Prelaunch
Mission Operation Report
No. M-492-201-82-05

August 24, 1982

TO: A/Administrator

FROM: M/Associate Administrator for
Space Flight

SUBJECT: Delta Launch of the Telesat-G Mission

The Telesat-G spacecraft (which will be designated the Anik-D satellite in orbit) is scheduled to be launched on a Delta 3920 launch vehicle from the Eastern Space and Missile Center (ESMC), no earlier than August 26, 1982. Telesat/Canada will reimburse NASA for the cost of providing standard Delta 3910 launch support in accord with the terms of a Launch Service Agreement between NASA and Telesat/Canada, dated June 21, 1982, as well as the incremental cost of providing Delta 3920 launch support in accord with a special agreement signed March 6, 1980.

The purpose of this satellite is to provide point-to-point communications between widely scattered remote areas throughout Canada in the 6/4 GHz bands. This satellite is the first of two satellites being built for Telesat/Canada to replace the original Anik-A series (Telesat-A, -B, -C) satellites launched by Delta in November 1972, April 1973 and May 1975. Telesat-E, -F, -H, and -I are planned for launch on Shuttle in 1982 thru 84 to replace the Anik-B (Telesat-D) satellite launched on Delta in December 1978 and to initiate new service.

The launch vehicle for the Telesat-G mission will be the new Delta 3920 which consists of the Extended Long-Tank Thor Booster with RS-27 engine, nine Castor IV strap-on motors and the new Aerojet ITIP second stage. The payload will include the McDonnell-Douglas PAM stage which will place the spacecraft in a transfer orbit with apogee 35,787 km, perigee of 185 km, and inclination of 24.5 degrees. Approximately 3 days (7th apogee) after launch, the spacecraft Apogee Kick Motor (AKM) will circularize the orbit at roughly 36,000 km geosynchronous altitude and its hydrazine system will drift the satellite to its final location above the equator at 104 degrees West longitude.

The Anik-D (Anik is the Eskimo word for brother) satellite was developed for Telesat/Canada by Hughes Aircraft Co. The Telesat/Canada network of ground stations, with its central station at Allan Park, Ontario (just west of Toronto), will take over control of the satellite after separation from the vehicle.

J. Abrahamson

JAMES A. ABRAHAMSON
Lt. General, USAF
Associate Administrator for
Space Flight

NASA
National Aeronautics and Space Administration

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Mission Operation Report

OFFICE OF SPACE FLIGHT

Report No. 0-492-201-82-05

Anik-D1/Delta Launch

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.

Primary distribution of these reports is intended for personnel having program/project management responsibilities which sometimes result in a highly technical orientation. The Office of Public Affairs publishes a comprehensive series of reports on NASA flight mission which are available for dissemination to the Press.

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GENERAL

A Launch Services Agreement (LSA) was signed June 21, 1982, between the NASA and Telesat/Canada which sets forth terms and conditions whereby NASA would furnish launch of the Telesat-G (Anik-D1) mission. The launch support NASA will provide is defined in the Delta Standard Services List and includes:

- standard launch support of the baseline Delta 3910 vehicle inserting the payload* into circular orbit
- working area for the payload at ESMC
- spacecraft telemetry reception during launch preparation
- network communications support necessary for launch

A separate agreement was signed by NASA and Telesat/Canada on March 6, 1980, wherein NASA agreed to provide a Delta 3920 vehicle and launch support for this mission in place of the standard 3910 vehicle/support.

Telesat/Canada undertook to do or certify that the following was done:

- provide mission requirements
- assure payload* compatibility with launch vehicle and tracking and data facilities
- provide a payload interface specification
- provide a flight-ready payload to the range
- assure to NASA that payload has been properly tested
- provide documentation that apogee motor meets range standards
- determine launch criteria for payload and supporting stations

The standard Delta 3910 launch support for the Telesat-G mission is being provided on a reimbursable basis at a fixed price of $25.0M. The Delta 3920 vehicle/support is being provided as a non-standard service on a reimbursable basis for actual costs with a ceiling price of $5.25M.

*Payload is defined as the Anik-D1 spacecraft, McDonnell Douglas PAM-D and associated adapters, attach fitting, and spin table.

NASA MISSION OBJECTIVE FOR THE TELESAT-G (ANIK-D1)

Launch the Telesat-G satellite on a two-stage Delta 3920 vehicle with sufficient accuracy to allow the MDAC PAM-D and the spacecraft propulsion system to place the spacecraft into a stationary synchronous orbit while retaining sufficient stationkeeping propulsion to meet the mission lifetime requirements.

Joseph B. Mahon
Joseph B. Mahon, Director
Expendable Launch Vehicles
Office of Space Flight

Date: August 19, 1982

J. Abrahamson
JAMES A. ABRAHAMSON
Lt. General, USAF
Associate Administrator for
Space Flight

Date: 20 August 82

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MISSION DESCRIPTION

The Telesat-G satellite system will provide fully switched all-digital service in a TDMA mode and will transmit voice, high-speed data, facsimile, and video.

The Hughes spacecraft offers 24 channels of point-to-point service in the 6/4 GHz bands.

The satellite will focus a single gain-weighted shaped beam over Canada, as shown in Figure 1.

TYPICAL GEOGRAPHICAL COVERAGE OF THE TELESAT-G
SATELLITE AT 104°W LONGITUDE

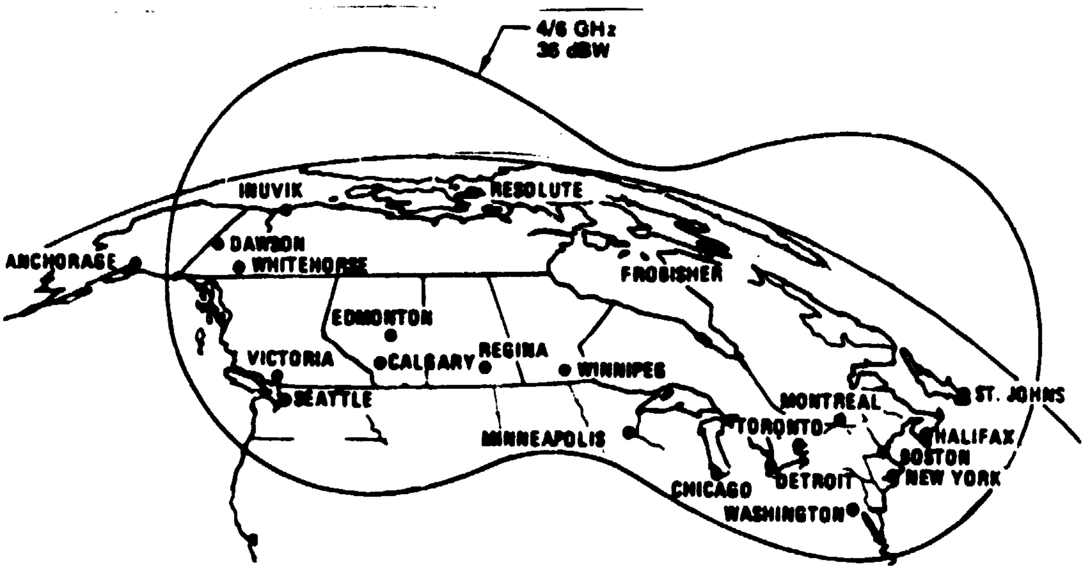

Fig. 1

Anik D1 will be launched from the Eastern Space and Missile Center (ESMC) aboard the new Delta 3920 expendable launch vehicle. The mission to geostationary orbit will consist of the following five phases: powered flight, transfer orbit, drift orbit, deployment and on-orbit test and evaluation.

Parameters of these phases are summarized in Table 1.

TABLE 1
TELESAT-G MISSION PHASES

PHASE	DURATION	ORBIT	COMMENTS
Boost	11.0 min	Ballistic Trajectory	Delta Launcher
Parking Orbit	12.0 min	Near-Circular, 185 km	
Transfer Orbit	70 hrs, 6-1/2 rev.	Perigee Altitude 185 km Apogee Altitude 36365 km Inclination 24.5° Ascending Node Toward the Sun	Guam 1st AOS
Drift Orbit	1-2 wks	Perigee Bias -500 km Apogee Bias 555 km Inclination 0.02° Mean Drift Rate -3.7°/day	Station Acquisition Within 16 Days
Station	9 yrs	Longitude 104°W+0.05° Latitude 0° $\mp$0.05° Altitude 0.0° $\mp$0.07° From Orbit-Normal	

POWERED FLIGHT

After completion of prelaunch operations and final countdown, the Delta main engine, two vernier engines, and six of the nine Castor IV solid motors are ignited for lift-off. The vehicle then follows a trajectory controlled by the Delta Inertial Guidance System (DIGS) until Second Engine Cut-Off (SECO), after achievement of a parking orbit at 185 km altitude and 28.7° inclination. Spin-up to 50 rpm is achieved by spin rockets. Eleven minutes after SECO, the spacecraft/PAM separates from the second stage, and the PAM, acting as a Perigee Kick Motor (PKM), is fired to inject the spacecraft into transfer orbit at approximately 0°W longitude. The launch sequence is illustrated in Fig. 2.

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TELESAT-G/3920 MISSION SCENARIO

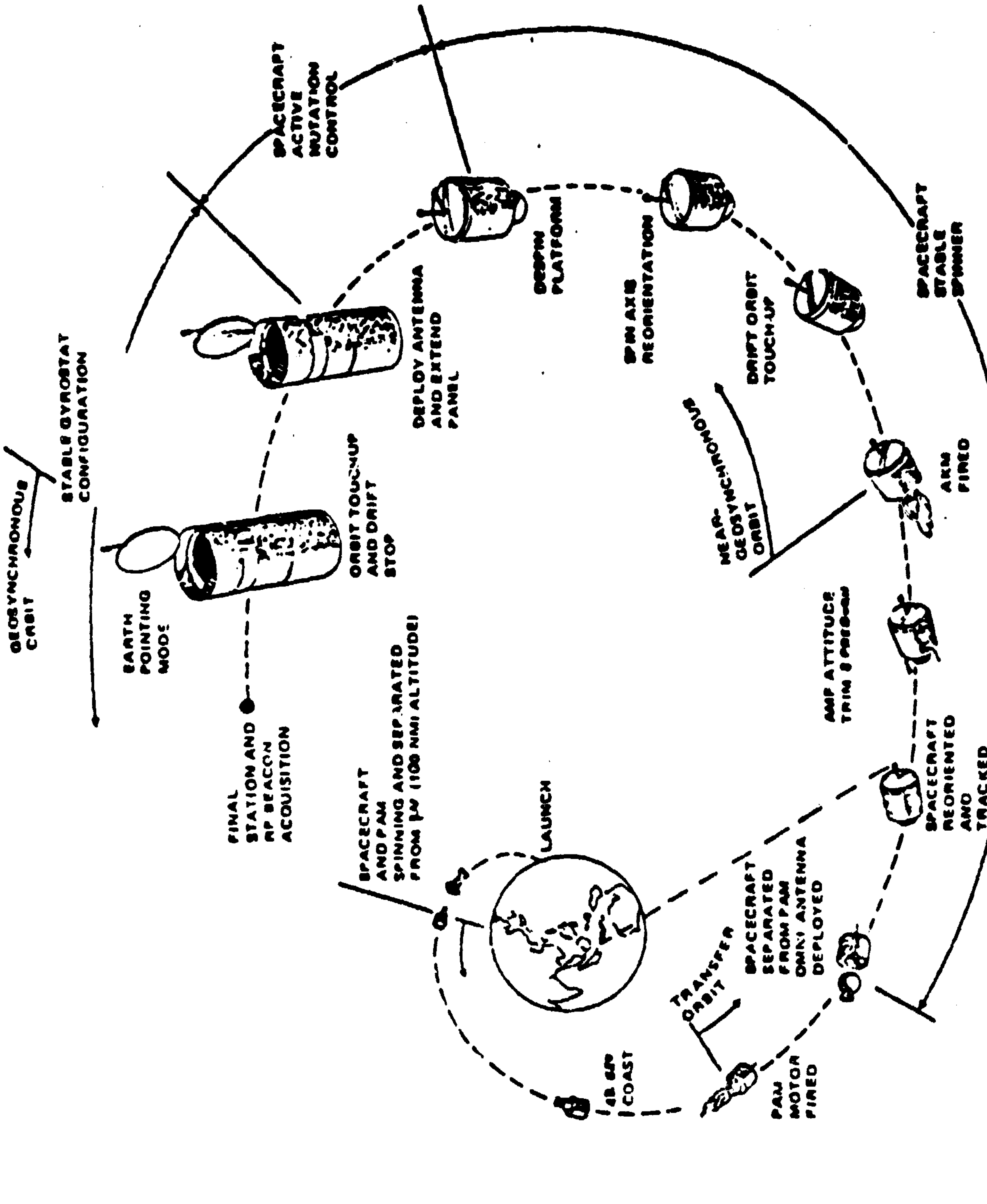


Fig. 2

TRANSFER ORBIT

The transfer orbit has nominal parameters: Perigee Altitude of 185 km, Apogee Bias of 555 km, and Inclination of 24.5°.

Injection occurs near local midnight with Acquisition of Signal (AOS) at Guam (TTS) about 37 minutes after injection. Near first apogee,the spin axis is reoriented to Apogee Motor Firing (AMF) attitude. The spacecraft is a stable spinner throughout transfer orbit, and no active nutation control is required. Near fifth apogee, a preburn maneuver is performed to augment the Apogee Kick Motor (AKM). AMF occurs near the equator crossing at seventh apogee, at a longitude of 152°W. TTS and TTAC tracking stations have AOS before seventh apogee and can see the satellite during AMF.

Injection into transfer orbit occurs 23.5 minutes after lift-off, at about 0°W longitude. Approximately 37 minutes later, the satellite crosses the horizon at TTS and acquisition procedures may begin. Immediately following AOS, telemetry is analyzed to determine spacecraft health and commandability and accelerometer data is examined to measure nutation induced by PMF. A reorientation maneuver, using a pulsed axial Reaction Control System (RCS) thruster, begins soon after the reception of Earth sensor data.

Near equator crossing of the fifth apogee, a preburn maneuver of 86 m/s is executed to augment the AKM motor. This maneuver raises the transfer orbit perigee from 185 km to 808 km, increasing the period by 12 minutes, and reduces the inclination to 22°. Just before equator crossing at seventh apogee, at 152°W longitude, the AKM is fired, placing the satellite into drift orbit. If errors in the PKM performance or pointing cause AMF longitude to be farther west than 152°, AMF may be delayed until the ninth apogee.

The AMF occurs just before the equator crossing at the seventh apogee, unless dispersions cause a delay until the ninth apogee, and is a 30-second burn generating 1.625 km/sec of velocity increment from 510 kg of solid propellant. The drift orbit which results has an apogee bias of 555 km, a perigee bias of -500 km, and a westward drift rate of -3.7°/day.

DRIFT ORBIT

After AMF, the nominal drift orbit has the following parameters: Perigee Bias of -500 km, Apogee Bias of 555 km, Mean Drift Rate of -3.7°W/day, and Inclination of 0.02°.

Acquisition of geostationary orbit at 104°W requires two major and related procedures: circularization and station acquisition. Circularization is a process of removing the apogee and perigee biases from the drift orbit. In principle, it is achieved by a positive tangential burn at apogee, and a negative one at perigee. To do this, the satellite spin axis must first be reoriented into the orbit plane, in the positive tangential direction, a reorientation of 23°. After the first maneuver of the pair, a continuous axial burn of 15 m/s, the drift rate rises to -15°/day. The second maneuver, of almost equal magnitude, must be done at perigee; i.e., some odd multiple of 1/2 orbit period after the first maneuver.

Upon completion of the circularization maneuvers, the satellite will be in a near-circular orbit, drifting toward station at approximately -4°/day. At this point, the spin axis can be erected to orbit-normal by a reorientation through 90°. Once thus configured, the tracking station (TTAC) has continuous acquisition of the omni antenna and deployment and testing may begin. To acquire the station longitude of 104°W, the drift rate and eccentricity are corrected by pulse firing of the radial thrusters.

After erection, the deployment sequence to final configuration may begin. Next, squibs are fired to release four launch locks which hold the despun shelf to the spun shelf. Despin is effected by two motors, one of which is turned off when the platform rate is equal and opposite to the rotor rate. This maneuver takes about 3 minutes. Nutation control is provided by the Active Nutation Control (ANC) system during the above steps.

Now squibs are fired to release the launch locks which hold the antenna reflector down on top of the platform during launch and transfer orbit. One of the redundant Antenna Positioning Mechanisms (APM's) is used to drive the reflector through 70° to its operational position.

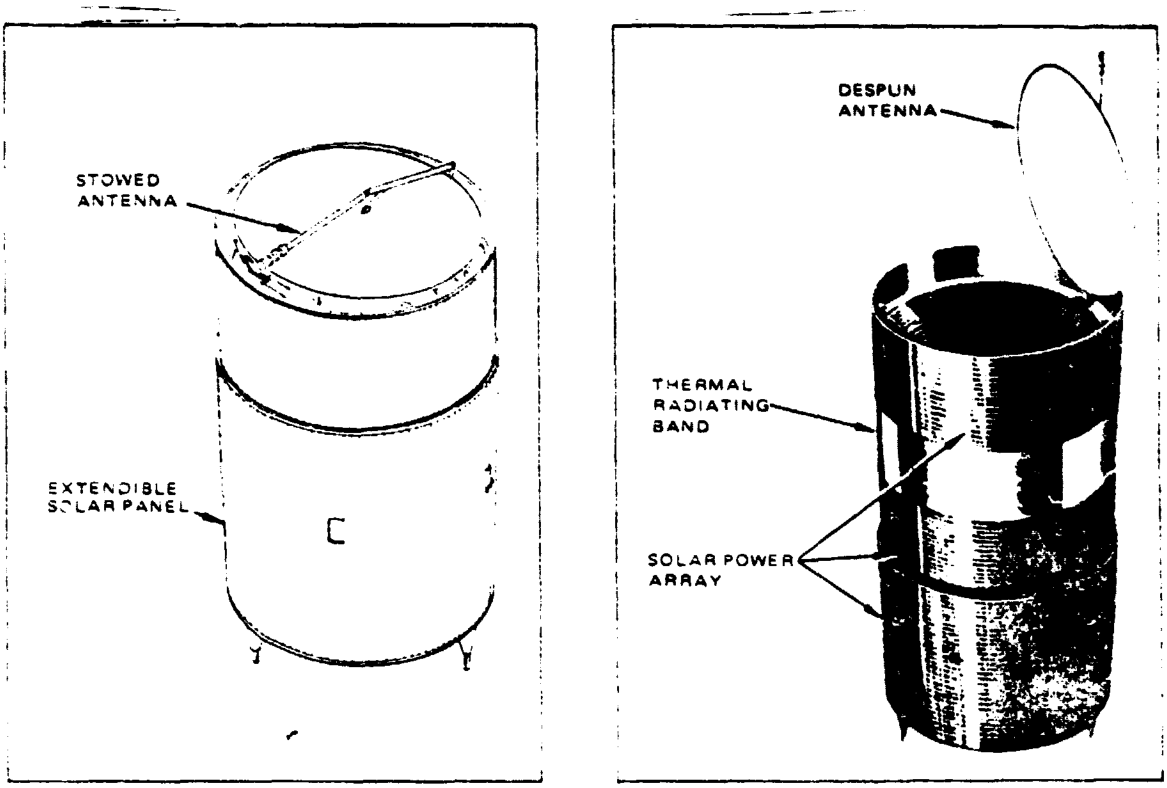
Squibs are fired to release launch locks, and the aft panel is driven down and is locked at the fullest extent of the Solar Drum Positioner (SDP) system. On completion of this phase, heaters and other hardware are commanded on for on-orbit operation.

Once deployed on station, spacecraft wobble is measured and corrected by differential stepping of the SDP. Testing of the bus systems and communication system are carried out both in drift orbit and on station to verify that all performance parameters meet their specifications.

SPACECRAFT DESCRIPTION

The Telesat-G (Anik-D1) spacecraft is a spin-stabilized 24 channel satellite, built by Hughes Aircraft Co., shown in Figure 3. It utilizes two concentric cylindrical solar panels, and when the outer panel is deployed downward, the combination provides the power required by the communication task.

TELESAT-G CONFIGURATION



LAUNCH CONFIGURATION   OPERATIONAL CONFIGURATION

Fig. 3

The Telesat-G (Anik-D1) spacecraft, shown in an exploded view in Figure 4, is 85.3 inches in diameter, 265 inches high when the solar panel and antenna are deployed and weighs 2730 lbs. after PAM separation and injection into the transfer orbit. This coupled with a PAM weight of 4637 lbs. and a spin table attach fitting eu al weight of 285 lbs. results in a total payload weight of 7641 lbs. After the apogee kick motor burnout, the on-station weight of the satellite is 1610 lbs.

SPACECRAFT EXPLODED VIEW

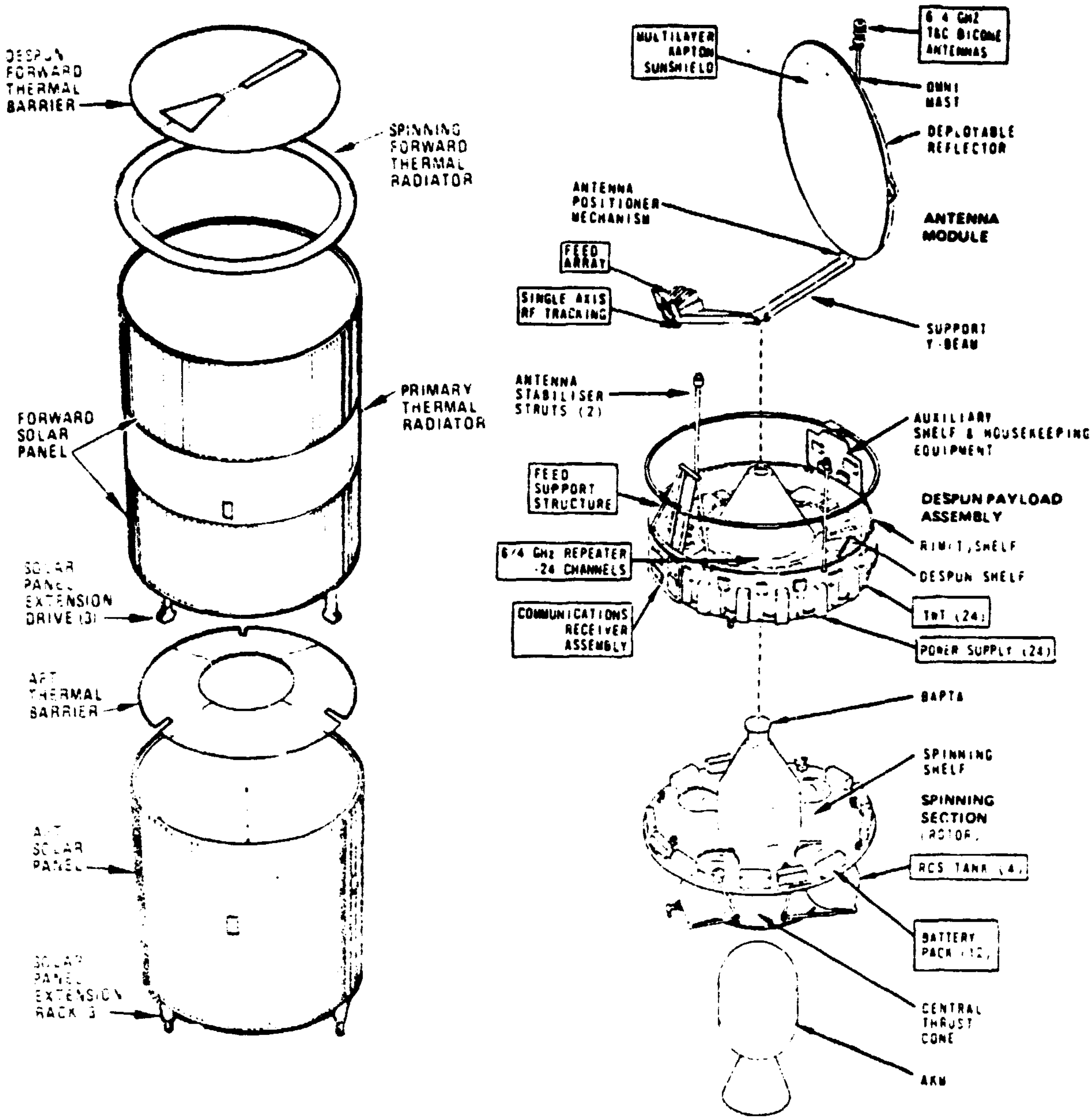


Fig. 4

On-orbit stationkeeping and attitude control is provided by four thrusters operating with monopropellant hydrazine carried in four titanium tanks.

The spacecraft is integrated with the PAM-D stage by McDonnell Douglas and Hughes. These two elements, coupled with the appropriate adapters, attach fitting, and spin table constitute the final payload to be integrated with the NASA two stage 3920 Delta vehicle.

The propulsion subsystem consists of the Thiokol Star 30B Apogee Motor and Reaction Control Subsystem (RCS). The solid propellant apogee motor is designed to accomplish the final orbit insertion and is an integral part of the spacecraft. The apogee motor characteristics are shown in Table 2.

TABLE 2
APOGEE MOTOR CHARACTERISTICS

Total impulse	310,000 lb-sec
Average Thrust	6000 lb
Duration	51.5
Effective Specific Impulse	295.8 sec
Nozzle Expansion Ratio	75.8 to 1
Total Motor Weight	1114 lbs
Propellant	1042
Burnout	66

The spacecraft is built around a central thrust tube composed of two frustrum cones, a cylinder, and five ring frames. The equipment shelf, attached to the thrust tube, is an 80.6 inch diameter, 1.5 inch thick, aluminum honeycomb sandwich platform with 0.008 inch thick aluminum facesheets. The despun compartment structure consists of a monocoque conical frustrum, annular and cylindrical honeycomb sandwich shelves, and a pair of bipods, which support the antenna assembly. All communication equipment is located on the despun shelf. The outer load path comprises four tubular struts extending from the spacecraft separation plane interface to four locking devices at the spinning shelf rim where the despun and spinning sections are joined for launch. Four propellant tanks between eight radial support struts are connected by tubular bipod/tripod structures to the central cone.

The spinning equipment shelf, supported at and near its rim by eight struts, carries Earth sensors, radial thrusters and batteries on the forward face and, on the aft face, the encoders, decoders, power control electronics, and altitude control equipment. Components also are mounted to the central thrust tube cone; these include the axial thrusters, the safe and arm unit, the spacecraft/PAM interface umbilical connectors, and the bus limiters.

The Anik D 6/4 GHz satellite communications subsystem consists of two basic sections: a dual polarization-selective, grid antenna that provides independent transmit and receive beams at both polarizations and a communications repeater composed of broadband input and channelized output sections. The communications subsystem receives low level signals from the transmitting groundstations, amplifies and converts these signals from the receive 6 GHz band to 4 GHz, channelizes the signals for routing to the output traveling wave tube amplifers (TWTAs) where the signals are further amplified, and then feeds them to the high gain antenna for transmission.

The vertical and horizontal polarized communications signals are received by the antenna subsystem and processed in a 4 for 2 redundant broadband receiver input section. It is in this section that the 6 GHz signals are convered to 4 GHz. The signals in turn are channelized signals that are recombined in the output multiplexer into odd and even channel groups and are then routed to the dual mode ports of the horizontal and vertical transmit feed arrays. Each of the 24 transponders or channels is 36 MHz wide and designed to accommodate either analog FM transmissions or digital transmissions.

A compact antenna system is achieved by positioning two offset paraboloids, each 71 inches in diameter and having a 60 inch focal length, one in front of the other so as to share a common aperture. The front paraboloid reflecting surface is a grid of parallel conductors (oriented horizontally) which allows orthogonally polarized waves to pass through with little attenuation. The rear reflector has a vertically oriented grid as its reflecting surface. Geometries of the two paraboloids are chosen to provide a displaced focus permitting the use of separate feed systems (for horizontal and vertical polarizations) for maximum beam shaping efficiency.

Telemetry and command signals are accessed through a pair of deployable C-band omni antennas. The omni antennas deployment is two-stage: the first deployment is of the upper mast and occurs during transfer orbit; the second deployment occurs during reflector deployment when the satellite reaches its geosynchronous orbit location. The second deployment is such that the omni antenna mast remains parallel to the spin axis during the entire deployment maneuver. Thus, acquisition of telemetry and command signals through the omni antennas is continuous during all spacecraft deployments and maneuvers.

The telemetry, command/track, and ranging subsystem provides the ground command capability and the spacecraft performance and status information required to properly control the spacecraft. The subsystem also provides single axis spacecraft communications antenna pointing information to the attitude control subsystem (ACS) by monopulse tracking the command uplink signal (RF beacon tracking function). The subsystems can be configured as a transponder for transfer orbit tone ranging.

All RF hardware is located on the despun side of the spacecraft. The baseband telemetry and command (T&C) hardware consists of redundant despun command decoders and telemetry encoders and redundant spinning command decoders, telemetry encoders, and squib and solenoid drivers. The baseband spinning and despun units interface through signal slip rings contained within the bearing and power transfer assembly (BAPTA).

The spacecraft telemetry subsystem gathers subsystem performance, sensor, status, and attitude information necessary for the proper operation of the spacecraft. The subsystem provides this information via an RF downlink during transfer orbit, drift orbit, and on-station operation.

The subsystem provides independently, on each of two telemetry downlinks, three different types of data (selected by ground command): pulse code modulation (PCM) data; FM real time attitude sensor data; and FM real time nutation accelerometer data. Each of the two data streams is independently commanded to provide the type of data desired; thus, it is possible to simultaneously receive FM data on one channel while receiving PCM data on the other channel.

Data are gathered redundantly by two spinning and two despun encoders together with two telemetry subcommutators and three battery cell voltage monitor units. In the PCM mode, spinning encoder data is routed via slip rings to the despun encoders using a biphase modulated 8 kHz subcarrier and hyperpulse major frame sync. The spinning PC data are then interleaved with despun encoder data, and the resultant 1 kilobit PCM biphase modulates a 32 kHz subcarrier. When either FM data mode is required, the spinning encoder is commanded into the appropriate mode, and the despun encoder is commanded off. The FM data modulate a 14.5 kHz subcarrier within the spinning encoder, which is then routed through the off despun encoder.

The telemetry/ranging switches accept the 32 or 14.5 kHz telemetry subcarriers from the despun encoders and ranging tones from the C-band command receivers. The two ranging telemetry switches each select either the telemetry stream from the associated encoder for telemetry operations or the output of the associated receiver for ranging operations. The selected baseband signals are then routed to either pair of transmitters via the cross-strap switch. The signals are phase modulated on the telemetry carriers at one radian peak deviation.

The two telemetry transmitters transmit thru the communications antenna via a hybrid, a harmonic filter and a directional filter; and thru the telemetry bicone antenna using a pair of TWTAs which are shared with the communications subsystem. On station, the telemetry subsystem shares the communications subsystem antenna feed network. The telemetry transmitter has two power output levels. During transfer orbit, the lower drive level is applied to each of the two communications TWTAs. The tube outputs are connected to the telemetry bicone antenna. For on-station operation, the higher power level is fed via a directional filter to the communications subsystem horizontal polarization, odd channel output multiplexer.

The modulation input to the telemetry transmitter is selected by command and is either the output of the telemetry encoder or the ranging output of the command/track receiver.

The telemetry bicone antenna provides a toroidal beam coverage in transfer orbit with a beam width of ±20 (at the 2 dB points) about a plane perpendicular to the spacecraft spin axis while the communications antenna provides area coverage on station.

The command signal received by the reflector antenna is separated from the communications signal by a track directional filter (TDF) and applied to the command/track receiver via a diplexer. The diplexer consists of two bandpass filters and combining network. The filters are tuned to the two command frequencies. The bicone is connected to the other input of the diplexer. The bicone antenna remains on when the spacecraft is on station for backup purposes. To minimize multipath effect that would otherwise degrade antenna pointing accuracy, the signals from the two antennas are discriminated by their frequency separation and orthogonal polarization. The combined signal is filtered and fed to both of the command/-track receivers.

The command uplinks are frequency modulated with tones in the 5 to 15 kHz band with the format discussed below. The corresponding peak deviation of these tones is 173 to 75 kHz varying with frequency to compensate for the frequency compressive effects of the command/track receiver's frequency-locked-loop. A 100 Hz triangular waveform is also used to frequency modulate the uplink at 5 MHz peak-to-peak deviation. This FM is used to generate AM waveforms whose amplitudes are proportional to antenna pointing error. The command/track receiver locks to the 100 Hz waveform and uses it as a reference for detecting the east-west error signals. The command tone FM is linearly summed with this track FM waveform (but with much smaller deviation), resulting in the uplink modulation. The receiver simply detects the command tones, unaffected by the track FM. As a result, both the command and track functions are provided simultaneously without degradation to either function.

The telemetry and command antennas consist of biconical horns that radiate 360° in azimuth with 20° (2 dB) and 35° (2 dB) beamwidths in elevation, respectively. Dual mode operation of the telemetry antenna is achieved by using a 3 dB squarax hybrid. A three-probe polarizing section is used to provide dual mode for the command antenna. Six transverse resonant dumbell slots, equally spaced around the circumference of a circular waveguide, transmit vertical polarization for the telemetry antenna. Eight longitudinal resonant slots, equally spaced around the circumference of a circular waveguide, receive horizontal polarization for the command antenna. The two bicone antennas are coupled to redundant transmitters and receivers through flex cables that run along the omni mast down to the shelf.

The command/track RF subsystem provides both single axis antenna pointing control and the command uplink function. The bicone antenna provides coverage with a toroidal beam of ±35° (at 2 dB points) beamwidths in elevation, respectively. Dual mode operation of the telemetry antenna is achieved by using a 3 dB squarax hybrid. A three-probe polarizing section is used to provide dual mode for the command antenna. Six transverse resonant dumbell slots, equally spaced around the circumference of a circular waveguide, transmit vertical polarization for the telemetry antenna. Eight longitudinal resonant slots, equally spaced around the circumference of a circular waveguide, receive horizontal polarization for the command antenna. The two bicone antennas are coupled to redundant transmitters and receivers through flex cables that run along the omni mast down to the shelf.

The command/track RF subsystem provides both single axis antenna pointing control and the command uplink function. The bicone antenna provides coverage with a toroidal beam of ±35° (at 2 dB points) beamwidth about a plane perpendicular to the spacecraft spin axis. The bicone is used in transfer orbit for command and ranging while the reflector antenna is used on-station for ground RF beacon tracking, command, and ranging. The command spot beam is generated by sharing the use of a small segment of the communications receiver feeds.

The command subsystem consists of two identical, redundant, and simultaneously operating channels of receiving demodulation and decoding hardware that continually provide complete control capability over all spacecraft states and modes of operation. The command receiver baseband output consists of a 25 bit command. The command is composed of 0 and 1 tones in an RZ tone digital format used for addressing and loading specific commands into a selected decoder. A third tone is used for real time execute of the loaded command. Two groups of three tones are used to remove receiver ambiguity; one set is associated with each receiver and slip ring combination. Each spacecraft has unique decoder addresses in this format. The stored command and its execute status are telemetered every minor frame (512 ms) for ground verification. The command decoders are capable of redundantly providing 255 despun commands and 191 spinning commands. All commanded automatic functions can be overridden by ground command.

The command subsystem is also equipped to handle baseband formats used for special functions. These are the axial thruster off-pulsing and pseudo Earth formats.

The command subsystem includes a spinning squib and solenoid driver unit, and despun squib drivers located in the antenna positioner electronics (APE). The spinning unit contains squib drivers to initiate pyrotechnic devices for firing the apogee motor and for releasing the despun shelf and solar panel locks. It also contains valve drivers for the axial and radial thrusters and the latch valves. The despun squib drivers release the omni antenna mast and the communication antenna reflector. All squib firing commands are provided with separate enable commands and enable status telemetry.

Solenoid drivers are used to actuate isolation latch valves and the thruster valves in the reaction control subsystem. Each solenoid driver can be actuated by either of two spinning decoders.

The communications transponder is a single conversion, channelized design operating in the 6/4 GHz satellite telecommunication bands. Each element of the transponder has associated with it a major system function and thus determines one or more of the performance characteristics of the system. The transponder elements are grouped into four major sections.

The first section of the transponder, the receiver input section, consists of four receivers in a 4 to 2 redundancy switching arrangement. The receivers are all solid state MIC designs and operate over the entire 500 MHz receive bandwidth. The receiver establishes the system noise figure, provides approximately half the total repeater gain, and downconverts the received signals to the transmit frequency band. It operates in a linear mode and provides constant performance over any given channel. The receivers are configured to permit switching between units without communications interruption.

The second section consists of 4 channelizing input multiplexers which separate the receive signals into odd and even channels. Each multiplexer utilizes dual mode elliptic function filters in a circulator-coupled channel dropping arrangement. The filters establish three of the key channel transmission characteristics of the communication subsystem: input out-of-band attenuation, gain slope, and group delay.

The third section consists of 24 TWTAs; each TWTA has a nominal saturated RF output power of 11.5 watts. The TWTA provides the remainder of the required channel gain and establishes the transponder output power. Although it is a broadband device,each TWT is chosen for optimum performance over the channel to which it is assigned.

The fourth section consists mainly of four output multiplexers which combine the odd and even channel output signals. The output multiplexer establishes the required output out-of-band attenuation as well as the attenuation necessary to suppress the harmonics and receive band noise generated by the TWTAs. Test couplers, which are provided to facilitate system test, and the output harmonic filters complete the hardware complement of this section.

LAUNCH VEHICLE DESCRIPTION

The Telesat-G (Anik-D1) spacecraft will be launched by the new thrust-augmented NASA Delta 3920 launch vehicle (Figure 5). The Delta 3920 launch vehicle characteristics are shown in Table 3. A schematic of the launch vehicle is shown in Figure 6. This will be the 164th flight for Delta. Of the previous 163 flights, 151 have successfully placed satellites into orbit. This will be the second launch of the new Delta 3920 configuration and the first launch of the Delta 3920/PAM combination.

DELTA 3920 LAUNCH VEHICLE FOR THE TELESAT-G MISSION

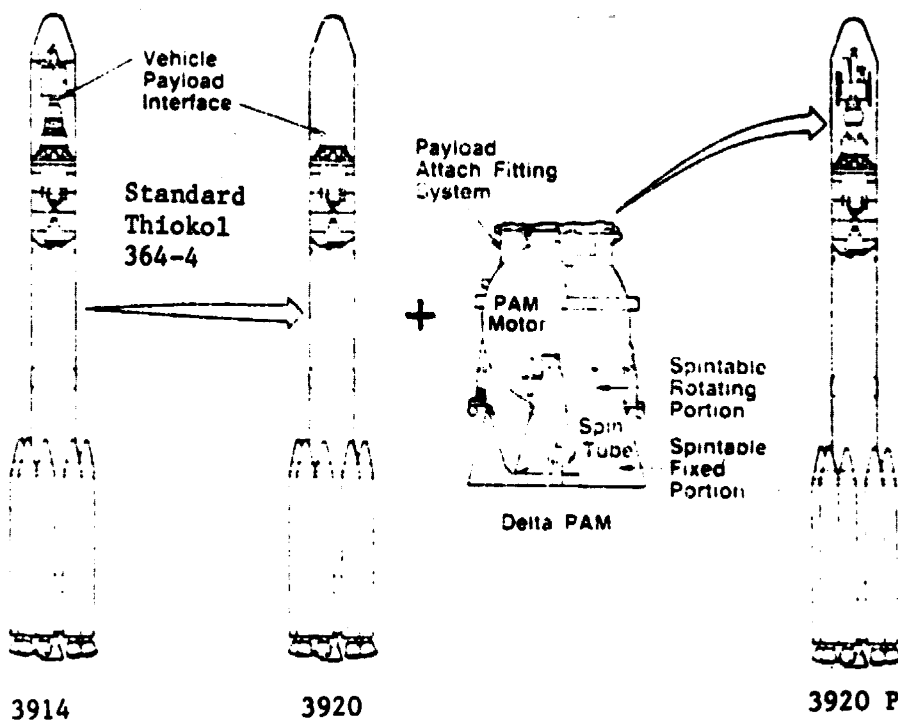


Fig. 5

Delta is managed for the NASA Office of Space Flight 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 Corporation, Huntington Beach, CA, is the Delta prime contractor for the vehicle and launch services.

Overall, the Delta 3920 is 35.5 meters long (116 ft), including the spacecraft shroud. Lift-off weight is 189,087 kg (415,990 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 60 seconds after lift-off).

TABLE 3
DELTA 3920 LAUNCH VEHICLE CHARACTERISTICS

	STRAP-ON	STAGE I	STAGE II
Length	11.3m (37.0 ft)	21.3m (70.0 ft)	700.0cm (276 in)
Diameter	101.6 cm (40 in)	243.3 cm (96 in)	175.3 cm (69 in)
Engine Type	Solid	Liquid	Liquid
Engine Manufacturer	Thiokol	Rocketdyne	Aerojet
Designation	TX-526	RS-27	ITIP
Number of Engines	9	1 (+2VE)	1
Specific Impulse Avg.	229.9	262.4	319
Thrust (per engine) (Avg.)	407,000 N (91,520 lb)	911,840 N (205,000 lb)	41,969N (9,443 lb)
Burn Time	58.2 (sec)	228 (sec)	445 (sec max)
Propellant	TP-H-8038	RP-1 (LOX oxid.)	A-50 (N_2O_4 oxid.)

DELTA 3920 - VEHICLE ELEMENTS

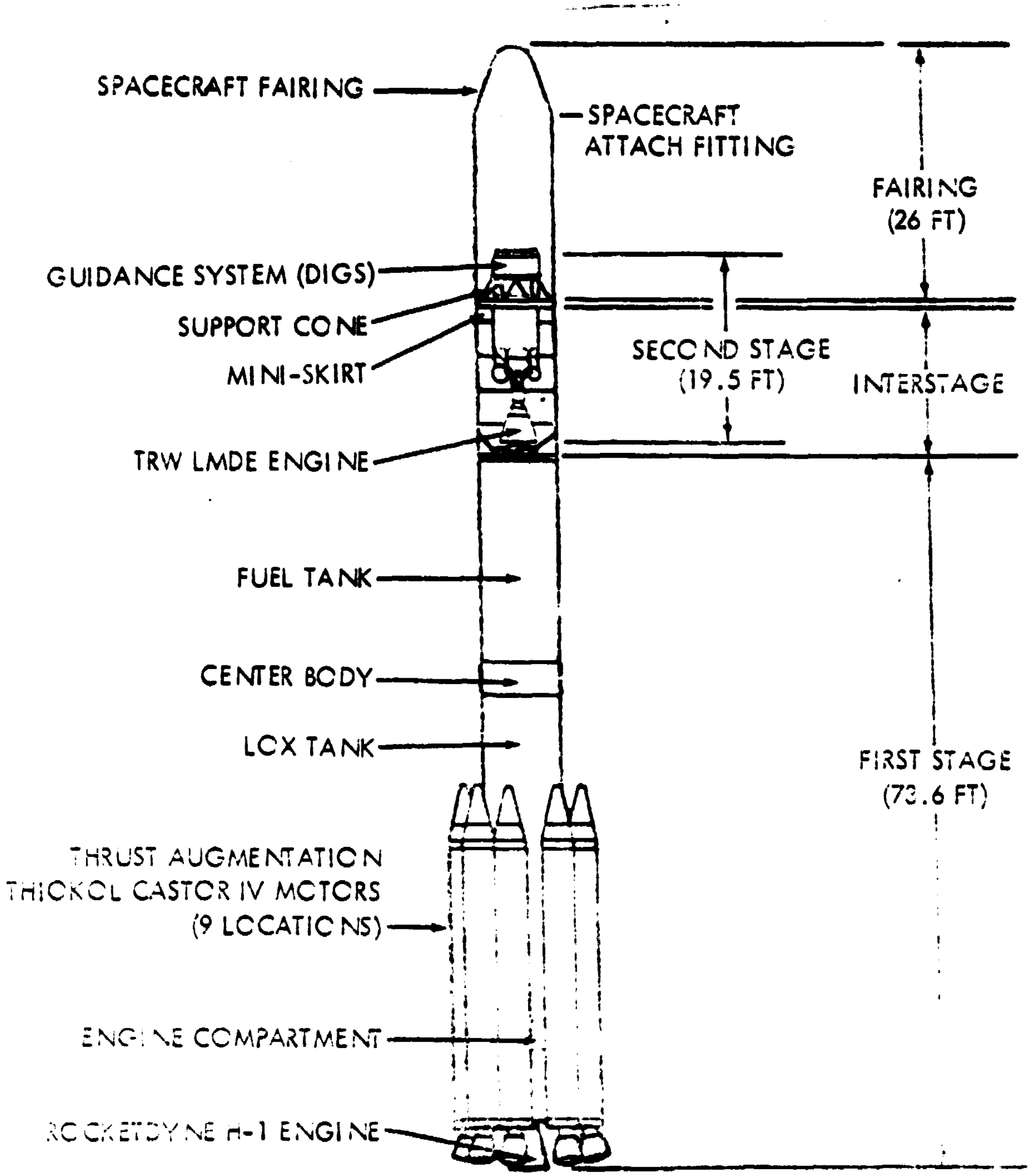


Fig. 6

The first stage booster is 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.

The Delta 3920 incorporates a new second stage consisting of large diameter propellant tanks coupled with the new Aerojet Liquid Rocket Company's AJ-10-118 Improved Transtage Injector Program (ITIP) engine shown in Figure 7. This stage is powered by the liquid bipropellant engine using N_2O_4 as the oxidizer and Aerozene-50 as the fuel. Pitch and yaw steering during powered flight is provided by gimballing the engine. Roll steering during powered flight and all steering during coast are provided by the GN_2 cold gas system. A comparison of this Aerojet stage with the TRW second stage used on the standard Delta 3910 configuration vehicle is shown in Figure 8.

DELTA 3920 - IMPROVED SECOND STAGE

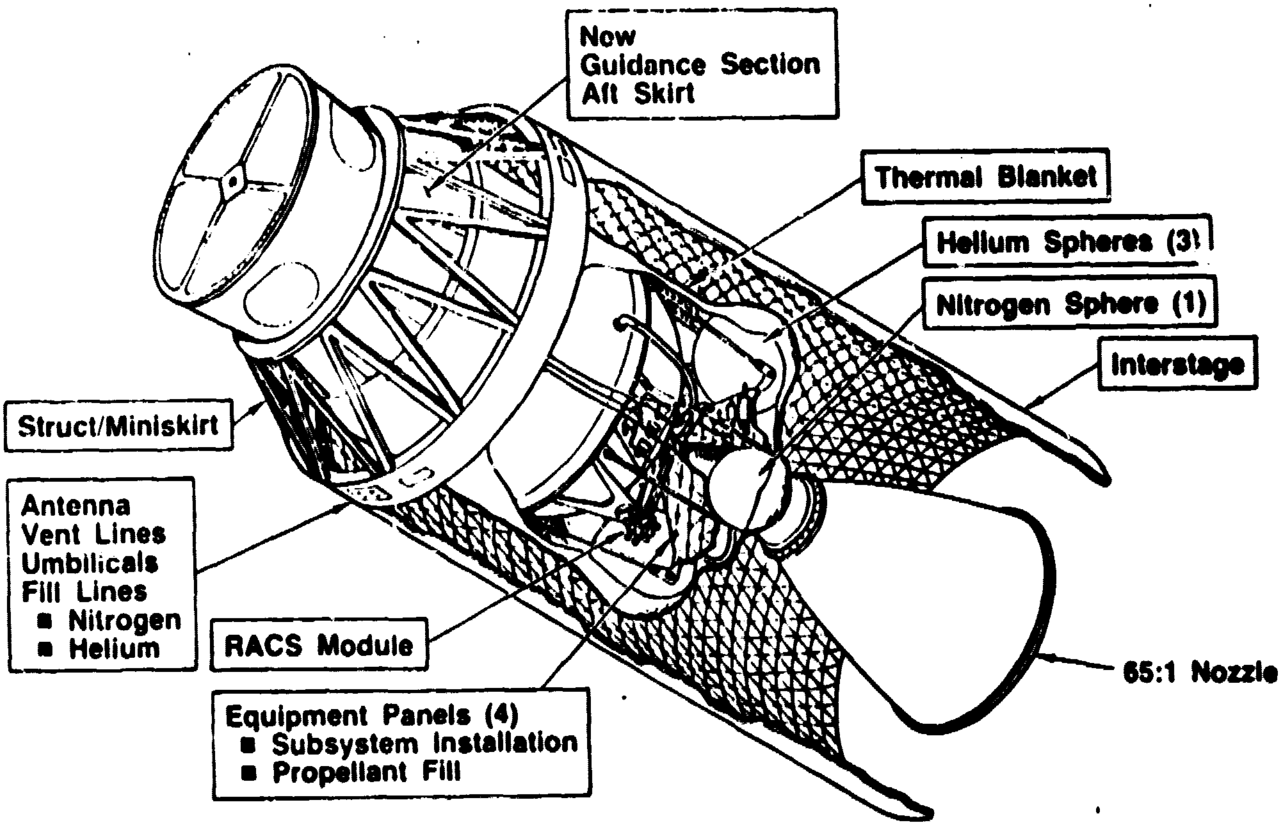


Fig. 7

DELTA 3910/3920 SECOND STAGE COMPARISON

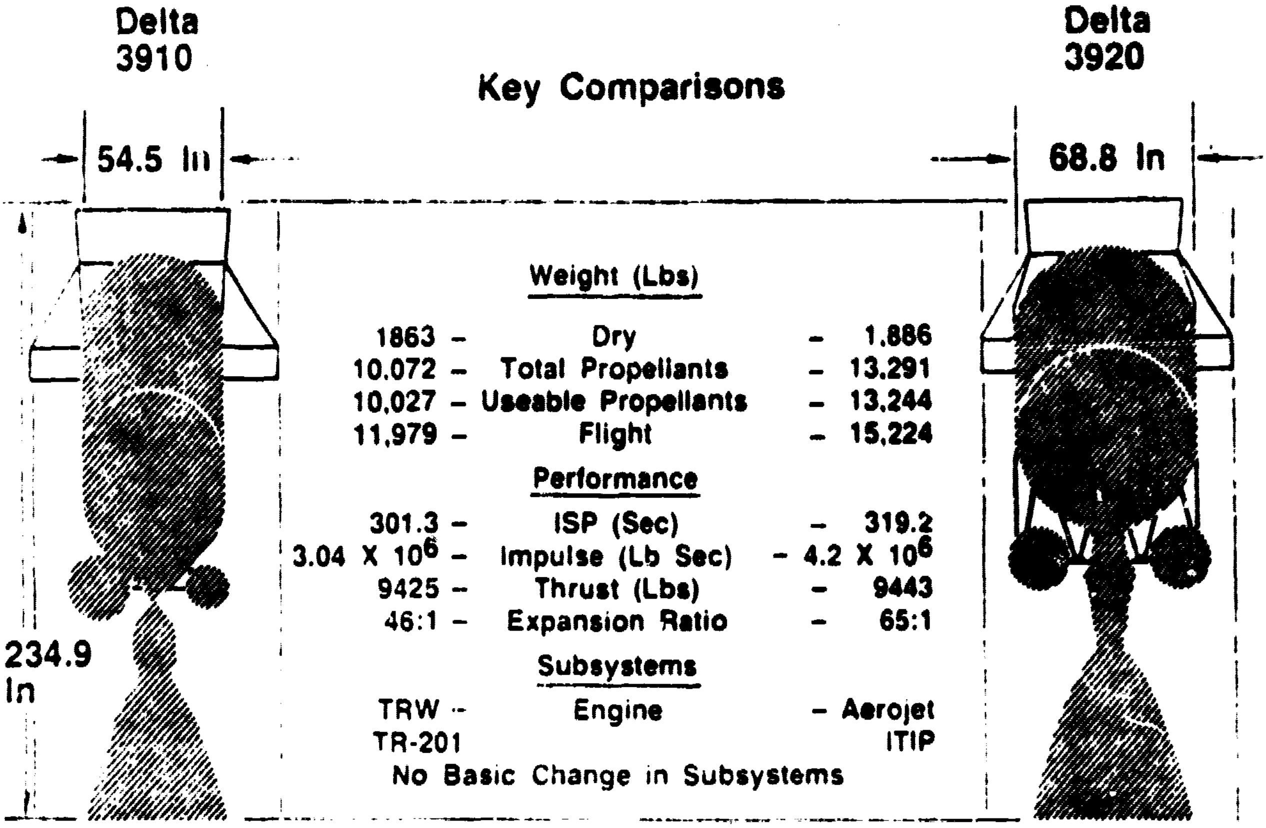


Fig. 8

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 4 through 7 show the flight sequence of events, the mission requirements, the flight mode description, and the predicted orbit dispersion. Figures 9 and 10 show the vehicle ascent profile for the Telesat-G mission.

TABLE 4
TELESAT-G FLIGHT SEQUENCE OF EVENTS

EVENT	TIME (SEC)
Stage 1 Liftoff	0
(6) Solid Motors Burnout	57
(3) Solid Motors Ignition	62
Jettison (3) Solid Motors Casings	70
Jettison (3) Solid Motor Casings	71
(3) Solid Motors Burnout	119
Jettison (3) Solid Motor Casings	122
Main Engine Cutoff	224
Vernier Engine Cutoff	230
Stage I-II Separation	232
Jettison Fairing	245
Second Engine Cut Off Command	672
Final Cutoff--Stage II	672
Start Stage III Ignition Time Delay Relay	1257
Fire Spin Rockets	1257
Jettison Stage II	1259
Stage III Ignition	1297
Stage III Burnout	1383
Jettison Stage III	1497
First Apogee	20628

TABLE 5
MISSION REQUIREMENTS

NOMINAL ORBIT PARAMETERS AT SPACECRAFT INJECTION	
Apogee Altitude	19,823 NM (Integrated)
Perigee Altitude	100 NM
Inclination	24.5 Degrees
Spin Rate	50 RPM
SPACECRAFT WEIGHT (AT LIFT-OFF)	2730 lb
Final Geosynchronous Location	104° West Long. Above the Equator

TABLE 6
FLIGHT MODE DESCRIPTION

Launch from PAD 17B at ESMC
Launch Window is 7:19 to 7:29 p.m. EDT
Six Solids Ignited at Lift-off
Three Solids Ignited at 62 seconds
Fairing Separation Occurs at 245 seconds

TABLE 7
PREDICTED ORBIT DISPERSIONS (99.865% PROBABILITY)

Apogee Altitude	+794 NM
Perigee Altitude	∓3 NM
Inclination	∓0.4 Degree
Spin Rate	±5 RPM

TELESAT-G MISSION
DELTA 3920 BOOST PROFILE

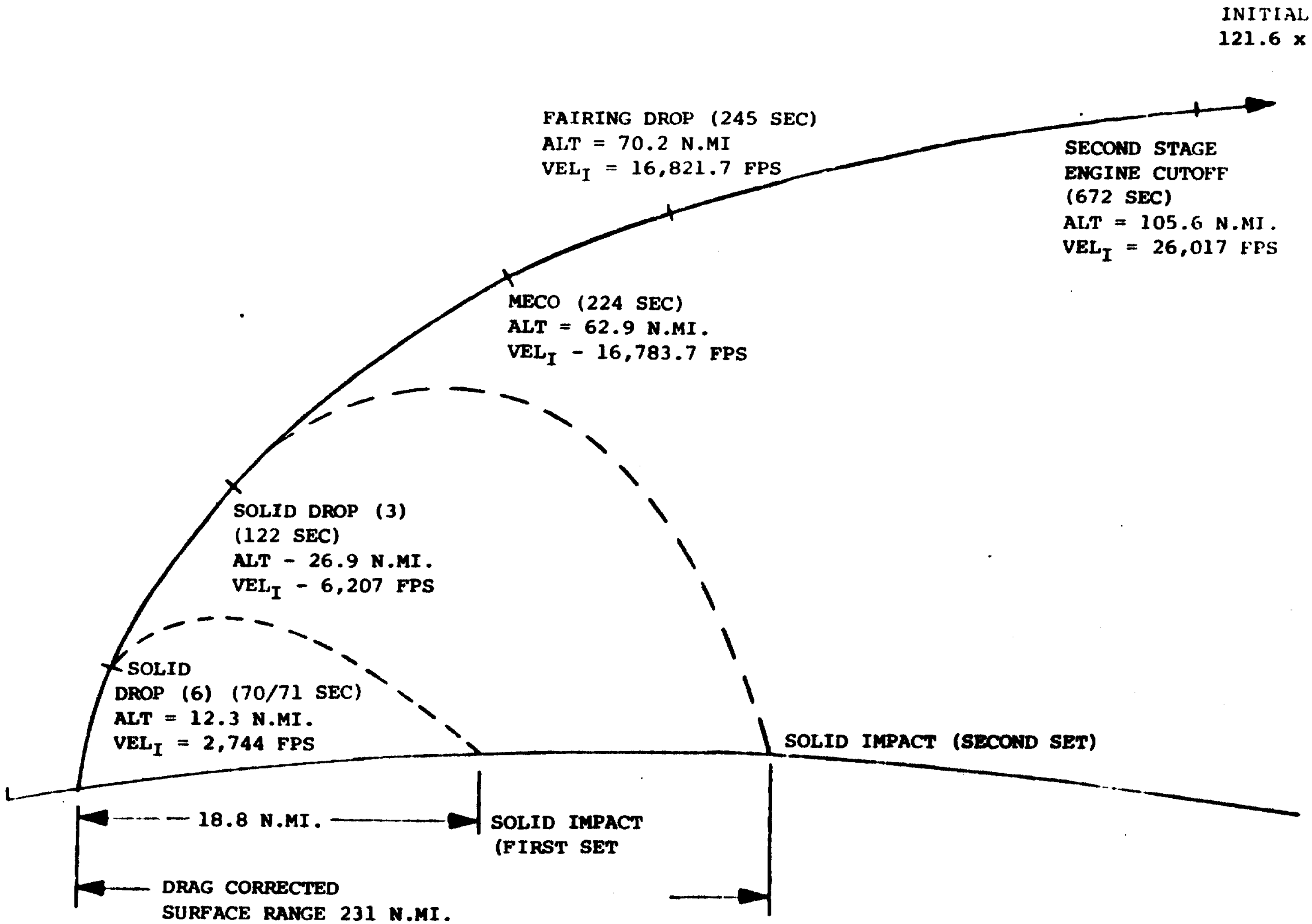


Fig. 9

TELESAT-G TRAJECTORY PLANE VIEW

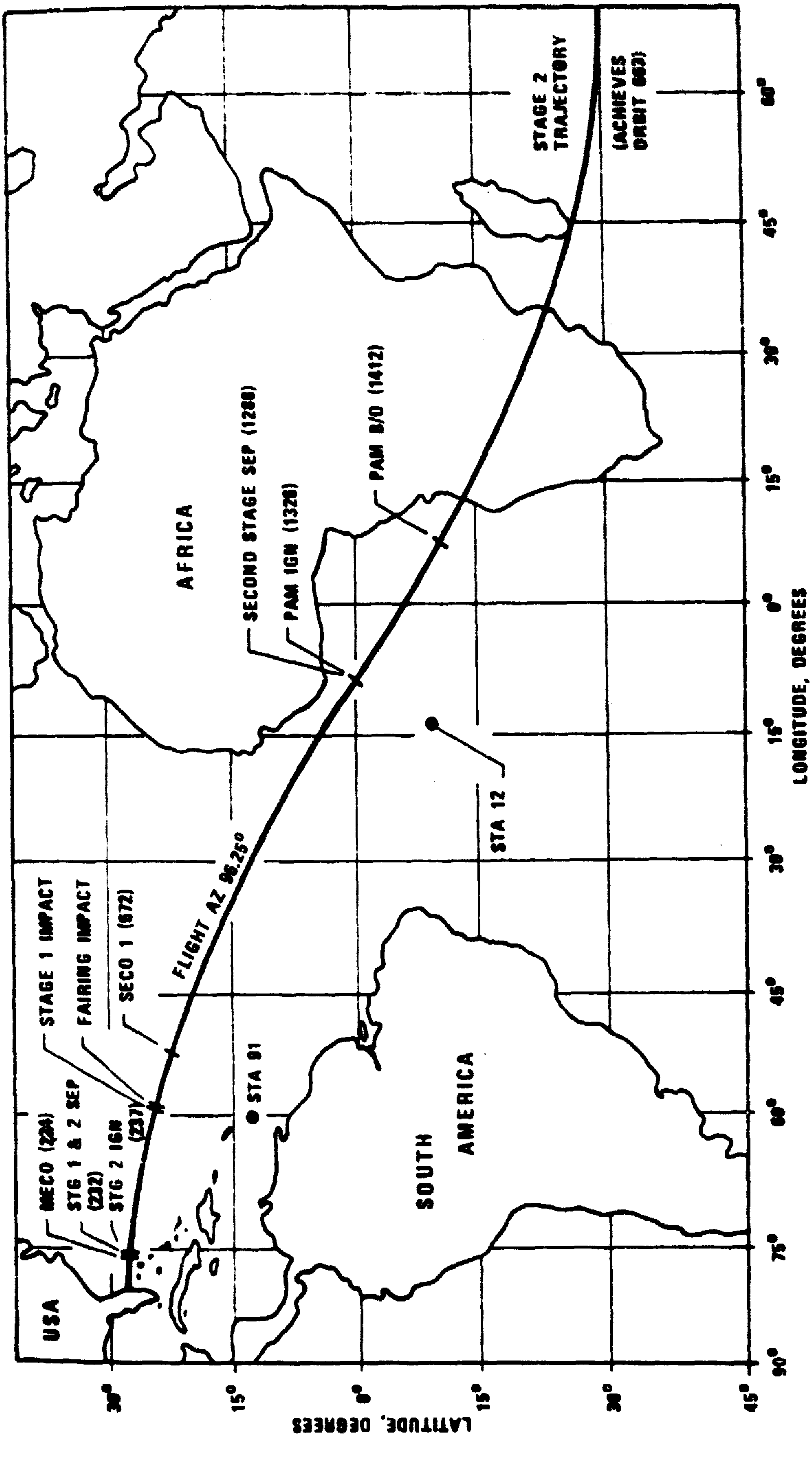


Fig. 10

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 Telesat/Canada, if required.

TRACKING & DATA SUPPORT

ESMC range stations will track the first and second stages. A nominal orbit will be provided approximately 30 minutes after launch based on this data. Telesat/Canada has established stations that will be used to determine the final transfer orbit and also to provide data necessary for the firing of the apogee motor. The principal Earth station will be at Allan Park, Ontario, just west of Toronto.

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