AN ANALYSIS OF AIR FORCE MASTER PLANNING AND THE EFFECT OF SPACE PROGRAMS ON LAND DEVELOPMENT

by

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CHAPTER I

INTRODUCTION

Techniques and procedures of city planning have, in recent years, developed at a rapid rate. The profession of city planning in the civilian community is rapidly growing. There is, in the opinion of the writer, a lag in professional growth of city planning in the Air Force. The purpose of this thesis is to investigate Air Force master planning techniques, procedures, and standards, especially as involves space support facilities, and to propose additional land use standards and procedures.

The average Air Force base is a complete city, the principal mission of which is national defense. This mission requires a wide variation of facilities ranging from airfield pavements to family housing. That the Air Force has long considered each base as a "city" is demonstrated by the fact that a master plan for development is required. Further, the organization responsible for operation, development and maintenance of the base, the civil engineering organization, is normally authorized a city planner. Unfortunately, the supply of formally trained city planners in the Air Force is extremely limited; thus, the development of the master plan must be closely guided by suitable Air Force manuals.

Such manuals are currently in existence. However, it is the opinion of the writer that the techniques, procedures, and standards of planning as developed in recent years can do much to improve Air Force planning. This thesis has been accomplished with the belief and hope that its contents will aid in the proper development of master plans for Air Force bases.

The contents of the study were prepared without consideration for the justification of individual facilities. Readers will find little assistance in the preparation of required documents to defend the need and justify the cost of an individual facility, regardless of importance. What is stressed, however, is the interrelationships of these facilities to each other; that is, the relationship of housing to aircraft facilities, the effects of noise and dangerous fuels on location of facilities and the use of planning standards in determining land use. The writer has generally made no effort to discuss the architectural treatment, the interior requirements, or the types of materials to be used for individual facilities. These subjects are studies within themselves and are of too great a scope to be included here.

Of major importance within the thesis is the investigation of space support facilities and their effect on the development of a master plan. A space support facility may be defined as any facility necessary for the direct support of a mission involving a space program. These might range from the astronaut training facility to the actual launch and launch control facilities necessary to send the vehicle on its way.

There are many similarities in the planning techniques of Air Force facilities and civilian cities. An early chapter in the thesis will discuss these likenesses. Later chapters dwell upon land use analysis and the four major subjects of primary mission facilities, community centers, housing and transportation facilities. Further, the writer has attempted to demonstrate his thesis by the preparation of a case study which is included in the Appendix. Using a hypothetical base with a stated mission, the study begins with the development of a list of needed facilities based upon a table of organization and its required manning, and ends with the completion of a general plan for physical development on an actual site.

Many sources of information have been used in the preparation of this thesis. In addition to the normal sources such as books on planning, the writer has received valuable assistance from existing Air Force manuals in the civil engineering series, the libraries of the Air Force Academy, Colorado, the Air University, Maxwell Air Force Base, Alabama, and the National Aeronautics and Space Administration, Houston, Texas. These libraries provided information on space facilities, manning principles, the activities of the Air Force in space and many illustrations. Sources discussing the interrelationships of space support facilities are extremely limited. Much of the information contained herein is a result of exhaustive research of periodical literature supplemented by the Office of Information, Air Force Eastern Test Range, Air Force Systems Command, Patrick Air Force Base, Florida, and the John F. Kennedy Space Center, National Aeronautics and Space Administration, Cocoa Beach, Florida. As a result, it is believed that the Bibliography is a fairly complete listing of information sources on space support facilities and their interrelationships.

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CHAPTER II

AIR FORCE PLANNING AND SPACE PROGRAMS

The military instrument of the United States is employed for the fundamental purpose of supporting the national objectives. The abilities of the United States Air Force are designed to meet these national objectives in five major goals:[1]

1. To deter general or limited war.
2. If general war occurs, to defeat the enemy as quickly as possible.
3. If limited war occurs, to be able immediately to conduct selective operations wherever required for the prompt resolution of the conflict under acceptable circumstances.

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[1]Air Force Manual 1-2, United States Air Force basic doctrine, p. 9.

4. In cold war, to conduct special operations as directed; to counter or forestall activities considered harmful to the interests of the United States and its allies.
5. In peacetime, to conduct such operations in space as will advance men's knowledge and capabilities, with benefits to people everywhere.

It is this last major goal to which this thesis is dedicated, especially as concerns the activities of the United States Air Force in space. The mission of the Air Force is not space, it is defense. However, the technical capabilities of the nations of the world today make the entrance of the Air Force into an active scientific space program essential. Appendix A contains a further discussion on the role of the Air Force in space programs.

Air Force Master Planning

Inasmuch as the average reader of this thesis will not be a member of the Air Force, a brief description of Air Force master planning requirements in comparison to civilian city planning requirements is presented.

The development of a master plan for an Air Force base is, in itself, a difficult, time-consuming and frequently frustrating task. Air Force master plans are based on a stated primary mission for the base under development. The planner heretofore has not been able to predict with any degree of certainty the myriad of changes in mission and weapon systems which the base would undergo during the time period to be covered by the plan. Therefore, master planning of Air Force bases is a continuing activity. Changing aero-space developments and the introduction of new weapon systems into the inventory often call for construction of new bases and the revision and rearrangement of existing bases. This requires constant revision and review of master plans.

Copies of the current master plan of each Air Force base are on file at Headquarters, United States Air Force, Washington, D.C. These are updated annually and are used by the Air Force in determining the capability of any given base to support its mission or a potential change in mission. If a reduction in missions is forthcoming, evaluation of development will lead to a decision on which bases to curtail or close.

Local base officials use the master plan as a guide in the efficient utilization of facilities and in the siting of new facilities. Their objectives are the same as those of civilian city planning officials; namely, to provide for maximum operational efficiency hand in hand with optimum living and working conditions for the citizens.

In order to accomplish Air Force master planning, a system of controls and standards is needed. Controls are the legal acts and ordinances established by a controlling authority which enables a lower authority to plan. Standards are the quality control tools against which planning results are compared. Table 1 displays a comparative analysis of planning controls and standards sources between the Air Force and the civilian community.

Table I. Sources of control and standards.

Air Force Control and Standards	Civilian Control and Standards
Legal Foundation	
AIR FORCE REGULATION 86-4 "MASTER PLANNING"	STATE ENABLING ACT
Planning Accomplished By:	
BASE CIVIL ENGINEER PLANNING BRANCH OR ARCHITECT/ENGINEER SERVICES CONTRACT	PLANNING DEPARTMENT OR PRIVATE CONSULTANTS BY CONTRACT
Planning Review	
BASE FACILITIES UTILIZATION BOARD CREATED BY AIR FORCE REGULATION 86-7	PLANNING COMMISSION CREATED BY LOCAL ORDINANCE
Planning Approval	
MAJOR AIR COMMAND HEADQUARTERS	CITY COMMISSION BY PROCLAMATION
Zoning Control	
AIR FORCE REGULATION 86-11 "AIRFIELD ZONING" 86-6 "AIR BASE MASTER PLANNING" AIR FORCE MANUAL 86-7 "AIR FORCE ZONING" 86-8 "AIRFIELD AND AIRSPACE CRITERIA"	LOCAL ORDINANCE AND MAP
Subdivision Development Control	
AIR FORCE MANUAL 88-3, CHAPTER 5 "GENERAL PROVISIONS AND GEOMETRIC DESIGN FOR ROADS, STREETS, WALKS AND OPEN STORAGE AREAS" AIR FORCE MANUAL 88-25 "FAMILY HOUSING"	LOCAL SUBDIVISION REGULATIONS
Standards for Construction	
AIR FORCE MANUAL 88-15 "STANDARD OUTLINE SPECIFICATIONS FOR AIR FORCE FACILITIES"	LOCAL BUILDING, PLUMBING, ELECTRICAL AND FIRE PREVENTION CODES
Standards for Housing	
AIR FORCE MANUAL 88-26 "DEVELOPMENT, CONSTRUCTION, SUPERVISION AND CONTRACT ADMINISTRATION OF AIR FORCE FAMILY HOUSING"	LOCAL HOUSING STANDARD CODES

Requirements of an Air Force Master Plan

In addition to the authorities for master planning mentioned above, there is a need for a printed document that can be designated as the master plan against which future development proposals are compared in order to control development. The existence of a master plan accomplishes four things:[1*]

1. It benefits the planning program internally by making the planning board (Facilities Utilization Board) and the planning staff (base civil engineer organization) plan.
2. It gives the public (base residents) and members of the governing body (base commander and staff) some understanding of what the planners are trying to achieve, a specific and detailed understanding of the proposals for achieving these objectives, a framework or guide to direct their thinking, and guidance and encouragement to take voluntary actions in line with the plan.
3. The plan serves the city council (base commander and staff), the planning staff (base civil engineer organization) and the operating departments of the city government (various base organizations) by

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[1]Philip P. Green, Jr., Planning law and administration, 3:5.

*Comments in parenthesis are the writer's attempt to align comments with a typical Air Force base organization.

furnishing a framework within which individual departments may plan particular improvements and a basis for most effective use of the capital improvements program, zoning, subdivision regulations, urban renewal, and similar devices.

4. The plan furnishes a stronger legal basis in support of regulations such as zoning, subdivision regulations, et cetera, by indicating to the courts that such regulations are carefully worked out, are based on overall community-wide considerations, and are not arbitrary restrictions aimed at particular individuals. (In the case of the Air Force it will assist in the control of unnecessary construction, rehabilitation, and alteration projects, assist during inspections of the base by higher headquarters and assist Headquarters, United States Air Force, in assigning missions worldwide and in defending facilities programs of development before Congress.)

To further demonstrate this close parallel between Air Force and civilian master planning, Fig. 1 compares the requirements of a civilian master plan with that for an Air Force base. The similarity is notable.

ITEMS IN BLACK ON LOWER PAGE (MILITARY MASTER PLAN) SHOWING THROUGH TO THIS PAGE (CIVILIAN MASTER PLAN) ARE NORMAL CONTENTS IN BOTH PLANS.

MILITARY CIVILIAN MASTER PLAN

Tab A. Narrative

(1) LOCATION
(2) HISTORY
(3) EXISTING CONDITIONS
(4) METEOROLOGICAL DATA
(5) FLIGHT HAZARDS
(6) BASIC MISSION
(7) UTILITIES DESCRIPTION
GEOGRAPHICAL DESCRIPTION
ECONOMIC BASE

Tab B. Regional Map

(1) REGIONAL MAP
(2) VICINITY MAP

Tab C. Basic Plans & Data

(1) BASIC PLAN
(2) OMITTED
(3) STREET PLAN
(4) REAL ESTATE MAP
(5) AIRFIELD PAVEMENTS
(6) SOIL BORINGS
(7) AERIAL PHOTOGRAPHS
INVENTORY AND CLASSIFICATION OF LAND USE

Tab D. Meteorological Data

(1) METEOROLOGICAL DATA

Tab E. Terrain Clearances

(1) RUNWAY PROFILES

Tab F. Development Plans

(1) DEVELOPMENT PLAN
(2) OMITTED
(3) NOISE CONTOURS
(4) ZONING PLAN

Tab G. Utilities Plans

(1) WATER SUPPLY
(2) SANITARY SEWAGE
(3) STORM DRAINAGE
(4) ELECTRICAL DISTRIBUTION
(5) HEATING & GAS
(6) AIRFIELD LIGHTING
(7) LIQUID FUEL

Fig. I. Requirements of a civilian and Air Force master plan.

Master Planning and Space Programs

It has been said by many that city planning is mainly a coordinating activity. A good city planner knows a little bit about a lot of things and how to organize and control them. The space age city planner is no exception. Before he can understand the requirements of planning a space support base, he must know a little bit about a lot of space facts. To assist the planner in understanding the requirements of a space support base, Appendix B is included which is a discussion on future space missions. Appendix C is a glossary of space terms for further assistance.

The technical editor of Air Force and Space Digest magazine, Mr. J. S. Butz, Jr., has stated that there are nine basic space building blocks.[1] These are as follows: (1) launch vehicles, (2) space propulsion and power, (3) space weapons, (4) bioastronautics, (5) rendezvous and docking, (6) reentry, recovery, and landing, (7) communications (8) ground facilities and (9) understanding the environment. It is important that every planner understand the scope of these nine basic areas so that he may better be prepared to develop adequate space support facilities to meet the mission requirements. Appendix D is a discussion of these nine building blocks.

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[1]J. S. Butz, Jr., The ABC's of space building blocks, Air Force and Space Digest, April 1963, pp. 58-59.

CHAPTER III

RELATIONSHIPS AND LAND USE PLANNING

Functional activities which occur on Air Force bases can be placed within six primary categories of land use. These are as follows: (1) airfield/missile launch land use, (2) industrial land use, (3) administrative land use, (4) community support land use, (5) housing land use, and (6) community recreation land use.

Air Force Manual 86-4 is a shopping list of standard Air Force facilities and Air Force Manual 85-27 is a listing of standard codes and nomenclature for these facilities. The writer has taken the facilities listed in these manuals and has catalogued them in the proposed six primary land use categories. Appendix E is a display of this listing.

Review of Appendix E indicates the nature of the six land use categories. They are functional categories which have desirable and undesirable interrelationships. Most of these are obvious such as separating airfield facilities that are large noise generators from hospitals and housing. Others are not as obvious. But the planner locating the facilities can be guided by the basic relationships suggested in Fig. 2. These are surprisingly similar to conventional civilian community relationships as indicated in Fig. 3.

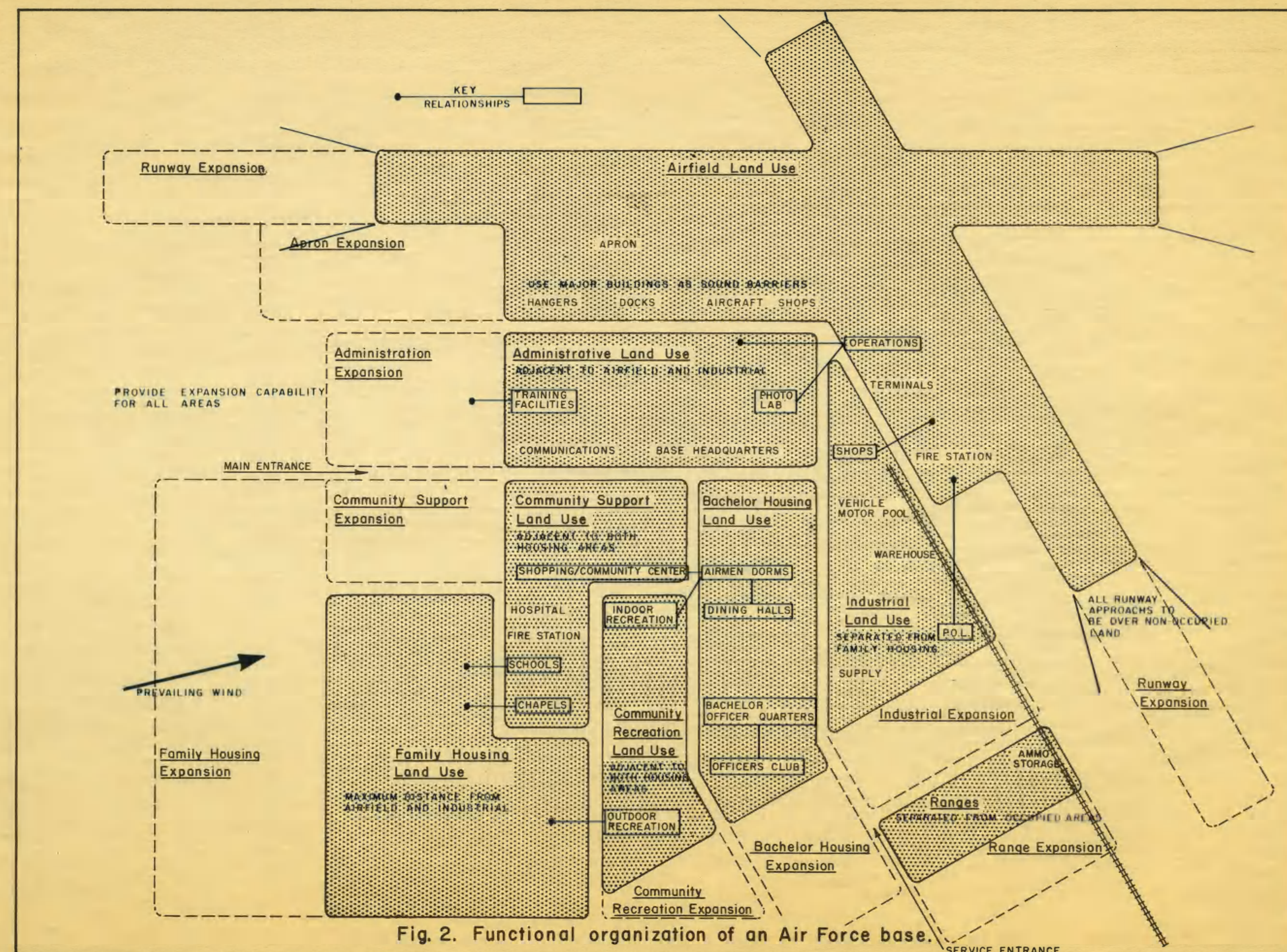

Fig. 2. Functional organization of an Air Force base.

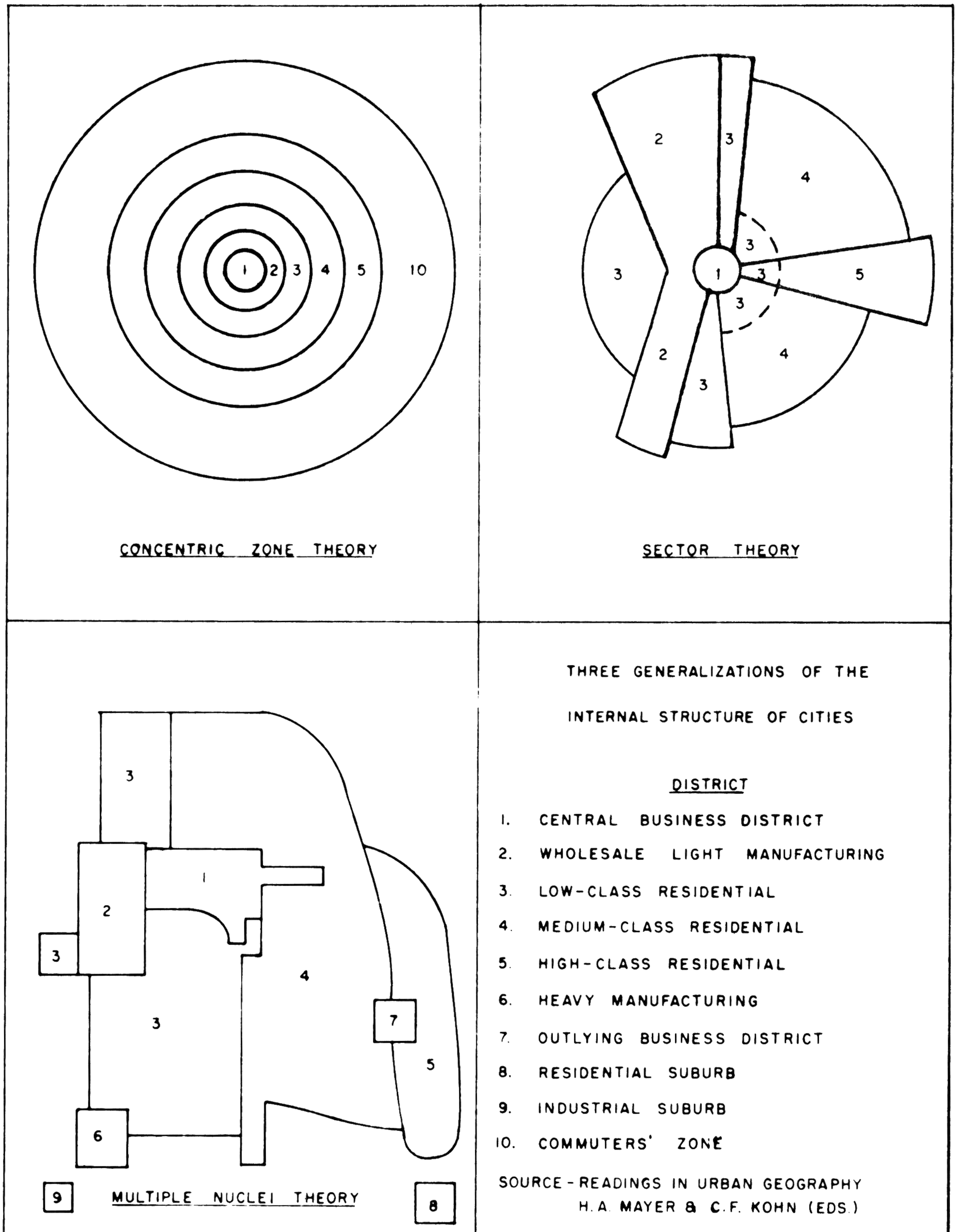

Fig. 3. Functional organization of a civilian community.

In accomplishing site planning of facilities to produce the best functional relationships, the planner should consider the following points:[1]

1. The general plan of the base should be such as to permit maximum flexibility of utilization. This is known as the multi-mission concept. The principle also applies to the planning of the individual land use areas and to the facilities within those areas. Provision must be made for expansion capability. Buildings should be arranged for the most satisfactory and efficient intended use.
2. Buildings should be located with proper consideration given to topography, sunlight, prevailing winds, vehicular circulation, and vistas. Buildings should be spaced adequately to admit light and circulation of air and permit fire safety clearances.
3. Individual facilities and land use areas should be planned with proper consideration given to noise sources. These may be aircraft, missile or industrial sources.
4. Buildings and facilities should be arranged in a pleasant and functional manner. Avoid monotony and regimentation. Provide open areas for breathing

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[1]Air Force Manual 86-6, Air base master planning, p. 19.

space and recreational activities.

5. Locate facilities for minimum circulation conflicts between vehicular and pedestrian traffic, simple pedestrian traffic patterns, adequate parking and service access to buildings and adequate fire access to buildings.
6. A major consideration should be population density. Acceptable densities should be used in locating facilities, especially in dormitory, bachelor officer quarters and family housing areas.

Effect of Space Support Requirements on Functional Relationships

Two major factors must be considered by the planner developing the functional relationships indicated by the land use plan of a base containing missile launch and/or test facilities. These are the effects of noise and the dangers of air pollution by missile fuels and fuel exhaust products.

Effects of Noise. In addition to the distance requirements of maintaining a safe launch area, the requirements of distance for noise control present some real challenges. Intense noise is an important design factor for large missile engines. For instance the noise pressure produced by a Saturn V missile engine will be approximately one hundred eighty decibels. Structural damage can result from such acoustical loadings. In Complex 39, described in Chapter V, the vertical assembly building is designed to accept acoustical pressures of up to one hundred forty-five decibels on the skin surfaces of the building. The nearest firing facility is approximately three and one half miles away.[1] Launch crews as well as astronauts must be protected from such high-intensity noise. At Saturn Complex 39 a three and one half mile minimum to seven mile maximum safety zone is required for noise control alone.

Figure 4 indicates typical sound levels with which the city planner should be familiar. A decibel reading of one hundred ten is commonly called the threshold of pain to individuals. Figure 5 indicates the relation between experienced community response and noise. The goal of the city planner should be to locate all facilities other than missile launch facilities beyond the eighty-five decibel contour line.

The nature of noise is a science unto itself. However, the city planner should be familiar with the basic considerations of how to control noise. The average human ear responds to frequencies from about twenty cycles per second (cps) to over fifteen thousand cycles per second. The most intense sounds to which the ear responds are more than a hundred million times the sound pressure of the least intense sound that is audible. Thus, the ear functions over wide ranges of both intensity level and frequencies. Although the loudness of a sound is principally related to its intensity, it is also influenced by frequency.

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[1]Max O. Urbahn, The vertical assembly building, The Military Engineer, November-December 1964, p. 400.

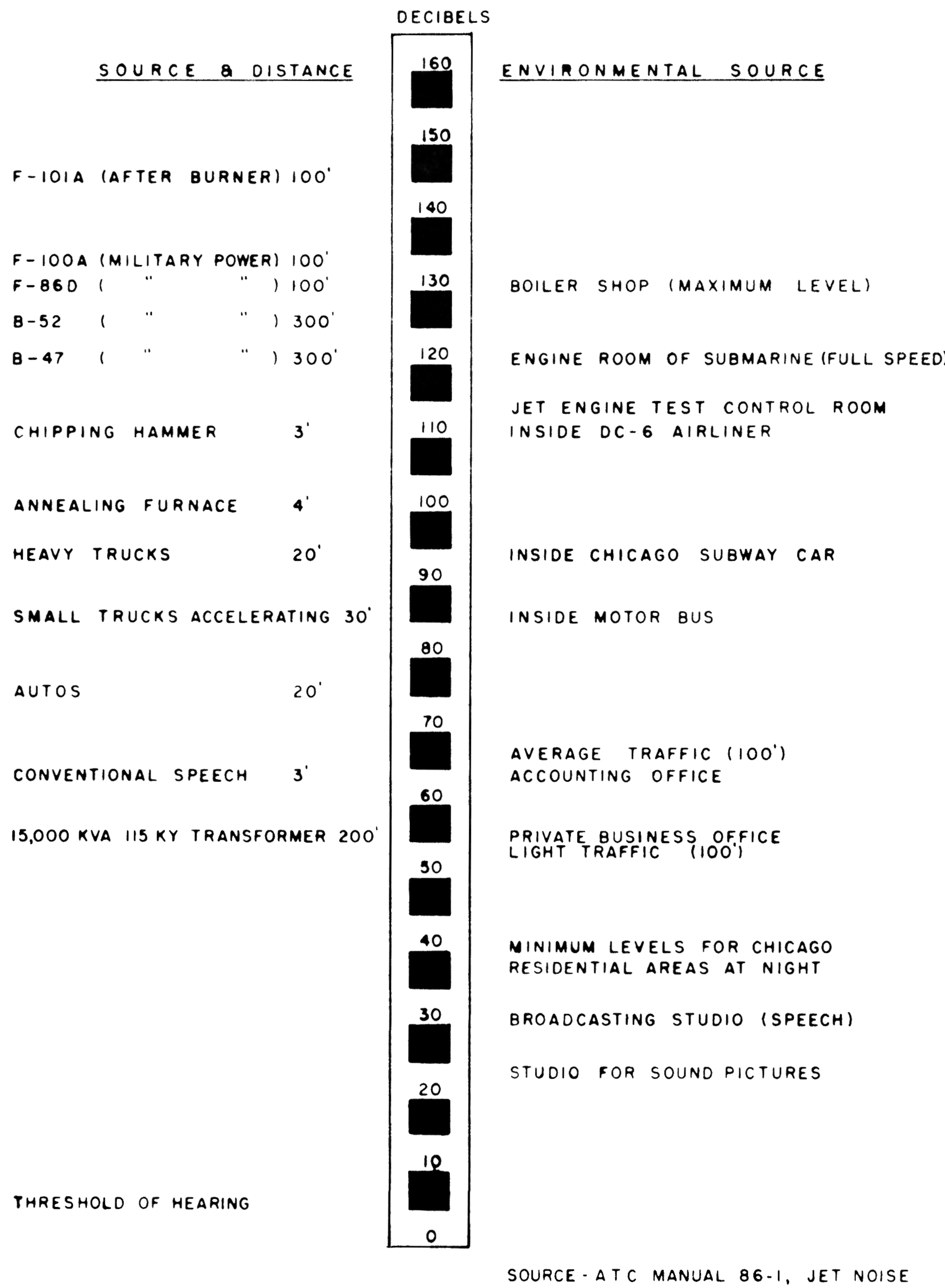
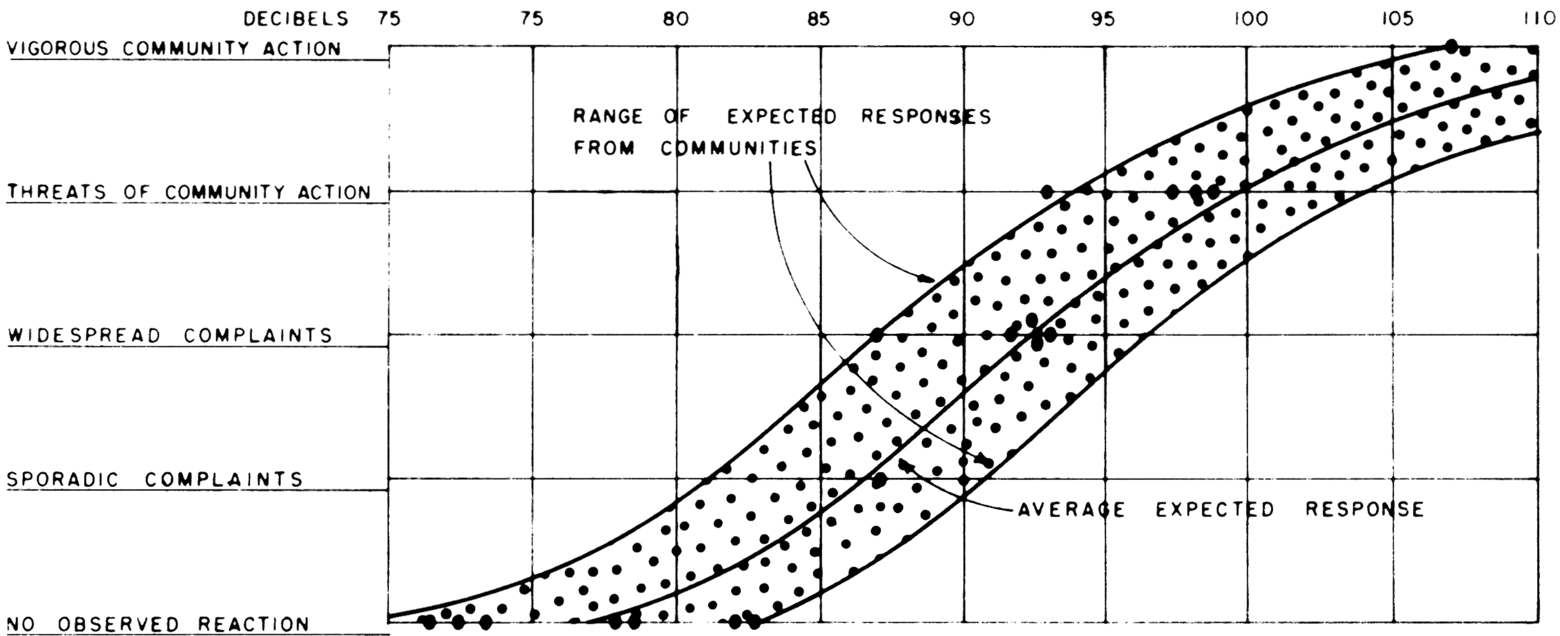


Fig. 4. Typical sound levels.



THE WIDE CURVE SHOWS THE RANGE OF RESPONSES THAT CAN BE EXPECTED FROM COMMUNITIES EXPOSED TO NOISES OF INCREASING SEVERITY THE CENTER CURVE IS THE AVERAGE RESPONSE. EACH POINT REPRESENTS A CASE HISTORY OF NEIGHBORHOOD REACTION.

SOURCE - A.T.C MANUAL 86-1, JET NOISE

Fig. 5. Relationship between community response and noise rating.

At high sound intensity such as from a missile launch, the ear responds more or less uniformly to all frequencies. As intensity decreases, the loudness varies greatly with frequency.

Low frequency noise is heard as, for example, the roar of a diesel truck, rumbling of thunder, the rattling of window panes, and the roar of a jet engine with afterburner or a space vehicle engine. On the other hand, the sound heard as the hissing noise of a compressor air jet or the whine of an idling turbojet engine is typical of high frequency noise. Low frequency noise has high energy, long wavelength, and is not radiated directionally, Low frequency noises are very readily transmitted over long distances through solid materials, often to large surfaces capable of radiating them noisily. High frequency noise is less readily transmitted through solid objects and its effect is generally felt as direct radiation or reflection of direct radiation. High frequency noise is more readily controlled by interposing barriers between its source and areas to be protected. Low frequency noise is best controlled by providing a discontinuity in the path of its transmission through solid material (vibration, insulation, cushioning material, et cetera,) that is, in building design.

Noise levels in free space are inversely proportional to the distance from the source. Each time this distance doubles, the noise pressure is halved. This is known as the Inverse Square Law. This gives a decrease of six decibels in the sound pressure reading of a sound level meter for each time the distance from the noise source is doubled.

To control noise, the city planner needs some indication of the anticipated noise contours from the noise source: the missile firing stand. Figure 6 is an example of such a contour map being for a Titan III missile and a certain configuration of launching pad.

With this basic beginning and using the Inverse Square Law described above, the contours can be projected until an acceptable sound level for other facilities is reached. This is known as the use of space for reduction of noise by increasing the propogation path (distance). This distance may, in some cases, be unacceptable. If so, other ways of lessening the sound level must be used. Three basic considerations are offered:

1. Use of obstacles, buildings and forests to deflect and scatter sound. An example would be to use the shadow zone of the supporting buildings such as the vertical assembly building at Complex 39 as a location for other facilities.
2. Use of land contours for possible shielding. Locate firing facilities in such a manner that elevated ground is between them and other facilities.
3. Point exhaust stacks away from, rather than toward, occupied areas to take advantage of directivity.

   This basic guide must be used by the city planner in locating all areas of facilities in relation to the launch pad.

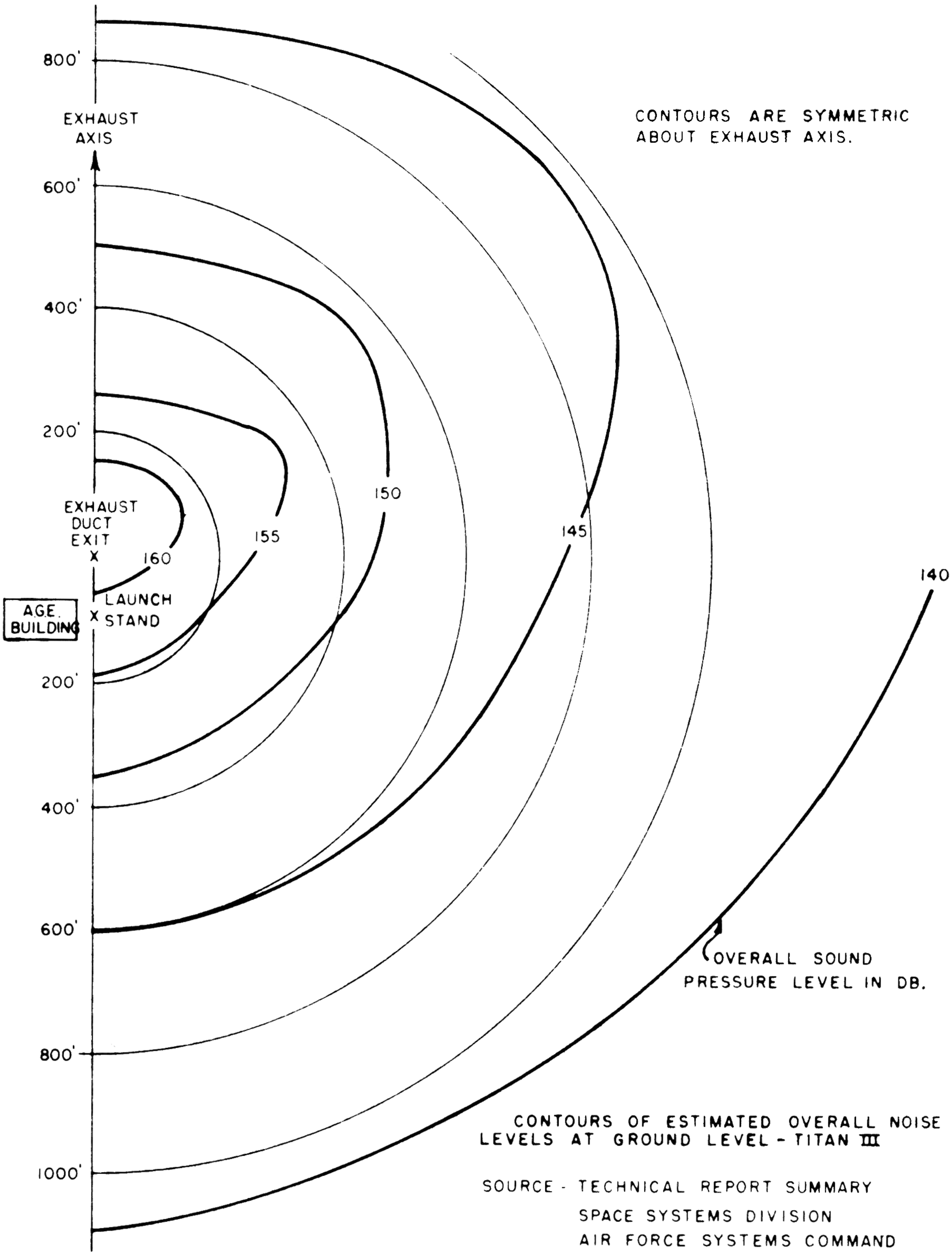


Fig. 6. Example of estimated noise contours.

Effects of Missile Fuel Dangers. Fuels and explosives appear to be the most dangerous item in determining the location of missile facilities. Their potential destructive capacity must be understood. Almost any propellant that gives good performance is apt to be a very active chemical. Further, most are corrosive, flammable, or toxic, and are often all three.

Fuels can be grouped into two general classes: solid and liquid. Two types of solid propellants are in use. The first, the so-called double-base propellant, consists of nitrocellulose and nitroglycerine, plus additives in small quantity. There is no separate fuel and oxidizer. The other type of solid propellant is the composite. Here, separate fuel and oxidized chemicals are used, intimately mixed in the solid grain. The oxidizer is usually ammonium nitrate, potassium chlorate, or ammonium chlorate. Solid propellants offer the advantage of minimum maintenance and instant readiness. However, they require carefully controlled storage conditions. Protection from mechanical shocks or abrupt temperature changes that may crack the grain is essential.

Liquid chemical propellants form the second general class. Most liquid chemical rocket engines use two separate propellants: a fuel and an oxidizer. Typical fuels include kerosene, alcohol, hydrazine and its derivatives, and liquid hydrogen. Liquid hydrogen, which must be maintained at four hundred twenty-three degrees below zero Fahrenheit to remain liquid, produces forty percent greater thrust than other chemicals. Oxidizers include nitric acid, nitrogen tetroxide, liquid oxygen and liquid fluorine. Certain propellant combinations are hypergolic, that is, they ignite spontaneously upon contact of the fuel and the oxidizer. Others require an igniter to start them burning. Liquid oxygen is the standard oxidizer used in the United States missile engines. It is chemically stable and noncorrosive, but its extremely low temperature makes pumping, valving and storage difficult. If placed in contact with organic materials, it may cause fire or an explosion.

The evaporated state of many of the fuels described above produces highly toxic fumes. Further, the exhaust gas products from burning many of these fuels produce similar toxic conditions. The problem of predicting the rate and amount of toxic substances is difficult and must mainly be solved by experimentation. The direction and distribution that these toxic gases take is essentially a meteorological problem, that is, mixing of aerosols emitted to the atmosphere.

Prior to the construction and operation of a facility utilizing toxic materials, climatic data are required for site selection, planning and facility design. These data are often difficult to obtain and the planner may be forced into the position of research and experimentation studies of a site prior to final selection. In any case the problem is of such a nature that qualified consultants are justified and should be used by the planner in arriving at conclusions.

The two most important factors for determining the amount of distance (isolation) required for emitting toxic pollutants to the atmosphere are the toxicity of the materials in question and its rate of diffusion or dilution in air.[1] Equally important, since diffusion rates are dependent upon constantly varying meteorological conditions, is a foreknowledge of the frequency of acceptable diffusion conditions for the area under consideration. The firing rate of missile engines directly affects the diffusion rate and thus the isolation necessary. Therefore, the hazard area for toxic propellants is a function of the downwind toxic vapor and fume concentrations.

The extent of danger can be considerable. Hydrogen fluoride, the main component of the exhaust gases from a liquid fluorine propellant appears to be the principal toxic material which must be considered in siting the missile facility. Liquid fluorine appears to be so reactive in the atmosphere that it is probably changed to fluoride almost immediately. The primary hazard to be considered is the effect which it can have upon persons exposed to even low concentrations. In addition to the health aspect, fluoride can also damage vegetation and various structural materials.

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[1]Owen H. Kittilstad, Toxic hazards, paper presented at the Air Force Systems Command Master Planning Symposium, Arnold Engineering Development Center, September 28, 1964, p. 2.

Prior to the siting of missile facilities that produce toxic conditions, the planner must know the type of fuel or fuels to be used, their toxicity, the frequency of firing, and prevailing meteorological conditions of the site. It is highly recommended that a qualified specialist in this subject be consulted for advice. Opinions reached by this method, plus data and considerations necessary for successful noise control as previously cited, will permit a better siting of these types of facilities.

Land Use Planning

The ideal situation is to have the opportunity, time, and ability to develop the master plan of an Air Force base on a virgin site. This is not normally the situation. Most military bases have grown over a period of years, with periods of accelerated and lean development into a mixture of functional areas. In order to determine what needs to be done to correct such conditions two major steps are required. These are an inventory of physical structures on the existing base, and an inventory and classification of land use by survey methods.

Inventory of Physical Structures. Fortunately there already exists a complete inventory of physical structures of every Air Force base. This exists in two places: the master plan Tab C-1 (See Fig. 1) and the real property records of the base civil engineer. These sources list each facility on the base with pertinent information such as dimension, size, capacity, condition, utilities, et cetera.

Inventory and Classification of Land Use. A land use map is a planning tool, not a solution plan. A land use plan is a rational expression of how the land of a base should be used; that is, the development plan Tab F-1 shown in Fig. 1. A land use map is descriptive, not prescriptive; it indicates how land is used now. To a certain degree Tab C-1, with the accompanying facilities listing, meets this requirement. Unfortunately, it is difficult to determine from the map exactly what use a particular structure has. To determine this, the building code number must be obtained from the map and reference made to the facility number listing. It is the contention of the writer that Air Force master planning will be improved with the inclusion of a land use map in the master plan. It will serve as a graphical display of land use for planners, the Facilities Utilization Board, staff agencies and higher headquarters. Inclusion as Tab C-2 is suggested. In connection with these uses it can assist in the preparation of Tab F-1 development plan and Tab F-5 zoning plan. It will provide much of the information necessary to develop a comprehensive plan of growth. Another important application is that it reveals the points on the base where most of the traffic is generated such as the shopping center and various industrial centers. It further indicates how they relate to the existing circulation system. It will assist in anticipating the impact of proposed new facilities on the traffic pattern. A major traffic advantage would be the ability to see existing and potential parking facilities and their relationship to roads, intersections and heavy traffic districts. Together with building quality records, the land use map allows immediate determination of areas of incompatible land uses, surplus buildings, shortages of facilities, et cetera.

Land Use Survey

In order to produce a land use map, persons or teams must go through the base and systematically determine the use (or uses) of each facility. The general information contained in the real property records cannot be depended upon. Many buildings contain dual uses, such as an administrative headquarters containing a cafeteria. This building would combine two functions: administrative and community support services. The only sure method of preparing an accurate land use map is a physical analysis by observation. The goal of a land use survey is to discover these uses, catalogue them, and classify them.

Before any land use study can be undertaken, a suitable basic map is required. This may be any map of the base showing streets, buildings, and other facilities. Tab C-1, Fig. 1, is an excellent source for the map. Its accuracy should be checked, however, with the real property records prior to the survey.

The use of a tracing overlay to a recent aerial photograph is another good basic map source.

Land Use Classification

As suggested earlier, land uses have been organized into six classifications. Each land use falls within one of these basic classifications which are:

	Code Letter	Title
1.	A	Airfield/Missile Launch Land Use
2.	B	Industrial Land Use
3.	C	Administrative Land Use
4.	D	Community Support Land Use
5.	E	Housing Land use
6.	F	Community Recreation Land Use

It should be noted that each use is assigned a code letter. Each Air Force facility has a category number as contained in Air Force Manual 85-27. Functions found on an Air Force base not listed in this manual will be few.

After the information has been gathered, a system of presenting it is required. The basic land use classifications and colors listed in Table 2 closely follow current practice in the planning profession. This system provides a standard for comparison between Air Force bases, yet is flexible enough to serve each purpose for which it is employed. Where specific land uses indicated in Table 2 list more than one land use code letter, Appendix E is used to determine the proper letter for a given facility.

Table 2. Proposed land use classification system.

LAND USE	CODE LETTER	CATEGORY NUMBER	PENCIL SYMBOL	COLOR SYMBOL	PATTERN SYMBOL
			NUMBERS REFER TO PRISMA COLOR PENCILS, EAGLE PENCIL COMPANY	COLORS REFER TO ZIP-A-TONE COLOR SHEETS, PARA-TONE INC.	NUMBERS REFER TO ZIP-A-TONE PATTERN SHEETS, PARA-TONE INC.
AIRFIELD PAVEMENTS					
RUNWAY	A	111			
TAXIWAY	A	112			
APRON	A	113			
OTHER AIRFIELD PAVEMENTS	A	116	935, 909	LIGHT GREEN	457
LIQUID FUEL DISPENSING					
FUEL DISPENSING	A	121			
MARINE FUEL DISPENSING	B	122			
VEHICLE FUEL DISPENSING	B	123			
PIPELINE & PUMPING	B	125			
FUEL LOADING & UNLOADING	B	126	925	DARK RED	443
COMMUNICATIONS, NAVAIDS & AIRFIELD LIGHTING					
COMMUNICATIONS	C	131			
COMMUNICATIONS SCATTER	C	132			
DIRECTION FINDING	A	133			
NAV AIDS	A, C	134			
TELEPHONE SUPPORT	D	135			
LIGHTING	A	136	946, 936	LIGHT GREY	671
LAND OPERATIONAL					
OPERATIONAL	A, B, C, D	141			
GUIDANCE STATIONS	A, B	149	935, 922	LIGHT RED	436
WATERFRONT OPERATION					
PIERS	B	151			
WHARVES	B	152			
SEA WALLS	B	154			
TRANSIT STORAGE	B	159	935, 918	LIGHT ORANGE	426
HARBOR & COASTAL					
HARBOR & COASTAL BUOY	B	163			
IMPROVEMENTS	B	164	935, 905	LIGHT BLUE	447

Table 2 (cont.)

LAND USE	CODE LETTER	CATEGORY NUMBER	PENCIL SYMBOL	COLOR SYMBOL	PATTERN SYMBOL
TRAINING FACILITIES			909, 910	DARK GREEN	662
ACADEMIC & TRAINING	C	171			
RANGES	C	179			
MAINTENANCE FACILITIES			935, 922	VERMILION	445
HANGERS & AIRCRAFT SHOPS	A, B	211			
MISSILE SHOPS	B	212			
MARINE FACILITIES	B	213			
VEHICLE MAINTENANCE	B	214			
ORDINANCE EQUIPT. MAINT.	B	215			
AMMUNITION MAINTENANCE	B	216			
ELECTRONICS MAINTENANCE	B	217			
MISC. EQUIPT. MAINTENANCE	B	218			
CIVIL ENGINEERING FACILITIES	B, D	219			
PRODUCTION FACILITIES			931	VIOLET	349
AIRCRAFT PRODUCTION	B	221			
MISSILE PRODUCTION	B	222			
WEAPONS PRODUCTION	B	225			
EXPLOSIVES PRODUCTION	B	226			
ELECTRONICS PRODUCTION	B	227			
MISC. ITEMS PRODUCTION	B	228			
PLANT FACILITIES	B	229			
RESEARCH, DEV. & TEST			941	MEDIUM BROWN	441
BUILDINGS	C	310			
STRUCTURES	A, B	390			
SUPPLY			933	MEDIUM BLUE	458
LIQUID STORAGE	B	411			
AMMUNITION STORAGE DEPOT	B	421			
BASE AMMUNITION STORAGE	B	422			
LIQUID PROPELLANT STORAGE	B	423			
COLD STORAGE DEPOT	B	431			
BASE COLD STORAGE	B	432			
HAZARDOUS FLAM. STOR. DEPOT	B	441			
BASE HAZARDOUS FLAM. STOR.	B, D	442			
OPEN STORAGE DEPOT	B	451			
BASE OPEN STORAGE	B	452			
HOSPITAL & MEDICAL			912, 909	MEDIUM GREEN	625
HOSPITAL FACILITIES	D	510			
DISPENSARY "A"	D	520			
LAB, FOOD INSPECTION	D	530			
DENTAL CLINICS	D	540			
DISPENSARY "B"	D	550			

Table 2 (concl.)

LAND USE	CODE LETTER	CATEGORY NUMBER	PENCIL SYMBOL	COLOR SYMBOL	PATTERN SYMBOL
ADMINISTRATIVE			904	DARK PASTEL BLUE	632
ADMINISTRATIVE FACILITIES	A,B,C	610			
MISC. SUPPORT FACILITIES	C,D	690			
FAMILY HOUSING			916	MEDIUM YELLOW	310
FAMILY HOUSING	E	711			
GOVERNMENT TRAILERS	E	712			
PRIVATE TRAILER SUPPORT FAC.	E	713			
GARAGES AND CARPORTS	E	714			
TROOP HOUSING			943	LIGHT SANDALWOOD BROWN	451
ENLISTED DORMITORIES	E	722			
SUPPORT FACILITIES	D,E	723			
OFFICER HOUSING	E	724			
ATTENDENTS HOUSING & DINING	D, E	725			
COMMUNITY SUPPORT			935, 930	LAVENDER	340
SUPPORT AND SERVICE	C, D	730			
COMMUNITY INTERIOR RECREATION	D, F	740			
COMMUNITY EXTERIOR RECREATION	F	750			
UTILITIES & GROUNDS IMPR.			906, 936	MEDIUM GRAY	515
ELECTRIC SOURCES	B	811			
ELECTRIC DISTRIBUTION	D	812			
HEATING SOURCES	B	821			
HEATING DISTRIBUTION	D	822			
GAS SOURCES	B	823			
GAS DISTRIBUTION & STORAGE	D	824			
SEWAGE TREATMENT	B	831			
SEWAGE COLLECTION	D	832			
REFUSE FACILITIES	B	833			
WATER SUPPLY & TREATMENT	B, D	841			
WATER DISTRIBUTION	D	842			
NON-POTABLE WATER FACILITIES	D	843			
ROADWAY FACILITIES	D	851			
PARKING & WALKWAYS	D	852			
RAILROAD FACILITIES	D	860			
STORM DRAINAGE FACILITIES	D	871			
FENCES	D	872			
FIRE PROTECTION FACILITIES	B, D	880			
MISCELLANEOUS FACILITIES	B, D	890			
REAL ESTATE			912, 935	DARK PASTEL GREEN	658
LAND, FEE PURCHASE/DONATION	D	911			
LAND, PUBLIC DOMAIN	D	912			
LAND, LICENSE	D	913			
LAND, PUBLIC POSSESSIONS	D	914			
LAND, EASEMENT	D	921			
LAND, LEASE	D	922			
LAND, FOREIGN LAND	D	923			
MISCELLANEOUS ITEMS			946, 935	BLACK	678
EQUIPMENT	D	931			
LAND CONTROL	A,B,C,D	932			
HAZARDS	D	933			

Field Work. With copies of the basic map available, the base is divided into convenient sections and field workers are assigned. They should be equipped with the base map which covers their area and a listing of the six basic land uses as categorized above. The first step is to visit each facility to determine its use and indicate it on the basic map by stating the actual use, or dual use. This is demonstrated in Fig. 7. In areas where there is little development, this may be accomplished by a "windshield" survey in which one person records the land use by buildings on the basic map while the accompanying person drives. This method is particularly adaptable to housing areas but caution is advised due to the possibility of several uses in other facilities.

When more than one use is applicable in an area or a facility, the multiple uses should be recorded on the basic map. The suggested procedures are demonstrated in Fig. 8.

As each section of the basic map is completed by the field worker, it should be turned in to the office so that the survey notes can be checked against the real property record stated use. If discrepancies are found, they can be explained by the field worker while the area is still fresh in his mind or checked again in the field. This also has the effect of updating the real property records with additional or changed information.

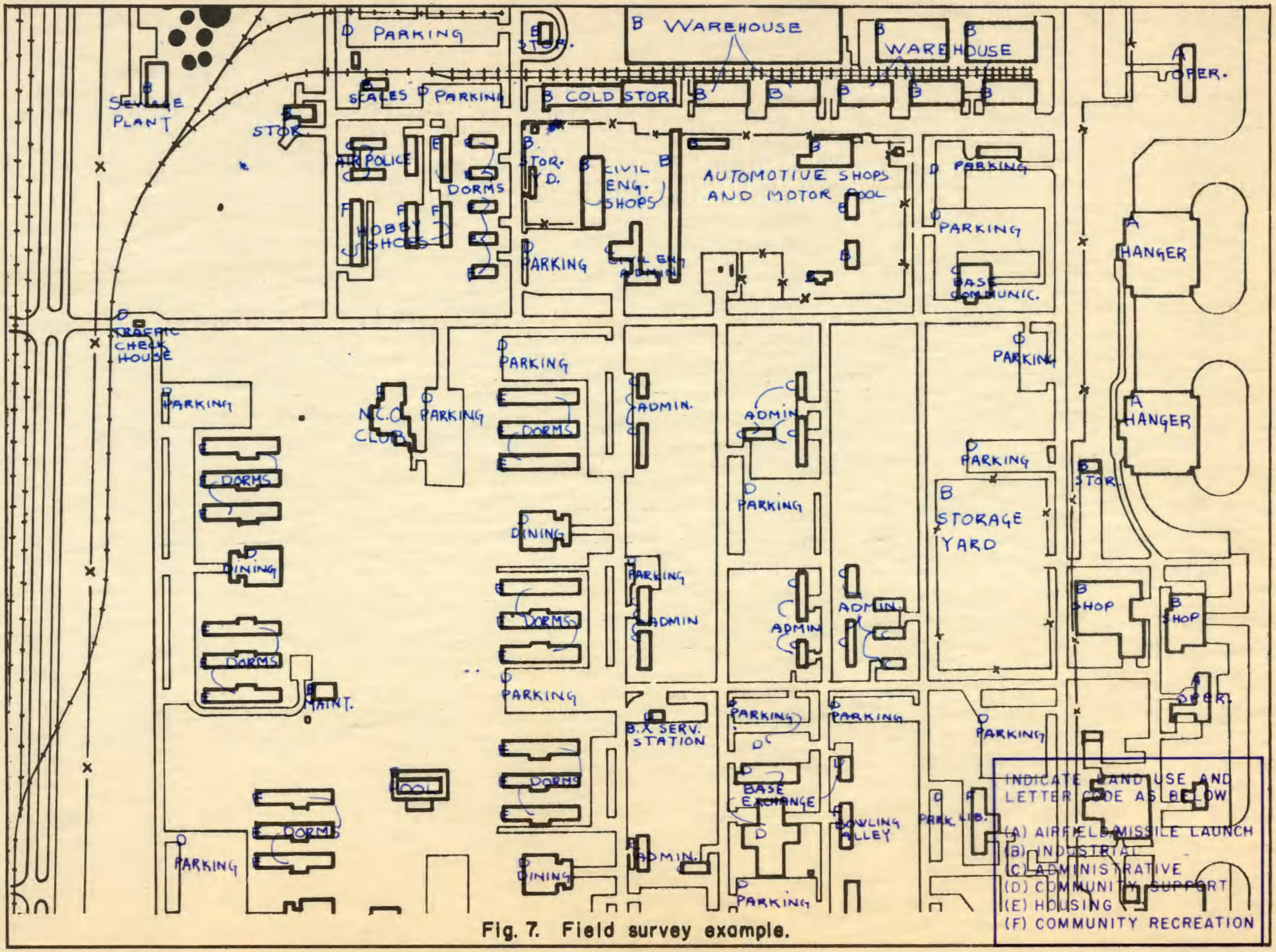
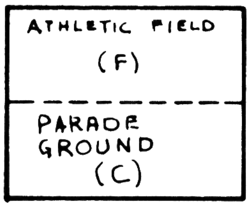
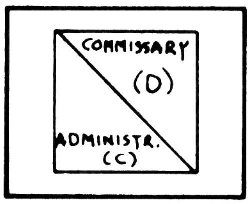


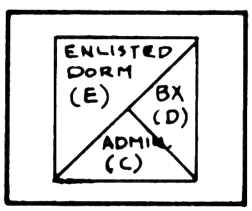
Fig. 7. Field survey example.



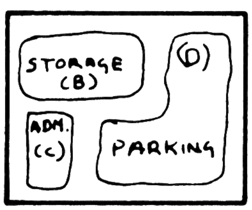
WHERE DISTINCT USES DIVIDE A SMALL AREA, SHOW EACH USE SEPARATELY.



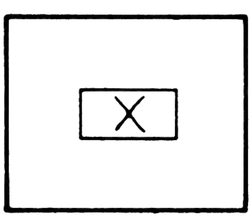
WHERE A BUILDING IS OCCUPIED BY TWO DIFFERENT USES, ONE ON EACH FLOOR, SPLIT THE AREA DIAGIONALLY SHOWING THE GROUND FLOOR USE AT THE FRONT OF THE AREA AND THE SECOND FLOOR USE AT THE BACK.



WHERE A DIFFERENT USE IS FOUND ON EACH OR SEVERAL FLOORS OF A BUILDING WITH THREE OR MORE STORIES, USE THREE DIAGIONAL LINES WITH THE FIRST FLOOR USE NEAREST THE FRONT, THE SECOND FLOOR USE NEXT NEAREST AND THE PREDOMINENT USE ABOVE THE SECOND FLOOR SHOWN AT THE BACK.



WHERE A LARGE AREA HAS SEVERAL USES, DIVIDE IT INTO AREAS DEVOTED TO EACH USE.



VACANT AREAS OR BUILDINGS ARE SHOWN WITH AN "X" THROUGH THEM.

Fig. 8. Methods of indicating mixed land uses.

Preparing the Final Map Tab C-2. Once the field work has been completed, the preparation of a final, large-scale map for study and reference purposes and inclusion in the base master plan may begin. Methods of reproducing small-scale maps for use of interested persons, such as the Facilities Utilization Board, should also be considered. For large bases a sectional atlas for reference purposes of the base civil engineer may be desired.

The large-scale color display map will also be needed for presentation purposes at Facility Utilization Board meetings, staff meetings, and for briefings for higher headquarters visiting and inspection teams. The scale of this map will be determined by the size of the base, but scales such as fifty feet, one hundred feet, or two hundred feet to the inch should be considered.

The final wall map is usually prepared in color, using the colors prescribed in the proposed classification system. Color numbers refer to Prismacolor numbers, made by the Eagle Pencil Company or Zip-A-Tone color sheets as manufactured by Para-Tone, Inc. Reproduction of maps in color is a costly process; therefore, black and white reproductions may be more practical. Satisfactory maps can be prepared by using the black and white classification chart column. Zip-A-Tone pattern sheet numbers are specified as a guide in the preparation of this type of map.

In preparing both the large-scale color map and the black and white reproductions, always include the following items on the map:

1. Title.
2. Legend, explaining what each color or black and white symbol represents. (Adopt the classification system itself but leave out uses not found on the base.)
3. Scale of map.
4. North point.
5. Name of base and organization preparing map.
6. Date of land use information.

CHAPTER IV

LAND USE STANDARDS

The planner developing a military base must organize the functional relationships of the community on established land use standards. In the case of a new base, these standards can be applied during the initial development of the master plan. In the case of changes or additions to an existing base, they can be applied only after the results are known from the previously described land use analysis procedure.

Location Requirements

Location requirements take the form of basic statements used as guiding principles for placing various uses on the land. They involve a whole range of physical, economic, and social considerations. They are concerned with the location relationship of every individual land use to every other use and includes necessary supporting items such as utilities, services, and circulation facilities. They relate to health, safety, convenience, economy, and the general level and method of urban living.

The three major areas of an urban complex can be defined as work areas, living areas, and leisure-time areas. Classifying the recommended six classifications of land use into these three areas indicates that the major work areas of an Air Force base are airfield/missile launch land use, industrial land use and administrative land use. The living areas involve community support land use and housing land use. Leisure time areas include community recreation land use areas.

Work Areas--Airfield Land Use, Industrial Land Use, Administrative Land Use

Work areas should be located near living areas with adequate circulation routes to insure easy access between. Separation should be given airfield land use however. Interrelated work areas, such as airfield aprons and aircraft supporting shops, should be in convenient proximity. Some work areas should have access to heavy transportation facilities and large capacity utility lines. Work areas should meet the following location standards:

1. Reasonably level land, preferably with five percent slope maximum and capable of being graded without undue expense.

2. Direct access to heavy transportation facilities such as railroads, truck roads, or if appropriate, port areas.
3. Within easy commuting distance of residential areas and accessible to major circulation routes.
4. Adequate utilities such as power, water, and disposal facilities with capacity to permit expansion.

Living Areas--Community Support Land Use and Housing Land Use

Living areas should be located on reasonably level land for facilities involving structures, accessory parking, and related facilities. Shopping and service facilities should be within convenient driving range of housing and adjacent to major circulation routes. Schools and churches should be on reasonably level sites within easy walking distance of housing areas and located with due consideration for safety of children.

Leisure Time Areas--Community Recreation Land Use

Leisure time areas are of two classes: indoor and outdoor. Indoor facilities should be on reasonably level land and located adjacent to housing areas. Outdoor recreation, such as spectator sports, also should be so located. Parks and golf courses can be located in fringe areas.

Location Standards

Location standards used in planning should not be minimum standards but should be desirable standards, a quality somewhere between minimum and optimum. The three factors to consider in location are: (1) convenience, (2) performance and (3) security. The writer has researched many documents in an attempt to gather relevant standards in these three areas. Below are those which are applicable to military base planning.

Convenience Standards. Convenience standards involve standards of location based on use, time, and distance criteria. Relative terms to which they refer are close proximity, convenient driving range, easy walking distance, and accessibility to railroad, transit or utilities.

1. Shopping Facilities--Within one half mile or ten minutes of family housing.
2. Elementary Schools--Within one half mile of family housing served.
3. High School--Within one mile or twenty minutes of family housing served.
4. Playgrounds--Within one half mile of family housing served.
5. Recreation Centers--Within one mile or twenty minutes of family housing served.
6. Bachelor Officer Quarters--Within eight hundred feet of dining facilities.

7. Family Housing Distances--Forty-five hundred feet minimum from airfield land use. One thousand feet minimum from arms firing ranges. Two hundred feet minimum from administrative, community support, and community recreation land use. Fourteen hundred feet minimum from industrial land use.

<u>Performance Standards.</u> Performance standards involve standards of location based on health, safety, and the amenity elements of the public interest. Involved are land use activities creating smoke, dust, noise, glare, odor, and activities generating traffic or producing wastes. Examples of control methods are: building codes, electrical codes, plumbing codes, fire codes, subdivision regulations and industrial performance standards. Performance standards are as yet imperfectly developed. Those general rules applicable to Air Force bases are presented below:

1. Aircraft Pavements--Three thousand feet from occupied nonrelated direct support facilities. Forty-five hundred feet from housing, schools, and churches. Eight thousand feet from hospitals and infirmaries.
2. Missile Firing Facilities--Facilities other than direct support or facilities in downrange areas must be twenty thousand feet minimum from missile launch area. (Flight safety only, no noise control or toxic fuel considerations.)

3. Aircraft Pavements--Land clearances required in the area of airfield pavements are indicated in Air Force Manual 86-7, "Air Force Zoning."
4. Fire Safety Clearances--These are prescribed in Corps of Engineers Manual Part XI, "Fire Prevention."
5. Ammunition Explosive Safety Distances--These are prescribed in Air Force Regulation 86-6.
6. Nuclear Safety Distances--These are prescribed in Air Force Letter 136-5.

Security Standards. Security standards are generally based on public safety or national well-being. On a large-scale the 1951 national industrial dispersion program is an excellent example. On the small-scale of a military base these standards concern primarily the placement of facilities that require security control. Below are typical examples:

1. Industry of adjacent urban centers should be located away from military bases.
2. Communications facilities, prime power sources, weapons and ammunition storage areas, classified facilities and other key security areas should be semi-isolated with appropriate security fencing and control points.
3. Present Air Force criteria require that:
   a. New bases be located a minimum of fifteen miles from the outskirts of large population centers (twenty-five thousand population) with a

lateral distance of at least four miles from the runway center line extended ten miles beyond the base.

b. Approaches must be free of habitation for seven miles from the end of the runway by four miles wide.

c. The new base must be twenty miles from all other military or civil airports.

d. The new base must be forty miles from other airports if it is along the extended center line of the instrument runway.

e. The new base must be at least ten miles from major civil airways.

f. The new base must be expandable by at least ten thousand acres.

Land Area Requirements

The change from location requirements to land area requirements involves a change in concept from <u>where</u> some land use function should be placed to one of how much land will be needed to accommodate it. This includes future anticipated growth. An Air Force base does not grow in the sense that a civilian community grows. The base population is closely controlled by the assigned mission. Growth or expansion considerations are not as critical, but provision for them must be made in the overall development plan.

A list of functions to be accommodated must be available to determine how much land is needed. Of equal importance is an estimate of population. With these two factors available an estimate of the physical plant and area requirements can be made. Density standards are employed as a guide in computing area requirements. This approach is demonstrated in the case study, Appendix F.

The writer has attempted to research density standards as applicable to Air Force facility requirements and presents them for use in estimating land requirements as follows:

1. Airfield Missile Launch Land Use--For relationship with other airfield facilities in the area see comments under "Security Standards," page 45. Aircraft Maintenance Facilities--Thirty to fifty workers per gross acre. Open Space Ratio--One (building) to four (open space).
2. Industrial Land Use--Density Class Intensive--Fifty workers per gross acre. Density Class Intermediate--Eighteen workers per gross acre. Density Class Extensive--Six workers per gross acre. Two to fifteen square feet floor area per base capita. Open Space Ratio--One (building) to four (open space).
3. Administrative Land Use--Two to fifteen square feet floor area per base capita. Open Space Ratio--One (building) to six (open space).
4. Community Support Land Use--See Table 3, page 49.

5. Housing Land Use--Family Housing Density--Minimum suggested is four and one half family units per gross usable acre. On a net acreage basis, the suggested minimum density criteria are as follows:

   a. Single Units--Four per net acre (1/10,880 sq. ft.)
   b. Duplex Units--Six per net acre (1/7,250 sq. ft.)
   c. Row Units--Eight per net acre (1/5,400 sq.ft.)

      Net acreage is usable land exclusive of roads, streets, sidewalks, utility easements and community facilities. Maximum density should be ten families per net acre. Minimum lot size should be ten thousand square feet.

   d. Bachelor Housing Density--Seventy to one hundred population per net acre.
   e. Open Space Ratio--One (building) to ten (open space).

6. Community Recreation--See Table 4.

Table 3. Community support land use area requirements.

SHOPPING FACILITIES

- RECOMMENDED OPEN SPACE RATIO — 1 (BUILDING) / 5 (OPEN SPACE)

- BASE POPULATION	ACRES/100 POPULATION
1,000	0.9
2,500	1.0
5,000	1.5
10,000	2.0
20,000	3.0
30,000	5.5

DATA BASED ON A PARKING RATIO OF THREE SQUARE FEET OF PARKING FOR ONE SQUARE FOOT OF BUILDING FLOOR AREA.

SCHOOL FACILITIES

TYPE OF SCHOOL	ENROLLMENT RANGE	MINIMUM ACRES	DESIRABLE ACRES	PREFERRED RANGE-ACRE	RADIUS OF AREA SERVED
ELEMENTARY	300-800	5	5+1/100 PUPIL	10-25	0.5 MILES
JUNIOR HIGH	1,000-1,500	10	15+1/100 "	25-50	1.0 "
SENIOR HIGH	1,500-2,500	20	25+1/100 "	40-100	2.0 "

THE ABOVE SUGGESTED STANDARDS CAN BE USED TO ESTIMATE TOTAL REQUIREMENTS OR TO CHECK EXISTING FACILITIES FOR ADEQUACY

Table 4. Community recreation land use area requirements.

FACILITY OR AREA	POPULATION STANDARD	SITE SIZE STANDARD
CHILDRENS PLAY AREA (WITH EQUIPMENT)	0.5 ACRES/1,000 POPULATION	1.0 ACRE
PLAYGROUND	1.0 ACRE / 800 "	3-6 ACRES
PLAYFIELD	1.0 ACRE / 800 "	10-30 ACRES
LOCAL PARK	1.0 ACRE / 1,000 "	2+ ACRES
ATHLETIC PARK	1.5 ACRES / 1,000 "	15 ACRES

TO COMPUTE ESTIMATED RECREATIONAL AREA REQUIREMENTS BY FACILITY OR AREA TYPE, USE POPULATION TOTAL WITH POPULATION STANDARD INDICATED. RESULTING FIGURE IS TOTAL ACREAGE RECOMMENDED FOR THAT TYPE OF RECREATIONAL FACILITY. THE TOTAL ACREAGE IS THEN DIVIDED INTO UNITS USING THE SUGGESTED SITE SIZE STANDARD. THE RESULTING NUMBER OF UNITS INDICATES THE RECOMMENDED RECREATIONAL FACILITIES WHICH ARE THEN SUITABLY PLACED DURING THE DEVELOPMENT OF THE MASTER PLAN. THIS METHOD MAY ALSO BE USED TO DETERMINE IF EXISTING COMMUNITY RECREATION FACILITIES ARE ADEQUATE OR IF ADDITIONAL FACILITIES SHOULD BE PLANNED AND INCLUDED IN AN IMPROVEMENT PROGRAM

CHAPTER V

LAUNCH FACILITIES LAND USE

The facilities to support space missions are numerous, complex, and expensive. Each launch complex is custom designed for a particular mission and there is no definitive design that is equally applicable to all. There are, however, certain basic elements that are common to all in various design configurations. In addition there are many auxiliary or supporting facilities that can be of benefit to several different launch complexes. Since the individual facilities themselves are normally custom designed for a particular mission and missile, an understanding of their scope and relationships can best be obtained by a close look at some existing facilities and their functions.

Basic Requirements

Listed below are the basic requirements for facilities at a typical launch complex.

At Pad. The major facility at the pad or launch site is the service gantry. The main purpose of the facility is to provide a means of access to the entire missile while it is in a vertical position to accomplish checkout of the missile immediately prior to firing and possibly for passenger boarding. Other facilities at the launch site include the main deck, the flame deflector, the umbilical tower and the supporting system for holding the missile. A major item is the blockhouse containing all controls for fueling operations by remote control and television monitor. Also contained in the blast protected structure are computers, tracking devices, communications facilities and other monitoring controls.

Near Pad. The major facility in this category is the fuel storage facility for liquid fuels.

Primary Support Area. Many important facilities fall in this category including reentry vehicle checkout buildings for the assembly and testing of the payload, missile assembly buildings where the missile is assembled and tested before transfer to the launching pad and related maintenance shops, machine shops and administration facilities.

Downrange. Downrange facilities include data gathering facilities, communications facilities, monitoring and control facilities, data computing and data analysis facilities.

Existing Examples

There are four major space launch complexes constructed in recent years or currently under construction. Study of the layout plans and relationship of facilities will indicate to the planner trends in launch complexes and items to be considered in the planning of future facilities. These four complexes are as follows: (1) Titan III Launch Facilities, (2) Saturn Complex 34, (3) Saturn Complex 37, and (4) Saturn Complex 39.

Titan III Launch Facilities. The Air Force plans to launch seventeen Titan III vehicles during a forty-five month flight test program period beginning in 1965. Facilities at Cape Kennedy are presently being prepared for this program and are known as the Titan III ITL Complex. The ITL Complex is designed to permit the assembly of a launch vehicle and its payload, integrated with ground support equipment, and checkout of the total system, all within a controlled factory environmental outlet prior to transfer of the vehicle to the launch site; hence ITL, Integrate-Transfer-Launch.

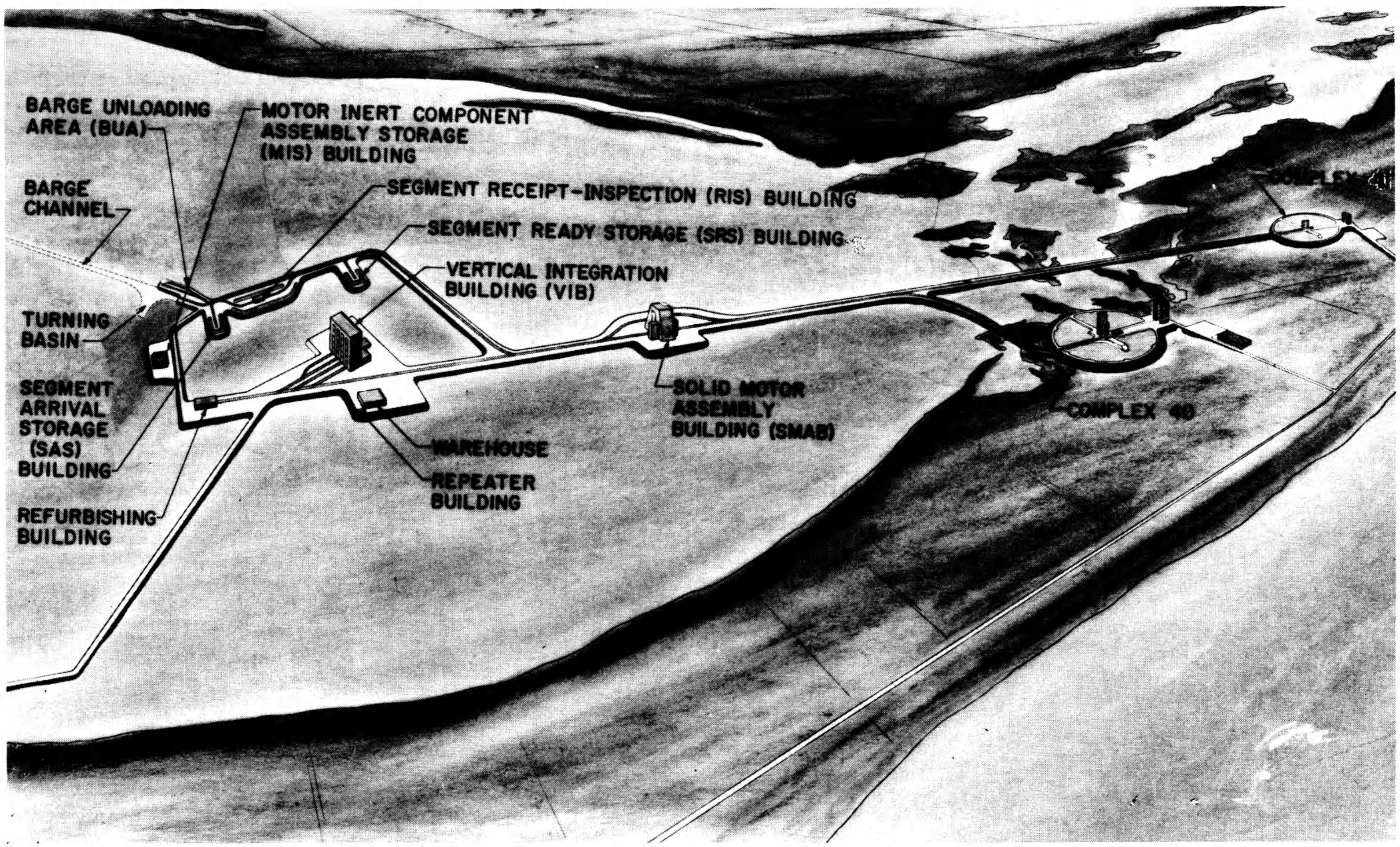
The facility consists of four man-made and interconnected islands in the Banana River as follows: (1) Titan assembly and system launch control area, (2) solid propellant motor assembly and integration area, (3) receiving, inspection and maintenance area, and (4) liquid propellant storage area.

After delivery of vehicle components by barge, the vehicle will be assembled vertically on a rail mounted launch platform. It will be supported by the umbilical tower. Associated ground equipment (AGE) for support and checkout is housed in boxcars hooked to the platform. When ready for launch, diesel engines move the platform, its Titan III unfueled core, and the AGE boxcars through the solid motor assembly building to one of two launch facilities. (See Appendix D for missile description.) Launch facilities are a minimum of eight thousand one hundred feet from the solid motor assembly building and include a service gantry for last minute checkout and entry of passengers. Plate I indicates facilities layout.

EXPLANATION OF PLATE I

The Titan III launch facilities at Cape Kennedy, Florida. Missile parts arrive by truck while the large sections of the missile itself are delivered by barge.

PLATE I


BARGE UNLOADING AREA (BUA)
MOTOR INERT COMPONENT ASSEMBLY STORAGE (MIS) BUILDING
BARGE CHANNEL
SEGMENT RECEIPT-INSPECTION (RIS) BUILDING
SEGMENT READY STORAGE (SRS) BUILDING
VERTICAL INTEGRATION BUILDING (VIB)
TURNING BASIN
SEGMENT ARRIVAL STORAGE (SAS) BUILDING
SOLID MOTOR ASSEMBLY BUILDING (SMAB)
COMPLEX 40
WAREHOUSE
REPEATER BUILDING
REFURBISHING BUILDING

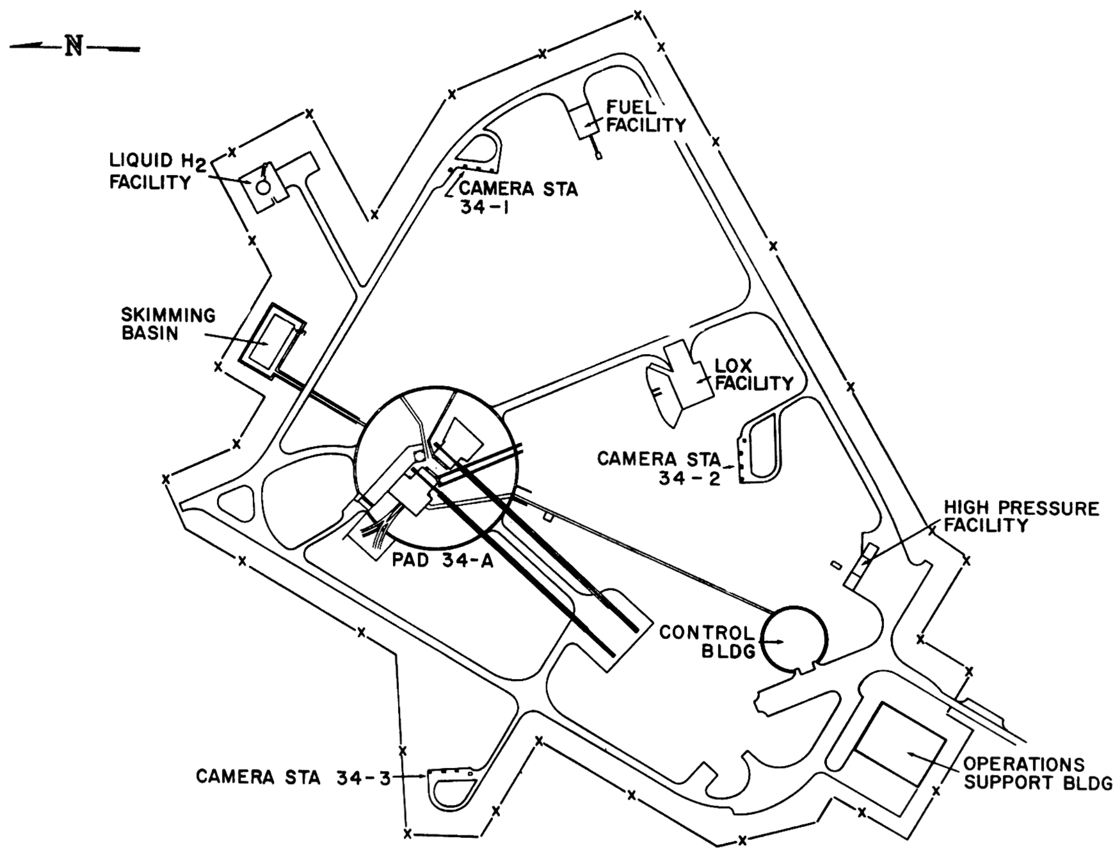
Saturn Complex 34. Saturn Launch Complex 34 is the first test facility for a series of large rocket test flights leading to Project Apollo. The complex consists of forty-five acres of land, a service gantry, a blockhouse, fuel and LOX storage facilities, a launch pad and an automatic ground control station. The Saturn I vehicle to be launched from this complex will be a two-stage or three-stage rocket. (See Appendix D for missile description.) Plate II gives the principal features which are as follows: (1) Launch control center, (2) service gantry, (3) launch pad, pedestal and flame deflectors, (4) umbilical tower--for electrical and pneumatic lines, (5) fuel facilities--RP-1 and liquid oxygen, (6) high pressure gas facility--eleven hundred feet from launch pad, (7) skimming basin--to separate water and spilled fuel, and (8) operations support building.

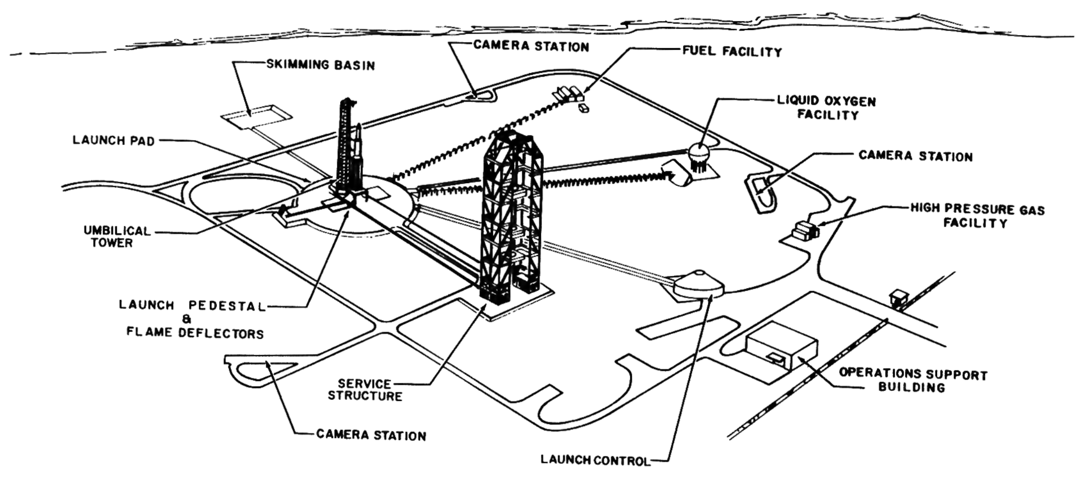
Saturn Complex 37. This complex requires one hundred twenty acres and contains two launch pads. Both pads have individual automatic ground stations, launch pedestals, and umbilical towers. Structures common to both launch pads include a launch control center, operations support building, propellant storage and transfer facilities, and a mobile, self-propelled service gantry which is the largest movable structure in the world. Plate III indicates the facilities relationships.

EXPLANATION OF PLATE II

Relationship of launch facilities at Complex 34, Cape Kennedy, Florida. This complex has only one launch pad; therefore, considerable recovery time is required between launches.

PLATE II



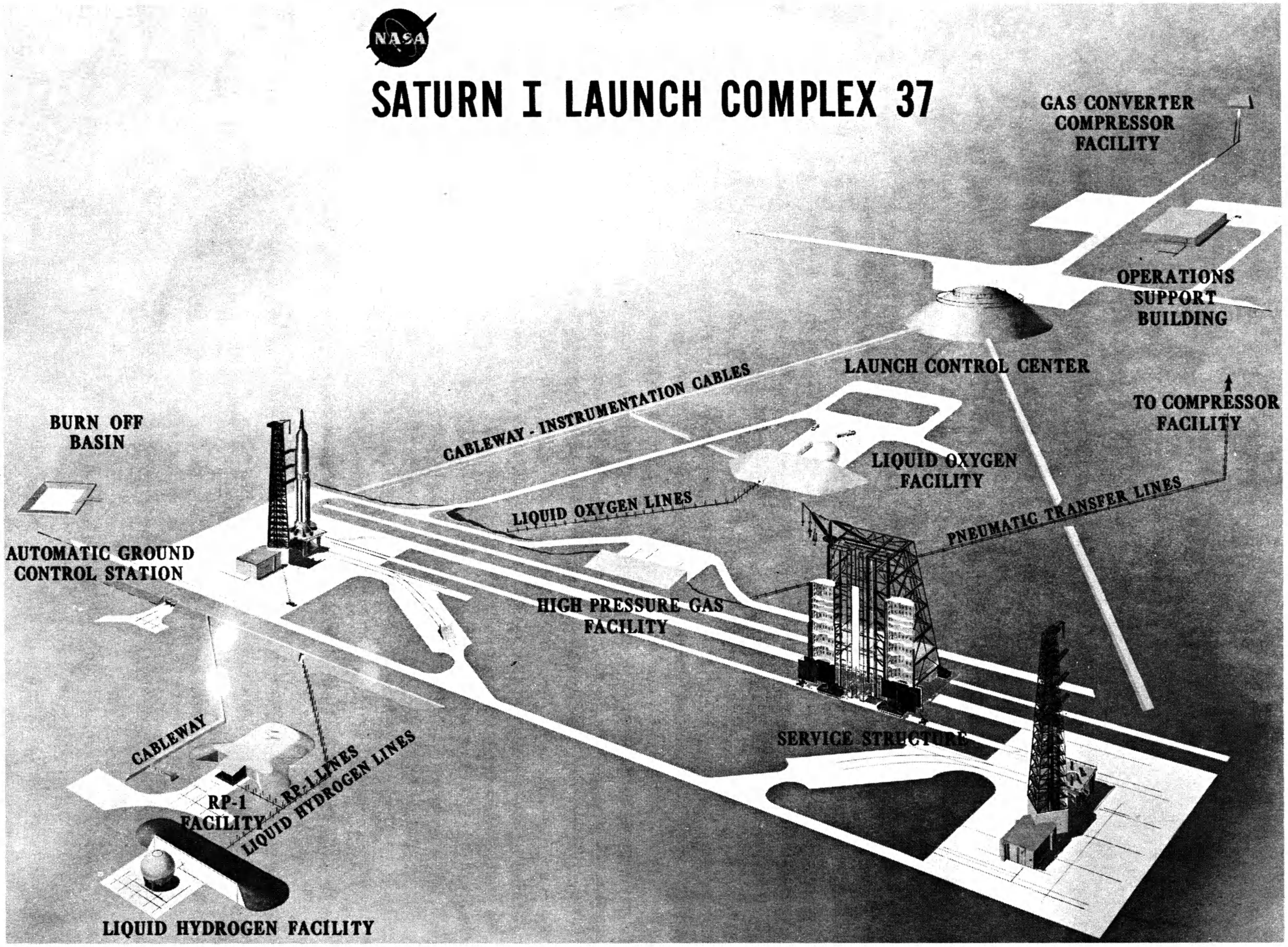


LAUNCH COMPLEX 34

EXPLANATION OF PLATE III

Relationship of launch facilities at Complex 37, Cape Kennedy, Florida. With two launch pads available, less time is required between launches thus increasing facility efficiency. Short-use facilities such as the launch control center and fuel facilities are shared by both launch pads.

PLATE III



NASA
SATURN I LAUNCH COMPLEX 37
GAS CONVERTER COMPRESSOR FACILITY
OPERATIONS SUPPORT BUILDING
LAUNCH CONTROL CENTER
TO COMPRESSOR FACILITY
CABLEWAY - INSTRUMENTATION CABLES
BURN OFF BASIN
LIQUID OXYGEN FACILITY
LIQUID OXYGEN LINES
PNEUMATIC TRANSFER LINES
AUTOMATIC GROUND CONTROL STATION
HIGH PRESSURE GAS FACILITY
CABLEWAY
SERVICE STRUCTURE
RP-1 LINES
LIQUID HYDROGEN LINES
RP-1 FACILITY
LIQUID HYDROGEN FACILITY

<u>Saturn Complex 39.</u> The operation principle of Saturn Complex 39 is different from that of Complex 34 and Complex 37. In the latter two facilities, space missiles were assembled and checked out in the launch area requiring considerable time between firings. Complex 37 does improve this time lag somewhat by having two launch stands served by one service gantry and mutual supporting facilities. With the development of later space programs, the requirement for rapid firing of missiles became apparent. A typical case would be a series of ferry vehicles for parts of a space station under construction which would have to arrive at the construction site (a given point in space) within days of each other. Therefore, Saturn Complex 39, like the Titan III complex, operates on the principle of missile assembly and checkout being accomplished in a central location and the missile moved to the firing site in a vertical position with little time being required at the actual point of launch.

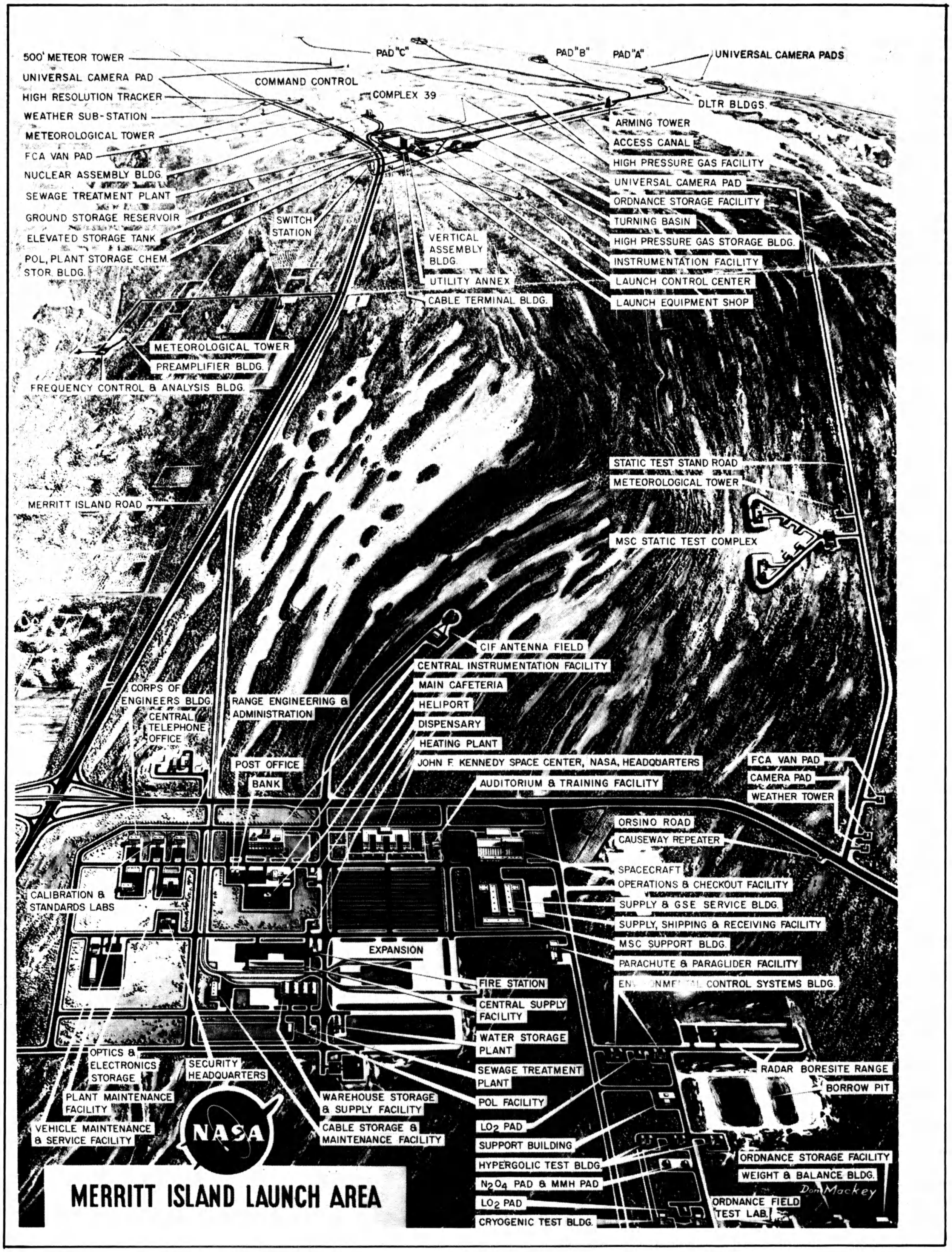
Complex 39 is by far the largest development to this date. Included with the launch and preparation area is a sizable support area. The total complex is known as the Merritt Island Launch Area and is shown in Plate IV. Major elements in the missile area are as follows:

1. A vertical assembly building (VAB) with bays to assemble and check out six Saturn V missiles at one time. (See Appendix D for missile description.) This will be the worlds largest building and will enclose

EXPLANATION OF PLATE IV

Facilities at Cape Kennedy, Florida, known as the Merritt Island Launch Area. In addition to support facilities shown in the foreground, the area includes Complex 39, the launch area for Saturn V missiles.

PLATE IV


500' METEOR TOWER
UNIVERSAL CAMERA PAD
HIGH RESOLUTION TRACKER
WEATHER SUB-STATION
METEOROLOGICAL TOWER
FCA VAN PAD
NUCLEAR ASSEMBLY BLDG.
SEWAGE TREATMENT PLANT
GROUND STORAGE RESERVOIR
ELEVATED STORAGE TANK
POL, PLANT STORAGE CHEM. STOR. BLDG.
PAD "C"
COMMAND CONTROL
COMPLEX 39
PAD "B"
PAD "A"
UNIVERSAL CAMERA PADS
DLTR BLDGS.
ARMING TOWER
ACCESS CANAL
HIGH PRESSURE GAS FACILITY
UNIVERSAL CAMERA PAD
ORDNANCE STORAGE FACILITY
TURNING BASIN
HIGH PRESSURE GAS STORAGE BLDG.
INSTRUMENTATION FACILITY
LAUNCH CONTROL CENTER
LAUNCH EQUIPMENT SHOP
SWITCH STATION
VERTICAL ASSEMBLY BLDG.
UTILITY ANNEX
CABLE TERMINAL BLDG.
METEOROLOGICAL TOWER
PREAMPLIFIER BLDG.
FREQUENCY CONTROL & ANALYSIS BLDG.
STATIC TEST STAND ROAD
METEOROLOGICAL TOWER
MSC STATIC TEST COMPLEX
MERRITT ISLAND ROAD
CIF ANTENNA FIELD
CENTRAL INSTRUMENTATION FACILITY
MAIN CAFETERIA
HELIPORT
DISPENSARY
HEATING PLANT
JOHN F. KENNEDY SPACE CENTER, NASA, HEADQUARTERS
AUDITORIUM & TRAINING FACILITY
CORPS OF ENGINEERS BLDG.
RANGE ENGINEERING & ADMINISTRATION
CENTRAL TELEPHONE OFFICE
POST OFFICE
BANK
FCA VAN PAD
CAMERA PAD
WEATHER TOWER
ORSINO ROAD
CAUSEWAY REPEATER
SPACECRAFT OPERATIONS & CHECKOUT FACILITY
SUPPLY & GSE SERVICE BLDG.
SUPPLY, SHIPPING & RECEIVING FACILITY
MSC SUPPORT BLDG.
PARACHUTE & PARAGLIDER FACILITY
ENVIRONMENTAL CONTROL SYSTEMS BLDG.
CALIBRATION & STANDARDS LABS
EXPANSION
FIRE STATION
CENTRAL SUPPLY FACILITY
WATER STORAGE PLANT
SEWAGE TREATMENT PLANT
POL FACILITY
LO2 PAD
SUPPORT BUILDING
HYPERGOLIC TEST BLDG.
N2O4 PAD & MMH PAD
LO2 PAD
CRYOGENIC TEST BLDG.
RADAR BORESITE RANGE
BORROW PIT
ORDNANCE STORAGE FACILITY
WEIGHT & BALANCE BLDG.
ORDNANCE FIELD TEST LAB.
OPTICS & ELECTRONICS STORAGE
SECURITY HEADQUARTERS
PLANT MAINTENANCE FACILITY
VEHICLE MAINTENANCE & SERVICE FACILITY
WAREHOUSE STORAGE & SUPPLY FACILITY
CABLE STORAGE & MAINTENANCE FACILITY
NASA
MERRITT ISLAND LAUNCH AREA
Don Mackey

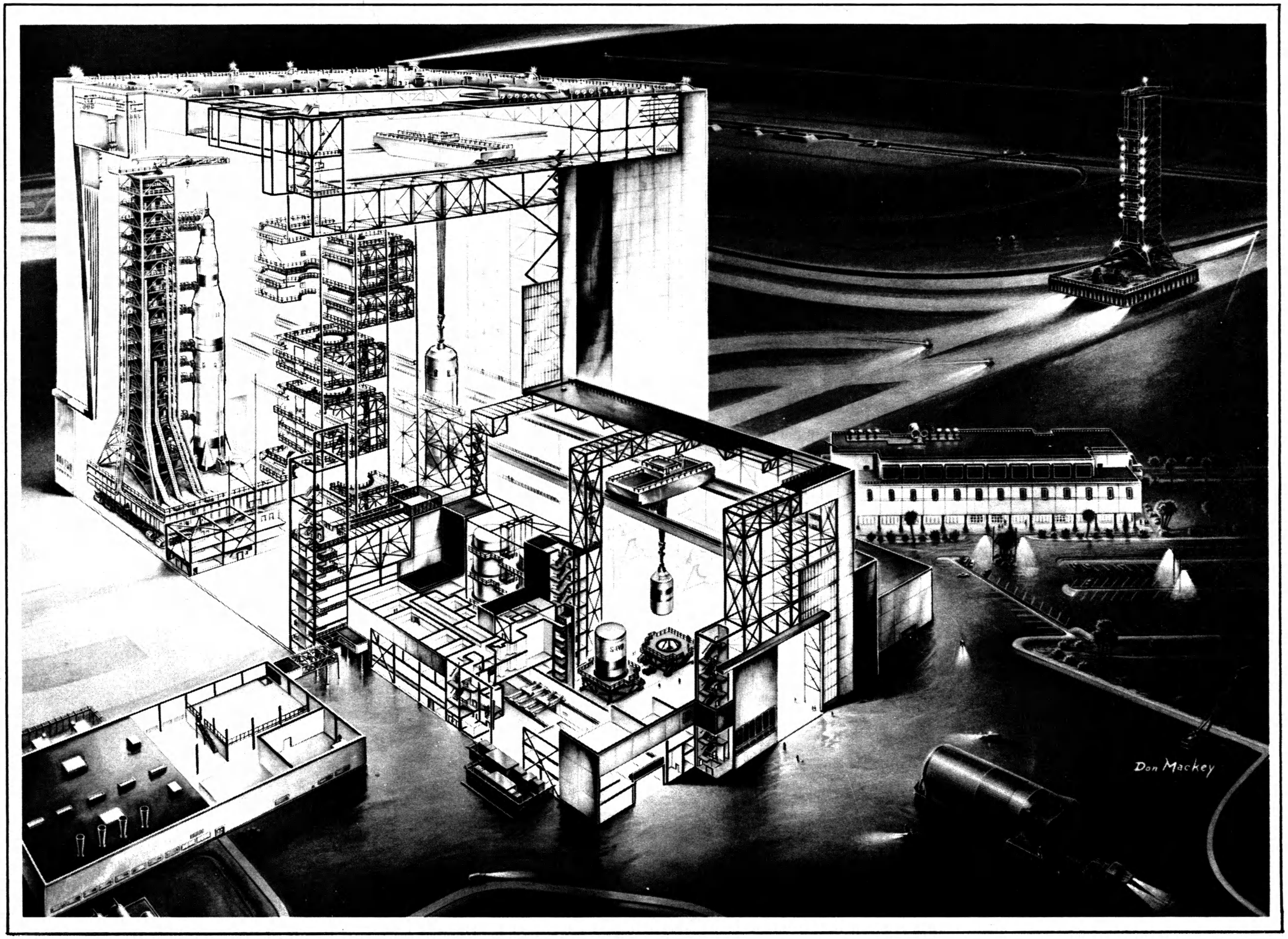
one hundred twenty-eight cubic feet of space. Plate V pictures this facility.

2. Four launch pads, each separated from the rest by a minimum of nine thousand feet. Each pad includes a flame deflector, a launch platform approached by an inclined ramp and a propellant and pressurized-gas loading system. All pads are a minimum of sixteen thousand feet from the vertical assembly building.
3. An arming tower located along the main roadway from which explosive charges necessary for flight can be attached to the vehicle after it leaves the assembly building.
4. Four crawler transporters move the prepared Saturn V missiles to the launch pads. The missile, assembled on its own launcher umbilical tower (LUT) platform, will be moved in an upright position to the launch pad three and one half miles away. Plate VI indicates this activity. It is comparable to moving a forty-five story building.

EXPLANATION OF PLATE V

An exposed view of the Saturn V vertical assembly building. This building provides a controlled environment for assembly of the three sections of the Saturn V in a vertical position.

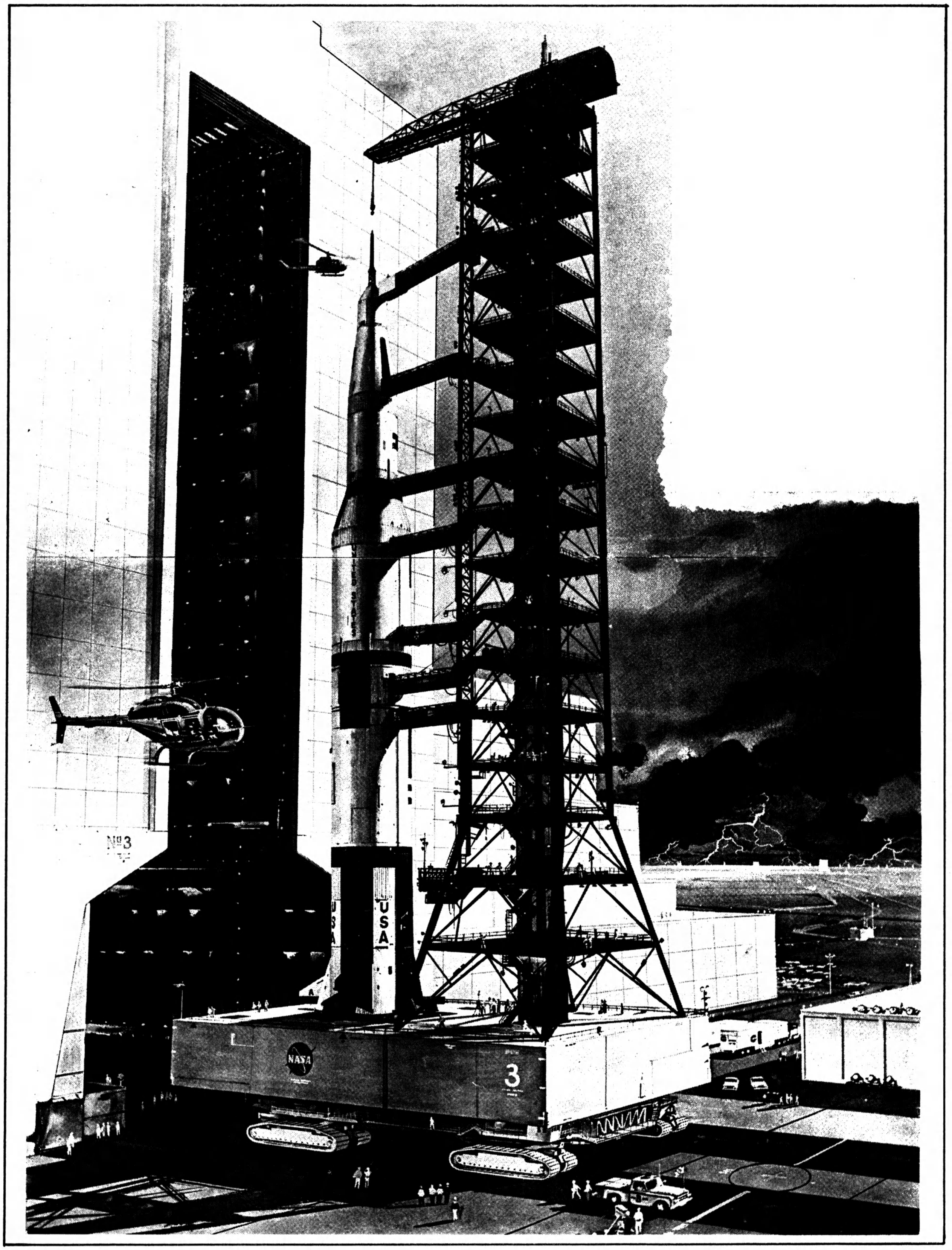
PLATE V



EXPLANATION OF PLATE VI

The transportation vehicle for moving the assembled Saturn V from the vertical assembly building to a launch area in Complex 39. Total transported load will be some three thousand tons. The platform supporting the Saturn V and its supporting tower is one hundred thirty feet by one hundred fifteen feet and is moved by electrical motors receiving their power from diesel driven generators located in the platform.

PLATE VI



CHAPTER VI

COMMUNITY CENTER LAND USE

The community center on a military base is a neighborhood shopping center and central business district combined. Immediately adjacent are usually located the major administrative facilities and bachelor housing. Family housing normally surrounds the community center on at least two sides.

The facilities are used by all personnel. Therefore, the basic need of the shopper is for a conveniently accessible, amply stocked, shopping center with plentiful parking. Civilian shopping centers are normally classed in one of three different classes: (1) the neighborhood center for a population of seventy-five hundred to twenty thousand, (2) the community center for a population of twenty thousand to one hundred thousand, or (3) the regional center for a population of one hundred thousand to two hundred fifty thousand. The military shopping/community center normally is classed in the category of the neighborhood center. Larger military bases may approach the community center class.

Many different facilities should be located in the military shopping/community center. Consolidation of the facilities listed in Table 5 will allow excellent utilization of facilities, and parking. The consolidated center is obviously more convenient and timesaving to users.

Table 5. Military shopping/community center facilities.

MERCHANDISING

EXCHANGE SALES STORE	EXCHANGE CONCESSIONS*
COMMISSARY STORE	CLOTHING SALES STORE
EXCHANGE SERVICE STATION	PARTY SHOP

SERVICES

CHAPEL	CHAPEL ANNEX
BANK*	POST OFFICE
LAUNDRY CONCESSION*	DRY CLEANING CONCESSION*
BARBER SHOP*	BEAUTY SHOP*
RED CRCSS OFFICE	PERSONAL AFFAIRS
TELEPHONE-TELEGRAPH CENTER	YOUTH ACTIVITY CENTER
INFORMATION CENTER	EDUCATION CENTER
NURSERY	BUS SHELTER
EXCHANGE MAINTENANCE SHOP	EXCHANGE RETAIL WAREHOUSE
COLD STORAGE	EXCHANGE CAFETERIA
PUBLIC RESTAURANT*	DISPENSARY
DENTAL CLINIC	FLORIST*
SHOE REPAIR*	OPTICAL SHOP*
PHOTO STUDIO*	TRAVEL AGENCY*
TAILOR*	

RECREATIONAL

THEATER	SERVICE CLUB
LIBRARY	BOWLING ALLEY
RECREATION HOBBY WORKSHOP	GYMNASIUM
FIELDHOUSE	SWIMMING POOL

*

NOTES SERVICE CONCESSIONS INCLUDED UNDER THE GENERAL HEADING OF MERCHANDISING (EXCHANGE CONCESSIONS).

Site Criteria

In selecting a site for a military shopping/community center close consideration to those factors used in civilian shopping center site selection is of benefit. These are:[1]

1. The site must be located in the general area established as most desirable by the economic survey.
2. It must be owned or controlled by the developer, or its acquisition must be feasible.
3. The cost of the land must be in keeping with overall economic considerations.
4. Existing zoning must permit usage of the site for shopping center purposes, or there must be a reasonable likelihood that rezoning can be achieved.
5. There must be enough land to allow construction of facilities that will meet the sales potential.
6. The shape of the site must be such that advantageous planning is feasible.
7. The land must be in one piece, free of intervening roadways, rights-of-way, easements, or major waterways, et cetera, that would force development in separated portions.
8. Physical characteristics of the land must permit advantageous planning and resonably economical construction.

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[1] Victor Gruen and Larry Smith, Shopping towns USA, p. 38.

9. The surrounding road pattern and the accessibility of the land must allow the full utilization of the business potential of the projected center.
10. The possibility of achieving visibility of the shopping center structure from major thoroughfares must be present.
11. Surrounding land uses should be compatible with the operation, free of competitive developments; and should, if possible, offer contributing and enhancing characteristics.

Of the eleven points listed above, all but points one through four are applicable to military shopping/community centers. Of major importance is the centralization of the facilities in relation to bachelor and family housing as demonstrated in Fig. 2. Inasmuch as military shopping/community centers are normally in the upper level of the neighborhood class or the lower level of the community class and they, in effect, have a captive clientele in the fact that they have no other competition on the military base, the distance of one half mile or ten minutes travel time is suggested for the relationship of the facilities to family housing. It should be immediately adjacent to bachelor housing.

Site Planning

Of major importance in site planning is the consideration of the road network and vehicular circulation from the various land use areas of the base to the shopping/community center.

In analysis of the site the following additional factors must be considered:

1. Topography--Minimum slope adequate for surface drainage.
2. Soil Conditions--Soil must have adequate bearing capacity.
3. Natural Features--A site that has natural features such as existing tree growth is desired and these features should be maintained.
4. Utilities--The availability of adequate existing utilities is mandatory.
5. Expansion--The final selection must have available open land for future expansion.

In determining site requirements, the planner must know the population to be served, the facilities to be included, and the size of the various facilities. With this information, the total size requirement of the site can be estimated using the standards suggested in Chapter IV. After selection of the site the planner then allocates portions of the site to seven specific usages. These are:

1. Structures (See Table 5).
    a. Merchandising.
    b. Services.
    c. Recreational.
2. Car Storage--Both shopper and employee.
3. Pedestrian Areas--To and between facilities and parking.
4. Automobile Movement Areas--Cars and delivery vehicles.
5. Public Transportation Areas--Bus stops, taxi stands.

6. Buffer Areas--Between parking and shopping facilities.
7. Reserve Areas--For future expansion.

In allocating this space the planner should use the following principles:

1. Safeguard surrounding areas against undesirable vistas, mixed land use, and traffic congestion.
2. Expose merchandising facilities to maximum foot traffic.
3. Separate various merchandized traffic types from each other and from pedestrian traffic.
4. Create a maximum of comfort and convenience for shoppers and merchants.
5. Achieve orderliness, unity, and beauty.

Layout of Facilities

Figure 9 demonstrates the four basic types of layout which are as follows:

1. Strip Type. The strip type center is a line arrangement of buildings set back from a road to allow off-street parking in front, and possibly at rear and ends. This type is only considered suitable for very small bases with a minimum of facilities. The appearance and atmosphere created are not that of a community center.
2. Court Type. The court type center may be an open arrangement somewhat similar to the strip arrangement; a building group arranged to form a completely enclosed court, or a U-shaped form. A relatively large

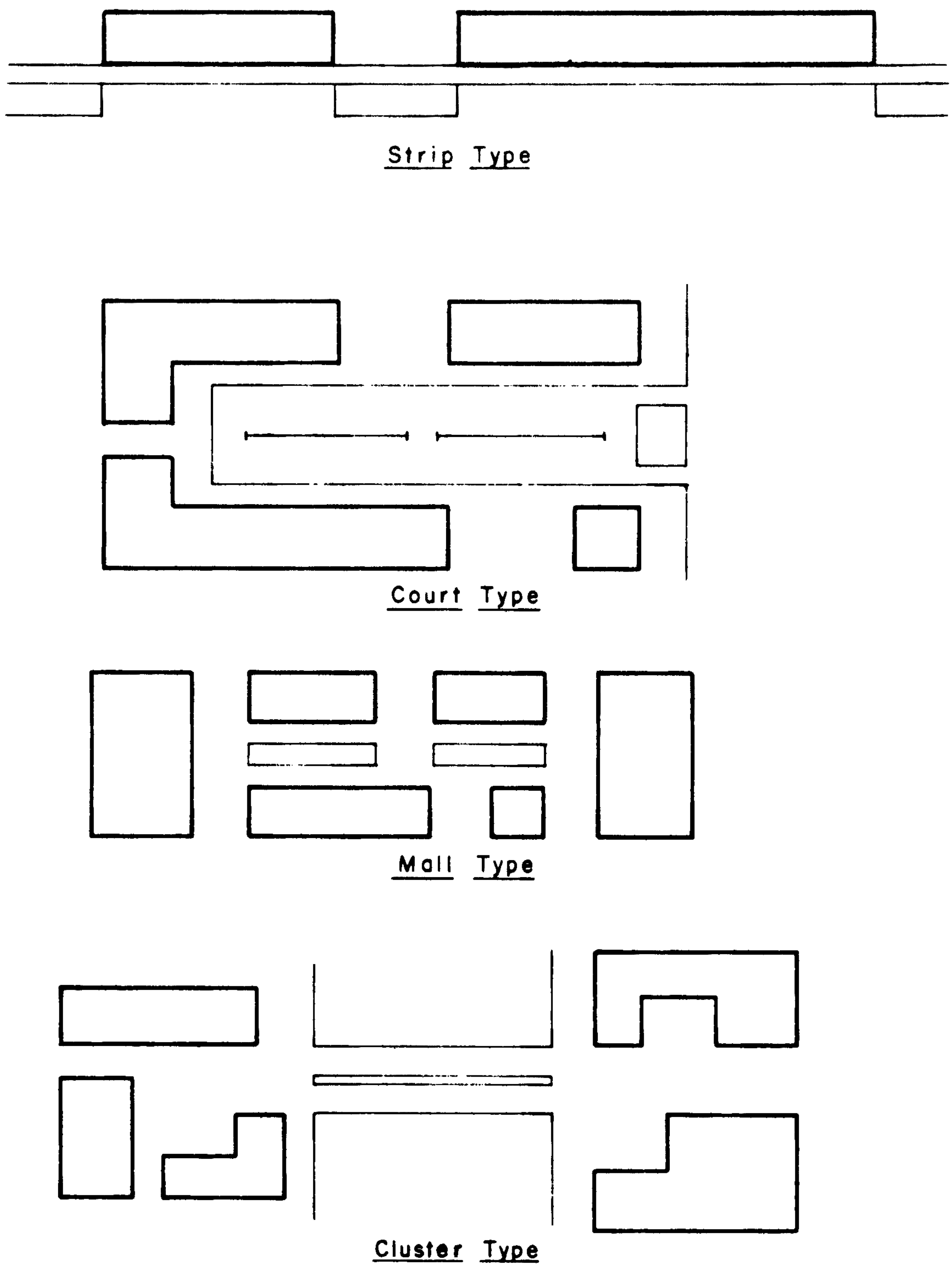


Fig. 9. Four basic types of shopping center layout.

area in the center may be used for parking. This type of arrangement is considered suitable for small or moderate sized centers.

3. Mall Type. The mall type layout, composed of two strips with building fronts facing each other across an open enlongated pedestrian area, is considered suitable for large centers. Parking surrounds the building group.

4. Cluster Type. The cluster type center is generally used for very large centers in order to secure compactness and adequate close-in parking.

The most important primary attractions in the military shopping/community center are the commissary and the base exchange. They should, therefore, receive the most important considerations in siting. For instance in the mall type layout, they could be placed at opposite ends of the mall. The other secondary attractions such as the bank, post office, cafeteria, et cetera, can be placed along the main axis in the mall type layout. Close vehicular access to the commissary for loading groceries is mandatory.

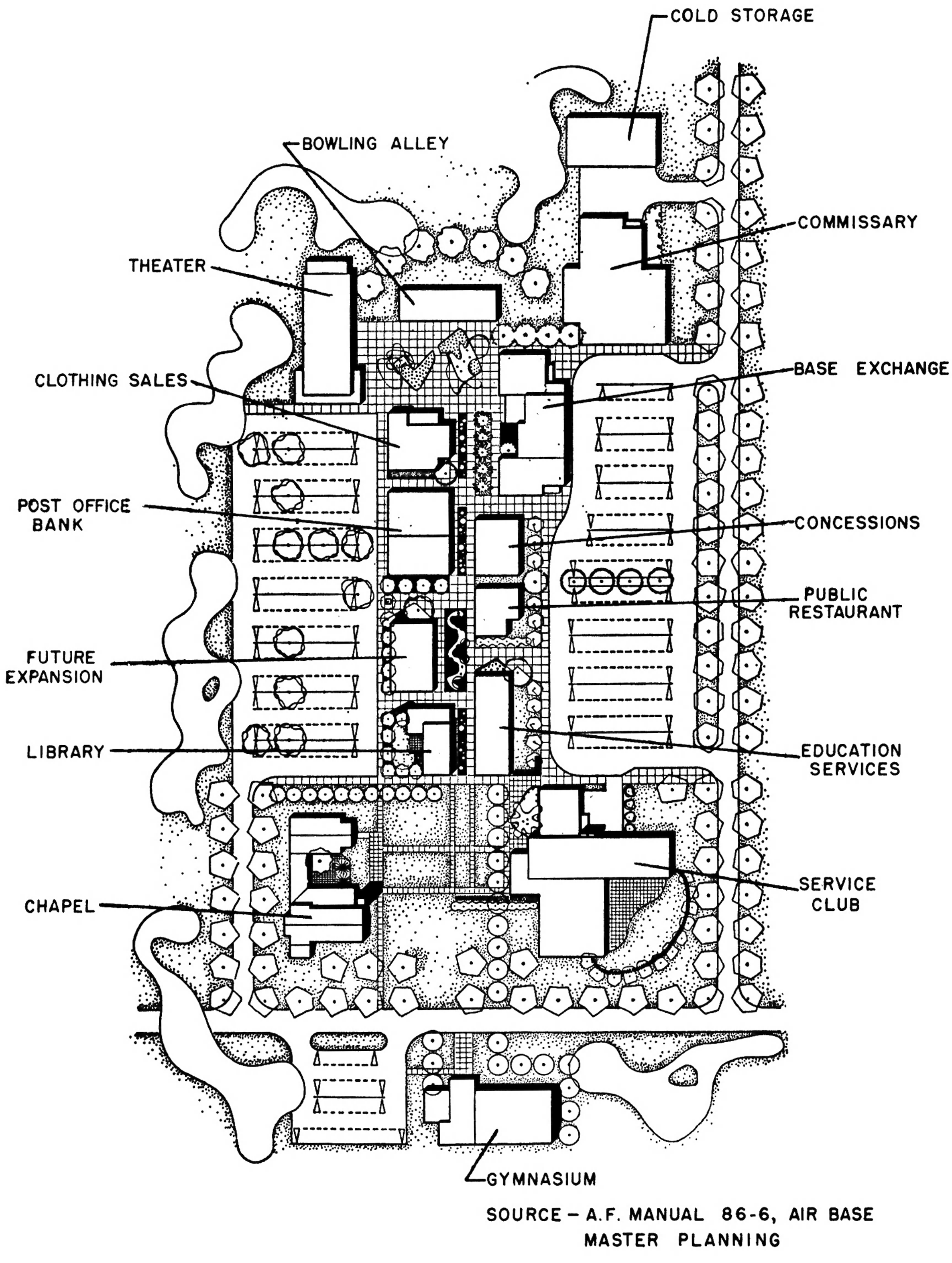
The gasoline service station should be located beside the principal road entrance to the center parking facilities, yet removed from the major traffic pattern. Recreational facilities may be located in other adjacent clusters with appropriate consideration given to their relationships. Proper relationships between the parking areas and the facilities used during the day, as opposed to those used principally at night, will decrease the requirement for parking spaces. The chapel should have an appropriate predominate setting and should be so located that the parking areas of the other community center elements may be used for chapel activities. Figure 10 is a suggested arrangement for a shopping/community center on a military base of three to five thousand military personnel.

CHAPTER VII

HOUSING LAND USE

The subject of housing on a military base involves two primary types which are family housing and bachelor housing. Family housing is separated into two classes: officer housing and enlisted housing. Each class has many types of dwellings ranging from single family units to duplex and row family units. Recent consideration has been given to multiple story apartment dwellings to combat the high cost of construction.

Bachelor housing involves officer housing in Bachelor Officer Quarters (BQQ),both male and female, and troop housing in dormitories. Bachelor officer housing ranges from individual rooms in large buildings to a family concept of a single unit housing three or four officers with a complete kitchen, living-dining facilities and private bedrooms. Troop housing is usually in a multiple story building with two to three men per room and joint bath-shower facilities.



SOURCE – A.F. MANUAL 86-6, AIR BASE MASTER PLANNING

Fig. 10. Suggested shopping center/community center arrangement.

Neighborhood Concept

The neighborhood concept, long proposed for civilian communities is just as applicable to military communities. The neighborhood unit is defined by Arthur B. Gallion as:[1]

> ... Simply a physical environment in which a mother knows that her child will have no traffic streets to cross on his way to school, a school which is within easy walking distance from home. It is an environment in which the housewife may have an easy walk to a shopping center where she may obtain the daily household goods, and the man of the house may find convenient transportation to and from his work. It is an environment in which a well-equipped playground is located near the home where the children may play in safety with their friends; the parents may not care to maintain intimate friendship with their neighbors, but children are so inclined and they need the facilities of recreation for the healthy development of their minds and spirit.

The key contents of this definition are applicable to the military community. The neighborhood of family housing dwellings should contain no heavy traffic streets, a school, close access to shopping facilities, recreation, religious facilities and some sort of public transportation system. Keeping these requirements in mind and using the standards for space requirements contained in Chapter IV, the planner can develop an orderly, acceptable neighborhood.

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[1]Arthur B. Gallion and Simon Eisner, The urban pattern, p.251.

Estimating Requirements

The determination of housing requirements is based on data obtained from an annual housing survey conducted by the Deputy Assistant Secretary of Defense (Family Housing). The information developed from the annual housing survey has, over the past few years, become the major source for basic data in support of all housing programs, not only for new construction, but to support pay and allowance legislation, to show the disparity between rental rates and basic allowance for quarters (BAQ), to support operation and maintenance (O&M) legislative requests, and to give the overall housing picture to the review and approval agencies. From the information gathered, housing requirements, both bachelor and family, can be estimated. As an example, the survey revealed that more than eight-four percent of the officers are married while fifty-five and nine tenths percent of the enlisted personnel are married. Table 6 indicates the relative figures resulting from the survey. These figures plus the unit manning document giving the authorized manning of the military base will allow the city planner to compute all housing requirements.

Table 6. Selected data on military population composition.

Grade	28 Feb. 1963 Strength	Number who have dependents	Number of dependents	Dependents per officer/airman	Dependents per officer/airman who have dependents	Percent married
0-6 COLONEL	4,841	4,796	17,146	3.5	3.6	98.2
0-5 LT COLONEL	15,082	14,621	50,895	3.4	3.5	95.4
0-4 MAJOR	25,723	24,880	95,946	3.7	3.9	94.8
0-3 CAPTAIN	52,042	47,472	158,410	3.0	3.3	89.1
0-2 1 ST LT	19,485	12,536	28,250	1.4	2.3	63.5
0-1 2 ND LT.	13,405	6,260	10,831	0.8	1.7	47.5
W/O	3,230	3,169	10,774	3.3	3.4	96.3
TOTAL	133,808	113,734	372,252	2.8	3.3	84.3
E-7, 8, 9 M/SGT	48,426	45,932	152,105	3.1	3.3	93.0
E-6 T/SGT.	67,520	63,213	217,371	3.2	3.4	90.6
E-5 S/SGT.	149,414	133,657	421,772	2.8	3.2	86.3
E-4 AIRMAN 1 ST.	165,569	113,518	296,043	1.8	2.6	66.2
E-3 AIRMAN 2 ND.	171,260	53,970	91,783	0.5	1.7	29.6
E-2 AIRMAN 3 RD.	107,786	10,806	26,256	0.2	2.4	13.0
E-1 AIRMAN BASIC	24,619	2,142	2,928	0.1	1.3	6.3
AVIATION CADET	332					
TOTAL	734,926	423,238	1,208,258	1.6	2.9	55.9

SOURCE - DIRECTOR OF MILITARY PERSONNEL, HQ. U.S.A.F.

Site Criteria

When selecting a site for military family housing the following factors are of paramount importance:

1. Location and accessibility in relation to shopping centers, medical facilities, children's schools, entertainment, religious, and recreational areas.
2. The size and shape of the site must be adequate for the number of units anticipated, the necessary and related supporting facilities, and future expansion. The shape of the site should be compact to minimize costs for roads, utilities, and other related construction.
3. The site should have good natural surface drainage. Moderately sloping sites under eight percent grade are the best. Preservation of natural features (trees and ground forms) is mandatory.
4. Consideration must be given to soil and foundation conditions.

Site Planning

The site planning of bachelor housing areas consists of the basic standards discussed in Chapter IV plus consideration of the relationships of dining facilities to dormitory facilities. These relationships are demonstrated in Fig. 11.

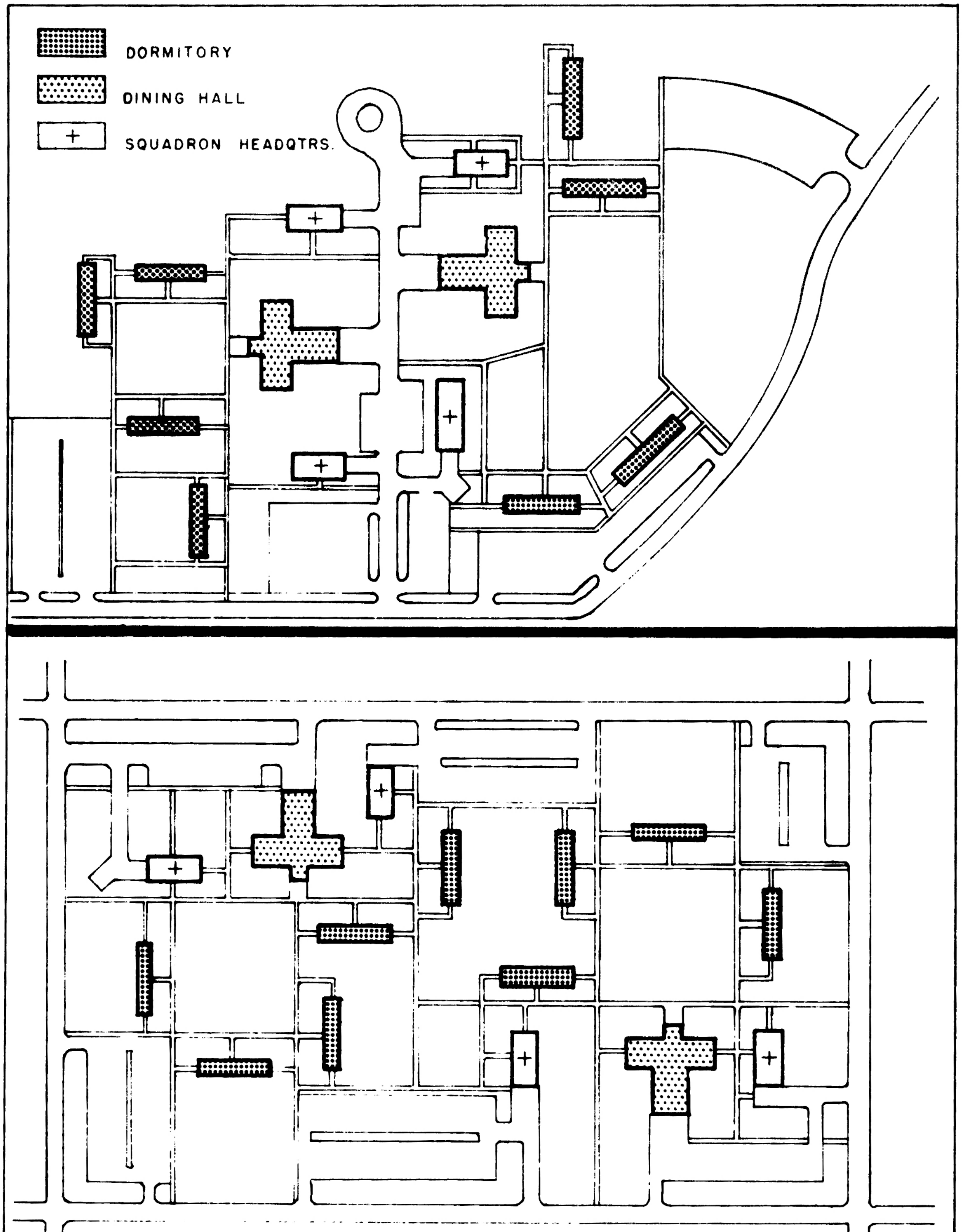

Fig. 11. Relationship of dining facilities and dormitory facilities.

Site planning of family housing areas is much more involved. After the planner has determined the quantity of units required by type and has selected a site, the next logical step is the development of street and lot patterns.

A good street and lot pattern must take into consideration both land cost and development cost. Military housing has an advantage over civilian housing by the fact that lot lines to determine extent of legal ownership are not required. This should not preclude the planner from creating an atmosphere of home ownership by suggesting the extent of lots. In order to establish the minimum lot requirements the building setback and spacing criteria indicated in Fig. 12 are suggested as the minimum criteria.

Military family housing is also an excellent opportunity for development of "cluster" housing.[1] This concept is one of several units sharing certain common facilities such as entrance drives, utility stubs and extra parking. Figure 13 illustrates the difference between standard layout and cluster layout. Cluster housing for military family housing areas offers these advantages:

1. No garage doors (or carports) face directly to the street.
2. Guest parking is on private cul-de-sac driveways. If street parking were prohibited, the streets could be

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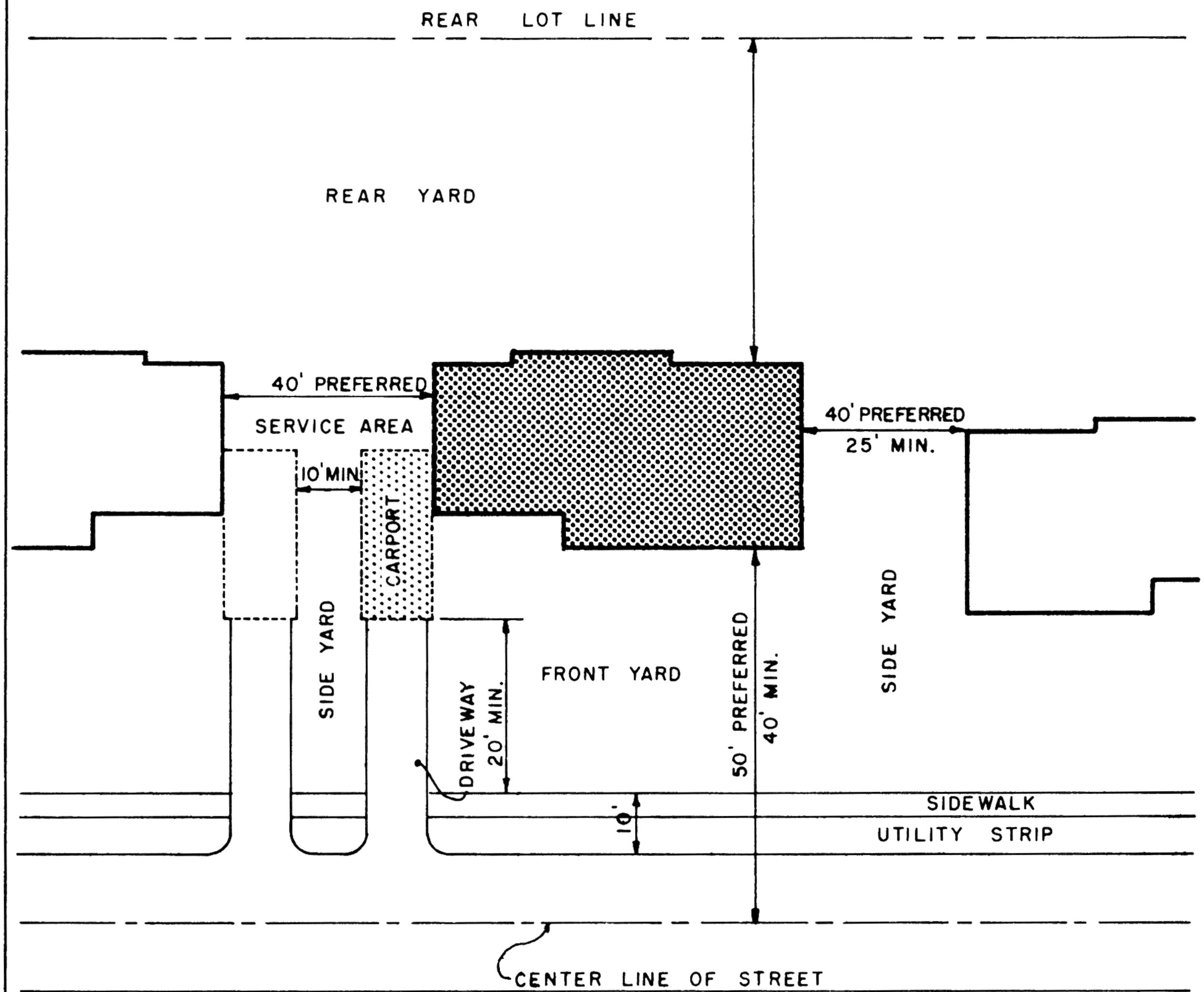
[1]A. Quincy Jones and Frederick E. Emmons, Builders' homes for better living, p. 34.



SETBACKS AND SPACINGS ARE MEASURED FROM THE MAIN HOUSE MASSES.
MINIMUM SETBACKS AND SPACINGS MAY BE USED TO REDUCE UTILITY OR OTHER COSTS, TO MEET DENSITY CRITERIA, OR BECAUSE OF DIFFICULT TERRAIN.

Fig. 12. Suggested building setback & spacing criteria for family housing.

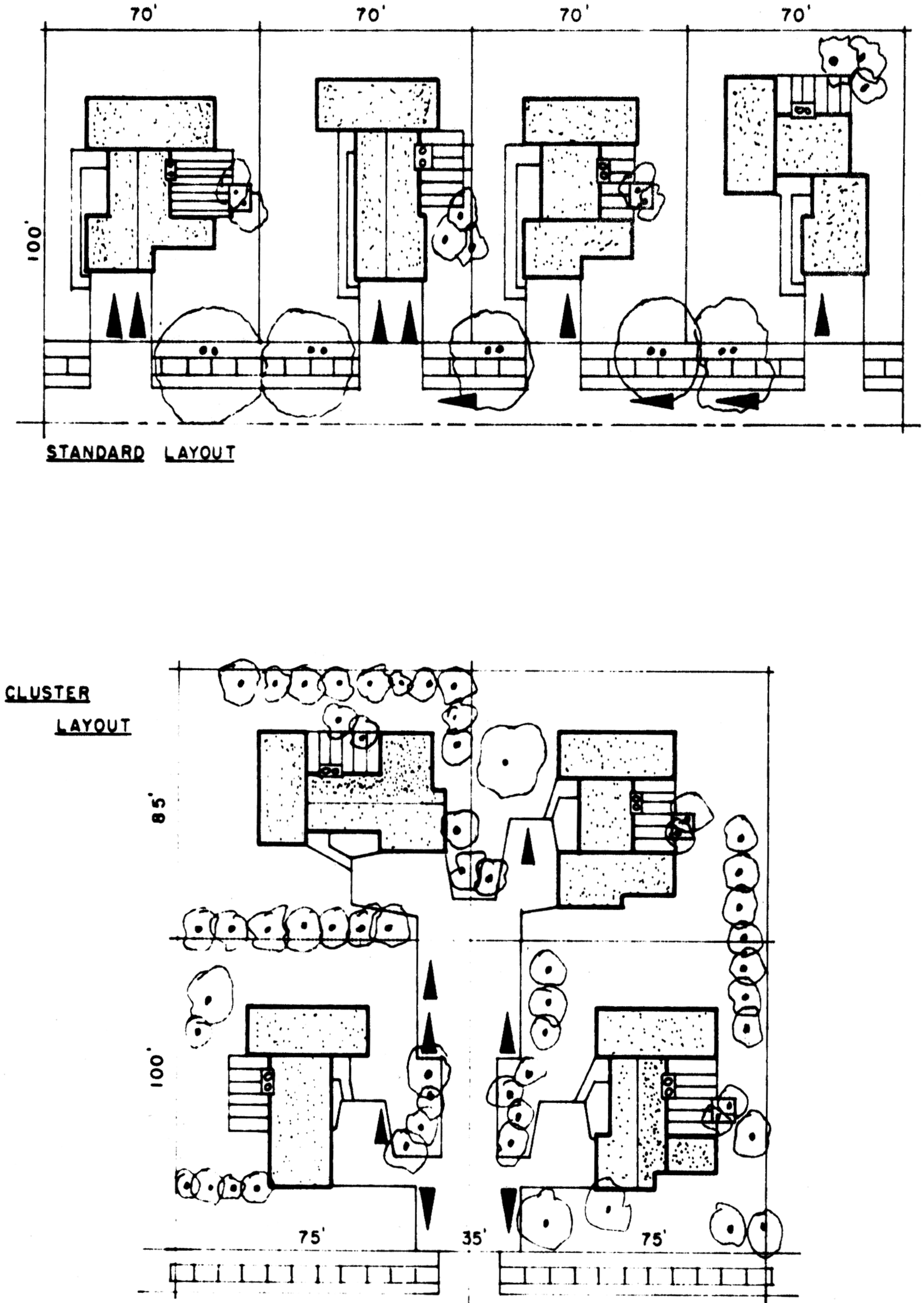


Fig. 13. Cluster housing concept.

twenty-five percent narrower, and thus provide an additional saving in development costs.

3. Each house faces a cul-de-sac road, eliminating the dangers of children at play and pedestrians on a through street serving the house.
4. Visually, the houses appear to have a greater separation than when placed on the conventional row type lot.
5. The finished lot shapes permit easier and more imaginative house design and landscaping plans.

CHAPTER VIII

TRANSPORTATION LAND USE

Nearly all Air Force bases are near metropolitan centers and thus draw a sizable number of employees from the population of that city. In view of this fact transportation planning divides itself into several distinct missions. The first mission is the movement of people and goods to and from the base over public transportation facilities either by highway or rail. An integral part of this problem of movement is the matter of terminals at the base.

The second major mission of transportation is to provide for circulation within the base. As in cities, problems of circulation within the base are closely related to problems of land use. Therefore, while transportation within an Air Force base is vital to the operation of it, transportation is not an objective within itself. Transportation is important only as it assists in accomplishing the objectives of the base; transportation, therefore, should be planned to assist and support the operational needs of the base. Whereas in certain civilian situations it may be proper for a highway to proceed on a direct line through a community without regard for the effects on local land use, for an Air Force base land use and operating requirements are of first priority and the transportation system must be built around the framework of operational requirements.

The third mission for transportation is the conservation of military personnel and government property. One source of waste of both manpower and property is traffic accidents. Therefore, the planning of transportation facilities must include maximum consideration to a type of efficiency that will produce a maximum reduction in traffic accidents.

The responsibility of the city planner is to understand the transportation requirements of the community, either civilian or military, and to develop a circulation system that will permit the accomplishment of these three major missions. The traffic engineer assists in providing traffic handling equipment and technical advice. In Air Force activities, the base civil engineer has the responsibilities of both the city planner and the traffic engineer.

Base Design Considerations

There are six important elements of design that the city planner must consider in planning the traffic pattern for a military base. These are:[1]

1. Relate the base to the highway development of the region.
2. Determine the type and quantity of transportation the base employees need.
3. Design access facilities to the base, including public highway entrances and security gates.
4. Analyze traffic generating properties of the internal functional grouping of base facilities.
5. Design the internal road network, establishing classification of systems, pattern, cross sections, and traffic control.
6. Determine location and capacity of parking facilities, and relate them to the road net.

Each of these six elements will be discussed in the following paragraphs.

<u>Relationship of Base to Regional Development</u>. Every military base is a major generator of traffic. Since most bases are located within the sphere of influence of an urban area,

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[1]Air Force Manual 86-6, Air base master planning, p. 128.

major traffic volumes will require handling between the base and its neighboring community. The most desirable highway pattern is one which gives the base quick access to the maximum number of highways via routes that avoid congested areas. Further, maximum highway frontage is an asset. It gives the base opportunity to create major entrances and exits and provides possible location of entrances in various directions of approach.

<u>Employee Transportation Requirements.</u> The determination of employee transportation requirements is mainly the result of data collection. The following points should be investigated:

1. Number and type of personnel employed on the base. This factor is the key issue. The three major types are officers, enlisted personnel, and civilians. Their place of residence, either on-base or off-base is highly important. From this data, trends in street use, origin-destination and volumes of traffic can be determined.
2. Maximum base strength is important and when this figure is reached; it is also a key point. Shift strengths must be known in order to determine probable time and size of peak traffic loads.
3. Location of the base with respect to urban areas in the region will reveal probable routing of access roads as well as potential loading of traffic facilities of the region.

4. Proximity and concentration of off-base housing for employees is also important. Few military bases provide on-base housing for civilian employees. If adequate housing for military personnel is available on the base, the civilian employees become the major off-base traffic load. Location of access roads enabling civilian employees easy access to civilian housing is desirable.
5. Dependence on public transportation for carrying employees between home and work should be determined; however, this factor is of minor importance. Surveys conducted by the writer on several Air Force bases indicate that from ninety-seven to ninety-eight percent of all travel to and from the bases surveyed was by private vehicle. However, consideration should be given to available public transportation between adjacent civilian urban centers and the military base.
6. Vehicle ownership by employees is a major point and indicates potential traffic and parking loads. Surveys conducted by the writer on several Air Force bases indicate that the average vehicle to population ratio is 1.07/1. Most bases will have 1.07 vehicles registered on the base for every assigned military and civilian employee. Table 7 indicates the breakdown of this figure which is an empirical design value.

Table 7. Ratio of vehicles to assigned population.

Owner	Number Assigned	Number of Vehicles	Vehicle/Strength Ratio
Officer	1,029	1,659	1.6/1.0
Enlisted	5,024	4,422	1.0/0.88
Civilian	426	852	2.0/1.0*
	6, 479	6,933	1.07/1.0

*The high civilian vehicle ratio is explained by the fact that the number of vehicles registered includes commercial delivery trucks and service vehicles that are registered to permit daily or frequent entry to the base without continual registration as a visitor. The actual civilian employee registration ratio is similar to that of the enlisted personnel.

Source

The above data are averages obtained from Air Police vehicle registration records from three widely separated Air Force bases.

7. The extent to which ride sharing is practiced will influence traffic loads. Ride sharing among officer personnel is infrequent. Enlisted personnel show some increase in sharing activities. Civilian employees and military personnel living off the base employ the most ride sharing. All totaled, such activity is minor. In a survey conducted at several Air Force bases the average occupancy per car was 1.9 persons. Fifty-five percent of the vehicles entering the bases contained only the driver.
8. Dependence on other modes of transportation than motor vehicles for the movement of goods also influences traffic loads. This factor is related to availability of rail, water, and air transport for goods. The extent of its availability will affect the volume of commercial truck traffic to the base.

Access Design. The approach route and access control point are the first indicators of base character to persons. They should satisfy the visual requirements of a pleasing entry vista and also be satisfying in the functional requirement of making the base clearly accessible. Access design can allow base approach in many ways. The approach can be minimized by alignment of the road, screening, or creating a visual portal. On the other hand, a clear route with its own character of design aids in orientation of the stranger to the base. The capacity of the access is clearly important. The design load maximum will appear when the duty hours of the base are beginning and ending. Commercial vehicle traffic will occur during these duty hours and will normally be of a lesser amount. Therefore, the design load is mainly dependent upon base employee strength, on-base housing available, and hours of duty.

Other factors affecting access design include the number and location of points of entry, requirement for interchanges with public highways, need for deceleration and acceleration lanes as affected by highway speed, channelization and signalization requirements.

Grouping of Functions. The internal arrangement of the functional components of the base is directly influenced by the mission and military requirements. This arrangement has been discussed in previous chapters and demonstrated in Fig. 2. Proper arrangement of the functional areas will greatly aid traffic characteristics. The better the grouping of related functions the less will be traffic problems. This grouping of activities yields many advantages. It promotes efficiency and minimizes circulation. It allows pooling of parking areas; it simplifies traffic movements that parking generates. The isolation of certain activities will allow better utilization of them. A good example is medical hospitals. In view of the comparatively small amount of traffic generated by such facilities, they may well be by-passed by primary traffic arteries.

Design of Internal Road Network. The design of the internal road network is the most important design effort. It must be designed to effectively serve the needs of the base and is dependent on the grouping of functions, the access points, the amount of circulated traffic and the standards to be met in physical capacities.

The following principles of network design are highly desirable and must be considered in planning the road network:[1]

1. Blocks, or area subdivisions, containing related activities should be interconnected as directly as possible by primary circulation streets located at their periphery.
2. Blocks should not be bisected by primary circulation streets.
3. A circumferential route should connect all parts of the base.
4. Provision should be made, apart from the normal traffic stream, for the movement of cumbersome industrial type vehicles such as heavy equipment, trailers, vans, tankers, and commercial trucks and trailers.
5. Design standards and cross sections must be established so that each road is adequate to perform its function.

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[1] Air Force Manual 86-6, Air base master planning, p. 130.

Full consideration must be given to pedestrian traffic including the provision of sidewalks and designated cross walks at appropriate locations.

6. Traffic control must be established consistent with the various classes of roads and streets, and will include parking regulations, establishment of reasonable speed limits, designation of through streets, and control of right-of-way at intersections.

Classification of Streets. In planning the network the city planner of a military base must be aware of the different classes and uses of roads. There are three classifications of internal road networks as indicated below.[1] Suggested standards are indicated in Table 8.

1. Primary base roads and streets serve as main distributing arteries for all traffic originating outside and within a base. They provide access to, through, and between various functional areas. They are planned and designed to accommodate large volumes of traffic composed of all types of vehicles required to operate regularly on the base. They may be classed as arterials.

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[1]Air Force Manual 86-4, Standard facility requirements, p. 194.

Table 8. Suggested street standards.

Road Type	Function and Design Features	Spacing	Widths R.O.W.	Widths Pavement	Desirable Maximum Grade	Speed	Other Features
PRIMARY	MAIN FEEDER STREETS. SIGNALS WHERE NEEDED. STOP SIGNS ON SIDE STREETS. OCCASIONALLY FORM BOUNDARIES FOR NEIGHBORHOODS.	3/4-1 MILE	80 FT.	60 FT.	5 %	35-40 M.P.H.	REQUIRE 5 FT. WIDE DETACHED SIDEWALKS, PLANTING STRIPS BETWEEN SIDEWALKS AND CURB 5-10 FT. OR MORE, AND 30 FT. BUILDING SET-BACK LINES.
SECONDARY	MAIN INTERIOR STREETS. STOP SIGNS ON SIDE STREETS.	1/4-1/2 MILE	64 FT.	44 FT. 2-12 FT TRAFFIC LANES 2-10 FT. PARK LANES.	5 %	30 M.P.H.	REQUIRE 4 FT. WIDE DETACHED SIDEWALKS. VERTICAL CURBS, PLANTING STRIPS DESIRABLE. BUILDING SET-BACK LINES 30 FT. FROM RIGHT-OF-WAY.
TERTIARY	LOCAL SERVICE STREETS. NON-CONDUCIVE TO THROUGH TRAFFIC.	AT BLOCKS	50 FT.	36 FT. WHERE ST. PARKING IS PERMITTED	6 %	25 M.P.H.	SIDEWALKS 4 FT. WIDE FOR DENSITIES GREATER THAN 1 DWELLING UNIT PER ACRE. CURBS AND GUTTERS
CUL-DE-SAC	STREET OPEN AT ONLY ONE END WITH PROVISION FOR A TURN-AROUND AT THE OTHER END.	ONLY WHERE PRACTICAL.	50 FT. 90 FT. DIA. TURN-AROUND	30-36 FT. 75 FT. TURN-AROUND	5 %		SHOULD NOT HAVE A LENGTH GREATER THAN 500 FT.

2. Secondary base roads and streets supplement the primary system by providing access to, between, and within various functional areas. They are usually planned and designed to accommodate a reasonable volume of comparatively light weight vehicles and an occasional passage of the maximum size vehicle expected to operate regularly on the base. They may be classed as collector streets.
3. Tertiary roads and streets provide access from other roads and streets to individual units of facilities of a functional area. They are planned and designed according to traffic anticipated at the individual facility they serve. They may be classed as local streets.

In designing the three network systems the city planner must keep in mind design standards on roadway capacity. Suggested design capacities are as follows:[1]

Two-lane road (one lane each way) in developed areas design capacity is five hundred vehicles per hour per approach direction. In open areas design capacity is four hundred vehicles per hour per approach direction.

Four-lane road (two lanes each way) in developed areas and open areas the design capacity is one thousand vehicles per hour per approach direction.

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[1]Air Force Manual 86-6, Air base master planning, p. 132.

Figure 14 indicates a diagrammatic layout for the three systems of street classes applicable to a military base.

Intersections. In designing street systems, particularly in family housing areas, careful consideration of intersection design is mandatory. It is safe to say that the plan with the most intersections will usually have the highest accident rate. The incorporation of the "T" intersection as much as possible will greatly aid in decreasing accident potential. This has the effect of reducing conflict points from sixteen in the four-way intersection to three in the "T" intersection. This principle is demonstrated in Fig. 15. Another advantage of the "T" intersection is the automatic assignment of right-of-way. Vehicles entering the intersection from the discontinuous street must turn and thus tend to assume the vehicles on the through street have the right-of-way.

In planning family housing areas the limited access design will greatly improve neighborhood safety. Continuous through streets between secondary streets tend to increase traffic volume and speed. By limiting the points of access from each neighborhood to secondary streets to a minimum of one quarter mile apart, speed and volume are reduced with a corresponding reduction in accidents. Figure 16 demonstrates some possible street plans of the limited access type.

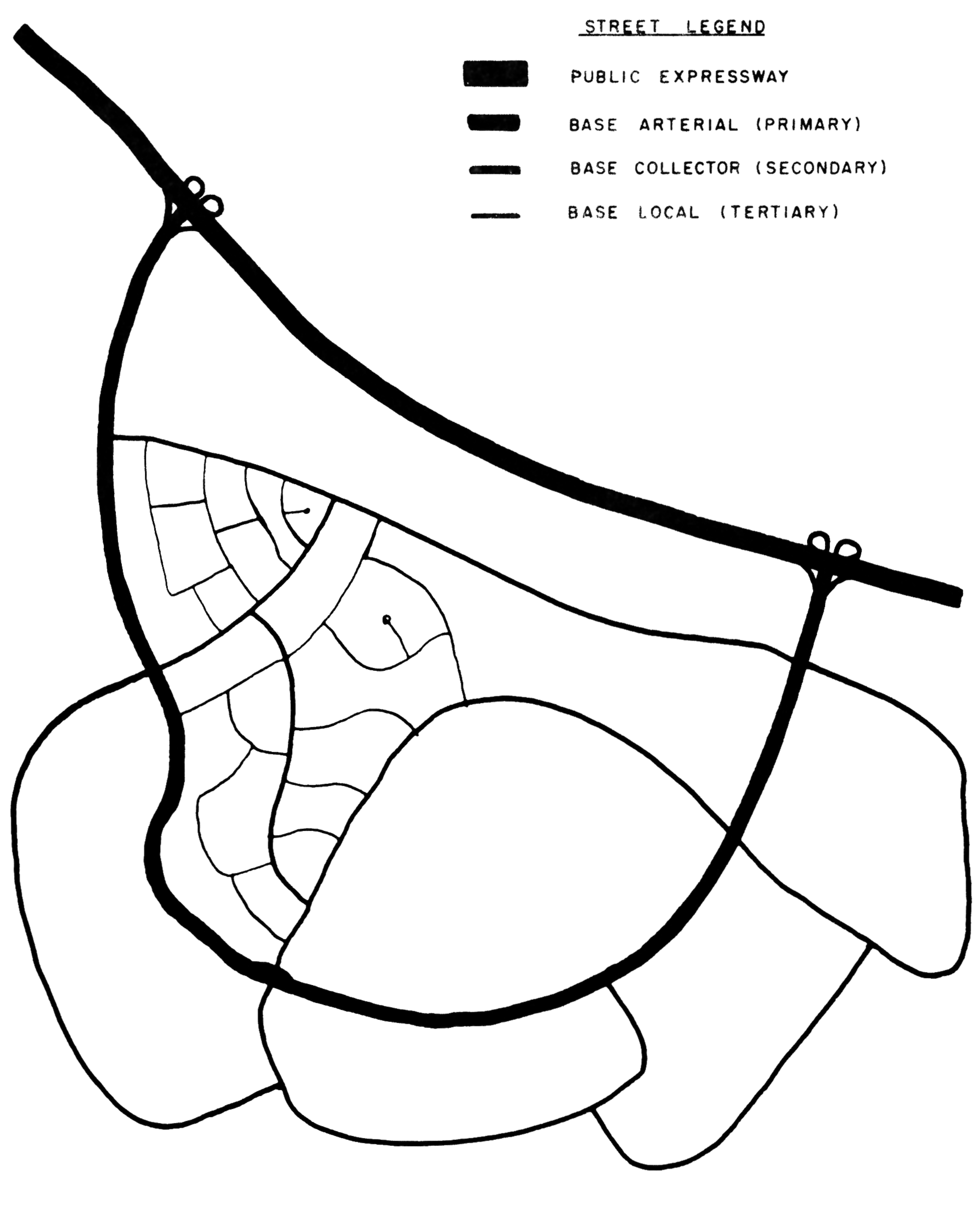


Fig. 14. Diagrammatic layout of road classes.

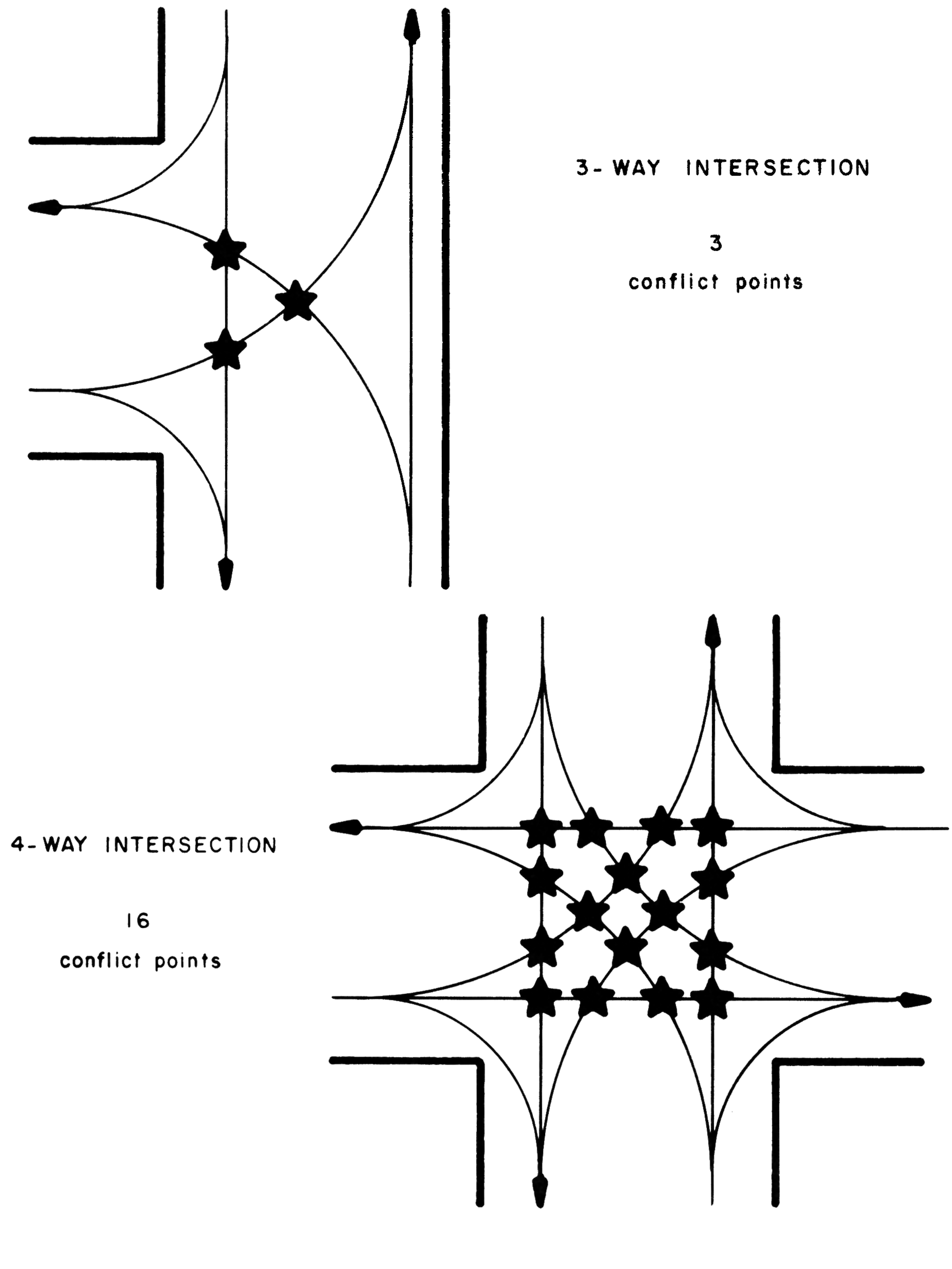


Fig. 15. Comparison of intersection conflict points.

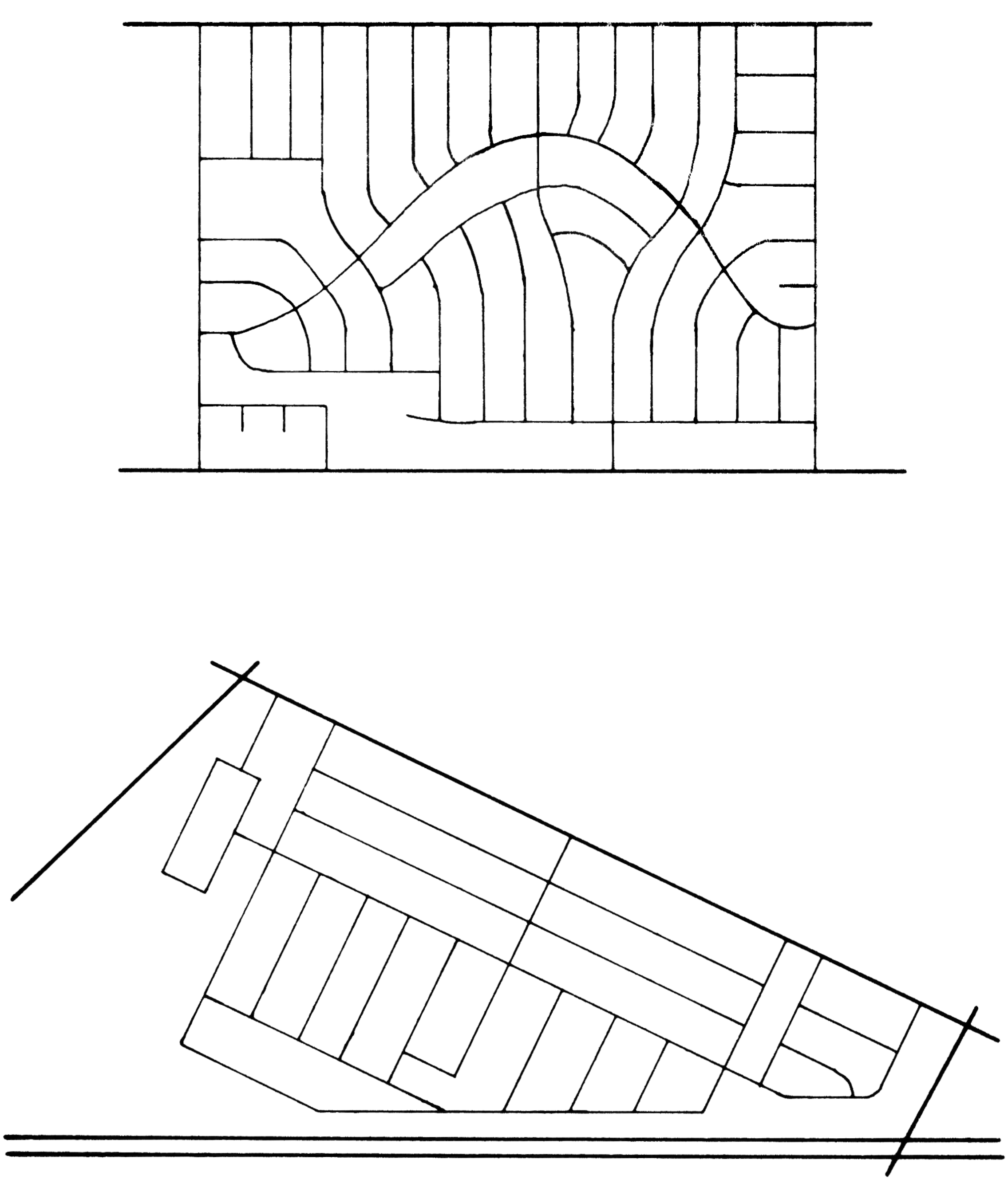


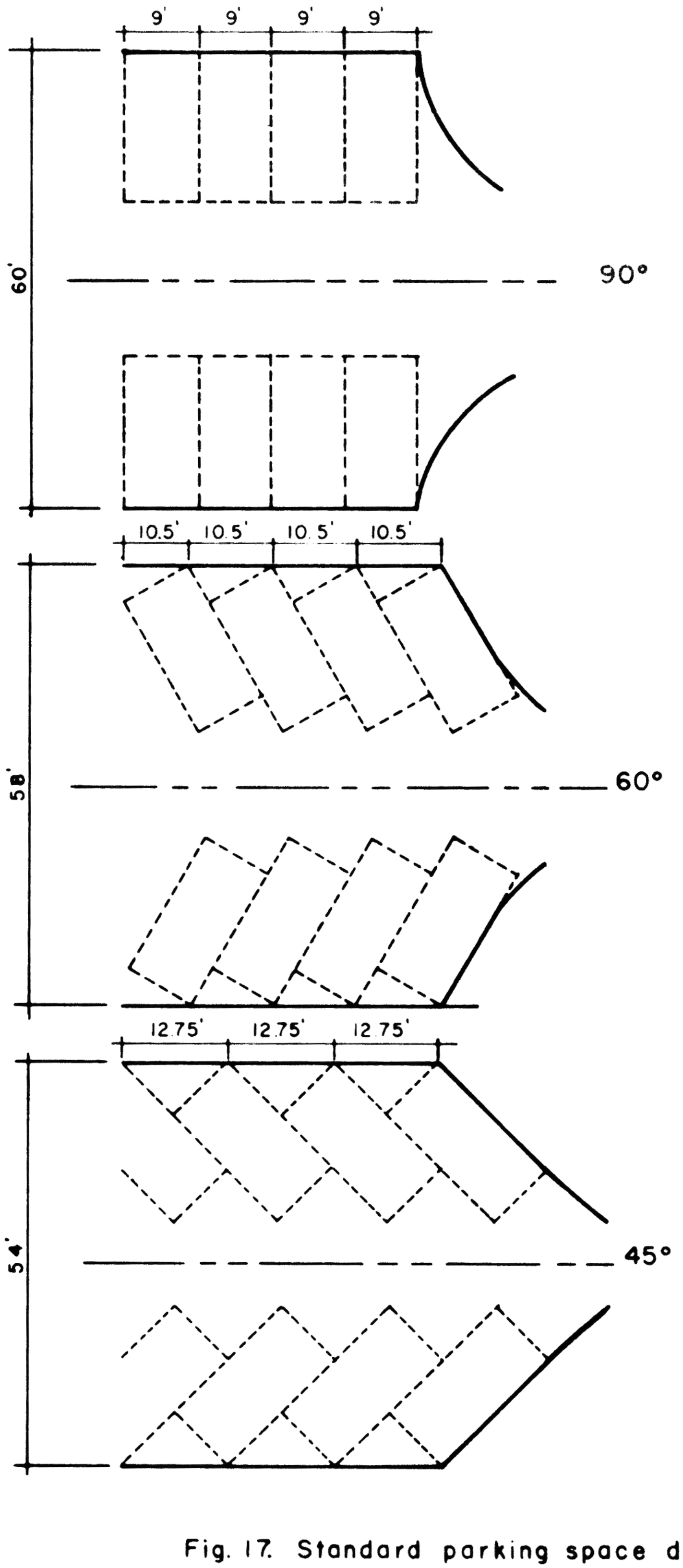
Fig. 16. Examples of limited access street patterns.

Parking Requirements. Air Force criteria are applicable to the estimating of parking requirements. With the high ratio of vehicles to employees indicated previously, a parking facility represents the destination of most employees. Their location materially influences the traffic pattern of the base. They must be properly located to serve functional areas. Other factors that influence the quantity of parking facilities required are the type of base, type of personnel employed, convenience of family housing to other facilities, and quality of mass transit service available. Parking areas must be internally designed to permit safe and maximum usage. Figure 17 indicates the proposed standard for parking space dimensions.

Preparation for Planning

It is the belief of the writer, as mentioned before, that it is the intent of the Air Force for the base civil engineer to have overall responsibility for air base transportation planning. As a part of the research for this thesis, all known Air Force publications dealing with the subject of transportation engineering have been carefully reviewed. The basic data are presently contained in nine publications as follows:

1. Air Force Regulation 23-33--Base Civil Engineer Organization and Functions.
2. Air Force Regulation 32-1--Responsibility for Ground Accident Prevention Program.



VEHICLE SPACES OUTLINED ARE INTENDED TO ACCOMMODATE ANY NORMAL PASSENGER VEHICLE WITH ADEQUATE CLEARANCE FOR ALIGHTING ON THE SIDES AND WITHOUT THE VEHICLE OVER-LAPPING THE ENDS.

Fig. 17. Standard parking space dimensions.

3. Air Force Regulation 32-2--Ground Safety Private Vehicle Accident Prevention Program.
4. Air Force Regulation 32-17--Private Vehicle Drivers Education Program.
5. Air Force Regulation 125-1--Provost Marshal Function.
6. Air Force Regulation 125-14--Motor Vehicle Traffic Supervision.
7. Air Force Manual 32-3--Accident Prevention Handbook.
8. Air Force Manual 86-6--Air Base Master Planning.
9. Air Force Manual 125-7--Motor Vehicle Traffic Supervision.

Review of the above nine documents indicates the fact that three separate organizations are involved: (1) the base civil engineer, (2) ground safety organization, and (3) the base air police organization. This fact, plus the fact that functions, responsibilities, and guidance are given in at least nine separate documents, would tend to explain the reason for an overall inefficient transportation engineering program.

The writer recommends one basic document outlining the responsibilities of the various involved organizations. Since the base civil engineer has overall responsibility for transportation engineering, the document should be in the civil engineering series. It should clearly point out this overall responsibility and should define the ground safety and air police organizations as having supporting functions to the base civil engineer. Further, the document should incorporate the latest techniques in developing the six important elements of design previously discussed. A suggested information outline for this data is contained in Table 9.

The average base engineer in the Air Force has not had the opportunity to obtain training and education on the procedures of transportation engineering. The manual should also cover this subject. A logical first step in planning transportation facilities is to prepare an inventory of existing facilities. In accomplishing this the following points should be reviewed:

1. Classify existing street systems into local, collector, and arterial streets.
2. Determine the capacities of these street networks and indicate the average daily traffic.
3. Prepare an accident dot map indicating the location and type of accidents thereon.

The second step is the preparation of an inventory of travel. This is accomplished for two purposes: (1) to increase the understanding of the nature of the travel and (2) to serve as a basis for projecting future travel volumes. A properly prepared land use map as discussed in Chapter III will greatly aid in studying this problem.

Other excellent aids are: (1) origin-destination surveys, (2) traffic volume surveys, (3) travel time studies, (4) street capacity studies, (5) parking inventories and (6) control devices inventories. The information gained by these study methods together with design standards, techniques and procedures,

Table 9. Information outline for recommended Air Force manual.

Transportation Engineering Item	Suggested Information Source
Relate base to the highway development of the region.	
- NON-AIR FORCE LOADING OF ADJACENT HIGHWAYS AND FUTURE DEVELOPMENT PROGRAMS	- LOCAL CITY GOVERNMENT, COUNTY GOVERNMENT AND STATE HIGHWAY DEPARTMENT - HIGHWAY CAPACITY MANUAL[1]
Determine employee transportation requirements.	
- NUMBER OF PERSONNEL ASSIGNED AND NUMBER OF DEPENDENTS	- BASE DIRECTOR OF PERSONNEL
- NUMBER OF PERSONNEL HOUSED ON AND OFF THE BASE	- BASE HOUSING OFFICE
- VEHICLES REGISTERED	- BASE AIR POLICE
- EXTENT OF RIDE SHARING	- BASE AIR POLICE GATE CHECK AND/OR ORGANIZATION SURVEY
- COMMERCIAL DELIVERY LOADS AND HOURS.	- BASE AIR POLICE
- TRAFFIC VOLUME PEAKS	- BASE AIR POLICE
- ACCIDENT STATISTICS	- BASE AIR POLICE AND GROUND SAFETY, 3E-MAINTAINING ACCIDENT RECORDS[2]
- PUBLIC TRANSPORTATION AVAILABLE, ROUTES AND HOURS OF SERVICE.	- LOCAL PUBLIC TRANSPORTATION COMPANY, 4A-MEASURING TRANSIT SERVICE[2], 8A-RECOMMENDED STANDARDS, WARRANTS AND OBJECTIVES FOR TRANSIT SERVICES AND FACILITIES[2].
Design access facilities to the base.	
DESIGN ACCESS FACILITIES	- CHANNELIZATION-THE DESIGN OF HIGHWAY INTERSECTIONS[3]
Analyze traffic generating properties of internal land use.	
- LOCATION OF MAJOR TRAFFIC GENERATORS.	- ANALYSIS OF LAND USE MAP, 1A-DETERMINING STREET USE[2], 2A-ORIGIN-DESTINATION AND LAND USE[2], 2B-CONDUCTING A HOME INTERVIEW-ORIGIN-DESTINATION SURVEY[2], 3A-MEASURING TRAFFIC VOLUMES[2], 3B-DETERMINING TRAVEL TIME.[2]
Design internal road network.	
- DETERMINE ROAD CLASSES	- 5A-INVENTORY OF THE PHYSICAL STREET SYSTEM[2]
- DETERMINE DESIGN STANDARDS AND CROSS SECTIONS.	- 7A-STANDARDS FOR STREET FACILITIES AND SERVICES[2]
- LOCATE TRAFFIC CONTROL DEVICES	- MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES[4]
- DESIGN INTERSECTIONS	- HIGHWAY CAPACITY MANUAL[1]
Determine location and capacity of parking facilities.	
- DESIGN PARKING FACILITIES	- PARKING GUIDE FOR CITIES[5], 3C-CONDUCTING A PARKING SURVEY[2]

1. U.S. DEPT. OF COMMERCE, BUREAU OF PUBLIC ROADS, 1950.	4. U.S. DEPT. OF COMMERCE, BUREAU OF PUBLIC ROADS, 1961.
2. PUBLIC ADMINISTRATION SERVICE, 1958.	5. U.S. DEPT. OF COMMERCE, BUREAU OF PUBLIC ROADS, 1956.
3. HIGHWAY RESEARCH BOARD, NATIONAL RESEARCH COUNCIL, 1962.	

all combined in one manual would give the base civil engineer and other organizations involved an excellent means of solving transportation problems and accomplishing proper design on future construction programs.

CHAPTER IX

SUMMARY AND CONCLUSIONS

The United States Air Force has a mission in space. This mission is to conduct operations in space for the advancement of men's knowledge and capabilities. Therefore, future missions of many Air Force bases will require the consideration of space support facilities.

City planning as a profession is developing rapidly. The "state of the art" as practiced in the civilian community is more advanced than as practiced by the Air Force. The techniques, procedures, and standards used by the city planning profession in developing civilian master plans can be of assistance to Air Force master planning. They are required tools for successful development. Land use standards, in particular, are needed to permit personnel responsible for Air Force planning to check existing facilities for adequacy and to allow computation of total land requirements for new bases and facilities.

The Air Force lacks trained professional planners. To overcome this shortage, there is a need for an adequate Air Force manual on master planning encompassing the latest techniques, procedures and standards. They must be prepared with the thought in mind that most persons using them for the development of an Air Force base master plan are not formally educated city planners. It has been the intent of the writer that the contents of this thesis be a starting point toward this effort.

Land Use Planning

Air Force land use can be placed in six primary categories as follows: (1) airfield/missile launch land use, (2) industrial land use, (3) administrative land use, (4) community support land use, (5) housing land use, and (6) community recreation land use.

There are desirable and undesirable functional relationships of these uses of land. Many are standard and are easily recognized. Two, however, are generated by the requirements of space support. These involve the effects of noise and the effects of safety requirements from the dangers of missile fuels and fuel exhaust products. Determination of the extent of these land use requirements is a difficult and extensive process. Land requirements for noise control can be determined if the strength of noise at the source is known. The requirements of land for safety requirements from fuel dangers is more difficult to determine. It is essentially a meteorological problem and must usually be solved by experimentation. Both problems are of the nature that the planner should consult professional experts in the fields of noise and fuels before determining the extent of land rquired.

In order to accomplish successful master plan development a system of land use analysis is needed. Such a system is included in Chapter III. An analysis of land use is a necessary tool for successful planning. It reveals many facts which must be considered during planning such a mixture of land use, location of major points of traffic generation, good and poor functional relationships and facilities that require relocation or replacement.

To assist in land use planning various procedures and standards for Air Force use are required. These include open space ratio for various classifications of land use and population density standards, where applicable. Requirements involving launch facilities, shopping/community centers, housing and transportation are discussed in detail. Procedures suggested by the writer include transportation planning (Chapter VIII) and a philosophy of planning development (Appendix F). There are as many variations of these as there are planners. However, the points outlined are workable methods which can produce a successful master development plan.

In the area of transportation planning there are six important elements of design that must be considered by the planner in developing transportation facilities on an Air Force base. These are:

1. Relate the base to the highway development of the region.
2. Determine the type and quantity of transportation the base employees will need.

3. Design access facilities to the base, including public highway entrances and security gates.
4. Analyze traffic generating properties of the internal functional grouping of base facilities.
5. Design the internal road network, establishing classification of systems, pattern, cross sections and traffic control.
6. Determine location and capacity of parking facilities and relate them to the roadnet.

In the area of planning development there are six distinct steps necessary to develop a successful plan. These are:

1. Understand the programming directive.
2. Determine the population to be served.
3. Determine the facilities necessary to accomplish the mission.
4. Consolidate estimates and analyze land use by type.
5. Select the location of the proposed base or facility to be added.
6. Develop the master plan of land use.

Conclusion

There is no question as to the importance and need for continued master planning in the Air Force. Further, techniques, procedures and standards must be carefully prepared and presented in such a manner that they can be used by nonprofessional planning personnel. The preparation of the contents of this thesis has been toward this goal.

Further Study Needed

During the preparation of this thesis the writer has formed opinions on areas of future research needed for continued improvement of Air Force master planning. Many are beyond the ability of the general planner and require assistance of other technically trained personnel. A coordinated program by planners, architects and engineers will greatly aid in furthering understanding in these suggested areas.

1. Administration of Master Planning. Current Air Force regulations assign the first review responsibility for the master plan of an Air Force base to the Facilities Utilization Board. They act in a capacity similar to a city commission. There is a definite need for a management manual for the use of Facilities Utilization Board members covering all responsibilities including those involving master planning. This should be coordinated with a system of land use planning. Included could be the application of civilian planning control techniques such as zoning ordinances and subdivision regulations to the military community. This general subject area is presently under study as a thesis subject by First Lieutenant D. B. Cavender, Kansas State University graduate student. The thesis title is "A Comparative Analysis of Air Force and Civilian Land Use Administration."

2. Continued research is needed in the field of noise and noise control from missile launch facilities. Further, the field of missile fuel dangers should be included. An evaluation of the noise producing mechanism of the missile engine as a function of thrust could conceivably provide the planner with a basis for analyzing the impact of noise levels. This evaluation should include research on other types of propulsion units which are on the horizon and should permit the planner to at least evaluate, qualitatively, the possible impact on facility development.
3. Continued research in the fields of planning techniques, procedures and standards is recommended. The field of standards is particularly important because of the lack of professional master planners in the Air Force. One possible area of research could be a study of current land use on Air Force bases and resulting standards in comparison to acceptable land use standards used for similar facilities in civilian application. The survey could possibly be conducted through the use of the automated real property records system.
4. Another potential area is the effect of planning on the character of an air base. Terms such as paths, districts, edges, landmarks and nodes are applicable here. How do people relate these characteristics in

classifying an Air Force base as desirable or undesirable? Professors Kevin Lynch and Gyorgy Kepes of Harvard University have made a study of what people mentally extract from the physical parts of a city.[1] Their techniques could be as easily applied to a military community and could possibly result in a better organized, more attractive development which would certainly have some effect on morale and efficiency of the occupants.

5. Future research should include patterns of land use and facilities included in various sizes of military shopping/community centers. The concept of a central area for the location of community shopping and recreation facilities is appealing, timesaving and of some potential savings of construction money. Second Lieutenant James Brenneman, Kansas State University graduate student,is currently pursuing a study in this area.

6. The general subject of family housing as concerned in master planning is a fruitful area of research. The Air Force currently has quite detailed and adequate manuals covering the architectural design and construction of housing units but includes

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[1]Kevin Lynch, The image of the city, p. 46.

little on site planning patterns, especially in relation to economics of construction. Research efforts should include the "cluster" concept as proposed by the writer and involve potential economics as well as occupant satisfaction for a pleasant place to live.

7. Most certainly future research efforts should include the subject of transportation engineering. Comments on this important area are included in Chapter VIII.

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APPENDIX

APPENDIX A

ROLE OF THE AIR FORCE IN SPACE PROGRAMS

The Air Force has three primary objectives in space. These are:[1]

1. To acquire the capability to utilize space in support of the military forces operating in the familiar environments of land, sea, and air.
2. To acquire the necessary defense capability for the aerospace regions themselves.
3. To make sure that no aggressor can exploit space, either from expansionism on Earth or interference in space with the peaceful pursuits of the free world.

A scientific space program on the part of the Air Force will overlap the defense field. The real property facilities necessary for the defense program are already well known, planned and many have been constructed. However, the Air Force is just now on the threshold of the scientific space program. The master planning, design and construction of these types of facilities is in the immediate future.

The space age was born on October 4, 1957, when the Soviets successfully placed Sputnik I into orbit. Since then many man-made objects and man himself have orbited about the Earth.

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[1]From a speech by Honorable E. M. Zuckert, Secretary of the Air Force to a "Dining-In" audience at Patrick Air Force Base, Florida, March 2, 1963.

Yet the conquest of space has barely begun. It has already caused many changes in our lives by creating an entire new industry, the aero-space industry. This alone has had a healthy effect on the national economy. In addition, the national investment in space exploration has produced new materials, metals, alloys, fabrics and compounds. Many of these accomplishments of science challenge the imagination, but they are insignificant when compared to the enormous task that lies ahead.

There are four factors which give importance, urgency, and inevitability to the advancement of space technology in the Air Force. The first of these factors is the compelling urge of man to explore and to discover, the thrust of curiosity that leads men to try to go where no one has gone before.

The second factor is the defense objective of space. If space is to be used for military purposes, we must be prepared to use space to defend ourselves. The Air Force realizes the importance of spacecraft in the defense of the United States and has stated that the following are foreseeable missions of maneuverable spacecraft.[1]

1. A manned orbital bomber.
2. A super U-2 global reconnaissance craft.
3. An orbital interceptor to capture or destroy enemy orbiters.

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[1]Richard Skinner, Editorial, Air Force and Space Digest, April 1963, p. 19.

4. Supply, maintenance, and rescue craft for space stations.
5. An aerospace plane that could simply take off and return from orbit like an ordinary airplane.
6. Inspection and control vehicles that will be needed to keep the peace even if international control of space becomes a reality.

Third, there is the factor of national prestige. A strong and bold approach to space technology will enhance the prestige of the United States among the peoples of the world and create added confidence in our scientific, technological, industrial, and military strength.

Fourth, space technology gives new opportunities for scientific observation and experimentation which will add to our knowledge and understanding of the Earth, the solar system, and the universe.

Future Space Programs

The National Research Council of the National Academy of Sciences has published a recommended future national space program.[1]

1. Astronomy. Continuance of the balloon, X-15, and sounding rocket programs. Small satellites will continue to be used. The Orbiting Astronomical Observatories (OAO) program is to be expanded with

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[1]National Academy of Science, A review of space research, National Research Council Publication No. 1079., p.10.

the introduction of a large space telescope preferably on an Earth satellite or in a lunar observatory.

2. Celestial Mechanics. Continuance of study of the gravitational fields of the Earth, Moon and Venus by the use of satellites.
3. Lunar and Planetary Research. Emphasis should be continued on the use of unmanned spacecraft for determining the physical conditions on the lunar surface. Included should be lunar exploration by observation, collection of representative samples and installation of monitoring equipment. The group listed a number of investigations, primarily astronomical, that are best accomplished by man's presence on the Moon. The group definitely can foresee the need for a manned lunar laboratory.
4. Atmospheres of the Solar System. The group recommended Orbiting Solar Observatories (OSO) to measure and monitor radiation from the sun. Further, satellites should be used to accomplish fly-by observations of Mars and Venus.
5. Meteorological Rockets and Satellites. The group urges the development of a meteorological rocket system to measure winds, pressure, temperature and density at various heights.
6. Biology. The scientists feel that life on the Moon and Venus is very unlikely. However, life on Mars is a

strong possibility. They recommend a life-detection experiment if sterilization of the spacecraft, especially in back-contamination, quarantine of the samples, and sterilization of the returning astronauts can be accomplished.

7. Space Probe Sterilization. Of utmost importance is development of sterilization techniques using dry heat, ionizing radiation and/or chemical sterilization.

Scientific Role of the Air Force in Space Exploration

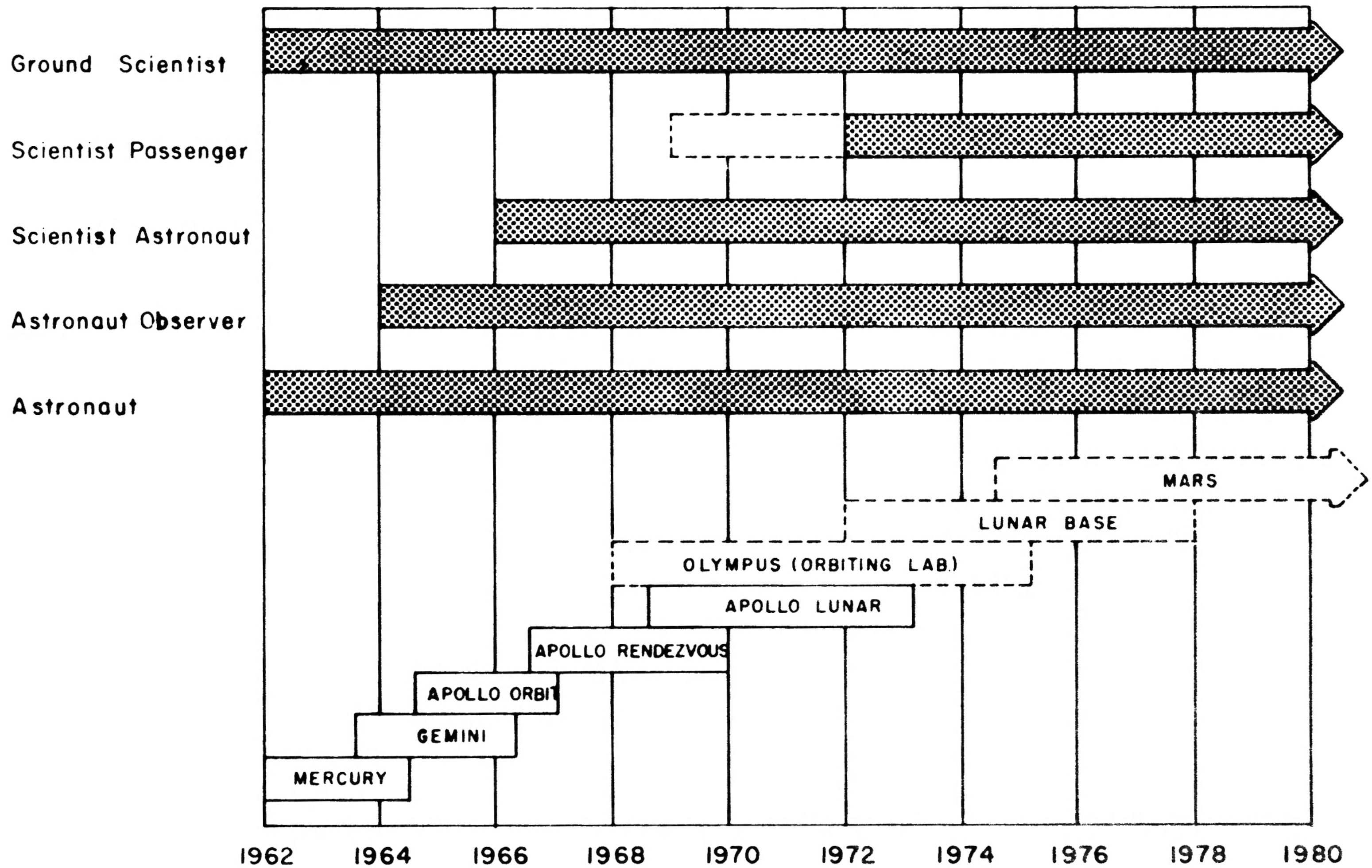
The planning, financial and educational requirements of such a program as outlined above are tremendous. As an example, during 1962 the space program cost each American about forty cents a week. It is interesting to note the fact that life on Mars is considered a good possibility. The Space Sciences Board has established the recommended date of 1972 for the conducting of manned missions to Mars. The plan will include:

1. Manned orbiters.
2. Manned landings.
3. Landings on the natural Martian satellites (moons) of Phobos and Deimos.
4. The establishment of a semipermanent observing station on the side of Phobos facing the planet for continuous observation of Mars.

This mission of an observing station on Phobos is used in the case study discussed in Appendix F. Further, the case study includes another major step recommended by the Space Science Board: the establishment of an Institute of Space Sciences. This facility would be for the training of the scientist-astronaut. It would maintain liaison with major centers of research in the United States and abroad. The Institute, through affiliation with major universities, would function as a graduate school offering advanced degrees in various areas of science. Specific missions would be:

1. Train scientist-astronauts.
2. Advance space science generally.
3. Provide indoctrination and education for another new group, the astronaut-observer.
4. Familiarize and train a third new group, the scientist-passenger, in the requirements of space flight.
5. Bring ground scientists together with crew members of space vehicles for the attainment of coordinated efforts in carrying out scientific missions.
6. Maintain a complete library of historical and current space flight data as well as comprehensive literature in the sciences relevant to space flight missions.

Of utmost importance is the scheduling of this required education and training with the presently phased program in space. Figure 18 illustrates the suggested combined schedule as recommended by the Space Sciences Board. Table 10 is a schedule of individual projects with proposed accomplishment dates as seen by the United States Air Force. It is interesting to note



SOURCE - A REVIEW OF SPACE RESEARCH, NATIONAL RESEARCH COUNCIL PUBLICATION 1079

Fig. 18. Time requirements for personnel in manned space missions.

Table 10. Space program schedule.

Project	Mission	Schedule	Purpose
EXPLORER	Unmanned space and lunar probes	1959	S, M
TELSTAR	Unmanned communications satellites	1960	M, C
ECHO	Unmanned communications satellites	1960	M, C
SAMOS	Unmanned reconnaissance satellites	1961	M, S
MIDAS	Unmanned attack warning satellites	1961	M, S
NIMBUS	Unmanned weather reporting satellites	1961	M, C, S
TIROS	Unmanned weather reporting satellites	1961	M, C, S
TRANSIT	Unmanned navigation satellites	1961	M, C
RANGER	Unmanned lunar and planetary satellites	1963-64	M, S
GEMINI	Manned space vehicle	1965	M, C, S
SURVEYOR	Unmanned lunar surface vehicles (soft landing capability)	1965	M, S
APOLLO	Manned lunar circumnavigation (and return to earth)	1966	M, S
MOL	Manned defensive-offensive space vehicles	1967	M
MOL	Manned all-purpose space station (astronautical) observatory, earth surveillance, weather reporting and communications relay.	1968	M, S, C
LEM	Manned lunar vehicle (landing and return to earth)	1968	M, S
—	Manned lunar base (start construction)	1969	M, S

M – Military

S – Scientific

C – Commercial

Source – B/G H. A. Boushey
Director of Advanced Technology
U.S.A.F.

that many of the planned missions have several purposes; that is, scientific, military, and/or commercial.

APPENDIX B

FUTURE SPACE MISSIONS

To further the understanding of the city planner in the standards and relationships of the master planning of space support facilities, it is considered necessary that he have some understanding of the scope of a typical space mission of the future. Future missions will be closely similar to the plans of the current program Apollo. Therefore, to provide some idea of the scope of these future missions, it is considered best that the Apollo mission be described.

Project Apollo is the culmination of a series of extensive space projects. As of January, 1964, the new six-year timetable appeared as follows:[1]

1964 Two-man voyages (Project Gemini). A capsule carrying two men. First flights will be unmanned. Later flights will be from ten to fourteen days long to check the effects of long periods in space.

1965 Line-up in space. Gemini continued. Crews practice joining up with a second orbiting vehicle.

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[1]On the road to the Moon--more 'spectaculars' ahead, U. S. News and World Report, January 13, 1964, pp. 74-75.

1966 Test flight of moonship (Project Apollo). First launch of unmanned moonship using Saturn rocket.

1967 Three-man maneuvers. Full crew of three men take moonship around Earth for first manned tests. Astronauts check out equipment and practice rendezvous between Lunar Excursion Module and Apollo mother ship

1968 Scouting the Moon. Apollo and crew survey Moon for landing sites using Saturn V booster.

1968 Actual landing. First landing on Moon comes when a crew of two descend in Lunar Excursion Module, explore the surface, join orbiting mother ship and return to Earth.

This plan is ambitious. But not nearly so much as that developed before the Committee on Science and Astronautics, U. S. House of Representatives, Eighty-Seventh Congress. Table 11 is a listing of these missions between 1960 and 1975.

Apollo Vehicle

In considering the lunar flight vehicle, size is difficult to comprehend. Plate VII indicates the relative sizes of Mercury, Gemini, and Apollo vehicles. The complete Saturn V will stand three hundred sixty-two feet high, one hundred sixty-two feet taller than the Statue of Liberty. Three principal sections will get Apollo into orbit about the Earth.

Table II. U. S. Space Missions 1960 — 1975.

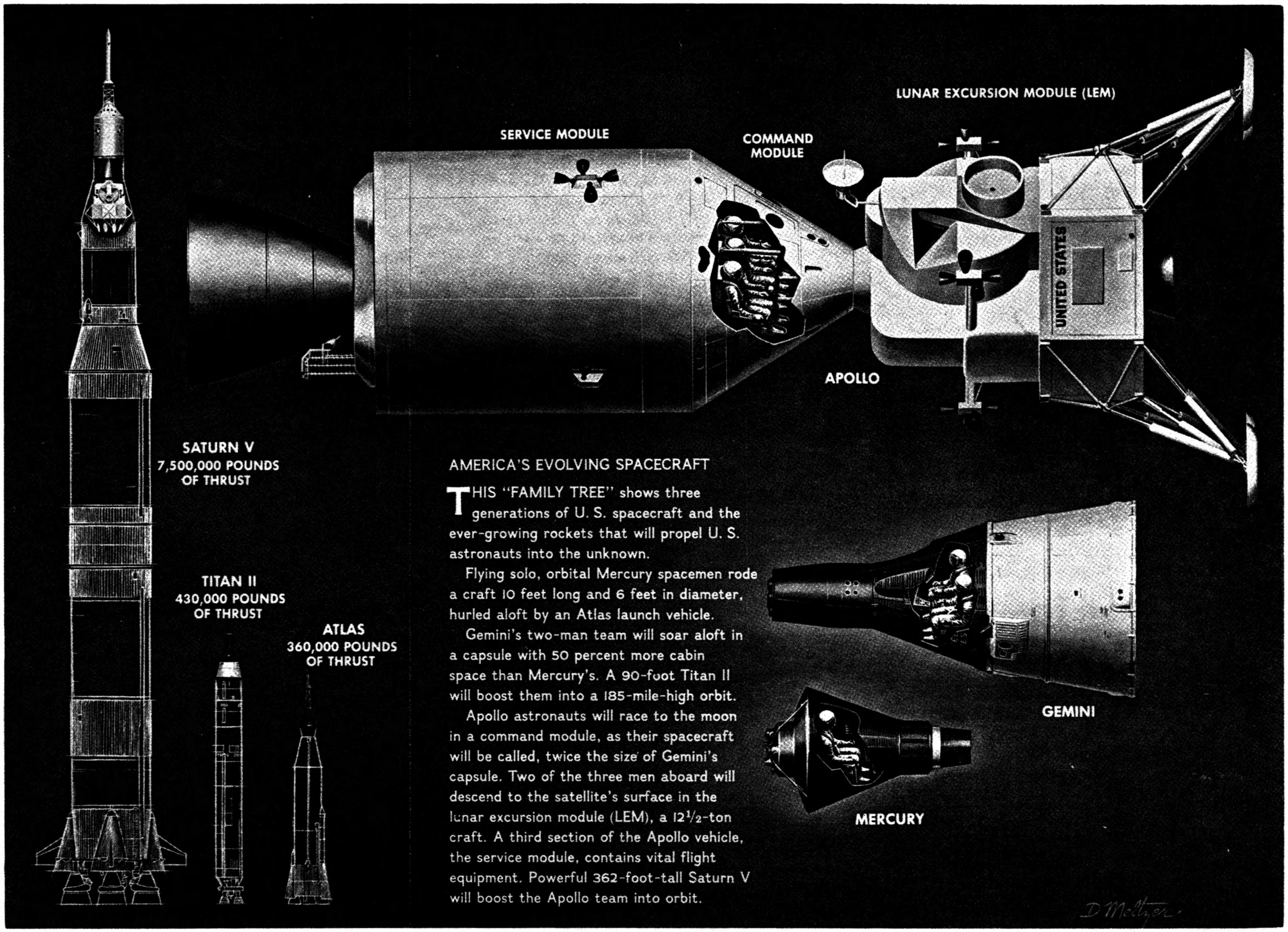
NO.	CUSTOMER OR PRIME AGENCY	UTILIZATION	PROJECTOR CODE NAME	MISSION OR OPERATION	PRESENT BOOSTER STAGE	UPPER STAGE DESIGNATION	BOOSTER THRUST IN 1000 LBS.	PAYLOAD WEIGHT IN LBS.	ORBIT ALTITUDE IN MILES	ESTIMATED NUMBER OF PLANNED FLIGHTS PER YEAR 60	61	62	63	64	65	66	67	68	69	70	FLIGHTS BETWEEN 1971–1975	FLIGHTS BETWEEN 1965–1975
1.	NASA	Meteorology	TIROS	Weather Observation Satellite	THOR	ABLE DELTA	165	270	450	2	3	–	–	–	–	–	–	–	–	–	–	–
2.	NASA	Meteorology	NIMBUS	Same Advanced Version	THOR	AEGENA B	165	600–700	700	–	1	2	2	2	1	1	2	3	1	1	30	39
3.	NASA	Meteorology	AEROS	24-hr. Satellite Weather Observation	ATLAS	CENTAUR	390		23,000	–	–	–	–	2	2	2	2	4	2	2	15	29
4.	NASA	Observation	OAO	Orbiting Astronomical Observatory	ATLAS	AEGENA B	390	3500	550	–	–	–	1	2	3	3	3	3	3	3	15	33
5.	NASA	Observation	OGO	Orbiting Geophysical Observatory	ATLAS THOR	AEGENA B (EGO) AEGENA B (POGO) CENTAUR	390 165	1000 1500	150–60,000 170–10,000 170–650	–	–	–	2	4	5	5	5	5	5	–	15	40
6.	NASA	Observation	OSO	Orbiting Solar Observatory	THOR	DELTA	165	350	300	–	3	3	–	–	–	–	–	–	–	–	–	–
7.	NASA	Nuclear Test Vehicle	RIFT	Chemical Launch of Nuclear Upper Stages	SATURN,SI	NUCLEAR	1500	19,000 5,000	350 Escape	–	–	–	–	–	–	1	2	2	2	2	10	19
8.	NASA	Exploration	MOONSHOT	Early Circumlunar Probe	ATLAS	ABLE	390		Escape	1	1	–	–	–	–	–	–	–	–	–	–	–
9.	NASA	Exploration	MERCURY	Man-in-Space Early Satellite	REDSTONE ATLAS	—	78 390	2400	120	1 –	10 7	– 6	– 1	– –	– –	– –	– –	– –	– –	– –	– –	– –
10.	NASA	Exploration	APOLLO	3-Man Space Capsule Circum-lunar & Orbital Flights	ATLAS SATURN,SI	AEGENA B S IV, SV	1500 1500	20,000 8,500	300 Escape	–	–	3	3	1	2	2	2	2	2	2	10	22
11.	NASA	Observation	RANGER-1-2	Interplanetary Flights	ATLAS	AEGENA B	390	700	Escape	–	2	2	2	1	–	–	–	–	–	–	–	–
12.	NASA	Exploration	RANGER-3-4-5	Hard Lunar Landing	ATLAS	AEGENA B	390	2,500	Escape	–	–	3	–	–	–	–	–	–	–	–	–	–
13.	NASA	Exploration	SURVEYOR	Soft Lunar Landing	ATLAS	CENTAUR	390	2,500	Escape	–	1	4	5	4	4	4	–	–	–	–	–	8
14.	NASA	Exploration	PROSPECTOR	Soft Lunar Landing & Return	SATURN,SI	SIV, SV	1,500	2,500	Escape	–	–	–	–	–	1	1	1	1	1	1	5	11
15.	NASA	Exploration	MARINER	Mars & Venus Probe	ATLAS	AEGENA B CENTAUR	390	8,500 1,500	300 Escape	–	–	1	2	1	1	1	1	–	–	–	15	18
16.	NASA	Exploration	VOYAGER	Advance Planetary Landings	SATURN,SI	S II, S IV, S V	1,500		Escape	–	–	–	–	–	1	1	1	1	1	1	5	11
17.	NASA	Exploration	MAN-ON-THE MOON	Manned Lunar Landing & Return	NOVA (F-1)	—	10,000	135,000	Escape	–	–	–	–	–	–	–	–	1	2	2	15	20
18.	NASA	Communication	ECHO	Passive Communication Satellite	THOR	DELTA	165	130	1,000	2	1	1	–	–	–	–	–	–	–	–	–	–
19.	NASA	Communication	REBOUND	Same Advanced Version	ATLAS	AEGENA B	390	–	–	–	–	1	10	15	20	2	2	2	2	2	–	30
20.	INDUSTRY	Communication	INDUSTRY PROJECT	Commercial Communication Satellite	UNKNOWN	—	—	175	2,200	Unknown ------------------------------											–	50
21.	ARMY	Communication	COURIER	Repeater Communication Satellite	THOR	ABLE STAR	165	475	650	1	4	–	–	–	–	–	–	–	–	–	–	–
22.	ARMY	Communication	ADVENT	24-hr Stationary Repeater Satellite	ATLAS	AEGENA B	390	600	22,300	–	2	2	2	2	3	–	–	–	–	–	15	18
23.	NAVY	Navigation	TRANSIT	Beacon Satellite for Polaris Subs	THOR	ABLE STAR	165	230	230-480	2	4	6	6	8	8	8	8	8	8	8	40	88
24.	AIR FORCE	Surveillance	SAMOS	Photo Satellite w/Recovery	ATLAS	AEGENA B	390	4000	250-300	3	10	20	8	8	8	6	6	6	6	6	30	68
25.	AIR FORCE	Surveillance	MIDAS	ICBM IR-Detection Satellite	ATLAS	AEGENA B	390	5,000	300	–	3	10	10	10	10	8	8	8	8	8	40	90
26.	AIR FORCE	Surveillance	SAINT	Ground Launched Inspection Satellite	ATLAS	AEGENA B	390	3,500	500	–	4	4	4	8	6	6	6	6	6	6	30	66
27.	AIR FORCE	ICBM Defense	BAMBI	Satellite & AICBM	ATLAS	AEGENA B	390	–	—	–	–	–	2	4	6	6	6	6	6	6	30	66

FROM: HEARINGS BEFORE THE COMMITTEE ON SCIENCE AND ASTRONAUTICS, U.S. HOUSE OF REPRESENTATIVES, EIGHTY-SEVENTH CONGRESS, FIRST SESSION, MARCH 6, 7, 8, AND 10, 1961.

EXPLANATION OF PLATE VII

Compared sizes of missiles and missile occupied capsules. All missiles are drawn at the same scale as are occupied capsules for size comparison.

PLATE VII



AMERICA'S EVOLVING SPACECRAFT

THIS "FAMILY TREE" shows three generations of U. S. spacecraft and the ever-growing rockets that will propel U. S. astronauts into the unknown.

Flying solo, orbital Mercury spacemen rode a craft 10 feet long and 6 feet in diameter, hurled aloft by an Atlas launch vehicle.

Gemini's two-man team will soar aloft in a capsule with 50 percent more cabin space than Mercury's. A 90-foot Titan II will boost them into a 185-mile-high orbit.

Apollo astronauts will race to the moon in a command module, as their spacecraft will be called, twice the size of Gemini's capsule. Two of the three men aboard will descend to the satellite's surface in the lunar excursion module (LEM), a 12½-ton craft. A third section of the Apollo vehicle, the service module, contains vital flight equipment. Powerful 362-foot-tall Saturn V will boost the Apollo team into orbit.

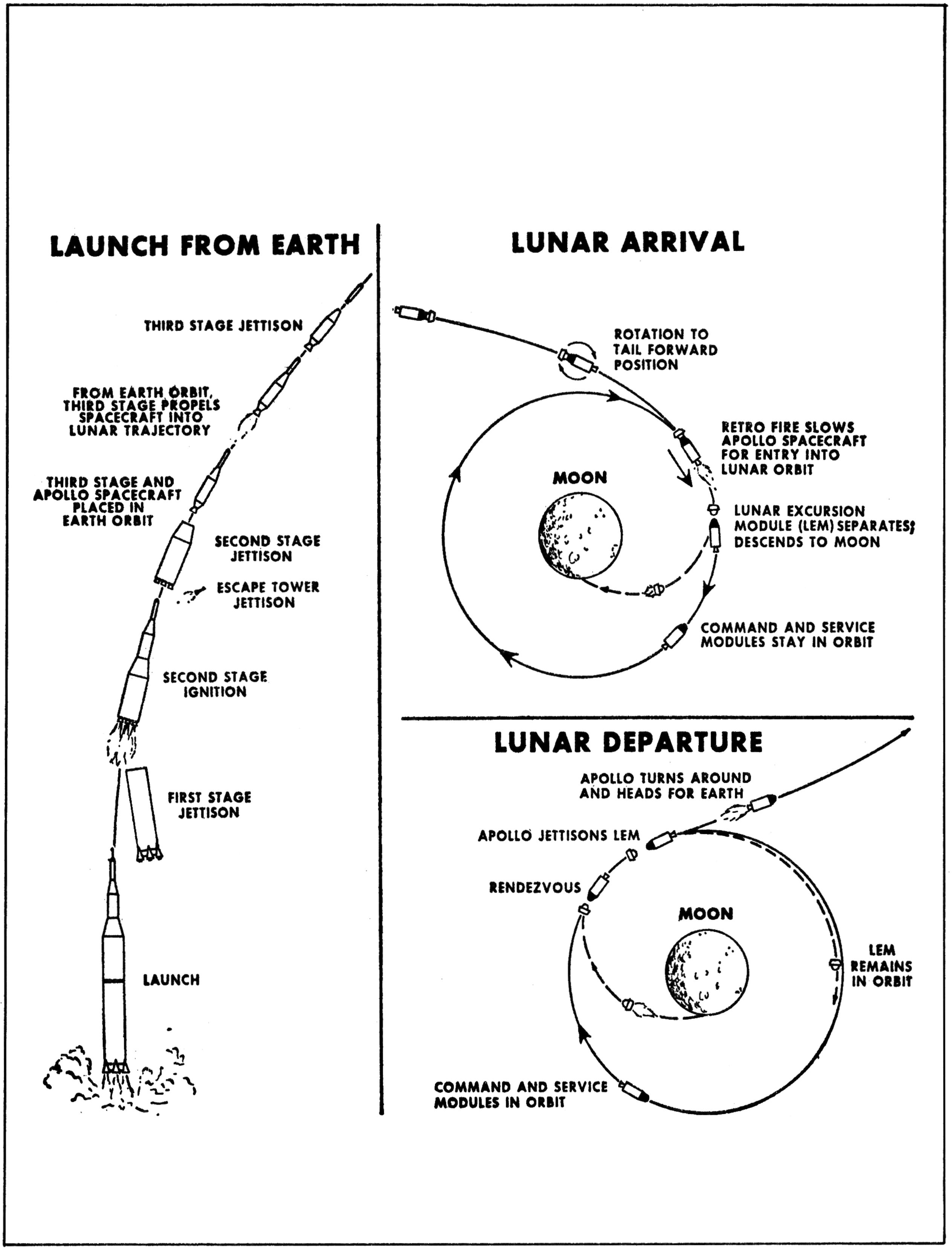
The bottom stage is one hundred thirty-eight feet long, thirty-three feet wide and will produce seven and one half million pounds of thrust in five F-1 engines burning kerosene and liquid oxygen. It will be fired only one hundred fifty seconds but in that time it will lift the six million pound vehicle four miles and to a speed of nine thousand feet a second. The second stage is eighty-two feet long and uses five hydrogen engines to produce one million pounds of thrust. The top stage is sixty feet long and has one hydrogen engine giving two hundred thousand pounds of thrust. Above these three stages will be the Lunar Excursion Module (LEM), the service module, the command module for the three astronauts and the launch escape system.

Plate VIII indicates the projected flight program. During lift-off by the lower stage the five F-1 engines burn thirty thousand pounds of fuel. When the lower stage engines run out of fuel, explosive bolts separate the deadweight first stage which falls into the sea. The second stage ignites and the escape tower, weighing sixty-six hundred pounds, is blown off. The five hydrogen-oxygen engines burn six and one half minutes bringing the vehicle to an altitude of ninety miles and a speed of twenty-two thousand feet a second. The second stage is then jettisoned. The third stage rocket then fires a burst from its single engine for one and one half minutes. This puts the spacecraft into an Earth orbit at one hundred miles altitude and twenty-five thousand feet a second speed.

EXPLANATION OF PLATE VIII

The three major sections to the Apollo flight plan.

PLATE VIII


LAUNCH FROM EARTH
THIRD STAGE JETTISON
FROM EARTH ORBIT, THIRD STAGE PROPELS SPACECRAFT INTO LUNAR TRAJECTORY
THIRD STAGE AND APOLLO SPACECRAFT PLACED IN EARTH ORBIT
SECOND STAGE JETTISON
ESCAPE TOWER JETTISON
SECOND STAGE IGNITION
FIRST STAGE JETTISON
LAUNCH
LUNAR ARRIVAL
ROTATION TO TAIL FORWARD POSITION
RETRO FIRE SLOWS APOLLO SPACECRAFT FOR ENTRY INTO LUNAR ORBIT
MOON
LUNAR EXCURSION MODULE (LEM) SEPARATES; DESCENDS TO MOON
COMMAND AND SERVICE MODULES STAY IN ORBIT
LUNAR DEPARTURE
APOLLO TURNS AROUND AND HEADS FOR EARTH
APOLLO JETTISONS LEM
RENDEZVOUS
MOON
LEM REMAINS IN ORBIT
COMMAND AND SERVICE MODULES IN ORBIT

Computers in Houston, Texas, then take over to determine the precise orbit and its relation to the Moon's location in three days. When the precise second is determined, the third stage refires to send the craft into escape velocity. Fairings covering the Lunar Excursion Module are jettisoned and the two remaining sections of the Apollo spacecraft; that is, the command module with the astronauts and the service module with power and fuel, separate from LEM, the unit which actually lands on the Moon. The astronauts then swing their craft one hundred eighty degrees to connect nose-to-nose with the LEM and disengage it from the third stage, which now drops off.

The first day out the spacecraft loses speed from thirty-six thousand feet a second to nine thousand feet a second. The second day it drops to twenty-two thousand feet a second until it leaves the Earth's gravational field and enters that of the Moon. It then accelerates to nine thousand feet a second. This speed is too fast so the LEM engine is used as a brake to slow the craft to fifty-three hundred feet a second putting it into lunar orbit at sixty miles from the Moon surface. Two of the astronauts then transfer to the LEM. They separate their craft when the landing spot is determined and drop to sixty thousand feet altitude. Retrorockets are fired and the LEM stops at one hundred feet above the Moon where it hovers as if it were a helicopter. It can move several hundred feet sideways. Then it settles to the surface of the Moon as shown in Plate IX.

EXPLANATION OF PLATE IX

The lunar excursion module (LEM) immediately after landing on the surface of the Moon. Astronauts will then proceed with scientific observations.

PLATE IX

Three major tasks are to be performed on the Moon. These are: (1) observation of natural phenomena and geological exploration, (2) collection of material to be brought back to Earth, and (3) the enplacement on the Moon of earth-made equipment such as a compact power reactor, a radio beacon, and devices that will take measurements and readings of a long lived nature and broadcast the findings back to Earth. The astronauts separately spend three to four hour periods on the Moon. The LEM serves as a communications center and as the oxygen supply source whenever the roving astronaut returns to replenish his back-pack. The stay on the Moon is expected to last two days but can be extended to three days if necessary.

The LEM's upper manned-stage takes off leaving the landing stage behind. Its ascent path brings it within maneuvering distance of the still orbiting Apollo, and it docks to the command module. The astronauts leave the LEM and reenter the command module, the LEM is jettisoned, and the service module's engine is fired to put the Apollo on the escape trajectory for the return to Earth. Because the Moon has no atmosphere and generates only one-sixth the gravity of Earth, the returning spacecraft requires only a speed of about five thousand miles an hour to break the Moon's hold. The increased pull of Earth's gravity builds the spacecraft speed up to twenty-five thousand miles an hour as it approaches the atmosphere. The spacecraft will rely on atmospheric friction to slow it down to parachute landing speeds. Once the spacecraft is on the right course for a successful entry into the narrow entry corridor, the service module is jettisoned.

The spacecraft enters with the blunt heat shield forward to absorb and dissipate the five thousand degree Fahrenheit heat that develops. At twenty-five thousand feet a parachute opens and at fifteen thousand feet, three main parachutes open and the spacecraft floats to Earth.

Space Stations

The first step toward the establishment of space stations will be the Manned Orbital Laboratory (MOL). This is the nation's primary manned military space vehicle. The Manned Orbital Laboratory will make it possible for the Air Force to establish the extent to which man can perform military tasks in space. The first Manned Orbital Laboratory will be about the size of a small house trailer, six or seven feet in diameter and less than twenty feet long. The crew will vary with the mission but will be at least three men. Gemini X, an enlarged and modified version of the two-man Gemini, will be developed to serve as the Manned Orbital Laboratory's reentry vehicle. It is to be sent into orbit firmly attached to the Manned Orbital Laboratory and after a two-to-four week stay the crew would use it to return to Earth. A Titan III missile will launch the system.

Following this initial step, a Military Orbital Development Station (MODS) is planned. This station would have five primary missions: (1) general reconnaissance, (2) request reconnaissance of given spots, (3) post-strike reconnaissance, (4) continuous surveillance of an area, and, (5) ocean surveillance.[1] Following this step a Large Orbital Research Laboratory (LORL) is recommended.[2] This "Space Station" would be fourteen stories high and could accommodate up to thirty-six crew members.

By whatever name you call them, these proposals are the first true "Space Stations." General Thomas S. Power, Commander in Chief of the Strategic Air Command, has said:[3]

> We may find that, eventually, the only really survivable command and control structure--not only the Strategic Air Command but all our military forces--would be one employing a maneuverable command post in space. Here, thus, may be the first major requirement for military men in space.

The true space station is not placed in orbit already constructed. Many ferry trips are necessary to place various parts and supplies together to assemble the station. Two outstanding problems to be overcome in establishing a space station are the problem of rendezvous between the station and supply rockets, and the propulsion/weight problem that individual

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[1]MOL-a plus with some minuses, Air Force Magazine, January 1964, p. 16.

[2]U.S. Department of the Air Force, Orbiting laboratory, Contact, June 1964, p. 21.

[3]Office of the Secretary of the Air Force, A command post in space may be needed, Air Force Information Policy Letter for Commanders No. 117, p. 2.

shipments be of sufficient size to permit construction to begin. Manned space stations will probably represent the highest attainment of space technology within the two decades ahead. Many of the functions that could be performed by a space station could also be performed by Earth satellites which are neither large, permanent, nor manned. The unique function of the space station is its use as a base for large space vehicles. Scientific observations incapable of performance in unmanned vehicles will be possible. A space station in a stationary orbit would provide greatly increased capability for nationwide television, global communications, and weather forecasting. Men selected for future lunar and interplanetary missions will train in space stations. But most important of all, the space stations will serve as a base for the assembly of the large vehicles required for manned exploration of the near planets. Plate X shows a concept of this mission. Component parts of the vehicles could be boosted to the vicinity of the station and assembled by crews based in the station. This method would permit the assembly of a space ship of very large size, utilizing boosters no larger than those used to assemble the space station itself.

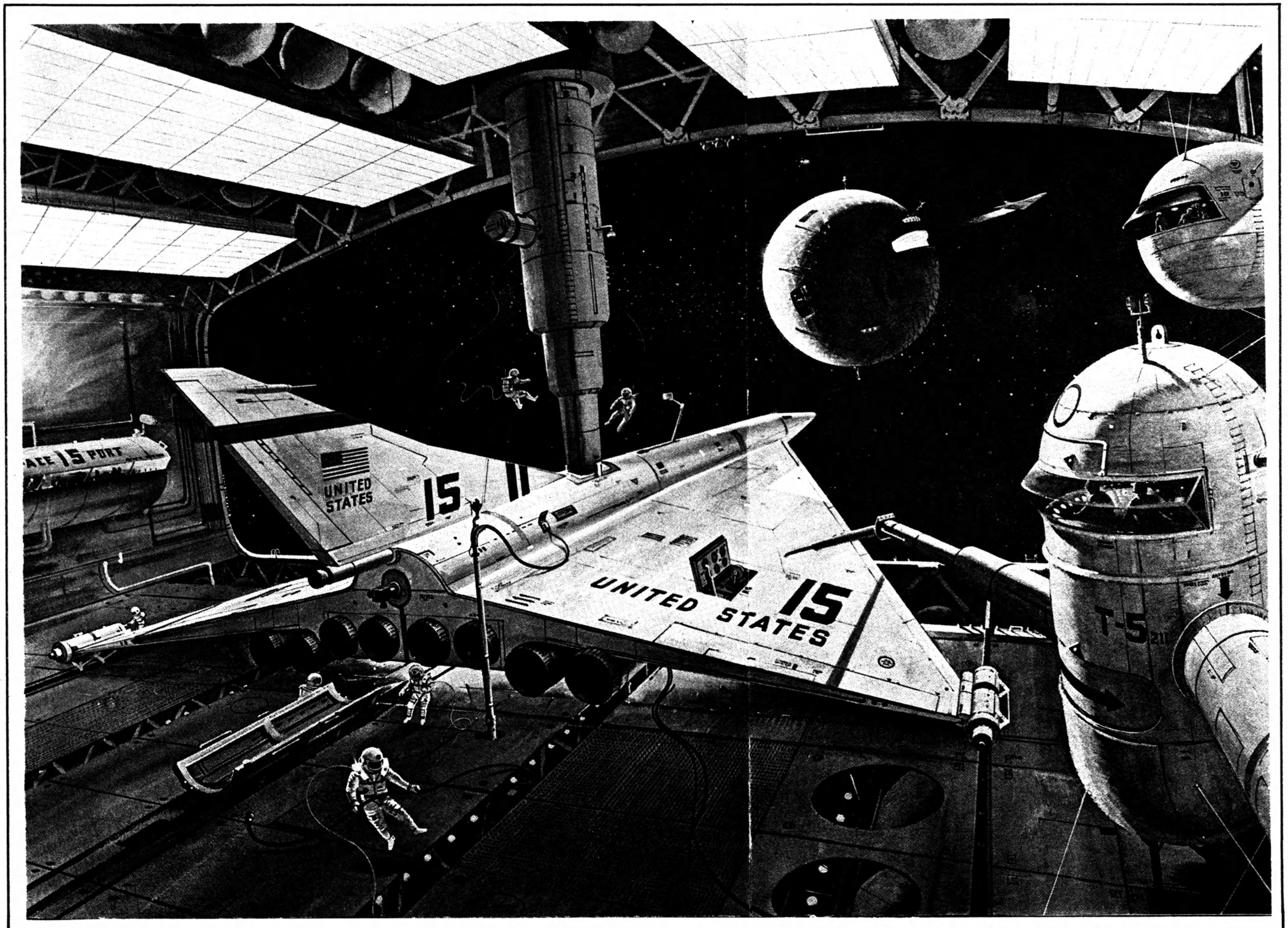
Summary

This, then, is a look to the future missions in space. There are many practical and technical problems to be solved and many of the taxpayers' dollars to be appropriated by a willing Congress. But space will be entered by man and man will gain much knowledge by his actions.

EXPLANATION OF PLATE X

The age of space travel will require the establishment of manned space stations. Plate X is a typical concept of such a station. They will be used as weather stations, astronomical observatories, supply points, data collection centers and training centers for astronauts and scientists. The most valuable use will be as a launch platform for interplanetary spacecraft.

PLATE X



APPENDIX C

SPACE AGE GLOSSARY[1]

Aerodynamics - That field of dynamics dealing with the motion of bodies relative to the air and the forces that act upon them, especially as related to flight.

Aeropause - A portion of the upper region of the atmosphere which does not provide aerodynamic support for either manned or unmanned flight.

Algae - A group of aquatic plants, including seaweeds and many types of one-celled organisms, containing chlorophyll. Some species, being particularly efficient at producing free oxygen from carbon dioxide and water through photosynthesis, are being considered for use in replenishing air and providing food on long space voyages.

Apogee - The high point in an orbit. The apogee refers to the maximum distance away from the earth of an orbital vehicle. It is the opposite of perigee, or point of nearest approach.

Artificial Satellite - A man-made object placed in orbit.

Asteroids - The thousands of minor "planets" which revolve around the Sun, most of them in orbit between those of Mars and Jupiter. Ceres, the largest asteroid, is more than four hundred miles in diameter. Most are probably only a few miles across.

Astrionics - Electronics as applied especially to astronautics.

Astronautics - The art of science of designing, building, and operating space vehicles. The science and technology of space flight.

Astronomical Unit - The mean distance between the earth and the sun. It is used as a yardstick for many astronomical measurements.

Atmospheric Braking - The action of atmospheric drag in decelerating a body that is approaching a planet; can be deliberately used to lose much of the vehicle velocity before landing.

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[1]Erik Bergaust, The next fifty years in space, pp. 243-260: and, NASA, The challenge of space exploration, pp. 45-47.

Ballistic Trajectory - The curved portion of a missile flight path traced after the propulsive force is cut off and the body is acted upon only by gravity, aerodynamic drag and wind.

Barber Chair - (Slang) Adjustable seat for an astronaut.

Beast - (Slang) Big missile or rocket.

Bipropellant - A rocket propellant consisting of two unmixed or uncombined chemicals (fuel and oxidant) fed to the combustion chamber separately.

Bird - (Slang) Any rocket or missile.

Blockhouse - Reinforced concrete structure, located near missile launching pad, which houses special control systems, used by operating personnel to effect the remote control launching of a missile.

Boiloff - The vaporization of liquid oxygen as the temperature of the propellant mass rises during exposure to ambient conditions of the missile tank or other container.

Booster - Auxiliary rocket which provides additional thrust to assist normal propulsion system of vehicle in some phase of its trajectory or flight path.

Brain - (Slang) Missile guidance system.

Burnout - The time at which a rocket engine ceases to burn because of the exhaustion of fuel. The term is distinct from "cutoff" which implies an intentional command cessation of burning. Burnout also is used to describe the rupture of a combustion chamber through excessive heating.

Burnout Velocity - The velocity attained at the time the propellant(s) is (are) exhausted or cutoff occurs.

Captive Test - A test conducted while the missile is secured to a test stand. Primarily intended to verify proper operation of the propulsion and flight control subsystems under full thrust conditions. May also test the operation of any or all of the remaining airborne subsystems.

Celestial Guidance - The guidance of a missile or vehicle by reference to celestial bodies. (The missile is equipped with gyroscopes, telescopes, mechanically or electrically recorded navigational tables, computers and other instruments and devices that sight stars, calculate position, and direct the missile.)

Celestial Mechanics - The study of motion in space, natural or man-made.

Characteristic Length - In propulsion, the ratio of the chamber volume to its nozzle throat area. A measure of the length of travel available for the combustion of the propellants.

Checkout - A sequence of operational and calibrational tests needed to determine the condition and status of a weapon system. Automation is frequently used to shorten the checkout time cycle.

Circular Velocity - The speed required to maintain a body in circular orbit.

Cislunar - Space between the earth and moon.

Command Destruct - A system which destroys the missile, actuated on command of the Range Safety Officer, whenever missile performance degrades enough to be a safety hazard.

Command Destruct Signal - A radio signal initiated by the Range Safety Officer that detonates an explosive in a missile or rocket to destroy the vehicle in flight.

Coriolis Effect - A phenomenon attributed to the earth's rotation which tends to deflect a projectile to the right in the northern hemisphere and to the left in the southern hemisphere.

Cosmic Rays - Atomic nuclei moving at almost the speed of light which rain down continually on the earth's upper atmosphere. Most are protons, the nuclei of hydrogen atoms. Some are nuclei or atoms as heavy as iron. Like other radiations in space, they can be a hazard to space vehicle crews.

Cosmos - The whole of the observed and postulated universe. In the cosmos at large, earth is a minor planet of a not-extraordinary star in the outer portion of one galaxy.

Countdown - The numbered and timed sequence of events and checks that must be made during the last few hours before launching of missile or space vehicle. (Serving to check countless switches, valves, and components to warm up and start subsystems, to check readiness of launch facilities and range stations, antennas and tracking gear, to load propellants, etc., the countdown may last more than 24 hours.) It is measured in T-Time (T minus time prior to initiation of engine start sequence and T plus time thereafter). It is also used to describe the step-by-step process leading to captive tests, flight readiness firings and mock firings.

Cutoff - The shutting off of a liquid or solid propellant combustion process of a rocket engine, thereby causing a rapid drop toward zero thrust. In large rocket engines a significant impulse may occur during the delay from full thrust to zero thrust.

Data Reduction - The process wherein raw data gathered by various electronic and optical devices on a test missile's flight are fed through automatic reduction machines to provide usable information on the missile's performance.

Destruct - The deliberate action of detonating or otherwise destroying a rocket, missile, or vehicle after it has been launched, but before it has completed its course.

Destruct Line - A graphic representation drawn on a geographical map to show the boundary which a missile must not cross during flight. These lines are all superimposed on maps, in pairs, and together define the space corridor in which missiles may fly. A missile which moves beyond the destruct line on either side is destroyed by the Range Safety Officer.

Doppler Effect - The apparent change in frequency of a sound or radio wave reaching an observer or a radio receiver, caused by a change in distance or range between the source and the observer or the receiver during the interval of reception.

Dovap - An abbreviation for "Doppler Velocity and Positions," DOVAP is a system consisting of a ground transmitter station and a series of ground receiving stations which operate in conjunction with a transponder in the missile. Function of the system is to obtain information on the position and velocity of the missile. The Doppler effect principle (above) is employed.

Eccentricity - The degree of deviation from a circular orbit.

Ecliptic - The plane of earth's orbit around the sun.

Electromagnetic Radiation - Radiations comprising the full "electromagnetic spectrum" from radio waves to infrared, visible light, ultraviolet rays, X-rays and gamma rays. They are all the same "family" of radiations but different in wavelength. Radio waves are longest in wavelength, gamma rays shortest.

Elephant Ear - (Slang) Thick metal plate that reinforces a missile's skin.

Escape Velocity - The minimum velocity required for a rocket, missile, or other object to escape the gravitational attraction of a planet or other spatial body. The earth's escape velocity is nearly seven miles per second (about 25,000 mph): the moon's is about 1.5 miles per second (5,400 mph).

Exotic Fuel - New fuel combinations, currently under development, intended to provide greater thrust than propellants now in use.

First Motion - In guided missile terminology, the first indication of motion of the missile or test vehicle from its launcher. It is synonymous with "take-off" for vertically launched ballistic missiles.

Fission - The release of nuclear energy through splitting of atoms.

Flares, Solar - Sudden disturbances on the sun's surface in the source of which high-energy particles are shot toward earth. Solar Flare Radiations are considered among the greatest potential dangers to space travelers within the solar system.

Free Fall - The motion of any unpowered body traveling in a gravitational field.

Fusion - The release of nuclear energy through uniting of atoms.

G-Force - The force exerted on an object by gravity or by an acceleration. One G is the measure of the gravitational pull exerted on a body by earth at approximately sea level.

Galaxy - Gigantic aggregation of stars of which our sun is one star among probably 100,000,000,000 or so. What we see in the heavens as the "Milky Way" is the galaxy as it appears from earth. A galaxy is any comparable star system.

Gantry - A crane-type structure, with platforms on different levels, used to erect, assemble, and service large rockets or missiles. It may be placed directly over the launching site and rolled away before firing.

Garbage - (Slang) Rocket parts that go into orbit along with a satellite.

Gimbaled Motor - A rocket motor mounted on a movable frame, or gimbal. It corrects for pitching and yawing rotation movements to steer a missile.

Grain - A body of a solid propellant, formed in a particular shape and size to provide even burning.

Ground Start - A propulsion starting sequence through ignition to main stage which is initiated and cycled through to completion on the ground. This is in contrast to an in-flight or "air" start where the starting sequence and power buildup occur in flight at some time after launch. In large rocket vehicles this ground start is commonly effected from pressurized propellant tanks external to the missile, permitting the vehicle to take off with its internal propellant load intact.

Guidance - The process of intelligent maneuvering which causes a missile or other vehicle to reach a specified destination. Guidance is accomplished by control in two phases: Attitude control and path control. The general term "guidance" includes the entire scheme, i.e., sensing devices,computers, and the servo systems necessary to convert the calculated guidance commands into vehicle response. Guidance may be separated into phases of the flight path as: initial, midcourse, and terminal. Essentially there are eight basic guidance systems: preset, terrestial reference, radio navigation, automatic celestial navigation, inertial, command, beam rider and homing.

Guidance, Beam Rider - A scheme of guidance in which the missile follows a radar beam to the target by means of on-missile computers and controls which are sensitive to radar beams.

Guidance, Celestial - A form of navigation using the celestial bodies as reference points much the way early sailors used the stars as navigational aids.

Guidance, Command - A system of guidance in which the vehicle is directed in its flight path by radio commands from a ground station.

Guidance, Homing - A system wherein a missile steers itself toward a target by means of a self-contained mechanism which is activated by some distinguishing characteristic of the target.

Guidance, Infrared - A method of reconnaissance of targets and navigation using infrared heat sources.

Guidance, Midcourse - The guidance applied to a missile between the termination of the launching phase and the start of the terminal phase or guidance.

Guidance, Preset - A technique of missile control wherein a predetermined path is set into the control mechanism of the vehicle and cannot be adjusted after launching.

Guidance Station Equipment - The ground-based portion of the ballistic missile guidance system necessary to provide ground-based guidance during missile flight; ground station equipment specifically includes the tracking radar, the rate measuring equipment, the data link equipment, and the computer and test and maintenance equipment integral to these items.

Guidance System - A system which measures and evaluates flight information, correlates this with target data, and converts the resultant into parameters necessary to achieve the desired flight path of a missile and communicates this data in the form of commands to the missile flight control system. A guidance system may be self-contained within the missile, or the guidance function may be performed by various combinations of ground and airborne components.

Guidance, Terminal - The guidance applied to a missile between the termination of the midcourse guidance and impact.

Guidance, Terrestial Reference - A technique of missile control wherein the predetermined path set into the control system of a missile can be followed by a device in the missile which reacts to some property of the earth, such as magnetic or gravitational effects.

Guided Missile - An unmanned vehicle moving above the earth's surface, whose trajectory or flight path is capable of being altered by a mechanism within the vehicle. Following are some types of guided missiles (preceded by their basic designations, in which the first letter designates the origin of the missile and the second letter designates the objective):

AAM - Air-to-Air Missile
ASM - Air-to-Surface Missile
AUM - Air-to-Underwater Missile
SAM - Surface-to-Air Missile
SSM - Surface-to-Surface Missile
SUM - Surface-to-Underwater Missiles
UAM - Underwater to Air Missile
USM - Underwater-to-Surface Missile

Gyroscope - A device consisting of a wheel so mounted that its spinning axis is free to rotate about either of two other axes perpendicular to itself and to each other; also the wheel of this device. (The characteristic of a gyroscope to maintain equilibrium makes it a useful component for many aircraft instruments.)

Hard Base - Launching base that is protected against a nuclear bomb by a structure or terrestrial cover (natural or man-made tunnel): the structures are designed for a specified amount of overpressure.

Hold - A pause in the launching or testing sequence or countdown of a missile or space vehicle. Pauses may be scheduled (i.e., to meet scheduled lift-off time) or unscheduled (i.e., weather, equipment malfunction).

Hypersonic - Speeds faster than Mach 5.

ICBM - Abbreviation for Intercontinental Ballistic Missile. ICBM range is normally considered 5,000 miles or more. The Atlas, Titan and Minuteman are designated ICBM's.)

Igniter - A device used to initiate burning of a fuel mixture of a propellant in a ramjet or rocket combustion chamber.

Ignition - The initiation of combustion of a rocket motor. During the ignition phase, a supporting flame is maintained and a low flow rate of primary propellants is begun. As soon as the propellants are burning properly, either an automatic or manual changeover to maximum performance burning is begun.

Impact Predictor - A system which predicts the exact area in which a missile would impact during powered flight if its engine thrust were terminated. The impact predictor at Cape Canaveral is composed of three principal elements: (1) The Azusa tracking system, (2) an IBM 709 highspeed digital computer, and (3) a plotting board in the Cape Central Control building. Position data received by the Azusa are automatically relayed to the computer. The computer's output is relayed by cable to a plotting board monitored by the Range Safety Officer in Central Control. If it appears that the missile is approaching an unsafe area, the flight is terminated.

Inertial Guidance - A system for guiding rockets or other vehicles by using acceleration-sensing devices to measure each change in velocity or direction. From this data, other instruments deduce the vehicle's correct position and flight path and, if necessary, call for corrections in course.

Ion Propulsion - Rocket propulsion achieved by recoil from the ejection of high-velocity charged particles. Ion rockets have been proposed for use in interplanetary journeys. Because of their low thrust, they would not be suitable for lifting a vehicle directly from the planet's surface.

Ionosphere - That portion of the earth's atmosphere, beginning about thirty miles above the earth's surface, which consists of layers of highly ionized air capable of bending or reflecting certain radio waves back to the earth.

IRBM - Abbreviation for Intermediate-Range Ballistic missile. IRBM range is usually considered about 1,500 miles. (The Thor, Jupiter, and Polaris missiles are designated IRBM's.)

Kick in the Apogee - (Slang) Raising a satellite's orbit by firing a rocket engine at its point of maximum altitude.

Launch - The initial motion in transition from static repose to dynamic flight. The moment when the missile is no longer supported by the launcher. The take-off.

Launch Complex - A general term intended to include all support facilities within a confined area which are vital to missile preflight checkout and launching. The combination of blockhouse, launch pad, and nearby supporting facilities are referred to as a "launch complex", since they are all contained within a relatively small area and all support the ultimate launching.

Launch Pad - A concrete or other hard surface area on which a missile launcher is positioned.

Launcher - A mechanical device, either mobile or stationary, which rigidly "cradles" or supports a missile in its proper launching position until the missile is launched. It directs the missile in the desired direction of flight during initial motion, but does not itself propel the missile.

Lift-Off - Initial movement of a ballistic missile or space vehicle. (When applied to aerodynamic, or cruise missiles, this action is known as the "take-off.")

Liquid Propellant - Any liquid ingredient fed to the combustion chamber of a rocket engine.

Lox - Abbreviation for liquid oxygen. Used as a common oxidizer in liquid propellant rocket engines, it is oxygen super-cooled so that its physical state is liquid.

Lunar - Of or pertaining to the moon.

Main State - In the ignition sequence of a liquid propellant rocket, full thrust burning cannot be attempted immediately In the early rocket motors the ignition began with an electrically ignited squib around which a small amount of propellant, a second step called primary stage burning was entered. In this step both propellants at limited flow rates were ejected into the combustion chamber. When burning appeared normal to a visual observer, a command would be given for full thrust, or so called main-stage burning. This was the full thrust level burning which would result in lift-off of the rocket.

Module - A combination of components, contained in one package or so arranged that together they are common to one mounting, which provides a complete function or functions to the sub-systems and/or systems in which they operate. Sometimes called Black Box, a vernacular term which should not be used.

Nose Cone - Assembly at the forward end of a missile (or rocket vehicle) from which it is separated at the end of propelled flight. (In a research space vehicle, the nose cone contains the satellite and instrumentation equipment; in a military missile, the nose cone carries the warhead.)

Orbit - The path in which a celestial body revolves about moving in a closed orbit around the sun, planet, or other celestial body. Orbital velocity of the earth is 18,000 mph.

Pacific Missile Range - The instrumented range used by the Air Force Ballistic Missile Division for tracking missiles and which extends many thousands of miles from Vandenberg Air Force Base, California, southward down the Pacific Ocean. Similar to the Atlantic Missile Range only in the sense that optical and radio tracking devices are placed along the range on islands and aboard ships, PMR's mission is operational testing of missile weapon systems and satellite research.

Pad - A permanent or semipermanent load-bearing surface constructed or designed as a base upon which a launcher can be placed. Short for Launch Pad.

Pad Chief - The individual charged with coordinating overall operations on the pad.

Pad Safety Officer - The individual responsible for maintaining safety practices during the launching operation. This includes such areas as fueling, arming of destruct packages, etc.

Payload - In a missile, the warhead, fuse, and container. In research and test vehicles, this includes equipment for taking data and transmitting (or otherwise recovering) it.

Perigee - That point in an orbit nearest the earth. It is the opposite of apogee, or point in an orbit farthest from the earth.

Prelaunch tests - Tests of missile and/or ground equipment to determine readiness to launch. May include a countdown and a flight readiness firing with all launch complex equipment operating, but not including actual launching of the missile.

Probe - An unmanned projectile sent into space to gather information.

Propellant - An energy-yielding material used to drive a vehicle. It may be either in liquid or solid form. If liquid, it may consist of one or more materials (although it generally contains two: fuel and the oxidizer).

Radar - An electronic device which transmits bursts of radio energy and receives reflections of that energy from objects. The time consumed in the transmission-reflection cycle is accurately measured and converted to distance (range) from the radar to the objects. The highly directional nature of radar beams enables an accurate determination of direction to the object from the radar. The distance and direction information is presented on instruments allowing an operator to locate accurately in space. The word was derived from a contraction of the phrase "Radio Direction and Ranging."

Recovery - The act of retrieving a portion of a launched missile or satellite which has survived reentry.

Reentry Vehicle - A ballistic missile subsystem which was originally called the "nose cone." It normally is understood to include a heat shield, a warhead, an arming and fusing system, a reentry attitude control system, when necessary, and some device for separation of the reentry vehicle from the main missile structure.

Retro-rocket - A rocket fitted on or in a vehicle that discharges counter to the direction of flight, used to retard forward motion.

Rocket - A thrust-producing system, or a complete missile, which derives its thrust from ejection of hot gases generated from material carried in the system, no required intake of air or water. (Rockets may be of either liquid or solid propellants.)

Satellite - An unpowered object in space which revolves about another body.

Satelloid - An artificial body or vehicle like an artificial satellite except that it is under engine thrust (intermittent or continuous) in its orbit.

Scrub - Missile jargon for the act of canceling a scheduled launch.

Sequencer - A timing device which starts and stops instrumentation equipment according to a preset timed schedule. It may also be used to control automatically missile preflight operations and checkouts of the "countdown."

Sky Screen - An element of equipment used by the Range Safety Officer. The sky screen (either electronic or optical) provides a positive indication to the Range Safety Officer whenever the missile deviates from its planned trajectory. In operational use, one sky screen is used to monitor flight azimuth, and another is used to monitor vertical programming.

Soft Base - An installation on which facilities are functionally designed to accomplish an assigned mission without being constructed to resist overpressure, heat, radiation, or penetration of other weapon effects to be anticipated under enemy attack.

Static Firing - The testing of all operational functions of a missile, including ignition and run-up of the propulsion stages while the missile is tied down to its test stand.

Static Tests - Ground tests intended to investigate the structural integrity of a missile. Sometimes used as synonymous with Captive Test.

Stratosphere - A calm region of the upper atmosphere characterized by little or no temperature change with a change in altitude. The stratosphere is separated from the lower atmosphere, or troposphere, by the tropopause. An important part of the stratosphere is ozone, which plays a vital role in the phenomenon of selective absorption and seems to have a significant correlation with surface weather conditions. The stratosphere is free from the clouds and convestive currents of the troposphere.

Telemetering System - A method of taking measured values within the missile and transmitting these values electronically to a ground station. The information received at the ground station can be used to evaluate the internal performance of a missile in flight.

Telemetry - Telemetry is the radio link between a missile and the ground station used to transmit information described (above) under the telemetering system.

Theodolite - Basically, an accurate surveyor's transit. On the range a conventional transit or theodolite is ill adapted to recording missile position during flight. Accordingly, the theodolites for range use have evolved into cine-theodolites and photo-theodolites. The latter differ from cine-theodolites in that the cine camera is replaced by a precision, fixed (glass) plate camera in which a large field is viewed and multiple exposures are made on the arc plate of the missile as it moves through the field of view. A cine-theodolite is locked in position during the photographic recordings.

Throat - In rocket and jet engines, the most constricted section of an exhaust nozzle. At the throat gas flow velocities (for supersonic flow rates) always equal sonic velocity. After the throat, the nozzle expands and flow velocities increase to supersonic values.

Thrust - The driving force exerted on a rocket or missile by its jet or rocket engine or engines, or other propulsive force.

Thrust Decay - When a rocket motor burns out or is cut off, propulsive thrust does not fall to zero instantaneously, but progressively declines over some fraction of a second. This graduated reduction and loss of thrust is known as "thrust decay."

Trajectory - The path described by a space vehicle.

Transponder - An electronic device that receives a challenging signal and automatically transmits a response. The transponder consists of a receiver, which receives the signal impulses, and a responder (or transmitter) that returns signal impulses to the interrogator-responser.

Tropopause - The boundary or transition zone between the troposphere and the stratosphere.

Troposphere - The lower layer of the earth's atmosphere, extending from the surface of the earth to an altitude of ten miles. Although the composition of the air remains more or less constant, its density decreases rather rapidly with altitude; 75 percent of the atmosphere's weight is found in the troposphere.

T-Time - The time of lift-off (or take-off) of a missile from its launch pad.

Umbilical Cord - A cable fitted to the missile with a quick disconnect plug, through which missile equipment is controlled and tested while the vehicle is still attached to launching equipment. The umbilical cord is detached at or just prior to lift-off of the missile and is supported by the umbilical tower.

Vernier - A rocket engine of small thrust used in a ballistic missile to control the roll, pitch, and yaw attitudes during propelled flight and to make the final adjustment of the missile's velocity and trajectory just after the thrust of the final stage main engines has been cut off.

Warhead - Normally, that part of a missile containing an explosive, chemical, or other charge intended to damage the enemy.

Weightlessness - Lack of resistance to the influence of gravity.

APPENDIX D

SPACE BUILDING BLOCKS

Launch Vehicles

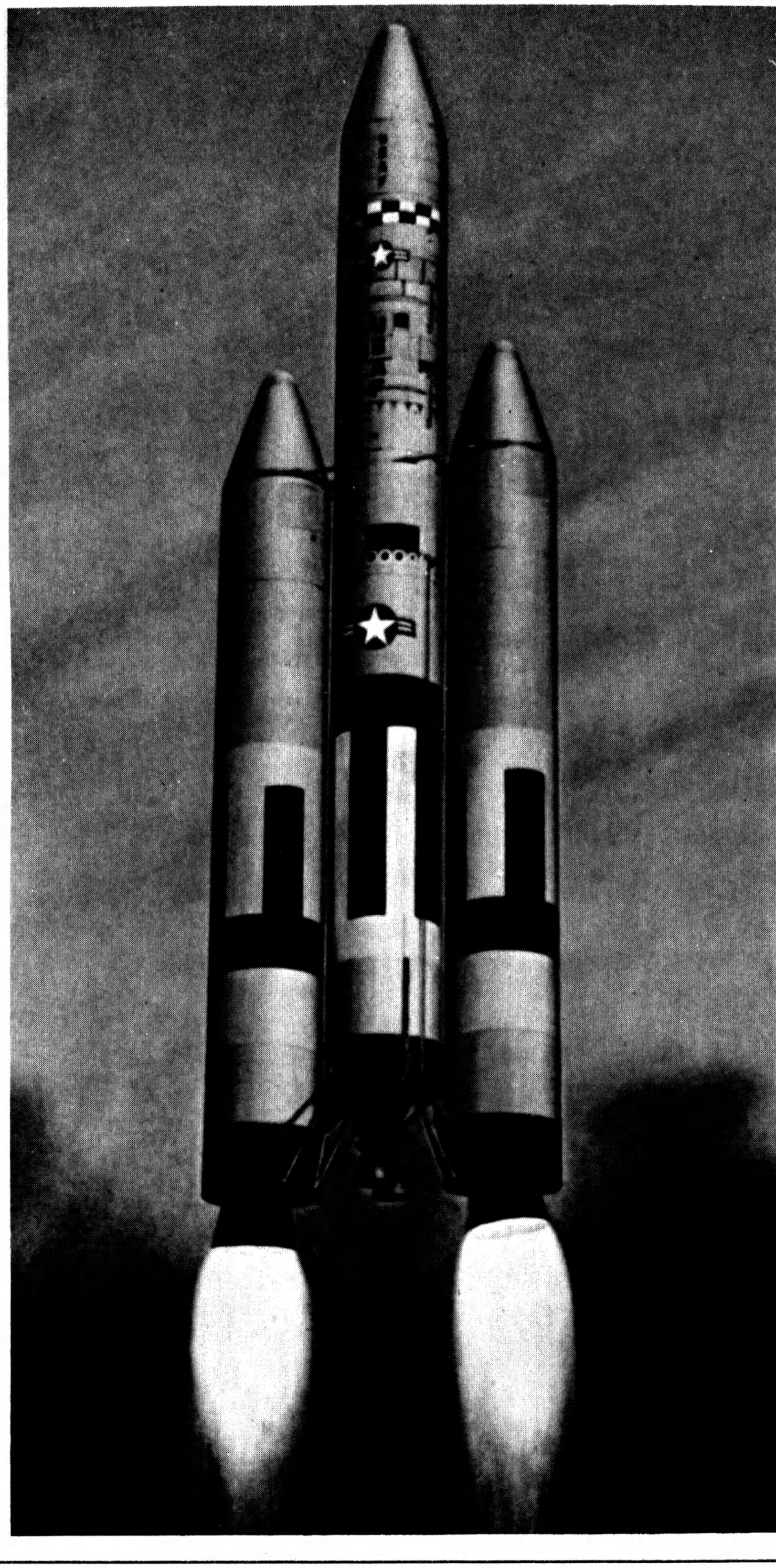
Currently advanced work is in progress on two major missiles, the Titan III and the Saturn series. The Titan III is a standardized space launch system capable of performing a variety of manned and unmanned booster missions. It will launch the USAF's Manned Orbiting Laboratory. Total thrust capability is about three million pounds. Titan III will employ an integrate-transfer-launch (ITL) complex which permits the missile to be completed, assembled, and checked out in the assembly area, then move intact to a simplified launch pad. This reduces the time on the pad and the number of pads required. The Titan III missile height is one hundred twenty feet, diameter is thirty feet, and launch weight is more than six hundred tons. Fuel is in the solid state in the outboard engines and is liquid in the main central chamber. PLATE XI is an artist's conception of Titan III in flight.

Two heavy space vehicles are being developed by the National Aeronautics and Space Administration under the project name "Saturn." The Saturn project is providing vehicles capable of sending payloads of many tons into earth orbit, to the moon and into deep space. A main purpose of the project is manned space exploration, including the landing of men and equipment on the Moon within the current decade. The first version of the rocket, called Saturn I, has a booster developing one and one half million pounds thrust. The current largest version is the Saturn V. This latter configuration uses five one million five hundred thousand pound thrust engines to provide seven and one half million pounds of thrust in the first stage and five two hundred thousand pound thrust engines in the second stage. The first stage is over thirty-three feet in diameter and eighty-two feet long. Total height is over three hundred sixty feet. Plate XII shows a Saturn V missile. The vehicle uses liquid hydrogen and liquid oxygen fuels.

EXPLANATION OF PLATE XI

This plate indicates the Titan III immediately after launch.

PLATE XI



EXPLANATION OF PLATE XII

A cutaway drawing of the Saturn V vehicle.

(1) Five rocket engines which power the first stage.

(2) Curved bulkhead, top of kerosene tank.

(3) Paddle-shaped baffles used to reduce oxygen turbulence which would interupt flow.

(4) Bottles, mounted on ribbed aluminum wall, contain helium released to maintain oxygen pressure.

(5) Five rocket engines which power the second stage. Spherical containers hold helium to start fuel pumps.

(6) Curved bulkhead which separates liquid oxygen and liquid hydrogen fuels.

(7) Fuel line on outer skin which carries hydrogen to engines.

(8) Tapered skirt which covers base of third stage.

(9) Retrorocket which pulls skirt free before third stage fires.

(10) Egg-shaped tank which holds liquid oxygen.

(11) Spheres which contain helium to pressurize hydrogen tank.

(12) Tube that bypasses liquid hydrogen around oxygen tank.

(13) LEM, stored with legs folded on top of hydrogen bulkhead.

(14) Capsule where astronauts ride.

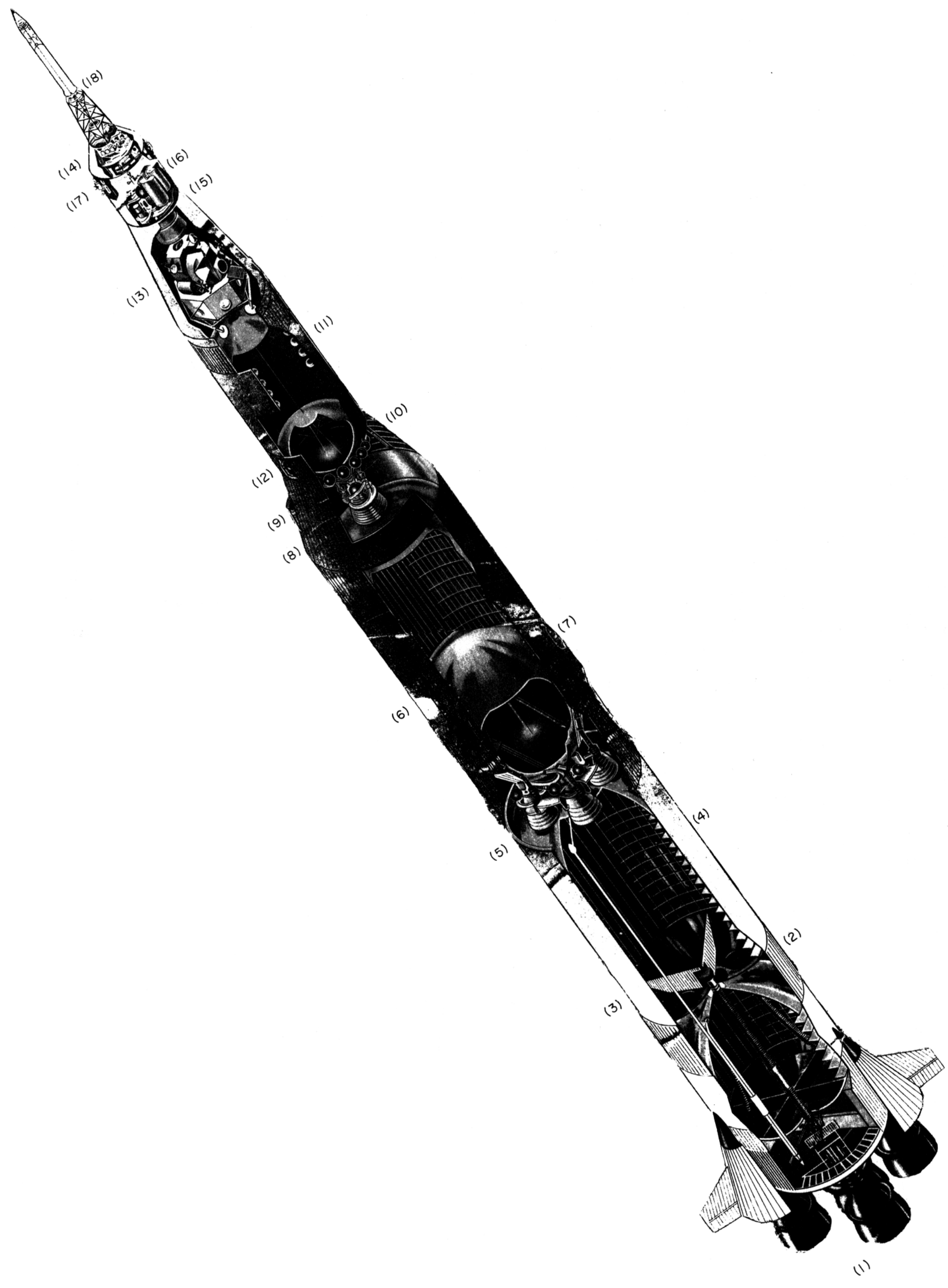
(15) Capsule engine.

(16) Service module which supplies fuel to capsule engine.

(17) Uutboard rocket engines that control flight of capsule.

(18) Escape towers used to remove capsule if emergency conditions prevail during initial launch from earth.

PLATE XII



Space Propulsion and Power

During the next decade, liquid propellant rockets will be the primary propulsion systems for orbital boosters and for vehicles maneuvering in space. Two concepts will be followed in the future for the development of larger booster vehicles: (1) the clustering of previously tested and accepted engines and (2) the development of large single-chamber engines. Total clustered thrust levels of boosters under development will reach twenty-five to sixty million pounds by 1972.

Nuclear rockets are presently under development. The very high specific impulse of a nuclear engine makes it suitable for use in missions which no other propulsion system can accomplish. The first nuclear rocket will be used as an upper stage on the Saturn missile. The nuclear rockets will use reactors to impart heat to liquid hydrogen, which will provide thrust as it expands rapidly and is expelled through the rocket nozzle. This differs from liquid chemical engines in that no oxygen is needed to produce the heat to transform the hydrogen from liquid to a gas. The fissioning process of the reactor produces the heat.

Fuel-stingy, low-thrust ion engines to keep space stations in proper orbit and to make slow orbit changes are in the experimental stage. But the most promising propulsion system is the so-called photonic propulsion. Photonic propulsion will, perhaps, make it possible for the speed-of-light barrier to be penetrated. The photonic rocket consists of a chamber in which hydrogen or some other suitable gas is smashed in a fusion process, like the principle used to explode the hydrogen bomb. The ionized particles that result from this process are made to escape through the rocket nozzle in a stream of light particles or photons. Since photons are traveling at the speed of light, the space vehicle itself, theoretically, also can obtain this velocity inasmuch as every action has an equal reaction.

The principle of ion propulsion has been described by many scientists as the ultimate in propulsion devices that could eventually send a manned spacecraft to Mars at a speed of two million miles a day. An ion engine's special characteristic is its need for far less fuel to produce a pound of thrust than a conventional chemical rocket; however, it has such a low initial thrust that it cannot boost a space vehicle from the earth's surface. This will probably be accomplished by the chemical rocket engine.

Space Weapons

A variety of space weapons are being studied. Some which have been mentioned publically are: pellets accelerated by high-explosive charges, focused nuclear weapons of relative small yield, electronic countermeasures gear, and electronic counter-countermeasures equipment. Lasers are in an early experimental stage.

Bioastronautics

Another building block is the science of bioastronautics. Bioastronautics is the science of living organisms and the effect of space on them. Currently astronauts are prepared for space travel by excellent physical conditioning. To date this has been sufficient even though the medical doctors are seeking the Optiman.[1]

> --a man whose outward appearance is quite normal, but who has been adapted to the oxygen requirements of a Himalayan Sherpa, the heat resistance of a walker-on-coals, who needs less food than a hermit, who has the strength of a Sonny Liston, and runs the mile in 3 minutes flat while solving problems in tensor analysis in his head.

Astronauts of this quality are, as yet, rare. However, this is not the ultimate goal sought. Going far beyond Optiman or any similar proposal is the concept of the Cyborg (for cybernetic organism). The study has been described by Life magazine as follows:[2]

> Cybernetics is the study of the relationship between computing machines and the human nervous system. It deals with the art of handling vast quantities of information, running the data through complex computing systems which then feed back new and useful data. To run an automated oil refinery, for example, data are constantly being absorbed and fed back in order to carry out all the intricate industrial processes involved. There are scientists who now believe that the human body could be run cybernetically--i.e., it could be automated--in a similar fashion, though the job would be much harder.

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[1]Rosenfeld, Albert. Pitfalls and perils out there. Life, October 2, 1964, p. 122.

[2]Ibid.,pp. 122-124.

> The Cyborg, though cybernetically controlled, would be a human being . . . A cyborg would still look like a man, but an unearthly one indeed. He would be encased in a skintight suit, needing no pressurization because his lungs would be partially collapsed and the blood in them cooled down, while respiration--and most other bodily processes--would be carried on for him cybernetically by artificial organs and senses, some of them attached to the outside of his body, some of them implanted surgically. His mouth and nose, too, would be sealed over by the suit, because he would not need them to breathe with. Cyborgs would communicate with one another by having the electrical impulses from their vocal cords transmitted by radio. The artificial organs--actually a tiny, complex computer system constantly receiving and feeding back information to regulate the body of its changing environment--would keep a Cyborg's metabolism steady despite radical fluctuations in external temperatures and pressures. The Cyborg could travel in an unsealed cabin through the vacuum of space, walk around on the moon or on Mars protected from heat, cold or radiation by a variety of chemicals and concentrated foods being pumped directly to the stomach or bloodstream. Wastes would be chemically processed to make new food. The tiny bits of totally worthless waste matter would be deposited automatically in a small canister carried on the back.

Rendezvous and Docking

Project Gemini is the first major step on the road to the rendezvous and docking of two vehicles in space. This program is highly important. Techniques to be developed are mandatory for the resupply and crew change requirements of future space stations either in orbit or on other planets. Launch at a precise time, midcourse flight-path correction, terminal guidance and control as the two vehicles approach each other, the final docking maneuver, and the ability of crews to operate outside their spacecraft are all basic necessities to successful space operation.

Reentry, Recovery and Landing

Much advancement in this field is necessary, particularly to reduce costs. As a vehicle is fired into orbit all but the basic payload is lost to the sea or is consumed during reentry. No less important is the reentry, recovery and landing of the payload, manned or unmanned.

Communications

Instantaneous, secure, and reliable communications are vital. Requirements for higher message volume and greater transmission distances will be placed on space systems. Radio, television, and public communications will all be greatly improved in quantity and quality in the future decades.

Ground Facilities

Ground facilities vary from the launch pad to the assembly office.[1] The city planner is most interested in these items and is probably the most unfamiliar with the requirements. Involved directly with the vehicle are ground control stations, tracking networks, large computer facilities for programming and controlling launch, flight and reentry operations and assembly and test facilities.

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[1]See Chapter V, pp. 50-67.

Understanding the Environment

This is a vital and continuing process, and good progress has been made. The Air Force in its Discoverer satellite series contributed much important basic data. The National Aeronautics and Space Administration Goddard Research Center continues to advance basic knowledge. Work in the future will include study of solar flares, the Van Allen radiation belts, the incidence and effect of meteoroids and the peculiarities of the upper atmosphere. These areas must be thoroughly understood before the space program can advance.

APPENDIX E

SIX BASIC LAND USE CATEGORIES

The Air Force presently places all identifiable facilities in a code system for file and reference. The system is outlined and procedures explained in various Air Force manuals. The principal listing manual is Air Force Manual 85-27, Real Property Standard Codes and Nomenclature.

Here the listings in this manual are categorized in one of the six basic land use categories previously discussed in Chapter III. The following listings indicate the recommended division. The code numbers provide a means of correlating the results of all Air Force bases and their activities from the initial planning stages through the complete cycle of programming, construction, inventory, accountability and facility maintenance. Since the system is automated, the descriptive nomenclatures are limited in length in order that they can be properly imprinted on the punch cards. The standard Air Force abbreviation in this nomenclature is indicated. Further information may be obtained from Air Force Manual 85-27.

Section A--Airfield/Missile Launch Land Use

Basic Item No.	Nomenclature
111-112	RUNWAY, CROSSWIND
111-113	RUNWAY, INSTRUMENT
111-114	RUNWAY, MINOR
111-116	RUNWAY, PARALLEL
111-117	R/W, PRIM/INSTR
111-118	RUNWAY, PRIMARY
111-119	RUNWAY, OVERRUNS
112-212	TAXIWAY, ALERT
112-213	TAXIWAY, APRON ACCESS
112-215	TAXIWAY, R/W ACCESS
112-217	TAXIWAY, SUPPORT
113-322	APRON, HANGAR ACCESS
113-323	APRON, LOADING
113-324	APRON, OPERATIONAL
113-325	APRON, DEPOT MAINT
113-327	APRON, BASE FLIGHT
113-328	APRON, TRANSIT
113-329	APRON, OPER ALERT
116-641	SHOULDER, STABIL
116-642	PAD, BLAST
116-652	HARDSTAND, CALIBRATION
116-654	HARDSTAND, DISPER FUEL
116-656	HARDSTAND, DISPER PARK
116-661	PAD, ARM & DISARMING
116-663	PAD, HELICOPTER
116-664	PAD, POWER CHK
116-666	PAD, WARMUP-HLDG
116-668	PAD, LAUNCHING
116-672	CORROSION CONTL A/C
116-922	BARRIER, A/C ARREST
116-933	BUTT, FIRING-IN
116-945	DEFLECTOR, BLAST
121-115	AVFUEL DISPENSING
121-122	HYDRA FUEL, AVFUEL
121-124	HYDRA FUEL BLDG
133-313	DIR/FINDING, HF
133-314	DIR/FINDING, UHF
133-315	DIR/FINDING, VHF
134-332	GCA SEMI-MOBILE
134-225	GCI
134-338	GCA VAULT
134-352	ILS
134-373	TURNTABLE, RADAR
134-374	PRECISION RADAR
134-375	RAPCON CENTER
134-376	AREA SEARCH RADAR
134-394	RACON
134-422	RADIO BEACON, FAC
134-445	RADIO RANGE, L/F
134-465	TACAN STATION, FIXED
134-467	TACAN STATION, MOBILE
134-473	TOWER, NAVAID
134-482	VHF-TVOR
134-484	VHF-OMNI-DIR-RANGE
134-678	WIND DIR INDICATOR
136-635	LIGHT, BEACON
136-661	LIGHTING, APPROACH
136-662	LIGHT, OBSTRUCTION
136-664	LIGHTING, R/W
136-666	LIGHT, AFLD, SPECIAL
136-667	LIGHTING, TAXIWAY
141-141	FIRE STATION, LINE
141-144	FIRE STATION, LINE/STR
141-172	G/M AUTONAVIGATOR FAC
141-173	G/M ERECTOR ENCL
141-175	G/M LAUNCH CONTROL
141-177	G/M SHELTER
141-181	AIRCRAFT SHELTER
141-183	HANGAR, ALERT
141-232	MISSION STAGING OPS
141-453	OPERATIONS, BASE
141-454	OPERATIONS, SPECIAL
141-459	READINESS, CREW
141-472	GARAGE, AMBULANCE
141-621	WEATHER, CEILOMETER
141-622	WEATHER, MODULATOR
141-624	RADAR, CLOUD HGT MEAS
141-625	RADAR, HORIZ VISIBILITY
141-626	WEATHER, RAWINSONDE
141-627	SHELTER, INSTR WEATHR
141-628	WEA TRANSMISSOMETER
141-629	REPRE, WEA OBS STA

Basic Item No.	Nomenclature
141-631	RADAR STORM, DETECT
141-632	TEMP, REL, HUMID, MEAS
141-633	WIND, MEAS SET
141-753	SQUADRON OPERATIONS
141-782	TERMINAL AIR FREIGHT
141-783	TERM AIR FRGHT/PASS
141-784	TERMINAL, AIR PASS
141-785	FLEET SERVICE
141-813	H/C TARGET STORAGE
141-911	MISSILE OPS BLDG
149-511	GUIDANCE STA, P/AC
149-512	MISSILE LAUNCH FAC
149-514	GUIDANCE STA, MISSILE
149-516	GUIDANCE STA, AIRCRAFT
149-952	TOWER, CONTROL
211-111	HANGAR, MAINT, FIELD
211-112	HANGAR, MAINT, ORG
211-116	HANGAR, RESRV FORCES
211-119	HANGAR, RESRV FORCES
211-147	SHLTR, A/C WEAPON CAL
211-152	SHOP, A/C GENRL PURPS
211-154	SHOP, A/C MAINT ORG
211-157	SHOP, A/C ENG I&RPR
211-158	SHOP, A/C PERIODIC MT
211-159	A/C COR CCNT COV
211-173	MAINT, DOCK LARGE A/C
211-175	MAINT, DOCK MED A/C
211-177	MAINT, DOCK, SM A/C
211-183	TEST CELL
211-193	TEST STAND
390-485	M/THEODOLITE STA
390-532	M/LAUNCHING TEST FAC
390-551	M/LANDING TEST FAC
390-611	PROPUL ENG/T, FUEL
390-612	PROPUL ENG/T, STAND
390-614	PROPUL ENG/T, CELL
610-129	ADMIN WG MAINT CTROL
932-584	REVETMENT, HANGAR

Section B--Industrial Land Use

Basic Item No.	Nomenclature
122-111	MARINE DISP SYS
123-335	VEHICLE FUELING STA
125-554	PIPELINE, LIQUID FUEL
125-977	PUMP STA, LIQ FUEL
126-925	L/F FILL STAND, TRUCK
126-926	L/FUEL STAND, UNLOAD
141-112	AA FAC
141-154	CRASH BOAT CREW STA
141-391	RAD TRANS/COMPUTER
141-392	RAD TRANS BLDG
141-393	SCANNER BLDG
141-411	RADOME TWR BLDG
141-421	RADAR TWR BLDG
141-465	UPS, URD, CONTROL PT
141-763	TECHNICAL LABORATORY
141-765	LAB QUAL CONTROL DEP
141-766	TECH LAB L/FUEL ANAL
141-912	RE-ENTRY VEHIC BLDG
141-913	SPEC FUEL FAC
141-914	MISSILE GUID FAC
149-811	TUNNEL
149-963	TOWR, CRASH BOAT, CTRL
149-965	TWR, TEXAS, PLATFORM
149-967	TOWER, OBSERVATION
149-968	TOWER, SPECIAL
151-153	PIER, CARGO
151-155	PIER, L/FUEL UNLOADG
152-111	WHARF
154-452	WATER FRT IMPR

Basic Item No.	Nomenclature
159-353	WHSE, TRANSIT CARGO
163-212	BUOY
164-211	HBR MAR IMPR
211-124	RECLAMATION FAC SHOP
211-242	SUPPLY & ISSUE, SHOP
211-251	SHOP, TURBINE DEPOT
211-252	SHOP, RAM/AIR, DEPOT
211-253	SHOP, ALTERN, DRVE
211-254	SHOP, A/C&ENG DEPOT
211-256	SHOP, ENG TST&STR DEP
211-271	SHOP, MAG INST OVHAUL
212-212	SHOP, MISSILE ASSY
212-215	SHOP, MISSILE RUN-UP
212-216	SHOP, MISSILE SERVICE
212-217	SHOP, MISL WRHED, ASSY
212-218	SHOP, MISSILE MAINT
212-252	SHOP, P/AC
213-332	BOAT STORAGE
213-363	MARINE MAINT SHOP
213-436	MARINE RAILWAY
214-422	AUTO SERV RACK
214-425	AUTO MAINT SHOP
214-426	AUTO STORAGE, HEATED
214-428	AUTO STORAGE, SHED
214-462	SHOP, HEAVY EQUIP
214-467	SHOP, REFUELING VEH
215-552	SHOP, ORD, EQUIP, BASE
215-553	SHOP, A/C WPN OVH DEP
215-554	SHOP, ORD, EQP DEPOT
215-555	SHOP, CTRGE, OVH DEPOT
215-592	SHOP, S&L
216-642	SHOP, AMMO MAINT
217-712	SHOP, ARM & ELECT
217-722	SHOP, COMM & ELECT
217-735	SHOP, ELECTRNC OV, DEP
217-736	SHOP, RADOME OVHL, DEP
217-742	AFCS, MAINT FAC
217-752	SHOP, METER EQP
217-762	SHOP, NAV/AIDS
217-772	SHOP, RADIO & RADAR

Basic Item No.	Nomenclature
218-712	SHOP, GRND SUPP EQUIP
218-822	SHOP, CLOTH & EQIP
218-842	SHOP & SHLTR, LOCL
218-852	SHOP, PARA & DINGHY
218-862	SHOP, REPAIR
218-868	LAB, PREC MEAS EQIP
218-872	SHOP, PAINT
218-892	SHOP, WOODWORKING
219-943	CE, MAINTENANCE SHOP
219-944	CE, MAINTENANCE SHOP
219-946	CE, STORAGE, COVERED
219-947	CE, STORAGE SHED
221-221	PRODUCTION, AIRCRAFT
221-222	PROD, A/C ENGINES
221-223	PROD, A/C SUPPORT
221-224	PROD, A/C NUCLR PROP
222-222	PROD, GUIDED MISSILES
222-223	PROD, G/M ENGINES
222-224	PROD, G/M SUPPORT
225-225	PROD, WEAPONS, SPARES
226-226	PROD, AMMO EXPL&TOXIC
226-227	PROD, PROP, FUEL OX
227-227	PROD, ELECT, COMM EQIP
228-228	PROD, MISC PROCURED
229-982	ASPHALT PLANT
229-984	CONCRETE PLANT
229-986	OXYGEN GEN PLANT
229-987	ROCK CRUSHER PLANT
229-988	SAWMILL
390-125	AERODYN W/T, SUBSON
390-127	AERODYN W/T, SUPERS
390-128	AERODYN W/T, TRANSO
390-129	AERODYN W/T, HYPERS
390-155	GAS DYN W/T, HYPERS
390-157	Gas,DYN W/T, SUPERS
390-171	A/C RSCH TEST STND
390-173	A/C RSCH LNCH STND
390-221	ARM RSCH STORAGE
390-223	ARM TEST CELL ALTI
390-224	ARM T/C, HYPERBALL

Basic Item No.	Nomenclature
390-225	ARM T/C, HYPERSONIC
390-311	ELECT RSCH RADAR
390-381	ELECT RSCH NAVAID
390-411	EQP RES PARACHUT/T
390-475	M/INSTRMNTATION STA
390-484	M/RADAR STATION
390-562	M/STORAGE, FUEL
390-711	TRACK STA SATEL
390-715	COMM STA SATEL
390-717	TRANSMIT STA SATEL
390-718	RECEIV STA SATEL
390-719	TEST TRACK
390-721	T/R AIR TO AIR
390-723	T/R AIR TO GRND
390-727	T/R MISSILE
390-733	T/R SPACE POSITION
390-735	T/R SPECIAL
390-737	T/R PARACHUTE
411-123	STOR BSE DEM/WATER
411-127	STOR BSE WTR/ALCOHOL
411-128	STOR BSE SPEC LIQ
411-131	STOR, AVGAS
411-132	STOR, AVLUBE
411-134	STOR, DIESEL
411-135	STOR, JET FUEL
411-137	STOR, MOGAS
411-138	STOR, SOLVENTS
411-139	STOR, SPEC FUEL
421-131	STORAGE, DEPOT, AMMO
421-132	STOR,DEP, EXPLOSIVE
421-135	STOR,DEPOT,PYROTECH
421-136	STOR, DEPOT,RKT,ASSY
421-137	STOR, DEPOT, SEG,MAG
421-138	STOR, DEP S/ARMS AMMO
422-251	STORAGE, BASE, AMMO
422-252	STOR, BASE,EXPLOSIVE
422-253	STOR, BSE, M/CUBIC MAG
422-254	STOR, BASE, GAR
422-255	STOR, BASE, PYROTECH
422-256	STOR, BASE RKT ASSY
422-257	STOR, BASE SEG MAG
422-258	STOR,BSE,S/ARMS AMMO
422-259	STOR, BSE, BOMB PODS
422-261	STOR, A-STRUCT
422-263	STOR, A-C STRUCT
422-264	STOR, IGLOO
422-265	STOR, SPARES, INERT
422-266	STOR, DETONATOR
422-267	STOR, AMMO AIR DEF
422-268	STOR, G/M WARHEAD
423-111	AMMO, STOR, LQ, PROPLNT
431-183	COLD STOR, DEPOT
432-283	COLD STOR, BASE
441-253	STOR, CHEMICALS, DEPOT
441-254	STOR, GASES, BOTTLED
441-255	STOR, OIL & GREASE, DEP
441-257	STOR, PAINT&DOPE,DEP
441-623	SHED, DISP&SALV DEP
441-626	SHED, LUMBER, DEPOT
441-628	SHED, SUP&EQP DEPOT
441-753	WHSE, DISP&SALVG DEP
441-754	WHSE, FLYAWAY KIT, DEP
441-758	WHSE, SUP&EQUIPMENT,DEP
442-253	STOR, CHEMICALS BASE
442-254	STOR, GASES, BOTTLED
442-255	STOR, OIL&GREASE, BSE
442-257	STOR, PAINT&DOPE BSE
442-258	STOR, LIQUID OXYGEN
442-623	SHED, DISP&SALV BASE
442-626	SHED, LUMBER,BASE
442-628	SHED, SUB & EQP BASE
442-753	WHSE, DISP&SALVG,BSE
442-754	WHSE, FLYAWAY KIT
442-758	WHSE, SUP & EQUIP,BSE
451-134	OPEN, STORAGE, DEPOT
451-137	RECLAMATION YARD, DEP
452-251	AUTO STORAGE, OPEN
452-252	OPEN STORAGE BASE
452-255	CE STORAGE OPEN
452-256	RECLAMATION YARD BSE

Basic Item No.	Nomenclature	Basic Item No.	Nomenclature
452-257	REFUEL VEH STOR OPEN	831-168	SAN SEWAGE FAC BLDG
		831-169	SEWAGE SEPTIC TANK
610-121	AUTO MAINT ADMIN	831-172	DISP RADIOACT WASTE
610-123	POL,OPERATIONS & ADM	831-173	DEMOLITION/BURN FAC
610-332	FARM FACILITIES		
610-594	HORT, GREENHOUSE	833-352	GARBGE, FAT RENDRING
610-596	HORT, LATH HOUSE	833-354	GARBAGE, INCERATOR
610-597	HORT, NURSERY	833-356	GARBAGE, REPOSITORY
610-632	KENNEL, CANINE	833-625	REFUSE INCINERATOR
610-633	KENNEL, SUPPORT FAC		
610-717	PLANT, PRINTING	841-162	WATER, COMMERCIAL SUP
610-718	PLANT, REPRODUCTION	841-163	WATER, SURFACE SUPPLY
610-761	PRISON, FEDERAL	841-165	WATER, SUPPLY TREATMT
		841-166	WATER, WELL
811-142	COMM POWER	841-169	BUILDING
811-143	ELE EMERG POWR PLANT		
811-144	ELEC SWITCH STATION	880-257	FIRE PROT, POL, TK,FRM
811-145	ELE PRIMARY PWR GEN		
811-148	ELE PRIM PWR TRANSF	890-134	COMPRESSED AIR PLANT
811-149	ELEPWR STATION BLDG	890-136	COMPRESSED AIR PLT BLDG
		890-151	TRAMWAY AERIAL
821-111	COAL YARD	890-152	LOAD/UNLOAD, AREA
821-112	HEATING FUEL OIL STOR	890-153	LOAD/UNLOAD, CONVEY
821-115	HTG PLT LESS 3.4MB	890-154	L/UN, GANTRY, CRANE
821-116	HTG PLT, OVER 3.4 MB	890-156	LOAD/UNLOAD, PIT
821-117	HEATING FACILITY BLDG	890-157	RR, TRESTLE, UNLDG
821-155	STEAM, PLANT INDUSTRIAL	890-158	L/UN, PLATFORM
821-156	STEAM FACILITY,BLDG	890-159	LOAD BOMB HOIST
		890-171	MISC STORAGE TANK
823-111	HEAT, GAS SOURCE	890-197	WEIGHING, SCALE
823-243	GAS COMPRESSOR	890-231	NUCLR ENERGY GEN PLT
823-244	GAS STORAGE	890-257	CORR CONT UTIL STOR
823-248	GAS, VAPORIZER		
		932-582	REVETMENT, AMMUNITION
831-155	IND WAST TRET & DISP	932-586	REVETMENT, PASSIVE DEF
831-165	SEWAGE TREMT & DISP	932-587	REVETMENT, POL

Section C--Administrative Land Use

Basic Item No.	Nomenclature
131-111	COMMUNICATIONS CTR
131-112	COMMUNICATIONS, BASE
131-113	TELEPHONE EXCHANGE
131-115	COMM, RECEIVER
131-116	COMM, TRANS/REC
131-117	COMM, TRANSMITTER
131-118	RADIO RELAY FAC
131-119	SHELTER, TEL REPEAT
131-122	AIRCOM REL CENT
131-123	CUMLOGNET
131-125	AIRCOM REC
131-128	MICROWAVE RELAY
131-143	GAPFILLER
132-132	COMM SCATTER
134-119	REMOTE CONTROL CKT
141-385	MOTION PICTURE LAB
141-387	FILM STORAGE VAULT
141-446	COMBAT CNTR FAC
141-447	DIRECTION CNTR FAC
141-449	DIR/COMB CNTR FAC
141-451	OPS,COMBAT CENTER
141-452	OPERATIONS, AUXIL
141-456	OPERATIONS, AFSS
141-458	CONTROL CENTER
141-461	AC&W OPR DEWLINE
141-469	AC&W OPR BLDG
141-743	PHOTO LAB, BASE
141-745	PHOTO LAB RECON
171-152	LECTURE HALL
171-153	ACADEMIC, CLASSROOM
171-154	LAB TRAIN GEN
171-155	ACADEMIC EXHIBIT FAC
171-157	NATATORIUM & PHYS ED
171-158	BAND PRACTICE FAC
171-212	FLIGHT SIMULATOR TNG
171-213	FLT TRAINING, BASIC
171-214	HIGH ALTITUDE TNG
171-216	HI-SPEED/HI-ALT TNG
171-217	SUPERSONIC TRAINING
171-218	SYNTHETIC TNG GEN
171-352	LIBRARY, ACADEMIC

Basic Item No.	Nomenclature
171-356	LIBRARY, RES & PROF
171-357	LIBRARY, TECHNICAL
171-393	NAV TNG, CELESTIAL
171-395	NAV TNG, PLANETARIUM
171-412	OPER MISSION TNG
171-415	SQ OPS TRAINING
171-471	RANGE CONTROL HOUSE
171-472	RANGE, S/ARMS STORAGE
171-473	RANGE, TARGET STORAGE
171-475	RANGE, SM/ARMS I/D
171-612	TRAINING, AIR DEF
171-613	TNG SPECIAL WEAPON
171-614	TRAINING, GENERAL
171-616	TNG AID GAS CHAMBER
171-617	TRAINING AIDS, SHOPS
171-618	MOBILE TRAINING UNIT
171-619	WEATHER TRAINING
171-712	TARGET INTEL TNG
171-714	TARG INTEL SECUR STG
171-812	MSL TRNG FAC
171-822	SPACE TRNG FAC
171-832	WPN SUP TRNG
171-842	C&S TRNG
171-852	A/C WPN TRNG
171-862	M&P TRNG FAC
171-872	INT WPN TRNG
179-471	RGE, SMBOR RIFL/CARB
179-472	RGE, HIGH POWER RIFLE
179-473	RGE, PISTOL
179-474	RGE, SM ARM 1000 INCH
179-477	RANGE, SKEET
179-481	RANGE, OQ GUNNERY
310-112	AERODYN RES LAB
310-113	AERODYN RES T BLDG
310-132	GAS DYN RES LAB
310-133	GAS DYN RES T BLDG
310-171	A/C RES LAB AERODY
310-172	A/C LAB TEST
310-175	A/C RES LAB ENG
310-222	ARM RES LAB BALLIS
310-223	ARM LAB TEST
310-236	ARM RES LAB ENG
310-273	ARM RES T SHOP

Basic Item No.	Nomenclature	Basic Item No.	Nomenclature
310-311	ELECT RES LAB	310-927	SC LAB METEOROLOGY
310-316	ELEC LAB TEST	310-928	SC LAB SOIL ENG
310-317	ELECT RES LAB ENG	310-929	SC LAB BIOLOGICAL
310-411	EQ LAB TEST	310-943	NUCLR ENG TEST BLDG
310-415	EQ RES LAB ELECT	310-944	LAB, WEAPONS GUID
310-441	EQ RES LAB	310-946	LAB, MATRLS TEST
310-471	M/ASSEMBLY TEST BLDG	310-951	TEST TRACK BLDG
310-472	M/RES LAB		
310-473	MISSILE LAB TEST	610-125	ADMIN,OFFICE
310-516	M/RES LAB ENG	610-142	COMMERCIAL TRANS FAC
310-541	M/RES TEST SHOP	610-153	PROTECT FAC CMD POST
310-561	M/RES STORAGE BLDG	610-155	PROTECTIVE SHELTER
310-611	PROPUL RES LAB	610-243	HQ GROUP AIR BASE
310-613	PROPUL RES T BLDG	610-247	HEADQUARTERS, SQ
310-632	PROPUL RES LAB FUEL	610-249	HEADQUARTERS, WING
310-664	PRO RES LAB ROCKET	610-282	HQ AIR FORCE
310-666	PRO RES LAB NUCLEAR	610-284	HQ MAJ COMMAND
310-668	PRO RES LAB SOLAR	610-285	HQ NUMBERED AF
310-670	PRO RES LAB ELECT	610-286	HEADQUARTERS, DIV
310-672	PRO RES LAB IONIC	610-288	HQ RESERVE FORCES
310-674	PRO RES LAB PLASM	610-311	RECORDS REPOSITORY
310-676	PRO RE LAB ARC-JET	610-673	LOGISTICAL FAC BASE
310-911	SC LAB PHYSICS	610-675	LOGISTICAL FAC DEPOT
310-912	SC LAB SONIC	610-711	PLANT, DATA PROCESS
310-913	SC LAB ASTROPHYSIC	610-815	MUSEUM
310-915	SC LAB CHEMISTRY	610-821	ARMORY, ACADEMY
310-916	SC LAB ELECTRONICS		
310-917	SC LAB NUCLEONICS	690-625	SHELTER, TROOP
310-919	SC LAB GEOPHYSICS	690-792	STAND, REVIEW, COVERED
310-921	SC LAB MEDICAL	690-795	STAND, REVIEW, OPEN
310-922	SC LAB HUMAN ENG		
310-923	SC LAB SOLAR	730-835	AIR POLICE OPS
310-924	SC LAB RADIATION		
310-925	SC LAB AERO ENVIRON	932-455	OBSTACLE COURSE
310-926	SC LAB ENVIRONMENT	932-457	PARADE & DRILL FIELD

Section D--Community Support Land Use

Basic Item No.	Nomenclature
135-583	TELEPHONE DUCT FAC
135-586	TELEPHONE POLE FAC
135-587	MARINE CABLE
141-143	FIRE STA DINING HALL
141-145	FIRE TOWER & COMM CTR
141-146	FIRE STA STRUCT
141-147	FIRE HOSE HOUSE
219-945	CE, HOSP MAINT SHOP
442-515	STOR,MED EQP & SUPPLY
510-001	COMPOSITE MED
510-141	AUTOPSY & MORGUE
510-142	EENT CLINIC
510-143	CLINICAL LABORATORY
510-145	OCCUPATIONAL THERAPY
510-146	X-RAY-THERAPUTIC
510-147	PHARMACY
510-148	PHYSICAL THERAPY
510-149	X-RAY-DIAGNOSTIC
510-175	FLIGHT SURG CLINIC
510-212	HOSPITAL DINING HALL
510-217	HOSPITAL KITCHEN
510-255	INCINERATOR, HOSPITAL
510-263	MED&DENT S/SPACE
510-265	M&D NURSING UNIT
510-271	ISOLATION NUR UNIT
510-275	MED NURSING UNIT
510-276	INTENS CARE NUR UNIT
510-277	PED NURSING UNIT
510-278	AEROMED EVAC PAT HLD
510-312	NP CLOSED NUR UNIT
510-314	NP HOLDING UNIT
510-315	NP MENTAL HYG UNIT
510-316	NP OPEN NURSING UNIT
510-317	NP RECTN & DINING
510-342	OB DELIVERY FAC
510-344	OB LABOR
510-345	OB NURSERY FAC
510-347	OB NUR FORMULA PREP
510-349	OB NURSING UNIT
510-375	ORTHO NURSING UNIT
510-411	AIR FORCE CLINIC
510-672	CYSTOCOPY

Basic Item No.	Nomenclature
510-673	ORTHOPEDIC, OPER ROOM
510-674	SURGERY, OPER ROOM
510-675	SURG NURSING UNIT
510-676	SURGICAL RECOVERY
510-712	HOSP CENTRAL STERIL
510-714	HOSP LINEN SUP FAC
510-915	PATIENTS RECREATION
510-917	RED CROSS, WELFARE
520-142	DISPENSARY-A
530-155	BLOOD PROC LAB
530-634	MED FOOD INSPECTION
540-242	AREA DENTAL LAB
540-243	DENTAL CLINIC
540-244	DENT SURG&RECOVERY
540-245	DENTAL PROS LAB BASE
550-143	DISPENSARY-B-MIL
550-145	DISPENSARY-B-OTHER
690-252	BILLBOARD
690-432	FLAG POLE, BASE
690-511	CEMETERY
690-512	MONUMENTS & MEMORIALS
723-351	DINING HALL, AIRMEN
723-356	DINING HALL, OFFICER
723-384	KITCHEN, DETACHED
723-388	KITCHEN, IN-FLIGHT
723-392	SANITARY, LATRINE
723-394	SAN LATRINE & SHOWER
723-396	SANITARY LAVATORY
723-398	SANITARY SHOWER
725-122	ATTNDTS DINING HALL
725-124	ATTNDNTS SAN FAC
725-513	CAMP, NATIVE
725-517	CAMP, TROOP
730-182	BAKERY, BREAD
730-186	KITCHEN, PASTRY
730-275	BUS SHELTER
730-277	BUS STATION
730-278	RAILROAD STATION

Basic Item No.	Nomenclature	Basic Item No.	Nomenclature
730-551	LAUND-DRY CLEAN-BASE	740-717	RED CROSS OFFICE
730-552	LAUND-DRY CLEAN-DEP	740-731	SHOP CENTER, PUBLIC
730-652	DRY CLEANING, BASE	740-735	RESTAURANT, PUBLIC
730-654	DRY CLEANING, DEPOT	740-891	EDUCATION, CENTER
730-711	LAUNDRY, BASE		
730-713	LAUNDRY, DEPOT	812-223	PRIMARY DIST LINE OH
730-715	LAUNDRY, DISINFECTING	812-224	SECOND DIST LINE OH
730-724	PLANT, ICE	812-225	PRIMARY DIST LINE UG
730-725	PLANT, ICE CREAM	812-226	SECOND DIST LINE UG
730-784	SCHOOL, DEP ELEMENTARY	812-227	TRANSMISSION LINE
730-785	SCHOOL, DEPENDENT HI	812-921	ELEC A/C OUTLETS
730-786	SCHOOL, DEP INTERMED	812-922	STREET LIGHTS
730-788	SCHOOL, DEP KINDERGRTN	812-923	FLOOD LIGHTS
730-789	SCHOOL, DEP NURSERY	812-927	SUB-STATION
730-831	CONFINEMENT FACILITY	812-928	TRAFFIC CONTROL SYS
730-832	A/POLICE CONTROL&ID		
730-833	SECUR CENTRAL CNTL	822-245	HOT WATER MAINS
730-837	SECURITY, SENTRY HSE	822-248	HOT WATER PUMP STA
730-839	TRAFFIC CHECK HOUSE	822-265	STEAM HEAT MAINS
		822-268	CONDENSATE PUMP STA
740-153	BANK, BRANCH		
740-233	CHAPEL, BASE	824-462	GAS METER FAC
740-235	CHAPEL ANNEX	824-464	GAS MAINS
740-236	CHAPEL BASE/ANNEX	824-466	GAS ODORIZER FAC
740-237	CHAPEL, HOSPITAL	824-468	GAS VALVE FAC
740-253	DEPENDENTS ASST CNTR		
740-255	THRIFT SHOP	832-255	IND WASTE MAIN
740-262	STORE, BOOK	832-266	SAN SEWAGE MAIN
740-264	STORE, CLOTHING SALES	832-267	SAN SEWAGE PUMP STA
740-266	STORE, COMMISSARY		
740-267	STORE, CADET	841-423	WATER STOR DAM
740-381	EXCH, CAFE SNCK BAR	841-425	WAT STOR RESERVOIR
740-382	EXCH, BRANCH	841-427	WATER STOR TANK
740-383	EXCHANGE, SERVICE STA		
740-385	EXCHANGE MAINT SHOP	842-245	WATER MAINS
740-387	EXCHANGE RETAIL WHSE	842-249	WATER, PUMP STATION
740-388	EXCHANGE SALES STORE		
740-389	EXCH SERV OUTLET	843-314	FIRE PROTEC WTR MAINS
740-443	GUEST HOUSE VISITOR	843-315	FIRE HYDRANTS
740-466	GUEST TRAILER VISITOR	843-316	WATER, FIRE PUMP STA
740-633	POST OFFICE, CENTRAL	843-318	FIRE PROTEC DELUGE
740-652	RADIO, AMATEUR	843-319	FIRE PROT WATER STOR
740-655	RADIO, MARS	843-362	WATER SUP NON/POT BLDG
740-656	TV STATION	843-363	WATER SUP MAINS, N-POT
740-657	ANTENNA MSTR, TV REC	843-367	WATER SUP STOR, N-POT
740-715	RED CROSS SERV CLUB	843-368	WATER SUP NON-POTABLE

Basic Item No.	Nomenclature
851-142	ROAD BRIDGE
851-143	CURBS & GUTTERS
851-145	DRIVEWAY
851-146	APRON, STUB SER VEH
851-147	ROAD
851-148	RETAINING WALL
852-262	PARK, VEHICLE, NON_ORG
852-268	PARK, VEH GND EQP
852-282	WALKWAY, BRIDGE
852-287	WALKWAY, COVERED
852-289	SIDEWALK
860-612	RAILROAD BRIDGE
860-616	R.R. SHELTER, PERSNL
860-617	RAILROAD TRACKAGE
871-183	STORM DRNGE, DISPL
871-185	STORM DRNGE, PUMP STA
872-245	FENCE, BOUNDRY
872-246	FENCE, ELECTRIC
872-247	FENCE, SECURITY
872-248	FENCE, INTERIOR
872-841	SECURITY ALARM SYS
872-845	SECURITY GUARD TOWER
880-211	FIRE ALARM SYS
880-213	FIRE DETECTION SYS
890-122	AIR COND PLANT
890-123	AIR COND PLANT BLDG
890-144	COMPRESD AIR DISTR
890-181	UTILITY LINE DUCTS
890-185	UTILIDOR
890-187	UTILITY VAULT
890-267	PNEUMATIC TUBE
911-125	LAND, DONATION,PRIVATE
911-127	LAND, DONATN, S&L GOVT
911-142	LAND FEE, CONDEMNATION
911-146	LAND, FEE, PURCHASE
912-261	LAND, P/D, E.O.
912-262	LAND, P/D, P.L.O.
912-263	LAND, P/D, T.O.
912-268	LAND, P/D, PMT
912-269	LAND, P/D, NOTATION
913-384	LAND,LICENSE, GEN, USE
913-393	LAND, PERMIT, GEN, USE
914-263	LAND, PUBLIC, E.O.
914-266	LAND, PUBLIC, T.O.
921-162	LAND, EASEMENT, ACCESS
921-164	LAND, EASEMENT, CLEAR
921-167	LAND, EASEMENT, RSTRC
921-168	LAND, EASEMENT, RT/WAY
922-274	LAND/LSE, ST&LOC
922-276	L/LSE, SUB/RECAP
922-278	L/L, PRIV/ENTRP
922-292	LAND, LEASE&SUSPENSN
922-294	LAND, IN-LSE, MINERAL
922-296	LAND, IN-LSE, OIL&GAS
922-298	LAND, IN-LSE, SPECIAL
922-355	FORGN L/LSE UND 99 YRS
922-357	FORGN L/LSE 99 YRS
923-322	FORGN L/AGMT BSE RTS
923-326	FORGN L/AGMT R/AID
923-346	FORGN LND COMMANDEER
923-366	FORGN LND REQUISTN
923-376	FORGN LAND MISC
931-214	AUTO SPRINK WTR FLOW
931-215	A/C ACCDNT EMER ALRM
931-216	AUTO SPRINKLER SYS
931-217	MAN FIRE&EVAC ALARM
931-911	COLLATERAL EQUIPMENT
932-277	LANDSCAPING
932-682	S/PREP EXCS CUT & FILL
932-683	SITE PREP CLEARING
932-684	SITE PREP DREDGING
932-686	SITE PREP GRADING
933-364	REMOVAL, HAZARD

Section E--Housing Land Use

Basic Item No.	Nomenclature	Basic Item No.	Nomenclature
711-111	FAM HSG CAPEHART	714-431	GRGE F/HSG DETCHD
711-121	FAM HSG WHERRY	714-432	CARPORT, F/HSG DTCHD
711-131	FAM HSG LANHAM		
711-141	FAM HSG APPROPRIAT	722-211	DORMITORY, AIRMEN
711-151	FAM HSG SURP COMOD	722-218	DORMITORY, WAF
711-161	FAM HSG DEUTSCH-M		
711-171	FAM HSG YEN	723-155	LOUNGE, DAYROOM
711-181	FAM HSG OTHER	723-242	GARAGE, AUTO
711-191	FAM HSG RELOCATE		
711-211	FAM HSG RENT GUARA	724-414	OQ MEN
711-221	FAM HSG LEAS HOUS	724-417	OQ WOMEN
711-311	FAM HSG ATCH GRGE	724-433	QUARTERS, CADET
711-312	FAM HSG ATCH CARPORT		
		725-128	ATTNDTS SRVNTS DORM
712-244	FAMILY HSG TRAILER		
713-352	TRAILER CT SUP FAC		
713-366	TRLR CT PARKING		

Section F--Community Recreation Land Use

Basic Item No.	Nomenclature	Basic Item No.	Nomenclature
740-315	CLUB, ROD&GUN	750-172	ATHLETIC FLD, BASEBALL
740-316	CLUB, SERVICE	750-175	ATHLTC FLD, FOOTBALL
740-317	CLUB, AERO	750-177	ATHLTC FLD, TRACK
740-612	OPEN MESS, AIRMEN	750-178	ATHLTC FLD, SOFTBALL
740-613	OPEN MESS, CADET	750-179	ATHLTC FLD, STAND
740-614	OPEN MESS, CIVILIAN	750-349	COURT, RECREATIONAL
740-617	OPEN MESS, NCO	750-371	DANCE FAC OD
740-618	OPEN MESS, OFFICER	750-422	GOLF FAC
740-671	RCTN, BOWLING ALLEY	750-426	GOLF COURSE, 9 HOLE
740-672	RCTN, BOXING ARENA	750-427	GOLF COURSE, 18 HOLE
740-673	RCTN, FIELD HOUSE	750-581	MISC REC FAC
740-674	RCTN, GYMNASIUM	750-811	SWIM POOL BATH HSE
740-675	RCTN, LIBRARY	750-812	SWIM POOL CONSOLIDID
740-676	RCTN, MULTI-PURP	750-813	SWIMMING POOL, AIRMEN
740-677	SWIM POOL, INDOOR	750-817	SWIMMING POOL, OFF
740-678	RCTN, SKATING RINK	750-818	SWIM POOL, WADING
740-679	RCTN, WORKSHOP	750-819	SWIM POOL, WTR TREMT
740-681	CADET SOCIAL CENTER	750-835	THEATER, EXTERIOR
740-873	THEATER, BASE		
740-883	YOUTH CENTER		

APPENDIX F

A CASE STUDY

This appendix involves a case study for the purpose of demonstrating the points brought out in the thesis. It is written in the form of a sample Air Force programming directive.

Programming Directive

This is design and programming directive FY1966-1 for a space program support base. Location of the base within the continental limits of the United States is as contained in classified document 1023-A-41. Responsibility for design and construction of the facilities is assigned to the United States Air Force. Primary contract authorization is assigned to the Corps of Engineers, United States Army. Upon completion of the initial design and construction efforts, the facility will be assigned to and operated by the United States Air Force. Major tennant will be the National Aeronautics and Space Administration.

Mission. The mission of this Air Force facility will be as follows:

1. Launch and support of manned space operations into deep interplanetary space.
2. Launch and support of a military orbital development station.
3. Training of astronauts, scientist-passengers, scientist-astronauts and astronaut-observers, both military and

civilian, through the use of an Institute of Space Sciences.

4. Research in all sciences involved in space programs.

Principal details on the four major missions as listed above are:

1. The first manned space operation will be a manned orbit of Mars followed by a manned landing on Mars. Depending upon information thus obtained, this will be followed by the establishment of a manned semi-permanent observing station on Mars or one of its two satellites, Phobos or Deimos. Following this major effort, programs will include further research and observations in deep space.

2. The second mission involves the launch, construction, and continuous support of a manned orbital space station with a military mission as primary. The station will initially be thirty-three feet in diameter and one hundred forty feet long. Manning will be up to thirty-six men. Primary missions will include orbital vehicles using the station as a home base to accomplish general reconnaissance, given-spot reconnaissance and post-strike reconnaissance on the surface of the earth. Secondary missions of the main orbital station will include communications relay and resupply base for interplanetary travel.

3. The mission of the Institute of Space Sciences includes the following:

   a. Train scientist-astronauts.

   b. Advance space science generally.

   c. Provide indoctrination and education for astronaut-observers.

   d. Familiarize and train scientist-passengers in the requirements of space flight.

   e. Bring ground scientists together with crew members of space vehicles for the attainment of coordinated effort in carrying out scientific missions.

   f. Maintain a library of historical and current space flight data as well as comprehensive literature on the sciences relevant to space flight missions.

   The institute will maintain liaison with major universities throughout the world. Through affiliation with certain educational facilities in the United States, advanced degrees in the various areas of science will be offered.

4. In addition to the training program outlined above, the faculty will conduct basic research in all sciences involved in space programs. Included will be astronomy, celestial mechanics, planetary research, solar systems atmospheres, meteorology, biology and space probe sterilization.

Assigned Population Estimate. Based on the four missions previously outlined, assigned population is estimated at 10,247. Figure 19 outlines the organization and Table 12 gives the breakout by rank and status. This organization population will prevail until there is a major change in mission or testing programs. No housing will be provided for civilians. Those employed on the facility will require housing in adjacent communities. Therefore, civilian dependents will not be included in population figures. Housing will not be provided for enlisted personnel below the rank of E-4 or for E-4 personnel with less than four years service as this is prohibited by public law.

Basic Site Criteria. The final site selection of the proposed Air Force base depends upon the determination of the operational requirements for the mission. It has been estimated that a minimum of one hundred thousand (100,000) acres is needed for this base. This amount is required to satisfy safety and noise control conditions created by the space missiles.

In addition, the site must meet the following criteria:[1]

Air Space Analysis.

1. The selected air base site must be located at least twenty miles from all other military or civil airports.
2. It must be located at least forty miles from other airports if it is along the extended centerline of the instrument runway.

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[1]Air Force Manual 86-6, pp. 35-37.

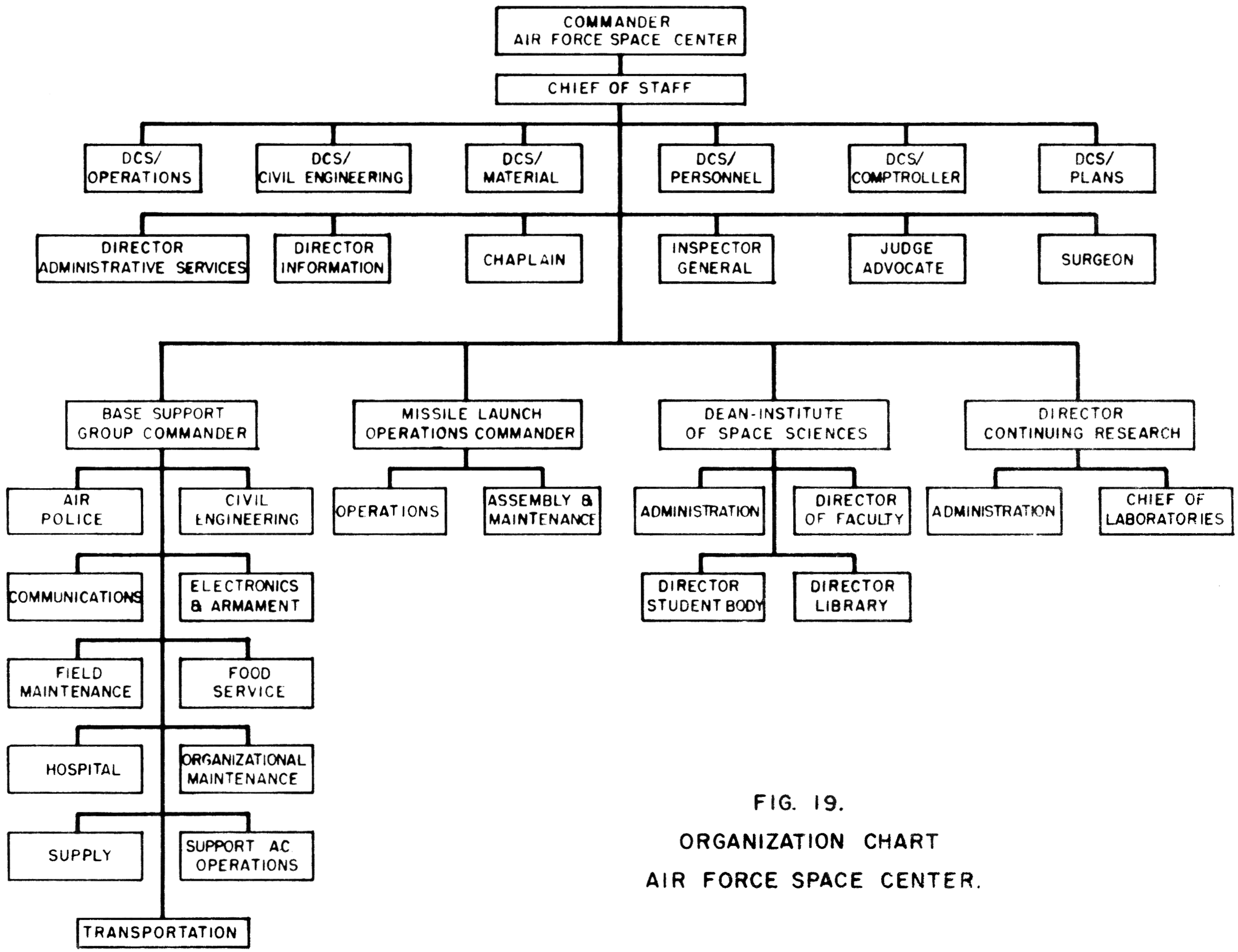

FIG. 19.
ORGANIZATION CHART
AIR FORCE SPACE CENTER.

TABLE 12.
ASSIGNED POPULATION STUDY.

Organization	Total	Officer	N.C.O. E-5-E-9	*Airman E-4	*Airman E-1-E-4	Civilian
COMMAND AND STAFF	461	47	187	67	125	35
BASE SUPPORT	666	64	190	50	250	112
AIR POLICE	686	15	93	172	400	6
CIVIL ENGINEERING	927	17	190	201	307	212
COMMUNICATIONS	449	14	58	108	262	7
ELECTRONICS & ARMAMENT	577	12	164	87	300	14
FIELD MAINTENANCE	314	4	111	87	100	12
FOOD SERVICE	280	7	82	81	107	3
HOSPITAL	360	72	87	53	117	31
ORGANIZATIONAL MAINTENANCE	340	4	106	50	153	27
SUPPLY	752	26	197	182	300	47
SUPPORT AIRCRAFT OPERATIONS	118	87	16	4	7	4
TRANSPORTATION	521	12	90	86	275	58
SUBTOTAL	5,990	334	1,384	1,161	2,578	533
MISSILE LAUNCH & OPERATIONS						
COMMAND	407	47	140	89	112	19
OPERATIONS	677	117	146	172	199	43
ASSEMBLY/MAINTENANCE	972	48	312	186	384	42
SUBTOTAL	2,056	212	598	447	695	104
INSTITUTE OF SPACE SCIENCES						
ADMINISTRATION	302	49	68	41	81	63
FACULTY & STUDENTS (ACADEMIC)	691	286	14	36	42	313
LIBRARY	78	6	2	6	16	48
SUBTOTAL	1,071	341	84	83	139	424
CONTINUING RESEARCH CENTER						
ADMINISTRATIVE	65	9	4	12	38	2
TECHNICAL	604	71	12	31	92	398
SUBTOTAL	669	80	16	43	130	400

GRAND TOTAL — 10,247

MILITARY — 8,749
CIVILIAN — 1,498

* E-1 TO E-4 ---- E-4 LIMITED TO THOSE WITH LESS THAN 4 YEARS SERVICE
E-4 TO E-5 ---- E-4 LIMITED TO THOSE WITH MORE THAN 4 YEARS SERVICE

3. It must be at least ten miles from major civil airways.
4. The total air traffic of the added military mission and projected (twenty year) civil traffic must not saturate the available airspace.
5. It must meet the FAA and Regional Airspace Subcommittee approval.

Airfield Flight Conditions.

1. There must be no conflict with the current Air Force criteria of the maximum limitation of five hundred foot elevation within a fifty thousand foot radius of the airfield reference point.
2. There must be no conflict with the current Air Force criteria of the maximum limitation of one thousand foot elevation within a one hundred thousand foot radius of the airfield reference point.
3. The approaches to the site shall be free of mental hazards to aircraft flight operations.
4. Required off-base zoning and easements to safeguard aircraft and space flight operations and air base expansion must be readily attainable.

Noise and Nuisance.

1. The site shall be at least fifteen miles from the planned expansion limits of a support city of at least twenty-five thousand population.
2. The extended centerlines of the runways shall not pass within four miles of the edge of developed portions

of communities within ten miles of the site, if such developed portions exceed a population density of one thousand per square mile with a total population of at least five hundred people.

3. Insure that no residences and places of public assembly, or areas of sensitive nature are located within an area four miles wide by seven miles long from the ends of the runway systems. The downrange zone from all missile firing facilities must be over water at all points for a distance of one hundred miles.

Expansibility.

1. The site selected shall be at least one hundred thousand (100,000) acres of suitable land plus ten thousand acres available to permit expansion, principally in the airfield area. Sufficient acreage shall be obtained to provide for operational requirements, safety and noise distance, and possible expansion.
2. Planned development will provide for possible future extensions of the runway system without impairing the approach zone requirements.

Meterology.

1. A maximum number of days of good flying weather conditions must be available within the strategic area.
2. The location shall be free of severe storms, earthquakes, or flooding conditions.

Regional Planning. The selected site shall be compatible with both State and local master plans for development.

Engineering.

1. Both the surface and subsurface geological conditions shall be suitable for the proposed construction, especially to meet the foundation requirements of launch facilities.
2. There shall be freedom from mining operations or conflict with mineral rights which would permit harmful mining operation.

Hydrological Data. The ground water table shall be low enough to avoid construction problems and within reasonable reach if required for ground water supply.

Water and Materials Data. There shall be an adequate local supply of water and construction materials or means of shipping in materials.

Topographical Data.

1. The site shall be of gently rolling topography with good natural surface water and air fog drainage. Especially important is the availability of a ridge or series of hills between the main base and the launch area. Also desired is heavy forest cover. These will greatly assist in noise control and safety as well as providing suitable siting for vehicle tracking facilities.
2. Surrounding topography must permit compliance with established criteria for airfield clearances and approach zones

Real Estate.

1. The suitable land must be available at a reasonable market price.
2. The land deeds must be free of restrictions or rights which would limit Air Force utilization.

Public Services.

1. Transportation: Rail, highway, water, and air transportation must be adequate or expansible to meet the demand. Of special importance is suitable barge docking facilities for space vehicle delivery.
2. Utilities: The area must be available to provide adequate or expandable utilities to meet the increased demand. This includes power, water, sewage treatment, gas, and communications.

Community Support. The ideal site will be within twenty-five miles radius (not over forty-five minutes normal driving time) from the planned or forseeable expansion limits of a support city of twenty-five thousand to ninety thousand population. Control over use of land adjacent to the base must be reflected in a community attitude favorable to appropriate zoning. Family housing must be available at favorable market rentals or satisfactory locations for construction of private housing must be available.

Facilities. This Air Force base will be programmed with adequate facilities in accordance with current criteria plus suitable special facilities to meet mission requirements.

Design Analysis

The above is typical of Air Force directives. The mission is stated, an organizational chart is furnished and the assigned population is computed from standard manning tables into a unit manning document. Further, special criteria such as clearances, safety requirements and location with respect to surrounding urban areas is stated.

Upon receipt of such a document a master planning organization should use an established plan of development to reach a successful master development plan. It is important to remember, however, that many of the steps in the plan can be accomplished consecutively or simultaneously, depending upon the personnel type and number available. In any case the production of a master development plan takes considerable time, many meetings and much research before a solution can be presented.

The following paragraphs outline a recommended planning procedure.

1. Understand the programming directive. Many manhours of labor can be wasted if this basic understanding is not accomplished. This step may take meetings with the future occupying organization, visits to similar bases and much research; the time is well spent, however.
2. Determine the population to be served. The assigned population developed from standard manning tables is not the ultimate population of the base. Before a list of facilities can be developed or the acreage

necessary to accommodate the base estimated, a gross population estimate is required. Table 6, Chapter VII, contains data which can be utilized to compute gross population. In this case study it is assumed that the base will allow dependents and is not a remote facility. Table 13 demonstrates the computation of the gross population for this case study.

3. Determine facilities necessary to accomplish mission. The basic document used in this endeavor is Air Force Manual 86-4, Standard Facility Requirements. This document lists all standard Air Force facilities including applicable criteria necessary to justify many of them. Many of the facilities listed therein include sufficient information to estimate sizes as well as number of units required. Air Force Manual 88-2, Definitive Designs of Air Force Structures, also contains much information that can be used in determining facility size.

Table 14 exhibits the estimate for facility requirements necessary to accomplish the mission stated in the requirements programming directive. Air Force Manual 86-4 was used to produce columns 1, 3, 4, and 5. Air Force Manual 88-2 was used to produce columns 2, 8, 14, 15, 16, 17 and 18. Where information was not included on certain facilities, standard engineering procedures and/or experience

TABLE 13.
GROSS POPULATION STUDY.

Rank	Total [1]	Percent Married	Married [5]	Single	Dependent /Married Personnel	Women	Children /Married Personnel	Children [6] Age 0-4 29.2%	Age 5-9 27.2%	Age 10-14 24.3%	Age 15-19 19.3%	Total	Total
GENERAL	3	100.0	3		1	3							6
FIELD GRADE [2]	430	96.2	413	17	3.7	413	2.7	326	303	271	216	1,116	1,959
COMPANY GRADE [3]	581	74.2	430	151	2.7	430	1.7	213	199	178	141	731	1,742
SUBTOTALS	1,014		846	168		846		539	502	449	357	1,847	3,707
N.C.O. E-8, E-9	153	93.0	142	11	3.3	142	2.3	96	89	80	63	328	623
N.C.O. E-5, E-6, E-7	2,114	88.5	1,870	244	3.3	1,870	2.3	1,257	1,170	1,045	838	4,310	8,294
AIRMAN E-4 [4]	1,801	66.2	1,191	610	2.6	1,191	1.6	557	518	467	364	1,906	4,898
AIRMAN E-1, E-2, E-3, E-4	3,667	16.3	598	3,069	1.8	598	0.8	140	130	116	92	478	4,743
SUBTOTALS	7,735		3,801	3,934		3,801		2,050	1,907	1,708	1,357	7,022	18,558
TOTALS	8,749		4,647	4,102		4,647		2,589	2,409	2,157	1,714	8,869	22,265

TOTAL MILITARY AND DEPENDENT STRENGTH	22,265
CIVILIAN EMPLOYEE STRENGTH	1,498
TOTAL STRENGTH	23,763
LESS OFF-BASE PERSONNEL [7]	3,172
PERSONNEL HOUSED ON BASE	20,591

NOTES

(1) SEE TABLE 12, PAGE 197 FOR ORGANIZATION BREAKOUT.

(2) FIELD GRADE OFFICERS INCLUDE COLONEL, LIEUTENANT COLONEL AND MAJOR.

(3) COMPANY GRADE OFFICERS INCLUDE CAPTAIN, 1ST LIEUTENANT, 2ND LIEUTENANT AND WARRENT OFFICER

(4) E-4 AIRMEN WITH LESS THAN 4 YEARS SERVICE AND ALL E-1 THRU E-3 AIRMEN ARE NOT AUTHORIZED FAMILY HOUSING.

(5) AVERAGE BY RANK CATEGORIES WERE OBTAINED BY COMPUTING AVERAGES FROM DATA IN TABLE 6, PAGE 80.

(6) AGE DISTRIBUTION OF DEPENDENT CHILDREN FROM U.S. BUREAU OF CENSUS, U.S. CENSUS OF POPULATION: 1960 "FAMILIES".

(7) PERSONNEL RESIDING OFF-BASE INCLUDE 1,498 CIVILIAN EMPLOYEES AND 1,674 AIRMEN AND DEPENDENTS NOT AUTHORIZED HOUSING.

Table 14. Facility requirements master development plan

Category Item No. (1)	Drawing Number (2)	Facility Item (3)	Unit (4)	Units Required (5)	Cost Per Unit (6)	Cost Total(000) (7)	Land Use Hgt. Stories (8)	Land Use O.S.R. (9)	Land Use Net Req Acres (10)	Land Use % Add (11)	Land Use Circ. Acres (12)	Land Use Gross Acres (13)	Utilities Power - Kw connected ld. (14)	Utilities Power - Kw est. demand (15)	Utilities Water-g.p.d. (16)	Utilities Sewage-g.p.d. (17)	Utilities Heat-m.b.t.u./hr. (18)	Notes (19)
AIRFIELD/ MISSILE LAUNCH LAND USE																		
111-112		RUNWAY, CROSSWIND	SQ.YD	89,000	$12.90	$11,480			962	5	48.1	1010.1						HEAVY PAVEMENT 200' X 4000'
111-117		RUNWAY, PRIMARY/INSTRUMENT	"	223,500	"	23,827			INCLUDED IN 111-112									" " 200' X 10,500
111-119		RUNWAY OVERRUN	"	44,500	5.00	222.5			"	"	"	"						200' X 1000' (2 EA.)
112-213		TAXIWAY, APRON ACCESS	"	32,000	12.90	4,125			"	"	"	"						FROM APRONS TO HANGERS
112-215		TAXIWAY, RUNWAY ACCESS	"	117,000	"	15,100			"	"	"	"						FROM APRONS TO RUNWAYS
112-217		TAXIWAY, SUPPORT	"	10,000	"	1,290			"	"	"	"						TO HARDSTANDS AND HELICOPTER PAD
113-322		APRON, HANGER ACCESS	"	15,000	"	1,934			"	"	"	"						BETWEEN HANGERS AND SHOPS
113-323		APRON, LOADING	"	10,000	"	1,290			"	"	"	"						SERVES AIR FREIGHT TERMINAL
113-324		APRON, OPERATIONAL	"	10,000	"	1,290			"	"	"	"						SERVES SQUADRON OPERATIONS
113-328		APRON, TRANSIENT	"	25,000	"	3,230			"	"	"	"						SERVES BASE OPERATIONS
116-652		HARDSTAND, CALIBRATION	"	10,446	"	1,348			"	"	"	"						
116-663		PAD, HELICOPTER (3) 50' X 150'	"	2,500	9.95	24.3			"	"	"	"						1 AT AIRFIELD, 2 AT LAUNCH FACILITIES
116-664		PAD, POWER CHECK	"	3,851	12.90	490			"	"	"	"						OFF TAXIWAY IN REMOTE AREA FOR NOISE CONTROL
116-666		PAD, WARMUP/HOLDING	"	10,200	"	1,318			"	"	"	"						AT END OF PRIMARY RUNWAY
116-672	DEF-36-40-12-R1	WASHRACK, AIRCRAFT	"	4,540	15.50	96.2			"	"	"	"	10	8.5	10,000	10,000		OFF TAXIWAY INCLUDES $25,800 FOR BUILDING
116-945	AD-86-19-01-R3	DEFLECTOR, BLAST	EA	7	2500.	17.5			"	"	"	"						ONE AT POWER CHECK PAD, SIX ALONG APRON
134-332		GROUND CONTROL APPROACH (GCA)	SQ.YD.	100	5.00	0.5			"	"	"	"						HARDSTAND FOR VAN PARKING
134-352		INSTRUMENT LANDING SYSTEM GLIDE SLOPE TRANS.	SQ.FT.	182	12.80	2.3			"	"	"	"						" " " "
134-353		" " " LOCALIZER TRANSMITTER	"	182	"	2.3			"	"	"	"						" " " "
134-356	AD-35-46-05	" " " MIDDLE MARKER	"	624	"	8			"	"	"	"						" " " "
134-358	" " " "	" " " OUTER "	"	75	"	1			"	"	"	"						" " " "
134-374		PRECISION RADAR	SQ.YD	100	5.00	0.5			"	"	"	"						" " " "
134-375	AD-86-08-09	RADAR APPROACH CONTROL CENTER	SQ.FT.	9,605	24.60	246			"	"	"	"	495	400	2,000	2,000	500	
134-376	AD-60-02-63	AREA SEARCH RADAR	"	20,175	"	495			"	"	"	"	2090	1767	1,800	1,800	1,000	TRANSFORMER VAULT
134-394		RADAR BEACON	"	565	15.00	8.5			"	"	"	"						FOUNDATION PAD AND BUILDING
134-422		RADIO BEACON - MEDIUM POWER	"	200	"	3			"	"	"	"						EMERGENCY POWER BUILDING
134-465	AD-86-16-15	TACAN STATION, FIXED	"	485	"	7.3			"	"	"	"	0.9	0.4			16.5	FOUNDATION PAD AND BUILDING
134-635		BEACON LIGHT	EA.	1	6,000	6			"	"	"	"	0.5	0.5				
134-678		WIND DIRECTION INDICATOR	L.S.	1	10,000	10			"	"	"	"	1	1				
136-661		LIGHTING, APPROACH	SYSTEM	1	746,000	746			"	"	"	"	15	15				HIGH INTENSITY, 500 WATT ELEV. FIXTURES, 5 DEG. BRIGHTNESS
136-662		LIGHTING, OBSTRUCTION	"	1	58,000	58			"	"	"	"	5	5				ON HIGH AIRCRAFT HAZARDS
136-664		LIGHTING, RUNWAY, HIGH INTENSITY	LIN. FT.	14,500	25.00	362			"	"	"	"	40	40				HIGH INTENSITY, 500 WATT
136-667		LIGHTING, TAXIWAY	" "	19,010	19.00	365			"	"	"	"	35	35				ELEVATED, MEDIUM INTENSITY, 45 WATT
141-142	AD-36-30-08	FIRE STATION, LINE	SQ.FT.	10,780	19.85	214	1	1/4	1	25	0.25	1.25	62.1	46.6	1,520	1,520	1,240	6 STALLS
141-144	" " " "	FIRE STATION, COMBINATION	" "	16,940	18.40	311	1	1/4	1.5	25	0.27	1.77	80	60	2,480	2,480	1,948	10 STALLS
141-145	" " " "	FIRE OBSERV. TOWER AND COMM. CENTER	" "	4,620	23.00	106	3	1/4	0.4	25	0.1	0.5	42	37.5	520	520	531	2 STALLS
141-181		AIRCRAFT SHELTER	" "	50,000	23.60	1,180	1	1/4	4.6	25	1.2	5.8	1200	900	9,000	9,000	3,700	
141-453	AD-30-07-18	OPERATIONS, BASE	" "	8,715	30.00	261	2	1/6	0.5	25	0.1	0.6	100	68	8,440	8,000	435	
141-454	AD-30-10-10	OPERATIONS, SPECIAL	" "	26,800	20.15	540	2	1/6	2.0	25	0.5	2.5	79	65.5	4,200	4,200	1,512	
141-621		CEILOMETER-FIXED BEAM	L.S	1	7000	7							7	7				
141-622	AD-35-50-02	WEATHER MODULATOR	SQ.FT	344	37.50	12.9							2.5	1.5			19	
141-626	DEF-35-48-04	WEATHER RAWINSONDE	"	1,502	44.50	66.7	1	1/4	0.2			0.2	2.5	1.7	300	300	15	
141-628		TRANSMISSOMETER	L.F.	700	10.00	7							0.1	0.1				700 UNDERGROUND DUCT
141-629		WEATHER OBSERVATION STATION	SQ.FT	180	37.50	6.8							0.8	0.7			18	IN CONTROL TOWER
141-632		TEMP.-RELATIVE HUMIDITY MEASURING STATION	"	21	5.00	0.02							0.01	0.01				CONCRETE PAD, 10,000 DUCT AT $10.00/FT.
141-633		WIND MEASURING STATION	"	25	5.00	0.02							0.01	0.01				" ", 20,000 " " " "
141-782	DEF-36-41-02	TERMINAL, AIR FREIGHT	"	4,000	22.70	90.7	1	1/4	0.5	25	0.1	0.6	89	60	7,000	7,000	1,000	
141-784	DEF-36-41-03	TERMINAL, AIR PASSENGER	"	15,000	"	341	1	1/4	1.4	25	0.35	1.75	INCLUDED IN 141-782					
149-512		STAND, MISSILE FIRING W/GANTRY, UMBILICAL TWR.	L.S.	1	4,000,000	4,000			20,000	5	1,000	21,000	1500	1312	100,000	0	3,630	COOLING WATER TO NATURAL DRAINAGE
149-512		" " " " " " "	"	1	2,300,000	2,300			20,000	5	1,000	21,000	900	780	70,000	0	2,000	" " " " "
149-512		" " " " " " "	"	1	3,800,000	3,800			20,000	5	1,000	21,000	1200	1085	90,000	0	2,200	" " " " "
149-512		" " " " " " "	"	1	3,600,000	3,600			20,000	5	1,000	21,000	1150	1012	82,000	0	2,700	" " " " "
149-962	AD-86-06-05	TOWER, CONTROL	SQ.FT.	1,970	L.S.	122			INCLUDED IN 111-112				45	39.5	450	450	5	
211-111	AD-39-01-82	HANGER, FIELD MAINTENANCE	"	127,750	18.35	2,340	1	1/4	12	5	0.6	12.6	1500	1300	10,000	10,000	7,000	2 HANGERS AT 63,875 SQ. FT.
211-112	AD-39-01-65	HANGER, MAINTENANCE, ORGANIZATIONAL	"	57,800	19.95	1,154	1	1/4	5.3	5	0.27	5.57	1374	913	9,000	9,000	3,632	2 " " 28,900 " "
211-152	AD-35-01-28	SHOP, AIRCRAFT MAINTENANCE, GEN. PURPOSE	"	47,000	12.95	608	1	1/4	2.7	25	0.67	3.37	1000	600	6,000	6,000	1,640	2 BUILDINGS
211-154	AD-35-01-38	" " " , ORGANIZATIONAL	"	10,800	13.75	148.5	1	1/4	1	25	0.25	1.25	180	172	700	700	740	
211-157	AD-35-79-03	" " ENGINE INSPECTION AND REPAIR	"	21,900	19.85	435	1	1/4	2	25	0.5	2.5	284	262	4,000	4,000	650	
211-173		AIRCRAFT MAINTENANCE DOCK	EA.	2	148,000	296	1	1/4	13.6	5	0.68	14.28	800	650	1,000	1,000	6,090	
211-193		TEST CELL, JET ENGINE	SQ.FT.	12,000	16.80	204	1	1/4	1.1	25	0.25	1.26	10	9				SHAW ESTES STAND (30,000 LB. THRUST)
390-531		ROCKET STATIC TEST TOWER	L.S.	1	3,500,000	3,500			20,000	5	1,000	21,000	240	208	80,000		740	COOLING WATER TO NATURAL DRAINAGE
390-531		" DYNAMIC " "	"	1	9,000,000	9,000			20,000	5	1,000	21,000	4700	3650	13,700		1,268	" " " " "
610-129		ADMINISTRATION, AIRCRAFT MAINT. CONTROL	SQ.FT.	7,400	24.50	181	1	1/4	0.68	25	0.17	0.85	90	58	7,000	7,000	1,000	
931-215		AIRCRAFT/MISSILE ACCIDENT EMERGENCY ALARM SYSTEM	EA.	1	40,000	40												
				Totals		$104,276.54			121,012.48		6,054.36		19,330.42	15,571.52	521,110	84,970	45,229.5	
												127,066.84						

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Table 14 (cont.)

Category Item No.	Drawing Number	Facility Item	Unit	Units Required	Cost		Land Use						Utilities					Notes
					Per Unit	Total (000)	Hgt Stories	O.S.R.	Net Req. Acres	% Add	Circ. Acres	Gross Acres	Power-Kw. connected ld	Power-Kw. est demand	Water-g.p.d.	Sewage-g.p.d.	Heat-mbtu/hr.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
INDUSTRIAL LAND USE																		
123-335		VEHICLE FUELING STATION	EA.	4	31,500	126		1/4	9			9	21	15				EACH 350' X 700' - 1 PER 150 VEHICLES
126-925		LIQUID FUEL STAND, TRUCK	EA.	1	9,500	9.5		1/4	0.5			0.5	7	5				AT P.O.L. STORAGE DEPOT
141-232		LAUNCH OPERATIONS SUPPORT BLDG.	SQ.FT	60,000	17.60	1,050	2	1/4	2.7	25	0.7	3.4	1400	1000	9,000	9,000	3,800	SHOPS AND ADMIN. AT LAUNCH AREA
141-911		MISSILE TRACKING/DESTRUCT SAFETY FAC.	L.S	1	1,200,000	1,200	2	1/4	2	25	0.5	2.5	1341	1207	1,080	1,080	274	
141-912		SPACE VEHICLE MAINTENANCE AND TESTING	SQ.FT.	50,000	38.60	1,430	2	1/4	2.3	25	2.6	2.9	500	420	5,000	5,000	2,560	
152-111		BARGE DOCK	L.S.	1	180,000	180			4	25	1	5	25	20	4,000	4,000	3,400	
211-124		RECLAMATION SHOP, BASE	SQ.FT.	1,000	17.60	17.6	1	1/4	0.9	25	0.2	1.1	300	260	900	900	300	
212-212		BOOSTER ASSEMBLY BUILDING	"	120,000	38.60	4,640	2	1/4	5.5	25	1.4	6.9	1500	1350	11,000	11,000	8,000	
212-212		MISSILE ASSEMBLY BUILDING	"	80,000	"	3,090	2	1/4	3.7	25	0.9	4.6	700	610	5,000	5,000	4,000	
212-216		VERTICAL ASSEMBLY BUILDING	"	180,000	"	6,950	2	1/4	8.3	25	2	10.3	1600	1400	12,000	12,000	10,000	
214-425	AD-35-02-58	AUTOMOTIVE MAINTENANCE SHOP	"	30,000	16.70	502	1	1/4	2.7	25	0.7	3.4	181	97	9,000	9,000	3,200	
214-467		SHOP, REFUELING VEHICLE	"	3,400	19.35	658	1	1/4	3.1	25	0.8	3.9	14	10	1,000	1,000	350	
217-762	DEF-35-58-02	SHOP, NAVIGATIONAL AIDS AND COMM. EQUIPT.	"	3,600	21.10	76.3	1	1/4	0.3			0.3	100	84	1,000	1,000	640	
218-712	AD-35-32-05	SHOP, GROUND POWERED EQUIPT. MAINT.	"	4,300	20.20	86.8	1	1/4	0.4	25	0.1	0.5	103	88	1,000	1,000	670	
218-842	AD-39-08-07	SHOP AND SHELTER, LOCOMOTIVE, BASE	"	4,000	24.85	99.3	1	1/4	0.4	25	0.1	0.5	21	17	1,000	1,000	100	
218-852	AD-36-33-10	SHOP, PARACHUTE AND DINGHY, BASE	"	11,225	22.45	252.5	1	1/4	1.0	25	0.2	1.2	89	55	7,800	1,250	1,100	
219-942	AD-30-08-07	BASE ENGINEER ADMINISTRATION	"	8,200	18.80	154	1	1/4	0.7	25	0.2	0.9	33	25	1,280	1,280	764	
219-943	" " " "	BASE ENGINEER PAVEMENT AND GROUNDS SHOP	"	3,700	18.25	67.5	1	1/4	0.2			0.2	14	10	1,040	1,040	362	
219-944	" " " "	BASE ENGINEER MAINTENANCE SHOP	"	21,200	"	387	1	1/4	1.9	25	0.4	2.3	120	90	2,160	2,160	1,231	
219-946	" " " "	BASE ENGINEER COVERED STORAGE	"	21,200	12.00	254	1	1/4	1.9	25	0.4	2.3	19	14				
219-947		STORAGE SHED	"	21,200	9.85	208.5	1	1/4	1.9	25	0.4	2.3						
229-986	AD-26-03-92	OXYGEN GENERATING PLANT	"	4,000	22.50	90	1	1/4	0.4	25	0.1	0.5	12	11	500	500	4,000	
390-562		MISSILE FUEL RP-1 STORAGE	BBL	160,000	2.05	328			32.2	5	1.6	33.8	1	1				ABOVE GROUND
390-562		LIQUID GAS STORAGE	GAL	100,000	2.10	210			24.9	5	1.3	26.2	1	1				5000 GAL NITROGEN, 1000 GAL HELIUM, 94,000 HYDROGEN
390-611		MISSILE ENGINE MAINTENANCE AND TESTING	SQ.FT.	100,000	38.60	3,860	2	1/4	4.6	25	1.1	5.7	1460	1310	9,000	9,000	6,000	
411-123		DEMINERALIZED WATER FACILITY	"	400	10.00	1,090	1	1/4	0.5	25	0.1	0.8	29	23	5,700	100	200	25,000 GAL. STORAGE AT $3.70/GAL. EQUIPT-$12,500
411-127		WATER-ALCOHOL FACILITY	"	400	26.60	37.1	1	1/4	0.5	25	0.1	0.6	10	7	1,000	90	10	25,000 GAL. ALCOHOL STORAGE, 25,000 GAL. BLEND STORAGE
411-131		AVIATION FUEL STORAGE	BBL	200,000	2.00	400			41.3	5	2	43.3	1	1				ABOVE GROUND
411-132		" LUBRICATION STORAGE	"	20,000	3.70	54			8.3	5	0.4	8.7	1	1				" "
411-134		DIESEL STORAGE	"	55,000	2.60				12.4	5	0.6	13.	1	1				" "
411-137		MOGAS STORAGE	"	80,000	2.30	180			18.6	5	0.9	19.5	1	1				" "
411-139		SPECIAL FUEL STORAGE (CLASS 07 & 24 CHEMICAL)	"	25,000	7.35	36.7			4.1	5	0.2	4.3	1	1				2-12,500 BARREL TANKS UNDERGROUND
422-257	AD-33-13-17	SEGREGATED MAGAZINE STORAGE (AMMUNITION)	SQ.FT.	1,800	34.20	61.6	1	1/4	0.2			0.2	2	2				BURRIED MAGAZINE
422-258	" " " "	SMALL ARMS AMMUNITION STORAGE	"	6,600	11.50	75.8	1	1/4	0.6	25	0.2	0.8	12	10				ABOVE GROUND MAGAZINE
422-264	AD-33-15-11-R2	IGLOO ORDINANCE STORAGE	"	2,150	20.60	44.2			0.2			0.2						BURRIED MASS DETONATING EXPLOSIVE STORAGE
432-283	AD-33-04-28	BASE, COLD STORAGE	"	9,135	32.00	29.2	1	1/4	0.8	25	0.2	1.0	10	9	500	500	8,000	
442-258	AD-26-03-92	STORAGE, LIQUID OXYGEN	GAL	120,000	30,00	3,750			24.9	5	1.3	26.2	10	8				INCLUDES 2000 GALLONS FOR BREATHING
422-628		SHED, SUPPLIES AND EQUIPMENT STORAGE	SQ.FT	30,000	4.75	142.5	1	1/4	2.8	25	0.7	3.5	10	9				
442-753	AD-33-02-95	WAREHOUSE, DISPOSAL AND SALVAGE, BASE	"	50,000	8.90	445	1	1/4	4.6	25	1.1	5.7	51	47	480	480	1,000	
442-758	" " " "	" , SUPPLIES AND EQUIPMENT, BASE	"	257,000	7.00	1,799	1	1/4	23.6	25	5.9	29.5	250	230	1,830	1,830	5,400	
452-251		AUTO STORAGE, OPEN	SQ.YD.	32,500	7.20	234	1	1/4	26.9	25	6.7	33.6	130	120				
452-252		OPEN STORAGE, BASE	"	4,000	4.00	16	1	1/4	3.1	25	0.8	3.9	2	2				
452-255		BASE ENGINEER OPEN STORAGE	"	11,700	7.20	843	1	1/4	9.7	25	2.4	12.1	27	23				
452-256		RECLAMATION YARD, BASE	"	1,500	"	10.8	1	1/4	1.2	25	0.3	1.5	5	4				
452-257		REFUELING VEHICLE STORAGE, OPEN	"	16,500	"	12.1	1	1/4	13.6	25	3.4	17	2	2				42 REFUELING VEHICLES ESTIMATED
610-121	AD-35-02-58	AUTOMOTIVE, ADMINISTRATIVE	SQ.FT	2,200	20.25	44.6	1	1/4	2	25	0.5	2.5	9	6	4,000	4,000	320	
610-123	AD-30-05-04	P.O.L. OPERATIONS AND ADMINISTRATION	"	2,400	22.80	54.7	1	1/4	0.2			0.2	16	11	1,000	1,000	125	
610-718	SG-202-STD-32A	PRINTING PLANT	"	8,000	16.65	130	1	1/4	0.7	25	0.2	0.9	10	9	1,500	1,450	150	
811-143	AD-26-03-26	ELECTRICAL EMERGENCY POWER	KW	3,473	260.00	903			5	25	1.2	6.2	12	8				1 EA AT HOSPITAL, COMM, AIRFIELD LGT, NAV. AIDS, COLD STORAGE
811-145		ELEC. POWER SUPPLY (PRIME GENERATION)	"	200,000	260.00	52,000	3	1/4	5	25	1.2	6.2						2 KW/CAPITA TOO LOW BECAUSE OF MISSION REQUIREMENTS
821-116		HEATING PLANT, CENTRAL, STEAM GENERATING	MBTU/HR	700,000	7.80	5,460	3	1/4	5	25	1.2	6.2	11,000	11,000	40,000	12,000	2,000	2 PLANTS AT 350,000 M BTU/HR EA, GAS FIRED, OIL STANDBY
831-155		INDUSTRIAL WASTE TREATMENT FACILITY	EA	1	200,000	200	1	1/4	5	25	1.2	6.2	100	80	1,400	1,400	100	
831-165		SANITARY SEWAGE TREATMENT PLANT	EA	1	570,000	570	1	1/4	5	25	1.2	6.2	150	99	400	400	2,400	24,000 CAPITA CAPACITY
833-354		GARBAGE INCINERATOR	EA	1	97,000	97	1	1/4	5	25	1.2	6.2	20	15	100	100	500	
841-165		WATER SUPPLY STORAGE	GAL	2 MILLION	0.10	200		1/4	4	25	1	5	80	80				
841-427		" " TREATMENT	"	3 "	0.12	360		1/4	4	25	1	5	100	85	100	100	400	
860-617		RAILROAD TRACKAGE	MILES	25	63,300	1,582.5												$12.00/FOOT
				Totals		96,789.8			354.3		52.7	407	21,614	19,994	140,770	99,660	71,356	

Table 14 (cont.)

Category Item No.	Drawing Number	Facility Item	Unit	Units Required	Cost: Per Unit	Cost: Total (000)	Land Use: Hgt. Stories	O.S.R.	Net Req. Acres	%Add	Circ. Acres	Gross Acres	Utilities: Power-Kw connected ld	Power-Kw est demand	Water-g.p.d.	Sewage-gpd	Heat-m btu/hr.	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
ADMINISTRATIVE LAND USE																		
131-111		SPACE COMMUNICATIONS CENTER	SQ.FT	40,000	37.00	1,480	2	1/6	2.7	25	0.7	3.4	400	360	12,000	12,000	1,000	TELEMETERY AND COMPUTER CENTER EQUIPMENT INCLUDED
131-112	AD-38-04-31	COMMUNICATIONS, BASE	"	9,680	25.20	244	1	1/6	1.5	25	0.4	1.9	48	36	1,200	1,200	330	
131-113	DEF-38-06-03	TELEPHONE EXCHANGE	"	7,000	"	176	1	1/6	1	25	0.2	1.2	26	22	1,000	1,000	286	
131-115	AD-38-12-24	COMMUNICATIONS RECEIVER	"	1,000	21.10	21.1	1	1/6	0.2	25		0.2	300	265	960	960	314	
131-117	" " " "	COMMUNICATIONS TRANSMITTER	"	1,000	"	21.1	1	1/6	0.2			0.2	INCLUDED IN 131-115					
131-122	AD-38-12-10	AIRCOM RELAY CENTER	"	1,000	"	21.1	1	1/6	0.2			0.2	15	10	450	450	86	
131-125	" " " "	AIRCOM RECEIVER	ACRE	500	"	10.6			500			500	INCLUDED IN 131-122					} MUST BE SEPARATED BY 8 MILES
131-126	" " " "	AIRCOM TRANSMITTER	"	500	"	10.6			500			500	" " "					
131-128	AD-38-04-24	MICROWAVE RELAY	SQ.FT.	4,640	24.40	113.2	1	1/4	0.4	25	0.1	0.5	32	30	320	320	81	4 EA AT 1,160 SQ.FT.
133-314		DIRECTION FINDING RADAR	"	600	21.10	127	2						12	9	185	185	400	BUILDING ONLY
134-119	DEF-38-12-09	REMOTE CONTROL FACILITIES	"	1,144	18.70	214	1		0.2			0.2	60	58	100	100	300	
141-458		SPACE MISSION CONTROL CENTER	"	80,000	37.50	3,000	2	1/6	5.5	25	1.4	6.9	800	620	2,000	2,000	2,000	
141-743	AD-36-32-13	PHOTO LABORATORY, BASE	"	5,000	32.30	162	1	1/6	0.7	25	0.2	0.9	103	76	5,000	5,000	180	
171-152		GENERAL LECTURE HALLS	SEAT	1,000	330.00	330	1	1/6	5	25	1.25	6.25	55	48	4,442	4,000	840	
171-153	AD-28-14-10	ACADEMIC CLASSROOM FACILITY (BASE)	SQ.FT.	4,500	18.30	82.2	2	1/6	0.3			0.3	20	16	2,000	2,000	167	BASE PERSONNEL TRAINING
171-212	AD-28-13-103-R1	FLIGHT SIMULATOR TRAINING	"	8,200	24.65	202	1	1/6	1	25	0.25	1.25	228	143	17,280	14,860	480	" " "
171-214	AD-28-12-04	HIGH ALTITUDE TRAINING	"	7,200	21.10	154	1	1/6	1	25	0.2	1.2	62	45	1,495	1,350	275	" " "
171-352		SPACE LIBRARY CENTER	"	100,000	20.00	2,000	3	1/6	4.6	25	1.1	5.7	3,460	2,785	51,000	51,000	9,220	
171-356		SPACE LAW CENTER	"	4,000	"	80	2	1/6	0.3			0.3	24	19	1,200	1,200	720	
171-393		INSTITUTE OF SPACE SCIENCES-ASTRONOMY	"	4,000	21.50	86	1	1/6	0.5	25	0.1	0.6	14	10	1,000	1,000	1,000	
171-393		" " " " -RADAR ASTRONOMY	"	6,000	"	128	1	1/6	0.8	25	0.2	1.0	18	15	1,400	1,400	945	
171-393		" " " " -CELESTIAL MECHANICS	"	6,000	"	128	1	1/6	0.8	25	0.2	1.0	18	15	1,400	1,400	945	
171-412	AD-28-18-01	OPERATIONAL MISSION TRAINING	"	9,000	20.90	188	1	1/6	1.2	25	0.3	1.5	347	257	5,180	5,120	522	BASE PERSONNEL TRAINING
171-475	AD-84-06-05	SMALL ARMS RANGE, INDOOR	"	15,000	25.50	382	1	1/6	2	25	0.5	2.5	15	14	1,000	1,000	385	5 POSITION
171-614		INSTITUTE OF SPACE SCIENCES-TECHNICAL TRAINING	"	50,000	17.00	850	3	1/6	2.3	25	0.6	2.9	1,950	1,585	30,000	30,000	5,840	
171-614		" " " " -ECONOMICS	"	4,000	20.00	80	2	1/6	0.3			0.3	24	19	1,200	1,200	720	
171-617	DEF-28-16-05	TRAINING AIDS CENTER	"	25,272	17.60	444	3	1/6	1.2	25	0.3	1.5	167	97	8,000	8,000	3,400	
310-112		INSTITUTE OF SPACE SCIENCES-AERO/THERMODYNAMICS	"	40,000	21.50	860	2	1/6	2.7	25	0.7	3.4	900	740	6,800	6,800	1,600	
310-171		" " " " -AERONAUTICAL ENG.	"	11,000	"	236	2	1/6	0.8	25	0.2	1.0	140	127	700	700	840	
310-317		" " " " -ELEC. INSTRUMENT. LAB	"	40,000	"	860	2	1/6	2.7	25	0.7	3.4	900	740	6,800	6,800	1,600	
310-415		" " " " -DATA INTERPRETATION	"	100,200	22.50	5,300	4	1/6	7	25	1.7	8.7	4,850	4,165	6,100	6,100	9,100	
310-472		" " " " -STRUCTURAL DYNAMICS	"	57,000	21.10	1,600	2	1/6	3.9	25	1.0	4.9	1,481	1,197	30,000	30,000	5,181	
310-611		" " " " -PROPULSION COMP. EVAL.	"	38,000	27.50	1,000	2	1/6	2	25	0.5	2.5	891	612	4,814	4,814	1,461	
310-613		" " " " -PROPELLANT FLOW	"	39,400	"	1,300	2	1/6	2.7	25	0.7	3.4	912	718	4,000	4,000	1,500	
310-666		" " " " -NUCLEAR ENGINE	"	82,000	37.20	5,000	2	1/6	5.7	25	1.4	7.1	2,760	2,141	80,000	80,000	1,874	
310-911		" " " " -MECHANICAL ENG.	"	10,000	21.50	215	2	1/6	0.7	25	0.2	0.9	350	246	5,200	5,200	588	
310-913		LUNAR AND PLANETARY RESEARCH LAB	"	14,000	27.60	386	2	1/6	1	25	0.2	1.2	160	131	2,000	2,000	1,350	
310-913		HOT GAS RADIATION RESEARCH LAB.	"	39,500	26.00	2,600	2	1/6	2.7	25	0.7	3.4	888	612	14,000	12,100	1,450	
310-915		INSTITUTE OF SPACE SCIENCES-PHYSICS/CHEMISTRY	"	30,000	25.60	768	2	1/6	2	25	0.5	2.5	740	585	4,200	4,200	1,250	
310-916		SPACECRAFT CONTROL TECHNOLOGY LAB.	"	38,500	21.50	6,000	2	1/6	2.6	25	0.7	3.3	528	416	3,120	3,110	621	
310-922		MULTIPLE AXIS SPACE TEST INERTIA FACILITY	"	20,000	35.00	2,200	1	1/6	2.8	25	0.7	3.5	487	323	3,720	3,720	848	
310-925		VACUUM SPACE CHAMBER LAB.	"	20,000	29.50	2,600	1	1/6	2.7	25	0.7	3.4	186	131	680	680	750	
310-925		ZERO GRAVITY CHAMBER LAB.	"	20,300	"	2,610	1	1/6	2.7	25	0.7	3.4	190	142	691	691	712	
310-925		ENVIRONMENTAL CENTRIFUGE LAB.	L.S.	1	2,500,000	2,500	2	1/6	2	25	0.5	2.5	860	495	1,000	1,000	1,250	30,000 SQUARE FEET
310-926		SOLAR SYSTEMS ATMOSPHERES LAB.	SQ.FT.	22,500	32.90	7,400	2	1/6	1.5	25	0.4	1.9	195	161	2,100	2,100	1,581	
310-926		ATMOSPHERIC RE-ENTRY MATERIALS LAB.	"	40,000	24.00	5,900	2	1/6	2.7	25	0.7	3.4	840	693	4,850	4,850	1,218	
310-927		METEOROLOGICAL SYSTEMS LAB.	"	80,000	27.50	4,100	2	1/6	5.5	25	1.4	6.9	4,137	3,416	4,000	4,000	6,991	
310-929		LIFE SCIENCES LAB.	"	198,700	"	4,800	4	1/6	2.7	25	0.7	3.4	4,915	4,271	20,000	20,000	11,415	
310-929		BIOLOGY LAB.	"	12,000	21.50	258	2	1/6	0.8	25	0.2	1.0	27	21	1,600	1,600	1,182	
310-944		INERTIAL GUIDANCE LAB.	"	100,000	27.60	5,700	2	1/6	7.	25	1.7	8.7	3,150	2,641	48,000	48,000	10,800	
610-125		FACULTY OFFICES	"	14,000	22.80	319	3	1/6	0.6	25	0.1	0.7	300	245	1,850	1,850	1,395	
610-125	AD-30-04-17	HEADQUARTERS, BASE	"	239,680	25.50	6,120	4	1/6	8.2	25	2.0	10.2	1,745	1,467	27,750	27,000	5,210	130 SQ. FT./PERSON (1,836 OCCUPANTS)
610-142		COMMERCIAL TRANSPORTATION	"	1,500	26.40	39.6	1	1/6	0.2			0.2	200	180	500	500	260	
610-247	AD-30-02-65	HEADQUARTERS SQUADRON AND SUPPLY	"	33,000	22.10	732	2	1/6	2.3	25	0.6	2.9	152	114	5,868	5,868	3,836	12 SQUADRONS AT 2,800 SQ.FT. EA., 6 BUILDINGS
730-835		HEADQUARTERS, AIR POLICE	"	2,650	26.40	70	1	1/6	0.4	25	0.1	0.5						
771-822		HIGH ALTITUDE TEST AND RESEARCH LAB.	"	82,700	25.50	3,000	2	1/6	5.7	25	1.4	7.1	3,114	3,096	32,000	32,000	6,247	
				Totals		85,208.5			1,118.2		29.1	1,147.3	43,196	36,380	472,155	466,428	112,546	

Table 14 (cont.)

Category Item No. (1)	Drawing Number (2)	Facility Item (3)	Unit (4)	Units Required (5)	Cost: Per Unit (6)	Cost: Total (000) (7)	Land Use: Hgt Stories (8)	O.S.R. (9)	Net Req Acres (10)	%Add (11)	Circ. Acres (12)	Gross Acres (13)	Utilities: Power-Kw connected ld (14)	est. demand (15)	Water-gpd (16)	Sewage-gpd (17)	Heat-m btu/hr. (18)	Notes (19)
COMMUNITY SUPPORT LAND USE																		
141 - 146	AD-36-30-08	FIRE STATION, STRUCTURAL	SQ.FT.	5,740	$22.15	127	1	1/5	0.7	25	0.1	0.8	47	35	760	760	660	3 STALLS
219 - 945		BASE ENGINEER HOSPITAL MAINTENANCE	"	1,200	21.60	25.9	1	1/5	0.2			0.2	200	180	500	500	250	IN 510-001 (HOSPITAL)
442 - 515	SG-202-STD-32A	STORAGE, MEDICAL EQUIPMENT AND SUPPLY	"	75,600	10.35	787	1	1/5	8.7	25	2.2	10.9	INCLUDED IN 510-001					" " "
510 - 001		HOSPITAL, 150 BED	"	118,000	30.60	3,613	6	1/5	2.3	25	0.5	2.8	2,000	1,800	48,000	48,000	3,000	
510 - 175		FLIGHT SUREGONS CLINIC	"	2,800	31.50	88.3	1	1/5	0.2			0.2	INCLUDED IN 510-001					" " "
530 - 634	AD-32-57-01	MEDICAL FOOD INSPECTION	"	1,100	22.50	247	1	1/5	0.1			0.1	2	1	5,000	5,000	100	ADD TO 432-283 (COLD STORAGE)
540 - 243		DENTAL CLINIC	"	10,618	31.50	334	1	1/5	1.3	22	0.3	1.6	3	3	10,000	10,000	650	20 DENTAL OPERATING ROOMS (2 IN HOSPITAL)
550 - 145	AD-32-06-27	DISPENSARY, "B", CONTRACTOR	"	6,250	"	196.8	1	1/5	0.7	25	0.2	0.9	99	78	5,550	5,550	570	LOCATED NEAR MISSILE LAUNCH FACILITIES
723 - 351	AD-36-05-98	DINING HALL, AIRMAN	"	57,540	25.00	1,437	1	1/5	6.6	25	1.6	8.2	1,800	1,560	87,600	87,000	8,760	5 DINING HALLS, 3-1000 MAN, 1-800 MAN
730 - 182		BAKERY, BREAD	"	10,800	28.80	311	1	1/5	1.2	25	0.3	1.5	1,000	850	12,000	11,000	1,250	
730 - 784		SCHOOL, DEPENDENT, ELEMENTARY	"	150,920	17.00	2,720	1		25	25	6	31	8,000	7,000	4,000	4,000	1,365	GRADES 1-8, 2,156 PUPILS, 70 SQ.FT./PUPIL, (NOT GOV. FINANCED)
730 - 785		" " , HIGH	"	118,580	"	2,080	1		35	25	8.7	43.7	6,900	5,400	3,500	3,500	1,210	" 9-12, 1,078 " , 110 " " " "
730 - 831	AD-27-02-36	CONFINEMENT FACILITY	"	5,800	35.00	203	1	1/5	0.7	25	0.2	0.9	29	22	3,600	3,600	448	32 MAN FACILITY
730 - 832	AD-27-05-05	SECURITY CONTROL AND IDENTIFICATION	"	900	29.60	26.6	1	1/5	0.1			0.1	3	3	150	150	74	
730 - 833		SECURITY, CENTRAL CONTROL	"	1,270	27.75	35.2	1	1/5	0.2			0.2	3	3	160	160	100	
730 - 839	AF-27-05-06	TRAFFIC CHECK HOUSE	UNIT	6	1,000	6	1						1	1			100	
740 - 153	AD-36-18-05	BANK, BRANCH	SQ.FT.	3,200	21.80	69.8	1	1/5	0.4	25	0.1	0.5	15	13	175	175	160	
740 - 233	AD-38-01-40	CHAPEL, BASE	SEATS	900	29.00	26.1	1	1/5	1	25	0.3	1.3	98	89	4,925	4,925	2,472	3-300 SEAT CHAPELS
740 - 235	AD-38-01-45	" , EDUCATION WING	SQ.FT	8,700	25.40	221	1	1/5	1	25	0.3	1.3	142	107	4,050	4,050	714	2-4,350 SQ.FT PROTESTANT WINGS
740 - 264	AD-36-07-24	STORE, CLOTHING SALES	"	6,400	12.15	77.7	1	1/5	0.7	25	0.2	0.9	50	48	238	238	332	
740 - 266	AD-36-07-23	" , COMMISSARY	"	26,800	17.70	474	1	1/5	3.1	25	0.8	3.9	129	123	3,510	2,990	681	CLASS 6
740 - 316	AD-31-18-428	CLUB, SERVICE	"	47,600	21.00	1,000	1	1/5	5.5	25	1.4	6.9	226	170	10,350	10,350	5,049	2 CLUBS AT 19,800 SQ.FT. AND 27,800 SQ.FT.
740 - 381	AD-36-06-60	EXCHANGE CAFETERIA	"	9,100	24.50	222.5	1	1/5	1	25	0.3	1.3	INCLUDED IN 740-388					345 PERSON CAPACITY
740 - 382		EXCHANGE, BRANCH	"	1,500	19.50	29.2	1	1/5	0.2			0.2	" " 510-001					
740 - 383	DEF-36-21-02	EXCHANGE SERVICE STATION	"	1,500	27.00	40.5	1	1/5	0.2			0.2	4	3	4,000	4,000	110	
740 - 385		EXCHANGE MAINTENANCE SHOP	"	1,500	18.25	27.4	1	1/5	0.2			0.2	4	3	1,000	900	110	
740 - 387		EXCHANGE RETAIL WAREHOUSE	"	7,000	12.00	84	1	1/5	0.8	25	0.2	1.0	45	38	230	230	200	
740 - 388	AD-36-06-60	EXCHANGE SALES STORE	"	16,900	16.10	272	1	1/5	1.9	25	0.5	2.4	282	229	6,950	6,950	1,092	
740 - 443		GUEST HOUSE	"	16,600	16.00	297	2	1/5	0.9	25	0.2	1.1	290	235	17,000	17,000	1,100	
740 - 633	AD-36-08-23	POST OFFICE, CENTRAL	"	5,300	18.60	98.5	1	1/5	0.6	25	0.1	0.7	22	17	1,600	1,600	424	
740 - 717		RED CROSS OFFICE	"	583	21.60	12.6	1						INCLUDED IN 510-001					
740 - 735		RESTAURANT	"	12,500	25.00	313	1	1/5	1.4	25	0.4	1.8	450	410	20,000	20,000	2,500	AUTHORIZED TO ACCOMODATE CIVILIAN CONTRACTORS
740 - 891		CENTER, EDUCATION	"	6,450	17.95	115.8	1	1/5	0.7	25	0.2	0.9	50	44	240	240	340	
812 - 223		ELECTRICAL DISTRIBUTION, PRIMARY, OVERHEAD	LIN.FT	200,000	3.00	600												OVER 600 VOLTS
812 - 224		" " , SECONDARY, "	"	900,000	"	2,700												LESS THAN 600 VOLTS
812 - 225		" " , PRIMARY, UNDERGROUND	DUCT FT	2,000	10.00	20												OVER 600 VOLTS
812 - 226		" " , SECONDARY, "	"	450,000	"	4,500												LESS THAN 600 VOLTS
812 - 922		STREET LIGHTS	SYSTEM	1	685,000	685							1,250	1,250				
812 - 927		ELECTRICAL SUBSTATIONS	KVA	262	20.00	524												2 STATIONS, CLOSED LOOP SYSTEM
824 - 464		GAS MAIN (DISTRIBUTION)	FT.	400,000	2.85	1,140												
831 - 356		SANITARY LAND FILL	EA	1	8,000	8			40	25	10	50						GROUND CLEARANCE AND ACCESS ROAD
832 - 266		" SEWAGE COLLECTION AND DISPOSAL MAINS	FT	500,000	3.85	1,925												
842 - 245		WATER SUPPLY DISTRIBUTION MAINS	"	500,000	5.40	2,700												
843 - 315		FIRE HYDRANTS	EA	500	790	397												
851 - 143		CURBS, GUTTERS, STREET INLETS	MILES	300	17,160	5,148												$3.25 PER LIN.FT.
851 - 147		ROADS AND STREETS	"	150	23,760	3,564	COVERED BY CIRCULATION ACRES											40FT. WIDE AVERAGE $4.50 PER SQUARE YARD
852 - 262		PARKING, VEHICLE	SPACES	10,307	115.00	1,185.3	" " " "											5.00/SQ.YD., 22 SQ.YDS/SPACE
852 - 289		SIDEWALKS	SQ.YD	60,000	2.30	138	" " " "											4 FT. MINIMUM WIDTH WALK
871 - 183		STORM DRAINAGE	FT.	200,000	3.90	780												
872 - 247		FENCE, SECURITY	"	215,000	3.10	666.5												8' CHAIN LINK SECURITY AND BARBED WIRE PERIMETER FENCE
880 - 211		FIRE ALARM SYSTEM	SYSTEM	1	156,000	156							INCLUDED IN BUILDINGS CONTAINING STATIONS					
880 - 213		FIRE DETECTION SYSTEM	"	1	31,000	31							" " " " "					
890 - 122		AIR CONDITIONING FACILITIES	INCLUDED IN APPROPRIATE BUILDING COST															
911 - 146		LAND, FEE PURCHASE	ACRE	130,000	250.00	32,500												
931 - 214		AUTO. SPRINKLER - WATER FLOW ALARM	INCLUDED IN APPROPRIATE BUILDING COST															
931 - 216		AUTOMATIC SPRINKLER SYSTEM	" " " " "															
932 - 277		LANDSCAPING	L.S.	1	3,593,000	3,593												$1,500/LANDSCAPED ACRE
933 - 364		REMOVAL OF HAZARDS (SITE PREPARATION)	ACRE	2,500.00	500.00	1,250												
				Totals		75,029.7			142.6		35.1	177.7	23,144	19,715	255,088	252,868	33,821	

Table 14 (concl.)

Category Item No.	Drawing Number	Facility Item	Unit	Units Required	Cost: Per Unit	Cost: Total (000)	Land Use: Hgt Stories	Land Use: O.S.R.	Land Use: Net Req. Acres	Land Use: %Add	Land Use: Circ. Acres	Land Use: Gross Acres	Utilities: Power-Kw connected ld	Utilities: Power-Kw est. demand	Utilities: Water-gpd	Utilities: Sewage-gpd	Utilities: Heat-mbtu/hr.	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
HOUSING LAND USE																		
711 - 111		HOUSING, OFFICER, FIELD GRADE (LT. COL., MAJ.)	UNITS	303	$ 17,600	5,332.8	1		76	25	19	95	17,000	15,420	117,200	117,200	INDIV. PLANTS	1,400 SQ. FT./UNIT, SINGLE UNITS
711 - 111		" " COMPANY " (CAPT., LT.)	"	581	15,400	7,262.5	1		146.	25	36.5	182.5	INCLUDED IN ABOVE				" "	1,250 " " " " "
711 - 111A		" ENLISTED (ALL RANKS)	"	3,479	13,200	45,922.8	1		580	25	145	725	62,622	57,110	521,650	521,650	" "	1,080 " " " DUPLEX UNITS
711 - 141		" OFFICER, COMMANDER (GENERAL)	"	1	22,000	22	1		1	25	0.3	1.3	INCLUDED IN 171-111 ABOVE				" "	2,310 " " " SINGLE UNIT
711 - 141		" " (GENERAL)	"	2	22,000	44	1		1	25	0.3	1.3	" " " " "				" "	2,100 " " " " UNITS
711 - 141		" " SENIOR GRADE (COL.)	"	50	19,800	990	1		12.5	25	3.1	15.6	" " " " "				" "	1,837 " " " " "
711 - 312		GARAGE, FAMILY HOUSING (CARPORT)	"	4,416	INCLUDED IN HOUSE COST													1/HOUSING UNIT
722- 211	AD-21-01-146	DORMITORY, AIRMAN	SQ.FT.	433,375	14.00	6,070	6	1/10	16.6	25	4.2	20.8	2,016	1,412	73,584	73,584	54,000	125 SQ.FT./OCCUPANT X 3,467 = 18 BUILDINGS
722- 218	"	" " WAF	"	28,000	"	392	3	1/10	2.1	25	0.5	2.6	224	157	1,022	1,022	13,000	140 " " " X 200 = 2 "
724- 414	AD-25-06-74	BACHELOR OFFICERS QUARTERS, MEN	"	125,000	16.00	2,256	6	1/10	4.8	25	1.2	6	11,020	8,900	47,100	47,000	1,220	500 " " " (INCLUDES 150 VISITING OFFICER SPACES)
724- 417	"	" " " WOMEN	"	16,000	"	256	6	1/10	0.6	25	0.1	07		INCLUDED IN 724-414				
				Totals		68,548.1			840.6		210.2	1,050.8	92,882	82,999	760,556	760,456	68,220	
COMMUNITY RECREATION LAND USE																		
740- 617	AD-31-03-40	OPEN MESS, NONCOMMISSIONED OFFICER	SQ.FT	22,000	27.00	594	1	1/5	2.5	25	0.6	3.1	186	140	14,127	12,000	2,624	2,267 NCO'S ASSIGNED
740- 618	AD-31-02-48	" " OFFICER	"	22,000	"	594	1	1/5	2.5	25	0.6	3.1	186	140	14,127	12,000	2,624	1,014 OFFICERS ASSIGNED
740- 671	AD-14-28-02	RECREATION, BOWLING ALLEY	"	7,700	21.40	163.4	1	1/5	0.9	25	0.2	1.1	20	20	800	640	244	10 LANES
740- 673		" FIELD HOUSE	"	50,000	18.10	905	2	1/5	10	25	2.5	12.5	250	228	88,800	88,800	7,652	WITH SWIMMING POOL
740- 674	AD-31-06-17	" GYMNASIUM	"	11,100	21.55	239.2	2	1/5	2	25	0.5	2.5	84	77	7,600	7,600	5,135	
740- 675	AD-29-04-23	" LIBRARY	"	7,800	20.20	156.6	1	1/5	0.9	25	0.2	1.1	31	28	1,370	1,160	712	
740- 679	AD-31-24-03	" WORKSHOP (HOBBY)	"	7,850	21.85	173.5	1	1/5	0.9	25	0.2	1.1	55	41	1,555	1,555	586	WITH AUTOMOTIVE HOBBY SHOP
740- 873	AD-31-01-141	THEATER, BASE	SEATS	1,350	330	446	1	1/5	2.3	25	0.6	2.9	84	70	3,150	3,150	1,501	1-1,000 SEAT, 1-350 SEAT
750- 172		ATHLETIC FIELD, BASEBALL	EA	1	752,000	752			8	25	2	10	40	40	50,000	1,000		WITH LIGHTS AND BLEACHERS
750- 175		" " FOOTBALL	EA	1	INCLUDED IN 750-172				4	25	1	5	INCLUDED IN 750-172					
750- 178		" " SOFTBALL	EA	2	" " " "				4	25	1	5	" " " "					1 LIGHTED
750- 349		COURT, RECREATIONAL	EA	1	" " " "				2	25	0.5	2.5	" " " "					2 HANDBALL, 3 BASKETBALL, 4 TENNIS, 6 VOLLEYBALL COURTS
750- 421		GOLF COURSE, 18 HOLE	ACRES	100	3,000	1,200			100			100			200,000			
750- 811	AD-31-10-23	SWIMMING POOL BATH HOUSE	SQ.FT.	19,400	26.00	504		1/5	2.2	25	0.6	2.8	INCLUDED IN 750-813 AND 750-817 BELOW					4 UNITS, 2 AT 3,700 SQ FT EA., 2 AT 6,000 SQ. FT. EA.
750- 813	AD-31-10-24	" " AIRMAN	"	17,748	17.75	315		1/5	2	25	0.5	2.5	144	100	44,400	44,400		1 AIRMAN, 1 NCO POOL, EACH AT 8,874 SQ. FT.
750- 817	AD-31-10-23	" " OFFICER	"	10,352	19.30	200		1/5	1.2	25	0.3	1.5	100	90	26,000	26,000		
				Totals		6,242.7			145.4		11.3	156.7	1,180	974	451,929	197,905	21,078	

from other like facilities was used to develop utilities requirements.

Columns 6 and 7 were produced with the aid of Air Force Pamphlet 88-08-1, USAF Construction Pricing Guide. This pamphlet, prepared after review of cumulative Air Force construction costs by region, is based on basic cost for construction in the Washington, D.C., area. Adjustment factors are furnished for all other regions of the world. In this particular study, a location factor of 1.1, the prevailing factor for the region under consideration, was used for all estimates.

Standards cited in Chapter IV were used to develop columns 9, 10, 11, 12, and 13. This effort is important as it results in an estimate of land required.

4. Consolidate estimates and analyze land use by type. Everyone concerned is interested in how much the program is going to cost. Therefore, the next logical step is an estimate of final costs. Table 16 is a presentation of the final estimate of cost and Fig. 20 illustrates how this estimate is divided. Standard Air Force estimates were used for including contingencies fund requirements and architect/engineer fees.

TABLE 15.
FACILITY REQUIREMENTS SUMMARY.

LAND USE	COST (000)	NET REQ ACRES	CIRC. ACRES	GROSS ACRES	POWER-KW CONN. LD.	POWER-KW EST. DEM.	WATER G.P.D.	SEWAGE G.P.D.	HEAT M.BTU/HR.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AIRFIELD/MISSILE LAUN.	104,276.54	121,012.48	6,054.36	127,066.84	19,330.42	15,571.52	521,110	84,970	45,229.5
INDUSTRIAL	96,789.8	354.3	52.7	407.	21,614.	19,994.	140,770	99,660	71,356
ADMINISTRATIVE	85,208.5	1,118.2	29.1	1,147.3	43,196	36,380	472,155	466,428	112,546
COMMUNITY SUPPORT	75,029.7	142.6	35.1	177.7	23,144	19,715	255,088	252,868	33,821
HOUSING	68,548.1	840.6	210.2	1,050.8	92,882	82,999	760,556	760,456	68,220
COMMUNITY RECREATION	6,242.7	145.4	11.3	156.7	1,180	974	451,929	197,905	21,078
TOTALS	436,095.34	123,613.58	6,392.76	130,006.34	201,346.42	175,633.52	2,601,608	1,862,287	352,250.5

FINAL SUMMARY

TOTAL ESTIMATED LINE ITEM COST	$ 436,095,340
LOCATION FACTOR (1.1)	43,609,534
	479,704,874
CONTINGENCIES FUND (10%)	47,970,487
	527,675,361
ARCHITECT/ENGINEER FEES (6%)	31,660,522
TOTAL ESTIMATED COST	$ 559,335,883

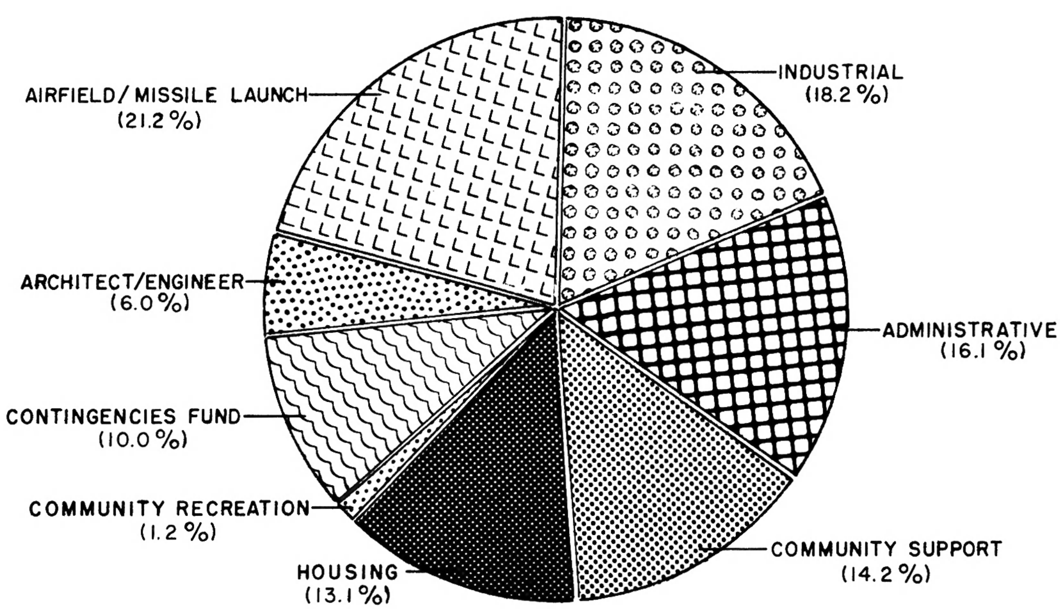


FIG. 20.
How the Money is Divided.

Land use analysis is another important step toward site selection. The basic information required to accomplish this is included in Table 15, column 5. It is important to realize that certain mission requirements may drastically effect this analysis. In the case of bases containing space missile launch facilities, this is especially true.

Figure 21 is an analysis of land use for this study. Figure 21-A indicates the true land use analysis from the data contained in Table 15, column 5. Comparison of this diagram with the money division in Figure 20 does not give a true relationship. Gross areas of vacant land required for safety and danger zones must be removed. Therefore, a re-analysis of airfield/missile launch land was accomplished by removing the land required for runways, actual launch facility hazard areas and related safety zones. The final airfield/missile launch land use requirement includes that land necessary for related support facilities and structures other than airfield pavements. The resulting land use analysis is shown in Figure 21-B. Comparison of the percentages resulting from this effort with the data in Fig. 20 gives a much more realistic analysis.

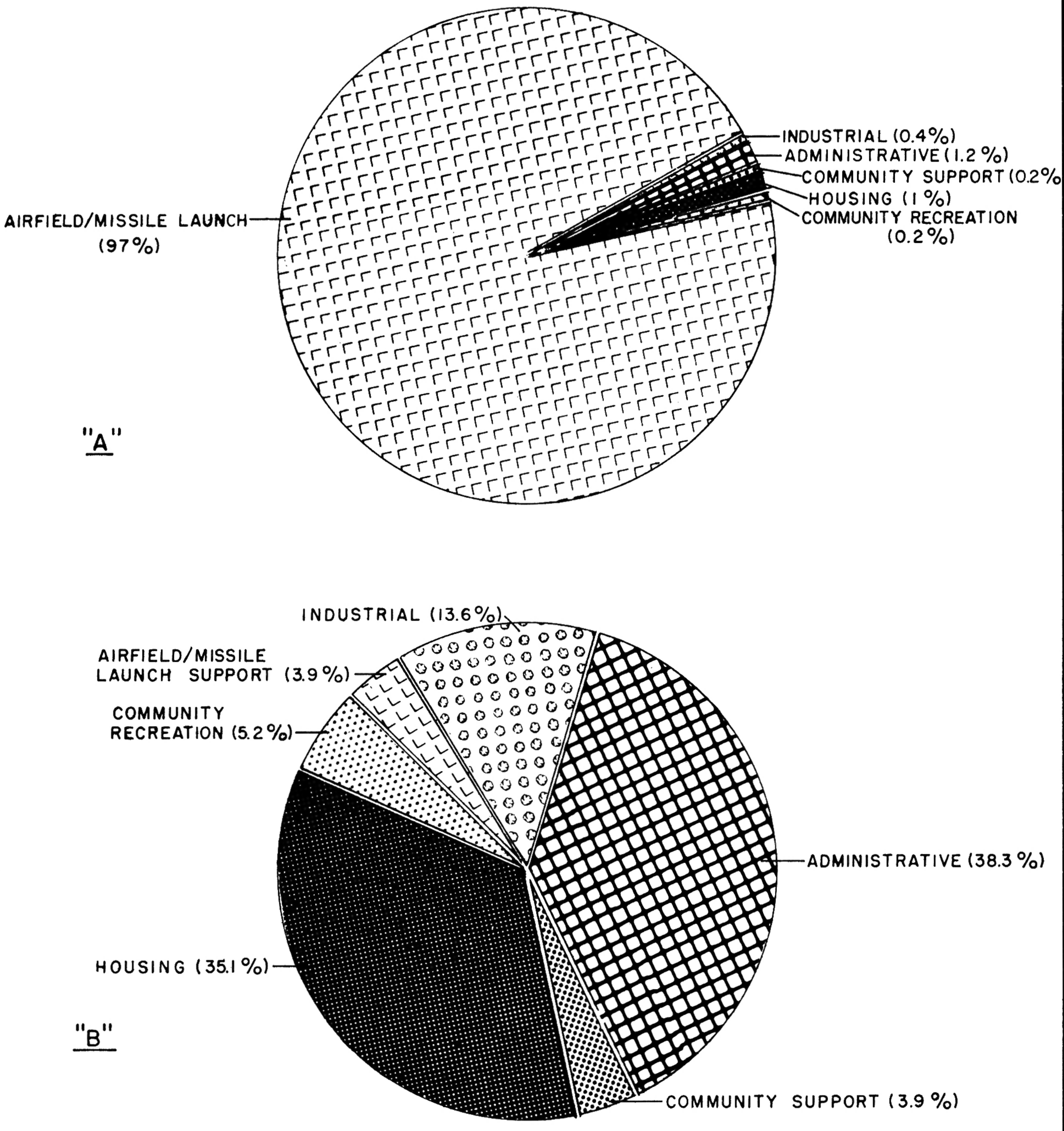


FIG. 21.

LAND USE ANALYSIS.

5. Select location of proposed base. After the collected data and the construction program are approved by the appropriate organizations, the site selection and land purchase may be accomplished. The original requirements programing directive will normally contain a statement as to the region of the proposed base. Analysis of the data developed will allow selection of the final site.
6. Develop the master plan of land use. Not only must the planner understand the characteristics of the site and the criteria to be met, but he must also use basic relationships of functions and land use standards to develop the ultimate master development plan.

   Figure 22 and Figure 23 display the final master development plan for this case study. Plate XIII and Plate XIV are photographs of the model constructed for study use during plan development.

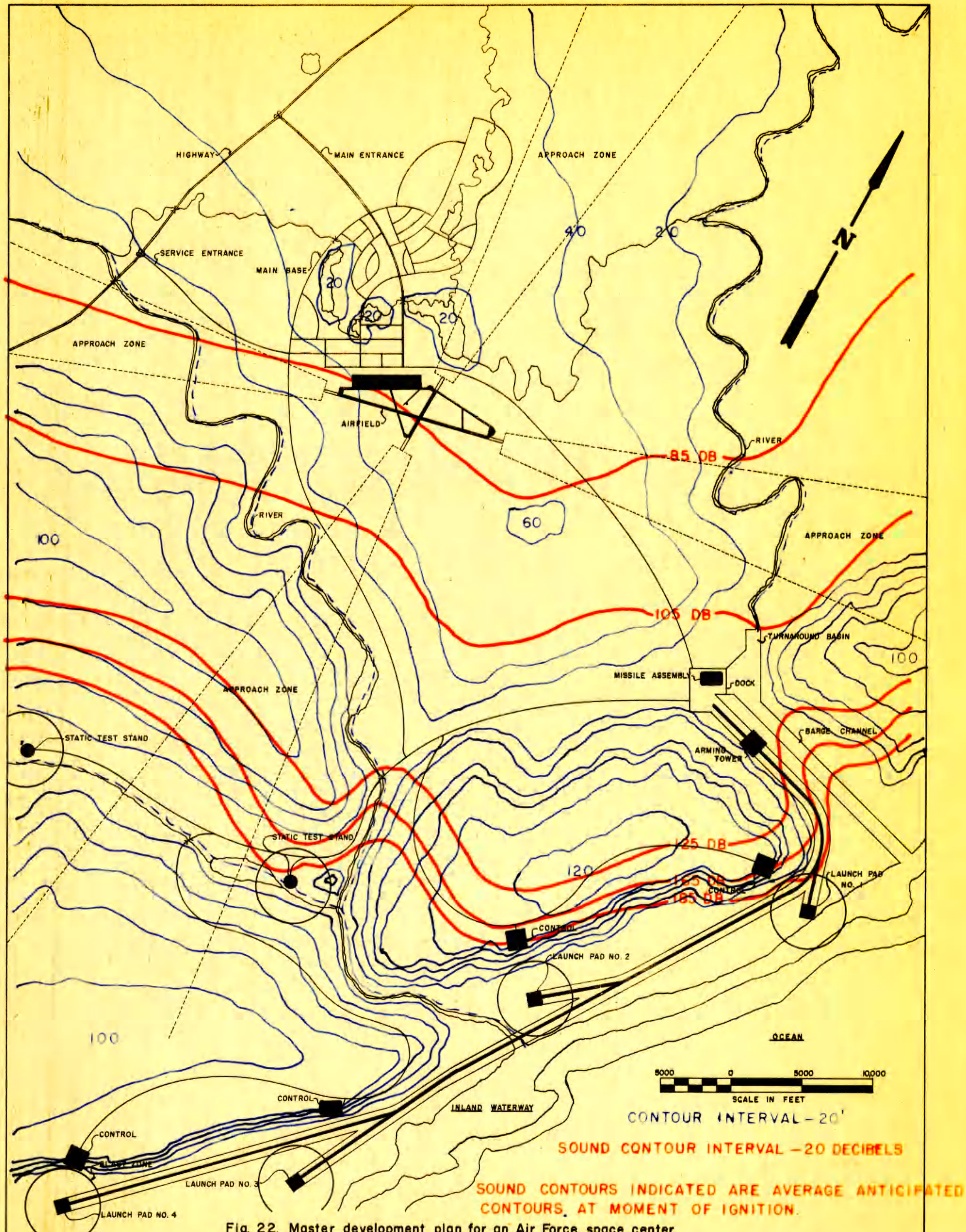


Fig. 22. Master development plan for an Air Force space center.

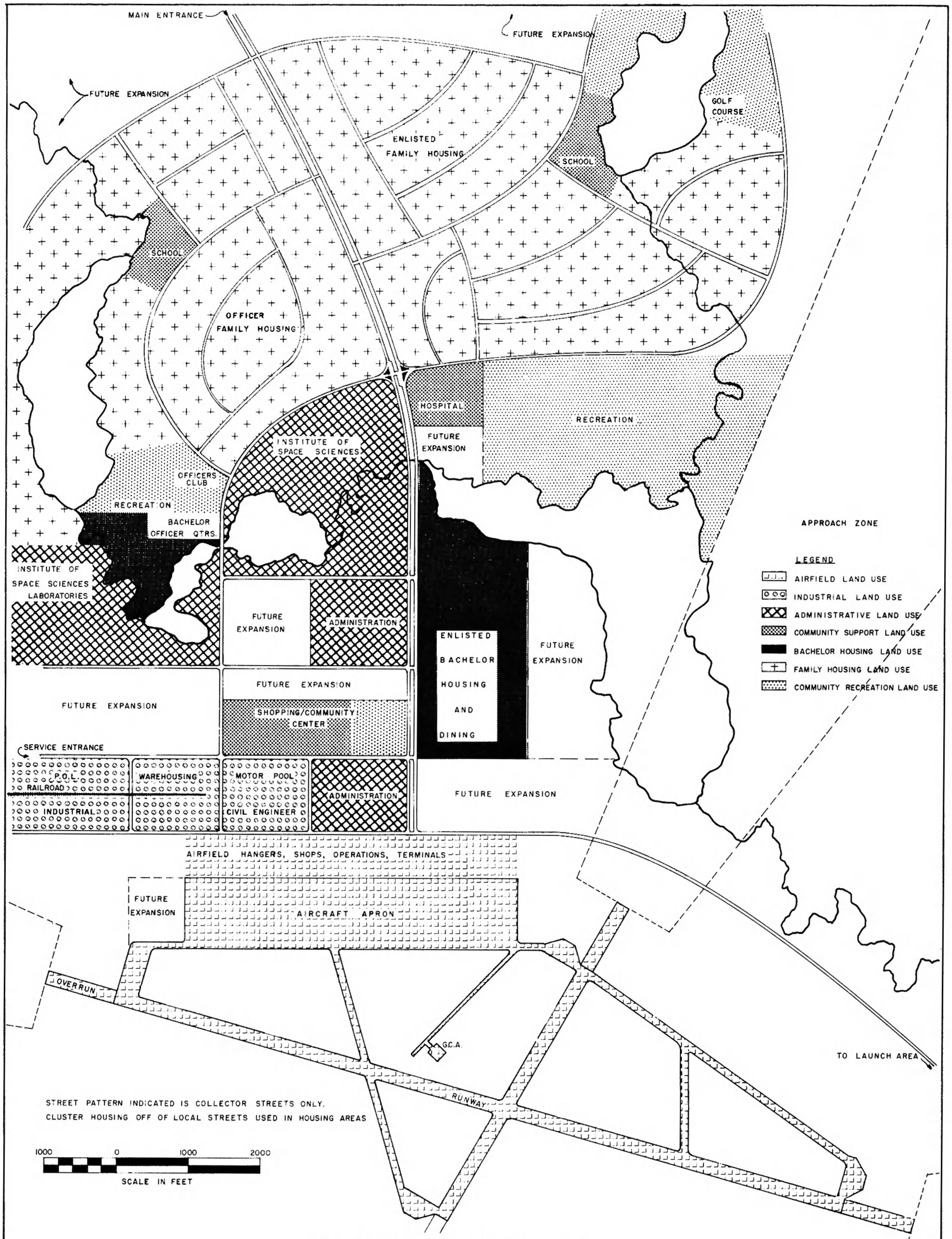


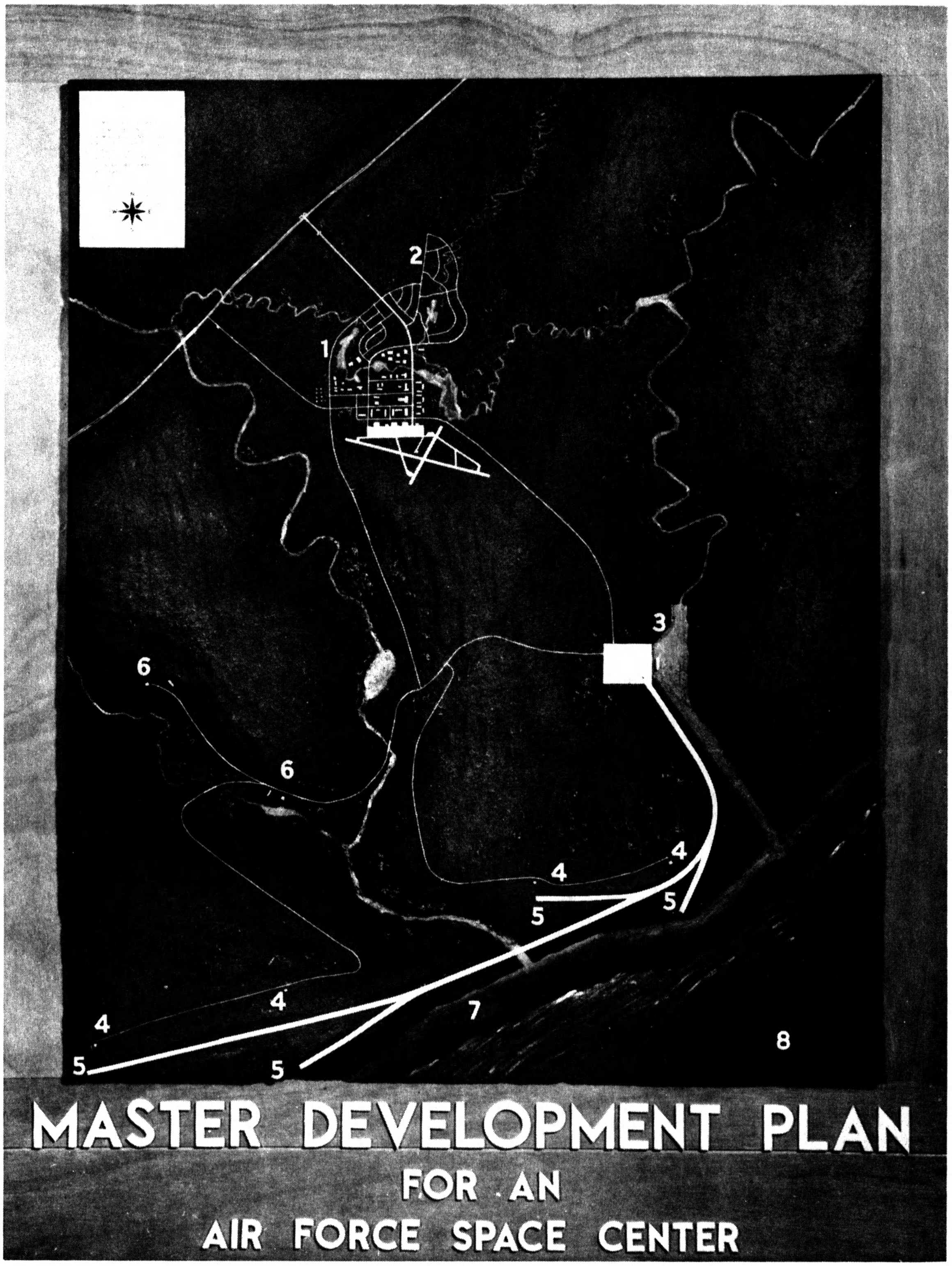
Fig 23. Main base development plan.

EXPLANATION OF PLATE XIII

Overall view of case study development model showing land development plan.

1. Main Support Base
2. Family Housing
3. Missile Assembly Area
4. Launch Control Center
5. Launch Pad
6. Static Test Stand
7. Inland Waterway
8. Ocean

PLATE XIII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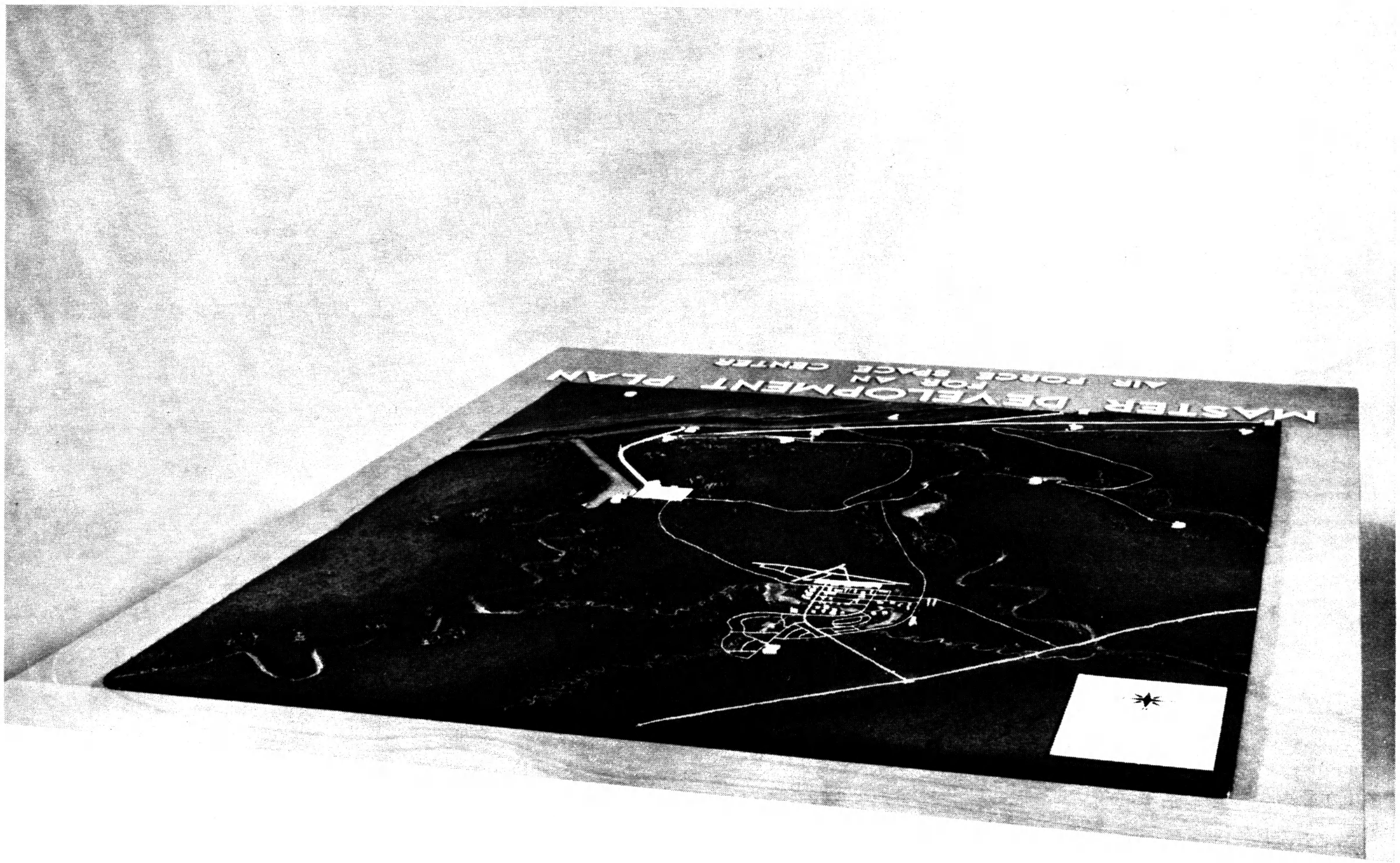
MASTER DEVELOPMENT PLAN
FOR AN
AIR FORCE SPACE CENTER

EXPLANATION OF PLATE XIV

Oblique view of case study development model.

PLATE XIV



AN ANALYSIS OF AIR FORCE MASTER PLANNING
AND THE EFFECT OF SPACE PROGRAMS ON LAND DEVELOPMENT

by

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B. A., Kansas State University, 1954

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1965

AN ANALYSIS OF AIR FORCE MASTER PLANNING
AND THE EFFECT OF SPACE PROGRAMS ON LAND DEVELOPMENT

The purpose of this thesis is the furtherance of Air Force planning techniques, procedures and standards through review and comparison of civilian and Air Force city planning. Particular attention has been given to the effects of space support facilities on land development.

A comparative analysis procedure has been used. This has been supplemented with extensive literature research on space support facilities.

The organization of master plans for Air Force bases and civilian cities is similar. There is a strong likeness between civilian and Air Force planning controls. Air Force controls are deficient in the areas of zoning, community organization and community planning administration. There is a lack of appropriate planning standards to guide Air Force base development. The writer advocates several applicable standards.

The functional activities which occur on an Air Force base can be placed within six categories of land use: (1) airfield/ missile launch, (2) industrial, (3) administrative, (4) community support, (5) housing, and (6) community recreation. A system of land use analysis and data display is outlined.

The functional organization of an Air Force community is similar to that of the civilian community. Key relationships are found in the six categories of land use.

The two major effects of space support requirements on this functional organization are noise control and air pollution from

missile fuels and fuel exhaust products. Knowledge as to the extent of these two effects is essential prior to locating missile facilities. Future space launch facilities will probably be similar to present-day facilities except for size and complexity. Forecasts on engine sizes indicate this growth pattern.

The military shopping/community center is similar to an expanded civilian neighborhood shopping center and should serve as the commercial-recreational-cultural center of the military community. Improvement in Air Force family housing siting served by this community center can be accomplished through use of the cluster concept. This concept has aesthetic advantages and potential economic savings.

There are six elements of transportation design applicable to a military base: (1) relationship of the base to the region, (2) type and quantity of transportation required, (3) design of base access facilities, (4) land use pattern of the base, (5) internal road network design, and (6) location and capacity of parking facilities.

Six steps are necessary for development of a successful master plan: (1) understand the programming directive, (2) determine the population to be served, (3) determine the facilities necessary to accomplish the mission, (4) consolidate estimates and analyze land use by type, (5) select and study the location, and (6) develop the master plan of land use.

Continued study and amelioration of Air Force city planning techniques, procedures and standards is mandatory.

Indicated areas of study and improvement include administration of master planning, space support requirements, noise and missile fuel controls, development standards, air base character, land use patterns and function relationships, family housing siting, community center development, and transportation engineering.