AIR TRAINING COMMAND

STUDENT STUDY GUIDE

OBR1821/3121-3-I-1

OBR1821/3121-3 I-2

COURSE ORIENTATION AND FACILITY FAMILIARIZATION

GENERAL WEAPON SYSTEMS MISSION AND CONFIGURATION

16 July 1963

RESPONSIBLE AGENCY OF ATC

SHEPPARD TECHNICAL TRAINING CENTER
SHEPPARD AFB, TEXAS

ABOUT STUDENT STUDY GUIDES AND STUDENT WORKBOOKS

Student study guides and student workbooks are designed by the Air Training Command as student training publications for use in training situations peculiar to courses of this command. Each is prepared for a particular Unit of Instruction as reflected in the course syllabus.

The **STUDENT STUDY GUIDE** *contains the specific information required in the Unit of Instruction or it will refer to other publications which the student is required to read. It contains the necessary information which is not suitable for student study in other available sources. The material included or referred to is normally studied either outside the classroom or during supervised study periods in the classroom. Also included are thought-provoking questions which permit self-evaluation by the student and which will stimulate classroom discussion.*

The **STUDENT WORKBOOK** *contains the specialized job procedures, important information about the job, questions to be answered, problems to be solved and/or work to be accomplished by the student during the classroom/laboratory, airplane/missile/equipment activity. It serves as a job sheet, operations sheet, mission card, check list or exercise to be performed during classroom or laboratory periods. Also included are questions which will aid the student in summarizing the main points of the Unit of Instruction.*

The **STUDENT STUDY GUIDE AND WORKBOOK** *is a training publication which contains both student study guide and student workbook material under one cover.*

Since this publication is DESIGNED FOR ATC COURSE USE ONLY and must not conflict with the information and/or procedures currently contained in Technical Orders or other official directives, it is updated frequently to keep abreast of changes in qualitative training requirements. Students who are authorized to retain this publication after graduation are cautioned not to use this material in preference to Technical Orders or other authoritative documents.

TABLE OF CONTENTS

COURSE ORIENTATION

AND FACILITY FAMILIARIZATION

OBJECTIVE

- To welcome you to the Department of Missile Training and the OBR1821B/3121-3 Course.
- To familiarize you with the Missile Launch/Missile Officer Course.
- To familiarize you with the training complex facilities.

INTRODUCTION

Training for Missile Launch Officers and Missile Officers is conducted in several segments, some in ATC, others in SAC. This course is the first segment; it is designed to provide you with skills and knowledge required as prerequisite training for entry into courses in support of SM-65, SM-68, and SM-80. Instruction is provided in fundamentals and principles of weapon systems; Missile Maintenance and Management concepts; mathematics; physics; pneudraulic systems; electrical circuits; electronic circuits; guidance; flight controls; propulsion; propellant and propellant loading; facilities and environment; Aerospace Ground Equipment, checkout and test equipment; launch control and countdown.

There is no typical ballistic missile, however many of the basics apply to all. We present information on specific weapon systems to convey principles and show their applications. Headquarters USAF has directed a common basic course of this type for missile officers. The resulting benefits include money and manpower savings and the development of a cadre of professional missile officers.

In addition to basics, areas of instruction common to all weapon systems include: general security and safety, AF Technical Orders, AFM 66-1, and the missile inspection and record system.

DEPARTMENT OF MISSILE TRAINING
3750th Technical School, USAF (ATC)
Sheppard Air Force Base, Texas

It is a pleasure to welcome you to the Department of Missile Training on behalf of all the personnel engaged in the training effort.

We have the prime responsibility to train Officers and Airmen on the SM-65 and SM-68 ICBM weapon systems and to prepare officers for training in the SM-80 weapon system. Thus, we are responsible for the basic training of all officers in the ICBM weapon systems. The Officers Fundamentals Course will provide you with general missile and missile system knowledge, background understanding, and related information to aid you in the study of a specific weapon system. We are also responsible for introducing or reviewing you on current USAF policies, procedures, and practices as outlined in USAF directives and technical publications.

We sincerely hope that your stay at Sheppard Air Force Base will be enjoyable and informative. Good luck in the Missile Field.

Charles W. Leigon

CHARLES W. LEIGON
LtColonel, USAF
Director

ORGANIZATION

MISSILE DEPARTMENT

Department Director

Name LT. COL LEIGON BLDG 1900
RM

Branch Chief

Name MAJ GORDON ~~BLDG~~ RM 1001
PH 2223

Course Supervisor

Name MAJ. MARCELLINO ~~BLDG~~ RM 1087
2316

BLOCK I Supervisor

Name CAPT. BIBB

BLOCK II Supervisor

Name CAPT. BIBB

BLOCK III Supervisor

Name CAPT DOYLE

BLOCK IV Supervisor

Name CAPT. DOYLE

BLOCK V Supervisor

Name CAPT RODGERS BLDG ________

COURSE OUTLINE

The following list shows the areas of instruction and the number of hours devoted to each.

SUBJECT	HOURS
BLOCK I - Weapon System Introduction	
Course Orientation and Facility Familiarization	3
General Weapon System Mission and Configuration	9
Technical Publications System and Application	12
Technical Publication Maintenance	6
Safeguarding Classified Information	2
Equipment Hazards and Personnel Safety	4
Missile Airframe, Re-entry Vehicle Construction and AGE	6
Rocket Propulsion, Propellants, Propellant Systems and AGE	12
Introduction to Malfunction Analysis	3
Measurement (Written Test)	3
Total	60

SUBJECT	HOURS
BLOCK II - Missile Electrical System	
Basic Theory of Electricity	12
Use of Measuring Devices in Analysis of DC Circuits	9
Principles of Alternating Current	12

SUBJECT		HOURS
BLOCK II - Missile Electrical System (Cont'd)		
Principles of AC Circuits		12
Basic Theory of Transformers		3
Measurement (Written and Performance Tests)	O-S	4
Identification and Use of Control Devices		2
Theory and Maintenance of Primary and Secondary Battery Cells		3
Operation and Use of Rectifiers and Battery Chargers		3
Theory of Rotating Electrical Devices		6
Interpretation of Electrical Symbols and Wiring Diagrams		8
Missile Electrical System Components, Malfunction Analysis, and Applicable AGE		12
Measurement (Written and Performance Tests)		4
Total	SS	90

SUBJECT	HOURS
BLOCK III - Launch Complex Systems	
Principles and Maintenance of Diesel Engines	6
Operation and Control of Diesel Generators and Switch Gears	6
Function, Operation and Malfunction Analysis of Facility Electrical Distribution Systems and Components	6
Familiarization and Operation of Water and Waste Disposal Systems	6

SUBJECT	HOURS
BLOCK III - Launch Complex Systems (Cont'd)	
Theory and Application of Air Conditioning and Blast Protection	6
Purpose and Function of Detection and Protection Systems and Components	2
Protective Clothing / Safety Equipment	6
Fundamentals and Application of Pneudraulics	4
Identification, Prevention, and Control of Corrosion	3
Measurement (Written Test)	3
Total	48

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SUBJECT	HOURS
BLOCK IV- Guidance and Controls	
Operation and Use of Basic Servo Loops	4
Basic Principles of Vacuum Tube Circuits	8
Principles of Transistor Amplifier Circuits	12
Theory and Application of Transistor Oscillator and Control Circuits	8
Measurement (Written and Performance Tests)	4
Theory and Familiarization of Radio and Launch Complex Communication	6
Application of Physics Principles to Missile Trajectories	9
Principles of Attitude Control	9
Theory, Operation and Malfunction Analysis of Inertial Guidance Systems and Associated AGE	9
Measurement (Written and Performence Tests)	3
Total	72

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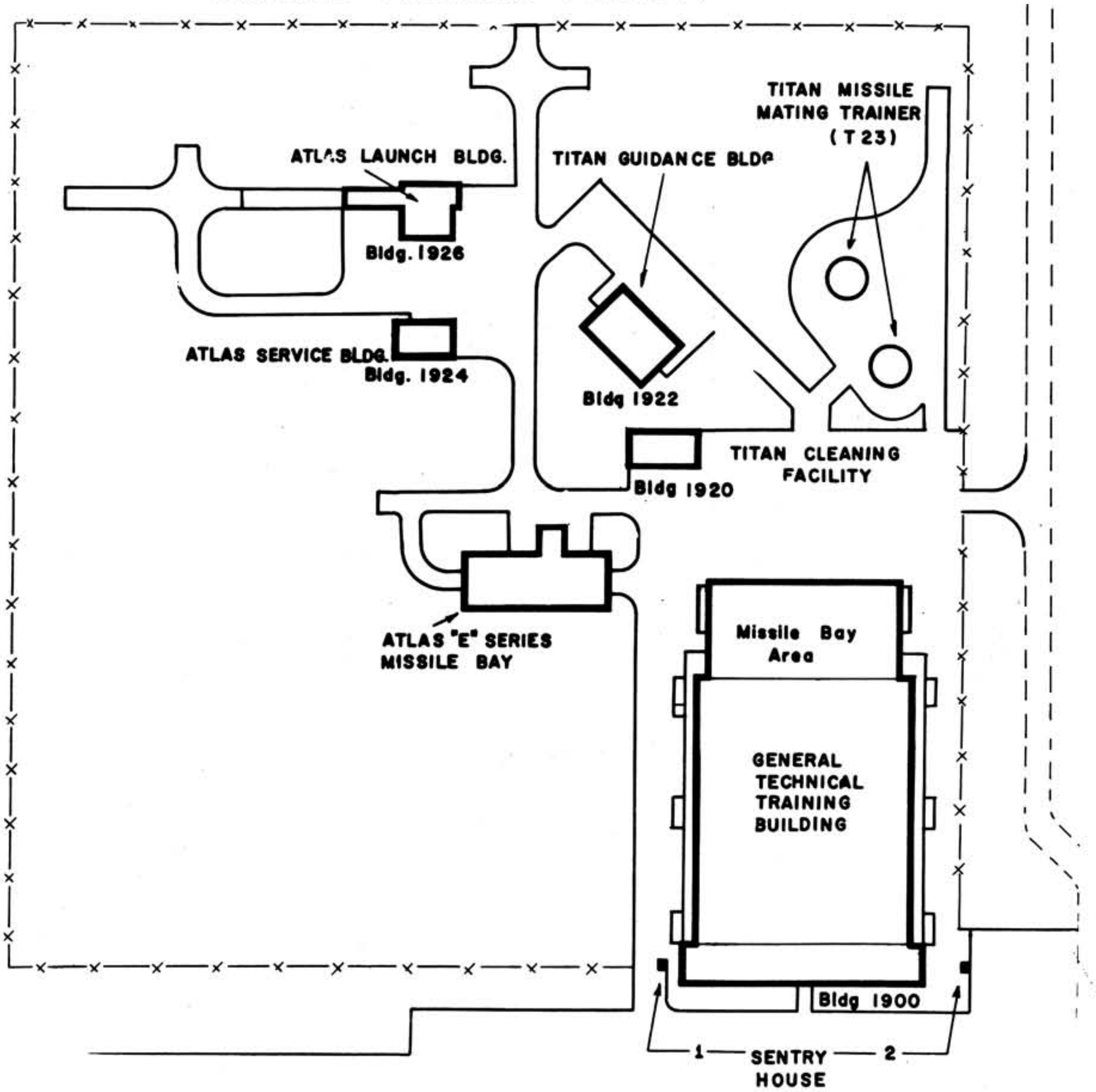
SUBJECT	HOURS
BLOCK V - Management	
Duties and Responsibilities of Missile Squadron Personnel	3
Analysis of Missile Maintenance Functions	9
Familiarization with Maintenance Date Collection and Manhour Accounting Systems	8
Use of Missile Inspection Forms and Records	7
Measurement (Written Test)	3
Total	30

MISSILE TRAINING FACILITY



GRADING POLICY

While enrolled as a student officer in this course, you can expect frequent quizzes, even daily quizzes, from your instructor. These quizzes are designed to assist you in learning the course material. If you do well on these quizzes, then the mid-block or block tests should not be insurmountable. Some of you may be eligible for "proficiency advancement" in the course. That is, instead of your taking 10 weeks to graduate, you might graduate in less time. If you have had previous experience or training in a subject area of this course, and feel that you can pass the test over that area, you should make this known to your instructor. You will then be tested for that portion of the course and, if you pass, you may be advanced to another class in the course.

As a general rule, you will be given either a written or practical test or both, every 5 to 15 days. These tests are for "grades" and will record your progress through the course. Your grade will be expressed by adjectives; either "outstanding", "satisfactory", or "unsatisfactory". In short, this is the "O", "S", and "U" system of scoring. These adjective grades are derived by using a modified standard score system of computation which is directed by Headquarters Air Training Command. In computing your grade for the block and course, your achievement is compared with previous officers who have already taken that test. You will be advised of your grades as you progress through the course. If your grade becomes marginally "Satisfactory" or "Unsatisfactory" you will be advised in private consultation with your Instructor or Instructor-Supervisor. Approximately 5 - 7% of all student officers will achieve high enough scores to be designated as an "outstanding" or "Honor" graduate. Grading of officers holding the rank of Colonel is optional. Any Colonel who desires to be tested must make this known to the Instructor. Regulation r f Department Office Instruction 52-5 and Air Training Command [illegible] 52-3.

TEST CRITIQUE

At the end of each block and the end of the course, each test will be discussed. At that time you may ask about the questions you think you missed.

INSTRUCTIONAL TV

The closed circuit television system at Sheppard Air Force Base was installed December 1961, and was in operation January 1962. The purpose of this installation is to increase the effectiveness of instruction within the Missile Department by use of TV as a supplementary instructional aid to the instructor.

Within the television system there are three types of program sources available for presentation to the classrooms. They are (1) live, (2) film, (3) taped programs. The techniques of utilizing television in the classroom are similar to those in use for other teaching devices. However, there are a few differences which the student must recognize and be prepared for:

- He cannot stop the telecast and have it repeated if he misses a portion.
- He must think ahead, trying to anticipate the direction in which the presentation will go.
- He should take time to summarize mentally and take notes. He should learn to detect transitional interludes which are furnished by the production staff throughout the recordings.
- He should weigh the evidence presented in support of the purpose and the main ideas.

Television teaching, to be effective, demands that students give their undivided attention to the lesson presented on the television monitor. Instruction on television is compact. Extraneous materials are eliminated and digression by the instructor is reduced to a minimum.

SECURITY BADGES

There are three types of Security Badges used by this department:

a. The "OFF-LIMITS" Area Badge - sometimes referred to as the permanent badge is issued to personnel employed by the department who are cleared for access to information of SECRET or higher.

b. The "T" Badge (Temporary) - is normally issued to students, visitors, or other cleared for access to SECRET or higher information. Official visitors also use this badge.

c. "LIMITED ACCESS" badge - is issued to personnel who have NO need for access to classified information or areas.

Access to the department is controlled by the conspicious wearing of these badges and they MUST be displayed at all times within the confines of the area. Military personnel must wear the badge on the left side, over the pocket of the OUTER garment (except when topcoat or overcoat is worn).

If the badge is lost it will be reported immediately to the Security Officer.

Security badges alone do not authorize access to classified information or material.

Other information on badges can be obtained from the Department Office Instructions Number 205-4.

SCHOOL POLICIES

School policies, as described in this guide, are those policies that pertain to students in the Department of Missile Training (OBR1821B/3121-3 Course).

Duty Hours

The duty hours for students are:

"A" Shift	0600 - 1155
"B" Shift	1200 - 1755
"C" Shift	1800 - 2355

Breaks. Every instructional day will include breaks which are scheduled to provide the most effective utilization of training concepts, time, trainers, and cafeteria facilities.

Remedial Instruction. Remedial instruction for students of the OBR1821B/3121-3 (Missile Launch/Missile Officer) course is that instruction beyond the normal six hour day. Remedial instruction will be available at the course facility for those students who require such tr[illegible] to improve their understanding or skills over units of instruction wh[illegible] satisfa[illegible] retention is questionable. Your instructor will attempt to keep you [illegible]formed as to your progress if you are a marginal or below marginal st[illegible] dent. Some of you will require no remedial instructions while others will receive assistance several times during the course. If the instructor does not suggest extra instruction and you feel that it is needed, you are encouraged to request additional assistance for as much or as little as deemed necessary.

School Policy References

• Duty hours and shifts • Break periods • Formations	TSCHR 52-3
• Uniform	AFM 50-5
• Fire Drill and Nuclear Evacuation	DOI 92-1
• Disaster control plan	DOI 355-1
• Smoking	DOI 89-1
• Area cleanup	TSCHR 52-3
• Security badges and clearances	DOI 205-4
• Classroom conduct	DOI 50-1 & TSCHR 50-20
• Class leader	TSCHR 11-1
• Absence from class	ATCR 50-11 Supplements
• Grading system	DOI 52-5 & ATCR 52-3
• Failure & Elimination (Washbacks)	DOI 53-1
• Proficiency advancement	ATCR 52-10 Supplements
• Selection of honor students	ATCR 52-8 Supplements

• Instructional methods	DOI 50-1 & TSCHR 50-1
• Student study guides & workbooks	ATCR 52-7 & TSCHR 50-20
• Remedial instruction	ATCR 52-10 Supplements

STUDY METHODS

You have probably spent countless hours of study time in completing various courses in the past. This time spent studying may or may not have been beneficial. Try to improve your method of studying. Remember, study improvement is not just for the poor student. No one has perfected his method of studying to the point where he cannot make improvements. Everyone should strive to study more effectively.

In order for you to improve, you must first recognize the faults of your present method of studying, and have an earnest desire to correct those faults. Some causes of ineffective study are listed below:

- Poor study situation
- Poor listening ability
- Lack of ability to organize thoughts for writing or speaking
- Lack of ability to locate authoritative information
- Poor reading ability

Taking Notes

Notes should be taken in an orderly manner so they make sense when you read them over for review and study. Following an outline form, as shown in Figure 1, will keep your notes organized.

Underlining the important words and phases in your notes will serve as a guide when reviewing. Keep your notes neat and easy to read and they will be your most helpful aid in studying.

ELECTRICAL METERS

1. Voltmeters

    a. Direct current
    b. Alternating current
    c. Used to measure voltage

2. Ammeter

    a. Direct current
    b. AC
    c. Clamp-on
    d. Used to measure current

Figure 1 Outline of Topic

P. Q. R. S. T. Method of Study

Our leading universities have been searching for a method of study that can be used by all. One of the best is the P. Q. R. S. T. method. The letters P. Q. R. S. T. stand for the five steps in learning. These steps are easy to use and will become a habit if used for a short length of time.

P. for Preview. If you are told where you are going, you can pick the straightest path to that point. Likewise, when you know what you are going to study, your thoughts can be directed to that subject.

Preview the material and get an idea of what you will be studying. Every movie shows a preview of coming attractions so that you may become interested and want to see them. Sell the material to yourself with a preview.

There are several different ways to preview. One is to check the topic or subtopic headings. These usually describe what the topic is about. Some articles don't have topic headings. On these, read the first sentence in the paragraph. The first sentence will usually give you a preview. A third way, used in some books, gives you a complete summary at the end of each chapter. A fourth method is to scan the chapter looking for the important sentences or phrases.

Q. for Question. Ask yourself, "What is important in the material I am studying?" Questions will help you set up specific things to look for as you read. These specific objectives help you to concentrate, because you will look for answers to your questions as you read.

Another good thing about questioning yourself is that is helps you determine future test questions. You will find that the questions you ask yourself are similar or the same as those asked on the test. After all, there are only a few good test questions that can be taken from any selection of material.

R. for Read. After previewing and questioning yourself, you are ready to read. How do you read? Is there more than one way to read? The answer is "yes" to the last question; you answer the first one. Perhaps one of the following common reading habits will help you answer your question.

Vocalized reading is reading word-by-word, that is pronouncing each word either aloud or to yourself. This habit causes very slow reading.

A rate adjusting reader starts reading at a fairly fast rate and then slows down to get all the meaning. This level is slightly better than the vocalized level and is the highest reading level reached by most students.

In prediction reading, the student tries to guess what is coming next. This habit increases understanding of the subject and also increases reading speed.

On a planned reading level, you must plan the reading time according to the difficulty of the material. You read with your head as well as with your eyes. Planned level readers are fast because they read line-by-line instead of word-by-word.

Now, find your present reading level and try to improve it.

Improving Your Reading

Reading is divided into two main types - fiction and nonfiction. Most of our reading here in school is nonfiction. Therefore, we will discuss the skills required for that type reading.

Most people read too slow. An average person reads about 150 to 250 words per minute. This is slower than most people talk. Reading slow does not mean that you will remember or understand what you read. More will be remembered if you read faster.

In order to increase your rate of reading, you must become conscious of the enemies of reading. The greatest enemies of reading are: 1. Vocalization, 2. Faulty eye movement, 3. Poor concentration and 4. Poor comprehension.

If you read less than 200 words per minute you probably vocalize (read word-by-word). This type reading and poor understanding usually go together. Most of the material in any selection is for explanation of the main points. If you look for these main points you will increase your reading speed.

Faulty eye movement means that you stop movement of your eyes too many times in each line you read. The technical term for this is eyefixation. Most people spend too much time on each fixation, referring back to the line that has just been read.

As you are reading this and the following paragraphs, check yourself for such faulty eye movements. Try to form a smooth rhythm and coordination as your eyes sweep from one sentence to the next.

Poor concentration reduces reading rate more than you might think. The best way to concentrate is to study in a suitable place as free from distractions as possible.

Poor comprehension is sometimes caused by a poor vocabulary. This is especially true when you are reading books of a technical nature. It often happens that the one word in the sentence that you don't understand is the key word in the sentence. If you don't know the meaning of a technical word, look it up in a dictionary or glossary of terms. This will improve your understanding of the information.

S. for State. The fourth step of the PQRST method of study is "S" for "state". After you read something, practice stating it in your own words. Either say it to yourself or write it down. If practical, say it aloud. In the process of stating what you read, you are reviewing, organizing and repeating information. This process will help you to remember it.

T. for Test. The last step of the PQRST method of study is "T" for "testing". To make sure that you have retained what you have studied, test yourself at a later time. You can test yourself by making an outline of what you remember. Then compare your outline to the text. This will show you what you have forgotten.

GENERAL WEAPON SYSTEMS MISSION AND CONFIGURATION

OBJECTIVE

This study guide familiarizes you with the development of ballistic missiles; the function and relationship of major missile systems; the mission, operational capabilities, and configuration of ballistic missile weapon systems; and gives you an insight of the duties and responsibilities of a launch and missile officer.

INTRODUCTION

The first liquid propellant rocket flight occurred on 16 March 1926. The ignition system was a blowtorch, the velocity 60 MPH, and it had no guidance system. Today's missiles use pyrotechnic and hypergolic igniters, reach velocities exceeding 24, 000 FT/SEC and are controlled by exacting guidance systems. Your task is to acquire all the knowledge about these missiles and their ground environment.

MISSILE DEVELOPMENT

The basic principles of rocketry were developed by Konstantin E. Ziolkovsky, Herman Oberth and Robert Goddard.

In 1903, the Russian school teacher Ziolkovsky proposed space flight by reaction propulsion in a paper titled "Investigation of Cosmic Space by Reactive Machines". Ziolkovsky is the father of space travel.

In 1923, Herman Oberth, a German, published his booklet, "The Rocket into Interplanetary Space", which was the first complete mathematical paper on the mechanics of flight beyond the atmosphere.

When Dr. Goddard, American Physics Professor, first started his experiments with rockets no related technical information was available. Through his scientific experiments he pointed the way to the development of rockets as we know them today. From these experiments he wrote a paper titled, "A Method of Reaching Extreme Altitudes". In this paper he outlined a space rocket of the step (multi-stage) principle theoretically capable of reaching the moon.

Goddard discovered that with a properly shaped nozzle he could increase the ejection velocity eight times with the same weight of fuel. Dr. Goddard was the first man to:

- Launch a liquid-fuel rocket.
- Develop a rocket to exceed the speed of sound.
- Develop gyroscopic steering for rockets.
- Use vanes in the jet stream for rocket stabilization during the initial phase of flight.
- Patent the idea of step (multi-stage) rockets.

After proving on paper and in test that a rocket could travel in a vacuum, he developed the mathematical theory of rocket propulsion and rocket flight, including a basic design for long-range rockets. All of this information was available to our military men before World War II, but its immediate use did not seem applicable.

German Development

The Versailles Treaty specifically prohibited Germany from manufacturing artillery; as a result they concentrated on liquid rockets for war purposes. Liquid-fuel rockets offered, at least in theory, a greater range and effectiveness than either aircraft or artillery. The decision was made in 1929 to develop the "war rocket". This decision eventually led to the establishment of "Experimental Station" 17 miles south of Berlin. The station was under the command of Col. Walter Dornberger. The first civilian employee of the station was Wernher Von Braun. Almost 3 years elapsed from the time "Experimental Station" was established in 1930 before the first rocket was launched. The name chosen for this rocket was Aggregate I or A-1. This was a small rocket, weighing only 85 pounds and developing 650 pounds of thrust. It served only one useful purpose: to prove a need for less restricted space.

In 1937, the "Peenemunde" project, located on an island just off the northeast German coast near the village of Peenemunde, became a reality. This was a much better firing range because of the Baltic Sea, and because of its relative isolation. Here the research, planning, construction and testing of the A series rockets continued. Wernher Von Braun continued his research and planning toward a much bigger rocket called V-2.

After many set-backs in development, the V-1 and V-2 were successfully demonstrated in May 1943. In June 1944 the V-1 was launched against England, and the V-2 in September of the same year. The significance of the V-2 cannot be overemphasized since it is the direct predecessor of present ballistic missiles.

The V-2 was extremely inaccurate and highly inefficient as a strategic weapon compared to its cost in skilled manpower and critical materials. Yet it was effective to a degree that General Dwight D. Eisenhower, in his book, Crusade in Europe, said; "It seemed likely that if the German had succeeded in perfecting and using these new weapons six months earlier than he did, our invasion of Europe would have proved exceedingly difficult, perhaps impossible. I feel sure that if he had succeeded in using the weapons over a six-month period... OVERLORD (the main cross-channel assault) might well have been written off."

American Development

American rocket development during World War II was practically nonexistent. After Pearl Harbor, Dr. Goddard offered his services to the U.S. Navy and worked at Annapolis, designing and building take-off rockets for navy planes.

The need for rocket research was realized late in World War II and a search for an appropriate proving ground was begun in 1944. After detailed study and visiting several sites, the area north of El Paso, Texas was chosen. White Sands Proving Ground is conveniently located near Ft. Bliss, Biggs, and Almagordo Air Force bases. By the end of July, 1945, the base was ready for the arrival of the captured V-2 components. The "V-2 Program" was a plan for systematic expenditure of V-2 rockets at the planned rate of two per month. The purpose of the program was:

- To make experiments bearing directly on the design of future rockets.
- To obtain experience in the handling and firing of large missiles and getting hints on the design of ground equipment.
- To provide vehicles for operational test of components for future rockets.

- To obtain ballistics data.

- For upper atmosphere research.

The V-2 program was considered a complete success. A total of 75 V-2's were fired from the White Sands and Florida Missile Testing Ranges. The most significant achievements of the program are perhaps illustrated by two sub-programs:

- "Operation Sandy" - firing of a V-2 from the flight deck of the carrier, Midway, near Bermuda in September 1947.

- "Project Bumper" - A V-2 was used as a booster stage for a WAC Corporal. This combination gave man his first step into cosmic space. On February 24, 1949, the WAC Corporal reached an altitude of 250 miles.

Even though V-2 firings continued for a full 5 years after the initial launch in May 1946, it was only a matter of time until the last V-2 would be expended.

What then? Produce more V-2's? No, this would have been equivalent to standing still. New rockets were needed - new types, new designs - not just V-2's. The problem was: <u>just what was wanted</u>?

The Military men naturally wanted a ballistic missile. The scientist wanted to go on exploring the upper atmosphere. The military wanted rockets to carry large warheads, while for the scientist, pay loads less than 200 LBS were fully sufficient.

The decision: to develop both types of rockets. Late in 1946, the Air Force let three research and development contracts, each significant in its own right.

<u>Aerobee (Aerojet-General)</u>. This was a relatively small rocket designed to carry 100-150 LB payload. A later version, the Aerobee-Hi held the world altitude record of 193 miles for a single stage rocket.

<u>Viking (Martin)</u>. The Viking was a larger rocket than the Aerobee, designed to carry payloads of 500 to 1,000 LBS to altitudes of 100 to 150 miles. Like the Aerobee, it too, was used for upper atmosphere research. Because of the experience the Martin Company gained through the Viking project, the company was selected for prime contractor on "Project Vanguard".

MX774 (Convair). The MX 774 was officially dubbed "HIROC" (High Altitude Rocket). The MX 774 is the forerunner of the ATLAS. This project is most significant for its contributions of three distinctly American inovations to the universal field of rocketry.

- Gimbaling (Swiveling) of engines for directional control. The V-2 used graphite, rudder like, vanes in the exhaust gases.)
- Integral tanks (Skin of the missile serving as the walls for the propellant tanks.)
- Separable re-entry vehicle (Nose cone). (The V-2 warhead did not stage.)

The U.S. missile program had its ups and downs as did the German development. In 1947, Defense Department economy cut-backs cancelled the ICBM program. The Aerobee and Viking continued in research and development for upper atmosphere soundings. Convair continued limited research on the MX 774.

Technically, the Defense Department had cancelled the ICBM program for two seemingly insurmountable problems:

- The weight of an effective warhead VS. the thrust required to deliver it to a target.
- The heat problem encountered during re-entry into the earths atmosphere.

With the advent of the Korean War in 1951, new appropriations for ICBM development began to trickle from congress. Convair was again awarded a contract for ICBM development. The project was called MX 1593 and later changed to code name "ATLAS".

The Atlas component development program was started in 1952. The military requirements included a 5500 nautical mile range with a special weapon payload. 1952 was also the year the U.S. exploded its first thermonuclear device.

The AF Strategic Missile Evaluation Committee, better known as the "Teapot Committee" was formed in 1953. Later during the same year, this committee and the AF Scientific Advisory Board reported to the Chief of Staff, USAF, that thermonuclear weapons of small size and weight, ideal for missile warheads, were feasible.

The ICBM development program began to receive larger appropriations following the report. In February 1954, the Strategic Missiles Evaluation Committee recommended a new and comprehensive weapon system study and called for high priority and necessary funds.

The following month, General Twining submitted a memo to the Secretary of the Air Force approving ICBM acceleration. Simultaneously, "Operation Castle", tests conducted at Pacific Proving Ground confirmed the "Thermonuclear Breakthrough" which made ICBM's practical as military weapons.

In 1955, President Eisenhower placed the ICBM program on the highest priority, subject to change only by presidential action.

The mission of developing the Thor Intermediate Range Ballistic Missile was assigned in 1955. Within ten months after signing the airframe and missile assembly contract the first test missile was delivered to Cape Canaveral for the initial test flight. Three months later, on 25 January 1957, the first Thor was launched.

Atlas fabrication began in San Diego in 1955. Engine tests were conducted in June 1956 and the Atlas was successfully launched on December 19, 1957. Tests continued throughout the year and on November 28, 1958, Atlas made its first full range flight. The system became operational in 1959. The Titan I was also under development; it became operational at Lowry AFB in early 1962.

FUNCTION AND RELATIONSHIP OF MAJOR MISSILE SYSTEMS

A ballistic missile has four basic systems: airframe, propulsion, guidance and control, and re-entry. Later in the course, each system will be covered in detail. The following is an introduction.

Airframe

The airframe is the supporting structure for the missile. It must be built strong enough to withstand the large forces encountered during flight. But at the same time it must be built as light as possible. Some of the ways in which both objectives are satisfied is by the use of: integral tanks; monocoque construction (like an egg shell); advanced fabrication processes such as milling and extruding; and of course the application of fantastic advances in metallurgy. Some of our missiles are even substituting fiberglass for metals.

Propulsion

Two types of propulsion systems, solid and liquid, are used in ICBMs. These systems are able to operate in space because they carry both the fuel and oxidizer. This differs from an aircraft engine which relies on the air for its source of oxygen. The theory of operation of these engines is simple. High velocity gases are forced through a nozzle to create a force, called thrust, which causes the missile to move.

The liquid propulsion system is more complicated than the solid propulsion system. It requires pumps to feed the liquids into the engine. These pumps are operated at high RPM by a gas turbine - reduction gear system. Considerable plumbing and valving is necessary in the complete system to insure that the liquids arrive inside the combustion chamber at the required high pressure.

A solid propellant rocket, not too much different than a 4th of July skyrocket, is a simple device. It consists of a granular mixture of fuel and oxidizer molded in a heavy casing. An open port area through the center of the casting is included. The grain is ignited by a pyrotechnic device. The entire exposed inner area of the port is ignited and continues to burn the remaining grain from the inside out. The produced gases are the source of thrust.

Guidance and Control Systems

A missile must have a means of control. This is accomplished by two integrated systems; the flight control system and the guidance system.

The flight control system, much like a pilot of an aircraft, is [illegible] cerned with the attitude control of the missile. It must mainta[illegible] stabilized flight and prevent any sudden or erratic missile m[illegible]s.

The guidance system performs a function like the navigator aboard an aircraft. Both are concerned with the present position and speed, destination of the flight, and certainly the best course to follow to arrive at the destination. As such, the guidance system concerns itself with the continual correction of the missiles flight to select the best trajectory to the target. (Figure 1, Missile Flight Profile)

ICBM's use either a radio command guidance system or an inertial guidance system. The Atlas D and Titan I use the radio guidance system. It has a ground antenna, ground computer and an airborne receiver and transmitter. The ground antenna remains "locked on" the missile during powered flight. Missile movement is detected by the antenna and sent

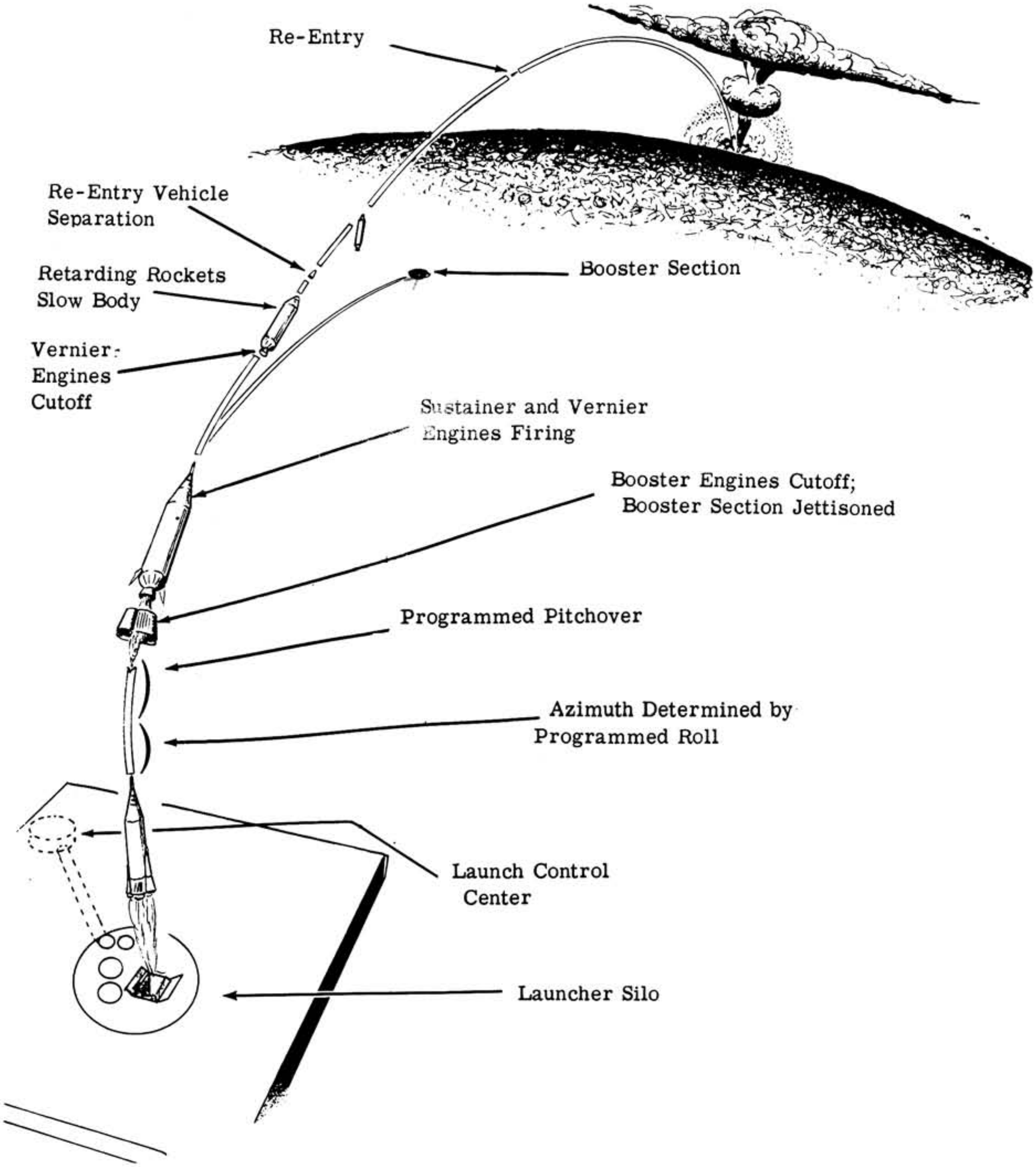


Figure 1 - Missile Flight Profile

to the computer. The computer uses this information to calculate missile steering corrections which are sent to the missile via the antennae. A radio guidance system controls a single missile at any time.

An inertial guidance system is an advanced form of dead reckoning navigation. It is self contained and jam proof. A reference position is established at launch and maintained throughout guided flight by a highly accurate arrangement of gyroscopes. Deviations from this reference position are sensed and measured by accelerometers and stabilization gyros which send this information to a digital computer. Here, it is compared with data from the memory section and resulting correction signals are computed to insure the missile will maintain a good trajectory. These correction signals are sent to the engine gimbaling control systems. All advanced ICBM's use an inertial guidance system.

Re-entry Vehicle

The mission of an ICBM is to send a warhead to the target. The warhead is housed inside of the re-entry vehicle. One of our biggest problems in missilery has been the search for a successful method of returning a re-entry vehicle through the atmosphere.

When a re-entry vehicle begins to re-enter the atmosphere it has a tremendous velocity. The collision of the vehicle's surface with the air particles causes high temperatures and 'g' loads. Thus, it was necessary to construct a re-entry vehicle which would be able to withstand these two extremes. Aerodynamic design and material development have given us a satisfactory R/V. An ablative covering on the vehicle, which melts and vaporizes as it re-enters, is used on all of our ICBM re-entry vehicles.

Copper - heat sink

MISSION OPERATIONAL CAPABILITY, AND CONFIGURATION OF BALLISTIC MISSILE WEAPON SYSTEMS

Two major objectives of our aerospace force are fulfilled by the establishment of a ballistic missile weapons system. These objectives, as stated in Air Force Doctrine (AFM 1-2), are

- To deter a general or limited war
- To defeat the enemy as quickly as possible if a general or limited war occurs.

Too often we are inclined to associate the reasons for maintaining a missile force solely in terms of the second objective. The day to day peace we enjoy is in a large part due to the deterrant value of our ballistic missile weapons system as stated in the first objective.

When we refer to the ballistic missile weapon we are concerned with than just the missile. A WEAPONS SYSTEM IS DEFINED AS A SELF SUFFICIENT COMBAT INSTRUMENT OF STRIKING POWER IN ITS INTENDED OPERATIONAL ENVIRONMENT. Thus the entire system includes the missile, and all the related equipment, materials, personnel, skills and techniques to operate the missile. The equipment necessary to support the missile is referred to as AGE (Aerospace Ground Equipment). This includes all facility equipment. Equipment that is required to restore or maintain a weapons system in operating condition is called MGE (Maintenance Ground Equipment).

It follows that the scope of the missile combat crew duties will not be limited to the missile maintenance. In fact, missile maintenance will be the minor portion of crew's duties. The problems associated with the maintenance of the entire complex will consume most of the crew's time and efforts.

CONCURRENCY

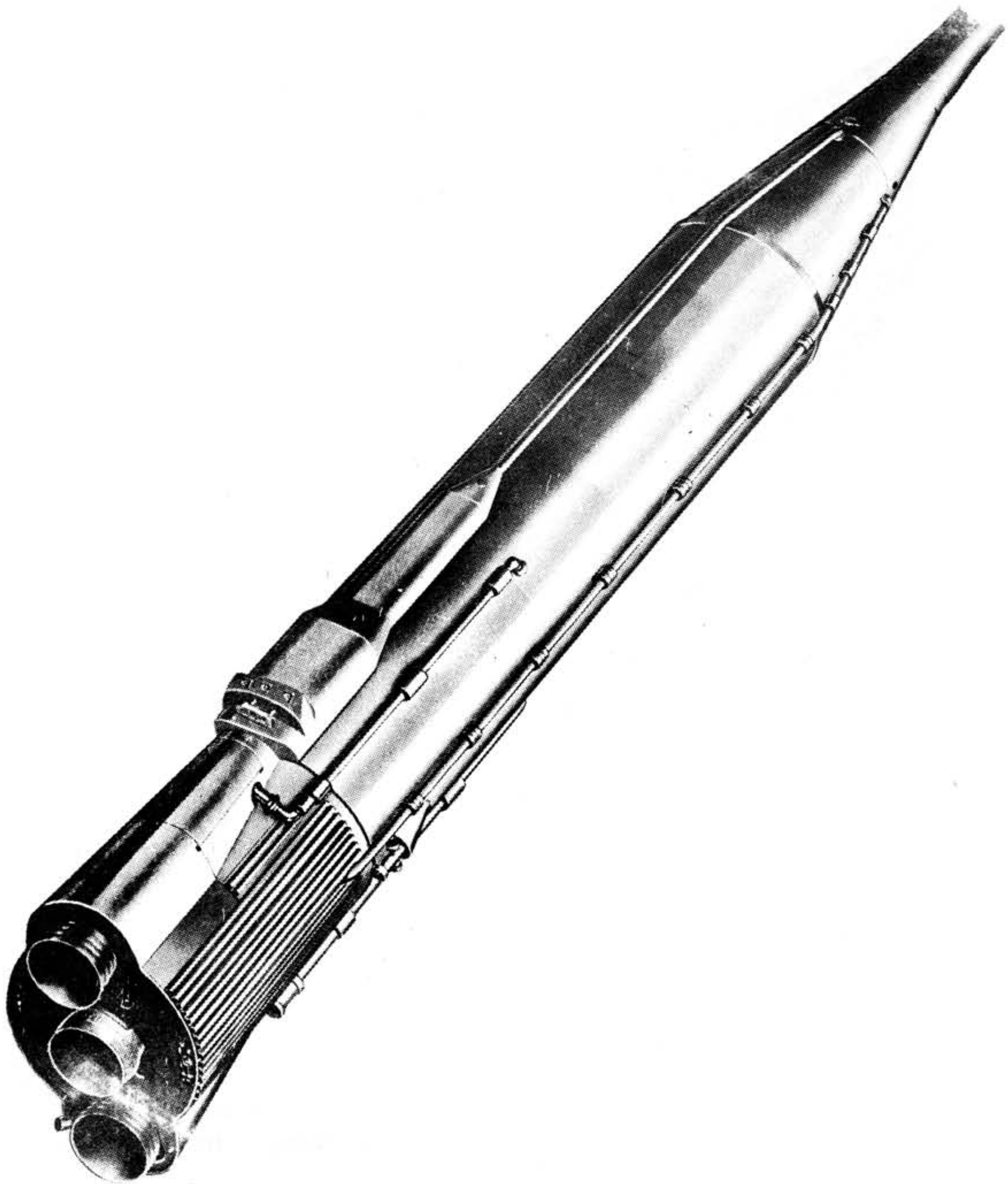
As stated above a weapon system includes the missile, related equipment, materials, and personnel required to operate and maintain the weapon system. To decrease the lag time from drawing boards to operational status of a weapon system the concurrency concept has been used with the ICBM weapon systems. The objective of the concurrency concept is that when the missile and related equipment is fully tested and ready for implementation, the sites have been constructed, and the personnel trained.

The Air Force designates its missiles according to mission. For example, the IRBM's and ICBM's are called Strategic Missiles (SM). Missiles which replace or supplement interceptor aircraft are called Interceptor Missiles (IM), while missiles that replace fighter bombers are known as Tactical Missiles (TM). Other designations are the Guided Aircraft Rocket (GAR) and Guided Aircraft Missile (GAM). GAR's are normally thought of as "air-to-air" weapons and GAM's as "air-to'ground" weapons. This study guide will cover a brief familiarization of Strategic Missiles.

Strategic Missile Mission and Operational Capability

Strategic Missiles (SM) are those missiles designed for use in strategic attack. By definition, strategic attack is "an attack directed at selected targets of an enemy nation so as to destroy his war-making capacity or his will to fight." Generally speaking, strategic missiles may be classified as either IRBM or ICBM, depending on the range of the missile.

Intermediate Range Ballistic Missiles (IRBM). IRBM's are those strategic missiles with a range of 200 to 1500 miles. The limitation of



The SM-65 Missi

The Atlas is 75 feet long and 10 feet in diameter which flares to 16 feet at the nacelles. Its liquid propulsion rocket engines burn liquid oxygen and RP-1 (similar to JP-4). The airframe is a stainless steel monocoque construction that requires constant pressure to maintain its rigidity.

The Atlas missile, with its unique one and one-half staging, differs from other missiles in that it has several engines but only one propellant tank structure. All of the engines are ignited at liftoff. There is no risk of a flight abort due to a failure of an air start of a second stage engine. This gives the Atlas a factor of reliability which no other missile duplicates.

The Atlas is powered by a cluster of five engines which provide a total of 389,000 pounds of thrust. Two booster engines combine to provide 330,000 pounds of thrust. They are operated during the first two minutes of flight and are then stopped and detached in flight from the rest of the missile. The 57,000 pound thrust sustainer engine and two 1,000 pound vernier control engines continue to operate for the remaining three minutes of powered missile flight. These engines are stopped after the missile has achieved sufficient speed to carry the re-entry vehicle to the target.

Most Atlas weapon systems carry the Mark 4 ablative re-entry vehicle. The E and F series use an inertial guidance system unlike the Atlas D which uses a radio command guidance system.

The Atlas D weapon system is a soft, above ground layout. Each complex has three missiles and one control center for the remote launching of its missiles. A missile remains in an unloaded horizontal position in a cinder-block building. The order of events for the launching of an Atlas D missile is: open the movable roof over the missile, erect the missile to a vertical position with the hydraulic erection equipment, load the missile tanks with RP-1 and liquid oxygen, and then ignite the engines. Because the Atlas D uses a radio command guidance system, it is possible to launch and control only one missile at a time.

The Atlas E is a much improved missile weapon system over its predecessor. It incorporates an inertial guidance system and is stored below ground level in a semi-hard state. This method is better known as the "coffin configuration". (See Figure 3, Launch and Service Building) There is a control center for each Atlas E missile. Because this missile is stored in a horizontal unloaded position it must go through the same sequence as the Atlas D before it can be launched.

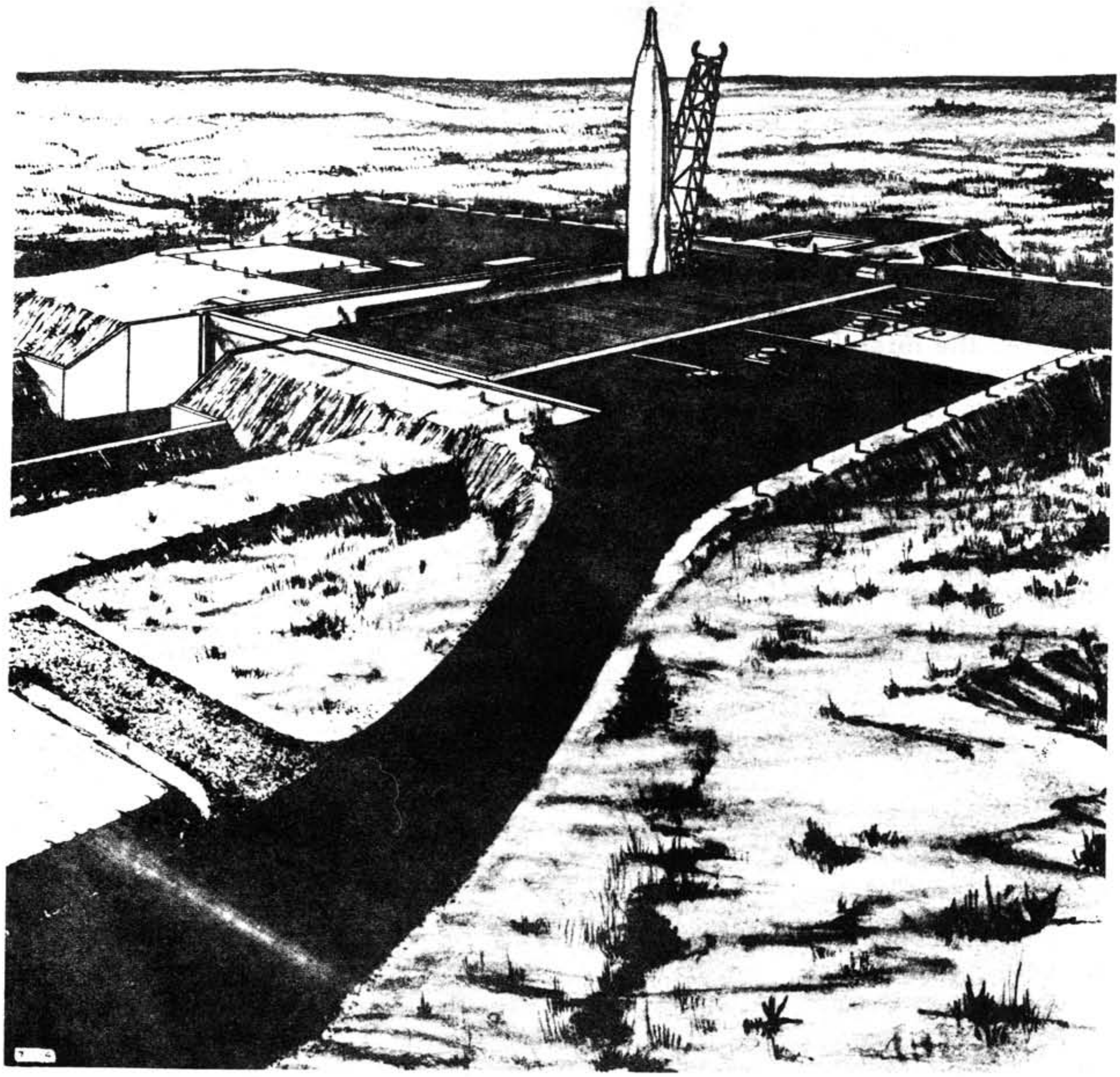


Figure 3 - Launch and Service Building (E - Ho[illegible])

The design of an Atlas F weapon system includes the advantages of a hard silo configuration and the storage of an Atlas missile in a vertical position. (See Figure 4, "F" Launch Complex Ground Layout) These features are not shared by the Atlas D and E systems.

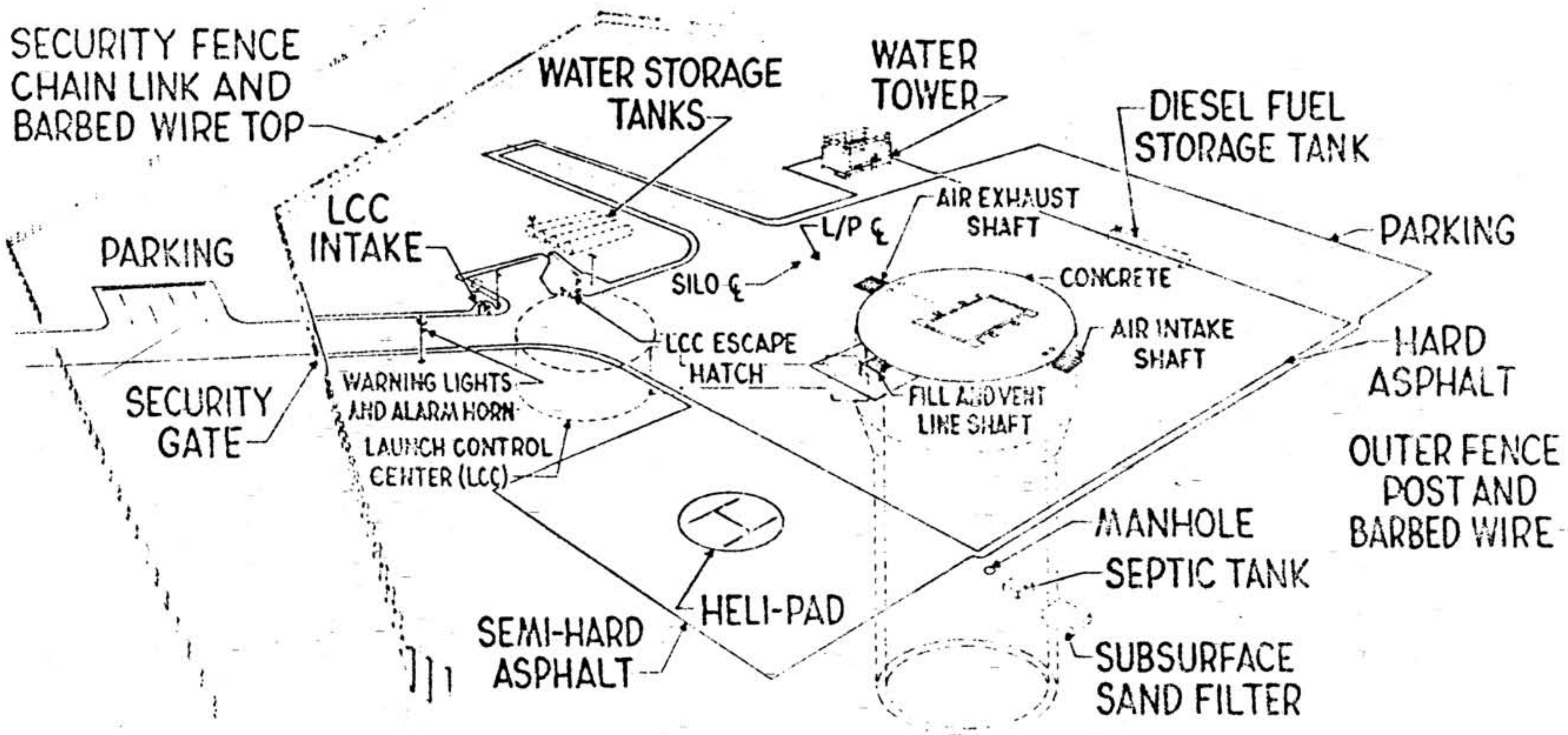
The Atlas F complex consists of a missile silo and attached control center, both of which will be able to withstand the effects of a nearby blast. The control center includes the personnel living quarters and power and control equipment used in the launching of the missile. Inside the silo is an elevator and its support structure. The missile is mounted on this elevator and it will be elevated to ground level prior to launch. The total weight of this structure and equipment exceeds 1500 tons. Two hydraulicly operated silo doors protect the silo when they are in the closed position

Titan I

The Titan I missile weapon system was designed to supplement the Atlas series weapon systems. It is a two stage liquid propulsion missile that is deployed in groups of three per completely hardened complex.

The first stage develops a thrust of 300, 000 pounds of thrust from its booster engines. After the first stage is burned out, the 80, 000 pound second stage engine is ignited. Both engines use liquid oxygen and RP-1 as a propellant. The RP-1 is stored aboard the missile and like the Atlas F the oxidizer is loaded during the launch countdown. The three missiles of each complex are controlled by a single radio guidance system. The ablative re-entry vehicle is carried by the Titan I.

The underground complex of the Titan I is the most elaborate complex of all our ICBM's. (See Figure 5, Complex) Three missile silos, a control center, a powerhouse, an entrance portal and equipment and propellant storage areas are connected by over 2000 feet of underground tunnels. The powerhouse has four large diesels and an air conditioning system for the entire complex. The control center contains the personnel living areas and the electronic equipment to remotely launch the three missiles. Each missile silo includes a shock mounted structure and an elevator apparatus to lift the loaded missile to the surface for launching. The silo is protected by two reinforced concrete silo doors which open prior to raising the missile.



"F" LAUNCH COMPLEX GROUND LAYOUT (TYPICAL)

Figure 4

Figure 5 - Complex

A six man crew is used to maintain the Titan I missile in an around the clock state of readiness. A large crew is necessary to keep the powerhouse in operation and to man the radio guidance system with its complex ground computer system. Before all three missiles can be sent on their flight, they must each be loaded with liquid oxygen, the silo doors opened, the missiles elevated to the surface and then in turn lift off and be radio guided on their trajectories.

Titan II

The third member of our liquid propulsion ballistic missiles is the Titan II. It is an outgrowth of the Titan I missile system. In 1959 a series of changes and new ideas were advanced that would greatly improve the performance and capability of the Titan I missile. These recommendations resulted from technological advances and experience achieved from previous missiles. Because Titan I facilities were already under construction, it was decided to incorporate the proposed sweeping changes into an entirely new missile - - the Titan II. (See Figure 6, SM68B Launch Complex)

The major refinements of the Titan II are:

- Storable propellants, an in-silo launch.
- Inertial guidance.
- An automatic launch sequence.

These factors have given us a missile weapon system that has a reaction time of less than one minute, an increased payload and much greater reliability.

The Titan II is a two stage liquid propelled missile that is capable of sending a large ablative covered re-entry vehicle in excess of 6000 nautical miles. (See Figure 7, Titan II Airframe) The first stage develops a thrust of 430, 000 pounds of thrust and the second stage develops 100, 000 pounds of thrust. Both engines use the same hypergolic propellant (ignites upon contact), which eliminates the need for an ignition system. The fuel is Aerozine 50 [a mixture of 50% hydrazine and 50% unsymmetrical dimethylhydrazine (UDMH)] and the oxidizer is nitrogen tetroxide. These dangerous chemicals require special clothing and equipment for the men working with them.

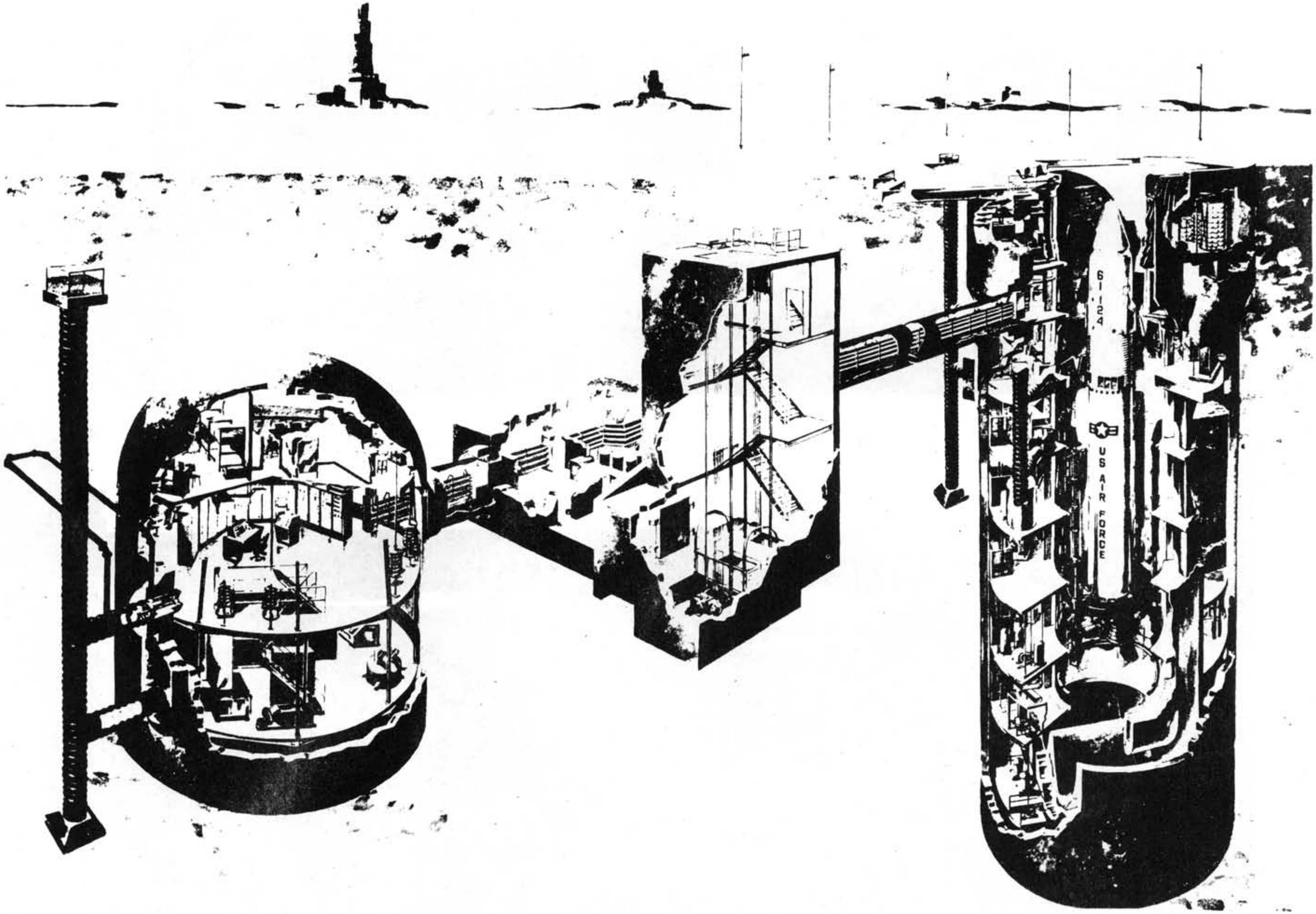


Figure 6 - SM68B Launch Complex

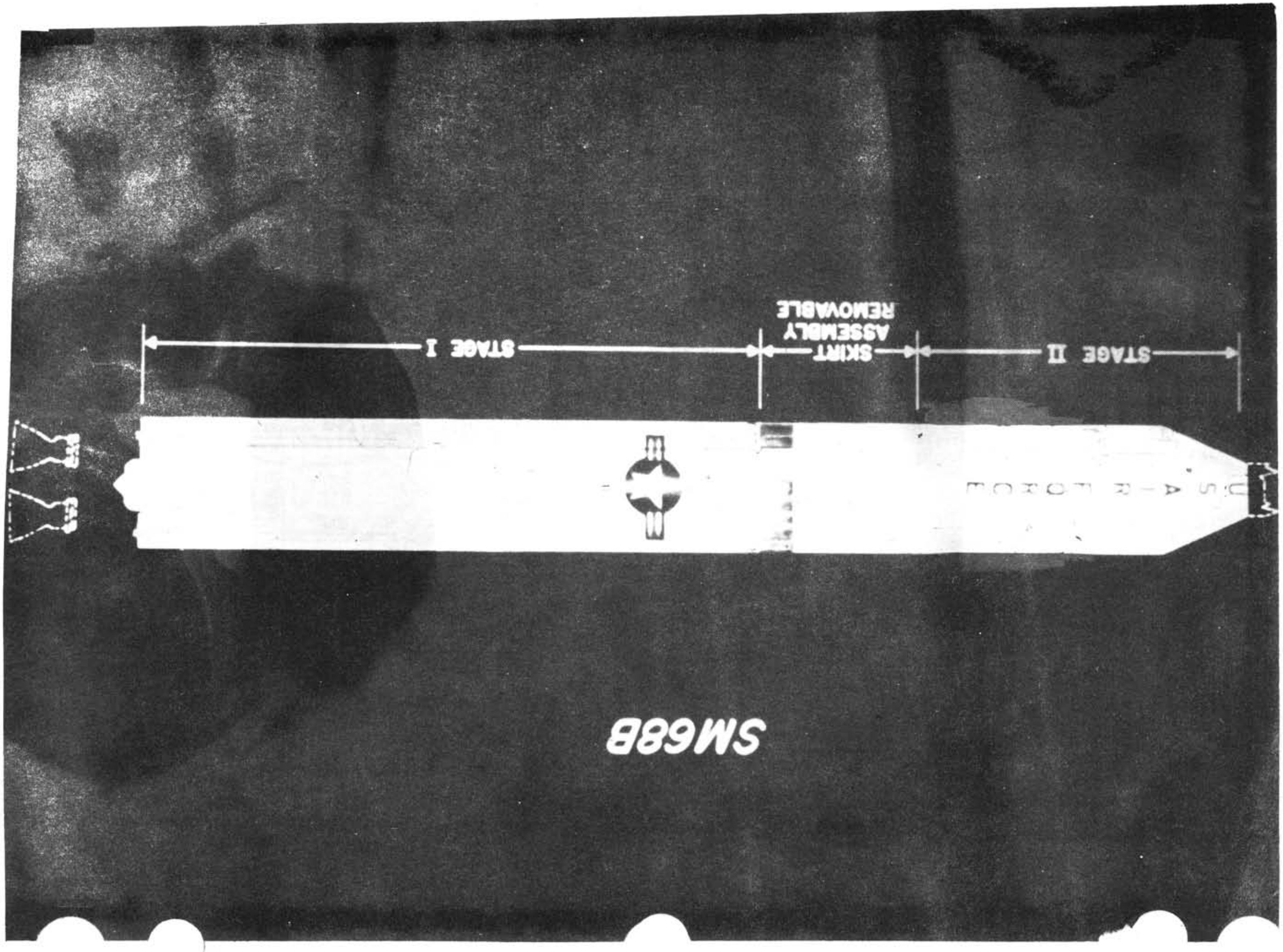


Figure 7 - Titan frame

The launch complex for a Titan II missile is buried underground. It includes three reinforced concrete structures that provide protection from a nearby blast. These structures house the personnel, missile and associated equipment necessary to launch the missile. An access portal area serves as an entrance, and blast door housing. Fifty feet from this is the control center where the crew's living quarters and necessary equipment to remotely launch the missile are located. The silo, over 225 feet from the control center, houses the missile. It is covered with a 700 ton reinforced concrete door. The inner section houses the missile and is lined with acoustical tile that absorbs sound waves to protect the missile during an in silo launch. The outer section has nine levels that contain support equipment and a "W" configuration at the bottom of the silo that directs engine exhaust gases through ducts extending to ground level.

The Titan II requires a four man crew, two officers and two enlisted men. The Launch Control Officer commences the launch from the control center, which, in less than one minute, will cause the silo door to slide open, engines fire and the missile lift from the silo and proceed to the target.

Minuteman

The latest missile added to our weapon system arsenal is the Minuteman (WS-133A). It embodies the changes and newly established requirements of a missile weapon system. As development of liquid propellant missiles progressed, the high cost of these complex missiles, plus the required skills for operation and maintenance of the ground equipment, precluded the prospect of using such missiles in large numbers. Furthermore, the Department of Defense wanted a weapon system that would not only deter any aggressor, but in the event of enemy attack, would provide a means for instant massive retaliation. This called for a new philosophy in modern weapons: a missile weapon system concept involving large numbers of widely dispersed, long range missiles, capable of being remotely launched within seconds after a positive command.

The Minuteman ICBM is a three-stage solid propellant rocket. (See Figure 8, SM-80 Complex) Each stage contains a one-piece-grain of propellant enclosed in a sheet metal or fiberglass case. The first stage engine develops 170,000 pounds of thrust; the second stage engine develops 65,000 pounds of thrust; the third stage develops 35,000 pounds of thrust. A thrust termination system in the third stage

MISSILE INSTALLATION AND ALIGNMENT

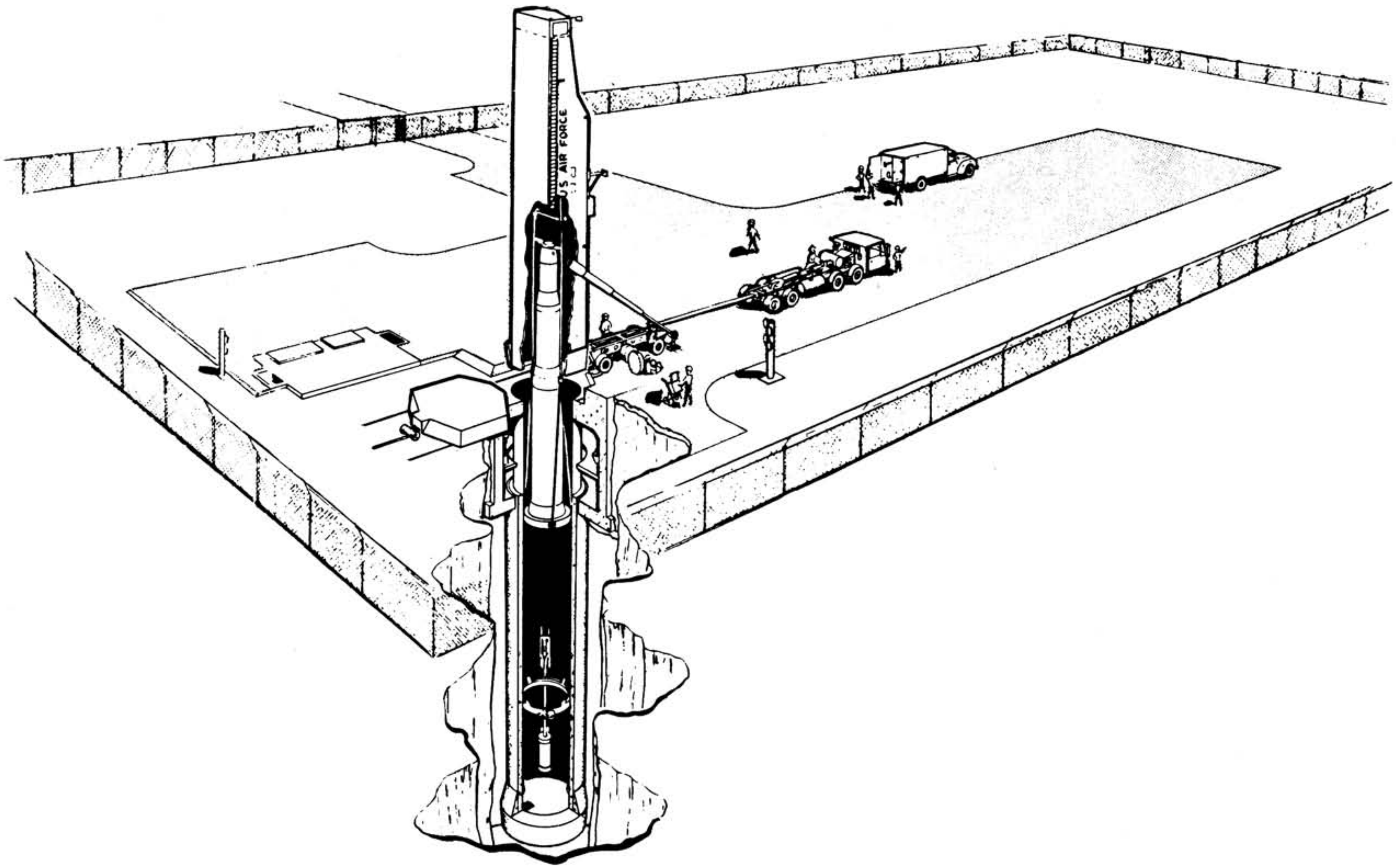


Figure 8 - SM-68 Complex

limits the maximum velocity of the missile by stopping the forward thrust on signal from the guidance system. Each engine has four gimbaled nozzles at the aft end for steering in flight. These nozzles are controlled by the guidance and control systems. A feature of its inertial guidance system is that it is in continual operation during an alert status. The re-entry vehicle is covered with an ablative layer to protect it during its return through the atmosphere.

The assembled missile is transported from the support base to the silo by the transporter-erector. This mobile unit includes apparatus that erects the entire unit and lowers the Minuteman missile into its launcher. Once the missile is installed the silo is sealed and left un-manned.

The missile is housed in an 80 foot-deep, steel-lined concrete launch tube. Adjacent to the silo is a two level equipment room. It contains the communication, electrical, hydraulic and monitoring equipment used for the remote launching of the Minuteman. The silo is covered by a 40-ton, three-foot thick silo door which will protect the missile from the effects of a nuclear blast. This door is quickly opened prior to launch by a "Ballistic gas actuator".

For each group of ten missiles there is a launch control center. It consists of two structures. Above ground is the launch control support building that contains living quarters, electrical power plant (standby), security station and environmental control equipment. Beneath this structure, and connected by an elevator and ladder shaft is the capsule. It is reinforced concrete structure which can withstand the severe shocks of a blast. Its massive vault like door can be locked or unlocked only from the inside.

Each capsule will be manned by a crew of two officers [illegible] sions are made, if such a situation should arise, for these me[illegible] subsist for a period of 63 days without exiting from the capsule.

The Minuteman has a reaction time of less than a minute. This results from the solid propellant propulsion system that commences its flight with an in-silo launch and a sophisticated operational ground equipment (OGE) system. The Minuteman missiles that will soon be dispersed over a wide area of our northwest represent our most advanced missile weapon system.

DUTIES AND RESPONSIBILITIES OF MISSILE LAUNCH/MISSILE OFFICERS

PERSONNEL

No weapon system is complete without the trained personnel to operate and maintain the system. AFM's 35-1, 36-1, and 39-1 contain job descriptions and information for officers and airmen for the various Air Force Specialties required to operate and maintain the weapon systems. Strategic Air Command regulations, supplements, and directives will further specify organizational structure and the duties and responsibilities of specific job assignments within the missile units.

"Missile Launch Officer" and "Missile Officer" are Air Force Speciality (AFS) titles. An AFS includes all positions (jobs) which require the same basic abilities. Thus, no one officer can perform all of the duties and assume all of the responsibilities of the AFS at one time. However, selected officers can be developed to perform all of the duties and assume all of the responsibilities of the AFS at different times. Demonstration of proficiency in only one position is adequate to indicate that the officer is capable of per.-forming all of the positions of the AFS provided that he fulfills the mandatory qualifications of the speciality. The major points, extracted from the Officer Classification Manual, are listed below.

Missile Launch Officer

The missile launch officer's entry level code is 1821 and fully qualified is 1825. He may manage missile launching crews and firing teams, or he may command missile units (smaller than a squadron).

His duties and responsibilities include:

- Planning and organizing missile launch operations activities.
- Directing missile launch operations activities.
- Coordinating missile launch operations activities.
- Performing technical functions incident to missile employment.

The missile launch officer qualifications are:

- Knowledge of tactical capabilities of guidance systems, propulsion, re-entry, and related ;components is "Mandatory" for fully qualified.
- Knowledge of mathematics through plane trigonometry, general chemistry, physics, and principles of aerodynamics is desirable.

- Bachelor's degree in electrical or aeronautical engineering is desirable.

- A minimum of 12 months in the Missile Launch Officer assignments is mandatory for fully qualified.

- Completion of a missile launch operations course is desirable.

The authorized grade spread is second lieutenant through lieutenant colonel.

Missile Officer

The missile officer's entry level code is 3121 and fully qualified is 3124. He may manage missile maintenance and operations activities including launch facilities, missile systems and related aerospace ground equipment. He may also command missile units.

His duties and responsibilities include:

- Planning and organizing missile activities.

- Directing missile activities.

- Coordinating missile activities.

- Performing technical missile functions.

The missile officer's qualifications are:

- Completion of college level courses in theory of electricity and electronics is desirable.

- Knowledge of mathematics through differential equations is desirable.

- Bachelor's degree in electrical or aeronautical engineering is desirable.

- Fundamental knowledge of theory of flight and principles of jet and rocket engines is desirable.

- A minimum of 18 months experience in missile maintenance or operations is mandatory.

- Experience must include organization and direction of such activities as maintenance under field or shop conditions and/or missile launch operation.

Missile	Air Force Missile Designation	* Numerical Configuration	Hardened Configuration	Length	Stages	Propulsion System	Propellants	Thrust	Guidance	Crews
TITAN I	SM68 HGM 25A	3 X 3	Hard	86' & Nose Cone	2	Liquid	Liquid Oxygen & RP-1	I-300, 000# II-80, 000#	Radio	6 Men
Titan II	SM68B HGM 25C	1 X 9	Hard	96' & Nose Cone	2	Liquid	Nitrogen Tetroxide & Aerozine 50	I-430, 000# II-100, 000#	Inertial	4 Men
Minuteman	SM80 LGM 30	10 X 5	Hard	47.5' & Nose Cone	3	Solid	Solid Mixtures	I-170, 000# II-65, 000# III-35, 000#	Inertial	2 Officers
Atlas D	SM65D CGM 16D	3 X 3	Soft	72' & Nose Cone	1 1/2	Liquid	Liquid Oxygen & RP-1	Boosters 150, 000# each. Sustainer 60, 000#	Radio	14 Men
Atlas E	SM65E CGM 16E	1 X 9	Semi-Hard	72' & Nose Cone	1 1/2	Liquid	Liquid Oxygen & RP-1	Booster 165, 000# each. Sustainer 60, 000#	Inertial	5 Men
Atlas F	SM65F HGM 16F	1 X 12	Hard	72' & Nose Cone	1 1/2	Liquid	Liquid Oxygen & RP-1	Booster 165, 000# each Sustainer 60, 000#	Inertial	5 Men

Chart 1

QUESTIONS

1. List three of the five achievements Dr. Goddard contributed to rocketry.

   1. Multi stage rocket
   2 Fired first liquid fuel
   3 Supersonic
   4 Gyros
   5 Vanes

2. What were the purposes of the "American V-2 Program"?

   Gain technological data + info for the US.

3. What is the difference between a guidance system and a flight control system?

   INTEGRAL RADIO

   Guidance system is the brains Control the missil.

4. What are the major components of the radio guidance systems?

   Ground antenna
   " computer
   Airborn transmitter + receiver

5. List the missiles that use LOX and RP-1 as a propellant.

   ATLAS DEF
   TITAN - I

6. List the inertial guidance missiles deployed in a HARD configuration.

   ATLAS - F
   TITAN - II
   M.M.