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FINAL ENVIRONMENTAL STATEMENT
UNITED STATES AIR FORCE
SPACE LAUNCH VEHICLES

75 FEB 1

DEPARTMENT OF THE AIR FORCE
SPACE AND MISSILE SYSTEMS ORGANIZATION
AIR FORCE SYSTEMS COMMAND

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UNITED STATES AIR FORCE SPACE LAUNCH VEHICLES

75 FEB 1

Reviewed by:

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Approved for the Commander:

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Director of Civil Engineering

1. INTRODUCTION

1.1 PROGRAM DESCRIPTION

United States Air Force sponsored programs provide launch vehicles for major United States Department of Defense space programs. In addition, launches are performed for other governmental agencies, foreign governments, and international organizations. This responsibility is met by the Titan III, the Atlas, and the Scout series of booster vehicles. This final environmental statement is limited to only these space launch vehicles. These programs are directed by the Space and Missile Systems Organization, Air Force Systems Command, Los Angeles Air Force Station, Los Angeles County, California.

The current family of space launch vehicles and a brief tabulation of significant features is given in Table 2. Basic research, development and testing have already been accomplished and the current major activities are those associated with manufacture and launch of the vehicle systems. However, on-going research and development activities continue on a small scale to support improvements and refinements in both the launch vehicles and the propulsion systems.

1.1.1 Titan III

The Titan III family of space launch vehicles is manufactured by the Martin Marietta Corporation in Littleton, Jefferson County, Colorado. Liquid propulsion systems are provided by the Aerojet-General Corporation in Sacramento, Sacramento County, California and the solid rocket motors are furnished by the United Technology Center, Sunnyvale, Santa Clara County, California.

There are three members of the Titan III family; these vehicles are shown in outline drawings on Figure 1, and a brief description of each is provided in Table 2. It is expected that the configurations and descriptions provided here will adequately describe the program for at least the next two years. The Titan IIIB is a two-stage liquid propellant vehicle using hypergolic fluids N_2O_4 and Aerozine 50 as the oxidizer and fuel respectively. The Titan III C and D employ a multi-stage liquid propellant core section to which two

TABLE 2. USAF SPACE LAUNCH VEHICLES

Vehicle	Vehicle Status	Type of Propellants	Quantity of Propellants (lb)[a]	Total Vehicle Weight (lb)	Thrust Levels At Zero Altitude (lb)	Maximum Cross-Axis Dimension (ft)	Length (ft)[b]	Launch Site(s)
Titan IIIB	Operational			383,500	458,200	10 dia.	149	VAFB
Stage I		N_2O_4/Aerozine 50	295,000					
Stage II		N_2O_4/Aerozine 50	67,600					
Titan IIIC	Operational			1,398,000	2,220,400	33	159	CCAFS
Stage Zero		AP/Al/PBAA/AN N_2O_4	870,000					
Stage I		N_2O_4/Aerozine 50	259,000					
Stage II		N_2O_4/Aerozine 50	67,000					
Stage III (Transtage)		N_2O_4/Aerozine 50	23,400					
Titan III D	Operational			1,364,000	2,220,400	33	159	VAFB
Stage Zero		AP/Al/PBAA/AN N_2O_4	870,000	vs 1.55 M for 2 STG				
Stage I		N_2O_4/Aerozine 50	259,000					
Stage II		N_2O_4/Aerozine 50	67,000					
Atlas SLV3, F	Operational	LO_2/RP-1[c]	268,000	322,200	411,338	16	117	CCAFS, VAFB
Scout	Operational			39,600	98,720	9 (including fins)	74	VAFB
Stage 1[c]		AP/Al/PU	21,355					
Stage 2		AP/Al/PBAA	8,310					
Stage 3		AP/Al/NC/NG	2,590					
Stage 4		AP/Al/PBAN	608					

(a) Expended weight, including miscellaneous fluids and gases, TVC fluid, ablatives, etc., in addition to propellant. See note below for nomenclature.
(b) Length varies with the payload shroud and may be greater than shown for some configurations.
(c) Mixture ratio of LO_2 to RP-1 is ~2.28:1

NOTE: The following notation has been used for propellants:

Aerozine 50	=	equal parts of hydrazine and unsymmetrical dimethyl hydrazine
Al	=	aluminum
AN	=	acrylonitrile
AP	=	ammonium perchlorate
LO_2	=	liquid oxygen
NC	=	nitrocellulose
NG	=	nitroglycerine
N_2O_4	=	nitrogen tetroxide
PBAA	=	polybutadiene-acrylic acid
PBAN	=	polybutadiene-acrylic acid-acrylonitrile
PU	=	polyurethane
RP-1	=	a kerosene type hydrocarbon

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practicable. Our space launch vehicles exist to place space packages in orbit to achieve priority scientific or defense objectives. There is no other way to launch these payloads.

6. Comments on the draft environmental statement were received from the organizations listed below. Responses to these comments are provided.

Department of Interior
Environmental Protection Agency
Advisory Council on Historic Preservation
Resources Agency of California
Department of Agriculture
National Aeronautics and Space Administration

7. The draft statement was made available to the Council on Environmental Quality and the public in August 1973.

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FIGURES

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FINAL ENVIRONMENTAL STATEMENT
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SPACE LAUNCH VEHICLES

Summary

1. This environmental impact statement is in final form.

2. This action is entitled "United States Air Force Space Launch Vehicles." It is an administrative action.

3. This environmental statement encompasses the family of Titan III, Atlas, and Scout space launch vehicles. These vehicles were developed and/or are being operated under the direction of the Space and Missile Systems Organization of the Air Force Systems Command. The major activity covered by this statement is launch. This activity is concentrated in, but is not restricted to California and Florida.

4. The potential environmental impacts expected from vehicle launch are summarized in Table 1. Infrequent short term, non-persistent air pollution occurs close to the launch complex. In the unlikely event of on-pad aborts or accidents occurring to any of the USAF Space Launch Vehicles, it is anticipated that any resulting air pollution will be less than Public Emergency Limits established by the National Academy of Science and would not be expected to cause damage to life or property. Such air pollution that does occur is a transient effect expected to last for only a few minutes over any given ground location. Containment provisions at launch complexes prevent spilled propellants or contaminated process waters from being released without appropriate treatment. Effects on ocean waters from an unlikely vehicle abort (accident) condition are of local transient significance. Noise pollution occurring from three to four minutes at each launch, aside from the annoyance factor, is deemed of little environmental significance. Chances of adverse effects from reentry debris are remote.

5. Alternatives considered include the use of different propellants, relocation of launch sites, and the use of scrubber equipment to trap pollutants. None of these alternatives is deemed physically or economically

TABLE 1. SUMMARY OF ENVIRONMENTAL IMPACT OF USAF SPACE LAUNCH VEHICLES

	TYPE OF EVENT OR ACTIVITY		
Area of Concern	Normal Launch	Accident or Abort	Development
Air Pollution	No significant effect for Titan IIIB, Atlas, Scout. Short term, localized, non-persistent exposure to HCl concentrations above criteria level may be possible in controlled area for Titan IIIC and Titan IIID launches.	No significant effect. (Pollution will occur in the immediate vicinity of the launch pad.)	No significant effect
Water Pollution	No significant effect	Localized, short term, non-persistent, pollution in ocean water may result from improbable combinations of events for all vehicles.	No significant effect
Noise	No significant effect	No significant effect	No significant effect
Reentry Debris	No significant effect	No significant effect	No significant effect
Environmental Enhancement	None	None	None
Commitment of Resources	No significant commitment of scarce or limited resources.	No significant commitment of scarce or limited resources.	No commitment of scarce or limited resources

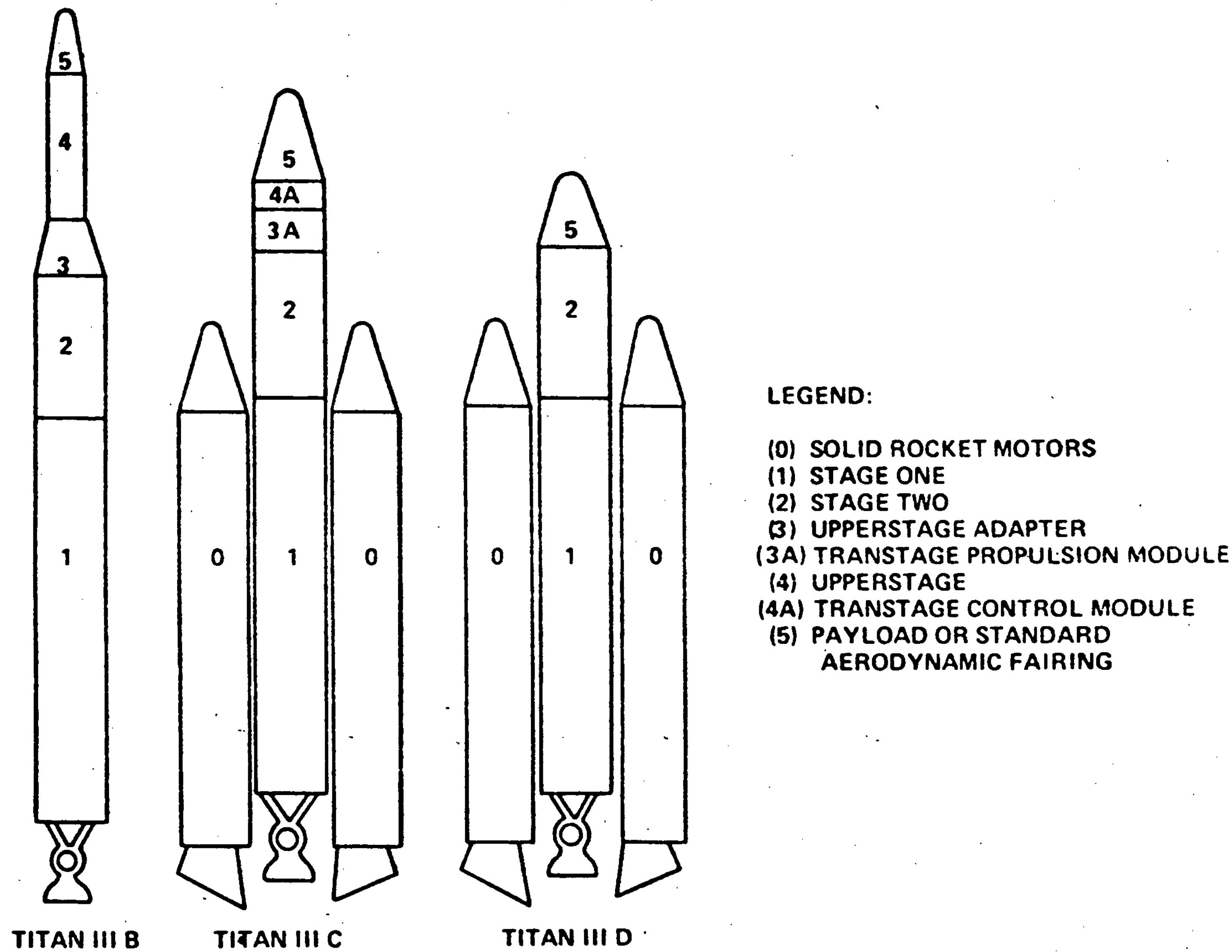


Figure 1 Titan III Basic Configurations

solid rocket motors are attached. The solid stage becomes the zero stage and each of the stages fires sequentially.

The Titan III vehicles are launched from two sites: Cape Canaveral Air Force Station in Brevard County, Florida and Vandenberg Air Force Base in Santa Barbara County, California. Figure 2 shows the over-all Integrate Transfer Launch (ITL) facility installation at Cape Canaveral Air Force Station. Shown is the Vertical Integration Building (VIB) where the Titan III C vehicle core is assembled, the Solid Motor Assembly Building (SMAB) where the solid rocket motors are mated to the core, and Launch Complexes 40 and 41 from which the vehicles are launched. The payload is mated to the launch vehicle on the launch pad. The aerial view of Complex 41 is shown in Figure 3. Figure 4 is a map of the Cape Canaveral area and the ITL installation is indicated. Excellent separation is provided at this site from uncontrolled areas.

At Vandenberg Air Force Base the assembly/launch concept is different from that at Cape Canaveral. At Vandenberg, the launch vehicles are built up on each of two launch pads. Figure 5 is a picture of SLC-4 (Space Launch Complex 4). On-site support for both SLC-4E and SLC-4W is housed in the buildings shown on the left of Figure 5. A map of the Vandenberg area is shown on Figure 6 and the location of SLC-4E and 4W is indicated. Separation from uncontrolled areas is adequate although less than that available in Florida.

1.1.2 ATLAS

The AF operates two models of the Atlas space launch vehicle, the SLV-3 and the F; the latter is a phased-out strategic missile which has been adapted to perform space launch missions. The Atlas vehicles are built by the Convair Division of General Dynamics Corporation at San Diego, San Diego County, California. Liquid propellant engines for the system are furnished by the Rocketdyne Division of North American Rockwell Corporation in Canoga Park, Los Angeles and Ventura Counties, California.

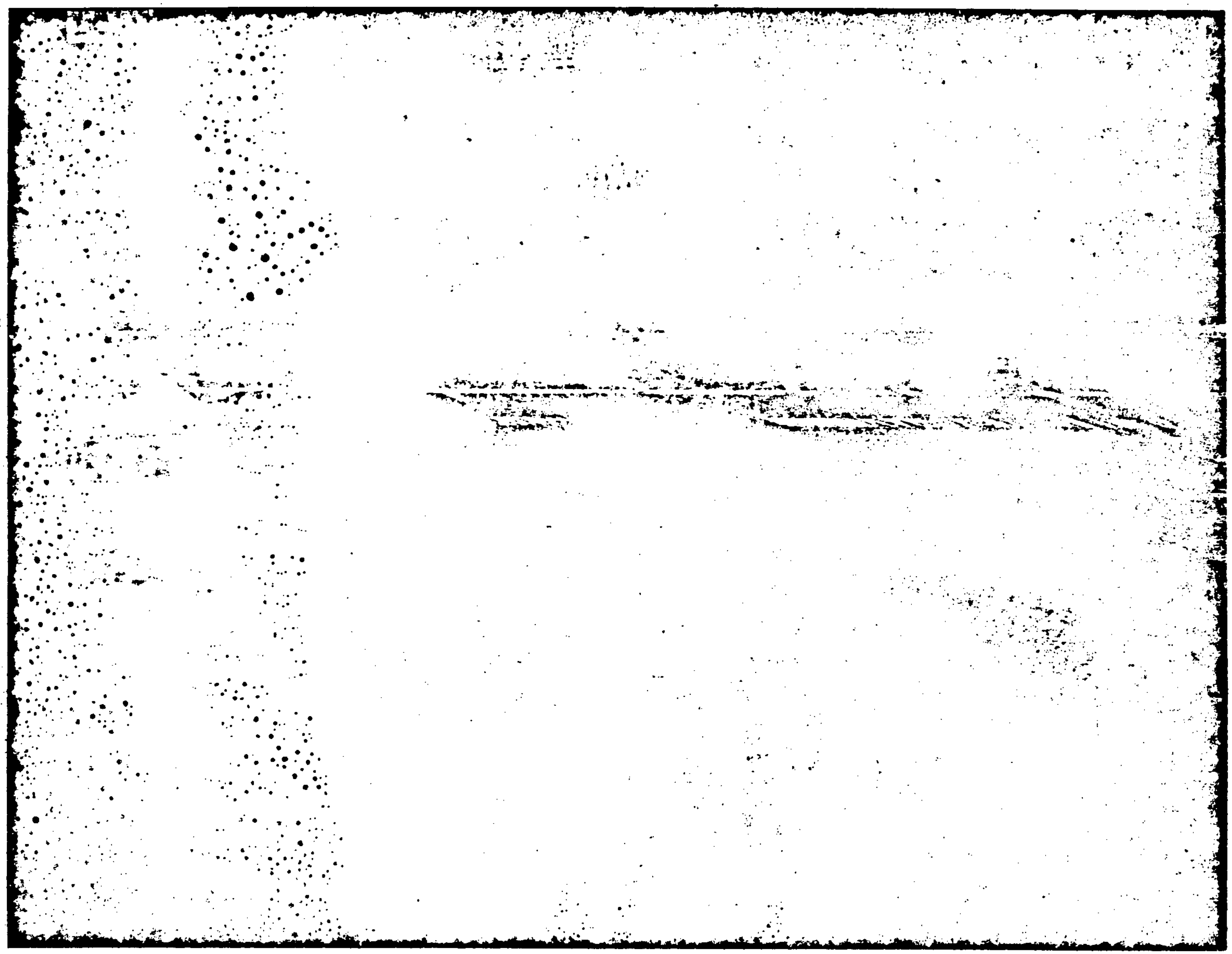


FIGURE 2. AERIAL PHOTOGRAPH OF TITAN III ITL

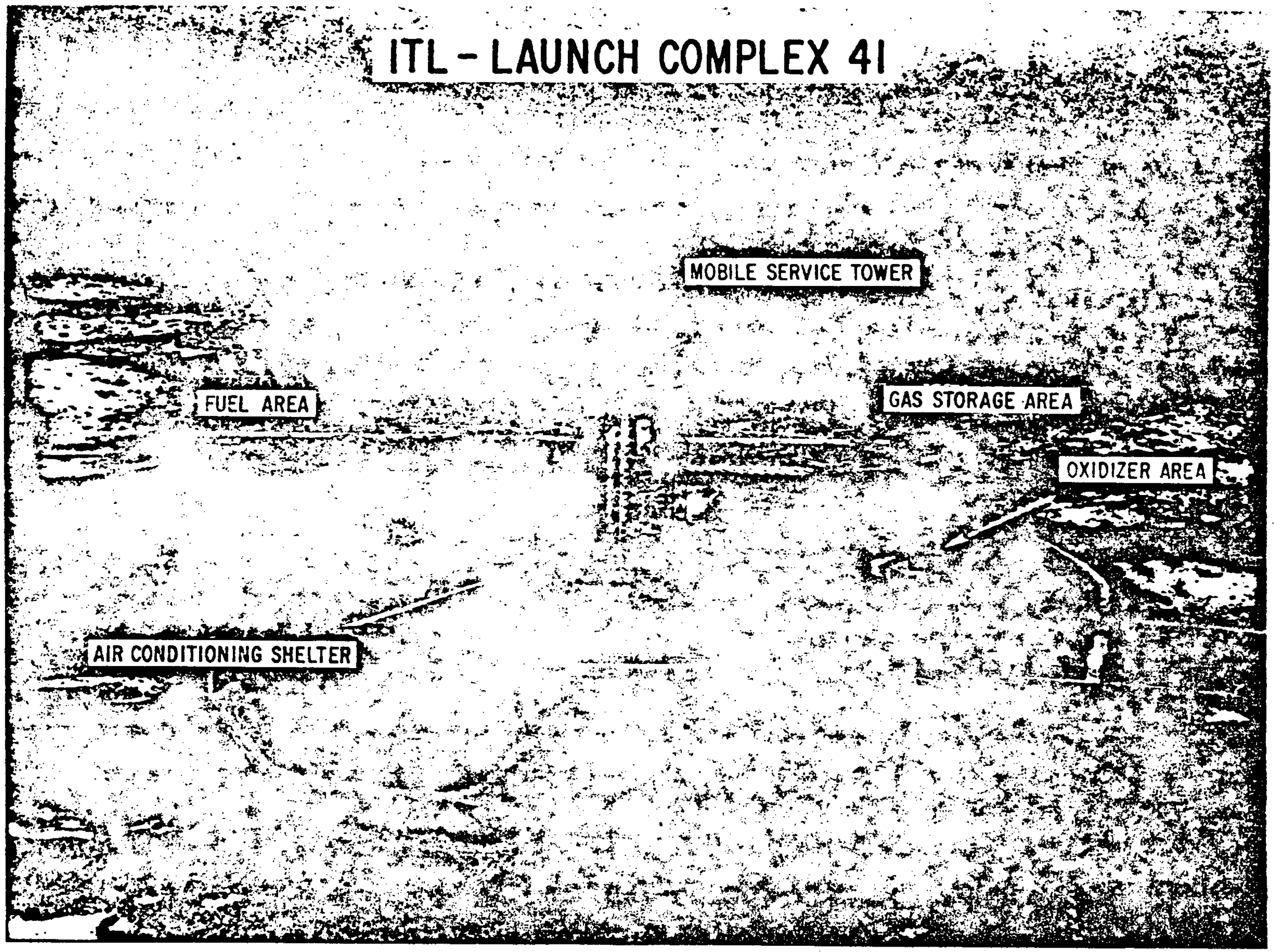


Figure 3. Aerial View of Complex 41

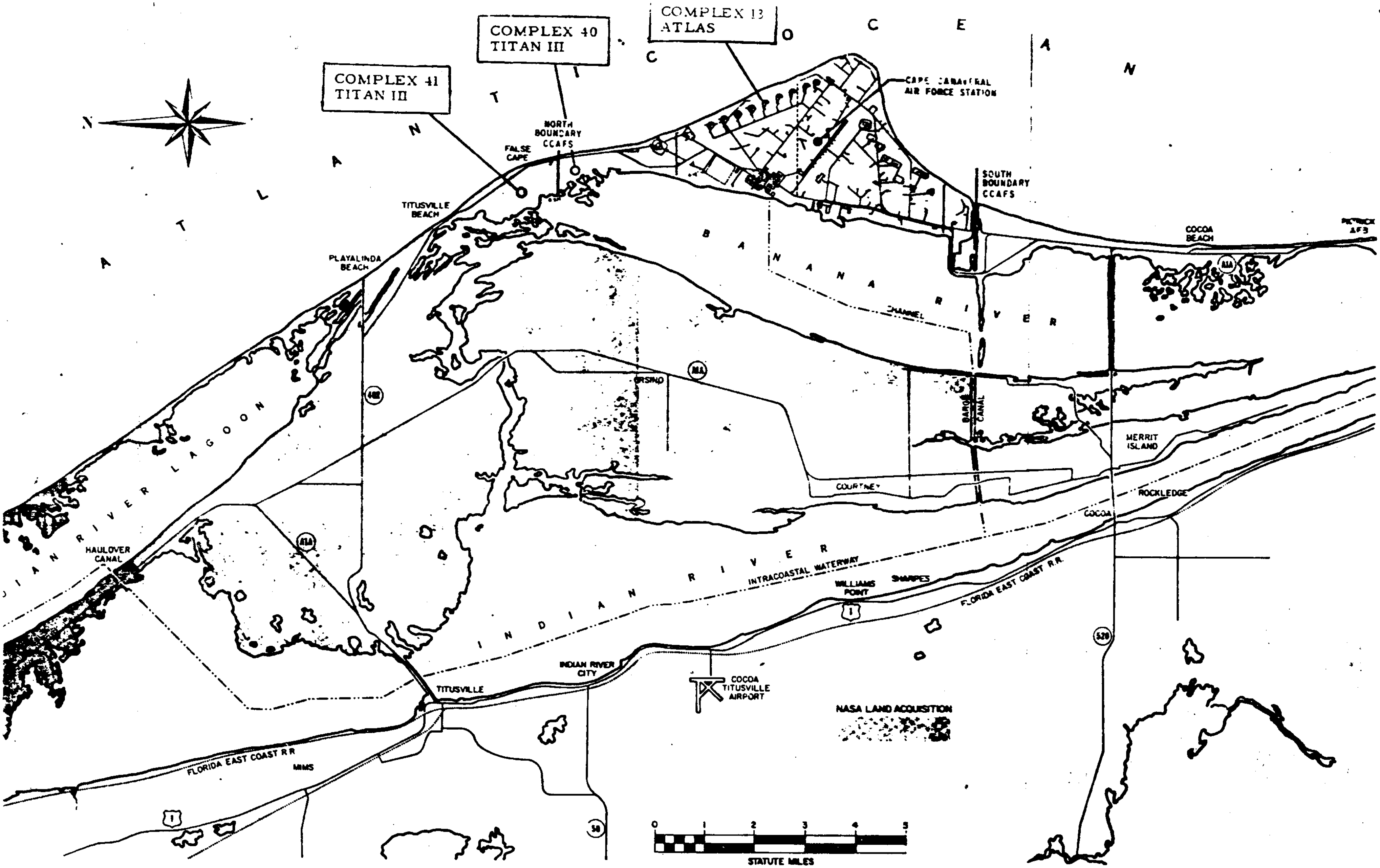


Figure 4 MAP OF CAPE CANAVERAL AREA

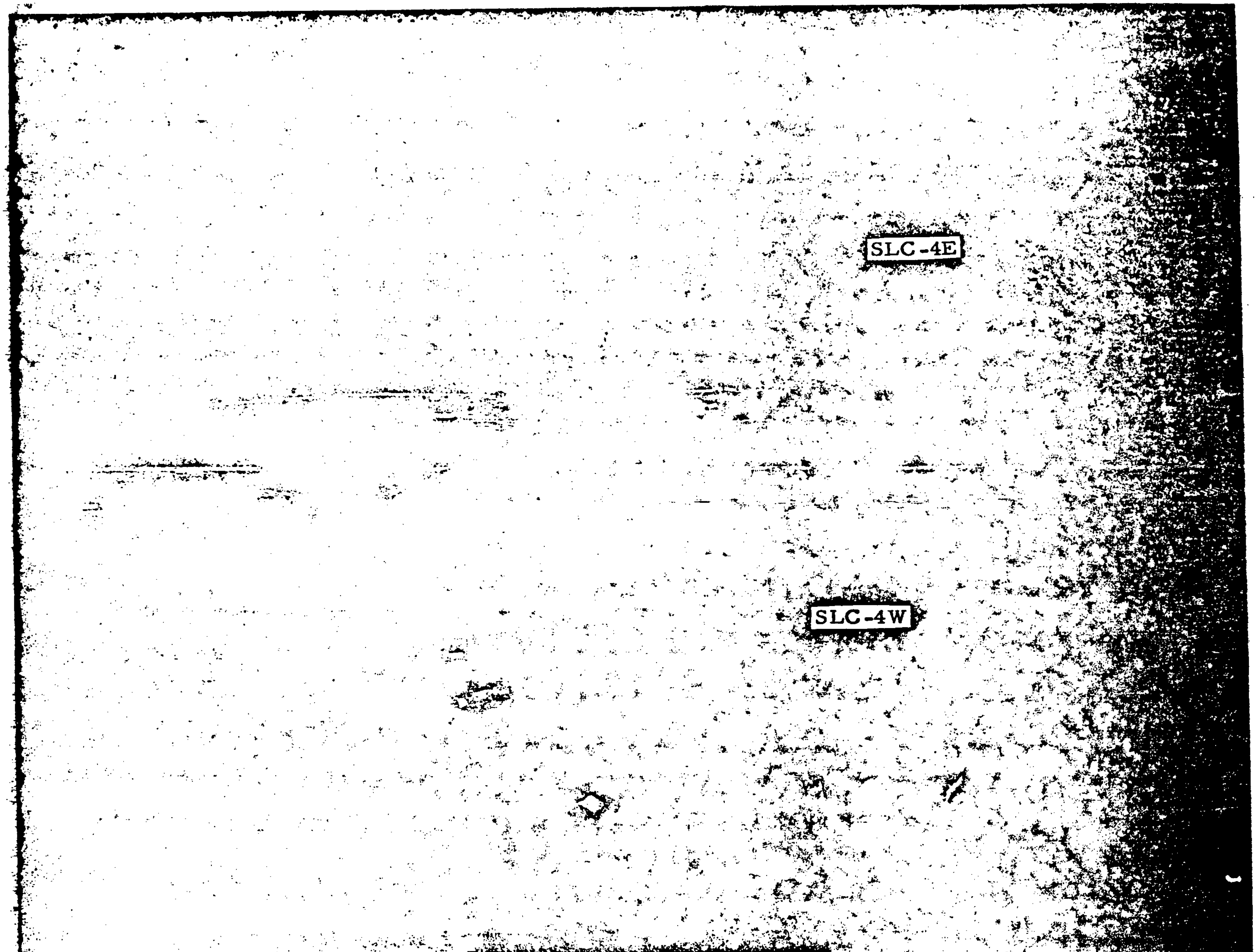


Figure 5. Aerial View of SLC-4

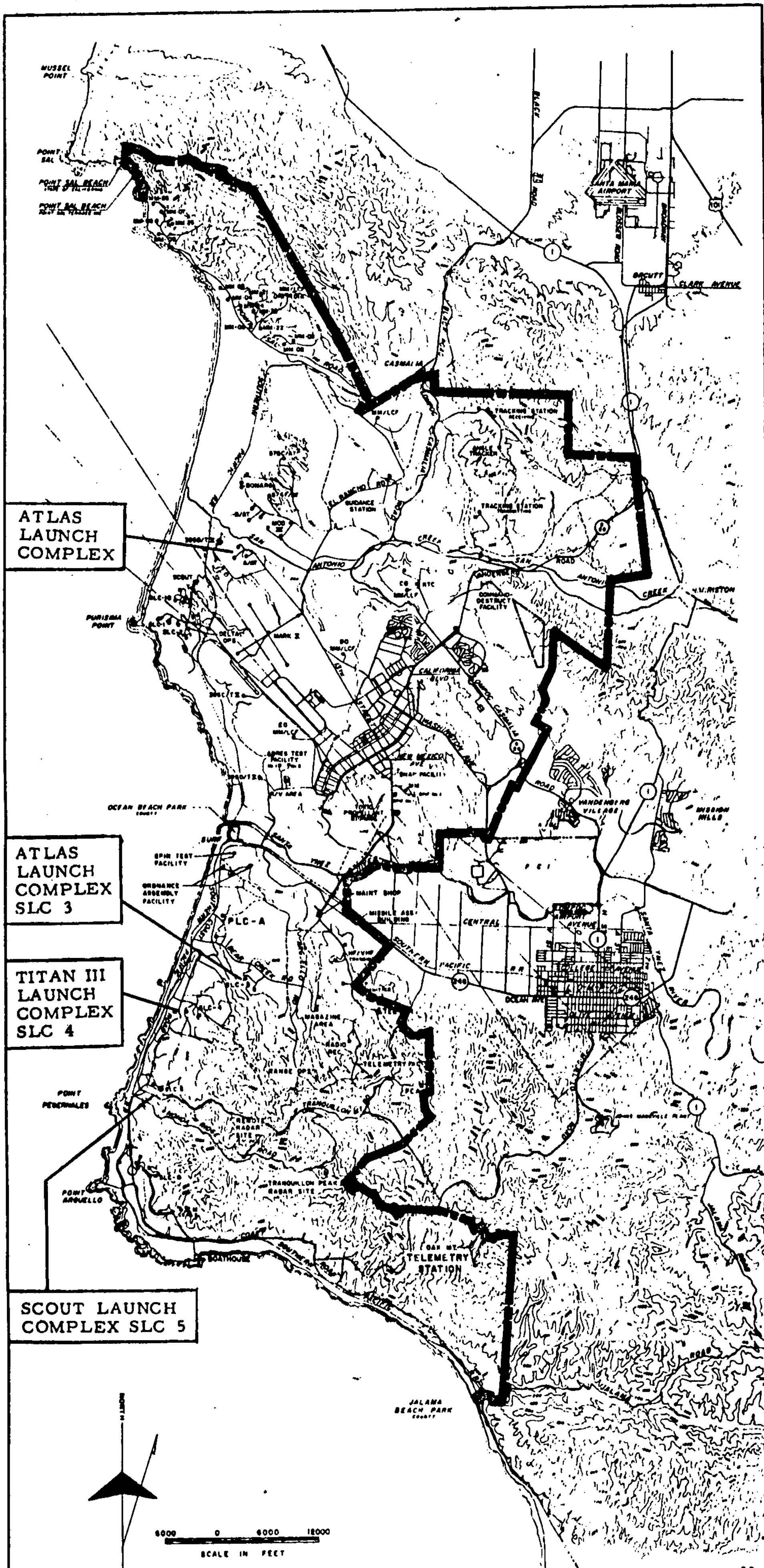

ATLAS LAUNCH COMPLEX
ATLAS LAUNCH COMPLEX SLC 3
TITAN III LAUNCH COMPLEX SLC 4
SCOUT LAUNCH COMPLEX SLC 5
MUSSEL POINT
POINT SAL
PURISIMA POINT
OCEAN BEACH PARK
POINT PEDERNALES
POINT ARGUELLO
SANTA MARIA AIRPORT
CLARK AVENUE
TRACKING STATION
CALIFORNIA BLVD
NEW MEXICO
VANDENBERG VILLAGE
MISSION HILLS
PLC-A
SOUTHERN PACIFIC
CENTRAL
TELEMETRY STATION
BOATHOUSE
JALAMA BEACH PARK
SCALE IN FEET
6000 0 6000 12000

Figure 7 shows the configuration of the Atlas vehicle and a brief description of significant factors is contained in Table 2. The Atlas is a stage and a half liquid propellant vehicle using LO_2/RP-1 as propellants. They are launched from both CCAFS in Florida and VAFB in California. Figure 8 shows Atlas Launch Complex 13 and Figure 4 locates the site at CCAFS. Launch sites at VAFB are depicted on Figures 9 and 10 (SLC-3E); these are located on base by the map shown in Figure 6. Atlas vehicles are delivered to the launch areas in a pre-assembled condition and are erected on the launch pad, serviced and launched.

1.1.3 SCOUT

The Scout vehicle is a small solid propellant booster system which is operated "on call" in very limited numbers by USAF. Figure 11 shows the configuration of the booster, and Figure 6 locates launch site SLC-5 at VAFB from which it is launched. Figure 12 shows the SLC-5 launch facility. The Scout vehicle is described briefly in Table 2. The first stage Algol 2C is built by the Aerojet-General Corporation at Sacramento, Sacramento County, California and the second stage is the Castor-2 manufactured by Thiokol Corporation at Huntsville, Madison County, Alabama. The third and fourth stages are designated as X-259 and X-258 respectively and are made by the Allegany Ballistic Laboratory Division of Hercules at Cumberland, Allegany County, Maryland. An alternate fourth stage, designated FW/4S may be used and that stage is built by United Technology Center at Sunnyvale, Santa Clara County, California. The stages are delivered in kit form from each of the suppliers and these are assembled into a launch vehicle in the Ordnance Assembly Building at VAFB and transported to SLC-5 for erection and launch.

1.2 EXISTING SITE CHARACTERISTICS

1.2.1 Vandenberg Air Force Base

1.2.1.1 Georgraphic Location (Reference 1)

Vandenberg Air Force Base is located in Santa Barbara County approximately 55 miles northwest of Santa Barbara, 140 miles

ATLAS CONFIGURATION

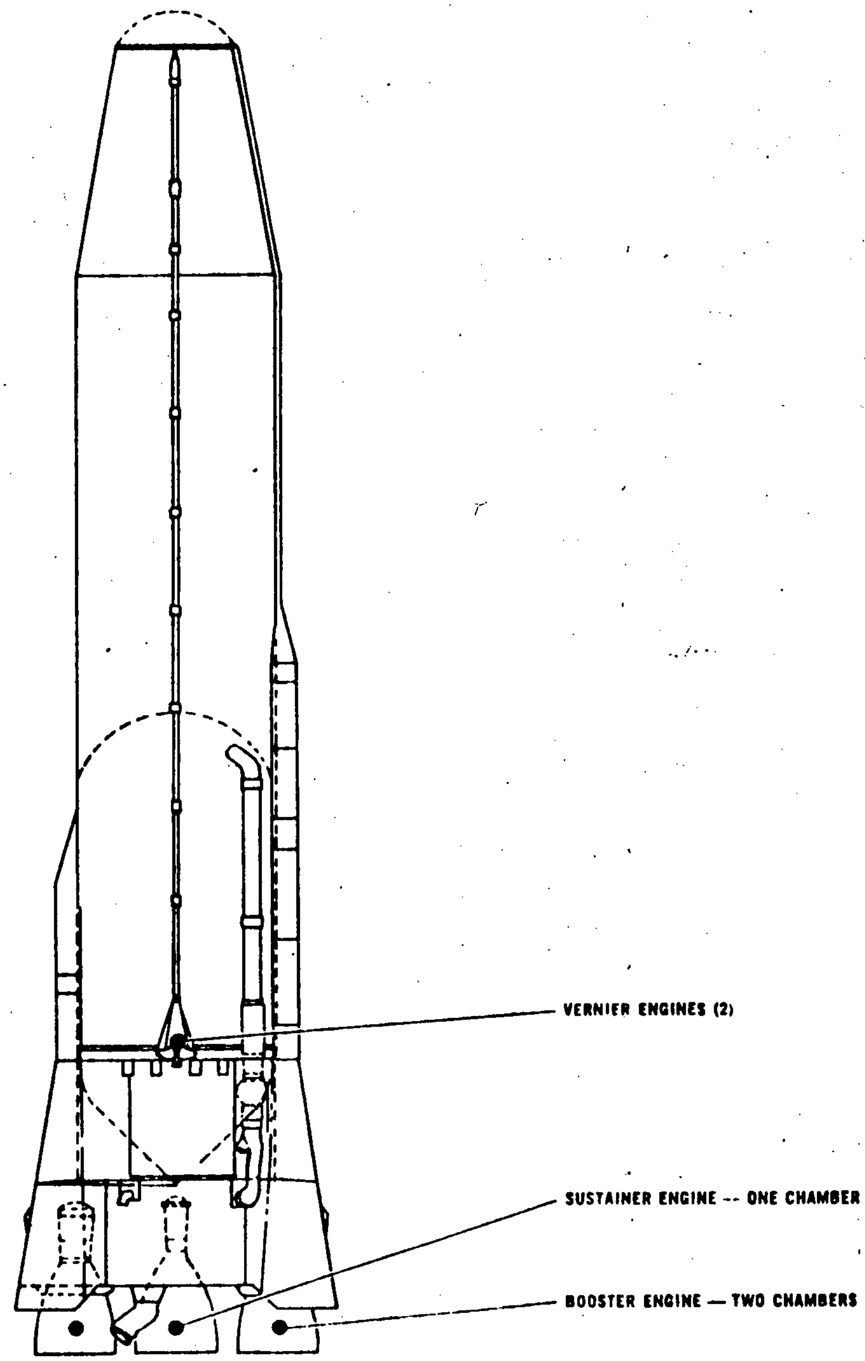


FIGURE 7

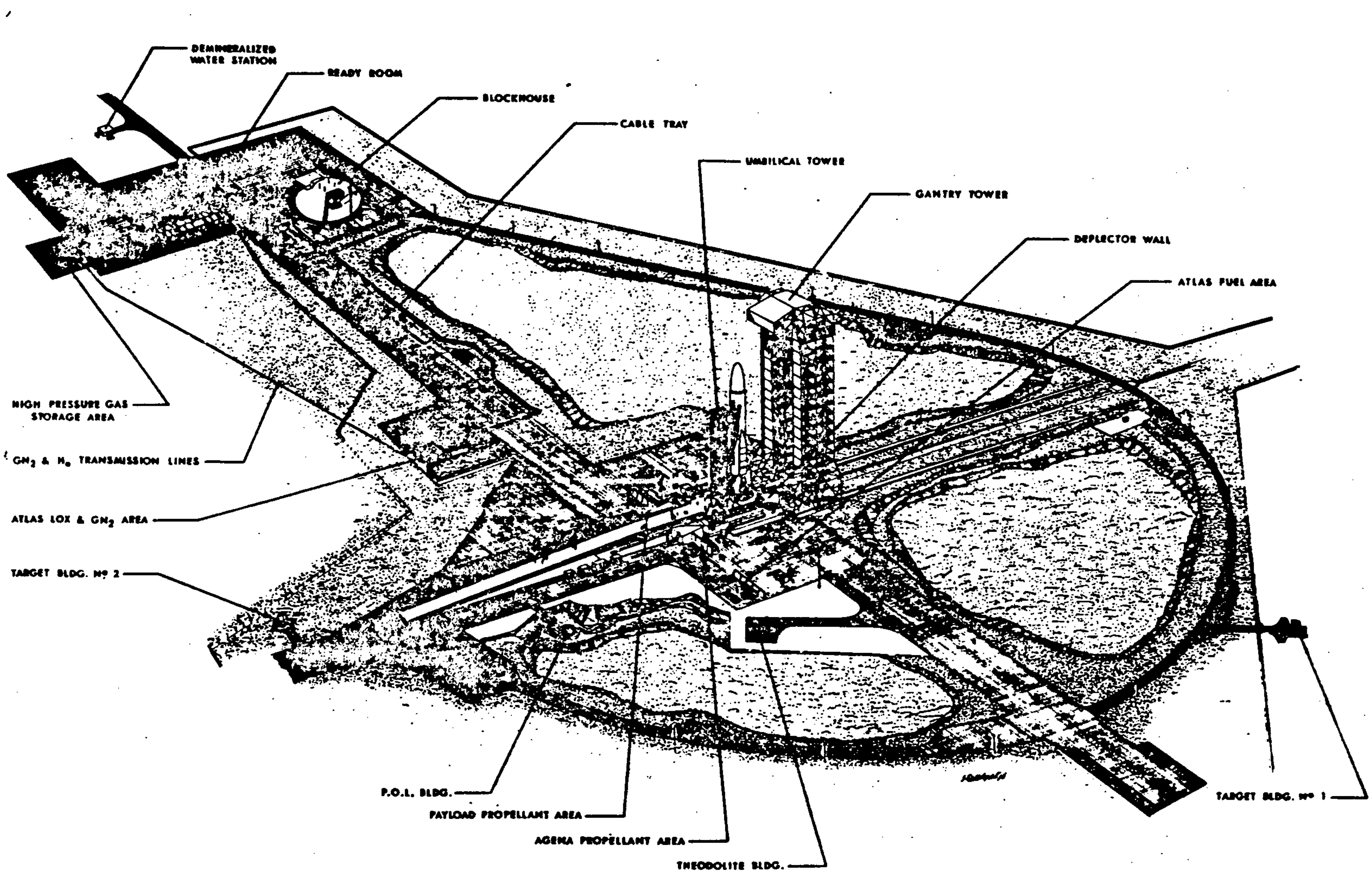
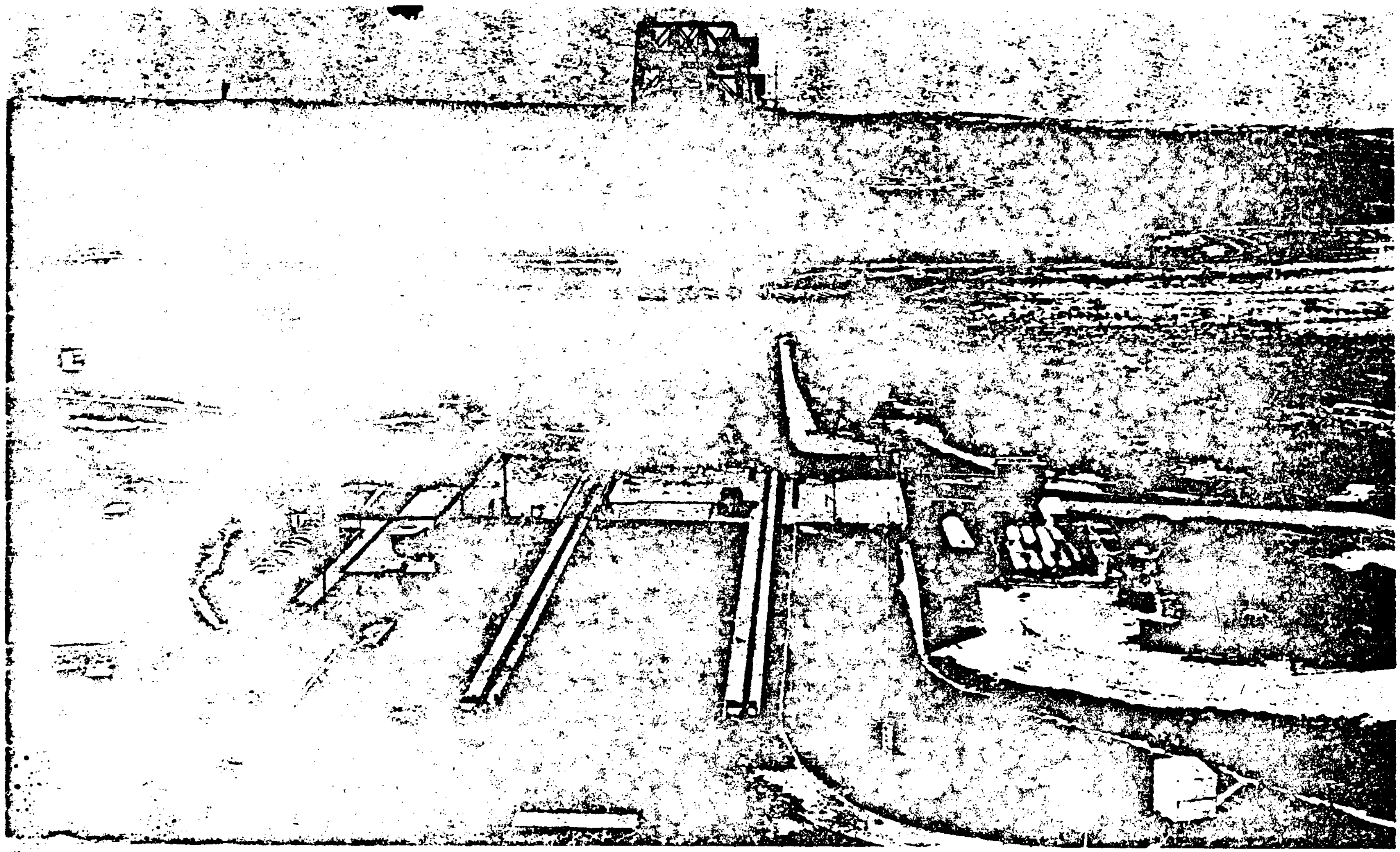


FIGURE 8. COMPLEX 13 - CCAFS

Figure 9. Atlas Launch Site - VAFB



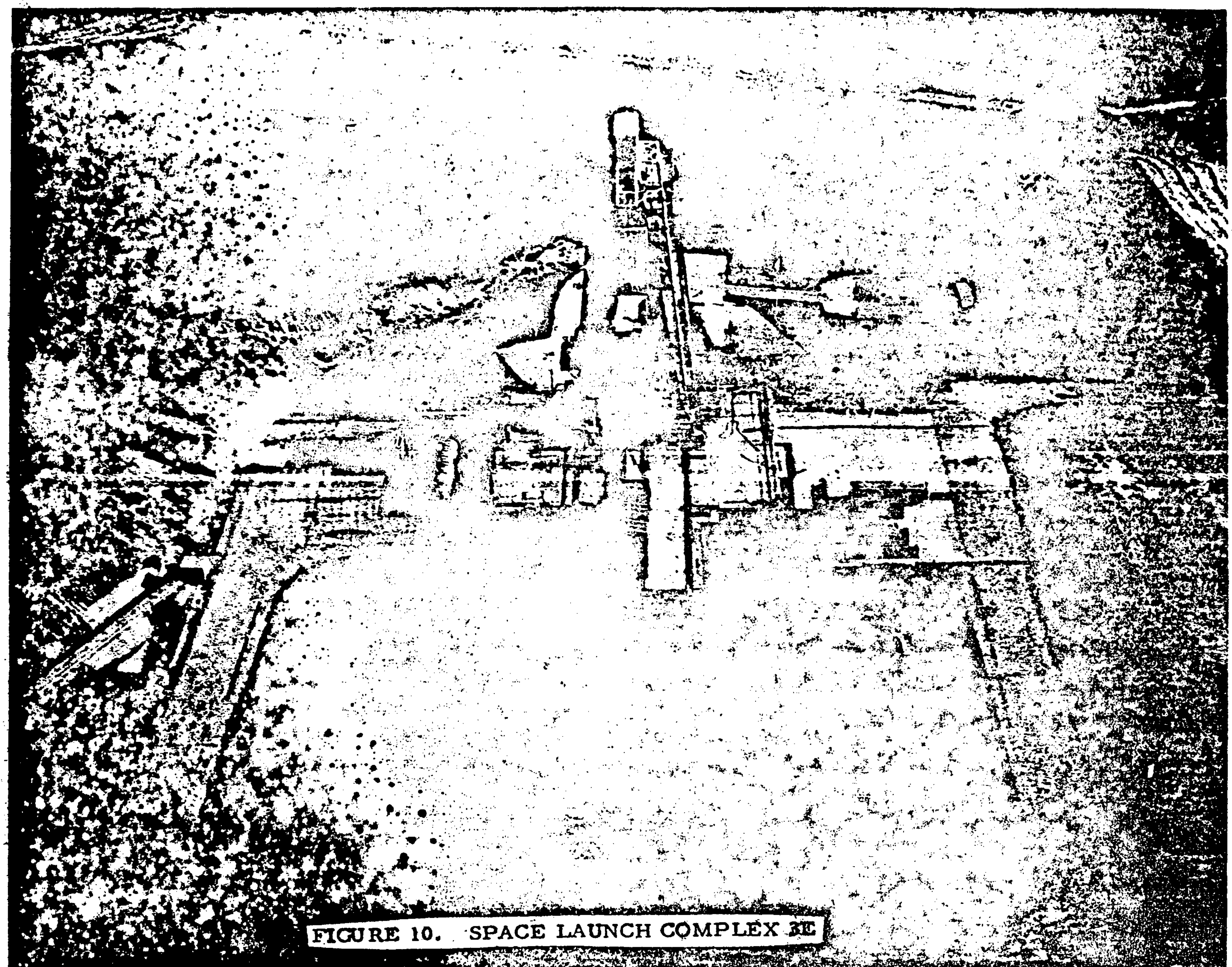


FIGURE 10. SPACE LAUNCH COMPLEX 3E

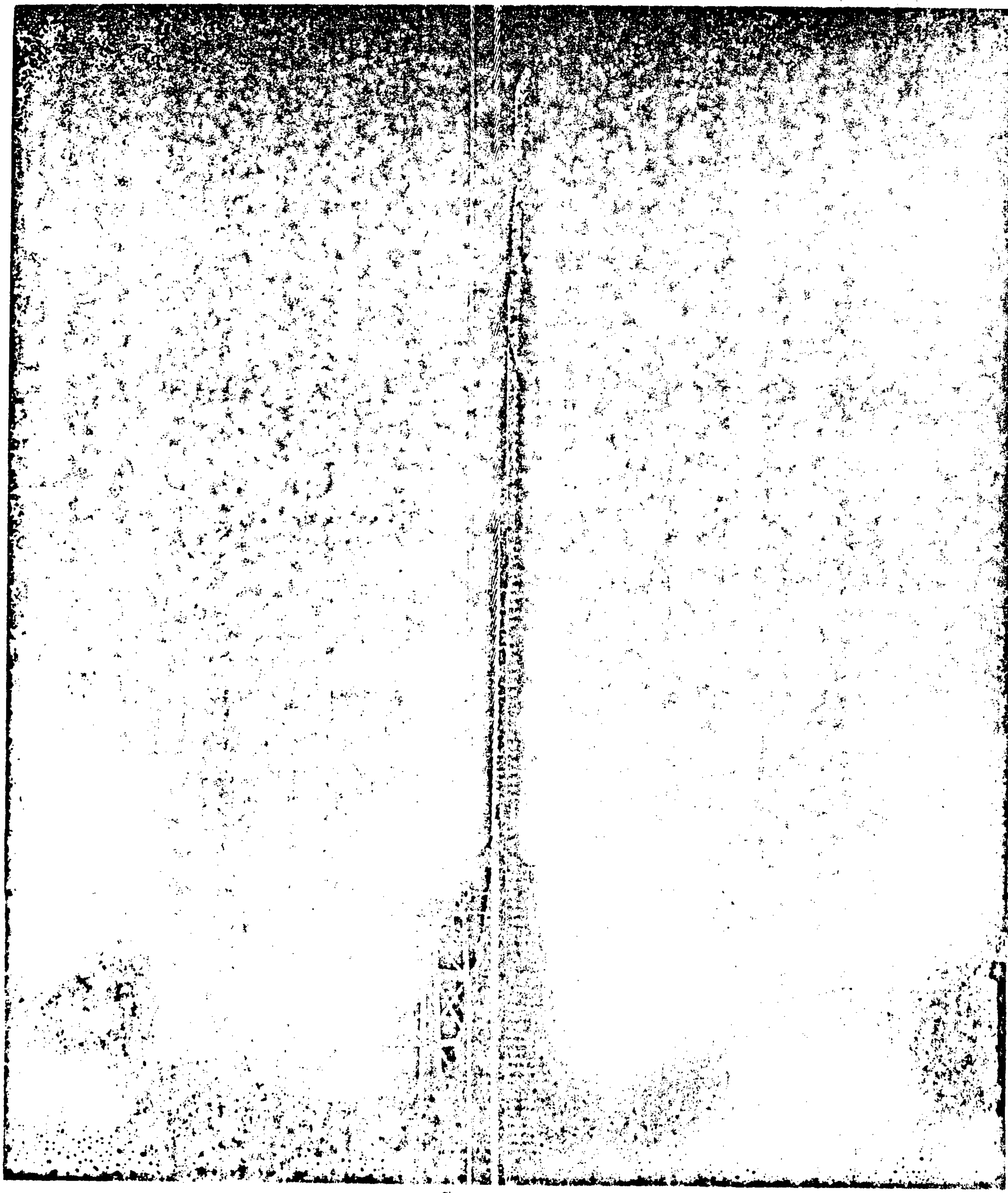


FIGURE 11. SCOUT VEHICLE

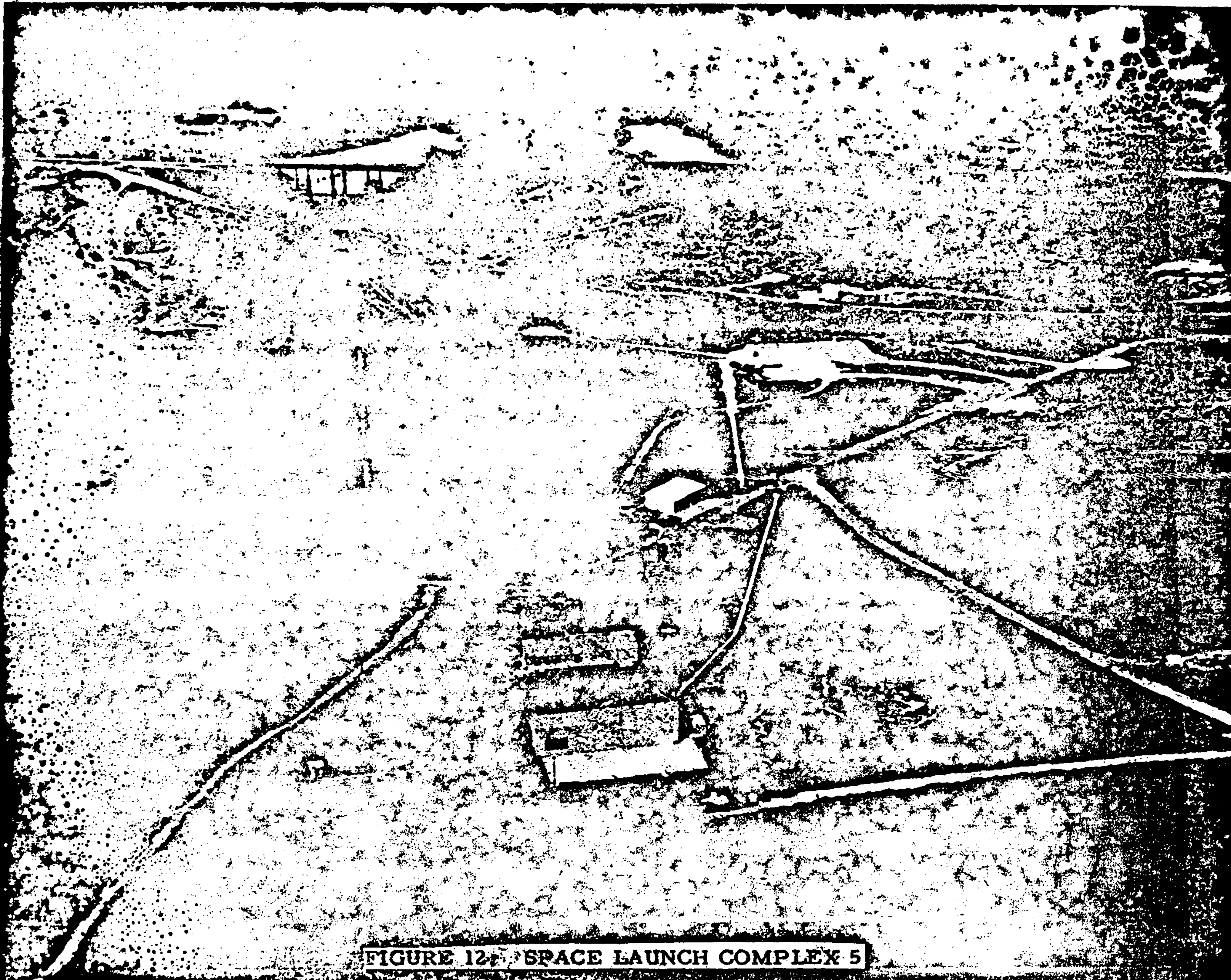


FIGURE 12: SPACE LAUNCH COMPLEX 5

north of Los Angeles, and 275 miles south of San Francisco, California.

1.2.1.2 Topography (Reference 1)

The base is sited on a low lying plateau (Burton Mesa) at an elevation of approximately 400 feet. The plateau is surrounded by canyons which lead north to San Antonio Creek, south to the Santa Ynez River, and westward to the Pacific Ocean. The Santa Ynez Mountains to the south are the principal range, its highest peak being Mt. Tranquillon (elevation 2150 feet). The Casmalia Hills dominate the extreme northern base boundary, their highest point having an elevation of about 1600 feet. The Purisima Hills, to the north of the base cantonment area, run east and south with a maximum elevation of approximately 1500 feet. The base occupies a total area of 98,400 acres, with another 10,665 acres under lease or use permits.

1.2.1.3 Vegation (References 1 and 2)

The general locale is devoid of intense tree coverage. The primary species existing in the cantonment area are Eucalyptus and Monterey Pine which were planted prior to and during World War II as wind breaks. The types of vegatative cover dominant in the unimproved areas of the base include coastal sage, oak wood land, grassland, and chaparral consisting of ceanothus, manzanita, scrub oak, and chamise.

1.2.1.4 Wildlife (Reference 2)

Wildlife existing in the unimproved areas of the base include black-tailed deer, feral pigs, rabbits, squirrels, racoons, fox, bob-cat, opossum, badger, and a few mountain lion. Also found in these areas are waterfowl, waterbirds, shorebirds, songbirds, and a few rare and endangered species (Least Tern, Prarie Falcon and Peregrine Falcon).

1.2.1.5 Geology and Hydrology (References 1 and 3)

Vandenberg AFB is composed primarily of Pleistocene Terrace deposits, with surface soils of predominately silty sand. It is situated in the lowland agricultural districts of the Santa Ynez and the San Antonio Valleys in Santa Barbara County, California. The area is underlain by consolidated or semi-consolidated deposits, containing water bearing strata of coarse-grained material. These deposits are almost completely enclosed by the adjacent hills and mountains of consolidated rocks, which neither take up or yield water in substantial quantities.

Santa Ynez Valley

The Santa Ynez Valley is an elongated depression that contains the westward-flowing Santa Ynez River and that lies along the north flank of the Santa Ynez Mountains. This valley contains two extensive agricultural and groundwater areas, the Middle Santa Ynez Valley and the Lower Santa Ynez Valley.

The Middle Santa Ynez Valley extends eastward from Santa Rita Creek to San Lucas Bridge. It comprises a narrow tongue of alluvium along the river and an extensive terraced upland, which lies east of Solvang and Los Olivos and extends northward to the foothills of the San Rafael Mountains. Hydrologically, the alluvial tongue and the upland are almost completely separated from one another by a narrow barrier of consolidated impermeable rock, which lies north of the river and extends from Solvang eastward to and beyond San Lucas Bridge.

In the downstream reach of the alluvial tongue in the Middle Santa Ynez Valley, westward from Solvang, ground water is found chiefly in the younger alluvium and river-channel deposits. Many wells drilled on the cultivated terraces along the river obtain water from the coarse gravel that rests in part on consolidated rock and that evidently is continuous with the river-channel deposits. This coarse gravel corresponds to that which forms the main water-bearing zone of the Lompoc Valley, but here the greatest thickness is only about 50 feet. Many shallow wells derive water from the river channel deposits. Essentially, it is river underflow.

In the upland area northeast of Solvang, most wells derive water from deformed, partly consolidated beds of older alluvial deposits, which here underlie a thin cover of terrace deposits and, beneath the northeastern part of the upland, extend to a depth of at least 1,500 feet beneath the land surface. Few wells, however, are more than 400 feet deep. The older deposits are composed largely of interfingering tongues and lenses of clay, clayey sand, somewhat pebbly sand, and clayey gravel. The bulk of the deposits is relatively impermeable and transmits water slowly.

The water-bearing lenses in the older deposits are replenished largely by the slow infiltration of rain, and perhaps locally by percolation from streams that head in the San Rafael Mountains.

The lower Santa Ynez Valley comprises the alluvial plain about Lompoc--called the Lompoc Plain-- and the surrounding upland area of terraces and hills. Most of the surrounding area is underlain by consolidated rocks and semi-consolidated deposits, but the Lompoc Plain and the adjoining narrow tongues that extend up the Santa Ynez River and tributary streams are underlain by the unconsolidated younger alluvium. This formation, which ranges in thickness from a thin edge to about 200 feet, contains three water-bearing zones. The lowest is a body of coarse gravel, which underlies the northern two-thirds of the Lompoc Plain and extends eastward in a narrow tongue through the Santa Rita Canyon of the Santa Ynez River. This body is the main water-bearing zone of the area and yields copiously to most of the irrigation wells on the plain. A secondary water-bearing zone is contained in older alluvial deposits that are less productive than the lowest member of the younger alluvium but that are the chief source of water beneath the southernmost and easternmost parts of the plain. A third, or shallow water-bearing zone, is at shallow depth beneath the entire plain; locally it yields small quantities of water for domestic use and for stock.

Water in the main secondary zones is confined under pressure and, when encountered in wells, rises to within 30 to 40 feet of the land surface. Water in the shallow zone is unconfined. These water-bearing zones are replenished by percolation from the

Santa Ynez River, by percolation from tributary streams, and by infiltration of rain. The main zone is also replenished to an unknown but probably appreciable extent by underground percolation from adjacent parts of the secondary zone.

San Antonio Valley

The San Antonio Valley lies immediately north of the Santa Ynez Valley. This valley is underlain by three general classes of deposits or rocks, as follows: 1) Unconsolidated deposits, which underlie the central lowland areas (the main agricultural districts) which contain ground water, and coarse-grained members which yield water more or less readily to wells: 2) partly consolidated deposits, which underlie the unconsolidated deposits beneath the central lowlands and crop out in the adjacent hills and terraces, and which also contain water and 3) consolidated rocks, which underlie and crop out beyond the partly consolidated deposits and which neither take up nor yield water in appreciable quantities. The partly consolidated deposits are more compact, less permeable, and accordingly yield water to wells somewhat less readily than the unconsolidated deposits. The consolidated rocks are generally impermeable and form the hilly or mountainous areas that enclose the ground water basins.

The San Antonio Valley is a narrow synclinal trough between the Purisma Hills on the south and the Casmalia and Solomon Hills on the north. San Antonio Creek flows westward through the valley and drains an area about 29 miles long and from 5 to 7 miles wide. Its tributaries are short and intermittent. The chief agricultural district lies in the middle reach of the valley and is nowhere more than a mile wide. The flat floors of the larger tributary canyons are also cultivated to some extent. The central cultivated part of the San Antonio Valley is underlain directly by unconsolidated alluvial fill, which is probably nowhere more than about 100 feet thick. This fill consists mostly of sand and silt which, though loose and porous, is not sufficiently permeable to yield large amounts of water to wells. Most wells pass through the unconsolidated fill and enter the underlying partly consolidated deposits, which also are generally fine-grained but contain some thin lenses of somewhat more permeable gravel. As a whole, however, the partly consolidated deposits have relatively low permeability, and wells penetrating them have small to moderate yields.

The unconsolidated alluvial fill obtains its water mainly by seepage from San Antonio Creek and its tributaries, but possibly in some part from permeable members in the underlying partly consolidated deposits. The latter deposits underlie an extensive area north of, and a narrow area south of, the central lowland and in those areas they receive water chiefly by infiltration of rain. The water is mainly unconfined, but some wells in the vicinity of Los Alamos tap water under sufficient artesian head to flow moderately at the land surface.

1.2.1.6 Climatology (Reference 1)

The climate of VAFB is typical of the mid-California coast, with year-round mild temperatures and no clearly defined seasons. Mean temperatures range from 50°F in January (the coldest month) to 61°F in September (the warmest month). In general terms there are two seasons, distinguishable primarily on the basis of the amount of rainfall which occurs. The wet season (winter) extends from November through April, and is characterized by generally fair weather interspersed with short periods of cloudiness and rainshower activity. Ninety-two percent of the annual precipitation occurs during this period. The dry season (summer) extends from June through September. This season is characterized by low cloudiness and persistent fog during the night with sunny afternoons, and very little rainfall. The months of May and October are considered transition periods between the two seasons. A strong marine temperature inversion is present over 80% of the time during the months of May through October at all times of the day.

The unequal daytime solar heating over land and ocean, in conjunction with the Pacific high circulation, gives rise to a consistent and prevailing northwesterly low level wind during most afternoons. Approaching fronts and storms during the winter are the major causes for disrupting this wind, at which times it generally changes to the southeasterly direction. The winds are light and variable during most nights and mornings the year round.

1.2.1.7 Land Use, On Base (References 1 and 4)

Vandenberg AFB land use falls into three general categories which can be described as launch area, base support area, and technical support area.

The Launch Area encompasses the existing launch facilities and extends over the entire coastline of the base. The easterly boundary is defined by the provision of safe distances between the launch facilities and the concentrations of population in Casmalia, the Base Support Area and the South Vandenberg cantonment area.

The Base Support Area includes the facilities required to operate and maintain the base. Included in this area are administrative, industrial, and housing facilities.

The Technical Support Area comprises all of the base area not occupied by the Launch and Base Support Areas. These areas are generally unsuited for launch sites or large support functions because of location or topographic conditions. The mountainous parts of these areas provide ideal locations for the guidance and tracking facilities located there.

The entire base area of 98,400 acres provides a debris fallout area to retain the primary pieces of vehicle debris in the event that destruction is necessary shortly after liftoff.

The multiple land use concept is reflected in the non launch vehicle related activities for which base land is also used. Currently 15,062 acres are out-leased to other government agencies and private individuals, and 28, 101 acres are permitted to the Bureau of Prisons, Federal Correctional Institution (FCI) at Lompoc. The primary use of these leases is grazing and agriculture. Extensive areas are permitted to other governmental agencies for special programs. For example, extensive training areas are made available for seasonal use by the Navy Seabees, California National Guard, Air Force ROTC, and the Army Reserve.

The generally beneficial effects of VAFB are realized in the provision of recreational areas for use by base personnel and the general public with access regulated by safety considerations during launch periods. Recretional provisions available include hiking trails, campsites, picnic grounds and beaches. A fish and wildlife conservation program has been developed in conjunction with State and Federal Fish and Game Offices. This plan complements the other land uses discussed here.

1.2.1.8 Land-Use, Off Base (Reference 1)

Off-base population centers include Guadalupe, 4 1/2 miles north of the base boundary; Casmalia, adjacent to the northern boundary; the Santa-Maria-Orcutt area, 2 1/4 miles northeast of the base boundary; the Vandenberg Village-Mission Hills area, located 1 1/4 miles southeast of the base boundary; and Lompoc, three miles southeast of the base boundary. The total area population is approximately 83,000. The primary contributors to this total are Santa-Maria (population 34,000) and Lompoc (25,000).

The area along the northern and eastern boundaries of the base is primarily open and grazing land. Large agricultural areas are located adjacent to the communities of Guadalupe, Santa Maria, and Lompoc. A facility for the mining of diatomaceous earth is located south of Lompoc.

Privately owned or uncontrolled lands along the coast include the Southern Pacific Railroad right-of-way (which traverses the base from Point Sal to Jalama), the railroad community at Surf, Point Sal Beach, Ocean Park Beach, and Jalama Beach Park.

North and east of the city of Lompoc lies the La Purisima Mission State Historical Monument. This mission is the only property in the VAFB area listed in the February 1974 National Registry of Historic Places and the March 1974 update of this list.

1.2.2 Cape Canaveral Air Force Station

1.2.2.1 Georgraphic Location (Reference 5)

Cape Canaveral Air Force Station (CCAFS) is located on the east coast of Florida, 150 miles south of Jacksonville and approximately 50 miles east of Orlando. It is sited on Cape Canaveral, in Brevard County, between the Banana River and the Atlantic Ocean. The station is approximately 10 miles long and varies in width from 1 to 4 1/2 miles. Its north boundary adjoins the south boundary of Kennedy Space Center (KSC).

1.2.2.2 Topography (Reference 6)

The site of CCAFS is part of the Gulf-Atlantic coastal flats. The land is flat sandy beach and salt marshes with essentially no relief, its average elevation being from four to six feet above mean sea-level. The Banana and Indian Rivers are shallow lagoons which lie to the west and north of the Cape respectively. Average depths are from 3 to 4 feet except for the Intracoastal Waterway which is maintained at a depth of 12 feet.

1.2.2.3 Vegetation (Reference 6)

Vegetative cover in the areas of CCAFS and the adjoining KSC is principally live oaks, sea oats, and southern mixed forest. The higher ground is covered with palmetto shrubs, a few scattered sabal palms and species of southern pine, along with the undergrowth of weeds and other shrubs native to the area.

1.2.2.4 Wildlife (Reference 6)

Birdlife, reptiles, and mammals are abundant and may be seen in and around the Launch Complex areas as well as throughout the KSC-Cape Canaveral area. In the Merritt Island area just west of Cape Canaveral, about 250 varieties of birds (including rare species) have been identified.

1.2.2.5 Geology and Hydrology (References 6 and 7)

The CCAFS-KSC site is situated on platform deposits overlying basemant rock of the Paleozoic Age. Sedementary rock is from recent time - at most from the Pleistocene Age. There are no caverns and no significant metal or mineral deposits in the area. Earthquakes are of no concern since the site is in a Zone O and no damage is expected. The soil in this area varies from sandy to warm moist cracking clay or warm wet podsals. The principal ground water source in the coastal lowlands arises from the Floridan aquifer, a limestone aqiufer which underlies the entire Saint Johns River and adjacent coastal basins of Florida. It is the principle source of water for all uses except some industrial processes and in the generation of electric power. In addition to the Floridan aquifer, some small municipalities and rural domestic users obtain ground water from shallow sand or sand and shell aquifers that occur above the Floridan aquifer. Surface water is sued for irrigation in source areas and a few municipalities obtain water from lakes.

The top of the limestone of the Floridan aquifer, which ranges in thickness from 500 to more than 1000 feet, is at or near land surface near the western divide and more than 400 feet below land surface and sea level in the northern and southern parts of the area. Large supplies of good quality water may be obtained from much of the Floridan aquifer.

Moderate amounts of good quality water can be obtained from the shallow sand and shell aquifers and from sand and shell beds in the areas along the coast where the water in the Floridan aquifer is of poor quality because of the high mineral content. Ground water in Brevard County occurs under both unconfined conditions (non-artesian aquifer) and confined conditions (artesian aquifer).

Non-artesian Aquifer

The non-artesian aquifer of Brevard County is composed of Pleistocene and Recent deposits and is exposed at the land surface. The sediments average about 50 feet in thickness in the coastal ridge but are less than 20 feet thick in the vicinity of the Saint Johns River. Non-artesian water saturates about 40 feet of the sediments in the coastal ridge area and the zone of saturation thins toward the Saint Johns and Indian Rivers.

In the sandy coastal ridge area, nearly all the rainfall enters the soil during or immediately after dry seasons. During the wet seasons the rainfall rate exceeds the infiltration rate and the surplus water drains off. In the low-lying swampy areas, very little rainfall enters the soil because the aquifer is nearly full. In the barrier islands area where the soil is very sandy, a large part of the rainfall soaks into the ground. Although part of this water is returned to the atmosphere by evaporation and transpiration, most of it seeps downward to the zone of saturation. Water in the zone of saturation moves laterally toward the ocean or river. On the mainland, flow is generally east and west from the water table divide which is parallel to and 0.5 to 1.5 miles west of the Indian River.

Artesian Aquifer

The Saint Johns River Basin is underlain by several waterbearing formations with varying water availability and quality. The principal source of water underlying this area is the Floridan aquifer through which most of the ground water flows. The source of the largest supply of ground water in Brevard County is, as for the whole of the Saint Johns River Basin, the Floridan aquifer. Well yields are generally high: wells eight inches in diameter and from 120 to 600 feet deep yield more than 1000 gpm. Because the Floridan aquifer water is highly mineralized, water from shallow aquifers is pumped for domestic and commercial uses.

Surface Water Hydrology

Surface waters are plentiful in the Cape area. Aside from the ocean itself, these include the mainland streams and lakes, and the Indian River Basin. The latter is considered to include the many sloughs and marshes in the Merritt Island area. It has been estimated that of the total land associated area of approximately one-million acres within 50 kilometers (~30 miles) of the launch site, approximately 228,000 acres are covered by surface water. Approximately one-half of the land associated surface area within 20 kilometers (~13 miles) is covered with surface water. Most of this surface water area consists of the Indian and Banana Rivers and the Mosquito Lagoon.

The Indian River is in reality a lagoon which joins the Banana River at Port Canaveral. The Brevard County section of this lagoon, including the Banana River, covers 150,000 acres and receives the drainage from 540,000 acres of the surrounding land area. Assuming an average depth of six feet for this lagoon, its volume can be estimated at about 900,000 acre-feet, or about 3 X 10^{11} gallons. The Indian River is separated from the Atlantic Ocean by a long, narrow island ranging from a few hundred feet to a few thousand feet in width except near Cocoa where it widens to form the Cape. This section of the Indian River has only one direct connection to the ocean, Sebastian Inlet. It has two indirect connections; at the northern end, the indirect connection is through Haulover Canal to the Indian River Lagoon and hence through Ponce De Leon inlet to the Atlantic; southward, the connection is through the Fort Pierce inlet at Fort Pierce.

The most prominent drainage feature of the mainland is the Saint Johns River, flowing northward to Jacksonville. The natural channel of the river becomes well defined downstream from Lake Helen Blazes in Brevard County. A marsh area extends about 40 miles from its headwaters to the lake.

Drainage in the coastal strip between the Saint Johns River and the Atlantic Ocean is into lagoons, formed by barrier islands, and to the ocean.

Coastal ocean water movements in the area have been investigated by oceanographers of the Woods Hole Oceanographic Institute (WHOI) and the Cheseapeake Bay Institute (CBI) of the John Hopkins University.

The results of a study carried out during March and April, 1962, by WHOI indicate a shoreward direction of the current for the entire depth, surface to bottom, in the region out to depths of 60 feet at about 16 miles offshore at speeds of several miles per day. Wind-driven currents generally determine the current flow at the surface. In this region, the flow is lightly to the north with an east reversal when the winds blow to the south. Beyond this distance, the water flows to the north most of the time and is known as the Florida Current of the Gulf Stream.

1.2.2.6 Climatology (References 6, 8 and 9)

The climate of CCAFS is generally warm, the mean temperatures ranging from the low sixties (Fahrenheit) in the winter months to the low eighties in the summer months. Precipitation is moderately heavy, the average annual rainfall being 46.83 inches measured at CCAFS over a 13 year period.

Precipitation occurs in all months of the year, the amounts ranging from averages of 1.65 inches during December (the dryest month) to 7.33 inches in September (the wettest month). The months of September and October are considered the hurricane season. Although these tropical cyclones can occur over a longer period, they most frequently occur during these two months.

The spring and summer months are characterized by southerly and easterly winds. During the fall, north and easterly winds occur most often, while in winter the predominant winds are north and north-westerly. The average annual occurrence of calms is 5.2% of the total hours. These are more likely to occur during the summer months, and are more common during nighttime than daytime. The seabreeze and land breeze phenomena occur commonly during summer and infrequently in winter. The seabreeze occurs during the day due to unequal solar heating of the air over land and over ocean. Land breeze occurs at night when air over land has cooled to a lower temperature than that over the sea. Temperature inversions occur very infrequently (in the order of 2% of the time).

1.2.2.7 Land Use, On Base (References 5 and 6)

Of the total land and water area occupied by CCAFS and KSC, approximately 140,000 acres are under the jurisdication of KSC. Of this, about 85,000 acres are owned by NASA. The remaining 55,000 acres are owned by the state of Florida and are dedicated to the exclusive use of the U. S. government.

The land along the coastlines of CCAFS and KSC encompasses the existing launch facilities. The remaining controlled areas enclose the facilities required to operate and maintain the two launch bases. These include separate administrative and industrial facilities of CCAFS and KSC. These large land areas and their adjoining water bodies provide sufficient area to afford adequate safety to the surrounding civilian community during launches.

Some 85,000 acres of KSC area is permitted to the Department of the Interior for use as the Merritt Island National Wildlife Refuge. Under agreement with the Bureau of Sport Fisheries and Wildlife, the boundaries of the Merritt Island Wildlife Refuge and KSC are now co-extensive. The Bureau exercises primary administration of all property (excepting the launch and support facilities) for purposes unrelated to launch activities. These include the conservation of wildlife, fish and game, recreation and education, the outleasing of orange groves, fish camps and aviaries, and the management of Playalinda Beach. Legislation has been introduced to allow the joint use of the KSC area north of the Haulover Canal by the National Park Service as a National Seashore Park. This area is currently a part of the wildlife refuge.

Citrus groves on KSC, operated under lease, have produced bumper crops and leases are actively sought under competitive bidding procedures. All leases include pollution control clauses and restrictions on the use of pesticides and fertilizers.

The generally beneficial effects of CCAFS/KSC on the area include the provision of recreational facilities and the control of the wildlife refuge. Recreational provisions avilable include parks, beaches, and game preserves, as well as the use of adjacent waterways for water sports. Launches preclude access to these areas for relatively short periods, in order to provide the required safety distances. Controlled access imposed on employees and the public to CCAFS and KSC assures minimum interference with wildlife food, shelter, and breeding places.

Launch Complex 39 A/B has been identified to the state of Florida as an historical entity for recording as a line item in the national inventory of significant landmarks.

1.2.2.8 Land Use, Off Base (Reference 6)

The major population centers around the CCAFS/KSC area include the following communities:

Orlando, 50 miles to the west, population 99,000

Daytona Beach, 50 miles north, population 45,300

Melbourne, 40 miles south, population 40,200

Merritt Island, 14 miles south, population 29,200

Titusville, 12 miles west, population 30,500

Most of the population supporting CCAFS and KSC resides in the communities of Titusville, Cocoa, Cocoa Beach, Eau Gallie, Satellite Beach, Melbourne, Merritt Island and Orlando.

Industry and agriculture-oriented Orlando serves as the local economic hub. A variety of small aerospace oriented industrial firms were established in Brevard and Orange Counties as a result of past programs. Large sections of the rural areas are agricultural.

2. PROBABLE ENVIRONMENTAL IMPACT OF OPERATIONS OF USAF SPACE LAUNCH VEHICLES

2.1 GENERAL

The activities which result from operations of USAF space launch vehicles include:

- Advanced Studies
- Research and Development
- Launch Vehicle Manufacturing
- Launch Vehicle and Component Testing
- Launches of Automated Spacecraft

Possible environmental impacts which might result from these activities include:

- Population shifts (due to manpower needs for program)
- Air Pollution
- Water Pollution
- Reentry of Launch Vehicle Debris
- Noise

2.2 ADVANCED STUDIES, RESEARCH AND DEVELOPMENT, VEHICLE MANUFACTURING AND TESTING

Advanced studies, most research and development activities, except for rocket engine firings, manufacturing and most testing are relatively clean and quiet operations and do not directly produce significant environmental effects. However, such activities do consume power, steel, aluminum, paper, etc., and thus, may have some secondary impact on the environment. These secondary impacts are difficult to quantify, but probably do not differ grossly from those resulting from the employment of an equal number of people in other activities. Consequently, secondary factors will not be considered further.

2.3 PROPULSION SYSTEM RESEARCH AND DEVELOPMENT, TEST AND LAUNCHES OF AUTOMATED SPACECRAFT

Some research and development activities and testing related to rocket propulsion systems result in the handling and consumption of propellants which may contribute to air and water pollution and noise generation. At the present time, acceptance testing of production liquid propellant rocket engines is the major consumer of propellants in these areas of activity; propellant consumption in current research and development activities is minor. The actual launch and flight of launch vehicles is the major activity which may have some effects on the environment. In addition to normal vehicle flight, the environmental impact of possible abnormal conditions will be considered. Discussions of all of these impacts are contained in sub-sections of Section 3.

2.4 POPULATION SHIFTS

The major USAF space launch vehicle activities are concentrated in, but not restricted to California, Colorado, and Florida. Since the USAF family of space launch vehicles are established systems in production and operation, no significant population shifts are expected to result from current or projected future activities. As a result, no socio-economic changes are anticipated in the surrounding communities. In addition, no changes to the current environment is anticipated, including the surface hydrology, ground water hydrology, and land use.

2.5 AIR POLLUTION

The solid rocket motors used in the Titan III C and D and the Scout booster system emit three materials of concern into the lower atmosphere. These are hydrogen chloride (HCl), carbon monoxide (CO) and aluminum oxide (Al_2O_3). The two gaseous materials are potentially toxic while the Al_2O_3 is in particulate form and is a niusance dust which may evoke some cellular response in lung tissues. Other forms of air pollution, including oxides of nitrogen and Aerozine 50 can occur as the result of venting or spilling certain toxic propellants. All of these will be discussed in Section 3.2.

2.6 WATER POLLUTION

Water pollution may occur as the result of spills of liquid propellants. Further, water pollution can occur from the residual materials contained in solid rocket motor cases and in the reentry debris from spent stages of the booster vehicles which are programmed to land in remote sections of the ocean. Water pollution is discussed in more detail in Section 3.3.

2.7 REENTRY OF LAUNCH VEHICLE DEBRIS COMPONENTS

It is anticipated that the solid rocket motor cases of the Titan III C and D will return to the surface of the ocean within approximately 200 miles of the launch site. Precautions are taken to ensure that the impact area is clear. Similar precautions are taken to ensure that the impact area for other sub-orbital booster segments is clear. The precautions against these hazards and their potential impact are treated in Section 3.4.

2.8 NOISE

The rocket engine noise at lift-off of the USAF space launch vehicles can be characterized as being very intense but of relatively short duration, and composed of predominantly low frequency energy. In addition, sonic booms will be experienced both during the lift-off and during the return of sub-orbital space launch vehicle segments and during the random reentry of orbital segments. These noise sources are discussed in Section 3.5.

3. PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED IN OPERATIONS OF USAF SPACE LAUNCH VEHICLES

3.1 GENERAL

In this final environmental statement for USAF space launch vehicles, only those environmental impacts directly related to the booster vehicles will be treated. Environmental effects associated with payloads are unique to those payloads and will not be treated here.

It will be shown in this section that there are differences in the environmental effects of each of the several launch vehicles which are related to the differences in the propulsion systems. These impacts are dependent upon the propellants used, the physical size and thrust rating of the vehicle and on the planned flight trajectory. The approach will be to identify a particular environmental impact, identify those vehicles contributing to that impact, and to treat in some detail the magnitude of the impact caused by the greater contributor. The significance of the largest environmental impact will be judged and by comparisons, impacts caused by other smaller vehicles will be assessed.

3.2 AIR POLLUTION

3.2.1 Source and Nature

The USAF family of space launch vehicles is powered by chemical rocket engines. The types of fuels and oxidizers used in each vehicle are listed in Table 2. The products of combustion at the engine nozzle exit plane, both for the solid rocket motors and the liquid propellant engines are given in Tables 3a, 3b, and 3c. Knowledge of the detailed combustion species of the rocket exhaust gases is largely based on thermo-chemical calculations which were validated by comparing the dynamics of the gas flow with the actually measured engine thrust. As indicated in Tables 3a, 3b, and 3c, products of combustion exhausted at the rocket nozzle exit plane include compounds or molecular fragments which are not stable at ambient conditions and/or which react with the abundant oxygen in the ambient atmosphere in a post-burning

TABLE 3a. PRODUCTS OF COMBUSTION AT NOZZLE EXIT PLANE TITAN III AND SCOUT(1)

	PRODUCTS OF COMBUSTION	WEIGHT FRACTION	POTENTIAL HAZARD
Solid Propellant	H^+	.0002	(2)
Titan III C & D	C^-	.0022	(2)
Scout	CH^-	.0002	(2)
	HCl	.2055	Toxic
	H_2O	.0711	None
	H_2	.0244	(2)
	CO	.2775	Toxic (2)
	CO_2	.0248	None
	N_2	.0827	None
	$AlCl_3$	.0089	
	Al_2O_3	.3010	Nuisance Dust

(1) Data presented is for Titan III SRM's. Differences, if any, for Scout vehicles are of no importance to this document.

(2) It is expected that at altitudes less than 125,000 ft, only those underlined products of combustion will be detectable in significant quantities because of instability of molecular fragments and/or post-burning of the other materials in air of the lower atmosphere.

TABLE 3b. PRODUCTS OF COMBUSTION AT NOZZLE EXIT PLANE TITAN III ENGINES (N_2O_4/A-50)

	PRODUCTS OF COMBUSTION	WEIGHT FRACTION	POTENTIAL HAZARD
Liquid Propellants	CO	.025	Toxic (1)
Titan III B, C, D	CO_2	.181	None
	H	.000	(1)
	H_2	.002	(1)
	H_2O	.350	None
	O	.000	(1)
	OH	.004	(1)
	O_2	.007	(1)
	N_2	.411	None
	NO_x	.019	Toxic

(1) It is expected that at altitudes less than 125,000 ft, only those underlined products of combustion will be detectable in significant quantities because of instability of molecular fragments and/or post-burning of the other materials in air of the lower atmosphere.

TABLE 3c. PRODUCTS OF COMBUSTION AT NOZZLE EXIT PLANE ATLAS ENGINES (LO_2/RP-1)

	PRODUCTS OF COMBUSTION	WEIGHT FRACTION	POTENTIAL HAZARD
Liquid Propellants			
Atlas SLV-3A	H^+	.0001	(1)
Atlas F	H_2	.0175	(1)
	OH	.0003	(1)
	CO	.3548	Toxic (1)
	CO_2	.3601	None
	H_2O	.2720	None

(1) It is expected that at altitudes less than 125,000 ft, only those underlined products of combustion will be detectable in significant quantities because of instability of molecular fragments and/or post-burning of the other materials in air of the lower atmosphere.

process leaving only those products indicated in significant quantities.

Of the major detectable exhaust products, aluminum oxide (Al_2O_3), carbon monoxide (CO), hydrogen chloride (HCl), and oxides of nitrogen (NO_x) are recognized as air pollutants presenting a potential hazard in the lower atmosphere depending on their concentrations. As the result of some observations and analyses, it is anticipated that CO generated by the SRM's will oxidize to CO_2 due to the initial high temperature of the CO and the abundant presence of oxygen in the lower atmosphere. However, for conservatism CO will be treated in the following discussions as if it did not burn in the post burning process.

Aluminum oxide (Al_2O_3), which is in the form of particulates having a mean size of 10 microns, is classified as a nuisance dust by the American Conference of Governmental Industrial Hygienists. Nuisance dusts are those which have a long history of little or no adverse effect on lungs and do not produce significant organic disease or toxic effect when exposure is kept under reasonable control; however, any dust may have some cellular response in the lungs when inhaled in gross amounts. In the case of nuisance dusts, there is no impairment of lung passages, no significant scar tissues are formed, and any tissue reaction is reversible. Concentrations of Al_2O_3 high enough to cause cellular response are not expected to occur.

Guidelines developed for general public exposure to HCl by the National Academy of Sciences/National Research Council indicate it has been reported in the United States that the odor threshold for HCl is between 1 and 10 ppm, and that concentrations greater than 5 to 10 ppm are disagreeable or irritating. Concentration and exposure criteria have been established to preclude any irreversible physiological effects or injuries to man. Although not injurious to man, it is recognized that formation of acid mist or rain resulting from natural clouds in the atmosphere containing an HCl concentration may produce spotting on vegetation.

In the upper atmosphere, the effect of water vapor, carbon dioxide, and oxides of nitrogen from the engine exhaust may be of concern due to the low natural concentration of these materials. The possible influence on the earth's health balance and on ozone and electron concentrations is of interest and is considered.

During preparations for liquid engine tests or vehicle launch when liquid propellants are being loaded, there is a potential for spills. In the event of flight accidents, it is possible that liquid propellants may also be spilled. The vapors from both nitrogen tetroxide (N_2O_4) and Aerozine 50 (fuel) are toxic; therefore, attention must be given to the mixing of these vapors into the atmosphere.

In the event of a vehicle failure in flight, or a commanded vehicle destruct, liquid propellant tanks and solid rocket motor cases are ruptured. Under these circumstances, most of the released liquid propellants will ignite and burn. The sudden reduction in chamber pressure caused by rupturing solid rocket motor cases will probably extinguish some of the solid propellants and only a portion will continue to burn. There is no meaningful information available concerning the products of combustion formed in a failure mode situation, nor the extent to which the propellants are consumed.

Liquid propellant rocket engines are subjected to an acceptance firing at the manufacturer's facility. The propellant consumed in these tests may be as much as twice the amount required in flight, but it is typically 15 to 30 percent of the normal flight quantity. Also, research and development activities result in the consumption of propellants other than in-flight. At the present time, liquid engine research and development activities result in significantly less propellant consumption than does acceptance testing.

The Titan III solid rocket motors were successfully developed and qualified in a series of 16 full scale motor firings, the last of which was completed in 1970. There are no immediate requirements for any further full scale testing. Any research work with solid propellants which may be required in the foreseeable future will be accomplished at a scale small enough to be of no practical concern to the environment. However, to provide a complete overview, solid rocket motor test firings are treated later.

The several SRM segments powering the Scout space launch vehicle are also developed items. The largest of these segments contains less than 5% of the propellant contained in a single Titan III SRM and is small enough so that any future required research work will pose no environmental problems of practical concern.

In summary, potential air pollutants from USAF space launch vehicle operations may arise from launch operations, engine tests, on-pad accidents or in-flight accidents as a result of which propellants are burned or liquid propellants are spilled.

Table 4 lists the combustion products and propellants of primary concern in the near-ground atmosphere together with some reported and estimated human exposure criteria. It is against the criteria for uncontrolled population, in the two right-hand columns of Table 4, that all USAF space launch vehicle operations are planned. The exposures (ppm-min) of uncontrolled populations to toxic materials are several orders of magnitude less than the exposures resulting from Threshold Limit Values (TLV) given in column 2 permitted for a 40-hour work week.

3.2.1.1 Short Term Public Limits (STPL)

Short Term Public Limits (STPL) are used as criteria when assessing predictable excursions arising from single or occasionally repeated events. These would apply during normal launch events.

The STPL's for HCl are time weighted averages not considered to present any health hazard. It should be recognized that excursions above these levels are likely to produce objectionable odors and/or irritations. The concept of time-weighted averages allows excursions above the level; however, the degree of permissible excursion is related to a number of factors, such as the nature of the contaminant, whether the effects are cumulative, whether acute poisoning will result, the frequency of excursion, and the duration of such excursions. These factors were evaluated by the Systems Command Surgeon and an allowable excursion factor of 2 was established.

The STPL's of 1 ppm for 10, 30 or 60 minutes for oxides of nitrogen represent "ceiling" values not to be exceeded. The 0.5 ppm limit for a 5 hour/day, 3 or 4 days per month, represents an average value for the 5-hour period, as long as the "ceiling" limit of 1 ppm is not exceeded.

The STPL's for hydrazine and UDMH are time weighted averages.

TABLE 4. CONCENTRATION AND EXPOSURE CRITERIA FOR POTENTIALLY HAZARDOUS COMBUSTION PRODUCTS AND PROPELLANTS

Material		Criteria for Controlled (Occupational) Personnel: TLV[a]	Criteria for Controlled (Occupational) Personnel: Suggested Short Term Emergency Limit[b]	Criteria for Uncontrolled Population: Short Term Public Limit[c]	Criteria for Uncontrolled Population: Public Emergency Limit[d]
HCl	(C)	5 ppm	30 ppm, 10 min. 20 ppm, 30 min. 10 ppm, 60 min.	4 ppm, 10 min.[e] 2 ppm, 30 min. 2 ppm, 60 min. 2 ppm, 1 hr daily 0.7 ppm, 5 hr/day 3-4 day/month	7 ppm, 10 min.[e] 3 ppm, 30 min. 3 ppm, 60 min.
Al_2O_3		10 mg/m^3		(See National Air Quality Standard 40CFR 50.6)	
CO		50 ppm	200 ppm, 1 hr	90 ppm, 10 min.[h] 35 ppm, 30 min. 25 ppm, 60 min. 15 ppm, 4-5 hr/day 3-4 day/month	275 ppm, 10 min.[h] 100 ppm, 30 min. 60 ppm, 60 min.
$N_2O_4(NO_2)$	(C)	5 ppm	30 ppm, 10 min. 20 ppm, 30 min. 10 ppm, 60 min.	1 ppm, 10 min.[f] 1 ppm, 30 min. 1 ppm, 60 min. 0.5 ppm, 1 hr/day 3-4 day/month 1 ppm, 1 hr/day/yr	5 ppm, 10 min.[f] 3 ppm, 30 min. 2 ppm, 60 min.
Hydrazine		1 ppm	30 ppm, 10 min. 20 ppm, 30 min. 10 ppm, 60 min.	15 ppm, 10 min.[g] 10 ppm, 30 min. 5 ppm, 60 min. 2.5 ppm, 5 hr/day 3-4 day/month	30 ppm, 10 min.[g] 20 ppm, 30 min. 10 ppm, 60 min.
UDMH		0.5 ppm	100 ppm, 10 min. 50 ppm, 30 min. 30 ppm, 60 min.	50 ppm, 10 min.[g] 25 ppm, 30 min. 15 ppm, 60 min. 1 ppm, 5 hr/day 3-4 day/month	100 ppm, 10 min.[g] 50 ppm, 30 min. 30 ppm, 60 min.

NOTES:

(a) Threshold Limit Values - From Reference 10. Occupational Standards for an 8 hour workday, 40 hour work week - (for comparative purposes). Values preceded by a "C" are ceiling limits not to be exceeded; all others are time weighted averages.

(b) Reference 11.
(c) Short Term Public Limit (STPL), as explained in the text, applicable during normal launch operations.
(d) Public Emergency Limit (PEL), as explained in the text, applicable during unexpected releases (accidents)
(e) Reference 12.
(f) Reference 13.
(g) Reference 14.
(h) Reference 15.

3.2.1.2 Public Emergency Limits (PEL)

Public Emergency Limits (PEL) are Emergency Exposure Limits for the public during situations in which pollutants escape in an uncontrolled manner at unpredicted times and places as a result of accidents, such as, in transportation, fires, launch aborts, etc. Although under optimum conditions, the STPL's require there be no adverse health effects, the PEL's recognize the possibility of some temporary discomfort, provided, of course, that the effect is reversible and that no serious sequelae result from it.

The impact of the PEL's for HCl is felt to be no more than strong odor, or, at the most, slight irritation of the mucous membranes. Although, the National Academy of Sciences "Guide for HCl" did not specifically establish the PEL's for HCl as time weighted averages, current sampling and analysis methods do not permit the determination of instantaneous peak concentrations. Sampling procedures after a 10 minute time period would, in essence, reflect the 10 minute time weighted average. For conservatism, the permitted excursion of concentrations is limited to a factor of 2. The impact of the PEL's for NO_2 is that it should be acceptable for an asthmatic to develop some reversible and temporary bronchial constriction, provided this does not exceed the degree or duration that might occur as the result of moderate exercise, deep breathing, exposure to inert particles, or exposure to other gases or dusts normally present in the air. They should have no impact on normal healthy persons. The PEL's for hydrazine and UDMH are time weighted averages.

Table 5 lists the combustion products of concern emitted into selected atmospheric layers. Note that quantities of CO_2 and H_2O are tabulated for the higher altitudes due to the postulate that these materials may have an influence on the earth's heat balance or on the ozone concentrations at high altitudes.

3.2.2 Low Level Air Pollution

3.2.2.1 Hydrogen Chloride

As developed in the foregoing section, hydrogen chloride (HCl) is one of the solid rocket motor exhaust constituents available in quantities

TABLE 5. PREDICTED QUANTITIES OF POTENTIAL POLLUTANTS EMITTED AT EXIT PLANE OF ENGINE NOZZLE INTO SELECTED ATMOSPHERIC LAYERS

Atmospheric Layer	Lower Mixing/ Nocturnal Inversion 0-1600 ft.			Subsidence Inversion 0-5000 ft.			Troposphere 1600-65,000 ft.		
Vehicle	HCl	CO	NO_x	HCl	CO	NO_x	HCl	CO	NO_x
Titan IIIB	0	950	722	0	1667	1270	0	3800	2890
Titan IIIC	22,600	31,250	795	39,100	54,300	1681	102,500	142,200	7545
Titan III D	22,900	31,800	683	40,000	55,600	1188	102,500	142,400	9193
Atlas SLV-3 and F	0	13,900	0	0	22,100	0	0	53,600	0
Scout	130	240	0	400	685	1	5040	9000	14

Atmospheric Layer	Stratosphere 65,000 -220,000 ft.					Mesosphere-Thermosphere Above 220,000			
Vehicle	HCl	CO	NO_x	CO_2	H_2O	HCl	CO	NO_x	CO_2
Titan IIIB	0	2595	1970	18,800	36,400	0	1572	1194	11,38
Titan IIIC	44,500	64,030	6500	22,390	48,300	0	6400	4860	46,30
Titan III D	42,000	62,970	4330	18,980	41,600	0	6190	4700	44,80
Atlas SLV-3 and F	0	38,600	0	28,800	25,200	0	10,000	0	745(
Scout	1680	2140	5	229	740	990	1830	3	14(

EMISSIONS ARE IN POUNDS

great enough to be significant to the environment. Each Titan III C and D vehicle has approximately 855,000 pounds of solid propellant aboard. Each scout vehicle has approximately 1/40 of that amount in the first stage. As indicated in Table 3a, approximately 20.5% of the solid propellant weight is emitted through the exhaust nozzle as HCl. This is certainly a significant quantity for the Titan III C and D and the Air Force has considered the impact on operations and environments since the inception of the Titan III C program.

Prior to the first flight of the Titan III C from Cape Canaveral Air Force Station in 1965, the potential hazard of HCl in the atmosphere was evaluated (Reference 16). Because of the high sensible energy in the exhaust of rocket engines, the exhaust clouds have been observed to rise rapidly from the launch area. The largest and most dense volume of exhaust gases soon reaches thermal equilibrium with the atmosphere and diffusion by the usual weather-induced turbulent forces begins. Using weather parameters typical of the Cape Canaveral Area, it was concluded that the ground level hazard from HCl was no greater than that resulting from an accidental spill of nitrogen tetroxide (See Sections 3.2.1 and 3.2.2.4). Since it had been previously determined that a toxic N_2O_4 spill would not affect uncontrolled population, it was recommended that Titan III C flights proceed. Based on this rationale, and conditional on the results of monitoring the first three launches, the initial vehicle was cleared for flight. Experience has demonstrated the validity of the HCl hazard assessment for the Titan III C at Cape Canaveral Air Force Station. There have been 18 Titan III C launches through 1972 from the CCAFS in Florida and in no case has there been an HCl toxic hazard observed at ground level. At least eleven of these launches have been monitored and in no case has HCl been detected at ground level except within the exhaust ground cloud in the immediate vicinity of the launch complex, (Reference 17).

When operations of the Titan III D were planned for VAFB, a question arose as to the applicability of the rationale developed for Florida to the Vandenberg area. The major differences prompting this question were those of climatology and of separation distances from the launch pad to uncontrolled population. These differences are summarized in Table 6.

TABLE 6. COMPARISON BETWEEN CAPE CANAVERAL AIR FORCE STATION AND VANDENBERG AIR FORCE BASE

FACTORS	CCAFS	VAFB
Wind Direction (prevailing)	Off-shore	On-shore
Subsidence Inversion Layer	Very infrequent	Persistent
Separation Distances (Launch Pads to Uncontrolled Areas)	More than 10 miles	Less than 10 miles (Min. 4 miles in Easterly Direction Only)

A joint Air Force/Aerospace Corporation HCl Working Group was established in October, 1968, with a primary goal of determining the magnitude of the HCl toxic hazard. Two independent concurrent studies, References 18 and 19 were initiated by members of the HCl Working Group to assess the HCl hazard following launch activity at VAFB. There was good agreement between both studies as to the anticipated downwind HCl concentrations following a Titan III D launch or abort. In addition, the work conducted by the GCA Corporation provided mathematical modeling of atmospheric mixing processes which permits near real-time prediction of the rate of dissipation of HCl in the atmosphere.

3.2.2.1.1 Anticipated Effects of HCl

In considering criteria for HCl, it is important to have a feel for the anticipated effects of the material on people. The office of the SAMSO Surgeon (Reference 20) has related concentrations of HCl to effects on humans and these are shown in Table 7. This table is based on short term exposure to the contaminant. Therefore, only effects of HCl concentrations are shown. It is expected that no irreversible physiological effects or injuries would be induced. Considering the permissible concentration for HCl as directed by the Air Force Systems Command for uncontrolled population (4 ppm for 10 minutes, with concentration excursion to 8 ppm permitted within an exposure of 40 ppm-min.) coupled with the short time of actual exposure, a substantial degree of conservatism is noted.

Throughout this environmental statement emphasis is placed on the effect of HCl on man. It is recognized that vegetation and wildlife may react adversely to high concentrations of HCl. However, several studies, as summarized in Reference 12, indicate that HCl presents little hazard to plants when compared to other phytotoxic air pollutants and animals should not experience irritation in excess to that experienced by man at similar concentrations. On this basis, the criteria for man is used as a guide to safeguarding the total environment.

3.2.2.1.2 Normal Launch Operations

In a normal launch, exhaust products are distributed along the

TABLE 7. ANTICIPATED EFFECTS OF HCl ON MAN[a]

CONCENTRATION	EFFECTS
0-2 PPM	None - odor detectable by some people
2-10 PPM	Odor detectable - some people may experience slight discomfort
10-20 PPM	Moderate irritation
20-30 PPM	Disagreeable irritation, no injuries anticipated
30-50 PPM	Very irritating - possible effect on persons with respiratory problems
50-100 PPM	Severly irritating - effect on persons with respiratory problems. No deaths expected

(a) Abstracted from Reference 20

trajectory path. Due to the rate of acceleration of the vehicle and the staging processes, the quantities of exhaust gas emitted per unit length of the trajectory are greatest at ground level and decrease continuously. In a practical sense, the relatively large quantity of exhaust gases in the first 2,500 feet of the atmosphere is most likely to be detectable, and in the case of solid rocket motors, has the potential for local short term measurable polluting of the atmosphere with HCl near ground level. It has been observed from many launches of the Titan and other booster systems that the portion of the exhaust plume that persists for more than a few minutes is that portion emitted during the first few seconds after ignition and which is concentrated in the pad area and referred to as the ground cloud. Because the ground cloud does persist over a period ranging from many minutes to hours, the rate of dilution of that cloud is of significance with respect to ground level environment.

The second stage of mixing of an exhaust ground cloud into the atmosphere takes place at the end of the ground cloud formation. At this time, approximately two minutes after launch, a cloud of finite size exists in the atmosphere and the predominant forces effecting further mixing are those imparted by natural atmospheric motions. The size of the initial exhaust ground cloud establishes the initial source strength (Reference 21). Further diffusion of this exhaust ground cloud has been modeled as the result of many empirical analyses (References 18, 19 and 22). Such models treat elevated finite sources as if they had emanated instantaneously from a virtual point source upwind of the actual launch. Mathematical models have been constructed which estimate the peak on-axis ground level concentration and exposure which may be expected as the ground cloud diffuses. The rate of diffusion of the exhaust ground cloud is obviously dependent on the rate of its growth in volume. Relating normally measured weather parameters to the rate of growth of the cloud dimensions is the key to predicing diffusion. Predicting techniques for use in the field were provided by the GCA Corporation, Reference 19, and amended by the Aerospace Corporation, and have been demonstrated to be a conservative technique for estimating the growth behavior of the exhaust ground cloud. These processes are applicable to all of the materials in the exhaust cloud even though HCl is the only substance singled out because of its importance in launch operations planning.

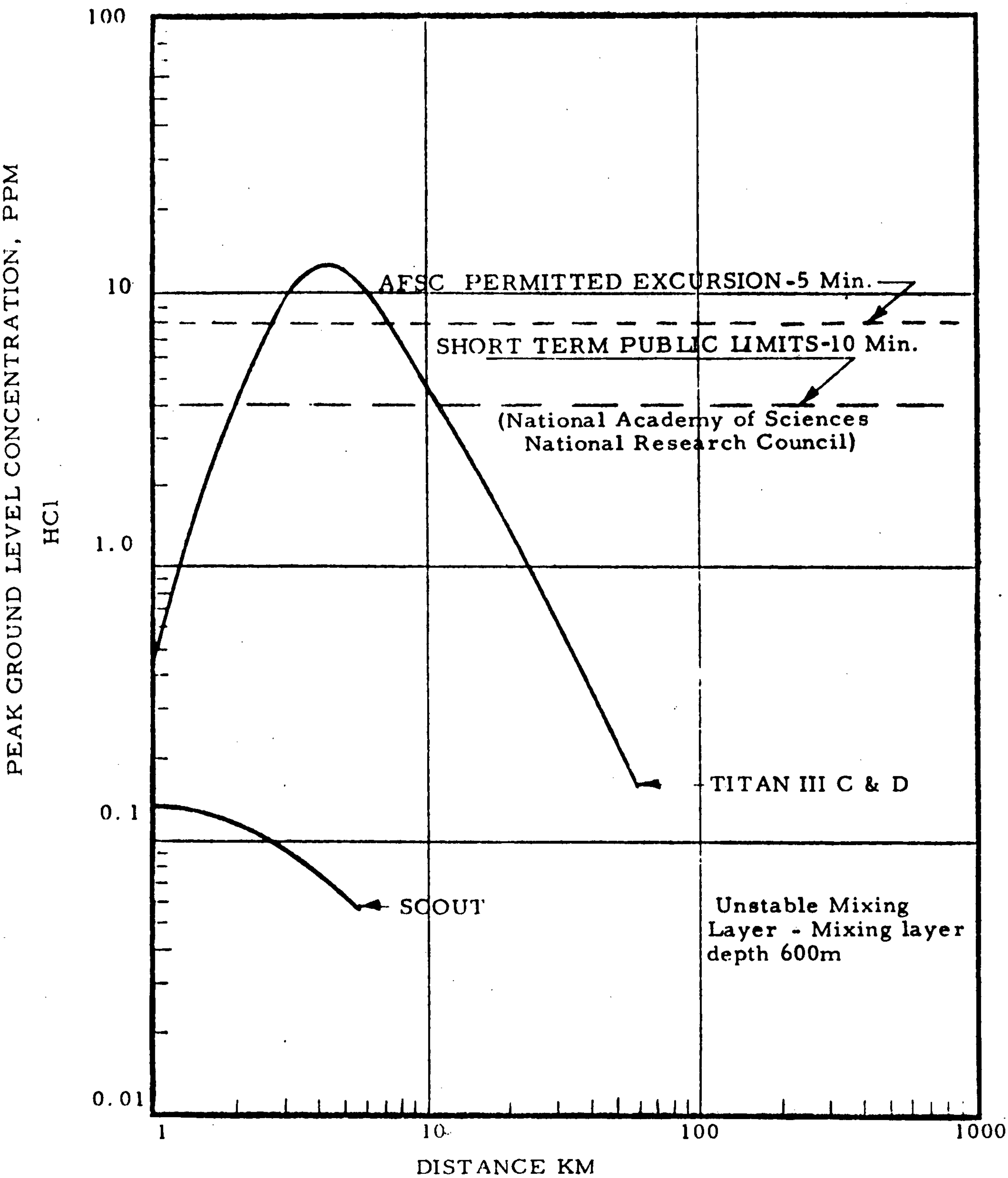
The diffusion model used here to calculate peak ground level concentrations assumed an instantaneous elevated volume source. The vertical distribution of the exhaust products was initially assumed to be Gaussian about the actual stabilized height of the exhaust ground cloud to permit calculations of the weight of HCl contained in the portion of the exhaust ground cloud within the surface mixing layer. The model required that an effective source height for the HCl be determined within the surface mixing layer. A spherical cloud with a trivariate Gaussian distribution of the material within the mixing layer was assumed to be centered at the effective height.

Using typical weather parameters and the expected performance and trajectory of the Titan III C, D and the Scout vehicles, analytical predictions of the peak ground level concentration of HCl were calculated. These predictions are presented in Figure 13 and were prepared using the techniques described in References 18, 19 and 22. From Figure 13, it may be seen that the criteria for uncontrolled population may be expected to be exceeded by the Titan III C and D vehicles at distances less than 11 km (7 miles) from the launch pad for normal launches. Depending on the wind direction the exhaust cloud could pass over uncontrolled areas at concentrations exceeding the criteria level given in Table 4 for launches at Vandenberg Air Force Base. If one considers that the predicted concentrations represent peak ground level values occurring along a narrow path as the ground cloud moves downwind from the launch pad, that the actual duration of the exhaust cloud over any given ground point is of short duration (a few minutes) then one might consider that the permitted concentration excursion factor of two would indicate that the critical downwind distances from the launch pad for uncontrolled population is of the order of 6.5 km (4 miles) during normal launches.

The other space launch vehicle emitting HCl into the atmosphere is the Scout. The first stage of the Scout is smaller than the two SRM's

FIGURE 13 ESTIMATED PEAK GROUND LEVEL HCl CONCENTRATIONS DOWNWIND FROM LAUNCH SITE

NORMAL LAUNCH



To convert to miles, multiply KM by 0.62

of the Titan III C and D by a factor of more than 40. In addition, the acceleration of the Scout vehicle is greater than that of the Titan III C and D vehicles so that the expected concentration of HCl downwind from the launch pad is more than two orders of magnitude less than that expected from Titan vehicles. There is no practical hazard from HCl associated with normal launches of the Scout vehicle.

3.2.2.1.2.1 Other Diffusion Models

The diffusion model described above which is being used by USAF to evaluate HCl ground level peak concentrations is a simple model, easily applied in the field, which yields conservative predictions. Other diffusion modeling techniques are considerably more sophisticated and permit what may be a more realistic treatment of the initial exhaust ground cloud geometry. The vertical distribution of HCl is again assumed to be Gaussian about the actual exhaust ground cloud stabilization height. The portion of the stabilized exhaust ground cloud within the surface mixing layer is partitioned into a number of sublayers which are then permitted to mix vertically. In the newer multilayer approach, it is not necessary to reconfigure the source. Also, because partitioning of the HCl along the vertical more closely approximates the actual distribution of material in the exhaust ground cloud, the calculated ground-level concentrations within 5 to 10 kilometers of the launch site should be more realistic than those calculated by means of the simple volume model used in the 1970 GCA report (Reference 19).

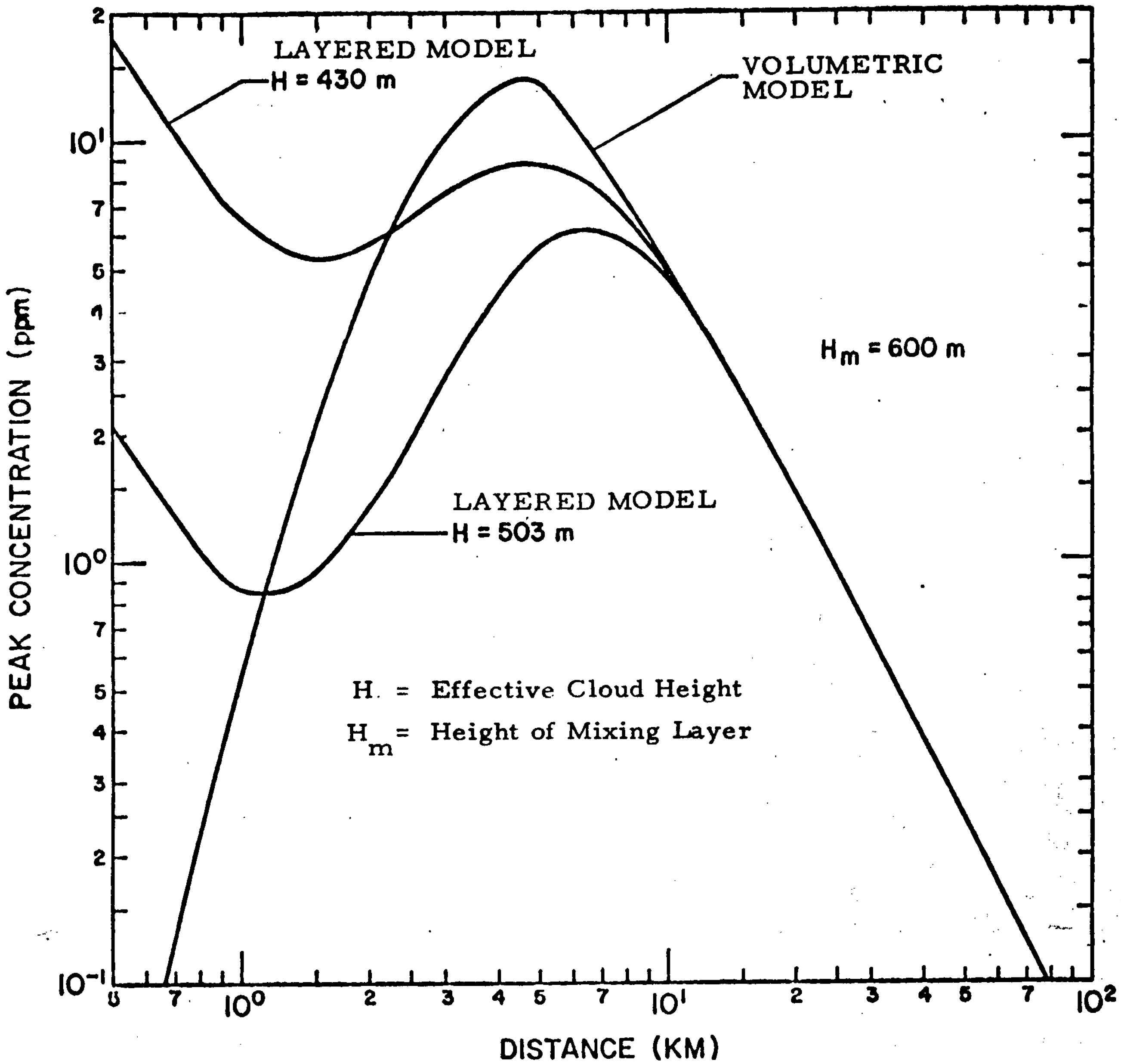
These newer diffusion models are being explored and developed by NASA/MSFC with additional expertise being provided by contractors and other investigators (References 23, 24, 25, 26). Because these newer techniques permit real-time estimation of exhaust ground cloud formation (stabilized height and dimensions) and because the multi-layered approach coupled with the assumption of Gaussian distribution in the exhaust ground cloud, NASA has predicted peak ground level concentrations of HCl resulting from Titan III C launches (Reference 27) which appear to be different from those reported here by USAF. In order to demonstrate that the prediction techniques are, in fact, compatible, the layered model is compared to the volumetric model in Figure 14.

The meteorological and source inputs for both models are identical and include a mixing depth of 600 meters, a wind power law exponent p = 0.1, and exhaust ground cloud stabilized height of 503 m, (1,650 feet), cloud radius of 244 m (800 feet) and a total of 19,400 lbs of HCl in the stabilized ground cloud. With this set of assumptions, (which yields the maximum ground level peak concentration prediction), a total of 15,600 lbs of HCl is available in the mixing surface layer.

Two sets of calculations using the newer multi-layer model are shown in Figure 14. One uses an exhaust ground cloud stabilized height of 503 m (1,650 feet), while the other uses an effective stabilized height of 430 m (1,410 feet). In both sets of calculations, the mixing layer depth was divided into six sublayers. It is evident from Figure 14 that all three concentration curves converge to form a single curve at downwind distances greater than 10 km (6.2 miles); the calculations are no longer sensitive to the details of the initial vertical distribution of the HCl. From this, it may be concluded that at distances beyond 10 km (6.2 miles), both of the modeling techniques give identical results for identical inputs.

At distances between 4 km (2.48 miles) and 10 km (6.2 miles) downwind from the launch site, the prediction of peak ground level HCl concentrations currently afforded by the volumetric model is higher and hence in this region represents a more conservative approach. At downwind distances less than 4 km (2.4 miles) substantial variation between the prediction techniques is evident. This is due to assumptions made concerning the vertical distribution of material in the initial exhaust ground cloud. It is important to recognize that detailed knowledge of the actual vertical distribution of HCl in the stabilized exhaust ground cloud is not available from actual measurements. Therefore, predictions of ground level peak concentrations close to the launch pad (in controlled areas) are subject to considerable uncertainity.

Another feature of the newer prediction technique which is not illustrated by Figure 14 is the ability to estimate exhaust ground cloud rise and size based on real-time meteorological data. Should these data result in a prediction of an initially higher and larger volume exhaust ground cloud,



To convert to miles, multiply KM by 0.62

FIGURE 14 CONCENTRATION PREDICTION COMPARISONS OF MODELS the effect would be to displace the concentration curves downward to predict lower HCl concentrations at given downwind distances from the launch pad.

3.2.2.1.3 Fumigation of HCl from Inversion Layers

Material entering into an inversion layer will tend to remain there and such material may be transported downwind with diffusion limited to only lateral and along-wind directions. The process by which such material comes out of an inversion layer is termed fumigation. Fumigation is initiated by the solar heating of ground surfaces so that layers of air close to the ground surface become heated by radiation. When the temperatures of these lower layers increase to temperatures greater than those existing in the inversion layer, the stable inversion layer then becomes part of an unstable or mixing layer. A typical fumigation is analogous to erosion of the stable layer from the underside up. It has been estimated that the transport of HCl to the ground level during typical fumigation is well below acceptable criteria level concentrations (References 19 and 28).

It has been hypothesized that a complete fumigation might occur. For such an event, one would have to assume atmospheric action of such scale and vigor so as to cause the entire cloud to move downward to the ground almost instantaneously. This is not to say that such an event could not occur, but the probability is very low and if the presence of such vigorous atmospheric activity were known, other vehicle considerations certainly would have precluded attempting to launch.

3.2.2.1.4 Precipitation Scavenging

A matter of concern with respect to HCl is that of precipitation scavenging. This factor has been treated in a limited way, Reference 19, but the process remains the least understood at this time. It is expected that launching a Titan III C or D into a clear atmosphere of saturated air will not result in the formation of droplets which might fall out. Droplets do occur in fog or in natural clouds and due to the great affinity of HCl and water, an acid mist or rain may be expected. It has been estimated that the HCl concentration of such droplets would be less than 1%. The bounding parameters, such as the effects, the possibly affected areas, the rate of dillution of the droplets, the rate of burn-off of clouds or fog, etc. are not well known. At present, a real-time decision would have to be made regarding a launch. For example, if it were raining at launch time and the cloud path were expected to be over controlled areas, launch could be recommended since the rain would serve as an effective scrubber and any potential effects to vegetation would be on-base and of no major significance. Similarly, if a fog or cloud bank were in the process of burning-off, the evaporation of the water droplets and HCl would probably be at a rate commensurate with typical partial fumigation and again a launch could be recommended. On the other hand were a fog or cloud bank moving toward uncontrolled population with no indication of burn-off, a recommendation to hold the launch would be made.

3.2.2.1.5 Castastrophic Failures

The Titan III C and D vehicles are both reliable systems. The probability of an on-pad accident which will result in burning of all or part of the solid propellants is remote - on the order of 2×10^{-4}. However, the occurrence of an unanticipated event can be postulated and these sorts of accidents have been examined in References 19 and 29. It is judged that the accident modes and subsequent combustion cloud behavior as presented in Reference 29 are credible and realistically represent remotely possible events. Calculations of HCl ground level concentrations were made for two types of abort situations. For one set of calculations - slow burn - it is assumed that the cases of the two solid rocket motors of the zero stage are ruptured resulting in the solid propellant from both engines being scattered and burning over a 5 minute period. In the other set of calculations - single engine burn - only one zero stage engine was assumed to ignite and burn a normal two minute firing period with the vehicle remaining on the launch pad. From these calculations based on the newer prediction techniques, it is anticipated that the public emergency limit criteria of 7 ppm of HCl for 10 minutes will not be exceeded.

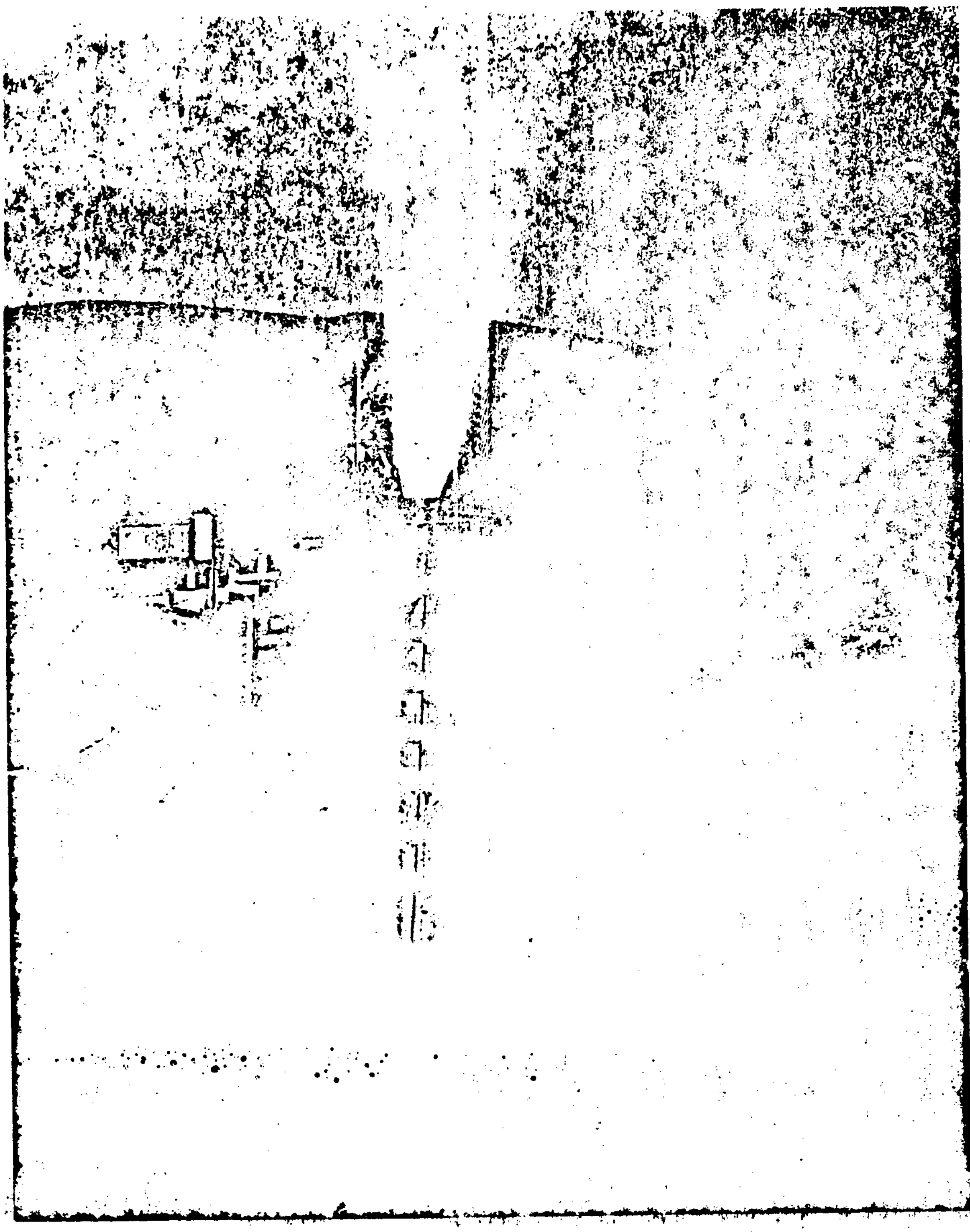
3.2.2.1.6 Air Sampling Programs - HCl

Air samples have been taken during the Titan III C and D programs to monitor the presence of HCl in the lower atmosphere. Both ground based and airborne chemical air samplers have been employed.

To verify diffusion theories and assumptions, it has been of interest to know the concentration of HCl within the exhaust ground cloud. Several attempts have been made to obtain air samples by penetrating the exhaust cloud with aircraft equipped with air sampling equipment. An adaptation of laboratory bubbler towers has worked and three successful cloud sampling missions have been accomplished. Penetration into a Titan III C exhaust ground cloud approximately 30 minutes after launch yielded a measurement of 0.5 ppm indicating that effective diffusion had occurred from the assumed initial condition of approximately 100 ppm concentration of HCl at 2 minutes after launch. A Titan III D launch at Vandenberg was monitored and the exhaust ground cloud was penetrated at a time when a concentration of 20.5 ppm of HCl was expected; the measured value was 9.66 ppm. The third exhaust cloud penetrated was from a 7 segment solid rocket motor test fired at Coyote Pass. At the time of the aircraft penetration, United Technology Center (UTC) estimated that a mean concentration of 23 ppm was expected; the measured value was 10.6 ppm. In the case of the Titan III D launch and the test firing at Coyote Pass, additional penetrations were made into the exhaust cloud at intervals following ignition. It was found that the rate of diffusion was within reasonable agreement with that predicted by the mathematical models. In these two cases, the measured concentration of HCl has been approximately half that expected. A portion of this difference can be explained by a known error in sampling technique which accounts for about 15% of the difference. The remaining is suspected to be due to loss of HCl from the sample by absorption on the walls of the bubbler inlet probe.

During the approximately sixteen full firings of solid rocket motors at the Coyote Pass, California facility of the United Technology Center, Figure 15, no HCl concentrations were detected at ground level. UTC conducted its test firings under agreement with the San Francisco Bay area Air Pollution Control District which imposed certain meteorological constraints on the test firings. These constraints were not a burden to the program. In addition, it was required that HCl detecting equipment be deployed to monitor

Figure 15. Static Firing of Solid Rocket Motor
United Technology Center
Coyote Pass, California



the immediate area. In no case was any HCl ever detected at ground level. This was expected since the terminal altitude of the thermally stable exhaust cloud from an inverted static firing is 6,000 to 8,000 feet above the test pad.

At Cape Canaveral Air Force Station, at least eleven of the Titan III C launches have been monitored with ground based samplers (Reference 17). In no case has HCl been detected at ground level except within the confines of the launch complex. In accordance with diffusion theories, it appears possible that the samplers placed downwind of the launch pad were not in the proper location to have measured HCl returning to the ground. On the other hand, it has never been reported that anyone has seen the exhaust ground cloud return to ground level. In any event, all eighteen launches from the Cape Canaveral Air Force Station have been incident free with respect to HCl.

At Vandenberg Air Force Base, four Titan III D vehicles have been launched. For the first launch, approximately 85 chemical air samplers were deployed at ground level downwind of the launch pad at distances ranging up to 21 km (13.5 miles). Even though the exhaust ground cloud was observed to have passed directly overhead of some of the sampling stations during the first of these launches, there was no HCl detected at ground level. This is consistent with meteorological data which indicated the exhaust ground cloud was within the inversion layer and with observations that the exhaust ground cloud did not return to the ground (References 30 and 31).

During the second, third and fourth Titan III D launches at VAFB, extensive exhaust cloud monitoring has been continued toward the end of increasing the available insitu data bank on diffusion processes. In addition to the ground based and airborne chemical samplers already noted, hundreds of pH paper samplers were deployed on the ground and exposed from a helicopter chasing the exhaust ground cloud to sample the air and cloud content (Reference 32). Extensive photographic coverage of the exhaust ground cloud both from the ground and the air has also been accomplished. Data from the second launch was released during August 1972 (References 32, 33, 34 and 35). These documents indicate that as in the case of the first launch, the volumetric prediction model, used to determine ground level HCl concentrations, yielded conservative predictions. Again, the exhaust ground cloud was contained within the inversion layer and the cloud was not observed to touch down on any land areas. The results of the third Titan III D launch (Reference 36) indicated that neither the airborne nor ground sampling methods used were sufficiently developed to permit extrapolation of the data collected. Because of the weather conditions prevailing during the fourth Titan III D launch (Reference 37), the data collected were inconclusive.

Work is continuing at VAFB in the evaluation of the use of pH paper samplers for detecting the presence of HCl. Qualitatively, pH papers provide an indication of the presence of acidic materials easily and at minimal cost - a substantial advantage over other methods. Efforts are continuing to determine how well the pH papers can be adapted to a quantitative assessment of the indicated acidic material. Applications techniques are being investigated for both ground based and airborne sampling stations (Reference 32).

In the development of atmospheric diffusion theory and modeling, the temperature of the materials of interest have generally been relatively low and the effect of molecular diffusion and chemical reactions with the atmosphere have been neglected because of their insignificant contribution to the diffusion process. However, in the case of rocket engines where the exhaust temperature is high, it has been suggested (Reference 32) that molecular diffusion and the chemical processes may have an effect worthy of consideration. The theory is that because of the highly excited state of the HCl molecules at the engine exit plane, greater than traditionally expected diffusion of these gaseous molecules may be occurring. This theory is being explored in the laboratory and during the monitoring of exhaust ground clouds from Titan III D vehicles at VAFB. If conclusive evidence can be developed demonstrating the postulate to be true, then there would be an increase in the effective initial size of the exhaust ground cloud which in turn would reduce the predicted ground level concentrations of HCl. It would be necessary to develop new still more complex diffusion modeling techniques to account for these additional factors should the theory be proved.

3.2.2.2 Carbon Monoxide

Carbon monoxide is generated at the exit plane of the Titan III C and D, Atlas and Scout vehicles. As noted earlier, CO is not expected to be found in detectable quantities near ground level because it is expected to have oxidized to CO_2. This is a result of the high gas temperature at the exit plane of the rocket engines and the abundant availability of atmospheric oxygen to complete the reaction. However, for conservatism, CO is treated as if there were no post burning occurring. As indicated in Table 4, there are industrial standards for exposure of controlled (occupational) personnel to CO, and there are levels recommended by the National Academy of Sciences/ National Research Council for short term public exposures. The National Primary and Secondary Ambient Air Quality Standard 40 CFR 50. 8, Reference 38 states that concentrations of CO should not exceed 9 ppm for eight hours more than once in a year period, nor exceed 35 ppm for one hour more than once in a year. The latter standard would limit the absorption of CO into the blood stream to well below a significant level and provide a margin against the hazards of impaired judgment of distances and time intervals.

Using the same diffusion prediction techniques described in connection with HCl diffusion, References 18, 19 and 22, the expected peak ground level concentrations of CO resulting from normal launch operations of these several space launch vehicles were predicted and are presented in Figure 16. The predicted concentrations of CO for the largest of the vehicles are shown to be below criteria indicated by both the American Conference of Governmental Industrial Hygienists and the National Academy of Sciences, National Research Council. Taking into account the short duration of exposure, the predicted concentrations are also below the National Air Quality Standard 40 CFR 50. 8. It is expected that CO emitted by any of the USAF space launch vehicles will cause no practical adverse impact on the environment in the lower atmosphere.

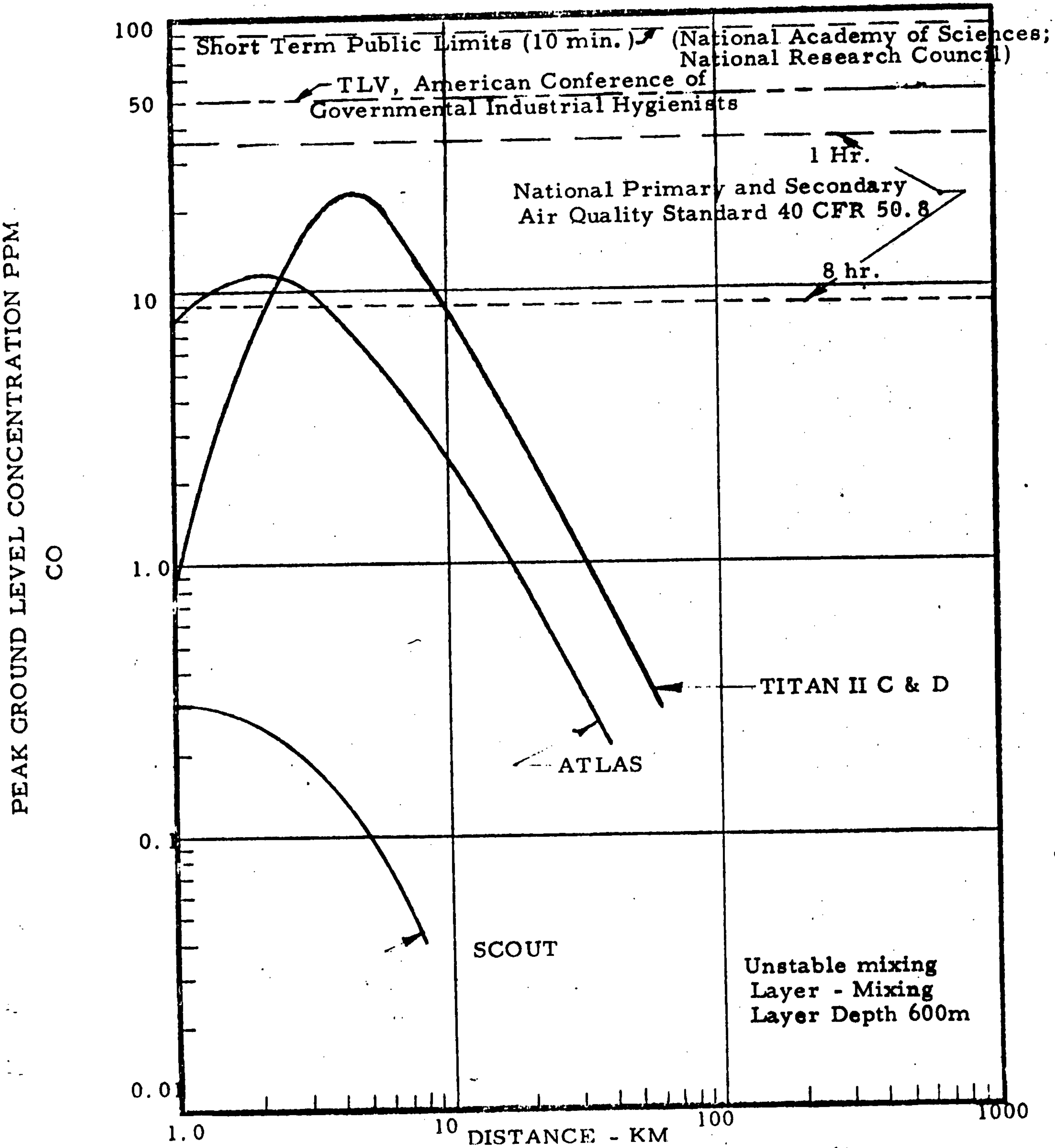
3. 2. 2. 3 Aluminum Oxide

Emissions of aluminum oxide (Al_2O_3) into the atmosphere result from the operation of Titan III C, D and Scout vehicles. Industrial standards for exposure to the material are shown in Table 4; no standards for short term public exposure have been established. The National Ambient Air Quality Standard 40 CFR 50. 6 (Reference 39) for particulates in the nuisance dust category specifies as the primary standard an annual geometric mean concentration of 75 $\mu g/m^3$ and a maximum mean concentration of 260 $\mu g/m^3$ for 24 hours once a year.

FIGURE 16

ESTIMATED PEAK GROUND LEVEL CO CONCENTRATION DOWNWIND FROM LAUNCH SITE

NORMAL LAUNCH



To convert to miles, multiply KM by 0.62

Using the same diffusion prediction techniques described in References 18, 19 and 22, the peak centerline concentrations of Al_2O_3 at ground level were calculated for different downwind distances. These predictions are shown on Figure 17. It may be seen that the Al_2O_3 concentrations are expected to be below the standard set by the American Conference of Industrial Hygienists, at distances beyond 10 km (6.2 miles). Because of the infrequency of launches, there is no question but that Al_2O_3 from Titan III C and D launches will be far below the primary standard of the National Ambient Air Quality Standard. It has been calculated that the peak predicted Al_2O_3 concentration (28 mg/m^3) would have to occur for 13.4 minutes over a given location to equal the primary air quality standard. However, since the peak concentration will decline rapidly beyond 4.7 km (~3 miles) from liftoff and since the duration of the concentration over any given ground cloud is variable and relatively short, it is judged that Titan III C and D operations will meet the primary standard. Also, it is expected that the Scout vehicle, being so much smaller than the Titan vehicles, will be well within the National Air Quality Standards.

3.2.2.4 Toxic Liquid Propellants

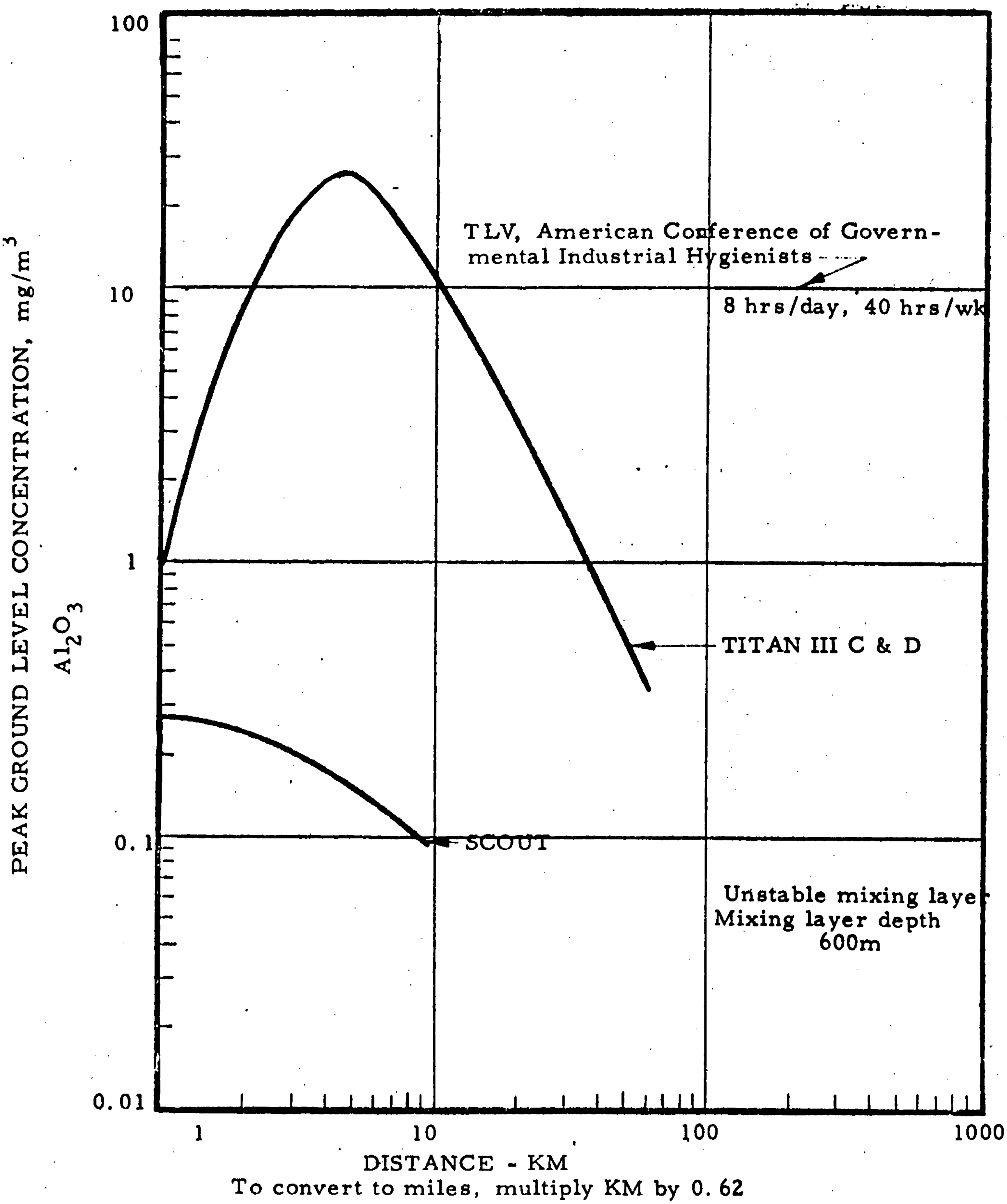
In late 1960, the Air Force initiated a series of activities to determine the potential toxicity problems that would be encountered both at Cape Canaveral Air Force Station and Vandenberg Air Force Base with the use of the hypergolic liquid propellants N_2O_4 and Aerozine 50 aboard Titan launch vehicles. These actions were directed toward assuring safe range operation. Although the Aerozine 50 mixture is considered to be more toxic than N_2O_4, the vapor pressure of the oxidizer is higher than that of the fuel, resulting in a higher rate of evaporation. Therefore, in considering possible problems associated with propellant spills, the more severe case wherein N_2O_4 is spilled is always assumed.

A program was performed at the Air Force Rocket Propulsion Laboratory to assess the toxic source strength resulting from a liquid propellant spill or a missile failure. Another program was initiated with the Air Force Cambridge Research Laboratory to perform an experimental diffusion program to evaluate the dilution of the propellant vapors in the

FIGURE 17

ESTIMATED PEAK GROUND LEVEL Al_2O_3 CONCENTRATIONS DOWNWIND FROM LAUNCH SITE

NORMAL LAUNCH



atmosphere. An outgrowth of these two programs was the establishment of a Weather Information Network Display (WIND) system for both east and west coast launch bases. The WIND system is a network of meteorological observation towers ranging in height from 6 to 300 feet which are located at representative locations throughout CCAFS and VAFB. The meteorological data observed by these respective stations is transmitted to a central receiving station where the data is processed by a computer and presented on a scaled map display panel. Weather parameters as observed at each of the stations are displayed at discrete intervals. In addition, these data are called up from the computer for use in meteorological prediction programs.

The test programs conducted at Air Force Rocket Propulsion Laboratory provided the needed data to determine evaporation rates from the surface of spilled liquid propellants. It was found that the vapor pressure of the fluid, the surface area, the wind velocity and the wetness of the surface on which the propellants were spilled all contribute to the evaporation rate. These data were considered in the subsequent test program by Cambridge Research Laboratory, Reference 40, and an empirically derived prediction equation was developed so that it was possible to predict the downwind distance to a safe concentration level resulting from a propellant spill. The prediction model makes use of measured weather parameters derived from the WIND system.

The most critical condition that can be encountered is that of a total spill of the full quantity of N_2O_4 aboard a Titan III onto the ground into a pool. This condition is always assumed when evaluating weather conditions prior to propellant transfers. Such a spill would evaporate over a period of time and use of Public Emergency Limit criteria is appropriate in evaluating the hazard. The downwind distances are calcuated to the point beyond which safe concentrations (see Table 4) of the propellant vapor would be expected. Under nighttime adverse weather conditions, this distance might be as much as 4.1 kilometers (~2.5 miles) based on 5 ppm of NO_x (for 10 minutes). This criterion was selected because emergency actions including activation of a water deluge to effect rapid dilution of the spill are expected to reduce the evaporation rate substantially. Taking into account the direction of the wind, if the critical distance were to include an uncontrolled area, even though such is on base, propellant loading would be deferred. Those personnel actually involved in the propellant transfer are provided with protective clothing and breathing equipment. All those persons not involved in the transfer operation are excluded from this area.

There are three other sources from which oxides of nitrogen may enter the atmosphere. One is from the Titan IIIC and D thrust vector control system. A second source may be the exhaust products from the rocket engines. In both cases, the total quantity emitted is so small as to be insignificant compared to the spill previously discussed. The third source is also small and infrequent. It becomes necessary from time to time that the liquid propellant storage vessels or flight vehicle tanks be vented to maintain proper operating pressures. The normal method of venting oxidizer includes the use of the propane burner to ensure complete reduction. Venting into the atmosphere is permitted only when atmospheric conditions preclude exposure of uncontrolled populations (Reference 41).

3.2.2.5 Summary - Low Level Air Pollution

The foregoing discussions have treated the propellants and the materials in the rocket engine exhausts which have been identified as having a significant potential for low level air pollution. It has been shown that the expected concentration of CO and Al_2O_3 are below practical criteria levels for each of the space launch vehicles from which these materials are emitted. The Atlas and Scout space launch vehicles are free of significant low level air pollution under normal launch operations.

Operations associated with Titan III vehicles have the potential for polluting the low level atmosphere with HCl and NO_x. The normal and abnormal operating regimes were identified which may result in the release of these materials into the lower atmosphere. For convenience, the estimated downwind distances beyond which one would not expect to detect concentrations of toxic pollutants greater than the criteria levels have been summarized in Table 8. These distances have been determined using the prediction techniques mentioned earlier. These estimates are believed to

TABLE 8. SUMMARY OF ESTIMATED DOWNWIND DISTANCES TO CRITERIA LEVEL CONCENTRATIONS AT GROUND LEVEL - TITAN III C AND D

Event	Distance at which Concentration reaches Criteria	Limiting Pollutant	Criteria Used	Meteorological Conditions
Normal Launch	11 km (7 mi)	HCl	4 ppm[a] 10 min.	2100 ft. inversion
	7.2 km (4.6 mi)	HCl	8 ppm[b] 5 min.	
Cold Spill	4.1 km (2.5 mi)	N_2O_4	5 ppm[c] 10 min.	328 ft. inversion Low wind speed, night
On-Pad Fire	Not Exceeded	HCl	7 ppm 10 min.	
One Engine Burn On-Pad	Not Exceeded	HCl	7 ppm[c] 10 min.	
Engine Test	Not Exceeded	HCl	4 ppm[a] 10 min.	

(a) Short Term Public Limit
(b) Short Term Public Limit with excursion factor of 2 as authorized by AFSC/SGP
(c) Public Emergency Limit

be very conservative since efforts to measure HCl concentrations at locations up to 13-1/2 miles downwind of the launch site have not detected HCl at ground level (approximately 1 meter above grade). In addition to the conservatism of the prediction techniques and of the exposure criteria, the real risk to uncontrolled areas during normal launch operations, as indicated in Table 7, is minor.

For normal operations at Cape Canaveral Air Force Station, the separation distance (greater than 16 km) between the launch complex and uncontrolled areas is large enough so that there is no practical basis for HCl toxicity concern. At Vandenberg Air Force Base, the minimum separation distance to uncontrolled areas is 6.5 km (4 miles) and in addition, the likelihood of on-shore winds is considerably greater. As a result, monitoring of weather conditions begins at Vandenberg well in advance of scheduled launch time and is continued through liftoff. Should the predicted path of the exhaust ground cloud from a Titan III D pass over uncontrolled areas at a concentration estimated to be greater than 4 ppm for 10 minutes, a recommendation to hold the launch would be made. Because of the substantially smaller size of the Scout space launch vehicle there is no practical environmental impact expected from combustion of its SRM either in the normal or abnormal mode.

3.2.3 Upper Atmosphere Effects

The effect of rocket engine emissions into the atmosphere above the near ground mixing layer will be discussed in this section. Emissions into the troposphere between 2,500 and 36,000 feet altitude are rapidly diluted by turbulent mixing and wind shears in that layer. It is not expected that ground level concentration of HCl would be detected as a result of vehicle climb-out. Similarly, even if the large quantity of CO indicated at the exit plane of the Titan III solid rocket motor exhaust did not oxidize to CO_2 in the atmosphere, the same rapid dilution noted above would preclude measurable concentrations from reaching ground level. It is expected, therefore, that CO will not be a concern in the troposphere either.

In the stratospheric layer of the atmosphere, the several launch vehicles exhaust a quantity of H_2O vapor, CO_2, and NO_x; the greatest quantities result from Titan III C and D operations. The principal concern regarding increase of H_2O, CO_2 and NO_x in the upper atmosphere is the effect these constituents might have on global radiation balance through absorption and scattering of incoming and outgoing radiation. The potential effect of NO_x on the ozone levels in the stratosphere is the area of interest for that material. Complete agreement does not exist in the scientific community as to the magnitude of the effects of the foregoing materials. More than 50 governmental laboratories from many agencies are actively engaged in the investigation of the complexities of the upper atmosphere. The Climatic Impact Assessment Program of the Department of Transportation (Reference 42) is designed to provide an objective assessment of the impact on the upper atmosphere caused by emissions from propulsion systems operating there. While disagreement exists with respect to causes and effects, chemistry and dynamics of the upper atmosphere, it is agreed that the major problem is lack of definitive measurements which properly and adequately define the upper atmosphere.

The potentials for affecting the upper atmosphere with respect to the USAF family of space launch vehicles will be examined in an indirect quantitative manner. Emphasis will be placed on the Titan III series since they are the largest of the USAF vehicles.

The stratospheric case has been given much attention recently with regard to the supersonic transport. A summary of findings has been published by the Massachusetts Institute of Technology, (Reference 43). This study assumed a fleet of supersonic transports using the equivalent of 1700 GE-4 jet engines operating an average of 7 hours per day every day. The output of one GE-4 engine for one hour is similar to what the Titan III family emits into the stratosphere during one launch. Table 9 shows this comparison.

The conclusion of the MIT report with respect to the supersonic transport contamination of the stratosphere was that the supersonic transport fleet did not create a dangerous situation in the stratosphere. Although this environmental statement is not intended as an unqualified endorsement of the MIT findings, the conclusions of that study should be considered here for comparative purposes. The stratosphere contamination resulting from the Titan III launches, which may occur 8 or 9 times a year, and from the 12 to

TABLE 9. STRATOSPHERIC EMISSIONS (lbs)

	Titan III C for 1 launch	GE-4 Jet Engine for 1 hour
NO_x	6, 500	1, 400
CO_2	22, 390	103, 500
H_2O	48, 300	41, 400

16 additional launches a year for smaller Atlas and Scout space launch vehicles, would be several orders of magnitude less than that caused by a fleet of supersonic transports.

The above cited work reaffirms earlier studies by Kellogg, Reference 44, who calculated that in order to double the quantity of water vapor in the stratosphere, it would require launching 6.7×10^3 super rockets emitting almost twice as much exhaust gas above 300,000 feet as does the Titan family. An even greater number of launches (1.4×10^5) would be required to double the CO_2 concentration. The 8 to 9 launches per year of Titan vehicles and 12 to 16 launches per year of Atlas and Scout vehicles quantitatively suggests that no detectable change in H_2O and CO_2 concentration will result.

Even though the stratospheric layer has great stability against vertical mixing because of its temperature inversion, lateral diffusion will occur. NASA-OSSA has estimated that at an altitude of 25 kilometers, a cross section through the exhaust plume of a Titan III C would have to expand laterally to an area of only one square kilometer for the water vapor concentration to reach the ambient value given in the standard atmospheric tables. At a 60 kilometer altitude, the cross section of the plume would have to expand laterally to 800 square kilometers to reach an equilibrium with ambient water concentrations. In the case of CO_2 at an altitude of 25 kilometers, the section through the exhaust plume would have to expand laterally to less than 1/10 square kilometers before the CO_2 would reach ambient levels. At 60 kilometers altitude, the plume would reach ambient levels of CO_2 concentration after it expanded laterally to a cross sectional area of 4 square kilometers.

Nitrogen oxides emitted from the exhaust of the Titan boosters are similarly expected to dissipate to levels well below the natural concentration levels above 60 kilometers. Although there is a question as to the magnitude and impact of the disassociation of nitrogen oxides on the ozone concentration in the stratosphere, there is no reason to expect that the near negligible amounts of NO_x produced by the Titan III family will be detectable since the operation of a supersonic transport fleet was judged to be safe.

There is some concern that HCl emitted into the stratosphere will be ionized by solar radiation and result in radio interferences upsetting communications and telemetry. In the case of Titan III C and D vehicles, emission of HCl ceases with the burnout of the SRM's in the lower stratosphere. Ultra-violet radiation of sufficiently short wave length to cause ionization will have been absorbed in the atmosphere above the stratosphere. In the case of the Scout, the small quantity of HCl per unit length of the vehicle trajectory is expected to be of no significance.

In summary, there is no significant effect of the USAF family of space vehicles on the upper atmosphere. Current and future planned activities appear to be many orders of magnitude below those which could produce any detectable changes in the upper atmosphere.

3.3 WATER POLLUTION

3.3.1 Source and Nature

USAF space launch vehicles may contribute potential pollutants to bodies of water in the following ways:

- o Normal flight, which results in the impact of spent, suborbital stages (containing some residual propellants) and jettisoned hardware into the ocean.
- o Eventual reentry of spent stages which have achieved orbit.
- o In-flight failures which may result in vehicle hardware and propellants falling into the ocean.
- o On-Pad accidents and propellant spills which may result in run-off of propellants to local drainage systems.

During normal launch operations, those vehicle stages which do not go into earth orbit are programmed in trajectories which result in an ocean impact. Stage hardware and residual and reserve quantities of propellants ramaining with the stage enter into the sea. In addition, and as the result of orbital decay, those stages having achieved the initial planned orbit will reenter the atmosphere, breakup and also may fall into the water.

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above 500°F. Disposal would be by controlled burning. At atmospheric pressure, solid propellant burning rate is much lower than during normal motor operation. Although the products of combustion are the same, the rate of emission of these products at atmospheric pressure is so low as to constitute an insignificant level of air pollution.

The major problem of water pollution relates primarily to the toxicity of materials which may be released to and are soluble in the water environment. A second aspect of the water pollution problem relates to hydrocarbon propellants and other materials which are essentially immiscible with water, but which if released, may float on the surface of the water, inhibiting oxygen transfer, coating feathers of sea fowl and fouling gills of fish which may come into contact with it. The toxicity hazard is reviewed in Table 10 along with estimated maximum allowable concentrations (MAC) for the chemical species for which there should be concern. Later discussions will explain that other materials released are not expected to pose significant toxic threats to plant or animal life. The values in Table 10 are estimates for various species of aquatic biota based on experiments conducted largely with fresh water. The effect of a given concentration of a water pollutant is dependent on many factors, including the tolerance of the involved biota to the material, the chemical composition of the water receiving the given pollutant, and the synergistic and antagonistic effects which may evolve. It is expected that the saline ocean waters will tend to have a buffering effect which should make the values in Table 10 conservative.

Maximum acceptable concentrations (MAC) of a pollutant in water are those which have little or no lasting effect on the biota being considered. The median tolerance limit (TLm) is the concentration of pollutant at which 50% of the test organisms are able to survive for the specified period of exposure. The most critical material aboard USAF space launch vehicles is Aerozine 50, because of the quantity involved in the Titan III series of boosters.

Vehicle hardware will normally sink in the ocean and slowly corrode. Such hardware consists primarily of aluminum, steel, copper and reinforced plastics and, in addition, there is a multitude of compounds

TABLE 10. POLLUTANT CONCENTRATIONS IN WATER FOR AQUATIC BIOTA

Chemical Species	Maximum Acceptable Concentration (MAC) mg/l		Median Tolerance Limit (TLm) mg/l - 24 Hrs.	
Hydrazine (N_2H_4)	0.7[a]	Based on experimental value for trout which lost equilibrium after 24 hrs. exposure	3.2[b] 1.7[b]	Goldfish 1 Daphnia pulex
UDMH $(CH_3)_2N_2H_2$	1.0	Estimate based on testing reported in Reference 46	69[b] 32[b]	Goldfish Daphnia pulex
Aerozine 50	0.5	Estimate based on combined toxic effect of N_2H_4 and UDMH	2.3[c] 15[c]	Shrimp in sea water Sheephead minnows in sea water
Nitrogen Tetroxide N_2O_4	95	Estimate based on values for nitric acid	320[b] 320[b]	Goldfish Daphnia pulex
Ammonium Perchlorate NH_4ClO_4	90	Estimate based on testing reported in Reference 46	280[b] 320[b]	Goldfish Daphnia Pulex
RP-1	40[a]	Estimate for fish when RP-1 is dispersed on surface-based on exposure of trout to gasoline contamination in water.		

(a) Reference 47

(b) Reference 46

(c) Reference 48

and elements which are used in launch vehicles in small quantities. Neither the stage hardware nor its corrosion products are believed to represent a significant water pollution problem as will be discussed subsequently.

3.3.2 Impact on the Environment

Potential sources of pollutants to the marine environment and the probable major pollutants are:

- o Hardware - Heavy metal ions and miscellaneous compounds
- o Solid Propellants - Ammonium perchlorate
- o Liquid Propellants - Aerozine 50, N_2O_4, and RP-1

Jettisoned or reentered hardware will corrode and thus contribute various metal ions to the water environment. The rate of corrosion is slow in comparison with the mixing and dilution rate expected in a marine environment, and hence toxic concentrations of metal ions (including heavy metal ions) will not be produced. The miscellaneous materials (e. g., battery electrolyte, hydraulic fluid) are present in such small quantities that at worst, only very localized and temporary effects would be expected.

The ammonium perchlorate in solid propellants is mixed in a rubbery binder and will thus dissolve slowly. Toxic concentrations would be expected only in the immediate (within a few feet) vicinity of the propellant, if they occur at all.

The release of Aerozine 50 into the marine environment may represent an immediate threat. Nitrogen tetroxide is like Aerozine 50 in that it is soluble in water, but poses a lesser threat (Table 10). Table 11 shows the amount of propellants remaining in a Titan III D vehicle at various points along the trajectory and these propellants are potentially available for release to the environment at that point in normal flight in the event of an abort. The approximate down range location of corresponding impact points is also indicated. The quantities of propellants are estimated from typical flow rate and trajectory data (Reference 49). This vehicle is the largest of the USAF family of space launch boosters. Example trajectory plots are shown in Appendix G.

TABLE 11. PROPELLANT QUANTITIES ABOARD THE TITAN III D AT SELECTED TIMES AFTER LAUNCH

Time from Launch (Seconds)		STAGE: Stage Zero (Solid)	Stage I (N_2O_4/A-50)	Stage II (N_2O_4/A-50)
9	Propellant remaining, lb.	847,908	259,000	67,000
	Propellant released, lb.			
	Normal	None	None	None
	Accident	847,908	259,000	67,000
	Location*	Near Launch Pad	Near Launch Pad	Near Launch Pad
40	Propellant remaining, lb.	487,218	259,000	67,000
	Propellant released, lb.			
	Normal	None	None	None
	Abort	487,218	259,000	67,000
	Location*	6	6	6
123	Propellant remaining, lb.		243,800	67,000
	Propellant released, lb.			
	Normal		None	None
	Abort		243,800	67,000
	Location*		175	175
280	Propellant remaining, lb.		1535(Residual)	64,600
	Propellant released, lb.			
	Normal		1535	None
	Abort		1535	64,600
	Location*		1030	1030
466.4	Propellant remaining, lb.			508 (Residual)
	Propellant released, lb.			
	Normal			508
	Abort			508
	Location*			2802

* Downrange location of impact point, n. mi.

The Atlas booster, propellant by LO_2/RP-1 may release these materials to the marine environment. RP-1 is relatively insoluble and hence is somewhat less hazardous to marine life than is Aerozine 50. However, the hydrocarbon can be dispersed and retained in suspension in sea water. Liquid oxygen poses no toxic hazard to marine biota, but a localized transient lowering of water temperature and a localized transient increase in dissolved oxygen content of the water would be anticipated in the event of a massive release into the sea.

3.3.2.1 Normal Launch Operations

A normal launch and flight will result in the down range impact of spent stages containing small quantities of residual propellants. Estimates of the maximum radius at which maximum acceptable concentrations (MAC) will occur are presented for the Titan III Stage I containing N_2O_4 and Aerozine 50 which would be the worst case. Estimates were based on symmetric diffusion into a semi-infinite ocean and diffusion limited to a depth of 10 feet, corresponding to a case where the vertical diffusion coefficient is much smaller than the horizontal diffusion coefficient.

Chemical Species	Maximum radius at which the MAC occurs, ft. Symmetric Diffusion	Depth limited to 10 ft
N_2O_4 (MAC -95 mg/l)	28	40
A-50 (UDMH + Hydrazine) (MAC -0.50 mg/l)	148	435

The radii were estimated from two diffusion models, one based on a point source for the symmetric diffusion case (Reference 50) and the other based on a line source for the depth limited case (Reference 51). The diffusion coefficients were obtained from the literature and were determined experimentally for quiescent systems. Since no account was taken of the effect of impact velocity on the location and rate of liquid propellant release, nor the possibility of some reaction between the hypergolic liquids upon stage breakup at impact, the estimated volumes of concern likely represent a worst case condition. In any case, the affected volume is insignificant and contamination does not persist due to continuing diffusion action.

Following a normal flight of an Atlas booster approximately 500 pounds of residual fuel would be released in the ocean. Because RP-1 is a petroleum distillate similar in character to kerosene, it is expected that it will disperse very rapidly into a thin film on the surface of the water. Some evaporation of the fuel layer will take place and wave action will tend to destroy the continuity of the film. Based on information and data compiled in Reference 47, an oil film thickness less than 3.95×10^{-4} inches thick will not affect the rate of solution of oxygen. The residual fuel slick need be approximately 315 feet in radius for its mean film thickness to be less than 3.94×10^{-4} inches. At a radius of 1785 feet, the oil film will be approximately 12×10^{-6} inches thick and will be identifiable by bright bands of color visible on the surface. An identifiable film will persist for a period of just a few hours. Except in the immediate area of release of the residual fuel, the concentration of RP-1 would be expected to be below the level that the natural defensive mechanism fish have for cleansing their gills can cope with. Because of the limited area involved and the infrequency of the event (12 to 16 launches per year divided between two oceans) and the non-persistence of the oil film, it is judged that the residual fuel from Atlas launch vehicles impacting in the ocean following a normal flight does not constitute a significant hazard to the environment.

3.3.2.2 Abnormal Operations

In the event of a flight terminated by the vehicle destruct system, the liquid propellant tanks are ruptured and the propellants are dispersed into the air. Again, considering N_2O_4/Aerozine 50, the propellants, being hypergolic, probably ignite and burn, but there appears to be no information available concerning the completeness of this burning. It is possible that some propellant may reach the ocean surface. If the flight of a Titan III C or D vehicle were terminated only a few seconds after liftoff, it is remotely possible that the vehicle might release the entire quantity of one liquid propellant into the ocean without fire.

In view of the uncertainty concerning the quantities of propellant that might reach the ocean in an abort, and the probablistic nature of parts of the problem, estimates of the radius at which the maximum acceptable concentration (MAC) would occur have been made for propellant quantities ranging from 1% to 100% of the propellant remaining at failure. The radii were estimated from the same two diffusion models considered previously, References 50 and 51. Results of calculations made for a Titan III C or D failure before ignition of Stage I are presented in Figure 18. It appears that a near-shore (shallow-water) impact of a vehicle might be regarded as a significant environmental event.

The probability of occurrence of an extreme event as described above resulting in release of all of the on-board liquid propellant into the ocean is extremely small. Because of the established reliability of the Titan III C and D vehicles, the probability of an early flight abort (before ignition of liquid Stage I) appears to be less than 2×10^{-4}. This rate means that only one failure would be expected in 5,000 launches (one in 560 years at a launch rate of 9 vehicles per year). For the extreme postulated incident to occur would require an early-flight failure of the Titan III vehicle. Simultaneously, it would require failure of the vehicle destruct system (never observed) and the physically unlikely situation of the hypergolic propellants not igniting following rupture of the propellant tanks on impact. Consequently, no practical significance is attached to the extreme event.

It is nearly inconceivable that an early in-flight abort of an Atlas booster would not result in consuming almost all of the fuel by fire. However, should such an event occur, somewhat less than the initial quantity of RP-1 on-board could be released into the ocean. Because of its nonviscous character, the RP-1 would be expected to spread rapidly into a thin surface film from which evaporation would occur. Based on data and information contained in Reference 47 it has been estimated for this worst case event that the approximately 80,000 pounds of RP-1 would cover an area less than 2 square miles with a mean film thickness of 3.94×10^{-4} inches. (This is the film thickness below which the rate of solution of oxygen is unaffected). It is expected that the spill would be dissipated completely within a few hours. Like the Titan family of vehicles, the Atlas space launch vehicle is reliable.

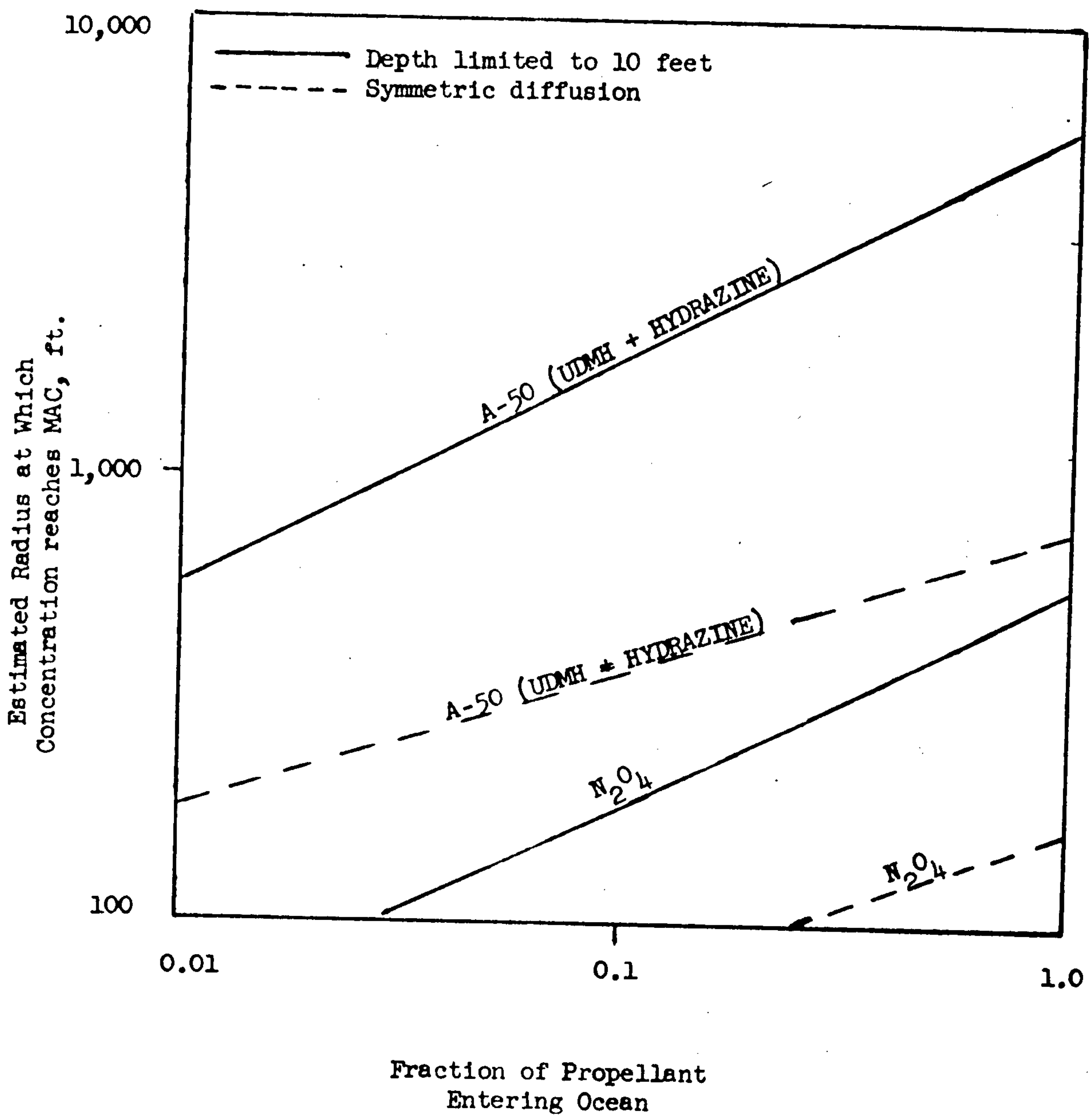


FIGURE 18. ESTIMATED RADIUS AT WHICH CONCENTRATION REACHES MAC FOR TITAN III C OR TITAN III D ABORTS

Taking into account the unlikelihood of an early in-flight Atlas abort, the relatively small affected ocean area and the degree of hazard, minimal practical significance is attached to such an event.

In summary, water pollution resulting from the operation of USAF space launch vehicles is expected to be insignificant except for worst case situations involving highly unlikely combinations of events involving the vehicles. Even should such a situation occur, the effects are not persistent, i. e., the toxicants will disperse to values below the MAC's within several hours. Because of the unconfined character of these impact areas and the lack of persistent effects, recovery in the marine environment would be expected to occur rapidly.

3.4 REENTRY OF LAUNCH VEHICLE DEBRIS

3.4.1 Source and Nature

Boost vehicle debris can impact on the earth's surface from the ascent phase of flight, and, in the case of the Scout, Titan III C and D, from the orbital phase. Impacts may occur as a result of the planned sequence of events, such as the jettisoning of a spent stage during the ascent trajectory or orbital decay of objects placed in orbit or as a result of a malfunction.

Responsibility for safety during the ascent phase of each USAF space launch vehicle is assigned to the commander of the launch range. General policies and practices for range safety are provided in SAMTECM 127-1 for Vandenberg, and AFETRM 127-1 for Cape Canaveral. Every reasonable precaution is taken in the flight planning to assure the safe operation of the vehicle, including constraints on azimuths that can be flown and wind conditions under which operations are permitted. In addition, hazard analyses may be required to evaluate the risk to nonparticipants associated with a launch. In these analyses, factors such as the probability of failure, debris characteristics, etc., are considered. There are also specific requirements relative to the location of the possible impact area for jettisoned bodies such as spent booster stages. Range Safety requirements are that no missile, space vehicle, payload reentry vehicle or jettisoned component will be intentionally impacted on land. Proposed flights will normally not be approved if normal impact dispersion areas for such items encompass land. Studies have shown that no significant hazard level exists to ships when the planned impact area is in open ocean. Typical examples of planned trajectories for USAF space launch vehicles are contained in Appendix G.

Objects placed in orbit about the earth are subjected to small retarding forces and other perturbating forces which eventually cause the orbit to decay and the object to reenter the atmosphere. Depending on the perigee of the orbit (and other orbital parameters), the ballistic coefficient of the object and the time of launch, reentry may occur after as little as one orbital revolution or after the lapse of many years. In the case of Titan and Scout vehicles, upper stages are placed in orbit. These stages eventually reenter the earth's atmosphere. Reentry by way of orbital decay is characterized by heating rates and decelerations at high altitude which typically cause the object to breakup into pieces of varying size, but do not necessarily cause complete "burnup." Pieces of such reentry debris have been recovered.

For this reason, a SAMSO safety program has been implemented with a specific objective of minimizing the hazards. SAMSOR 127-2, "Reentry of SAMSO Space Vehicle Components and Debris" establishes SAMSO policies, assigns responsibility and prescribes procedures for safety planning with respect to reentry from orbit. Responsibility for monitoring this program is assigned to the SAMSO Staff Safety Office. Data submittal requirements contained in SAMSOM 127-1 include a hazard evaluation for each flight or group of similar flights.

3.4.2 Impact on Environment

The casualty expectation, which is the total number of people expected to be affected, is the basic hazard evaluation parameter. For the ascent phase of flight, casualty expectation values for launches within the approved launch sector for each vehicle, have been less than 1×10^{-5}. The calculated hazard level for reentry of orbital debris for programs using the Titan III C booster have been generally less than 2×10^{-4}. An "acceptable" level of hazard has not been established for range safety purposes and each flight is evaluated on a "need vs risk" basis.

To further understand the meaning of casualty expectation values which are much less than one, the approach has been used for stating the number of flights that could be made before a casualty is expected. Thus, for a casualty expectation value of 2×10^{-4}, it can be stated that:

> In a very large number of similar flights, it is expected that on the average there would be one casualty every 5,000 flights.

From this interpretation, the remoteness of a casualty occurring becomes more apparent, especially for a program involving on an average of eight or nine launches per year. In addition, other studies of orbital decay debris hazards conducted for NASA by Battelle Memorial Institute (Reference 52) and another examining aspects of registering objects launched into outer space (United Nations, Reference 53), have shown that the incremental hazard to any individual from the impact of space vehicle debris is low compared to the hazards associated with day-to-day living experienced by an average individual.

Based on these data, the current safety programs assure that the hazards associated with the impact of debris are low and that the effect on the environment can be considered to be insignificant. These safety programs preculde recreational access to areas where early flight abort debris impact hazard is considered to exist. At VAFB, the only area of concern in this respect is Jalama Beach Park. It is closed during those launches when the launch azimuth, trajectory, and wind conditions could cause falling debris to endanger that area. To date, those conditions have prevailed during only one launch. By agreement with local authorities, it was closed during that launch and will be closed during any future launches when the same conditions prevail. In the CCAFS area, the Wildlife Refuge and beaches in the vicinity are closed for relatively short periods immediately prior to launch. Access to a defined safety zone of the ocean adjacent to the east coast of CCAFS is closed for water sports during the same periods.

3.5 NOISE POLLUTION

3.5.1 Source and Nature

Significant noise levels are generated in the operations of rocket engines and launch vehicles. This noise arises from the following sources:

- Combustion noise emanating in the rocket chamber.
- Jet noise generated by the interaction of the exhaust jet with the atmosphere.
- Combustion noise resulting from the post-burning of the fuel-rich combustion products in the atmosphere.
- Sonic booms.

The major source of noise in the immediate vicinity of the launch pad is the combination of that generated in the combustion chamber, by the interaction of the exhaust jet with the atmosphere, and by the post-burning of fuel rich combustion products in the atmosphere. The nature of the noise may be described as intense, of relatively short duration, composed predominantly of low frequencies, and occurring infrequently (approximately 24 times per year including all launch sites).

Both the acoustic power emitted and frequency spectrum of the noise is affected by the physical size of the rocket engine, its thrust level and the specific impulse which relates to the selected propellants. Table 12 and Figure 19 show appropriate overall sound pressure levels for the Titan and Atlas families of space launch vehicles vs. distance from the source. Table 12 also lists the thrust levels of the launch vehicles of concern in this statement. The larger, higher thrust vehicles project their acoustic energy farther from the source than do the smaller ones.

During lift-off and during reentry of suborbital and orbital stages, sonic booms are generated by the space launch vehicles. These sonic booms are believed to be an inevitable effect of flight speeds in excess of that of sound. The intensity of the sonic booms are a function of the vehicle size, configuration and velocity.

TABLE 12. ESTIMATED MAXIMUM GROUND-LEVEL SOUND LEVELS AND DURATION - USAF SPACE LAUNCH VEHICLES

Estimated Maximum Sound Pressure Level dB re: 2×10^{-5} newtons/meter^2				Distance in Miles	Duration of Sound Within Range of 20 dB of maximum
T III C and D	T III B	Atlas	Scout		
182	170	160	160	0	7 Sec.
136	127	126	120	0.5	
129	120	119	113	1	10 to 40 Sec.
122	114	113	106	2	
112	105	104	97	5	20 to 80 Sec.

Sea Level Thrust:		
	Titan III C and D	2,220,400 lb.
	Titan III B	458,200 lb.
	Atlas	411,338 lb.
	Scout	98,720 lb.

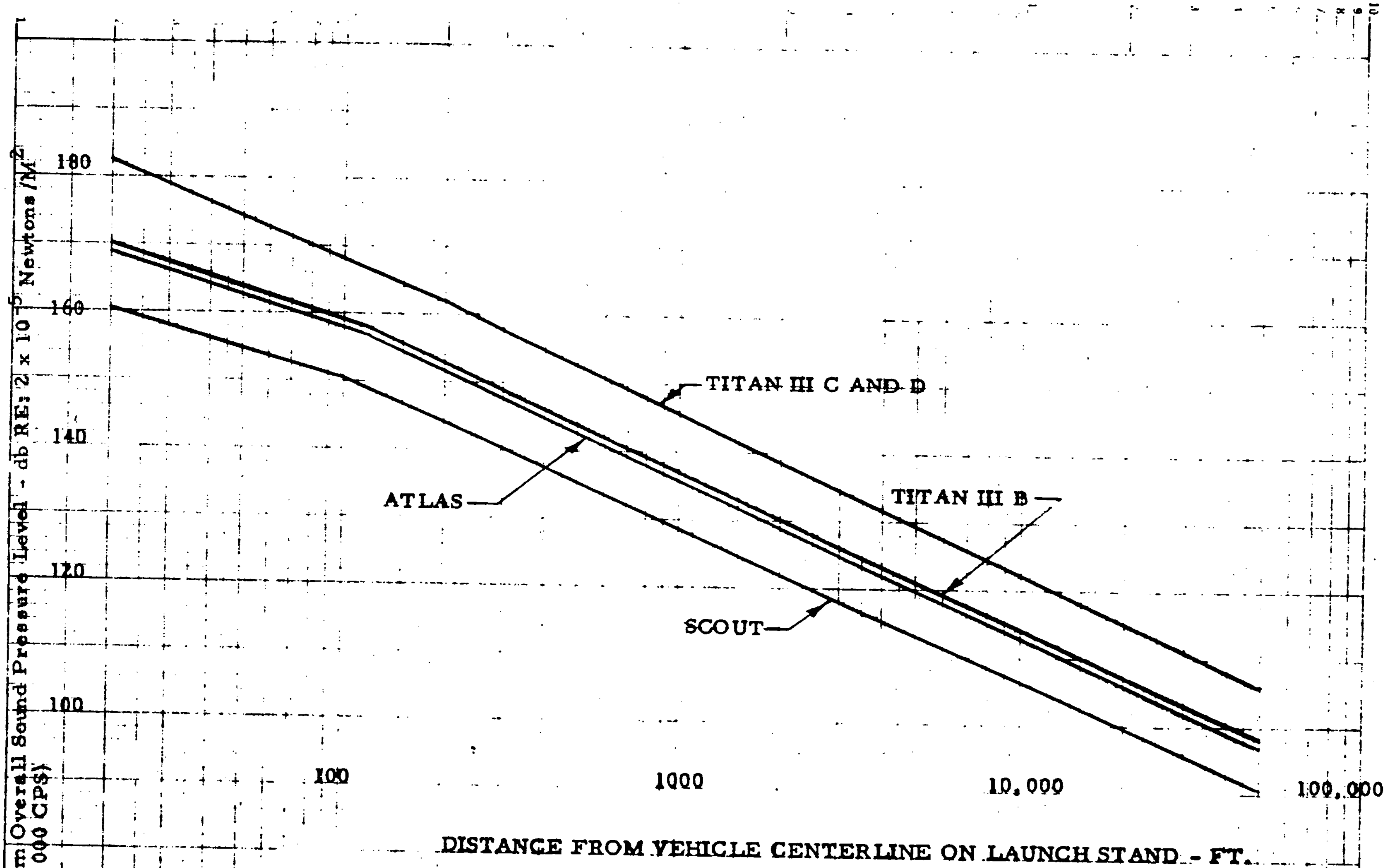


FIGURE 19. ESTIMATED MAXIMUM OVERALL SOUND PRESSURE LEVELS AT GROUND POSITIONS DURING LAUNCH OF TITAN III VEHICLES

3.5.2 Impact on the Environment

Launch vehicle noise does affect the environment, with its most important effects on man and on structures. Here we are concerned only with the adverse effects of that sound. Such acoustic energy hazards may range from bodily injuries through performance impairment down to simple perception of the presence and/or annoyance of the sound intrusion into the environment. The effects of sound waves on man and man's expected response to them have been studied extensively, and the effects and responses can be predicted with a limited degree of assurance. There is a range of tolerance in sound energy levels which cause given effects on different people. The degree of annoyance, pain, or injury also involves a tolerance range. Because of both the psychological and physiological effects of sound, the net reaction of man to acoustic hazards is somewhat subjective. Nevertheless criteria have been proposed and/or accepted which tend to provide useful guidlines for evaluating the probable effects of acoustic hazards on people.

Chemical rocket propulsion systems generate acoustic energy fields that encompass an unusually wide frequency spectrum. Frequency components that contribute significant portions of the total acoustic energy range from below 1 Hz to well above 100,000 Hz and this full spectrum has been considered in evaluating the impact of rocket engine operations on the environment. In considering acoustic criteria as these apply to rocket engine noises, it is necessary to consider not only the overall sound pressure level, but also the frequency spectrum and the duration of exposure. Sound durations are short for rocket engine firings and launches are generally separated by one to many days. It is with these considerations in mind that the criteria which are presented in Table 13 should be examined. Observance of these criteria by either excluding personnel from areas of exposure in excess of the criteria levels or by providing controlled personnel with protection from such exposures will result in neither temporary nor permanent impairment of hearing from rocket engine or launch operations.

TABLE 13. PERMISSIBLE NOISE EXPOSURE CONTROLLED (OCCUPATIONAL) PERSONNEL (REFERENCE 54)

Duration Per Day (Hours)	Sound Pressure Level (dBA; re. 2×10^{-5} N/M^2)
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or Less	115

NOTE: Appropriate standards for the uncontrolled (general) population have not been published

Personnel whose services are required within the controlled area around the launch pad are either confined to structures which attenuate sound pressure to acceptable levels, or are provided with suitable ear protective devices. Road blocks are provided on access roads at least 2 miles away from the launch pads to exclude on-base personnel from hazardous areas at launch time. The predicted maximum sound pressure levels at this distance for the various space launch vehicles are shown in Table 14. The maximum overall SPL of 122 db (re: 2 $X10^{-5}$ N/m^2) for 40 seconds is less than the 125 db for 8 minutes allowable on a daily basis (See Table 13 and Figure 23).

TABLE 14. Max Overall SPL at Nearest On-Base Uncontrolled Area (10,000 feet from Launch Pads)

Space Launch Vehicle	Max Overall Sound Pressure Level (db)	Max Duration of Sound (Seconds)
Titan III C&D	122	40
Titan III B	114	40
Atlas	113	40
Scout	96	80

For communities 10-15 miles from the launch pad, the maximum sound pressure level is below 106 db. Both man and structures are safe in these sound fields for the time-duration typical of launch operations. (See Figure 9, Table 12, and Table 13). Vehicles have been launched from VAFB and CCAFB for a number of years and are a part of the socio-economic environment. In the surrounding communities the launch vehicle noise is usually perceived as a rumble in the distance. The noise element, at the worst, appears to be an infrequent nuisance rather than a health hazard.

The SPL and duration not to be exceeded to avoid physiological (hearing and body) damage, rather than hearing only, is given in Table 13. The maximum SPL from Titan III C&D, Atlas and Scout launches is less than 122 db (re: 2×10^{-5} N/m^2) for a 40 second duration in unrestricted on-base areas two miles or more from the launch pad, and less than 115 db (re· 2×10^{-5} N/m^2) for an 80 second duration in uncontrolled public areas beyond the minimum 4 mile limit of the launch base (VAFB). These are less than the levels shown in the damage risk criteria of Table 13.

In the following discussion o f acoustic energy, subdivisions of frequency range will be considered because of the differing degree of human responses which occur; the effects on man appear to be dependent on this sort of subdivision. Sound fields generated by chemical rocket engines contain energy in the infrasonic (inaudible frequency region below 20 Hz) in the audible (audio frequency range between 20 and 20,000 Hz) and in the ultrasonic region (frequencies above the 20,000 Hz high frequency detection capability of the human ear). Typically, the larger the chemical rocket engine in terms of its physical size and its thrust level, the larger the portion of total acoustic energy that is contained in the low frequency components of the spectrum. In addition to being predominant, these lower frequencies travel farther from the source and affect a greater area than do the higher frequencies. These important characteristics of rocket engine noise are illustrated on Figure 20 which indicates the typical rocket engine acoustic spectrum and further illustrate the greater persistence of the low frequency energy as distance from the source increases. The SPL spectra vs distance data shown in Fig. 20 were not directly measured. These data reflecting a sea level launch on a standard day were estimated from measurements made at Saturn launches. Subsequent measurements made during development firings of the Titan III solid rocket motors (which are essentially the same for TIII C and TIII D) and at a TIII C launch confirmed the scaling procedures used are conservative. Therefore, Fig. 20 is representative of the basic acoustic field for both TIII C and TIII D. Local terrain and atmospheric conditions, which vary with each launch,

SOUND PRESSURE LEVEL SPECTRA FOR A TITAN III D AT FOUR DISTANCES

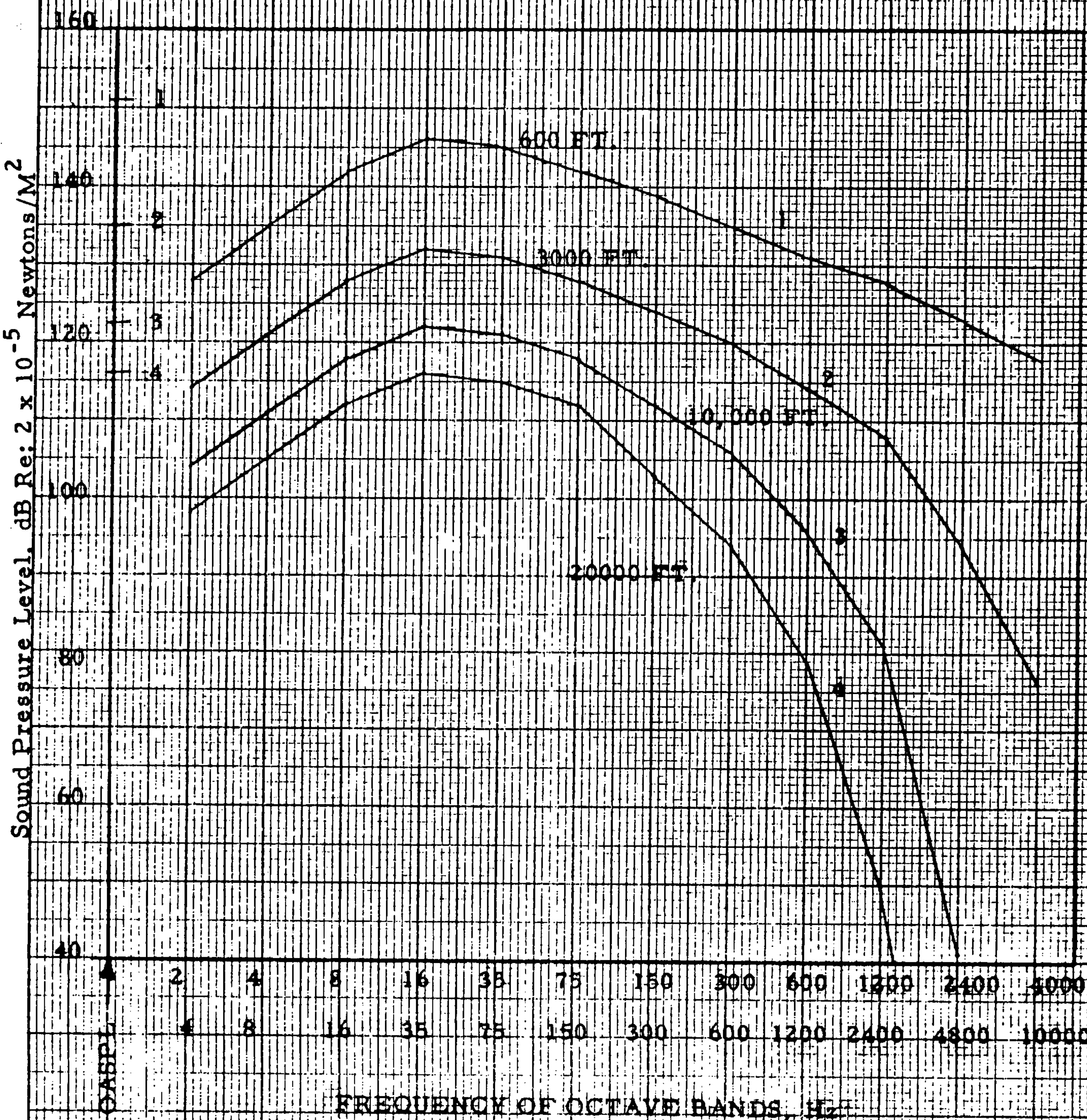


FIGURE 20

may cause some deviation to the sound propagation shown in Fig. 20. Figure 21 illustrates the typical acoustic energy duration experienced at a given ground point resulting from chemical rocket engine powered launches.

In examining rocket engine noise and its effects particular consideration is given here to vehicle launches of the Titan III C and D because these vehicles are the largest of the USAF space launch boosters. Launches of these two vehicles involve the application of two of the larger rocket engines; single engine firings and launches of smaller vehicles quite obviously will produce lesser acoustic energy.

Further, only man and his structures are considered here. It is obvious that wildlife is affected by acoustic energy but the effects of rocket engine operations are not specifically known for the range of species native to engine test and launch operations areas. Qualitatively, there seems to have been no significant impact from noise; deer and rabbits have been observed to continue feeding during engine test operations close to the operating sites.

3.5.2.1 Low Frequency Sound

In the subaudible range below 20 Hz, excessive sound pressure levels may induce pain and damage to the human hearing system even though these tones are not heard. Reference 55 provides a discussion of tests and investigations conducted by many researchers (References 56, 57, 58, 59 and 54) and as a result certain tentative criteria are proposed for sound pressure levels in the subaudible range; however, it is emphasized that these are tentative. It is suggested that exposure to sound pressure levels of 150 dB without ear protection is acceptable over the frequency range of 1 to 7 Hz; exposure to 145 dB is acceptable for 8 to 11 Hz; and exposure to 140 dB is acceptable from 12 to 20 Hz. These pressure level values apply to discrete single frequencies or to octave bands centered about the stated frequencies. No single exposure should exceed 4 minutes and at least 24 hours shall elapse between two consecutive exposures.

TYPICAL TIME - INTENSITY HISTORY OF ROCKET BOOSTER NOISE

(Derived from information in Reference 60)

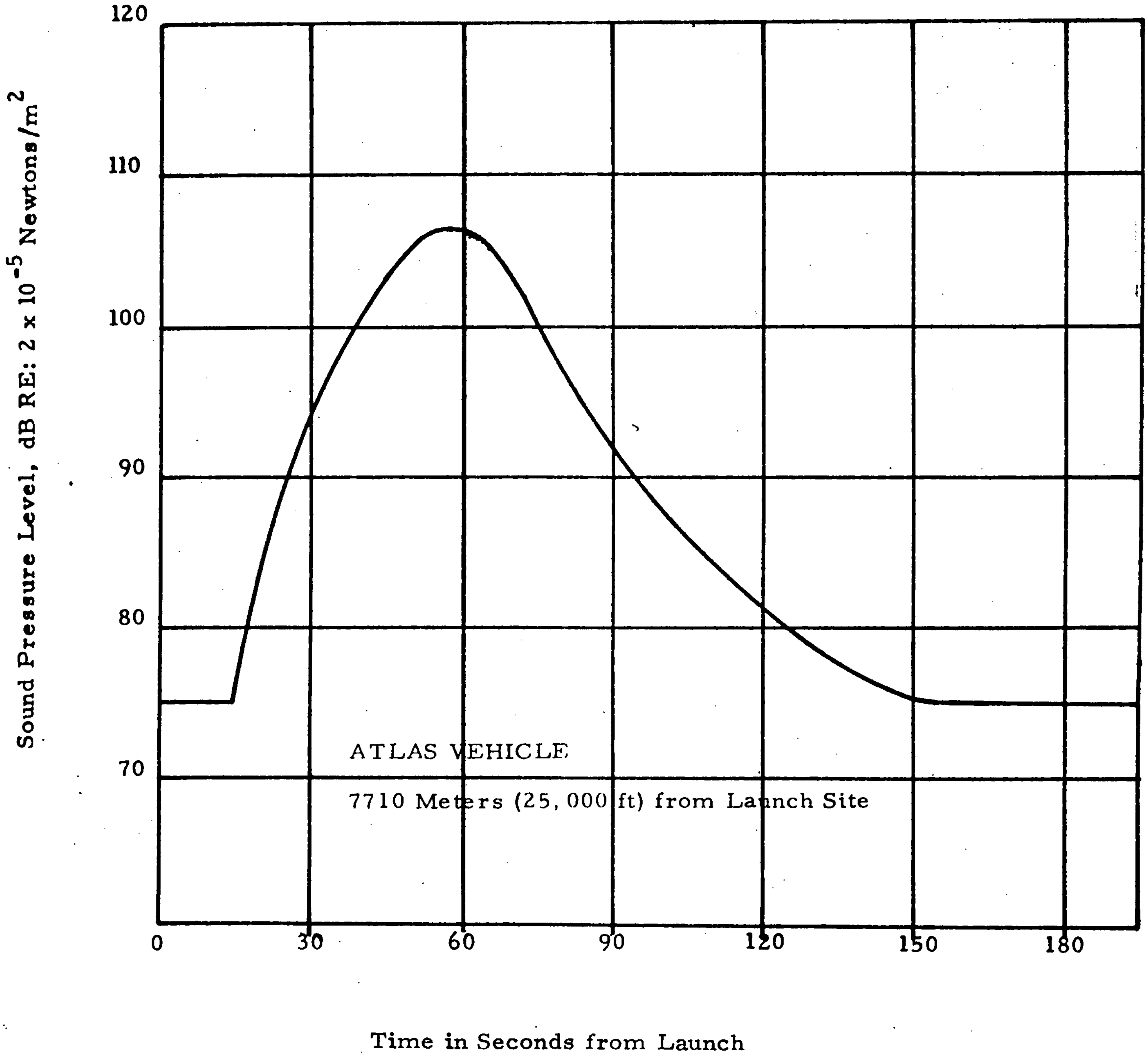


FIGURE 21

In considering these tentative criteria with respect to launch pad operations, it is evident that sound pressure levels in the above ranges occur at points very close to the launch pad - closer than personnel would be permitted to work without enclosure in substantial structures. Although these subaudible frequencies have the potential to damage the human hearing system, there is no practical hazard imposed on operating personnel because of the protection provided.

In the audible frequency range, from 20 to 100 Hz, sound pressure levels from 135 to 153 dB were judged to be tolerable in tests which are referenced and summarized in Reference 55. This frequency band has received little attention as regards to the formulation of exposure criteria, in part because it makes essentially no contribution to understanding speech signals. Based primarily on data presented in References 57 and 58, tentative criterion sound pressure level for pure tones of octave bands in the 20 to 100 Hz frequency range is set at 135 dB without protection equipment. This dB value is just below the pain threshold for exposures in the frequency range, and exposure time less than 20 minutes in a 24 hour period are specified. As applied to space vehicle launch operations, it is evident (Figure 19) that sound pressure levels above 135 dB do not extend beyond the controlled area around the launch pad and again required personnel are confined to structures which are capable of attenuating excessive sound pressure levels.

It is possible that sound pressure levels above ~100 dB in the below 20 Hz frequency range may excite vibrations in components of structures or of their fixtures and furnishings, and it is within this frequency range that acoustic energy is most hazardous to structures. It is not expected, however, that there will be enough acoustic energy (above 135 dB) to cause any structural damage beyond a radius of ~1/2 mile from where the launch of the largest vehicle will occur. All structures within this radius are in the controlled area and with appropriate structural materials and construction technique, damage of any sort has been avoided.

An investigation was conducted to assess the potential for acoustically-induced structural damage to La Purisima Mission, the only property in VAFB area listed in the National Register of Historic Places. Greater acoustical energy will reach the La Purisima Mission from launches of the Titan III D than from any other of the space launch vehicles. The separation distance between the Titan III D launch site and the mission is approximately 60,000 ft (11.5 mi); as the vehicle lifts off, the straight line distance or slant height between the vehicle and the mission increases rapidly. Figure 20 indicates the characteristic sound pressure level spectra for the Titan III D vehicle. Maximum acoustical energy is contained in the frequency range from 16 to 75 Hz and using validated conservative calculation techniques, a peak sound pressure level of 106 dB (re· 2×10^{-5} N/m^2) is predicted at the mission. This value is at least 30 dB below (more than an order of magnitude below) the sound pressure level necessary for incipient frequency induced structural damage. The negligible acoustic energy from space vehicle launches has not nor is it expected to pose a hazard to the La Purisima Mission. The Environmental Health Laboratory at McClellan AFB and the Aerospace Medical Research Laboratories at Wright-Patterson AFB were tasked to record and analyze noise and vibrational levels in occupied areas at and surrounding VAFB. The raw data confirms the above predictions; the formal reports will be available by mid-1975.

3.5.2.2 Middle Frequency Sound

Middle frequency sound is in the audible range between 100 and 6300 Hz. This band is indentified particularly because of its major importance in voice communications. For purposes of information, Figure 22 and Table 15 are included which relate quantitative criteria to qualitative experiences common to most people. Criteria established in the medium frequency range are basically for 8 hour exposure durations. These levels are considered to be compatible with retention of unimpaired hearing after exposure at work over a total period of more than 10 years.

FIGURE 22. NOISE CRITERIA CURVES

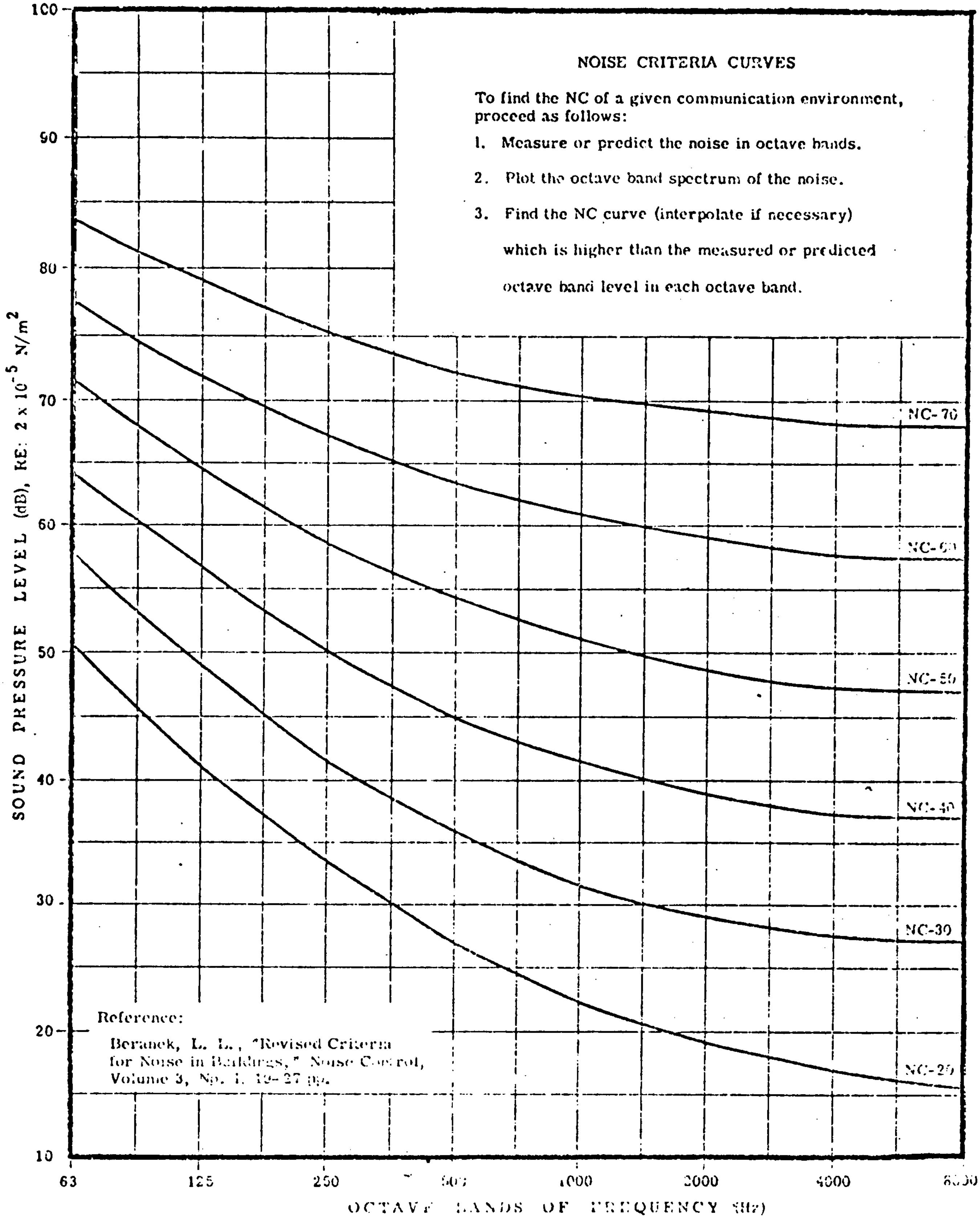


TABLE 15. NOISE CRITERIA FOR OFFICES AND WORK SPACES

Recommended Noise Criteria for Offices	Communication Environment
NC-20–NC-30	Very quiet office—telephone use satisfactory; suitable for large conferences.
NC-30–NC-35	Quiet office—satisfactory for conferences at a 15-foot table; normal voice 10–30 feet, telephone use satisfactory.
NC-35–NC-40	Satisfactory for conferences at a 6–8 foot table; telephone use satisfactory; normal voice 6–12 feet.
NC-40–NC-50	Satisfactory for conferences at a 4–5 foot table; telephone use occasionally slightly difficult; normal voice 3–6 feet; raised voice 6–12 feet.
NC-50–NC-55	Unsatisfactory for conferences of more than 2 or 3 people; telephone use slightly difficult; normal voice 1–2 feet; raised voice 3–6 feet.
Above NC-55	Very noisy office; environment unsatisfactory; telephone use difficult.
Recommended Noise Criteria for Work Spaces, Shop Areas, etc.	**Communication Environment**
NC-60–NC-70	Person-to-person communication with raised voice satisfactory 1–2 feet; slightly difficult 3–6 feet; telephone use difficult.
NC-70–NC-80	Person-to-person communication slightly difficult with raised voice 1–2 feet; slightly difficult with shouting 3–6 feet; telephone use very difficult.
Above NC-80	Person-to-person communication extremely difficult. Telephone use unsatisfactory.

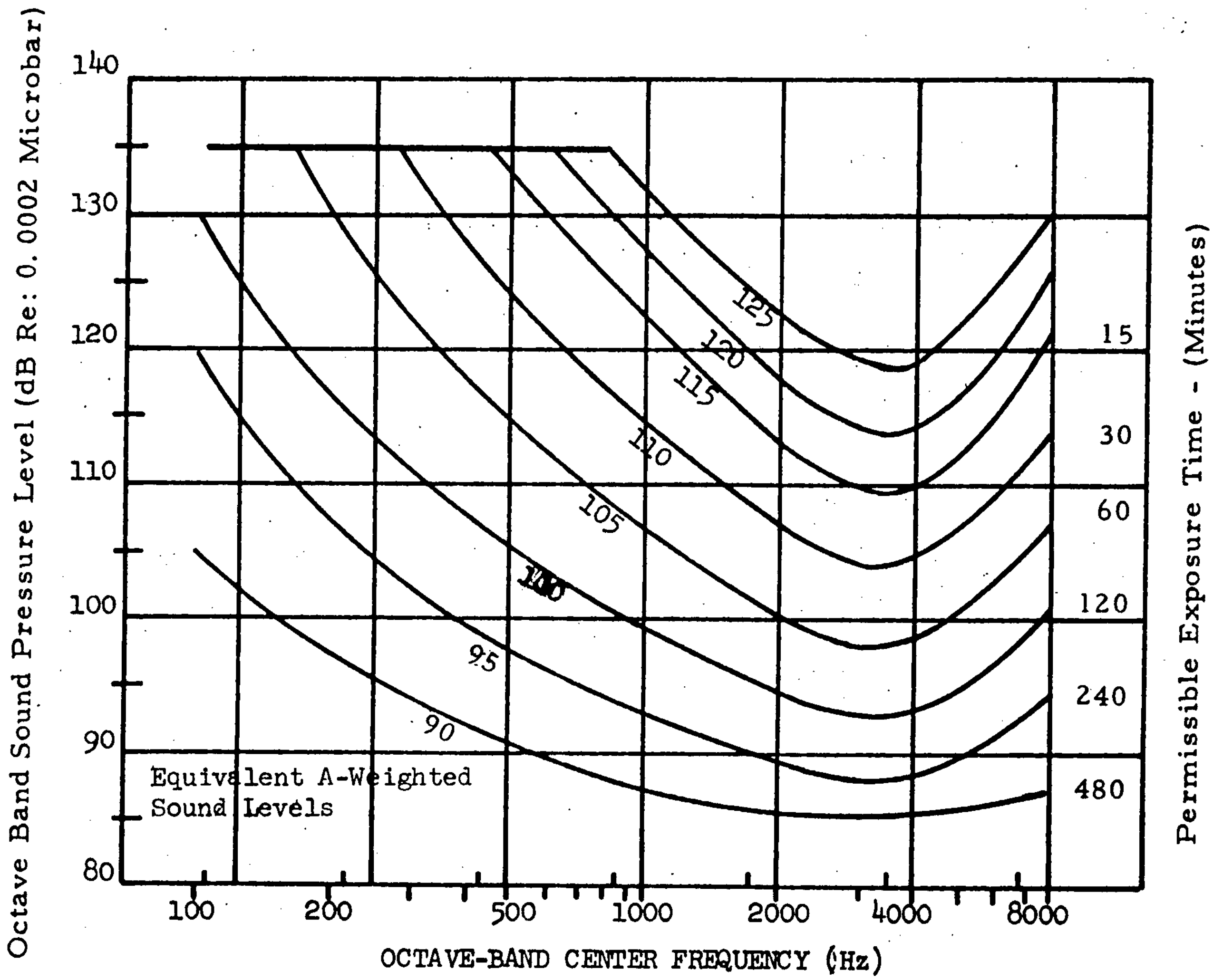
The basic criteria are further broken down to reflect the impact that exposure time has on the allowable sound pressure levels. These data from Reference 54 are presented in Figure 23.

In regard to the operations of large chemical rocket propulsion systems, the protective structures required for limiting explosive hazards tend to reduce the rocket engine sound field below the pressure levels compatible with voice communications. Since these sound pressure levels are below potential hearing impairment criteria, no risk of hearing impairment is expected for controlled personnel working either at the launch site or at engine test sites.

At the minimum distance to uncontrolled populations, the maximum, worst case sound pressure level would be about 95 dBA. This value was obtained by converting the Titan III 20,000 ft. frequency spectrum (Figure 20) to dBA using the equivalent sound level curve (Figure 23). Comprehensive noise exposure standards have not yet been published for the general populations. However, considering the maximum sound pressure levels anticipated in the uncontrolled areas and the very short exposure time (Figure 21), one can reasonably conclude that the noise generated during launch will not effect the health of the general public. The conservatism of this conclusion can be further demonstrated by comparing the maximum expected noise at 4 miles (95 dBA for about one minute) to the existing Permissible Occupational Exposure Limits, Table 13.

The intrusion of sound fields from rocket engine operations into the community environment represent an abrupt increase in sound level. The responses and reactions of the community residents either as individuals or as groups are extremely complex. In the cases of CCAFB and VAFB the communities are oriented toward and are heavily involved in the various space programs, and as a result are very tolerant. At the present time, AF-initiated methods aimed at relating community responses to effective perceived sideline noise level (EPNdB) resulting from aircraft operations has not been extended to rocket

FIGURE 23. DAMAGE RISK CONTOURS FOR DAILY EXPOSURE TO NOISE
Reference 54.



Equivalent sound level contours. Octave band sound pressure levels may be converted to the equivalent A - weighted sound level by plotting them on this graph and noting the A weighted sound level corresponding to the point of highest penetration into the sound level contours. This equivalent A-weighted sound level, which may differ from the actual A weighted sound level of the noise, is used to determine exposure limits.

launch base operations for the reason noted above.

3.5.2.3 High Frequency Sound

The high frequency sound region encompasses 6300 to 20,000 Hz. Although this range is still in the audible region, the perception of many people is very low and there are no communication criteria for this part of the spectrum because its contribution to understanding speech signals is negligible. Similarly, the contribution of these frequencies to hearing damage is of little importance because these frequencies are rapidly attenuated as distances increase from the sound source. With the separation distances existing at space vehicle launch and engine test sites, sound in the high frequency range has no practical significance in the surrounding community areas. No criteria appear to be required for this spectrum range and none have been developed.

3.5.2.4 Ultrasonic Sound

The sounds of this frequency range are above 20,000 Hz and are beyond the frequency detectable by the human ear. In addition, these frequencies are strongly attenuated on propogation through air and by construction materials so that no significant levels extend into outside communities. Although it is known that rocket engines contain frequencies in the ultrasonic range there appears to be no need for criteria pertaining to their effects on man.

3.5.2.5 Sonic Booms

3.5.2.5.1 Source and Nature

As any body moves through the air, the air must part to make way for that body and then close itself once the body has passed. In subsonic flight, pressure signals (precursor waves which travel at the speed of sound) move ahead of the body to forewarn of its approach and the parting of the air and the passage of the body is a smooth process. In supersonic flight, precursor waves cannot precede the body; the parting process is abrupt. A bow shock wave parts the air which expands as it passes around the body and then a trailing shock wave recompresses the air as it closes behind the body.

These waves travel through the atmosphere as pressure waves and, because of the abrupt noise they generate when passing an observer, are called sonic booms. This general pattern of bow shock wave, expansion region, and recompression shock is idealized as the N-wave signature commonly associated with the sonic boom. The phenomenon occurs for all supersonic flights (See Figure 24 for further nomenclature).

3.5.2.5.2 Impact on the Environment

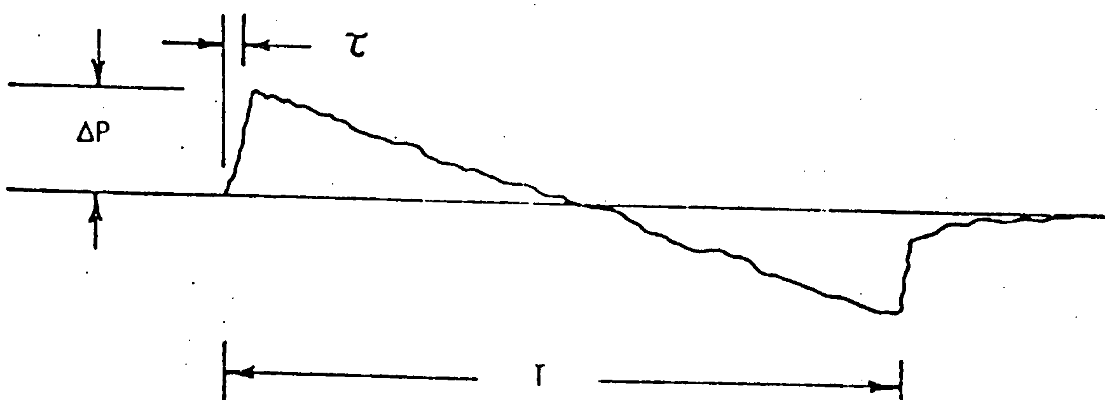
The abruptness of the pressure changes is responsible for much of the concern about sonic booms. It gives the startling audibility and dynamic pressure characteristics of an explosion. In some cases of aircraft flight, even at great distances from the supersonic field where pressure levels produced are physically harmless, some public complaints are received.

The characteristics of the shock pattern and its source are influenced by flight path characteristics, i.e., altitude, speed, angle of attack, flight path curvature, and accelerations either along or transverse to the flight path -- and body characteristics such as bluntness, weight, exhaust plume characteristics and volume. The pressure signature that reaches the surface of the earth is subject to the additional factors of air turbulence, winds, and temperature variations of the atmosphere traversed by the pressure wave in addition to certain of the flight path characteristics.

The ascent phase will create the largest sonic booms of a mission as the result of two distinct effects; first, the overpressure that will be experienced over the ocean during supersonic ascent will be increased by the rocket exhaust plume which increases the effective size of the vehicle. NASA tests indicate that the overpressures may be as much as double those of the vehicle alone. The second effect is that of focusing caused by the pitchover maneuvers necessary for a vehicle to achieve orbit. Focusing results from the accumulation and reinforcement of the pressure waves in a limited region. The overpressures in the focal zone will be limited to a

CLASSIC N WAVE ILLUSTRATION

The sonic boom disturbance, generated by the traverse of the shock wave created by supersonic flight across the surface of the ground, may be represented by the classical N wave as illustrated below.



Four parameters describe the N wave - rise time, τ; overpressure ΔP; period, T; and the impulse under the wave. These parameters, in turn, influence the reaction of people and structures to the disturbance. The characteristics of the N wave are a function of the aircraft (weight, shape, lift and volume), its operational characteristics (velocity, altitude, flight path angle, etc.) and the atmosphere through which it propagates (turbulence, temperature, winds, etc.). The near field disturbance for aircraft has a more complex shape caused by secondary shocks. As these disturbances propagate away from the source, however, the disturbance tends toward the classical N wave distribution.

FIGURE 24

very narrow margin at the ground track and the sonic boom will not be heard at the launch area. As far as is known, the focused ascent sonic boom appears anavoidable.

During descent of the spent sub-orbital booster stages and during the random reentry of spent orbital stages sonic booms also will occur. The overpressures resulting from these reentries will be small compared to the ascent boom.

In the history of the USAF space launch vehicle operations there have been no problems reported as a result of sonic booms. This is undoubtedly due to the fact that the ascent track of all of the vehicles is over open ocean and the planned reentry of spent suborbital stages is also over open seas, thus placing sonic booms away from land areas where they can be experienced. Shipping in the area likely to be affected is warned of the impending launches as a matter of routine and the occurrence of the sonic boom, if it is observed at all, is expected and of no practical consequence.

3.5.3 Summary

In controlled areas, personnel and structures are protected from acoustical damage in two ways: first, structures are designed to withstand the sound pressure levels expected as a result of rocket engine operation. Second, personnel are afforded protection from ear damage by the attenuation of sound achieved by the structures which house them or by the use of ear protection devices suitable for the environment.

For uncontrolled areas beyond the borders of the launch bases the maximum overall sound pressure levels are below 115 db (re: 2×10^{-5} N/m^2); both man and structures are safe in this sound field for time periods typical of launch operations. This criteria has evolved from operations of space launch vehicles and represents an overall sound pressure level acceptance by personnel and communities involved. No personal injury or structural damage in uncontrolled areas is anticipated.

Sonic booms caused by the USAF space launch vehicle programs, because they occur over ocean areas, pose no environmental problems.

4. ALTERNATIVES

The USAF family of space launch vehicles is beyond the development and test phase and, therefore, the major potential for environmental impacts is the result of actual launch of the vehicles. The primary areas of concern are the release of HCl into the atmosphere as a result of burning solid rocket motors on the Titan III C and D and the possible pollution of water as the result of residual propellants in jettisoned stages. Alternatives which have been considered are summarized in Table 16. The use of scrubbers to attempt to wash out HCl emissions from the solid rocket motors during launch is practical for only the first few feet of flight. Beyond that, the exhaust plume spews into the atmosphere and scrubbers would be ineffective. At a high cost it would be possible to provide scrubbers for full scale solid rocket motor firings. However, the development phase of the Titan III C and D is past and no further full scale solid rocket motor firings are required at the present time. There is no requirement for scrubbers in connection with the routine production testing of the liquid propellant engines used in the Titan III or Atlas families because the exhaust products cause no significant environmental impacts. Collectors are already provided to contain any liquid spills resulting from propellant handling accidents.

The use of more remote sites has also been considered. Present locations of launch and test operations are sufficiently remote as to pose no significant hazards to uncontrolled persons or property. While it is conceivable that even more remote locations could be found, such as mid-ocean islands, the effect on logistics to support the operational program would be extremely expensive. These added operating costs would be in addition to the substantial sums of money necessary to duplicate facilities existing at present test and launch operational sites.

The current solid propellants used for the Titan III C and D and Scout vehicles have been formulated to provide a high specific

TABLE 16. MATRIX OF ALTERNATIVES

Activity \ Alternative	Use of Scrubbers, Collectors, etc.	Use of Remote Sites	Development of "Clean" Solid Propellants	Replacement of All Solid Propellant and N_2O_4/A-50 Stages by LOX/Kerosene Stages	Replacement of All Solid Propellant and N_2O_4/A-50 Stages by LOX/LH_2 Stages
Research, Development and Ground Test	Potential for elimination of some objectionable emissions	Already reasonably remote. No significant problems present	Reduction or elimination of HCl emissions	Elimination of HCl emissions. Possible reduction of NO emissions. Increased CO, CO_2 and H_2O emissions.	Elimination of most objectionable emissions. Increases H_2O emissions. Effect on NO emission uncertain.
Launch	Practical only for first few feet of flight.	Already reasonably remote. Few alternative sites available. No significant problems at CCAFS, manageable at VAFB.	Reduction or elimination of HCl emissions	Elimination of HCl emissions. Possible reduction of NO emissions. Increased CO, CO_2 emissions.	Elimination of most objectionable emissions. Increases H_2O emissions. Effect on NO emission uncertain.
Comment	Increased development and operational expense. Minor overall reduction in emissions.	Extremely expensive Duplication of launch complexes required.	No formulations known with handling characteristics and performance comparable to current solid propellants. Would require motors of increased size and possibly increased objectionable emissions other than HCl.	Non-recurring expense of perhaps \$300M-500M. Some recurring cost increase. Changes character of emissions.	Non-recurring expense of perhaps \$1,000M. Recurring cost increase by factor of, perhaps 2 or more.

NOTE: The alternative of not launching was considered. However, the launch vehicles exist only to provide the means for orbiting space packages to achieve priority scientific or defense objectives. There is no other way to launch these payloads.

impulse, and the vehicles have been tailored to the performance potential of the SRMS. The search for solid propellants which will not emit toxic materials has not been entirely beneficial. Double base solid propellants are known which would not emit HCl, but which have a handling characteristic - that of being shock-detonatable - which is unacceptable for launch operations. Other formulations, also free of HCl, exhibit specific impulses substantially below that required for the present Titan III C and D and Scout vehicles. Use of such lower energy propellants would result in the requirement for much larger solid stages and at this point would represent a completely new and expensive development program. The possibility exists that the elimination of HCl could result in increased emissions of other materials (such as oxides of nitrogen) which are equally objectionable.

Elimination of solid propellant stages from the Titan III family or Scout would require an entirely new development and manufacturing program which would incur considerable costs. If a stage using liquid oxygen/kerosene propellants were substituted for the solids, increased emissions of CO and CO_2 and H_2O would result and the problem of residual propellants falling into the sea as a result of jettisoned stages would not be improved. Were an LO_2/LH_2 stage substituted, there would be substantially greater emissions of water vapor which very probably would not be objectionable, but major new development and manufacturing programs would be required and complexity would be added to the launch operations because of the cryogenic propellants. The major factor, however, would be that of costs.

None of the alternatives discussed above could be implemented in a time period less than 5 years. The adoption of any of the alternatives would have only a minor effect on the total environmental spectrum, would involve very significant expense and have significant effects on spacecraft payloads and delivery capabilities. In view of the very limited environmental impact of the current USAF family of space launch vehicles, no further consideration of alternatives is recommended.

Each of the USAF family of space launch vehicles is a space transportation system. The justification for developing each one was the requirement to deliver specific payloads to orbit. These payloads have been justified on the basis of their scientific and/or defense necessity and each has been approved specifically at high levels in the Government. Since these already operating payload programs require a specific space launch vehicle in order to perform their missions, the alternative of abandoning operation of the USAF family of space launch vehicles in not available.

5. RELATIONSHIP BETWEEN LOCAL SHORT TERM USE OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

In the preceding sections, it has been demonstrated that while the USAF family of space launch vehicles has the potential for impacting man's environment, these effects are minor, infrequent, transient and non-persistent. There are expected to be no long term detectable effects from the operation of any of the Titan III, Atlas or Scout vehicles.

The operation of a space transportation system by itself does not necessarily lead to any benefits for mankind. However, each of the vehicles does insert important scientific and defense payloads into orbit. The gains to man's total knowledge from these payloads with respect to his environment on earth and in space and to his well being are significant. Each of the USAF family of space launch vehicles is part of the systems which make these gains possible. On balance, it is believed that the benefits derived from the systems employing USAF space launch vehicles substantially outweigh the short term non-persistent impacts on the environment.

6. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES BY USAF SPACE LAUNCH VEHICLES

In a practical sense all of the committed resources represented by the USAF family of space launch vehicles are irreversible and irretrievable with launch. However, the materials other than the propellants, represent a relatively few number of pounds of metals and plastics. A very few automobiles would equal the unfueled vehicle weight of a Titan vehicle, for example. Of this hardware, the materials are easily replaceable from domestic sources with relatively small expenditures of manpower and energy.

By far the largest weight of materials making up a launch vehicle are the propellants. These are common chemicals derived by processes that are not unique to the space program. The resources and energy required for the production are nominal and quite insignificant compared to the resources and energy required, say, to produce one million barrels of jet fuel per week to satisfy the current jet aircraft requirements for private, commercial and military needs. To further put the use of propellants into perspective, it is interesting to note that the heat release of the solid rocket motors on a Titan III C or D is at the rate of less than 3×10^7 BTU per second. This may be compared to the average consumption of fossil fuels for electric power generation in the United States of approximately 4×10^8 BTU per second. Not only is the energy release of the Titan vehicle more than an order of magnitude below that for electric power generation, the energy release for the zero stage occurs for only 2 minutes, 8 or 9 times a year, while the consumption of fossil fuel for power generation continues on an uninterrupted basis.

Operation of the USAF family of space launch vehicles require commitment of certain lands for launch, manufacturing, test and launch sites; these commitments are not different from those necessary for many other research and industrial operations. None of the activities performed in connection with manufacture, test and launch of the USAF space launch vehicles result in persistent disruptions to the environment nor to curtailment of future beneficial use of land areas involved.

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APPENDIX A

COMMENTS FROM THE
UNITED STATES DEPARTMENT OF THE INTERIOR

Note: Responses to comments have been included in this Final Environmental Statement on pages indicated inside parentheses.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

In Reply Refer To:
POR (ER-73/1205)

NOV 7 1973

Dear Dr. Welch:

This is in response to your letter of August 23, 1973, requesting our comments on Department of the Air Force draft environmental statement U. S. Air Force Space Launch Vehicles, Florida and California.

The draft statement evidences consideration of the possible major environmental impacts that may result from launching space vehicles. The following comments are offered in terms of contributing to the statement's quality and completeness.

The major action covered by this statement is the launching of Titan III, Atlas, and Scout space vehicles. The effect of this action on public recreation activities and facilities is not specifically discussed in the statement. We feel that the statement would be improved by the addition of a discussion of the recreation resources at each of the involved areas, and the possible impacts of the action thereon. If such a discussion identified, quantified, and adequately described both the resources and possible impacts it would be most helpful. (pp. 23 and 29)

An appraisal of possible adverse impact on water resources in the launch pad areas should be, but is not, included in the statement. There is no description of the geology underlying the areas or of the related geohydrologic conditions. Detail similar to that relating to propellants entering the oceans should also be given for the possibility and prevention of groundwater contamination. (pp. 17, 24 and 72)

No mention of the propellant disposal sites is made. Further, on page 59 it is stated that "Contaminated water is suitably treated before release." How is it treated? Where is it released? We also suggest that some attention be given to secondary but significant hydrologic effects which may result from the impact of increased population in support of the total space effort in the general area. (pp. 32 and 72)

The statement on page 34, that "The criteria for man is used as a guide to safeguarding the total environment," appears much too broad.

Lower forms of life are often adversely affected at pollutant levels below those which directly affect higher forms of life or man and they are, therefore, used as biological indicators. Destruction of lower forms of life can have an adverse aesthetic effect or can interfere with the food chain on which higher forms of life depend. Lichens and bryophytes, for example, can be adversely affected by SO_2 concentrations as low as 0.02 ppm. The HCl fallout from the launchings could have a similar effect. (p. A-5)

We feel, therefore, that a comprehensive, continuous, chemical and biological monitoring program should be conducted in conjunction with the space launch activity. The monitoring program should include the identification and level determination of inorganic and organic constituents in the nearby waterways, as well as the identification and characterization of aquatic and terrestrial plant life, and fish and wildlife in the area. In this way, it would be possible to detect incipient changes in the environment that might be attributed to either the normal launching activity or to experimental rocket firings which generate different combustion products. (p. A-7)

The proposed action would not directly affect any existing, proposed or known potential units of the National Park System, nor any National Historic, Natural, or Environmental Education Landmarks. However, the proposed action could indirectly have an adverse effect on La Purisima Mission, a property listed on the National Register of Historic Places, located 4 miles east of the City of Lompoc. It is possible that noise emissions from the space vehicle launchings at Vandenburg Air Force Base could cause structural damage to the mission buildings. This possibility should be investigated and the findings included in the final environmental statement. This investigation should include consultation with the Advisory Council on Historic Preservation to determine if Section 106 of the National Historic Preservation Act of 1966 is applicable. (p. 95)

The statement is inadequate in not indicating the presence or absence of properties either listed on or in the process of nomination to the National Register of Historic Places. This should be accomplished by consulting the National Register of Historic Places, published monthly and updated annually in the Federal Register, and through consultation with the appropriate State Historic Preservation Officers (Director, Department of Parks and Recreation, 1416 Ninth Street, Room 1311, Sacramento, California 95814; and Director, Division of Archives, History, and Records Management, Department of State, 401 East Gaines Street, Tallahassee, Florida 32034). (pp. 23 and 29)

By providing substantive information regarding the project's impact upon historical resources, the decisionmakers will be afforded the opportunity to fully assess project impacts upon those resources.

We appreciate the opportunity to review and comment on this statement.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Dr. Billy E. Welch
Special Assistant for
Environmental Quality
Department of the Air Force
Washington, D. C. 20330

A.1 Response to Department of the Interior Letter, Paragraph 6.

The Department of the Interior, U.S. Department of Agriculture, and Resources Agency of California listed similar comments in that they cited the need for additional information about the effects that exhausted chemicals can have in vegetation, fish and wildlife. The relatively large amount of hydrogen chloride (HCl) that is generated and its high toxicity make it the prime exhaust gas constituent of concern. An insight into the problem can be gained by review of a National Academy of Sciences, National Research Council document, Aug 71, entitled "Recommended Guides for Short Term Exposures of the Public to Air Pollutants: Guide for HCl" (Reference 12). Effects upon animals can be summarized in the following table:

EFFECTS OF HCl ON ANIMALS

Species	Concentration	Time	Effects
Rabbits, guinea pigs and one monkey	30 ppm	6 hr/day 5 days/wk 4 weeks	none
Rabbits	30 ppm 60 ppm	10 min 5 min	ciliary activity ceased, no recovery
Rabbits, guinea pigs	70 ppm	5 days 6 hr ea.	no effects
Cats, rabbits	100-140 ppm	up to 6 hr	runny nose, salivation, no sequale
Rabbits, guinea pigs	300 ppm	6 hr	catarrh and cloudy cornea
Rabbits, guinea pigs	700 ppm	6 hr	100% fatal
Rabbits, guinea pigs	1350 ppm	75 min	Strong respirtory irritation and distress. Corneal opacity
Rabbits, guinea pigs	3400 ppm	90 min	Fatalities 2-6 day post exposure
Rabbits, guinea pigs	3700 ppm	5 min	No deaths
Rabbits, guinea pigs	4300 ppm	30 min	100% fatal
Rabbits, guinea pigs	30-400 ppm	3.2-0.5 min	Reversible ciliary inhibition.

It is evident that potential hazard to animals (wildlife) could exist only in the immediate area of the launch facility and that exposure guides for humans is much lower than the levels indicated in the above table as necessary to affect animals. Similarly, the same document addresses phytotoxicity and states that "hydrogen chloride has been reported to be of only minor concern as a phytotoxicity air pollutant", and that "In comparison to some of the other phytotoxic air pollutants, HCl has a relatively low order of hazard to plants". The threshold of injury for HCl is apparently 7-15 mg/m^3 (5-10 ppm) if continued for a few hours.

Levels of 0.06 mg/m^3 (0.03 ppm) ozone for four hours, 0.07 mg/m^3 (0.01 ppm) hydrogen flouride for two hours, and 0.06 mg/m^3 (0.05 ppm) ethylene for six hours are the injury thresholds for some other phytotoxic air pollutants. Viburnum and larch seedlings were killed in less than two days by exposure to HCl at 7-30mg/m^3 (5-20 ppm). Local lesions were observed on fir, beech, and oak after exposure for one hour at 1500 mg/m^3 (1000 ppm) HCl. Exposure of maple, birch and pear trees for one hr/day for 80 days to 3000 mg/m^3 (2000 ppm) produced necrosis along the leaf margins. Shriner and Lacasse exposed 38-day old tomato plants to HCl for two hours at 7 mg/m^3 (5 ppm) and observed leaf necrosis within 72 hours of the exposure. Thus, comparison of the concentrations of HCl expected to cause damage to vegetation and the criteria for man (Table 4 of statement) indicates that the criteria for exposure of man is the most strict. Comparison of toxicity data for animals (above) with the Short-term Public Limits (STPIs) also indicates that the STPLs are the most strict. Thus, the statement that "The criteria for man is used as a guide to safeguarding the total environment" does not seem too broad. The USAF does realize that data based upon the specific vegetation and wildlife common to the area surrounding Vandenberg AFB is desirable, especially in light of larger future programs such as the Space Shuttle. The Aerospace Medical Division (AMD), Brooks AFB, TX presently has a contract with the University of California at Riverside to better define areas needing further study. Accordingly, the comments from the Dept of Interior, U.S. Dept of Agriculture, and the Resources Agency of California concerning vegetation and wildlife have been forwarded to AMD for their consideration under the contract.

A. 2 Response to Department of the Interior Letter, Paragraph 7.

A comprehensive, continuous chemical monitoring program is being continued by the SAMTEC Technical Director's Office. The biological monitoring program suggested is far beyond SAMTEC's capability.

APPENDIX B

COMMENTS FROM THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Note: Responses to comments have been included in this Final Environmental Statement on pages indicated inside parentheses.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 12 1973

OFFICE OF THE ADMINISTRATOR

Colonel Herbert E. Bell
Headquarters USAF/PREV
Washington, D.C. 20330

Dear Colonel Bell:

The Environmental Protection Agency (EPA) has reviewed the draft environmental impact statement (EIS), "United States Air Force Space Launch Vehicles."

We concur with the general conclusions expressed in the draft statement that the Space Launch Vehicle programs can be conducted without undue risks to human populations. It is believed that the major environmental impacts will occur in the areas of air and noise pollution, however, we expect these impacts to be of relatively short duration.

Detailed comments on the draft statement and suggestions for additional items to be addressed in the final statement are enclosed (Attachment 1).

We have assigned the rating of LO-2 to this review: "Lack of Objections" to the action, and "Insufficient Information" in the draft EIS. An explanation of EPA's rating system is attached (Attachment 2).

We would appreciate the opportunity to review the final EIS prepared on this action.

Sincerely yours,

Rebecca W. Hanmer

for Sheldon Meyers
Director
Office of Federal Activities

Enclosures

Air Quality Aspects

In general, the air quality considerations of the Space Launch Vehicle program as presented in the draft impact statement is considered adequate. Provided that the launches do not occur during periods of rain or air stagnation, the emission of various air pollutants in the quantities and locations specified in the draft statement should not create any significant long-term air quality deterioration. The following comments and/or requests, however, seem to be appropriate.

1. Footnote (a) on page 27 of this statement and the Occupational Safety and Health Standards (page 22141, Federal Register, Vol. 37, No. 202, Part 2, 10/18/72) state that HCL is a species which has a ceiling value for occupational exposures which is not to be exceeded for short periods of time. Therefore, the concept of Emergency Limits as expressed in this statement seems inconsistent with the concept of a ceiling value for exposure to this compound. (p. B-7)

2. A separate impact statement should be prepared for any launch vehicle payload which contains radioactive

materials or has a significant environmental impact not previously discussed. (p. 34)

3. We encourage the continuation of air quality monitoring program to insure that unexpected adverse environmental impacts do not go undetected. (p. A-7)

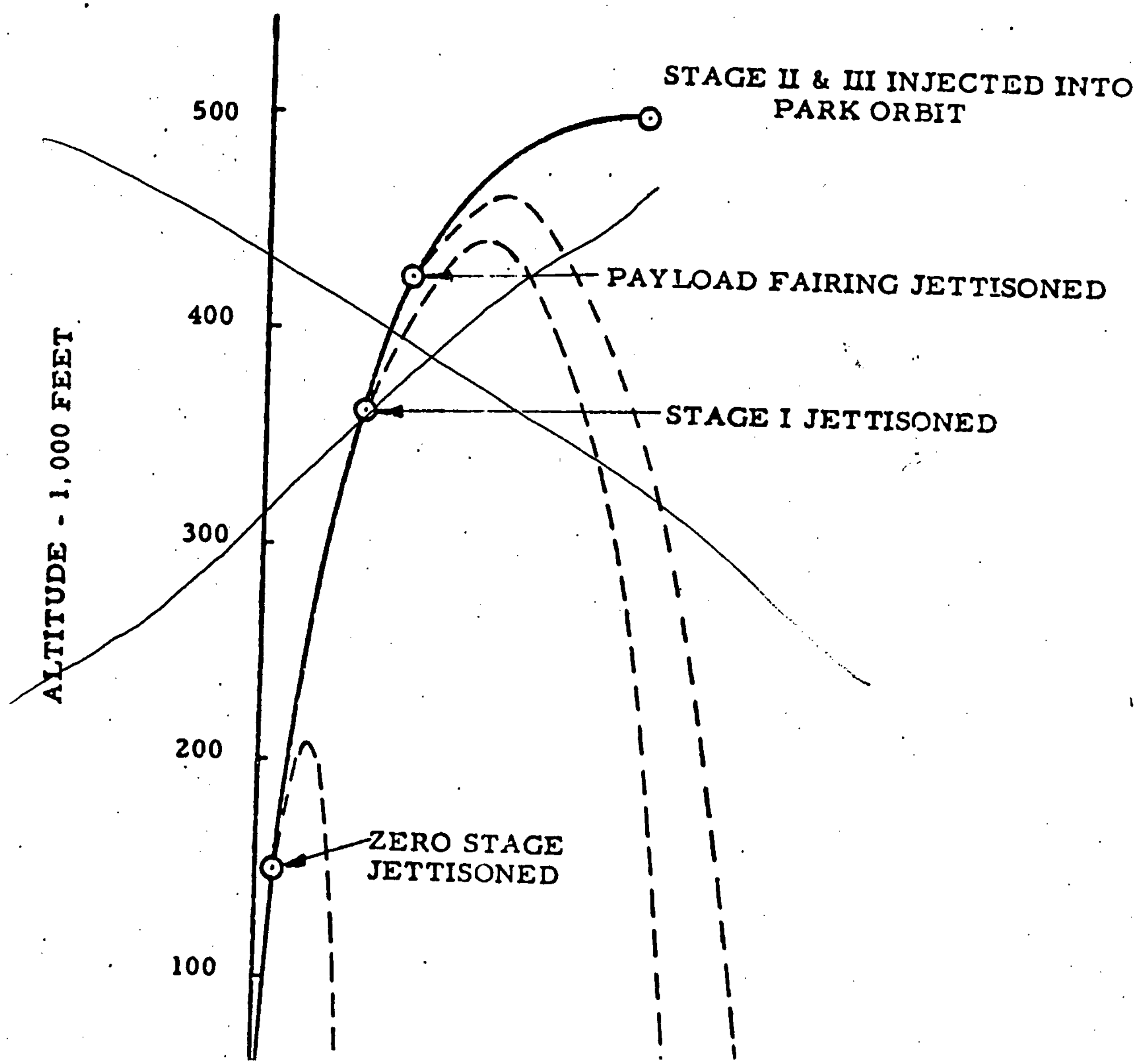
Water Quality Aspects

We believe the water quality aspects of the launch vehicle program have been adequately discussed.

Solid Waste Aspects

The EIS does not indicate whether any toxic or hazardous substances are formed or present during or after launch, under normal or abort conditions, which would require disposal. If none is formed or present, a statement to that effect should be made in an appropriate section of the EIS. If some are formed or present, the EIS should include the identification of these substances, a description of how they are to be handled or disposed of, and a statement of any expected impact on the environment resulting from the method of disposal used.

FIGURE G-2. TITAN III C TRAJECTORY FLIGHT PLAN VII
LIFTOFF TO PARK ORBIT INJECT



While the EIS does include information on the formation of toxic substances which enter the air and water environments during launch operations, it does not cover the matter of toxic/hazardous wastes which would require post-launch handling, treatment or disposal. (pp. 72 and 73)

Noise Aspects

1. The estimated information given in Table 12 and figure 19 concerning maximum sound pressure levels and duration of launches should be substantiated by actual measurement data. A noise monitoring program for all launches should be developed as standard procedure to accumulate more realistic data for community exposure assessments. Furthermore, it is not explicit whether the data presented in Figure 20 has been estimated or whether it is actual measured data. This should be expanded for evaluation in the final EIS. (pp. 90 and 95)

2. Discussion concerning the protection of personnel outside the controlled area of approximately 1/2 mile radius but within the bases should be included. (pp. 89 and 90)

3. Due to high sound pressure levels involved, communities much farther from the test sites (10-15 miles) than those shown in the area maps might be affected. It is suggested that the effects of noise be considered for more distant communities. (p. 89)

4. The assessment of the potential noise problem is addressed primarily to hearing losses. Additional consideration to other aspects such as health and welfare effects of the communities should be included in more detail. (pp. 89 and 90)

B.1 Response to U.S. Environmental Protection Agency Comment 1.

This office concurs with the U.S. Environmental Protection Agency comment on HCl that "the concept of Emergency Limits--- seems inconsistent with the concept of a ceiling value for exposure to this compound"; however, we take exception to the ceiling value assigned to HCl. Other references cited by the statement recognize short term exposures to levels greater than the 5 ppm TLV ceiling value for both the controlled (occupational) and uncontrolled populations. Documentation in the cited references show that no adverse effects would accrue the populations thus exposed. It is also pointed out that the TLVs are applicable to the occupationally exposed personnel who are supposedly healthly and free of asthmatics or others with respiratory problems. Further, they can be exposed to the TLV for 7 or 8 hours per day, 40 hours per week, for their working life with no adverse effects to be expected. The possibility of asthmaties, those with other respiratory problems, and infants being in the uncontrolled population accounts for the lower Short Term Public Limits (STPL) and Public Exposure Limits (PEL). It is reiterated that the short term, localized, non-persistent exposure to NCl concentrations above criteria level may be possible in the controlled area for Titan III C and Titan III D launches, however, it is anticipated that the public emergency limit criteria of 7 ppm of HCl for 10 minutes will not be exceeded. It has always been the philosophy and the practice of the USAF to keep exposures of all toxic chemicals to the lowest possible level consistent with mission objectives.

APPENDIX C

COMMENTS FROM THE
ADVISORY COUNCIL
ON
HISTORIC PRESERVATION

(IN LETTER DATED DECEMBER 10, 1973)

Note: Responses to comments have been included in this Final Environmental Statement on pages indicated inside parentheses.

ADVISORY COUNCIL
ON
HISTORIC PRESERVATION
WASHINGTON, D.C. 20240

DEC 1 0 1973

Mr. Harvey L. Segal, Acting Chief
Environmental Protection Group
Directorate of Civil Engineering
Department of the Air Force
Headquarters U.S. Air Force
Washington, D.C. 20330

Dear Mr. Segal:

This is in response to your request of October 31, 1973, for comments on the environmental statement for United States Air Force Space Launch Vehicles, August, 1973. Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Act of 1969, the Advisory Council on Historic Preservation has determined that your draft environmental statement is inadequate regarding our area of expertise as it does not contain sufficient information to enable the Council to comment substantively. Please furnish additional data indicating:

1. Compliance with Section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. 470[f]). The Council must have evidence that the most recent listing of the National Register of Historic Places has been consulted (see Federal Register, February 28, 1973, and monthly supplements each first Tuesday thereafter) and that either of the following conditions is satisfied:

   a. If no National Register property is affected by the project, a section detailing this determination must appear in the environmental statement. (pp. 23, 29 and 95)

   b. If a National Register property is affected by the project, the environmental statement must contain an account of steps taken in compliance with Section 106 and a comprehensive discussion of the contemplated effects on the National Register property. (Procedures for compliance with Section 106 are detailed in the Federal Register of November 14, 1972, pp. 24146-24148. Copy enclosed.)

2. Compliance with Executive Order 11593 of May 13, 1971.

   a. In the case of land under the control or jurisdiction of the Federal Government, a statement should be made as to whether or not the proposed undertaking will result in the transfer, sale, demolition, or substantial alteration of potential National Register properties. If such is the case, the nature of the effect should be clearly indicated.

b. In the case of lands not under the control or jurisdiction of the Federal Government, a statement should be made as to whether or not the proposed undertaking will contribute to the preservation and enhancement of non-federally owned districts, sites, buildings, structures, and objects of historical, archeological, architectural, or cultural significance.

To insure a comprehensive review of historical, cultural, archeological, and architectural resources, the Advisory Council suggests that the environmental statement contain evidence of contact with the appropriate State Historic Preservation Officers and that a copy of their comments concerning the effects of the undertaking upon these resources be included in the environmental statement. The State Historic Preservation Officer for California is William Penn Mott, Jr., Director, Department of Parks and Recreation, State Resources Agency, P. O. Box 2390, Sacramento, California 95811. The Florida State Historic Preservation Officer is Robert Williams, Director, Division of Archives, History and Records Management, Department of State, 401 East Gaines Street, Tallahassee, Florida 32304.

Should you have any questions or require any additional assistance, please contact Louis S. Wall of the Advisory Council staff.

Sincerely yours,

Ann Smith

Ann Webster Smith
Director, Office of Compliance

Enclosure

APPENDIX D

COMMENTS FROM THE UNITED STATES DEPARTMENT OF AGRICULTURE

(IN LETTER DATED SEPTEMBER 6, 1973)

Note: Responses to comments have been included in this Final Environmental Statement on pages indicated inside parentheses.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D.C. 20250

September 6, 1973

Subject: Draft Environmental Statement - United States Air Force Space Launch Vehicles

To: Billy E. Welch
Special Assistant for
Environmental Quality
HQ, USAF/PREV
Washington, D.C. 20330

The Agricultural Research Service has reviewed the subject draft environmental statement. It is noted that any potential hazards from HCl are evaluated on the basis of its effect on humans. No evaluation appears as to the possible effect of HCl on vegetation. Some plants are very susceptible to small amounts of HCl in the atmosphere. Tomato plants, for example, can be seriously injured when exposed to as little as 5 ppm HCl for 2 hours.

We feel the report should include an evaluation of the effect that the exhausted chemicals will have on vegetation. (p. A-5)

H. L. Barrows
Staff Scientist
National Program Staff

APPENDIX E

COMMENTS FROM THE RESOURCES AGENCY OF CALIFORNIA

(IN LETTER DATED JANUARY 11, 1974)

Note: Responses to comments have been included in this Final Environmental Statement on pages indicated inside parentheses.

THE RESOURCES AGENCY OF CALIFORNIA

SACRAMENTO, CALIFORNIA

United States Department
of the Air Force SAF/ILE
Washington, DC 20330

Attention: Dr. Billy E. Welch

Gentlemen:

The State of California has reviewed the Draft Environmental Statement on "United States Air Force Space Launch Vehicles", dated August 1973, which was submitted to the Office of Intergovernmental Management (State Clearinghouse) within the Governor's Office. The review accomplished by the State fulfills the requirements under Part II of the U. S. Office of Management and Budget Circular A-95 and the National Environmental Policy Act of 1969.

The Statement was reviewed by the State Departments of Fish and Game, Navigation and Ocean Development, Parks and Recreation, Food and Agriculture, Health, Transportation, and Water Resources; the State Water Resources Control Board; the Air Resources Board; and the Solid Waste Management Board.

The State's comments are as follows:

1. The Statement is deficient in its treatment of the possible impacts of this project on the fish and wildlife resources in the area. This Statement is probably the forerunner of many environmental statements that will be required as a result of the participation of Vandenberg Air Force Base in the Space Shuttle Program. For this reason, we recommend that the services of a qualified biologist be obtained to determine the effects of such projects on the fish and wildlife. (p. A -5)

2. La Purisima Mission, a National Historic Landmark located 4 miles east of the City of Lompoc has been afforded full protection under the National Historic Preservation Act of 1966. Because this landmark is located in the vicinity of Vandenberg Air Force Base, the sponsor should determine if the mission would experience any visual, physical, esthetic, or peripheral effects in compliance with Section 106 of the Act and Executive Order No. 11593. In particular, the sponsor should determine if the mission would be affected by vibrations caused by launching operations. (p. 95)

Thank you for the opportunity to review this Statement.

Sincerely yours,

N. B. LIVERMORE, JR.
Secretary for Resources

By______________________________

cc: Mr. Mark Briggs
Director of Management Systems
State Clearinghouse
Office of Planning and Research
1400 Tenth Street
Sacramento, CA 95814
SCH No. 73110518

APPENDIX F

COMMENTS FROM THE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
(NASA)

Note: Responses to comments have been included in this Final Environmental Statement on pages indicated inside parentheses.

NASA COMMENTS ON SPACE LAUNCH VEHICLES
DRAFT ENVIRONMENTAL STATEMENT

1. Page 45, para 2, last line. If data is now available, it should be included in the statement. (Page 59)

2. Page 52, Top Para, Last Line. Is the propane burner still used? (Page 65)

3. Page 62, Table 11. Should the 9 in Column 1 (Time) be 0? In Column 4 (Stage I) how can the "Propellant Remaining" be 259,000 and the "Propellant Released, Accident" be 264,260? (Table 11, page 76)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: ADA-1

May 20, 1974

Dr. Billy Welch
Department of the Air Force
Room 4D873, Pentagon
Washington, D.C. 20330

Dear Dr. Welch:

The National Aeronautics and Space Administration has examined the draft environmental statement of the Department of the Air Force, "United States Air Force Space Launch Vehicles," dated August 1973. In general, the statement is in substantial agreement with the corresponding NASA environmental statement. We do, however, have the following two comments:

1. Concentrations and exposure criteria for Hydrazine and UDMH are listed in Table 4 (page 27) of the draft statement for controlled and uncontrolled populations. For these two chemicals, public emergency limits for uncontrolled populations (attributed to the U.S. Air Force Surgeon General) are shown as equal to emergency limits for a controlled population. The other two materials listed in that table for which such criteria are available (HCl and N_2O_4 (NO_2)) have exposure limits for uncontrolled population significantly more stringent than those for controlled population, consistent with the ability to monitor exposure, treat effects, and prevent recurring exposures for the latter group. Public exposure limits for Hydrazine and UDMH should be correspondingly more stringent and the listed values should be reevaluated.

Exposure limits ultimately **established** for uncontrolled populations **should** be adequately referenced. **(Table 4, pp. 41 and F-5)**

2. A single meteorological model has apparently been used for the prediction of launch vehicle exhaust product concentration as a function of distance from each launch site. Although the meteorology model selected may be that which yields the maximum peak downwind concentration, it is suggested that alternative meteorological models be investigated as well. Typical meteorological conditions for the two launch sites differ significantly, and even at a single site the diurnal and seasonal variations may lead to significant differences. We have found that the model which yields the maximum peak downwind concentration may predict lower concentrations than another meteorological model at other downwind locations. These different models then may each have significance for a different class of population. **(pp. 48, 51 and 52)**

Sincerely yours,

Nathaniel B. Cohen

Nathaniel B. Cohen, Director
Office of Policy Analysis

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SYSTEMS COMMAND
ANDREWS AIR FORCE BASE, DC 20334

5 AUG 1974

REPLY TO ATTN OF: VN

SUBJECT: Final Environmental Statement (FES) - USAF Space Launch Vehicles

TO: SG

Paragraph 1 of the attached letter objects to the use of the PELs for hydrazine and UDMH. Request your comments on their objections. Your input will be used in providing guidance to SAMSO on the FES.

FRANCIS J. SMITH, Col, USAF BSC
Director
Environmental Protection Office

1 Atch
NASA Ltr, 20 May 1974

Cy to: SDSS

1st Ind

6 SEP 1974

AFSC/SGP

TO: VN

1. The PEL's and STPL's cited in the Final Environmental Statement are those recommended by the National Academy of Sciences/National Research Council (NAS-NRC) Committee on Toxicology. Their report, prepared for the Office of Air Programs of the Environmental Protection Agency, is entitled "Guides for Short-Term Exposures of the Public to Air Pollutants V. Guide for Hydrazine, Monomethylhydrazine, and 1, 1-Dimethylhydrazine" and is dated June 1974.

2. Permission to cite this report was received by Col. Kittlestad on 26 August 1974 from Dr. Ralph Wards, Director, Advisory Center on Toxicology.

ARTHUR P. CALDWELL, Major, USAF, BSC
Command Bioenvironmental Engineer
Office of the Command Surgeon

1 Atch
nc

APPENDIX G

EXAMPLE TRAJECTORIES OF USAF SPACE LAUNCH VEHICLES

Figures G1 through G5 present typical trajectory data for the Titan B, C and D, Atlas and Scout. Also shown on these figures are the separation points for jettisoned hardware and the corresponding impact range. At the distances indicated, the quantity of propellant remaining in the vehicles is small.

Nearly every mission lauched by USAF space launch vehicles is unique in some sense and vehicle trajectories are designed to satisfy the unique requirements of the mission. For every launch, trajectories and impact point loci are calculated at a level of detail impossible to include in the generalized treatment here. Full consideration is given to the location of the impact points of jettisoned hardware to assure water impact for a normal launch and to assure very low probability of land impact in event of abort during launch. When necessary, trajectories may be modified to control the impact point of jettisoned hardware.

FIGURE G-1 TITAN III B TRAJECTORY 12 HOUR INCLINED ORBIT MISSION LIFTOFF TO PARK ORBIT INJECT

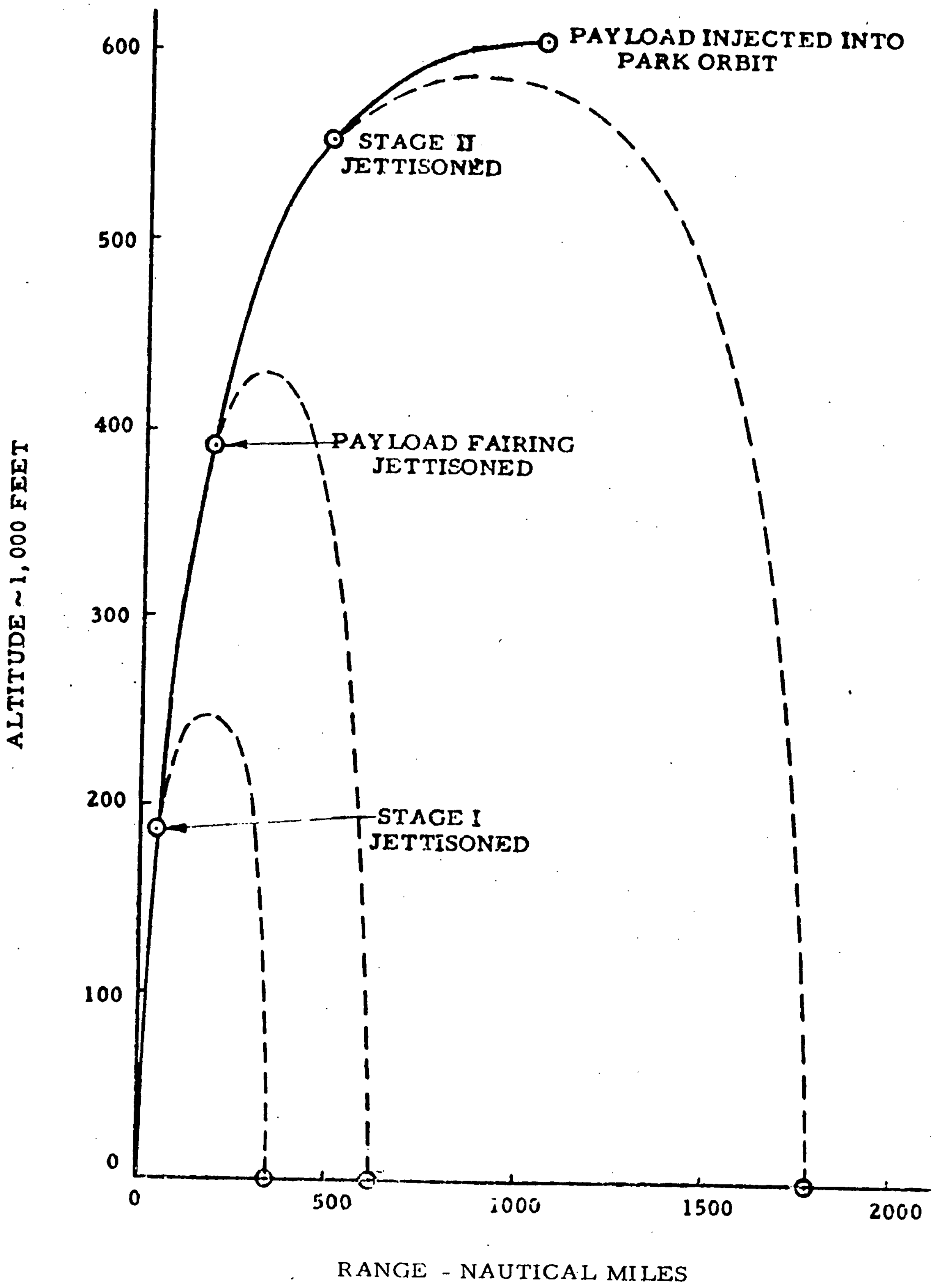


FIGURE G-2. TITAN III C TRAJECTORY FLIGHT PLAN VII
LIFTOFF TO PARK ORBIT INJECT

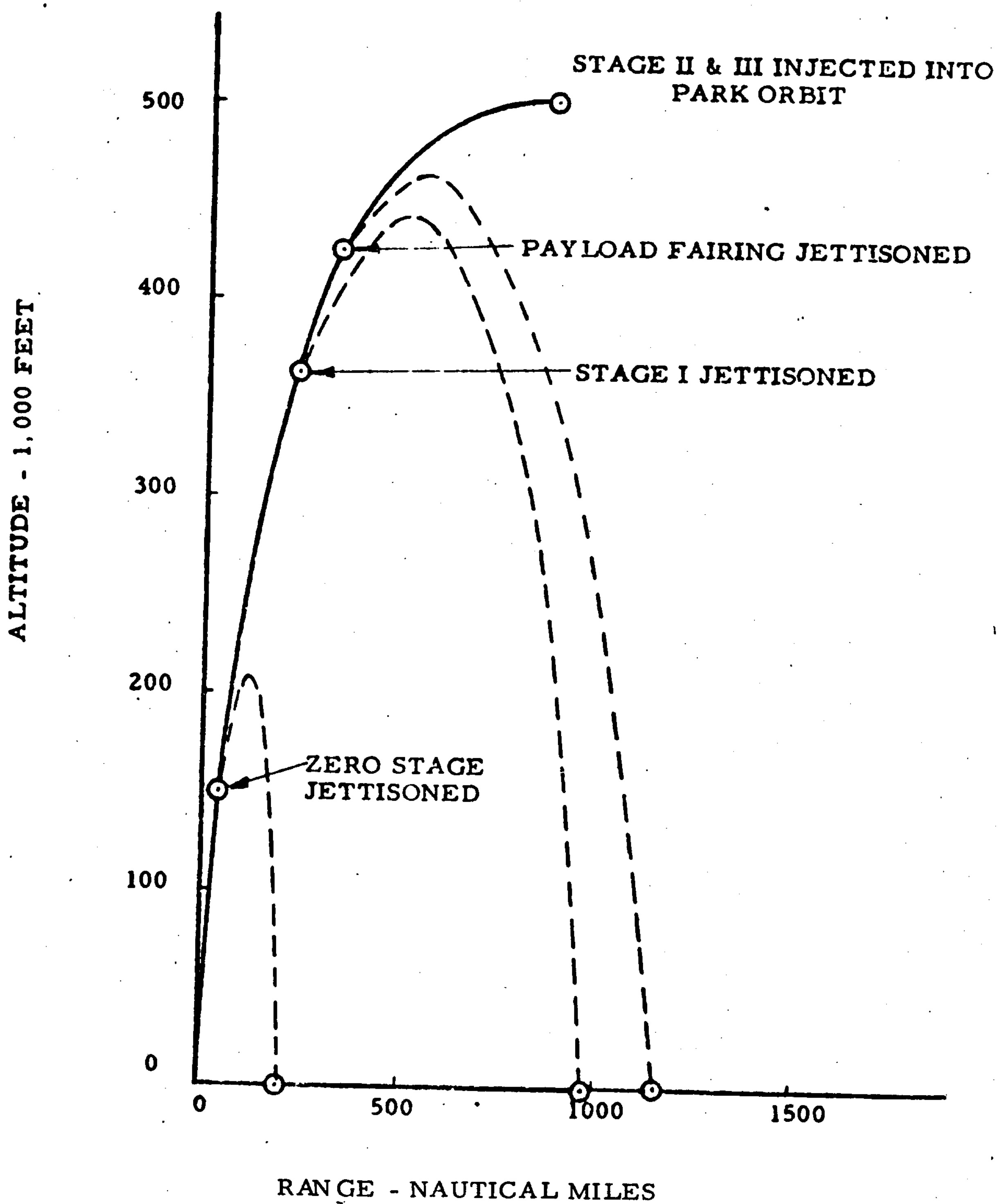


FIGURE G-3. TITAN III D TRAJECTORY SYNCHRONOUS TRANSFER ORBIT MISSION LIFTOFF TO PARK ORBIT INJECT

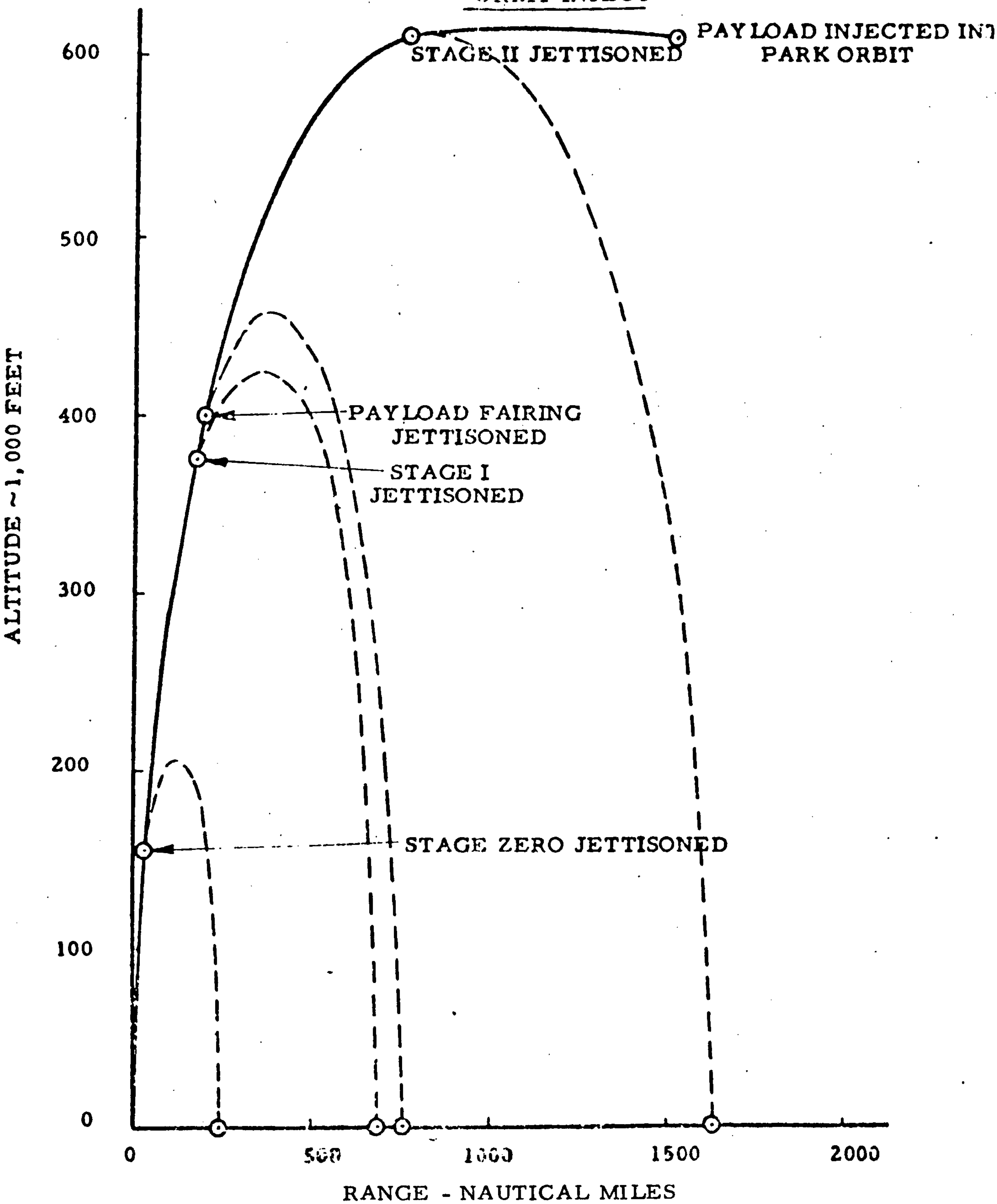


FIGURE G-4 ATLAS SLV-3 TRAJECTORY LIFTOFF TO PARK ORBIT INJECT

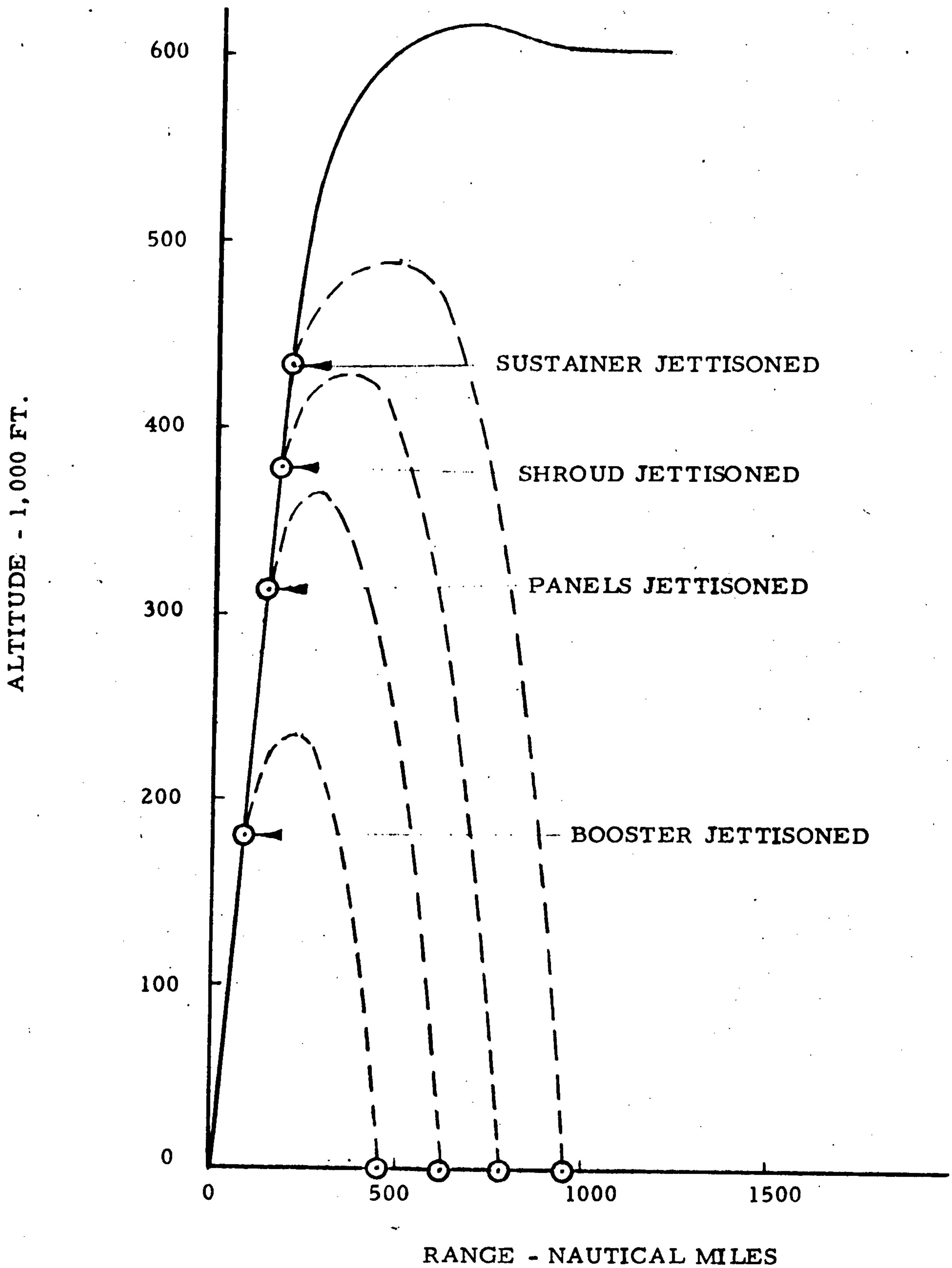
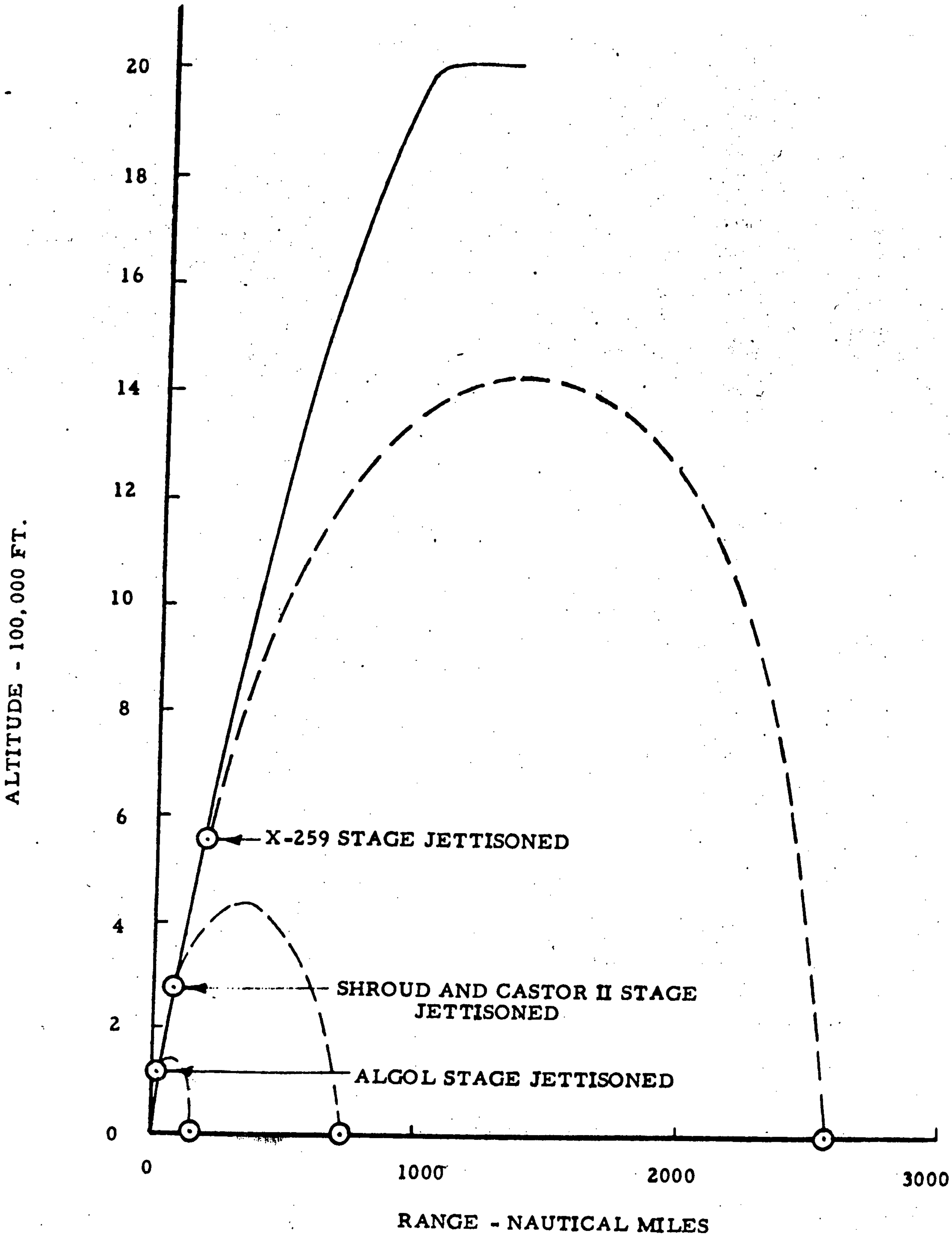


FIGURE G-5 SCOUT TRAJECTORY LIFTOFF TO PARK ORBIT INJECTION



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