Communications Research Centre

NINETEENTH TRI-ANNUAL
ISIS PROGRESS REPORT
FOR THE PERIOD
1 MARCH TO 30 JUNE, 1969

DEPARTMENT OF COMMUNICATIONS, CANADA

CRC TECHNICAL NOTE NO. 625

OTTAWA

NOVEMBER 1969

COMMUNICATIONS RESEARCH CENTRE

DEPARTMENT OF COMMUNICATIONS
CANADA

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(National Space Telecommunications Laboratory)

Published November 1969
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69-302

C O N T E N T S

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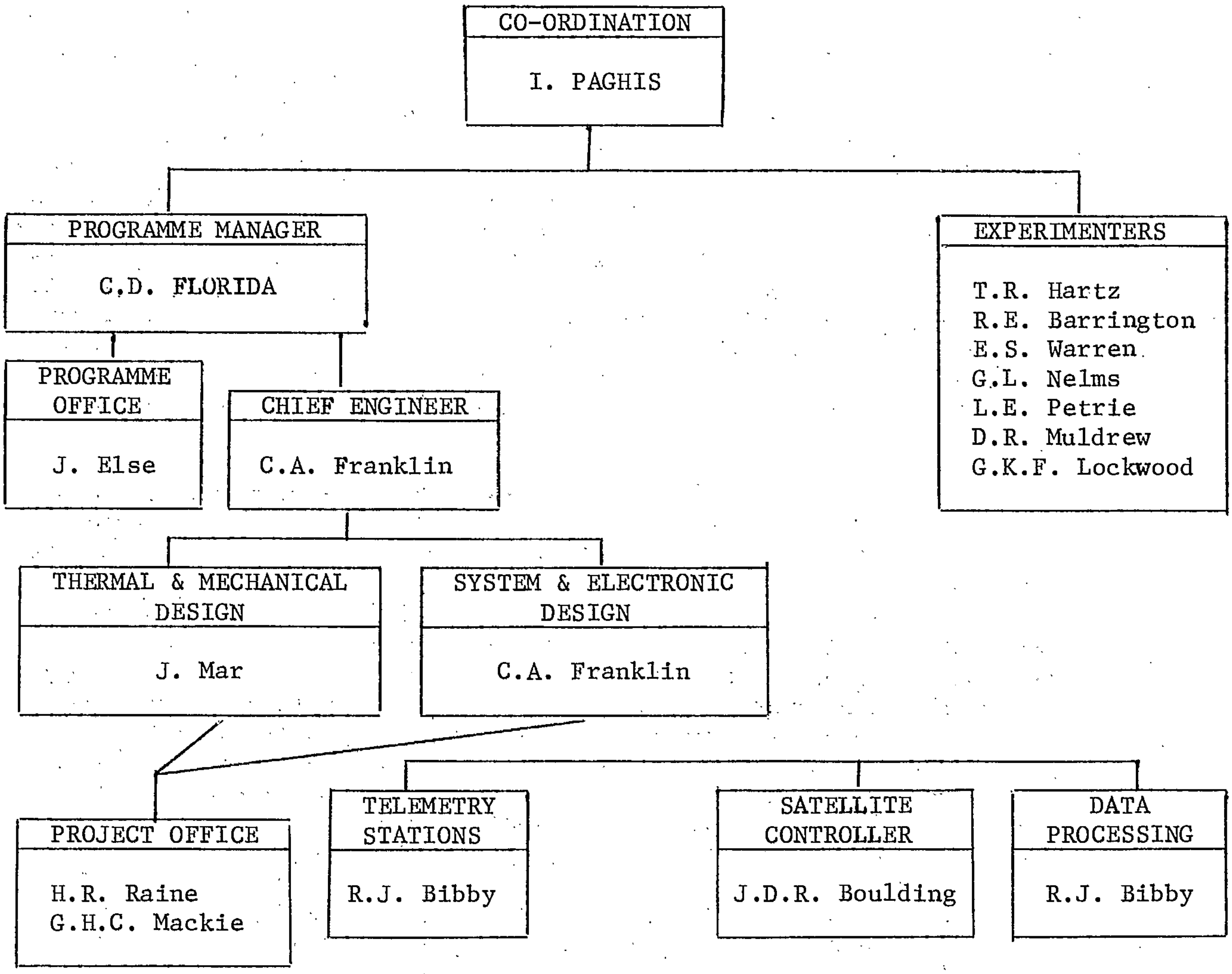
CRC PROGRAMME ORGANIZATION



2. INTRODUCTION AND SUMMARY OF PROGRESS

Aloüette I continues to provide sounder and VLF data for about 1-1/4 hours per day. No further changes in this satellite are reported.

The 300W power amplifier of the sounder system in Alouette II developed a malfunction at approximately 0255Z on 11 May, 1969. Diagnosis of the fault suggested that a wet tantalum capacitor in the +70V supply had developed a short circuit. As this fault could not be cleared, the back-up 100W power amplifier was switched into service on 12 May. The spacecraft continues to provide good sounder data, with some reduction in the usable frequency range. The current daily operating schedule for this satellite is 5-1/2 hours in maximum sun and 3-1/2 hours in minimum sun. The spin rate has now decreased to 1.88 rpm.

Over the reporting period, ISIS-I has been operated between 7-1/2 and 10 hours per day. Approximately one hour per day is recorded by the on-board tape recorder providing coverage of previously inaccessible regions. Since orbit 40 the IMS experiment has only been switched on for engineering checks. This experiment remains inoperative. The sounder system ramp off-set voltage was switched in in mid-May to compensate for the frequency drift of the VCO in the sounder RF generator. Over a six-week period, this frequency drift resulted in a change of over 60% in the fixed frequency sounding period. Although this spacecraft is essentially immune to spurious commands compared to Alouette II, a high level of background interference at the command frequency desensitizes the command receivers and produces occasional commanding problems. The attitude control was exercised during this reporting period and was found to perform to specification. The spin rate of this satellite is being maintained between 2.75 and 2.95 rpm.

During May the orbit planes of all three satellites were nearly coincident and much simultaneous data was collected. Some difficulties were encountered however, due to the similarity of the telemetry systems and to station conflicts.

Integration of the wiring harness on the ISIS-B prototype spacecraft began in early May. This activity is essentially complete and preliminary antenna matching is expected to begin early in the next reporting period. Fit checks of most of the hardware, including the optical experiments, have now taken place and some minor adjustments to solar panels to solve interference problems are in hand. Power turn on is expected in early August when electrical integration begins. Approximately forty units are presently available for integration. Failure analysis of semiconductor components in the main and back-up clock and programmers is giving some cause for concern, but resolution of these problems is expected early in the next reporting period. It has been decided that the mixed mode sounding on the spacecraft will consist of the transmission of one of the fixed frequency sounding frequencies whilst the sounder receiver operates in the sweep mode. A 'VLF Only' mode can also be selected to replace the fixed frequency sounder. The video format has been modified to provide zero, full scale, and three intermediate levels for video calibration. To minimize mutual interference between the sounder and the VLF systems, the input of the VLF receiver will be blanked during sounder transmissions. It has also been decided to include an on-board height marker to permit a cross-check with the height calibration levels derived from ground station equipment. As a result of the failure of the Alouette II 300W power amplifier, it has been decided to include two 400W power amplifiers in the ISIS-B flight spacecraft, instead of using a 100W as a back-up. The estimated all up weight of this model is 548 lbs. Delivery of the flight structure is expected late July, when installation of the wiring harness will commence. Although the latest CPM schedule indicates essentially about 8 weeks' negative slack with respect to the 21 December, 1970 launch, this stems from the flight clock and programmer and may be alleviated by rescheduling and the application of increased resources when the semiconductor problem is resolved. Integration of the direct measurement experiments is still scheduled to begin in mid-October 1969.

A preliminary study has been completed of the major system parameters and possible experiments for ISIS-C, particularly the radio sounder.

3. ALOUETTE II

3.1 Characteristics

Orbit

Apogee	2982 Km
Perigee	502 Km
Inclination	79.8^{o} Prograde
Spin Rate	2.25 RPM
Period	121.4 Minutes

Attitude Sensing

Three-axis flux gate magnetometer	-600 to +600 millioersteds per channel
Digital solar aspect sensor	180^{o} field view; scans entire celestial sphere per spin of satellite

Sounder

Tuning range of transmitter	0.2 MHz - 15 MHz
Receiver	0.13 MHz - 15 MHz
	0.15 MHz/s below 2 MHz
	1.0 MHz/s above 2 MHz
Transmitter power No. 1	300 watts
No. 2	100 watts
Modulation	100 μsec pulse
PRF	30 Hz
Receiver characteristics pre-amp & filter No. 1	Frequency response as in Alouette I
No. 2	Three bands switched at 2.0 and 7.0 MHz

A linear-logarithmic receiver with an AGC loop and two switched-loop filters.

Rise Time	Fall Time	Frequency Range MHz
500 ms	100 ms	0.13 - 2.0
60 ms	12 ms	2.0 - 15.0

Control range is 50 dB for AGC voltages 0 - 4.5V, and 70 - 75 dB for AGC 0 - 5.0V.

Antenna 240' tip-to-tip, and
75' tip-to-tip crossed dipoles

Frequency markers (on 30 KHz subcarrier or on wideband telemetry on command).

Frequencies (a) 0.5, 1.5, 2.5, 3.5, 4.5, 5.5, 6.5, 7.5, 8.5, 9.5, 10.5, 11.5, 12.5, 13.5, 14.5 MHz.
(b) 0.2, 0.55, 0.9, 1.25, 1.60, 2.0, 7.0 MHz.

Flyback 3.6 seconds

VLF Receiver

Frequency 50 Hz to 30 KHz
AGC 60 dB for 3 dB output change. Monitored AGC.

Telemetry

Transmitter No. 1

Frequency	136.080 MHz
Power	4 watts
Subcarrier modulation	
FM/FM	(a) Langmuir probe
PAM/FM/FM	(b) Spacecraft operation or frequency markers (selectable on command)

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

Transmitter No. 2

Frequency	136.590 MHz
Power	1 watt
Subcarrier modulation	
PAM/FM/FM	(a) 22 KHz spacecraft operation
	(b) 5.4 KHz particle counters
FM/PM	(c) 14.5 KHz scintillation counters
	(d) 3.9 KHz cosmic noise

Beacon - Unmodulated

Frequency	136.980 MHz
Power	100 mw

Command System

7 tone AM AVCO system operating at 148.260 MHz.
Automatic turn-off circuit--turns the satellite off 13 minutes after it has been turned on.
Delayed general turn-on unit--turns the satellite on 13 minutes after receipt of DGTO command.
Command gate--to protect against spurious commands, the gate timer must receive execute tones within 10 seconds of receipt of address tone.

Particle Counter (NRC)

Detector A - Electrons:	3.9 MeV minimum
- Protons:	40 MeV "
Detector B - Electrons:	40 KeV "
- Protons:	500 KeV "
Detector C - Electrons:	250 KeV "
- Protons:	500 KeV "
Detector D - Protons:	1 - 8 MeV
- Alpha particles:	5 - 24 MeV
Detector E - Protons:	100 MeV minimum
Detector F - Protons:	100 MeV to 600 MeV
Detector G - Electrons:	40 KeV minimum
- Protons:	500 KeV

Langmuir Probe

Electron density	10^3 to 10^6 e/cc
Electron temperature	400 to 5000°K

Weight 321 lbs.

Power Drain 57 watts

Spacecraft Daily Operating Schedule

	100% Sun Orbit	Max. Shadowed Orbit
At launch	6.9 hours	--
After 2 months	--	5.4 hours
After 4 months	7.6 hours	--
After 12 months	6.5 hours	4.2 hours
After 18 months	6.5 hours	4.25 hours
After 22 months	6.5 hours	4.50 hours
After 26 months	6 hours	4.25 hours
After 30 months	6 hours	4 hours
After 34 months	6 hours	4 hours
After 38 months	5.75 hours	3.75 hours
After 42 months	5.5 hours	3.5 hours

3.2 Spacecraft and Operations

3.2.1 Summary - Mechanical

With the exception of the spin rate, which is presently 1.88 rpm, there is no change in the status of Alouette II.

J. Mar.

3.2.2 Summary - Electrical

On 11 May about 0255Z a wet tantatlum capacitor short-circuited in the +70V supply rail to the 300W sounder transmitter. This transmitter is no longer usable, and on 12 May the back-up 100W unit was switched in. With this transmitter Alouette II continues to provide good sounder data but the frequency range is restricted. With the 300W transmitter the useful sounding frequency range was 200 KHz - 13 MHz. With the 100W transmitter the frequency range is reduced to 900 KHz - 11 MHz.

C.A. Franklin.

4. ISIS-I

4.1 Satellite Characteristics

Orbit

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

Spacecraft Stabilization

Spin stabilized 1 to 3 rev/min.

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

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 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.
Back-up--after 30 mins. unconditionally.
Spin and attitude control--$1\,^{+0}_{-1}$ and $5\,^{+0}_{-1}$ 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.

Telemetry

Transmitter 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 housekeeping

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, 60/sec
Antennas	240' and 61.5' tip-to-tip
Flyback	3 secs.

Frequency Range

(a) Normal Sweep 0.1 to 10 MHz

Frequency Range	Sweep Rate	Time to Cover Frequency Range
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	5.0 seconds
	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

Frequency Range	Sweep Rate	Time to Cover Frequency Range
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	15.0 seconds
	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 msecs. Fall time 12 msecs.

(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 40 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/cm^3
- (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 responsible 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.

4.2 Spacecraft and Operations

4.2.1 Electrical Summary

ISIS-I was launched into a 77% sun orbit on 30 January, 1969, reached 100% sun on 6 March, and should reach a minimum of 70% sun during the first week of July. During this period the spacecraft has, in general, performed very well. There have, however, been a number of problems.

a) The IMS experiment failed during the period 2-3 February. Useful data was acquired prior to failure but the life of this experiment has clearly fallen far short of expectations.

b) There have been command problems with ISIS-I caused by high-level interfering signals in the command frequency band. Compared with Alouette II the spacecraft is essentially immune to spurious commands but this performance has been achieved at the cost of reduced sensitivity in the presence of background interference.

c) The starting frequency of the sounder sweep frequency oscillator began to increase rapidly with time at the end of March and it became necessary to reduce the frequency by switching in a command offset voltage to a varactor-controlled oscillator on 13 May.

d) The SEA experiment power converter introduces interference on ionograms over the frequency range 1 - 1-1/2 MHz. The interference is not serious.

e) Some difficulty has been experienced in decoding the time code channel during playback of the spacecraft tape recorder. The problem appears to be caused by interference from the side-bands of the PCM signal when the two are transmitted together.

f) The AGC performance of the sounder receiver is inferior to that of the Alouette II receiver and has significantly reduced the value of the radio noise experiment in ISIS-I. A new AGC system for the ISIS-B sounder receiver has been developed at CRC and will hopefully be flown.

g) Interference on ionograms from the VLF receiver is severe and was expected. The addition of a junction FET gate at the front end of the VLF receiver should however largely eliminate this problem in ISIS-B.

h) As expected, the loading of the clock and programmer is a lengthy task. Time taken is approximately 20 minutes,and is restricting the use of the tape recorder particularly for perigee passes over Ottawa.

C.A. Franklin.

4.2.2 Mechanical Summary

The main activity since the last report has been in attitude sensing and control operations. Considerable effort was devoted to automating the reduction of ISIS-I attitude data. A computer programme has been developed which computes and prints out attitude, magnetic field, and orbital data,using as input satellite telemetry information stored on digital magnetic tape. At present the programme computes information for each second of time, but it is being modified to print out the data averaged over a 10-second interval.

Other work has been associated with changing the attitude of ISIS-I to provide the NRC probe with a 10° tilt out of the orbit plane.

J. Mar.

4.3 Primary Clock and Programmer

The clock oscillator runs fast during 66% sun periods and slow during 100% sun periods. Since the spacecraft spends longer periods in 66% sun than in 100% sun, CLOCK ADVANCE has been transmitted once while CLOCK RETARD has been transmitted twice.

A potential problem caused by thin metallization on "0" pf transistors was detected during testing of ISIS-B flip-flop modules. Investigations into this problem are currently being carried out using the scanning electron microscope at CRC.

N.S. Hitchcock.

4.3.1 Back-Up Clock and Programmer

No change since last report.

N.S. Hitchcock.

4.4 Tape Recorder

The tape recorder in ISIS-I has been used for an average of about one record-playback cycle per day since launch and continues to produce data of good quality. Some difficulty has been experienced in decoding the Time Code channel without error, due to interference from the sidebands of the PCM signal when the two are transmitted together. We are considering a slight modification in the ISIS-B recorder to increase the modulation ratio of the time code signal as it is recorded on the tape.

The highest temperature reached by the recorder, under 100% sun conditions, was $+30^{\circ}C$ and the rise in temperature during recording has been found to be an additional $4^{\circ}C$ for a 66 minute run. The case pressure has been monitored since launch and some evidence found of a slight decrease (about 1% in 4 months) but this is not considered significant.

A contract is being negotiated for the refurbishment of the prototype and flight 1 recorders to be used in ISIS-B.

M.A. Maclean.

4.5 Attitude Sensing and Control

4.5.1 Sensing

Processing of attitude sensing data continued in this reporting period though not yet on a routine processing schedule. Operation of attitude sensing devices appears to be normal.

4.5.2 Control

An attitude control manoeuvre was carried out during the early part of this reporting period. This operation involved an angular movement of the spacecraft spin axis of about 10° out of the orbit plane at an average rate of

2^{o} per orbit; a figure which agrees very well with the digital computer simulation for this motion.

H. Kowalik.
R.G. Fujaros.

5. ISIS-B

5.1 Satellite Characteristics

Orbit

1700 KM circular
Inclination 75^{o} prograde.

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^{o} 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^{o} 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^{o} per orbit at a 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 operating 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}_{-0} and 11^{+1}_{-0} hours, selectable by command.

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.

Telemetry

Transmitter 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	400W 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 msecs. Fall time 12 msecs.

(3) VLF Experiment

VLF receiver	0.05 - 30 KHz
	Monitored AGC voltage.
A VLF swept frequency exciter	Range 500 - 0 - 9500 Hz.
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
	.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	97
Experiments	148
Telemetry & Command	96
Power	148
ASC	23
Cable Harness	36
Total	548 lbs.

5.2 ISIS-B Project Office Report

General

All the ISIS-B System Specifications have now been approved by the Design Authority.

Design reviews have been held during the reporting period dealing with the following:

a) Essential Housekeeping Commutator (Unit BR) on 1 April.
b) Telemetry System on 17 April
c) VLF Exciter Driver (Unit AP) on 29 May
d) Antenna Interface Unit (Unit AC) on 29/30 May
e) R.F. Generator (Unit AF) on 30 May
f) Ground Support Equipment on 4/5 June

Approximately 40 flight standard units are available for integration. Assembly and testing of the remaining units should be complete by October, 1969 when integration of the direct measurement experiments is scheduled to commence.

The wiring harness is virtually complete and integration of the prototype spacecraft has begun.

Changes to ISIS-B

(a) Sounder

i) Mixed Mode

Mixed mode sounding will consist of the transmission of any one of the six fixed frequencies, while the sounder receiver is sweeping.

ii) Alternate VLF-Sounder Mode

The "VLF only" mode can be selected to replace fixed frequency sounding.

iii) Video Calibration

The video format now provides for five calibrate levels: zero, full scale, and three intermediate levels.

(b) VLF

Blanking of the VLF receiver input is now provided during sounder transmissions to reduce mutual interference between the VLF and sounder experiments.

(c) Cosmic Noise

The feasibility of modifying the sounder receiver AGC characteristics to improve the dynamic range and resolution is being investigated.

Clock & Programmer

An investigation carried out by the CRC Failure Analysis Group on a number of failed Motorola '0' pf devices has shown evidence of irregularities in the metallizing, which in two cases has resulted in an "open-circuit" condition. Work is in progress to determine the nature and extent of this problem, and the contractor has been advised to hold up further installation of these devices until the reliability implications have been assessed.

Back-Up Clock

Present indications are that the problem with excessive glass frit on the Fairchild 9000 series I/C's which was reported by NASA, does not extend to the devices used on this unit. The Failure Analysis Group has, however, reported evidence of two types of metallization faults which are still under investigation. A hold has been placed on installation of these devices pending the completion of a detailed study of this problem.

400 MHz UHF Antenna

Total radiated power patterns submitted by the contractor in April showed a null 6 dB or greater, covering a cone of approximately 120^{o} looking at the bottom of the spacecraft.

Following discussions with, and at the recommendation of the contractor, the antenna was raised 5" and further measurements made to determine the characteristics of the revised configuration.

A substantial improvement was realized, which brought the performance of the antenna up to acceptable levels.

The improved patterns were evaluated and approved by CRC early in June.

Ground Checkout Equipment

This has been expanded considerably from the facility used for ISIS-I.

Additional peripheral equipment for the existing on-line computer has been purchased by the contractor, and a second off-line PDP8 computer and peripherals wll be furnished by CRC early in July.

Agreement has been reached on the make up of the DIVCON display equipment to be used in conjunction with the computer-controlled spacecraft checkout facility, and an order has been placed for delivery of this equipment in early September.

Work has begun on the planning and preparation of the software to be used with the checkout facility. Indications to date are that this is progressing extremely well.

Ni-Cd Cells

Discussions have been held with the supplier to review some of the difficulties experienced during production and testing of the ISIS-I cells.

The welding procedures to be used on the cells for ISIS-B have been formalized, and in the light of previous experience tighter mechanical tolerances have been placed on the materials to be welded.

Minor but important structural modifications have been made to the pressure gauge adaptors on the cell top, to avoid the leaks and breakage losses encountered on ISIS-I.

As a result of the improved techniques developed mainly by DREO (formerly DCBRE) during the production of the ISIS-I cells, it has been possible to place tighter limits on the acceptable cell pressures for ISIS-B.

G.H.C. Mackie.

5.3 Spacecraft and Operations

5.3.1 Electrical Summary

There has been considerable discussion and anxiety concerning the accuracy of height markers on ionograms produced at DRTE/CRC. We are currently planning to reprocess as many as two ionograms per day of operation at the Data Processing Centre at Ottawa. Up to 750 tapes could eventually be involved. A detailed report is to be prepared on this subject and will be summarized in the next Tri-Annual Report.

As the result of continuing accuracy worries over height markers it has been decided to add a 666.65 km height marker in ISIS-B. This will appear whenever the sounder is turned on and will be derived from the crystal-controlled clock oscillator within the spacecraft.

For ISIS-I ionograms a height marker will be generated from the crystal-controlled PCM bit train and will be added during processing in the CRC Data Centre. This added marker will serve as a check on the normal height marker grid, which is now crystal controlled. It will also serve to provide a check on the speed of the spacecraft tape recorder.

C.A. Franklin.

5.3.2 Mechanical Summary

With the exception of a lowering of spin to transverse moment of inertia ratio resulting from the elevated mounting of the 400 MHz antenna, no major spacecraft changes from the ISIS-I configuration are envisaged. The implications of a reduction in favourable moment of inertia ratio on such factors as separation tip-off will be analysed when updated launch vehicle data becomes available.

Other major activities are connected with the effects of a possible change in launch vehicle. NASA have been considering the possibility of using either a Delta N or Delta L for the ISIS-B launch. The Delta N is essentially a Long Tank Thor 2-stage vehicle with 9 castors (strap-on's), whereas the Delta L is a 3-stage vehicle using 3 castors and an FW4 3rd stage motor. Both vehicles would provide increased orbit capability compared to the original DSV-3.

In the case of the Delta L, the vibration environment is expected to increase significantly in the thrust direction between 17 to 25 Hz. If the L vehicle is chosen, a complete assessment of the present ISIS-B structural design and resulting payload to launch vehicle dynamics would have to be carried out to ensure stress compatibility.

J. Mar.

5.4 Mechanical Design

A conceptual design review of the mechanical system was held at RCA, Montreal, on 10 April, 1969.

Spacecraft Structure

The first of two flight structures was received at RCA, Montreal, early in May, 1969.

Spacecraft Dynamics

A dynamics review meeting was held at CRC on 17 June, 1969.

The present calculated moment of inertia ratio is 1.06 in the launch configuration and 1.03 in the orbit configuration.

Consideration is being given to building a facility at RCA, Montreal to measure the moment of inertia of the spacecraft.

Solar Cell Panels

The solar cell panels which are presently being manufactured for the ISIS-B spacecraft will differ only marginally from those supplied for ISIS-I.

There will be a type "C" panel with a centre cutout. All panels have .012' thick formed aluminum channel attached to the sides and lower outside edges in place of the core fill material used on previous panels.

N.A. Harrison.

5.5 Other Satellite Electronics and Experiments

5.5.1 VLF Receiver

During this period, further testing and evaluation of the input gate for the VLF receiver system was carried out by R. Bonhomme of RCA on the ISIS-A engineering model at CRC. Results have shown that considerable improvement can be achieved by gating the input to the VLF receiver with a pair of shunt FET switches followed by a pair of series FET switches. This shunt-series switch arrangement is gated by the VLF gate "B" pulse from the sounder control such as to blank out the portion of the input signal centred around the transmitter "on" period.

The input low-pass filter ringing level of the output signal is reduced by approximately a factor of 10 and the AGC voltage level reduced from 1 volt (depends on the portion of the band considered) to essentially zero.

For further details see DRTE Memorandum 0204-02-59 (E) of April 15, 1969 by A.A. Angerilli, and the trip report RCA file 2107.2 of April 17, 1969 by R. Bonhomme.

The ISIS-B VLF receiver engineering model has been built and tested by RCA. Preliminary information from RCA indicates that the receiver operation and performance are satisfactory.

T. Nishizaki.

5.5.2 Converter 6

This unit is basically the same as the ISIS-A design except for a few minor additions and modifications. An "extended spin and attitude control use relay" has been added to permit selection by command, of input battery line for supply of power to the spin and attitude control system. The flag circuits have been modified to unambiguously monitor the converter status.

For further details on these changes, refer to the RCA contribution to this progress report.

T. Nishizaki.

5.5.3 DC to DC Power Converters
Main Clock and Programmer
Back-Up Clock and Programmer
Spin and Attitude Control System

As detailed in DRTE Memorandum 0204-02-105-3 (E) of January 15, 1968, all Fairchild FCT 1125 reference diodes were substituted by Dickson IN4569-A zener reference diodes. At the time, there was some question as to the availability of the FCT 1125's. However, the FCT 1125's have recently become available for flight use, and these units will revert to the use of the originally specified FCT 1125 reference diode.

T. Nishizaki.

5.6 RCA Ltd. Status Report

5.6.1 Management

5.6.1.1 Proposal

All system specifications have been accepted and approved by the Design Authority, CRC. The Quality Assurance Plan has also been approved. The Reliability Plan has been negotiated and is acceptable with the exception of the definition of partial operation of the spacecraft.

5.6.1.2 Subcontracts

The main subcontractor, SPAR Aerospace Products Limited, delivered a completed structure and modified handling dolly during this period. One completed set of associated hardware was also received and fit checks undertaken. Sounder antennas have not been received as yet. A problem, left over from ISIS-A, continued to plague the production of satisfactory sounder antenna drive motor canister seals. SPAR has decided to redesign the seal and it is reported that all problems have been resolved. Antenna deliveries are expected early in the next reporting period.

Subcontracts for coulometers, solar pippers, and crystal bandpass filters have been placed and satisfactory delivery promises have been negotiated.

5.6.1.3 CPM Planning and Schedule

Two updated computer runs were completed in the last reporting period. The critical path includes the sounder control unit (AH) which has had changes made to it to incorporate a 4-level calibrate and a modified VCO ramp voltage characteristic. (Further details are given in 5.6.4.5 a).)

Some rearrangement of the main integration network has become necessary to remove some of the negative slack from late units.

5.6.2 Project Engineering

The Spacecraft Specification, RCA Drawing 1816300, Revision 6, was approved by CRC and formally released after incorporation of corrections and new information. Other system specifications which were also signed off by CRC and released are; Power System, 1816303, Revision 1; Telemetry System, 1816304, Revision 2; Command System, 1816305, Revision 1; Attitude Sensing and Control System, 1816306, Revision 3; Sounder System 1816307, Revision 2; VLF System, 1816312, Revision 4.

System schematics and block diagrams which were released during this period are the Command System, Telemetry System, Grounding and Return Line System. Work is continuing on system schematics for the Power Distribution System, the ASCS, the Sounder System, and the VLF System. A list of system unit schematics and block diagrams was prepared and released. (RCA Drawing 1816365)

The General Arrangement Drawing of the spacecraft has been updated and a reduced copy of it appears elsewhere in this report. The final Equipment

Layout Drawings are not yet available. Revisions to these are being made as a result of detailed checking of dimensions, changes to battery layout and addition of sub-assemblies not previously shown.

The wiring harness for the prototype spacecraft has been transferred from the wiring jig to the spacecraft structure and at the time of writing approximately 90% of the connectors have been installed. Completion is anticipated by July.

The harness for the flight spacecraft is being assembled on the wiring jig and over 80% of the wires have been run.

Programming of the PDP-8 computer of the ground support equipment for decommutation and display of spacecraft telemetry data has continued. Programmes and routines used for ISIS-A are being revised to suit the increased requirements of ISIS-B and of the expanded computer. Display formats for the new DIVCON alpha numeric display screens have been designed and routines for input of the data to the DIVCON system are being worked out.

5.6.3 Spacecraft Integration

5.6.3.1 Electrical Activities (Prototype Spacecraft)

The first integration activity consisting of RF harness and antenna matching tasks will commence as soon as the overall wiring harness is complete, scheduled for early July, 1969.

An Integration Test Plan covering all activities up to but not including sounder system integration has been prepared and will be released before the end of June 1969.

5.6.3.2 Mechanical Activities (Prototype Spacecraft)

The prototype spacecraft structure was received at RCA Limited on May 8, 1969. Unit integration is dependent upon completion of the wiring harness; however, fit checks of tested units have been performed as the units become available.

A vibration test plan for the upper heat shield assembly has been issued and the test, using the dynamic model structure, is scheduled for late in June, 1969.

5.6.4 Systems

5.6.4.1 Power System

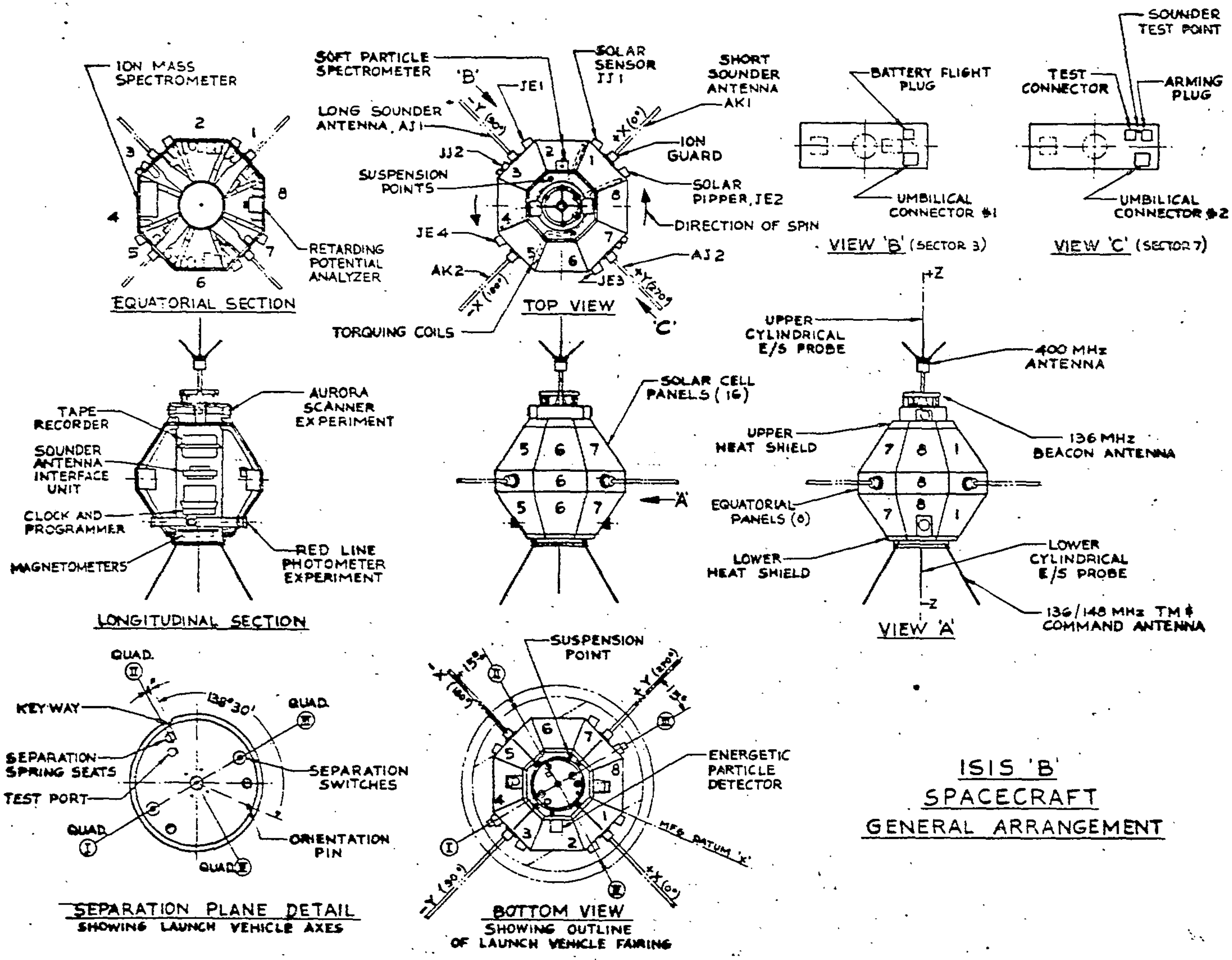
a) System Design

No changes have been made to the system design in the reporting period.

b) Primary Power System

Contracts have been let for the solar cells, batteries, and coulometers.

UNCLASSIFIED



ISIS 'B' SPACECRAFT GENERAL ARRANGEMENT

UNCLASSIFIED

Final agreement has been reached on solar cell panel edge design and thermal design requirements. Drawings are presently being updated.

No problems have occurred as yet in the battery or coulometer contracts. A life test being made at RCA has resulted in a coulometer failure after 6 months (875 cycles) of operation. The coulometer has been given to CRC for analysis.

c) Unit Design

Design of all units is complete. All prototype units have passed acceptance test except for units DC and DJ which are in the late stage of manufacturing. Flight units are progressing through manufacturing, except for DQ which has passed acceptance tests.

5.6.4.2 Command System

As the hardware of the command system for ISIS-B is essentially the same as that of ISIS-I, there is little design effort being expended. The command receivers have been received as have the command decoders with their new address tone requirements and modifications dictated by reliability considerations.

The prototype automatic turn-off unit, which has had a number of design differences from the ISIS-I unit, is complete at the time of writing.

The prototype clock and programmer assembly and test is proceeding satisfactorily, with expectation of completion by mid-September, but the "low power" integrated circuits intended for the back-up clock are suspected of being a reliability hazard. The resolution of this problem may result in delays in the clock package for integration.

5.6.4.3 Telemetry System

a) General

Most of the effort during this reporting period has been concerned with the construction and test of engineering and prototype units. There is now available for integration on the prototype spacecraft either an engineering or prototype model of all RF telemetry and antenna units except for the experimenter selector (BY), the 400 MHz transmitter (BG) and the VHF telemetry/command duplexer unit (BE). The sub-carrier oscillators for units BY and BG will be available in July.

Completion of the 400 MHz FM transmitter is held pending results of a vacuum induced electrical breakdown evaluation. This evaluation was recommended following anomalies encountered during the ISIS-I vacuum testing.

Preparation of the test procedure for telemetry system spacecraft tests is in progress and should be completed about the end of July, 1969.

b) Transmitters

The 136 MHz FM transmitter is available for integration. The flight 136 MHz PM transmitter still requires acceptance testing.

c) Sub-Carrier Oscillator (BV)

The design and development of more reliable sub-carrier oscillators for the experiment selector unit BY and the 400 MHz transmitter unit BG has begun. A breadboard model of the 30 kHz oscillator is under test.

d) Tape Recorder (BW)

The implications of the change in the output level of the clock channel from 1 volt to 2 volts were analyzed. No rework of the 400 MHz system, due to this change, was found to be required.

The refurbished prototype tape recorder is expected to arrive at RCA about 1 August, 1969.

e) Experiment Selector Unit BY

The engineering model of the unit BY is complete, except for the 30 kHz sub-carrier oscillators. The final design review is scheduled for early July, 1969.

f) Antenna Systems

i) VHF Telemetry

All the units of the VHF telemetry system, with the exception of the VHF telemetry/command duplexer, unit BE, are now qualified and available for integration on the prototype spacecraft. The prototype unit BE is under modification, following capacitor failures on the unit.

ii) UHF Telemetry

Further development work was carried out on the 400 MHz turnstile antenna to improve coverage on the underside of the spacecraft, and resulted in array being raised by 5 inches. An engineering model, fully assembled and potted, will be available for vibration test on June 19th. The prototype and flight units are being manufactured, and the harnesses for both these units are being qualified at the moment.

iii) Beacon Antenna

The problem of mutual coupling between the beacon antenna and the UHF antenna experienced during pattern tests has been eliminated, with small modification in the design. The prototype beacon diplexer, and beacon harness, together with the engineering model antenna unit BX, are now available for integration on the prototype spacecraft. The prototype unit BX is in Manufacturing.

g) Digital Units

All digital telemetry system units are progressing satisfactorily.

The telemetry output of EB-Auroral Scanner has been changed from "Bit Stream" to "Change on Zero" to ensure bit synchronization in the GSE.

5.6.4.4 Attitude and Spin Control System

a) System Design

No changes have been made to the system design in this period.

A method has been devised to check out the ASC system during the computer-controlled autocheck operation. The basis of the method is the application of controlled currents to small fixed stimulus windings placed around the magnetometers.

b) Sub-Contract Items

A torquing coil was received but could not be used because it was not bifilar wound. A new coil will be supplied.

The flight magnetometer electronics unit (JH) was received following replacement of a faulty module but is still not operating correctly. Trouble-shooting is in progress. The oscillator for the second unit JH has been received at RCA and will be installed in plant. Consideration is being given to the procurement of a magnetometer electronics unit to a new RCA design.

Solar pippers have been ordered for the flight spacecraft.

c) Unit Design

Minor modifications are being made to the design of unit JC (converter 6) and JD (spin and attitude control unit) following reliability analyses. All drawings have been released and the modifications are being covered by ECN's.

5.6.4.5 Sounder System

a) System Design

Several modifications have been incorporated to improve both system performance and reliability and to increase the experimental capability of the sounder system.

Among the most significant changes is the addition of a mixed mode sounding facility which will permit pulsed fixed frequency sounding while the receiver is operated in the normal swept frequency mode. This system will make use of the six existing fixed frequencies in the RF generator.

The sounder video format has been altered to include four stepped telemetry calibrate levels and to provide a calibrate level equal to that of the maximum echo amplitude of -4.5 volts.

A study of the sounder receiver AGC system is in progress to determine the feasibility of incorporating a revised AGC system that is less temperature dependent at low cosmic noise levels.

b) Unit Design

The sounder control unit has been extensively redesigned to provide the video format changes and a modified VLF receiver output gating arrangement described briefly in the VLF system report. Further redesign was necessary in order to return to a revised VCO ramp voltage characteristic which can cope with considerably more frequency shifts than was possible with the previous arrangement. A back-up circuit was also added to ensure continued ramp operation in the event of additional or erratic frequency markers.

The frequency calibrator unit is being modified to be compatible with the revised ramp reset characteristics.

The mixed mode feature has required the addition of a small housing to the RF generator unit to accommodate the additional circuitry. This mixed mode unit is now undergoing engineering tests with the prototype RF generator where circuitry has also been changed to achieve proper interfacing with the mixed mode unit.

All sounder system units have now entered the flight production stage and several flight units are expected to enter initial flight testing shortly.

5.6.4.6 VLF System

a) System Design

No significant changes have taken place.

b) Unit Design

Two major modifications have been made to the VLF receiver circuitry.

A blanking circuit has been added to the receiver input to minimize interference of the sounder pulse by blanking the receiver input during the sounder pulse. This has required a small housing to be mounted on the VLF receiver to contain the new circuitry.

The gating of the VLF receiver output to the 400 and 136 MHz transmitters has been revised to enable these outputs during the fixed frequency period only if no fixed frequency sounding is being performed. This will allow the VLF receiver to be used during fixed frequency periods without interfering with the swept frequency sounder experiment.

Engineering model testing of the new VLF exciter and impedance measuring circuits is complete and the units have entered flight production. Combined testing of the two units has exposed an interface problem resulting from a slight discontinuity in the exciter output waveform. This is being analyzed and improved operational amplifiers are being investigated.

5.6.4.7 Optical Experiments

a) Auroral Scanner

The mission of this experiment is to observe the 3914Å and 5577Å emission lines of the earth's aurora. The engineering models of the units of this experiment are under test at the time of writing, and the mechanical and optical sub-assemblies have been received.

The digital outputs of this experiment have been changed from "bit stream" to "change on zero". This alteration was prompted by the realization that in the pre-launch and immediate post-launch states, the experiment outputs will be zero due to the position of the shutters. If this all zero state be transmitted to the ground as "bit stream" bit synchronization problems will arise. Thus the change from NRZ-C to NRZ-S.

b) Red-Line Photometer

The engineering model of this experiment, which studies the 6300Å atomic oxygen emission line in the earth's upper atmosphere, is now complete. Preliminary engineering tests have been successfully completed, and environmental tests will be commencing in the near future.

A fit check has been performed with the engineering model experiment on the engineering model spacecraft. This test disclosed some interference between solar panels and shutter mechanisms. Steps are being taken to remedy the problem.

5.6.4.8 Mechanical System

The current weight estimate for the spacecraft is 547 lbs., made up of 288 lbs. weighed, 186 lbs. estimated, and 73 lbs. based on measured unit weights combined with estimated encapsulant weights.

The current inertia ratio of the spacecraft is 1.058. This low value reflects the new increased height of the 400 MHz antenna support. This increased height will also increase the vibration loading of the support on the heat shield. A qualification type vibration test is about to be carried out to check out the structural design of the top heat shield and antenna assembly. Engineering models of the top heat shield, and the beacon and 400 MHz antennas will be mounted on the dynamic model of ISIS-I.

The solar panel thermal design is changed from ISIS-I, allowing a wider range of possible values of absorptivity and emissivity from which to select desired parameters for ISIS-B.

5.6.5 Reliability Activities

5.6.5.1 Reliability Programme Management

The ISIS-B Reliability Programme Plan is still under negotiation. Negotiations are being carried out to define "Partial Satisfactory Performance".

A series of Reliability Indoctrination meetings were held to acquaint the personnel engaged in the ISIS-B project with the reliability requirements of the contract.

The second volume of the Component Application Notes has been issued containing additional information on transistors.

A small vacuum station was put into operation. It is equipped with a 12" bell-jar, radiation heater unit, and has a capability of 1 x 10^{-5} mm Hg vacuum. It will be used mainly for component investigation, but units could be evaluated, too.

The malfunction reporting system has been revised. Quality Assurance Administration has taken over administration of the reports. Reliability Engineering is responsible for component analyses.

5.6.5.2 Design Reviews

During this reporting period the following Design Reviews were held:

E.H. Commutator, Unit BR
EPD Experiment, Unit EL/EV
Mechanical System
AIT Control Unit, Unit AQ
93 kHz SCO
Ground Support Equipment
Antenna Interface Unit, AC
RF Generator, Unit AF
VLF Exciter Driver, Unit AP
Converter No. 6, Unit JC
Red-Line Photometer Equipment, Unit EC

5.6.5.3 Component Procurement

Several trips were undertaken to suppliers in connection with non-standard parts for the two optical experiments. As a result almost all Procurement Specifications have been released.

Particular attention was paid to the Corotron regulator tubes in view of their failures on several satellites including ISIS-I.

Because of delivery problems a visit was paid to a capacitor supplier. As a result of this trip the supplier has promised to tighten their internal quality control to achieve better yield in the case of the small ceramic capacitors for the clock and programmer. Also a scheme was worked out to speed up the documentation flow resulting in improved delivery.

5.6.5.4 Component Investigations

a) LPDTμL Integrated Circuits

GSFC's Failure Analysis Report (FAR 10-006) pointed out a new, different kind of deficiency; namely, conductive glass frit in certain lots of integrated circuits. At present, CRC's Failure Analysis Facility is conducting a further investigation of the problem.

b) Zero-pF Transistors

Because of failures occurring during assembly operations, an extensive investigation was carried out to localize potential problem areas.

It was found that the presently used soldering irons may carry transients picked up by the cords acting as antennas or generated by SCR's controlling heating of the tips. At present a new type of iron equipped with a berillium-oxide tip is being evaluated. This type of tip has excellent heat-transfer capability and at the same time is electrically non-conductive. In addition, CRC's Failure Analysis Facility discovered metallization problems in the devices. Investigations are still underway.

J. McNally.

6. SATELLITE CONTROL

6.1 General

The orbital planes of ISIS-I, Alouette II, and Alouette I were all nearly coincident during May. The argument of perigee of ISIS-I was between 345 and 285 degrees, while that of Alouette II was between 120 and 65 degrees during this period. Much simultaneous data was collected during this period but operations were seriously hampered by the similarity of the telemetry systems of the 3 spacecraft and by station conflicts.

There have been many cuts in the Alouette and ISIS schedules because of conflicts at the STADAN and Tromso stations.

6.2 Alouette I

Alouette I continues to operate in the sounder and/or VLF mode for about 1.3 hours per day. There has been no other change in the operation of Alouette I.

6.3 Alouette II

On 11 May at about 0255Z a capacitor apparently developed a low dc resistance which shorted the +70 volt supply in the 300 watt power amplifier. This power amplifier is no longer serviceable. On 12 May the back-up 100 watt amplifier was switched into service. The sounder system is fully operational with the back-up amplifier.

Alouette II operated between 5-1/2 and 3-1/2 hours per day since the last reporting period. The spin rate is now 1.88 rpm. There have been no other changes in the operation or status of Alouette II.

6.4 ISIS-I

ISIS-I was launched into a 77% sun orbit on 30 January, 1969, reached 100% sun on 6 March, left 100% sun on 27 April, and should reach a minimum 70% sun during the first week of July. During this period the spacecraft has performed as expected, with a few exceptions.

The IMS high-voltage failed during the 2-3 February. This experiment has been turned on for only short periods since to collect engineering data. The oscillator in the swept frequency sounder drifted resulting in a decrease of the fixed frequency sounding period from about 4.5 seconds in March to about

1.3 seconds in mid-April. Compensation was switched in during mid-May which increased the fixed frequency period to about 4.7 seconds. The SEA experiment power converter causes a herringbone effect on ionograms. There have been no other problems with the experiments.

The spacecraft clock has been held to within one second of GMT. The clock was retarded by one second on 30 May and will probably be retarded by one second during the last week of June.

The spin and attitude control system is operating as expected. The system is capable of changing the spin rate by 0.04 rpm/hr and spin axis position by 1.0^{o}/hr. The spacecraft was despun to less than 3 rpm during 1-2 February, and has been kept between 2.95 and 2.75 rpm since. At the beginning of April the spin axis was moved about 15 degrees out of the orbit plane. The spin axis is now coning about the orbit normal with a period of about six months. Currently the angle of the spin axis to the sun is about 25 degrees.

During this reporting period it was discovered that most of the problems encountered in commanding ISIS-I have been caused by high-level interfering signals (greater than 15μv have been observed at the receiver input) which desensitize the command receivers and inhibit the command decoders.

The ISIS-I spacecraft has been operating between 7-1/2 and 10 hours per day since launch, of which about one hour per day has been stored on the on-board tape recorder. The power system is presently capable of operating up to a maximum of about 11 hours per day, but data acquisition network conflicts have decreased the actual operating time from that schedule.

J.D.R. Boulding.

7. DATA PROCESSING

Due to new equipment problems, mainly with the recording camera, the processing of ISIS-I tapes was slow starting but is now proceeding on a routine basis at four times real time speed.

The frequency of the fixed frequency sounding is now printed out automatically from the PCM data by the computer. It appears, in coded form, in the second character position of the satellite identification number. For example, a printout of 34 in the satellite identification position would indicate satellite #3 (ISIS-I) and frequency #4 (1.95 MHz) were employed. A zero (0) in the second position would indicate that no fixed frequency sounding was done, and a seven (7) would indicate the fixed frequency was unknown--a condition that can exist if valid PCM data is not available during filming of the ionogram.

To date the backlog of ISIS-I tape is approximately 300--about 75% of the tapes on hand have been processed.

Processing of Alouette I and II tapes in the new high-speed processing position has suffered from the priority of data acquisition from ISIS-I, and in the old position from equipment problems. Consequently the old position--as a "gap fill-in" measure--has been extensively redesigned to process Alouette II at double speed. It is therefore anticipated that the large backlog of tapes (3200 for Alouette II and 390 for Alouette I) can be effectively reduced in the near future by the continuous employment of both positions.

Compacting of electrostatic probe data from Alouette II has continued routinely since the last report. Over 4000 original tapes have been compacted since the new year.

The interface electronics for serially handling of the PCM data from the bit synchronizer and converting it to synchronized parallel word transfers into the computer has been completed and debugged. This interface along with the time code input has now been fully operational since mid-April.

A control/display panel with related circuitry has been completed and is now fully operational for providing the following functions.

a) Indication of the computer mode (search, check, lock) in dealing with the PCM data.

b) Priming information, set in by the operators for defining the number of bit errors in the PCM frame sync words, and the number of times these errors will be tolerated.

c) Fixed frequency readout in the form of indicators and BCD signals for decimal printout by the film annotation diode display unit.

d) Eight bit readout for monitoring the 3rd word in the PCM data stream.

A high speed paper tape reader (1000 characters/sec) has been acquired and the interface card containing the associated electronics for computer interrupt and reader control has been designed and constructed so that the reader is compatible with the Hewlett Packard computer.

R.J. Bibby.
D.P. Henderson.

8. TELEMETRY STATIONS

8.1 Ottawa

There have been no significant changes to the status of the station since the last reporting period. We continue to record telemetered data from Alouette I, II, and ISIS-I. Operations on both the 136 MHz and 400 MHz ISIS-I telemetry links have been going well. Occasionally the station experiences problems with the command of ISIS-I. We believe the problem to be one of transmitting with the incorrect polarization and have ordered relays to provide a polarization switching system. These should be installed by the next reporting period.

8.2 Resolute Bay

The station has continued to operate receiving data from Alouette I, II, and ISIS-I. Resolute has also experienced some command problems with ISIS-I and though the station radiates considerably less power than Ottawa we believe the problem to be one of polarization. We have relays on order to provide polarization switching on both antennas.

A visit to Resolute Bay is planned for August, at which time we hope to overhaul the station.

W.S. Campbell.

9. QUALITY ASSURANCE

To date, 69 ISIS-B malfunction reports have been generated by RCA Ltd. Of these, the most serious are the 23 reports highlighting Motorola SS1018 and SS1019 "zero pf" transistor degradation and failures that occurred on printed circuit modules for the clock and programmer. An investigation by CRC Failure Analysis Group on a number of these devices has indicated gross metallization defects and poor workmanship which are serious reliability hazards. Also, on receiving the GSFC Failure Analysis Report FAR10-006, April 1969, that referred to a glass frit overflow causing diode high leakage current in an LPDTμL 9044 device batch 6844, a sample quantity of LPDTμL 9040, 9041, 9042 integrated circuits from the RCA Ltd. stock was evaluated by CRC Failure Analysis Group. The evaluation (Quality Assessment of Fairchild LPDTμL 9040, 9041, 9042 Integrated Circuits, by D.V. Sulway, file CRC 6663-110-5 (NSTL)) has indicated no serious glass frit problems, but has revealed gross metallization defects and shoddy workmanship which are serious reliability hazards.

A visit was made to Sonotone Corporation on 14 April, 1969 to discuss welding procedures for ISIS-B Ni-Cd cells and coulometers. At the same time, the resident US Government Inspector was informed that source inspection on the coulometers would be delegated to the US Government Inspection Agency DCASR by the DND/QAB resident at RCA Ltd.

The RCA Ltd. ISIS-B Quality Programme Plan was approved on 22 May, 1969.

J.E. Tennuci.

10. PROJECT SUPPORT

10.1 ISIS Planning and Scheduling

10.1.1 RCA Ltd. Status

Assembly, test, and implementation of design changes on the remaining outstanding units for the ISIS-B spacecraft are continuing. Approximately 40 units are now available for integration and have undergone fit checks on the prototype structure.

A system of scheduled daily objectives in manufacturing, assembly, and test was implemented during the reporting period to maintain a tight control of critical path items.

There have been four main CPM networks issued to date with the latest indicating essentially 8 weeks' negative slack.

10.1.2 CRC Status

An investigation of problems encountered with Fairchild LPDTμL's and Motorola '0' pf transistors has been undertaken by the CRC Failure Analysis Group. A Quality Assessment report on Fairchild LPDTμL's was issued on 4 June, 1969, and a report on Motorola '0' pf's is expected in early July, 1969.

It is not anticipated that the recommendations contained in these reports will have any significant impact on the overall programme schedule.

A preliminary design and feasibility study was conducted at CRC on a revised AGC system for the sounder receiver.

Tests were also carried out on the ISIS-A engineering model VLF receiver to determine the feasibility of gating the input. The design was then taken to RCA Ltd. for incorporation into the ISIS-B system.

J.A. Moffatt.

11. SUPPORTING RESEARCH AND DEVELOPMENT

11.1 Future Spacecraft

The ISIS-C proposal has been redrafted and considerably expanded. Detailed scheduling, manpower, and cost estimates have been produced.

The proposed spacecraft will carry ten experiments, the most complex being a radio sounder covering the frequency range 200 Hz to 20 MHz. Other possible experiments are as follows:

i) VLF, ELF, and ULF receivers for the frequency range 0.1 Hz to 10 kHz.

ii) Radio noise receivers for the frequency range 200 Hz to 20 MHz.

iii) A rubidium-vapour and flux gate magnetometer system with a threshold sensitivity and resolution of 1 gamma.

iv) Antenna impedance and antenna mutual coupling experiments for the frequency range 200 Hz to several MHz.

v) Quasi-static electric field measurements.

vi) A variety of particle experiments.

The spacecraft will weigh approximately 770 lbs. and will be launched by a Delta M-9 vehicle with 9 strap-on's into a 90°, 600 kilometer x 127,600 kilometer (20 earth radii) orbit. Present plans call for two orthogonal sounder dipoles in a plane perpendicular to the spacecraft spin axis each of which will measure 375 meters (1230 ft.) tip-to-tip.

C.A. Franklin.

11.2 Clock and Programmer

Final measurements on the plated wire memory plane indicate that operation over a temperature range from $-30^{\circ}C$ to $+60^{\circ}C$ is feasible without taking special precautions to compensate drive currents. It has also been established that a 12 bit - 4000 word memory could be designed which would consume less than 5 watts when busy (clock rate of 1 MHz) and about 1 watt on standby due to the sense amplifiers. It may be possible to reduce the 1 watt figure to 0.5 watt with a special integrated circuit sense amplifier and/or reorganization of the memory to reduce the total number of sense amplifiers from 36 to 12.

N.S. Hitchcock.

11.3 Computer-Aided Design

11.3.1 Network Analysis Programmes

The ECAP programme has been modified to make it more compact. By minimizing the overlaying required when the programme is run on the CDC 3200, the programme will run faster, particularly for transient analysis. This is very desirable when the programme is being used from a remote terminal. The modification has entailed restricting the size of networks to 20 nodes and 60 branches. We are currently developing a technique for submitting a job to ECAP from the PDP-9 using the PDP-9 editor programme to create and modify the ECAP input statements which are then stored on magnetic tape and transmitted to the 3200. The results of the analysis will be returned to the PDP-9 where they will be typed or displayed on the CRT. This facility will provide an improved service for small analysis jobs but will chiefly be used for the further development of techniques for the input of circuit data and the display of results.

11.3.2 Computer Communication Link

The hardware for linking the PDP-9 to the CDC 3200 has now been completed and tested. Software packages for both ends of the link have been written to carry out the data transfer and transmit diagnostic messages from user programmes in the 3200 to the PDP-9. A test programme has been written to test the link with a variety of data patterns.

CRC will install a SDS Sigma 7 computer towards the end of 1969, replacing the 3200, and the communication requirements of this new machine are being studied. Because of the greater distance to the new Computing Centre, it is likely that the present 12-bit parallel link will be replaced with a serial link.

11.3.3 Computer Graphics

The display system hardware is now operating very reliably and well. Experience is showing that the time taken to rewrite the display is not bothersome to the user, particularly when only one drum channel is being displayed. In fact, the momentary flicker that occurs serves to underline that action is being taken on his request.

A programme for drawing circuit schematics on the display, using the light pen, is being written. At the time of writing most of the functions needed for creating schematics of 2-terminal elements have been implemented and tested. The drawing programme builds up a data structure which is used by the display routines and will eventually be the source of the topological and numerical data required by an analysis programme. It is already apparent that the input of circuits by this means is very fast, error proof, and appears natural and convenient to the user.

11.3.4 Automated Semiconductor Device Measurements

It is proposed to build an automated measuring set using a programmable frequency synthesizer as a driving source and a programmable vector voltmeter as the sensing element to measure transistor admittance parameters over the 1 - 100 MHz frequency range. The transistor will be mounted in a measuring jig and terminated by 50 ohm impedances. The parasitic elements in the jig will be estimated so that an equivalent circuit can be constructed and this will be verified and adjusted by various calibration procedures. The Y parameters of the transistor will then be obtained by calculation from the measurements. Experiments carried out so far over the range 10 - 60 MHz have indicated that it is practicable to obtain a satisfactory equivalent circuit for the measuring jig. Design work for the interface to the PDP-9 computer is proceeding.

M.A. Maclean, H.G. Bown, R.G. Fujaros, H.M. Grant, J.B.Kenney, R.E. Warburton

11.4 Low Noise Receiver Preamplifiers

ISIS-B

Due to dissatisfaction with the AGC circuit in the ISIS-I sounder receiver; i.e., poor temperature stability and low accuracy at low signal levels, a new AGC circuit was designed and tested. With this circuit the AGC voltage logarithmic response over a 40 dB range and the signal level can be read to within ± 1 dB over the operating temperature range without having to apply a temperature correction. Due to the circuits involved, signal levels up to the saturation level of the input stage can be handled without serious distortion. The AGC stages consist of long-tail pairs in which one transistor acts as a common-base amplifier and the other as a diode. Varying the current in the diode produces the AGC action, with four stages being used.

ISIS-C

An analysis and measurement investigation was carried out to determine the noise characteristics of bipolar transistors at relatively high current levels (i.e., up to 20 mA). This was done in order to check the noise model for junction transistors, since for low distortion they must operate at higher currents than the best noise figure requires. Also, there was some suspicion that the noise level increased very rapidly with higher currents. The transistors tried were the 2N918, 2N2222, and 2N2501, and the frequency range was 1 to 20 MHz. The noise levels were predicted fairly well by the model and the expected excessive rise at high currents did not appear. The effect of f_T on noise was clearly visible as well. The noise figures of three heavily fed-back amplifier circuits with low distortion were measured and they agree fairly well with theory. This investigation is for the ISIS-C receiver and will appear in the front-end report now being written.

R.F. Hahn has completed experimental work on a test setup to measure intermodulation levels of 120-130 dB above 1 microvolt. The report is in preparation.

R.J. Bonnycastle.

11.5 ISIS-C VLF Receiver

No further work on the ISIS-C VLF receiver has been carried out during this reporting period.

T. Nishizaki.

11.6 Minimum Conversion Loss Mixers

The classical development of the theory of balanced-ring mixers terminated in frequency selective networks assumes that at unwanted frequencies the impedances are either zero or infinite. It was therefore decided that, in order to apply the theory directly to the wideband input case, it would be necessary that the input filter network present either a very low or a very high impedance to the mixer at unwanted frequencies. A computer-aided study was carried out to evaluate various networks as possible input networks. It was found that the impedance at the unwanted frequencies could not be made to remain sufficiently high or sufficiently low for broad enough frequency ranges to warrant the assumptions required by the theory. However, a theoretical investigation has just been completed for the case where the input network exhibits finite reactive impedances at the unwanted signal frequencies and it is assumed that the output is terminated in a simple high Q series or parallel tuned RLC network tuned to the IF. This theory predicts that even when the values of the reactances presented to the mixer input at the unwanted frequencies are of the same order of magnitude as the source resistance, it should be possible to obtain relatively low ($\approx$1 to 2 dB) values of conversion losses. These results are now being experimentally investigated.

Also investigated during this reporting period was a receiver front-end design which is related to the above. The input to the mixer is still low-pass filtered. However, in this case, the mixer is terminated in a series tuned impedance transforming network which is now assumed to be lossless. The output of this network is then amplified in a very low-noise FET amplifier. Although this configuration theoretically results in an infinite power conversion loss through the mixer, it was thought that since there was negligible thermal noise generated within the mixer, the design might result in a very low-noise figure. A mixer designed to operate over the signal frequency range of 100 to 450 kHz with an IF of 500 kHz was therefore developed. It was found that interwinding capacitances in the signal transformer permitted signal feedthrough to the mixer diodes resulting in excessive losses. The signal transformer was rewound to minimize this capacitance. The mixer and system thus developed had a wideband noise figure of approximately 5-6 dB dipping to as low as 3.5 dB at certain frequencies. This corresponds to a unity SNR minimum detectable signal of approximately 0.16 to 0.18 μv in series with a source resistance of 500Ω and operating in an IF bandwidth of 1 kHz.

The above two configurations are both capable of very low-noise figures. However, in the first case the noise figure is inherently limited to approximately 3 dB since the mixer is power matched to the source. In the second case a power match does not exist. However, in operation, the second system gave a noise figure of approximately 5 to 6 dB. Therefore, if the first system is not very lossy and is followed by a very low-noise amplifier, it could have a better noise figure. It may be that one of the two systems may have merits over the other when fed from a somewhat reactive antenna. Furthermore the intermodulation performance of the two systems must also be compared. A report on all of the above work is now being written and should be completed shortly.

R.J.P. Douville.

11.7 Microelectronics Facility

The clean room, although not completed, was taken over during the last week of May. Remaining work to be done includes the installation of the grills for correcting the direction of the air exiting from the photoresist room and modification to the humidification system. With regard to the humidification system, it was learned only recently that the central steam system, which was to be used to supply the humidity, contained additives such as amines and phosphates. Such chemicals, if precipitated out in the work area, would be detrimental to the operation of the integrated circuits, hence a clean humidifying system must be provided.

The various fabrication and assembly equipment, for hybrid circuits, are being moved into the clean room and made operational.

Although the diffusion furnaces have been received, these have been set aside in deference to mastering the skills necessary for the production of hybrid circuits. Due to financial and manpower constraints, purchase of the epitaxial and insulator deposition equipment has been postponed.

A.R. Molozzi.

11.8 The Soft Electron Spectrometer (SES) Rocket Experiment

DRTE personnel arrived at the Churchill Research Range on 20 February, 1969, to check out experiments in NRC rocket vehicles ABD-VB-23 and 24. These experiments included the 7th and 8th in a series of SES rocket instruments built for the Plasma Physics Section of RPL. The spectrometers were removed from their respective payloads on 21 February to check all the major circuit parameters against earlier calibration data. No significant changes in the electrical performance of the instruments had occurred as a result of payload integration and subsequent shake tests. The interference pulses on the SES output, associated with the commutation of the H.T. monitor line, were present in both payloads. The mechanical commutator was generating sharp 3 to 4 volt negative peak pulses on the low impedance monitor line. From the monitor line these large pulses were being coupled into the SES preamplifier. The addition of a

.01 μfd capacitor from the monitor line to ground in each electronic box satisfactorily resolved the problem.

Two sets of dynodes were activated on 22 February for the flight detector modules. By 7 March the detector for VB-24, which had been exposed for 6 days during test runs and aborted launch attempts, was somewhat down in gain. Two more sets of dynodes were activated 7 March and one of these put into the VB-24 detector for the remainder of the launch period. The VB-23 detector, which had been kept under vacuum since 22 February, had not deteriorated significantly by 7 March. It was considered to be sufficiently active to remain on flight standby status, under vacuum, for another two or three weeks if necessary. It was finally flown on 31 March without further vacuum tests and with an accumulated exposure time of about 80 hours. The VB-24 detector remained on standby in vacuum until the launch period terminated 11 April, without a suitable Type A auroral event (red aurora).

ABD-VB-23 was fired 31 March, into an intense but common, 5577 auroral event in the absence of a relatively rare Type A event. High voltage breakdown occurred in the SES from H.T. turn-on at T +63 seconds until T +64 seconds when full recovery occurred. About 90 seconds of data were obtained before re-entry. An investigation is to be made using the flight spare in an attempt at isolating the cause of the breakdown.

Calibrations of the newly designed curved deflection plate apertures, first used in January 1969, had frequently indicated an apparent instability in the deflection factor for electrons below 100 ev. It had been established that the variation was not due to changes in the deflection plate voltages or the mechanical geometry controlling the deflection factor. On 3 March, after some further vacuum diagnostic measurements of the deflection factor problem, the teflon blocks supporting the deflection plates were found to be negatively charged. The off angle soft electrons appeared to be striking the teflon spacer material at the top and bottom of the deflection plate cavity, causing a negative charge to form on some of the exposed surfaces of the insulating teflon support. The associated electrostatic field seemed to have a pronounced influence on the electrons, particularly the lowest energy ones below 100 ev. The effect was clearly demonstrated by manually charging or discharging the teflon blocks and observing a corresponding change in the apparent deflection factor. It was also possible to demonstrate that if the blocks were manually discharged, they could be recharged with electrons from the calibration source. Limited modifications were made at CRR, to the flight detectors, by machining away some of the exposed teflon. Although the results were encouraging, the improvement was small. More extensive modifications and diagnostic tests are now underway in the Plasma Physics Section to correct the problem.

Diagrams of the most recent electronic circuits are now completed and calibration data for all the instruments flown to date are being consolidated for reference purposes. The VB-24 rocket has been shelved until January 1970, when it will again be put on standby for Type A aurora.

G.T. Bird.

12. ISIS TRAVEL

Mar.	18-20	F. Daniels	Westmount
	5 - 6	J.A. Moffatt	"
	6	J. Else	"
	6	D. Henderson	"
	7	R. Hahn	"
	4 - 7	R. Gruno	Asheville, N.C.
	6	G. Mackie	Westmount
	12	J. Tennuci	"
	6	H. Raine	"
	5	J. Tennuci	"
	6	F. Daniels	"
	11-12	J. Moffatt	"
	13	J. Matsushita	"
	11-12	J. Else	"
Feb.	22- 10 Mar.	W.S. Campbell	Norway
Mar.	26	J. Tennuci	Westmount
	19-21	J.Moffatt	"
	26	J. Moffatt	"
	27	J. Matsushita	"
	26	F. Daniels	"
	19-20	T. Hartz	"
	19-20	H. Raine	"
	19-21	J. Else	"
	20	J.P. Bennett	"
	19-21	J.Matsushita	"
	20	J. Tennuci	"
	20	N. Harrison	"
	19-20	R. Barrington	"
	19-20	D. Boulding	"
	19-21	C.D. Florida	"
	19-21	G. Mackie	"
	19-20	G. Lockwood	"
Apr.	2	J. Moffatt	"
	10	J. Moffatt	"
	2	J. Tennuci	"
	1- 2	G. Mackie	Cold Spring, N.Y.
	10	N. Harrison	Westmount
	8- 9	F. Daniels	"
	10	J. Bennett	"
	1	J. Matsushita	"
	10	J. Else	"
	1- 2	J. Else	"
	9	R. Bonnycastle	"
	10	J. Tennuci	"
	13-14	J. Tennuci	Cold Spring,N.Y.
	17	J. Matsushita	Westmount
	16	J. Tennuci	"
	16	J. Moffatt	"
	17	J. Else	"
	17	F. Daniels	"
	17	J. Boulding	"
	23	J. Matsushita	"
	24	J. Moffatt	"

Apr.	23-24	J. Else	Westmount
	23	D. Boulding	"
	23	G. Mackie	"
	23-24	F. Daniels	"
	24	J. Tennuci	"
	17	R. Bibby	"
	30 - 1 May	J. Moffatt	"
May	1	F. Daniels	"
	1	J. Else	"
	1	G. Mackie	"
	1	R. Bibby	"
	1	J. Matsushita	"
Apr.	30	J. Tennuci	"
May	7	J. Tennuci	"
	7	J. Else	"
	7	J. Moffatt	"
	7	G. Mackie	"
	9	R. Aiken	"
	15	G. Mackie	"
	14-15	J. Else	"
	14-15	J. Moffatt	"
	22	F. Daniels	"
	15	F. Daniels	"
	22	J. Tennuci	"
	15	J. Tennuci	"
	13	J. Tennuci	"
	22	J. Moffatt	"
	22	G. Mackie	"
	28	J. Else	"
	27	N. Harrison	"
	20-22	N. Harrison	Los Angeles
	29-30	J. Moffatt	Westmount
	29-30	J. Matsushita	"
	22	J. Bennett	"
	29-30	J. Tennuci	"
	29-30	G. Mackie	"
	29-30	F. Daniels	"
Jun.	4	J. Bennett	"
	4	J. Tennuci	"
	4- 5	F. Daniels	"
	11	J. Else	"
	4- 5	J. Else	"
	4- 5	J. Matsushita	"
	11	J. Matsushita	"
	4	H. Raine	"
	11	R. Bonnycastle	"
	5	N. Harrison	"
	4- 5	G. Mackie	"
	11	R. Hahn	"
	4- 5	J. Moffatt	"
	12	J. Moffatt	"
	18	J. Moffatt	"
	9-13	J. Tennuci	Philadelphia
	19-20	G. Mackie	Westmount

Jun.	19	J. Tennuci	Westmount
	19-20	F. Daniels	"
	25-26	F. Daniels	"
	24-25	D. Boulding	Toronto
	24-25	C.D. Florida	"
	25	J. Else	Westmount
	26	J. Moffatt	"
	26	J. Tennuci	"
	24-25	J. Matsushita	Toronto
	24-25	H. Raine	"
	25-26	G. Mackie	Westmount
	20	J. Bennett	"
	25-28	A. Molozzi	Phoenix

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J. Else	1
J. Mar	1
Project Manager (Contractor)	8
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E.S. Warren	1
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E. Atkins	1
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R.A. Ironside DSS	1
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and Telecommunications, Kokubunji, P.O.
Tokyo, Japan ------------------------------------- 1