ROYAL AIRCRAFT ESTABLISHMENT

Technical Report 71172

August 1971

ORBITAL OPERATIONS HANDBOOK FOR THE X3 SATELLITE

by

V. W. Adams

CORRIGENDUM

Page No. 4.2 Orbital Elements

8 The nominal orbital elements have been changed and are now as follows:-

Apogee 1540 km	Inclination 82.2°
Perigee 550 km	Eccentricity 0.0665
Period 106 ±1 min	Longitude of ascending mode 140°
	Rate of change of ascending mode -805° per day
	Argument of perigee 337°
	Mean anomaly 8.027°
	Mean motion 4892° per day

The nominal injection cordinates are now as follows:-

Latitude -13.73°

Longitude 137.95°

Launch time 0400Z

11 Table 1

The Baudot code for command number 32 should read 'OFIG' and not 'OAG'

35 Last line - 'section 5.3' should read 'section 5.2'

45 Add - 'IRDT Motor Pressure' to list of Rocket third stage data.

Fig.4 Delete 'DAO2' under syllables 19, 35, and 51 of Rocket 3rd stage mode direct format and insert 'IRDT'.

UDC 629.19.085 : 629.195

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SUMMARY

The purpose of this Handbook is to provide general information to those concerned with X3 orbital operations. For detailed information on the ground stations and the RAE Control Centre (DATA CENTRAL) the reader is referred to the relevant ESRO and RAE support documents.

Departmental Reference: Space 378

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CONTENTS (Contd)

1 INTRODUCTION

The X3 satellite, the first technological spacecraft in the British National Space Programme, is scheduled to be launched on a Black Arrow vehicle in late 1971.

The spacecraft carries experiments to investigate performance of solar cells, characteristics of thermal surfaces, micrometeoroid flux and performance in orbit of a hybrid electronics package: section 4.4 gives details.

In addition newly developed data, telemetry, telecommand and power system will be tested in orbit. The micrometeoroid flux experiment has been contributed by the University of Birmingham, England.

2 RESPONSIBILITIES

2.1 Project management

The Procurement Executive, Ministry of Defence is responsible for project management of the spacecraft and launch vehicle systems. Arrangements for a Black Arrow launch at Woomera are made with the cooperation of the Weapons Research Establishment (WRE).

2.2 Spacecraft

The MOD(PE) is responsible for the design of the spacecraft and its support systems, integration, pre-launch testing and spacecraft-launcher integration.

The contractor responsible for the spacecraft mechanical construction and handling is the British Aircraft Corporation (BAC). Marconi Space and Defence Systems are responsible for the spacecraft electrical and communications systems, assembly, integration and test. They also supply the Operations Team for the spacecraft.

2.3 Tracking, data acquisition and spacecraft control

The MOD will provide orbital elements for the spacecraft's lifetime and ESRO will provide contingency tracking facilities.

The Satellite Control Centre and Telecommand Station at the Royal Aircraft Establishment, Farnborough, (DATA CENTRAL), the MOD(PE) VHF telemetry station at Lasham, RAE, and the European Space Tracking and Telemetry Network (ESTRACK) will provide primary data acquisition support for the lifetime of the spacecraft.

2.4 Orbital calculations

The RAE Satellite Control Centre and the ESRO Control Centre have responsibility for computing the orbit of the X3 spacecraft and for generating predictions to participating stations.

2.5 Data processing and reduction

The processing and reduction of the X3 telemetered data are the responsibility of the RAE (Space Dept.), (MOD(PE)).

2.6 Data analysis

The individual experimenters and sub-system designers involved in the X3 project will be responsible for the final analysis and interpretation of data.

3 ORGANISATION PROCUREMENT EXECUTIVE, MINISTRY OF DEFENCE

The following sections summarise the major responsibilities of MOD(PE) personnel assigned to support the X3 project.

3.1 Project Manager

Mr. R. Mawson of Space 3(b), MOD(PE) is the Project Manager and represents the Ministry in all activities pertaining to the Black Arrow X3 project.

3.2 Project Officer

Mr. B.W. Jacobs of Space Department, RAE, is the Head of the X3 Project Office.

3.3 Head of Spacecraft Operations

Mr. D.D. Hardy of Space Department, RAE is responsible for coordinating the activities of the various organisations involved with the project operations. He is also the network controller Woomera (NCW) during the launch period.

3.4 Satellite Controller

Mr. V.W. Adams of Space Department, RAE is responsible for specifying all spacecraft control requirements and all Telemetry and Telecommand support needed to fulfil the project.

3.5 Control Centre Operations

Mr. E.A.R. Anstey of Space Department, RAE is responsible for the operations at DATA CENTRAL. Mr. E. Jones of Space Department is responsible for the routine running and organisation of DATA CENTRAL.

3.6 Telemetry Station at RAE Lasham

Mr. M.J. Hammond of Space Department, RAE is responsible for the operation of the Telemetry Data Acquisition Station at Lasham.

3.7 Orbit Operations Team

The Control Centre at DATA CENTRAL and the telemetry station at Lasham will be manned by personnel from Space Department, RAE and Spembly Electronics Ltd.

4 IMPLEMENTATION

4.1 Launch vehicle

The X3 satellite will be launched by a three-stage Black Arrow vehicle, shown in Fig.1. Westland Aircraft is the main vehicle contractor and Rolls Royce supply the first and second stage motors. The third stage solid apogee motor designated 'Waxwing' has been developed by The Rocket Propulsion Establishment, Westcott, using a tube and nozzle manufactured by Bristol Aerojet.

4.2 Orbital elements

The X3 satellite will be launched from the WRE range at Woomera, Australia (longitude 136.5° E) into an eccentric near-polar orbit. A plot of the sub-satellite ground trace is shown in Fig.2. The nominal orbit parameters are as follows:-

Apogee	1850 km	Inclination 82.1°
Perigee	550 km	Eccentricity 0.085509
Period	109 ±1 min	Longitude of ascending node 140°
		Rate of change of ascending node 0.761° per day
		Argument of perigee 337°
		Mean anomaly 7.5207°
		Mean motion 5450° per day.

The nominal injection coordinates are as follows:-

Latitude	13.66°
Longitude	138.02°
Launch time	0430Z

4.3 Spacecraft

X3 is a spin-stabilised spacecraft with an external shape similar to a pumpkin. Its equatorial diameter is approximately 1.2 metre and its height approximately 0.7 metre. The spacecraft weighs about 70 kg and will be spin-stabilised at about 180 rev/min.

The general configuration is shown in Fig.3. For a full description see the Operations Manual for Black Arrow X3 Satellite, volume I, published by MSDS Ltd.

4.3.1 Configuration and structure

The spacecraft structure is built round a central box assembly comprising four panels, internal and external corner angles, and top and bottom corner fittings, all of which are bonded and bolted together. The bottom fittings form the separation plane of the craft, and provide attachment to the third stage electronics bay. The main four panels of the central box are used as mounting platforms for telemetry, command, storage battery, power control and experiment equipment. Eight large segments, designated modules, and eight small segments,designated fillets, comprise the outer structure of the satellite and are attached to the outer edges of the top and bottom fittings.

The modules which are hinged at their upper ends to provide access to the spacecraft interior carry the power generating solar cells, the experimental solar cells and associated aspect sensors. The fillets carry the thermal control surface units with experimental surface finishes. Two of the fillets have nutation dampers fitted to their inside surfaces.

Four telemetry aerials are mounted 90^{o} apart on the base of the spacecraft.

4.3.2 Power supply system

An array of silicon solar cells is the main power source for X3. Power during solar eclipses is provided by a storage battery consisting of twelve nickel-cadmium cells, each with a 6 ampere-hour capacity. Auxilliary equipment includes battery charging circuitry, a dc to dc converter, voltage regulators and a power distribution system.

The solar array comprises 3360 silicon solar cells mounted on the eight satellite modules in patches of 42 cells each. Four alternate modules carry four patches on each of their three facets whereas the remaining four modules carry four patches on their upper and lower facets only.

4.3.3 Telemetry system

The X3 satellite employs a PCM/PM split phase code telemetry system, with data time-multiplexed into an 8 bits per syllable, 64 syllables per minor frame, 64 minor frames per major frame format. The telemetery format is shown in Figs.4-6.

Real time data is transmitted at a rate of 2048 bits/second after being encoded by a high speed encoder. A low speed encoder with 1/32 sampling rate of the high speed encoder enables real time data to be recorded on a magnetic tape recorder which will record approximately 120 minutes of data. Sixteen seconds after receipt of a command signal, the tape recorder changes from the record mode to the playback mode which lasts approximately four minutes at 32 times the speed of the record mode. The recorded data is erased after the tape passes the playback head, and the recorder automatically reverts to the record mode at the completion of playback if record mode has not been commanded.

(a) Telemetry transmitter

The PCM output from either the high speed encoder or the tape recorder phase modulates a crystal controlled transmitter operating at a frequency of 137.56 MHz. Two transmitters are provided, and either one may be selected on a command signal from the ground. The RF power output from either transmitter is 300 mW. The RF signal bandwidth is about 8 kHz and 25% residual power is left in the carrier for tracking purposes.

4.3.4 Antenna system

The spacecraft antenna is omnidirectional, circularly polarised with a minimum gain of -5 dB. The antenna system is used for both telemetry transmitters and command receivers; a hybrid and filters provide the necessary isolation. The on-board transmission loss is -2 dB.

4.3.5 Command system

The X3 spacecraft utilises a PDM/AM/AM tone digital command system to NASA standards with a capacity of 40 commands. Table 1 gives a command list. The command carrier (148.25 MHz) is 75% modulated by a pulse modulated audio tone (7.0 kHz). The audio tone is pulse duration modulated by the coded digital command.

Two command receivers are simultaneously in use and the receiver with the larger input signal overrides the other. The output from the command receivers is coupled to two command decoders each with a separate address code. The decoder outputs are combined so that whichever one is addressed, the command is executed.

4.3.6 Stabilisation and attitude measurement

The X3 spacecraft is spin stabilised, and in support of the solar cell and thermal control surfaces experiments, sun and earth sensors are used to determine the spin axis orientation.

Table 1

Telecommands

Command number	Address word (octal)	Baudot	Decimal	Command
	140	PT	06.00	Decoder A
	237	B LET	09.15	Decoder B
Command number	Execute word (octal)			Command
1	360	LETT	15.00	Hybrid electronics experiment OFF
2	314	MM	12.12	Hybrid electronics experiment ON
3	303	MW	12.03	Thermal control surfaces experiment OFF
4	017	T LET	00.15	Thermal control surfaces experiment ON
5	063	WW	03.03	Transmitter OFF
6	074	WM	03.12	Transmitter ON
7	252	GG	10.10	Transmitter A
8	251	GB	10.09	Transmitter B
9	246	GP	10.06	Not allocated
10	245	GY	10.05	Not allocated
11	232	BC	09.10	Birmingham EHT ON/OFF
12	231	BB	09.09	Birmingham test pulse
13	226	BP	05.06	Command 'normal mode'
14	125	YY	05.05	Command 'surfaces mode'
15	126	YP	05.06	Command 'rocket third stage mode'
16	131	YB	05.09	See below between commands 36 and 37
17	132	YG	05.10	Command tape recorder to record
18	145	PY	06.05	Command tape recorder to playback
19	146	PP	06.06	Clock A
20	151	PB	06.09	Clock B
21	116	HV	04.14	HS divider A
22	123	YW	05.03	HS divider B
23	134	YM	05.12	LS divider A
24	143	PW	06.03	LS divider B
25	152	PG	06.10	HS (parallel to serial converter OR gate and Bi-phase-C converter) A
26	154	PM	06.12	HS (parallel to serial converter OR gate and Bi-phase-C converter) B
27	161	QZ	07.01	LS (parallel to serial converter OR gate and Bi-phase-C converter) A
28	162	QL	07.02	LS (parallel to serial converter OR gate and Bi-phase-C converter) B
29	164	QH	07.04	A-D converter, A on HS and B on LS
30	170	QO	07.08	A-D converter, A on LS and B on HS
31	207	OQ	08.07	HS parallel digital multiplexer A output gates
32	213	OAG	08.11	HS parallel digital multiplexer B output gates
33	215	OX	08.13	LS parallel digital multiplexer A output gates
34	216	OV	08.14	LS parallel digital multiplexer B output gates
35	223	BW	09.03	Data switching gates A on
36	225	BY	09.05	Data switching gates B on
16	131	YB	05.09	A-D converter A switching gates on
37	234	BM	09.12	A-D converter B switching gates on
38	243		10.03	Not allocated
39	254		10.12	Not allocated
40	261		11.01	Not allocated

(a) Spin rate

The third stage of the Black Arrow launcher spins up the spacecraft to 20 rad/s and this spin rate decays throughout the lifetime of the satellite.

(b) Nutation control

A nutation damping system is used to reduce the effects of spacecraft oscillation about the spin axis. This system consists of two tubes, one on the inside of each of two opposite fillets, filled with fluid. The motion of a ball inside each tube produces frictional forces tending to cancel the nutation effects.

(c) Attitude measurement

Two attitude sensor units are mounted on the equatorial facets of two diametrically opposite spacecraft modules, to provide redundancy. Each attitude sensor is a combination of two sun sensors and one earth horizon sensor. When stimulated, the pulses from the sensors start and stop counters driven from one of the satellite clocks, and the position of the spin axis can be determined to better than 1^o.

4.3.7 Heat balance and temperature control

A thermal design for the X3 satellite was developed in order to meet the temperature limits for the on board equipment. The internal ambient temperature is controlled by the use of bare metal surfaces, black painted surfaces and insulating blankets on the outside, and white paint on the inside, of the spacecraft.

Twelve thermistors are located on the spacecraft structure and thirteen are located on various units, for monitoring temperatures.

4.4 Experiments

The purpose of the experimental equipment on board the X3 spacecraft is to investigate and monitor the following:-

(a) The performance of thermal control surfaces.

(b) The performance of thin silicon solar cells and solar cell covers in space.

(c) The performance of lightweight satellite electronic systems in space, designated the hybrid electronics experiment.

(d) The flux of micrometeroids down to 0.1 micron or 10^{-14} g in size.

The experiments are detailed in the following sections.

4.4.1 Thermal control surfaces experiment

The purpose of this experiment is to measure the change due to the space environment, in the solar absorption and infra-red emittance of the experimental thermal control surfaces.

The values of absorption and emittance are calculated from calorimetric measurements employing gold plated sensor plates and thermistors.

Data from 96 channels is monitored when the data handling system is commanded into the surface mode.

The experimental thermal control surface units are mounted on the upper and equatorial facets of four satellite fillets.

4.4.2 Solar cell experiment

This experiment is designed to measure the performance and temperature of thin silicon solar cells. The short circuit current, current near the maximum power point and open circuit voltage are measured on three patches of cells. Short circuit current only is measured on a further three patches of cells which are irradiated with 10^{16} electrons cm^{-2} of 1 MeV energy before launch. In this way their performance should not change appreciably during the orbital lifetime so that any observed change may be attributed to the cell cover slips.

The solar cell patches are mounted on the equatorial facets of two diametrically opposite satellite modules, are thermally insulated from the modules and have their temperatures monitored.

The measurements are sampled when the data handling system is commanded to the solar cell mode.

4.4.3 Hybrid electronics experiment

This experiment, designed and made at the RAE, Farnborough, is to prove the performance in space of lightweight hybrid assemblies made up from film resistors, chip capacitors, and unencapsulated devices mounted on alumina substrates with conductor patterns. The experiment subsystem consists of a voltage to digital converter and an analogue multiplexer used to select calibration voltages from a potential divider. The multiplexer output is applied either to the experimental voltage to digital converter or the converter in the satellites data handling system. Comparison between the experimental and satellite systems will be made.

In order to monitor their behaviour, the voltage applied to the potential divider and the outputs from the two converters, are sampled.

4.4.4 Micrometeoroid experiment

This experiment measures the flux of micrometeoroids impinging on the spacecraft. A new detection method, which involves the measurement of charge released when a particle strikes a surface, is employed, and is expected to detect particles down to at least 0.1 micron diameter or 10^{-14} g mass. Electric currents of the order 10^{-5} amp are detected using particle multiplier techniques. The experiment is mounted close to the upper surface of the spacecraft and micrometeoroids enter through a port. Positive ions produced when a particle strikes a target plate are accelerated in an electric field to the first dynode of an electron multiplier which is at −2.5 kV with respect to the target. The multiplier has a current gain of the order 10^5 and is filled with dry argon at a pressure of half an atmosphere prior to launch. After launch, a vacuum tight flap opens under spring pressure when the ambient pressure falls to a predetermined value. The output signal of the multiplier is amplified, and spurious counts due to random noise or photo emission are masked by pulse amplitude and width discrimination. Two checks may be made in orbit on command from the ground. The first test produces a pulse of electrons from a UV source, which impinge on the first dynode, and in the second test a pulse is applied to the input stage of the amplifier.

4.5 Satellite tracking

During the launch and early-orbital stages the X3 spacecraft and launcher will be tracked by the following organisations:-

WRE Range Instrumentation Facilities and the Queensland Telemetry Station at Charters Towers.

Ministry of Defence.

During the normal orbital stage the spacecraft orbital elements will be provided by the MOD.

4.6 Command and data acquisition

Space Department, RAE will have primary responsibility for commanding the X3 spacecraft and acquiring data. The ESTRACK organisation will provide data acquisition support and will be required to send commands during the early part of the spacecraft's lifetime.

4.7 Orbit determination

The MOD will provide the orbit elements for the X3 satellite. Orbit predictions will be provided by DATA CENTRAL and the European Space Operations Centre (ESOC).

4.8 Spacecraft performance monitoring and control

Monitoring and operational control of the X3 spacecraft will be conducted from the RAE Control Centre, Space Department, RAE, Farnborough (DATA CENTRAL) supported by the ESTRACK network of ground stations, and the RAE Telemetry Station at Lasham.

5 OPERATIONS AND CONTROL

5.1 Introduction

The operations of the ESTRACK network and the RAE telemetry and command ground support facilities are the responsibility of ESRO and MOD(PE) respectively. All operations will be controlled from DATA CENTRAL either directly or through ESOC, Darmstadt. The organisation, facilities and operational procedures for discharging these responsibilities are specified below.

5.2 Launch and early orbit phases

The X3 spacecraft will be launched from the WRE range at Woomera, and the nominal sequence of events for the first 24 hours after lift-off is summarized opposite in Table 2.

5.2.1 Vehicle tracking and data acquisition

The launch vehicle will be tracked from lift-off to third stage separation and launch vehicle telemetry will be acquired to loss of signal. The launch data and flight telemetry will be reported from WRE to the RAE (DATA CENTRAL) for further reporting to all stations as soon as possible after launch.

5.2.2 Spacecraft tracking

During the early orbit phase the X3 spacecraft orbital elements will be provided by the MOD.

Table 2

Early orbit schedule

Notes:- Times are approximate and based on nominal orbit predictions.

Q/L 1, 2 or Auto refers to quick-look operations, see section 5.6.2 and section 5.6.1(a).

OMS 20 and OMS 28 are ESRO message numbers for quick-look and pass reports, respectively.

The following abbreviations are used in Table 2.

AOS - acquisition of signal
ESOC - European Space Operations Centre
FAL - Falkland Islands
FBA - Fairbanks, Alaska
LM - Lasham
LOS - loss of signal
MOD - Ministry of Defence
NCW - Network Controller, Woomera
Q/L - quick-look
RAE - Royal Aircraft Establishment, Farnborough
SPI - Spitsbergen
T - Teleprinter
T/C - Telecommand
V - Voice

Orbit	T + time	Stn.	T/C No.	Q/L	Event	Comms.
	00.01				Approx. lift-off time NCW - RAE/MOD - ESOC	T
	00.10				Lift-off time NCW - RAE/MOD - ESOC	T
	00.10				Injection into orbit	
	00.14				Lift-off time RAE - Lasham	V
1	00.15				Injection report NCW - RAE/MOD - ESOC	T
1	00.15				Close NCW/RAE and RAE/ESOC voice links	V
1	00.15				Injection report NCW - RAE/MOD - ESOC	T
1	00.35	FBA			AOS	
1	00.37	FBA			S/C carrier modulated? FBA - ESOC - RAE - MOD/NCW	T
1	00.38	FBA			S/C carrier modulated? RAE - Lasham	V
1	00.39	FBA		1	Max Ele 25°	

Table 2 (Contd)

Orbit	T + time	Stn.	T/C No.	Q/L	Event	Comms.
1	00.42	FBA			LOS	
1	00.48	FBA			OMS 28: FBA - ESOC - RAE (RAE calculate spin)	T
1	00.55				OMS 20: FBA - ESOC - RAE	T
1	01.20	FAL			AOS	
1	01.22	FAL		1		
1	01.27	FAL	18		Replay on	
1	01.30	FAL			Orbit elements MOD - RAE - ESOC	T
1	01.31	FAL	17		Record mode	
1	01.34	FAL			LOS	
1	01.37	FAL			OMS 28: FAL - ESOC - RAE (RAE calculate spin)	T
1	01.54	FAL			OMS 20: FAL - ESOC - RAE	T
2	02.00				Nominal orbit RAE - NCW/ESOC	T
2	02.25	FBA			AOS	
2	02.26	FBA		1		
2	02.29	FBA	18		Replay on	
2	02.29	FBA	14		'Surfaces' mode on	
2	02.33	FBA	17		Record mode	
2	02.35	FBA			LOS	
2	02.41	FBA			OMS 28: FBA - ESOC - RAE (RAE calculate spin)	T
2	02.55	FBA			OMS 20: FBA - ESOC - RAE	T
3	04.17	FBA			AOS	
3	04.18	FBA		1		
3	04.21	FBA	18		Replay on	
3	04.21	FBA	13		'Normal' mode on	
3	04.25	FBA	17		Record mode	
3	04.33	FBA			LOS	
3	04.34	FBA			OMS 28: FBA - ESCO - RAE (RAE calculate spin)	T
3	04.53	FBA			OMS 20: FBA - ESOC - RAE	T
4	06.07	FBA			AOS	
4	06.09	FBA		1		
4	06.14	FBA	18		Replay on	

Table 2 (Contd)

Orbit	T + time	Stn.	T/C No.	Q/L	Event	Comms.
4	06.18	FBA	17		Record mode	
4	06.24	FBA			OMS 28: FBA - ESOC - RAE (RAE calculate spin)	T
4	06.25	FBA			LOS	
4	06.45	FBA			OMS 20: FBA - ESOC - RAE	T
4	07.00				Voice and time check, RAE/LM, Request Lasham checkout: RAE - LM	V
4					Lasham system checkout starts	
5	07.59	FBA			AOS	
5	08.00	FBA		1		
5	08.00				Request Lasham simulation Test: RAE/LM	V
5	08.03	FBA	18		Replay on	
5	08.03	FBA	14		'Surfaces' mode on	
5	08.07	FBA	17		Record mode on	
5	08.11	FBA			LOS	
5	08.15	FBA			OMS 28: FBA - ESOC - RAE (RAE calculate spin)	T
5	08.30				Confirm Lasham readiness: LM-RAE	V
5	08.31	FBA			OMS 20: FBA - ESOC - RAE	T
5	08.32	RAE/ LM			Start set up phase for Orbit 6	V
6	09.00				Close RAE/NCW/MOD Teleprinter link	T
6	09.25				Confirm Lasham readiness: LM - RAE	V
6	09.29	LM			AOS confirm LM - RAE	V
6	09.30	RAE		Auto		
6	09.31	RAE	18		Replay on	
6	09.35	RAE	17		Record mode on	
6	09.36	LM			Max Ele 49^{o}	
6	09.37	RAE	13		'Normal' mode on	
6	09.45	LM			LOS confirm: LM - RAE	V
6	09.50	RAE			Start Q/L for Orbit 6	
6	10.30	RAE/ LM			Start set up phase for Orbit 7	V
7	11.20	LM			AOS confirm: LM - RAE	V

Table 2 (Contd)

Orbit	T + time	Stn.	T/C No.	Q/L	Event	Comms.
7	11.21	RAE		Auto		
7	11.22	RAE	18		Replay on	
7	11.26	RAE	17		Record mode on	
7	11.27	LM			Max Ele 31°	
7	11.27	RAE	14		'Surfaces' mode on	
7	11.34	LM			LOS confirm: LM - RAE	V
7	11.40				Start Q/L for Orbit 7	
8	13.22	SPI			AOS	
8	13.23	SPI		2		
8		SPI	18		Replay on	
8		SPI	17		Record mode on	
8	13.36	SPI			LOS	
9	15.10	SPI			AOS	
9	15.11	SPI		2		
9		SPI	18		Replay on	
9		SPI	17		Record mode on	
9	15.26	SPI			LOS	
10	17.00	SPI			AOS	
10	17.01	SPI		2		
10		SPI	18		Replay on	
10		SPI	13		'Normal' mode on	
10		SPI	17		Record mode on	
10	17.17	SPI			LOS	
	17.30				Request Lasham check out	V
10	18.00	RAE/ LM			Start set up phase for Orbit 11	V
11	18.55	LM			AOS confirm LM-RAE	V
11	18.56	RAE		Auto		
11	19.03	RAE	18		Replay on	
11	19.05	LM			Max Ele 38°	
11	19.07	RAE	17		Record mode on	
11	19.08	RAE	14		'Surfaces' mode on	
11	19.19	LM			LOS confirm LM - RAE	V
11	19.25	RAE			Start Q/L for Orbit 11	

Table 2 (Contd)

Orbit	T + time	Stn.	T/C No.	Q/L	Event	Comms.
11	19.45	RAE/ LM			Start set up phase for orbit 12	V
12	20.46	LM			AOS confirm LM-RAE	V
12	20.47	RAE		Auto		
12	20.50	RAE	18		Replay on	
12	20.54	RAE	17		Record mode on	
12	20.55	RAE	13		'Normal' mode on	
12	20.57	LM			Max Ele 76°	
12	21.13	LM			LOS confirm LM-RAE	V
12	21.20				Start Q/L for Orbit 12	
12	21.40	RAE/ LM			Start set up phase for Orbit 13	V
13	22.37	LM			AOS confirm LM-RAE	V
13	22.38	RAE		Auto		
13	22.40	RAE	18		Replay on	
13	22.44	RAE	17		Record mode on	
13	22.45	RAE	14		'Surfaces' mode on	
13	22.47	LM			Max Ele 24°	
13	22.58				LOS confirm LM-RAE	V
13	23.05	RAE			Start Q/L for Orbit 13	

5.2.3 Spacecraft data acquisition

Telemetry data acquisition during the launch and early orbit phases (3 weeks maximum) is the responsibility of the following stations and 24 hour coverage will be required.

(a) ESTRACK network stations:-

FAIRBANKS, ALASKA	(FBANKS)
FALKLAND IS.	(FALKIS)
REDU, BELGIUM	(REDUBE)
SPITSBERGEN	(SPITSB)

(b) RAE telemetry station at Lasham.

These stations will be scheduled by ESOC and DATA CENTRAL for data acquisition and quick-look operations. The telemetry carrier frequency is 137.560 MHz. All operations will be controlled from DATA CENTRAL via a teleprinter link with ESOC, Darmstadt and by direct link with Lasham.

Up to and including the fifth orbit, the spacecraft data will be acquired by the ESTRACK stations. After this phase, the main station will be Lasham with supporting facilities from the ESTRACK stations at FBANKS, FALKIS and SPITSB. The ESTRACK station at REDUBE will be required to acquire the spacecraft data during the first twelve orbits, and will be scheduled there-after only as a back-up (contingency) station.

During the launch and early-orbit phases, the RAE Control Centre (DATA CENTRAL) will control the spacecraft. Real-time telemetry data will be transmitted from Lasham to DATA CENTRAL during the pass, and quick-look operations will be performed at DATA CENTRAL both during and immediately following a pass.

(a) WRE Range (Woomera)

A check-out trailer will be manned during launch by the Spacecraft Operations Team, and the launch status of the spacecraft will be transmitted to DATA CENTRAL for information to all stations at T-6 minutes.

(b) Telemetry and telecommand support requests

The RAE Control Centre at DATA CENTRAL will request telemetry support and telecommand action in the form of 'Telemetry Support Request' messages. Requests will normally be sent weekly so as to arrive at ESOC/OFSO by mid-day Thursday and will include support requests for a period beginning Wednesday 0001Z and ending the following Tuesday 2400Z. A series of coded remarks will be listed, headings added to the data columns and orbit numbers added at the end of the line. Alternative passes will be indicated by the use of 'equals' signs.

ESOC will inform DATA CENTRAL of the accepted passes by transmitting a message in the same format as the request, under the heading 'Confirm the following requests'. This notification will be sent by midday Sunday prior to the scheduled period.

(c) Short notice requests

Short notice requests for special telemetry and telecommand support will be in the same format as request messages and headed 'Short Notice Requests'. They will be transmitted to ESOC Control (INFO OFSO) 24 hours prior to the operations requested.

When commands are sent by ESTRACK stations, ESOC will supply a pass report as soon as possible in the normal ESRO format.

5.2.4 Command

The launch and early orbit phases will normally last a maximum of three weeks and during this period it is intended to command the replay mode once per orbit. In addition, it is intended that the spacecraft mode will be changed, as scheduled by DATA CENTRAL, by sending commands 13 and 14. The Birmingham Expt. EHT will be switched on (command 11) and the Birmingham expt. calibrations performed (command 12).

The X3 spacecraft is capable of accepting 37 commands, and the data acquisition stations listed in section 5.2.3 will be responsible for commanding X3 as requested by DATA CENTRAL.

WARNING

The Birmingham EHT ON/OFF command (No.11) is to be sent only from the station at RAE, and special care must be taken not to transmit this command. Unscheduled transmission from ESTRACK stations could result in the command being invalidated since ESTRACK commands are normally sent twice as a matter of routine.

(a) Command format

The format of a command frame consists of the following coded works:

address, adress, execute, execute, execute, blank pulse period and a synchronisation pulse, where the first five words are each eight-bit words, as shown in Fig.7. Each command is preceded by a one half second transmission of unmodulated RF carrier and a command is effected by the reception of any one valid address word and any one execute word in the same series of five works.

Command encoding is effected with a PDM signal which has four states:-

(a) blank,

(b) synchronisation,

(c) logic 1,

(d) logic 0.

Address and execute words have a similar structure, i.e., a blank pulse period, a synchronisation pulse followed by an eight-bit digital code consisting of logic 1'S and 0'S.

(b) Command transmission

All commands transmitted from DATA CENTRAL are normally automatically sent on request by the operator. All commands from ESTRACK stations will be transmitted, when possible, by using punched paper tapes except when instructed by the RAE Control Centre. The punched paper tapes will be verified for the correct command format prior to the start of a pass.

Punched paper tapes will be prepared in accordance with the command format definition given in section 5.3.4(a).

ESTRACK stations must not have punched tapes containing command No.11.

(c) Tape recorder play-back commands

Transmission of the playback command (No.18) will be timed to occur after the satellite data telemetry signal has been acquired and after the satellite has reached an elevation of 10 degrees. To avoid loss of play-back data, the stations should ensure that play-back data is obtained as soon as possible after transmitting the play-back command. The following procedure will be used for DATA CENTRAL:

(a) At the scheduled time, transmit a complete command 18 (play-back) as defined in section 5.2.4(a).

(b) Verify tape recorder play-back by ensuring play-back data is received. If signal does not appear within a predetermined time, a contingency procedure, to be defined will be followed. At T + 230 seconds after sending

Command 18 a record command (No.17) will be sent. If this command 17 is unsuccessful, it should be repeated once. The X3 spacecraft has a timer, that should return the tape recorder to record mode approximately four minutes after a play-back command is received.

(d) Satellite clock commands

In order to obtain useful data from the solar cell experiment it may be necessary to command a change of satellite clock frequencies (commands 19 and 20). This is necessitated by the need to overcome possible synchronism of the two opposite solar cell patches with the spin of the satellite. Synchronism occurs every 7½ revolutions per minute from the nominal spin rate.

If required, a clock command (19 or 20) will be transmitted at the end of a play-back from the tape recorder.

(e) Birmingham experiment EHT ON/OFF Command

Command 11 switches the EHT supply to the Birmingham experiment either ON or OFF depending on the original state of this experiment. Since ESTRACK stations ordinarily send two commands as a matter of routine, the command No.11 must only be transmitted from the station at DATA CENTRAL.

5.3 Routine phase

The routine phase will begin when the spacecraft orbit has been determined, updated orbital predictions have been forwarded to all participating stations and the spacecraft has settled into routine operation. This phase should last for a period of 11 months.

5.3.1 Tracking

The MOD will provide tracking support during this stage, with limited contingency support from ESTRACK as requested by the RAE Control Centre.

5.3.2 Data acquisition

The RAE station at Lasham will provide primary data acquisition support, with limited support from ESTRACK as requested by the RAE Control Centre. It is proposed to monitor a total of 560 passes at the rate of about 50 passes per month. Sections 5.2.3(b) and 5.2.3(c) are also applicable to this section.

5.3.3 Command

During the routine phase it is intended to command the replay mode during every orbit monitored by the telemetry stations (i.e. 50 passes per month).

It is also anticipated that all the commands, in addition to the routine commands for replay, Birmingham cal. and mode change, will be transmitted at least once during this phase, as and when scheduled by DATA CENTRAL.

The sections 5.2.4(a) to 5.2.4(e) are also applicable to this section.

5.4 Equipment parameters

The equipment parameters to be used by the data acquisition stations are outlined in the following sections.

5.4.1 Telemetry receiving and recording

Set-up details for the equipment are listed below:

(a) Antenna parameters

Frequency band	137 to 138 MHz
Minimum gain	16 dB
Polarisation	circular

(b) Telemetry system

Frequency	137.560 MHz
Mode	phase lock
Loop noise bandwidth (double sided)	300 Hz*
AGC speed	1 to 3 ms.

(c) Magnetic tape recorder

Tape speed	7.5 ips

Track assignments for ESTRACK Stations, see Table below.

Magnetic tape recorder track assignments

Track	Record amplifier	Signal
1	Direct	Voice annotation WWV telecommand
2	Direct	LTSS reference frequency
3	FM	Conditional RT and TT data
4	Direct	PCM data from Group 2 receivers
5	Direct	PCM data from Group 1 receivers
6	Direct	NASA 36 bit timecode on 1 kHz carrier
7	Direct	FM multiplex. Irigs 1, 3, 5, 6, 7, 8, 9, 10, 11, 12 and 12.5 kHz ref frequency.

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* This figure refers to the Scientific Atlanta receivers used at Lasham. Receivers at other stations may have loop bandwidth defined in different terms. In this case bandwidth should be as low as possible consistent with reasonable ease of acquisition and maintenance of phase lock.

Note:- FM multiplex track 7 will contain the following:-

IRIG 1	non-coherent	AGC	R×1	Gp 1
3	"	"	R×2	Gp 1
5	"	"	R×1	Gp 2
7	"	"	R×2	Gp 2
8	"	"	Tracking error	
9	"	"	R×1	Gp 1
10	"	"	R×2	Gp 1
11	"	"	X	Tracking error
12	"	"	Y	" "

NB IRIG 6 contains the ground command receiver AGC

5.4.2 Command configuration

The command equipment configuration is summarised below. A list of commands, with Octal, Baudot and binary codes for each command, is shown in Table 1 in section 4.3.5.

(a) Antenna

Frequency band	148 MHz
Minimum gain	9 dB
Polarization	left and right hand circular

(b) Transmitter

Carrier frequency	148.250 MHz
Modulation	PDM/AM/AM
Percent modulation of RF carrier	75%
Minimum output power	200 watts

(c) Command encoder

Type	Tone digital
Tone frequency	7000 Hz.

5.5 Real-time data transmission

5.5.1 Lasham

Lasham will be scheduled by the RAE Control Centre to transmit spacecraft telemetry data in real-time to the Control Centre via the data link.

Voice and data circuits will thus be required for each pass and these circuits should be scheduled for a period of up to one hour, beginning 20 minutes prior to the start of a pass.

5.6 Quick-look operations

Quick-look operations will be performed on all scheduled data acquisition passes during the early orbit phase. After this period, quick-look operations will be scheduled at the ESTRACK stations as requested by the RAE Control Centre.

Decommutation of the real-time data from Lasham will be carried out at the RAE Control Centre (DATA CENTRAL) and a limited number of parameters will be displayed. Immediately after the end of a pass over Lasham quick-look operations and limited data processing will be performed and print-outs produced on the line printer for distribution to experimenters and sub-system designers (see section 8.2).

5.6.1 DATA CENTRAL decommutation and displays

(a) Automatic operations

The real time data from Lasham will be decommutated and the following operations are computer controlled:-

A spacecraft mode check will be made and the appropriate bits (24, 25 of the Sync Work) will be printed out.

One of the following automatic status checks will be scheduled for each pass:-

(a) A complete check and printout of all the status bits, i.e., all PGs from PG00 to PG37.

(b) A complete check and printout of those status bits which indicate a change from the launch status.

In addition, one of the following automatic performance checks will be scheduled for each pass:-

(a) A complete printout of all the performance parameters on the direct telemetry format, i.e., PPs from PP40 to PP83.

(b) A complete limit check selected performance parameters and print-out of those parameters which are outside the stated limits.

(b) Manual operations

The real time data from Lasham will be decommutated and the following channels on the Data Distributor (EMR 2745) selected for each scheduled pass.

(a) Digital

Parameter	Word	Frame
ID count	03	0
PGO	53	0
PG1	53	1
PG2	53	2
PG3	53	3

(b) Analogue

Parameter	Word	Frame
PP42	42	0, 8, 16, 24, 32, 40, 48, 56
PP47	58	1, 9, 17, 25, 33, 41, 49, 57
PP52	10	3, 11, 19, 27, 35, 43, 51, 59
PP54	42	3, 11, 19, 27, 35, 43, 51, 59
PP55	58	3, 11, 19, 27, 35, 43, 51, 59
PP56	10	4, 12, 20, 28, 36, 44, 52, 60
PP58	42	4, 12, 20, 28, 36, 44, 52, 60
PP61	26	5, 13, 21, 29, 37, 45, 53, 61
PP62	42	5, 13, 12, 29, 37, 51, 53, 61
PP66	42	6, 14, 22, 30, 38, 46, 54, 62
PP71	58	7, 15, 23, 31, 39, 47, 55, 63
PP73	33	All
PP79	10	0, 8, 16, 24, 32, 40, 48, 56
PP80	40	All
PP82	51	All
PP83	56	All
BPUL	50	All
BEHT	18	All

5.6.2 ESOC decommutation and display

The ESOC stations will decommutate and display the following channels, and during the launch phase (up to the first five orbits) will send a quick-look report to RAE via ESOC as soon as possible after a pass.

Quick-look No.1

(a) Octal

Parameter	Word	Frame	
AS03	37	8	8 consecutive values required
AS03	38	8	
AS04	45	8	
AS04	46	8	
Mode Id	03	0	
PG0	53	0	
PG1	53	1	
PG2	53	2	

(b) Analogue

Parameter	Word	Frame
PP42	42	0, 8, 16, 24, 32, 40, 48, 56
PP54	42	3, 11, 19, 27, 35, 43, 51, 59
PP56	10	4, 12, 20, 28, 36, 44, 52, 60
PP61	26	5, 13, 21, 29, 37, 45, 53, 61
PP66	46	6, 14, 22, 30, 38, 46, 54, 62
PP73	33	All
PP79	10	0, 8, 16, 24, 32, 40, 48, 56
PP80	40	All
PP82	51	All
PP83	56	All

Quick-look No.2

After the first five orbits, the quick-look selection will be as above with the exception of parameters AS03 and AS04, unless scheduled by the RAE.

5.6.3 Quick-look operating procedures

A data acquisition station will decommutate the spacecraft real-time data for quick-look operations as scheduled by the RAE Control Centre.

A quick-look operation at an ESTRACK station will be as defined in the ESRO Mission Operations Plan for X3. The stations will submit a quick-look report to DATA CENTRAL via ESOC. For the first five orbits the quick-look reports will be relayed to DATA CENTRAL not later than fifteen minutes after the pass. Following the first five orbits through to the end of the mission quick-look messages will be relayed to DATA CENTRAL within one hour after the pass.

5.7 Tape mailing instructions

All telemetry magnetic tapes will be forwarded, in accordance with the standard tape shipping instructions, to the following address:-

Procurement Executive, Ministry of Defence,
Royal Aircraft Establishment,
Farnborough,
Hants,
England.

For the attention of Room 224, Space Department

6 COMMUNICATIONS

6.1 Introduction

The control centres at DATA CENTRAL and ESOC will provide the necessary communications links, teletype, voice and data transmission to satisfy the operational requirements of the X3 project. A temporary teletype link operating in a conference mode will be provided between the launch range at WRE Woomera, the MOD centre in London and DATA CENTRAL at Farnborough, for a 24 hour period commencing at T -8 hours.

6.2 Teletype communications

ESRO will utilize the existing network for all teletype communications between the ESTRACK stations and the ESOC. An exclusive teletype link will be used for the first month for all teletype communications between ESOC and DATA CENTRAL. Thereafter the public telex network will be used for communications between ESOC and DATA CENTRAL. Teletype communications and procedures will be in accordance with the ESRO Mission Operations Plan for X3 and section 34 of the Estrack Operations Manual.

6.2.1 Addressing traffic

All project-oriented traffic will be addressed to DATA CEN SPACE RAE. All traffic to ESOC will be addressed to ESOC CONTROL.

6.3 Voice communications

Voice communications will be provided between DATA CENTRAL and the LASHAM telemetry station. A temporary voice communication will be provided between the WRE launch range, DATA CENTRAL and the ESOC, for a period between T -6 hours and T +15 minutes.

6.4 Data transmission

The data link between LASHAM and DATA CENTRAL will be used to transmit spacecraft data in real-time.

7 ORBITAL COMPUTATIONS SUPPORT

7.1 Introduction

Data Central, the RAE Space Department Dynamics Division (SP5) and ESOC are responsible for prelaunch and postlaunch orbit determination during the X3 project.

7.2 Prelaunch operations

A predicted world map printout and station observations will be computed from data supplied by DATA CENTRAL. Station predictions will be required for LASHAM and all ESTRACK stations for a 3 day period 10 days prior to launch. If trajectory changes occur prior to launch, the predicted data will be recomputed.

Copies of the predicted observations and world map printout, for a 3-day period, will be distributed to:-

ESRO Control centre
Darmstadt, Germany.

Data Central,
RAE, Farnborough.

X3 Satellite Controller,
RAE.

RSRS,
Slough, Berks.
(Mr. Luscombe).

BDRSS,
WRE, Salisbury,
S.A.
(Mr. K. Smith).

7.3 Post-launch operations

Orbit elements will be provided by the MOD, and will be used to generate the predicted world map and station observations. DATA CENTRAL will send orbital elements to ESOC every time they are updated and in any case the latest elements must be available at ESOC not later than T -7 days for the scheduling week.

8 DATA PROCESSING

8.1 Responsibility

RAE is responsible for evaluating the quality of the recorded data on the analogue tapes received from the telemetry stations, and is also responsible for processing the data.

8.2 Data evaluation

The station telemetry tapes will be received by DATA CENTRAL for evaluation and initial processing in order to provide digital magnetic tapes for subsequent computer processing in Mathematics Dept., RAE.

The digital magnetic tapes will contain formatted satellite data and identity blocks of the following form:-

(1) 9999

(2) YYMM

(3) DDHH

(4) ORBIT NO.

(5) STATION NO.

(6) ORIGINAL TAPE NO.

The station numbers to be used are as follows:-

FALKIS	0353
FBANKS	0352
REDU	0351
SPITS	0354
LASHAM (LTS1)	0001
LASHAM (LTS2)	0002

For passes over Lasham the ditital magnetic tape will be processed in DATA CENTRAL as soon as possible after a pass in order to provide the quick-look printout for distribution (section 5.6). This data will consist mainly of housekeeping parameters, as specified by the experimenters and sub-system designers.

9 COMPOSITE COUNTDOWN

The composite countdown is referenced to the nominal lift-off time and lists only those periods that involve or require action by the X3 project ground support elements. Abbreviations are as used in section 5.3.

COMPOSITE COUNTDOWN

Countdown	Message		TTY or voice	Responsibility from	Responsibility to
Between F -14 days and F -9 days	X3 F - days	Dress rehearsal sim lift off = Y M D H MIN	TTY	NCW RAE ESOC	RAE/MOD ESOC STATIONS
Between F -14 days and F -9 days	X3 F - days	Dress rehersal sim lift off = Y M D H MIN	voice	RAE	LASHAM
	(Note:- The dress rehearsal follows the same procedure as the launch countdown below, with times related to the simulated lift off. The rehearsal will be fast-timed where possible and communications with ESOC simulated. A rehearsal with ESOC will take place at F -3 days when communications with NCW will be simulated)				
F -3 days		ESTRACK station readiness report	TTY	ESOC	RAE
F -2 days		ESTRACK station readiness report	TTY	ESOC	RAE
F -1 days		ESTRACK station readiness report	TTY	ESOC	RAE
T -18 h	X3 T -18 h	Nominal lift off = Y M D H MIN	TTY	NCW RAE	RAE/MOD ESOC
T -17 h 45 min	X3	Nominal lift off = Y M D H MIN	TTY	ESOC	EASTRACK STNS
T -13 h	X3 T -13 h	Request support status MOD	TTY	RAE	MOD
T -12 h 50 min	X3 T -12 h 50 min	MOD support status Green or Red (followed by qualification if Red)	TTY	MOD	RAE
T -12 h 45 min	X3 T -12 h 50 min	MOD support status Green or Red (followed by qualification if Red)	TTY	RAE	NCW
	(Note:- MOD is assumed to be able to support the mission after this time unless RAE is notified otherwise)				

Countdown	Message	TTY or voice	Responsibility from	Responsibility to
T -8 h	Open Satellite Network		NCW RAE RAE ESOC	RAE NCW ESOC RAE
T -8 hr	X3 T -8h Comms check, fox message (Note:- This message to be repeated approx every ½h)	TTY		
T -7 h	X3 T -7 h Nominal lift off = Y M D H MIN	TTY	NCW RAE	RAE/MOD ESOC
T -6 h 50 min	X3 Nominal lift off = Y M D H MIN	TTY	ESOC	ESTRACK STNS
T -6 h 15 min	Request T -0.6.00 h station readiness report from ESTRACK stations	TTY	ESOC	ESTRACK STNS
T -6 h	ESTRACK station readiness report	TTY	ESTRACK STNS	ESOC
T -6 h	Open Voice links for a time check, close Voice links	VOICE	NCW	RAE/ESOC
T -5 h 55 min (approx)	X3 nominal lift off is H MIN. Voice and time check. Request Lasham checkout	VOICE	RAE	LASHAM
T -5 h 50 min to T -4 h 50 min	Lasham conducts system checkout			
T -4 h	Request simulation test	VOICE	RAE	LASHAM
T -4 h to T -3 h 30 min	Lasham conducts simulation test with RAE			
T -3 h 30 min	X3 T -3 h 30 min Request status all stations	TTY	RAE	ESOC
T -3 h 25 min	Request T -03.15 h station readiness report from EASTRACK stations	TTY	ESOC	ESTRACK STNS

Countdown	Message	TTY or voice	Responsibility from	Responsibility to
T -3 h 15 min	Request status Lasham. Lasham confirms Green or Red.	VOICE	RAE	LASHAM
T -3 h 15 min	ESTRACK station readiness report	TTY	ESTRACK STNS	ESOC
T -3 h 15 min	X3 T -3 hr 15 min ESTRACK status Greed or Red followed by qualification if Red	TTY	ESOC	RAE
T -3 h	X3 T -3 hr 15 min EASTRACK status Green or Red (followed by qualification if Red) Lasham status Green or Red (followed by qualification if Red)	TTY	RAE	NCW
	(Note:- All stations are assumed to be operational after this time unless RAE is notified otherwise)			
T -3 h	X3 T -3 h Nominal lift off - Y M D H MIN		NCW RAE	RAE/MOD ESOC
T -2 h 55 min	X3 Nominal lift off = Y M D H MIN	TTY	ESOC	ESTRACK STNS
T -1 h 30 min	X3 T -1 h 30 min Nominal lift off = Y M D H MIN	TTY	NCW	RAE/MOD
T -1 h 25 min	X3 T -1 h 30 min Nominal lift off = Y M D H MIN Request status all stations	TTY	RAE	ESOC
T -1 h 20 min	Request T -0.1.15 h station readiness report from ESTRACK stations	TTY	ESOC	ESTRACK STNS
T -1 h 15 min	ESTRACK station readiness report	TTY	ESTRACK STNS	ESOC
T -1 h 15 min	X3 nominal lift off is H MIN. Request status Lasham. Lasham confirms Red or Green	VOICE	RAE	LASHAM

Countdown	Message	TTY or voice	Responsibility from	Responsibility to
T -1 h 15 min	X3 T -1 h 15 min Estrack status Green or Red followed by qualification if Red	TTY	ESOC	RAE
T -1 h 10 min	X3 T -1 h 15 min Estrack status Green or Red (followed by qualification if Red). Lasham status Green or Red (followed by qualification if Red.	TTY	RAE	NCW
T -1 h	Open Voice links for a time check, close Voice links	VOICE	NCW	RAE/ESOC
T -55 min	Voice and time check	VOICE	RAE	LASHAM
T -40 min	Request T -00.30 h station readiness report from ESTRACK STNS	TTY	ESOC	ESTRACK STNS
T -30 min	ESTRACK station readiness report	TTY	ESTRACK STNS	ESOC
T -30 min	X3 T -30 min Firing sequence started nominal lift off = Y M D H MIN	TTY	NCW RAE ESOC	RAE/MOD ESOC STATIONS
T -29 min	X3 T -30 min ESTRACK status Green or Red	TTY	ESOC	RAE
T -25 min	X3 nominal lift off is H MIN	VOICE	RAE	LASHAM
Between T -30 min and T -15 min	Open Voice links for a time check and launch status	VOICE	NCW	RAE/ESOC
T -6 min	X3 T -6 min Spacecraft status all nominal	TTY	NCW	RAE/MOD
T -5 min (approx)	X3 T -6 min Spacecraft status all nominal	TTY	RAE	ESOC
T -4 min (approx)	X3 T -6 min Spacecraft status all nominal	TTY	ESOC	STATIONS
T -0 min (approx)	Confirmation of lift off followed by rocket status	VOICE	NCW	RAE/ESOC
T +30 s (approx)	Confirmation of lift off followed by rocket status	VOICE	RAE	LASHAM

Countdown	Message		TTY or voice	Responsibility from	Responsibility to
T +1 min (approx)	X3 T +1 min	Lift off was approx H MIN	TTY	NCW	RAE/MOD
T +2 min (approx)	X3 T +1 min	Lift off was approx H MIN	TTY	RAE	ESOC
T +3 min (approx)	X3 T +1 min	Lift off was approx H MIN	TTY	ESOC	STATIONS
T +10 min (approx)	X3 T +10 min	Lift off was H MIN S	TTY	NCW	RAE/MOD
T +11 min (approx)	X3 T +10 min	Lift off was H MIN S	TTY	RAE	ESOC
T +12 min (approx)	X3 T +10 min	Lift off was H MIN S	TTY	ESOC	STATIONS
T +14 min (approx)	X3 lift off was H MIN S		VOICE	RAE	LASHAM
T +15 min (approx)	End of launch summary, close Voice links		VOICE	NCW	RAE/ESOC
Between T +15 min and T +30 min	X3 T + 30 min	Injection report	TTY	NCW RAE ESOC	RAE ESOC STATIONS
T +35 min (approx)	X3 AOS	H MIN modulation on or no modulation	TTY	FBANKS ESOC RAE RAE	ESOC RAE NCW MOD
T +36 min (approx)	X3 AOS	FBANKS H MIN Mod on or no mod. close link	VOICE	RAE	LASHAM
T +45 min (approx)	OMS 28	FBANKS X3 ORBIT No.1 YY MM DD followed by QL	TTY	FBANKS ESOC	ESOC RAE
T +50 min (approx)	OMS 20	M D H MIN FBANKS followed by pass report	TTY	FBANKS ESOC RAE	ESOC RAE NCW
T +1 h 30 min (approx)	X3 orbit elements (Note:- Prepare update of orbital predictions)		TTY	MOD RAE	RAE ESOC
T +1 h 35 min (approx)	OMS 28	FALKIS X3 ORBIT No.1 Y M D followed by QL	TTY	FALKIS ESOC	ESOC RAE

Countdown	Message		TTY or voice	Responsibility from	Responsibility to
T +1 h 45 min (approx)	OMS 20	M D H MIN FALKIS followed by pass report	TTY	FALKIS ESOC	ESOC RAE
T +2 h (approx)	X3 ORBIT	Nominal or otherwise. Prepare to implement EOP or emergency phase		RAE ESOC RAE	ESOC STATIONS NCW
T +3 h (approx)	OMS 28	FBANKS X3 ORBIT No.2 Y M D followed by QL	TTY	FBANKS ESOC	ESOC RAE
T +3 h 10 min (approx)	OMS 20	M D H MIN FBANKS followed by pass report	TTY	FBANKS ESOC	ESOC RAE
T +4 h 50 min (approx)	OMS 28	FBANKS X3 ORBIT No.3 Y M D followed by QL	TTY	FBANKS ESOC	ESOC RAE
T +5 h (approx)	OMS 20	M D H MIN FBANKS followed by pass report	TTY	FBANKS ESOC	ESOC RAE
T +6 h 40 min (approx)	OMS 28	FBANKS X3 ORBIT No.4 Y M D followed by QL	TTY	FBANKS ESOC	ESOC RAE
T +6 h 50 min (approx)	OMS 20	M D H MIN FBANKS followed by pass report	TTY	FBANKS ESOC	ESOC RAE
T +7 h (approx)	Voice and time check. Request Lasham checkout		VOICE	RAE	LASHAM
T +7 h (approx) to T +8 h (approx)	Lasham conducts system checkout				
T +8 h (approx)	Request simulation test		VOICE	RAE	LASHAM
T +8 h (approx) to T +8 h 30 min (approx)	Lasham conducts simulation test with RAE				
T +8 h 30 min (approx)	OMS 28	FBANKS X3 ORBIT NO.5 Y M D followed by QL	TTY	FBANKS ESOC	ESOC RAE

Countdown	Message	TTY or voice	Responsibility from	Responsibility to
T +8 h 50 min (approx)	OMS 20 M D H MIN FBANKS followed by pass report	TTY	FBANKS ESOC	ESOC RAE
T +9 h (approx)	End of launch phase	TTY	RAE ESOC RAE	ESOC STATIONS NCW

Appendix A

X3 POTENTIAL FREQUENCY CONFLICTS

The purpose of this Appendix is to identify the spacecraft which are potential sources of radio frequency interference to the X3 project.

Details will be issued later.

Appendix B

X3 TELEMETRY CHANNELS

List of parameters

Attitude sensor data

AS01	Sync. pulse to sun sensor SS1	(spin position)
AS03	Sun sensor SS1 to sun sensor SS1	(spin period)
AS05	Sun sensor SS1 to sun sensor SS2	(spin axis-sun angle)
AS07	Sun sensor SS1 to horizon sensor 1.H1	(Earth position)
AS09	Sun sensor SS1 to sun sensor SS3	(structure distortion)
AS11	Sun sensor SS1 to sun sensor SS4	(structure distortion)
AS13	Sun sensor SS1 to horizon sensor 1.H2	(Earth position)
AS15	Sun sensor SS1 to horizon sensor 1.H1	(Earth position)
AS02	Sync. pulse to sun sensor SS3	(spin position)
AS04	Sun sensor SS3 to sun sensor SS3	(spin period)
AS06	Sun sensor SS3 to sun sensor SS2	(structure distortion)
AS08	Sun sensor SS3 to horizon sensor 2.H3	(Earth position)
AS10	Sun sensor SS3 to sun sensor SS1	(structure distortion)
AS12	Sun sensor SS3 to sun sensor SS4	(spin axis-sun angle)
AS14	Sun sensor SS3 to horizon sensor 2.H4	(Earth position)
AS16	Sun sensor SS3 to horizon sensor 2.H3	(Earth position)

Birmingham micrometeoroid experiment data

BEHT EHT monitor

PBUL EHT test pulse monitor
(See also GO/NO-GO data, i.e. PG25 to PG37 on page 49).

Hybrid electronics experiment data

DD01 11111111

DD02 Digital array experiment (11101100)
MSB

DD03 Digital array experiment (10100001)
LSB

RA01 to RA78 Hybrid electronic experiment (HEE) analogue outputs.

MSB = major increments

LSB = minor increments

RD01 to RD78 HEE digital outputs.

NOTE: RD01 corresponds to RA01 *et seq.*

Rocket third stage data

DA01	Donner accelerometer coarse
DA02	Donner accelerometer fine
GY01	Gyro output 1
GY02	Gyro output 2
HSKP	Housekeeping
SMON	Separation monitor
SS01	Sun slit

Solar cell experiment data

SC01	Module 3 unit 6101 short circuit current
SC02	Module 3 unit 6102 short circuit current
SC03	Module 7 unit 6103 short circuit current
SC04	Module 7 unit 6102 short circuit current
SC05	Module 7 unit 6103 short circuit current
SC06	Module 3 unit 6201 short circuit current
SC07	Module 3 unit 6101 maximum power point current
SC08	Module 3 unit 6102 maximum power point current
SC09	Module 7 unit 6103 maximum power point current
SC10	Module 3 unit 6101 open circuit voltage
SC11	Module 3 unit 6102 open circuit voltage
SC12	Module 7 unit 6103 open circuit voltage
ST01	Module 3 unit 6101 temperature
ST02	Module 3 unit 6102 temperature
ST03	Module 7 unit 6103 temperature
ST04	Module 7 unit 6102 temperature
ST05	Module 7 unit 6103 temperature
ST06	Module 3 unit 6201 temperature

Thermal control surfaces data

	Unit No.	Thermistor		Unit No.	Thermistor		Unit No.	Thermistor
TS01	5100	1	TS33	5700	14	TS65	5600	9
TS02	5500	4	TS34	5400	3	TS66	5800	9
TS03	5500	12	TS35	5600	14	TS67	5700	1
TS04	5200	1	TS36	5800	14	TS68	5700	9
TS05	5600	4	TS37	5100	4	TS69	5700	17
TS06	5800	4	TS38	5500	7	TS70	5800	1
TS07	5300	1	TS39	5500	15	TS71	5600	17
TS08	5700	4	TS40	5200	4	TS72	5800	17
TS09	5700	12	TS41	5600	7	TS73	5500	2
TS10	5400	1	TS42	5800	7	TS74	5500	10
TS11	5600	12	TS43	5300	4	TS75	5500	18
TS12	5800	12	TS44	5700	7	TS76	5506	2
TS13	5100	2	TS45	5700	15	TS77	5600	10
TS14	5500	5	TS46	5400	4	TS78	5800	10
TS15	5500	13	TS47	5600	15	TS79	5700	2
TS16	5200	2	TS48	5800	15	TS80	5700	10
TS17	5600	5	TS49	5100	5	TS81	5700	18
TS18	5800	5	TS50	5500	8	TS82	5800	2
TS19	5300	2	TS51	5500	16	TS83	5600	18
TS20	5700	5	TS52	5200	5	TS84	5800	18
TS21	5700	13	TS53	5600	8	TS85	5500	3
TS22	5400	2	TS54	5800	8	TS86	5500	11
TS23	5600	13	TS55	5300	5	TS87	5500	19
TS24	5800	13	TS56	5700	8	TS88	5600	3
TS25	5100	3	TS57	5700	16	TS89	5600	11
TS26	5500	6	TS58	5400	5	TS90	5800	11
TS27	5500	14	TS59	5600	16	TS91	5700	3
TS28	5200	3	TS60	5800	16	TS92	5700	11
TS29	5600	6	TS61	5500	1	TS93	5700	19
TS30	5800	6	TS62	5500	9	TS94	5800	3
TS31	5300	3	TS63	5500	17			
TS32	5700	6	TS64	5600	1			

TS95 Calibration resistor 1 TS96 Calibration resistor 2

Performance parameters designation recorded format

PP01	Solar cell array temperature (module 2 centre)
PP02	Output voltage of negative 12 volt tape recorder supply
PP03	Output current of positive 5.4 volt regulator
PP04	Output voltage of negative 12 volt regulator
PP05	Solar cell array temperature (module 2 top)
PP06	Heat balance temperature monitor (fillet 3/4 top)
PP07	Output voltage of positive 12 volt regulator
PP08	Output voltage of positive 5.4 volt regulator
PP09	Heat balance temperature monitor (module 1)
PP10	Solar cell array temperature (module 2 bottom)
PP11	Data handling calibration (positive 2.5 volts) (01000000)
PP12	Output current of positive 12 volt regulator
PP13	Power storage control temperature
PP14	Heat balance temperature monitor (fillet 3/4 centre)
PP15	Output current of negative 12 volt regulator
PP16	VHF automatic gain control 1
PP17	Tape recorder temperature
PP18	Heat balance temperature monitor (module 5)
PP19	Battery voltage
PP20	Data handling calibration (negative 4.7 volts (11110101)
PP21	Heat balance temperature monitor (face 8 foot casting)
PP22	Output voltage of negative 5.4 volt regulators
PP23	Output voltage of negative 5.4 volt regulator
PP24	Unregulated busbar voltage
PP25	Power regulators and distribution temperature
PP26	Power switching and monitoring temperature
PP27	VHF automatic gain control 2
PP28	Output current of positive 12 volt tape recorders supply
PP29	Heat balance temperature (fillet 3/4 bottom)
PP30	Battery temperature
PP31	Battery charge/discharge current
PP32	Total solar array current
PP33	Data handling calibration (0 volt)
PP34	Input voltage to battery converter
PP35	Input voltage to battery main charge regulator
PP36	Output voltage of positive 12 volt tape recorder supply
PP37	10000000
PP38	Output current of negative 12 volt tape recorder supply

Performance parameters designation direct format

PP40	Heat balance temperature monitor (face 7 top)
PP41	Heat balance temperature monitor (face 7 upper centre)
PP42	Output voltage of positive 12 volt regulator
PP43	Input voltage to battery converter
PP44	Heat balance temperature monitor (face 7 lower centre)
PP45	Heat balance temperature monitor (top cover skin)
PP46	VHF voltage standing wave ratio
PP47	VHF automatic gain control 1
PP48	Heat balance temperature monitor (face 7 bottom)
PP49	Heat balance temperature monitor (lower cover skin)
PP50	Output current of positive 12 volt tape recorder supply
PP51	Output current of negative 12 volt tape recorder supply
PP52	Programmer package temperature
PP53	Solar cell array temperature (module 2 top)
PP54	Output voltage of positive 5.4 volt regulator
PP55	Output voltage of positive 12 volt tape recorder supply
PP56	Battery temperature
PP57	Solar cell array temperature (module 2 centre)
PP58	Output voltage of negative 12 volt tape recorder supply
PP59	Input voltage to battery main charge regulator
PP60	Power regulators and distribution temperature
PP61	Tape recorder temperature
PP62	VHF automatic gain control 2
PP63	Power storage control temperature
PP64	Solar cell array temperature (module 2 bottom)
PP65	Direct encoder package temperature
PP66	Output voltage of negative 5.4 volt regulator
PP67	VHF transmitter power output
PP68	Record encoder package temperature
PP69	VHF transmitter temperature difference monitor
PP70	Hybrid electronic experiment temperature monitor
PP71	Data handling calibration (positive 2.5 volt)(01000000)
PP72	Data handling calibration (0 volt)
PP72	Battery voltage
PP74	Tape recorder pressure monitor
PP75	Hybrid electronic experiment (negative full scale deflection) -4.3925 V
PP76	Hybrid electronic experiment (positive full scale deflection) +4.3925 V
PP77	VHF package temperature
PP78	Data handling calibration (negative 4.7 volt)(11110101)
PP79	Output voltage of negative 12 volt regulator
PP80	Unregulated busbar voltage
PP81	Battery charge/discharge current
PP82	Total solar array current
PP83	Tape recorder, tape moving

Performance parameters designation GO/NO-GO bits

NOTE: PG suffix code:
MSB is the PG syllable identifier and LSB is the PG bit identifier.

PG00	Hybrid electronics experiment ON/OFF (logic 1 = ON)
PG01	Thermal surfaces experiment ON/OFF (logic 1 = ON)
PG02	Transmitter select A or B (logic 1 = A)
PG03	Logic 0
PG04	Tape recorder record or playback (logic 1 = record)
PG05	Data tray clock select A or B (logic 1 = A)
PG06	High speed divider select A or B (logic 1 = B)
PG07	Low speed divider select A or B (logic 1 = A)
PG10	High speed parallel to serial converter select A or B (logic 1 = B)
PG11	Low speed parallel to serial converter select A or B (logic 1 = B)
PG12	Analogue to digital converter select A or B (logic 1 = A on high speed and B on low speed. Logic 0 = B on high speed and A on low speed)
PG13	High speed digital multiplexer select A or B (logic 1 = A)
PG14	Low speed digital multiplexer select A or B (logic 1 = A)
PG15	Analogue to digital converter output gates select A or B (logic 1 = A)
PG16	Data switching gates select A or B (logic 1 = A)
PG17	Third stage interlock (logic 0 = third stage present)
PG20	Birmingham experiment logic test pulse monitor (logic 1 = pulse detected)
PG21	Birmingham experiment flap monitor (logic 1 = flap open)
PG22	Logic 0
PG23	Logic 1
PG24	Logic 0
PG25	Birmingham experiment most significant count bit digit 0
PG26	Birmingham experiment count bit digit 1
PG27	Birmingham experiment count bit digit 2
PG30	Birmingham experiment count bit digit 3
PG31	Birmingham experiment count bit digit 4
PG32	Birmingham experiment count bit digit 5
PG33	Birmingham experiment count bit digit 6
PG34	Birmingham experiment count bit digit 7
PG35	Birmingham experiment count bit digit 8
PG36	Birmingham experiment count bit digit 9
PG37	Birmingham experiment least significant count bit digit 10

PG40 through to PG47 Logic 0
PG50 through to PG57 Logic 0
PG60 through to PG67 Logic 0
PG70 through to PG77 Logic 0

Appendix C

STATION RESPONSIBILITIES

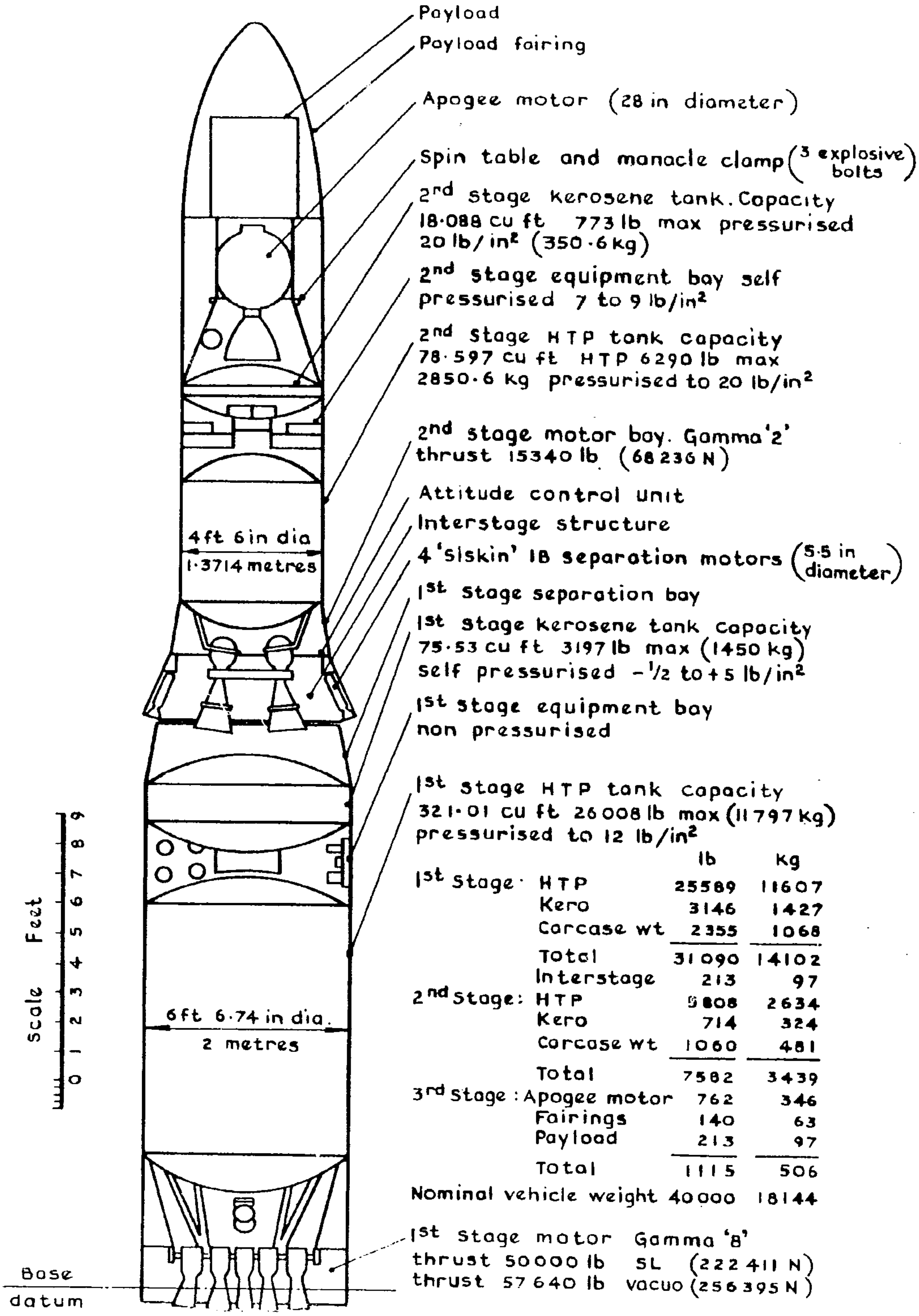
The following Table summarises the station responsibilities described in the X3 Operations Handbook and enables individual stations to obtain a quick reference to the relevant sections.

Station	Tracking	Data acquisition	Command	Quick-look operations	Recording procedure	Tape mailing	Communications	Real-time data transmission	Orbital predictions	Scheduling
Data central			5.2.4 5.3.3 5.4.2	5.6 5.6.1 8.2	5.4.1.4		6.2 6.3 9	5.5.1	7.2 7.3	5.2.3.2
ESOC						5.7	6.2 6.3 9		7.2 7.3	5.2.3.2
FALKIS		5.2.3	5.2.4 5.3.3 5.4.2	5.6 5.6.2	5.4.1.4	5.7	6.2 9			
FBANKS		5.2.3	5.2.4 5.3.3 5.4.2	5.6 5.6.2	5.4.1.4	5.7	6.2 9			
LASHAM		5.2.3			5.4.1.4		6.3 6.4 9	5.5.1		
MOD	5.2.2 5.3.1						6.2 9			
REDU	5.3.1	5.2.3	5.2.4 5.3.3 5.4.2	5.6 5.6.2	5.4.1.4	5.7	6.2 9			
SPITSB		5.2.3	5.2.4 5.3.3 5.4.2	5.6 5.6.2	5.4.1.4	5.7	6.2 9			
WOOMERA	5.2.1	5.2.3.1					6.2 6.3 9			

REFERENCES

No.	Author(s)	Title, etc.
1	H.J.H. Sketch	The Black Arrow X3 Spacecraft. RAE Technical Report 69203 (1969), presented at the eighth International Symposium on Space Technology and Science, Tokyo, August 1969
2	The Staff of RAE Space Department	The Black Arrow Satellite launching vehicle. RAE Technical Report 69088 (1969)
3	X3 Operations Team	Operations Manual for Black Arrow X3 Satellite, Vol.1, Functional descriptions, published by MSDS Limited formerly GEC-AEI (Electronics) Limited
4	V.W. Adams	Orbital operations plan for the X3 satellite. RAE Technical Report to be published, 1971

Fig. 1



		lb	kg
1st Stage:	HTP	25589	11607
	Kero	3146	1427
	Carcase wt	2355	1068
	Total	31 090	14102
	Interstage	213	97
2nd Stage:	HTP	5808	2634
	Kero	714	324
	Carcase wt	1060	481
	Total	7582	3439
3rd Stage:	Apogee motor	762	346
	Fairings	140	63
	Payload	213	97
	Total	1115	506
Nominal vehicle weight		40000	18144

Fig. 1 Basic construction of Black Arrow

T.R. 71172

004 903279

Fig. 2

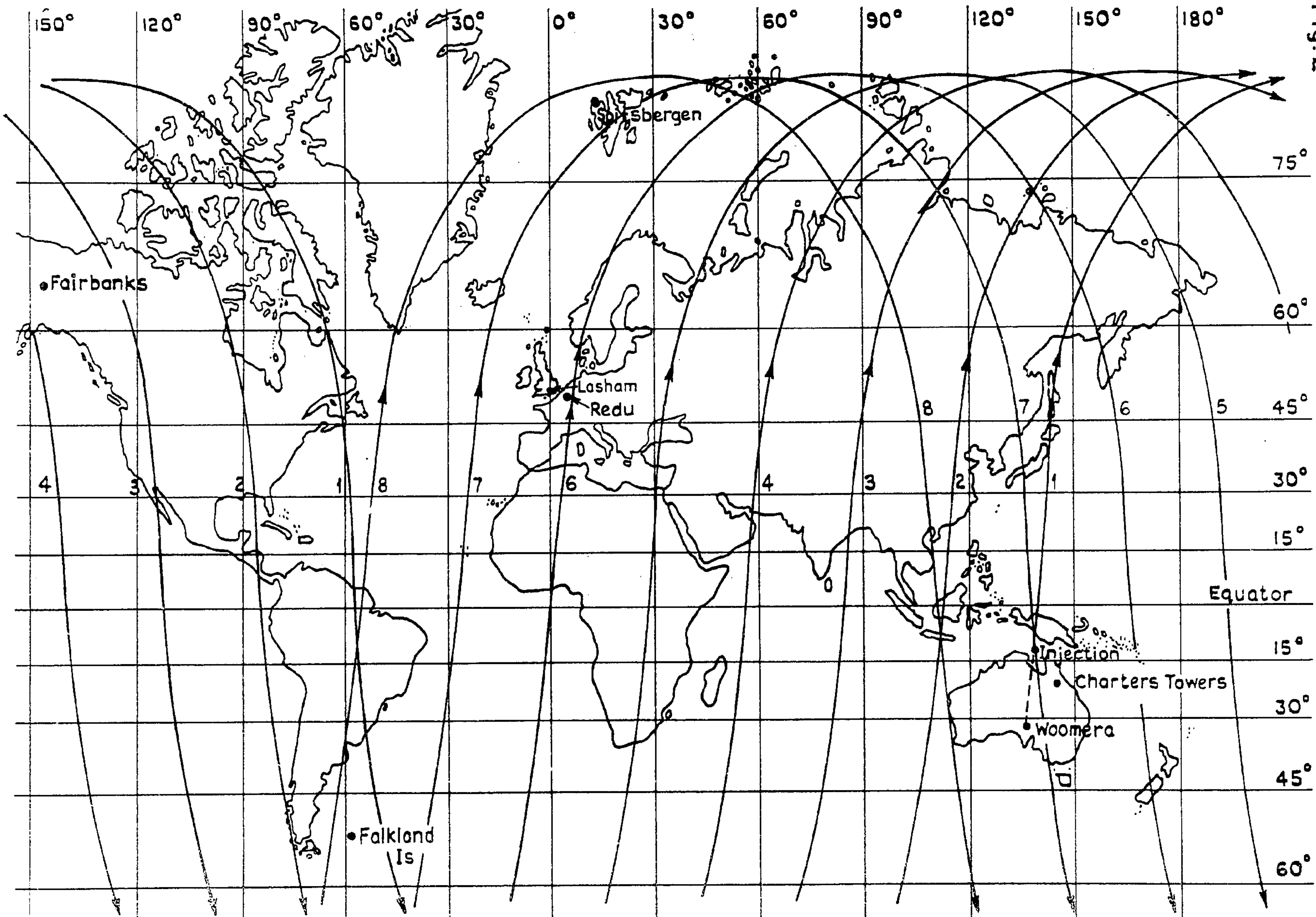


Fig.2 X3 subsatellite plot

004 903280

TK71172

Fig.3

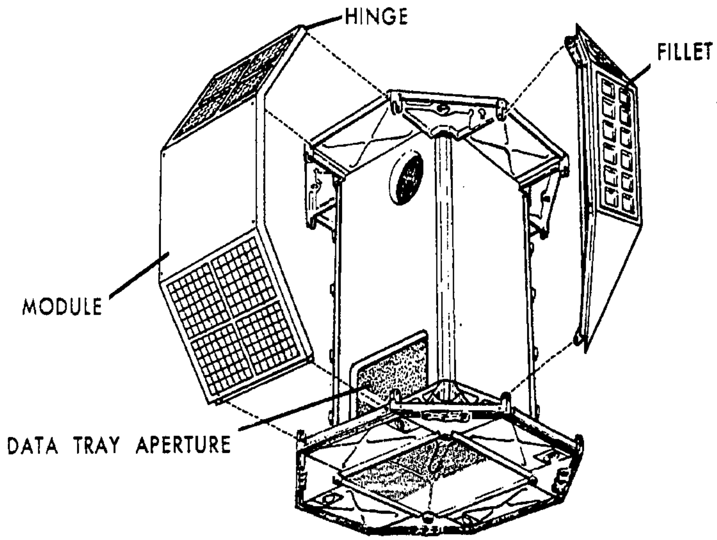


Fig.3a. Structural components

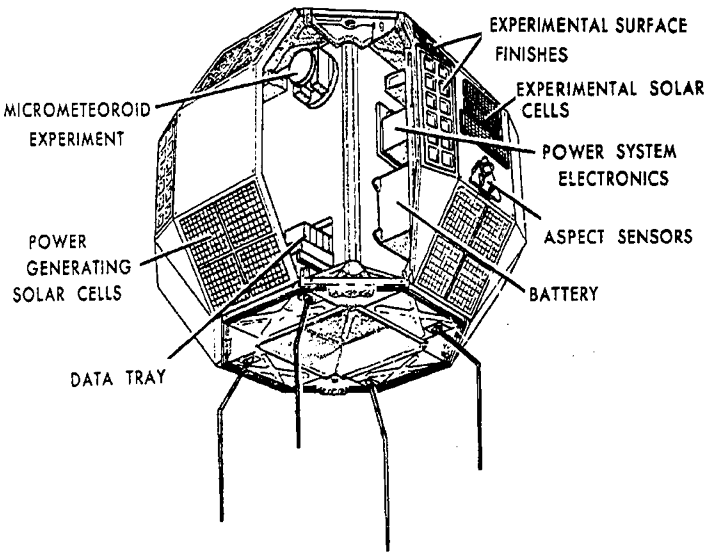


Fig.3b. Partly assembled structure

Fig.4

NOTE: In the normal mode direct format the AS parameters appear in only the first minor frame of each set of eight minor frames. Syllables 37 and 38, 45 and 46 in all other minor frames are not allocated and the digital outputs for each of the syllables are all zeros (eight bits).

MINOR FRAME \ SYLLABLE	0123	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
0	SYNC	RA02	RD01	RD02	SC01	PP75	ST01	PP79	SC02	RA04	RD03	RD04	SC03	PP76	ST02	BEHT	PP77	RA06	RD05	RD06	SC04	PP78	ST03	PP41	SC05	RA08	RD07	RD08	SC06	PP72	PP73	PP74	PP40	RA01
1	SYNC	RA12	RD11	RD12	TS01	PP75	ST01	PP44	TS02	RA14	RD13	RD14	TS03	PP76	ST02	BEHT	PP77	RA16	RD15	RD16	TS04	PP78	ST03	PP45	TS05	RA18	RD17	RD18	TS06	PP72	PP73	PP74	PP40	RA11
2	SYNC	RA22	RD21	RD22	SC01	PP75	ST01	PP48	SC02	RA24	RD23	RD24	SC03	PP76	ST02	BEHT	PP77	RA26	RD25	RD26	SC04	PP78	ST03	PP49	SC05	RA28	RD27	RD28	SC06	PP72	PP73	PP74	PP40	RA21
3	SYNC	RA32	RD31	RD32	TS01	PP75	ST01	PP52	TS02	RA34	RD33	RD34	TS03	PP76	ST02	BEHT	PP77	RA36	RD35	RD36	TS04	PP78	ST03	PP53	TS05	RA38	RD37	RD38	TS06	PP72	PP73	PP74	PP40	RA31
4	SYNC	RA42	RD41	RD42	SC01	PP75	ST01	PP56	SC02	RA44	RD43	RD44	SC03	PP76	ST02	BEHT	PP77	RA46	RD45	RD46	SC04	PP78	ST03	PP57	SC05	RA48	RD47	RD48	SC06	PP72	PP73	PP74	PP40	RA41
5	SYNC	RA52	RD51	RD52	TS13	PP75	ST01	PP60	TS14	RA54	RD53	RD54	TS15	PP76	ST02	BEHT	PP77	RA56	RD55	RD56	TS16	PP78	ST03	PP61	TS17	RA58	RD57	RD58	TS18	PP72	PP73	PP74	PP40	RA51
6	SYNC	RA62	RD61	RD62	SC01	PP75	ST01	PP64	SC02	RA64	RD63	RD64	SC03	PP76	ST02	BEHT	PP77	RA66	RD65	RD66	SC04	PP78	ST03	PP65	SC05	RA68	RD67	RD68	SC06	PP72	PP73	PP74	PP40	RA61
7	SYNC	RA72	RD71	RD72	TS13	PP75	ST01	PP68	TS14	RA74	RD73	RD74	TS15	PP76	ST02	BEHT	PP77	RA76	RD75	RD76	TS16	PP78	ST03	PP69	TS17	RA78	RD77	RD78	TS18	PP72	PP73	PP74	PP40	RA71
8	SYNC	RA02	RD01	RD02	SC01	PP75	ST01	PP79	SC02	RA04	RD03	RD04	SC03	PP76	ST02	BEHT	PP77	RA06	RD05	RD06	SC04	PP78	ST03	PP41	SC05	RA08	RD07	RD08	SC06	PP72	PP73	PP74	PP40	RA01
9	SYNC	RA12	RD11	RD12	TS25	PP75	ST01	PP44	TS26	RA14	RD13	RD14	TS27	PP76	ST02	BEHT	PP77	RA16	RD15	RD16	TS28	PP78	ST03	PP45	TS29	RA18	RD17	RD18	TS30	PP72	PP73	PP74	PP40	RA11
10	SYNC	RA22	RD21	RD22	SC01	PP75	ST01	PP48	SC02	RA24	RD23	RD24	SC03	PP76	ST02	BEHT	PP77	RA26	RD25	RD26	SC04	PP78	ST03	PP49	SC05	RA28	RD27	RD28	SC06	PP72	PP73	PP74	PP40	RA21
11	SYNC	RA32	RD31	RD32	TS25	PP75	ST01	PP52	TS26	RA34	RD33	RD34	TS27	PP76	ST02	BEHT	PP77	RA36	RD35	RD36	TS28	PP78	ST03	PP53	TS29	RA38	RD37	RD38	TS30	PP72	PP73	PP74	PP40	RA31
12	SYNC	RA42	RD41	RD42	SC01	PP75	ST01	PP56	SC02	RA44	RD43	RD44	SC03	PP76	ST02	BEHT	PP77	RA46	RD45	RD46	SC04	PP78	ST03	PP57	SC05	RA48	RD47	RD48	SC06	PP72	PP73	PP74	PP40	RA41
13	SYNC	RA52	RD51	RD52	TS37	PP75	ST01	PP60	TS38	RA54	RD53	RD54	TS39	PP76	ST02	BEHT	PP77	RA56	RD55	RD56	TS40	PP78	ST03	PP61	TS41	RA58	RD57	RD58	TS42	PP72	PP73	PP74	PP40	RA51
14	SYNC	RA62	RD61	RD62	SC01	PP75	ST01	PP64	SC02	RA64	RD63	RD64	SC03	PP76	ST02	BEHT	PP77	RA66	RD65	RD66	SC04	PP78	ST03	PP65	SC05	RA68	RD67	RD68	SC06	PP72	PP73	PP74	PP40	RA61
15	SYNC	RA72	RD71	RD72	TS37	PP75	ST01	PP68	TS38	RA74	RD73	RD74	TS39	PP76	ST02	BEHT	PP77	RA76	RD75	RD76	TS40	PP78	ST03	PP69	TS41	RA78	RD77	RD78	TS42	PP72	PP73	PP74	PP40	RA71
16	SYNC	RA02	RD01	RD02	SC01	PP75	ST01	PP79	SC02	RA04	RD03	RD04	SC03	PP76	ST02	BEHT	PP77	RA06	RD05	RD06	SC04	PP78	ST03	PP41	SC05	RA08	RD07	RD08	SC06	PP72	PP73	PP74	PP40	RA01
17	SYNC	RA12	RD11	RD12	TS49	PP75	ST01	PP44	TS50	RA14	RD13	RD14	TS51	PP76	ST02	BEHT	PP77	RA16	RD15	RD16	TS52	PP78	ST03	PP45	TS53	RA18	RD17	RD18	TS54	PP72	PP73	PP74	PP40	RA11
18	SYNC	RA22	RD21	RD22	SC01	PP75	ST01	PP48	SC02	RA24	RD23	RD24	SC03	PP76	ST02	BEHT	PP77	RA26	RD25	RD26	SC04	PP78	ST03	PP49	SC05	RA28	RD27	RD28	SC06	PP72	PP73	PP74	PP40	RA21
19	SYNC	RA32	RD31	RD32	TS49	PP75	ST01	PP52	TS50	RA34	RD33	RD34	TS51	PP76	ST02	BEHT	PP77	RA36	RD35	RD36	TS52	PP78	ST03	PP53	TS53	RA38	RD37	RD38	TS54	PP72	PP73	PP74	PP40	RA31
20	SYNC	RA42	RD41	RD42	SC01	PP75	ST01	PP56	SC02	RA44	RD43	RD44	SC03	PP76	ST02	BEHT	PP77	RA46	RD45	RD46	SC04	PP78	ST03	PP57	SC05	RA48	RD47	RD48	SC06	PP72	PP73	PP74	PP40	RA41
21	SYNC	RA52	RD51	RD52	TS61	PP75	ST01	PP60	TS62	RA54	RD53	RD54	TS63	PP76	ST02	BEHT	PP77	RA56	RD55	RD56	TS64	PP78	ST03	PP61	TS65	RA58	RD57	RD58	TS66	PP72	PP73	PP74	PP40	RA51
22	SYNC	RA62	RD61	RD62	SC01	PP75	ST01	PP64	SC02	RA64	RD63	RD64	SC03	PP76	ST02	BEHT	PP77	RA66	RD65	RD66	SC04	PP78	ST03	PP65	SC05	RA68	RD67	RD68	SC06	PP72	PP73	PP74	PP40	RA61
23	SYNC	RA72	RD71	RD72	TS61	PP75	ST01	PP68	TS62	RA74	RD73	RD74	TS63	PP76	ST02	BEHT	PP77	RA76	RD75	RD76	TS64	PP78	ST03	PP69	TS65	RA78	RD77	RD78	TS66	PP72	PP73	PP74	PP40	RA71
24	SYNC	RA02	RD01	RD02	SC01	PP75	ST01	PP79	SC02	RA04	RD03	RD04	SC03	PP76	ST02	BEHT	PP77	RA06	RD05	RD06	SC04	PP78	ST03	PP41	SC05	RA08	RD07	RD08	SC06	PP72	PP73	PP74	PP40	RA01
25	SYNC	RA12	RD11	RD12	TS73	PP75	ST01	PP44	TS74	RA14	RD13	RD14	TS75	PP76	ST02	BEHT	PP77	RA16	RD15	RD16	TS76	PP78	ST03	PP45	TS77	RA18	RD17	RD18	TS78	PP72	PP73	PP74	PP40	RA11
26	SYNC	RA22	RD21	RD22	SC01	PP75	ST01	PP48	SC02	RA24	RD23	RD24	SC03	PP76	ST02	BEHT	PP77	RA26	RD25	RD26	SC04	PP78	ST03	PP49	SC05	RA28	RD27	RD28	SC06	PP72	PP73	PP74	PP40	RA21
27	SYNC	RA32	RD31	RD32	TS73	PP75	ST01	PP52	TS74	RA34	RD33	RD34	TS75	PP76	ST02	BEHT	PP77	RA36	RD35	RD36	TS76	PP78	ST03	PP53	TS77	RA38	RD37	RD38	TS78	PP72	PP73	PP74	PP40	RA31
28	SYNC	RA42	RD41	RD42	SC01	PP75	ST01	PP56	SC02	RA44	RD43	RD44	SC03	PP76	ST02	BEHT	PP77	RA46	RD45	RD46	SC04	PP78	ST03	PP57	SC05	RA48	RD47	RD48	SC06	PP72	PP73	PP74	PP40	RA41
29	SYNC	RA52	RD51	RD52	TS85	PP75	ST01	PP60	TS86	RA54	RD53	RD54	TS87	PP76	ST02	BEHT	PP77	RA56	RD55	RD56	TS88	PP78	ST03	PP61	TS89	RA58	RD57	RD58	TS90	PP72	PP73	PP74	PP40	RA51
30	SYNC	RA62	RD61	RD62	SC01	PP75	ST01	PP64	SC02	RA64	RD63	RD64	SC03	PP76	ST02	BEHT	PP77	RA66	RD65	RD66	SC04	PP78	ST03	PP65	SC05	RA68	RD67	RD68	SC06	PP72	PP73	PP74	PP40	RA61
31	SYNC	RA72	RD71	RD72	TS85	PP75	ST01	PP68	TS86	RA74	RD73	RD74	TS87	PP76	ST02	BEHT	PP77	RA76	RD75	RD76	TS88	PP78	ST03	PP69	TS89	RA78	RD77	RD78	TS90	PP72	PP73	PP74	PP40	RA71
32	SYNC	RA02	RD01	RD02	SC01	PP75	ST01	PP79	SC02	RA04	RD03	RD04	SC03	PP76	ST02	BEHT	PP77	RA06	RD05	RD06	SC04	PP78	ST03	PP41	SC05	RA08	RD07	RD08	SC06	PP72	PP73	PP74	PP40	RA01
33	SYNC	RA12	RD11	RD12	TS01	PP75	ST01	PP44	TS02	RA14	RD13	RD14	TS03	PP76	ST02	BEHT	PP77	RA16	RD15	RD16	TS04	PP78	ST03	PP45	TS05	RA18	RD17	RD18	TS06	PP72	PP73	PP74	PP40	RA11
34	SYNC	RA22	RD21	RD22	SC01	PP75	ST01	PP48	SC02	RA24	RD23	RD24	SC03	PP76	ST02	BEHT	PP77	RA26	RD25	RD26	SC04	PP78	ST03	PP49	SC05	RA28	RD27	RD28	SC06	PP72	PP73	PP74	PP40	RA21
35	SYNC	RA32	RD31	RD32	TS01	PP75	ST01	PP52	TS02	RA34	RD33	RD34	TS03	PP76	ST02	BEHT	PP77	RA36	RD35	RD36	TS04	PP78	ST03	PP53	TS05	RA38	RD37	RD38	TS06	PP72	PP73	PP74	PP40	RA31
36	SYNC	RA42	RD41	RD42	SC01	PP75	ST01	PP56	SC02	RA44	RD43	RD44	SC03	PP76	ST02	BEHT	PP77	RA46	RD45	RD46	SC04	PP78	ST03	PP57	SC05	RA48	RD47	RD48	SC06	PP72	PP73	PP74	PP40	RA41
37	SYNC	RA52	RD51	RD52	TS13	PP75	ST01	PP60	TS14	RA54	RD53	RD54	TS15	PP76	ST02	BEHT	PP77	RA56	RD55	RD56	TS16	PP78	ST03	PP61	TS17	RA58	RD57	RD58	TS18	PP72	PP73	PP74	PP40	RA51
38	SYNC	RA62	RD61	RD62	SC01	PP75	ST01	PP64	SC02	RA64	RD63	RD64	SC03	PP76	ST02	BEHT	PP77	RA66	RD65	RD66	SC04	PP78	ST03	PP65	SC05	RA68	RD67	RD68	SC06	PP72	PP73	PP74	PP40	RA61
39	SYNC	RA72	RD71	RD72	TS13	PP75	ST01	PP68	TS14	RA74	RD73	RD74	TS15	PP76	ST02	BEHT	PP77	RA76	RD75	RD76	TS16	PP78	ST03	PP69	TS17	RA78	RD77	RD78	TS18	PP72	PP73	PP74	PP40	RA71
40	SYNC	RA02	RD01	RD02	SC01	PP75	ST01	PP79	SC02	RA04	RD03	RD04	SC03	PP76	ST02	BEHT	PP77	RA06	RD05	RD06	SC04	PP78	ST03	PP41	SC05	RA08	RD07	RD08	SC06	PP72	PP73	PP74	PP40	RA01
41	SYNC	RA12	RD11	RD12	TS25	PP75	ST01	PP44	TS26	RA14	RD13	RD14	TS27	PP76	ST02	BEHT	PP77	RA16	RD15	RD16	TS28	PP78	ST03	PP45	TS29	RA18	RD17	RD18	TS30	PP72	PP73	PP74	PP40	RA11
42	SYNC	RA22	RD21	RD22	SC01	PP75	ST01	PP48	SC02	RA24	RD23	RD24	SC03	PP76	ST02	BEHT	PP77	RA26	RD25	RD26	SC04	PP78	ST03	PP49	SC05	RA28	RD27	RD28	SC06	PP72	PP73	PP74	PP40	RA21
43	SYNC	RA32	RD31	RD32	TS25	PP75	ST01	PP52	TS26	RA34	RD33	RD34	TS27	PP76	ST02	BEHT	PP77	RA36	RD35	RD36	TS28	PP78	ST03	PP53	TS29	RA38	RD37	RD38	TS30	PP72	PP73	PP74	PP40	RA31
44	SYNC	RA42	RD41	RD42	SC01	PP75	ST01	PP56	SC02	RA44	RD43	RD44	SC03	PP76	ST02	BEHT	PP77	RA46	RD45	RD46	SC04	PP78	ST03	PP57	SC05	RA48	RD47	RD48	SC06	PP72	PP73	PP74	PP40	RA41
45	SYNC	RA52	RD51	RD52	TS37	PP75	ST01	PP60	TS38	RA54	RD53	RD54	TS39	PP76	ST02	BEHT	PP77	RA56	RD55	RD56	TS40	PP78	ST03	PP61	TS41	RA58	RD57	RD58	TS42	PP72	PP73	PP74	PP40	RA51
46	SYNC	RA62	RD61	RD62	SC01	PP75	ST01	PP64	SC02	RA64	RD63	RD64	SC03	PP76	ST02	BEHT	PP77	RA66	RD65	RD66	SC04	PP78	ST03	PP65	SC05	RA68	RD67	RD68	SC06	PP72	PP73	PP74	PP40	RA61
47	SYNC	RA72	RD71	RD72	TS37	PP75	ST01	PP68	TS38	RA74	RD73	RD74	TS39	PP76	ST02	BEHT	PP77	RA76	RD75	RD76	TS40	PP78	ST03	PP69	TS41	RA78	RD77	RD78	TS42	PP72	PP73	PP74	PP40	RA71
48	SYNC	RA02	RD01	RD02	SC01	PP75	ST01	PP79	SC02	RA04	RD03	RD04	SC03	PP76	ST02	BEHT	PP77	RA06	RD05	RD06	SC04	PP78	ST03	PP41	SC05	RA08	RD07	RD08	SC06	PP72	PP73	PP74	PP40	RA01
49	SYNC	RA12	RD11	RD12	TS49	PP75	ST01	PP44	TS50	RA14	RD13	RD14	TS51	PP76	ST02	BEHT	PP77	RA16	RD15	RD16	TS52	PP78	ST03	PP45	TS53	RA18	RD17	RD18	TS54	PP72	PP73	PP74	PP40	RA11
50	SYNC	RA22	RD21	RD22	SC01	PP75	ST01	PP48	SC02	RA24	RD23	RD24	SC03	PP76	ST02	BEHT	PP77	RA26	RD25	RD26	SC04	PP78	ST03	PP49	SC05	RA28	RD27	RD28	SC06	PP72	PP73	PP74	PP40	RA21
51	SYNC	RA32	RD31	RD32	TS49	PP75	ST01	PP52	TS50	RA34	RD33	RD34	TS51	PP76	ST02	BEHT	PP77	RA36	RD35	RD36	TS52	PP78	ST03	PP53	TS53	RA38	RD37	RD38	TS54	PP72	PP73	PP74	PP40	RA31
52	SYNC	RA42	RD41	RD42	SC01	PP75	ST01	PP56	SC02	RA44	RD43	RD44	SC03	PP76	ST02	BEHT	PP77	RA46	RD45	RD46	SC04	PP78	ST03	PP57	SC05	RA48	RD47	RD48	SC06	PP72	PP73	PP74	PP40	RA41
53	SYNC	RA52	RD51	RD52	TS61	PP75	ST01	PP60	TS62	RA54	RD53	RD54	TS63	PP76	ST02	BEHT	PP77	RA56	RD55	RD56	TS64	PP78	ST03	PP61	TS65	RA58	RD57	RD58	TS66	PP72	PP73	PP74	PP40	RA51
54	SYNC	RA62	RD61	RD62	SC01	PP75	ST01	PP64	SC02	RA64	RD63	RD64	SC03	PP76	ST02	BEHT	PP77	RA66	RD65	RD66	SC04	PP78	ST03	PP65	SC05	RA68	RD67	RD68	SC06	PP72	PP73	PP74	PP40	RA61
55	SYNC	RA72	RD71	RD72	TS61	PP75	ST01	PP68	TS62	RA74	RD73	RD74	TS63	PP76	ST02	BEHT	PP77	RA76	RD75	RD76	TS64	PP78	ST03	PP69	TS65	RA78	RD77	RD78	TS66	PP72	PP73	PP74	PP40	RA71
56	SYNC	RA02	RD01	RD02	SC01	PP75	ST01	PP79	SC02	RA04	RD03	RD04	SC03	PP76	ST02	BEHT	PP77	RA06	RD05	RD06	SC04	PP78	ST03	PP41	SC05	RA08	RD07	RD08	SC06	PP72	PP73	PP74	PP40	RA01
57	SYNC	RA12	RD11	RD12	TS73	PP75	ST01	PP44	TS74	RA14	RD13	RD14	TS75	PP76	ST02	BEHT	PP77	RA16	RD15	RD16	TS76	PP78	ST03	PP45	TS77	RA18	RD17	RD18	TS78	PP72	PP73	PP74	PP40	RA11
58	SYNC	RA22	RD21	RD22	SC01	PP75	ST01	PP48	SC02	RA24	RD23	RD24	SC03	PP76	ST02	BEHT	PP77	RA26	RD25	RD26	SC04	PP78	ST03	PP49	SC05	RA28	RD27	RD28	SC06	PP72	PP73	PP74	PP40	RA21
59	SYNC	RA32	RD31	RD32	TS73	PP75	ST01	PP52	TS74	RA34	RD33	RD34	TS75	PP76	ST02	BEHT	PP77	RA36	RD35	RD36	TS76	PP78	ST03	PP53	TS77	RA38	RD37	RD38	TS78	PP72	PP73	PP74	PP40	RA31
60	SYNC	RA42	RD41	RD42	SC01	PP75	ST01	PP56	SC02	RA44	RD43	RD44	SC03	PP76	ST02	BEHT	PP77	RA46	RD45	RD46	SC04	PP78	ST03	PP57	SC05	RA48	RD47	RD48	SC06	PP72	PP73	PP74	PP40	RA41
61	SYNC	RA52	RD51	RD52	TS85	PP75	ST01	PP60	TS86	RA54	RD53	RD54	TS87	PP76	ST02	BEHT	PP77	RA56	RD55	RD56	TS88	PP78	ST03	PP61	TS89	RA58	RD57	RD58	TS90	PP72	PP73	PP74	PP40	RA51
62	SYNC	RA62	RD61	RD62	SC01	PP75	ST01	PP64	SC02	RA64	RD63	RD64	SC03	PP76	ST02	BEHT	PP77	RA66	RD65	RD66	SC04	PP78	ST03	PP65	SC05	RA68	RD67	RD68	SC06	PP72	PP73	PP74	PP40	RA61
63	SYNC	RA72	RD71	RD72	TS85	PP75	ST01	PP68	TS86	RA74	RD73	RD74	TS87	PP76	ST02	BEHT	PP77	RA76	RD75	RD76	TS88	PP78	ST03	PP69	TS89	RA78	RD77	RD78	TS90	PP72	PP73	PP74	PP40	RA71

MINOR FRAME \ SYLLABLE	37 38	39	40	41	42	43	44	45 46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
0	AS01	SC07	PP80	ST04	PP42	SC08	RA03	AS02	SC09	PP81	ST05	BPUL	PP82	RA05	PG0	DD01	SC10	PP83	ST06	PP43	SC11	RA07	DD02	DD03	SC12
1		TS07	PP80	ST04	PP46	TS08	RA13		TS09	PP81	ST05	BPUL	PP82	RA15	PG1	DD01	TS10	PP83	ST06	PP47	TS11	RA17	DD02	DD03	TS12
2		SC07	PP80	ST04	PP50	SC08	RA23		SC09	PP81	ST05	BPUL	PP82	RA25	PG2	DD01	SC10	PP83	ST06	PP51	SC11	RA27	DD02	DD03	SC12
3		TS07	PP80	ST04	PP54	TS08	RA33		TS09	PP81	ST05	BPUL	PP82	RA35	PG3	DD01	TS10	PP83	ST06	PP55	TS11	RA37	DD02	DD03	TS12
4		SC07	PP80	ST04	PP58	SC08	RA43		SC09	PP81	ST05	BPUL	PP82	RA45	PG4	DD01	SC10	PP83	ST06	PP59	SC11	RA47	DD02	DD03	SC12
5		TS19	PP80	ST04	PP62	TS20	RA53		TS21	PP81	ST05	BPUL	PP82	RA55	PG5	DD01	TS22	PP83	ST06	PP63	TS23	RA57	DD02	DD03	TS24
6		SC07	PP80	ST04	PP66	SC08	RA63		SC09	PP81	ST05	BPUL	PP82	RA65	PG6	DD01	SC10	PP83	ST06	PP67	SC11	RA67	DD02	DD03	SC12
7		TS19	PP80	ST04	PP70	TS20	RA73		TS21	PP81	ST05	BPUL	PP82	RA75	PG7	DD01	TS22	PP83	ST06	PP71	TS23	RA77	DD02	DD03	TS24
8	AS03	SC07	PP80	ST04	PP42	SC08	RA03	AS04	SC09	PP81	ST05	BPUL	PP82	RA05	PG0	DD01	SC10	PP83	ST06	PP43	SC11	RA07	DD02	DD03	SC12
9		TS31	PP80	ST04	PP46	TS32	RA13		TS33	PP81	ST05	BPUL	PP82	RA15	PG1	DD01	TS34	PP83	ST06	PP47	TS35	RA17	DD02	DD03	TS36
10		SC07	PP80	ST04	PP50	SC08	RA23		SC09	PP81	ST05	BPUL	PP82	RA25	PG2	DD01	SC10	PP83	ST06	PP51	SC11	RA27	DD02	DD03	SC12
11		TS31	PP80	ST04	PP54	TS32	RA33		TS33	PP81	ST05	BPUL	PP82	RA35	PG3	DD01	TS34	PP83	ST06	PP55	TS35	RA37	DD02	DD03	TS36
12		SC07	PP80	ST04	PP58	SC08	RA43		SC09	PP81	ST05	BPUL	PP82	RA45	PG4	DD01	SC10	PP83	ST06	PP59	SC11	RA47	DD02	DD03	SC12
13		TS43	PP80	ST04	PP62	TS44	RA53		TS45	PP81	ST05	BPUL	PP82	RA55	PG5	DD01	TS46	PP83	ST06	PP63	TS47	RA57	DD02	DD03	TS48
14		SC07	PP80	ST04	PP66	SC08	RA63		SC09	PP81	ST05	BPUL	PP82	RA65	PG6	DD01	SC10	PP83	ST06	PP67	SC11	RA67	DD02	DD03	SC12
15		TS43	PP80	ST04	PP70	TS44	RA73		TS45	PP81	ST05	BPUL	PP82	RA75	PG7	DD01	TS46	PP83	ST06	PP71	TS47	RA77	DD02	DD03	TS48
16	AS05	SC07	PP80	ST04	PP42	SC08	RA03	AS06	SC09	PP81	ST05	BPUL	PP82	RA05	PG0	DD01	SC10	PP83	ST06	PP43	SC11	RA07	DD02	DD03	SC12
17		TS55	PP80	ST04	PP46	TS56	RA13		TS57	PP81	ST05	BPUL	PP82	RA15	PG1	DD01	TS58	PP83	ST06	PP47	TS59	RA17	DD02	DD03	TS60
18		SC07	PP80	ST04	PP50	SC08	RA23		SC09	PP81	ST05	BPUL	PP82	RA25	PG2	DD01	SC10	PP83	ST06	PP51	SC11	RA27	DD02	DD03	SC12
19		TS55	PP80	ST04	PP54	TS56	RA33		TS57	PP81	ST05	BPUL	PP82	RA35	PG3	DD01	TS58	PP83	ST06	PP55	TS59	RA37	DD02	DD03	TS60
20		SC07	PP80	ST04	PP58	SC08	RA43		SC09	PP81	ST05	BPUL	PP82	RA45	PG4	DD01	SC10	PP83	ST06	PP59	SC11	RA47	DD02	DD03	SC12
21		TS67	PP80	ST04	PP62	TS68	RA53		TS69	PP81	ST05	BPUL	PP82	RA55	PG5	DD01	TS70	PP83	ST06	PP63	TS71	RA57	DD02	DD03	TS72
22		SC07	PP80	ST04	PP66	SC08	RA63		SC09	PP81	ST05	BPUL	PP82	RA65	PG6	DD01	SC10	PP83	ST06	PP67	SC11	RA67	DD02	DD03	SC12
23		TS67	PP80	ST04	PP70	TS68	RA73		TS69	PP81	ST05	BPUL	PP82	RA75	PG7	DD01	TS70	PP83	ST06	PP71	TS71	RA77	DD02	DD03	TS72
24	AS07	SC07	PP80	ST04	PP42	SC08	RA03	AS08	SC09	PP81	ST05	BPUL	PP82	RA05	PG0	DD01	SC10	PP83	ST06	PP43	SC11	RA07	DD02	DD03	SC12
25		TS79	PP80	ST04	PP46	TS80	RA13		TS81	PP81	ST05	BPUL	PP82	RA15	PG1	DD01	TS82	PP83	ST06	PP47	TS83	RA17	DD02	DD03	TS84
26		SC07	PP80	ST04	PP50	SC08	RA23		SC09	PP81	ST05	BPUL	PP82	RA25	PG2	DD01	SC10	PP83	ST06	PP51	SC11	RA27	DD02	DD03	SC12
27		TS79	PP80	ST04	PP54	TS80	RA33		TS81	PP81	ST05	BPUL	PP82	RA35	PG3	DD01	TS82	PP83	ST06	PP55	TS83	RA37	DD02	DD03	TS84
28		SC07	PP80	ST04	PP58	SC08	RA43		SC09	PP81	ST05	BPUL	PP82	RA45	PG4	DD01	SC10	PP83	ST06	PP59	SC11	RA47	DD02	DD03	SC12
29		TS91	PP80	ST04	PP62	TS92	RA53		TS93	PP81	ST05	BPUL	PP82	RA55	PG5	DD01	TS94	PP83	ST06	PP63	TS95	RA57	DD02	DD03	TS96
30		SC07	PP80	ST04	PP66	SC08	RA63		SC09	PP81	ST05	BPUL	PP82	RA65	PG6	DD01	SC10	PP83	ST06	PP67	SC11	RA67	DD02	DD03	SC12
31		TS91	PP80	ST04	PP70	TS92	RA73		TS93	PP81	ST05	BPUL	PP82	RA75	PG7	DD01	TS94	PP83	ST06	PP71	TS95	RA77	DD02	DD03	TS96
32	AS09	SC07	PP80	ST04	PP42	SC08	RA03	AS10	SC09	PP81	ST05	BPUL	PP82	RA05	PG0	DD01	SC10	PP83	ST06	PP43	SC11	RA07	DD02	DD03	SC12
33		TS07	PP80	ST04	PP46	TS08	RA13		TS09	PP81	ST05	BPUL	PP82	RA15	PG1	DD01	TS10	PP83	ST06	PP47	TS11	RA17	DD02	DD03	TS12
34		SC07	PP80	ST04	PP50	SC08	RA23		SC09	PP81	ST05	BPUL	PP82	RA25	PG2	DD01	SC10	PP83	ST06	PP51	SC11	RA27	DD02	DD03	SC12
35		TS07	PP80	ST04	PP54	TS08	RA33		TS09	PP81	ST05	BPUL	PP82	RA35	PG3	DD01	TS10	PP83	ST06	PP55	TS11	RA37	DD02	DD03	TS12
36		SC07	PP80	ST04	PP58	SC08	RA43		SC09	PP81	ST05	BPUL	PP82	RA45	PG4	DD01	SC10	PP83	ST06	PP59	SC11	RA47	DD02	DD03	SC12
37		TS19	PP80	ST04	PP62	TS20	RA53		TS21	PP81	ST05	BPUL	PP82	RA55	PG5	DD01	TS22	PP83	ST06	PP63	TS23	RA57	DD02	DD03	TS24
38		SC07	PP80	ST04	PP66	SC08	RA63		SC09	PP81	ST05	BPUL	PP82	RA65	PG6	DD01	SC10	PP83	ST06	PP67	SC11	RA67	DD02	DD03	SC12
39		TS19	PP80	ST04	PP70	TS20	RA73		TS21	PP81	ST05	BPUL	PP82	RA75	PG7	DD01	TS22	PP83	ST06	PP71	TS23	RA77	DD02	DD03	TS24
40	AS11	SC07	PP80	ST04	PP42	SC08	RA03	AS12	SC09	PP81	ST05	BPUL	PP82	RA05	PG0	DD01	SC10	PP83	ST06	PP43	SC11	RA07	DD02	DD03	SC12
41		TS31	PP80	ST04	PP46	TS32	RA13		TS33	PP81	ST05	BPUL	PP82	RA15	PG1	DD01	TS34	PP83	ST06	PP47	TS35	RA17	DD02	DD03	TS36
42		SC07	PP80	ST04	PP50	SC08	RA23		SC09	PP81	ST05	BPUL	PP82	RA25	PG2	DD01	SC10	PP83	ST06	PP51	SC11	RA27	DD02	DD03	SC12
43		TS31	PP80	ST04	PP54	TS32	RA33		TS33	PP81	ST05	BPUL	PP82	RA35	PG3	DD01	TS34	PP83	ST06	PP55	TS35	RA37	DD02	DD03	TS36
44		SC07	PP80	ST04	PP58	SC08	RA43		SC09	PP81	ST05	BPUL	PP82	RA45	PG4	DD01	SC10	PP83	ST06	PP59	SC11	RA47	DD02	DD03	SC12
45		TS43	PP80	ST04	PP62	TS44	RA53		TS45	PP81	ST05	BPUL	PP82	RA55	PG5	DD01	TS46	PP83	ST06	PP63	TS47	RA57	DD02	DD03	TS48
46		SC07	PP80	ST04	PP66	SC08	RA63		SC09	PP81	ST05	BPUL	PP82	RA65	PG6	DD01	SC10	PP83	ST06	PP67	SC11	RA67	DD02	DD03	SC12
47		TS43	PP80	ST04	PP70	TS44	RA73		TS45	PP81	ST05	BPUL	PP82	RA75	PG7	DD01	TS46	PP83	ST06	PP71	TS47	RA77	DD02	DD03	TS48
48	AS13	SC07	PP80	ST04	PP42	SC08	RA03	AS14	SC09	PP81	ST05	BPUL	PP82	RA05	PG0	DD01	SC10	PP83	ST06	PP43	SC11	RA07	DD02	DD03	SC12
49		TS55	PP80	ST04	PP46	TS56	RA13		TS57	PP81	ST05	BPUL	PP82	RA15	PG1	DD01	TS58	PP83	ST06	PP47	TS59	RA17	DD02	DD03	TS60
50		SC07	PP80	ST04	PP50	SC08	RA23		SC09	PP81	ST05	BPUL	PP82	RA25	PG2	DD01	SC10	PP83	ST06	PP51	SC11	RA27	DD02	DD03	SC12
51		TS55	PP80	ST04	PP54	TS56	RA33		TS57	PP81	ST05	BPUL	PP82	RA35	PG3	DD01	TS58	PP83	ST06	PP55	TS59	RA37	DD02	DD03	TS60
52		SC07	PP80	ST04	PP58	SC08	RA43		SC09	PP81	ST05	BPUL	PP82	RA45	PG4	DD01	SC10	PP83	ST06	PP59	SC11	RA47	DD02	DD03	SC12
53		TS67	PP80	ST04	PP62	TS68	RA53		TS69	PP81	ST05	BPUL	PP82	RA55	PG5	DD01	TS70	PP83	ST06	PP63	TS71	RA57	DD02	DD03	TS72
54		SC07	PP80	ST04	PP66	SC08	RA63		SC09	PP81	ST05	BPUL	PP82	RA65	PG6	DD01	SC10	PP83	ST06	PP67	SC11	RA67	DD02	DD03	SC12
55		TS67	PP80	ST04	PP70	TS68	RA73		TS69	PP81	ST05	BPUL	PP82	RA75	PG7	DD01	TS70	PP83	ST06	PP71	TS71	RA77	DD02	DD03	TS72
56	AS15	SC07	PP80	ST04	PP42	SC08	RA03	AS16	SC09	PP81	ST05	BPUL	PP82	RA05	PG0	DD01	SC10	PP83	ST06	PP43	SC11	RA07	DD02	DD03	SC12
57		TS79	PP80	ST04	PP46	TS80	RA13		TS81	PP81	ST05	BPUL	PP82	RA15	PG1	DD01	TS82	PP83	ST06	PP47	TS83	RA17	DD02	DD03	TS84
58		SC07	PP80	ST04	PP50	SC08	RA23		SC09	PP81	ST05	BPUL	PP82	RA25	PG2	DD01	SC10	PP83	ST06	PP51	SC11	RA27	DD02	DD03	SC12
59		TS79	PP80	ST04	PP54	TS80	RA33		TS81	PP81	ST05	BPUL	PP82	RA35	PG3	DD01	TS82	PP83	ST06	PP55	TS83	RA37	DD02	DD03	TS84
60		SC07	PP80	ST04	PP58	SC08	RA43		SC09	PP81	ST05	BPUL	PP82	RA45	PG4	DD01	SC10	PP83	ST06	PP59	SC11	RA47	DD02	DD03	SC12
61		TS91	PP80	ST04	PP62	TS92	RA53		TS93	PP81	ST05	BPUL	PP82	RA55	PG5	DD01	TS94	PP83	ST06	PP63	TS95	RA57	DD02	DD03	TS96
62		SC07	PP80	ST04	PP66	SC08	RA63		SC09	PP81	ST05	BPUL	PP82	RA65	PG6	DD01	SC10	PP83	ST06	PP67	SC11	RA67	DD02	DD03	SC12
63		TS91	PP80	ST04	PP70	TS92	RA73		TS93	PP81	ST05	BPUL	PP82	RA75	PG7	DD01	TS94	PP83	ST06	PP71	TS95	RA77	DD02	DD03	TS96

NORMAL MODE DIRECT FORMAT

MINOR FRAME \ SYLLABLE	0123	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
0	SYNC	GY01	GY02	SMON	SS01	DA01	GY01	GY02	SMON	SS01	DA02	GY01	GY02	SMON	SS01	HSKP	DA02	GY01	GY02	SMON	SS01	DA01	GY01	GY02	SMON	SS01	DA02	GY01	GY02	SMON	SS01	HSKP	DA02	GY01	GY02	SMON	SS01	DA01	GY01	GY02	SMON	SS01	DA02	GY01	GY02	SMON	SS01	HSKP	DA02	GY01	GY02	SMON	SS01	DA01	GY01	GY02	SMON	SS01	DA02	GY01	GY02

ROCKET 3RD STAGE MODE DIRECT FORMAT

Fig.4. X3 telemetry format direct mode

Fig.5

MINOR FRAME \ SYLLABLE	0123	4	5	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
0	SYNC	PP01	PP02	PP03	PP04	PP05	TS01	TS02	PP06	PP07	TS03	TS04	PP08	ST01	TS05	TS06	PP09	ST04	TS07	TS08	PP10	PP11	TS09	TS10	PP12	PP13	TS11	TS12	PP14	ST02	PP15	PP16	PP17	ST05
1	SYNC	PP01	PP02	PP03	PP04	PP05	TS13	TS14	PP06	PP07	TS15	TS16	PP08	ST01	TS17	TS18	PP09	ST04	TS19	TS20	PP10	PP11	TS21	TS22	PP12	PP13	TS23	TS24	PP14	ST02	PP15	PP16	PP17	ST05
2	SYNC	PP01	PP02	PP03	PP04	PP05	TS25	TS26	PP06	PP07	TS27	TS28	PP08	ST01	TS29	TS30	PP09	ST04	TS31	TS32	PP10	PP11	TS33	TS34	PP12	PP13	TS35	TS36	PP14	ST02	PP15	PP16	PP17	ST05
3	SYNC	PP01	PP02	PP03	PP04	PP05	TS37	TS38	PP06	PP07	TS39	TS40	PP08	ST01	TS41	TS42	PP09	ST04	TS43	TS44	PP10	PP11	TS45	TS46	PP12	PP13	TS47	TS48	PP14	ST02	PP15	PP16	PP17	ST05
4	SYNC	PP01	PP02	PP03	PP04	PP05	TS49	TS50	PP06	PP07	TS51	TS52	PP08	ST01	TS53	TS54	PP09	ST04	TS55	TS56	PP10	PP11	TS57	TS58	PP12	PP13	TS59	TS60	PP14	ST02	PP15	PP16	PP17	ST05
5	SYNC	PP01	PP02	PP03	PP04	PP05	TS61	TS62	PP06	PP07	TS63	TS64	PP08	ST01	TS65	TS66	PP09	ST04	TS67	TS68	PP10	PP11	TS69	TS70	PP12	PP13	TS71	TS72	PP14	ST02	PP15	PP16	PP17	ST05
6	SYNC	PP01	PP02	PP03	PP04	PP05	TS73	TS74	PP06	PP07	TS75	TS76	PP08	ST01	TS76	TS78	PP09	ST04	TS79	TS80	PP10	PP11	TS81	TS82	PP12	PP13	TS83	TS84	PP14	ST02	PP15	PP16	PP17	ST05
7	SYNC	PP01	PP02	PP03	PP04	PP05	TS85	TS86	PP06	PP07	TS87	TS88	PP08	ST01	TS89	TS90	PP09	ST04	TS91	TS92	PP10	PP11	TS93	TS94	PP12	PP13	TS95	TS96	PP14	ST02	PP15	PP16	PP17	ST05

MINOR FRAME \ SYLLABLE	37 38	39	40	41	42	43	44	45 46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
0	AS01	PP18	PP19	PP20	PP21	PP22	PP23	AS02	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
1	AS03	PP18	PP19	PP20	PP21	PP22	PP23	AS04	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
2	AS05	PP18	PP19	PP20	PP21	PP22	PP23	AS06	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
3	AS07	PP18	PP19	PP20	PP21	PP22	PP23	AS08	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
4	AS09	PP18	PP19	PP20	PP21	PP22	PP23	AS10	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
5	AS11	PP18	PP19	PP20	PP21	PP22	PP23	AS12	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
6	AS13	PP18	PP19	PP20	PP21	PP22	PP23	AS14	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
7	AS15	PP18	PP19	PP20	PP21	PP22	PP23	AS16	PP24	ST03	PP25	PP26	PP27	ST05	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38

SURFACES MODE RECORDED FORMAT

MINOR FRAME \ SYLLABLE	0123	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
0	SYNC	PP01	PP02	PP03	PP04	PP05	SC01	SC02	PP06	PP07	SC03	SC04	PP08	ST01	SC05	SC06	PP09	ST04	SC07	SC08	PP10	PP11	SC09	SC10	PP12	PP13	SC11	SC12	PP14	ST02	PP15	PP16	PP17	ST05
1	SYNC	PP01	PP02	PP03	PP04	PP05	SC01	SC02	PP06	PP07	SC03	SC04	PP08	ST01	SC05	SC06	PP09	ST04	SC07	SC08	PP10	PP11	SC09	SC10	PP12	PP13	SC11	SC12	PP14	ST02	PP15	PP16	PP17	ST05
2	SYNC	PP01	PP02	PP03	PP04	PP05	SC01	SC02	PP06	PP07	SC03	SC04	PP08	ST01	SC05	SC06	PP09	ST04	SC07	SC08	PP10	PP11	SC09	SC10	PP12	PP13	SC11	SC12	PP14	ST02	PP15	PP16	PP17	ST05
3	SYNC	PP01	PP02	PP03	PP04	PP05	SC01	SC02	PP06	PP07	SC03	SC04	PP08	ST01	SC05	SC06	PP09	ST04	SC07	SC08	PP10	PP11	SC09	SC10	PP12	PP13	SC11	SC12	PP14	ST02	PP15	PP16	PP17	ST05
4	SYNC	PP01	PP02	PP03	PP04	PP05	SC01	SC02	PP06	PP07	SC03	SC04	PP08	ST01	SC05	SC06	PP09	ST04	SC07	SC08	PP10	PP11	SC09	SC10	PP12	PP13	[illegible]	SC12	PP14	ST02	PP15	PP15	PP17	ST05
5	SYNC	PP01	PP02	PP03	PP04	PP05	SC01	SC02	PP06	PP07	SC03	SC04	PP08	ST01	SC05	SC06	PP09	ST04	SC07	SC08	PP10	PP11	SC09	SC10	PP12	PP13	SC11	SC12	PP14	ST02	PP15	PP16	PP17	ST05
6	SYNC	PP01	PP02	PP03	PP04	PP05	SC01	SC02	PP06	PP07	SC03	SC04	PP08	ST01	SC05	SC06	PP09	ST04	SC07	SC08	PP10	PP11	SC09	SC10	PP12	PP13	SC11	SC12	PP14	ST02	PP15	PP16	PP17	ST05
7	SYNC	PP01	PP02	PP03	PP04	PP05	SC01	SC02	PP06	PP07	SC03	SC04	PP08	ST01	SC05	SC06	PP09	ST04	SC07	SC08	PP10	PP11	SC09	SC10	PP12	PP13	SC11	SC12	PP14	ST02	PP15	PP16	PP17	ST05

MINOR FRAME \ SYLLABLE	37 38	39	40	41	42	43	44	45 46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
0	AS01	PP18	PP19	PP20	PP21	PP22	PP23	AS02	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
1	AS03	PP18	PP19	PP20	PP21	PP22	PP23	AS04	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
2	AS05	PP18	PP19	PP20	PP21	PP22	PP23	AS06	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
3	AS07	PP18	PP19	PP20	PP21	PP22	PP23	AS08	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
4	AS09	PP18	PP19	PP20	PP21	PP22	PP23	AS10	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
5	AS11	PP18	PP19	PP20	PP21	PP22	PP23	AS12	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
6	AS13	PP18	PP19	PP20	PP21	PP22	PP23	AS14	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38
7	AS15	PP18	PP19	PP20	PP21	PP22	PP23	AS16	PP24	ST03	PP25	PP26	PP27	ST06	PP28	PP29	PP30	PP31	PP32	PP33	PP34	PP35	PP36	PP37	PP38

NORMAL MODE RECORDED FORMAT

Fig.5. X3 telemetr, format recorded modes

Fig.6

Mode \ Bits	Sync code	T/R ident	Mode ident	Frame ident
	MSB 0 - - - - - - - - LSB 22	23	24 25	26 27 28 29 30 31
Normal direct	3 6 5 6 3 2 0 0	0/1	0 1	MSB —— LSB
Surfaces direct	3 6 5 6 3 2 0 0	0/1	1 0	MSB —— LSB
Third stage	3 6 5 6 3 2 0 0	0	1 1	MSB —— LSB
Normal recorded	0 1 2 1 4 5 7 7	0/1	0 1	0 0 0 MSB —— LSB
Surfaces recorded	0 1 2 1 4 5 7 7	0/1	1 0	0 0 0 MSB —— LSB
See notes	1	2	3	

NOTES:
1. SYNC CODE is shown as an octal representation of the bits with the MSB made from two bits.
2. T/R IDENT indicates '1' when the tape recorder has been commanded to playback.
3. Under certain circumstances the mode identification pulses, in normal mode, may appear as '0' '0'. In such a case the satellite will be commanded into NORMAL MODE with a mode identification '0' '1'.
4. MSB most significant bit.
5. LSB least significant bit.

Fig.6 Telemetry format for first 32 bits of each minor frame

Fig.7

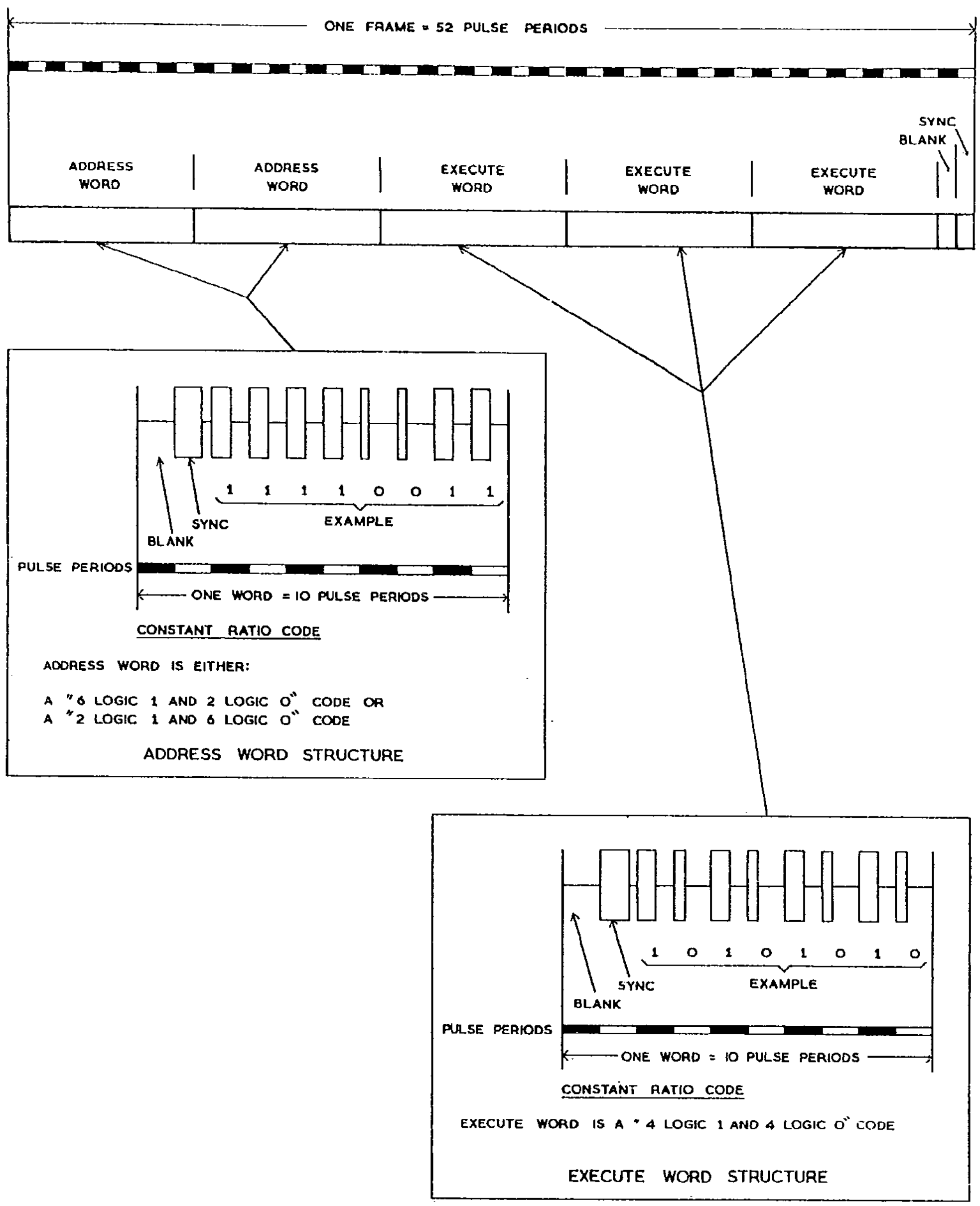


Fig.7. X3 command format