ENVIRONMENTAL IMPACT STATEMENT
FOR THE PROPOSED
CENTAUR UPPER STAGE
FOR USE WITH
SPACE TRANSPORTATION SYSTEM

FINAL STATEMENT

March 1985

NASA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, DC 20546

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Lead Agency: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)
Office of Space Transportation
Washington, DC 20546

In July 1982, NASA announced plans to use a Centaur-derived upper stage with the Space Transporation System (STS) to accomplish the Galileo and International Solar Polar planetary missions to be launched in 1986. On September 7, 1983, NASA announced its intention to prepare an environmental impact statement for the program. A draft statement for the program was distributed in early 1984.

Abstract: The proposed action is to design, develop and implement a derivative of the existing unmanned Centaur upper-stage launch vehicle in support of planned planetary missions in 1986. Candidate configurations have been selected and the design effort is underway. Concurrently, an environmental assessment of the proposed vehicle and its operational and inflight plans have been analyzed from an environmental impact point of view to determine what actions, if any, are required to best assure a safe operating environment. Much use was made of experience gained with similar vehicles at the manufacturing facilities and test sites as well as that obtained from its launch area operations over the past 20 years. Additionally, much use was made of previous environmental assessments accomplished for vehicle checkout at the launch area; the Air Force's Eastern Space and Missile Center and NASA's Kennedy Space Center, both on the east central coast of Florida. No modifications to the proposed plans were required as a result of the general review of the draft statement. Only one building modification has been added to the program since initial publication.

Alternative stages, spacecraft configurations and trajectories were evaluated against mission requirements and objectives. The USAF's Inertial Upper Stage could be used in some applications, especially if the planetary missions were delayed until planetary alignments were such that the IUS could meet the energy requirements.

Results of the assessment show no significant environmental risks exist from the implementation of the proposed vehicle, even if used in frequent application. Worst case unplanned events are identified and examined from a personnel safety and environmental standpoint. Results show satisfactory operational and emergency procedures exist to provide the acceptable degree of protection for man, hardware and the environment.

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FINAL ENVIRONMENTAL IMPACT STATEMENT

PROPOSED CENTAUR UPPER STAGE FOR USE WITH THE

SPACE TRANSPORTATION SYSTEM

SUMMARY

The Proposed Action - The proposal is to design, develop and implement a high-energy upper stage, with a basic designation Centaur, into the ongoing Space Transportation System (STS) which will serve as its booster vehicle. Two sizes of the Centaur are planned with the larger being designated G-prime. This G-prime vehicle will allow for a sufficient load of propellants and gases to accomplish the requirements of the planetary missions planned by NASA in 1986. Analyses and evaluations of the G-prime configuration, from an environmental standpoint, will also encompass the smaller version which may be used for lower energy orbits, thereby allowing for somewhat larger payloads to be flown. No deviations to this assumption were identified.

In a number of respects, this new Centaur stage is closely related to that Centaur stage which has been used to perform space missions for the past 20 years. These missions have encompassed low earth and geosynchronous orbits, lunar, solar, inner and outer planetary transfer trajectories and solar system escape trajectories.

During the operational lifetime from the Eastern Launch Site (ELS), a considerable amount of environmental data was collected and reported both by the NASA's Office of Space Science and Applications' "Environmental Statement" published in 1973, and by the "Environmental Impact Statement for the Kennedy Space Center" published in 1979. In processing the unmanned version of Centaur at ELS, a mature plan for conduct of vehicle operations has been developed to assure correct checkout of the hardware while meeting all safety and environmental objectives. Also available is an experienced management, engineering and technical team to implement the operations in an effective manner. This team, its operational plan and processing capability will be used to the extent applicable in the STS/Centaur program.

The G-prime vehicle is to be developed in particular to meet the energy requirements of the NASA Galileo and International Solar Polar (ISPM) missions. The proposed stage is somewhat larger than the expendable vehicle version of Centaur and includes certain integration and safety considerations required by the manned vehicle program but not by the expendable vehicle's program. Operationally, checkout, processing and servicing will be about as has been established in the past with some increase in the tasks which will be computer controlled rather than accomplished in a manual mode, primarily vehicle tanking. Basic design concepts remain as before.

The G-prime Centaur stage is characterized by:

Overall length:	29.6 feet
LO2 Tank Diameter:	10.0 feet

LH2 Tank Diameter:	14.2 feet
Propellant Capacity:	46,000 Pounds (LO2 and LH2)
Main Engines:	P&W RL-10 at 5:1 LO2/LH2
Coast Control Propellant:	170 Pounds N2H4

When fully loaded, the vehicle contains 38,333 pounds of liquid oxygen (LO2) and 7,667 pounds of liquid hydrogen (LH2) to provide prime propulsive force. Properly expended, these are the cleanest possible propellants where the product of combustion is water and the impact on the environment is minimal. The hydrazine aboard the vehicle is planned for orbital expenditure.

The propellants and gases used aboard Centaur are also used by the STS, but in much greater quantities. The addition of the Centaur stage increases the overall onboard liquid oxygen by less than 3%; the onboard liquid hydrogen by 3% and the onboard hydrazine (N2H4) by 23%. However, the combined use of N2H4 represents only 3% when compared to the monomethylhydrazine and nitrogen tetroxide (MMH/N204) used for STS orbital maneuvering and coast control. This hydrazine is the only toxic substance used onboard Centaur and the appropriate safety of handling and emergency condition procedures are in effect from loading at Complex 36 through launch at Complex 39.

The small increases in propellant capacity by including Centaur as part of the STS does not substantially change the environmental impact studies conducted for STS or for its launch sites. All previous impact analyses for STS at the launch site remain applicable.

Modification of existing facilities at the manufacturing and test sites in California and Florida will not change existing land assignment and usage but will temporarily disturb air, water and noise quality in the immediate vicinity of work, presenting minor, localized environmental effects like those associated with small modification tasks. In all instances, the sites being modified for test have existed for some time and have supported the types of test to be conducted for both design evaluation and operational uses of Centaur.

Alternatives - The only viable alternative to Centaur to perform the planned missions is the USAF's Inertial Upper Stage (IUS). However, its capability to perform the Galileo Mission with the desired spacecraft configuration in a direct transfer trajectory is dependent upon planetary alignment, such as that which existed in 1982 where considerable velocity could be gained with a flyby of Mars to enable the spacecraft to arrive at Jupiter in an acceptable time. Other Configurations, such as separating the Orbiter from the Probe on the Galileo spacecraft were examined as well as use of transfer trajectories using an earth flyby. Such techniques can be used but at the expense of requiring two launches to accomplish one mission or significantly increasing the transit time or both. Overall mission costs are significantly increased for either alternative.

Issues and Areas of Concern - The major issues and primary areas of concern were well identified by the previous detailed environmental assessments made at the launch site for the STS and several unmanned launch vehicle configurations including a Centaur upper stage whose characteristics for pre-flight processing and inflight performance are closely related to the version planned for STS. A re-review of those issues and concern areas previously identified along with changes in the G-prime configuration did not reveal any new areas or concerns not previously identified. The following environmental effects of Centaur usage as an upper state in STS have been analyzed:

- impact on air quality
- impact on water quality
- impact on land quality
- noise levels
- radiation
- socioeconomics
- ecology
- unplanned events

These issues were addressed in relation to the preparation of facilities, pre-flight processing, launch and inflight performance of the Centaur upper stage as proposed for use in the STS and are similar to the ones addressed in the Kennedy Space Center (KSC) Environmental Impact Statement (EIS) which included the Centaur stage as used in the expendable vehicle operations.

Worst case environmental effect for the Centaur stage itself would result from a catastrophic accident during a propellant tanking operation at Complex 36 or a major spill of hydrazine during loading or vehicle transport. A cryogenic spill would result in a fire or, at a minimum, an area with considerable freezing, either of which would impact the test facilities and temporarily damage local flora and fauna. A hydrazine spill would most likely result in a local toxic environment but has a capability to spread to inhabited areas. However, procedures for personnel safety, equipment to dilute the chemical and an active warning system are parts of the planned operations to initiate the action required to meet existing NASA and Air Force standards for personnel and equipment protection in such emergencies. Catastrophic accidents involving a combination of Centaur and STS are the same as those defined for STS alone. No additional environmental impact can be defined for this case.

Therefore, for any adverse operational or accidental cryogen or hydrazine spill only minor, localized and temporary environmental impact would be realized. This fact has been realized from very minor incidents occurring in the history of both the manned and unmanned program involving the use of such commodities. Operational and emergency procedures have proven adequate to protect personnel, hardware and the environment. The incorporation of the proposed Centaur into STS does not alter previously analyzed and established operational procedure.

Findings - Implementation of the proposed action, i.e. to use a derivative of the cryogenic Centaur to perform the 1986 planetary missions, will not be detrimental to either the launch area or space environment. Air quality, water quality nor the ecology will be impacted in anyway. No noise or radiation problems exist. The socioeconomic impact is beneficial though the change caused by introduction of the new stage is small since the operational team has been in place for some time. Long range benefits from the missions will be many and will enhance man's knowledge in general and a better understanding of his environment in particular. No environmental problems were uncovered during the investigation nor any cause to delay proceeding with the proposed action.

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ABBREVIATIONS AND ACRONYMS

A/C	ATLAS/CENTAUR
AFO	ABORT FROM ORBIT
AOA	ABORT ONCE AROUND
ATO	ABORT TO ORBIT
CASE	CENTAUR AIRBORNE SUPPORT EQUIPMENT
CCA	CENTAUR/CISS ASSEMBLY
CCAFS	CAPE CANAVERAL AIR FORCE STATION
CCE	CENTAUR CARGO ELEMENT
CCLS	COMPUTER-CONTROLLED LAUNCH SET
CCT	CENTAUR/CISS TRANSPORTER
CCTE	COMPUTER-CONTROLLED TEST EQUIPMENT
CDU	CENTRAL DISTRIBUTION UNIT
CIL	CRITICAL ITEMS LIST
CISS	CENTAUR INTEGRATED SUPPORT SYSTEM
CITE	CARGO INTEGRATED TEST EQUIPMENT
CPOCC	CENTAUR POSTDEPLOYMENT OPERATIONAL CONTROL CENTER
CPU	CENTRAL PROCESSING UNIT
CRT	CATHODE RAY TUBE
CSS	CENTAUR SUPPORT STRUCTURE
CSTP	CISS TRANSPORT PALLET
CU	CONTROL UNIT
C&W	CAUTION AND WARNING
dBA	DECIBEL- "A WEIGHTED" FREQUENCY MEASUREMENTS
DCU	DIGITAL CONTROL UNIT
DOD	DEPARTMENT OF DEFENSE
DUFTAS	DUAL-FAILURE TOLERANT ARM/SAFE SEQUENCER
EIS	ENVIRONMENTAL IMPACT STATEMENT
ELS	EASTERN LAUNCH SITE
ELV	EXPENDABLE LAUNCH VEHICLE
EPA	ENVIRONMENTAL PROTECTION AGENCY
ETC.	AND SO FORTH
ETR	EASTERN TEST RANGE
FMEA	FAILURE MODE EFFECTS ANALYSIS
FOM	FIGURE OF MERIT
FT.	FOOT
GAL.	GALLON
GDC	GENERAL DYNAMICS CORPORATION, CONVAIR DIVISION
GH2	GASEOUS HYDROGEN
GHe	GASEOUS HELIUM
GN2	GASEOUS NITROGEN
GO2	GASEOUS OXYGEN
GSE	GROUND SUPPORT EQUIPMENT
HER	HARDWARE EXTENSION, REMOTE
HI-REL	HIGH RELIABILITY

I.E.	THAT IS
IN.	INCH
IRU	INERTIAL REFERENCE UNIT
ISPM	INTERNATIONAL SOLAR POLAR MISSION
IUS	INERTIAL UPPER STAGE
KSC	KENNEDY SPACE CENTER, FL
KG.	KILOGRAM
LB.	POUND
LBF	POUNDS FORCE
LBM	POUNDS
MASS	
LH2	LIQUID HYDROGEN
LN2	LIQUID NITROGEN
LO2	LIQUID OXYGEN
MCC	MISSION CONTROL CENTER
MECO	MAIN ENGINE CUT OFF
MES	MAIN ENGINE START
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
N2H4	HYDRAZINE
NMI	NAUTICAL MILE
OMS	ORBITAL MANEUVERING SYSTEM
OPF	ORBITER PROCESSING FACILITY
PAM	PAYLOAD ASSIST MODULE
PGHM	PAYLOAD GROUND HANDLING MECHANISM
PPM	PARTS PER MISSION
PSIA	POUNDS PER SQUARE INCH - ABSOLUTE
PSIG	POUNDS PER SQUARE INCH- GAGE
PWA/GPD	PRATT AND WHITNEY AIRCRAFT/GOVERNMENT PRODUCTS DIVISION
RCS	REACTION CONTROL SYSTEM
RF	RADIO FREQUENCY
RTG	RADIOISOTOPE THERMOELECTRIC GENERATOR
RTLS	RETURN TO LAUNCH SITE
S/C	SPACECRAFT
SGLS	SPACE GROUND LINK SYSTEM
SRB	SOLID ROCKET BOOSTER
SRM	SOLID ROCKET MOTOR
STS	SPACE TRANSPORTATION SYSTEM
SUPER	
ZIP*	LOCKHEED SEPARATION SYSTEM - TRADEMARK
S/W	SOFTWARE
TAL	TRANSATLANTIC ABORT LANDING
T/C	TITAN/CENTAUR
TDRSS	TRACKING AND DATA RELAY SATELLITE SYSTEM
TTR	TEST AND TRANSPORT FIXTURE
USAF	UNITED STATES AIR FORCE
VPF	VERTICAL PROCESSING FACILITY

I. PURPOSE AND NEED FOR ACTION

A. Purpose

To realize the potential of the STS and to place spacecraft in orbits other than that obtainable by the STS itself, an upper stage attached to the spacecraft in the orbiter payload bay is required. The size and performance of this upper stage is dictated by the weight of the spacecraft and its final desired orbit. For high-energy missions such as geosynchronous orbits and the even higher energy requirements of planetary missions, a stage utilizing high-energy propellants is desirable and quite often necessary. NASA, following its decision to perform the planetary Galileo and International Solar Polar (ISPM) missions in 1986 determined that such a high-energy stage was needed to best assure mission success. Accordingly, a derivative of the existing Centaur stage was selected based on several studies of its capability to perform the task, the modifications required for implementation of the program and retention of a large element and design of Centaur components which had proven reliable in past applications.

B. Need for Centaur

Use of Centaur as an upper-stage vehicle in space launch activity provides the best means to couple high performance, polution-free propellants, demonstrated design and reliable operations as part of the same mission. Any presently planned or projected mission can be satisfied by including this stage. Flexibility, reliability, cost and schedule control have been demonstrated by the participating contractors and agencies by meeting all goals in several growth and product improvement versions of Centaur which have been incorporated over the years. With Centaur in STS, missions previously performed by the Atlas/Centaur program will no longer be required. Additionally, large solid propellant motor usage in space can be minimized.

Centaur, as an upper stage in the expendable vehicle's program, has already been a significant contributor to placing spacecrafts in orbit, including earth and solar, allowing for collections of data from a variety of conditions. Because of its capability, it has been used in accomplishing all major planetary operations and for launch of large sized observational, technological and communication satellites into near and geosynchronous earth orbits. Use of the data so collected has enhanced man's knowledge of his local, solar and planetary environments with the potential for long-term enhancement. Centaur's use in the STS will continue with such applications to help provide that information vital to man's enlightenment.

C. Summary of Environmental Comparison of Alternatives

The only reasonable alternative to the use of Centaur and still perform the desired mission is to await the proper time and use the appropriate configuration of the USAF's IUS. Such usage was given careful consideration from a technical and performance point of view with the analysis showing the need for the high-energy stage. From an environmental point of view, it has been determined that essentially no adverse effects exist from the already implemented IUS program or from the planned implementation of the new derivative of Centaur. However, the propellants used by Centaur are environmentally cleaner than those used by IUS and thus, in comparison, does perform in a manner which provides a more positive means of assuring long-term environment protection. Table

I-1 provides a comparison of several considerations of alternatives while Table I-2 rates the Centaur and IUS on special environmental parameters. Specific environmental consequences are addressed in Section III of this report.

TABLE I-1 SUMMARY OF CONSIDERATIONS FOR GALILEO AND ISPM

	Vehicle	Facililty Modifications	General Operations	Performance	Adverse Environmental Consequences - Near and Long Term -	CONCLUSION
Proposed Action	Modified Existing Centaur	Minor	Experienced Crew Available	Adequate	Minor	Best Candidate to Perform the Desired Missions
New Design - Staging Match to STS -	Unnamed	Minor	Would Require More Training	Best	Minor	Cost and Schedule To Risky for 1986. No Further Consideration
No Action Alternative (Alternate Stage)	IUS	Minor	Experienced Crew Available	Marginal *	Minor - But More Than Centaur	Not To Delay Missions And Not Use IUS
No Action Alternative (Cancel Missions)	None	None	None	None	None	Not To Cancel Missions And Take That Action Which Best Assures Success

* None for the 1986 opportunity.

TABLE I-2 COMPARISON OF ENVIRONMENTAL CONSEQUENCES OF PROPOSED ACTION TO ALTERNATIVE.

	Air Quality	Water Quality	Land Quality	Noise	Radiation	Socio-Economics	Ecology	Space	
Proposed Action - Centaur -	A	A	A	A	A	A	A	A	Normal Operations
	B	A	A	A	A	A	B	A	Unplanned Events
Alternate - IUS -	A	A	A	A	A	A	A	A	Normal Operations
	C	C	C	A	A	A	C	A	Unplanned Events

A - Nominal Environmental Effects - Similar to the operation of a small clean industrial plant.

B - Minor Effect - Release or burning of Cryogens - some potential for local impact.

C - Moderate Effect - Burning of solid propellant - some potential for localized damage.

NOTE: 1. Any accident involving hydrazine release would be the same for both vehicles. Generally the same type safety of handling procedures are in effect.

2. The effects listed are considered for processing of the Centaur or IUS when not mated to the STS. Centaur or IUS contributions to unplanned events with the STS are minor and the conditions as defined in Reference 1 apply.

II. ALTERNATIVES INCLUDING THE PROPOSED ACTION

A. Alternative 1: Develop the Vehicle as Proposed

1. Introduction to the Proposed Action

The STS is the new generation of booster vehicles which began launch operations from the John F. Kennedy Space Center, Florida in 1981. Because of its size, propellant capacity, both liquid and solid, its frequency of planned usage and all other substantial support requirements, both direct and indirect, an extensive analysis of its impact on the environment was conducted with the actions determined and implemented as necessary to protect the environment in general and the KSC launch site in particular.

The proposed Centaur stage for use with the STS uses the same commodities for pre-flight servicing and inflight expenditure as does STS. It will also be processed in the same general environs. In this regard, the EIS generated for STS at KSC is directly applicable and was extensively employed for the Centaur evaluations.

The Centaur stages are anticipated to become an integral part of the STS system to perform a variety of missions beginning with the Galileo and ISPM mission in 1986. Candidate vehicle configurations have been selected based upon several concepts evaluated and vehicle design is underway. The elements of vehicle design and implementation which may impact the environment have been and are being considered in the early phases of design to preclude downstream problems. Much information was readily available for this task which resulted from a previous analysis and the experience gained with the expendable vehicle version of Centaur. Such experience will help in providing a new vehicle which will satisfy mission requirements while allowing for safe operations and minimal environmental impact. Environmental effects resulting from the implementation of the Centaur stage are identified, analyzed and discussed in this draft environmental impact statement. Input received by outside agencies/organizations will be duly noted, analyzed and reported in the final statement. Any identified environmental impacts will be promptly put into work for resolution and incorporated in the EIS at the earliest reasonable time.

The high-energy Centaur stage(s) is being developed with two specific launches scheduled. However, it is quite likely that once developed, it may find application in several missions and become a routine operational element of the STS. Therefore, from an environmental point of view, consideration was given to several Centaur launches per year to assure that environmental effects would be known for any launch schedule. It was determined that no environmental impacts would be encountered with the repeated use of Centaur.

2. Centaur Experience and Planned Integration into STS

The concept of the high-energy Centaur stage was an outgrowth of the ICBM Atlas weapon's system developed in the 1950's. Incorporation of hydrogen as a fuel along with the newly developed Pratt and Whitney RL-10 engines, led to a stage matched to the Atlas vehicle as its booster with the combination being designated Atlas/Centaur (A/C).

The A/C space launch vehicle has been in continuous operation from the Eastern Launch Site (ELS) for more than 20 years. It has been responsible for many space achievement "firsts" and has performed missions requiring orbits from low earth to solar system escape. The experience gained with the receipt, storage, transfer, handling, loading and launch of the commodities associated with this Centaur vehicle directly applies to the version planned for use in STS and will be invaluable in establishing a safe and effective operation with the new vehicle. The A/C experience band includes an on-pad accident where an engine failure resulted in rapid propellant mixing and an explosion. Also, inflight failures have occurred preventing the vehicle from obtaining orbital velocity resulting in considerable debris re-entering the upper atmosphere. Detailed evaluation of these events have led to incorporation of more reliable flight systems in addition to procedural modifications to better assure personnel safety and environmental protection. Study results have indicated that the local and Range Safety protection procedures were well defined. These experiences and implementation of corrective measures have led to the reliable presently-operating vehicle. This reliability along with the good performance obtained from the higher energy hydrogen/oxygen propellants were a significant factor leading to its use in the STS.

Integration of the Centaur vehicle into the Space Shuttle offers a significant increase in the performance capability of the STS. During the past few years, substantial NASA and Contractor activity led to the conclusion that a "Centaur type" vehicle could be integrated safely into the Shuttle. The vehicle selected can perform the Galileo, Solar Polar and Tracking and Data Relay Satellite System (TDRSS) missions. It provides a payload capability of over 10,000 pounds into geosynchronous orbit. The G-prime configuration takes advantage of the Shuttle's 15-foot diameter payload bay by reshaping the tank structure in order to maximize the spacecraft length capability.

The configuration is derived from the flight-proven Atlas/Centaur and Titan/Centaur vehicles. The 120-inch tank for liquid oxygen is lengthened while maintaining its present diameter. The tank for liquid hydrogen has been shortened but increased in diameter to 170 inches. A conical transitional section joins the tank structures.

The configurations and approaches to be evaluated are based on current development and integration planning. The major ground rules and assumptions factored into the planned configurations include:

- Previous safety review results remain applicable,
- Centaur/Spacecraft will fly as a dedicated Shuttle payload,
- Impact on Shuttle hardware/software and facilities will be minimized,
- Door-closed abort duration will not exceed 6.5 hours,
- Centaur/Spacecraft will be installed in the orbiter payload bay while on Pad via the payload ground handling mechanism,
- Pad A at Complex 36 will be modified to check out the stage and to prepare the stage for spacecraft mate.

It has been determined that these ground rules can be satisfied and processing of the stage at Complex 36 is compatible with the ongoing Atlas/

Centaur operations being conducted from Pad B. A large amount of ground handling and checkout equipment is common between the two versions, again minimizing the need for large amounts of new equipment and its attendant operational procedure development.

3. Description of the Proposed Vehicle

An assessment of the NASA planetary and near-term synchoronous mission requirements has led to selection of a Centaur configuration to satisfy the NASA one-burn mission and be readily adaptable to the two-burn optional mission with minimal mission-peculiar differences. This Centaur configuration is characterized by:

- approximately 29.6-foot overall length,
- approximately 46,000-pound total propellant capability,
- standard RL-10 engines of 5:1 nominal mixture ratio and specific impulse of 446 seconds,
- low profile ellipsoidal forward LH2 tank bulkhead and 24-degree transition angle to LO2 tank.

The selected configuation (Figure II-1) accommodates a 30-foot payload length in the payload bay. Since performance with the well-proven Centaur propulsion system is adequate for the baseline missions, the existing engine bells will be used. Fluid interfaces with the orbiter are as shown (Figure II-2).

Centaur G-Prime Vehicle - The Centaur vehicle consists of a 120-inch diameter LO2 tank that transitions to a 170-inch diameter LH2 tank. The cryogenic tanks are insulated with combinations of helium-purged foam blankets and radiation shields. The forward end of the vehicle consists of a bolted-in cylindrical stub adapter and conical equipment module, which provides mounts for all vehicle electronics packages. The aft end of the vehicle consists of a cylindrical aft adapter and a pyrotechnic separation ring.

The Centaur G-prime main propulsion system consists of two Pratt & Whitney Aircraft RL10A-3-3A engines rated at 16,500 pounds of thrust. Liquid oxygen and liquid hydrogen is supplied to the engines through flexible feed ducts that allow for engine gimballing.

Propellant requirements are provided to the engines by pressurizing the propellant tanks. During the engine burn helium is used to pressurize the oxygen tank and hydrogen gas bled from the engine is used to pressurize the hydrogen tank.

Tank pressures in the hydrogen tank are controlled by a zero-G vent system during zero-G coast. Venting is also provided by vent valves. Pressure in the oxygen tank is controlled by a propellant mixer.

The reaction control system consists of a hydrazine storage sphere, four settling motors, and eight attitude control motors. The system is pressurized by regulated helium pressure.

The vehicle avionics system performs the functions necessary

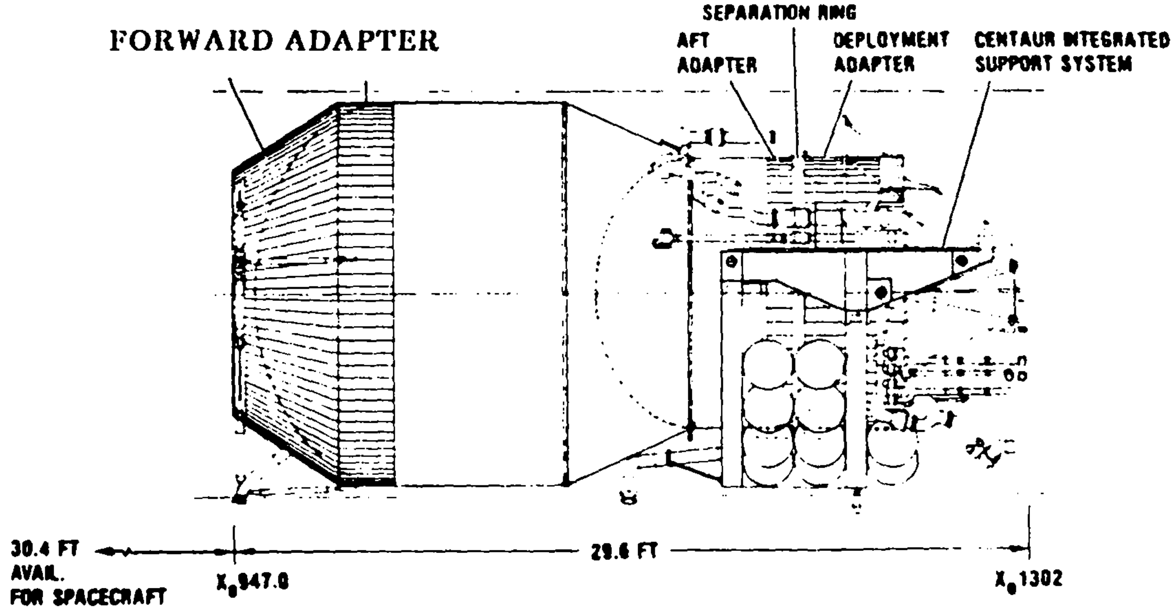


FIGURE II-1 - SHUTTLE/CENTAUR G-PRIME & CISS

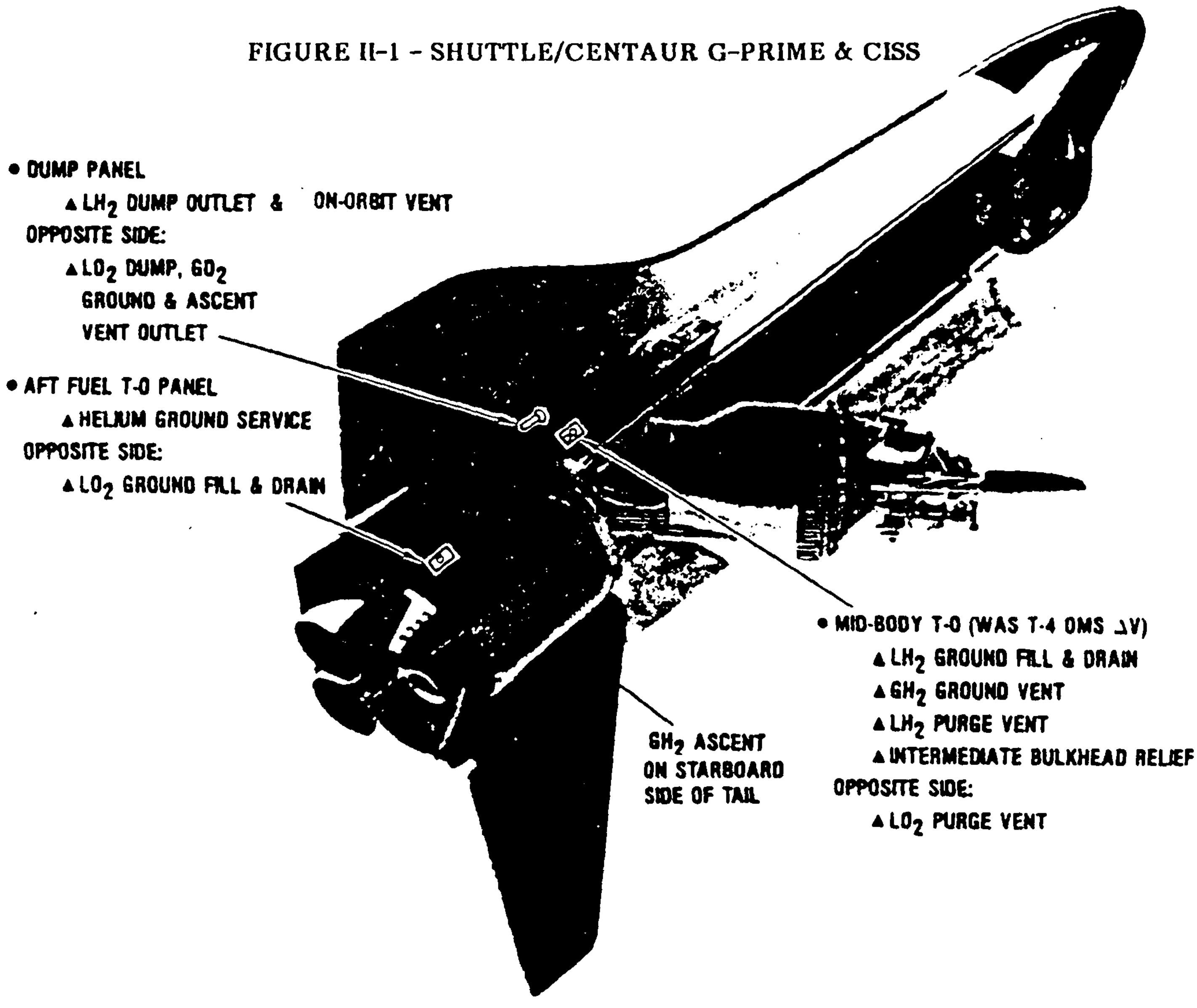


FIGURE II-2 - CENTAUR G-PRIME FLUID INTERFACES WITH ORBITER for autonomous control of the Centaur vehicle from Orbiter separation through post-separation maneuvers.

The guidance, navigation and control (GN&C) system for the baseline Centaur is the Atlas/Centaur GN&C system with minor modifications. The system was completely redesigned to NASA Hi-Rel standards in 1972. A star scanner may be added for attitude update and another command link has been added to permit data command and data uplink via the Orbiter when Centaur is attached. A secure telemetry system compatible with all known requirements has been added. Electrical power to safety-related avionics control functions is inhibited until the Centaur is a safe distance from the Orbiter.

Centaur Integrated Support System (CISS) - The CISS consists of a Centaur support structure (CSS), a deployment adapter, and the associated CISS electronics and fluid systems (Figure II-3). The CSS adapts the Centaur vehicle and deployment adapter to the Orbiter through a five-point support system. The development adapter attaches to the aft end of Centaur at the separation ring and to the CSS through two rotation trunnions and guide keel pin.

During deployment, the vehicle is rotated 45 degrees, to its separation attitude, by a rotation mechanism attached to the deployment adapter.

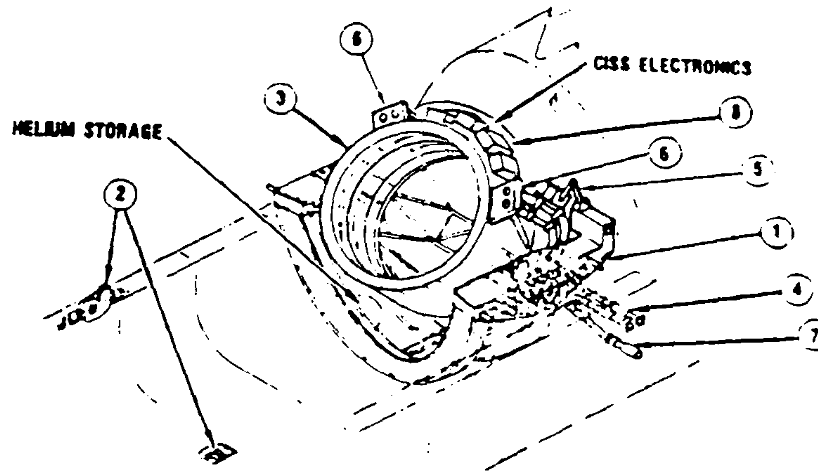
Fluid systems ducting and gimbals are provided to interconnect the various propellant tank service lines to their associated Orbiter overboard service ports (Figure II-4). The gimbals permit the Centaur to be rotated to the deployment position while maintaining all safety-related systems in a connected and functional state.

Helium storage spheres and two-failure tolerant pressurization and pressure regulation systems supply all helium for pressurizing Centaur tanks, actuating vent and dump system valves, and providing the necessary system purges to manage Centaur propellants safely.

CISS avionics performs all control functions for vehicle safety while the Centaur is attached to the Orbiter and for deployment. Two-failure tolerant control is achieved with five strings of microprocessor-control avionics, associated sensors and controllers.

The baseline Centaur G compatibility provides for a 10,000-pound and 11,500-pound spacecraft, with cg of 160- and 130-inches, respectively, forward of the interface plane. As a growth option, Centaur G can accommodate a 16,000-pound spacecraft.

Centaur G-Prime Tank Configuration - The basic propellant tank arrangement is a LO2 tank and a LH2 tank, as illustrated in Figure II-5. The weight-effective, pressure-stabilized tank configuration has been proven in Atlas, Atlas/Centaur, and Titan/Centaur flights. This structurally efficient Centaur G tank contains the main engine propellants, establishes vehicle primary structural integrity, and supports vehicle systems and components. NASA has determined that the cryogenic Centaur can be safely integrated into the Space Transportation System. Extensive testing of the Atlas/Centaur tank has demonstrated that the tank has a much greater strength capability than the design values. Internal tank installations are as shown (Figure II-5). A comparison of the planned Centaur G and G-prime tankage and adapter arrangements are shown in Figure II-6.



INTERFACE COMPATIBILITY

1. FIVE-POINT AFT SUPPORT SYSTEM BETWEEN CISS AND ORBITER (STANDARD FITTINGS WITH ADJUSTMENT CAPABILITY ADDED TO FORWARD SILL LATCHES)
2. THREE-POINT FORWARD SUPPORT SYSTEM BETWEEN CENTAUR AND ORBITER (STANDARD LATCHES WITH STOPS ADDED FOR PASSIVE RESTRAINT)
3. DEPLOYMENT ADAPTER WITH SPRING THRUST TO EJECT CENTAUR
4. FLUID SERVICING FOR LO_2 AND LH_2 FILL & DRAIN, PRELAUNCH/FLIGHT VENTING & ABORT DUMP
5. DEPLOYMENT ADAPTER ROTATION SYSTEM (TO 45 DEGREES)
6. FUEL AND OXIDIZER DISCONNECT PANELS

SAFETY CONSIDERATIONS

7. PROPELLANT ABORT DUMP
8. FIVE AUTONOMOUS CONTROL UNITS PROVIDE TWO-FAILURE TOLERANT CONTROL

FIGURE II-3 – CENTAUR INTEGRATED SUPPORT SYSTEM DESIGN CONSIDERATIONS

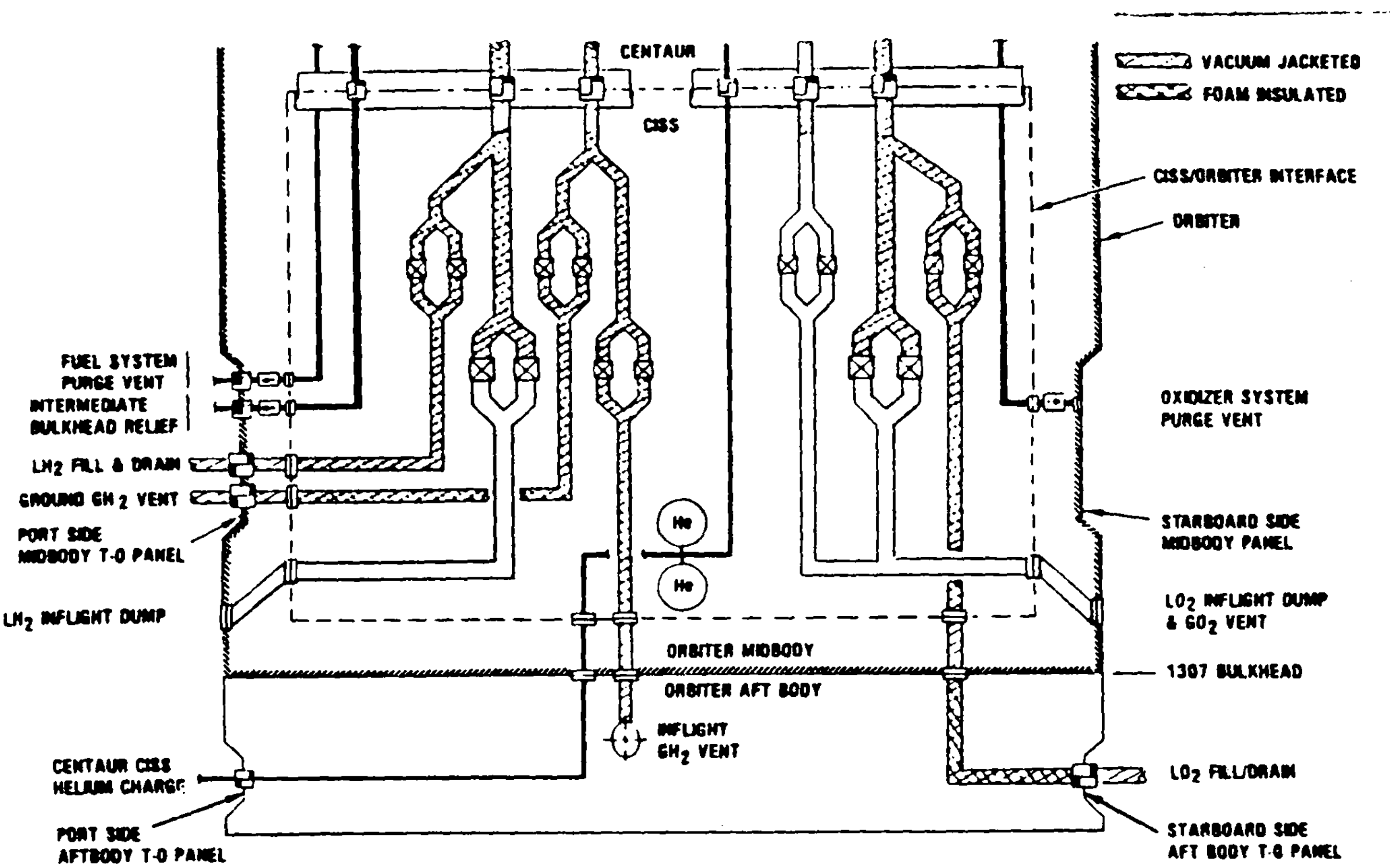


FIGURE II-4 – CENTAUR/ORBITER FLUID INTERFACES

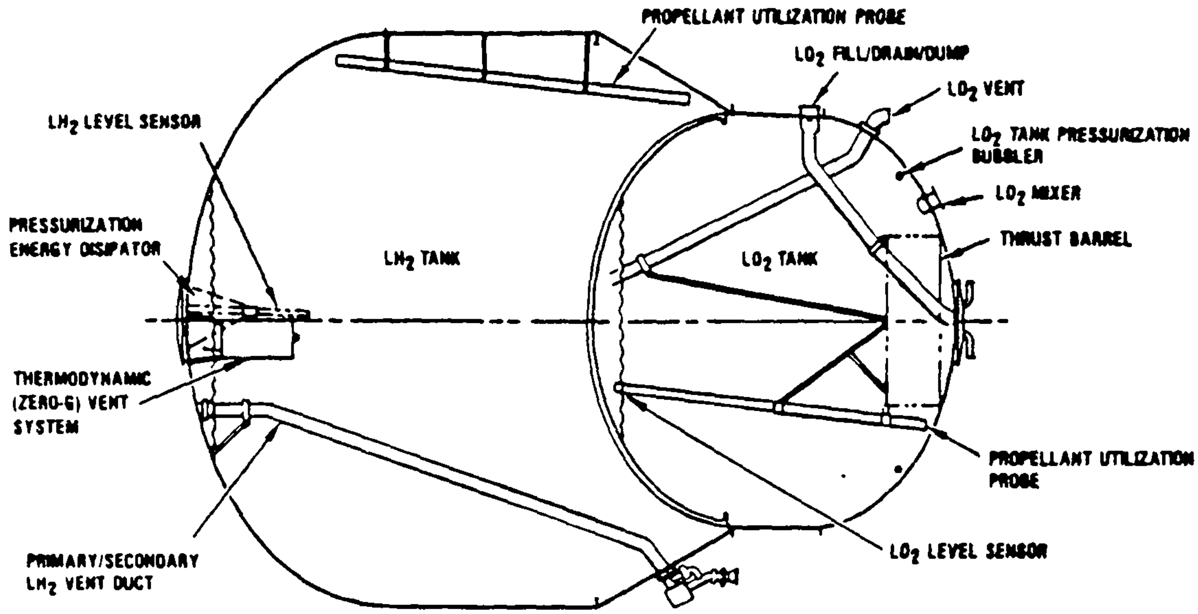


FIGURE II-5 - CENTAUR G-PRIME TANK & INTERNAL INSTALLATIONS

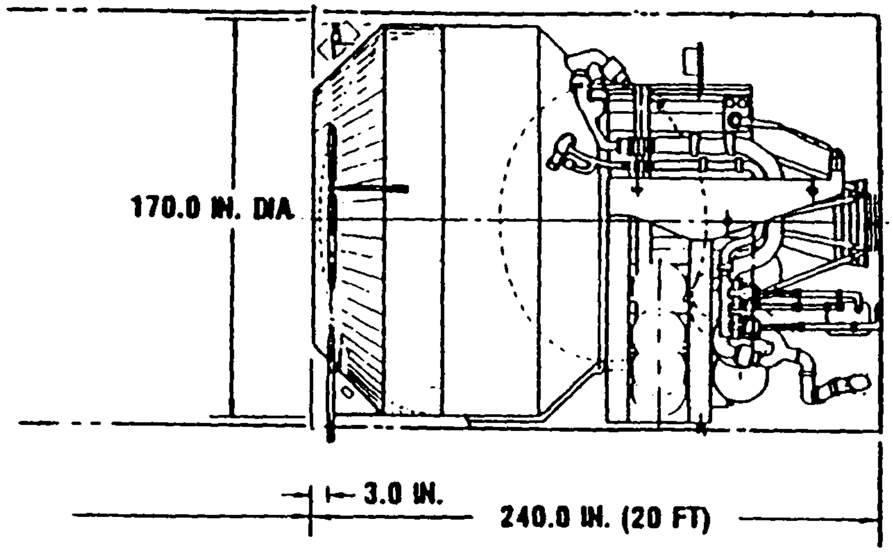
Centaur Adapters - Two new vehicle adapters (forward and aft adapter) are being designed. They are similar to existing Centaur adapters in form and function. Extensive use of finite-element analysis for sizing and designing these adapters has shown a very close correlation with test results.

The forward adapter consists of cylindrical and coinical structural sections. The cylindrical section is a graphite/epoxy structure 170 inches in diameter and 25 inches long. The coinical section is a conical aluminum skin-stringer alloy structure with a 170-inch diameter base. It is 47 inches long and 108 inches in diameter at the forward end. The forward adapter serves as a mount primarily for the avionics boxes. The forward end of the structure interfaces with the spacecraft-peculiar adapters.

The aft adapter is a 10-foot diameter, 11.2-inch cylindrical graphite/epoxy structure with attachment rings at each end. This adapter distributes CISS support loads into the Centaur tank and provides an interface for attaching the separation system. The forward ring bolts to the liquid oxygen tank aft ring and the aft ring attaches to the separation ring. Support structure is mounted on the aft adapter for the vehicle separation springs, fluid disconnect panels, radiation shields and wiring.

Separation System - The reliable Lockheed Super*Zip pyrotechnic separation system, which has become an industry standard, will separate Centaur from the CISS (and Orbiter). Lockheed will provide a separation ring containing the Super*Zip system. It is a 10-foot diameter, 5.50-inch long, aluminum alloy cylinder section with attachment rings at each end. The separation ring simply bolts to the aft adapter and the CISS deployment adapter.

Super*Zip is a dependable, redundant, dual pyrotechnic system. When it fires, a spring system thrusts the Centaur from the CISS deployment adapter. Should the Super*Zip not separate, the Centaur and deployment adapter can safely be lowered back into the payload bay.



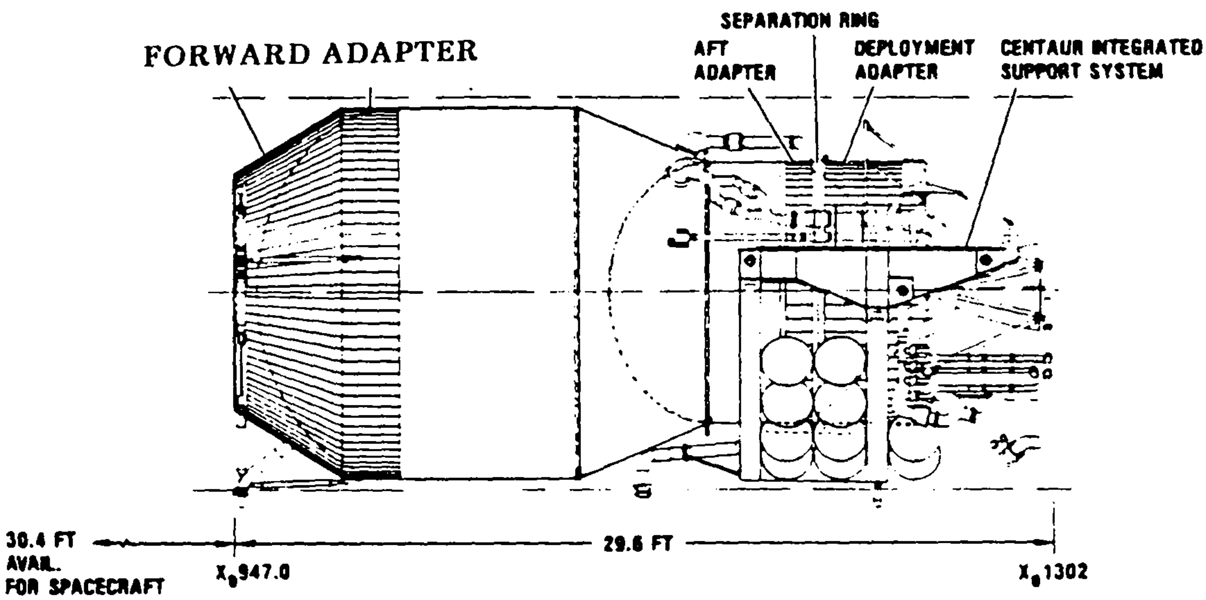


FIGURE II-6

CENTAUR G AND G-PRIME TANK CONFIGURATIONS

A Super*Zip system was used for shroud separation on Titan/Centaur.

LH2 Tank Insulation System - This system consists of two major portions (Figure II-7): the forward bulkhead insulation, and the tank sidewall insulation. The forward bulkhead two-layer foam insulation blankets are installed on the hydrogen tank forward bulkhead and enclosed by the cylindrical stub adapter and the conical equipment module. The tank sidewall two-layer foam insulation blankets are attached at the outboard flange of the foward ring of the stub adapter and extend aft along the full length of the hydrogen tank sidewall cylindrical and conical section and are attached to the purge collector plenum.

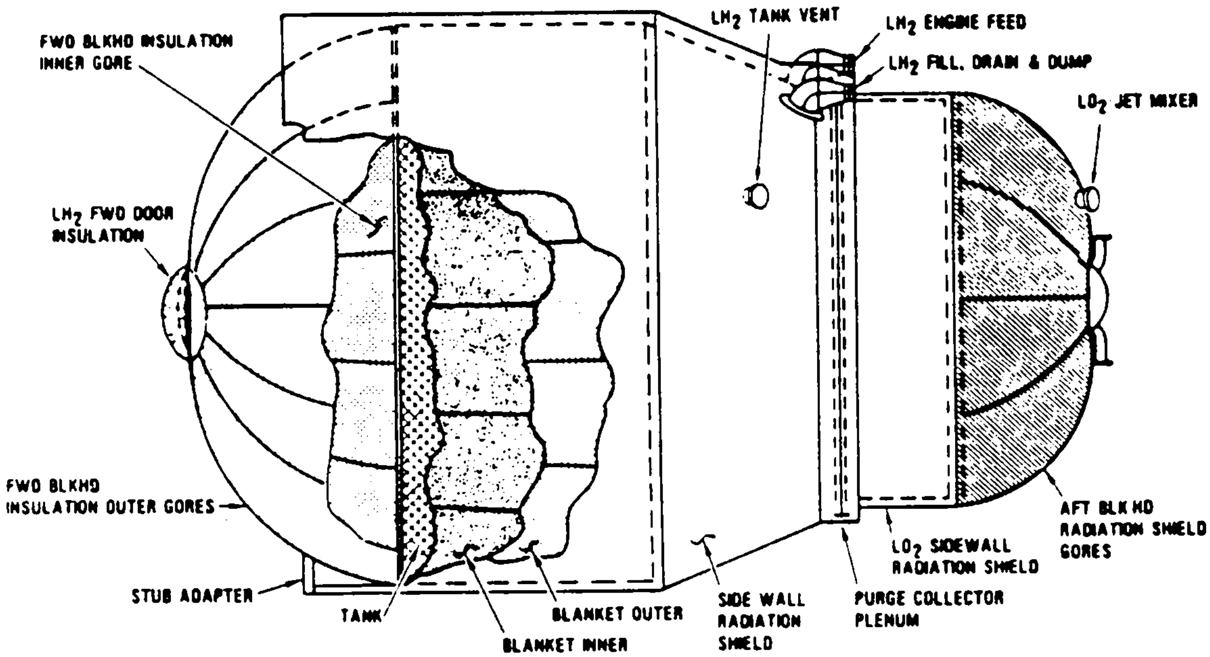


FIGURE II-7
CENTAUR INSULATION

Purge and Vent - The insulation system is purged with helium gas introduced at ambient temperature and at 20 to 60 pounds per hour at the forward end of the equipment module. A dual-position vent door on the equipment module opens to vent the compartment during ascent. Before riseoff, equipment module purge gas flows into the sidewall insulation at the forward end through holes in the stub adapter. The gas flows aft to an annular purge plenum and vents through relief devices and another dual-position vent door for ascent venting. The doors will close to permit blanket repressurization during an abort reentry sequence when the Centaur tank will contain postdump residual propellants. The restart of purge flow during reentry and the foam blanket rigidity prevents liquid air run off.

Helium Supply System - The helium supply system consists of the two Kevlar overwrapped helium storage spheres and a charge line connected to a disconnect in the Centaur/CISS oxidizer umbilical panel through a quad set of check valves. An analysis has determined that the two 26-inch diameter helium spheres will contain the helium mass required. The helium charge is controlled by valves located on the CISS. The system also contains a regulator to provide the various purge systems, pneumatic actuated valves, and N2H4 bottle pressurization, with a nominal 450-psig supply. A relief valve provides protection from overpressurization in the 450-psig portion of the system.

Main Propulsion/Propellant Supply - The main propulsion system consists of two Pratt & Whitney RL10A-3-3A engines rated at 16,500 lbf nominal thrust, each operating at a 5:1 mixture ratio of oxidizer to fuel. A silver throat results in a specific impulse of 446.4 seconds. The net positive suction head (NPSH) required by the engine turbopumps is provided by pressurizing the vehicle propellant tanks. Propellants are delivered to the main engine turbopumps through feed ducts from the vehicle propellant tanks. The feed ducts contain flex joints to accommodate engine gimballing and are overwrapped with a three-layer, double-aluminized Kapton radiation shield.

Pneumatically actuated prevalves located at the propellant tank outlets provide series redundant backup for the engine inlet shutoff valves (Figure II-8). A parallel set of pyro valves and solenoid valves provides two-failure tolerance against inadvertent opening of the engine inlet shutoff valves. The pyro valves will be fired open after Centaur is deployed a safe distance from the Orbiter.

Reaction Control System - The system consists of twelve 6-lbf thrust units, a positive expulsion tank with 170-lbm hydrazine capacity, two sets of parallel pyro valves, one fill/drain and two pneumatic checkout valves, and heated feed lines (Figure II-9). All feed line joints, including those that interconnect components, are welded to provide a leak-proof, contamination-free system.

The fill/drain and pneumatic checkout valves (with redundant pressure sealing caps) are required to maintain a positive system GN2 standby pressure, facilitate component functional checkout, and load the hydrazine tank. A set of parallel pyro valves are used in the hydrazine tank inlet and outlet lines to provide positive isolation of the hydrazine tank. The downstream set of parallel pyro valves and thruster series solenoid valves provide two-failure tolerance against inadvertent thruster operation. The pyro valves will be fired open, pressurizing the system and allowing hydrazine flow to the thrusters, after Centaur is deployed a safe distance from the Orbiter. The arming mechanism is provided by the DUFTAS and is two-failure tolerant against inadvertent operation.

Inflight thermal control of the system is provided by multilayered insulation over the tank shell, periodic thruster warming firings, and spiral-wrapped, redundant line heaters. The reaction control system is tolerant of a thruster valve failure to open. Failure to close is protected against by series redundant solenoid valves on each thruster.

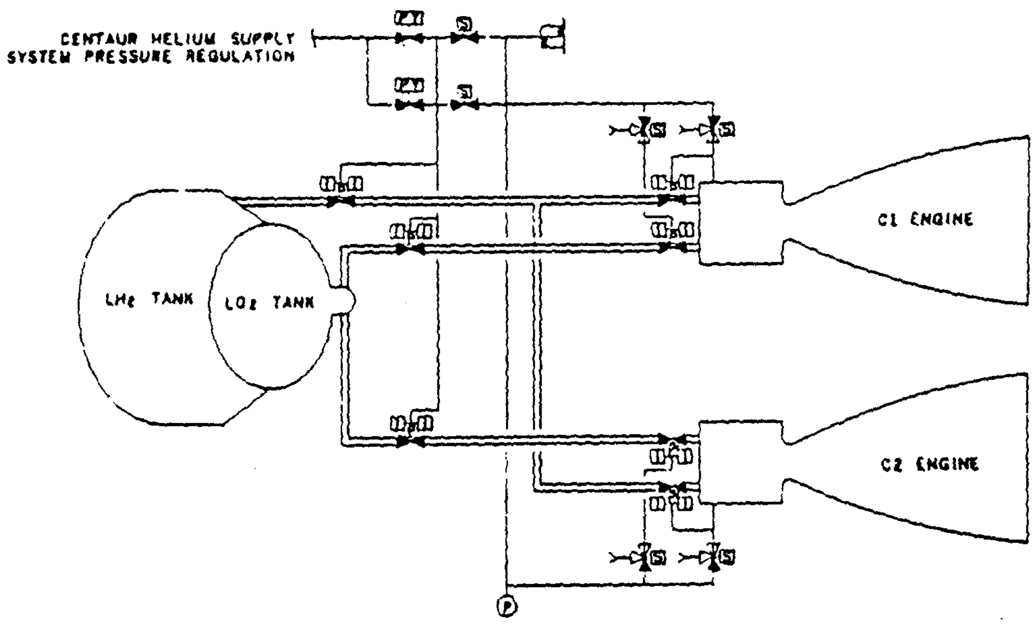


FIGURE II-8
PROPELLANT FEED AND MAIN ENGINE VALVE ACTUATION CONTROL

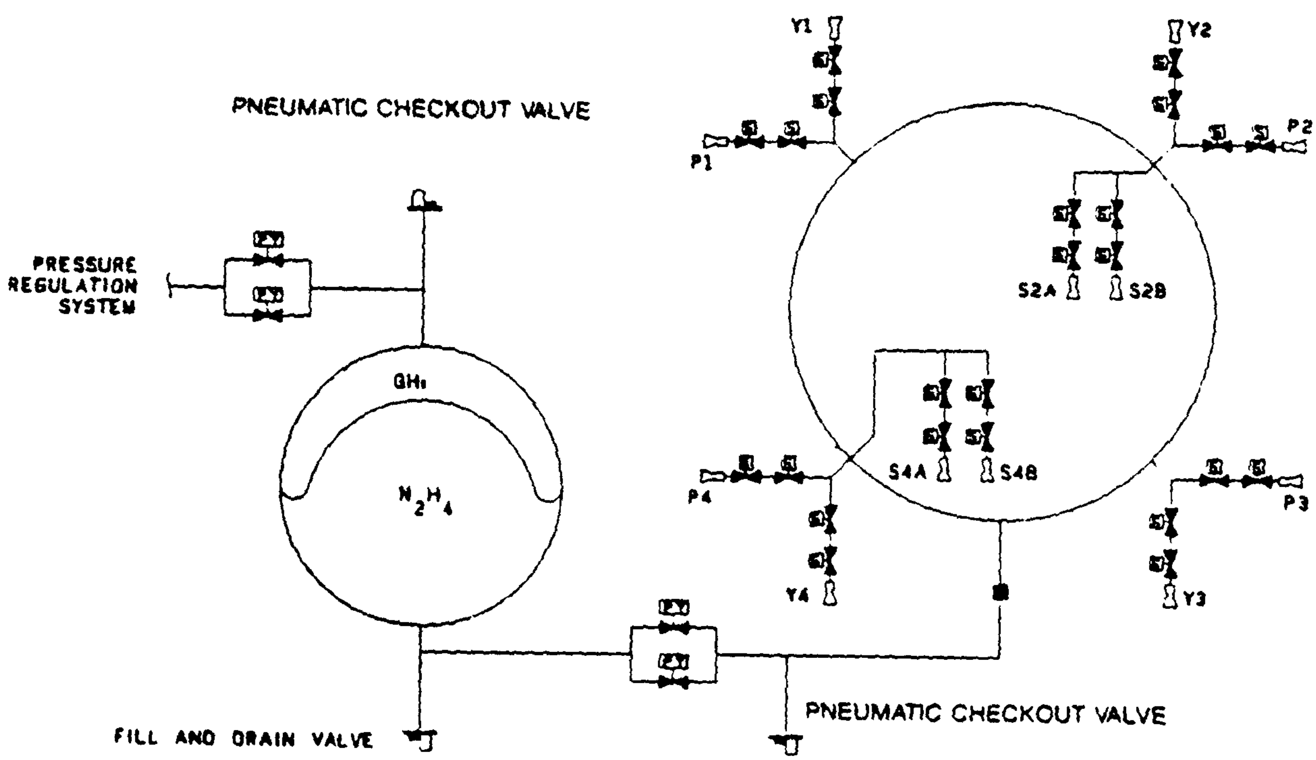


FIGURE II-9
REACTION CONTROL SYSTEM IS UNPRESSURIZED UNTIL SAFELY DEPLOYED FROM ORBITER

In that the reaction control propellant, hydrazine (N_2H_4), is th only toxic commodity aboard Centaur, it has been carefully considered fro the design and operational aspects to avoid personnel or environmental problems As shown, a number of safety items are incorporated such that the system i tolerant of a single failure without affecting system's operation. Since ma is in the servicing loop, the time of tank loading and stabilization is most critical. If a problem is encountered during the N_2H_4 loading operations, personnel and procedures exists to back out, dilute spills or offload as required. The chance of any such problem developing into a significant event for either personnel or the environment is small. Additionally, for the small amount of N_2H_4 present, any effect on the environment would be local and temporary. Personnel and hardware protection become the prime consideration. The N_2H_4, once loaded, remains aboard the vehicle during the remainder of its processing and transport. It is attended full time so that the appropriate emergency action may be initiated in the event a problem develops. First action is to clear the area of personnel to keep exposure levels below that listed in Table II-1. Once the area is cleared, follow-on action is determined by the indicated conditions. Experience has demonstrated that once hydrazine is tanked and its stability assured, that it remains stable and causes no difficulty with operations.

Vent Systems (Figure II-10) - Each propellant tank contains a mechanical self-regulating vent valve, with solenoid lockup capability for controlling ground and ascent venting. The valve is the same as that used on all previous Centaur vehicles. A pneumatically actuated open and spring-loaded closed ball valve provides backup ground and ascent vent capability.

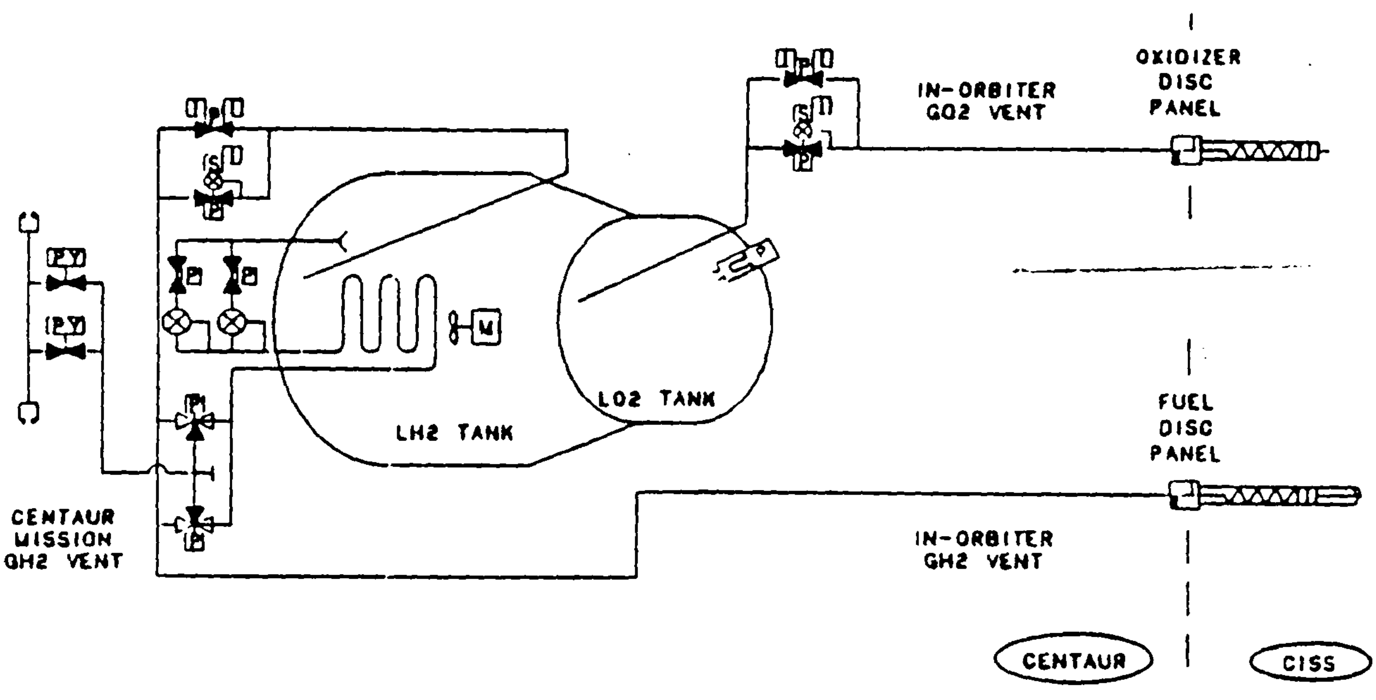


FIGURE II-10
VENT SYSTEMS PROVIDE REDUNDANT
GROUND, ASCENT AND ON-ORBIT VENTING

TABLE II-1

EXPOSURE CRITERIA FOR HYDRAZINE

THRESHOLD LIMIT VALUES

1ppm*

SHORT TERM EMERGENCY

OCCUPATIONAL PERSONNEL

30ppm - 10 min.
20ppm - 30 min.
10ppm - 60 min.

PUBLIC LIMIT

15ppm - 10 min
10ppm - 30 min.
2.5ppm - 5 hr/day, 3-4 day/mo.

PUBLIC EMERGENCY LIMIT

30ppm - 10 min.
20ppm - 30 min.
10ppm - 60 min.

*The American Conference of Governmental Industrial Hygienists, 1976 Listing, shows an intended change downward to 0.1ppm.

LH2 tank valves are mounted at the outlet of a standpipe that penetrates the LH2 tank through the aft conical section. The standpipe continues upward inside the LH2 tank to the underside of the forward bulkhead. The duct inlet will be covered with a baffle device to prevent liquid ingestion. The outlet of the valves are connected to a common duct that runs directly aft to a disconnect in the Centaur/CISS fuel umbilical panel. The disconnect contains a self-sealing poppet to provide backup shutoff capability after disconnect panel separation.

The LO2 tank valves are mounted on the outlet flanges of the LO2 tank vent standpipe and connect to a common duct that connects to a disconnect in the Centaur/CISS oxidizer umbilical panel. This disconnect in the panel also contains a self-sealing poppet to provide backup shutoff capability after Centaur separation.

The LH2 tank vent system contains an additional thermodynamic vent system for vent control while in a zero-g environment. The system consists of a heat exchanger with a parallel set of throttling regulators and shutoff valves at the heat exchanger inlet and a parallel set of three-way, penumatically actuated valves downstream of the heat exchanger.

The three-way valves route the GH2 through a balanced thrust vent system that also contains normally closed pyro valves to preclude venting in the Orbiter payload bay before Centaur deployment. The thermodynamic vent system also contains a dual-motor electrically-driven pump to circulate propellant through the heat exchanger and to maintain the LH2 propellant mixed to minimize the need for venting. This single-failure tolerant vent system has been sized to maintain propellant tank pressure control while in the closed door payload bay environment, which represents the maximum boiloff condition.

The thermal energy storage potential of the LO2 is such that the LO2 tank (in the payload bay environment) can absorb all energy input, if the propellant is adequately mixed. The LO2 tank will contain a pneumatically operated pulse-jet mixer.

From an environmental standpoint, the venting of gases—the elements oxygen, hydrogen, helium, nitrogen—either on ground or during flight is of no consequence. These pure gases are quickly mixed with air or expanded in space such that local concentrations are quickly returned to normal. No enviornmental impact results from venting. However, since venting of gases is often required as part of normal operations, safety precautions are always taken to preclude venting in manned areas. Additionally, hydrogen is only vented through a controlled system to a burner. During transfer from delivery trucks to the storage tanks some hydrogen venting could occur. Therefore, such transfers are carefully performed with minimum personnel.

Fill/Dump System - The fill/dump system is designed to ensure Centaur compatibility with all Shuttle abort modes that occur before vehicle deployment. The system has been sized to provide single-failure tolerant propellant dump capability within 300 seconds, or within 250 seconds with no valve failures—the minimum time allowed during a return-to-launch-site abort. With this system, a simultaneous dump of LH2 and LO2 can be accomplished safely while the Orbiter is above 100,000 feet altitude, which corresponds to an ambient pressure less than 0.1

psia. Extensive testing has demonstrated that a hydrogen-oxygen mixture will not ignite at pressures below 0.1 psia.

The fill/dump system is shown in Figure II-11. This high-flow capability, foam-insulated duct system and a parallel set of "normally closed" pneumatically actuated dump valves interconnect the LH2 and LO2 propellant tanks to a self-sealing disconnect in the respective Centaur/CISS fuel and oxidizer umbilical panels. Propellant loading and draining are accomplished through the same system during preflight operations. The self-sealing disconnects provide single-failure tolerance against inadvertent dumping after Centaur separation.

A small quick-disconnect is provided in each tank dump line to allow connecting the standby pneumatic control unit for manual and/or mechanical regulation of tank pressures when the automatic avionics control system is not in operation. The ports are sealed with dual-seal caps for launch.

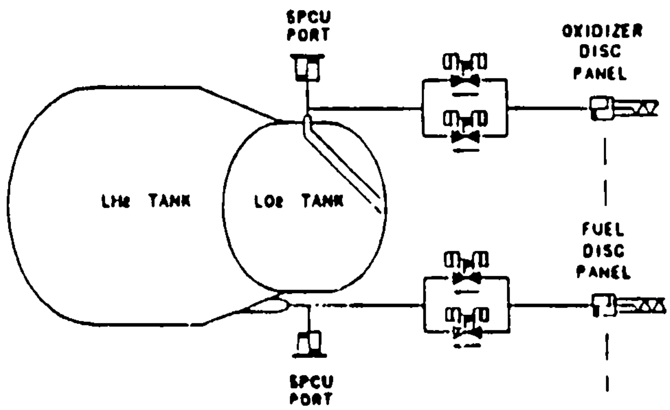


FIGURE II-11
REDUNDANT FILL/DUMP SYSTEMS PROVIDE REDUNDANT DUMP AND BACKUP PRESSURE RELIEF

While on the launch pad, loading or unloading of the vehicle is accomplished with inplace transfer systems. If a problem is detected, loading may be stopped and held at the condition or detanked as the situation demands. Any large loss of Centaur propellants by other than the transfer system would entail significant danger to Centaur and its ground support hardware if at Complex 36 or to the STS, payload and ground support hardware if at the launch site.

A catastrophe at the launch site caused by the Centaur vehicle would be identical to that caused by the STS and described in the KSC EIS. Though significant damage occurs to the launch site hardware and to the space effort itself, the enviornmental impact of this worst case on-pad condition is local and temporary. The same condition occuring at the tanking site on Complex 36 would be of less overall impact on both the Space Program and the enviornment.

<u>Overall Environmental Effects</u> - The vehicle systems described in the foregoing section are those that through normal operation, malfunction or accident could result in the release of commodities into the enviornment. Accordingly, they are presented in sufficient detail to show the level of design to assure their proper

operation and the controlled release of all commodities in the accomplishment of mission objectives. It is determined that the incorporation of the proposed Centaur into STS can be accomplished with the same or less environmental impact than exists today. This is primarily because of the long operational experience coupled with the many additional failure-tolerent systems which are designed into the STS version as shown in the system-by-system description. The most severe accidents identified would result in local and temporary impact only. No long term effects are identified.

In space expenditure by proper burning or dumping of the crogens impacts the enviornment less than that caused by the expenditure of hydrazine or solid propellants, though none of the quantities used are of much consequence. The ability to dump Centaur propellants in the event of a problem also provides a better abort configuration for STS and helps assure a safe landing with its potential for better crew, hardware and environmental protection.

4. Facility Modifications

The tasks of implementing the Centaur program involves the design, manufacture, assembly, testing and ground and flight operations. In fulfilling these various tasks, many people, locations, techniques and materials are employed, all of which have some degree of impact on the environment. For most locations of manufacture of the individual components, the task entails conducting business as usual with no additional requirements. However, some aspects of the program implementation require facility modifications of sufficient environmental significance to be considered separately and these aspects are discussed in the following sections. Contractors performing these modifications have a contractual obligation to be in compliance with environmental pollution control laws.

Prime Contractor, General Dynamics Corporation, Convair Division, San Diego, CA (GDC) - As prime contractor for the Centaur vehicles, General Dynamics Corporation's Convair Division is responsible for the overall design, manufacture, integration, assembly and checkout of the vehicle to specifications imposed by the Government Program Office. This responsibility is the same as that which has been in effect for both the Atlas and Centaur programs for both NASA and the DOD for the past 25 years. Design techniques, tooling, facilities, personnel, manufacturing, assembly and test areas are established and functioning in accordance with applicable regulations for production of the vehicle. Costs and scheduling associated with delivery of the articles are established. This well-defined background is the basis for planning and costing the new Centaur vehicle. In general, assigned areas for Centaur remain the same.

The hazardous test and development activity is performed at the test area in Sycamore Canyon in San Diego County to provide the necessary isolation for safety of operations along with the appropriate buffer zones. As with past vehicles, the Sycamore Canyon site will be used to demonstrate adequacy of vehicle design in the early phases of the program.

Changes to the General Dynamics facilities in San Diego are primarily tooling modifications to accommodate the change in Centaur tank geometry. Fabrication of all versions of the Centaur tank will continue at the GDC operated Air Force Plant 19 in downtown San Diego. After fabrication, the Centaurs are transported to the Convair Division's Kearney Mesa Plant in North San Diego for final assembly. Subsystem installation and checkout will be performed primarily in Building 5 of the Kearny Mesa Plant. The dock area will be modified to accommodate the new tank configuration. Changes to the existing pneumatic checkout equipment for testing the Centaur and CISS will be minimal.

The CISS will be supported in the test and transport fixture (TFF) during checkout and transportation. No hazardous operations are conducted at the Kearny Mesa facility.

Test facilities at the GDC Sycamore Canyon test area in San Diego County have been used for hazardous test and evaluation operations in support of many activities of the type required by the Centaur stage in STS. This facility will be modified so the Centaur may be properly mounted in the test fixture to undergo a series of tests as follows:

- Demonstrate structural integrity of Centaur tank and aft adapter components to ultimate loads.
- Perform rotation tests under varying installation misalignment, operating conditions and cryogenic flows to verify functional and structural integrity of the Centaur-to-CISS gimbal duct line and rotation loads.
- Demonstrate purge system capability to maintain insulation blanket delta-P under various conditions.
- Perform outflow tests with scaled LH2 and LO2 tanks to determine quantity of liquid being expelled as determined by tank residuals.
- Conduct individual LN2 and LH2 flow tests through a representative flight propellant dump system to verify predictions.
- Perform LH2 outflow test with simulated scale model tank to determine sump design.

The intent in these evaluation tests is to maintain control of the configuration at all times and to avoid catastrophic failures leading to equipment or environment damage. However, the nature of the tests accepts that such failure may occur during conduction of the hazardous operations and safety of personnel, equipment and environmental considerations are in effect. In addition, emergency crews and equipment are on standby to minimize damage from any unplanned test event. Minor to no environmental impact would result from any test failure being conducted. No engine firings will take place at this facility.

Engine Contractor, Pratt and Whitney Aircraft, West Palm Beach, FL - The engines planned for use with Centaur in the STS are those of the RL-10 series which have been successfully used for the past 20 years in the Centaur and Saturn programs. These engines are manufactured and acceptance test fired at the P&W facility in West Palm Beach, FL. Manufacturing techniques, tooling and plans for the Centaur engines are merely a continuation of those tasks performed to produce engines for the Centaur D-1 program. No new requirements, constraints, or component test methods have been defined which alter the degree of enviornmental impact over that which is presently accepted in the manufacture of the RL-10 and aircraft jet engines.

The test firings of completed engines is the normal method of acceptance of the final product and this requirement is imposed for engines that will be used in the STS/Centaur program. Test facilities exist nearby the P&W plant where engines are installed for hot firing to allow for thrust trimming and the determination of overall engine performance.

These test facilities have supported test and acceptance firings throughout the history of manufacture of the engines and are sufficiently isolated that the minor noise pollution exists in the test area only. Operational and safety procedures are well developed and experience has shown that the environment is not impacted by conduction or such hot firing operations. Toxic chemicals are not used. Handling of the cryogens is in accordance with standard operating procedure. The product of combustion of the engine firings is steam which is quickly cooled and returned to earth as water.

The engine test facilities, like most such facilities where hazardous operations and experimentation are conducted, are designed, instrumented and operated such that catastrophic failure can be avoided or somewhat contained to minimize facility damage while providing for personnel safety and environment protection. The use of the existing facilities in support of Centaur meets the goals of the program to use existing resources which are acceptable from a minimal environmental impact standpoint. No change to the present engine acceptance operation or to the facility is necessary.

RL-10 (E-6) Rocket Engine Test Stand - The active rocket engine test facility at P&WA/GPD used for RL-10 production and development testing is the E-6 test stand used solely for the NASA programs. This test stand has the capability to test liquid hydrogen/liquid oxygen rocket engines up to 25,000 pounds thrust and up to a simulated altitude of 60,000 feet ($\approx$1 psia). The structural capacity of the test stand is 150,000 pounds thrust. Engines up to 40" diameter and 70" in depth can be tested in the vacuum capsule. The maximum exhaust capture diameter is 40 inches. Altitude simulation is provided by an 85-pound per second, two-stage, steam ejection system which is used to evacuate the engine capsule and exhaust system to 1 psia. Steam is applied by steam accumulators which can provide the required flow for approximately 15 minutes. There are three 10,500 gallon accumulators and five 37,300 gallon accumulators which can be used in various combinations depending on desired run duration. Steam is generated by a nearby steam boiler which is used to charge the accumulators. Fire water and cooling water can be supplied at 18,500 gpm and up to 100 psig pressure. Propellant and pressurizing gas capacities are as follows:

Fluid	Capacity	Pressure
LO2	3,000 gallons	150 psig
LH2	10,000 gallons	150 psig
GH2	4 inch supply line	900 psig
GHe	0.15 lbs/sec.	1200 psig
GN2	3 inch supply line	900 psig

In addition, adjacent propellant/gas storage areas have the following capacities:

Fluid	Capacity	Pressure
LO2	14,000 gal	65 psig
LH2	90,000 gal	65 psig
GH2	210,000 scf	5000 psig
GHe	73,000 scf	5000 psig
GN2	145,000 scf	5000 psig

Maximum run duration is 650 seconds and is limited by the size of the E-6 propellant run tanks. Maximum propellant flow rates are 9.2 pounds/sec.

liquid hydrogen and 46 pounds per second liquid oxygen. A test crew of nine is normally required per shift to run the stand. Two full duration firing can be accomplished per shift and engine changeover can be accomplished in second shifts.

The data system has 86 analog channels with 10K Hz max frequency capability and 300 digital channels with a maximum sample rate of 25 scans/sec. There are 45 real-time display channels. On-line data reduction is limited to a computer which calculates engine trim conditions and provides closed loop control of engine thrust and mixture ratio.

The rocket test site encompasses an area of two square miles, with a minimum buffer zone of one-half mile. At present E-6 is the only active rocket engine test stand and is used for the RL-10 production and development testing. No change to this plan is expected.

Other Manufacturers and Suppliers - In the manufacturing of a complex launch vehicle stage, many companies are involved to supply components and/or systems within their particular area of expertise. Though parts are obtained from many manufacturers, in no case does a manufacturer exist where that product being supplied to the Centaur program represents the sole reason for the company's existence. Each supplier has other products and services available to other customers. In no case does the Centaur program impose any special test or requirement that involves a commodity of danger to the environment or personnel safety in excess of that which is standard and normal practice to the manufacturer. In this respect, the servicing of the Centaur program for STS has not required a change to normal operations by the individual manufacturers.

Cape Canaveral Air Force Station (CCAFS) facilities - Pad A of Complex 36 on CCAFS, designed and configured to support the Atlas/Centaur expendable vehicle operations for the past 20 years, will be modified for assembly, checkout and cryogenic tanking operations for the STS/Centaur stage only. This task entails the structural activity to install an STS type payload bay, handling gear and platforms to accommodate the Centaur stage. Rerouting of existing servicing lines is also required. No new materials, products or commodities will be required over that which has been used in the past. Though hydrazine is new to the Centaur vehicle, it has been used at the site before with spacecraft and is in use on Pad B with the version of Centaur used with Atlas.

An air conditioned environmental enclosure will be provided. Where feasible, the Orbiter/Complex 39 installation will be simulated. Included in this simulation will be the Orbiter bay liner and nitrogen purge, the transfer lines connecting the LO2 control skid, LH2 control skid, and helium control skid to the CISS and portions of the Centaur LO2 and LH2 tank ground vent systems.

The safety and security procedures of past operations will directly apply to STS/Centaur operations conducted on Pad A. Pad B will remain configured to support ongoing Atlas/Centaur operations.

Industrial Area Support - The industrial area facilities, primarily Hangars H, J and K, are adequately configured to support STS/Centaur as they are at present for Atlas/Centaur. Only new handling and transport gear is necessary. Support for both operations may proceed in parallel.

Ordnance and Propellant Storage - Propellants and ordnance items for Centaur are like those presently in use for the STS systems. Special areas for receipt, storage and transfer of these items do not require change as a result of STS/ Centaur implementation.

Kennedy Space Center (KSC) Facilities - At the Vertical Processing Facility, Rotating Service Structure, and Orbiter Processing Facility, the Centaur/CISS assembly will use existing KSC handling equipment. General Dynamics will provide the required slings and handling adapters. Access will be provided by existing work platforms with small portable workstands provided by General Dynamics where necessary. Interfacing the Centaur and CISS assembly with the facility pneumatic system will be accomplished with hoses provided, as required, by General Dynamics. Transport between the KSC facilities will be in the multi-use mission support equipment (MMSE) canister provided by KSC. Following a normal mission, the CISS will be removed from the Orbiter in the Orbiter Processing Facility using the MMSE strongback, and placed in the test and transport fixture mounted on the CISS transport pallet (CSTP) provided by General Dynamics for return to Hangar J.

Centaur propellants will be loaded and the airborne helium bottles charged during launch countdown at Complex 39. All fluids will come from Shuttle supply sources and will be controlled by the LO2, LH2, and helium control skids. Piping required to interface the skids with the Orbiter and supply sources will be provided by KSC. Hydrazine will be loaded at Complex 36A before CCA departure for KSC. Alternatives to loading the hydrazine at Complex 36 were thoroughly analyzed with the decision to tank early being based on the isolation needed to tank the vehicle coupled with the stability of the propellent once tanked and the experience gained with this technique in processing spacecraft. The longer exposure of personnel and hardware is preferable to loading during the last days of the STS countdown. As previously described, the system is fully attended with the proper safety and emergency procedures in effect.

Modifications to the launch facility are those to provide cryogenic, gas and electrical servicing to the Centaur stage while installed in the STS payload bay. New interfaces will be installed on the STS to mate with the ground facilities required by Centaur. Some new Centaur peculiar ground support interface equipment will also be installed in existing space. No land use assignment changes are required.

Land Assignments - NASA exercises authority over the entire 56,000 hectares (140,000 acres) which comprise the Kennedy Space Center (KSC). The U.S. Air Force exercises authority over the Cape Canaveral Air Force Station (CCAFS) property. NASA is assigned operational control of prime support areas for Centaur operations on CCAFS though modifications or any physical change in the assigned areas or changes which would affect the environment require both NASA and Air Force concurrance before such change is implemented.

All contractor and government installations required for the support of STS/Centaur are presently engaged in space launch activity which encompass all the materials, commodities, procedures and operational techniques needed to perform the STS/Centaur operations. Therefore, the "hands on" safety, security and processing requirements and policies are well defined for the operational mode in all assigned areas. Implementation of these existing policies and regulations for STS/Centaur will assure the continual protection of man, the hardware and the immediate enviornment in which each task is performed.

For the larger environment, certain policies also apply and were elaborated in the EIS for KSC as follows:

(1) Merritt Island National Wildlife Refuge.

(2) Canaveral National Seashore.

(3) Coastal Zone Management.

(4) Floodplains and Wetland Restrictions.

(5) Mosquito Control.

The Centaur program is responsive to KSC management for any impact in these areas.

NASA's Apollo Launch Complex 39 has been listed in the National Register of Historic Places. To accommodate Space Shuttle operations, modifications to the site were required. NASA entered into the appropriate agreements for those modifications in accordance with procedures for compliance with Section 196 of the National Historic Preservation Act of 1966. The addition of the Centaur stage integrated with STS and its supporting modifications do not impact or alter previous agreements or changes to the facility from the Historic Site aspect.

Overall Environmental Effect - Facility requirements to implement the Centaur in STS program are minimal and consist entirely of modifications to existing facilities to accommodate the new tank geometry and commodity interfaces. No changes in the operational usage of the facilities for either manufacture, test, checkout or launch is required. The minor temporary disturbance of an area during the modification task is local only and quickly re-stabalized at completion of the construction task. The launch pad is deactivated from its launch capability of the expendable vehicle version of Centaur.

5. General Operations

Shipment to the launch site of the vehicle and most of its supporting commodities are separately accomplished. Storage of each is in a designated area until the vehicle is moved to its checkout site and the need for a particular commodity arises. Examples of material shipped directly to the launch site and held in joint-use facilities include cryogens, gases, hydrazine, pyrotechnics and various cleaning agents. The implementation of Centaur for STS does not use any new product or commodity not already in use where adequate receipt, transfer, storage and handling facilities exist in sufficient capacity to allow for use by the Centaur program. Use of these commodities does not alter previously submitted Impact Statements submitted by the Kennedy Space Center and the Cape Canaveral Air Force Station.

Chemical waste products from the Centaur project are disposed of by turn-over of such products to the appropriate KSC or CCAFS disposal units. The alternative of implementing procedures and equipment for final disposal by the project is not cost effective. Existing resources for chemical waste will be used.

Vechicle Receipt - Normally before the flight vehicle is received at the ELS, the ground facilities and equipment needed to process and checkout the flight vehicle will be validated to assure their correct operation in all aspects of their use including the flow of cryogens throughout the transfer systems. Vehicle and CISS simulators are used to verify the correct interfaces with the controlling computers. The propellent skids, used to transfer propellants, are also validated prior to installation at the launch site on Complex 39. Figure II-12 depicts receipt of Centaur through transport to Complex 36.

Checkout and Servicing - The prime build-up and checkout facility is Pad A on Complex 36. Here, following transport of the Centaur stage, it is erected and mated with the CISS. Systems build-up is completed along with leak and functional checks. A cryogenic tanking operation is performed to validate the fluid systems and to demonstrate capability to prepare the stage for launch by an active countdown demonstration. Hydrazine servicing is also performed along with transport and readiness to mate with spacecraft operations. Alternatives to tanking hydrazine at Complex 36 were thoroughly evaluated with the decision being it could be more safely and timely accomplished at this location. The cost is the additional system's nonitoring throughout the remainder of the vehicle processing.

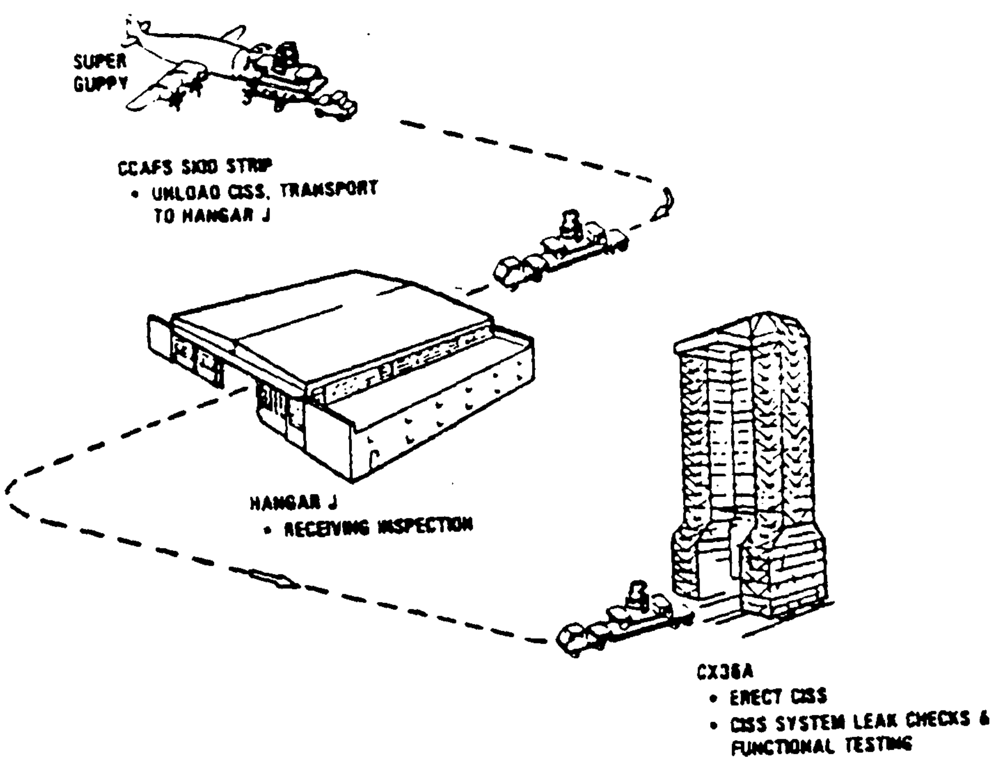


FIGURE II-12
CENTAUR RECEIPT AT ELS

One additional consideration from an environmental standpoint, which was evaluated was to limit the integrated testing at Complex 36 and thereby prevent one exposure of the environment to the potential of problems existing from the tanking and detanking of the vehicle.

However, failure to perform a tanking operation at Complex 36 would essentially be exposing an unverified vehicle to a first tanking out of view in the Orbiter payload bay. Such risk has been deemed unacceptable. The additional cost and introduction of the hydrogen, oxygen, helium and nitrogen vent products into the local environment are considered acceptable.

Most electrical energy for routine operations for the Centaur program is generated off-site by the Florida Power and Light Company. This electrical power is supplemented and backed up by on-site diesel-fueled generators. The alternate conditions of supplying all power from on-site generators rather than just as needed for critical operations has been determined not to be cost effective. Existing resources for electrical power will be used.

Following completion of build-up and checkout at Complex 36, the Centaur is transported to the Vehicle Processing Facility (VPF) for the major functions of mate to the spacecraft, transfer to the transport canister and transport to the launch pad. Additional activity at VPF includes final cleaning before spacecraft mate and some interface testing with the spacecraft and Orbiter simulators. At times of installing or removing from the VPF cells while hydrazine is loaded, extra care is taken in that emergency crews are on standby to quickly tend to any accident which may involve the hydrazine system. This protection is required by safety procedures to best protect both personnel and the environment.

After completion of testing at the VPF facility, the combined cargo element is transported to the launch site for installation into the Orbiter payload bay to be made ready for launch. Minor checkout is performed though a considerable amount of final servicing is required before payload bay door closure and launch of Centaur. The overall Centaur flow at the launch site is as shown in Figure II-13.

Final operations at the launch site are integrated into the overall STS countdown activities with completion of all requirements culminating in launch of the overall mission element.

Normal Operations - Normal processing of the Centaur vehicle requires the expenditure of propellants (hydrogen and oxygen), and gases (over 99% of which are nitrogen and helium). At release of these commodities, a very localized concentration exists which is quickly dispersed by convection. Safety procedures are in effect for personnel and equipment protection when using or venting these commodities.

In support of these normal operations, gasoline and diesel engines are required for transportation, power generation and equipment handling, which results in some adverse effects from the engine emissions. Lubricants, cleaners and paints are also used resulting in their normal contribution to adverse environments.

Impacts upon air and water quality, noise, topography and soils are those associated with the facilities required to support a 400-man operation performing tasks as previously presented. No unusual requirement exists, other than special safety procedures, to implement vehicle processing. Environmental constraints for this 400-man crew are essentially in effect today since many facilities, equipments and personnel will be shared with the existing expendable vehicle program presently operating.

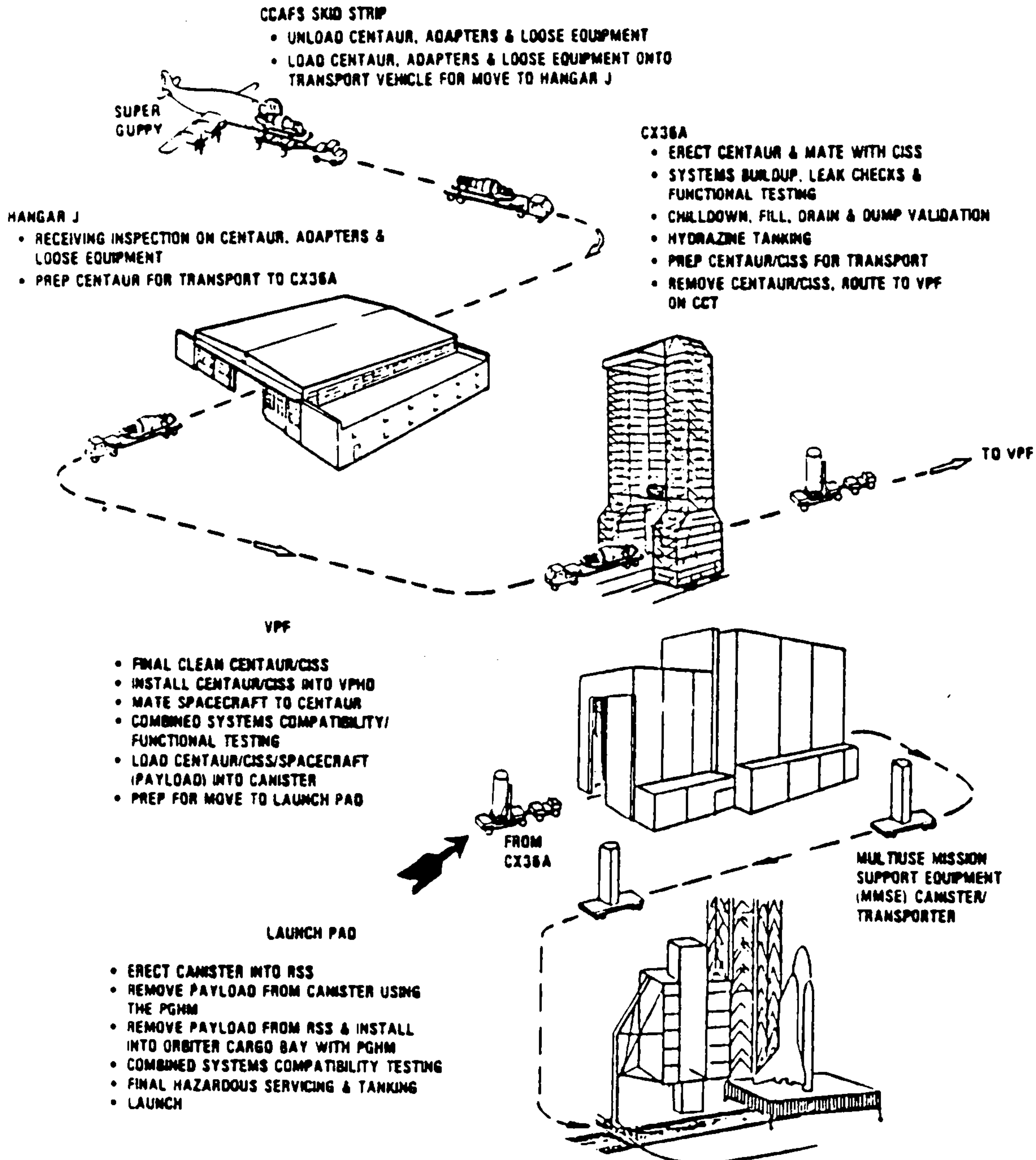


FIGURE II-13
OVERALL CENTAUR FLOW AT THE LAUNCH SITE

Safety Zones for Cryogenic and Launch Operations - Presently at Complex 36, protection of man, hardware and environment is assured by operating procedures to provide area clearance for cryogenic tanking operations and vehicle launch. Additionally, contingency elements are on standby to handle any unplanned events which may occur. The standby crews are equipped to handle emergencies for personnel injuries or spread of fires or toxic environment. These procedures will be in effect for operation on the CCAFS for Centaur.

In support of ongoing STS operations, safety and security zones are presently defined and controlled during all aspects of STS processing. For STS launch, certain air and sea restrictions are also in force. Centaur operations on KSC will be subject to these same regulations and will be integrated into the overall STS operations. No change to these controls are required as a result of Centaur integration.

Preparation of the Centaur vehicle at the launch pad essentially duplicates the propellant tanking operation previously conducted at Complex 36. However, rather than detank propellants at completion, the propellants are secured after tanking in the Orbiter payload bay for later use in orbit. As discussed earlier, the propellants and gases used by Centaur are the same as those required by STS. In the event of an accident the results would be as reported in the KSC Environmental Statement with a 3% to 4% increase in overall severity.

Catastrophic Accidents - The most devastating accident while at Complex 36 would need to occur during a propellant tanking operation to verify the vehicles' readiness for flight. Worst case would be mixing of the hydrogen and oxygen and an ignition source. The resulting fire and explosion would cause significant facility damage but would be limited to the Pad A area of Complex 36. No personnel or environmental damage is to be expected. Without an ignition source, mixing of hydrogen and oxygen or, most likely, a spill of one of the propellants would produce a hazardous condition until evaporation and securing of the operation.

A second catastrophy could result from a large spill of hydrazine during servicing at Complex 36 or while in the VPF. The toxic environment created is more of a threat to operations personnel than to any but the local environment. Procedures would be in effect to quickly identify the emergency to minimize the damage to personnel and equipment. Tanking hydrazine at other locations such as the VPF or launch pad to minimize tanked time have been carefully analyzed. Minimum risk exists with the choice for tanking at Complex 36.

Overall Environmental Effect - Over 20 years experience with launch operations of the Centaur stage has demonstrated both near and long-term assurance that the operations task can be performed with insignificant impact to the environment. In fact, any impact which exists is that associated with accommodating the launch crew and the special tooling necessary to checkout and process the vehicle. Strict controls and operating standards are rigidly enforced to provide a high degree of safety to the crew, the hardware and the environment. The quality of the environment receives a great deal of consideration in routine operations and its protection is assured.

6. Mission Performance

Centaur can inject 5,622 pounds of payload into an Earth-escape orbit with an energy of 80 km^2/sec^2 for launches from the Eastern Launch Site using a 130-nmi circular, 28.5-degree inclined parking orbit supplied by the STS. The Shuttle lift requirement for this application is 65,000 pounds, as indicated by the weight summary of Table II-2. Figure II-14 presents the orbital energy capabilities of the Centaur for payload weights up to 6,000 lb. Mission requirements for the 1986 Galileo mission and the 1986 International Solar Polar mission (ISPM) are included. Centaur propellant margins for Galileo and ISPM are reflected in Figure II-15.

Additionally, Centaur can inject approximately 13,500 pounds of payload into a geostationary orbit (circular, zero inclination) for launches from the Eastern Launch Site, departing from a 130-nmi, 28.5 degree inclined parking orbit supplied by the STS. The Shuttle lift requirement for this application is 65,000 pounds.

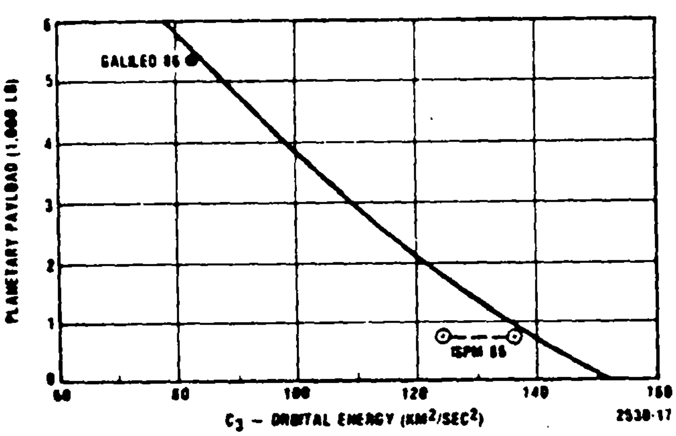


FIGURE II-14
CENTAUR PLANETARY
PERFORMANCE

Item	Weight (lb) One-Burn Galileo	Weight (lb) Two Burn Geosynch
Total loaded weight	65,000	65,000
Total support weight	9,058	8,868
Spacecraft airborne support equip	1,027	837
Centaur airborne support equip	8,031	8,031
Total vehicle weight	55 942	56 132
Spacecraft gross weight	5 534	13,457
Centaur tanked weight	50 408	42 675
Centaur dry weight	5 839	6 091
Centaur residuals	616	733
Centaur expendables	43,953	35,851
Propellants	43,831	35,598
Main impulse (1)	43,216	34 738
Other	615	860
Hydrazine	120	250
Helium	2	3

(1) Offloaded 9,820 lb for geosynch and 1,620 lb for Galileo

TABLE II-2
CENTAUR MISSION
WEIGHT SUMMARIES

Flexibility - Zero Inclination and Eccentricity - Figure II-16 presents geosynchronous performance capability as a function of final orbit inclination to show the sensitivity for other than equatorial missions.

The versatility of Centaur software and the excess payload for existing missions provide mission flexibility by allowing many options for Contingency planning. For example, Centaur software capability increases mission flexibility by allowing Centaur deployment and/or mission initiation on successive revolutions in the parking orbit. Orbit parameters can be selected automatically from previously validated multiple-targeting sets as a function of time to account for mission initiation delays. Software for contingency options has been flight-proven; typical examples are automated in flight re-targeting capability for High-Energy Astronomical Observatory (HEAO) launches (Atlas/Centaur) and provision for contingency parking-orbit revolution for Voyager launches (Titan/Centaur).

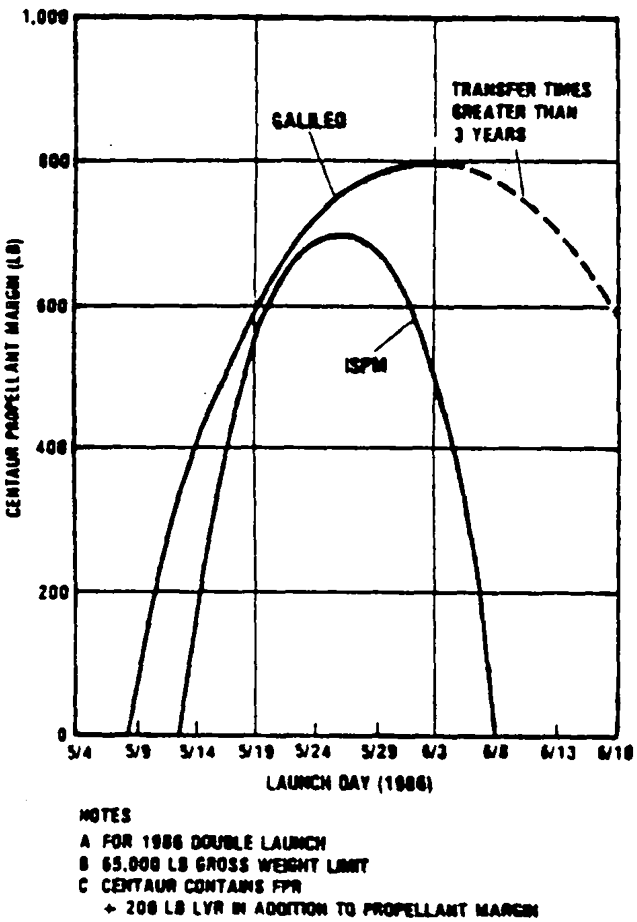


FIGURE II-15
CENTAUR PERFORMANCE MARGINS

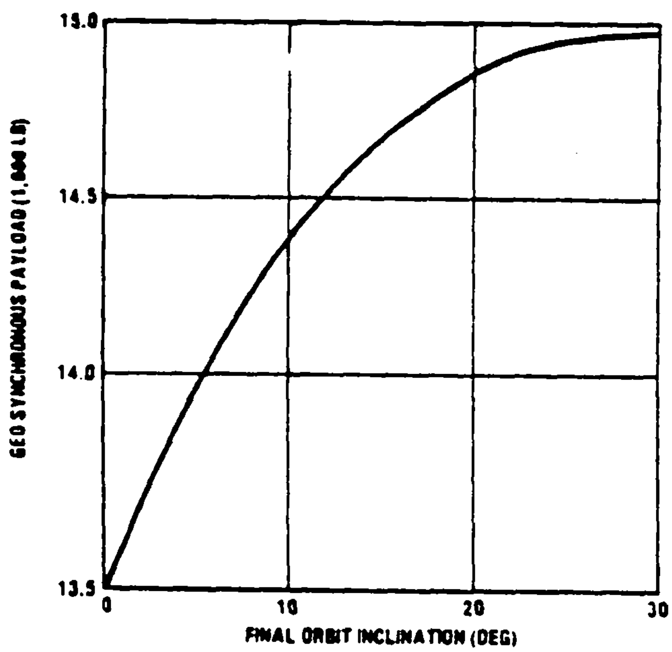


FIGURE II-16
CENTAUR GEOSYNCHRONOUS
ORBIT CAPABILITY

Normal Flight Sequence - Nominal CCE flight operations are continuous from launch through orbit injection and postseparation maneuvers. The CCE is limited to safety functions such as passive navigation, vent control and pressurization control until the crew assumes an active role in CCE on-orbit predeployment operations. Based on Shuttle flight requirements for ascent phase and on-orbit reconfiguration, the earliest time that CCE on-orbit predeployment operations can begin is 1 hour 17 minutes (all times referenced to liftoff). Nominal flight operations from this point on are illustrated in Figures II-17 through II-20.

From liftoff through Centaur predeployment operations, the Mission Control Center (MCC) and the Centaur/Payload Operations Control Center (CPOCC) will monitor the health and safety of the CCE via the telemetry link. The crew also has independent access to status information via a CRT display and can act as a backup source during attached operations.

Figure II-17 illustrates the Orbiter crew control/interface for the Flight operations by means of the standard switch panel or through the Orbiter keyboard. Switch-initiated actions are identified by asterisks in Figure II-18 and II-19, along with an outline of the computer-controlled automatic sequences.

Figure II-19 shows the Centaur checkout and deployment operations required to deploy a Centaur with the Galileo spacecraft. Also shown are the Orbiter support operations required (e.g., reorientation maneuver, Orbiter RCS inhibit times, etc.), Orbiter crew control functions (denoted by asterisks), and two go/no-go key decision points: (1) to initiate the rotation operation at about 33 minutes before Centaur separation and (2) turn off RTG cooling at about 13 minutes before separation.

The deployment timeline is based on the reference Galileo mission, with the Centaur main engine start (MES) consistent with mission requirements.

All Flight operations requirements, both generic and mission-peculiar, are met by this sequence. This includes requirements for crew initiation of events, Centaur platform alignment (star scan in the earth's shadow) to meet the mission FOM, deployment attitude thermal control for the spacecraft, and Centaur separation in daylight.

Figure II-20 illustrates operations from Orbiter/Centaur separation to Galileo spacecraft separation. Centaur coast attitude and sequence times are appropriate to meet spacecraft thermal constraints. Centaur separation coast and inhibit/arm sequence times are sufficient to ensure Orbiter safety constraints before MES, and can allow additional revolutions in the parking orbit. If the nominal deployment opportunity is lost, additional contingency deployment opportunities with Centaur may be realized.

Two Orbiter postdeployment operations are required after Centaur separation: (1) Orbiter maneuvers away from the Centaur without contaminating the spacecraft, and (2) the CISS will be in a safe mode for atmospheric reentry and landing (e.g., venting the pressurant bottles and lines to atmospheric levels).

After Orbiter landing, the CISS will be removed from the Orbiter and returned to Hangar J as shown in Figure II-21.

Environmental Effect - Expenditure of the propellants and gases in the normal flight sequence results in local concentration of emission products along the flight path. These water and helium emissions are quickly dispersed without any long-term environmental effects.

For normal operations, the Centaur stage is expendable and will remain in an earth or solar orbit relatively intact. Power and residuals will be depleted such that the stage will be space debris. It will be continuously tracked as part of the overall space tracking network. In the event of a catastrophic explosion, debris would be scattered over large areas. The amount which would re-enter the earth's atmosphere depends upon where the accident occurs. The effect the residual debris would have upon the overall environment is small.

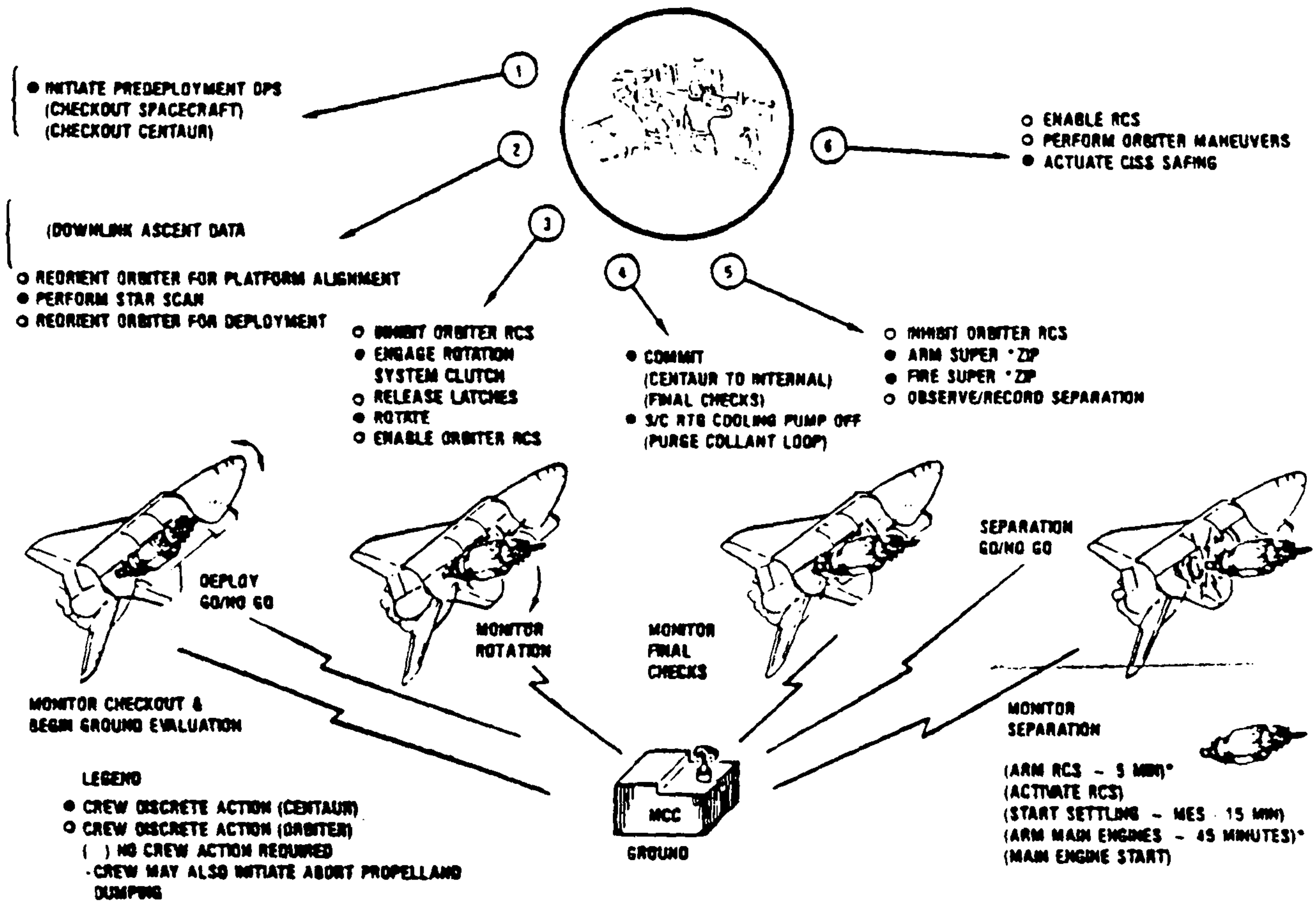


FIGURE II-17
ORBITER CREW HAS OPERATIONAL CONTROL OF CRITICAL FUNCTIONS

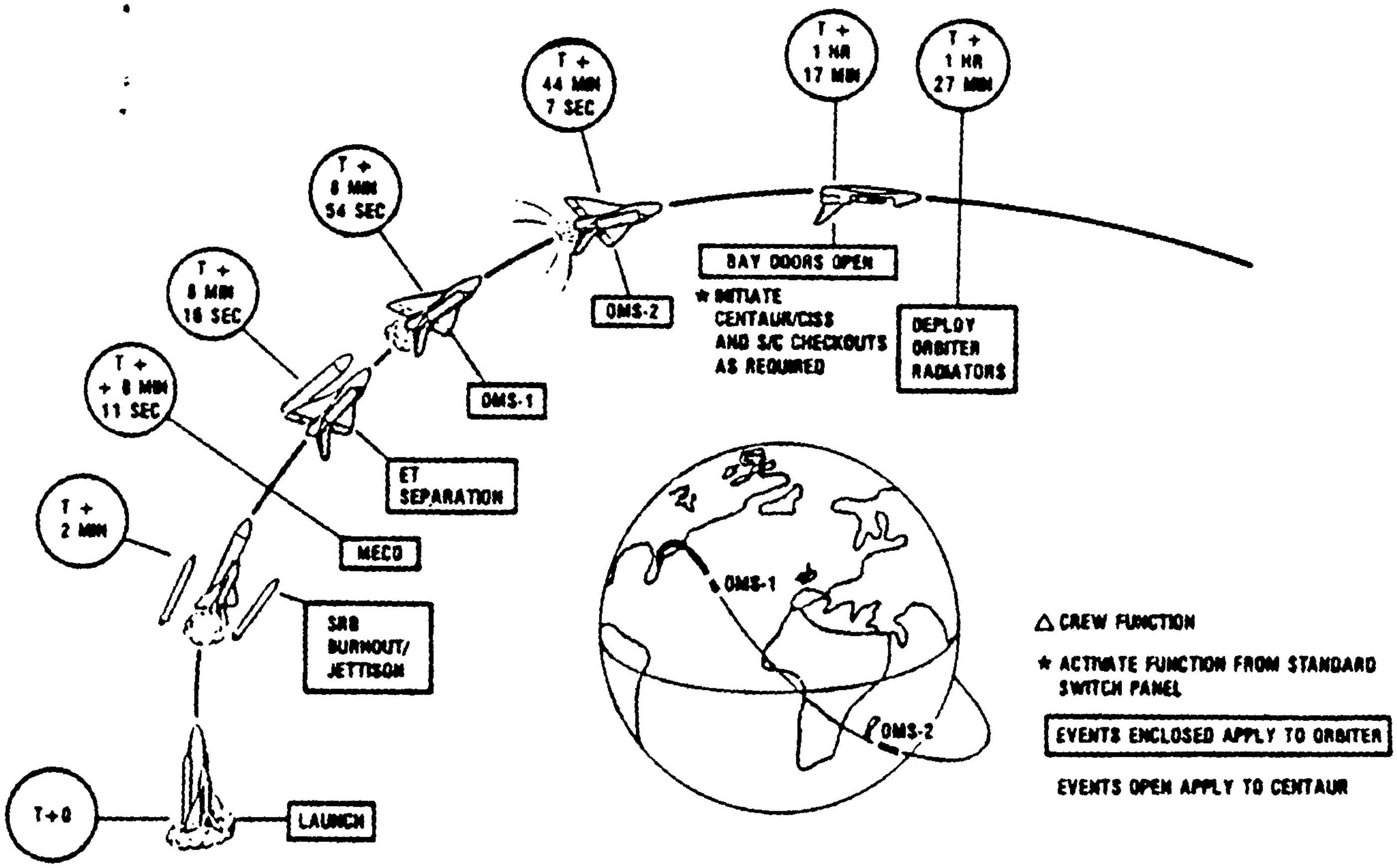


FIGURE II-18
NOMINAL CCE ASCENT OPERATIONS
ARE INDEPENDENT OF ORBITER OPERATIONS

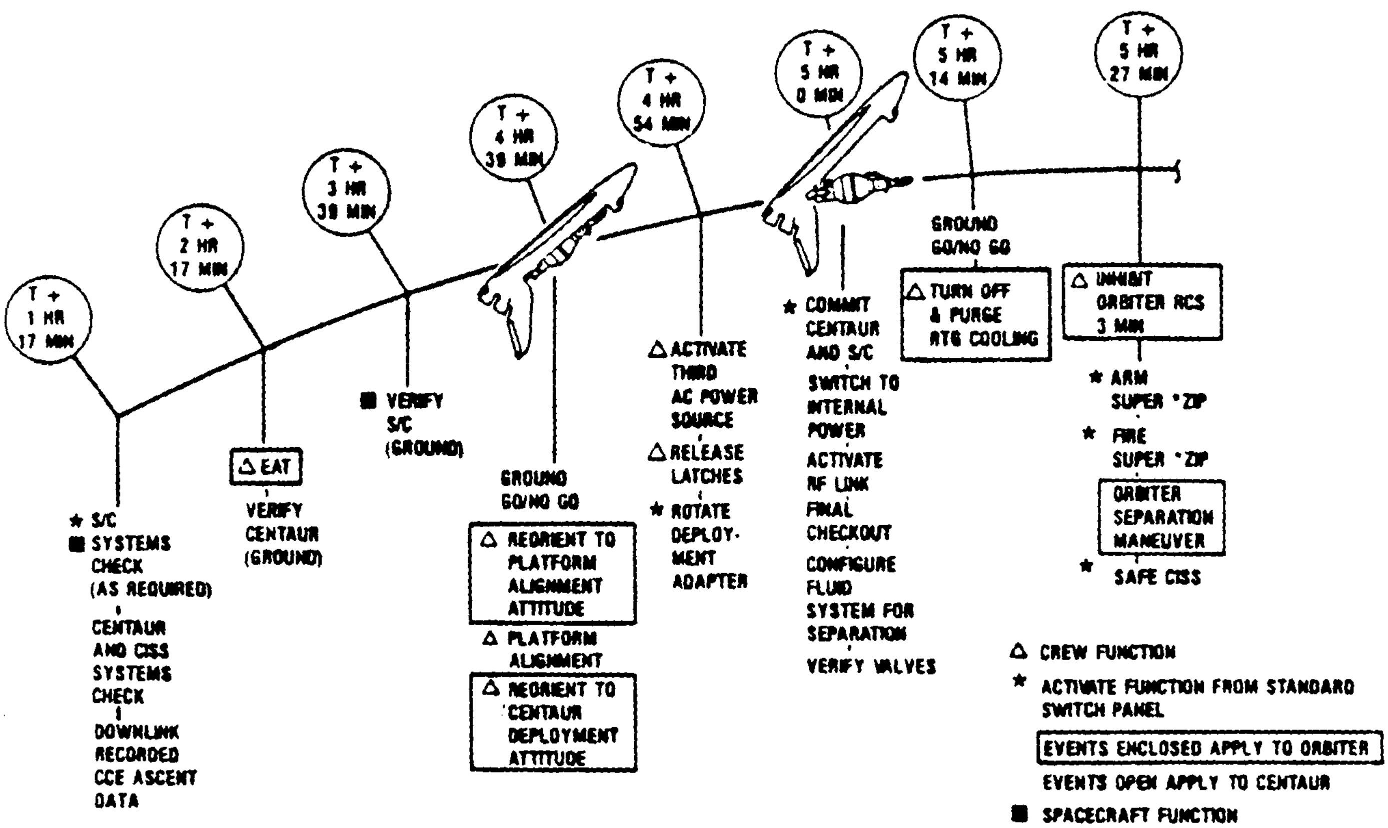


FIGURE II-19
CENTAUR WITH GALILEO
IS PLANNED FOR DEPLOYMENT ON REVOLUTION 4

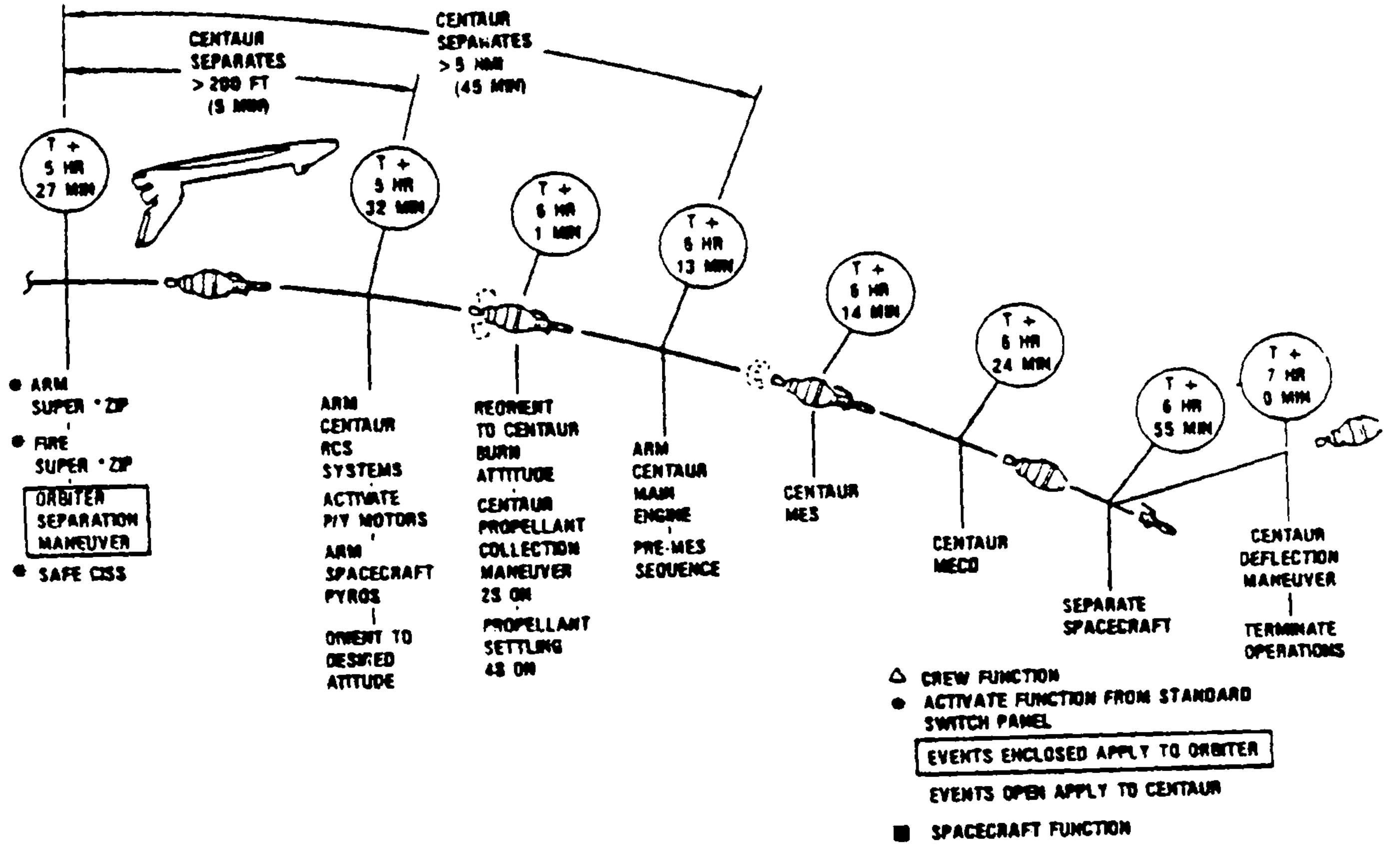


FIGURE II-20
NOMINAL CENTAUR POSTDEPLOYMENT OPERATIONS
ARE INDEPENDENT OF ORBITER OPERATIONS

Abort Operations - The Centaur vehicle servicing requirements are an integral part of the Orbiter safing and securing procedure following the return from an abort (Figure II-21). At the Shuttle Landing Facility, the Centaur/CISS system status will be assessed via telemetry data. Within a short time after Orbiter landing, access will be required to the Orbiter aft fuel T-0 panel to connect a gaseous helium charge line to replenish the CISS helium supply. Following confirmation that all safety requirements are met, the Orbiter is towed to the Orbiter Processing Facility.

In the Orbiter Processing Facility, the Orbiter is prepared for Centaur/CISS spacecraft assembly removal. The assembly is removed and placed horizontally in the multi-mission support equipment canister, then moved to the Vehicle Assembly Building, where the canister is rotated to the vertical position. In this configuration, the assembly can be returned to the VPF for spacecraft removal and subsequent refurbishment and checkout as required.

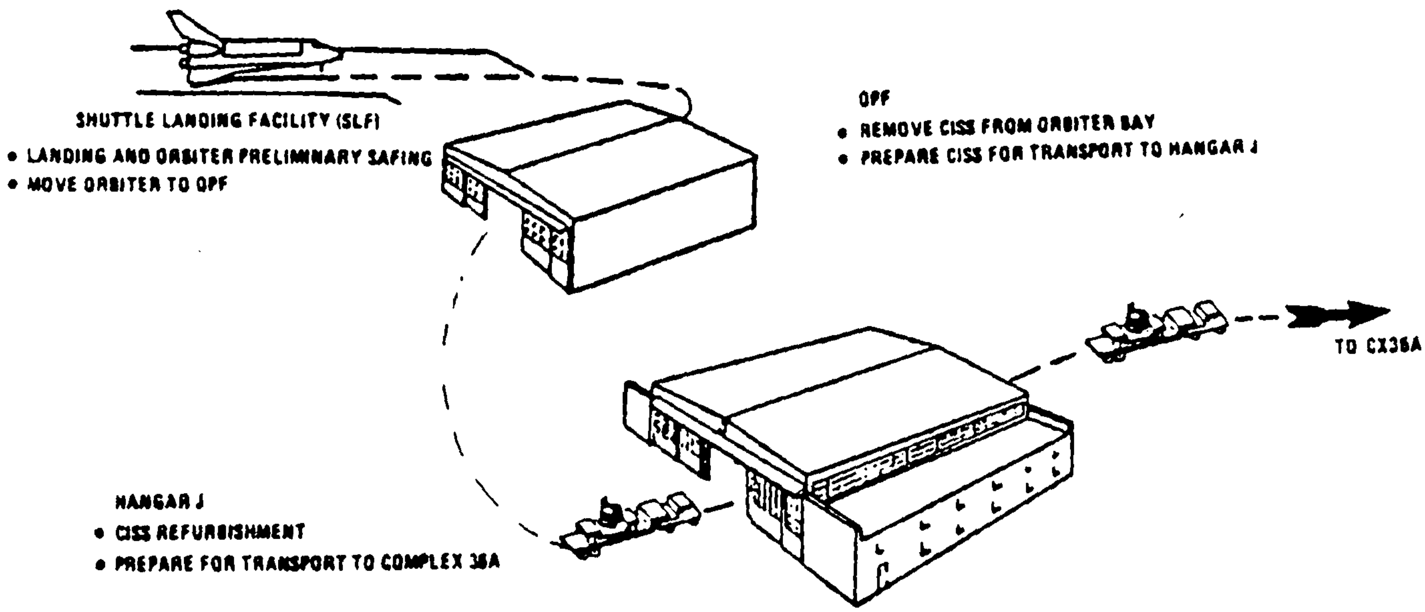


FIGURE II-21
CISS REMOVED FROM ORBITER IN THE OPF

The primary abort objective is to land safely with the spacecraft, Centaur, and CISS intact and reusable (after refurbishment) for a later flight. The Centaur/spacecraft can be restowed in the Orbiter payload bay up to the time of physical separation of the Super*Zip separation ring.

CCE flight operations will be developed for five preplanned Shuttle abort modes:

(1) Return to Launch Site (RTLS).

(2) Trans-Atlantic Abort Landing (TAL).

(3) Abort Once Around (AOA).

(4) Abort to Orbit (ATO).

(5) Abort From Orbit (AFO).

A deployment backout sequence will be developed that can be performed at any time from a normal deployment sequence. This backout sequence will be computer controlled, leaving the Orbiter crew free to attend to Orbiter operations; however, a certain degree of CCE support may be required to manually back up abort operations; e.g., initiate Centaur propellant dump.

To return with the CCE intact, a Centaur propellant dump is planned before reentry for AOA and AFO aborts, or before Orbiter main engine cutoff for RTLS and TAL aborts. Analyses of this propellant dump capability have been made for all preplanned Shuttle abort modes, as illustrated in Figure II-22.

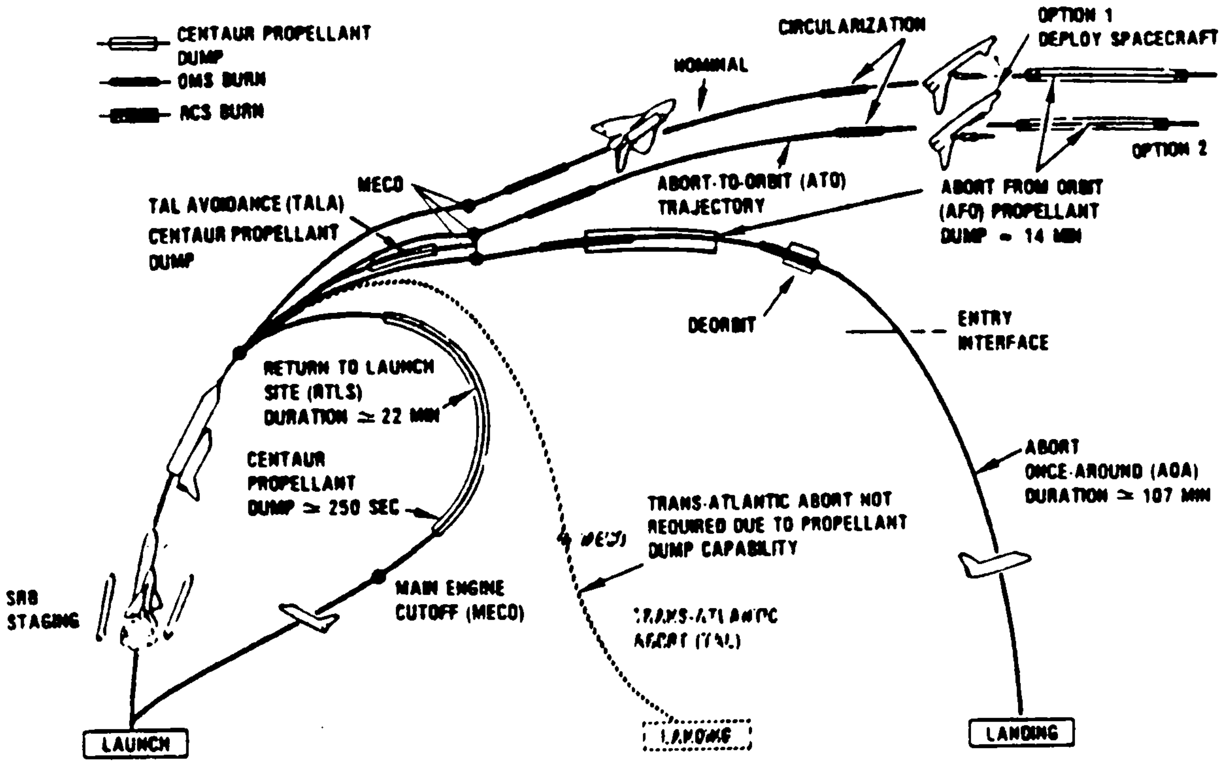


FIGURE II–22
CENTAUR CAN DUMP PROPELLANTS
SAFELY IN ALL ABORT MODES

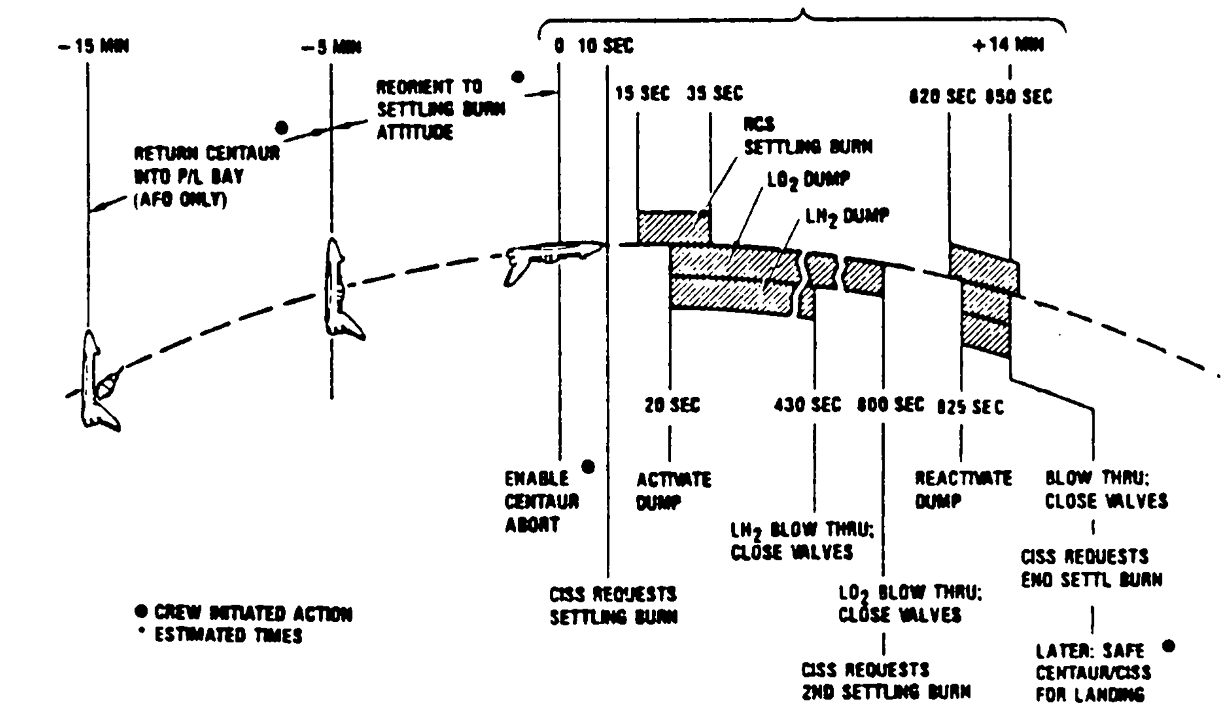


FIGURE II–23
ZERO–G PROPELLANT DUMP REQUIRES
TWO SETTLING BURNS

Centaur nominal dump time of 250 seconds during RTLS and TAL aborts, is usually completed before MECO. (The TAL mode may be virtually eliminated by dumping Centaur propellants and continuing into an ATO or AOA mode.) The dump system can operate in a zero-g environment (on-orbit, Figure II-23), but requires a settling acceleration at the start and end of the dump to minimize residual propellants. These settling burns may be provided by either the Orbiter RCS (AFO mode) or by the orbital maneuvering system (OMS) during normal OMS burns (AOA mode).

An abort to orbit may still result in a successful mission. When an ATO is caused by non-mission-critical functions, the Orbiter can remain in its 105 nmi ATO orbit from five orbital revolutions up to one day; consequently, Centaur can proceed with deployment and perform the Galileo mission. All planned abort operations are in accordance with contingency requirements.

The STS uses a caution and warning (C & W) system that will require CCE inputs. The criteria for issuing a C & W signal will be programmed into the safety and health status software of the CUs. This evaluation will be provided to the Orbiter crew and to the ground MCC/CPOCC; specific systems will be identified and their tolerance condition indicated. The crew and ground support can also review the status data on any CRT display to highlight critical items. Alternative flight plans will be developed for such possible contingency conditions and will be included in the Flight Operations Support Annex.

Environmental Effect - In the event of a requirement for orbiter abort, the Centaur propellants will be dumped overboard prior to landing. Emissions in this case are hydrogen, oxygen and helium. Again the localized concentration of these elements would be quickly dispersed without long-term environmental impact.

7. Safety and Quality

Safety - The system's safety program for Shuttle/Centaur will ensure that Centaur will generate no hazards that will endanger the personnel, Space Transportation System or the environment.

This level of safety will be achieved by incorporating the system safety engineering discipline into the detailed design, assembly, test and ground and flight operations of Shuttle/Centaur.

System's safety requirements of both NASA and the Air Force are common and well defined in NHB 1700.7A, "Safety Policy and Requirements for Payloads Using the Space Transportation System," which is the document accepted by both agencies.

The hazardous aspects of operating a cryogenic upper stage in the STS have been under analysis since the initial Space Tug studies of 1972. This analysis has determined that Centaur can safely operate as an STS element. As detailed safety requirements have been identified, the design of the current Atlas/Centaur has evolved into the STS Centaur to satisfy them. Early studies led directly to the 1982 Phase 1 safety review to the requirement of NHB 1700.7. The review of the Centaur vehicle and airborne and ground support equipment was conducted by both the Johnson Spacecraft Center (JSC) and KSC Safety

Committees. They concluded the Centaur can safely operate from the Orbiter payload bay.

The integrity of the propellant tanks to contain cryogenic fluids and the validity of the tank analyses have been demonstrated over the last 20 years with launches using both Atlas and Titan boosters.

Redundancy to provide the safety necessary for Centaur has been provided in the fluids, mechanisms, and CISS avionics systems. Appropriate parallel and series valves have been added to the tank pressurization, vent and drain/dump functions to ensure that valve failure does not lead to a hazard. Mechanisms for erecting the Centaur are also redundant to achieve the required failure tolerance. CISS avionics control these systems. The avionics has been designed to be fully independent of the Centaur guidance, navigation and control system. This separation allows the critical flight functions to be accomplished by the fault-tolerant CISS system before Centaur/Orbiter separation. No matter what the condition of the basic Centaur avionics, the CISS will retain control and prevent the occurence of hazards. CISS control functions are implemented by five control units that allow 3 out of 5, or 2 out of 3 voting to accomplish the required control redundancy.

The system's safety program will build on our preliminary safety studies. Hazard reports will continue to be generated as hazards are identified and closed out when appropriate preventive measures are defined. Hazard identification will be accomplished using failure modes and effect analysis (FMEA), engineering analysis, and specific safety analysis. Periodic reviews of the hazard reports by customer agencies will be accomplished.

The task of identifying all potential hazard causes and their inter-relationships is a primary concern. Qualitative fault tree analysis will be performed to systematically examine the causes of hazards and their relationships. The fault trees allow confirmation that the required level of fault tolerance has been achieved, and that failure causes are, indeed, independent. The end events of the fault trees will be related to the hazard reports as a cross-check to ensure that all basic failure causes have been identified.

CISS avionics control all functions that impact Orbiter safety. To ensure unconnected events do not occur, a sneak circuit analysis of the CISS avionics will be performed. This technique has been successfully used in other programs, such as the Atlas E/F, cruise missiles, and high-performance aircraft. The analysis is typically performed using related engineering drawings so that the actual flight hardware is verified.

System safety engineers assigned to the Shuttle/Centaur program will participate in all trade studies performed on the Centaur and its support systems. They will also participate in all design and test reviews, both in-house and with the customer.

Quality - Twenty years of reliability and quality growth have led to a mature operational system.

The STS/Centaur reliability/quality program meets the intent of NHB 5300.4 (ID-2), as defined in the mission Assurance Plan, Convair Report BGJ 72-006. Reliability and quality are designed into the vehicles and care is taken to ensure that there is no degradation of inherent design reliability through the succeeding steps from fabrication to end use.

During the design phase, functional and environmental requirements will be translated into functional requirements documents. Safety margins, derating factors and failure effects will be developed and analyzed. Physical parameters and constraints will be addressed and test requirements, including overstress tests and test quantities, will be identified.

Reliability effort includes failure modes and effects analyses (FMEA) and a critical items list (CIL). These efforts emphasize the identification of single-point failures at the system and subsystem level to determine possible modes of failure and their effects on mission objectives and crew safety.

A complete electronic parts control program will be implemented through the Space Parts Control Board, as defined in the Mission Assurance Plan, including parts selection in accordance with Lewis Research Center (LeRC) established policies. The parts program also includes a derating policy, qualification of piece-parts, and detailed control drawings.

Quality tasks are identified in the Mission Assurance Plan. These tasks include:

- Design assurance
- Process Control
- Identification and Data Retrieval
- Procurement Control
- Fabrication Control
- Inspection
- Nonconformance Control

All of these tasks are being accomplished for the Atlas/Centaur program and will be continued for the Centaur G-Prime.

8. Summary of Environmental Consequences

It has been determined from a thorough review of the proposed action that the incorporation of Centaur into STS causes a minimal and acceptable impact to the environment. The impacts identified are local effects only and are quickly disseminated.

Extremely clean burning chemical propellants are used for the prime propulsive system. Release of either hydrogen or oxygen or their combustion product, water, into the ground or space environment results in minimal to no pollution. Rapid dissemination of the products quickly returns the local environment to normal. Hydrazine was selected over the previously used hydrogen peroxide as Centaur's coast control propellant because of its better performance and stability. While the decomposition product of hydrogen peroxide is water and oxygen, its greater sensitivity to decomposition by contaminants results in more severe handling problems. For hydrazine, the handling and operational procedures are well developed making it the preferred product in spite of its toxicity.

The incorporation of the Centaur vehicle as an upper stage of the STS launch system does not conflict with existing land use plans, policies or controls. Those facilities requiring modification were previously dedicated to a similar function. No change is anticipated in the existing safety and security restrictions since procedures for ongoing operations can be readily modified and adapted to the new configuration. The integration of the new Centaur stage with the STS will be accomplished with the diligence and thoroughness of past Centaur integration efforts to assure the continuation of reliable operations and flight performance.

Unavoidable adverse environmental effects identified in the course of Centaur operations are those associated with the expenditure of propellants, gases, oils, paints and engine emissions associated with the processing of the vehicle. Other adverse effects result from the normal support of personnel and equipment to service the vehicle and its facility. Catastrophic accidents would affect local environment only and would be quickly normalized.

The decision to develop versions of the Centaur stage for use with STS came about after several years of planning and studies to select a stage to meet both cost and performance objectives needed to fulfill mission requirements. The output of these considerations was that the design concept used by the existing Centaur Program could be safely adapted to manned missions and that cost and performance objectives would be met. Experience with a similar stage in the unmanned program and with large vehicles in the manned program has proven that these vehicles can be safely used without unreasonable danger to personnel or the environment. Accordingly, the STS/Centaur program was initiated.

B. Alternative 2: The "No Action" Alternative

1. Introduction

Possible alternatives to the proposed action of developing a derivative of the existing Centaur vehicle are: 1. Design a new high-energy stage which is a performance match to the STS and the planned missions in 1986 or 2. A "no action" alternative which could be (a) cancel the planned 1986 missions or (b) use the Inertial Upper Stage (IUS) with a redefined mission at time when the IUS can accomplish the mission.

The development of a completely new stage is ruled out both on cost and inadequate time before its use is required. Some performance improvement would be realized with a new design, but it would be a considerable departure from the existing ground rules. One of the key considerations has been to maintain as much design, hardware and operating experience as practicable in order to reduce cost and better assure schedule effectiveness. Since the Centaur configuration in the proposed action has sufficient performance capability and can be redesigned in both the time and cost limitations, consideration of a completely new stage was dropped. Environmentally, such a new stage would be no improvement over the proposed action.

The "no action" alternative received much consideration with the missions at one point being considered for cancellation and at other times planned for accomplishment with the IUS as the energy package for transfer of the spacecraft from low earth orbit to the planetary transfer trajectories. However, peformance needed to best assure mission success in the desired configuration at the time the missions are scheduled became the prime factor in the determination that a stage with high-energy propellants was best. Accordingly, the task of implementing the well-studied and feasible Centaur derivative was begun. From an environmental point of view, the use of a stage with hydrogen/oxygen propellants is better than a stage using solid propellants, as does the IUS.

2. Description of the Alternative Vehicle

Implementation of the "no action" alternative to perform the NASA 1986 planetary mission implies use of the USAF's IUS. Insomuch as the IUS is an USAF project with an environmental impact statement of its own (Ref. 5), this report will only summarize results applicable to a comparison with Centaur for the planned missions.

The IUS is a solid rocket motor propulsive unit incorporating the necessary guidance, control, navigation, communications, structural, mechanical, ordnance, separation, reaction control and interface, both ground and airborne, systems for its use as a spacecraft booster. The propulsive units may be "stacked" in a building block fashion to provide flexibility to meet a range of energy requirements. The configuration defined for the high-energy planetary missions consists of two "large motors" or "two large motors and one small motor". About 47,500 lbs. of solid propellant are used in the larger version. The major product of combustion from expenditure of these propellants is hydrogen chloride (HCL). Exhaust products are discussed in detail in the IUS environmental statement along with comparisons of the products and amounts with that of other vehicles using similar propellants.

The IUS, like Centaur, uses hydrazine in its reaction control system which is expended in orbit as are the main propulsive propellants. Use of solid propellants simplifies the vehicle's design by eliminating the need for the extensive plumbing and the control thereof, required by the cryogenic propulsion and pneumatic systems. Thermal control venting and conditioning requirements for the STS payload bay are also less for IUS as are the mechanical ground and airborne interfaces. Control, communication, ordnance, navigation and spacecraft interface system requirements are comparable. Use of a simpler system with solid propellants is offset by its inability to "dump" propellants and thereby provide for a lighter and safer configuration for an emergency landing and its inability to provide the high energies required by some missions. The prime consideration came down to the energy requirements of the missions to be flown and to select that configuration which best fulfilled objectives.

3. Summary of IUS Facility Modifications

As stated in Reference 5, Boeing, as prime contractor, will accommodate the IUS program activities in existing contractor-owned facilities at Boeing Space Center, Kent, Washington during the validation, full scale development and production phases through completion of assembly and testing with inert motors. An existing building at the Eastern Launch Site (ELS) was modified for conducting final assembly and checkout of the flight model during the full-scale development phase and all subsequent production. These resources are supplemented by major subcontractor facilities with unique existing capabilities.

Existing government facilities at ELS are used for final assembly operations, hazardous storage and Reaction Control System (RCS) servicing. The Arnold Engineering and Development Center, in Tennessee, and the Air Force Rocket Propulsion Laboratory at Edwards Air Force Base (AFB), California were utilized for test firing of solid rocket motors.

Major subcontractors include: Teledyne at its Plant 25 in Northridge, California; Hamilton Standard at its plant in Farmington, Connecticut; TRW, Inc. at its plants in Redondo Beach, California and Colorado Spring, Colorado; Motorola, Inc. at its facility in Scottsdale, Arizona; Cubic Corp. at its facility in San Deigo, California; and The Chemical Systems Division of United Technologies at its facilities in Sunnyvale, California and at its Development Center facilities in the Diablo Mountain Range 25 miles southeast of Sunnyvale, California. None of these subcontractors required government facilities or major modifications to its own facilities for the implementation of the IUS program.

Facility modifications to process IUS at the ELS were not extensive from an environmental impact standpoint. Mostly the modificationss were required to allow for proper stage handling, final assembly, checkout and for all mechanical and electrical interfacing required by the stage. All modification tasks have been completed and IUS stages have been processed through the facilities.

In overall magnitude, the facility requirements of the IUS and Centaur are not much different, as would be the case for upper stages of these general performance requirements.

4. Operations

IUS operations at the ELS and KSC have been implemented and the IUS has been used with STS in a Tracking and Data Relay Satellite System's (TDRSS) launch. The adequacy of the facility modifications and vehicle processing procedures have thus been proven.

The vehicle is received at ELS with the propulsive units, ordnance items and hydrazine being stored in existing explosives storage areas. Final assembly and checkout are conducted in the facility modified for that purpose at a USAF vehicle processing area. When supporting NASA missions, the vehicle, after final assembly and checkout, is transported to the NASA Spacecraft vertical processing facility (VPF) where it is integrated with the spacecraft, installed in the transport (MMSE) container and moved to the launch area for installation in the Shuttle cargo bay. Some final tasks are accomplished at the launch site concurrently with final shuttle readiness tasks culminating in an integrated count-down and launch.

Since the IUS vehicle has been processed and launched, the launch team is essentially in place with hardware and procedure processing requirements for safety and training being satisfied. As with any active technical operation, improvements and changes to the checkout and processing techniques and equip-ment are normal occurrences. Such changes have the goal of assuring better checkout reliability, safety of handling and efficiency of crew utilization. None of these standard operating improvements should affect the conclusion of the initial impact analysis.

5. Mission Performance

The capability of the IUS to perform missions is dependent upon many variables and is the responsibility of the USAF to define and commit to for each application. For the planned NASA planetary missions, in particular the Galileo mission, a considerable planning effort took place to define conditions of IUS configuration, spacecraft configuration, transfer trajectories and launch times which could satisfy mission objectives. Also of consideration was the time at which the hardware and other mission elements could reliably be committed to launch. Both technical and financial resources were factors in such determina-tions.

The IUS impact analysis had concluded its acceptability for missio support from an environmental point of view. Exercises with different configura-tions of spacecraft, trajectories and transfer times as a function of launch date were made which also showed the acceptability of the IUS to perform the tas for some launch dates. In particular, 1982 was a year where its overall capabilit to accomplish the task was good. Its potential for use in the planetary missior was reduced after that year because of less favorable planetary alignments pre-venting the use of transfer trajectories, such as the Mars flyby, and its accompar ing significant velocity gain. The IUS is incapable of meeting the performanc requirements of the mission in 1986 with the selected spacecraft configuratio Its capability to perform the task later can be improved by separating the Galil spacecraft into its Orbiter and Probe sections and using two STS launches or by using indirect trajectories such as an earth flyby. However, such techniques are costly to the mission in that an extra launch is required or the arrival time is significantly delayed, or both.

6. Centaur Postdeployment Operational Control Center (CPOCC)

An open item at the time of publication of the draft statement concerned the selection of a permanent location for the CPOCC. It has since been determined that to best consolidate both pre and post launch operations an existing facility on the CCAFS would, when enlarged and modified, well serve the program's needs. Accordingly, plans are now in work to design and incorporate the required modifications. Environmental impact is again the short term disturbances caused by the routine of construction. No land usage reassignments were required and no long term impact incurred.

7. Summary of Environmental Consequences

The conclusion reached from the impact analysis of the IUS on the environment as reported in Reference 5 is that, for normal operations, no significant impact on air quality, water quality, noise or biology would result. Electromagnetic radiation is minimal and the socioeconomic impact is beneficial. Any impact on the space environment would result from an estimated 250 tons of combustion products being introduced each year along with the debris of the expended stages themselves. The combustion products will rapidly diffuse throughout space and should have minimal effect as compared to the millions of tons of combustion product debris being introduced into the earth's atmosphere each year from other sources.

For a catastrophic accident some impact could be expected. If an accident occurred on the ground away from the launch pad some impact on the local environment could be expected with air quality down wind of the accident being in most peril. Steps would immediately be taken to assure the safety of or evacuation of personnel. Standard safety practice requires safety zones, limited access and other precautions to protect personnel in all areas where access to and work is performed on the stages. Such safety procedures would be in effect at the time of an accident.

If the catastrophic accident were to occur at the launch site, then that action defined and planned for STS alone adequately details the impacts. The IUS contribution to the conflagration would be of the order of 1 to 2 percent.

IUS stages have been received, processed and launched at the ELS without any difficulty with regard to the environment. Thus, the conclusion of the impact analysis that no detrimental environmental consequences would be caused by implementation of the IUS program has been proven for the short term.

III. ENVIRONMENTAL CONSEQUENCES OF CENTAUR IN STS

A. Introduction

Environmental consequences from the integration of Centaur into the STS are well defined as based on long experience in using a Centaur stage with Atlas and Titan boosters and of the experience gained to date with the operational aspects of STS. Worst-case unplanned events are discussed including that experience gained with Centaur in such applications. The methods, materials and equipments planned for use with STS/Centaur have been described. The anticipated environmental impact on the overall launch site environment from the addition of Centaur are discussed.

B. Air Quality

The possible environmental effects on the air quality imposed by Centaur operations can be attributed to three general sources: (1) automotive vehicle emissions, (2) waste products of fuel combustion by diesel generators, and (3) chemical releases by venting and evaporation.

1. Automotive Vehicle Emissions

Emissions from vehicles supporting Centaur are produced by the vehicles of employees, General Service Administration (GSA) and contractor vehicles which mostly operate within the confines of CCAFS and KSC. Special use vehicles such as fork lifts, cranes, lawn mowers, etc. also support center operations. Basically, the amount of auto emissions to be added by incorporation of Centaur for STS are essentially nil. No significant increase in any category is expected. Present Atlas/Centaur operations use all such equipment and were accounted for in the initial KSC EIS. Direct Centaur contribution represents about 4% of those emissions at KSC based upon a 400-man support element as compared to about an overall 10,000-man effort supporting similar operations. The Atlas/Centaur crew were considered part of the overall personnel complement.

2. Waste Products of Fuel Combustion by Diesel Generators

Diesel generators are used, at times, to provide back-up or prime power in hazardous or critical operation. Such diesel operating time is a few percent as compared to power supplied by Florida Power and Light Company. Centaur contributions from diesel emissions are much less than 1% of the total of such emissions as reported by the KSC EIS.

3. Chemical Releases by Venting and Evaporation

Chemical releases by venting and evaporation at Complex 36 are the elements hydrogen, oxygen, helium and nitrogen and are considered innocuous as far as environmental effects are concerned. Vent areas are located such that rapid dissemination of the vented product occurs in safe areas and will not be trapped in any enclosed area to present a personnel safety problem. No hydrazine venting is anticipated though worst case emergency conditions have been duly considered.

4. Air Quality Impacts and Mitigating Measures

Proposed Centaur activity imposes no known environmental impacts on air quality that exceed state or Federal standards. This statement would remain applicable even if a Centaur were launched with every STS. The only contribution to an adverse air quality condition is the venting of innocuous elements.

C. Water Quality

Possible environmental effects on water quality imposed by Centaur operations can be attributed to three general sources: (1) water use, (2) discharge into sewage plants, (3) washdown of facility for hazardous condition protection.

1. Water Use

Potable water is supplied to the Centaur supporting facilities by the CCAFS and KSC system who obtain that service from the City of Cocoa municipal supply. Centaur usage is not expected to significantly change from that presently being used and included in impact statements of CCAFS and KSC.

2. Discharge into Sewage Plants

The Centaur program has no direct responsibility for sewage disposal as this is another of the services supplied the program as a tenant of the CCAFS and KSC. Centaur usage of this service is not expected to significantly change from that presently being used.

3. Facility Washdown

A facility washdown capability exists at Complex 36 as a means of diluting and removing spills which occur on the test stand. Catch basins are included to collect all washdown water and to provide a means of removing any chemical not acceptable for absorption into the local water table. This operation has been in effect for many years and will continue for the proposed operations.

4. Water Quality Impacts

Adverse effects on water quality from incorporation of Centaur into STS are essentially none and generally less than with the expendable vehicle program. Operational use requirements remain essentially the same as at present with local water table protection techniques in place.

D. Land Qaulity

Possible environmental effect on land quality results from minor construction that may be required from time to time and normal operations at the complex. The amount of land allocated to Centaur operations as compared to the combined CCAFS and KSC is a small fraction of one percent.

1. Facility Construction

As presented earlier, some modifications to the existing facility (Pad A) are required for Centaur-in-STS support. Only temporary and localized disruptions will occur from accomplishment of this task. Other minor changes may need to be incorporated depending upon future vehicle changes or requirements. Such modifications do not change the present land use assignment nor impact long term quality.

2. Normal Operations

Specific areas have been set aside for land use assignments by Centaur. Only Pad A of Complex 36 will be set aside for sole use by the Centaur for STS. All other areas of support required by this stage will be shared by Atlas/Centaur, expendable vehicles in general, spacecraft and STS, alone or in conujunction. Conduction of normal Centaur operations in these environments is essentially the same as that in effect today where land use assignments exist and the utilization of such property is in accordance with environmental regulations and restrictions. Incorporation of Centaur-in-STS does not alter such land usage or the quality of such use.

E. Noise Levels

Noise generated by day-to-day Centaur operations are limited to those sources from conduction of (1) industrial operations and (2) traffic noises. No engine firings from Centaur take place at the launch site.

1. Industrial Operations

Noise generated by the day-to-day operations are those that result from the intermittent use of hydraulic pumps, diesel generators, cranes and fork lifts and the venting of high pressure gases. The loudest noise is the venting of high pressure gas; however, safety procedures are in effect for these operations. Hazardous noise areas are in the immediate vicinity of the vent ports. Other industrial operations do not present a safety problem to personnel or a hazard to the environment.

2. Traffic Noise

Intermittent noise from the automobiles and trucks supporting Centaur operations is not greater than that associated with a medium-sized shopping mall. Such noise does not present a safety problem to personnel or a hazard to the environment.

F. Radiation

Support of Centaur operations requires radiation sources that produce both ionizing and non-ionizing radiation. Both types are well controlled through the use of specific procedures for safety during operations.

1. Ionizing Radiation

Materials and machinery which produce 33 electron-volts and up are termed ionizing radiation sources. Such radiation has the capability of causing damage to living organisms and may cause long-term contamination of irradiated zones. Some ionizing sources are used in support of the Centaur program as follows: (1) smoke detectors for protection and (2) laboratory instruments for calibration. Such usage is considered minor and not a safety or environmental hazard. The major ionizing source results from use of X-ray equipment which range up to 250,000 curies or more. X-rays are used for hardware diagnostic purposes and are provided to the Centaur program as requested by the KSC. Centaur program, in itself, does not operate or maintain X-ray equipment. During use of X-ray equipment, safety procedures and restrictions are in effect.

2. Non-Ionizing Radiation

Non-ionizing radiation in support of Centaur operations is that radiated from the airborne RF transmitters of low power. No personnel, safety or environmental hazard exists from these RF sources. Transmitter operation is controlled consistant with use of RF frequency bands and to assure non-radiation during periods of ordnance handling.

G. Socioeconomics

Possible impact on local socioeconomics would result from (1) change of workforce of (2) changes in wages or type of work.

1. Change in Work Force

Implementation of Centaur for STS is occurring at a time when requirements for support of the expendable vehicle program are minimal. Therefore, the initial staffing is to use existing personnel for both operations and such assignments are being made. The overall size of the workforce will change little unless some significant increase in the use of expendable vehicles occurs, an occurrance which is not currently anticipated. The more significant workforce change factor results from retirements within the present ranks with replacements being brought onboard at about a one-for-one exchange rate. Phase-in of these new operations will not result in any noticable impact on local socioeconomics.

2. Changes in Wages or Type of Work

Wage rates for Centaur operations are consistant with those in the aerospace business in general. Very minor changes to the type of work presently being done will be required by the new Centaur. Experience is directly transferable on a one-for-one basis.

H. Ecology

Impact on the local ecology, either abiotic or biotic, from Centaur operations is essentially nil. Major effect would result from repeated launches and such conditions were discussed in the KSC EIS. Centaur engines are not fired at the launch site. A second effect would result from a major spill. Centaur propellants and gases are essentially innocuous in this respect and would have minor impact. Impact from a hydrazine spill would also be minor and local since the quantities involved are small. Any effect Centaur would have on the ecology would be minor, local and temporary.

I. Unplanned Events

The discussion thus far has focused on impacts from events which occur as a normal, planned part of Centaur operations. An unplanned event, for the purposes of this document, is defined as any mishap which has a negative impact on the environment, disrupts mission scheduling, or imperils human health or welfare. An unplanned event would probably result from human error or equipment failure. Recognizing these sources, NASA has instituted measures to forestall such occurrences to the maximum possible extent. It is also recognized that despite the regulations and procedures described herein, unplanned events can occur. To provide an understanding of the nature of potential mishaps and the actions which would be taken, two categories of unplanned events are described, along with examples of specific actions which might be taken.

1. Potential Mishaps in Daily Operations

The following unplanned events, although not as serious as "worse-case" occurrences, have a high probability of happening because of the statistical frequency of performance of daily operations.

a. Traffic accidents.

b. Facility fires.

c. Human contact with, or inhalation of, a toxic or caustic substance.

d. Rupture of a high-pressure line.

e. Facility damage or personal injury from heavy lifting and moving operations.

f. Falling objects, elevated workstand hazards.

The effects of these events could range from minor, local disruption of activities to the death of local flora and fauna, destruction of habitat areas and the possible loss of human life. No effects are expected to reach beyond Centaur operational boundaries.

To preclude problems and avoid accidents, KSC, ESMC and Centaur operations provide extensive workforce training and operator certification programs, comprehensive procedural coverage for all planned activities, safety and quality control inspections, spill prevention, control and counter-measure plans, contingency plans, and active operations monitoring.

Safety Precautions - KSC and ESMC maintain Safety Offices which constantly monitors the area for safety violations. This group periodically issues bulletins describing hitherto unrecognized hazards or unobserved unsafe practices. Medical and firefighting personnel and equipment are available on base for emergency response. The substance involved in a personal injury or a fire are made known so that proper action can be taken. In the case of a release of toxic vapors, the services of meterorologists are immediately available to predict the movement of the effluent so that the affected area can be cleared. All facilities where an employee could be injured by accidental contact with chemical substances are equipped with emergency showers and eyewash fountains. Facilities where explosion or fire could occur are equipped with automatic deluge systems in addition to the standard fire hoses and fire extinguishers. Facilities which could experience the release of colorless, odorless gases are equipped with detectors which sense the dangerous condition and alert the area with visible and audible signals. Whenever hazardous operations are required, a safety zone is established in advance and noninvolved persons are dismissed from the area. Such operations are scheduled for periods when casual traffic is at its lowest. Finally, all persons whose duties could require them to encounter a hazardous situation are required to attend classes and lectures to acquaint them with the use of safety equipment and the escape routes and procedures for a particular area.

Hazardous Operations Controls - Specific task-related actions which are closely monitored and controlled are:

a. Lifting Equipment. To lessen the probability of lifting equipment failure, all cranes, derricks, hoists, forklifts and elevators are periodically inspected and certified.

b. High-Pressure Lines. Lines used to transfer high-pressure gases and liquids are inspected and certified to ensure meeting the applicable burst, proof, and operating pressure. In addition, most substances are delivered through panels which measure and indicate the pressures within the lines and containers and permit isolation of malfunctioning portions of the system.

c. Flight Hardware. All flight hardware components which provide critical functions are inspected, tested and monitored by sensing devices from installation to lift-off.

d. Movement of Equipment. Many operations in several locations at KSC require the lifting, transporting and emplacing of equipment. Each such activity is governed by written procedures and safety requirements which are monitored and enforced by supervisory and safety personnel.

e. Liquid Propellant Handling. The handling of liquid propellants receives particularly close supervision. Not only are the technicians constantly observed, but safety perimeters are installed to exclude unauthorized persons from the danger zone. In the case of hypergolic fuels, all facilities and operations are deisgned to isolate the fuel handling from the oxidizer handling. Possession of flammable materials (matches or lighters) is forbidden in restricted areas. Inadvertent small spills are immediately removed by equipment assigned to the area for that purpose. All propellant storage areas are prominently identified and the appropriate restrictions are posted. Wherever incorrect substances could be delivered into a connection, mechanical design is used to make such an occurrence impossible.

f. Toxic Fumes. Mixing and loading operations can generate or release toxic fumes. All chemical mixing areas are equipped with air handlers, fans, and vents to collect, remove and treat toxic fumes. Protective clothing and equipment are issued to all operators. Loading operations take place in the open air so that the leakage that can occur when lines are connected and disconnected will dissipate harmlessly.

g. Falling Objects. Hardhat areas are clearly identified and monitored. Personnel working on elevated platforms are required to tether handtools and are forbidden to carry small objects (lunch boxes, vacuum bottles, etc.) aloft. All open areas and pits are identified by warning signs and where possible, protected by barriers.

During the 20 years of Centaur operations at KSC and ESMC, there have been minor unplanned events. These occurrences were thoroughly investigated and measures were instituted to prevent the repetition of similar mishaps.

2. Worst-Case Unplanned Events

The following unplanned events have been categorized as "worst-case" possible occurrences:

a. Launch pad abort, with explosion and fire.

b. Propellant spills or storage tank rupture.

The foregoing events are described and results are analyzed in the following paragraphs.

Launch Pad Abort With Explosion and Fire - The most serious consequence of an on-pad fire involving the entire Space Shuttle vehicle would be the release of toxic combustion products from the SRB's. The large heat release associated with the burning of the main engines' propellants will assist the cloud of combustion products in rising to a high altitude. Although the quantity of SRB combustion products released at ground level will exceed that released at or near ground level in a normal launch, the additional heat and cloud rise contributed by the main engines' propellants will compensate in terms of ground-level concentrations of hydrogen chloride and chlorine. Analysis of on-pad solid propellant fires have been completed and reported in the KSC EIS. The addition of Centaur in the payload bay to such a conflagration would be of minor consequence. As might be expected, extensive precautions exist to prevent any premature ignition, especially of the solid propellant stages.

The worst case fire and explosion at Complex 36 would involve the hydrogen and oxygen only and such damage would be limited to the confines of the complex. Such an accident has occurred at Complex 36 resulting from an Atlas failure at lift-off. Handling of this worst case event showed that the safety restrictions in effect were adequate.

Propellant Spills or Storage Tank Rupture - Potentially hazardous fluids handled in connection with the Centaur program are: liquid hydrogen, liquid oxygen, liquid nitrogen and hydrazine. Liquid hydrogen is extremely flammable; hydrazine is flammable and toxic and liquid oxygen and nitrogen are cryogens.

a. Liquid Oxygen and Liquid Nitrogen Spills. Liquid oxygen is used both on ELV's and on the STS as one of the engine propellants. Liquid nitrogen is used as a refrigerant and a source of gaseous nitrogen for pressurization and control. The largest launchsite storage capacity at KSC is 3,406 kiloliters (900,000 gallons) of liquid oxygen and 1,892 kiloliters (500,000 gallons) of liquid nitrogen. Storage capacity on Pad A of Complex 36 is 45,000 gallons of liquid oxygen and 28,000 gallons of liquid nitrogen.

If spilled in large quantities, either liquid oxygen or liquid nitrogen could cause local damage because of the intense cold, 90 and 77 Kelvin (-297 and -320 degrees Fahrenheit), respectively. Liquid oxygen, if mixed with finely divided combustible material, forms explosive mixtures. The gaseous oxygen evaporating from the liquid oxygen will also intensify any pre-existing fire. The gaseous nitrogen evaporating from a liquid nitrogen spill is inert, but in high concentrations it is an asphyxiant. Industrial Standards prohibit asphyxiant concentrations that reduce the oxygen concentration below 18 percent. This would correspond to the 17 percent addition of nitrogen to air.

Both liquid oxygen and liquid nitrogen are commercial materials handled in vast quantities but spills are not frequent. There have been no reports of lasting environmental damage caused by such spills or of damage beyond the small localized areas involved in the spills. There is no indication that even the largest possible spill at the launchsite would endanger the public or the ecology of any area except in the immediate vicinty of the spill.

b. Hydrazine Spills. Handling of hydrazine is recognized as a hazardous operation because of its toxicity and spontaneous flammability when mixed. For a workroom environment, the 1978 American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values for hydrazine as 0.1ppm. Extreme precautions are taken, and quarterly personnel qualifications/ certification training on the handling of spills and pertinent safety practices are stressed. The actual fluids are used in these training classes. Only small amounts of hydrazine are used by Centaur.

c. Liquid Hydrogen Spills. The liquid hydrogen storage tank at the KSC Space Shuttle launch pad has a capacity of 3,217 kiloliters (850,000 gallons). A total of 1,450 kiloliters (383,000 gallons) will be loaded into the ET for each Space Shuttle launch. Liquid hydrogen capacity on Pad A of Complex 36 is 28,000 gallons.

Spills of liquid hydrogen present an extreme fire hazard and under certain circumstances may also present an explosion hazard. In these respects, liquid hydrogen differs in degree but not in kind from the hazards associated with common commercial products such as propane. On a volumetric basis, the heat released by liquid hydrogen is less than that released, for example, by propane or gasoline. Liquid hydrogen spills could ignite either immediately or at some later time. Ignition immediately following the spill will cause a flash as the inventory of gaseous hydrogen is burned, followed by burning above the pool of evaporating liquid. As in any large fire of a volatile liquid, destruction in the involved area will be considerable. In terms of environmental effects, the major feature of such a large fire would be the thermal radiation. With normal atmospheric humidity, the thermal radiation from the flash (which could last for 30 seconds) is estimated to be about 2 calories per square centimeter at a distance of about 300 meters (950 feet) for a 3,200-kiloliter (950,000 gallon) spill. The approximate threshold limit value to cause first-degree burns to exposed skin is 2 calories per square centimeter; it is also the approximate threshold value for ignition of paper and other light combustibles. The radiation from the burning pool is estimated to be less by a factor of about 5 than the flash radiation.

If the spilled liquid hydrogen evaporates without burning, the cloud of gaseous hydrogen may be carried downwind and ignited at some downwind position. The greatest distance at which ignition can occur will depend on meteorological conditions which govern the dispersion of the cloud. The high molecular diffusivity of hydrogen will augment the meteorological dispersion. Once the highest concentration of hydrogen in the cloud reaches the lower flammable limit (the lowest concentration which is flammable), ignition and burning can no longer occur. Any process that is sufficiently violent to cause accidental rapid release to large quantities of liquid hydrogen would be expected to cause some spark, hot spot or damage to nearby power devices which would ignite the hydrogen immediately. Gaseous hydrogen has the lowest ignition energy requirement of any fuel which does not ignite spontaneously.

Mixtures of hydrogen and air near the chemically correct proporations can explode or detonate. However, for unconfined hydrogen and air mixtures, ordinary ignition sources do not cause detonation. Because immediate ignition is expected for a large, rapid spill and because detonation may not be caused by ignition by ordinary sources, detonation of the hydrogen/air cloud is not considered a credible event.

In summary, if a large hydrogen spill could ignite, extensive damage to a localized area would result, including death or serious injury to persons within that area. However, environmental damage outside that area would be negligible. The rapid spilling of large quantities of liquid hydrogen without immediate ignition is improbable because an extremely violent event would be required to initiate the process.

J. Relationship Between the Short-Term Uses and Long-Term Maintenance and Enhancement of the Environment.

1. Introduction

The overall short and long-term effect on the environment induced by the implementation of Centaur-in-STS are described in this section. In that the processing, checkout and launch of this upper stage will take place from areas previously devoted to checkout and launch, both the short and long-term effects are well known and documented. Centaur-in-STS does not degrade the short-term environment and has considerable potential to add to man's better understanding of his universe.

2. Short-Term Uses

a. Background

Incorporation of Centaur in STS and the preparations leading to the first launch is the short-term of consideration. No use exists until a successful launch and injection of the spacecraft onto the proper trajectory occurs. Therefore, the short-term use of Centaur is to place the NASA planetary spacecraft on the proper planetary intercept trajectories in 1986. As to the ground operations, the prime area of checkout and processing, Complex 36, has been in operation for over 20 years and was activated specifically for launch of a modified Atlas weapon system booster with a newly designed Centaur stage using the pneumatically stabilized structural principle of Atlas with high-energy propellants. The Atlas/Centaur launch area has long been stabilized from an environmental standpoint and many launches have taken place resulting in many firsts in near space and planetary explorations. Today the Complex remains active and in operation under the processing and safety techniques developed over the years for the Expendable Vechicle Programs. The assignment of one of the two launch pads for STS/Centaur checkout, if anything, reduces the environmental impact since launch operations will no longer be conducted from that pad. Further, NASA plans for phase-out of the remaining pad now supporting the Expendable Vehicle operations. Some possibility exists that the pad may be used in its present form for commercial applications but no such plans have been finalized.

The continued use of Complex 36 for the next decade or so can be accomplished, as it has been in the past, without detrimental impact on the environment.

b. Launch Operations

Launch operations for Centaur-in-STS will be in conjunction with STS, integrated in the countdown timelines and subject to the same operational and safety restrictions. The short-term effect of launching an STS/Centaur is the same as that presently experienced by operational launches of STS. The short-term effects on the environment of the Space Shuttle Launches from Complex 39 will be localized and will produce a relatively short duration of air and noise pollution. There are no substantial changes in land use or significant differences in operations at Complex 39 beyond that established in the past with both manned and unmanned expendable vehicles, with the exception of Orbiter return from a normal or abnormal operation with or without its cargo. These short-term launch area disadvantages are small as compared to the potential for advancing man's knowledge and understanding of his environment.

3. Long-Term Maintenance and Enhancement of the Environment

a. Experience

Space Vehicle Operations, now in their third decade, have evolved into reliable means to deliver sizeable and super-sensitive spacecraft into well defined trajectories and orbits to accomplish a variety of mission objectives. Accomplishment of this feat was the result of careful analysis of failures, learning better techniques for design of space hardware and the implementation of better materials for the various critical applications. Other fall-outs from these operations included better processing and checkout procedures, safety of operations and protection of the environment by minimizing pollution by performing hazardous operations in the appropriate weather conditions.

Today, environmental scars resulting from space launch operations are essentially none and the flora and fauna of the local environment survive in abundance. The addition of Centaur into STS will not degrade this condition in any respect.

b. Enhancement of the Environment

Long-term enhancement of the environment is a function of man's knowledge and understanding of the universe in general and of the earth in particular and his willingness to apply this knowledge to better his environment. Orbital spacecraft, like no other form of observation, has allowed for global monitoring of the environment by the same sensors calibrated to the same reference. Such global monitoring is accomplished in a relatively short duration allowing for time-sensitive relationships to be evaluated. Land use and ocean conditions may be monitored and evaluated. Weather systems can be carefully tracked. Pollution monitoring can be accomplished. The collection and analysis of earth's environmental data is routine today and will be improved as better monitors and sensors are devised. Already, such data is being disseminated and operated on in positive ways to improve the environment. In this respect the space program has enhanced the environment to a far greater extent than it has degraded it. The relatively non-polluting Centaur stage addition to STS will add to the capabilities of the space program to improve all aspects of its assignments beginning with the further exploration of the planetary environments.

K. Irreversible and Irretrievable Commitment of Resources

The materials which make up a launch vehicle as it sits on the pad ready for launch are largely irretrievable once the launch process is initiated. For STS, the Orbiter is returned intact following its mission objectives and the casings for the SRB's are recovered since the SRB's are expended near the launch area. However, the expended resources are relatively easily replaced and, in general, are replaceable from domestic resources with relatively insignificant expenditure of manpower and energy.

By far the largest portion of material making up a launch vehicle is the propellants. These have previously been enumerated and defined; they are common chemicals and liquified atmospheric gases. After propellants, the next largest amount of materials are iron and aluminum. The remaining fraction of a percent of material may be anything which best meets a specific application.

Expended natural resources are common items and of small usages as compared to the daily commercial and industrial activity. Space vehicle costs lie not in the raw materials but in the very special design and processing to meet the many requirements needed to insure strength, lightweight, thermal and electrical conductivity, etc., to guarantee maximum performance both from the standpoint of delivered orbital energy to the spacecraft and assurance of long orbital life of the spacecraft in meeting its total mission objectives. The Centaur planned for STS essentially meets these objectives. While the initial Centaur design was a staging match for the Atlas vehicle as its booster, some changes have been made to improve its stage matching characteristic with STS. In some aspects a small stage-matching performance penalty has been elected to avoid major configuration design change and requalification costs. Performance analyses

IV. DESCRIPTION OF THE AFFECTED ENVIRONMENT

A. Introduction

A detailed description of the existing environment for the launch site areas of the Kennedy Space Center and the Cape Canaveral Air Force Station in Florida has been determined and documented in great depth and reported in the "Environmental Impact Statement for the Kennedy Space Center" dated October 1979. The proposed use of the Centaur stage in STS operates in precisely the existing environment as reported in the KSC EIS. Like the expendable vehicle's program using Centaur, some operations are from the CCAFS. Like the STS program, some operations are from KSC. Therefore, impact on the environment has been determined in depth. In preparing the EIS for KSC, consideration of CCAFS was given in that the NASA Centaur and Delta expendable vehicle operations were being conducted primarily from the CCAFS area. For STS/Centaur, certain processing, checkout and servicing operations will be performed at CCAFS.

For consideration of Centaur-in-STS, certain portions and summaries are taken from the KSC EIS (Ref. 1) and presented here for areas where Centaur could have impact on the overall environment. Topics discussed include topography, geology, climatology, hydrology, air quality, water quality, land quality, noise, sonic boom, ecological resources and areas, and social and economic resources.

Only the general environment at the launch site is considered and described in some detail because the ongoing launch site program activities comprise by far the greatest opportunity for environmental impact from normal processing of the crogens, gases, hydrazine or explosives or from accidents that may arise from the required processing of Centaur. The engine test area at West Palm Beach, FL is a well isolated and confined area where many years of engine test have shown that the environment is not impacted. Additionally, the description of the environment for the launch area does not differ in great respect from that at the engine test site.

The minimal test activity planned for the Convair Sycamore Canyon test site in San Diego County, CA is a continuation of evaluation type tests which have been conducted there for many years. The one-time limited, but necessary, activity for the Centaur program at the site is insufficient justification for a detailed study of the overall area environment. Reasonable precautions can best prevent the minor and localized impact resulting from the most severe test accident defined.

B. Regional Physiography

1. Topography

The general topography of the KSC area and Brevard County is characterized by a marine terrace system formed during the Pleistocene epoch. As the ocean receded, a series of north-to-south barrier beach and dune systems were formed. The plain or flatbed between a previous dune system and a more easterly newly forming system emerged as a terrace. When the ocean receded further, new dunes built up and older ones eroded. Cape Canaveral and Merritt

Island are recently formed dune systems and the Banana and Indian Rivers are submerged terraces inundated by brackish water. The physical influences which have shaped the present topography of Cape Canaveral and Merritt Island include the longshore current, the onshore/offshore breezes, and natural land building processes. The project area is part of a barrier beach system which is bordered by the Silver Bluff marine terrace on the northeast and the Pamlico marine terrace on the west. The Pamlico and Silver Bluff terraces stand at 8 to 11 meters (25 to 35 feet) and 0.9 to 2.4 meters (3 to 8 feet) above mean sea level (msl), respectively. Cape Canaveral and Merritt Island have numerous strands of north-to-south dune ridges which are approximately 3 meters (10 feet) above msl.

2. Geology

During the Eocene epoch, the Florida peninsula was inundated repeatedly by the sea. Between inundations, limestone formations in Brevard County were exposed to erosion. Erosion is thought to have reduced the thickness of the limestone formations and is responsible for several missing layers of Oligocene and Lower Miocene Age deposits. The existing Oligocene and Lower Miocene deposits consist of a thick series of sands, silts and clays of varying thickness. Generally, the first 12 to 18 meters (40 to 60 feet) consist of loose to fairly compact fine sands and shelly sands. The silts and clays range from soft to moderately stiff. These deposits overlie the Hawthorn Formation which consists of calcareous clays and silts, sandy phophatic limestone, and phophatic clay. Local sand and shell beds also occur within the Hawthorn Formation. In certain areas a thin, hard limestone or silkstone occurs about 9 to 11 meters (30 to 35 feet) above the top of the Ocala Group. The Hawthorn Formation is generally recognizable by its phosphatic content and its olive-green coloration.

The Ocala Group contains the Crystal River, Williston, and Inglis Formations. These formations are abundant with cavities and consist of Eocene limestone which is creamy white in color. The Ocala Group overlies the Avon Park Formation which ranges in color from light brown to white and is chalky in texture. In some places, the Avon Park Formation has been changed largely to dolomite. The lower portion of the Avon Park Formation is relatively impermeable and is believed to retard the vertical movement of water. The upper part of the Avon Park Formation is the principal source of deep artesian wells in Brevard County. In Figure IV-1, a generalized geologic column for Brevard County is illustrated.

3. Climatology

Kennedy Space Center experiences both tropical and temperate meteorological influences. The Florida peninsula is insulated by the warm Florida Current which flows south along the Florida west coast and northward along the Florida east coast to Vero Beach. The influences of this current are noticeable as far north as Cape Canaveral where the Florida peninsula's contour moves northwest away from the current.

The dominant weather pattern (May to October) is characterized by southeast winds which travel around the Bermuda Anticyclone. With the wind comes moisture and warm air which helps create almost daily thunderstorms. Approximately 70 percent of the average annual rainfall occurs during this period.

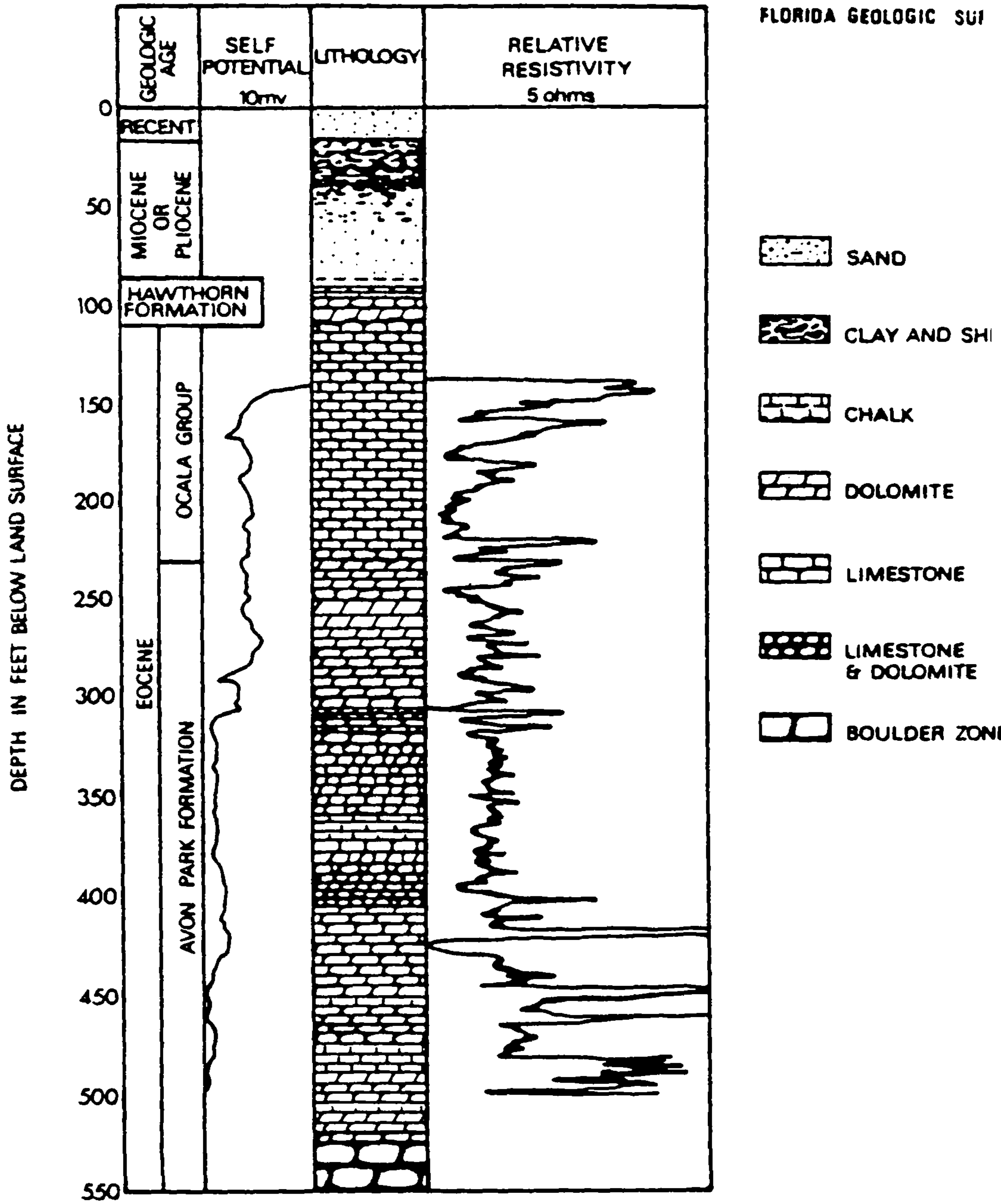


FIGURE IV-1
GENERALIZED GEOLOGIC COLUMN
BREVARD COUNTY

The monthly precipitation average is 10 centimeters (4 inches), with the greatest amount of rain occurring in September. Although tropical depressions and hurricanes occur throughout the wet season, only 24 hurricanes have passed within 185 kilometers (100 nautical miles) of KSC and CCAFS since 1887.

Temperatures during the wet season average 26 degrees Celsius (79 degrees Fahrenheit) and rarely exceed 32 degrees Celsius (90 degrees Fahrenheit). Relative humidity averages 90 percent in the early morning hours and declines to approximately 70 percent by early afternoon. Weather patterns in the dry season (November to April) are influenced by cold continental air masses. Rains occur when these masses move over the Florida peninsula and meet warmer air. In contrast to localized, heavy thundershowers in the wet season, rains are light and tend to be uniform in distribution in the dry season. In the dry season, total rainfall averages 38 centimeters (15 inches).

Dry season temperatures average 18 degrees Celsius (64 degrees Fahrenheit), but have sharp gradients when the cold air masses move over the project area. Although the extreme low temperatures have usually not gone below 0 degree Celsius (32 degrees Fahrenheit) in the past decade, the recent winters have had long cold periods. Relative humidity during the dry season averages 55 percent.

The quality and characteristics of the atmosphere determine the loading capacity of the air and its ability to disperse gases and particulates. The atmosphere for the purposes of this assessment is discussed in terms of two meteorlogical systems and the interrelationship of these two systems with wind speed, wind persistence, and atmospheric stability.

Surface Atmosphere - The surface atmosphere extends from ground level to 1,000 meters (3,281 feet). Wind directions are influenced by seasonal meteorlogical conditions and by the thermal differences between the Atlantic Ocean and the Cape Canaveral - Merritt Island land mass.

Heat is gained and lost more rapidly from land than water. During a 24-hour period, water may be warmer and again cooler than adjacent land. Cool air replaces rising warm air creating offshore (from land to ocean) breezes in the day. These sea breezes have been recorded at altitudes of 1,000 meters (3,281 feet) and higher, and reach further inland during the wet season.

Upper Atmosphere - The upper atmosphere extends from 1,000 meters (3,281 feet) to 5,000 meters (16,404 feet). Above 2,000 meters (6,562 feet), the wind direction is primarily from the west. Between 1,000 and 2,000 meters (3,281 and 6,562 feet), wind direction is influenced slightly by the thermal differences between the land and water.

Air Pollution Potential - The KSC area can be characterized as one offering a low potential for accumulation of air pollutants. This derives from good ventilation, absence of topographic barriers, and generally favorable climate. In fact, Central Florida has one of the lowest incidences of air stagnation of any area of the contiguous 48 states and consequently, a low incidence of pollution.

4. Hydrology

Surface Water - The surface waters which drain Cape Canaveral and Merritt Island are the Mosquito Lagoon (also known as the Indian River Lagoon), Indian River, Banana River, Banana Creek, and numerous canals throughout the area. The Banana and Indian River are lagoons which drain approximately 2,170 square kilometers (939 square miles) of land. The Banana River is directly connected to the Atlantic Ocean by an artificial inlet and locks at Port Canaveral. The Indian River is indirectly connected to the Atlantic Ocean on the north by Haulover Canal, Mosquito Lagoon and the Ponce de Leon Inlet and on the South by Sebastian Inlet.

The Banana River is a northeast extension of the Indian River Basin and is separated from the Indian River by Merritt Island. Banana Creek connected the Banana River to the Indian River before the Complex 39 Crawlerway was constructed. The creek still drains the area north of the Crawlerway into the Indian River. South of the Crawlerway the ground waters drain to the Banana River.

Neither lagoon system is influenced by tides in the KSC area because of the distance and the effect of natural and manmade constrictions between these systems and the ocean. Winds are primarily responsible for water movement; however, fresh water surges during the wet season have a slight influence on those movements. Dike and drainage systems in the project area discharge to both the Indian and the Banana Rivers. The Indian and Banana Rivers and Mosquito Lagoon are estuaries representing nurseries which provide habitats for wading and migratory birds and for commercially important fish, shellfish, and sportfish. Several sections of the rivers are used for commercial and sport fishing, and the Intercoastal Waterway lies in the Indian River.

Mosquito control canals and impoundments are maintained throughout the Indian and Banana River basins. Mosquito control is accomplished by flooding marshlands where the mosquito breeds. The impoundments and canals have extensively altered the productivity and stability of many coastal marshes and have shifted the fauna and lora composition of the basins from the previous natural state.

Ground Water - Ground water underlying the project area occurs under both confined (artesian) and unconfined (nonartesian) conditions. The nonartesian aquifer is composed of the Pleistocene and recent deposits. This aquifer is exposed to the land surface and will absorb water until it is filled by rain. After the saturation point has been reached, additional water will remain on the ground surface until it flows off or evaporates. Water percolating through the sandy soils of the project area quickly moves to the zone of saturation, the upper surface of which is the ground water table. Permeable areas above the water table hold some water due to the molecular action between the sand grains. The nonartesian aquifer is recharged by local rainfall.

The Floridan Aquifer, an artesian aquifer, underlies the project area. The Ocala Group and the Avon Park Formation comprise the Floridan Aquifer in Brevard County. Rain falling to the west of Brevard County recharges the Floridan Aquifer. Recharge also occurs in certain areas between the Silver Bluff and Pamlico Terraces. The coefficient of storage in the upper part of the Floridan Aquifer in Brevard County is 0.0008 and transmissibility is 3,725 kiloliters per day per meter (300,000 gallons per day per foot). In Figure IV-2, the hydrologic conditions of Brevard County are diagrammatically illustrated.

Residual salt water entered the Floridan Aquifer during the Pleistocene era. It is slowly being flushed as fresh water recharges the aquifer. Flushing has proceeded less rapidly in the western portions of Brevard County where the chloride levels are highest along a fault. The piezometric surface of the Floridan Aquifer is slightly above mean sea level in north coastal Brevard County where increased pumping has resulted in saltwater intrusion from the Atlantic Ocean and the Indian and Banana Rivers.

Oceanography - The Atlantic Ocean borders CCAFS on the east. Out to depths of about 18 meters (60 feet), sand shoals dominate the underwater topography. The bottom continues seaward at about the same slope out to about 48 kilometers (30 miles) where it drops downward to the 731- to 914-meter (2,400- to 3,000-foot) depths of the Blake Plateau. The Blake Plateau extends out about 370 kilmeters (200 nautical miles) to the Blake Escarpment.

C. Environmental Quality

1. Air Quality

The quality of the atmosphere at KSC is considered to be quite good, due primarily to its remoteness from major sources of pollution. Regional air quality is primarily influenced by industrial and private sources rather than by sources within KSC.

Air quality monitoring equipment at KSC (including the capability to measure toxic gases generated during launches) and State air quality measurements since 1973 have provided data confirming the absence of major pollutants in the KSC vicinity. During 1978, for example, the range of pollutant concentrations was (in micrograms per cubic meter): (1) sulfur dioxide: 0 to 1976; (2) nitrogen dioxide: 0 to 100; (3) particulates: 12.76 to 94.35; and (4) ozone: 4 to 382. Data on hydrocarbons and oxides of carbon are not available at this time.

Ozone measurements made using new EPA calibration standards (ultraviolet source) and new national ambient air quality standards (240 vs. 160 micrograms/cu. meter) currently show only isolated, seasonal (spring, fall) high levels of ozone which appear to correspond with certain weather patterns and may involve long-range transport phenomena. KSC limitations on mechanical activity and proscribed burning restrict the amount of pollutants entering the atmosphere. Thus the major sources of air pollutants generated within KSC are private motor vehicles and launches of space vehicles.

2. Water Quality

The surface waters surrounding KSC are brackish lagoons. Those waters north of KSC are Class II (suitable for shell harvesting and the propagation of marine life). Waters to the south, west and within KSC are considered Class III (suitable for fish and shellfish propagation and water contact sports) pursuant to Chapter 17.3 of the Florida Administrative Code. Mosquito Lagoon and the portion of the Banana River that is adjacent to KSC and CCAFS are classified

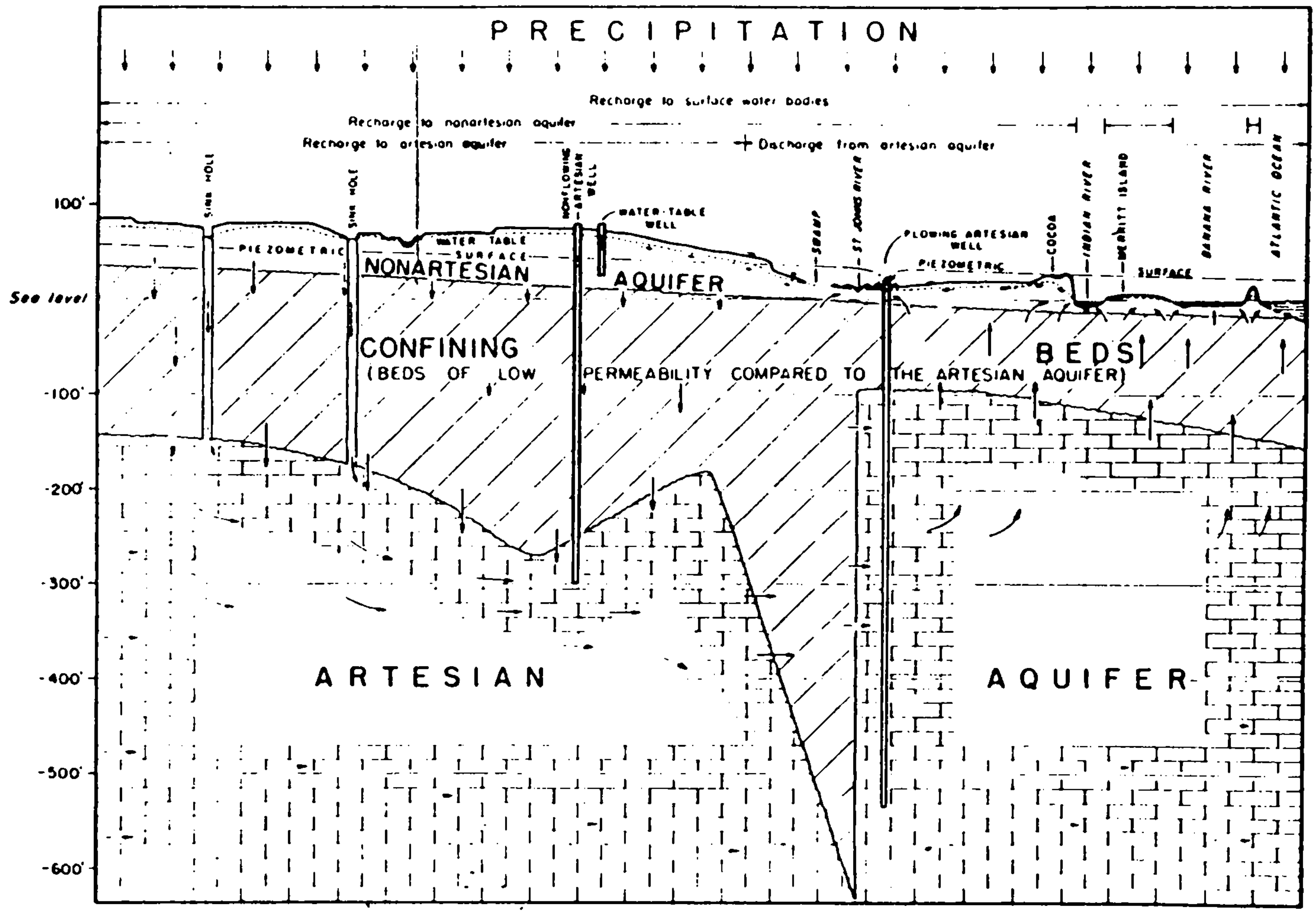


FIGURE IV-2
GENERALIZED HYDROLOGIC COLUMN
BREVARD COUNTY

as aquatic preserves pursuant to the Florida statutes. KSC is part of the St. Johns River Water Management District.

As required by Section 106 of the Federal Water Pollution Control Act (FWPCA) as amended, Public Law 92-500 (33 U.S.C., Paragraph 1256), the Florida Department of Environmental Regulation (DER) completed a state-wide revision of stream segment delineation, classification and ranking which now provides the basis of priority for all DER water program activities. In this endeavor, the 13 major river basins in the state were divided into 115 segments. The segment delineations generally include those surface waters which have common hydrological characteristics, common natural, physical, chemical and biological processes and common reactions to external stresses.

KSC and CCAFS lie, for the most part, in stream delineation segments 27.1GA and 27.1EA. Of the 115 stream segments in the State, segments 27.1GA and 27.1EA rank 83rd and 72nd, respectively. Relative to those nine stream segments that are contained in the Florida East Coast Basin, segments 27.1GA and 27.1EA rank 5th and 3rd, respectively.

In general, lagoonal water quality is considered good, but variable with regard to turbidity. Winds affect the lagoonal systems significantly.

3. Land Quality

It can be fairly stated that the quality of land within the boundaries of KSC has been protected during the planning, construction and operation of facilities directly involved in launch operations and facilities used for support functions. The presence of KSC has isolated this large and environmentally important segment of the Florida East Coast from the type of extensive commercial development that has occurred to the north and south of its boundaries. This protective philosophy will be continued.

Approximately 80 percent of the undeveloped land within the KSC boundaries falls within the definition of floodplains and wetlands; controls have been established in consonance with Presidential Executive Orders 11988 and 11990.

4. Noise

The 24-hour average ambient noise level on the KSC is appreciably lower than the EPA recommended upper level of 70 dBA. This is on a scale ranging from approximately 10 dBA for the restling of grass or leaves to 115 dBA, the unprotected hearing upper limit for exposure to a missile or space launch.

The backwoods and National Wildlife Refuge areas of KSC are exposed to relatively low ambient noise levels, in the range of 35 to 40 dBA. In these sections, it is possible to identify bird calls from distances of serveral hundred meters. The traffic access routes during periods of heavy flow are rated at about 65 to 70 dBA, measured at 30 meters (100 feet) from the traffic artery. During past periods of construction, the use of heavy equipment such as dump trucks, bulldozers, draglines and earthmovers produced noise levels as high as 95 to 100 dBA.

The highest noise levels are produced during the first two minutes of vehicle launch with levels in excess of 160 dBA existing near the vehicle. Observer areas and security zones are located on a basis of 115 dBA maximum for personnel protection.

5. Sonic Boom

The term sonic boom actually describes the reception of bow shock waves generated by a vehicle traveling at supersonic speeds. The dynamic characteristics include the rise time, overpressure, time of duration, size and velocity of the generating vehicle. All missiles and space vehicles that are successfully launched from the KSC and CCAFS produce a sonic boom; however, these booms are produced well out over the ocean, away from the populated coast and do not affect land masses at all. Ships and aircraft in the area likely to be affected are warned prior to each launch.

D. Ecological Resources - Flora and Fauna

1. Introduction

Merritt Island supports large and diverse communities of flora and fauna. Much of the island has been maintained in an undeveloped state as a result of protection within the Merritt Island National Wildlife Refuge and the Canaveral National Seashore. The area is a mosaic of natural and developed coastal communnities typical of east-central Florida and includes citrus groves, shoreline and standing water vegetation in impoundments and construction ditches, vegetation in abandoned pastures and around old home-sites, plantings of Australian pine, eucalyptus, and Florida holly, and cultivated vegetation (grasses and ornamentals) along roads and around KSC and CCAFS facilities. The diversity of flora and fauna in this area is made even greater by the fact that Merritt Island is the northernmost area in the United States with both tropical and subtropical species.

Fauna include: crustaceans, mollusks, manatees and various transient fish, birds and snakes. See Reference 1 for listings of representative floral and faunal species found on Merritt Island.

2. Critical Ecological Areas

Certain commodities on Merritt Island are considered to be more fragile or of more ecological importance than others. Pursuant to the Coastal Zone Management Act of 1972 (Public Law 92-583), the Florida Bureau of Coastal Zone Planning identified certain areas on the Island as of critical importance which should be preserved or conserved. These areas include Class II waters, marine grass beds, aquatic preserves, coastal mangrove communities and dune communities.

Extreme care should be taken to protect these and other areas from undue disturbance or perturbation for several reasons. The marsh communities are important feeding areas for waterfowl and wading birds. The Spartina marsh is the only habitat of the endangered dusky seaside sparrow. Dune communities are very fragile and their destruction would eliminate a protection for inland areas from the atlantic Ocean. The mangrove communities also are very fragile and could be easily altered by dredging, flooding, impounding and clearing. They are important detritus sources within a complex marine food chain and are protected by Florida Statute 861.02. The marine grasses provide food and habitat for many marine animals, including the endangered Florida Manatee. Hammocks can act as fire breaks and are a refuge for wildlife during extended droughts. An openinig in their canopy may ultimately destroy the hammock as will changes in the water level or drainage flow in or near them. Hammocks and flatwoods appear to recover very slowly from even slight perturbation. Palm savannas cannot be developed without extensive filling which would prohibit the re-establishment of the original community.

Merritt Island is in general a fragile ecosystem and effects of land use on the biota must be closely monitored.

E. Social and Economic Resources

1. Introduction

This paragraph describes the existing socioeconomic environment of Brevard County, Florida, with emphasis on the area immediately surrounding KSC (see Figure IV-3). This area has been significantly impacted over the years by space program operations at KSC and earlier military launch activities on Cape Canaveral. Operations at KSC will continue to have measurable social and economic effects on Brevard County and to a lesser degree on outlying counties.

The inclusion of Centaur in STS will little affect existing resources. Manpower levels and mode of operation are essentially established and are in transition from the existing Atlas/Centaur program.

2. Population

The major population areas around the Eastern Launch Site are:

City	Miles from the ELS	Direction from ELS	1970 Census
Titusville	12	NW	30,000
Cocoa Beach	12	S	17,500
Merritt Island	14	SW	30,000

Most of the work force at the ELS comes from these areas and are stable in relationship to the space program. Population is increasing based on new industry, a new retirement element and tourism.

The larger population areas are at least 40 miles from the ELS and include Melbourne to the south, Orlando to the west ~~and Daytona~~ Beach to the north. These are rapidly growing areas experiencing growth in the industrial base, tourism, retirement and agriculture. Population in the east central Florida area is about one million with forecasts for continued growth. However, the

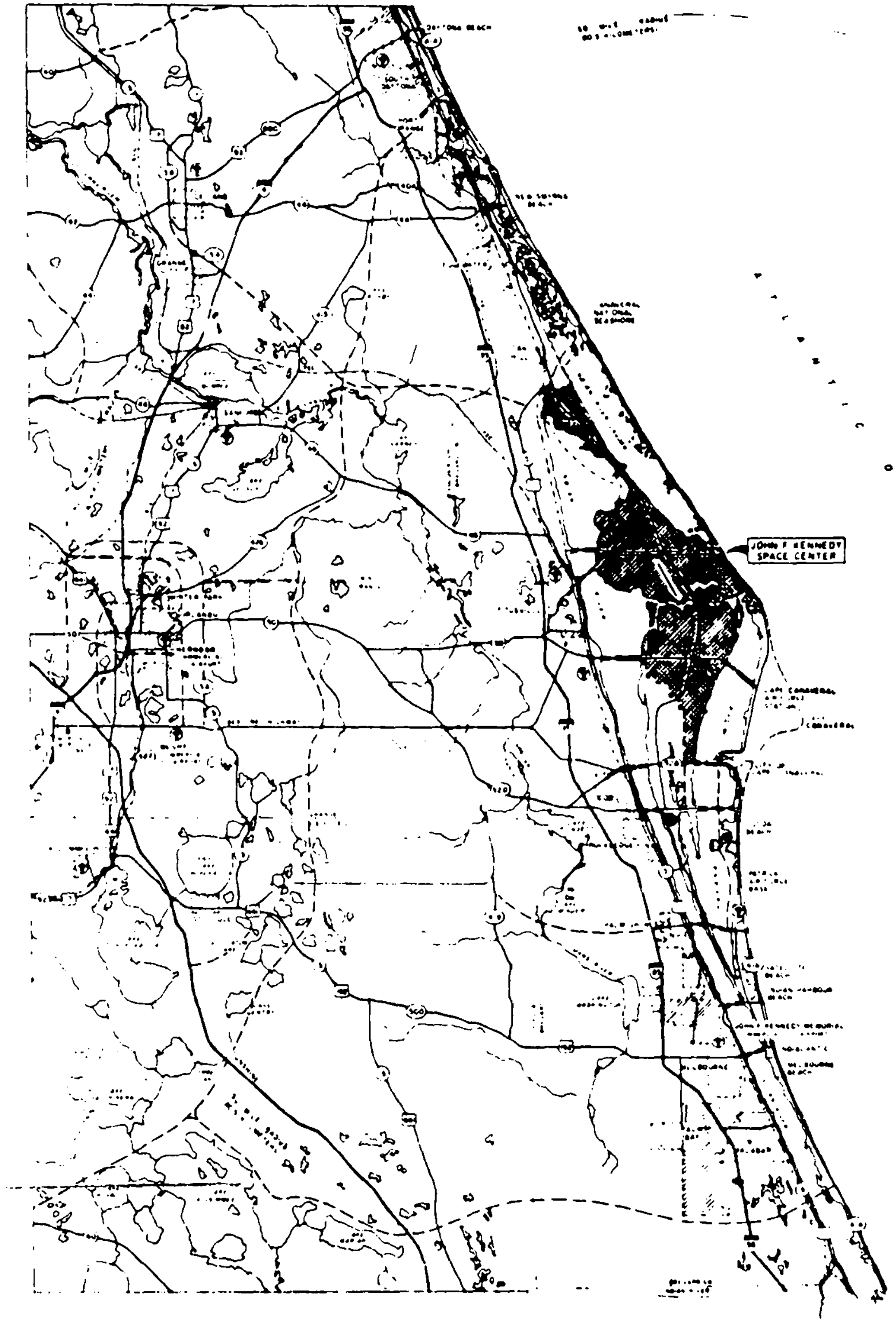


FIGURE IV-3
AREA SURROUNDING KENNEDY SPACE CENTER

growth that has occurred and that forecast will not significantly impact the ongoing space program or its operating environs.

3. Aesthetics

Brevard County located midway along the east coast of Florida, offers its residents and visitors the choice of urban, suburban, country and seashore or rivers edge living. The semitropical climate experiences warm, sunny summers and mild to cool winter days. The soil contributes to thriving lawns and lush, tropical landscaping. Birds and animals are abundant either as indigenous or migratory species. The natural beauty of the area, coupled with natural and manmade recreational resources, contributes to a healthful and satisfying life.

Evidence of the area's aesthetic value can be found in the 1975 Congressional legislation establishing the Canaveral National Seashore Park, the purpose being to preserve this beautiful and ecologically sensitive area for current and future generations of Americans. Additionally, the Merritt Island National Wildlife Refuge has, for years, operated successfully within KSC boundaries, ensuring the preservation of species of flora and fauna and providing interpretive wildlife programs for the public.

The interagency cooperation between NASA and these Department of Interior elements has illustrated that a large-scale technological effort such as space launches can be carried out without unacceptable impacts on the environmental aesthetics. It is expected that current and future operations will also be compatible with the preservation of the area's beauty.

V. LIST OF PREPARERS

1. ANALEX CORPORATION
   Washington, D.C.

The report integration and preparation was asssigned to Analex Corporation's Launch Vehicle Group at Cleveland, OH. A team led by John D. Gossett of the Senior Staff was responsible for the overall task.

2. LEWIS RESEARCH CENTER - NASA
   Cleveland, OH

The Lewis Research Center's Launch Vehicle Division with a team led by Ed Muckley, Mission Engineer for Galileo, reviewed the text and provided inputs.

3. NASA HEADQUARTERS
   Washington, DC

John Castalano, Centaur Program Office, Lewis Andrews, NASA Environmental Compliance Officer reviewed the text, provided inputs and gave approval for publication.

4. KENNEDY SPACE CENTER - NASA
   Kennedy Space Center, FL

Consultation with Kirby Key, et al, Environmental Management Staff.

5. GENERAL DYNAMICS CORPORATION - CONVAIR DIVISION
   San Diego, CA

Dan Sarokon, Chief, ETR Launch Operations provided inputs on operations and interface with the San Diego program office.

6. PRATT-WHITNEY AIRCRAFT - GOVERNMENT PRODUCTS DIVISION
   West Palm Beach, FL

Walt Schubert, Centaur Program Manager, inputs regarding the engine test area.

VI. CONSULTATION AND COORDINATION

A. Approach and Scoping Process

The approach and scoping process is as defined in the notice of intent to prepare an environmental impact statement for Centaur published in the Federal Register dated 7 September 1983. The process involved making use of environmental analysis work performed for STS operations at the launch area and considering the specific design of the Centaur for use in STS against that data. Additionally, much experience had been gained in the processing and launch of a similar Centaur stage over a period of 20 years. The analysis included comparing the existing Centaur stage to that planned for a determination of possible environmental impact.

As pointed out in the report, the incorporation of Centaur into STS does not introduce any new commodity or mode of operation not already considered for the STS or expendable vehicle's program. In this respect, the task was to evaluate the effect of adding the new Centaur stage for STS on a one-for-one basis of previous enviornmental considerations for the KSC EIS, the expendable vehicle program and a full evaluation of the new configuration itself. This process amply allowed for a complete environmental assessment based upon some extensive works delineating the environmental sensitivities at the launch site and drew upon a large vehicle operational experience. Consultations as necessary took place with those who were involved in the preparation of the documents. In this regard, no public reviews of this draft were held.

All applicable studies and reports were reviewed to make use of tasks already accomplished and consultation with the contractors and governmemt agencies knowledable on vehicle operations took place as necessary to assure all aspects of the environmental analysis was covered. Finally, the draft reports were reviewed by both NASA and Air Force personnel as well as by their respective contractors.

B. Review of the Draft Environmental Impact Statement (DEIS)

This DEIS will be available for review for a period of 45 days by Federal, State and local agencies and the public as applicable. All information received will be considered during preparation of the Final Environmental Impact Statement. Comments are solicited from the following:

Federal Agencies:
- Department of the Air Force
- Department of the Army
- Department of Commerce
- Department of Defense
- Department of Health and Human Services
- Department of the Interior
- Department of Labor
- Department of the Navy
- Department of Transportation
- Environmental Protection Agency
- National Aeronautics and Space Administration

State Agencies:
- Florida
  - Department of Environmental Regulation
  - East Central Florida Regional Planning Council
  - Intergovernmental Coordination - Office of the Govenor
- California
  - California State Clearinghouse, Office of Planning & Research
  - Resources Agency of California
  - San Diego State University

Local Agencies:
- Florida
  - Brevard County
    - Board of Commissioners
    - Economic Development Council
    - Planning and Zoning Department
  - Palm Beach County
    - Board of Commissioners
    - County Administrator
    - Environmental Health Division
    - Planning and Zoning Commission
  - Canaveral Port Authority
  - Cape Canaveral, City of
  - Cocoa, City of
  - Cocoa Beach, City of
  - Titusville, City of
- California
  - San Diego County
    - Property Department, Economic Development Division
    - Planning Commission
    - Planning Department (Zoning)
  - San Diego, City of

Private Agencies:
- Air Polution Control Association
- Center for Urban Affairs and Policy Research
- Concern, Inc.
- Ecological Society of American
- Environmental Action, Inc.
- Environmental Policy Center
- Sierra Club
- Wilderness Society
- Wildlife Society, Inc.

Corporations:
- General Dynamics, Convair Division
- Pratt-Whitney Aircraft, Government Products Division

Copies available on request.

VII. COMMENTS RECEIVED AND NASA RESPONSES

A. Introduction

Comments on the Draft Environmental Impact Statement were requested from Federal and State agencies and from Interest groups. Of the seven responses received, none took exception to the Statement though two raised questions which elicited a NASA response.

B. Agencies Responding to the Draft Impact Statement

1. United States Environmental Protection Agency
2. United States Department of the Interior
3. The Resources Agency of California
4. The City of San Diego
5. State of Florida, Department of Environmental Regulation
6. State of Florida, Department of Natural Resources
7. Florida Game and Fresh Water Fish Commission

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30365

AUG 0 1984

4PM-EA/GM

Mr. John W. Boyd
Associate Administrator for Management
NASA
Washington, D.C. 20546

Dear Mr. Boyd:

We have reviewed the draft environmental impact statement for the proposed "Centaur Upper Stage for Use With the Space Transportation System." Although the document projects a number of environmental effects as a result of this action, it appears that none of the anticipated impacts will be significant or of long-term. This is reflected by our assigned rating of LO-1, viz., no significant objections and no further information is required.

If we can be of further assistance, please advise.

Sincerely yours,

Sheppard N. Moore, Chief
Environmental Review Section
Environmental Assessment Branch

United States Environmental Protection Agency,
Region IV, Atlanta, Georgia

Statement: The proposed Centaur Upper Stage for use with the Space Transportation System is assigned a rating of LO-1, viz., no significant objections and no further information is required.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

JUL 24 1984

ER 84/804

Mr. John W. Boyd
Associate Administrator for Management
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Mr. Boyd:

This responds to your request for the Department of the Interior's comments on the draft environmental statement for **Centaur Upper Stage for Use with Space Transportation System.**

The draft statement adequately addresses impacts to resources of concern to this Department.

Thank you for the opportunity to provide these comments.

Sincerely,

Bruce Blanchard, Director
Environmental Project Review

Resources Building
1416 Ninth Street
95814

(916) 445-5656

Department of Conservation
Department of Fish and Game
Department of Forestry
Department of Boating and Waterways
Department of Parks and Recreation
Department of Water Resources
California Conservation Corps

GEORGE DEUKMEJIAN
GOVERNOR OF
CALIFORNIA

THE RESOURCES AGENCY OF CALIFORNIA
SACRAMENTO, CALIFORNIA

Air Resources Board
California Coastal Commission
California Waste Management Board
Colorado River Board
Energy Resources Conservation and Development Commission
San Francisco Bay Conservation and Development Commission
State Coastal Conservancy
State Lands Commission
State Reclamation Board
State Water Resources Control Board
Regional Water Quality Control Boards

Mr. John Castellano
Centaur Program Officer
Office of Space Transportation
NASA
Washington, D.C. 20546

July 5, 1984

Dear Mr. Castellano:

The State has reviewed the draft EIS, Proposed Centaur Upper Stage for Use with Space Transportation System, submitted through the Office of Planning and Research.

This review was coordinated with the State Water Resources Control Board and the Department of Transportation.

We have received no comments from the reviewing entities concerning this document. Therefore, the State will have no comment.

Thank you for providing the report for review and comment.

Sincerely,

Charles K. [signature] for
Gordon F. Snow, Ph.D
Assistant Secretary for Resources

cc: Office of Planning and Research
1400 Tenth Street
Sacramento, CA 95814

(SCH 84060610)

The Resources Agency of California,
Sacramento, California

Statement: No comments from the reviewing entities of this document were received. Therefore, the State will have no comment.

THE CITY OF
SAN DIEGO
CITY ADMINISTRATION BUILDING • 202 C STREET • SAN DIEGO, CALIF. 92101

JUL 24 9 02 AM '84

ENVIRONMENTAL
QUALITY DIVISION
PLANNING
DEPARTMENT
236-5775

June 20, 1984

John W. Boyd
Associate Administrator for Management
National Aeronautics and Space Administration
Washington, D.C. 20546
ATTN: NXG

Dear Mr. Boyd:

SUBJECT: NASA CENTAUR UPPER STAGE ENVIRONMENTAL IMPACT STATEMENT

The City of San Diego Planning Department has reviewed the above referenced Environmental Impact Statement (EIS). The primary concern we have is the hazardous test and development activity at the General Dynamics test area located near Sycamore Canyon in San Diego County. It is our understanding that testing (such as test firings of completed engines) which would result in excessive noise levels will not be conducted in San Diego County. If testing which would generate excessive noise is planned for our area, this should be addressed in the final EIS.

This concludes the comments we have at this time. Please contact Tom Huffman at (619) 236-7054 if you have any questions regarding our review.

Sincerely,

David A. Potter

David A. Potter, Acting Deputy Director
City Planning Department

TBH:DAP:kap

cc: Walt Hauschildt, City Economic Development Division
Robert E. Asher, Department of Planning and Land Use,
County of San Diego

The City of San Diego, San Diego, California

Comment: The primary concern we have is the hazardous test and development activity at the General Dynamics test area located near Sycamore Canyon in San Diego County. It is our understanding that testing (such as test firings of completed engines) which would result in excessive noise levels will not be conducted in San Diego County.

Response: The understanding is correct. No engine firings are planned for San Diego County. Excessive noise levels are not expected from any of the hazardous test activity being conducted in the area.

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

TWIN TOWERS OFFICE BUILDING
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301-8241

BOB GRAHA
GOVERNO

VICTORIA J. TSCHINKE
SECRETAR

RECEIVED JUN 29 1984

June 29, 1984

Mr. Walt Kolb
Senior Governmental Analyst
Office of Planning and Budgeting
Office of the Governor
404 Carlton Building
Tallahassee, Florida 32301

Dear Walt:

Re: Draft Environmental Impact Statement for the Proposed Centaur Upper Stage for Use with Space Transportation System, SAI No. FL8406081297C

We have reviewed the above referenced environmental report and have no objections to the development and use of the Centaur upper stage as a part of the Space Transportation System for proposed Galileo and Internationa Solar Polar planetary missions. The National Aeronautics and Space Administration should coordinate closely with our St. Johns River District Office in Orlando concerning construction changes to any Kennedy Space Center or operation facility that may result in air or water pollution.

Although the document did not include a federal consistency determination pursuant to 15 CFR 930, Subpart C, we do not anticipate any adverse impacts to Florida's Coastal Zone from Centaur development and use. Accordingly, we find the project to be consistent with this department's authorities in Florida's Coastal Management Program.

Sincerely,

John B. Outland

John B. Outland
Intergovernmental Programs
Review Section

JBO/jb

Protecting Florida and Your Quality of Life

State of Florida, Department of Environmental Regulation
Tallahassee, Florida

Comment: The National Aeronautics and Space Administration should coordinate closely with our St. Johns River District in Orlando concerning construction to any Kennedy Space Center or operation facility that may result in air or water polution.

Although the document did not include a federal consistancy determination pursuant to 15 CFR 930, Subpart C, we do not anticipate any adverse impacts to Florida's Coastal zone from Centaur development and use.

Response: In section IIA 4, Land Assignments, of the draft Impact Statement, it was stated that the Centaur program is responsive to the Kennedy Space Center for any impact to the larger environment which included the Merritt Island National Wildlife Refuge, the Canaveral National Seashore, Coastal Zone Management, Flood Plains and Wetland Restrictions and Mosquito Control. It was inadequately presented that KSC's execution of these responsibilities include the conduction of an environmental assessment of all facility requirements for use, construction or modification. KSC further interfaces with affected environmental agencies and obtains all necessary permits. Details are provided in the referenced Environmental Impact Statement for the Kennedy Space Center. The Centaur Program's role in obtaining facilities is then to provide requirements, funds and acceptance of the design and final validation.

State of Florida
DEPARTMENT OF NATURAL RESOURCES

DR. ELTON J. GISSENDANNER
Executive Director
Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard, Tallahassee, Florida 32303

June 25, 1984

MEMORANDUM

: Walt Kolb, Senior Governmental Analyst
Office of Planning and Budgeting
Office of the Governor

FROM : Dale Adams, Administrative Assistant
Division of Resource Management

SUBJECT: EIS on Proposed Centaur Upper Stage
for Use With Space Transportation System

I have reviewed the report on this project and feel that it will not adversely effect any Department's program area. Thus, I have no objection to the report.

JDA/amm

State of Florida, Department of Natural Resources,
Tallahassee, Florida

Statement: I have reviewed the report on this project and feel that it will not adversely effect any department's program area. Thus, I have no objection to the report.

FLORIDA GAME AND FRESH WATER FISH COMMISSION

FARRIS BRYANT BUILDING
620 South Meridian Street
Tallahassee, Florida 32301
(904) 488-1960

June 21, 1984

RECEIVED
JUN 25 1984

Mr. Walt Kolb
Office of the Governor
The Capitol
Tallahassee, FL 32301

RE: EIS for the Proposed Centaur Upper Stage for Use With Space Transportation System

Dear Mr. Kolb:

The ~~Office of~~ Environmental Services has reviewed the referenced project and has no comments.

If we may offer further assistance, please contact us.

Sincerely,

Douglas B. Bailey

Douglas B. Bailey
Assistant Director,
Office of Environmental
Services

DBB/ms
ENV. 1-3-2

State of Florida, Florida Game and Fresh Water Fish Commission,
Tallahassee, Florida

Statement: The office of Environmental Services has reviewed the referenced project and has no comments.

APPENDIX A

REFERENCES

1. "Environmental Impact Statement for the John F. Kennedy Space Center" Final Statement, October 1979.

   Note: This extensive work considered the overall environment at the launch site including all land areas in use for Centaur. This work, including its more than 50 references along with inputs from many outside agencies, is the basic environmental reference for the launch site area.

2. "Environmental Statement for the Office of Space Science, Launch Vehicles and Propulsion Programs" NASA, Washington, DC 20546, Final Statement, July, 1973.

3. "Environmental Narrative, Cape Canaveral Air Force Station, Cape Canaveral, Florida" Pan American World Airways, Inc., Aerospace Services Division, December, 1977.

4. Centaur G, Technical Description: "A High-Performance Upper Stage for use in the Space Transportation System" General Dynamics, Convair Division, February, 1983.

5. "Environmental Impact Analysis Process, Candidate Environmental Statement, Interim Upper Stage Segment" Department of Defense, Space Transportation System, Department of the Air Force, November, 1977.

6. "Threshold Limit Values of Airborne Contaminants" American Conference of Government Hygienists, 1971.

7. "Compendum of Human Responses to the Aerospace Environment" Volume III, NASA, CR-1205 (111), November, 1968.

8. "Guides for Short-Term Exposures of the Public to Air Pollutants, V. Guide for Hydrazine, Monomethylhydrazine and Dimethylhydrazine" National Academy of Sciences/National Research Council Committee on Toxicology, June, 1974.

9. "Description of the RL-10 Rocket Engine Test Facility" Pratt and Whitney Aircraft, West Palm Beach, FL, 1983.

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