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Prelaunch
Mission Operation Report
No. M-492-206-83-07

TO. A/Administrator

FROM: M/Associate Administrator for Space Flight

SUBJECT: RCA Advanced Satcom VI (RCA-F) Launch on Delta

RCA-F is the second in a new series of high-traffic capacity, 24-transponder communications satellites. It is scheduled to be launched on a Delta vehicle from the Eastern Space and Missile Center (ESMC) no earlier than April 8, 1983. The launch support for this mission will be provided by NASA, on a reimbursable basis, to RCA-Americom, a subsidiary of the Radio Corporation of America (RCA), at an estimated price of $31M. Launches of RCA-A, -B, -C, -C', -D, and -E were successfully conducted on December 12, 1975, March 26, 1976, December 6, 1979, November 19, 1981, January 15, 1982, and October 27, 1982, respectively.

The RCA-F mission will use the Delta 3924 launch vehicle configuration which incorporates the Extended Long Tank Thor booster, nine Castor IV strap-on motors, the Aerojet AJ-118 second stage, and the Thiokol TE-364-4 third stage.

This vehicle configuration places the spacecraft in a synchronous transfer orbit. Three days after launch, the spacecraft apogee kick motor will be fired at transfer orbit apogee to circularize its orbit at geosynchronous altitude of 19,300 NM above the equator at approximately 128 degrees W longitude where it will service commercial and government voice, digital, and video communications requirements between Alaska and CONUS.

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

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National Aeronautics and
Space Administration

Mission Operation Report

OFFICE OF SPACE FLIGHT

Report No. M-492-206-83-07

RCA-F /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 NMI 8610.3D, dated May 13, 1982. 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.

Reports are prepared and issued for each flight project just prior to launch. Following launch, updating reports for each mission are issued to keep management currently informed of definitive [illegible]on results as provided in NASA Management Instruction HQMI 86[illegible]B.

These reports are sometimes highly technical and are for personnel having program/project management responsibilities. The Public Affairs Division publishes a comprehensive series of reports on NASA flight missions which are available for dissemination to the news media.

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GENERAL

On May 26, 1981, an agreement was signed between the NASA and RCA-Americom which set forth terms and conditions whereby NASA would furnish Delta launch vehicles and associated services on a reimbursable basis for the purpose of launching RCA-D, C', G, and H missions. Negotiations are currently being concluded for an amendment to that agreement that adds launch support for the -E and -F missions.

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 standard Delta 3910 launch vehicle to place RCA payloads into orbits desired by RCA.
  - Provide working area for the RCA 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.

  NASA will then provide the new Aerojet 3920-type second stage and the Delta TE-364-4 third stage and associated launch support as an optional service.

- RCA 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 standard Delta 3910 launch support of the RCA-F mission is being provided to RCA-Americom at a fixed price of $25.0M. The additional incremental costs of replacing the standard TRW second stage with the new Aerojet stage and the provision of the TE-364-4 third stage will be provided as optional services at a cost currently expected to amount on the order of $3.8 to $6M.

NASA MISSION OBJECTIVES FOR THE RCA-F MISSION

Launch the RCA-F spacecraft into a synchronous transfer orbit on a three-stage Delta 3924 launch vehicle with sufficient accuracy to allow the spacecraft apogee kick motor to place the spacecraft into a stationary synchronous orbit while retaining sufficient stationkeeping propulsion to meet the mission lifetime requirements.

for
Joseph B. Mahon, Director
Special Programs Division
Office of Space Flight

Date: 29 March 83

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

Date: March 31, 1983

MISSION DESCRIPTION

RCA-Americom is now introducing a larger, second-generation satellite design that exploits the economy and payload capacity of the uprated Delta launch vehicle. System profitability studies show that this expanded domestic network should remain at C-band (6/4 GHz), with traffic capacity per satellite increased by a combination of higher EIRP, improved filter characteristics, and more advanced terrestrial equipment. Increased propellant capacity, additional component redundance, and greater power system capability will extend the satellite's life and reliability. Earth station improvements to complement these spacecraft features and to thereby double the per-transponder channel capacity include modifications to the RF stages of the terrestrial facilities and development of more efficient modulation techniques.

The first two 24-channel RCA Satcom satellites (Satcom I and II) were filled during their four years of service, and RCA planned a third satellite for service in early 1980. The Satcom III (F-3) satellite had the same channelization and effective isotropically radiated power (EIRP) as Satcoms I and II, but carried four spare traveling-wave tube-amplifiers (TWTA) and higher-capacity batteries to assure improved reliability throughout its projected eight-year design life. Unfortunately, contact with the satellite was lost after ignition of its apogee motor. Similar fourth and fifth satellites (-C', -D) were launched in 1981-2 to supplement the Satcoms I and II.

Design changes to these spacecraft, in addition to transponder redundancy, extended their orbit life to ten years, supported improved communication-subsystem performance, and provided a superior attitude-control system.

The sixth and seventh (-E, -F) satellites are being launched in 1982-3 to expand the satellite constellation. RCA-Americom has selected a second-generation spacecraft design that has a higher traffic capacity and a lower cost-per-transponder per year. Like the original series, the Advanced Satcom satellites will be designed, fabricated, and controlled into orbit by RCA Astro-Electronics. Complementary improvements in ground stations and transmission equipment will assure that spacecraft enhancements are used efficiently to maximize system capacity and profitability.

SYSTEMS REQUIREMENTS

The RCA-Americom system serves four distinct domestic communications traffic markets--commercial, government, video/audio, and Alaska.

Government communications services provides voice, video and high-speed data services to federal agencies (NASA, DoD, NOAA, etc.) via RCA-owned Earth stations located on various government installations.

Video and audio services provide point-to-point and point-to-multipoint distribution of television, radio and news services to broadcasters, cable-TV operators and publishers. The network of receive-only stations owned and operated by the CATV industry has expanded most rapidly, with approximately 3,000 such stations now being served by the RCA Satcom system.

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Alascom Services gives Alascom, Inc., the long-distance common carrier for Alaska, the satellite capacity for interstate and intrastate message and video transmission.

Although radio-frequency interference (FRI) congestion of terrestrial microwave networks does not limit K-band station locations, frequency coordination for C-band stations has become less formidable now because interference levels can be precisely measured on-site, and natural or artificial shielding can be judiciously used. Rooftop antennas for the customer--K-band's appeal--are already being utilized in C-band by numerous major business and government facilities located in suburban areas removed from metropolitan RFI congestion. Although K-band has no prescribed downlink flux-density limits, the C-band limit is on flux-density per unit bandwidth. Therefore, we can use adaptive energy dispersal, in which the energy spreading waveform is inversely proportional to the signal level, to meet the C-band limit without sacrificing a constant fraction of the frequency deviation--hence, signal-to-noise (S/N)--for dispersal purposes.

Large downlink margins are required at K-band to overcome the deep fades due to precipitation in the transmission path. These margins dictate that high-power transmitters--necessarily, TWTAs for the next decade--be used. On the other hand, lower-power C-band amplifiers can employ the more reliable solid-state technology of gallium-arsenide field-effect transistors (GaAsFETs). Lastly, the economic attraction of a hybrid satellite with greater spectral capacity diminishes when we consider the practical difficulties of orbit slot complications due to different spacings for C-band and K-band satellites (4 degrees and 3 degrees, respectively) and to high restoration costs and operational complexity when partial failures occur.

In accordance with the geographical coverage requirements of RCA-Americom, the spacecraft design provides the specified radiated power over the areas shown in Figure 1. With the satellite positioned at 128 degrees west longitude, a corresponding E-W pointing offset maintains the beam coverage over these areas independent of the actual longitude station. Frequency and polarization interleaving of the separate channels is employed with the transponder and four antennas to achieve 24 channels, each having a 36-MHz usable bandwidth within the 500-MHz allocation. The narrowband command and telemetry channels use the edges of the allocated 500-MHz band on both the 6-GHz uplink and 4-GHz downlink. Using standard techniques of FSK-tone commands, with unique spacecraft address and FM telemetry, permit a single ground-station command and telemetry facility to control several in-orbit spacecraft.

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

- Boost phase, from lift-off through burn-off and separation from the spinning Delta third stage; during this phase, only the command receiver and telemetry transmitter of the spacecraft are active.

- Transfer orbit phase, from third stage separation to apogee motor ignition; during this phase of 68 hours, 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.

RCA SATCOM SYSTEM (THRU -F)

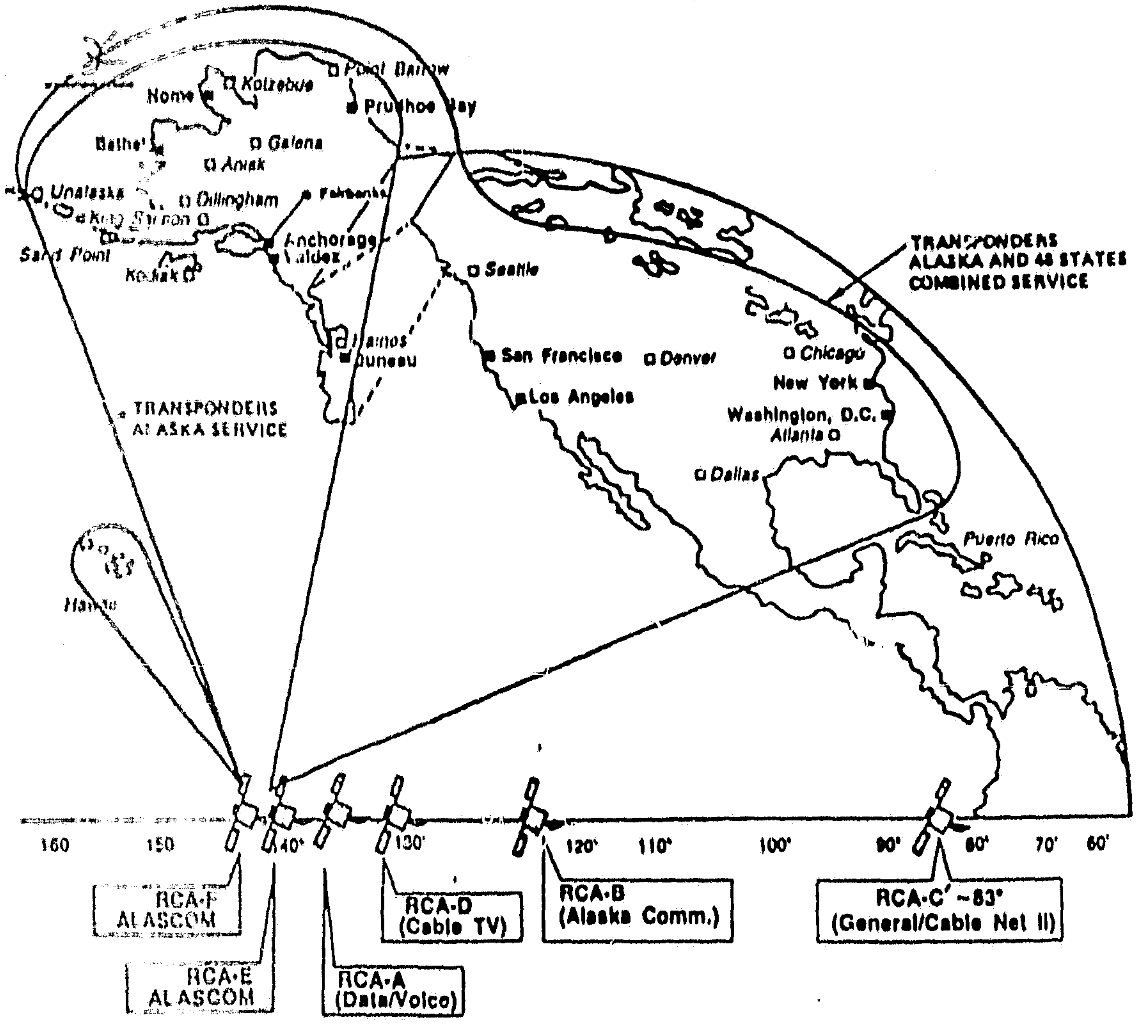


Fig. 1

- 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. This event is nominally planned for the seventh apogee pass.

- 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 is 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. This phase is completed in approximately 6 hours.

After the spacecraft is fully deployed and prepared for mission operation, it is necessary to correct the orbit injection errors and to move the spacecraft from the injection longitude to the desired station by commanding appropriate thrusts of the reaction control system (RCS). During the 2-week period of final station acquisition, various operational checkout tests will be conducted to ensure that the system is fully operational.

The orientation of the spacecraft and solar array relative to the Earth is shown in Figure 2 at three different time positions in the 24-hour orbit. Also indicated are the rotating attitude-coordinate-reference axes for roll (velocity vector), pitch (orbit normal), and yaw (local zenith vector). The momentum-wheel attitude control subsystem is designed to orient the main body continuously toward the local vertical, while the solar arrays are controlled to point toward the Sun. The propulsion subsystem will maintain the orbit parallel to the equator within 0.05 degree and will adjust the longitude position of the spacecraft within 0.1 degree. With respect to the Earth, the spacecraft will then appear nearly stationary at the preselected location of 128 degrees west longitude on the equator.

ON-ORBIT GEOMETRY

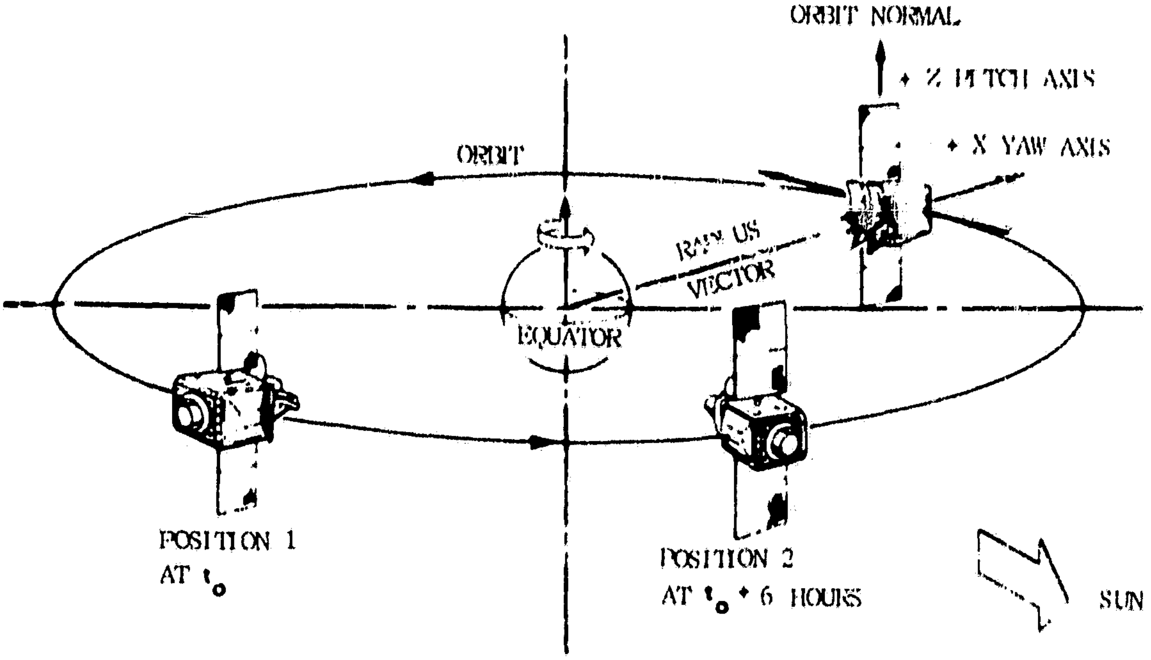


Fig. 2

In the normal steady-state operating mode, the inertial gyroscopic stability of the momentum wheel tends to maintain the pitch axis parallel to the Earth axis. Control of the spacecraft about the pitch axis is accomplished by varying the wheel speed in accordance with error signals generated by the Earth sensor. Data from this sensor is also used with magnetic torquers for controlling roll and yaw (i.e., maintaining the wheel axis alignment). Unbalanced solar torque is cancelled by bias torque coils mounted on the solar arrays. The attitude control subsystem is also designed to maintain precise antenna pointing during north/south and east/west velocity changes required for stationkeeping. Both north/south and east/west thrusters are fired at a nodal crossing once every 3 weeks. It is during these ΔV maneuvers, and only during these times of high disturbance torque, that the gyros are used as a short-term attitude reference. Multiple alternate modes of operation are provided in the design of the attitude control and reaction control subsystems to achieve reliability and to back up any component failure.

SPACECRAFT DESCRIPTION

Although the Advanced Satcom spacecraft will be larger and heavier than the first-generation spacecraft now in service, it will retain the basic features of its predecessors: three-axis body stabilization, Sun-oriented solar panels, and cross-gridded antenna reflectors for frequency reuse, as shown in Figure 3. Propellant supply, power-system capacity, and component reliability/redundancy will be sufficient to ensure that all channels operate continuously for 10 years. To achieve greater traffic capacity within the 24 channels, RCA will incorporate technological advances over the present designs into each of the major communications subsystem elements. For example, a shaped-beam antenna increases gain over the coverage area; an improved receiver (lower noise temperature) further increases uplink carrier-to-noise; sharper multiplex filters decrease crosstalk and distortion noise; and higher-powered amplifiers with improved linearity reduce intermodulation distortion and permit greater capacity. The attitude and velocity control systems will be modified to match the larger structural configuration, as will the array size and battery capacity to support the higher power consumption of the payload.

ADVANCED SATCOM ON-ORBIT CONFIGURATION

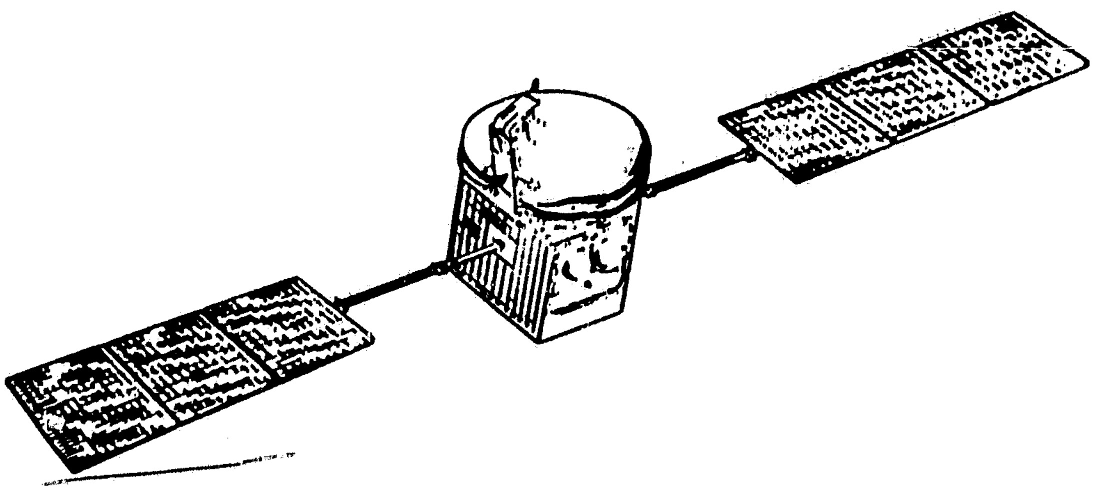


Fig. 3

Leading particulars of the Advanced Satcom are given in Table 1.

COMMUNICATIONS PAYLOAD

The RCA Satcom VI communications capability is provided by 28 individual 8.5 watt RF solid-state power amplifiers (SSPA's) and four electronic power conditioners (EPC's). Each EPC contains two dc-to-dc power converters that provide power for six SSPA units on common 8.5 volt, and -3.0 volt buses. Redundancy includes three power converters for each two required and seven SSPA's for each six required. Previous RCA Satcoms used traveling wave tube amplifiers (TWTA's). Performance advantages of the SSPA vs. TWTA are higher reliability, much simpler power supply requirements, improved carrier to third order intermodulation, and improved phase linearity characteristics.

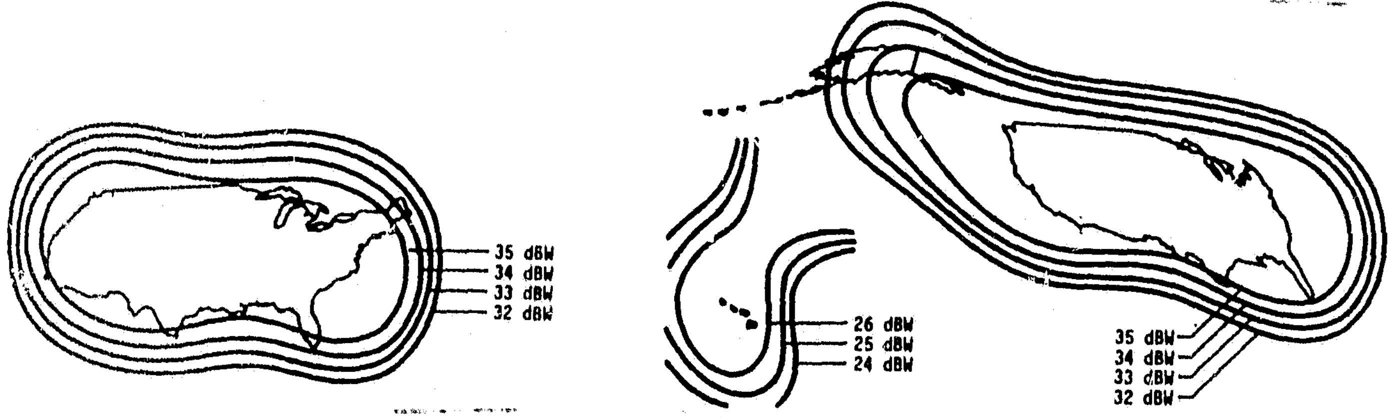
TABLE 1
SPACECRAFT CHARACTERISTICS

ITEM	DESCRIPTION/VALUE
. Mission Life	10 Years
. North-South Station-keeping Accuracy	±0.1 Degree
. East-West Station-keeping Accuracy	±0.1 Degree
. Eclipse Capability	100% (24 channels fully powered)
. Stabilization	Three-Axis
. Transfer Orbit Weight	2461 Pounds
. Channelization	24 Transponders 12 each on Orthogonal Polarizations
. Redundancy	28-for 24 SSPA, 4-for-2 Receivers
. EIRP/Channel	
- CONUS	35 dBW
- CONUS/Alaska	34dBW
- Hawaii	26 dBW
. Receive G/T, CONUS/Alaska	-3dB/degree K
. Receive Frequencies	5925-6425 MHz
. Transmit Frequencies	3700-4200 MHz
. CR&T Frequencies	
- Uplink	6423.5 MHz
- Downlink	3700.5 and 4199.5 MHz
. Array Power (Minimum @ 10 yrs)	1050 Watts

This all-solid-state communications satellite also incorporates an RCA-designed frequency re-use, shaped beam antenna design, incorporating a pair of orthogonally-polarized, overlapped, offset parabolic reflectors. Each reflector accommodates a linearly polarized, rectangular horn fed array designed to provide optimum shaped-beam antenna patterns of both vertical and horizontal polarization.

A major consideration in antenna design is CONUS-Alaska versus CONUS-only coverage. Americom has chosen two generalized beam shapes, as illustrated in Figure 4(a) and (b), for eastern and western orbital locations. Thus, prelaunch adjustment of the feed power-splitting and phasing network for specific beam shapes is planned since orbital stations will generally be preassigned.

ADVANCED SATCOM EIRP COVERAGE



(a) Eastern orbital positions

(b) Western Orbital positions

Fig. 4

As on the current Satcom satellites, the reflector is composed of overlapped, cross-gridded surfaces to achieve the two orthogonal linear polarizations. The axial separation of the two surfaces provides a corresponding separation of their focal points that accommodates multiple sets of feed horns.

TRANSPONDER ENHANCEMENTS

Each element of the transponder incorporates design improvements that, together with the higher antenna gain, double the traffic capacity per channel of these satellites. The receivers use GaAsFETs in both the 6-GHz preamplifier and 4-GHz driver sections to achieve greater than 3-dB improvement in noise figure. Advanced multiplex filter designs realize sharper channel band-edge attenuation with lower inband gain slope (and, thus, reduced crosstalk). These advanced designs have six-pole group-delay-equalized elliptic function characteristics for the input filters and four-pole elliptic-function response for the output filters.

All-solid-state GaAsFET power amplifiers (SSPA), used in lieu of TWTAs, will significantly improve both the performance and reliability of the final amplifier. In comparison with a TWTA, the SSPA is a more linear amplifier, particularly near the full-power operating point. This linearity of the power transfer function, with less gain compression at the nominal saturation point, is exhibited in terms of the level of intermodulation between two (or more) carriers. With the SSPA, the signal-to-third-order intermodulation distortion between two carriers is 3 to 8 dB better than with the TWTA. Hence, to achieve a given signal quality, for example 20dB S/IM_3, the input back-off required for the SSPA is approximately 5 dB less than that for a TWTA, thus providing a higher signal-to-noise ratio and, resultantly, greater channel-traffic capacity. Additional capacity increases are realized when other transponder enhancements--for example, improved G/T, filters, antenna gain, and so on--are considered.

The Advanced Satcom transponder, by virtue of SSPA linearity in combination with phase-equalized elliptic function filters, can support two simultaneous video transmissions with high quality and without crosstalk.

Elimination of the hot-cathode life-limitation and high-voltage power-supply complexity of TWTAs will greatly increase the probability that the amplifier will survive the full 10-year mission. A spare SSPA, installed for each of the four groups of six channels, also increases transponder reliability.

SPACECRAFT BUS

Structure

The spacecraft main body, measuring 56" x 64" x 69", mounts all electronic boxes, batteries, propulsion, and attitude control equipment on six honeycomb structural pallets or panels. Transponders and housekeeping components are mounted on four panels, two each on the north and south sides of the spacecraft. Additional housekeeping equipment is mounted on a base panel, facing away from the Earth.

An Earth-facing panel provides a mounting surface for the two communication antenna-reflectors, with their composite feed assembly, two command/telemetry antennas, and the Earth sensors for attitude sensing.

The two sides between the equipment pallets and Earth-facing pallet provide shear stiffness for the mainbody structure. Integrated with these assemblies are four spherical propellant tanks. The 1183-pound kick motor is housed in the center cylinder of the spacecraft through the sixth side of the mainbody. A conical adapter attaches the motor to the cylindrical column and also provides transition support from the launch vehicle interfaces to the baseplate structure.

Attitude Control

The attitude control subsystem employs a sealed, high-speed (4000 rpm) wheel with a separate Earth sensor and closed-loop magnetic roll control. The RCA-designed STABILITE momentum-bias attitude control system provides three-axis control by virtue of the gyroscopic rigidity of the wheel and its servo-controlled exchange of angular momentum with the spacecraft mainbody.

The inertial stability permits attitude determination by a single, roll/pitch Earth-horizon sensor without the complexity of a star sensor. Continuous control of the pitch axis alignment to the orbit normal is achieved by magnetic torquing with no expendables or moving parts.

The system maintains orientation during normal orbital operation, orbit adjust, and the acquisition and injection maneuvers. The pointing capability during normal operation is ±0.19 degree about roll, ±0.25 degree without yaw, and ±0.12 degree about pitch.

The spacecraft has 12 hydrazine thrusters in a closed-loop system for North/South and East/West stationkeeping.

Thermal Control Subsystem

A Thermal Control Subsystem provides control of heat absorption and rejection to maintain all components of the spacecraft within safe operation temperatures, which normally range from 10 to 30 degrees Celsius.

Highly-reflective mirrors and thermal blanketing insulation are employed to provide passive heat control.

Layers of aluminized insulating material offer high resistance to radiant heat flow. The highly reflective mirrors maximize heat rejection and minimize heat absorption.

Power Subsystem

The Power Subsystem consists of two tri-folded solar array panels and three nickel-cadmium batteries. The subsystem delivers a maximum output of 1450 watts of regulated 35 volts at beginning of life and 1100 watts after 10 years. During the two eclipse periods that are experienced each year, power will be supplied by the batteries. Sun-oriented solar arrays and a direct array-to-load connection maximize the efficiency and minimize the weight of the electrical power generation, storage, and regulations subsystems.

With the spacecraft mainbody always aligned vertically, a single-axis clock-controlled drive shaft maintains the array toward the Sun. Solar cells, which convert the Sun's energy into electrical power, cover an area of 125 square feet.

Input converters in each subsystem convert the 24.5 to 35.3 main bus voltage range to their specific requirements at constant power and efficiency. These converters are designed to preclude a major single-point failure mode.

Propulsion Subsystem

An on-board propulsion subsystem is designed to maintain the spacecraft on station throughout its 10 year life.

The Advanced RCA Satcom carries 315 pounds of hydrazine monopropellant in four tanks for in-orbit use. Upon command from the ground, selected thrusters can be fired to provide spin-axis control in the transfer orbit, as well as velocity control in synchronous orbit. The hydrazine reacts with a catalyst to provide the energy thrust from the 12 reaction engine assemblies.

The passive surface-tension propellant feed ensures operation with no risk of bladder deterioration. Two independent, cross-connected half-systems are designed to maintain control, even in the event of failure of any thruster, valve, or tank.

Maintenance of the station longitude and equatorial orbit inclination to 0.1 degree requires about 30 minutes of thrusting once every 3 weeks.

Command, Ranging and Telemetry Subsystem

The functions of command reception, decoding and distribution, along with automatic and manual telemetry and transponding range tones are handled by the command, ranging, and telemetry subsystem.

Command signals are modulated on a 6 GHz carrier and received by one of the spacecraft's two onmi antennas. Each of the two command receivers produces three isolated outputs containing the Frequency Shift Key (FSK) command tones. Two outputs from each receiver are sent to the dual command logic demodulator for further processing and conversion to a digital bit stream.

Logic level commands are distributed to the spacecraft from the demodulator. Other commands, such as thruster driver, relay closure, and pyrotechnic firing, are generated in the central logic processor. The processor has the capability to implement 160 redundant commands.

During attitude maneuvers, the processor provides an interface between the thruster firing commands and the actual operation of the thrusters.

The ranging function involves the use of the two command receivers and two beacon transmitters.

The telemetry function is performed by the dual telemetry module. This unit transmits 8-bit telemetry words for a total of 256 words at 128 works per second. The sampling is controlled by counters within the module. The telemetry points are available for storing housekeeping data, synchronization codes, and spacecraft identification.

The two beacon transmitters with carrier frequencies of 3.7 and 4.2 GHz can operate at two selectable output power levels. The high-power output is used continuously during launch and transfer orbit operations and prior to Earth geosynchronous mission operations.

Apogee Motor

The solid-propellant apogee kick motor (AKM) is designed to transfer the spacecraft from the inclined, elliptical, transfer orbit to the equatorial, geosynchronous orbit. An integral part of the spacecraft, the AKM is fired at the apogee of the transfer orbit to change the velocity and the plane for injection into a circular, synchronous orbit.

The AKM is the Thiokol STAR-30 (a new engine not used on previous Satcom missions) specifically designed for Delta and Shuttle geosynchronous applications. It provides a total impulse of 326,947 lbs-sec.

Figure 5 shows an exploded view of the spacecraft structural arrangement. The assembled view, with folded solar panels as mounted within the Delta fairing, is shown in Figure 6.

RCA-F SPACECRAFT STRUCTURE

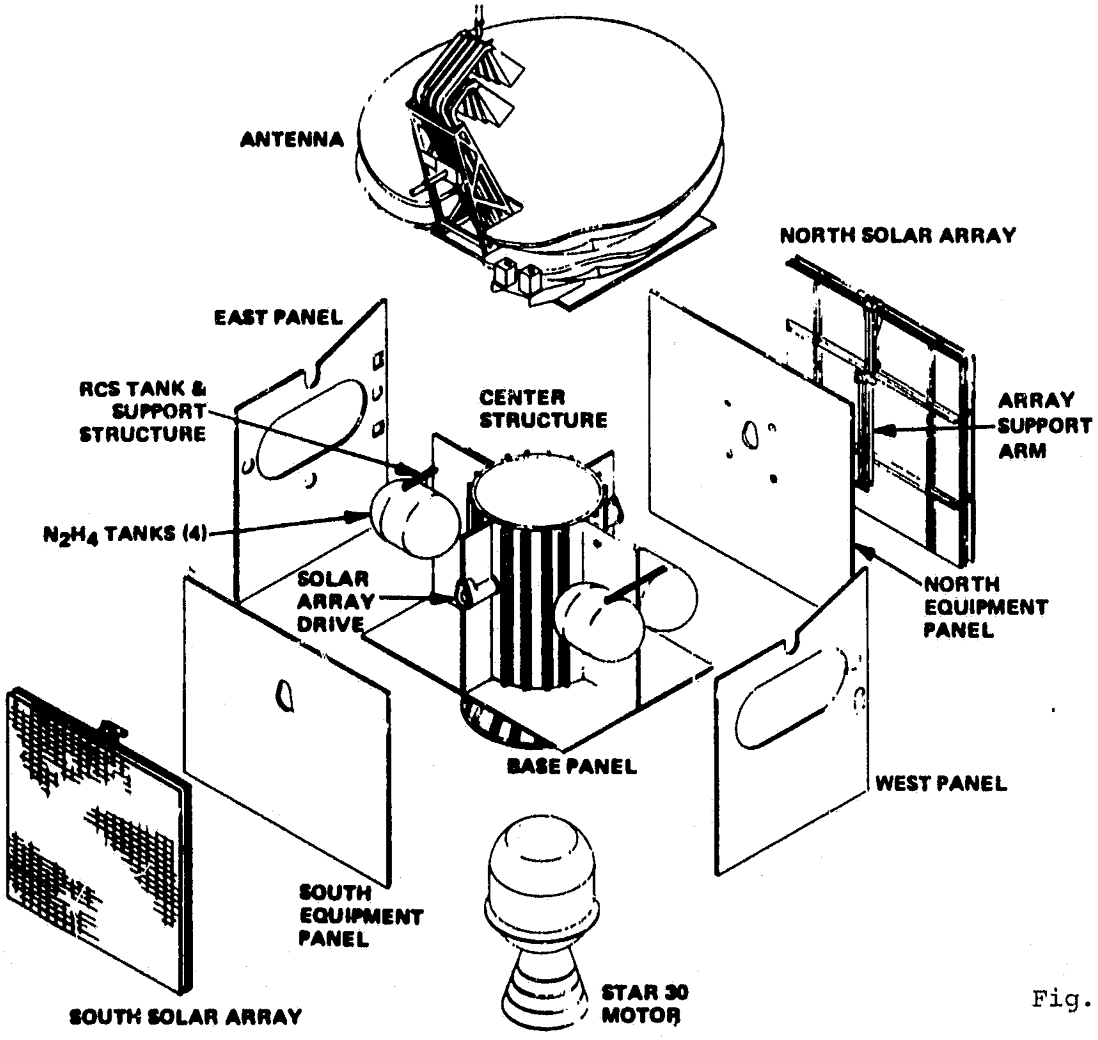


Fig. 5

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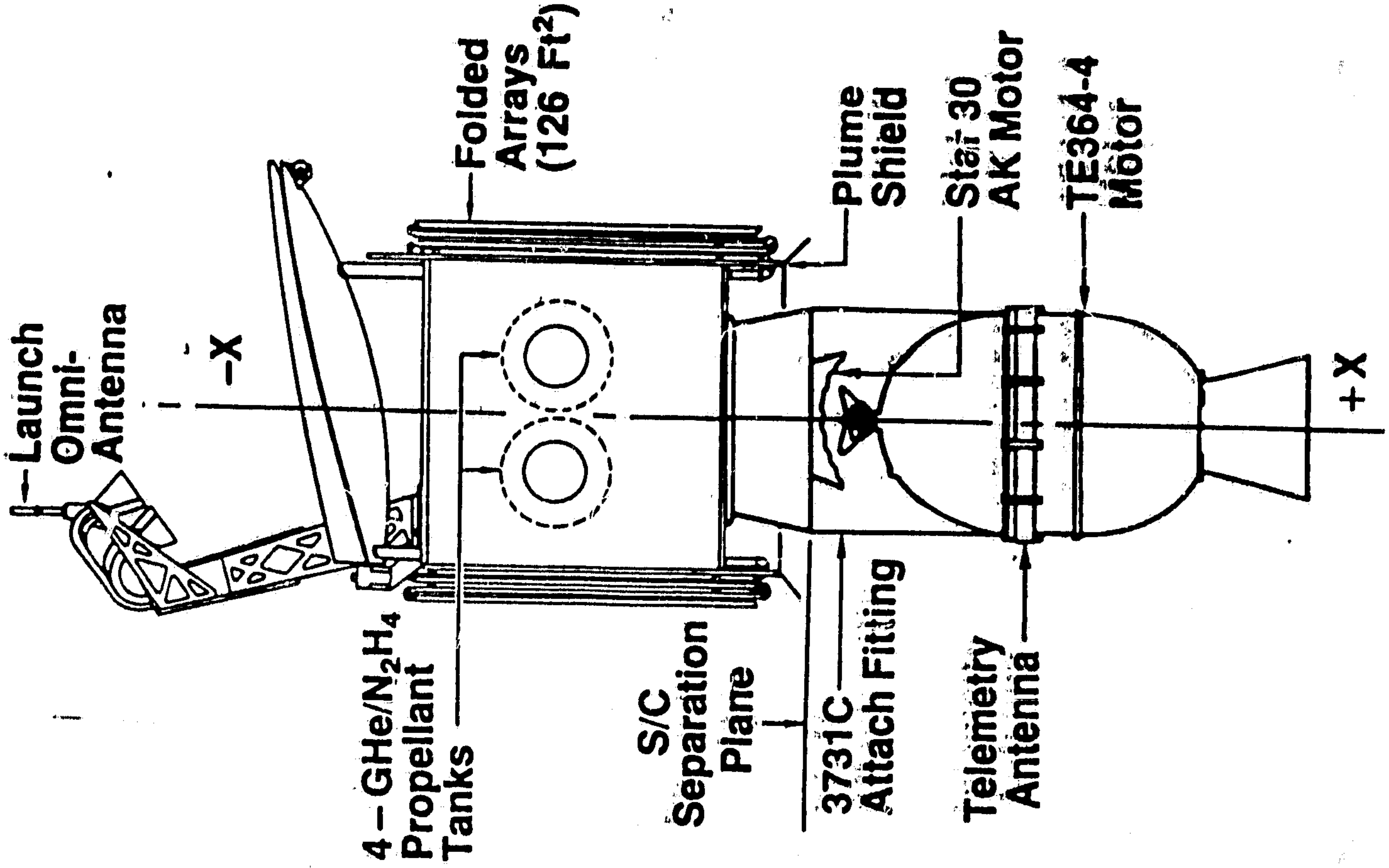

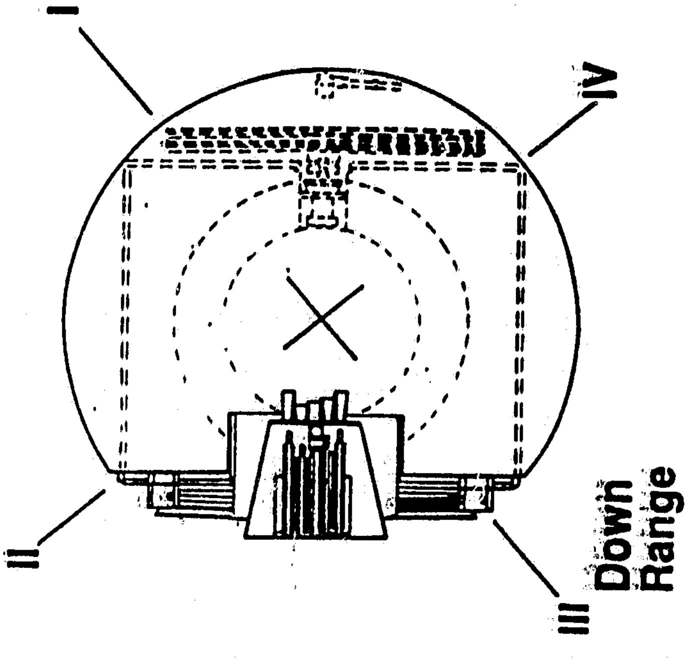

RCA-F LAUNCH CONFIGURATION

Fig. 6

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LAUNCH VEHICLE DESCRIPTION

The Satcom-VI (RCA-F) spacecraft will be launched by the thrust-augmented NASA Delta 3924 launch vehicle whose principal elements are shown in Figure 7. The launch vehicle characteristics are listed in Table 2. This will be the 167th flight for Delta. Of the previous 166 flights, 154 have successfully placed satellites into orbit.

DELTA 3924 - PRINCIPAL ELEMENTS

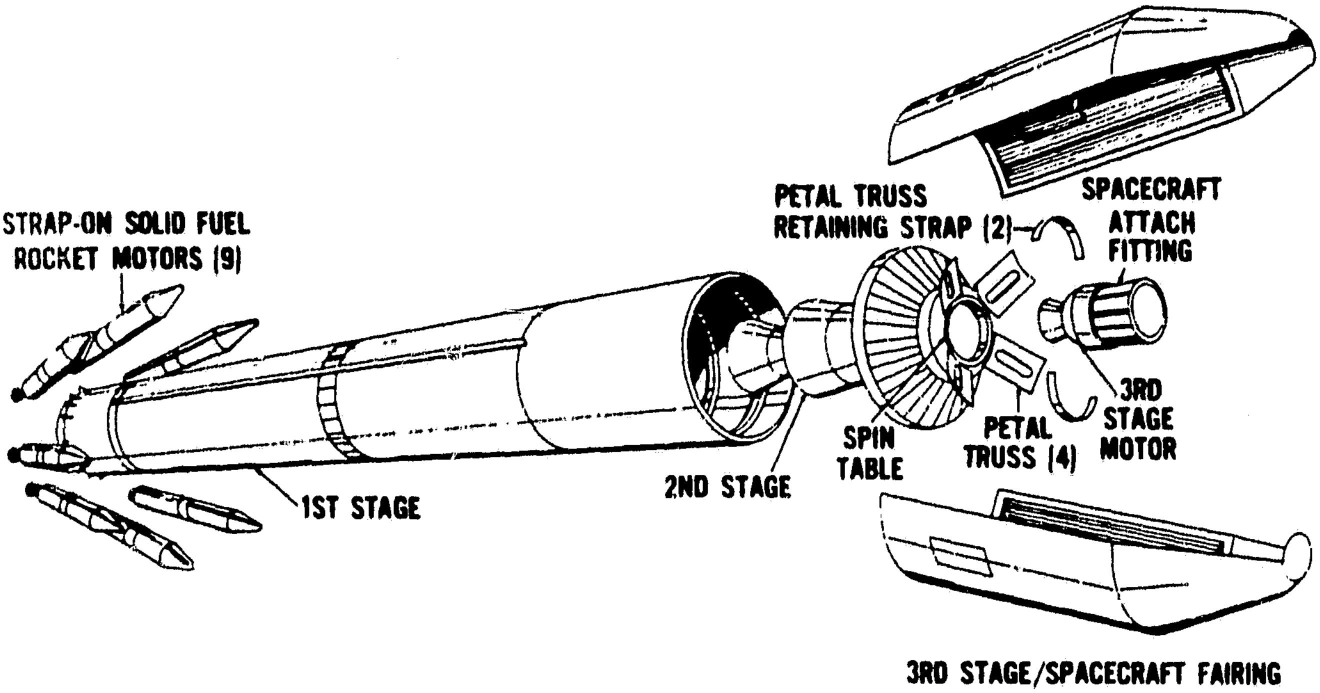

Fig. 7

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 3924 is 35.5 meters long (116 ft), including the spacecraft shroud. Lift-off weight is 190,210 kg (418,368 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).

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.

TABLE 2
DELTA 3924 LAUNCH VEHICLE CHARACTERISTICS

	STRAP-ON	STAGE I	STAGE II	STAGE III
Length	11.3m (37.0 ft)	21.3m (70.0 ft)	7.0m (23 ft)	1.47m (6 ft)
Diameter	101.6 cm (40 in)	243.3 cm (96 in)	175.3 cm (69 in)	192.1 cm (37 in)
Engine Type	Solid	Liquid	Liquid	Solid
Engine Manufacturer	Thiokol	Rocketdyne	Aerojet	Thiokol
Designation	TX-526	RS-27	ITIP	TE-364-4
Number of Engines	9	1 (+2 VE)	1	1
Specific Impulse Avg.	229.9	262.4	319	285
Thurst (per engine)(Avg.)	407,000 N (91,520 lb)	911,840 N (205,000 lb)	41,969 N (9,443 lb)	63,105 N (13,900 lb)
Burn Time	58.2 (sec)	228 (sec)	445 (sec max)	44 (sec)
Propellant	TP-H-8038	RP-1 A-50 (LOX oxid.)	TP-H-3062 (N_2O_4 oxid.)	

The Delta 3924 incorporates a second stage consisting of large diameter propellant tanks coupled with the Aerojet Liquid Rocket Company's AJ-10-118 Improved Transtage Injector Program (ITIP) engine shown in Figure 5. 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 sold gas system.

The third stage is the TE-364-4 spin-stabilized solid-propellant motor. This motor is secured on a spin table mounted to the second stage. The firing of two to eight solid propellant rockets fixed to the spin table accomplishes spinup of the third-stage assembly to approximately 55 rpm.

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.

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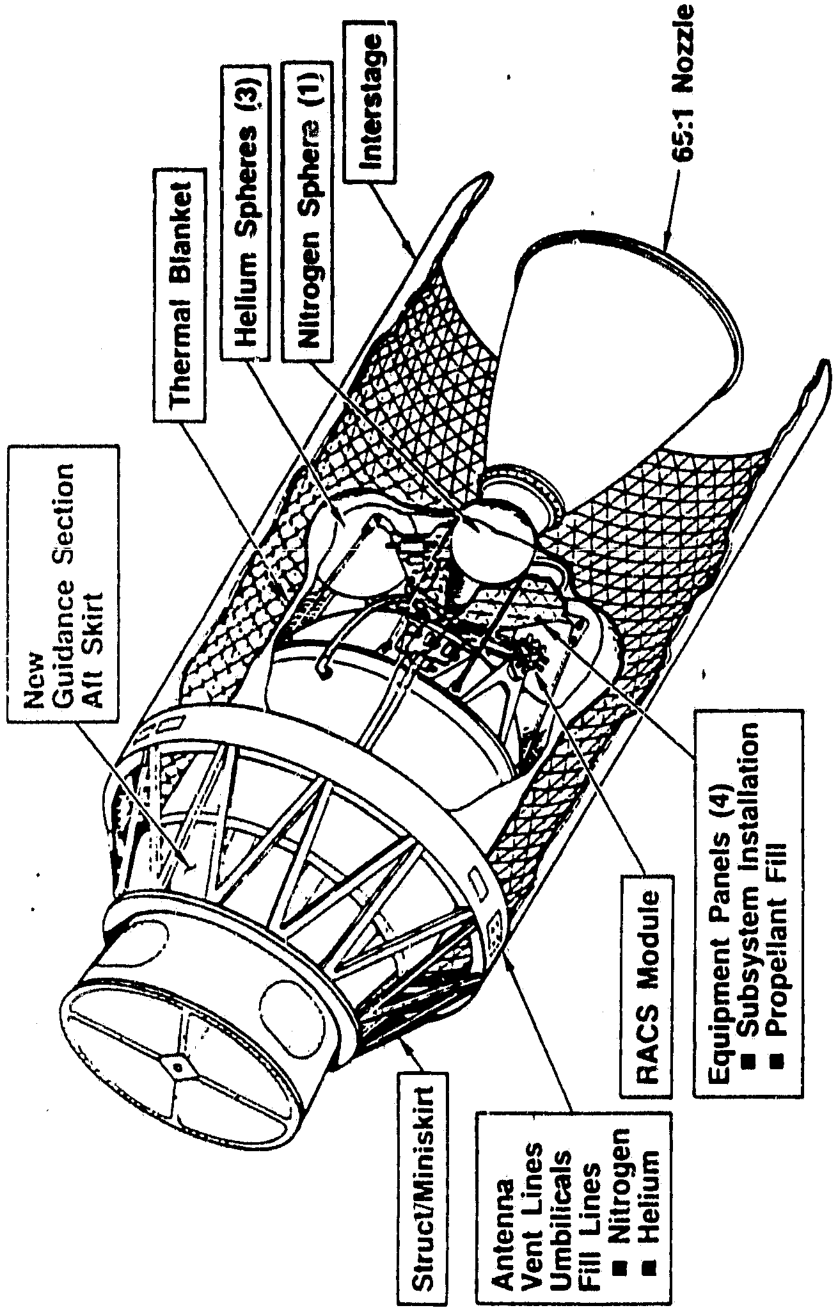

DELTA 3924 - IMPROVED SECOND STAGE

Fig. 8

The system is composed of a digital computer provided by Delco and the Delta Redundant Inertial Measurement System (DRIMS) provided 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. Figures 9 thru 11 show the vehicle ascent profile for the RCA-F mission.

TABLE 3
RCA-F - TRAJECTORY SEQUENCE OF EVENTS

EVENT	LIFTOFF (SEC)
LIFTOFF	0.0
6 SOLID BURNOUT	59.0
3 SOLID IGNITION	63.0
SEPARATE 3 SOLIDS	64.0
SEPARATE 3 SOLIDS	65.0
3 SOLID BURNOUT	122.2
SEPARATE 3 SOLIDS	123.5
MECO	223.8
FIRST/SECOND STAGE SEPARATION	232.1
SECOND STAGE IGNITION	237.1
FAIRING DROP	259.1
SECOND STAGE ENGINE CUTOFF (SECO 1)	593.8
BEGIN COAST PHASE PITCH MANEUVER	700.6
END COAST PHASE PITCH MANEUVER	800.6
BEGIN COAST PHASE YAW MANEUVER	805.6
END COAST PHASE YAW MANEUVER	905.6
RESTART	1230.1
SECOND STAGE ENGINE CUTOFF (SECO 2)	1315.9
FIRE SPIN ROCKETS	1357.7
SECOND/THIRD STAGE SEPARATION	1359.7
THIRD STAGE IGNITION	1401.9
THIRD STAGE BURNOUT	1445.5
SPACECRAFT SEPARATION	1532.9
DEPLETION BURN IGNITION	3801.2
SECOND STAGE DEPLETION SHUTDOWN	

TABLE 4
MISSION REQUIREMENTS

NOMINAL ORBIT PARAMETERS AT SPACECRAFT INJECTION

Apogee Altitude	19,323 NM
Perigee Altitude	90 NM
Inclination	25.3 Degrees
Spin Rate	50 RPM
SPACECRAFT WEIGHT (AT LIFT-OFF)	2472 lb
FIRST GEOSYNCHRONOUS LOCATION	145 Degrees West Longitude Above the Equator

TABLE 5
FLIGHT MODE DESCRIPTION

Launch From PAD 17A at ESMC
Launch Window is 5:46 - 6:22 p.m. EST
Six Solids Ignited at Lift-off
Three Solids Ignited at 62 seconds
Fairing Separation Occurs at 254 seconds

TABLE 6
PREDICTED ORBIT DISPERSIONS (99% PROBABILITY)

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

ADVANCED RCA SATCOM LAUNCH SEQUENCE

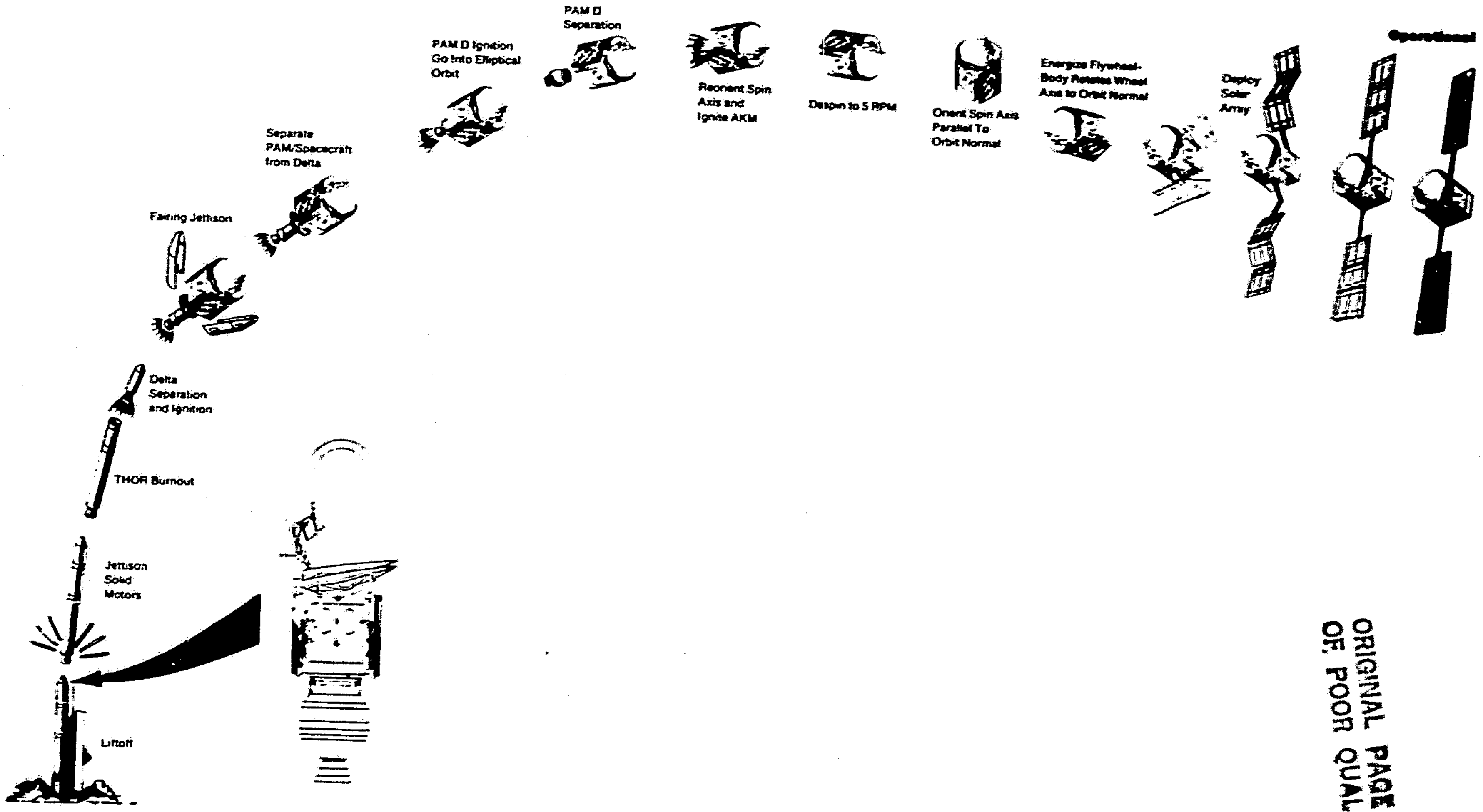

Fig. 9

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RCA-F BOOST PROFILE

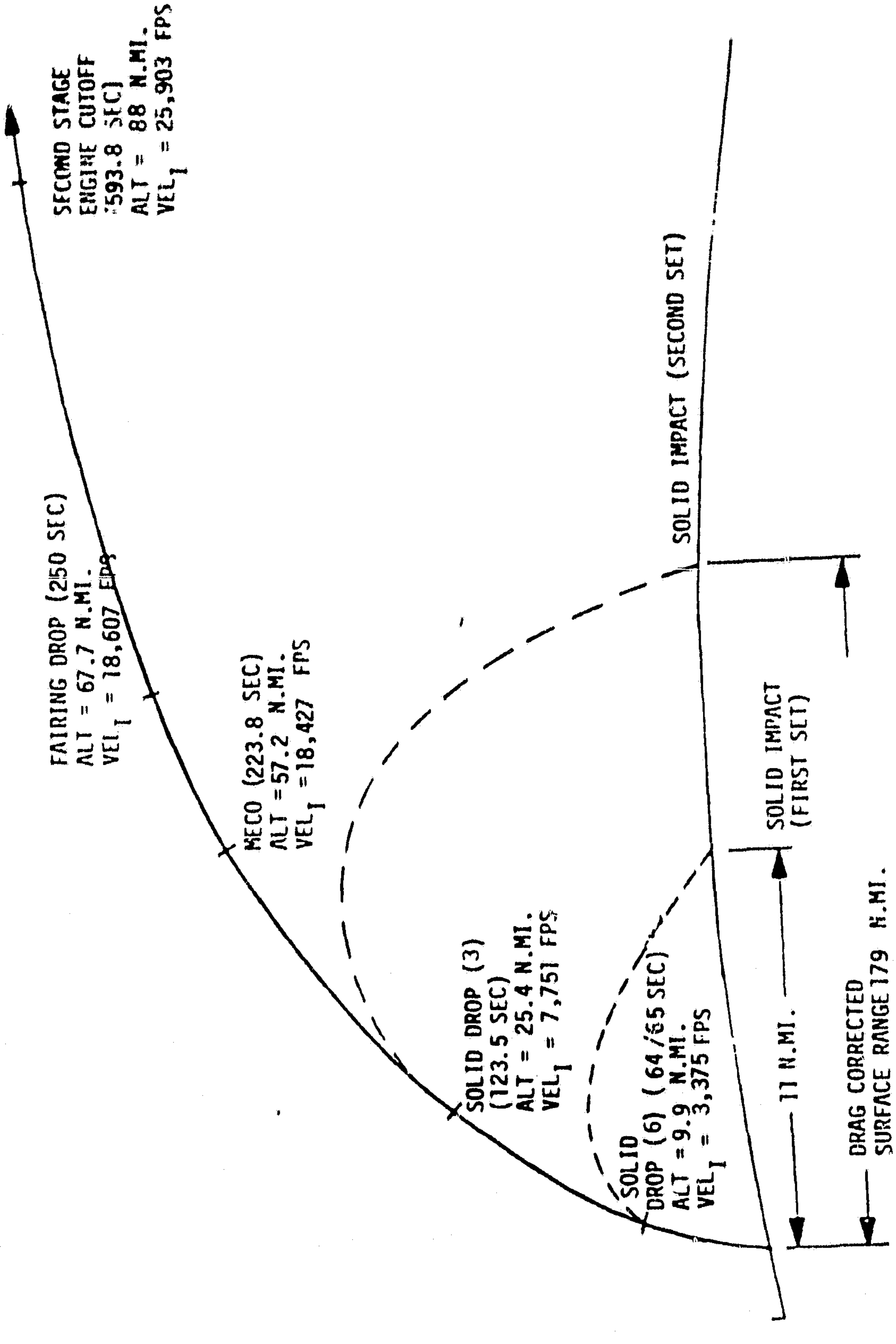


Fig. 10

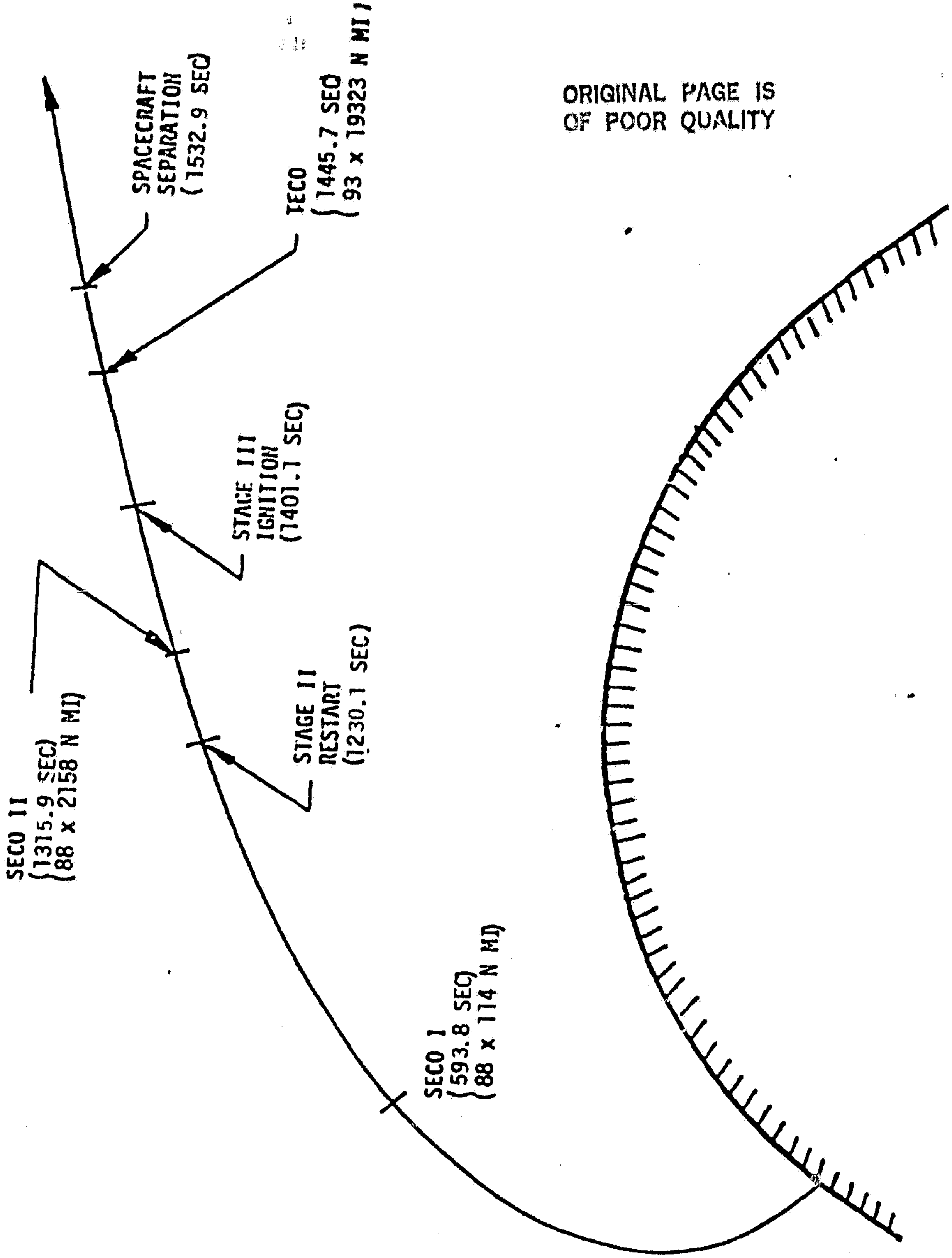
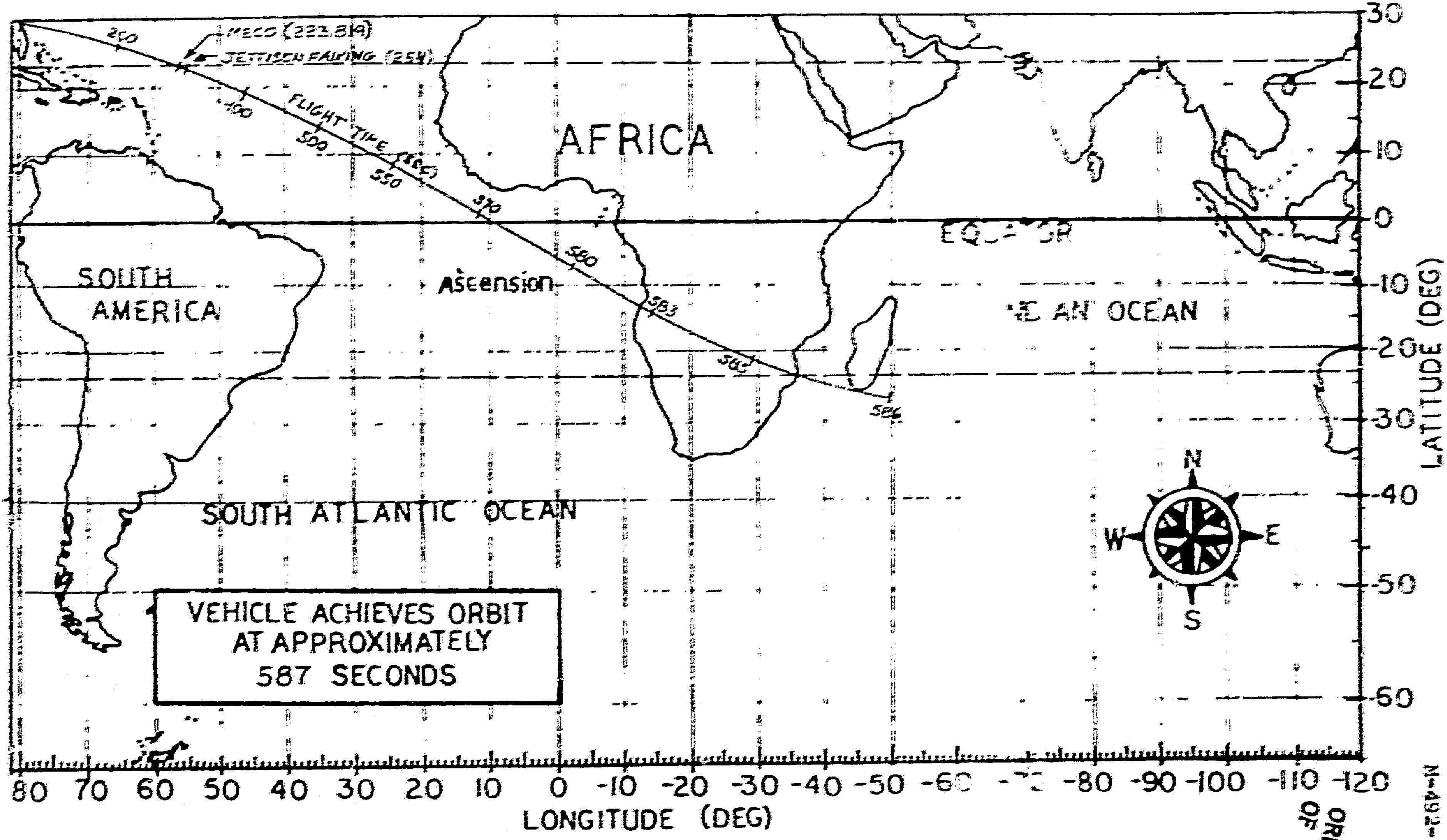


Fig. 10
(Concluded)

RCA-F ASCENT TRACE



DELTA MODEL 3924
NOMINAL IIP FOR FIRST AND SECOND STAGES
(VACUUM RE-ENTRY)

Fig. 11

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 RCA, if required.

TRACKING AND DATA SUPPORT

ESMC Range stations will track the vehicle, and a nominal trajectory and orbit will be provided approximately 30 minutes after launch based on this data. RCA 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

The constallation of RCA Satcom spacecraft are controlled and monitored by two identically-equipped stations. One of these is located at Vernon Valley, New Jersey, and the other at South Mountain, Santa Paula, California. Either of these stations may act as the operations control center of the system with the other acting as a supporting telemetry, tracking, and command station. During the transfer orbit, the services of two subordinate telemetry, tracking, and command stations at Carnarvon, Western Australia, and at Fucino, Italy, will be rented from INTELSAT/COMSAT to provide global coverage of preoperational events. Just before each launch, a telemetry data link will be established to the NASA ESMC at Cape Canaveral, Florida, to provide a data base for the new satellite. Each T&C/SOCC station will also be provided with links to off-line computing services leased from University Computing Company and Information Systems Design. These links will give access to UNIVAC 1108 computers for orbit determination, stationkeeping calculations, and other computations requiring a large computer.

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J. Donald Kraft	Manager, Delta Mission Analysis and Integration
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Joseph Elko	Manager, Spacecraft Engineering

MAJOR CONTRACTORS

RCA Astro-Electronics Division Princeton, NJ	Spacecraft
McDonnell Douglas Astronautics Co. Huntington Beach, CA	Delta Launch Vehicle