

RCA / aerospace + Defense / Gov't. Communications  
Systems Division

FINAL REPORT

FOR

UARS

SPACECRAFT RECORDER

NAS-5-29186

1N-35

72622-CR

P.32

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RK

(NASA-CR-180768) UARS SPACECRAFT RECORDER  
Final Report (RCA Aerospace and Defense)  
32 p CSCL 14C

N88-22331

G3/35 Unclass  
0092622

PREPARED FOR:

GODDARD SPACE FLIGHT CENTER  
GREENBELT, MD 20771

23 JULY 1987

A. PROGRAM OBJECTIVE

The objective of this program was the design, development and fabrication of UARS Spacecraft Recorders per the requirements of Attachment 1, GSFC, Statement of Work for the UARS Tape Recorders, dated October 24, 1984. This contract (NAS-6-29186) was awarded in July, 1985, and was scheduled for hardware delivery by June 15, 1987.

B. RECORDER SUMMARY

The UARS REcorder is a tailored configuration of the RCA Standard Tape recorder STR-108 (AT) (see attached data sheet). The tailored UARS configuration consists of two EU's and two TU's in a cross-strapped configuration providing maximum redundancy. In this configuration either EU is able to operate either TU non-concurrently. Viewgraph #3 in the attached Pre-Ship Review package is a photograph of the actual UARS system in its cross-strapped configuration. VG #4 depicts the uncovered TU mechanism.

Recorder Highlights

UARS recorder highlights and design improvements such as single record/play head, multilayer boards, extensive thermal stress testing and Grade 1 parts are shown in VG #6. Specific command structures and record play speeds are tabulated in Viewgraph #8.

Examples are:

Record speed	4 MUX = 0.84 IPS
	8 MUX = 0.42 IPS
Play speeds	4 MUX - 6.7 IPS & 13.4 IPS
	8 MUX - 6.7 IPS & 13.4 IPS
Fwd & Rev Rewind	is 34.7 IPS

Parts - Although the UARS RECORDER IS A Grade 2 program, 95% + of the parts are Grade 1 as a result of the concurrent parts procurement of UARS and NOAA. See VG #10.

NASPAR/SCD status

All NSPARS were approved - Viewgraph #11 provides the details of each NASPAR.

Deviations/Waivers

All deviations and waivers were approved - details are shown in Viewgraph #12.

MRB's

Two MRB's were performed and approved - details are shown on Viewgraph #13.

Part Failures

Only four part failures (all informal) occurred during the program. Details are given on VG #14.

### Environmental Test Summary

Critical parts and subassemblies are thermally cycled over extreme temperatures many times, e.g. 25 times for transformers  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , circuit boards eleven times  $-20^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$ .

Verification tests on the recorder system were performed prior to acceptance at  $-15^{\circ}\text{C}$  to  $+45^{\circ}\text{C}$ . Acceptance Tests included six thermal cycles ranging between  $-10^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ , and Random Vibration 3 axis one minute each 10 g's RMS plus a leak test at  $1 \times 10^{-5}$  MM Hg vacuum.

Details of these environmental tests are covered in Viewgraphs #16 through #19.

### Spacecraft Configuration Verification

The UARS system configuration was verified against the spacecraft mounting specifications. VG #21 depicts the configuration and significant dimensions.

### C. PROGRAM RESULTS

All hardware design, fabrication, test and documentation (other than this final report) was completed per GSFC SOW and delivered to NASA on June 12, 1987.

All deliverables, services and reviews per the SOW and Section B items A-1 through A-6, and items B-1 through B-3 have been completed in full compliance with the contract and are listed below.

Item B-4 sustaining engineering, 400 hours, is in reserve (through October of 1989, the original UARS launch date)) for any required assistance during spacecraft integration and test.

1. Hardware

<u>Item</u>	<u>Description</u>	<u>Quantity</u>	<u>Status</u>
A-1	Flight Spacecraft Recorders	2	Complete
A-2	Cross-Strap Harness	1	Complete
A-3	Mating Half 7 Each Spacecraft Interface Connector	1 1/2 full set	Complete
A-4	Reusable Shipping Container	2	Complete
A-5	Connector Savers	1 set for each Recorder	Complete
A-6	Fit Check Template	1	Complete

2. Reviews/Services

<u>Item</u>	<u>Description</u>	<u>Quantity</u>	<u>Status</u>
B-1	Preliminary Status Review	1	Complete
B-2	Pretest Review	1	Complete
B-3	Documentation & Reviews	As specified in Schedule and/or State- ment of Work	Complete
B-4	Sustaining Engineering	400 hours	As needed

D. PRE-SHIP REVIEW DOCUMENTATION

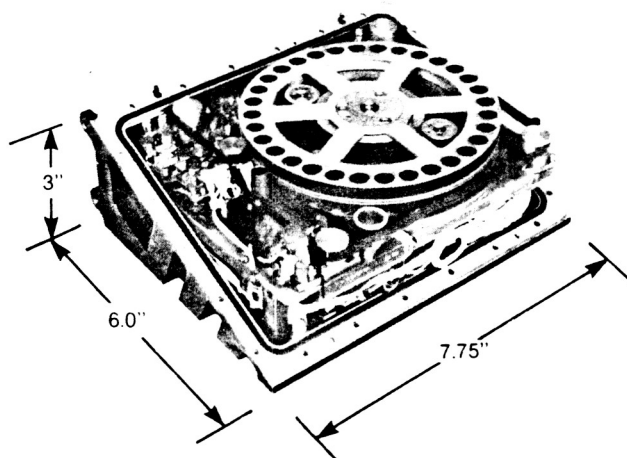
Attached is a copy of the complete Pre-Ship Review presentation held on June 11, 1987 which provides a summary of design, test, and environmental results, Deviations/Waivers, Malfunction Reports/Closures and Contract Item satisfaction.

# STR-108 (AT)

## 5 x 10<sup>8</sup> Bit Spaceborne Standard Tape Recorder System

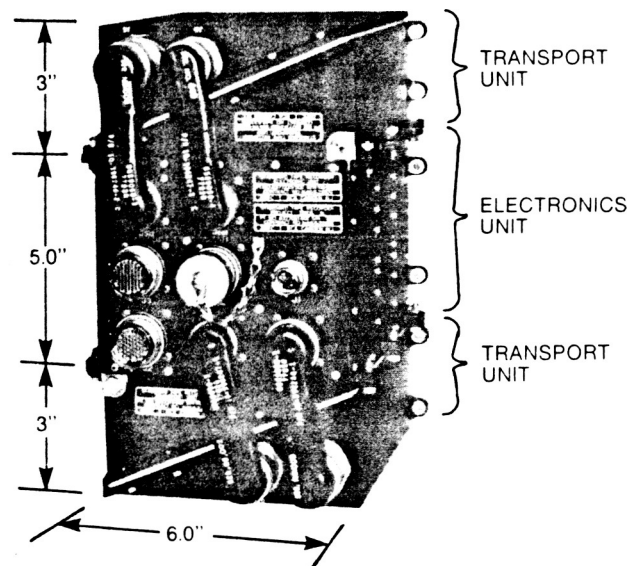
## STR-108 (AT)

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TRANSPORT UNIT

Dimensions exclude connectors and mounting flange



TWO TRANSPORT CONFIGURATION

### DESCRIPTION

The STR-108 (AT) is the *Advanced Technology* version of the STR-108, a complete magnetic recorder/data storage system designated by NASA as the Standard Tape Recorder in its capacity range. Development and production of this system has been sponsored by the Goddard Space Flight Center.

*Advanced Technology* enhancements provide the STR-108 (AT) with unmatched space recorder reliability.

#### Extended Thermal and Electrical Prestressing

- Increased Reliability

#### Extended Life

- Tested Beyond 50,000 Tape Passes

#### Single Record/Play Head

- Decreased Tracking Error
- Increased Error Budget
- Increased Tape Life

#### Advanced Packaging Techniques

- Repeatable Quality
- Improved Serviceability

Designed to operate unattended in the space environment, the STR-108 system consists of two units: the Transport Unit (TU) and the Electronics Unit (EU). The system features serial input and output ports and provides automatic internal multiplexing to accommodate a wide range of data rates. The hermetically sealed TU consists of a coaxial reel-to-reel tape transport with associated negator-spring tape tensioning system, bearing assemblies, motor/capstan, record/playback head, and erase head. TU circuitry includes motor drive electronics, redundant end-of-tape sensors, record amplifiers, preamplifiers, and transport-related telemetry systems. The vented EU contains the balance of the data conditioning circuitry as well as the command and telemetry subsystems, power conditioning circuitry, and timing references.

The STR-108 is designed for flexible mounting and operation. Electronic Units (EU's) and Transport Units (TU's) are constructed so that they can be mounted separately or in stacked assemblies. One EU can operate with one or two TU's; Two EU's can operate with either of two TU's.

### FEATURES

- Brushless DC Direct Drive Motor
- Two Magnetic Tracks for Each Data Channel
- Tape Speed Ratio of 160:1 in Either Direction
- Record or Play in Either Direction
- Separate Electronics & Transport Packages
- 5.3 x 10<sup>8</sup> Bits Storage Capacity Per Transport Unit
- I/O Continuously Variable from 2.0 Kb/s to 2.56 Mb/s
- Designed for Use on Diverse Spacecraft
- Wide Variety of Mounting Options
- EU/TU Cross-Strapping Modes Available

### ENVIRONMENTAL QUALIFICATIONS

- Random Vibration: 24.4 G RMS
- Sine Vibration: 20 G
- Operating Temp: -10°C to +40°C
- Storage Temp: -20°C to +50°C
- Radiation: 10<sup>5</sup> RADS
- EMC: MIL STD 461

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# Specifications

## GENERAL

Transport Configuration	Coaxial Reel-to-Reel
Tape Tensioning	Negator Spring, No Gears
Tape	¼" x 1 mil (nom) x 625 ft.
Tape Drive	Direct Capstan, No Belts
Motor	Brushless DC Direct Drive
Tape Speed	0.33 (0.2)* ips to 35 ips
Tape Packing Density	9560 Bits/Inch/Channel
Number of Channels	8 (16 Heads, Redundant)

## INPUT POWER REQUIREMENTS

Voltage	±28 V DC ±35%
Record	7 to 10 Watts (depending on tape speed)
Playback	16 to 19 Watts (depending on tape speed)
Standby	1.4 Watts

## SIGNAL CHANNEL SPECIFICATIONS

No. of Channels	8, Each with separate Record/Play Amplifiers
Total Data Storage	5.3 x 10 <sup>8</sup> bits (Single Transport Unit)
Record Data Rates	3.0(2.0)* Kb/s to 2.56 Mb/s
Playback Data Rates	32 Kb/s to 2.56 Mb/s
Error Rates (Max)	5 x 10 <sup>-7</sup> (Beginning of Life) 1 x 10 <sup>-6</sup> (End of Life)
Date Format on Tape	Bi-Phase
Input	NRZ or Bi-Phase Level plus Clock
Output	NRZ or Bi-Phase Level plus Clocks and Preamble
Record/Playback Mode	Single Channel, Multiplexed Two, Four or Eight Channels
Output Timing Errors	None, Removed by Buffer

## COMMAND/TELEMETRY

The Command/Telemetry System of the STR-108(AT) is supplied with an interface adaptable to match any mission need. Two plug-in boards in the EU are available to accommodate specific spacecraft command/telemetry requirements.

Specifications furnished by RCA are believed to be accurate and reliable. However, all Specification data is subject to change without notice.

## PHYSICAL

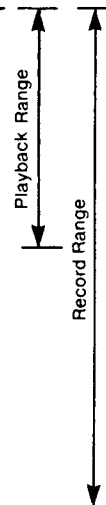
	Transport Unit	Electronics Unit
Size (excluding connectors & mounting flanges)	6.0 x 7.75 x 3.0 in 15.2 x 19.7 x 7.6 cm	6.0 x 7.75 x 5.0 in 15.2 x 19.7 x 12.7 cm
Weight (Less Cables)	6.7 lbs. 3.0 Kg	7.2 lbs. 3.3 Kg

## PLAY/RECORD TIME

Eight Channels Multiplexed	3.4 Minutes to 9.2 Hours
All Channels in Sequence	27 Minutes to 73 Hours

## STANDARD BIT RATES AND SPEEDS

DATA RATES				TAPE MOTION	
Single Channel (Kb/s)	2 Channel MUX (Kb/s)	4 Channel MUX (Kb/s)	8 Channel MUX (Kb/s)	Speed (IPS)	Duration of One Pass (Minutes)
320	640	1280	2560	33.5	3.43
256	512	1024	2048	26.8	4.29
200	400	800	1600	20.9	5.50
160	320	640	1280	16.7	6.88
128	256	512	1024	13.4	8.58
100	200	400	800	10.5	10.9
80	160	320	640	8.37	13.7
64	128	256	512	6.69	167.2
50	100	200	400	5.23	22.0
40	80	160	320	4.18	27.5
32	64	128	256	3.35	34.3
25	50	100	200	2.68	42.9
20	40	80	160	2.09	55.0
16	32	64	128	1.67	68.8
12.5	25	50	100	1.34	85.8
10	20	40	80	1.05	109
8	16	32	64	.837	137
6.25	12.5	25	50	.669	172
5.0	10	20	40	.523	220
4.0	8	16	32	.418	275
3.1	6.25	12.5	25	.335	343
2.5*	5.0*	10*	20*	.268*	429
2.0*	4.0*	8*	16*	.209*	550



## NOTES:

1. Recording can be made at any speed regardless of the assignment of a playback range.
2. Data rates other than those shown are available by varying the input clock rate (external reference) or selecting specific crystal oscillators. (Internal Reference)
3. The playback rates can be varied by command up to 10:1 range.

\* Residual Angular Momentum increases from 0.007 to 0.16 in-lb-sec (@33.5 ips) when configured to record at 0.268 and 0.209 ips.

For Further Information Please Contact:  
Manager, Marketing, Recording Systems  
Building 2-4  
Camden, New Jersey 08102  
(609) 338-3047

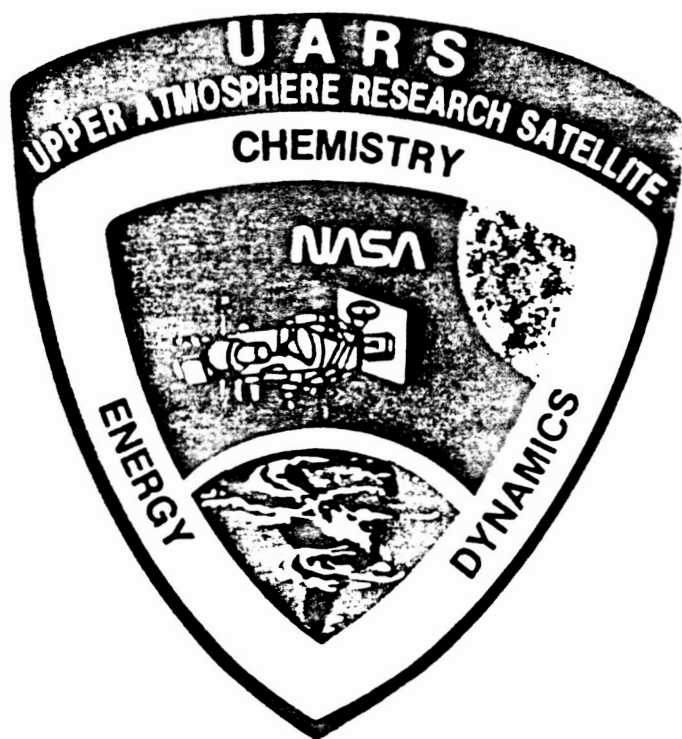
GSD/SCN-307-76 (Rev 2/86)



Communication and  
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UARS  
PRE-SHIP REVIEW



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UARS  
PRE-SHIP REVIEW

NASA

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VG #1

## AGENDA

### AGENDA/INTRO

### THE UARS RECORDER

### UPDATE OF DOCUMENTATION

#### NSPAR/SCD

#### DEVIATIONS

#### MRB'S

#### PART FAILURES (MR'S)

### ENVIRONMENTAL EXPOSURES

#### SUBASSEMBLIES

#### RECORDER SYSTEM

### VERIFICATION OF CONFIGURATIONS

### OTHER CONTRACTUAL ITEMS

### DISCUSSION

E. BARCARO

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E. WARE

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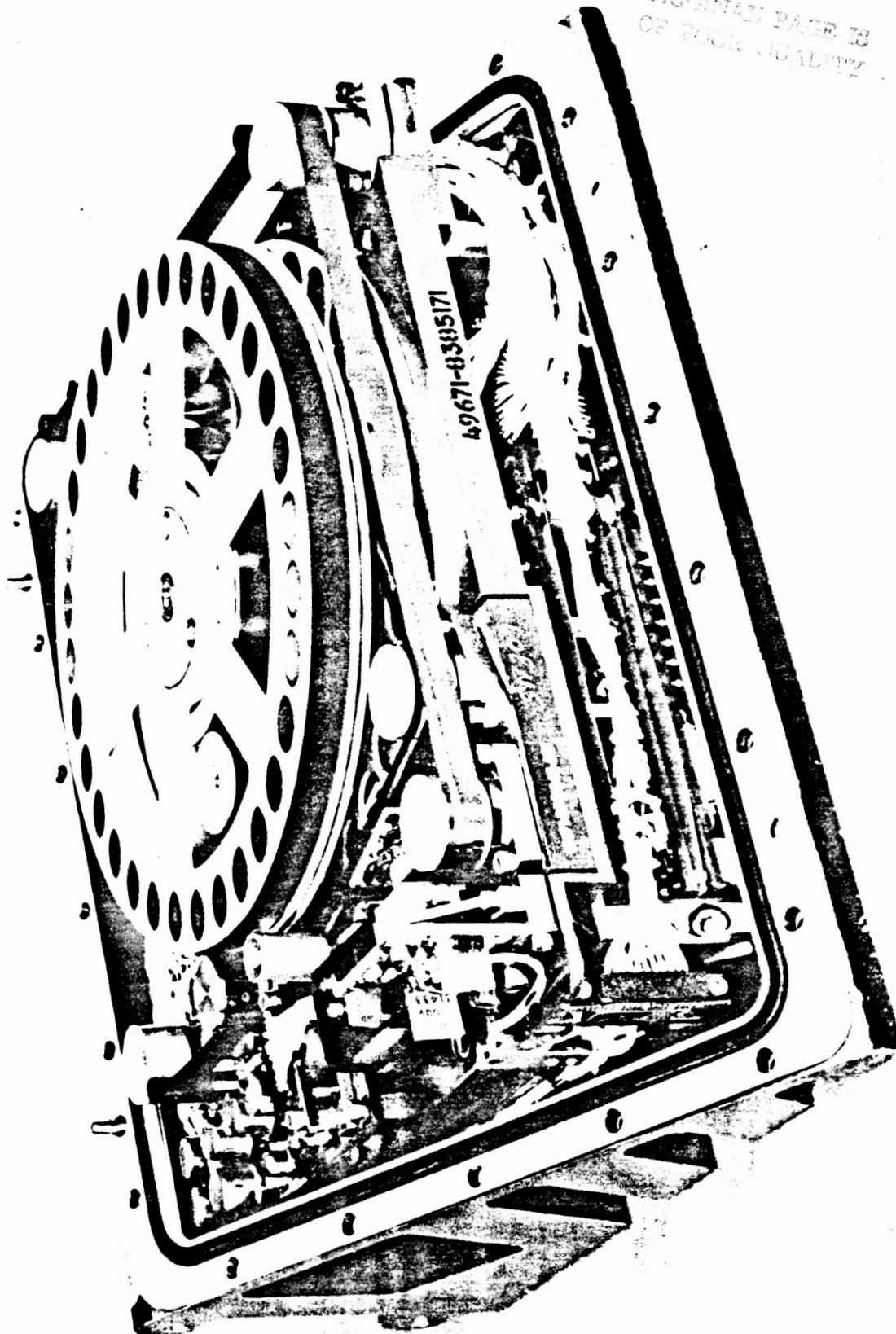
**Upper Atmospheric Research  
Satellite  
(UARS)  
Digital Tape Recorders**



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UARS RECORDER

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VG #5

UARS RECORDERS  
(HIGHLIGHTS)

- INCORPORATES NOAA DESIGN IMPROVEMENTS
  - SINGLE RECORD/PLAY HEAD
  - MULTILAYER TU BOARDS
  - EXTENSIVE THERMAL STRESS TESTING
  - GRADE 1 PARTS
- CROSS-STRAPPED CONFIGURATION OF STR-108(AT)
- NEW PREAMBLE
  - ALL ONES
  - ACTIVE EXCEPT DURING SERVO LOCKED PLAYBACK
- DIGITAL AND ANALOG TM MANAGEMENT PER UARS REQUIREMENT
- SIMPLIFIED OPERATION
  - ELIMINATED UNUSED COMMANDS
  - OPERATING MODE DETERMINES TAPE MOVEMENT DIRECTION
  - INDEPENDENT REVERSE AND FORWARD WIND
  - FORWARD PLAY FOR TEST (8 MUX)
- CLOCK SOURCE
  - RECORD - EXTERNAL
  - PLAY - INTERNAL
- ERASE DURING RECORD, PASS 1

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VG #6

## UARS OPERATION

- POWER UP RECORDER STATE

STANDBY  
8 MIX  
512 KBPS PREAMBLE  
PRIMARY ENCODER

- OPERATING MODES

STANDBY  
RECORD  
PLAY  
FWD WIND  
REV WIND  
FWD PLAY - (TEST ONLY)

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VG #7



# UARS COMMAND STRUCTURE

- STANDBY (120)
- RECORD (123)
  - 4 MUX (150), 0.84 IPS (55)
  - 8 MUX (152), 0.42 IPS (56)
- PLAY (124)
  - 4 MUX (150), 6.7 IPS (52)
  - 4 MUX (150), 13.4 IPS (51)
  - 8 MUX (152), 6.7 IPS (52)
  - 8 MUX (152), 13.4 IPS (51)
- FWD WIND (125), 34.7 IPS
- REV WIND (127), 34.7 IPS
- FWD PLAY (126)

{ PASS 1 START (110)  
PASS 2 START (111)

{ PASS 1 START (110)  
PASS 2 START (111)

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VG #8

UARS

DOCUMENTATION

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VG #9

## THE UARS RECORDER

CONTRACTUALLY, THE UARS RECORDER IS A GRADE 2 PROGRAM:  
HOWEVER, SINCE THE PARTS WERE ORDERED IN CONJUNCTION WITH  
THE NOAA RECORDERS, THE UARS RECORDER COULD ALMOST BE  
CONSIDERED A GRADE 1 RECORDER.

JUNE 11, 1987  
VG #10

# NSPAR/SCD STATUS

<u>NSPAR</u>	<u>SCD</u>	<u>ITEM</u>	<u>NOAA STATUS</u>	<u>COBE /UARS*</u>
CN001B	8558192	CD4XXX	CONCURRENCE	CONCURRENCE
CN002		JANTXV1N5811	CONCURRENCE	CONCURRENCE
CN003	8558854	CONNECTOR	CONCURRENCE	CONCURRENCE
CN004	8558855	MALCO CB, ASSY.	CONCURRENCE	CONCURRENCE
CN005B	8545434	PRESS. TRANS.	CONCURRENCE	CONCURRENCE
CN006	8558868-1 THRU 9	M38510 CLASS B	CONCURRENCE	NOT REQUIRED
CN007B	8570509	DS7820A, DS7830	CONCURRENCE	CONCURRENCE
CN008A	54LS122W/SDB 54LS151W/SFB 5438W/SDB	TI - TTL	CONCURRENCE	CONCURRENCE
CN009B	8558870-1	MH0007H	CONCURRENCE	CONCURRENCE
CN010B	8558871-1	3341A DM0B	CONCURRENCE	CONCURRENCE
CN011	8558856-2	TRANSFORMER	CONCURRENCE	CONCURRENCE
CN012	8559030-6	RELAY W/PSD, PAD	CONCURRENCE	CONCURRENCE
CU001		CD4025BK/1SZ CD4050BK/1SZ	N/A	CONCURRENCE
CN013	8570558		CONCURRENCE	CONCURRENCE
NU001	8558856-2	TRANSFORMER	N/A	N/A

\*NEW SUBMITTAL NOT REQUIRED

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VG #11

# DEVIATIONS/WAIVERS

(APPLICABLE TO UARS RECORDER #1 AND #2)

<u>CODE</u>	<u>WAIVER DEVIATION NO.</u>	<u>DESCRIPTION</u>	<u>PREV STR WAIVER NO.</u>	<u>DATE SUBMITTED</u>	<u>DATE APPROVED</u>
D	28193-1	WELDED WIRE W3 VS RCA 2280710, REV. A	T/N-W9	2/15/85	10/2/85
D	28193-3	STRAPPING COMPOUND EMERSON CUMMINGS	T/N-W66	2/15/85	10/2/85
D	28194-4	MOLDING MATERIAL PRC 1592	NONE	6/14/85	10/8/85
D	28193-5	MARKING OF RCA AED WELDED WIRE BOARDS		8/19/85	10/10/85
	REV. B			REV B (10/8/85)	
W	28193-6 REV 1	CD4000 SERIES NON-DESTRUCT BOND PULL	NONE	8/20/85	2/27/85
W	28193-8	MINOR VOIDS IN PLATED-THRU HOLES		2/13/86	3/17/86
W	28193-9	3 WIRE SPLICES IN TU HARNESS		2/28/85	3/19/86
W	28193-10	REWORK OF CAPSTAN SERVO (ADD CAPACITOR)		4/15/86	4/18/86
W	29186-1*	4 WIRE SPLICES IN TU HARNESS	28 193-9	11/13/86	4/28/87

\*SUPERCEDES 28193-9

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VG #12

UARS MRB'S

<u>NCR NO.</u>	<u>PART TIME</u>	<u>DESCRIPTION</u>	<u>DATE APPROVED</u>	<u>RECORDER #</u>
UARS-1-86	A-2 CONTROL BOARD ASSY	BROKEN TRACE	11/4/86	U101
UARS-2-87	LIMITER BOARD ASSY	DAMAGED TRACE AND LIFTED PAD	2/10/87	U102

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VG #13

UARS  
PART FAILURES

<u>RECORDER</u> <u>#</u>	<u>MR</u> <u>#</u>	<u>FORMAL</u> <u>INFORM.</u>	<u>DESCRIPTION</u>	<u>FAIL.</u> <u>ANAL.</u>	<u>CORRECTIVE</u> <u>ACTION</u>	<u>DATE</u> <u>INIT.</u>	<u>DATE</u> <u>COMPL.</u>
102	ID0001	INFORMAL	NON-OUTPUT PIN #8 (U85)	CENTRAL ENG. REPORT #87-0197	REPLACED U85 RETESTED PER FLOW 5005	2/15/87	4/30/87
102	ID0002	INFORMAL	DAMAGED/TRACE/LIFTED PAD	DAMAGED BY OPERATOR	MRB-2-87	2/11/87	4/23/87
102	ID0003	INFORMAL	BOARD OSCILLATES UNDER STEP LOAD	CENTRAL ENG. REPORT #87-5335	REPLACED TRANSFORMER	3/12/87	6/9/87
102	ID0004	INFORMAL	NO OUTPUT ON U13 PIN-2	DAMAGED BY TEST TECH	REPLACED U13	4/15/87	5/13/87

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VG #14

UARS

ENVIRONMENTAL EXPOSURES

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VG #15



UARS  
SUBASSEMBLY ENVIRONMENT EXPOSURES

<u>SUBASSEMBLIES</u>	<u>TEMP RANGE</u>	<u># OF CYCLES</u>
TRANSFORMERS	-55°C TO +85°C	25 TIMES
SEMICONDUCTORS	-55°C TO +125°C +125°C	4 TIMES TYPICAL 240 HOURS BURN-IN TYPICAL
CIRCUIT BOARDS	-20°C TO +80°C	11 TIMES
BRUSHLESS MOTORS	-15°C TO +45°C	COLD START TEST
EU/TU SYSTEM	- 5°C TO +45°C	SYSTEM VERIF. - ENG. TEST
	-15°C TO +45°C	COLD START PB - ENG. TEST
	-10°C TO +40°C 0°C TO +40°C	6 CYCLES ACCEPT. TEST 1 CYCLE COLD START 5 CYCLES
	RANDOM VIBRATION	1 MINUTE PER EACH OF 3 AXES
	LEAK TEST	1 X 10 <sup>-5</sup> mm/Hg VACUUM

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VG #16

UARS  
SYSTEMS U101 & U102 TESTING

INTEGRATION AND SYSTEM TEST

RM TEMP. HOT +45° COLD -5°C COLD START -15°C	COMPLETE
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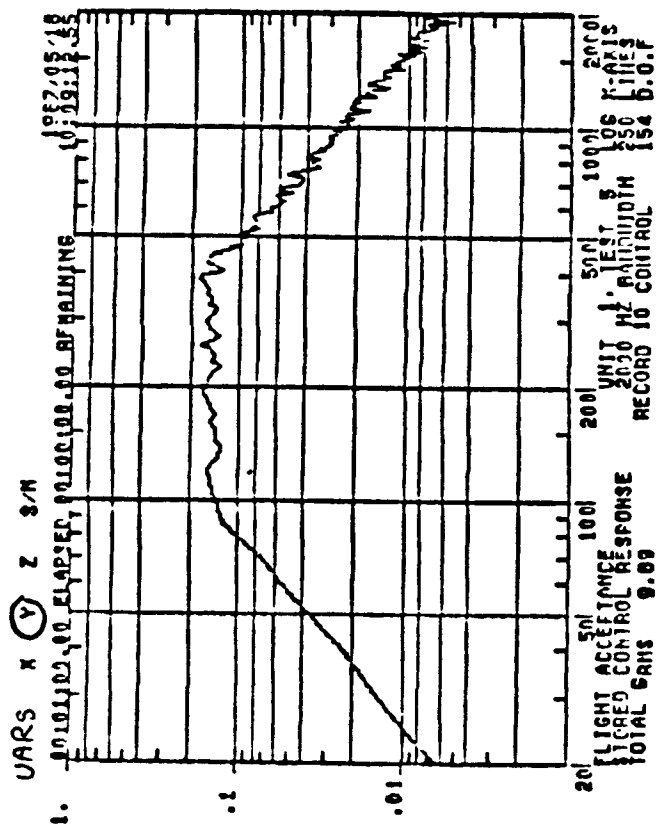
ACCEPTANCE TEST

INITIAL PERFORMANCE RANDOM VIBRATION (3 PLANES) LEAK THERMAL HOT 6 CYCLES +40°C COLD 1 CYCLE -10°C COLD 5 CYCLES 0°C FINAL PERFORMANCE CROSS STRAP CABLES ELECTRICAL TEST VACUUM TEST	COMPLETE COMPLETE COMPLETE  COMPLETE COMPLETE  COMPLETE
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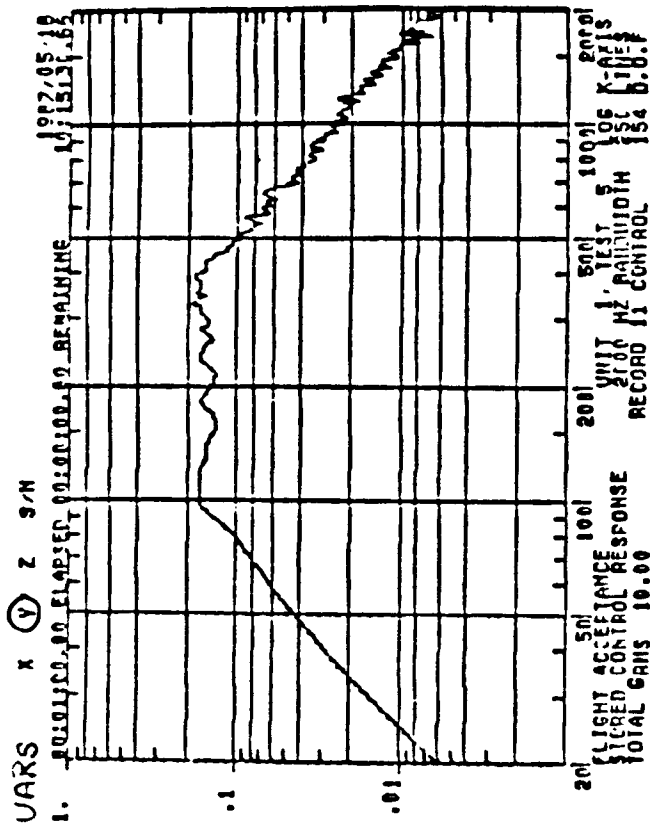
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VG #17

UARS

# TYPICAL VIBRATION SPECTRUM



Y AXIS FIXTURE

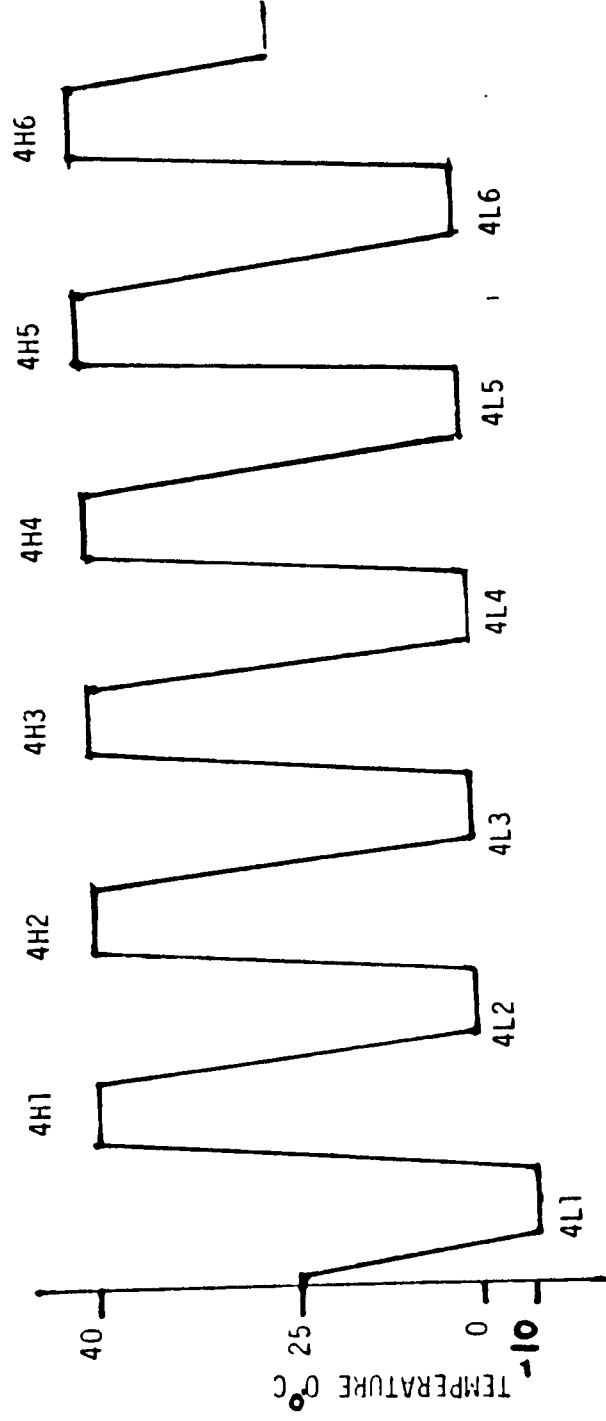


Y AXIS UARS S/N U101

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VG #18

UARS



TIME (HRS. MINIMUM)

MAX. RATE OF CHANGE = 1°C/MINUTE

TEMPERATURE PROFILE

JUNE 11, 1987  
VG #19

UARS

VERIFICATION OF CONFIGURATION

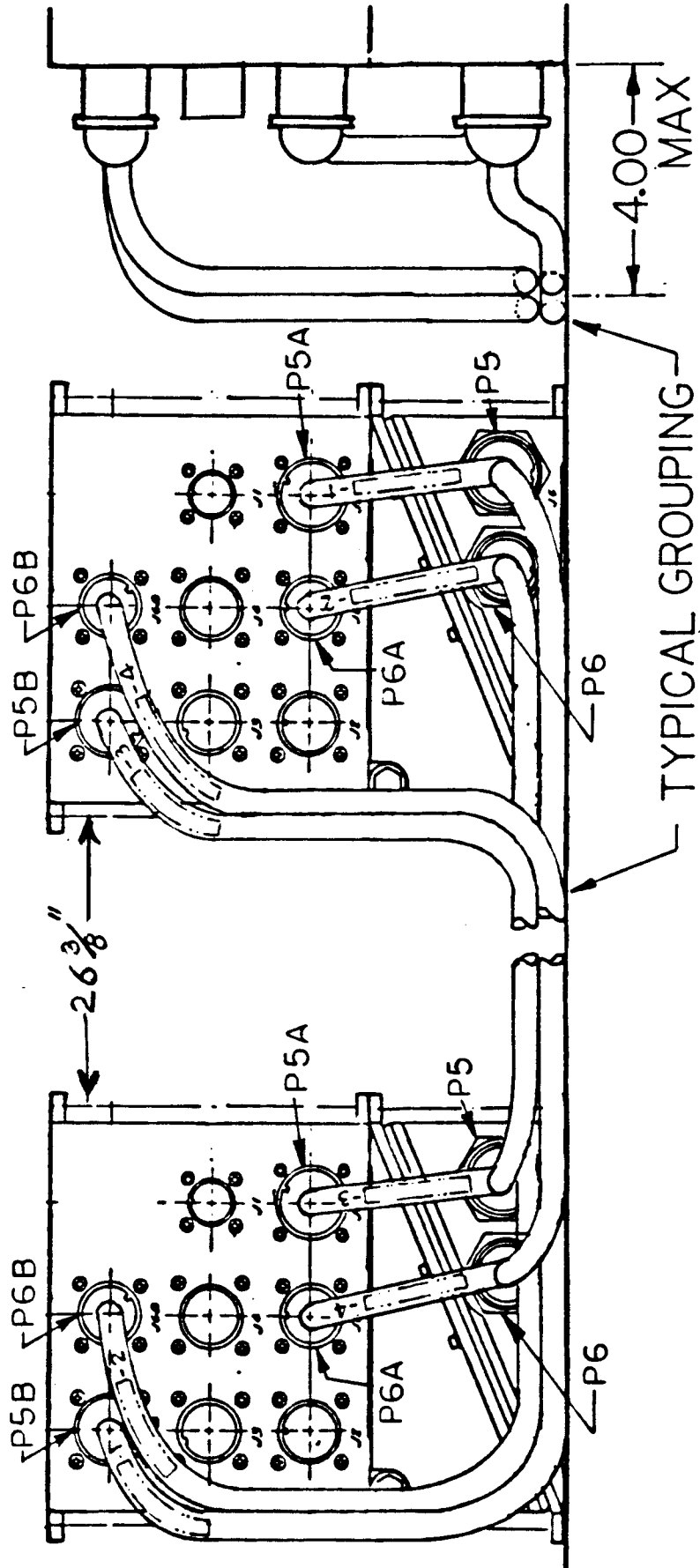
E. WARE

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VG #20

UARS  
VERIFICATION OF CONFIGURATION

- CONFIGURATION EU/TU
- CROSS STRAP CABLES RECORDER A & B

RECORDER A RECORDER B



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VG #21

UAPS

CONTRACTUAL ITEMS

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VG #22

UARS  
CONTRACTUAL REQUIREMENTS

DELIVERABLE DOCUMENTATION

INTERFACE CONTROL DOCUMENT (ICD)  
MASS PROPERTY REPORT (MPR)  
END ITEM DATA PACKAGE (EIDP)  
ACCEPTANCE TEST PROCEDURE (ATP)

COMPLETE  
COMPLETE  
COMPLETE  
COMPLETE

DELIVERABLE HARDWARE

RECORDER S/N U101  
RECORDER S/N U102  
1 SET CROSS STRAP CABLES  
SPACECRAFT INTERFACE CONNECTORS  
REUSABLE SHIPPING CONTAINERS (2 EA)  
2 SETS CONNECTOR SAVERS  
FIT CHECK TEMPLATE

JUNE 11, 1987  
VG #23