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

TELS. WO 2-4155
WO 3-6925

FOR RELEASE: SUNDAY
November 21, 1965

RELEASE NO: 65-355

P R E S S K I T

PROJECT: ISIS-X

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TO BE LAUNCHED NO EARLIER THAN NOV. 23

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NEWS NASA

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DOUBLE LAUNCHING SET FOR CANADIAN, NASA SATELLITES

A second Canadian Alouette satellite and another United States Explorer satellite will be launched together no earlier than Nov. 23 as a joint project of the National Aeronautics and Space Administration and the Canadian Defence Research Board.

The Canadian-built Alouette II and NASA's Direct Measurements Explorer (DME-A) are to be launched by a Thor-Agena B from the Western Test Range in California. The two satellites will make related studies of the Earth's ionosphere as they orbit in close proximity.

The double launch project, known as ISIS-X, is the first in a new cooperative NASA-DRB program for International Satellites for Ionospheric Studies (ISIS). Up to four Canadian-built spacecraft are involved in the ISIS program.

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Canada's Alouette I, launched by a Thor-Agena from the California range Sept. 29, 1962 in a joint NASA-DRB project, still is operating and providing valuable data.

The new Canadian spacecraft is similar in design and purpose to Alouette I but has been substantially modified and carries improved experiments. It will have a different type of orbit than Alouette I.

The initial Alouette carried out the first topside sounding survey of the ionosphere around the Earth. The survey showed the ionosphere to be far more dynamic and complicated than realized.

The ionosphere is a fluctuating ionized region of the upper atmosphere extending from about 35 miles above the Earth to thousands of miles into space. A major feature of the ionosphere is the number of free electrons present in it. These free electrons play a vital role in long-range radio communications.

The composition of the ionosphere varies markedly with time, altitude and latitude and it is the purpose of the Alouette II and the DME-A during their lifetimes to measure many of these varying quantities between their orbital high points and low points--about 270 to 1620 miles.

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The plane of the orbits will be inclined about 80 degrees to the Equator, bringing the satellites over the upper regions of the ionosphere above Canada's high latitudes, an area of particular interest to Canadian scientists.

The Alouette II was designed and built by DRB's Defence Research Telecommunications Establishment.

The DME-A was designed and built for the NASA Goddard Space Flight Center, Greenbelt, Md., by the Applied Physics Laboratory of John Hopkins University, Howard County, Md. This United Kingdom experiment will be carried on DME-A. APL also is responsible for final testing of the Alouette spacecraft.

Responsibility for the NASA portion of the joint program is assigned to the Office of Space Science and Applications and, within OSSA, to Physics and Astronomy Programs.

Project management is exercised by the Goddard Space Flight Center. NASA's Lewis Research Center, Cleveland, Ohio, is responsible for the launch vehicle which will be launched under direction of the Kennedy Space Center's Unmanned Launch Operations.

The Goddard center will track both satellites during their operating lifetimes. Data acquisition will be performed by networks of Canadian, British and NASA ground stations.

Data obtained will be made available to the international scientific community.

(TECHNICAL BACKGROUND FOLLOWS)

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BACKGROUND

The Canadian Defence Research Board's Alouette I, launched from the Western Test Range Sept. 29, 1962, was the first satellite designed and built in Canada. It was launched as a joint project of NASA and DRB.

Shortly afterwards, the new NASA-DRB cooperative program, International Satellites for Ionospheric Studies (ISIS), was arranged. Canada assumed responsibility for the design and construction of four more ionospheric satellites to be launched by NASA at intervals between 1965 and 1969, near the minimum and maximum of the present solar cycle.

It was decided to employ Alouette I's backup flight model as the first satellite in the new series. The spacecraft, Alouette II, has been modified substantially to repeat and to improve the experiments carried in Alouette I and to operate in an elliptical rather than a circular orbit.

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DME-A Added to Mission

In line with the overall aims of the ISIS program to conduct simultaneous in-flight measurements of most of the important ionosphere phenomena, NASA proposed that a direct measurement satellite, DME-A, be launched at the same time into the same orbit.

Scientists of DRB supported this opportunity to obtain further information earlier in the ISIS program than would otherwise have been possible.

The eight experiments on DME-A will be correlated with the five experiments on Alouette II.

The induced voltage effects of the long antenna on Alouette II, for instance, will be observed in detail by comparing Langmuier probe data from Alouette II with that from DME-A which will be orbiting nearby.

For these reasons, it is planned that the two spacecraft will remain within 1,000 miles of each other for the first month they are in orbit.

Because both ionospheric temperatures and composition vary with height in a complex manner, ISIS-X experiments are designed to explore these variations from near the peak of the most dense layer of the ionosphere up to apogee, the high point of the orbits.

Through this region of the ionosphere, temperatures of electrons vary from 800 to 4000 degrees above absolute zero, but the temperature of ions is often different, usually less than that of electrons. The neutral gas is usually cooler than the temperature of electrons and ions in this part of the ionosphere.

The ion composition varies from almost pure atomic oxygen near perigee (270 miles) to helium or atomic hydrogen or a mixture of both at apogee (1620 miles).

The ISIS-X experiments are designed to measure most of these quantities, sometimes by more than one method, as the two spacecraft move up and down through the region.

Ionospheric Conditions

The Canadian scientists responsible for the Alouette project are concerned primarily with the upper regions of the ionosphere above Canada's high latitudes.

Some of the radiation directed from the Sun towards the Earth is absorbed in the ionosphere which extends upward from approximately 35 miles above the Earth. During this absorption process, neutral air particles split into electrically charged ions and electrons. They create, in effect, an electrical conductor with the ability to reflect radio waves.

When the ionosphere becomes disturbed following solar storms or other phenomena associated with the Sun, its reflecting properties are affected. Consequently, radio communications are disrupted, sometimes for lengthy periods.

Hence, the deep interest of scientists in studying the upper atmosphere in order to find methods of overcoming the effects of ionospheric disturbances.

Variety of Disturbances

An unusual feature of the polar and subpolar ionosphere stems from seasonal variations of the polar atmosphere's sunlight--continuous daylight during summer and continuous night during the winter. A second feature of the ionosphere at high latitudes involves effects on ionization created by charged solar particles.

The high-latitude ionosphere exhibits a wide variety of disturbed conditions. It resembles that in the temperate zones only during quiet conditions and then only on rare occasions.

Perhaps the worst ionospheric condition, from the standpoint of communications, is the so-called "polar blackout". During such occurrences, reflections cannot be obtained from the ionosphere by most ground-based ionosphere recorders (called ionosondes).

Consequently, the ionograms (or records of electron density versus height) are sometimes completely blank. Rocket flights and other experiments have shown that these polar blackouts result from an abnormal increase in low-lying ionization caused by solar particles.

The effect on communications is a complete cessation of radio sky-wave transmissions at high frequencies due to absorption in the D-region of the ionosphere.

Disrupt Radio

Sudden ionospheric disturbances (SIDs) also cause loss of communications, producing abrupt and simultaneous radio fade-out throughout the hemisphere which may last from 10 minutes to an hour.

Polar blackouts, however, are more gradual in their beginning and recovery and last for substantially longer periods--sometimes continuously during the daylight hours for several consecutive days.

The "ionospheric storm" is another type of disturbance intensified in the auroral zones. It is characterized by a general instability of ionospheric conditions, a decrease in the maximum density of ionization and an increase in absorption. The maximum usable frequencies are much lower than normal during these periods and the restricted communication spectrum is subject to rapid fluctuations in signal intensity.

An ionospheric storm is usually accompanied by a magnetic storm, a period of unusual fluctuation in terrestrial magnetic intensity.

Topside Technique Valuable

The topside sounder technique is the only one known that can provide worldwide electron-density profiles above the height of maximum electron density of the ionosphere.

Such soundings permit the investigation of the physical properties of the ionosphere as a function of time and geographical location. The planned ISIS-X orbital inclination of 80 degrees will provide data on the little-known and very complex high-latitude regions (polar and auroral zones).

The profiles obtained in the equatorial regions are of interest because the magnetic field at the équator is nearly horizontal and vertical diffusion of the charged particles is significantly inhibited.

Should Improve Forecasts

In addition to its scientific value, the increased knowledge of the ionosphere is directly applicable to communications and tracking applications. The importance of the ionosphere to terrestrial radio communication is well known. Predictions of ionospheric storms and disturbances are often unsatisfactory because they are based on inadequate information. A better knowledge of the entire ionosphere mechanism should lead to more precise forecasts.

The prediction of maximum usable radio frequencies for communications purposes is based upon observations from ground-based ionospheric stations (ionosondes).

This information was considered of sufficient importance to justify the establishment of about 150 ground-based ionospheric sounding stations throughout the world. However, this number of stations is not sufficient for accurate worldwide mapping of the bottom-side ionosphere.

Two of the most important observations obtained by these stations are the height and density of maximum ionization in the ionosphere. In principle, several topside sounder satellites should provide this information synoptically and with better geographical coverage.

ALOUETTE SPACECRAFT

The Alouette II spacecraft weighs 320 pounds and is nearly oval in shape, 42 inches in diameter and 34 inches high.

The surface is covered with panels of solar cells. The 6,480 n-on-p solar cells convert solar energy to electrical power and charge the nickel-cadmium storage batteries.

Two sets of long dipole antennas extend from the main portion of the spacecraft for use in the topside sounding of the ionosphere. One set measures 75 feet from tip to tip. The other is 240 feet, tip to tip, when extended.

A four-antenna array (whip type) is used for telemetry and command functions and a single whip antenna extends from the spacecraft top for the radio beacon aboard.

Two short electron probe rods extend from the base of the spacecraft.

ALOUETTE II EXPERIMENTS

Alouette II will repeat its predecessor's four experiments over a wider range of heights and during a period of increasing solar activity. The experiments are:

(1) Sounding the topside of the ionosphere (the primary experiment); that is, making rapid and detailed measurements of the electron density from satellite heights down to the densest portion of the ionosphere (about 190 miles altitude).

(2) Measuring galactic and solar radio noise.

(3) Investigating "whistlers" (upper atmosphere very low frequency radio signals)initiated by lightning and other radio noises in the audible range.

(4) Detecting energetic particles (protons, electrons and alpha particles).

Fifth Experiment

In addition, as a new experiment, Langmuir probes on both Alouette II and DME-A will measure electron densities and temperatures near the two spacecraft. This fifth experiment will also measure plasma phenomena (a "halo" of positive ions) that occur around the satellite as a result of employing unusually long extendible antennas on the Alouette spacecraft.

A conductor, such as a long metallic antenna moving in a magnetic field (in orbit about Earth), induces a voltage along the antenna. This is likely to effect some of the experiments carried in the spacecraft, particularly when the latter is fitted with very long antennas such as Alouette II's 240-foot dipole.

By comparing the readings from the Langmuir probes on both spacecraft, one with and one without long antennaes, it is hoped to provide a better assessment of the voltage effect.

The Topside Sounder

The instrumentation designed for the Alouette topside sounder is a miniaturized version of a conventional ground-based sounder or ionosonde. A swept-frequency system is used in contrast to the fixed-frequency system employed in the U.S. Explorer XX launched Aug. 25, 1964.

The sounder will transmit and receive pulsed radio frequency signals and the carrier frequency will be swept periodically over the frequency range from 0.2 to 13.5 megacycles. The time-delay versus sounding-frequency information will be transmitted to the ground stations via telemetry and will be recorded on ½-inch magnetic tape. Ionograms will be produced through subsequent playback and decoding of the tape at DRTE's central data processing facility.

Cosmic Noise

As the DRB's second experiment, measurements of cosmic radio noise will be made at the satellite.

For this purpose, the background noise across the frequency band 0.2 to 13.5 megacycles will be measured. A signal derived from the swept-frequency ionospheric receiver automatic gain control circuit will be transmitted via the two watt telemetry system. Solar noise storms and the variation of radio noise across the galaxy are measured by this experiment.

Whistlers Experiment

Objective of the third experiment will be to listen in the very low frequency (VLF) radio spectrum (0.05 to 30 kilocycles per second). A very low frequency receiver with a bandpass of cycles per second to 30 kilocycles per second has been included in the spacecraft instrumentation.

The input to the receiver is permanently connected with the 240-foot dipole antenna by means of a low-pass filter. The output, normally open, can be connected by means of the command system to the four-watt telemetry system. This signal will sometimes be added to that from the ionospheric sounder's receiver and recorded with it at the ground telemetry stations. Subsequently, filters will be used to separate the very low frequency information from that of the sounder.

Particle Detectors

Particle detectors in the sounder payload will measure one of the causative agents of ionization in the polar ionosphere at the same time and place as their effects. This experiment will measure primary cosmic ray particles outside the Earth's atmosphere, including the electrons, protons and alpha particles.

The polar orbit permits measurement of changes in particle flux caused by the Earth's magnetic field. These measurements are particularly valuable for auroral studies and in investigating the precipitation of particles (corpuscular bombardment) from the Van Allen belts or magnetosphere.

Within Alouette are six detectors which will measure electrons with energy above 3,000 electron volts and protons with energy above 500,000 electron volts. Alpha and heavier particles with energies up to several billion electron volts also will be measured. The detectors are similar to those carried in the U.S. Explorer and Pioneer spacecraft.

Particle Measurements

The primary objective of the NASA Langmuir probe experiment on Alouette II is to make direct particle measurements of the ionosphere in the immediate vicinity of the spacecraft.

Because of the uncertainty of the affects of the long antennas, most of the direct-measurement experiments are placed in DME-A. One type of experiment however, the Langmuir probe, is carried on both satellites to assist in resolving this doubt.

ALOUETTE II MODIFICATIONS

The major modifications required for Alouette II were necessitated primarily by its planned elliptical orbit. Alouette I was launched in a circular polar orbit of 630 statute miles just prior to a period of Sunspot minimum.

Its successor will be launched during a period of increasing solar activity with the orbit ranging from 270 to 1620 statute miles.

Alouette II will be subjected to nearly four times the radiation dose rate (both natural and artificial) of its predecessor. Alouette II's solar cells deteriorated in efficiency about 40 per cent during its first year in orbit due to radiation damage.

To maintain an acceptable amount of power at the end of one year for Alouette II, the solar cells have been changed to a more radiation-resistant type. Radiation damage also has made necessary very careful selection of each semiconductor component in the spacecraft.

Another modification has been a change in the sounder receiver to improve data quality. Intense radio interference from broadcast transmitters encountered over highly populated areas affected the sounder in Alouette I.

Frequency Limits Changed

Because Alouette II will be launched during a period of increasing solar activity, the maximum electron density in the ionosphere will be higher than for Alouette I and the highest frequency of the sounder was raised accordingly.

Conversely, because the apogee will be higher, the local electron density and magnetic field should be lower than those experienced by Alouette I. This has made necessary a reduction in the sounder's lower frequency which involved increasing the length of one of the pair of dipole antennas.

Other modifications included altering the frequency sweep rate.

The antennas in Alouette II have again been provided by the deHavilland Aircraft Co. of Canada. Unlike the one-inch diameter steel tubes of Alouette I, these antennas are one-half inch diameter beryllium copper tubes and are both lighter and longer. The telemetry transmitters also were designed and manufactured by Canadian industry.

The bandwidth of the VLF receiver was increased to permit more detailed analysis of ion composition and temperature. As a final change, the attitude sensing equipment in the spacecraft has been improved to facilitate the recording of more accurate and detailed scientific data.

All these comprehensive changes made necessary the redesign of every electronic unit in the payload.

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ALOUETTE I AND II COMPARISONS

Alouette I Experiments

Ionospheric Sounder	
Frequency coverage	0.5 Mc/s to 11.5 Mc/s
Transmitter power	100 watts
Transmitter pulse width	100 microseconds
Pulse repetition frequency	66 pps
Frequency sweep rate	1 Mc/s/s
VLF	
Receiver, untuned	400 c/s to 10 Kc/s
Cosmic Noise	
From AGC of Ionospheric Sounder	
Energetic Particle	
Protons	0.5 to 700 MeV
Electrons	40 KeV to 3.9 MeV
Alpha	5 MeV to 2.8 BeV

Alouette II Experiments

Ionospheric Sounder	
Frequency coverage	0.2 Mc/s to 13.5 Mc/s
Transmitter power	300 watts
Transmitter pulse width	100 microseconds
Pulse repetition frequency	33 pps
Frequency sweep rate	0.15 Mc/s/s between 0.2 and 2 Mc/s
	1 Mc/s/s between 2 and 13.5 Mc/s
VLF	
Untuned receiver	50 c/s to 30 Kc/s
Cosmic Noise	
From AGC of sounder receiver	
Energetic Particles	
Protons	0.5 to 700 MeV
Electrons	40 KeV to 3.9 MeV
Alpha	5 MeV to 2.8 BeV
Langmuir Probe	
Electron density	10^3 to 10^6 e/cc
Electron temperature	400 to 5000° K

It will be noted that, compared with Alouette I, the sounder receiver bandwidth has been extended at both ends of the range, the sounder transmitter power has been increased, the pulse repetition frequency decreased, and the frequency sweep rate modified. The VLF receiver also has been given an extended bandwidth. Not shown is the much greater immunity to interference that is expected from the redesigned receiver.

Alouette I Instrumentation

Attitude Sensing	Single axis magnetometer
	Thermistors
Tracking Beacon	50 mW
Telemetry	2W FM 100 Kc/s bandwidth
	1/4W PAM/FM/PM 50 Kc/s bandwidth
Command	24 basic commands
Antennas	Sounder: crossed dipoles 150 ft. and 75 ft.
	Telemetry and Command: Turnstile whips
	Tracking Beacon: 1/4 wave whip
Power	6480 p-on-n type Solar Cells: Ni-Cd batteries

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Alouette II Instrumentation

Attitude Sensing	3 axis magnetometer
	Thermistors
	Solar Aspect sensor
Tracking Beacon	100 mW
Telemetry	4 W FM 100 Kc/s bandwidth 2 subcarriers
	2 W PAM/FW/PM 50 Kc/s bandwidth 4 subcarriers
Command	24 basic commands
Antennas	Sounder: crossed dipoles 240 ft.* and 75 ft.
	Telemetry and Command: turnstile whips
	Telemetry beacon: 1/4 wave whip
Power	6480 n-on-p Solar Cells: Ni-Cd batteries

* Note that the sounder's long antenna has been increased from 150 to 240 feet.

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Orbits

Alouette I - Actual Orbit

Inclination	80.5°
Apogee	642 statute miles
Perigee	617 statute miles

Alouette II (ISIS-X) - Planned Orbit

Inclination	80°
Apogee	1620 statute miles
Perigee	270 statute miles

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THE DIRECT MEASUREMENTS EXPLORER (DME-A) SPACECRAFT

The Direct Measurements Explorer (DME-A) spacecraft is an octagon weighing 215 pounds. It measures 30 inches across the top and is 25 inches high. A spherical ion mass spectrometer protrudes 21 inches above the top surface, making the total height 46 inches.

The spacecraft consists of two parts: an inner assembly where electronic components and other instrumentation is mounted; and an outer shell on which solar cells, a single-element antenna, and sensors are located.

Solar cells cover about 15 per cent of the spacecraft's surface. The glass-covered n-on-p solar cells charge nickel-cadmium batteries.

The eight experiments, the transmitter and some of the telemetry will receive power from a main converter. The command system has separate converters, one powered from the solar cell array for use when the satellite is in the sunlight, the other from the battery for use when in the dark.

All data acquisition is in real time and on command only. About two hours of data transmission each day are anticipated. Program timers automatically shut off a transmission 8.3 minutes after a command is executed.

The primary telemetry system is pulse code modulated (PCM), however, there is an alternate pulse amplitude modulation-frequency modulated (PAM/FM) mode of operation for acquiring housekeeping data only.

There is also a capability for operating experiments in two different modes, one with all experiments working simultaneously, the other with certain experiments in operation sequentially.

The telemetry transmitter, while transmitting data, will normally be used for tracking.

ATTITUDE CONTROL

In order to optimize experiment data, it is necessary to keep DME-A's spin rate at three revolutions per minute and to maintain the spin axis perpendicular to the orbital plane.

DME-A accomplished stabilization and control with a magnetic system, rather than gas jet controls, which would have a short useful life on a spacecraft needing frequent correction.

The spacecraft's attitude, in relation to the Sun and to the Earth's magnetic field, will be determined by a six-element analog Sun sensor and a three-axis fluxgate magnetometer.

Correcting the spacecraft's attitude will be done by ground command. Attitude is changed by discharging a capacitor through a coil wrapped around laminations of a permanent magnetic alloy, thus creating magnetic dipole moments which precess the spacecraft.

Since the orbital plane will precess in space about one degree per day, the spin axis can be constantly maintained within an angle of five degrees from the normal by corrections about every 10 days.

Spin rate will be controlled similarly by commutating electromagnets with components of the Earth's magnetic field. The spacecraft's magnetometer sensors detect the Earth's magnetic field and generate direct current (DC) voltages that are fed to DC power amplifiers which energize the electromagnets thus creating a magnetic moment.

DME-A EXPERIMENTS

Primarily, the DME-A will measure, directly, density of ions and electrons encountered during its orbit, and their temperatures, composition of ions, and corpuscular radiation. These data will lead to a better knowledge of the physical causes of the phenomena being examined by Alouette II, nearby in a nearly identical orbit.

Another objective is to analyze sheath perturbations which may affect direct measurement experiments because of the long antenna on Alouette. Both satellites carry identical electrostatic (Longmuir) probe experiments for comparative purposes when the satellites are in close proximity.

DME-A's experiments are:

Thermal Ion Experiment, by J. L. Donley of the Goddard Space Flight Center. This experiment is to determine the number, density, mass and temperature of positive ions having thermal energies.

Thermal Electron, by J. L. Donley of the Goddard Space Flight Center. This experiment is to measure the number, density and temperature of electrons having thermal energies. It will also measure the spacecraft potential.

Electrostatic (Longmuir) Probe, by L. H. Brace of Goddard, to measure electron temperature and density.

Electron Temperature, by A. P. Willmore, University College, London, to determine the energy distribution function of ionospheric electrons.

Spherical Ion Mass Spectrometer Experiment, by A. P. Willmore, University College, London, to determine the distribution function of positive ions.

High-Resolution Magnetic Ion Mass Spectrometer, by J. H. Hoffman, U. S. Naval Research Laboratory, to measure the abundance of positive ions in the mass spectrum from 1 to 20 AMU.

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<u>Energetic Electron Current Monitor</u>, by J. L. Donley, Goddard, to measure the total flux of electrons in the range 10^7 to $10^{10}/cm^2$ sec with energy discrimination up to 5000 ev.

<u>Energetic Electron Current Monitor</u>, by E. J. R. Maier, Goddard, to measure the total flux of electrons in the range 10^2 to $10^7/cm^2$ sec with energy discrimination up to 2000 ev.

TRACKING AND DATA ACQUISITION

The Goddard Space Flight Center's Space Tracking and Data Acquisition Network (STADAN) will track both Alouette and DME-A during their operating lifetimes.

Raw data will be acquired and forwarded to experimenters from stations of STADAN, the Canadian Defence Research and Telecommunications Establishment (DRTE) and the United Kingdom's Department of Scientific and Industrial Research.

These stations will acquire data: Resolute Bay, Northwest Territory (Special, Canada); Ottawa, Ontario (Special, Canada); St. Johns, Newfoundland (STADAN); Johannesburg, Republic of South Africa (STADAN); East Grand Forks, N.D. (STADAN); Blossom Point, Md. (STADAN); Fort Myers, Fla. (STADAN); Boulder, Colo. (Special); Quito, Ecuador (STADAN); Laurel, Md. (APL); Santiago, Chile (STADAN); South Atlantic (Special, United Kingdom); Winkfield, England (STADAN); College, Alaska (STADAN); Singapore (Special, United Kingdom); Kano, Nigeria (Special, NASA); Canberra, Australia (STADAN); and Kauai, Hawaii (Special, NASA).

The Canadian and British stations and NASA's STADAN facilities will be provided with command capability and all the information received at each ground station will be recorded on ½-inch magnetic tape in seven channels.

The satellite controller for Alouette II will operate from DRTE, assisted by personnel under contract from Computing Devices of Canada.

The DRTE data center at Ottawa is one of those which will process Alouette II data. It will process tapes from the telemetry receiving stations using Computing Devices of Canada personnel.

The tapes will contain three main signals:

(1) The ionosonde receiver output (the "video" signal), together with line and frame signals.

(2) The four subcarrier signals carrying the "housekeeping" information, cosmic particle experiments and cosmic noise and Langmuir probe data.

(3) The time code track which will be a one kilocycle per second carrier amplitude and width modulated in accordance with the NASA 100 pulses per second 36 bit time code format. In addition, voice announcements of the date, time, and station identification will be carried on one of the tracks, but ahead of the telemetry information.

The output of the tape replay units will provide ionospheric high frequency records ("B" scans) on 35 mm film, displaying time on a strip parallel to the film's edge.

THOR-AGENA LAUNCH VEHICLE

In this ISIS-X launch, the Thor-Agena-B launch vehicle has the unique task of spin-stabilizing two spacecraft in nearly identical orbits. The Agena, perhaps the most versatile upper stage space vehicle in use, must perform intricate maneuvers as it sequentially spins up and separates the spacecraft.

A rocket-driven spintable and petal-type structure to mount the spacecraft and perform the separation functions is attached to the forward end and is an integral part of the ISIS-X Agena.

After Agena has obtained the necessary altitude and velocity for the two spacecraft it carries, its job has just begun. Before separation of either spacecraft, Agena must maneuver to align the first spacecraft (Alouette-II) spin axis correctly, and ignite the spintable rockets to spin up the Alouette to 165 rpm. When all this is accomplished, Agena will separate the spin-stabilized spacecraft.

After Alouette-II is safely off and the spintable has slowed down, the Agena must separate the support petals to make room for injection of the second spacecraft (DME-A). This spacecraft, also spin-stabilized is spun up by rolling the Agena vehicle itself.

The vehicle must first go through a maneuver to ensure that the two spacecraft will not collide and yet remain in close proximity of each other during their first 30 days in orbit. After Agena performs the necessary maneuver, the vehicle rolls at four rpm and separates the DME-A spacecraft.

After separation of the DME-A, the Agena must change its altitude to minimize the possibility of interfering with the spacecraft.

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LAUNCH VEHICLE STATISTICS

	BOOSTER	AGENA
Propulsion	Rocketdyne MB3-Block III Main engine	Bell Model 8096 engine
Thrust	Main: 170,000 lbs.	16,000 lbs. at altitude
Propellants	Main engine: liquid oxygen oxidizer: RJ-1 fuel	unsymmetrical dimethyl-hydrazine (UDMH) and inhibited red fuming nitric acid (IRFNA)
Weight	132,000 lbs.	16,000 lbs.
Height	57 feet	21 feet
Diameter	5.33 feet upper diameter 8.00 feet lower diameter	5 feet
Prime Contractor	Douglas Aircraft Co., Santa Monica, Calif.	Lockheed Missiles & Space Co. Sunnyvale, Calif.

FLIGHT SEQUENCE

At liftoff, the vehicle rises vertically for some 10 seconds, followed by a roll and pitch maneuver to the required launch azimuth. For the first minute and a half the flight trajectory is maintained by the Thor autopilot. After that the WECO guidance system, in conjunction with the programmer, takes over.

During main-thrust powered flight, the Thor main engine provides thrust pitch and yaw control by thrust vectoring and the vernier engines provide roll control. During the nine-second vernier solo period, the vernier engines provide pitch, yaw and roll attitude control.

Main engine cutoff (MECO) occurs about 150 seconds after liftoff. Seven seconds after MECO, WECO guidance initiates adjustments in the Agena primary sequence timer and the Agena velocity meter. Both of these adjustments are the final corrections necessary to ensure that Agena will attain the desired orbit. VECO occurs some nine seconds after MECO. The Thor-Agena separation is initiated by a WECO command which ignites the pinpullers and retrorockets in the booster adapter.

After the booster has fallen away, the Agena flight phase begins a twofold program--(1) to increase the velocity sufficiently to reach the desired orbit and (2) to orient, spinup and inject each spacecraft into orbit at the correct time and with the proper separation velocity to meet the experiment requirements.

After a first coast of some 25 seconds, Agena begins its first burn. This lasts about 230 seconds although actual engine cutoff is commanded by the Agena velocity meter when the vehicle has gained the required velocity.

The second coast lasts some 42 minutes during which the vehicle circles half way around the globe. Second burn lasts about 12 seconds, but again, the exact duration is determined by the Agena velocity meter. After the engine is cut off, Agena's secondary sequence timer is started. (The primary sequence timer was started at liftoff).

To properly align the spin axis of Alouette II, Agena must go through both a yaw and a pitch maneuver before spacecraft separation. These two maneuvers accomplished, the spintable rockets are ignited and within two seconds, the Alouette is spun up to a rate of some 165 rpm and separated. The separation is accomplished by ignition of the separation pyros and releasing the clamps.

Some 50 seconds later, pyrotechnics are ignited to separate the petals around the DME-A spacecraft. The Agena secondary sequence timer then initiates the second yaw maneuver to insure that the final orbits of the two spacecraft are not too widely separated. This timer also starts the Agena roll maneuver which spins the DME-A up to about four rpm. Ten seconds after initiation of spin up, the DME-A is separated.

Agena goes through a final pitch maneuver to minimize the possibility of the launch vehicle interfering with the spacecraft.

LAUNCH TRACKING

The Western Test Range will track the Thor-Agena B launch vehicle from lift-off, using four radars each having a 12-foot diameter antenna. Two of the radars are at Point Arguello, the third is at Point Mugu, and the fourth is located on San Nicolas Island, all in California. These radars will either "skin" track or interrogate the vehicle's "C" Band beacon for range data.

The Point Arguello and Point Mugu radars will track the launch vehicle until loss of signal over the the radio frequency horizon. The radar on San Nicolas Island will track the Agena B through its first burn period and slightly beyond, if possible. Predictions indicate that the Agena B will be down to an elevation angle of about three degrees above the horizon and approximately 725 miles down-range from San Nicolas when the Agena first burn is completed.

Western Test Range computations on first-burn injection conditions will be forwarded to the Eastern Test Range (ETR) at Cape Kennedy, Fla., and Goddard Space Flight Center, Greenbelt, Md.

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After the Agena first-burn injection conditions are received at ETR, they will be forwarded to the ETR station at Pretoria, South Africa, and used in computing look-angles for that station.

ETR will track the Agena during its second burn period--from 60 seconds prior to second ignition to the end of the second burn period plus 60 seconds--using a radar having a 12-foot diameter antenna at Pretoria. This radar will be performing near the limits of its range and elevation but will be backed-up by a nearby 60-foot diameter parabolic antenna.

The raw data will be used at Pretoria to compute the final injection conditions. The raw data and other injection conditions will be forwarded from Pretoria to ETR for computation of new orbital elements and acquisition data for the College, Alaska, Minitrack Station. This data also will be relayed to Goddard and WTR.

POST-LAUNCH SEQUENCE

Event	Seconds after Liftoff
MECO	150
VECO	160
Booster separation	165
Agena first ignition	190
Shroud separation	200
Agena first cutoff	420
Agena second ignition	3020
Agena second cutoff	3030
Ignite spintable rockets	3295
Separate Alouette II	3300
Jettison spintable petals	3350
Apply Agena roll rate command	3365
Remove Agena roll rate command	3370
Separate DME-A spacecraft	3375

NASA'S ISIS-X TEAM

Personnel of the National Aeronautics and Space Administration with major responsibilities for the ISIS-X program are:

NASA Headquarters:

Dr. Homer E. Newell, Director, Office of Space Science and Applications.

Jesse L. Mitchell, Director, Physics and Astronomy Programs, OSSA.

Marcel J. Aucremanne, ISIS-X Program Director.

Dr. Erwin R. Schmerling, ISIS-X Program Scientist.

Edmond C. Buckley, Director, Tracking and Data Acquisition, NASA.

Lewis Research Center:

Dr. Abe Silverstein, Director.

Dr. Seymour Himmel, Agena Manager.

Roy K. Hackbarth, ISIS-X Agena Project Engineer.

Kennedy Space Center:

Dr. Kurt Debus, Director.

Robert H. Gray, Assistant Director for Unmanned Launch Operations.

Joseph Schwartz, Acting Director, WTR Operations Division of KSC.

Goddard Space Flight Center:

Dr. John F. Clark, Acting Director.

Dr. John W. Townsend, Jr., Deputy Director.

Dr. George F. Pieper, Assistant Director for Space Sciences.

John T. Mengel, Assistant Director for Tracking and Data Systems.

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Evart D. Nelsen, ISIS-X Project Manager, Space Sciences Division.

John E. Jackson, ISIS-X Project Scientist, Space Sciences Division.

John L. Donley, DME-A Project Scientist, Space Sciences Division.

Applied Physics Laboratory of Johns Hopkins University:

Dr. Donald R. Bianco, Program Director.

CANADIAN ISIS-X TEAM

The activities of the Canadian team are coordinated by Dr. J. H. Chapman, of DRTE, with C. D. Florida, also of DRTE, as ISIS Program Manager. Dr. Irving Paghis is responsible for the analysis of experimental data at DRTE.

The experimenters are:

(1) Topside sounder	Dr. E.S. Warren and the High Frequency Section, DRTE.
(2) VLF Receiver	Dr. J.S. Belrose, DRTE Dr. R.E. Barrington, DRTE
(3) Cosmic Radio Noise	Dr. T.R. Hartz, DRTE
(4) Energetic Particles	Dr. D.C. Rose, NRC (Canada) Dr. I.B. McDiarmid and the Cosmic Rays and High Energy Particle Physics Section, NRC
(5) Langmuir Probes	Dr. L.H. Brace, NASA/GSFC

Dr. C. A. Franklin is responsible, with his Space Electrical Section team, for the electrical system design in Alouette II while John Mar, with his Space Mechanics Section, is responsible for the mechanical and thermal systems design.

The contractors assisting in the design, construction and launch of Alouette II are RCA Victor, Montreal, and de Havilland Aircraft, Toronto. The RCA Victor project manager is J. M. Stewart, with H. R. Warren, of de Havilland as Deputy Project Manager.

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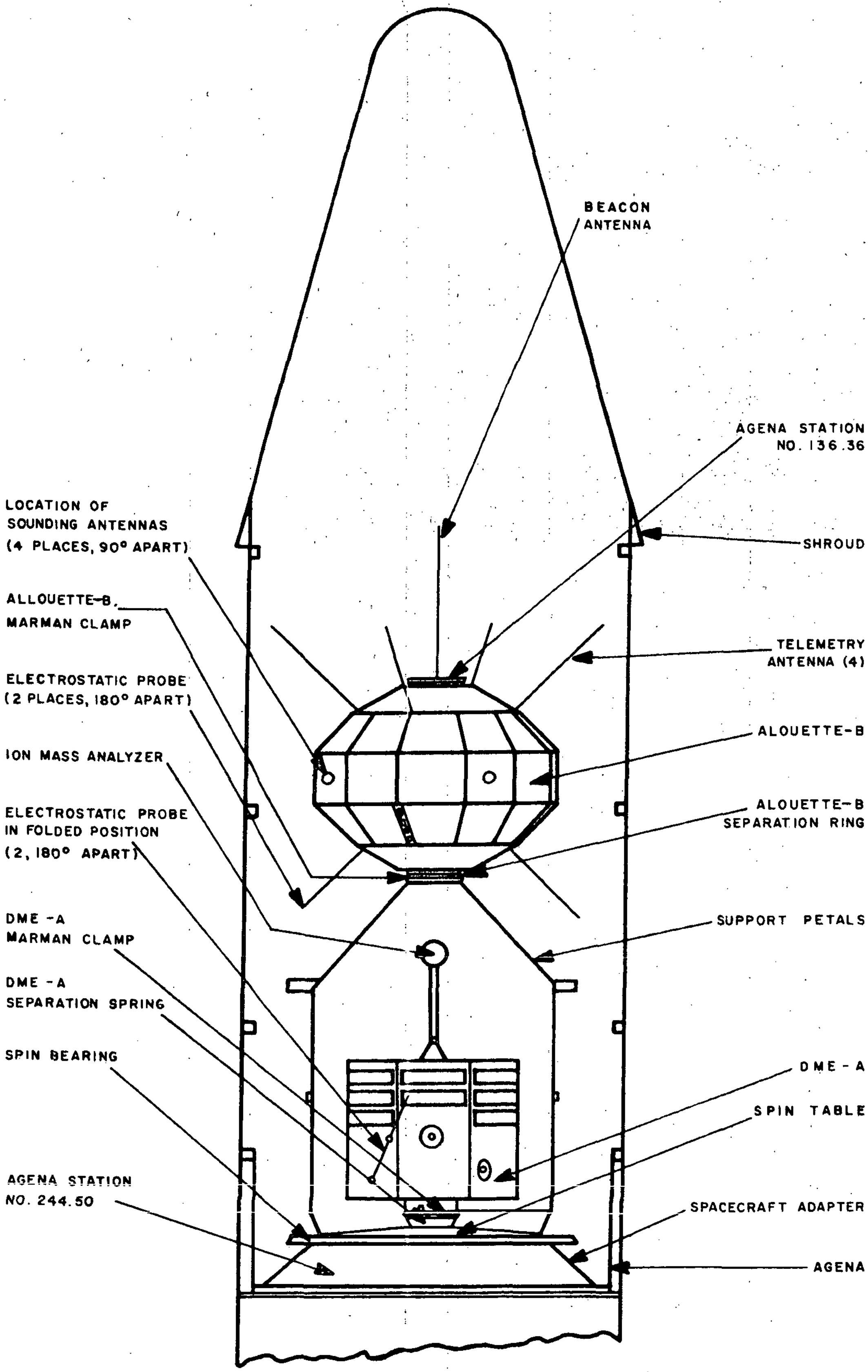
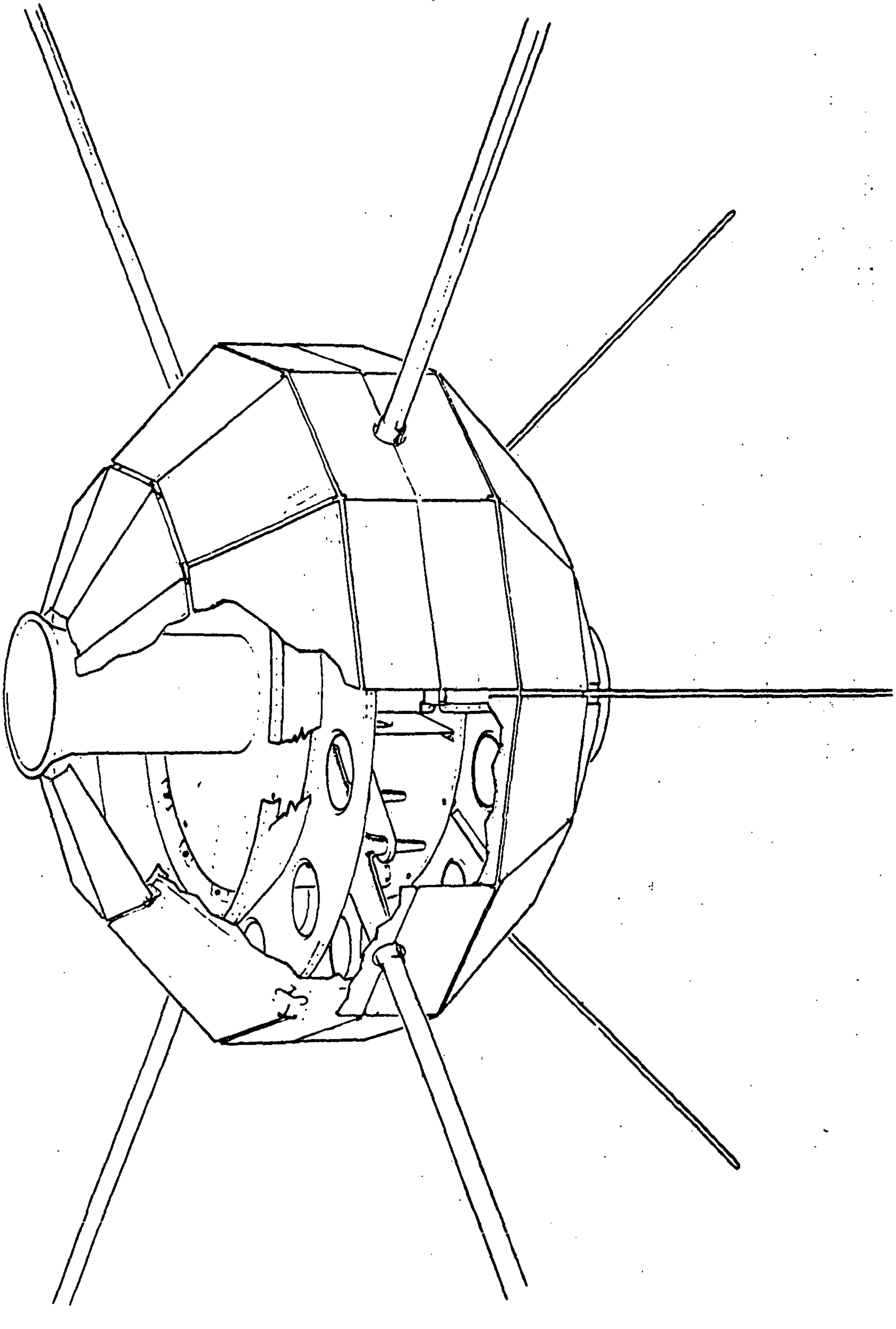
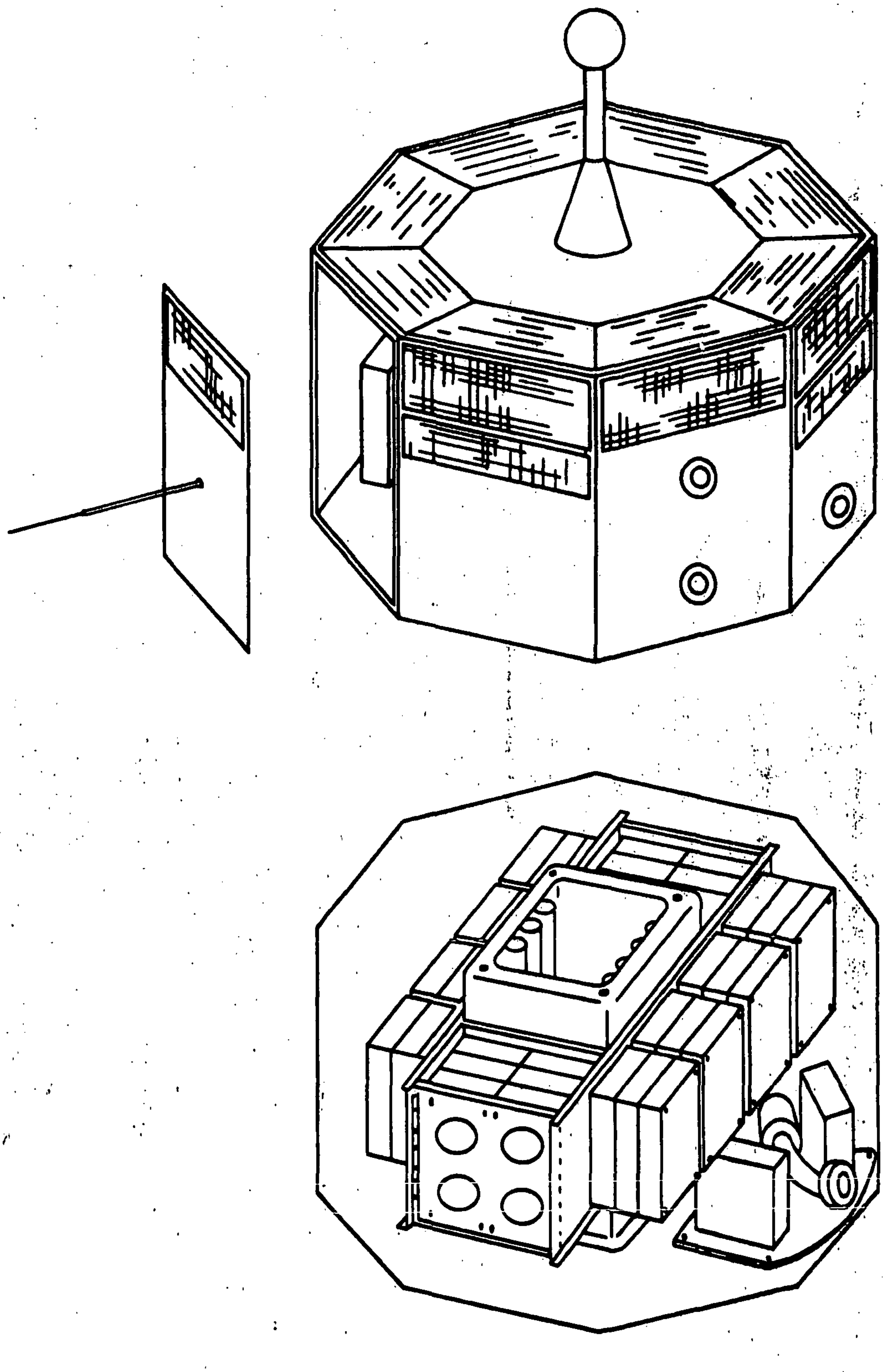

BEACON
ANTENNA
AGENA STATION
NO. 136.36
LOCATION OF
SOUNDING ANTENNAS
(4 PLACES, 90° APART)
SHROUD
ALLOUETTE-B,
MARMAN CLAMP
TELEMETRY
ANTENNA (4)
ELECTROSTATIC PROBE
(2 PLACES, 180° APART)
ALOUETTE-B
ION MASS ANALYZER
ELECTROSTATIC PROBE
IN FOLDED POSITION
(2, 180° APART)
ALOUETTE-B
SEPARATION RING
DME -A
MARMAN CLAMP
SUPPORT PETALS
DME -A
SEPARATION SPRING
SPIN BEARING
DME - A
SPIN TABLE
AGENA STATION
NO. 244.50
SPACECRAFT ADAPTER
AGENA

ISIS-X



Alouette-B Spacecraft (Cutaway View)



Artist's Conception of Final Configuration of the DME-A Spacecraft