name plate.

[redacted] The guidance analyzer must accurately generate the upper and lower limit reference voltages to be used in the tests conducted by the voltage comparator. The analyzer does this by means of two plus and minus voltage supplies which are referenced to two standard voltage cells in such a manner that no energy is withdrawn from them. To provide a wide selection of limit voltages for various tests, the plus and minus precision power supplies are connected across a voltage divider network. Taps on this voltage divider network provide the various upper and lower limit reference voltages needed.

[redacted] The guidance analyzer relies heavily on electrical switching techniques. An electrical switch alternately connects the input of the voltage comparator between the guidance voltage point under test and the respective reference limit voltages. This produces for the voltage comparator two square waves voltages, the amplitudes of which are dependent upon the difference values between the tested voltage and the reference upper and lower limit voltages. The amplitudes of the square waves are what the voltage comparator effectively measures. Stepping switches permit one voltage comparator to sequentially check voltages at many points throughout the guidance system. Electrical switching causes undesirable effects due to contact resistance and electrical transients. To overcome contact resistance, all the switch contacts are gold plated and to further force a good contact, narrow high voltage spikes are introduced into the switch contact circuits. The high voltage spikes are generated from a high impedance source and are short-circuited out when good contact is made. Interference in the voltage comparator from switching transients are eliminated by internally generated blanking voltages which render the voltage comparator inoperative during the making and breaking of stepping switch contacts.

[redacted] Not all of the guidance voltages tested by the analyzer are constant with time such as d.c. power supplies. The analyzer must be capable of evaluating a transient voltage. For example, the inertial guidance system has a platform whose angular position in the missile is specified by gyroscopes independent of roll, yaw, and pitching motions of the missile. An error voltage is developed whenever a misalignment angle exists between the platform and these gyroscopes. This error voltage is used to control the platform torquer motors which realign the table. In checking out the platform torquer loop, the analyzer uses variable dwell time stepping switches. Upon initiation of the test, the stepping switch causes a command to be sent to the guidance system which misaligns the guidance platform. The next advance of the stepping switch releases the table at which time the table begins to align itself. After a specified dwell time, the stepping switch again advances and engages the voltage comparator to test the error voltage for its limit values. Proper platform response should indicate a small overshoot error voltage at this time. (See figure 1.) After the predetermined time for the error voltage test has elapsed, the voltage comparator is disconnected by the stepping switch.

[redacted] It would be highly objectionable to have the guidance analyzer indicate a guidance system failure only to discover later the failure was in the analyzer. To improve its reliability the analyzer performs a self-analysis before proceeding with a guidance subsystem test. Through internal cross connections, the analyzer checks all its own power supplies, precision reference voltages, and voltage comparator circuits. Any errors discovered in these circuits are indicated by appropriate red lights.

[redacted] Development of the guidance analyzer is still continuing. A more rapid checkout time for the guidance integrators is under study, using forcing voltage functions from the analyzer. Eventually, it is desired that the guidance analyzer be able to perform a continual analysis of the guidance system without disturbing any pre-flight preparations made upon it.

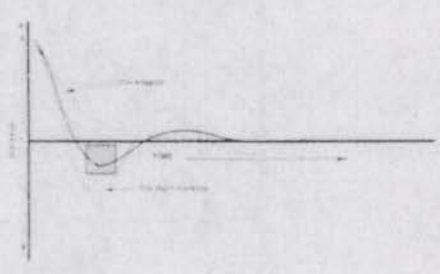

FIG.1 Graphical illustration showing the response of the guidance platform to a misalignment angle (voltage). The cross-hatched area encloses the voltage limits and time interval checked by the guidance analyzer upon release of the platform.

[redacted]

Statistics and Reliability

By Albin N. Benson

(U) From time to time the question is raised regarding the practical necessity for statisticians in the Reliability or Quality Control program. Cannot reliability be obtained by good design? Is not quality a product of careful manufacture? Why is there a need for Statistical Analysis?

(U) Although some statisticians may object to having a physicist plead the cause of statistics, it can be pointed out that the progress in physics is closely associated with the numerical evaluation of physical phenomena. As soon as we recognize the random nature of certain phenomena, we must begin a search for one number (or at least a few numbers) which can replace a frequency distribution.

(U) Statistical Analysis, by statisticians, has proven its worth in a great many fields. There are however many workers in the reliability field who believe that statistical analysis, as an area of specialization, is unnecessary. The "numbers racket" requires only "mature engineering."

(U) If we examine some of the relatively simple problems, we find that our "mature" sense may begin to bog down. Everyone knows that the odds of flipping a coin, and heads coming up are 50-50. If I have flipped a normal coin, heads, three times in a row, what are the odds of getting heads on the next throw? Undoubtedly anyone with normal "horse sense" would know the odds are still 50-50, but lets look at a little more complex problem.

(U) A test of 100 electronic components shows an exponential distribution with a mean life of 200 hours. How many of the 100 components should one expect to fail during the first 200 hours? Perhaps the "mature" engineer would know that the answer is 63 not 50.

(U) Recently I came across this statement by a rather prominent Physicist, "Now why do we want a high degree of reliability? From an operational point of view, the answer is obvious. If the reliability is 45% instead of 90%, for example, we have to fire twice as many missiles to get a required number on the target." It evidently is not obvious that with two missiles of 45% reliability the chance of at least one hit on the target is only 70%, not 90% as the author indicates. The discrepancy becomes more evident if we consider one missile of 100% reliability which would assure a hit; whereas with two 50% reliable missiles there is still a considerable possibility that both might be duds.

STATISTICS AND RELIABILITY

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Physicist

North Dakota State	B.S. Degree
University of Buffalo	M.S. Degree
University of Michigan	Ph.D.

Former Positions:

Quality Superintendent, Des Moines Ordnance Plant (U.S. Rubber Co.)

Chief Ballistician, Small Arms, Frankford Arsenal.

Present Positions:

Chief of the Reliability Division

Directorate of Test Engineering
Air Force Missile Test Center
Patrick Air Force Base, Florida

(U) A similar problem can be stated in this way: "Given a missile with a 50% reliability, how many must be fired to assure at least one hit with a 95% probability?" Although the answer is not difficult to calculate, it still requires something more than engineering judgement to arrive at the answer of 5 missiles.

(U) A safety engineer finds that in a factory employing 500 people on a specific job assignment, there have been 300 accidents on this job during the year. (B. Metz, EPA Bulletin No. 29, June 1958). He examines the records and tabulates them as follows:

275 employees had no accident
165 employees had one accident
49 employees had two accidents
10 employees had three accidents
1 employee had four accidents

(U) The manager with "horse sense" would probably warn the 165 and fire the other 60 as being "accident prone." A "mature engineer" might restrict the firing to eleven and decree a safety education course for the 214. A statistician should point out that this distribution exactly follows the Poisson distribution (which is the distribution to be expected in this type of problem) and that there is no indication of accident proneness. The proper approach, toward reducing accidents would therefore be a strenuous safety course for all 500 employees.

(U) In the missile business, time and money are important. Strange as it may seem, this is often used as a justification for not using statistical analytical methods in reliability analysis. The attitude sometimes seems to be: "Please don't confuse the problem with a lot of facts." Frequently a design engineer uses a component without any idea as whether the probability of a malfunction is one in five or one in a million.

(U) It must be recognized that statistics is only a tool and as such cannot replace good engineering. "Reliability Must be Designed into and Built into the Product." It is also true that statistical analysis cannot be used as a substitute for careful and accurate data collection.

(U) It is not intended to imply that a statistician only applies probability theory. In the March 1958 issue of the American Scientist, Mr. W. Lyrie writes. "It is the statistician's responsibility to ask these questions, not to answer them.

1. With respect to the experiment you are performing, just what are your ideas?

2. With respect to the scientific area to which these ideas refer, just what are they about?

3. How sure do you want to be of the correctness of these ideas?"

(U) Statistical Analysis procedures have proven their worth in many fields including Quality Control, Operations Analysis, and in the Laboratory. It is however important that the educational effort be maintained in order that engineers may understand the importance of statistics in the over-all evaluation effort. As new advances are made in the area of mathematical statistics, qualified engineers must be available to adopt these advances into a continually growing Quality Control Program.

SPEECH BRIEF

Maj. Gen. Ben I. Funk, Commander, Ballistic Missiles Center, AMC, to the Purchasing Agents Association of Los Angeles, Calif., January 8, 1959: "...it costs money to get the best possible product for any given task.... We cannot afford anything less than the best. Our annual expenditures for the ballistic missiles program of the Air Force approach $2 billion. But, when you consider that we are buying peace and freedom for us, our children, and the generations to come, you will realize that the price we are paying is cheap."

the PINCUSHION principle

By Harry Davis

[redacted]

beamwidth (provided we build large antennas which of course is desirable - since the cheapest overall system is obtained by using larger fixed antennas in place of higher average power) and, finally, receivers with significantly lower noise

Mr. Harry Davis is the Scientific Director of the Rome Air Development Center, located at Griffiss Air Force Base, Rome, New York. In this position, he is responsible for the technical direction of a large-scale program in the development of ground electronic equipment and systems for the U. S. Air Force.

He received a Bachelor of Science Degree in Physics in 1931 and an Electrical Engineering Degree in 1933 from the College of the City of New York, and a Master's Degree in Electrical Engineering in 1948 from the Polytechnic Institute of Brooklyn.

Mr. Davis served during 1955 as Instructor of Graduate Courses in Electrical Engineering at Columbia University and is a member of a study group which assists the staff of the Secretary of Defense in special studies involving the evaluation of weapon systems.

Mr. Davis is a member of Sigma Xi, American Physical Society, American Association for the Advancement of Science, American Ordnance Association, and the Institute of Navigation. He is a Fellow of the Institute of Radio Engineers.

figures than those of microwave receivers are available.

[redacted]

scattered energy. At microwave frequencies, [redacted] and it is believed that a large collector would have too much fading at [redacted]

[redacted]

[redacted]

cies because in this region broader bandwidth low temperature amplifiers are easier to design and the system looks at a "cold sky." The benefit of the noise reduction is more nearly gained thereby.

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(U) With this background, one asks: "How can we obtain the long range capabilities of the lower UHF frequencies at microwave frequencies? Particularly, how can we get average powers of the order of 500 kw (which are obtainable at UHF) at L- or S- or C-band?"

[redacted] The possibilities of the development of a single tube having such large average power do not appear promising. It is, by several orders of magnitude, too great a jump from existing capabilities.

[redacted] The next possibility is the combination of many low-power transmitters. If one simply tries to parallel many smaller powered transmitters, numerous difficulties arise. The problem of combining networks, constructing high power wave guides and, particularly, duplexing such high powers is approximately as difficult as that of developing a high power tube at microwave frequencies.

[redacted] Another possibility is the development of phased arrays. Here, we can combined many smaller transmitters "in space" and attain large peak powers without a wave guide power limitation or a duplexing problem. There is, however, a bandwidth limitation in phased arrays which is such that high range resolution will be obtained only with more sophisticated arrays that are now planned. Of more immediate concern, however, are many practical difficulties due to the effects of mutual impedances in extremely large arrays, component limitations, phase stability of amplifiers and phase control elements. Even

[redacted]

[redacted] Happily, there is a solution which allows the increase of the average power by utilization of many transmitters to achieve in effect a large beam even at microwave frequencies.

[redacted] applicable to many different forms of radar sets, we will describe a tracking radar in order to illustrate the idea. In particular, we will consider the simplest form of a tracking radar; namely, one having a movable, parabolic, reflector-type antenna which illuminates the target. The resultant illuminating beam is made to follow or track the target by mechanically moving the reflector so that the beam direction changes to remain on the target as it moves.

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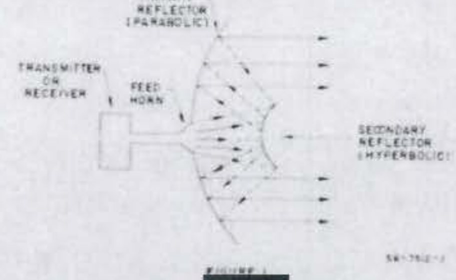

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[redacted] For convenience, we will designate the envelope of all the main lobes as the complete beam. Each main lobe from each radar will be called "sub-lobe." Figure 4 shows the configuration of the radiated pattern.

[redacted]

width is obtained much more easily with the microwave radar then with the UHF radar.

[redacted]

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SPEECH BRIEF

Lt. Gen. Clarence S. Irvine, DCS/Materiel, to the Northrop T-38 Suppliers Symposium, Los Angeles, California, January 19, 1959. "Industry must develop and produce the high-performance weapon systems necessary to maintain a superior aerospace power for whatever length of time necessary until a permanent lasting world peace is assured. The AF does not fabricate its own components or assemble them into a complete operational system. Therefore, it is directly dependent on industry's output to keep pace with or to stay ahead of the Soviet Union .... The companies that have enough interest and enthusiasm for Air Force hardware, who have initiative not to wait for subsidies before going ahead on their own, and who have enough confidence in their ingenuity and skill to take calculated risks - these are in a more favorable position for increased AF business."

A Unique Frequency Measuring System, the FR-118

By Robert W. Stolzenbach, WADC

(U) The FR-118( )/U is truly a unique frequency measuring system. For years accurate frequency measurements have been made by only trained technical personnel using complicated electronic devices requiring considerable time and under the most ideal conditions.

(U) The FR-118( )/U introduces a new era in frequency measurement. Inexperienced personnel may now make highly accurate frequency measurements directly off the air over large distances within a fraction of a second and under the most severe conditions of high modulation percentages and noise levels. And this isn't all— They can make measurements that heretofore were considered impossible with the same ease and simplicity. These include fast frequency shift keying systems, CW, and suppressed carrier single sideband transmissions.

(U) Many a Base Commander has been confronted with the problem of Military Communications interfering with commercial traffic with the customary request by the Federal Communications Commission to discontinue operations pending satisfactory evidence that the off-frequency operation has been corrected and has had to provide assurance that it will not occur in the future.

(U) The Commander's solution for a problem of this kind is the FR-118( )/U which can easily measure and record if required, the frequency of all transmitting stations operating on his base at regular intervals.

(U) Almost every communication and electronic system in the Air Force today depends on good frequency accuracy and stability, whether it be voice communications, use of beacons, IFF, data link and many others. Interference problems can be reduced by adhering closely to the exact assigned frequency, and in some cases, the success of transfer of vital information is directly dependent on being "on frequency"; otherwise the information may not be received.

Robert W. Stolzenbach (AB Physics, Wittenberg College, Springfield, Ohio, Advanced Study in Electronics and Electrical Engineering, University of Michigan, University of Maryland, Ohio Northern University, Antioch College and Ohio State University) is Chief of the Frequency Control and Standards Section, Communications Branch, Communication and Navigation Laboratory, Wright Air Development Center. His previous positions were with Wittenberg College, Springfield, Ohio, serving in the capacity of Instructor in Physics and Radio 1925-1931, Broadcast Engineering 1925-1941, member of the Technical Staff of WJR, Detroit, Michigan and WLOK, Lima, Ohio, Chief Engineer of WCSO, Springfield, Ohio, KQV, Pittsburg, Pennsylvania, and WLOG Logan, West Virginia.

Mr. Stolzenbach has been associated with the Government from 1941 to the present, first employed by the Office of the Chief Signal Officer, Washington, D. C., later assigned to the Aircraft Radio Laboratory, U. S. Signal Corps, Wright Field, Dayton, Ohio and then the United States Air Force, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. He has been associated with Amateur Radio since 1915 and is the holder of an Extra Class Amateur License W8KP, is affiliated with the Air Force MARS Network under the call sign of AF8KP. He is a Senior Member of IRE, the Quarter Century Wireless Association and Alpha Tau Omega fraternity. He is the holder of two U. S. Patents, one for a technique for the measurement of corona #1689, one for a high frequency wave analyzer #2771581, and a disclosure #6592 is currently on file for a "Communications Receiver - Direct reading Frequency Measuring Assembly."

(U) With the advent of suppressed carrier single sideband operation in SAC using Radio Sets AN/ARC-58 and AN/ARC-65 and, in the future, AN/ARC-68(V), we have the introduction of a possibility of "Donald Duck" voices over and above the comic strips. In a suppressed carrier system, it is absolutely essential that frequency stability be maintained because there is no longer a carrier for a frequency reference. Even moderate differences between receiver and transmitter cause oddities in voice quality. As the difference increases we quickly reach the region of very questionable intelligibility. Such communications subsystems require periodic checking to make sure that frequencies are within the limits prescribed for satisfactory intelligibility.

(U) It became apparent from these problems and others that a measuring device must be capable of accurately measuring frequencies utilizing the actual signal on the air, with modulation and through relatively high noise levels. Types of modulation encountered would include CW, Frequency Shift Keying (Radioteletype), double sideband amplitude modulation and suppressed carrier, single sideband amplitude modulation.

(U) It would be highly desirable to use some existing basic portion of a communication system which would permit an instrument of low cost and, therefore, wider application. With these factors as a guide, all previously known techniques for accurate frequency measurement were reviewed and studied for possible application. Unfortunately, nothing used previously was deemed applicable. Still believing that the requirement could and should be met, the author devised a new measurement technique. Basically the new method utilizes the desirable features of a modern communications receiver, particularly its good sensitivity and inherent filter characteristics. In addition, a translator device for presenting the information from the receiver to an electronic counter for display and recording purposes is required.

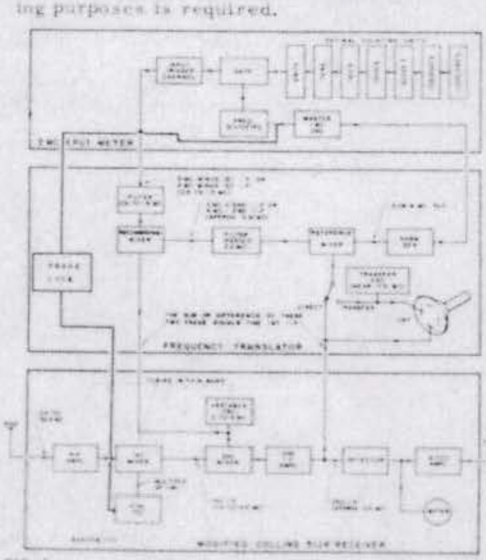


FIG. 1

(U) Figure 1 represents a simplified block diagram of the measuring system. Unique features are: the drift or error introduced by the receiver oscillator is automatically cancelled by the unique technique of frequency additions and subtraction; the crystal-controlled conversion mixers of the receiver are phase locked with the master one megacycle gate crystal, accurate to one part in 10^7. An atomic frequency standard may be utilized in this system, for example, to obtain accuracies of one part in 10^{10} or better, if such accuracy is required. Techniques are available even for reducing the ± one count error of the electronic counter. The author foresees no limit to accuracy or frequency coverage for this technique.

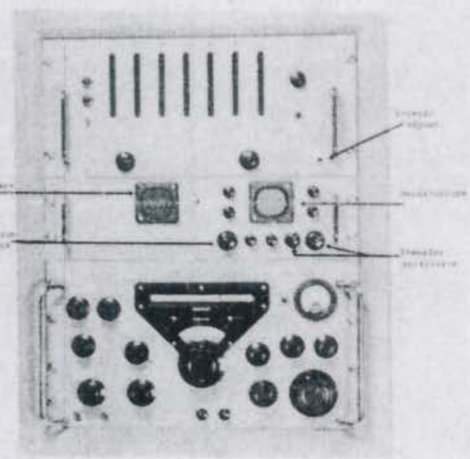
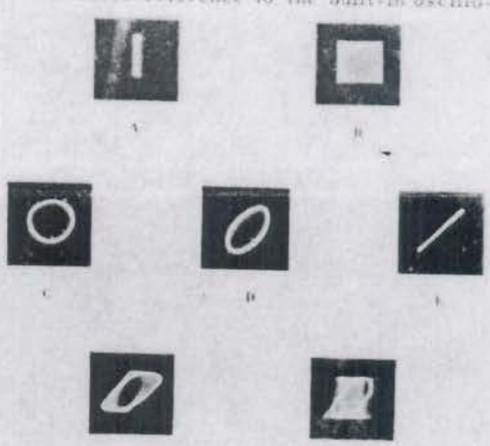


FIG. 2

(U) Figure 2 is an illustration of the complete assembly. A Collins 51J4 communications receiver is incorporated as the bottom portion of the device, with the translator device mounted above it, and the electronic counter is at the top of the complete assembly.

(U) The system will measure nearly all types of radio signals encountered in a frequency range of 500 KC/s to 30.5 MC/s including continuous or interrupted carriers, and signals which are amplitude or frequency shifted. When a carrier is completely absent such as in suppressed carrier systems, the apparent carrier can be measured by an aural technique of matching the inserted carrier to produce an audio signal with minimum distortion. This is a close approximation which generally gives results adequate for most purposes. In the case of other types of modulation in which a carrier exists, with modulation present or not present, the procedure is very simple and rapid. The operator need only tune the receiver to the signal, and read the frequency indication which appears in digital form on the electronic counter.

(U) In the case of interrupted carriers and shifted carriers, the operator simply adjusts the transfer oscillator (See Figure 2) in order to obtain a continuous signal of fixed frequency which is substituted for the signal from the receiver for the counter display. This operation involves reference to the built-in oscilloscope (See Figures 1, 2 and 3) which indicates when the oscillator frequency equals that of the signal from the receiver by the common circular Lissajous pattern.



FR 118 ( )/U

[illegible]

FIG. 3

(U) This measurement technique is unique in that, although, the receiver furnishes the information required for the counter display, it in no way contributes any error in the measurement. Even the tuning need not be exact, so long as the signal is within the passband of the receiver. Warm-up to stable conditions also is not required. Of interest also is the fact that the adaptations to the receiver do not prevent its employment as a normal communications receiver while the measuring and recording are being accomplished.

(U) A self calibrating feature is incorporated. The operator tunes in one of the standard frequency transmissions broadcast by stations WWV and WWVH. If the counter display indicates an error, the precision gating crystal (one part in 10^7) may be adjusted by the use of a small screwdriver inserted through the opening provided for this purpose on the front panel of the instrument.

(U) The development of the frequency measuring system FR-118( )/U is of interest as being somewhat unusual. The idea of the frequency measuring technique was disclosed to representatives of the Berkeley Division of Beckman Instruments, Richmond, California. In cooperation with the author, the measurement system was developed by the company at no cost to the Government. The instrument is now available in commercial form as Berkeley Division Model 7700 described as Micro-Sensitive Frequency Measuring System.

(U) Future plans include the extension of the frequency range from a top of 30.5 MC/s to 400 MC/s to include the military UHF frequency band utilized in command communications, thus greatly increasing the usefulness of the system. Over-all size, weight, and primary power consumption will be reduced by complete transistorization of the translator and the electronic counter. An additional feature will be the facility of visual presentation of a reconstructed carrier in suppressed carrier, single sideband communications, to replace the more laborious aural method now required.

(U) Figure 4 tabulates the technical characteristics of the present FR-118( )/U. It is believed that this facility will find use throughout the Air Force as a simple and accurate frequency measuring instrument for in-service adjustments of the complicated frequency synthesizers of the AN/ARC-58, AN/ARC-65 and later the AN/ARC-68(V) without physical connections or removing the communications facility from the aircraft. It will provide for each air base a frequency monitoring and emergency checking service prior to take off. The instrument will further provide the Air Force Depots with a new capability for use in major overhaul and modifications of transmitting and receiving equipments. Specialized Depots of the Air Force and Calibration Centers will find it invaluable for rapid precision calibration of other frequency measuring equipments. The FR-118( )/U fulfills a requirements of long standing for Communication Centers in rapid and accurate alignment of communication networks including CW, Voice and radio teletype systems. Research laboratories of the Air Force will welcome its use in development and test programs.

TECHNICAL CHARACTERISTICS

Frequency Measuring Range
: 0.54 to 30.5 mcs. Carrier frequency selected by tuning receiver within one of thirty 1 mcs bands.

Sensitivity
: Direct measurement: Under 5μV.
: Substitution method: Under 1μV.

Selectivity
: 3.1 kcs rectangular bandpass with adjustable crystal filter capable of narrowing bandpass to approximately 100 cps. Rectangular bandpasses of 1.4 kcs and 6.0 kcs are available on special order.

Tuning Aids
: A signal strength meter calibrated to 100 db over AVC threshold is included. A small loudspeaker is provided to monitor audio intelligence.

Frequency Indication
: Decimal digits.

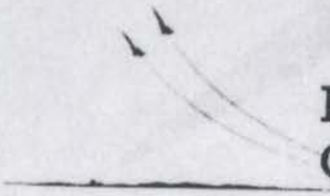
Over-All Accuracy
: Using a one-second counting period (the usual procedure) possible error of measurement is 1 cps ± frequency error master oscillator. Master oscillator frequency is set to within one part in 10^7 at the factory and may drift as much as 2 parts in 10^7 per week. The 1 cps error can be reduced to 0.1 cps by using a 10-second counting period.

Power Requirements
: 117 ± 10%, 50 to 60 cps, 400 watts

Dimensions
: With cabinet: 27" high, 21-1/2" deep, 21" wide.
: Without cabinet: Three panels each 19" wide, 17" deep with an over-all height of 24-1/2". (Will fit into standard 19" relay rack.)

Weight
: Approximately 100 lbs.

FIG. 4



Passive Electromagnetic Countermeasures

By David F. Barber

Mr. David F. Barber was graduated from Hamilton College in 1944 with a B.S. degree in Mathematics. In 1946, following his return from duty as a Weather Officer in the Army Air Corps, he studied at Cornell University and Massachusetts Institute of Technology, receiving a Master's degree in Meteorology from MIT in 1951. He joined the technical staff of RADC in September 1951 and since that time has continued advanced work in electromagnetic theory and physics. Mr. Barber has been associated with the Electronic Warfare Laboratory, RADC, since its inception in 1953 and is presently Project Officer on Electromagnetic Absorbing Materials for the United States Air Force.

(U) The development and use of radar in World War II dictated the development of countermeasures against this electronic all-weather "seeing eye." Techniques of jamming and deception, involving actual transmissions from ECM equipment, were almost immediately created and utilized as active countermeasures. At about the same time, passive countermeasures were developed and took the form of chaff or window and corner reflectors for confusion or signal enhancement, and absorbers for signal reduction and camouflage.

(U) The period immediately following World War II was characterized by general inactivity in the radar countermeasures area, but with the advent of the Korean conflict, some old equipment was dusted off and techniques which had been shelved were given new emphasis.

(U) This paper will review some of the more important passive Electronic Countermeasures (ECM) techniques and devices developed at Rome Air Development Center and elsewhere. Consideration of possible implications of passive ECM in the ground, air, and space environments will be followed by discussion of plans for the future.

(U) In general, any passive ECM system is required to enhance, confuse, or reduce a signal which is transmitted from another source. For the purpose of this paper, we shall consider the source to be a conventional radar.

(U) Problems associated with passive ECM vary widely, depending on the operating environment; that is, techniques and devices suitable for surface targets would require considerable modification before they could be used in an air/space system. The difference in radar background, as well as weight, bulk, aerodynamic effects, weathering, etc. must be given separate consideration.

[redacted] For passive target enhancement in either the surface or airborne environment, we must use reflecting devices, with size and shape dictated by the frequency coverage, amount of radar return, and the angular effectiveness desired. Surface targets of the size of large air [redacted] purposes is possible, using built-in reflectors of the corner or Luneberg lens types. Other operational possibilities exist and will be discussed later.

[redacted]

[redacted]

which remain may be further reduced by radar absorbers.

[redacted] Since the development of radar, scientists have been searching, with varying degrees of success, for materials that would make reflecting objects invisible. The impact of operational availability of such materials is immediately apparent. Even in the initial stages, radar target detection and identification become increasingly difficult, with improvement in absorber efficiency, radar could well become ineffective in both offensive and defensive situations.

[redacted] The first question we may ask about microwave absorbers is, "How can we absorb electromagnetic energy?" In this regard, we may compare microwaves to people - if one were out walking and were to come up against a total obstruction to his progress in one direction, the first reaction would be to change or reverse direction. If, however, the obstruction were of a particularly deceptive type, such as a gradually increasing snowstorm or a slowly deepening quagmire, one would perhaps continue his advance with little or no realization that his energy was being slowly dissipated and that eventually he would have no strength to retrace his steps. So it is with electromagnetic waves. A wave in air impinging in a conductive surface will be strongly reflected; however, if this surface is appropriately coated to eliminate this sudden change of parameters, little or no reflec-

[redacted]

ever increasing losses, until at last little energy remains to be reflected. Figure 2 shows a rel-

[redacted]

[redacted]

passage through the material.

(c) A relatively new but extremely promising attempt to accomplish broadband radar absorption utilized a technique shown in Figure 5. Investigators have for many years recognized the

[redacted]

[redacted]

[redacted] The next question to be answered is "What can be accomplished by passive ECM?" In an air defense environment, protection from radar detection can be furnished for such ground targets as SAC bases, Atomic Energy installations, missile launching sites, radar installations, and the like; in a tactical environment, radar camouflage and deception can help protect supply dumps, radar and communication vans, air base complexes, bridges, and many other ground targets. A typical example of possible ground camouflage and deception is shown in Figure 6. The simulated radar scope shows a

[redacted]

[redacted]

[redacted]

[redacted]

EFFECTS OF CAMOUFLAGE

[redacted]

strong area target, which might be an air base, along with a strong point return, such as that provided by a bridge. In addition, a water body [redacted]

[redacted] Airborne aspects can be generalized to include SAC, TAC, or ADC aircraft, missiles of the air-breathing or ballistic type, and, in fact, any airborne or space vehicle which comes under surveillance or any kind of radar. The effect of reducing the radar cross section is to reduce the radar detection range and hence protect the airborne target.

(U) Graph A shows radar range characteristics versus returned signal power. It can be [redacted]

[redacted] All radar systems are vulnerable to this type of countermeasure. The following discussion, however, will concern itself primarily with radars of the early warning, GCI, missile control and guidance, active or semi-active homing, and airborne interception types.

[redacted]

[redacted]

[redacted]

[redacted]

FIG. 9

[redacted]

overlap between adjacent sites may no longer [redacted]

[redacted] For Ground Control Intercept, a significant decrease in ground radar detection range brings about

- Decreased warning time, perhaps requiring defensive aircraft to be "on-station" for long periods, in anticipation of intercept.

- Decreased vectoring capability, which may force fighters to perform their own search and interception functions.

[redacted] computation cycle, and launch its air-to-air weapons. With camouflage, the AI radar may never lock on, or if it does, may not have sufficient time for computation and weapon release prior to mandatory pull-out.

[redacted] Against a radar-controlled, surface-to-air missile defensive complex, similar observations may be made regarding camouflage effectiveness. A combination of verified and postulated parameters for such a complex is shown in Figure 10. The missile-launching sites are arranged in two concentric rings at approxi-[redacted] knots, if the radar search range were halved by camouflage, the defensive radar would have less than four minutes between acquisition and loss of target. During this time, the ground site would have to acquire and track the target, launch a missile, and perform any required guidance function. It seems very unlikely that a high probability of kill could be expected.

[redacted] half, thus effectively eliminating all possible defense against it, either by interception or dispersal.

(U) These, then, are a few of the possible implications of the use of passive ECM. The items discussed are either within the current state-of-the-art or are presently in advanced stages of research and development.

[redacted] What does the future hold for passive ECM? Certainly, passive decoys will for some time render target location more difficult and when highly efficient absorbing materials are

[redacted]

FIG. 11

applied to the true target, the detection system may become so complex and so expensive that it may prove operationally unfeasible. However, a great deal of work remains to be done in the absorption area, some of it quite fundamental in nature. The possibility of synthesizing materials with desired electromagnetic properties by molecular or crystal engineering techniques is under investigation and will be emphasized. Development of absorbing materials with desirable high temperature characteristics will also be stressed. These materials may take the form [redacted]

[redacted]

[redacted] Thus, the silent conflict goes on, with each positive measure requiring development of a negative countermeasure to maintain equilibrium. And certainly while active or semi-active systems exist for detection, tracking weapon guidance, or target destruction, passive ECM will continue to be an integral part of the electromagnetic warfare battle plan.

SPEECH BRIEF

Deputy Secretary of Defense Donald Quarles, on the program for developing a nuclear-propelled aircraft, February 6, 1959: "The present program gives high-priority support to two alternative attacks on the fundamental propulsion problems. Progress along these lines, while impressive, has encountered substantial obstacles. It has been paced by science and technology rather than by funding...... The program assumes that as soon as there is a valid basis for passing from the present propulsion development phase to a weapon system development phase, this will be done.

"It is conceded that the Soviets might choose the more spectacular early flight course. If they do so at this time by building a plane of such low flight performance as to be militarily useless, we take some satisfaction in the fact that they will have wasted some of their resources."

TRAJECTORY MEASURING Systems at AFMTC

By Capt. John G. Ellis, Jr.

Captain Ellis is an engineer with the Directorate of Test Engineering, Test Design Division, at the Air Force Missile Test Center. He received his B.S. degree from Duke University in 1947 and flew with the 4th Fighter-Interceptor Group during the Korean action. He is the author of a series of instructional type articles in the "AOPA Pilot," a popular aviation magazine. Under the USAFIT program he obtained an M.S. degree from the Massachusetts Institute of Technology. Subsequent assignments have been as Chief of the Analysis & Requirements Branch, 58-61 Division, and his present position at the Air Force Missile Test Center.

(Synopsis of a speech given to representatives of the Aircraft Industries Association on 18 March 1958)

(U) The mission of the Air Force Missile Test Center is to operate and maintain a long range "shooting gallery" for testing guided missiles. For this purpose it has a test range extending 4,410 nautical miles from the Cape Canaveral launching complex to Ascension Island off the coast of Africa. An island chain extending over a large portion of the range provides permanent instrumentation sites for monitoring missile performance. These sites are augmented by picket ships, aircraft, and various temporary land sites for particular operations. Logistic and administrative support for the range is centered at Patrick Air Force Base fifteen miles south of Cape Canaveral.

(U) Of prime importance to any agency testing a new missile is a knowledge of where his missiles go and how they get there. Consequently, an important element among the Center's resources is the trajectory instrumentation which we shall discuss here.

(U) Trajectory information generally can be considered in three phases; launch, mid-course, and terminal. In the case of a ballistic missile, the position, velocity, and acceleration during powered flight will determine the subsequent path and impact point. Consequently, extremely accurate trajectory data is required during the launch phase. In the case of a cruise missile, trajectory data throughout the mid-course phase is required to evaluate guidance system performance. Both types require trajectory data during the terminal phase in order to evaluate impact accuracy and re-entry behavior.

(U) To meet these extensive and diverse requirements AFMTC operates and maintains a wide variety of trajectory measuring systems. They fall in three general categories, as follows: optical systems, radar systems, and continuous wave electronic systems.

(U) Our optical systems include three basic types. One is a fixed camera system consisting of mobile BC-5 and C2R cameras which are fixed at specific sites prior to missile launch. Orientation of the cameras is determined by photographing a series of target boards in the launch area. The cameras are started remotely by the firing sequencer, and their exposures are synchronized by phasing of synchronous motors driving the shutter drums. Timing accurate to one millisecond is imprinted on the film edge so that each camera provides a line of position versus time. Thus, trajectory data may be derived from the intersection of lines from two or more cameras. Limitations of the system are the good weather required and the limited field of view of any fixed camera system.

(U) Camera coverage is extended further through use of the cine-theodolite system. This includes seven permanent tracking camera installations each of which requires two operators to track the missile in elevation and azimuth. Dual photography with strobe lamps is synchronized to provide elevation and azimuth of the camera simultaneously with each exposure. This system provides position data accurate to less than one minute of arc at ranges up to twenty miles.

(U) The ballistic camera system provides extremely accurate long-range trajectory data.

It consists of BC-4 and BC-37 cameras which photograph missile-borne flares or flashing lights against a star background. Derivation of a line of position is based on known star orientation as determined from astronomical data. Position of the flare or light on the developed plate can be measured to an accuracy of about three to five microns. This corresponds to a position accuracy of three to ten seconds of arc depending on the focal length of the particular camera. The very high accuracy and reliability of this system makes it the "yardstick" for evaluation and calibration of the various electronic systems. Limitations are the requirements for night operation, missile-borne flares, and clear weather at all altitudes. However, techniques are being developed to permit day operation and use of the missile exhaust flame instead of flares.

(U) The AFMTC radar net provides trajectory data during all flight phases. The backbone of the net consists of twenty Mod II radars dispersed along the entire range. The range of each [redacted] frames permit further refinement of elevation and azimuth data when visibility conditions permit photography of the missile.

[redacted]

(U) The latest addition to the radar net is the FPS-16 which is a high precision C-band mono-

[redacted]

pulse tracking radar. [redacted]

[redacted]

(C) Important merits of the continuous wave electronic systems are their precision and all-

[redacted]

all [redacted] three. Figure three shows the transmitter and two of the receiving antennas found on each base [redacted] ground to the missile. The missile transmits [redacted]

[redacted] Cosine determination is based on measurement of the instantaneous phase difference between the carrier signals received at two antennas. As shown in figure three, a reference antenna and a cosine antenna are separated by a known distance, d. The difference in path length from the missile to each of these antennas is shown by δ. Because of this path length differ- [redacted]

must be utilized to obtain a rough cosine measurement which is then used to resolve the ambiguities in the solution provided by the reference antenna and the coarse cosine antenna. Then the solution provided by this antenna pair is used to resolve ambiguities in a still finer [redacted]

[redacted] Range is determined by measurement of the instantaneous phase difference between signals at the transmitter and one of the receivers. This phase difference will be proportional to the total path length from the transmitter to the missile and back again. [redacted]

[redacted] Data derived from the range and cosine determinations are parallax corrected to an [redacted]

(U) Cotar (correlation tracking and ranging) is another electronic trajectory measuring system. Although less sophisticated, it is similar [redacted] mination and a separate transponder and ground transmitter for range measurements. An experimental unit is operating on [redacted] A similar system programmed for [redacted]

(U) The Secor (sequential ranging) system utilizes phase difference techniques to measure range only. Three or more diverse sites are required in order to derive position from range intersections. Therefore, the accuracy depends on the base line lengths as well as the actual range accuracy.

(U) Another electronic trajectory measuring system is Dovap (Doppler velocity and position). A signal is transmitted from the ground to the missile and back again to a ground receiver. The return signal which is shifted in frequency due to missile motion is beat against the ground transmitted frequency to obtain the resulting doppler frequency. The doppler frequency is a function of missile velocity which, when integrated, provides range. Dovap requires several diverse receiver sites since position is derived from range intersections. Also data must be continuous from launch because of the integration necessary in the data processing.

(U) This well-balanced combination of optical, radar, and electronic trajectory measuring systems has been deployed throughout the Atlantic Test Range with particular emphasis on high precision and reliability in critical areas. This has enabled the Air Force Missile Test Center to support various agencies testing a wide variety of long and short range missile weapons.

SPEECH BRIEF

"In our Air Forcu missile-space program, we are trying to help to build that kind of a world--- to help make the ways of freedom prevail by achieving two aims: first, to provide a deterrent andretaliatoryforce in being which will prevent aggression by convincing our adversary that any attempt to destroy us would insure his complete annihilation: second, to gain time and the opportunity for waging the peace by means of diplomacy, by trade, by economic and cultural exchanges, and---above all---by spreading more widely the ideas of freedom, not just verbally, but by our actions, by what we do, at home and abroad. Otherwise, we will find ourselves defeated by default."

Maj Gen B. A. Schriever
1 June 1958

STRATEGIC SPACE FORCE
Key to National Survival

by
Richard S. Cesaro* and Robertson Youngquist*

[redacted] Introduction

[redacted] The initial probing of space with man-made satellites has placed mankind on the threshold of space and accordingly opened a new chapter in the phenomenal advance of man in science. With the rapid accumulation of knowledge of the space environment and its utility, a new era of science and technological expansion will occur at a rate greater than man has ever before experienced in the exploitations of any new field in the past. And, on the basis of historical evidence, any broad new field is bound to include latent military applications.

[redacted] While science and technology have generated a phenomenal rate of progress, the new capabilities available to us in the space age will be of little value unless our military thinking progresses at the same exciting rate. In a period of fifty years most of us here have been a part of this enormous national scientific growth. To point out a few of these key areas which have markedly changed military operations, one could start with the age of the airplane, first propeller driven, then propelled by the jet engine; then the missile age, from short-ranged vehicles to missiles capable of spanning continents. Another area, the dawn of the nuclear age and its rapid application to weapons and how it has revolutionized military warfare. Another area, the electronic age brought about by individual advances in many supporting technologies, resulting in useful devices such as radar, advanced communications television, and advanced computing machines. Finally, and most important to space, is the rocket age which will permit projection of men—as well as vehicles—into outer space. All of these advances and many more too numerous to mention occurring in a period of about fifty years.

[redacted] It is clearly vital to our national security to consider broadly, from both a technical and national point of view, those initial potential military capabilities in space which can be defined with our present limited vision. Man in the past has consistently made gross underestimates of the potential rate of growth of new fields. The Space Age will probably be no exception to this human failing.

[redacted] With the scientific-military aggressiveness the USSR has already demonstrated, it would be a fatal mistake to underestimate the military importance of space operations. As a nation, we are in deadly contest for our survival with Russia. Thus the major purposes of space vehicles will be shaped by their military requirements.

[redacted] The urgency of developing a space capability is basically set by the following factors: (1) Desire for scientific progress; (2) the need for military vigilance in space as in all other areas accessible to potential opponents as well as to us; (3) national prestige; (4) man's drive to explore the unknown.

[redacted] Processing an adequate space capability requires:

1. Scientifically—that we must stay abreast in space science--
2. Militarily—that we must be as capable as any other nation
   a. to operate weapon systems in space with missions pertaining to the earth's surface; and,
   b. to conduct earth-to-orbit and orbit-to-orbit operations both for defensive and offensive purposes.

*Technical Staff, Advanced Research Projects Division, Institute for Defense Analyses, Washington, D. C.

[redacted]

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[redacted] Being on the threshold of space operations does not automatically alter the role of national defense or offense. The basic need of an offensive force (to be used as a deterrent or, in the case of attack, to be used as a retaliatory force) and a defensive force still remains unchanged with the advent of space operations. Further, being on the threshold of space operations does not automatically alter the classical principles of military strategy and tactics. However, the combined technical revolution in rocket engines, structures, guidance and controls, propellants, and weapons, together with the environment of space flight, does provide a foundation for a totally new family of space offensive and defensive weapon systems and military bases which will revolutionize current concepts of military operations and to a major extent make obsolete currently planned weapon systems.

[redacted] The Congress of the United States with full appreciation of the importance of this new era of science and technology acted wisely and swiftly in constructing and passing the National Aeronautics and Space Act of 1958. A major policy declared by the Congress in this act was that activities in space should be devoted to peaceful purposes. However, the Congress, also fully aware of the defense implications associated with the space age, further declared that activities peculiar to, or primarily associated with, the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense.

[redacted] The thoughts contained in the discussion to follow are sober and technically sound, and the resulting military capability can be a cause for serious alarm if the USSR is permitted to develop this capability without the U.S. recognizing now the military potential in space.

[redacted] Discussion

[redacted] Let us first set military space operation in its proper perspective. The United States and Russia have now achieved the objective of hurling satellites into orbits around the earth. Space payloads will next be hurled to the vicinity of moon and before long to other parts of the solar system. Getting beyond the solar system--out to other stars, for example--will remain still a dream for a long time to come for two reasons:

1. The velocity of escape from the solar system--for an object which has escaped the earth's field--is about 26 miles/second. It takes 15 times as much energy to escape the sun's gravitational field as to escape the earth's field alone.

2. After escaping from the solar system, it would still take 10,000 years for an object to reach the nearest star if we could again get up to a speed of say 18 miles/second.

[redacted] Other stars are from 10 times to one-half billion times farther away still. We will obviously stay in the solar system for the present. In terms of scientific jumps, the achievement of getting outside the earth's atmosphere for the first time is a major step. However, we have taken only a very tiny step into real outer space.

[redacted] It appears, then, that our immediate operations in space will probably be confined for practical reasons to the nearest planets of our solar system; Mars and Venus and our moon. The mean distances to these near planets are extremely large; to Mars, about 50 million miles; to Venus, about 25 million miles; and the moon, only about 240,000 miles. Assuming straight line travel and an average speed of 25,000 miles per hour, it would require about 83 days to go to Mars, 41 days to Venus, and less than half a day to reach the moon. If we next consider the far planets within the solar system; Neptune, 2,700 million miles, and Pluto, 3,600 million miles; a one-way trip traveling at 25,000 miles per hour in a straight line would require 12 years to reach Neptune and 18 years to reach Pluto. This becomes a significant portion of man's current life span and, obviously considerable advances in propulsion must be made before such trips with man aboard are contemplated. We can expect, however, a considerable amount of both scientific and military space operations to occur in near earth orbits and within the cis-lunar volume. Important military operations in space will initially fall into the following four major areas:

1. <u>Defensive Missions:</u> where space systems

[redacted]

[redacted]

are used in part or entirely to defend the U.S. and its holdings against vehicles such as ICBM's, IRBM's, satellite weapon carriers, and other weapons.

2. Offensive Missions: where space systems are used in part or entirely to carry out the role of deterrence and strategic weapon delivery.

3. Information Missions: where space systems are used in part or entirely to carry out surveillance, communications, weather observations and space traffic control.

4. Military Space Bases and Logistics Missions: the utilization of space bases, man-made platforms, and the moon for support and supply, as an important part of developing the required military capability to operate effectively in space.

Important military space vehicles and base support to carry out these four major missions will include the following:

a. Global reconnaissance and surveillance vehicles.

b. Satellites used for early warning and space tracking systems, and satellites used as defense interceptor vehicles.

c. Strategic orbital weapon delivery vehicles.

d. "24-hour" stationary satellite vehicles.

e. "Man-made" space platforms used for emergency supply.

f. Moon base.

[redacted] For purposes of this paper, the definition of Strategic Space Force is the capability to carry out the four military missions discussed with the types of space vehicles and bases mentioned as an integrated military system.

[redacted] Let us first examine where we currently stand in the military space age and then discuss the military attractiveness of space vehicles for carrying out the four basic missions.

[redacted] Where we stand:

[redacted] As an important indication of where we now stand relative to Russia in space, Fig. 1

[redacted]

presents a broadbrush picture of payload weights in orbit. Payload weight capability is an important criterion of ability to carry out the aforementioned missions with the types of vehicles previously mentioned. The early family of military space vehicles will require payload energies equivalent to low-orbit payloads of about 2,000 to 10,000 pounds, rapidly followed by vehicle weights in orbit of about 20,000 to 30,000 pounds. Later, more advanced military vehicles will require the equivalent of low-orbit payloads up to perhaps 50,000 pounds.

[redacted] The data in Fig. 1 indicates a steadily-widening gap between Russian and American capability. They also show that the Russians have up in space an orbiting payload heavier than the payload we hope to have up nearly two years or more later. Up until a short time ago, we did not have any approved U. S. vehicles program which would provide a useful payload weight-carrying capability greater than that [redacted] proved two new vehicles which will provide an enormous increase in our weight lifting capability. These are, first, a new 30,000-pound, high-energy upper stage and, second, the 1.5 million-pound thrust clustered engine booster.

[redacted] Small lunar and interplanetary payload carrying capability can be obtained by using the booster power of the Thor, the Jupiter, and the Atlas to carry upper stages into space which transfer the required terminal velocity to the payload capsule proper. Because of its enormous booster power and availability, the Atlas

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[redacted]

can logically carry the greatest load into space at the earliest time. The Atlas, with the additional 30,000-pound high-energy stage development which altogether represents a smaller additional effort than the effort required for any other missile presently under development, can place sizable payloads of about 10,000 pounds in near-earth orbits and meaningful payloads can be carried for interplanetary missions. The combination of a clustered 1.5 million-pound thrust basement booster with a modified Atlas added can place some 15,000 pounds in orbit. Adding the 30,000-pound high energy stage to this group would result in a capability of placing some 25,000 pounds in orbit. A three-stage vehicle, consisting of, first, the clustered 1.5 million-pound thrust unit, then a new 200,000-pound high-energy stage, and finally, the 30,000-pound high-energy upper stage could place weights of between 40,000 and 50,000 pounds in near-earth orbits.

[redacted] It is reasonable to conclude from this early evidence that the Russians looked farther ahead sooner than we did or at least acted more boldly on the future they saw in space operations. It is also reasonable to conclude that if we are to approach the rate of progress the Russians are making in space capability and exploitations, we cannot follow a small-increment program of research and development toward short-term goals. Instead we must set far-sighted objectives and then leap-frog over many of the intermediate steps because of their cost and their early obsolescence. The reason we should try to approach the Russian rate of progress should become clearer as we now generally discuss the military attractiveness of various space vehicles for the several mission mentioned earlier.

[redacted] Defensive Missions

[redacted] The defensive role as carried out by a space force can be accomplished, for example, [redacted]

[redacted] The most practical and effective approach to detection or early warning, tracking, and destruction of enemy ICBM's and IRBM's may very well be through the utilization of a family of space vehicles that would perform these operations during the burning phase of the enemy missile. The current earth-based approaches to the AICBM problem are technically incomplete and enormously expensive in view not only of the basic problem but the associated problem presented with sophisticated decoys and the many directions from which enemy missiles can approach this country.

[redacted] A most attractive orbital system for use against enemy ICBM's during their launch and powered flight is one which detects and homes in on the IR radiation from the rocket exhaust. This signal is intense and is also of 2-1/2 to 5 minutes duration, depending on the range. The ICBM is in the early portion of its flight when the signal is being emitted; it is therefor moving relatively slowly, making its tracking and interception considerably easier than for a re-entering warhead and its sophisticated decoys. In addition, damage or destruction of the large and complex missile is easier than for a re-entering warhead since any modest damage done [redacted]

[redacted] Offensive Mission

[redacted] The military significance of orbiting strategic weapon delivery systems is that they provide a deterrent capability far in excess of anything heretofore achieved. The combination of enormous flight duration in space and in-flight alerted weapon delivery potential provides a unique and major military advantage. This advantage remains even with the restriction that these vehicles orbit outside of enemy territory

[redacted]

[redacted]

in time of peace. The ability to deliver a weapon on target from an orbital manned bomber can [redacted] greater than that expected of ICBM's.

[redacted]

launched requiring no refueling. An appreciation of the operational capacity of an orbiting bomber is obvious from a comparison of this type. For unmanned orbiting weapon delivery vehicles one could talk in terms of two to five years instead of seven days, and a corresponding comparison would show practically unlimited capacity. This would have an enormous effect on reducing dollar cost for this type of vehicle even though a large number of vehicles will probably be required.

[redacted]

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[redacted]

[redacted]

[redacted] to mention that creating realistic decoys of trivial weight dispersed over wide areas will further confuse the defense. These combined

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[redacted]

approaches alone will make the satellite bomber an extremely difficult if not impractical target to destroy.

[redacted] The question arises in considering space weapon systems whether the inclusion of a human crew in the vehicle will further its military capabilities. At one end of the spectrum, weapon delivery to target, some of the principal advantages of the system are peculiarly associated with the fact that a man is not present in the warhead. At the other end of the spectrum, it is likely that at least some of the potential advantages are directly connected with the presence of man in the orbiting system. Unfortunately, some of the benefits that are contributed by man are not as susceptible to precise analysis as are the more tangible hardware elements of the system. Man will play an important role in many space vehicles. Man can serve best in areas of complex judgment making, based on fairly diverse and complex information inputs, and, particularly, use of information of a type which might have been impossible to anticipate. In any event, consideration of manned space systems is mandatory in order to establish an effective military space force with the judgment that only man can execute.

[redacted] INFORMATION MISSIONS

[redacted] The value of military orbital information missions such as reconnaissance, surveillance, communications, mapping and weather has already been recognized in this country. Considerable emphasis is being put on programs to provide these capabilities. Again, it is worth pointing out in a typical example the tremendous capability operations in space will afford over current approaches. Plans for earth reconnaissance contemplate photographic, ferret, and infrared equipment in satellites. Satellites that operate in circular orbits 300 miles above the

[redacted]

Concerning global communications alone, such a system could handle billions of information groups per day, which is far beyond the possibilities of earth-bound global communications systems. The requirements imposed by the satellite system on its transmitters, receivers, recorders, power supplies, etc., are within the present technical state-of-the-art.

[redacted] MILITARY SPACE BASES AND LOGISTICS MISSION

[redacted] The utilization of space bases, man-made platforms, and the moon to support, supply and help carry out the military missions in space will be an important part of developing the required military capability to effectively operate in space. The military importance of establishing a moon base has been the topic of a good deal of misguided speculation. Accordingly, I will point out some potentially important uses for the moon. It is necessary, here again, to consider broadly, from both a technical and national point of view, the importance of a moon

[redacted]

[redacted]

base and how it might relate to the future national military space program. It is within the realm of technical feasibility today to construct manned space vehicles powered by chemical fuels and to utilize them to land on, construct, and maintain a moon base. What, then, can we presently foresee in the way of direct military benefits from such operations?

[redacted] First of all, we cannot afford, politically and psychologically, to give up the moon to Russia for her exclusive use and exploitation. Next, utilization of the moon as a base for space operations affords the following three major advantages:

1. The moon used as a space platform already exists in space and is enormous in size and mass relative to any future "man-made" space platforms.

2. The moon is a highly predictable and stable space platform.

3. The moon is a potential source of materials and energy.

Lunar base operations take on a unique role when viewed relative to the military missions discussed. Let us first discuss some of the advantages offered in communications and space surveillance.

[redacted] The military advantage obtained by processing a non-jammable communications and surveillance system to command, control, monitor and relay data on all military activities in space and on the earth is a system capability of obvious importance. The non-atmospheric environment of the moon, the potentially large [redacted] would be reduced considerably, if not entirely, due to the combination of both the large transmission power from the moon and the moon antenna gain advantage. The advantages provided in moon base operations in this area appear attractive and are worth studying in greater detail.

[redacted] A few words are in order next on how lunar base helps in the missions of defense and offense. As previously discussed, the possibility exists technically that weapons such as earth-based IRBM's and ICBM's may be large neutralized by a space system of detection and early destruction. In addition, conventional weapons operating in the earth's atmosphere could also be neutralized to a major extent. How then can weapon delivery be accomplished to maintain our national policy of deterrence?

[redacted] Moon base provides a means of constructing a totally new approach to the national policy of deterrence. Strategic weapon delivery might be carried out directly or indirectly through relay command control from a moon base.

[redacted] This does not necessarily mean that weapons must be launched from the moon, but rather that moon base could serve as a master operations control base to deliver the necessary intelligence to near-earth orbiting space systems capable of launching weapons. Here, again, we cannot afford to have an enemy develop this capability alone.

[redacted] Finally, the moon can be used as a source of basic materials for use by man in his operations on the moon and in space. Many of the chemical elements found on earth could also exist on the moon. For example, oxygen may be extracted chemically from the moon. Accordingly, it may not be necessary for man to transport such things as oxygen, food, and conceivably even water and rocket fuel to sustain man on the moon and his operations from the moon once he is established. Furthermore, the gravitational advantage for moon base operations is such that more than 20 times as much payload could be carried from the moon to earth as from earth to moon in the same size vehicle. Thus, as a refueling base for space vehicles, if only for oxidizer, the moon would have interesting potential. The enormously higher payload potential achieved through moon launch if applied, for example, to excess velocity capability would permit high-energy trajectories in space and would thereby considerably reduce transit time. In any case, the potential military uses for the moon require that the moon be explored by man at an early date to evaluate and determine how best it can be used.

[redacted]

[redacted]

[redacted] SUMMARY REMARKS

(S) In summary, it is well to keep in mind that man's vision in totally new areas has been and will probably continue to be limited. The Russians are well down the space road and will continue to uncover many new and vital facts before us if we do not change our pace. We must regain the advantage in the scientific offensive. This requires the development of totally new concepts. These concepts cannot simply be normal extrapolations of an orderly evolutionary program; they must be revolutionary. We cannot continue to follow the usual "safe," and conservative and critical line of approach which leads to a slow, "safe," and non-controversial course to progress. It has been demonstrated time and time again in the past that this conservatism and reluctance to engage in imaginative thought and advanced "state-of-the-art" change leads only to failure in the appreciation of useful applications for military-scientific principles and lessens or makes more expensive the pace of technical development when one tries to "catch-up." The best recent example of this [redacted] resolved. We lost as a nation at least five years of ICBM research and development background because of this attitude. We cannot afford to follow this approach to future problems in the space age if we are to survive as a free nation.

[redacted] In conclusion, the following seven points are made:

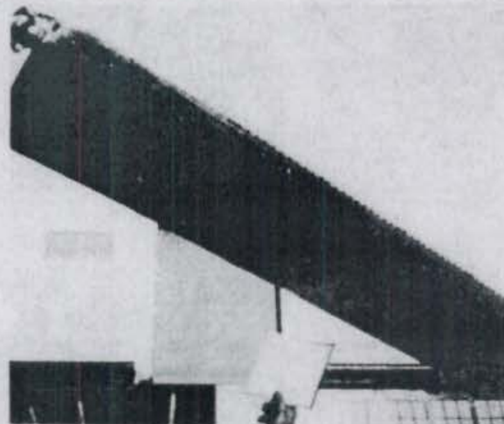
1. We must anticipate the tremendous impact that space technology's ever-increasing rate of advance will have upon military systems and operations.
2. We must orient our military perspective out to a new frame of reference - orbital space beyond Earth.
3. In this framework, we must compare our current status and rate with Russia's and must predict that we can well lose our deterrent capability and therefore our freedom.
4. We must, therefore, accelerate building up a strategic orbital space capability if we are to maintain a deterrent.
5. In accelerating, we must concentrate on taking a small number of seemingly large, leapfrog steps.
6. We must avoid dissipating our effort on many small-increment, conservative, overlapping, and costly weapon system steps which can be rendered obsolete by the first truly orbit-referenced space system, be it Russian or American.
7. We must attain rapidly a new military posture of strategic strength from space in four classically important roles, namely:

    Defense
    Offense
    Information
    Logistics and Supply Bases

[redacted] These are the points upon which this paper was developed. The scientist and the engineer must provide the technical ideas and knowhow for a strategic space force. Industry must build the physical elements of such a force. Our leaders and workers in the government and in the military establishment must set the research and development objective itself and must put urgent national emphasis on its attainment. Rapidly establishing a strategic space force may very well be the key to future national survival.

[redacted]

WADC
Flight Evaluation of a Helicopter
Icing Protection System....



Run #10 (De-icing) Heavy Icing Intensity

By Capt A. R. Wicker, WADC

Captain Arthur R. Wicker (B.S., Clemson A&M College, South Carolina, Mechanical Engineering; USAFIT, Aircraft Structural Design and Repair) is a project engineer in the Directorate of Flight and All-Weather Testing, WADC, where he has been assigned since September 1958. Captain Wicker entered the Air Force in September 1952 where he served as a Mechanical Engineer in the Base Maintenance Shop at Perrin AFB, Texas. He entered pilot training in January 1953 and was graduated in 1954 as a pilot on multi-engine aircraft. Captain Wicker served in 1954 through 1957 as a mission pilot on T-29 aircraft at Mather AFB, California. He was assigned as project engineer on the YH-40 and the H-38 helicopter adverse weather ice protection system evaluation at WADC.

(U) A series of helicopter icing flights were completed in December 1958 at the National Research Council's Helicopter Spray Rig Test Site at Uplands Airport in Ottawa, Canada. The helicopter used was a three blade single-main rotor type helicopter with a three blade anti-torque tail rotor. Both main and tail rotor blades were provided with icing protection.

(U) The flight tests held in Canada were to evaluate an alcohol-glycerin helicopter blade ice protection system in controlled artificially created icing conditions. This evaluation was primarily conducted to substantiate the favorable findings of the Adverse Weather static tests conducted on this system at the Climatic Hangar at Eglin Air Force Base, Florida in June and July 1958. Both tests were conducted by the Directorage of Flight and All-Weather Testing of Wright Air Development Center, Dayton, Ohio.

(U) The anti-icing system consisted of a fluid reservoir (29 US quarts capacity) and a two-speed pump which supplied fluid to the main and tail rotor slinger ring distribution systems. The main rotor slinger ring had three flexible hoses leading to each blade through which the fluid was fed by centrifugal force to three separate blade anti-icing sections. Each blade section dispersed its fluid through two staggered rows of holes in the leading edge of the blade. These holes were of the same size (.035" dia.) and vertical and horizontal spacing (1-3/16" between holes throughout the blade span. The tail rotor slinger ring had one flexible hose leading to each blade and one ice protection section serviced the entire blade span. The tail blade ice protection system dispersed its fluid through two in-line rows of leading edge holes that were of the same size (.035" dia.) and spacing (25/32" between holes) throughout the blade length.

(U) The recommended ice protection fluid mixture was 85 percent ethyl alcohol (200 proof) and 15 percent glycerin. Since 200 proof alcohol was not available, a mixture of 90 percent denatured alcohol and 10 percent glycerin was used for this test. The main blade system consumed this mixture at the rate of 1.11 quarts per minute with the fluid pump set at boosted flow and .72 quart per minute with a normal flow pump setting. The tail rotor blade system consumption was .12 and .08 quart per minute respectively.

(U) The spray rig used in the tests consisted of a frame 75 feet wide and 15 feet high and had 161 mounted spray nozzles. When in

Test Installation

operation, this frame is hoisted to the top of a 70-foot steel mast and can be rotated through 360 degrees to position it normal to the wind direction. The wind movement is the force that carries the spray cloud clear of the rig, and enables the helicopter to hover in absolute free flight in the spray cloud about 100 feet from the mast.

(U) The test temperatures during the thirteen test flights varied from 0 to 23.5 degrees F, and the icing conditions were considered moderate through heavy.

(U) Four types of test runs were conducted. They are: (1) Unprotected run (system off), (2) De-icing run (boosted flow), (3) Anti-icing run (normal or boosted flow, (4) Cyclic de-icing run (boosted flow - 5 min. on 5 min. off cycling time).

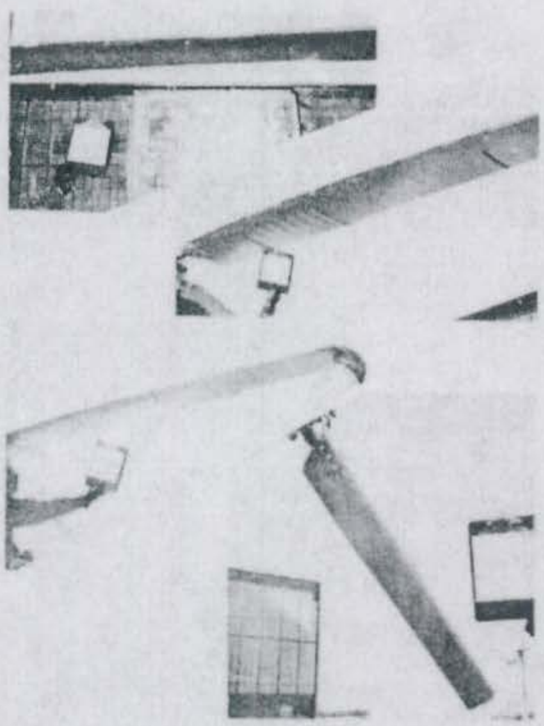
(U) The amount of main blade ice collected during the tests was dependent upon system fluid flow setting, cloud properties, ambient air temperature, and independent of time. That the blade ice collected was independent of time was indicated by the fact that for different runs at approximately the same temperature and spray setting, but not of the same time duration, the amount of ice collected was approximately the same. Consequently, at one set condition the ice formation reached equilibrium very early.

(U) During all anti-icing runs the main blade ice formation followed the contour of the blade airfoil. The ice formation never exceeded 1/16" in thickness and was a grainy, loose structure, the result of the fluid infecting the ice.

(U) When the alcohol-glycerin ice protection system was operating on boosted flow, the amount of ice collected near the leading edge formation was completely negligible. On a run using normal flow, there did occur a thin frost-like formation on the underside of the blade only.

(U) The tail rotor blades, except for the blade cuff area, were kept completely free of all ice. The blade cuff ice caused no problem since this area is not susceptible to unbalance from uneven ice shedding.

(U) Vibration from uneven ice shedding in all cases was either non-existent or at the most, barely perceptible. At no time did the fluid ejection holes become clogged or covered over with ice. Thus, in all cases, the main blades were adequately anti-iced and were kept completely clear of ice at most stations.

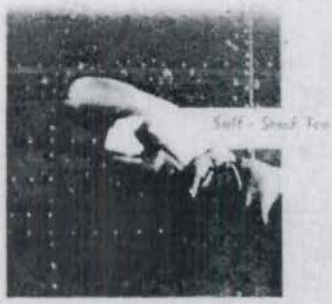


Run 13 (Cyclic Deicing) Heavy Icing Intensity

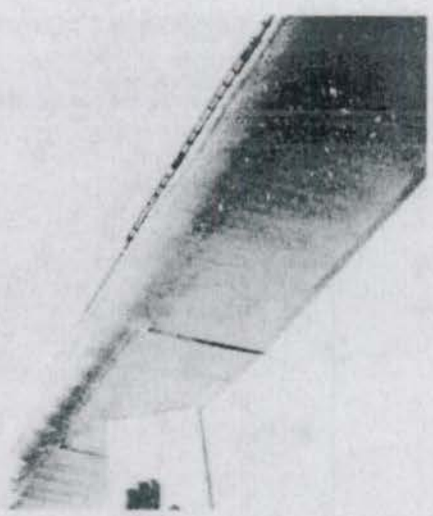
(U) Three de-icing runs were made following three unprotected runs where the ice was allowed to build from 3/8" to 3/4" thick on the leading edge. The de-icing times varied from 5 to 10 minutes. Ice remaining on the main blades after two ten-minute runs exactly resembled in quantity, size, distribution, shape, and texture, the ice that remained after comparative anti-icing runs. A five-minute de-icing run was made in which it was determined that the alcohol-glycerin fluid would penetrate 1/2" thick ice with little difficulty.

(U) The results of this test definitely indicate that a chemical type (alcohol-glycerin fluid ejection) blade ice protection system will give dependable and completely adequate protection to helicopter main and tail rotor blades during operation in icing conditions up to and including heavy intensity. The system also is a very efficient and reliable de-icing system even under heavy icing conditions.

(U) In operation, the system requires very little maintenance, and cleaning required nothing more than purging with alcohol and compressed air. The system weight less fluid is estimated at 40 pounds, and could be increased and still not penalize aircraft performance to the extent of other proposed ice protection systems. Because of its simplicity, reliability, ease of maintenance, etc. this alcohol-glycerin ice-protection system should be considered for all future helicopters requiring an all-weather capability.



Run 9 (Unprotected)
Heavy Icing Intensity
Leading Edge Ice -
3/4" Thick



Troposheric Refractive Effects on a MICROWAVE POSITION MEASURING SYSTEM

By Thomas J. Obst, AFMTC

(U) The Air Force Missile Test Center, in the past years, has received increasingly more stringent requirements for accurate trajectory data under all weather conditions. These requirements have forced the Center to seriously consider the use, as prime elements of instrumentation, of various pulse and CW trajectory systems operating in the microwave region of the spectrum.

(U) To successfully utilize such systems, however, it was apparent that specific knowledge must be acquired concerning the nature and extent of the corrections that must be applied to the data from electronic trajectory systems for errors introduced by tropospheric propagation anomalies.

(U) A review of the literature in this field uncovered many measurements of the index of refraction and index profiles as a function of altitude. In addition, several excellent theoretical treatments were found which dealt with the propagation of a microwave signal through the troposphere. We could not, however, find any quantitative work of the measured effect of tropospheric refraction on the performance of a microwave position measuring system. The development of the AFMTC range depended, in part, upon the acquisition of this knowledge. Further, all of the essential elements for an experimental determination of tropospheric effects under certain limited conditions existed on the range. Accordingly, a program was set up to:

1. Experimentally determine the scope, nature, and operational procedures required for the routine application of corrections for tropospheric refraction to electronics systems used for:

   Impact Prediction and
   Missile Trajectory Determination.

Thomas J. Obst received a BS in Physics and Chemistry from Long Island University in 1939. After one year of graduate work in Physics at Polytechnic Institute of Brooklyn he accepted a position with the Department of the Navy. Mr. Obst joined the staff at the U. S. Naval Ordnance Test Station where he was responsible for the station's activities in the field of Optical Instrumentation. He transferred to the Air Force at Patrick Air Force Base in September 1950 and has been assigned as a Physicist in the Directorate of Range Development.

2. Assemble basic data in this field to permit an intelligent interpretation to be made of future requirements for tropospheric propagation data in connection with missile guidance systems.

(U) The program, therefore, is concerned with the measurement of various atmospheric parameters, a determination of the deviation of the line of sight of microwave radiation passing through the troposphere, and an evaluation of the equipment and procedures that might be used to correct for the deviations measured.

(U) Since the program is concerned with the measurement of a dynamic, turbulent media, it is evident that the results must be made on the basis of a statistical approach, i.e., conclusive results cannot be drawn from a few isolated cases. Further, one must eatablish the reliability, repeatability and significance of basic data derived from the measuring tools available, i.e., radiosonde, refractometer, electronic trajectory system, measurement standard, competent meteorological judgment, etc.

(U) In addition, it is essential that the test program be established along lines that tend to duplicate the operational problem so as to eliminate the possibility of errors of extrapolation. If, for example, the data is to be used against targets at a range exceeding 150 miles at altitudes unobtainable by present day aircraft, it is apparent that the test vehicle must be a missile. Fortunately, the Army Ballistic Missile Agency was in the process of testing the Redstone missile and was willing and able to carry, on a limited number of flights, the beacons and transponders required by our test.

(U) Unfortunately, the number of Redstone test vehicles available was insufficient to meet the statistical needs of the test. Accordingly, an additional test program, involving an aircraft as the test vehicle, was activated to provide the bulk of the statistical data.

(U) On the basis of the considerations stated above, therefore, the AFMTC Tropospheric Propagation Program has been divided into three elemental tasks: a time-space comparison test of index of refraction, an aircraft test, and a missile test. The three tests are designed to investigate the following areas.

1. Comparison tests were designed to measure the time-space variation of the index of refraction derived from refractometer and rawinsonde data. These data can be broken down into three elementary comparisons:

   a. Refractometer aircraft helical ascents centered around the ascent path of the 10 A.M. synoptic rawinsonde balloon.

   b. Alternating ascents and descents over Cape Canaveral and along the flight path.

   c. Repeat ascents and descents over Cape Canaveral.

2. Aircraft tests were conceived using a T-33 aircraft as a simulated missile target at a range of 40nm from Cape Canaveral and at an altitude of 35,000 feet. These tests were designed to compare, through the use of a high altitude aircraft:

   a. The net gain in accuracy of the AZUSA tracking system by the application of tropospheric refraction corrections to the apparent range and angle data.

   b. The relative gain in system accuracy as a function of the nature of the tropospheric propagation correction applied.

   c. The scope, nature, and operational procedures required for the routine application of these corrections to a microwave radar system.

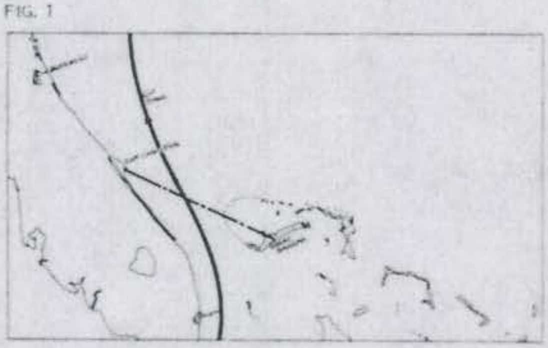
   d. The possibility of using predetermined refraction corrections for accurately correcting position data on a real time basis.

3. Missile tests were envisioned using the Redstone missiles scheduled to carry the AZUSA transponder and flashing lights. The missile tests were designed to provide the same basic information as described in the above T-33 aircraft tests but at a range of 150 rather than 40nm from the AZUSA site.

(U) The general locale of the tests is illustrated in Fig. 1. The significant characteristics of the area with respect to this experiment are: First, the general area is a semi-tropical coastal region bounded by a shallow continental shelf extending some 35 miles off shore. Beyond the shoal area, the Gulf Stream is encountered moving in a northerly direction. East of the Gulf Stream lies another shoal area, the little Bahama bank, which is bounded on the north, east and south by a line of cays, Great Abaco Island, and Grand Bahama Island.

(U) The Gulf Stream is responsible for the gradual buildup, during the hours of darkness, of a line of cumulus clouds which move in an easterly direction and gradually dissipate dur-

FIG. 1



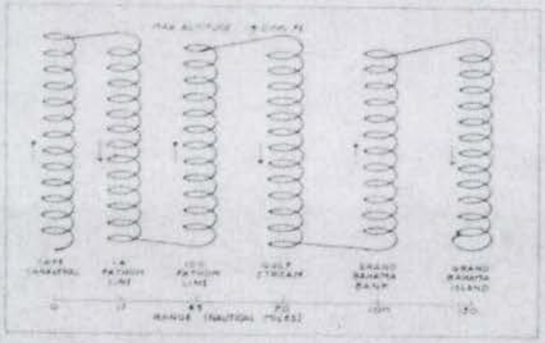


FIG. 2

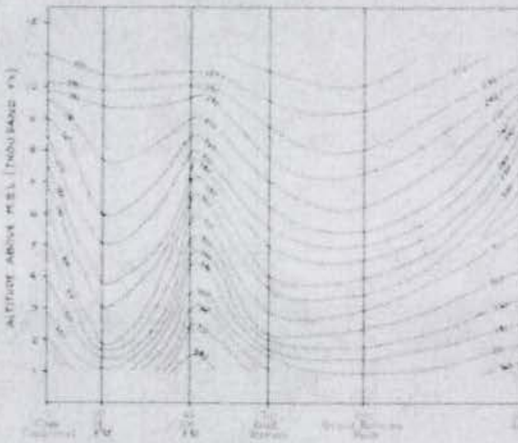


FIG. 3

ing the morning hours. Cumulus clouds reform during the day over the central portion of the Florida peninsula, move in an easterly direction and dissipate during the evening hours.

(U) The time-space study of the index of refraction in the microwave region of the electro-magnetic spectrum was set up to determine the effect of these dynamic forces on the consistency of the index of refraction throughout this region.

(U) Profiles of the index of refraction as a function of altitude were obtained by flying airborne refractometers in a C-131 and B-17 aircraft in a pattern diagrammatically illustrated in Fig. 2.

(U) The individual profiles obtained by executing the flight pattern illustrated can be combined and converted into iso-index contours and examined in terms of range in nautical miles from Cape Canaveral and altitude above mean sea level. In executing this conversion, allowance must be made for the lag in the aircraft altimeter unit. Typical profiles obtained from this work are illustrated in Figs. 3 and 4.

(U) It will be noted from examination of the profiles that the troposphere in the vicinity of Cape Canaveral departs considerably from a horizontally stratified media. Further, it appears that any attempt to perform an exact ray-tracing throughout the line of sight would be extremely tedious, if not outright impossible.

(U) In comparison to the rather extensive data obtained from airborne refractometers,

FIG. 4

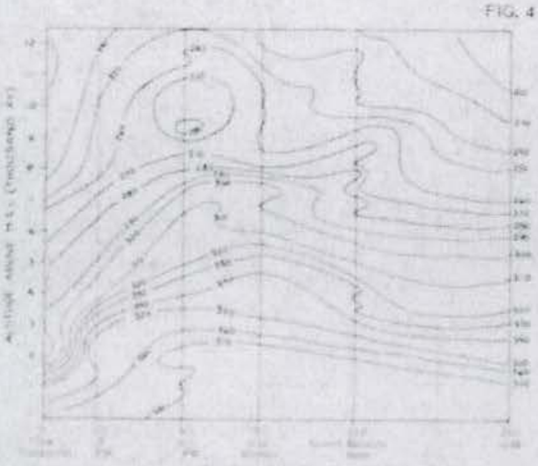
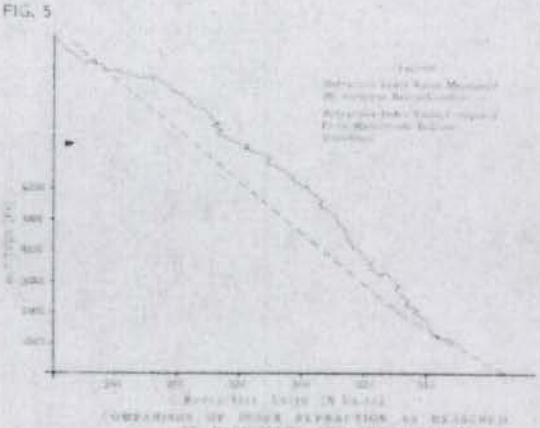


FIG. 5



the available radiosonde data would, in a cursory sense, appear to be insufficient to provide an effective input for correcting the tropospheric effects on a microwave instrumentation system. These limitations are brought about by the geographical location of rawinsonde release points, the slow response of the radiosonde detector elements and the slow information rate inherent to the radiosonde. The above items provide a powerful smoothing function to the radiosonde output data (Fig. 5).

(U) The T-33 aircraft test program was delayed due to operational and equipment problems. Therefore, no data is reported from this source at this time.

(U) The missile test program, fortunately, has been more successful. As previously mentioned, the missile test involved the use of the ABMA Redstone as a test vehicle. The missile carried an AZUSA transponder, a high-powered argon-xenon flash tube fired from command pulses generated internally within the missile and correlated with range time by a telemetry link that transmitted the command signal to ground receiver stations where it was recorded against range time.

(U) The instrumentation consisted of an AN/FRW-1 AZUSA system located at Cape Canaveral, and a group of three Wild BC-4 ballistic cameras in the Grand Bahama Island area. Airborne refractometers and rawindsone equipment were used to determine the refractive index in the microwave region.

(U) The tests were conducted at night to permit the BC-4 ballistic cameras to record time correlated star image which determined the orientation of the cameras. Through this technique, uncertainties due to mechanical malalignments in the camera mounts, or in the leveling of the camera mount structure, were eliminated from consideration.

(U) Since the rotation of the earth causes an apparent star movement of 15 seconds of arc per second of time, a timing correlation of approximately 70 milliseconds in the recording of star images theoretically produced an orientation accuracy of 1 second of arc. Further, by locating the cameras approximately 50 miles from the terminal portion of the trajectory and orienting them at relatively high elevation angles, the net effect, when viewed from the AZUSA site approximately 180 miles from the region of the terminal trajectory, was to further increase the apparent accuracy of the BC-4 system data with respect to the AZUSA system.

(U) The AZUSA system is an automatic, high precision, all-weather, electronic trajectory measuring system consisting of a single ground station and an airborne transponder. Continuous, unambiguous data is generated in real time in the form of two direction cosines, l and m, and range R, from which X, Y, and Z position coordinates or azimuth, elevation and range of missiles and aircraft can be derived.

[redacted]

(U) The system, as built, has a shortened baseline which tends to compensate for the effects of tropospheric refraction.

(U) The AZUSA data, in the region of BC-4 coverage, was processed and converted to azimuth and elevation angles and slant range. The AZUSA elevation angle and slant range data were then corrected in the following manner and compared to fully corrected BC-4 data:

1. No data reduction correction applied ("As built").
2. "Built in" correction removed.
3. Tropospheric refraction corrections were applied to the data in 2. above, assuming a vertically stratified atmosphere that was horizontally homogeneous. Inputs were made from the following sources:
   a. Refractometer profile selected to provide the best approximation to the region under study.

[redacted]

b. Refractometer profile of a. above modified to eliminate all detail short of a major inversion layer.

c. Rawinsonde data from Cape Canaveral Weather Station.

d. An empirical formula based on the general meteorological characteristics of the area.

[redacted] Data was obtained on two separate flights, one on August 8, 1956, the other on October 18, 1956. An examination of the August 8 elevation angle data, Fig. 6, indicates a difference between the basic AZUSA data and the BC-4 camera data [redacted] The difference [redacted]

[redacted] The residual difference between the two systems dropped significantly when a tropospheric refraction correction was applied to [redacted] spectively. Further, the differences in corrections made through the use of the basic refractometer profile, the smoothed refractometer profile, the radiosonde and the empirical formula were, to all intents and purposes, insignificant.

[redacted] If we now examine the October 18 elevation angle data, Fig. 7, we find essentially the

[redacted]

[redacted]

same situation prevails. In this particular case, the "built in" system correction is plotted along with the other data. Examination of this plot will show that the "built in" correction counteracts approximately 1/7 of the error due to tropospheric refraction. A tabulation of the pertinent data from the two previous figures, Table 1, indicates close agreement in these two measurements. The data also indicates that the [redacted] tory measuring systems without applying a correction for the effects of tropospheric refraction.

(U) Further, although the data is not conclusive, present results strongly indicate that little difference in system accuracy will result from the use of an airborne refractometer, rawinsonde, or a pertinent empirical formula to correct for the effects of tropospheric refraction.

[redacted] comparison of the slant range differences on both tests, Figs. 8 and 9, indicates a difference between the uncorrected and corrected data amounting to [redacted] and approximately [redacted] A close examination of the slant range data on both days indicates a closer correlation between the camera and the uncorrected data than is the case with the corrected data. This point is particularly evident on the August 8 date when a known difficulty was experienced with the AZUSA power output stage.

[redacted] Despite the difficulties encountered with the CW system in these two cases, it is interesting to note that the spread between the various corrective techniques amounted, in general, to less than one meter. In the particular case of the empirical formula on the August 8 shoot, the corrective factor was held too long at the lower elevation angles. Despite this known error, the results checked to within 3 meters.

(U) In conclusion, it must be reemphasized that this program is concerned with the experimental measurement of a dynamic, turbulent media and that conclusive results could not be drawn from a few isolated cases. Although this task is largely unfinished, the results of our efforts to date have been presented at this time with the hope that it will be of some assistance to those individuals engaged in the planning, engineering, or reduction of microwave systems used for range instrumentation or radio guidance purposes.

[redacted]

[redacted]

The RESEARCH ROCKET - A Specialized Missile

By Louis Kraft, Jr.

(U) Since the first flight in 1946 of a captured V-2 as a research vehicle, direct probing of the upper atmosphere by rockets has been established as a highly productive research technique.

(U) The more recent use of satellite vehicles and ICBM flights for scientific instrument-carrying offers much in the way of greater altitude, longer times of flight and geographical coverage. However, if one considers the cost of the data obtained, the allowable payload and telemetry, the complexity of the launching operation, and the fact that the trajectory and time of flight are controlled by considerations other than those of the experiment carried, it is obvious that there remains much to be said for the research vehicle as we have used it for the past twelve years. Provided the cost and complexity of the operation can be kept low and the payload-altitude characteristics high, the vertical flight rocket can continue to add greatly to our knowledge of the upper regions of the atmosphere.

(U) Using the present concept of the research rocket it would seem desirable to be able to carry moderate payloads to altitudes of one to two thousand miles.

(U) The first factor which should be determined is the needed altitude-payload characteristic of the vehicles. (See Fig. 1.) A study of the work which has been done in upper atmosphere research with rockets during the past shows that significant and sophisticated experiments have been performed within the 150-lb payload of the AEROBEE rocket. At the other extreme many experiments have been adequately done with a 25-lb payload. Logically, then, considering that developments in miniaturization are continually improving the use of any given payload, there should be no change in payload goals.

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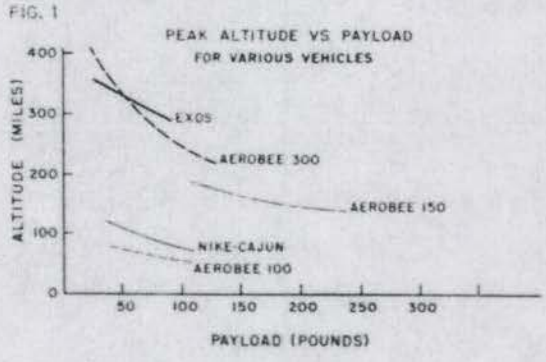
(U) In the matter of altitude, we are currently able to probe to about 300 miles. It seems likely, as will be seen later, that the maximum altitude of the low-cost research rocket will be in the vicinity of 2,000 miles. This range of altitudes can be covered by three vehicles: one to 500 miles, one to 1,000 and a third to 2,000, with each of these being capable of a range of payload-altitude variation. A building block approach, utilizing common items of hardware for all three vehicles, will be necessary if costs are to be kept low.

FIG. 1



(U) The research rocket in general requires no guidance except that necessary to obtain maximum altitude, and impact on the firing range. Stabilization systems investigated for research rockets up to the present have, aside from the increased cost, either required the greater portion of the available payload or required a much larger rocket to carry them.

(U) However, some means must be used to insure vertical thrust orientation and, consequently, maximum altitude for a given fuel expenditure. Since guidance per se seems to be impractical for our needs, there remain the alternatives of aerodynamic and/or spin stabilization. The latter promises to add some mileage to the upper limit, but the spinning platform is not welcomed by the experimenter. Aerodynamic stabilization has been the principal method used to date on the research rocket with the exception of the V-2 and Viking. However, since the aerodynamically stabilized rocket must terminate its burning within the sensible atmosphere and then coast to zenith, as these vehicles go higher, more exacting G-loading (acceleration) and Q environments (aerodynamic loading) with consequent heating must be tolerated to reach adequate coasting speeds below approximately 200,000 ft. These are the considerations which have led to the conclusion that the upper limit for the research rocket, as we have defined it, is in the vicinity of 2,000 miles.

(U) Next let us look at how such vehicles might come into being. To keep within the low-cost category, a necessary rule is to make as much use as possible of hardware already developed for other purposes. This is in keeping with the philosophy which successfully and at very low cost produced the NIKE-CAJUN, the EXOS, and the SPAEROBEE. It must be borne in mind, though, that there is much more to this approach than simply mating existing motors with appropriate fins, couplings, and firing circuits. The NIKE-CAJUN, for example, ran into difficulty because of divergence in the forward structure, and the EXOS exhibits its inefficiency in a 180G burnout at some 70,000 ft. These are, of course, representative of compromises which must be accepted if any vehicle is to remain in the low-cost category.

(U) In general, though, these research rockets should be assembled from existing power plants. Thus, one of the major costs of a rocket development is eliminated and if the unit chosen is part of a larger missile program, high reliability is obtained from the testing phase of that program.

(U) The choice of a single rocket motor or a combination of staged motors considers more than the ability of that motor or motors to carry the payload to the required altitude. The choice must be based primarily on the optimization of the trajectory in terms of acceleration and heating, and how these factors are affected by thrust and burning time. High thrust is desirable at takeoff in order quickly to attain aerodynamic stability and to avoid G-losses in carrying fuel. Because velocities are low during this period, drag losses are tolerable. As velocity increases, and until the rocket has reached thinner air, thrust should be lower so that most of the energy

FIG. 2

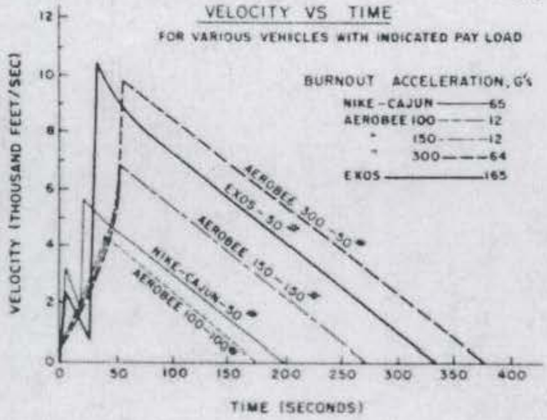
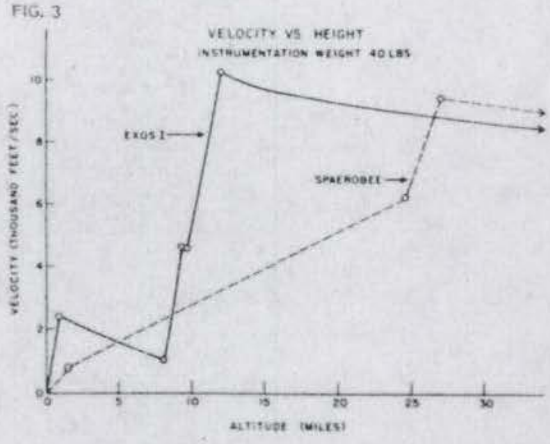


FIG. 3



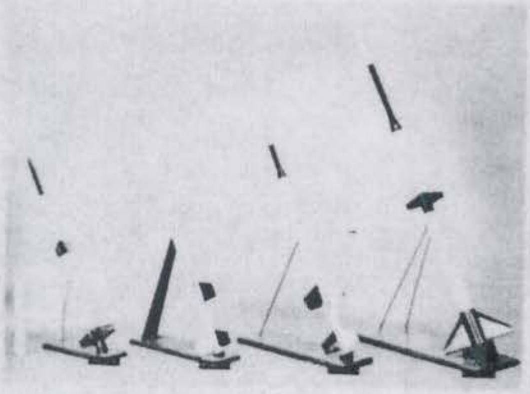


Fig. 4 Scale models of today's inventory of "work-horse" research rockets. From left to right: The NIKE-CAJUN, AEROBEE-HI, SPAEROBEE, and EXOS. Note the use of the same components on different rockets, e.g. The NIKE-CAJUN first stage is the EXOS second stage, and the SPAEROBEE is essentially the AEROBEE-HI with its nose cone replaced by a Sparrow rocket. The top mark of the scale on the left represents two feet.

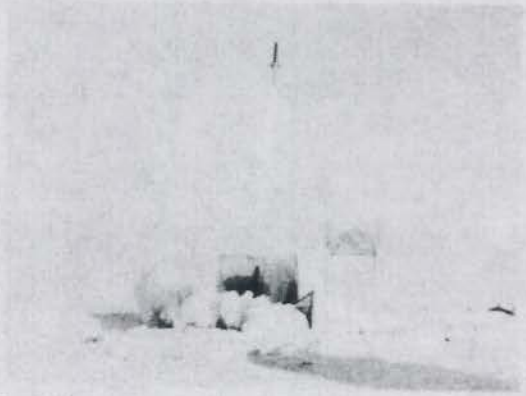


Fig. 5 A NIKE-CAJUN being fired from the IGY launching site at Ft. Churchill, Canada, on the west-central shore of Hudson Bay. Ft. Churchill was the first Free-World permanent launching site north of the Subtropics. The roof and doors of this launching building are kept closed until just before firing time.

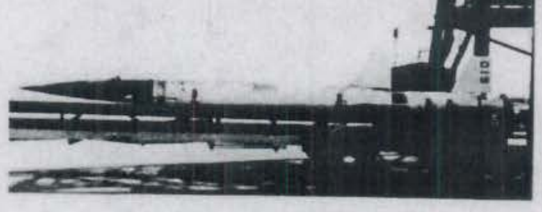
expended goes into acceleration and not into overcoming drag. As the rocket reaches the higher altitudes, advantage must be taken of the reduced drag by again increasing acceleration. Burnout, of course, must occur within the atmosphere if aerodynamic stabilization is being used. (See Figs. 2 and 3.)

(U) Once the choice of propulsion units has been made, these units in a multistage system must be married as a single rocket vehicle. Coupling devices must represent the optimum in structural integrity, and yet retain ease and simplicity in separation so that no unwanted moments are imparted to the vehicle at separation. Fins and stabilizing skirts must be designed for adequate stabilization and with proper consideration of the velocity-altitude profile of the vehicle. Stability under a variety of payload and wind-loading conditions must be studied, and corrections to trajectory and fin design fed back into these computations. Optimum coasting times between stages must be established in an effort to improve the heating and stability situations while maintaining performance.

(U) Finally, firing of the several stages must be accomplished at the proper time or altitude. This involves electrical timers, pyrotechnic delay trains or a pressure switch which signals the firing of a stage by sensing the decay of chamber pressure from burnout of the previous stage. There is also the requirement to carry high-current power supplies for in-flight ignition. This has the disadvantage of reducing the useful payload weight of scientific instrumentation.

(U) At this point we presumably have a rocket ready for flight. Now to select a launch site. The first step is to determine how much range is needed. A no-wind, undisturbed trajectory must be calculated for the particular rocket system under the planned launching elevation angle. Then the effects of wind must be evaluated by ballistics techniques. Other factors which will cause dispersion from the undisturbed impact point are evaluated: tip-off; disturbance from stage separation; thrust mis-

Fig. 6 An Aerobee-Hi on the ground-handling trailer prior to launching at the Air Force Missile Development Center, Holloman AFB, New Mexico. 97 of the 102 Aerobee types fired by AFCRC's Geophysics Research Directorate have used this missile test range.



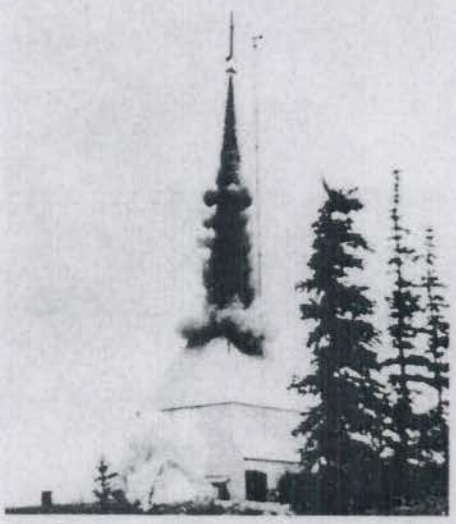


Fig. 7 A Spaerobee leaves the Aerobee Tower at Ft. Churchill, Canada. Obscured by the smoke plume is an enclosed tower extending above the peak of the main building. The required launching facility for the Aerobee is considerably more complex than that for the Nike-Cajun (compare Fig. 5).

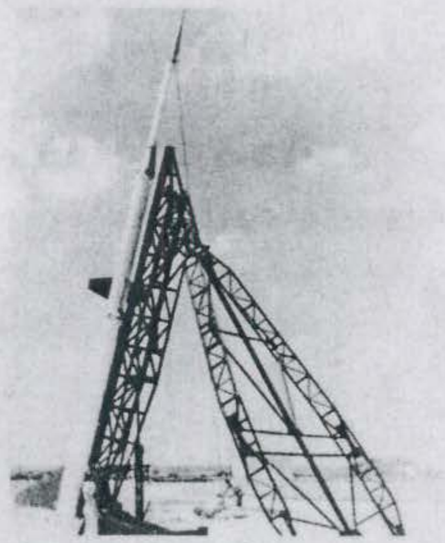


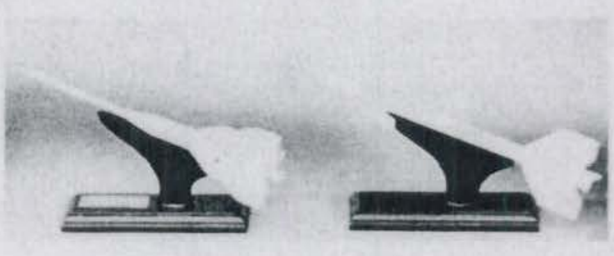
Fig. 8 At the NACA (now NASA) launch site at Wallops Island, Virginia, an Exos awaits firing. This is an all solid-fuel rocket with a 300-mile capability, and is exceptionally easy to handle for its size and range.

alignment; fin misalignment; and variation in thrust and burning time. All of these are added statistically and a maximum downrange impact distance is established.

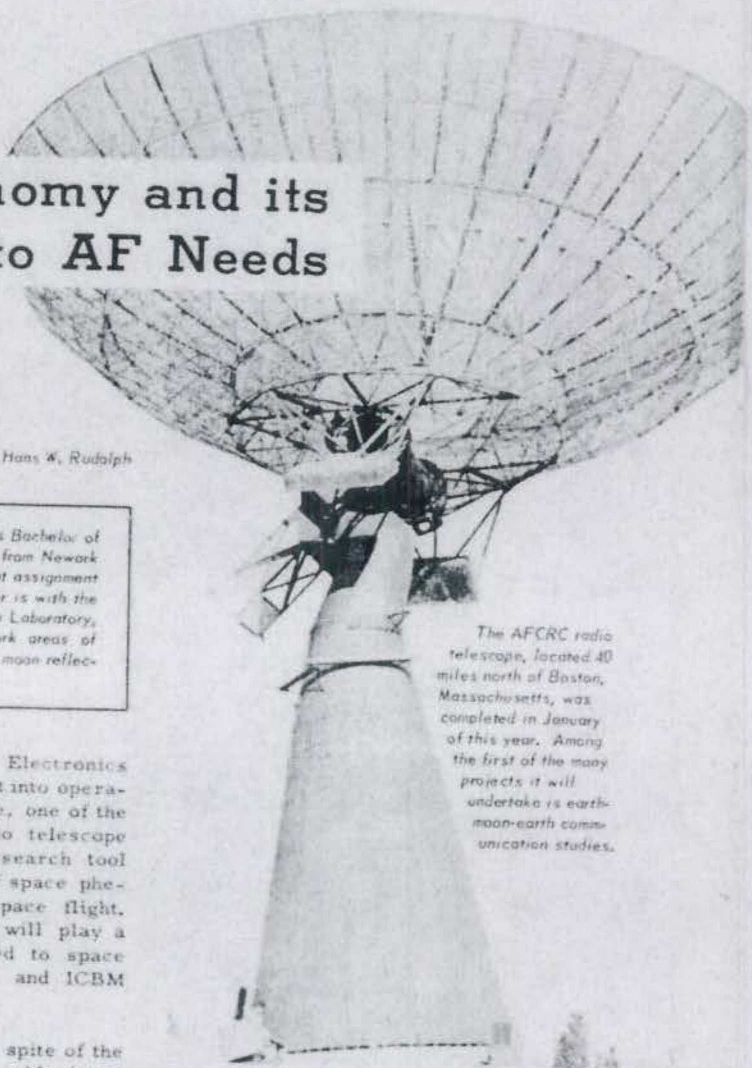
(U) This last step is necessary because of one of our thorniest problems--missile flight safety. One method of operation is to carry a destruct system and cut the rocket down or destroy it by radio link if it starts to veer from the planned flight path. The other operational procedure is to carry no flight-termination system but to have a rocket system in which the flight characteristics and structural integrity are so well known that one can say that all rockets flown will impact within the available range confines. We try to operate on this latter principle to avoid the decrease in reliability, and the expense, weight and complexity of a flight termination system. This is by no means a clean-cut situation and we sometimes find ourselves out of the realm of engineering and technology, and, instead, facing an issue that is philosophical.

(U) Figures 4-8 illustrate the present Air Force inventory of "workhorse" research rockets. At this writing, the AEROBEES and the NIKE-CAJUNS have flown, respectively, 102 and 36 geophysical research missions for the Air Force Cambridge Research Center. The EXOS and SPAEROBEE are relatively new, but an active schedule of firings is planned. The perfection of 500- and 1000-mile rockets, such as those illustrated in Fig. 9, will almost complete the versatile set of vertical probes which we envision to meet forseeable needs.

Fig. 9 Models of the Astrobee 500 and Astrobee 1000, the former now in development with the Aerojet-General Corporation. Assuming successful tests of the 500, the 1000 will be a follow-on effort utilizing many of the same components. Each is being designed to carry 50 lbs. of experimental equipment to its peak altitude.



Radio Astronomy and its Applications to AF Needs



The AFCRC radio telescope, located 40 miles north of Boston, Massachusetts, was completed in January of this year. Among the first of the many projects it will undertake is earth-moon-earth communication studies.

By Lt. Hans W. Rudolph

Lieutenant Hans W. Rudolph received his Bachelor of Science degree in Electrical Engineering from Newark College of Engineering in 1955. His present assignment at the Air Force Cambridge Research Center is with the Radio Astronomy Section of the Propagation Laboratory, Electronics Research Directorate. Major work areas of his include antenna alignment problems and moon reflection studies.

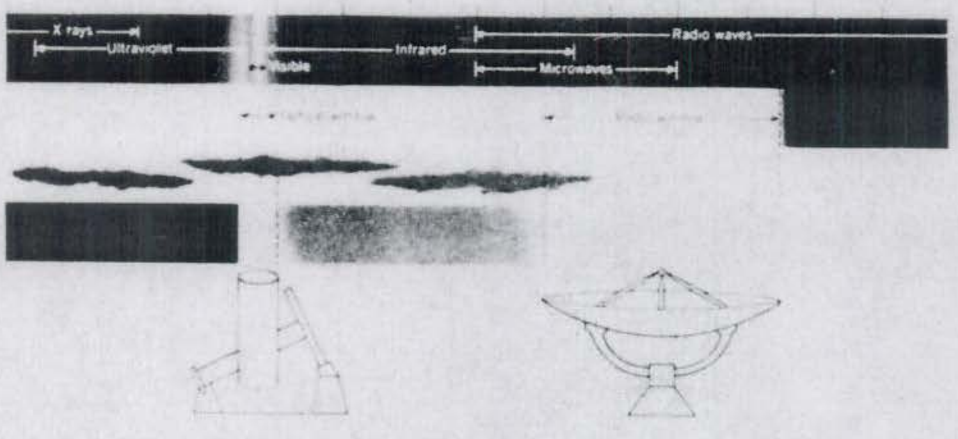
(U) In January of this year, the Electronics Research Directorate of AFCRC put into operation its new 84-foot radio telescope, one of the largest in this country. The radio telescope provides the best earth-bound research tool presently available for the study of space phenomena preparatory to manned space flight. The science of radio astronomy will play a dominant role in research devoted to space communications, space navigation, and ICBM detection.

(U) The ERD radio telescope, in spite of the tremendous weight of its dish assembly (total rotating weight is 136,180 pounds) operates with a position accuracy of plus or minus two minutes of arc in winds up to 30 miles an hour. It is located about 40 miles north of Boston near Ipswich, Massachusetts.

(U) The radio telescope is equatorially-mounted, which means that the rotation mechanism of the telescope is geared to the once-a-day revolution of all the stars about the North Star. The rotation rate for all stars about the North Star may be considered constant; once the antenna is fixed upon a given star the telescope will continue to track that star.

(U) During the first year or so of operation, the equipment will be used only as a receiver. Tentative plans call for the installation of transmitting equipment in order to extend capabilities to radar as well as radio astronomy. Radar astronomy is simply a means for probing the heavens using radar techniques.

(U) Radio astronomy is a comparatively new science which gained full recognition only after World War II. Its actual beginning dates back



The "radio window" (that span of the electromagnetic spectrum which is accessible to radio telescopes) is much larger than the "optical window" (that span of electromagnetic waves to which the eyes are sensitive).

about 25 years when Karl G. Jansky of Bell Telephone Laboratories first detected distant signals from space and made speculations on the nature of their origin. Today we know that radio signals are emitted from most planets, from clouds of gas in the spiral arms of our galaxy, from the debris of ancient exploded stars, from distant galaxies, and from a number of other sources as well.

(U) Radio astronomy has already greatly enlarged our picture of the universe, which, up until now, had been determined almost solely by optical investigation. Light and radio waves are basically the same except for their length. Radio waves cover a larger percentage of the electromagnetic spectrum than do light waves. Extensive regions of the universe are forever inaccessible to optical study because of interstellar dust which, however, is transparent to various radio wavelengths. On the other hand, ionized gas-regions surrounding the sun, or enveloping the stars in spiral gaseous galaxies, are transparent to light waves but reflect or absorb radio waves. Thus, optical and radio astronomy are complementary to each other.

(U) Air Force Application of Radio Astronomy

(U) While the Air Force has some interest in radio astronomy in the classical sense—that is, the study of the universe in order to increase our knowledge of it—present interest is more directly focused on certain operational problems. Although AFCRC's 84-foot radio telescope has a broad area of potential use, it was designed primarily for immediate applica-

These contour maps of the heavens are plots of received signals of a given frequency over a defined area. Frequencies included here are [illegible] Mcps. (left) and 400 Mcps. (right).

tion to current Air Force problems such as earth-moon-earth relay systems and ICBM detection. The remainder of this article is concerned with mentioning several of these concrete applications and illustrating how radio astronomy investigation promises to answer Air Force needs.

(U) Conventional Communication - Ionospheric storms and magnetic disturbances on earth often seriously affect communications. These storms and disturbances are caused by sunspot activity--the same activity which results in communication blackout in the arctic region. Radio astronomy may be used to study these storms, to catalogue and correlate them with magnetic disturbances on earth. Radio viewing of the sun is thus a vital part of the data-collection technique necessary for the prediction services which issue propagation storm warnings. The study of solar storms offers the best means for determining optimum normal HF transmission frequencies.

(U) Earth-moon-earth Relay Communication - A communication system which would take advantage of the moon as a reflecting surface is being investigated by means of the large, extremely sensitive radio telescope used in radio astronomy. Such a system would provide a high capacity, reliable method of communicating which would also be reasonably secure from interception by an enemy, because reception would be possible only within discrete geographical areas. AFCRC has made a thorough analysis of such a communications scheme. The 84-foot radio telescope will be used to accumulate experimental data along these lines.

(U) Satellite Communication - Various methods have been proposed for a communication system using, instead of the moon, artificial satellites as reflecting surfaces or as repeater stations. Transmitting and receiving antennas would be of the type required for radio astronomy. Experiments are necessary to determine the optimum parameters of such a system--that is, frequencies, power requirements, and so on.

(U) A radio telescope may also be used to communicate directly with space vehicles. Because of the sensitivity of these antennas, only a minimum of transmitted power would be required from the space vehicle. Propagation studies by means of radio astronomy, however, must precede the development of such a communication system.

(U) AFCRC has developed a passive satellite communication scheme involving a satellite in a synchronous orbit--that is, an orbit 22,300 miles above the earth in which the satellite would maintain a stable position relative to the earth. With a satellite of spherical shape, however, the necessary size (determined by transmitting-power-antenna requirements) of a spherically shaped satellite is prohibitive; the AFCRC system would use a flat plate as the reflector satellite instead of the traditional spherical configuration. Such a plate thirty feet in diameter would have the same reflection capabilities as a sphere of some 10,000 feet in diameter. This idea is being further investigated with emphasis on the problems of positioning and orbiting such a device.

(U) If the problems of satellite communications are not solved now, they will only reassert themselves in the future. When manned space flight becomes feasible, large antennas will be essential for reliable communications between space vehicles and the earth. Since the vehicle will not be able to carry high power transmitting equipment, extremely sensitive antennas are needed on the earth to detect signals from the vehicle. As a transmitter, the large dishes are necessary to direct sufficient power over the great distances required to reach the space vehicle.

(U) Navigation - Radio astronomy may be used to investigate a number of space navigation schemes. One idea would be to plot various radio stars at certain frequencies. Such stars could be used by vehicles to determine their relative position in space. Another means of space navigation to be investigated is an application of the homing technique. A radio signal from a powerful radio telescope could be directed toward a planetary body, and a vehicle could then home-in on the signal reflected from the body. Navigation is also possible through the use of the moon as a reflector and the establishment of an inverse hyperstolic system akin to Loran. The direct earth based signal and the moon reflected signal would be analogous to the two Loran stations.

(U) ICBM Detection - Throughout the heavens there exists large regions of galactic noise.

This galactic noise problem represents the background against which ICBMs must be detected, and in some cases a missile may become completely lost within this noise to the tracking radar. These noise regions are plotted on frequency contour maps of the sky. Such maps differ considerably, depending on the particular frequency plotted. To minimize the effects of galactic noise, it is necessary to avoid using frequencies at which this noise is most serious. But first of all, it is necessary to plot galactic noise regions, and radio astronomy provides the best means for doing this. Frequencies above 900 MCPS have not yet been plotted because of receiver sensitivity requirements, but large radio telescopes such as AFCRC's are well suited for this investigation.

(U) Atmospheric Refraction and Absorption - To locate accurately the position of a missile, the refraction characteristics of the atmosphere must be taken into account. A radio signal from the sun is received from a point much closer to the horizon than indicated by the astronautical position of the sun. That is, the sun appears to rise earlier than it actually does. Also, at very low angles of elevation, a signal emitted by the sun is greatly absorbed by the atmosphere, but as the sun rises more overhead and its emitted signal cuts through less of the atmosphere, signal intensity increases. By radio astronomy techniques, with the sun as a source, atmospheric refraction and absorption can be measured with some degree of accuracy, and even greater accuracy can be achieved through the use of extremely large radiotelescopes capable of focusing on distant radio star signal sources.

(U) Although the science of radio astronomy had its inception in this country we are now lagging behind both Britain and Russia in certain respects. Britain is now operating the largest radio telescope in the West, a 250-foot radio telescope located at Jordell Bank, England. AFCRC partially financed the construction of the transmitting equipment employed and the telescope has been used for several AFCRC experiments. Russia is planning the construction of a 950-foot research telescope for the not too distant future.

(U) Radio Astronomy is destined to continue its growing role of importance to science in general and the Air Force in particular. The six applications of Radio Astronomy to Air Force needs mentioned previously are by no means inclusive—a list of such applications could be expanded to include almost every form of electromagnetic communication. Although hardly out of its embryonic stage, Radio Astronomy promises to supply answers to a variety of earth, atmospheric and space communication problems, both current and anticipated.

Applications of radio astronomy to the fields of: (A) Propagation Research, (B) Space Communications, (C) Space Navigation, (D) Radar Astronomy