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U-SQR/71-4

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Quarterly Report

SPACE PROGRAMS

OCTOBER—DECEMBER 1971

THE JOHNS HOPKINS UNIVERSITY ▪ APPLIED PHYSICS LABORATORY

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13. ABSTRACT

A record of Applied Physics Laboratory activities in Space Research is issued in two volumes. The first (C-SQR) contains a record of the classified and unclassified work, and the second (U-SQR) contains a record of the unclassified work only. In this volume, activities are reported in the following categories: SAS-C preliminary thermal design; environmental tests of a small astronomy satellite; Triad dual-channel demodulators; Geoceiver buffer; NAVOCEANO Geoceiver navigation program; AN/SRN-9 program support; Project Magnet GASS system integration with RP-3D aircraft; and technical support of a U.S. Geological Survey.

I

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Satellite environmental tests
Small Astronomy Satellite
Triad satellite tests
Transit Improvement Program
U. S. Geological Survey support

II

U-SQR/71-4

Quarterly Report

SPACE PROGRAMS

OCTOBER–DECEMBER 1971

THE JOHNS HOPKINS UNIVERSITY • APPLIED PHYSICS LABORATORY
8621 Georgia Avenue ∘ Silver Spring, Maryland ∘ 20910
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FOREWORD

The Applied Physics Laboratory issues this Quarterly Report series to provide the defense establishment with a useful record of APL activities. At present the Quarterly consists of ten volumes organized by major Laboratory programs:

Programs	Quarterly Report Designators
Weapon Systems	
Surface Missile Systems	WQR...A
Polaris Support	WQR...B
Pershing Support	WQR...C
Special Air Defense Programs	WQR...D
Antiship Missile Systems	WQR...H
Research and Development	C-RQR and U-RQ
R&D for ARPA	S-RQR
Space Programs	C-SQR and U-SQR

The nomenclature for these volumes is as follows: The designation for Quarterly Report, "QR," is preceded in each case by a letter indicating that volume's basic program area ("W" for Weapon Systems, "R" for Research and Development, and "S" for Space Programs). For the R&D and Space volumes, this three-letter designator is preceded by a classification indicator ("S-" for secret and "C-" for confidential). After the "QR," a virgule is followed by a year indicator (e.g., "71-")and a number from 1 to 4 to specify the quarter of the calendar year. If a basic program area must be subdivided into several volumes for reasons other than security classification, the resulting volumes are distinguished from one another by a letter following the designator "QR" (e.g., WQR-A).

The internal Quarterly Report format is designed so that each technical article is presented on a single sheet of paper. Each article is given a section number (e.g., §75), which applies to the current Quarterly only. Each article is keyed to its major program (e.g., Research and Exploratory Development), its technical instruction (Amorphous Semiconductors), its budget code (A13B), the Laboratory Group or Groups that performed the work (e.g., CLO), and the agency that supported it (ORD-034). By proper selection of the pages printed for the basic volumes, the Reports Group can prepare special-purpose Quarterlies as required. The unclassified pages from the R&D and Space volumes are routinely published as separate Quarterlies (using the prefix "U-" for unclassified) to provide wider dissemination of this information. Other special-purpose reports issued are identified by a unique one- or two-letter designator before the "QR."

IV

TABLE OF CONTENTS

V

SUMMARY

NASA SPACE PROJECTS

Small Astronomy Satellite/C&D Study Program

The thermal louvers system concept will be incorporated in the thermal design of the SAS-C satellite. Basically, the total outer surface of the control section is insulated from the orbit environment with multilayer insulation blankets except for the radiator/louver area (§ 97).

Small Astronomy Satellite/SAS-B and C&D Study Program

All of the component packages and subsystems of the SAS-B satellite successfully completed the thermal vacuum and vibration acceptance tests (§ 98).

DOD SPACE PROGRAMS

Transit Improvement Program

Dual channel demodulators, designed to demodulate encoded telemetry information from the Triad satellite, are being built and tested (§ 101).

NAVOCEANO Geoceiver Hardware

APL is fabricating nine buffers for the AN/PRR-14 Geoceiver. All parts have been procured, and all mechanical design has been completed (§ 102).

Geoceiver PDP-9 Computer Program

In support of the U.S. Navy Oceanographic Office, APL is developing a Satellite Navigation Program Geoceiver/PDP-9 computer system (§ 103).

AN/SRN-9 Logistic Support

APL is currently providing technical support for 17 shipboard AN/SRN-9(XN-5) and CP-827(XN-1) radio navigation sets. This support includes shipboard checkout, operators' training, and a maintenance school for Navy technicians (§ 104).

NAVOCEANO GASS Integration and Support

The Geomagnetic Airborne Survey System is being updated. The existing magnetic survey equipment and the existing survey aircraft are being replaced (§ 105).

SPECIAL ASSIGNMENTS

U.S. Geological Survey Technical Support

APL is assisting the U.S. Geological Survey in conducting a survey in the Antarctic. Two AN/SRN-9(XN-5) navigation sets will be used for this Antarctic Field Test Survey (§ 106).

VI

NASA SPACE PROJECTS

VII

NASA SPACE PROJECTS §97
Small Astronomy Satellite – C&D Study
Program ID30S4S
Support: NASA
H. Burgos
October–December 1971

SAS-C PRELIMINARY THERMAL DESIGN

The design of the SAS-C satellite is based on a nonspinning satellite in an equatorial orbit typical of the SAS-A and -B orbits with a launch from Kenya, and an inclined orbit with a maximum of 82% sunlight from a launch at Wallops Island. However, other possible missions and applications of a SAS-C type satellite include a 100% sunlight polar orbit (earth locked) and a synchronous orbit mission.

Figure 1 illustrates the thermal characteristics to be incorporated in the structural design to convert it into the thermal louver system concept for the temperature control system. Basically, the total outer surface of the control section is insulated from the orbit environment with multilayer insulation blankets except for the radiator/louver area. The noninsulated area is sized to range from a maximum of 5 ft^2 to the value required by the operational mission. The radiator area is somewhat uniformly distributed about the circumference of the equatorial panels. The attach ring carries structural loads; it is well coupled structurally to the internal structure and therefore produces a low thermal resistance heat flow path. The experiment is mounted to the control section structure by four high thermal resistance insulator button joints typical of the SAS-A design. Since the structure is within the insulator blankets, the heat flow path is, in effect, to the internal mass.

A multilayer insulation blanket separates the control section internal mass from the base of the experiment. Therefore, except for heat flow by conduction across the interface joints, the temperature control system for the control section is independent of the experiment temperature control system.

Table 1

SAS-C Steady State Temperature Prediction, 300 nmi Polar Orbit

Sun (%)	Q_{INT} (watts)	Q_{ATC} (watts)	Louver Area (ft^2)	Louver Angle (degrees)	Temperature (°F) $T_{battery}$	T_{book} (hot)	T_{book} (cold)	Comments
				Hot Case ψ* = 120°				
100	32	--	5	90	84	64	61	α** = 0.2
100	32	5_{growth}	5	90	92	72	70	α = 0.2
				Hot Case ψ = 180° (Earth Locked)***				
100	32	--	5	60	76	67	63	α = 0.2 (earth locked)
				Cold Case ψ = 0°				
	26	--	5	0	39	40	39	α = 0.08
	26	5	5	0	57	58	57	α = 0.08

Table 2

SAS-C Steady State Temperature Prediction, 300 nmi Equatorial Orbit

Sun (%)	Q_{INT} (watts)	Q_{ATC} (watts)	Louver Area (ft^2)	Louver Angle (degrees)	Temperature (°F) $T_{battery}$	T_{book} (hot)	T_{book} (cold)	Comments
				Hot Case ψ* = 120°				
66	32	--	5	90	59	45	45	α** = 0.2
66	32	10_{growth}	5	90	77	64	63	α = 0.2
				Cold Case ψ = 0°				
	26	--	5	0	37	37	36	α = 0.08

Table 3

SAS-C Steady State Temperature Prediction, Synchronous Orbit

Sun (%)	Q_{INT} (watts)	Q_{ATC} (watts)	Louver Area (ft^2)	Louver Angle (degrees)	Temperature (°F) $T_{battery}$	T_{book} (hot)	T_{book} (cold)	Comments
				Hot Case ψ = 120°				
100	32	--	1	90	140	145	145	α = 0.2
100	32	--	2	90	129	120	120	α = 0.2
100	32	--	3	90	82	70	70	α = 0.2
100	32	--	4	90	65	48	48	α = 0.2
				Cold Case ψ = 0°				
	26	--	3	0	24	24	24	α = 0.08
	26	5	3	0	48	48	48	α = 0.08

*ψ is the angle of the satellite Z axis and the sun.
**α is the absorptivity of solar energy.
***Satellite spin axis normal to orbit plane, battery facing earth.

SUMMARY AND CONCLUSIONS

For the SAS-C thermal design, the polar orbit is the worst thermal environment because of the hot environment of 100% sunlight as well as the wide range between the hot and cold environments. The synchronous orbit missions produce the worst cold thermal environment (negligible heating by earth thermal radiation and earth-reflected solar radiation). Therefore, the thermal louver system must be designed to accommodate the worst hot case experienced in 100% sunlight of the polar orbits. The louver area can be reduced and replaced with multilayer insulation for the equatorial, low-inclination, and synchronous orbit missions.

For the purposes of this study, the design temperature range for the total electronic equipment located in the control section was considered to be from 40° to 90°F. Results of the studies of the worst cases for the possible missions are presented in Tables 1 to 3.

Based on the worst case external environmental conditions, the battery will stabilize at 84°F as shown in Table 1. A review of the heat balance network shows that the same thermal resistances were assumed for the battery quadrant and the three quadrants that house electronic book stacks. The internal heat load was assumed to be approximately uniformly distributed to the four quadrants. Therefore, the temperature of the books for

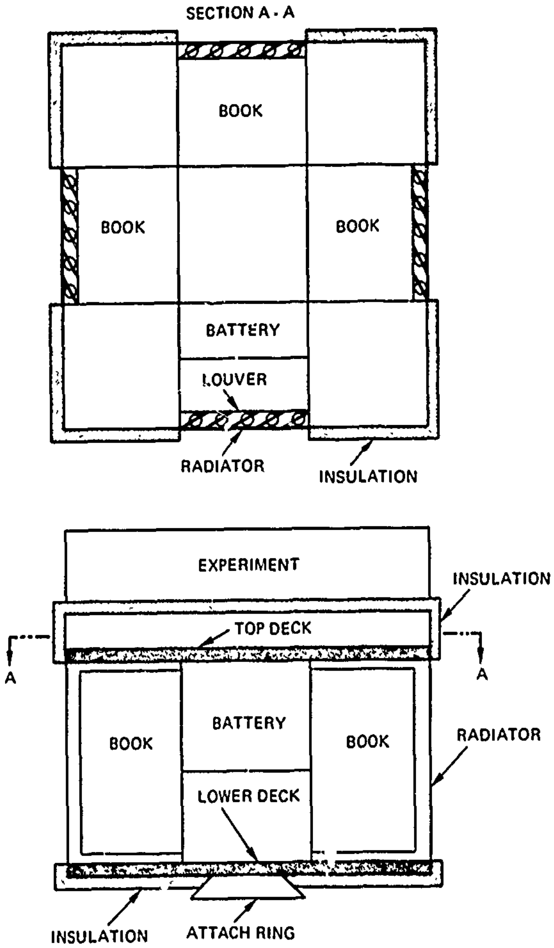


Fig. 1 SAS-C Configuration. (71-4/9)

the respective cases is nearly valid for the battery when the direct solar radiation is to a book quadrant rather than the battery quadrant.

Table 3 shows that for a synchronous orbit mission the radiator/louver area must be reduced below the 5 ft^2 used for polar and equatorial orbits. A value of 3 ft^2 provides an 82°F temperature level for the battery in the hot case. This same area results in an unacceptable temperature (24°F) for the cold case, however, 5 watts of ATC power increases the battery temperature well within the design temperature control range.

The results presented demonstrate that the thermal louver concept with the available area for the system and a louver system design that is immediately compatible with thermal-structural interfaces will provide the desired temperature control for sensitive items within design limits for orbit missions. Very little automatic temperature control (ATC) power is needed to enhance the temperature control system. The equatorial and synchronous orbit missions allow tailoring to an optimum thermal design by properly sizing the radiator/louver area or, alternatively, a larger than a normal satellite internal heat load can be used. The latter option could allow despinning or long-term attitude maneuvers with no limitations caused by thermal aspects, or more growth potential.

FUTURE PLANS

An evaluation of the thermal louver subsystem performance will be undertaken and a detailed heat balance network will be studied in order to predict more accurately temperature level and temperature gradients across the control section. Results from the new network will be used to evaluate heat leaks and to optimize the set point temperature for the bimetal springs of the louvers system and the set point temperature for the ATC system.

BACKGROUND

Of the possible thermal design concepts, three types showed significant improvement over the SAS-A and -B concepts. The three concepts were

1. Temperature control to two separate control-section compartments with different ranges of temperature control and separate ATC systems,
2. Use of a minimum amount of the satellite's surface area for a thermal louver system combined with an ATC system, and
3. Use of an optimal amount of satellite surface area for the thermal louver system.

Results showed that the third concept was the most suitable for SAS-C, since it allows maximum growth potential with respect to usable power for future experiments and/or missions. Structural considerations limited the radiator/louver system area to 5 ft^2. Use of this area depended upon a louver system that could be mounted in the 1.5-inch gap between the outboard edge of the electronic book stacks and battery and the outer panels that serve as the space radiator.

The design has a requirement to provide temperature control for the battery in the range from 35° to 90°F. The range requested for the tape recorders is from 40° to 90°F. 10° to 110°F is assigned for the electronic books and packages.

A mathematical model designed to represent the thermal configuration was analyzed. Thermal resistance between the experiment and the internal node was based on SAS-A interface joint test data and includes the four joints in parallel. The low thermal-resistance value for the attach ring to the internal mass is consistent with the load-carrying requirement previously mentioned. Battery and the electronic book stacks to internal thermal resistance values are representative of the typical SAS-A and -B mechanical designs. The 2.2°F watt value is also consistent with the resistance of a battery mounting using conductive grease per the SAS-A battery mounting thermal-vacuum test data. The multilayer insulation blanket thermal resistance value was derived from SAS-A test data based on hot-case operation. It is realized that at colder temperature an approximate 12% increase in performance of the blanket can be expected owing to the lower rate of radiation heat flow through the blanket.

NASA SPACE PROJECTS §98
Small Astronomy Satellite – C&D Study
SAS-B ID20/ID30BBE
Support: NASA
I. B. Irving
October-December 1971

SMALL ASTRONOMY SATELLITE ENVIRONMENTAL TESTS

Environmental testing of satellites is in direct support of the engineering and electronics branches of the APL Space Development Department. Design evaluation, design margin, and flight acceptance tests are performed on satellite components, subsystems, and complete payloads in the realms of shock, vibration, acceleration, and thermal vacuum to assure a flightworthy and spaceworthy satellite.

SUMMARY

The Small Astronomy Satellite (SAS) program consists of a series of earth satellites, each of which must be proven spaceworthy by environmental test. The first of these, SAS-A, was successfully tested and launched into orbit in 1970. SAS-B is now being tested prior to its scheduled launch in 1972. Components and subsystems for SAS-C are in process.

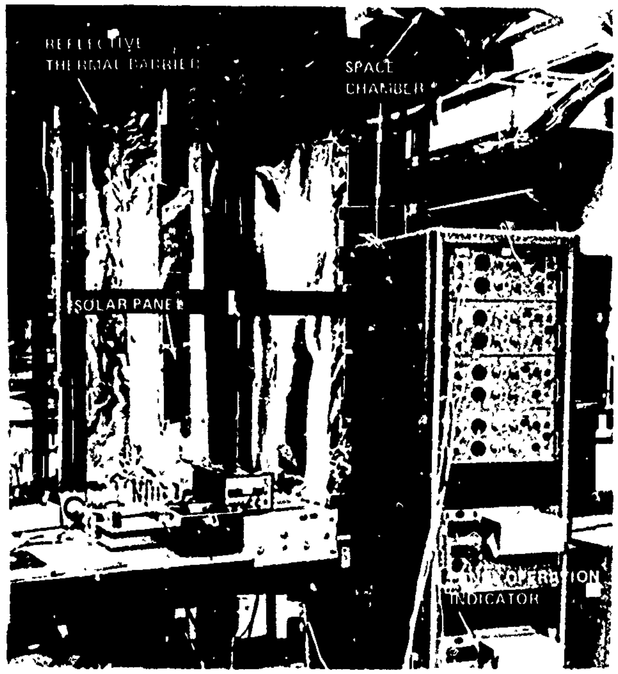
FUTURE PLANS

Tests on SAS-B will be completed by the end of May 1972. Extensive environmental and design evaluation tests will be performed on structures, component parts, and subsystems for the SAS-C satellite.

BACKGROUND

The simulation of flight environments for ground testing is a necessary step in the evaluation of the mechanical and electronic design of a satellite. Each satellite component is subjected to a series of environmental tests. Prototype packages are given more severe tests than is the flight hardware to qualify the package design. The assembled payloads are also subjected to similar tests. As a result of these tests, design changes to increase satellite reliability may be indicated.

Review of Experiments. All the component packages and subsystems of the SAS-B satellite have successfully completed their thermal vacuum and vibration acceptance tests. For the thermal vacuum tests, the internal packages are subjected to a temperature cycle that subjects the component to extremes of 120° and 0°F for 7-hour periods. The external components are tested on a similar cycle but with temperature extremes of +180° and -200°F. A typical external component, the SAS-B solar blade, is shown prepared for tests in Fig. 1.



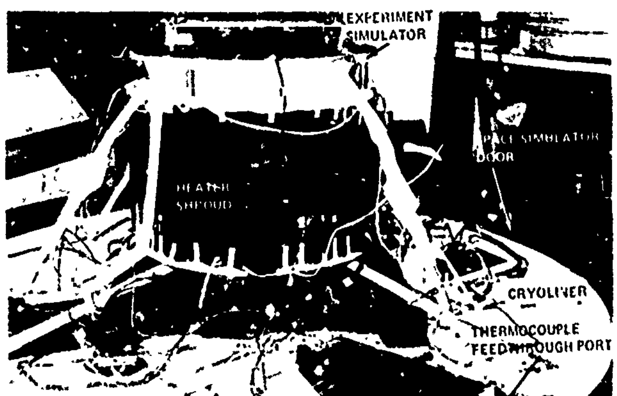


Fig. 2 SAS-B Control Section in its Thermal Shroud. (140847)

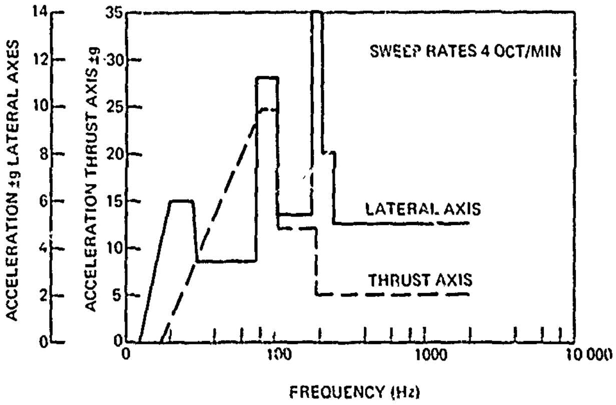


Fig. 3 SAS-B Package Flight Acceptance Vibration Levels. (71-4/10)

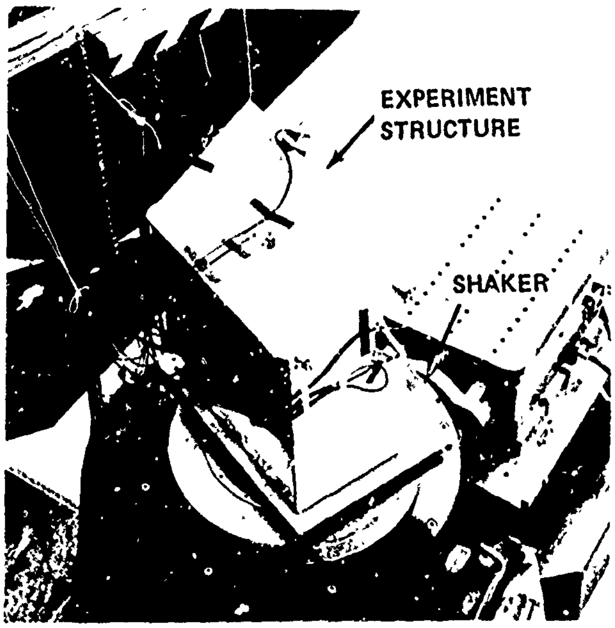


Fig. 4 SAS-C Experiment Structure on Vibration Table. (129893)

The spacecraft control section was given a thermal adjustment test to see if any changes in insulation or thermal sinks were necessary for the satellite to operate within the desired thermal range. A temperature cycle ranging from +80° to -80°F was applied at a vacuum pressure of 4×10^{-5} Torr at repetitive cycles of 150 hours over a period of 12 days. During this time temperatures were monitored at 100 locations inside the control unit while various power levels were applied. Results indicated that all thermal calculations were validated, and only minor thermal adjustments were needed in marginal areas. Figure 2 shows the test set-up prior to installation in the vacuum chamber.

Vibration acceptance specifications for SAS-B packages call for vibrations in three orthogonal planes with a sinewave and random input. Figure 3 shows the sinewave vibration profile for these tests. Each of the SAS-B packages has satisfactorily been subjected to this vibration profile plus a random vibration from 20 to 2000 Hz at 0.02 g^2/Hz for 2 minutes.

The SAS-C X-ray experiment that is being designed and manufactured by The Massachusetts Institute of Technology to fit the APL control body is being prepared for vibration testing. As a preliminary to this test, the mechanical structure was vibration tested at APL as shown in Fig. 4. This structure is of a unique honeycomb construction to minimize weight and provide stiffness. During this test a number of fasteners loosened, creating the potential of causing a high-frequency feedback to internal packages. The basic mechanical integrity of the structure was excellent, however, some redesign will be necessary to eliminate the fastener rattle. Another test is scheduled for February 1972.

UNCLASSIFIED

DOD SPACE PROGRAMS

-5-

DoD SPACE PROGRAMS §101
Transit Improvement Program S2V0S2T
Support: SP-24
W. T. Gray, T. E. McAdams, and
G. R. Seylar
October-December 1971

TRIAD DUAL-CHANNEL DEMODULATORS

The Triad satellite has the capability of encoding telemetry information by directly phase modulating the radio-frequency (RF) carrier or by phase modulating a subcarrier. The information may be transmitted to earth via two independent RF channels. Hence, to demodulate the signals received at the ground station, a dual-channel demodulator is required. An intermediate frequency (IF) demodulator, subcarrier demodulator, and bit detector are needed for each channel. The Triad dual-channel demodulators are designed to perform the above functions.

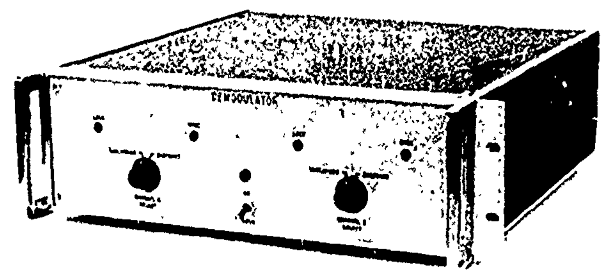


Fig. 1 Triad Dual Demodulator. (71-4/41)

SUMMARY AND CONCLUSIONS

Five Triad dual demodulators are required. To date, three have been built and tested. These units will be used at APL in conjunction with commercial receivers and do not require IF demodulators. All three units are currently installed in the Triad ground station and will be used during satellite subsystem tests. The other two units are designed for use with the AN/BRN-3 receivers and are nearing completion. Both of these have internal dual-channel IF demodulators. Figure 1 shows a typical Triad dual demodulator.

The bit detectors and the subcarrier demodulators are best characterized by measuring their output bit error rate as a function of input signal-to-noise ratio expressed in decibels (dB). Measurements on each bit detector indicated a deviation of less than 1 dB from the theoretically obtainable curve at bit error rates of interest. A similar test using the subcarrier demodulators in conjunction with the bit detectors yielded deviations of less than 2.5 dB from the theoretical curve.

FUTURE PLANS

Completion of the two remaining units in the near future is a current goal. A special test generator to aid in the evaluation of these units is currently being designed. When the dual demodulators and test generator are completed, system testing will begin. Bit error rate and system threshold will be measured while receiving test signals via the AN/BRN-3. Test evaluation, system documentation, and delivery of two units to NavAstroGru will then conclude this project.

DISCUSSION

Figure 2 is a block diagram of one-half of a Triad dual demodulator. It can be seen that there are several modes of operation. The mode selected depends on whether the input signal is an IF, subcarrier, or baseband signal. Each block of the diagram operates on a particular signal and will therefore be discussed as a distinct and separate unit.

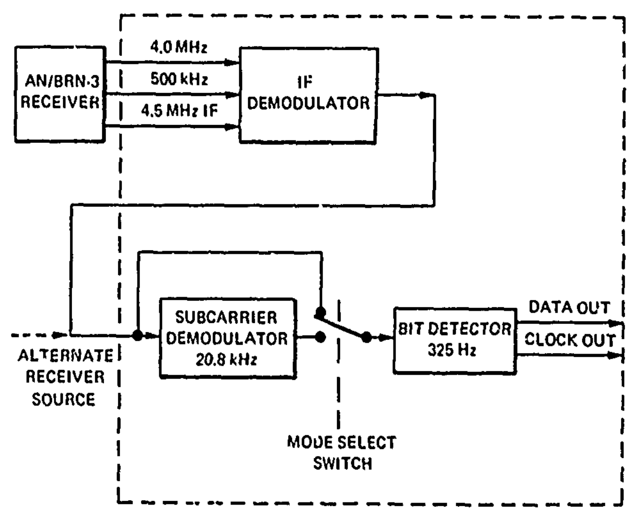


Fig. 2 One-half Triad Dual Demodulator. (71-4/42)

The BRN-3 IF demodulator circuit demodulates the phase-modulated carrier transmitted by the spacecraft. The demodulator obtains its input from one of the 4.5 MHz IF amplifiers in the BRN-3. This low level (10 to 100 μV) signal is amplified and then passed through a limiter to provide a constant level signal to a double-balanced diode phase comparator. The 4.5-MHz reference signal for the phase comparator is derived by mixing the coherent 4.0 and 0.5 MHz signals generated by the frequency synthesizer in the BRN-3. The resulting 4.5-MHz reference signal is then passed through a limiter identical to the one in the signal channel to provide a constant level reference to the phase comparator.

The phase comparator puts out a signal proportional to the difference in phase between the signal and the reference, thereby producing the demodulated output. Frequency errors in the received carrier from sources such as doppler shift are removed in the BRN-3 by its tracking loop. AGC action to the IF amplifiers in the BRN-3 is defeated in order to prevent phase shifting of the signal as a result of AGC action. Two of these demodulators are required, one for each of the RF channels.

Telemetry data are encoded by shifting the subcarrier phase ±90°. This phase-shift-keying (PSK) technique produces a suppressed subcarrier signal. The subcarrier demodulator operates on this signal to obtain a synchronous second harmonic component of the suppressed subcarrier. This component is tracked with a phase-lock loop. The output frequency of the phase-lock loop is divided by two, and the resulting signal is of the same phase and frequency as the received subcarrier. Demodulation is accomplished by multiplying the received subcarrier signal by the locally generated signal. This technique detects the subcarrier phase changes initially generated by the telemetry data in the satellite. An indicator lamp on the front panel indicates correct operation of the subcarrier demodulator. Further conditioning of the demodulated subcarrier signal is achieved by sending it to the bit detector.

The bit detector is needed to decode the 325 Hz Sφ (split-phase) telemetry data. A synchronous clock is derived, and the data are converted to NRZ (nonreturn-to-zero) format. This circuit was adapted from the high-speed bit detector in the Triad satellite (see Ref. 1). The method of bit detection depends upon first being able to derive the clock information from the data. An Sφ bit is a biphase signal, either positive the first half and negative the second, or vice versa. A transition should occur at least in the middle of each bit, and each transition pulses a hi-Q tank circuit tuned to twice the bit rate. The resulting sinusoid across the resonant tank is clipped and divided to provide a synchronous clock at the bit rate. This method unfortunately creates a half-bit ambiguity in the relation between the clock and data, but the circuit is designed to resolve this from the nature of an Sφ signal. The derived clock is then used to control the decoding of the input data. Each half of the Sφ bit is integrated separately, the integrals combined, and the result sampled to determine the NRZ bit.

Two complete bit detectors are contained in each unit. Each has a buffered input to accept signals from either the subcarrier demodulator or the IF demodulator. Differential outputs are provided from each bit detector so that long lines to data processing equipment may be driven. An indicator is provided on the front panel to signify that a reasonable Sφ input is present.

REFERENCES

1. E. J. Hoffman, "Triad High-Speed Bit Detector," Section IX/2c, Space Programs Quarterly Report, April-June 1970, APL/JHU U-SQR/70-2.
2. W. T. Gray, "Ground Recovery of Triad TM," APL/JHU S2T-3-118, August 1970.

-7-

UNCLASSIFIED

§ 102

DoD SPACE PROGRAMS
NAVOCEANO Geoceiver Hardware T1E1S3E
Support: NAVOCEANO
R. J. Danchik and S. B. Springer
October-December 1971

GEOCEIVER BUFFER

BACKGROUND

During 1971 NAVOCEANO requested APL to investigate the feasibility of outputting satellite ephemeral data on the Magnavox Geoceiver AN/PRR-14 paper tape punch.

After the investigation, a buffer was designed that used the computer output of the Geoceiver to obtain the ephemeral information (message set "A") and punch it in teletype format on five-level paper tape between the normal time, doppler, and refraction data intervals (Ref. 1).

Subsequently the design was modified (a) to permit the normal time, doppler, and refraction data as well as the message set "A" data to be punched in its raw (coded) form at the discretion of the operator, and (b) to incorporate a digital printer. The purpose of the modification was to provide for computation of the data with fewer manual inputs and to enhance operability and maintainability in remote operating areas. In addition the printer would provide a redundant data collection capability (Ref. 2).

An investigation of several different digital printers yielded a decision to incorporate a Keltron Model DM 400 rotating drum type printer.

SUMMARY

APL will fabricate nine buffers for the AN/PRR-14 Geoceiver. Each buffer and its printer will be housed in an aluminum combination carrying case 21 by 19 by 11 inches. The case will provide storage for cables and trouble shooting accessories. The package will match the Geoceiver in color and environmental design.

All parts have been procured, and all mechanical design has been completed. Delivery of special order items was completed by the end of this quarter, with the exception of the Keltron DM 400 printer. Items to be fabricated by APL are expected by 14 January 1972.

FUTURE PLANS

The first unit is scheduled to be completed by the week of 10 January 1972. The remaining eight units will be fabricated and delivered to NAVOCEANO by the first week of March 1972.

An operator's manual for the buffer will be in draft form by the second week of March and the final manual by the last week of April.

REFERENCES

1. "Design Approach and Cost Estimate for the Geoceiver Punch Interface," APL/JHU S3E-71-119.
2. "Expansion of Geoceiver Punch Interface to Include Keltron Printer Output," APL/JHU S3E-71-264.

UNCLASSIFIED

§ 103

DoD SPACE PROGRAMS
Geoceiver PDP-9 Computer Program T1LOS3E
Support: NAVOCEANO

J. W. Casey, J. G. Cusic, and M. O. Marshall

October-December 1971

NAVOCEANO GEOCEIVER NAVIGATION PROGRAM

BACKGROUND

In support of the U.S. Navy Oceanographic Office, APL is developing a Satellite Navigation Program Geoceiver/PDP-9 computer system. The system will be used for ship navigation and to provide a data base for remote surveys. This installation and application is the first of this type to be attempted.

SUMMARY

NAVOCEANO is using the Geoceiver as a navigation and survey tool. With the addition of a buffer the Geoceiver will be incorporated into a DEC PDP-9 computer system. The computer system consists of two 8K PDP-9 computers, a drum memory, magnetic tape/paper tape peripherals, the Geoceiver, data sensors, and X-Y plotters: One computer (designated on-line) supervises data collection by means of an executive program; the second computer (designated off-line) performs data reduction. Intermediate storage of data and communication between computers are via the drum memory.

The Geoceiver is operated in the 30-second doppler mode and uses the satellite signal for internal timing and data transfer control.

Orbital data and doppler data are stored on the drum and transferred to the off-line computer at the end of each 2-minute message. The Geoceiver navigation program resident in the off-line computer processes the satellite data, performs navigation fix computation, and adds the information to the data base in the form of perforated paper tape.

Program Design. The navigation program design is to develop the program in three steps, each of which increases the capability in functional steps as follows:

1. Repeatable navigation,
2. Remote navigation, and
3. Real-time navigation.

The repeatable navigation capability operates on previously processed data and reproduces known results to demonstrate program operability. The remote navigation capability processes the raw satellite data punched on paper tape by the Geoceiver.

The real-time navigation capability processes data directly from the Geoceiver/drum as the data are received from the satellite.

The Geoceiver navigation program coded in Fortran IV language has been checked out with test passes on the IBM 360/91. The Fortran IV generated code on the DEC PDP-9 overflows core memory, requiring the program to be rewritten in assembly language. This has been completed and the program is in the last stages of correction.

FUTURE PLANS

It is expected that the program will be completed early in the next quarter for use aboard a NAVOCEANO ship during sea trials.

DoD SPACE PROGRAMS §104
AN/SRN-9 Logistic Support Z230S3E
Support: NAVELEXSYSCOM
R. J. Finneran
October-December 1971

AN/SRN-9 PROGRAM SUPPORT

APL provides technical support for 17 shipboard AN/SRN-9 (XN-5) and CP-827 (XN-1) radio navigation sets, including shipboard checkout, operators' training, and a maintenance school for Navy technicians. Technical assistance is being provided on the production AN/SRN-9/CP-967 for shipboard use, the AN/SRN-9A and AN/WRN-5 for submarine use, and a submarine prototype AN/SRN-9 (XN-6).

SUMMARY

Of the 17 shipboard AN/SRN-9 (XN-5)/CP-827 navigation sets, 16 were operational on 31 December 1971 (Table 1). During this quarter, a navigation set was installed on the USS Wainwright. A three-week maintenance class for Navy ET's was held at APL during October. A survey was performed on the USS F. D. Roosevelt to investigate antenna shadowing on the AN/SRN-9 (XN-5) mast group. A recommendation was made to relocate the antenna at a more suitable site.

The navigation set on the USS Darter was removed and returned to APL for regrooming prior to installation on the USS Salmon.

The AN/SRN-9A evaluation at APL was completed, and the navigation set was shipped out on 27 December 1971 for use aboard an SSN submarine.

An updated navigation program was generated for the AN/SRN-9 (XN-6) on the USS Sunfish. The features of this updated 20-second short-count navigation program are (a) improved navigation fix computation time to less than 2 minutes, (b) doppler data angle editing, symmetrical editing, and three sigma stripping, (c) time-ordered alerts for five operational satellites, (d) improved rerun of satellite pass capability, (e) 1-minute update of time display, (f) ability to run alerts for future positions, (g) single channel 400- or 150-MHz navigation fix capability, and (h) 2-minute position entries from ship's inertial navigation system. The navigation program is now in use aboard the USS Sunfish.

APL is supplying technical assistance on a NAVELEX contract with Magnavox for an AN/WRN-5 submarine navigation set.

FUTURE PLANS

A navigation set will be installed on the USS Salmon.

Table 1

Status of AN/SRN-9/CP-827 Radio Navigation Sets, 31 December 1971

Location	AN/SRN-9 Serial No.	CP-827 Serial No.	Status
USS Albany (CG-10)	6	3	Operational
USS Okinawa (LPH-3)	7	9	Operational
USNS Eltanin (T-AGOR-8)	8	5	Operational
APL	9	1	Operational
USS Blue Ridge (LCC-19)	10	2	Operational
USS McMorris (DE-1036)	11	6	Operational
USC&GS Oceanographer (OSS-1)	12	4	Operational
USS Saratoga (CVA-60)	15	10	Operational
USS Salmon (SS-573)	16	8	To be installed
USS America (CVA-66)	17	7	Operational
USS Long Beach (CG(N)-9)	18	13	Operational
USS Ticonderoga (CVS-14)	19	12	Operational
USS Wainwright (DLG-28)	20	11	Operational
USS F. D. Roosevelt (CVA-42)	21	14	Operational
USS Chicago (CG-11)	22	15	Operational
USS J. F. Kennedy (CVA-67)	26	16	Operational
USS Goldsborough (DDG-20)	27	17	Operational
USS Perry (DE-1034)	28	18	Operational
USS Sunfish (SSN-649)	AN/SRN-9(XN-6)		Operational
APL	AN/SRN-9/CP-967		For evaluation

DoD SPACE PROGRAMS §105
NAVOCEANO GASS Integration and Support: Z440S3E
R. H. Bauer, M. O. Marshall, and C. E. Rehbein
October-December 1971

PROJECT MAGNET GASS SYSTEM INTEGRATION—RP-3D AIRCRAFT

The U.S. Naval Oceanographic Office has conducted worldwide and local geomagnetic airborne surveys since 1953 under the name Project Magnet. The Geomagnetic Airborne Survey System (GASS) is being updated in two ways. First, APL is replacing the existing magnetic survey equipment with a new system that will integrate the functions of survey control (navigation) and magnetic survey and provide an extensive data recording and processing capability. Second, the existing survey aircraft (NC-121K Super Constellation) is being replaced with the RP-3D, a version of the P-3C antisubmarine aircraft specially configured for geomagnetic survey.

SUMMARY

The software being developed by APL for Project Magnet is divided into the following four main categories: the off-line software support system; the real-time data collection, display, and recording program; the mathematical algorithms; and the postflight data analysis program. The status of software development in each category is discussed below.

DISCUSSION

The off-line software support system program is used as an aid in the development of software that will be flown in the aircraft. The primary feature of the system is a magnetic tape handler that an operator can control from the ASR-35 keyboard. Programs can be recorded onto magnetic tape from the card reader, from punched paper tape, or from the computer memory. As programs are developed and debugged, they are stored on the magnetic tape for further use and final program assembly. A preliminary version of the off-line software support system has been debugged and is presently in use. A more efficient version has been developed and will be tested soon.

The real-time data collection, display, and recording program is presently being coded. The executive program, which is the heart of the real-time program coordination and scheduling, has been coded. Preliminary checkout of the executive has started, but final checkout must await the availability of all the hardware. Coding is 80% completed for real-time data collection from the following equipments: Loran, Omega, sextant control module, AGC-6 keyboard, and the satellite receiver. Data display programs have been coded but not checked out for the following displays: AGC-6 line printer, survey display, and the magnetics display. These various programs will be checked out as hardware ' :omes available. Programs that have not yet been cod.. are: navigation data input, pilot's display, analog recorder, and the magnetic tape recording program.

The mathematical algorithms that have been coded and checked out on the H316 computer are: a double-precision, fixed-point mathematical package (multiplication, division, square root, and trigonometric functions); vector functions; coordinate rotations; great circle path with intermediate checkpoints; Loran and Omega fixes; star fix; and the generation of aircraft track to cover a prescribed survey area. The satellite fix computation (written in Fortran) works on the IBM 360 and is presently being tested on the H316. A Fourier coefficient routine (written in Fortran), which is a part of the magnetics calibration program, has been checked out on the IBM 360. Mathematical algorithms yet to be coded include, integration of inertial velocity to obtain position, maintaining a ground track using air sensor data and doppler data, and magnetic compensation.

No coding has been done for the postflight data analysis program. After the in-flight program is completed, the postflight data analysis programs will be developed. It is anticipated that many of the subroutines used in the flight program will be used in the postflight data analysis program.

SPECIAL ASSIGNMENTS

-12-

SPECIAL ASSIGNMENTS §106
U.S. Geological Survey Technical Support Z560S3E
Support: U.S. Geological Survey
R. E. Bateman and J. W. Casey
October-December 1971

U. S. GEOLOGICAL SURVEY

The Applied Physics Laboratory is assisting the U.S. Geological Survey in conducting a survey in the Antarctic. Two AN/SRN-9 (XN-5) navigation sets will be used for this Antarctic Field Test Survey.

The tests will consist of surveying seven preselected sites in the Antarctic during the period 14 December 1971 to 30 January 1972 (Fig. 1). The objective of the survey is to position the sites in two modes: one by absolute positioning, the other mode by using translocation techniques. During the test period, raw data will be recorded in the field. The analysis of these data will be accomplished by APL during the period 1 February to 1 May 1972.

SUMMARY

Two AN/SRN-9 (XN-5)'s were completely tested at APL prior to shipment. They were sent to the loading terminal for Deep Freeze 72, McMurdo Sound on 12 October 1971. A set of satellite alerts was supplied which covered the seven Antarctic sites to be surveyed. Mr. Clint Baumann, Bendix Field Engineer, will act as APL technical representative during the Antarctic survey. The two navigation sets were assembled at McMurdo Sound for the purpose of certifying the equipment operation. The two AN/SRN-9 (XN-5)'s were positioned 118 meters apart on two existing survey markers, "Hut Reset" and "International Satellite Triangulation No. 53, Astro Pier." Fourteen translocation satellite passes were taken and sent to APL to certify that the equipment was operational. The APL analysis showed that the navigation sets were operating properly.

The first survey operation, consisting of White Island to McMurdo Sound, Brown Peninsula to McMurdo Sound, and White Island to Brown Peninsula, started on 29 December 1971. This survey, consisting of three legs approximately 40 km in length, is expected to take 2 weeks.

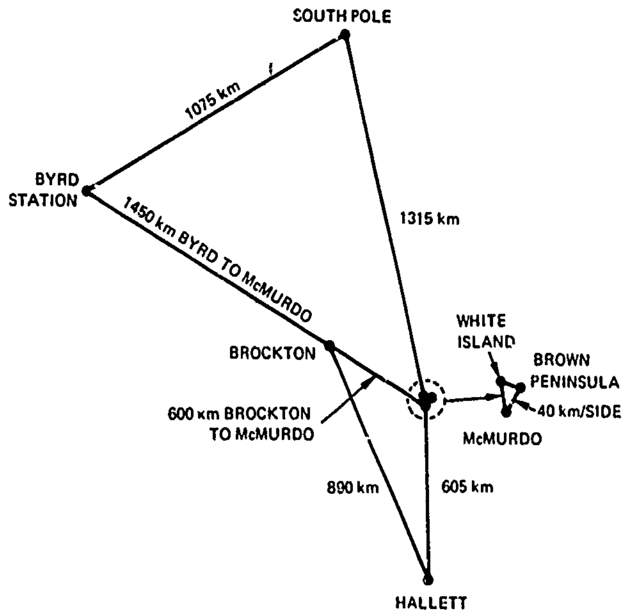


Fig. 1 Proposed U.S. Geological Survey/APL Survey Points, Antarctic Field Test Survey. (71-3/81)

FUTURE PLANS

Analysis will start on data received from the Antarctic Survey. A quick-look report will be published on the certification of the equipment.