Prelaunch
Mission Operation Report
No. O-492-203-82-05

TO: A/Administrator

FROM: O/Associate Administrator for Space Transportation Operations

SUBJECT: WESTAR-V Launch on Delta

WESTAR-V is the second in a series of second-generation large, 24-transponder communications satellites developed for the Space Communications Company. It is scheduled to be launched on a Delta vehicle from the Eastern Space and Missile Center (ESMC) no earlier than June 8, 1982. The launch support for this mission will be provided by NASA, on a reimbursable basis, to the Space Communications Company for a fixed price of $25.0M. Launches of their smaller, first-generation satellites, WESTAR-A, -B, and -C were successfully conducted in April 1974, October 1974, and August 1979, respectively. Launch for identical Westar-IV satellite was accomplished on February 25, 1982, successfully.

The launch vehicle for the WESTAR-V mission will be the Delta 3910 configuration which incorporates an Extended Long Tank Thor booster, nine Castor IV strap-on motors, a TR-201 second stage, and an 8-foot fairing.

The Delta launch vehicle will place the spacecraft along a suborbital trajectory. The McDonnell-Douglas Commercial PAM-D stage will then thrust it to a synchronous transfer orbit. Three days after launch, the spacecraft Apogee Kick Motor will be fired to circularize its orbit at geosynchronous altitude of 19,300 NM above the equator at approximately 75 degrees West Longitude.

Stanley I. Weiss

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NASA
National Aeronautics and
Space Administration

Mission Operation Report

OFFICE OF SPACE TRANSPORTATION SYSTEMS Report No. O-492-203-82-05

Westar-V

FOREWORD

MISSION OPERATION REPORTS are published expressly for the use of NASA Senior Management, as required by the Administrator in NASA Management Instruction HQMI 8610.1A, effective October 1, 1974. The purpose of these reports is to provide NASA Senior Management with timely, complete, and definitive information on flight mission plans, and to establish official Mission Objectives which provide the basis for assessment of mission accomplishment.

Prelaunch reports are prepared and issued for each flight project just prior to launch. Following launch, updating (Post Launch) reports for each mission are issued to keep General Management currently informed of definitive mission results as provided in NASA Management Instruction HQMI 8610.1A.

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GENERAL

On December 30, 1980, an Agreement was signed between the NASA and the Space Communication Company (SCC) which set forth terms and conditions whereby NASA would furnish Delta launch vehicles and associated services on a reimbursable basis for the purpose of this launching (as well as the launch of Westar-IV, already accomplished).

In accordance with the Agreement:

. NASA will provide support described in the "Delta Standard Services List," dated April 1980, which includes the following services:

- Provide and launch a Delta 3910 Launch Vehicle to place the WESTAR-V "Payload"* into an orbit desired by SCC
- Provide working area for the spacecraft at ESMC
- Provide for spacecraft telemetry reception during launch preparation and during the ascent
- Provide network communications support necessary for launch and initial orbit phase
- Calculate initial transfer orbit
- Provide various services, if required, to support the launch

. SCC will undertake to do or certify that the following has been done:

- Provide mission requirements
- Assure spacecraft compatibility with launch vehicle and tracking and data facilities
- Provide a spacecraft interface specification
- Provide a flight-ready spacecraft to the range
- Assure to NASA that spacecraft has been properly tested
- Provide documentation that apogee motor meets range standards
- Determine launch criteria for spacecraft and supporting stations

The NASA launch support of the WESTAR-V mission is being provided to SCC at a fixed price of $25.0M.

*Payload is defined as the WESTAR spacecraft, McDonnell Douglas PAM-D and Perigee Kick Stage, and all associated adapters, attach fittings, and spin table.

NASA MISSION OBJECTIVES FOR THE WESTAR-V MISSION

Launch the WESTAR-V satellite along a suborbital trajectory on a two-stage Delta 3910 launch vehicle with sufficient accuracy to allow the payload propulsion system to place the spacecraft into a stationary synchronous orbit while retaining sufficient station-keeping propulsion to meet the mission lifetime requirements.

Joseph B. Mahon

Joseph B. Mahon, Director
Expendable Launch Vehicle Programs
Space Transportation Operations

Date: May 24, 1982

Stanley I. Weiss

Stanley I. Weiss
Associate Administrator for
Space Transportation Operations

Date: May 25, 1982

MISSION DESCRIPTION

Events from launch to final mission attitude in geostationary orbit occur in a sequence comprised of four basic phases:

- Boost phase, from lift-off through Second Stage Cutoff (SECO), and separation of the payload from the spinning Delta second stage; during this phase only, the command receiver and telemetry transmitter of the spacecraft are active.

- Transfer orbit phase, from second stage separation to apogee motor ignition; during this phase, the spacecraft spin axis orientation and spin rate are measured and controlled to provide (a) stable thermal and power conditions during the interval and (b) final orientation for apogee motor firing. The spacecraft and apogee motor comprise a stable spinning inertia distribution during this phase so that only passive nutation damping is required.

- Synchronous orbit injection phase, during which the apogee motor burn increases the magnitude and changes the direction of satellite velocity to effect the change from the inclined, elliptical transfer orbit to the synchronous altitude, equatorial final orbit.

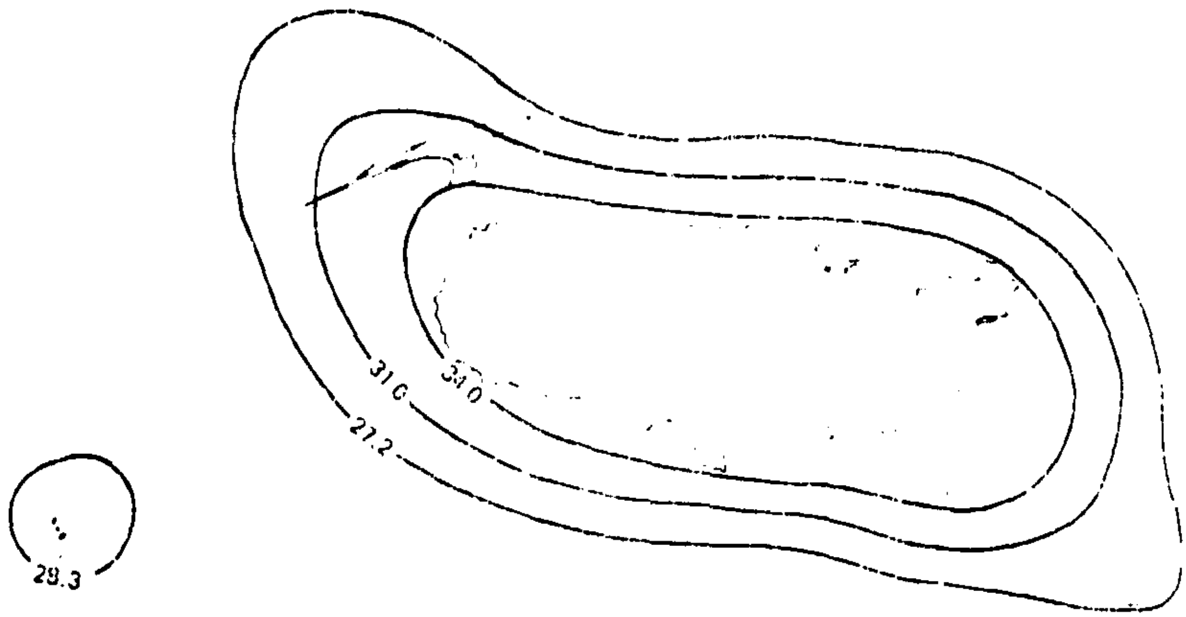
- Drift orbit and erection phase, during which the spin rate of the spacecraft is adjusted to the final system angular momentum range, the spin axis and momentum range, the spin axis and momentum vector are aligned to the orbit normal, and the momentum wheel is energized to cause the body pitch axis to align to the orbit normal. The solar array is then deployed, and Earth capture is accomplished by using Earth sensor error signals to control the momentum wheel rate.

The use of a new antenna design in which the channels are divided evenly between horizontally and vertically polarized signals doubles the channel capacity of the WESTAR system. This same technique was employed on the Palapa-B and Anik D satellites. The antenna consists of two superimposed reflecting surfaces. The front horizontal grid reflector is transparent to vertically polarized signals which are reflected from the rear reflector. Superimposition of the reflectors in a single aperture allows the two to share structural support and use the largest possible area atop the satellite. The reflectors are offset from one another at the bottom, which allows a corresponding offset of the focal planes. This positioning permits use of separate, noninterfering feed arrays for the transmit and receive functions. The antenna can be folded into a stowed position, enabling the satellite to be carried upright in an expendable launch vehicle or in the Space Shuttle bay. The antenna is deployed after the spacecraft is placed in its final synchronous orbit.

Unlike earlier WESTAR designs, the entire WESTAR-V transponder is despun. This permits use of a more complicated antenna feed and reduces power loss. In addition, each of the 24 communication channels in the satellite's transponder uses a single 7.5 watt traveling wave tube amplifier, in contrast to the 5 watt tubes used in the first three WESTARs. The transponder's traveling wave tubes (TWTs) are scaled versions of higher power Anik D TWTs; they are exactly the same but have a reoptimized helix for lower power. The change to higher power tubes is made possible by the greater battery capacity of the larger WESTAR-V spacecraft. With the antenna gain developed by the single, large, shaped beam reflector, a signal strength of at least 34 dBW is generated throughout the continental United States-- a 1 dB improvement over earlier WESTARs. The satellite also provides upgraded performance for its noncontinental coverage areas (see Figure 1). Redundant receivers in the transponder employ solid-state FET microwave integrated circuit techniques. This provides better weighted beam receive sensitivities in the coverage areas shown in Figure 2.

The satellite will focus a single gain-weighted shaped beam over the continental United States with the higher gain over the eastern portion of the U.S., as shown in Figure 1. The weighted beam will be created by a 183 cm reflector with two reflecting surfaces. The front horizontal grid reflector is transparent to vertically polarized signals, which are reflected from the rear reflector. Superimposition of reflectors in a single aperture allows two reflectors to share structural support and use the largest diameter possible. The two reflectors are offset from each other at the bottom, allowing a corresponding offset of the focal planes. This offset permits separate feed arrays for transmit and receive which do not physically interfere with each other.

WESTAR-V EIRP CONTOURS AT 4 GHz



Fig

WESTAR-V RECEIVE SENSITIVITY CONTOURS AT 6 GHz

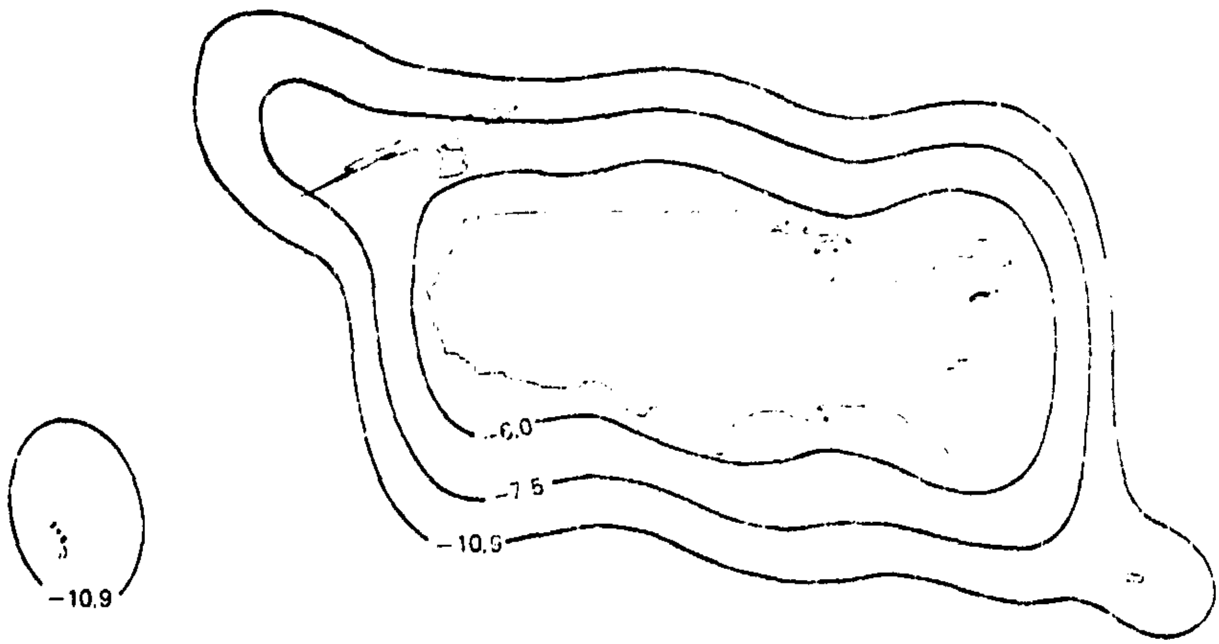


Fig. 2

SPACECRAFT DESCRIPTION

WESTAR-V is built by Hughes Aircraft Company and is a spin stabilized (HS 376) design (Figure 3). Hughes has contracted to build three for Satellite Business Systems (SBS), five for Telesat Canada (Anik C and D), two for Indonesia (Palapa-B), and four for Australia. The spacecraft has two concentric, telescoping cylindrical solar panels. The outer panel is deployed after the satellite is placed in synchronous orbit, doubling the solar cell area of satellites with comparable diameter. With the outer panel extended, the spacecraft will generate 684 watts of power at end of life.

The WESTAR-V spacecraft has in common with the other HS 376 satellites, its telemetry, command, propulsion subsystem, spinning section and apogee motor (Thiokol Star 30). Its power system is similar to previous Hughes designs and incorporates improved K-7 solar cells, providing 20 mW/cm^2. Two 19 A-hr nickel cadmium batteries supply full power service during eclipse operation for 10 years.

Heat generated by the HS-376 electronics equipment is radiated into space through a thermal radiation band around the middle of the satellite. In WESTARs I, II, and III, heat was radiated through the end of the cylindrically shaped spacecraft, making them more sensitive to the thermal changes created by seasonal variations in the incident sun angle.

The WESTAR-V spacecraft is 216 cm (86 in.) in diameter and 659 cm (257 in.) high when fully deployed in space. It weighs 1105 kg (2450 lbs.) following injection into elliptic transfer orbit. After its apogee motor fires, the on-station weight is 584 kg (1290 lbs.). On-orbit stationkeeping and attitude control are provided by four 22.2 Newton thrusters, which operate with 142 kg of monopropellant hydrazine carried in four titanium tanks. Telemetry, tracking, and command functions are performed at 6/4 GHz. A brief comparative summary of the second generation satellites with earlier WESTARs is shown in Table 1.

WESTAR-V CONFIGURATION

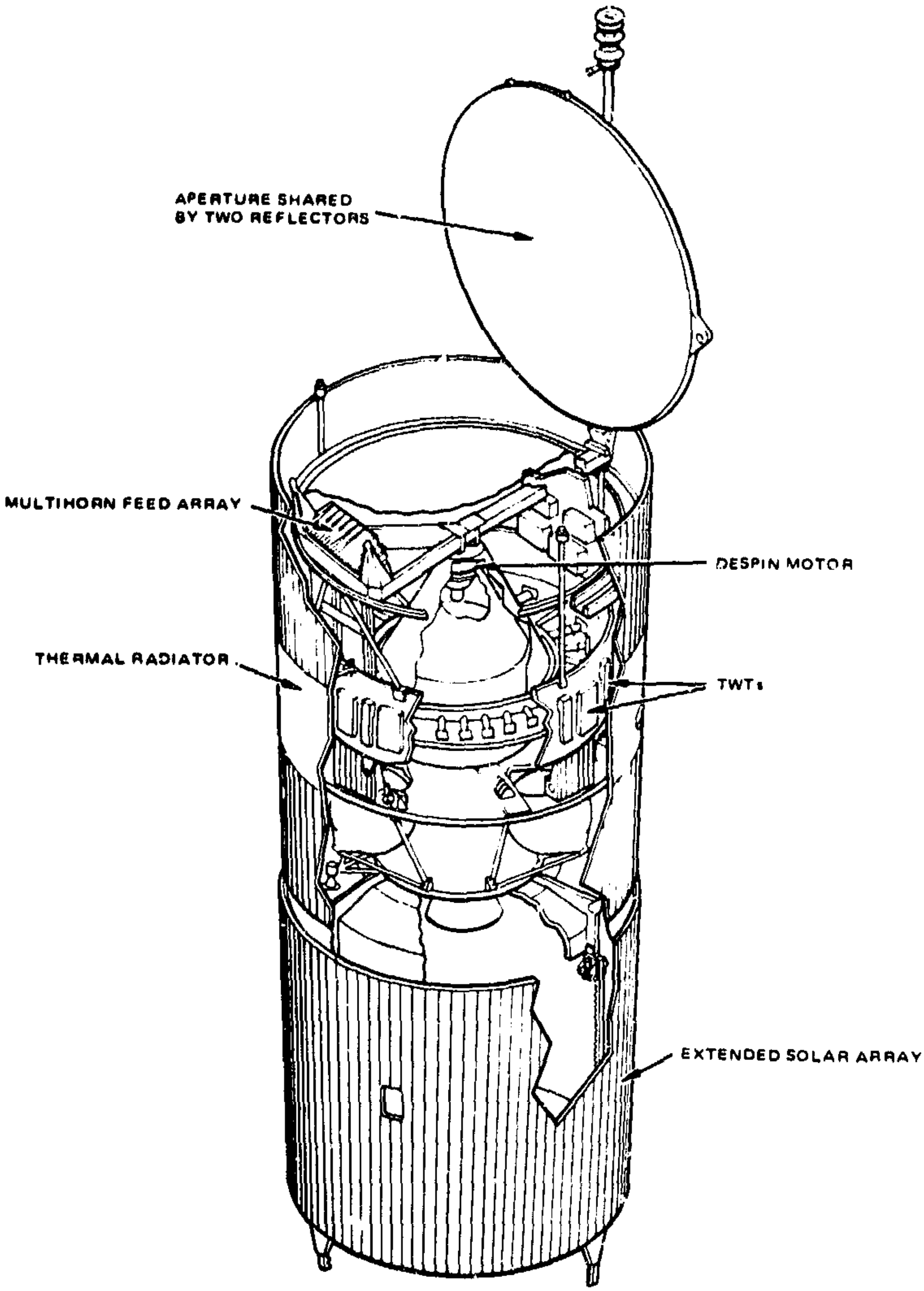


Fig. 3

TABLE 1
WESTAR SATELLITE COMPARISON

	First Generation WESTARs I, II, III	Second Generation WESTARs IV, V
Launch Vehicle	Delta 2914	Delta 3910
Weight, Beginning of Life, kg	306	584
Service, GHz	6/4	6/4
Channels	12	24
Dimensions, cm		
Height	345	659 (Deployed) 279 (Stowed)
Diameter	190	216
Power Capability, W		
Beginning of Life	307	822
End of Life	262	684
TWT Output Power, W	5.0	7.5
Design Life, Jr.	7	10
Performance		
EIRP, dBW	33.0 (CONUS) 24.5 (Alaska, Hawaii)	34.0 (CONUS) 31.0 (Alaska) 28.3 (Hawaii) 27.2 (Puerto Rico)
G/T, dB/^oK	-7.4 (CONUS) -14.4 (Alaska, Hawaii)	-6.0 (CONUS) -7.5 (Alaska) -10.9 (Hawaii) -10.9 (Puerto Rico)

LAUNCH VEHICLE DESCRIPTION

The WESTAR-V spacecraft will be launched by the thrust-augmented NASA Delta 3910 launch vehicle (Figure 4). The Delta 3910 launch vehicle characteristics are shown in Table 2. A schematic of the launch vehicle is shown in Figure 5. This will be the 162nd flight for Delta. Of the previous 161 flights, 148 have successfully placed satellites into orbit.

LAUNCH VEHICLE FOR THE WESTAR-V MISSION
DELTA 3910

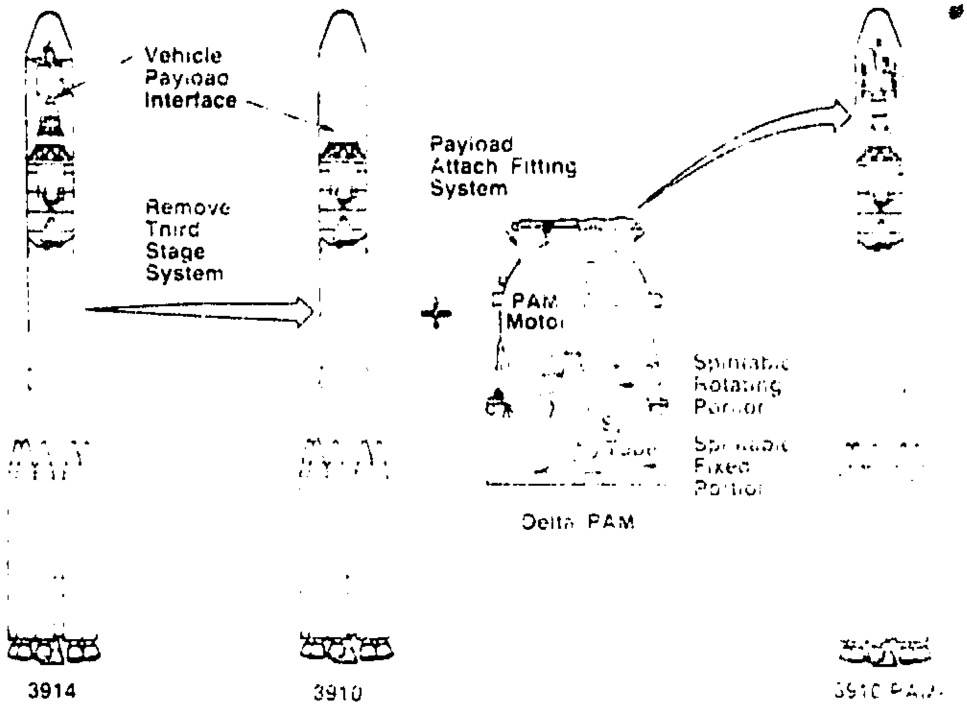


Fig. 4

Delta is managed for the NASA Office of Space Transportation Operations by the Goddard Space Flight Center, Greenbelt, MD. Launch operations management is the responsibility of the Kennedy Space Center's Deployable Payloads Operations Division. The McDonnell Douglas Astronautics Co., Huntington Beach, CA, is the Delta prime contractor for the vehicle and launch services.

Overall the Delta 3910 is 35.5 meters long (116 ft), including the spacecraft shroud. Lift-off weight is 190,630 kg (420,269 lb) and lift-off thrust is 2,058,245 newtons (547,504 lb), including the startup thrust of six of the nine solid motor strap-ons (the remaining strap-ons are ignited at 62 seconds after lift-off).

The first stage booster will be an extended long-tank Thor powered by the Rocketdyne RS-27 engine system which uses Hydrazine (RP-1) and liquid oxygen propellants. Pitch and yaw steering is provided by gimballing the main engine. The vernier engines provide roll control during powered flight and control during coast.

TABLE 2
DELTA 3910 LAUNCH VEHICLE CHARACTERISTICS

	Strap-On	Stage I	Stage II
Length	11.3 m (37.0 ft)	21.3 m (70.0 ft)	700.0 cm (276 in)
Diameter	101.6 cm (40 in)	243.3 cm (96 in)	139.7 cm (55 in)
Engine Type	Solid	Liquid	Liquid
Engine Manufacturer	Thiokol	Rocketdyne	TRW
Designation	TX-526	RS-27	TR-201
Number of Engines	9	1 (+2VE)	1
Specific Impulse Avg.	229.9	262.4	302
Thrust (per engine) (Avg.)	407,000 N (91,520 lb)	911,840 N (205,000 lb)	43,398 N (9,756 lb)
Burn Time	58.2 (sec)	228 (sec)	315 (sec max)
Propellant	TP-H-8038	RP-1 (LOX oxid.)	A-50 (N_2O_4 oxid.)

DELTA 3910 - VEHICLE ELEMENTS

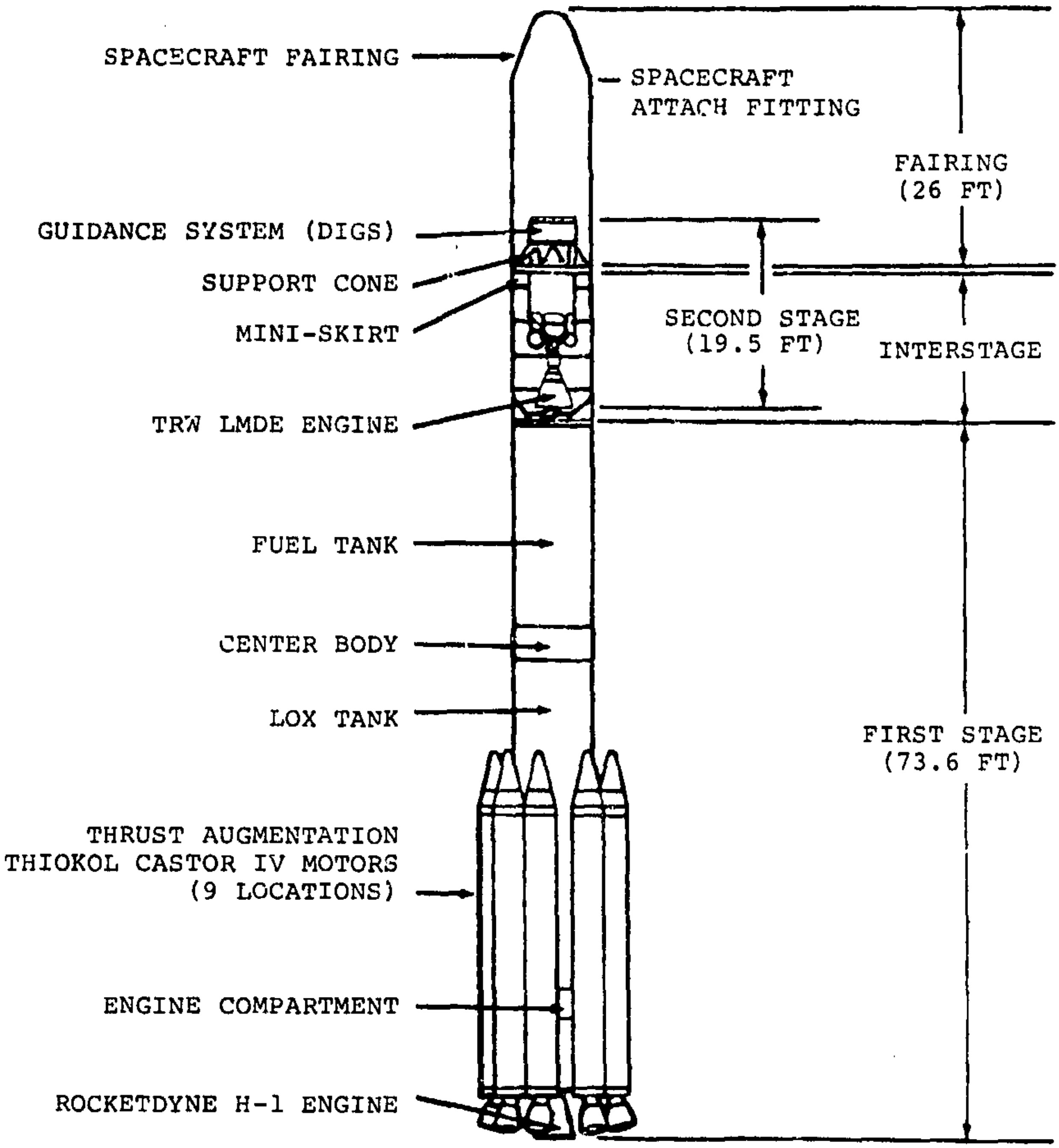


Fig. 5

The second stage is powered by the TRW TR-201 liquid bipropellant engine using N_2O_4 as the oxidizer and Aerozene-50 as the fuel. Pitch and yaw steering during powered flights is provided by gimballing the engine. Roll steering during powered flight and all steering during coast are provided by a GN_2 cold gas system.

The guidance and control system of the vehicle is located on top of the second stage. The strap-down Delta Inertial Guidance System (DIGS) provides guidance and control for the total vehicle from lift-off through attitude orientation. The system is composed of a digital computer provided by Delco and either the Inertial Measurement Unit (IMU) provided by Hamilton Standard or the Delta Redundant Inertial Measurement System (DRIMS) developed by MDAC.

First and second stage telemetry systems are similar, both combining the use of pulse duration modulation and frequency modulation. Critical vehicle functions are monitored to provide data for determining which components, if any, are not functioning properly during ascent.

Tables 3 through 6 show the flight sequence of events, the mission requirements, the flight mode description, and the predicted orbit dispersion. Figure 6 shows the vehicle ascent profile for the WESTAR-V mission.

TABLE 3
FLIGHT SEQUENCE OF EVENTS
(WESTAR-V MISSION)

EVENT	TIME (SEC)
Liftoff	0.0
Six Solid Motors Burnout	57.0
Three Solid Motors Ignition	62.0
Jettison Six Solid Motor Casings	71.0
Three Solid Motors Burnout	119.2
Jettison Three Solid Motor Casings	125.5
Main Engine Cutoff	223.9
Stage I-II Separation	231.9
Stage II Ignition	236.9
Jettison Fairing	241.0
SECO-1	542.6
Fire Spin Rockets	1220.0
Jettison Stage II, Activate Retro System	1222.0
PAM Ignition	1261.0
PAM Burnout	1347.0
Jettison PAM - Spacecraft Separation	1460.0

TABLE 4
MISSION REQUIREMENTS

NOMINAL ORBIT PARAMETERS AT SPACECRAFT INJECTION AFTER PAM OPERATION

Apogee Altitude	19,673 NM
Perigee Altitude	90 NM
Inclination	27.5 Degrees
Spin Rate	50 RPM
SPACECRAFT WEIGHT (AT LIFT-OFF)	2453 lb

TABLE 5
FLIGHT MODE DESCRIPTION

- o Launch from PAD 17A at ESMC
- o Launch Window is 8:23 p.m. to 9:26 p.m. EDT
  Flight Azimuth will be 99°
  Second Stage is Sub-Orbital and Impacts West of Africa at roughly 1° East Longitude and 7° South Latitude
- o Second Stage Apogee is 149 N.M.
- o PAM Spin Up and Separation occur at altitude of 112 N.M.
- o Final Location will be at 75° West Longitude

TABLE 6
PREDICTED ORBIT DISPERSIONS (99% PROBABILITY)

Apogee Altitude	±790 NM
Perigee Altitude	±5 NM
Inclination	±0.4 Degree
Spin Rate	±5 RPM

WESTAR-V SECOND STAGE TRAJECTORY SCHEMATIC

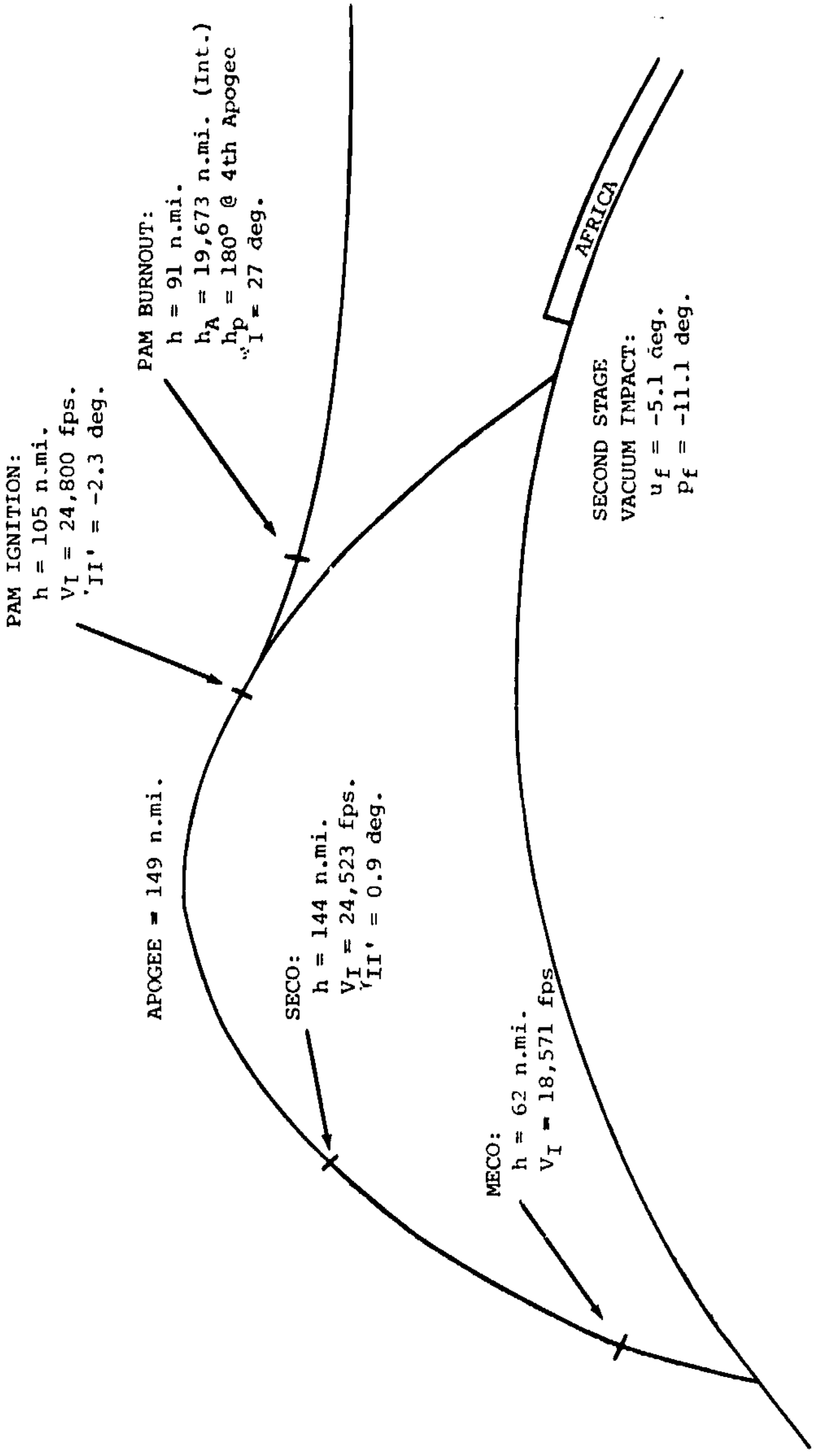


Fig. 6

MISSION SUPPORT

RANGE SAFETY

Command destruct receivers are located in the first and second stages and are tuned to the same frequency. In the event of erratic flight, both systems will respond to the same RF modulated signal sent by a ground transmitting system upon initiation by the Range Safety Officer.

LAUNCH SUPPORT

The Eastern Space and Missile Center (ESMC), the launch vehicle contractor, McDonnell Douglas, and NASA will supply all personnel and equipment required to handle the assembly, prelaunch checkout, and launch of the Delta vehicle. GSFC will provide technical advisory personnel to SCC, if required.

TRACKING & DATA SUPPORT

ESMC Range stations will track the first and second stages. A nominal trajectory and orbit will be provided approximately 30 minutes after launch based on this data and the assumption that the PAM was nominal. SCC has established stations that will be used to determine the final transfer orbit and also to provide data necessary for the firing of the PAM and the apogee motor.

GROUND COMPLEX

During the transfer stage, WESTAR ground stations at Glenwood, New Jersey, Estill Fork, Alabama, Lake Geneva, Wisconsin, Steele Valley, California, Cedar Hill, Texas, Sky Valley, California, and Issaquah, Washington, provide global tracking, telemetry and command coverage.

On the seventh apogee, the Star 30 apogee kick motor will be fired to produce a near-synchronous orbit. Positioning of the spacecraft at 75 degrees West Longitude above the equator will follow using the satellite's on-board altitude positioning gas system.

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McDonnell Douglas Astronautics Company	Delta Launch Vehicle and PAM-D Payload Stage
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Thiokol Corp. Huntsville, AL	Castor IV Strap-on Solid Fuel Motors
TRW Redondo Beach, CA	TR-201 Second Stage Engine
Delco Santa Barbara, CA	Guidance Computer

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