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TWENTY-FIRST TRI-ANNUAL ISIS PROGRESS REPORT FOR THE PERIOD 1 NOVEMBER, 1969 TO 28 FEBRUARY, 1970

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TWENTY-FIRST TRI-ANNUAL ISIS PROGRESS REPORT

For The Period

1 November 1969 to 28 February 1970

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Published June 1970

OTTAWA

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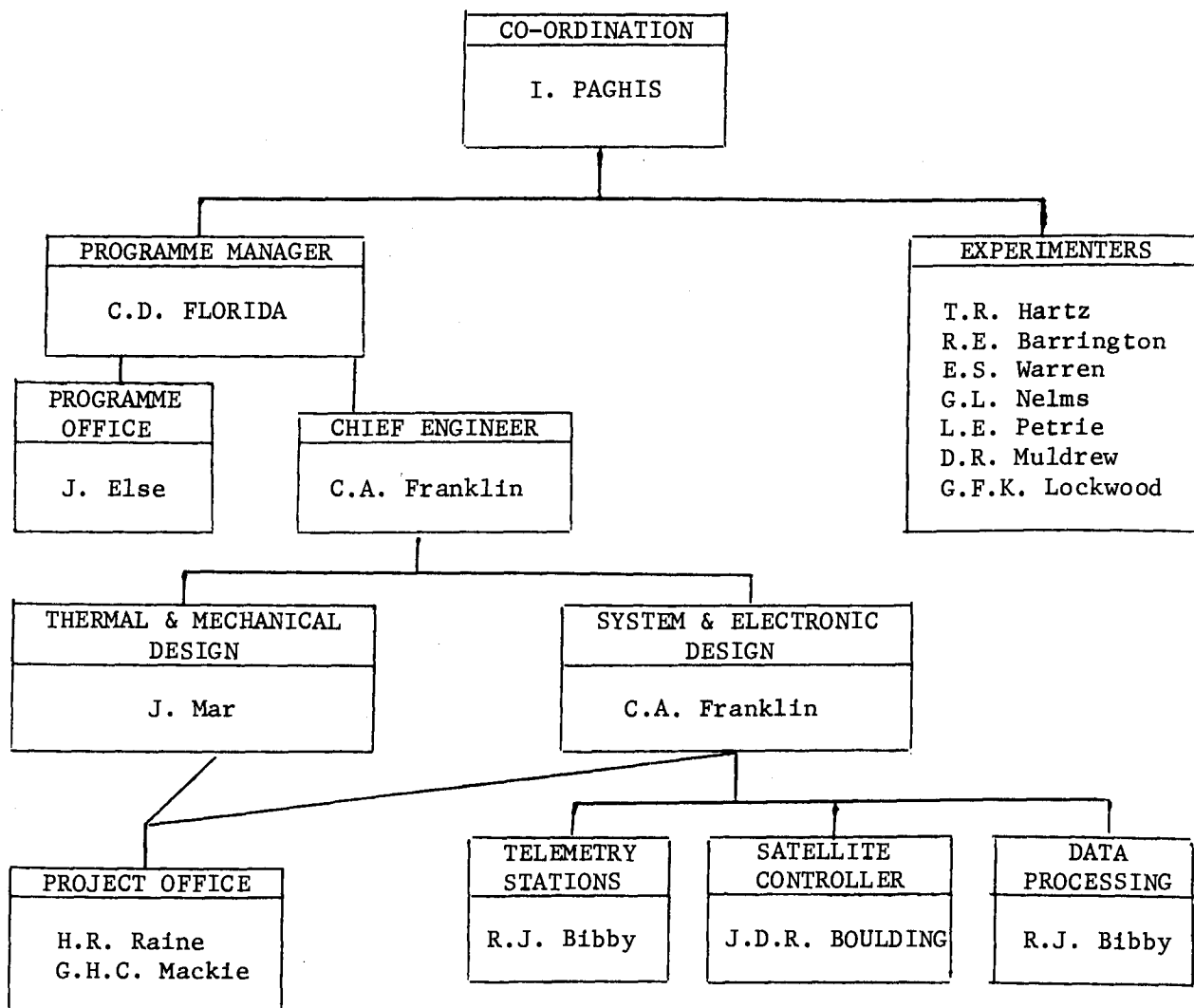
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TWENTY-FIRST TRI-ANNUAL ISIS PROGRESS REPORT

1 November, 1969 to 28 February, 1970

CRC PROGRAMME ORGANIZATION



2. INTRODUCTION AND SUMMARY OF PROGRESS

Due to power system limitations, Alouette I is now being operated in the sounder or VLF mode for about half an hour per day and then, only when in the sun. The battery that has supplied the FM telemetry system since launch was taken out of service at the beginning of December because of low solar cell charging currents. During the last week of January, sounder power amplifier B became inoperative and power amplifier A was switched into permanent service.

Alouette II continues to use the 100 watt sounder power amplifier and was operated between 3-1/4 and 5-1/2 hours per day during the reporting period. Except for a reduction of the spin rate to 1.83 rpm, no other changes in the operation or status of this satellite have been reported.

The ISIS-I daily operating schedule has been 5-1/2 hours in minimum sun and 9 hours in maximum sun. In late January the main clock began to advance by as much as 16 minutes over a 12-hour period. The clock readout became erratic on 13 February and failed completely on 14 February. The back-up clock and programmer was then switched in but failed to operate. Both clock and programmers were drawing nominal power. They were taken out of service on 19 February, leaving the sounder and PCM systems to operate from internal oscillators. As a result of these malfunctions only the 30-minute ATO function is operable. The on-board tape recorder speed and starting problems reappeared in late January coincident with the rise of the tape recorder temperature above 20°C. No use of the tape recorder was made whilst the clock problems were under investigation. With the failure of the clock and programmers, future use of the tape recorder for recording scientific data will be limited.

Integration of all systems and experiments into the ISIS-B prototype spacecraft has been essentially completed, although representative engineering model units have been used in several cases. RFI checks for mutual interference have been carried out and measures to correct anomalies are in work. Power turn on of the flight model spacecraft will be carried out early in the next reporting period. To facilitate initial integration, prototype units will be used in some critical systems. The weight of this model is estimated at 561 lbs. Because of possible operational difficulties arising from clock and programmer failures, similar to those of ISIS-I, the back-up ATO time is under review. A complete reassessment and replanning of the programme schedule has been carried out by CRC and the Contractor. If the revised schedule is maintained, launch of the flight spacecraft will be during the first quarter of 1971.

J. Else.

3. ISIS-I

3.1 Satellite Characteristics

Orbit

Apogee	3522
Perigee	574
Inclination	88.42° prograde
Spin	2.939 rpm
Period	128.3 mins.

Spacecraft Stabilization

Spin stabilized 1 to 3 rev/min.

Spacecraft Attitude Sensing

Six-probe flux-gate magnetometer

Four probes, range -600 to +600 millioersteds: z-y-z orthogonal set, and s probe along spacecraft x direction. Two probes, range -200 to +200 millioersteds: along spacecraft x and z directions.

Digital solar aspect sensor

Two sensors, each with 180° fan field of view; storage register in electronics.

Spin and Attitude Control System

Spin rate change capability 0.1 rpm/orbit.

Spin axis attitude manoeuvring capability 3°/orbit.

Power System

11,136 n-on-p 10-1/4% (A.M.O.) efficiency solar cells will charge 3 Ni-Cd batteries.

Six main system DC to DC converters.

Operational time after 1 year, minimum of 4 hours per day.

Continuous operation: Two consecutive pole-to-pole passes.

Command System

Command

Multiple tone-digital AM AVCO system.

2 receivers operating 148 MHz; 1 redundant.

Decoder capability--216 commands.

Programmer and Clock

Stored commands for remote turn-on execution.

Capability--5 remote turn-on from 10 commands.

Loading time 5 minutes.

Programme monitoring facility (readout time 3 secs.).

Clock output--serial time code BCD format 69 bps, once per second.

Ground correction capability.

Stability and accuracy 1 sec/week.

Automatic Turn-Off

Normal turn-off - after 16 mins.

Special turn-off - after 8 or 24 mins.

Programmed turn-off - after 16 mins.

Back-up - after 30 mins. unconditionally.

Spin and attitude control - 1 +0 and 5 +0 hours, selectable by command.

Tape Recorder

Record Time - 65 mins.

Playback - 4 times record speed.

Data channels - 4.

(a) FM data - sounder output FM bandwidth 1 Hz to 9 KHz.

(b) Ref. Frequency 11.52 KHz + AM Time Code.

(c) Digital data 11,520 bits per sec.

(d) Analog data - VLF output bandwidth 50 - 20,000 Hz.

TelemetryTransmitter No. 1

Frequency	136.080 MHz: bandwidth 100 KHz
Power	4 Watts
Modulation FM	Sounder
PAM/FM	SCO essential housekeeping and clock
FM	VLF

Max. range for 10 dB S/N 3500 miles with 19 dB ground antenna gain,

Transmitter No. 2

Frequency	401.750 MHz: bandwidth 500 KHz
Power	4 Watts
Modulation FM	Sounder
PCM/FM/PM	SCO experimental data and housekeeping
FM	VLF
AM/PM	SCO satellite clock

Max. range for 10 dB S/N 3500 miles with 19 dB ground antenna gain.

Transmitter No. 3

Frequency	136.59 MHz: bandwidth 50 KHz
Power	2 Watts
Modulation PCM/PM	Experimental data and house-keeping

Beacon

Frequency	136.410 MHz
Power	100 mw
Unmodulated	

Experiments(1) Swept Frequency Sounder

Power output	400W at PRF 30/sec. 100W at PRF 30/sec.
Antennas	240' and 61.5' tip-to-tip
Flyback	3 secs.

Frequency Range

(a) Normal Sweep 0.1 to 10 MHz

<u>Frequency Range</u>	<u>Sweep Rate</u>	<u>Time to Cover Frequency Range</u>
0.1 to 2.0 MHz	0.25 MHz/s	7.6 seconds
2.0 to 5.0 MHz	0.75 MHz/s	4.0 seconds
5.0 to 10.0 MHz	1.0 MHz/s	<u>5.0 seconds</u>
	Total time	16.6 seconds

Distance travelled about 75 Km at Apogee
about 125 Km at Perigee
Maximum change of height about 18 Km

(b) Extended Sweep 0.1 to 20 MHz

<u>Frequency Range</u>	<u>Sweep Rate</u>	<u>Time to Cover Frequency Range</u>
0.1 to 2.0 MHz	0.25 MHz/s	7.6 seconds
2.0 to 5.0 MHz	0.75 MHz/s	4.0 seconds
5.0 to 20.0 MHz	1.0 MHz/s	<u>15.0 seconds</u>
	Total time	26.6 seconds

Distance travelled about 120 Km at Apogee
about 200 Km at Perigee
Maximum change of height about 20 Km

(c) Sweep Law - Linear in all ranges.

(d) Frequency Markers
0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 3.0, 4.0, 5.0, 6.0,
7.0, 8.0, 9.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0 MHz.

(2) Fixed Frequency Sounder

The six frequencies selected for the fixed frequency sounder are 0.25, 0.48, 1.0, 1.95, 4.0, and 9.303 MHz.

Sounder Receiver Characteristics

Pre-amp. and filter No. 1, seven bands

(a)	0.1 - 1.0 MHz
(b)	1.0 - 2.0 MHz
(c)	2.0 - 3.0 MHz
(d)	3.0 - 5.0 MHz
(e)	5.0 - 8.0 MHz
(f)	8.0 - 13.0 MHz
(g)	13.0 - 20.0 MHz

Pre-amp. and filter No. 2 wideband 0.1 - 2.0 MHz.

Linear - logarithmic receiver with AGC loop characteristics.

Rise time 60 msec. Fall time 12 msec.

(3) VLF Receiver

0.05 - 30 KHz

Monitored AGC voltage

A VLF swept frequency exciter

Range 500-0-9500 Hz

Sweep rate at 50 Hz is 2 KHz/s

Sweep rate at 9500 Hz is 20 KHz/s

Sweep duration 1 second

Frame period 1.5 seconds

Output automatically sequences through two 20 dB steps.

(4) Energetic Particle Detectors (NRC)

Parallel to satellite axis

Detector G ₁	> 40 KeV Electrons
	>500 KeV Protons
G ₂	> 20 KeV Electrons
	> 0.3 MeV Protons

Perpendicular to spin axis

Detector G ₃	> 40 KeV Electrons
	>500 KeV Protons
G ₄	> 80 KeV Electrons
	>110 KeV Electrons
G ₅	>200 KeV Protons
	>140 KeV Electrons
	200 KeV - 770 KeV Electrons
G ₆	>400 KeV Protons
	> 25 KeV Electrons

Scintillation photomultiplier

S ₁ Current mode	> 8 KeV Electrons
Pulse mode	> 40 KeV Electrons
	> 60 KeV Electrons
Current mode	> 50 KeV Protons
Pulse mode	50 - 70 KeV Protons

Proton detector (not sensitive to electrons)

D ₁	0.15 - 25 MeV
D ₂	0.5 - 4 MeV
D ₃	3.4 - 12 MeV
D ₄	12 - 30 MeV
D _{background}	12.5 - 20 MeV

(5) Soft Particle Spectrometer (Heikkila)

Electrons 10 - 10,000 eV

(6) Ion Mass Spectrometer (Narcisi)

1 - 20 A.M.U.

(7) Cylindrical Electrostatic Probe (Langmuir Probe) (Brace)

Ne and Te

(8) Spherical Electrostatic Analyzer (Spherical Probe) (Sagalyn)

Measures:

- (a) Protons 10 to 6×10^6 particles/cm³
- (b) Thermal ion kinetic temperatures
700 to 4000°K.

- (c) Proton Flux and Energy 0 to 2 KeV
- (d) Potential of satellite to
undisturbed plasma

(9) Beacon (Forsyth)

136.410 MHz, 137.950 MHz, 100 mw beacons

Measures:

- (a) Ionosphere total electron content
- (b) Small-scale variations of
electron content
- (c) Ionic inhomogeneities respons-
ible for amplitude and angular
scintillations

(10) Cosmic Noise Hartz

From AGC of sounder receiver 0.1 to 16 MHz

(11) Antenna Bias

A negative bias may be switched on to both sounder dipole antennas on command; current will be monitored.

Weight Breakdown

Structure	96 lbs.
Experiments	125 lbs.
Telemetry & Command	100 lbs.
Power	150 lbs.
Attitude Sensing & Control	23 lbs.
Cable Harness	38 lbs.
Total	532 lbs.

3.2 Spacecraft and Operations

3.2.1 Electrical Summary

Failures have occurred in the operation first of the tape recorder then in the clock and programmer system. These systems are now completely inoperable.

The primary clock and programmer failure is under investigation. It is suspected that the thin metallization of the "0" pf transistors has failed in some unit whereby causing the failure of a bistable module. The back-up clock and programmer fault is probably due to a metallization microcrack. Both these deficiencies have been noted and remedial action, where possible, has been taken in the ISIS-B design.

Timing functions within ISIS-I have been taken over by internal oscillators in the PCM encoder and in the sounder. The frequency can be expected to vary somewhat as these oscillators are uncompensated LC type.

A.R. Molozzi.

3.2.2 Primary Clock and Programmer

During the last week in January 1970 it was noted that the ISIS-I clock and programmer was gaining time in discrete jumps of 130 msec. Some of these jumps were multiples of 130 msec. This occurred during a period when the satellite was entering a 100% sun cycle. The condition was an intermittent one which persisted for about two weeks. The code output then changed such that every 8th bit was a '1' - all other bits '0'. One day later, the code changes again - all bits became '1'. It was not possible to change this latter state by turning power off and on or by transmitting correct clock commands. So far, chart records of the analog code output have not revealed any one flip-flop (by latching in the '0' or '1' state) which could have caused the series of events related above. Consequently, the possibility of a cracked solder joint cannot be ignored. The unit has been turned off and further attempts will be made to diagnose the problem when the satellite enters 66% sun.

Back-Up Clock

Upon turning the primary unit off, the back-up clock was turned on. Although power consumption and voltage lines indicated nominal values, no outputs were observed from this unit. Since the 23.04 KHz synchronizing outputs were absent, the failure was narrowed down to one of seven flip-flops in the dividing chain from the 23.04 KHz point up to the clock oscillator itself. However, since it is known that the metallization on the flip-flops is of inferior quality (as discussed in previous reports) it seems more reasonable to suspect a flip-flop failure.

N.S. Hitchcock

4. ISIS-B

4.1 Satellite Characteristics

Orbit

1400 Km minimum circular
Inclination - not yet resolved.

Spacecraft Stabilization

Spin stabilized.

Spacecraft Attitude Sensing

Six-probe flux-gate magnetometer

Four probes, range -600 to +600 millioersteds; x-y-z orthogonal set, and s probe along spacecraft x direction. Two probes, range -200 to +200 millioersteds: along spacecraft x and z directions.

Digital solar aspect sensor

Two sensors, each with 180° fan field of view; storage register in electronics.

Spin and Attitude Control System

The system capability is designed to be as follows:

(1) Spin axis in the orbit plane:

- Spin change capability of 0.10 to 0.12 rpm/orbit.
- Attitude control (precession) capability of 2.0 to 2.5° per orbit at a spin rate of 3 rpm.

(2) Spin axis in cartwheel configuration:

- Spin change capability of 0.15 rpm per orbit averaged over one day of operation.
- Precession capability of 0.5° per orbit at spin rate of 3 rpm averaged over one day of operation.

Power System

11,008 n-on-p 10-1/4% (A.M.O.) efficiency solar cells will charge 3 Ni-Cd batteries.

Six main system DC to DC converters.

Operational time after 1 year, minimum of 4 hours per day in 70% sun condition.

Continuous operation: Two consecutive pole-to-pole passes.

Command System

Command

Multiple tone-digital AM AVCO system.

2 receivers operation 148 MHz; 1 redundant.

Decoder capability - 216 commands.

Programmer and Clock

Stored commands for remote turn-on execution.

Capacity - 5 remote turn on from 10 commands.

Loading time 5 mins.

Programmer monitoring facility (readout time 3 secs.).

Clock output - serial time code BCD format 60 bps, once per second.

Ground correction capability.

Stability and accuracy 1 sec/week.

Automatic Turn Off

Normal turn off - after 16 mins.

Special turn off - after 8 or 24 mins.

Programmed turn off - after 16 mins.

Backup - after 30 mins. unconditionally.

Spin and attitude control - 3 +1 and 11 +1 hours, selectable by command.

-0 -0

Tape Recorder

Record time - 64 mins.

Playback - 4 times record speed.

Data channels - 4

(a) FM data - sounder output FM bandwidth 1 Hz to 9 KHz.

(b) Ref. frequency 11.52 KHz + AM time code.

(c) Digital data 11,520 bits per sec.

(d) Analog data - VLF output bandwidth 50 - 20,000 Hz.

TelemetryTransmitter No. 1

Frequency	136.080 MHz: bandwidth 100 KHz
Power	4 watts.
Modulation FM	Sounder
PAM/FM	SCO essential housekeeping & clock.
FM	VLF

Max. range for 10 dB S/N 3500 miles with 19 dB ground antenna gain.

Transmitter No. 2

Frequency	401.75 MHz: bandwidth 500 KHz
Power	4 watts
Modulation FM	Sounder
PCM/FM/PM	SCO experimental data & housekeeping.
FM	VLF
AM/PM	SCO satellite clock.

Max. range for 10 dB S/N 3500 miles with 19 dB ground antenna gain.

Transmitter No. 3

Frequency	136.59 MHz: bandwidth 50 KHz.
Power	2 watts
Modulation PCM/PM	Experimental data and housekeeping.

Tracking Beacon

Frequency	136.410 MHz.
Power	100 mw.
Unmodulated	

Experiments(1) Swept Frequency Sounder

Power Output	400 W at PRF 45/sec.
Antennas	240' and 61.5' tip-to-tip.
Automatic ionogram transmission	

Frequency Range

- (a) Normal sweep 0.1 to 10 MHz. Sweep duration 10 secs.
- (b) Extended sweep 0.1 to 20 MHz. Sweep duration 20 secs.
- (c) Sweep law - linear in all ranges.
- (d) Frequency markers:
 - 0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 3.0, 4.0,
 - 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 12.0, 14.0, 16.0, 18.0,
 - 20.0 MHz.

(2) Fixed Frequency Sounder

The six frequencies selected for the fixed frequency sounder are:
0.25, 0.48, 1.0, 1.95, and 9.303 MHz.

Sounder Receiver Characteristics

Pre-amp. and filter No. 1 seven bands (a) 0.1 - 1.0 MHz
 (b) 1.0 - 2.0 MHz
 (c) 2.0 - 3.0 MHz
 (d) 3.0 - 5.0 MHz
 (e) 5.0 - 8.0 MHz
 (f) 8.0 - 13.0 MHz
 (g) 13.0 - 20.0 MHz

Pre-amp. and filter No. 2 wideband 0.1 - 20.0 MHz.

Linear - logarithmic receiver with AGC loop characteristics.

Rise time 60 msec. Fall time 12 msec.

(3) VLF Experiment

VLF Receiver 0.05 - 39 KHz
 Monitored AGC voltage
 Range 500-0-9500 Hz.

A VLF swept frequency exciter

Antenna impedance measurement

Antenna bias. A D.C. bias can be applied to the antennas by command.

(4) Energetic Particle Detector (I. McDiarmid, J.R. Burrows)

Gieger counters

Parallel to spin axis

G1	>40 KeV electrons
	> 5 MeV protons
G2	>20 KeV electrons
	>.3 MeV protons

Perpendicular to spin axis

G3	>40 KeV electrons
	>.5 MeV protons
G4	>20 KeV electrons
	>.3 MeV protons

Solid-state silicon junction detectors

G5 Energy thresholds of:	80 and 100 KeV electrons
	.2 MeV protons

G6 Energy thresholds of:	120 and 200 KeV electrons
	.4 MeV protons

Proton detectors

D ₁ , D ₂ , D ₃ , and D _B	0.15 - 55 MeV protons
---	-----------------------

Scintillation photomultiplier

Sc Current mode total energy	> 3 KeV electrons
	>20 KeV protons

Sp Pulse mode particles at	40 and at 60 KeV electrons
	50 KeV protons

(5) Soft Particle Spectrometer (W.J. Heikkila)

Electrons	10 - 10,000 eV.
-----------	-----------------

- (6) Ion Mass Spectrometer (J. Hoffman)
Direct measurement of positive ion density mass numbers.
1 - 64 amu.
- (7) Cylindrical Electrostatic Probe (Langmuir Probe) (L. Brace, J. Findlay)
Direct measurement of electron density and electron temperatures
using two Langmuir probes at opposite ends of the spacecraft.
- (8) Ion Temperature (J. Donley, E. Maier)
Direct measurement of electron temperature, ion temperature, ion
composition, and charged particle density by retarding potential
analyzer.
- (9) Beacon (P.A. Forsyth, G.F. Lyon, E.H. Tull)
136.410 MHz, 137.950 MHz, 100 mW beacons.
- (10) Cosmic Noise (T. Hartz)
From AGC of sounder receiver 0.1 to 16 MHz. Monitors background
radio noise levels due to galactic, solar, and ionospheric sources.
- (11) Oxygen Red-Line (6300Å) Photometer (G. Shepherd)
Direct measurement of oxygen red-line emission from aurora and from
night, twilight, and air-glow sources.
- (12) Auroral Scanner (3914Å/5577Å) (C. Anger)
Direct measurement and mapping of intensity of emissions at two
wavelengths.

Weight Breakdown

Structure	100 lbs.
Experiments	148 lbs.
Telemetry & Command	101 lbs.
Power System	148 lbs.
ASC System	25 lbs.
Wiring Harness	39 lbs.
Total	561 lbs.

4.2 Project Office Report

Prototype Spacecraft

Integration of the prototype spacecraft is essentially complete, although in some cases engineering model units have been used as temporary substitutes for a small number of prototype packages which are not yet available.

RFI tests carried out on the integrated spacecraft have revealed some cases of mutual interference. These have either already been corrected or work to eliminate the condition is still in progress.

By the end of the reporting period, it is expected that the packages comprising the sounder system will have been removed from the spacecraft, and work started on thermal vacuum testing of these units as a subsystem.

Flight Spacecraft

The telemetry and beacon antennae have been installed and tested. The power system, with the exception of one converter, is ready for turn on. With the exception of the optical Experimenters' units, there has been a substantial improvement in the delivery dates being projected for delivery of the remaining flight model experiments.

Spacecraft Checkout

The development of the ground support and checkout equipment has progressed to the point where it is now possible to use it for testing a complete spacecraft. The software for automatic checkout is being developed on a continuing basis.

Design Reviews

Design Review meetings were held dealing with the following:

Telemetry System
Sounder and VLF Systems
Attitude Sensing and Control System

Ni-Cd Cells

The assembly of lot #2 cells has been completed. Following a total delay of some 5 weeks, caused by equipment breakdown at the manufacturer's plant, screening tests have begun. It is still too early to judge whether these cells are of flight quality.

Magnetometer

Final design testing of a new magnetometer developed by RCA is still in progress. Test results available to date indicate that the unit will perform as planned, and provision has been made for the construction of two flight models one of which will be installed in the flight spacecraft.

G.H.C. Mackie.

4.3 Spacecraft Operations

4.3.1 Electrical Summary

To preclude the possibility of operational difficulties arising similar to those experienced with ISIS-I, the ISIS-B ATO time is under review. A modification to provide two different times for the back-up ATO facility is under consideration. Measures have also been taken to enhance the reliability of both main and back-up clock and programmers by component screening and evaluation.

Integration of the prototype spacecraft has been completed, using some engineering model units. Telemetry system calibration and total system evaluation are still outstanding on this model. A thorough review of the programme schedule indicates that emphasis should now be placed on flight model integration if a launch in the first quarter of 1971 is to be achieved. This is in planning and a revised schedule should be available early in the next reporting period.

A special procedure has been initiated to process failure analyses of ISIS semiconductors in the CRC Failure Analysis Facility. This involves the active participation of RCA Reliability personnel in the parts evaluation.

A.R. Molozzi.

4.4 Mechanical Design

Structure

A modified upper assembly comprising the 400 MHz antenna mounting and upper cylindrical electrostatic probe was attached to the ISIS-I dynamic model structure and successfully vibrated to protoflight levels at RCAL on 13-18 November, 1969.

Solar Cell Panels

All ISIS-B flight solar cell panels have been delivered by Centralab and accepted by RCAL.

N.A. Harrison.

4.5 Other Satellite Electronics and Experiments

4.5.1 VLF Receiver

The voltage overstress condition (beyond ISIS ratings) of the capacitors C1 and C2 in the output feedback amplifier (model A1A6), which was discussed in the previous progress report, has been resolved by reverting to the original 47 μ f at 35V capacitors and accepting the 0.8 dB degradation in the frequency response at 50 Hz.

The discrepancy, in the shape of the open-loop low-frequency response between the ISIS-B engineering model and the ISIS-I breadboard (BB) model, has been attributed to a combination of measurement errors resulting from external interference due to the exposed spread out construction of the BB receiver and differences in the low frequency response of the various sections of the receiver. Observation of the response curves of the ISIS-I engineering model, which is similar in construction to the ISIS-B receiver, show a low frequency response similar to the ISIS-B results.

For further details on the status of this unit, refer to the RCA contribution to this progress report.

T. Nishizaki.

4.5.2 Converter 6 (Spin and Attitude Control Systems)

Difficulty has been encountered by RCA in reducing the level of the switching transients on the output and input lines of this unit to the specified limits.

Rearrangement of ground leads and power return lines has been tried without significant reduction in switching transient levels. Reduction of the switching speed of the transistor switch in the regulator considerably reduces the switching transient levels between voltage rails and power return line, but no significant improvement was observed between the power return and spacecraft ground. Further work is being conducted at RCA on this matter.

There are no other changes to report on this unit.

T. Nishizaki.

4.5.3 DC to DC Power Converters

Main Clock and Programmer

Back-Up Clock and Programmer

There are no further design changes to report on these units. For details on the progress of the flight units, refer to the RCA contribution to this progress report.

T. Nishizaki.

4.5.4 Sounder Control Unit

The ramp voltage from Unit AH was being distorted by the ramp generator timing capacitor which utilized a ceramic dielectric. The distortion was traced to dielectric absorption in the capacitor, which is similar to hysteresis in ferrous materials. The capacitor has been replaced by a different type which apparently does not show this hysteresis effect to a significant degree. The investigation is recorded in CRC 6663-107-1.

R.J. Bonnycastle.

4.5.5 RCA Magnetometer

The status of the proposed RCA magnetometer was reviewed at a meeting held at RCA, Montreal on the 12th of November, 1969. The review of the electrical design aspect of the magnetometer basically involved the discussion of the points raised in the CRC memorandum 6663-106-3 (NSTL) of October 17, 1969

RCA have considered these points as well as other points raised at the meeting, and appear to have satisfactorily justified or modified the design.

Initial tally of the power consumption for the originally proposed design for the full 6 channels was twice the maximum required value of 1.3 watts. The bulk of this excess power consumption was due to the diode-transistor micrologic (DTuL) flip-flop operating from the +17.3 volt rail via a series regulator which reduced the voltage to the required +5V level. This power requirement has been reduced considerably by replacing the DTuL 931 flip-flops

with the low-power diode transistor micrologic flip-flops (LPDT μ L 9040) with appropriate discrete component buffer circuits to provide adequate drive at the interfaces.

Additional power saving has been achieved by reducing the full-wave phase sensitive detector (PSD) to a half-wave design. This reduces the power consumed in the drive circuitry to the PSD. It also eliminates both the signal input and reference drive transformers to the PSD.

Further testing at RCA revealed an undesirable phase-shift variation in the loop with error signal magnitude. This has been traced to phase-shift in the flux-gate sensor and has been reduced to a satisfactory level by adding a shunt capacitor (0.15 μ f) across the flux-gate sensor signal output winding and by the choice of an optimum drive level to the probe.

A signal breadboard channel with the modifications described above has been bench tested by RCA and found to perform satisfactorily. However, thermal tests and detailed calibration tests have not been conducted on the revised design.

For further information on the progress of the mechanical and electrical layout drawings for the ISIS-B flight magnetometers, refer to the RCA contribution to this progress report.

T. Nishizaki.

4.6 RCA Ltd. Status Report

4.6.1 Management

4.6.1.1 Subcontracts

The coulometers were not delivered as scheduled because of problems which the supplier has been experiencing in the production of both batteries and coulometers. A delivery promise has been received for delivery early in the next reporting period.

4.6.1.2 CPM Planning and Schedule

Monthly CPM runs have been made during this reporting period. A considerable reduction in the negative position of the project has been accomplished. Assembly of all units was completed with the exception of the optical experiments and the newly designed subcarrier oscillators and magnetometers. It now appears that spacecraft qualification testing will start at GSFC in early autumn. The spacecraft batteries and the optical experiments are the more critical units. Detail planning for the qualification phase at GSFC and launch phase is underway.

4.6.1.3 Reliability

- a) A total of three formal design reviews were held during this period.

<u>System</u>	<u>Type of Review</u>
Telemetry (including S/C RF System)	Final
Attitude Sensing and Control	Final
Sounder (including Units AC,AE,AF,AQ)	Final

b) Components

The new assembly techniques which were being tried out for field effect transistors have proved satisfactory and further failures are non-existent. However, after exhaustive failure analysis, the quality of the devices was found to be questionable. A number of failed devices were examined at CRC, and both failed and good devices at NASA/GSFC. It is our opinion that although the devices are not perfect, a wholesale replacement in qualified flight units is not warranted. It is planned to re-measure the gate characteristics of all commutators to detect any degradation in FET leakage.

An investigation is under way to replace the TRW 2N4040/2N4041 transistors in unit BG (400 MHz transmitter) with Motorola 2N5635/2N5636. Results so far look very promising.

Two long delivery items (diodes and transistors) were purchased from a distributor, and put through a complete screening sequence at Radix, with excellent results and at a considerable saving of time and money. If necessary, this procedure will be used again.

A new procedure has been instituted for preliminary failure analysis of components at CRC. The analysis will be performed by RCA personnel, under supervision and guidance by CRC's FAF staff, thus ensuring quick turn-around.

c) One clock oscillator has failed and it was returned to the supplier for repair. Major workmanship faults were found. The second unit will be returned for examination when the first becomes available.

d) Following the failure of one solar aspect sensor and the discovery of substandard workmanship on the two prototype sensors, the two sensor electronics units, four sensors, and eight pippers were taken to the supplier for examination. The four sensors and four of the eight pippers were found unacceptable, and will be reworked and retested in March 1970.

4.6.1.4 Quality Assurance

During the reporting period a training course was conducted by Q.A.E. in January 1970, and as a result 4 persons were certified to NASA Category III operators. This includes ISIS"B" Quality Control personnel and a member of Quality Assurance Engineering.

Material Review Boards were attended and dispositions made for 45 items on incoming inspection, 10 items on metal fabrication, and 10 items on assembly. Quality Assurance Engineering carried out follow-up action on most of the non-conformities.

Six Quality Control Notices were issued covering various aspects of quality improvement for incoming inspection, manufacturing and assembly area, engineering laboratory, and the integration area.

Malfunction Review Boards were attended and 55 malfunction reports were closed out. All check lists pertaining to the spacecraft integration stage were updated and completed.

During the reporting period problems were encountered on the quality of purchased printed circuit boards. Subsequent discussions of the problems with the vendor have resulted in better quality boards. Procurement specification 1816540 has been revised to reflect these changes.

The problems experienced on the soldering of Johanson capacitors have continued. New heat control techniques are being investigated.

4.6.1.5 Project Engineering

a) Draft copies of a document containing flow charts and explanatory text which together define the requirements of the Autocheck Program were given to the computer programmers. Design of the Autocheck Program executive routines and of the step instruction technique is in progress.

Preparation of the Autocheck Manual which will contain the detailed step instructions has also begun.

b) To aid in the planning of the individual autocheck steps, questionnaires were made up and distributed to the various system specialists and to the Experimenters. The test steps recommended in the replies have been used as the basis of many of the spacecraft integration tests involving the experiments.

c) System changes and/or spacecraft wiring changes arising from unit changes, design reviews, or from investigation of integration problems have included the following:

- addition of wiring to accommodate the modified AGC circuit of the sounder receiver;
- additions and revisions to suit the changes in the Experiment Selector, Unit BY;
- incorporation of 148 MHz traps in both 136 MHz transmitter output lines;
- changes of the routing of the -15V supply to Unit AC;
- addition of the "Spacecraft Separation" flag to one of the analog sub-commutator channels;
- addition of a "Replay Mode" flag to one of the digital sub-comm. channels;
- revision of connections of the 11,520 pps sync signals to the SPS, IMS and EPD experiments to overcome a potential interference problem in the event of FET failure in one of the PCM encoders;
- addition of a wire to the spacecraft test connector to disable the darkness inhibit circuit of the ASCS during testing;
- addition of wiring to the spacecraft test connector to provide hard wire monitors of the Command Receiver AGC levels when all telemetry is off.

4.6.2 Spacecraft Activities

4.6.2.1 Prototype Spacecraft Integration

During this period integration has been completed on the Sounder and VLF systems and they are now ready for calibration. Modifications to the Sounder Control had not been completed to allow a checkout of the AIT mode. The Clock and Programmer was also integrated successfully. Prototype models of the Cylindrical Electrostatic Probe, Soft Particle Spectrometer, Ion Mass Spectrometer, and Retarding Potential Analyzer, along with engineering models of the Energetic Particle Detector, Red Line Photometer and Auroral Scanner were installed and tested. All problems encountered during the integration of the experiments have been resolved except for interference between the VLF and Auroral Scanner data on the FM telemetry link. Mutual interference of VHF-UHF radiation tests were performed on the complete spacecraft.

4.6.2.2 Flight Spacecraft Integration

Preliminary matching and tuning of the VHF and UHF antenna systems has been completed. Command, Power and Telemetry units have been installed in preparation for the initial turn-on.

4.6.2.3 Electrical Equipment Engineering

a) Power System

All units are qualified and available with the exception of two converter units which are in the final phase of qualification testing, and the flight batteries. Production problems have been encountered and delivery of flight quality batteries is now scheduled for April.

b) Attitude Sensing and Control System

Prototype units JC (converter) and JD (Spin and Attitude Control unit) have been tested and successfully integrated on the prototype spacecraft. They require some minor circuit changes before final flight qualification is attempted.

Flight units JC and JD have been assembled and are presently undergoing preliminary testing.

All other prototype units are available. Some rework is being done to the Solar Aspect Sensors and the Solar Gate units (pipers) by the supplier to rectify substandard workmanship.

All other ASC system units are available.

c) Telemetry System

All prototype units are available with the exception of the 400 MHz transmitter (BG) which requires circuit changes to move the 93 KHz SCO outside the unit (it will be a separate unit in ISIS "B") and replacement of the 2N4040/2N4041 transistors. See Reliability Report section 1.3.

The unit is being used in its present state for integration work.

All flight units are either available or in final qualification test with the exception of unit BG which is awaiting new transistors for completion of assembly, and subcarrier oscillator units.

The multivibrator type subcarrier oscillator units were considered unreliable after a detailed analysis. A new design has been completed, based on a voltage controlled integrator. The prototype unit is 90% complete and flight unit production is underway. Breadboard tests have shown that the new SCO meets all specifications and should prove to be a more reliable unit. In the meantime integration has proceeded using the ISIS"A" units.

d) Command System

All prototype units are available and have been successfully integrated.

Flight units CC and CF (Main Clock and Back-Up Clock) have been delayed because of an oscillator failure. The oscillators have been returned to the manufacturer for rework and the present schedule indicates that the clocks will be qualified by May 2, 1970.

All other units are available.

e) Sounder System

Prototype sounder units have been installed on the spacecraft and checked out. They will be removed early in the next reporting period for minor modifications and calibration. A full complement of matched units will be available by mid-April 1970.

The flight units are in final stages of completion and they are expected to be qualified and calibrated as a system by mid-May 1970.

f) VLF System

Both VLF receivers have been assembled and qualification and calibration is underway with expected completion date in March 1970.

b) Optical Experiments

The engineering model units have been integrated in the prototype spacecraft. RFI problems have been encountered with the Red Line Photometer. The experiment is susceptible to VHF frequencies and it was also noted that operation of the experiment light protection circuit causes spurious commands in the spacecraft. These incompatibilities are being investigated and the required changes will be incorporated in the flight units.

The Auroral Scanner experiment appeared to work without RFI problems, however close examination of the data was not possible because of GSE problems.

The assembly of the flight units is complete up to shortages, the last of which is expected by March 1970 which will make electronic units available in April.

The optical systems are being fabricated by a local machine shop and the final finishing and optical alignment will be done by the Space Engineering Division of the University of Saskatchewan.

The individual Experimenters will have the responsibility of flight qualification and calibration of the experiments.

4.6.3 Ground Support System

4.6.3.1 Main GSE

All equipment has been installed in the racks and checkout tests on the integrated system have been carried out. The DIVCON display has been tested for adequate display refresh rate and found to perform satisfactorily. The display has also been examined critically by CRC and the monitors modified as a result.

The completed GSE has been moved into the spacecraft integration area where it is being used by the integration crew and programmers.

Wiring lists are being prepared for each rack and a wiring diagram (Drawing 2513736) when released will show the interrack wiring. A drawing will be produced to show the patch connections required to complete the signal path from spacecraft to the desired GSE terminal.

4.6.3.2 Auxiliary GSE

The auxiliary GSE continues to be used by the integration crew, though failure of the chart recorder and shortcomings of the portable command transmitter has curtailed its usefulness. Parts required for the chart recorder are on order.

4.6.3.3 Off-Line Computer

The off-line PDP-8 computer has been in operation approximately 8 hours/day in the preparation of software for ACE and has operated satisfactorily.

4.6.3.4 Software

All effort available has been concentrated on completing the new ACE system tape for ISIS "B". All the programs have been coded and debugged. A further week of work on the completed system tape is expected. Work is proceeding on the support documents for the finished programs.

General planning of the programs and step instruction format for AUTOCHECK has begun. Programming effort will be transferred gradually from ACE to AUTOCHECK within the period to March 6.

4.6.4 Mechanical Equipment Engineering

4.6.4.1 Prototype Spacecraft Integration

Unit integration and fit checks continue to be performed as the units become available, with approximately 95% of flight electronic boxes now

integrated. A minor problem of interference between the Ion Mass Spectrometer box and the terminal block mounted on Rib C was solved by redesign and manufacture of the mounting brackets.

Problems with installation of the upper RFI shield were experienced owing to an increased height of the engineering model VLF exciter Driver over that of the ISIS-I unit. The prototype and flight units have a cover which increases the height a further 0.3". The prototype RFI shield has been modified by cutting it in half and providing doubler and nut plates for joining the halves after location in the thrust tube. The upper shield will be installed with the concave side towards the bottom of the spacecraft.

Three threaded holes have been added to the equatorial panel of sector 4 for installation of a protective cover for the IMS experiment.

A velostat dust cover has been manufactured and is being evaluated. A similar cover will be made for the flight spacecraft.

4.6.4.2 Flight Spacecraft Integration

Unit integration and fit checks are proceeding as units become available. No problems unique to the flight spacecraft have occurred.

Modification of the auxiliary heatshield is now complete for both spacecraft. Repolishing and aluminum depositing will be done early in the next reporting period.

4.6.4.3 Mechanical System

The current weight estimate for the spacecraft is 561 pounds made up of 336 pounds actual, 105 pounds estimated and 120 pounds based upon measured unit weights combined with estimated encapsulant weights. The moment of inertia is 1.056.

The reinforcing structure of the auxiliary heatshields was redesigned and the heatshields modified accordingly. A tie down design for the support of the upper CEP to the 400 MHz antenna support was designed and fabricated. The heatshield assembly, 400 MHz antenna, beacon antenna and the CEP were installed on the dynamic model spacecraft and the whole subjected to a three axis random and sinusoidal vibration test at qualification levels and flight level duration. This test is reported in a test report issued on 26 November, 1969. The redesign proved satisfactory with no damage sustained during the test.

J.L. McNally.

5. SATELLITE CONTROL

5.1 General

During this reporting period satellite orbital computer programs have been converted from the CDC 3200 computer to the new CRC Sigma 7 computer. Some converted programs have been in use since early December but most of these were done quickly and require refining as time becomes available. This work, and the development of new programs, will continue into the next reporting period.

Schedule deletions due to conflicts at the STADAN stations continue to disrupt the data acquisition schedules of the three satellites. These disruptions have not been too serious during the reporting period because lower satellite operating capacity and greater use of the non-STADAN stations, has enabled a decrease in this programme's need of STADAN station time.

Kashima, Japan, started to acquire ISIS-I data, on a trial basis, on 19 January, 1970. Very little unique Alouette II data was recorded at Ahmedabad, India, due to a shortage of magnetic tapes.

5.2 Alouette I

Because of power system limitations, Alouette I is now operating in the sounder or VLF mode for about 1/2 hour per day, but only while in the sun. This is a decrease from the 1.2 hours per day last reported.

The battery which has supplied the FM telemetry system since launch was taken out of service at the beginning of December. There are now 3 out of the total of 6 batteries that can no longer be used. Low solar cell charging currents result in inefficient charging.

The re-arrangement of batteries has made it necessary to revise the commonly used turn ON commands to avoid the command desensitization problems at low temperatures.

During the last week of January, sounder power amplifier B was observed to be drawing excess power and that no echoes appeared on the ionograms. Power amplifier A was switched into permanent service on 31 January.

5.3 Alouette II

Alouette II continued to operate between 3.2 and 5.5 hours per day during this reporting period. The spin rate is now 1.83 rpm. The 100 watt power amplifier continues to be used in the sounder system. There were many cases of spurious commands being received in January. There have been no other changes in the operation or status of Alouette II during this period.

5.4 ISIS-I

ISIS-I operated between 5-1/2 and 9 hours per day during this reporting period.

Beginning 27 January, the main clock has been observed to advance as much as 16 extra minutes in a 12 hour period. This problem continues to some degree and is currently under investigation. Preliminary results of this investigation indicate that the pulse of the 1 pps clock output appears 0.133 or 0.266 seconds early resulting in clock advances of these durations and incomplete sub-frames of PCM data at these times. All occurrences of clock advancement detected to date seem to be a multiple of 0.133 seconds.

The main clock readout became erratic on 13 February and failed completely on 14 February. The oscillator and dividing logic down to 23 KHz remains operative and power consumption appears to be nominal.

The back-up clock was switched in on 14 February but no signal was present on any of the output lines. Power consumption appears to be nominal.

All clocks were taken out of service on 19 February. The sounder and PCM systems are now operating independently from their own oscillators. The PCM bit rate is about 11,400 bps. The only ATO unit remaining in operation is the 30 minute back-up ATO.

There were no on-board tape recorder abnormalities observed during November, December and the early part of January. One hour of data per day was stored during this period. In late January the playback problems, of erratic speed fluctuations and difficulty in starting tape motion, reappeared. This recurrence coincided with a tape recorder temperature rise to above 20°C. The tape recorder was not used during February while investigating the clock problems and because of the extreme difficulties encountered in the playback mode. Because of the loss of clock data, future use of the on-board tape recorder for recording scientific data will be limited.

The fixed-frequency sounding period remains at about 3 seconds. No corrections were applied during this period.

The Soft Particle Spectrometer developed a high voltage problem on 26 October. This problem made the proton detector inoperative and has seriously affected the electron detector. This experiment was turned ON for one minute on each Ottawa and Tromso pass during November and December. In January and February the turn ON's by Ottawa were timed to collect SPS electron data of special interest. The number of SPS turn ON's was cut back in February while investigating the clock problem.

There has been no change in the status of the Ion Mass Spectrometer experiment.

During most of this reporting period the antenna bias has been switched ON during two Ouagadougou sounder passes per week and one Ottawa mixed-mode pass per week.

J.D.R. Boulding.

6. DATA PROCESSING

6.1 Production

The production activities of the Data Processing Centre together with related information is summarized as follows:

a) ISIS-I

Film footage of ionograms produced for World Data Centre	19,300
Number of telemetry mag. tapes processed	1,951
Current backlog of mag. tapes	2,030
Processing of "dump" tapes is still under suspension pending successful tape playback speed correction.	

Current backlog of dump mag. tapes is 446

b) Alouette I

Ionogram film footage produced for
World Data Centre 12,200

Number of telemetry mag. tapes processed 586

Number of telemetry mag. tapes backlogged 269

Processing of Alouette I tapes was re-started October 15 after rebuilding of an ionogram processor was completed when a new sweep, range marker, and sync separation circuitry cards were installed.

c) Alouette II

Ionogram film footage produced for
World Data Centre 16,100

Number of telemetry mag. tapes processed 1,482

Number of telemetry mag. tapes backlogged 2,413

Number of mag. tapes compacted (Brace probe) 1,381

Number of mag. tapes for Brace probe
backlogged 10,975

Processing of ISIS and Alouette II on the Engineering Model Production Unit has been shared in a manner that permits continuous processing of either satellite's data for a period not less than two days. This procedure tends to minimize set-up error.

d) Number non-routine mag. tapes processed
(ionogram, strip charts, housekeeping, etc.) 900

6.2 Development

a) The first of two new ionogram production units was debugged during January and is now in semi-routine operation for performance evaluation.

The second of these new units should be placed in operation near April 1, 1970.

b) The speed compensation circuitry for the processing of dump tapes is under development but considerable difficulty has been experienced due mainly to (i) large degree of speed variation encountered (-15% to +5% of nominal), (ii) a large wow and flutter component.

Work is underway to overcome or bypass these problems.

c) The method of presenting "cosnograms" (ionograms bearing cosmic noise information superimposed on the higher range marker grid) has been approved in principle, and the initial circuitry design has been completed.

Evaluations are being held prior to incorporation of the circuitry in the new units.

d) The present test tapes have only range calibration data and should be made more versatile prior to general distribution. It was therefore considered prudent to withhold test tapes until more experience was logged with the production unit, so that a new tape could be made up with much greater flexibility for the testing and appraisal of sync circuits, range markers, "cosnogram" levels, and noise signal interference rejection, optical focus, exposure levels, etc.

D.P. Henderson.

7. TELEMETRY STATIONS

No change since previous report.

W.S. Campbell.

8. QUALITY ASSURANCE

During this reporting period, malfunctions reached a total of 212. To date, 74 of these have been closed.

Two outstanding device problems presently exist:

- a) Union Carbide junction field effect transistors (FETS)
- b) TRW 2N4040 and its proposed substitute Motorola 2N5636

Reasons for the FET failures, which were summarized in the preceding 20th Tri-Annual Report, are described in CRC "Failure Analysis Report on Union Carbide Junction Field Effect Transistors", by W. Leus and D.V. Sulway, 1 December, 1969. Further to this work, NASA-GSFC on behalf of RCA Ltd. examined 6 unused and 6 failed FET's. The results of GSFC examinations (RCA Ltd. Memorandum ISIS-B file 2110-2, R. Lubelsky to J. McNally, "Evaluation of FET's", dated 27 January 1970) confirm that the apparent cause of most of the FET failures has been localized breakdown, possibly from static discharge; but at this time is has not been conclusively proven. Another cause of FET failures has been due to a silicon particle bridging from source to drain which could act as a parallel leakage path.

Three TRW 2N4040 power transistors have been demonstrated by RCA Ltd. to be the direct cause of the 1/2 watt power loss at -20°C in the ISIS 400 MHz transmitter. The 2N4040 anomaly was being investigated by CRC Failure Analysis Facility, but it will now be preceded by the visual examination of an RCA Ltd. proposed alternative transistor Motorola 2N5636.

An initial investigation of Coulometer #21 that failed after 2500 hours of life testing, has indicated burned Kel. F. cover insulator, teflon top insulator, polypropylene separator and cellophane separator materials. The damage caused by excessive heat resulting from poor heliarc welding of the coulometer top cover plate.

Two flight items supplied by NASA-GSFC have failed tests at RCA Ltd. They are:

- a) Arvin Clock Oscillator Serial #909E02
- b) Adcole Aspect Sensor Serial #101

NASA-GSFC reported that the clock oscillator failure symptoms were: an intermittent output, a 10-cycle increase in frequency, and a current of 1.6 mA flowing into the +5 volt line. Removal of the sealed oscillator cover at the manufacturer's plant revealed poorly soldered connections where "select on test" parts had been installed.

On opening Aspect Sensor JJ #101, a wire was found broken close to a soldered connection, however, further examination of this sensor and Aspect Sensor JJ #102 clearly indicated unacceptable soldering and inferior workmanship. On returning Aspect Sensors JJ #101, 102, 105 and 106 and Aspect Sensor Electronics JK #101, 103 to the manufacturer, the following was decided by NASA-GSFC:

- a) Adcole will completely rebuild sensors JJ #101 and 102.
- b) Adcole will rework sensors JJ #105 and 106.
- c) No rework will be necessary on sensor electronics JK #101 and 103.

In addition to the Aspect Sensor work, the manufacturer will also rework some soldered connections on the Solar Pippers purchased by RCA Ltd.

J.E. Tennuci.

9. PROJECT SUPPORT

9.1 ISIS Planning and Scheduling

9.1.1 RCA Ltd. Status

Preliminary integration of the prototype spacecraft has now been completed. Representative engineering units of some experiments were used as substitutes for unavailable prototype units.

Integration of the flight spacecraft is underway and initial power turn-on is expected early in the next reporting period.

Monthly CPM runs have been made during this period with the optical experiments appearing as the most critical units.

9.1.2 CRC Status

The overall schedule of the flight spacecraft has been reviewed by CRC and the Contractor and now indicates the start of qualification testing at GSFC early in the last quarter of 1970, and a launch date during the first quarter of 1971. To accomplish this objective some prototype units will be used during initial integration and be replaced with flight units as they become available.

J.A. Moffatt.

10. SUPPORTING RESEARCH AND DEVELOPMENT

10.1 Computer-Aided Design

At the end of December the schematic-drawing program was interfaced to an ac analysis program so that circuit analysis with interactive graphical input was made possible. Since that time a number of improvements have been made so that the system now has the following characteristics:

Maximum circuit size	20 electrical nodes and 50 branches
Circuit elements	R, L, C, independent E, dependent and independent I
Analysis outputs	Node voltages or branch currents up to a maximum of 3, output on teletype identified by element name
Permanent Storage	Input and output of data-structures to paper tape
Hard copy	The circuit schematic is drawn by an XY recorder

Originally the analysis program used a matrix inversion process. This has now been replaced by the ac analysis routine from ECAP which reduces the circuit equations somewhat faster. A considerable improvement will be obtained when analysis is carried out by the SIGMA 7. This is presently held up awaiting delivery of parts for the SIGMA 7 end of the communication link. Magnetic tape file storage of circuit schematics will be available soon and time-domain analysis and graphical output are being worked on.

ECAP is now available on the SIGMA 7 in the batch mode. The limited memory available in the batch partition has made it necessary to overlay parts of the transient analysis section so that running times are longer than they could be. Some restriction of allowable circuit size would alleviate this and this solution is being considered.

An improved transistor test jig has been devised for the automated test facility. This has more predictable and stable parasitic elements and a satisfactory equivalent circuit has been obtained. Assembly of the facility is proceeding.

Circuits schematics drawn on the CRT can now be stored in digital form on magnetic tape. The stored data can be displayed on the CRT or in hard copy form at the Graphics Terminal. Modifications to schematics can be rapidly made by means of the CRT and light pen and the revised data can then be returned to tape storage.

Various methods of displaying computed network variables, such as mesh currents and node voltages are being investigated. Data at present is generated in numerical form and must be manually converted into graphical form.

Preliminary studies have started on the design of a low cost Graphics Terminal. This work will be carried out in cooperation with the CRC Computing Centre.

C.A. Franklin.

10.2 Low Conversion Loss Mixers

A new LO transformer designed specifically for low interwinding capacitance was wound in an attempt to reduce the conversion loss of the mixer system with a resistive source. The conversion loss of the resulting system was measured with and without the input lowpass filtered over the input frequency range 1 to 15 MHz. It was found that the system actually had less conversion loss without the input lowpass filtered and that this conversion loss was less than the predicted minimum for such a system. Also, it was found that the conversion loss increased rapidly for large LO levels. It was therefore decided to attempt to determine the cause of the anomalous behaviour.

The conversion loss performance of the mixer using various diodes (IN4307, IN3600, IN916A, HPA2374) was measured. Included was a Schotky barrier diode quad (HPA2374) in order to observe the effect of the minimization of diode charge storage. Also, in order to eliminate as far as possible all frequency dependencies, the output transforming circuit was replaced by a centre tapped resistance. The performance of the mixer in these various cases was very similar to that described earlier. It was then thought that the anomalous behaviour might be caused by varactor effects occurring in the diodes. Therefore, the diodes were replaced by VAT73ET varactor diodes. The mixer then actually exhibited a conversion gain (up to +6 dB) indicating that some of the LO power was being converted to the IF (i.e., parametric gain). Experimentation was terminated at this time.

A rough draft of the report on low conversion loss mixer systems has been completed and the report is forthcoming.

R.J.P. Douville.

10.3 The Soft Electron Spectrometer (SES) Rocket Experiment

In October the SES electronic package from the NRC rocket ABD-VB-24 was returned to CRC for thermal vacuum tests. These tests were considered necessary since the cause of the high voltage failure during the previous flight (ABD-VG-23) could not be conclusively established from the flight records. Some correlation has been observed between variations in the HT monitor and abnormal operations of some monostable circuits that were electrically isolated from the high voltage circuit. The irregular triggering of these monostable circuits suggested that large transients, characteristic of high voltage arcing had occurred. This type of arcing was thought more likely to occur in the high voltage circuit wiring than in the electron multiplier assembly.

The flight package for VB-24 was tested for a week in thermal vacuum with the chamber temperature varied from +10 to +35°C and pressure from 10^{-4} to 10^{-8} torr. Long periods of thermal cycling and vacuum soaking were utilized with the intent of reducing any pockets of trapped gases to critical breakdown pressures. The package was switched on periodically to check the high voltage performance. On the sixth day of tests, after the package had been in continuous operation for 20 minutes with a chamber pressure of $<10^{-4}$ torr and a package temperature of +35°C, the first indication of high voltage breakdown occurred. Initially the breakdown would only occur under high vacuum and not at atmospheric pressure, suggesting a trapped gas problem. Before the breakdown point could be located, the HV converter transformer failed. Both the transformer

and a suspect connector on the high voltage cable were replaced. Voids were found in the potting material of both of the original parts. The new parts were vacuum encapsulated and tested for approximately another week under vacuum with no further indication of high voltage failure.

Dynodes for the VB-24 SES detector were reactivated 17 November. The detector was assembled, calibrated, and sent along with its electronic package to the Churchill Research Range (CRR), 25 November. The package and associated rocket has been on standby for a type A aurora since 1 December. The project scientist has indicated that the dynodes have been stored under a good vacuum at CRR since their arrival and therefore will not be replaced before 1 March.

Further tests on the two new deflection plate assemblies have confirmed that they provide a significant improvement in low energy operation over the previous ones, allowing detection of 20 electron-volt electrons with a comparatively stable deflection factor. Detailed mechanical drawings and resolution calibration measurements have been completed for the new deflection assemblies.

Documentation of test data and circuit specifications for the last four spectrometers has been completed. CRC support for the project will cease 28 February, 1970.

G.T. Bird.

10.4 Device Failure Analysis

The following devices were examined for the ISIS programme:

- i) Motorola MC1709 Operational Amplifier. Two specimens examined, formal report issued. On one device, a loose particle caused an excessive base current to flow in an input transistor. On the second specimen, "spots" were seen in the oxide, similar to those reported in the NASA Alert.
- ii) Motorola 2N2222A Transistor. Severe electrical overload had damaged the metallization and fused one of the bonds.
- iii) Motorola 2N3251A Transistor. Severe electrical overload caused one of the bonds to fuse and short to the can.
- iv) Fairchild DTL 946 Logic Circuit. Two specimens examined. Both had been overloaded causing the metallization to go open circuit.
- v) Fairchild DTL 932 Logic Circuit. Device had been overloaded causing one of the bonds to fuse.
- vi) 2N4040 R.F. Power Transistor. This device had a power loss after temperature cycling. An SEM examination did not give any indication as to the cause of failure.

vii) Motorola 2N5636 R.F. Power Transistor. This was intended as a replacement for the 2N4040. Commercial items were procured and examined for possible failure mechanisms. Various faults were reported. However, the quality of the 2 specimens examined does not necessarily reflect the quality of the devices obtained from a high-reliability line.

C.A. Franklin.

11. DISTRIBUTION

Library -----	15
DSIS/DOC. File/Reference File -----	2
ADM(R) DOC -----	1
B.A. Walker DOC -----	1
TLO/DREO -----	1
DG/DDG, CRC -----	1
AD/NRPL -----	1
D/NCL -----	1
D/NSTL -----	1
CDRS(W) -----	1
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