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DATA COLLECTION PLATFORM/FIELD TEST SET PROGRAM

Report No. 73SD4233

G. C. VanNostrand/G. Meyerson  
GENERAL ELECTRIC COMPANY  
5030 Herzel Place  
Beltsville, Maryland 20705

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| 12. Sponsoring Agency Name and Address<br>Earl Painter, Technical Monitor<br>Goddard Space Flight Center<br>Greenbelt, Maryland 20771   |   | 15. Supplementary Notes   |                                      |
| 16. Abstract<br><br>The Data Collection Platform (DCP) Contract, NAS 5-21697, between the NASA Goddard Space Flight Center and General Electric Company, Space Division, provides for the fabrication, assembly, test and delivery of 200 Data Collection Platforms in conformance with specification SVS 7848, Earth Resources Technology Satellite Data Collection Platform design specification; the design, development, fabrication, assembly, test and delivery of 25 Platform Field Test Sets (FTS); and the associated spares, manuals, documentation and advisory services.<br><br>(continued on attached sheet) |   |   |                                      |
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Figure 2. Technical Report Standard Title Page

16. Abstract (continued)

List of reference material:

DCS Performance Evaluation for ERTS-1, 2 January 1973

ERTS DCP Field Installation, Operation and Maintenance Manual, 72SD4208

ERTS DCP Depot Manual 72SD4228

ERTS 1 Flight Evaluation Report 72SD4262

SVS 7925 "ERTS Platform Test Set Spec", 20 September 1971

SVS 7848 "ERTS DCS Data Collection Platform Design Specification"  
Revision C, August 19, 1971

47E225158 - FTS Top Assembly Drawing and Parts List

TP 5001 Test Plan for the ERTS DCS Data Collection Platform

"ERTS FTS Engineering Test Spec"

SVS 7900 ERTS Bit Design Spec, Revision C, August 7, 1971

E-GDHS-1006, SOW - Equipment and Services for ERTS DCP and FTS

47E22158 Test Procedure for Platform Tester Assembly, 2/8/72

## PREFACE

### (a) OBJECTIVE

This report presents the history of the overall project and the technical activities of its systems, subsystems and components. Appropriate technical information is discussed including significant techniques, procedures, equipment, tests, problems and project results. The DCP program work breakdown structure serves as the basic format of this report.

### (b) SCOPE OF WORK

Manufacture, test and deliver the following items and quantities per this contract:

|  |          |
|--|----------|
| ERTS DCP Field Test Set (Prototype)                              | 1 each   |
| ERTS Data Collection Platforms (DCP)                             | 200 each |
| ERTS DCP Field Test Sets (DCP/FTS)                               | 25 each  |
| ERTS DCP Installation, Operations & Maintenance Manuals Volume I | 225 each |
| ERTS DCP Depot Manual Volume II                                  | 45 each  |
| ERTS FTS Spare Parts   | 25 sets  |
| ERTS DCP Spare Parts   | 2 lots   |
| Technical Data, Manufacturing Data Pkg.                          |          |

### (c) CONCLUSIONS

General Electric successfully fulfilled the requirements of this production contract. Based on operational performance of the Data Collection System, the DCP's deployed throughout the network are providing reliable and accurate sensor data to the user community.

(d) SUMMARY OF RECOMMENDATIONS

Prior to going into production with a working prototype design, steps should be taken to evaluate the impact of the manufacturing processes on the prototype. This activity should precede solicitations to better determine the best terms for the contract.

The technical problems which resulted during the course of this program were primarily due to producibility aspects of the prototype DCP.

T A B L E   O F   C O N T E N T S

- I.        Program Management
- II.       A&GS Manufacturing DCP and FTS
- III.      DCP Production Engineering and Test
- IV.      Field Test Set
- V.        DCP/FTS Logistics and Spares
- VI.      Field Manuals and Depot Manuals
- VII.     Advisory Services
- VIII.    On Site Assistance and Applications Development
- IX.      DCP Systems Evaluation

## I. PROGRAM MANAGEMENT

The Data Collection Platform & Field Test Set Production Contract, NAS5-21657, was initiated in early November 1971 by virtue of an Advance Requisition. Although formal contractual start authorization was not effective until January 1972, General Electric was able to get the program started.

The program plan for the Data Collection Platform production and for the Field Test Set development & production was initiated and contained all the necessary functions for project direction. The program work breakdown structure was prepared, (Figure 1) reviewed, and released to provide a program control mechanism for measuring project activity. With initiation of the Program Master Schedule, Figure 2, progress was begun. Project activities per master schedule line items are discussed in the appropriate sections of this report.

During the first weeks of the DCP/FTS program, the primary activity was in the preparation for production of DCP's, including facility modifications, manufacturing planning, and the necessary material and drawing acquisition. Those problems unique to adopting the prototype design to manufacturing activity are discussed in appropriate sections of this report.

The role of maintaining coordination between VFSTC, A&GS, GE-Beltsville, and the GSFC counterparts was performed by the Program Office. In transitioning the FTS design from VFSTC to A&GS there was a need to establish a strong engineering interface between the designers and the manufacturing project engineers to help in the resolution of any checkout problems.

During the redesign effort on the DCP, program management responded rapidly to provide required personnel who were equipped to perform the necessary redesign.

During April and May 1972, the extensive redesign was performed which completely



stopped all DCP production and created a late delivery schedule for the majority of the units.

It should be pointed out that the credibility of the DCP circuit design was not challenged until after the established configuration baseline of March 1. The design had been evaluated to determine how well it supported the DCP system from an operational viewpoint.

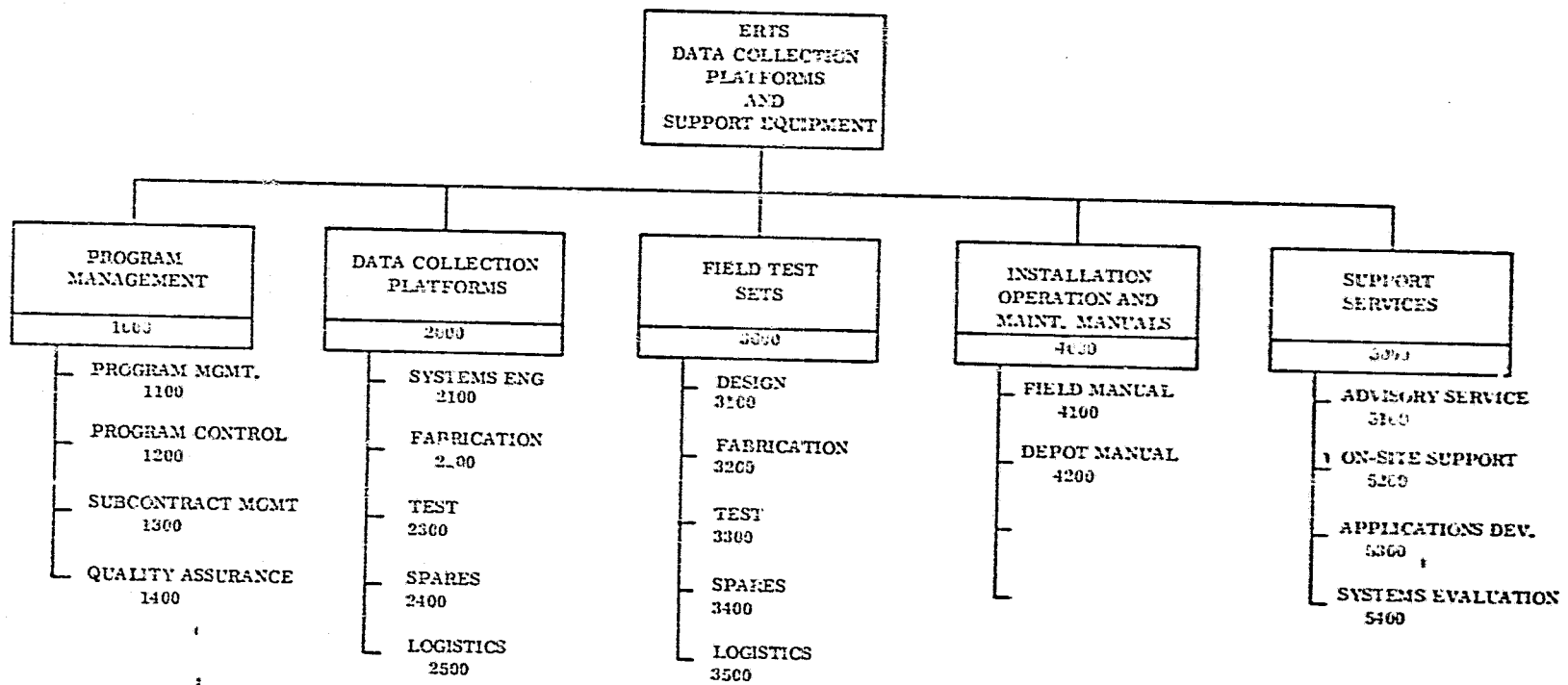


Figure 1. Work Breakdown Structure

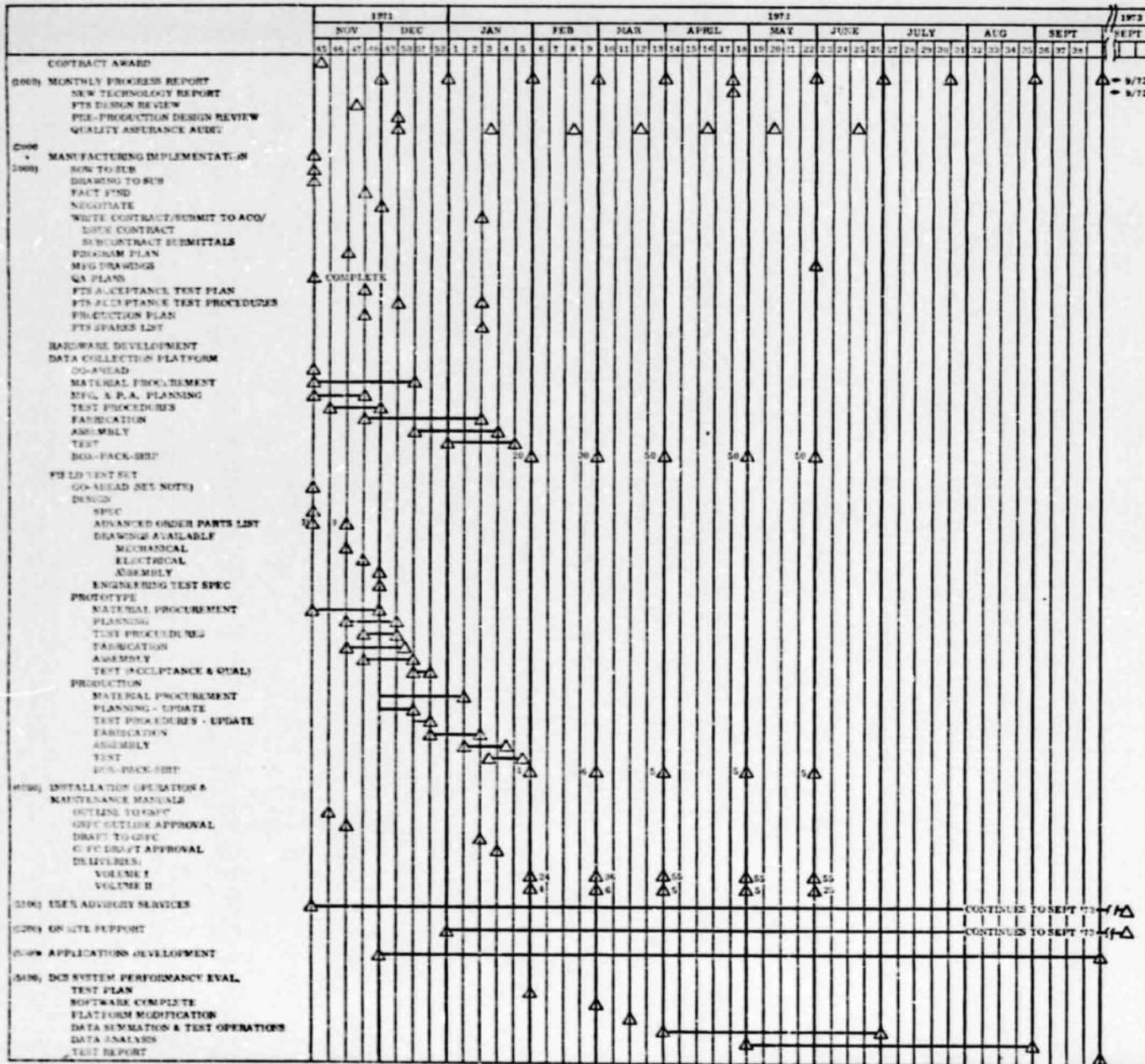


Figure 2. DCP/FTS Program Master Schedule

## II A&GS MANUFACTURING DCP AND FTS

A subcontract was awarded to the Apollo and Ground Systems operation of the General Electric Company under an inter-departmental transaction subject to the terms of the prime contract NAS-5-21697.

On October 12, 1971 SSO and AGS met to fact find the baseline proposal. During this session basic agreement was reached on the Statement of Work and Technical Requirements. Results of the fact-finding and review established the fixed price contract for the production.

The technical evaluation of the A&GS ability to manufacture quantities of DCP's and FTS's was affirmative. Facilities were viewed as more than adequate. However it was apparent that A&GS did not have all the baseline data that was required to perform satisfactorily on the proposed DCP/FTS schedule. Drawings and Specifications which comprised the Radiation Inc. manufacturing data package were incomplete. This data was subsequently provided to A&GS.

The baseline contract was amended to include new requirements. Change 1 included revisions due primarily to the agreed upon new requirement to provide project planning, schedule integration, additional reporting, configuration control and manufacturing drawings.

Change 2 which occurred later in the production phase of the program included increased cost due to a Q.C. documentation change, FTS design changes, and hardware repairs.

The A&GS implementation of the DCP/FTS production contract, together with modifications and any schedule impact is discussed in Section III, DCP Production Engineering and Tests.

Original DCP deliveries ran from February through June for 200 units. Actual deliveries ran from May through November due primarily to the redesign efforts required to make the DCP functional and producible.

The actual delivery schedule of DCP/FTS production was per Figure 3.

Deliveries of DCP's were concluded in November 1973 when the last 50 DCP's and 6 FTS's were completed and shipped.

A review of GE inter-department work transfer from Space Systems Organization to Apollo & Ground Systems is available. The following documentation was contained therein which collectively describes the procurement.

Copy of Procurement Order

Terms and Conditions required by Prime Contract

Summary Negotiations

Cost Breakdown Review - Form 4-8461

Technical Review

Competition - Comparison of Bids

Subcontractors Proposal/Supplier's Quotation

Authorization for use of Government owned equipment without charge

Letter of Intent

DCP/FIS Delivery

|        | <u>May</u> | <u>June</u> | <u>July</u> | <u>AUG</u> | <u>Sept</u> | <u>Oct</u> | <u>Nov</u> | <u>Totals</u> |
|--------|------------|-------------|-------------|------------|-------------|------------|------------|---------------|
| DCP's  | 20         | 2           | -           | 36         | 47          | 45         | 50         | 200           |
| FIS    | 5          | 1           | -           | 6          | 4           | 4          | 6          | 26            |
| SPARES |            |             |             | X          | X           | X          | X          |               |

FIGURE 3

The administration of a Quality Control program for this inter-departmental procurement was a requirement.

The Radiation Inc. Workmanship Standards Manual number 900060 was established early in the DCP/FTS Contract as the governing Quality Control standard.

This manual encompassed activities as follows:

- o Product Assurance

- Review Quality Requirements on Purchase Order

- Incoming Materials Inspection/Test

- In-Process Inspection/Test

- Pretest Inspection

- o Test

- Acceptance Testing

- Qualification Testing

- Nonconforming Material Contract

- Calibration and Maintenance of Test Equipment

- Final Inspection

- Failure Reporting and Analysis

- Shipping Documentation

- Shipping Controls

- Government Source Inspection

- o Configuration Control

- Document Baseline

- Change Procedures

- Configuration Verification

Due to growing differences between both NASA/GSFC and GE/SSO & AGS regarding the interpretation of the Radiation Inc. Workmanship Standards Manual for DCP manufacture, a joint meeting was held in March 1972.

It was the purpose of this GE-SSO/GE-AGS/NASA-GSFC meeting to review, approve, and implement a new GE-AGS Quality Inspection Standard (QIS) to the DCP contract as a replacement to the Radiation Inc. 90060 Workmanship Standards Manual.

In April 1972 GE-SSO amended the contract with GE-AGS accordingly.

The change agreed to by all parties helped immeasurably in the manufacturing activity from April until the conclusion of the production contract in November 1972.



### III. DCP PRODUCTION ENGINEERING AND TEST

The manufacturing of Data Collection Platforms was initiated on November 1971. All original design DCP drawings and parts lists were reviewed for producibility prior to initiation of the procurement cycle.

DCP planning and the manufacturing data package definition was started as scheduled. The DCP Assembly and Test areas were established and the necessary plant equipment put in place.

#### Producibility Changes

Producibility trade-off studies of specific parts and components were started and recommended changes requiring GSFC approval were submitted.

Changes to the original design data package were submitted and approved for incorporation into the production units. Changes approved were of the producibility type and are defined as follows:

1. Modification of the flexible cable for better fit.
2. Deletion of weldable lead requirements on capacitors, resistors, and solid state devices.
3. Deleted drawing requirements for environmental tests of shock, vibration and acceleration on piece parts. These requirements were general requirements on the RI drawings and were not applicable to the specific part being used.
4. Deleted requirement for helium leak test on TNC connectors. This was a general requirement on the RI parts drawing and was not applicable to the DCP application.
5. Dimensional discrepancies from RI drawings were corrected for the chassis. This change corrected errors in hole size and hole placement for the control switches.

6. Wiring harness retention bar was modified to eliminate interference with Programmer assembly removal.
7. Drawing errors were corrected and additional nomenclature provided to facilitate manufacturing.
8. The transmitter humidity seal was modified to properly locate and provide for transmitter connector J2 entry.
9. Dimensional discrepancies on chassis housing cover were corrected.
10. Parts designations were corrected where applicable.
11. DCP nameplate was modified for clarity and change in vendor.
12. The oscillator deviation for the transmitter has been changed from  $\pm 3.5\text{KH}_2$  to  $10\text{ KH}_2 -0 + 1$  in agreement with latest system configuration. The method used for setting deviation is being checked for both static and dynamic accuracy.

It appeared that the full production cycle for DCP's which was initiated in December 1971 could meet production units delivery schedule with a minimum slip. However, the unscheduled 21 day aging cycle requirement for the transmitter oscillator by the manufacturer began affecting early deliveries. Affected were the February and March deliveries of the first 50 DCP's.

A concern over the use of plastic encapsulated flat packs was investigated. A cost evaluation was conducted to determine the cost involved in using ceramic flat packs or using hand soldering for securing flat packs to the boards in place of wave soldering. A digital board with plastic flat packs wave soldered was fabricated for evaluation by GSFC. Flat packs, as delivered from the vendor, were compared via microscope with those on the wave soldered board and no conclusions could be drawn relative to any detrimental effects from the wave soldering relative to opening up the lack-lead point for a moisture path. GSFC concurred on the decision to proceed with wave soldering plastic flat packs in the production cycle.

#### Transmitter Board Changes

In March, a major design problem with the DCP transmitter caused a schedule slip and significant cost impact relative to the transmitter production. The original design was fabricated as defined and passed acceptance test; however, upon putting the DCP into qualification test, the transmitter power was found to fall significantly below specification requirements. A detailed evaluation of the problem disclosed improper interstage cooling as well as inadequate gain margins in all output stages. The original designer stated that the prototype had not been reproduced and made to operate; however, GE had not been notified of the latter activity until a detailed probe with the designer was implemented. At this point, GE started designing a "fix" for the power loss problem.

The design fix was tested and the details of the design were verbally transmitted to GSFC on 12 April 1972. The test unit was quite stable over both voltage and temperature variations and the spectrum was devoid of detrimental spurious harmonics. The parts for the design change were procured and the transmitter boards were modified commensurate with the design changes. The drawings and assembly procedures were modified as required and production of the modified units began during the week of 10 April 1972.

Qualification testing commenced on the revised units. The second DCP entered into test failed in temperature. The analog board incurred a failure which appeared to be the A to D converter. The failure occurred at  $-40^{\circ}$ . There was no output from the analog board. The unit was continued through the humidity portion of the test. The failure was analyzed upon completion of the humidity test and ten additional units were scheduled to be qualified at temperature.

This failure of the analog output of the DCP during qualification test was analyzed and verified to be a component (IC) failure on the analog board. The failure analysis indicated that this was a random failure and not indicative of any weak areas. The transmitter of the qualification unit performed within specification limits as did the programmer and digital card.

However, difficulty in manufacturing the DCP continued due primarily to the lack of performance repeatability with the transmitter design when fabricated with extreme care. The tuning continued to be critical to the point where all transmitters were aligned in temperature prior to submission for DCP assembly and then each DCP finally tested in temperature.

In order to eliminate this critical alignment procedure, additional design changes were necessary. This effort was extensive but when completed the desired results were achieved. The stability of the unit over the temperature and voltage range was significantly increased and the alignment procedure simplified.

This final fix eliminated many of the "critical" value chip capacitors used for tuning. Variable Johanson-type capacitors were inserted for alignment. Present test data shows about 1 db variance over the temperature range with a minimum voltage input. The RF power output with this condition is eleven watts nominal. The spectrum was searched for spurious harmonics and the latter were all verified

to be below specification requirements with the spectrum indicating good stability over the test range. With the incorporation of the above changes, the production rate on transmitters significantly increased and hence allow the DCP production rate to increase since the transmitter production cycle had been the limiting item. The engineering report on the detailed changes made to the DCP transmitter follows.

Engineering Report on DCP Transmitter Redesign

Prior to any actual electronic testing of the transmitters, it was confirmed by all parties that they were built in agreement and conformity with the Radiation drawings. This included considerations for all electrical, mechanical, and material call outs.

Commencing from the first production unit of the Radiation System Inc., DCP transmitter, up to and including fifty, constructed units, all fifty transmitters had failed to meet cold temperature test specifications. The transmitters in question were constructed, NASA inspected, and accepted as being built in agreement and conforming with the Radiation drawings; electrical, mechanical, and component prior to any actual electronic testing of these transmitters. Furthermore, transmitter stability under normal operating conditions was for the most part, difficult to achieve during the initial alignment at a specific VCC (21.0 volts). After the transmitter was tuned at 21.0 volts, and the VCC voltage increased to 28 VDC, the transmitter would, generally speaking, regenerate until realigned and and adjusted at the increased VCC (28.0 volts).

Upon initial investigation the transmitter PC board itself, the design opposed all attempts to insure stability coupling between amplifier stages within the multiplier circuits, Q9, Q8, Q7, and Q6. Also, Q3 (as per the manufacturer's spec.) should not be used as an amplifier below 500 MHZ. As a result, Q3 is a constant source of high power parasitic and sub-harmonic oscillations, and is conditionally stable during alignment and temperature testing.

In addition to the aforementioned, the internal dimensions of the DCP chassis, especially when the sheet metal rear cover was screwed down, formed a "low Q" 1/4 wave length cavity at the operating frequency of 401.55 MHz. Therefore, when a transmitter was placed in the DCP chassis, including rear cover plate, and power applied to the DCP, the transmitter suffered from either regeneration, loss of fundamental power, or both. After several engineering conferences between NASA & GE, both parties concurred that the transmitter's inability to perform satisfactorily, as regards function, producibility reliability, stability and R.F. power output versus temperature, would necessitate a major transmitter redesign effort.

The first order of business in the transmitter remodification sequences was to establish a criterion for amplifier stability, through the signal chain of the transmitters, multipliers and power amplifiers. As to the multipliers, component reorientation and removal of redundant components was required. A test "Signal Sampler" jig was constructed that would sample a portion of the signal and enable the engineer and test technician to monitor any condition of gain, loss, stability, and instabilities as pertinent to any one amplifier stage and/or amplifier stages incorporated in the transmitter. The benefits realized because of these changes were:

1. Excellent stability
2. Elimination of "parameter sensitive" and select at test components
3. Elimination of undesired "ground loops" within multiplier portion of the PC board
4. Greatly improved tuning characteristics

After the changes were introduced and completed, the unit was placed in the temperature chamber, and listed below are the results of that test.

1. RF Power Output Loss @ minus 45 F = .5 db.
2. Instabilities. The redesigned multipliers did not exhibit any tendencies towards oscillations nor instabilities, during the cold and hot test, when the VCC supply voltage was reduced from +28 volts to +10 volts. By way of comparison, the original design lost 2.5 db RF Power @ minus 45° F during the first 20 minutes of the same test and broke into oscillations when the VCC supply was reduced from 28 volts down to 21.0 volts.

To reiterate an earlier remark; Q3 had always, in its original circuit configuration, exhibited a remarkable degree of instability, i.e., the most predominant frequency of oscillations when Q3 was in an oscillatory state, was 200 MHZ. In UHF transistor power amplifiers, the most common instabilities occur at frequencies far below the operating frequency because the gain of the transistor increases at a rate of approximately 6.0 db per octave. For example, a transistor that has a power gain of 7.0 db at 400 MHZ will have a power gain of 14.0 db at 200 MHZ and may have a gain of as much as 28.0 db and 100 MHZ. With such potential gain available, plus the fact that the transistor input reactive component is capacitive to these lower frequencies, any stray/distributed inductance will set the amplifier circuit into violent oscillations and even cause the destruction of the transistor.

In order to stabilize Q3, R3 connected between Q3's Base and Ground was removed and replaced by a small choke broadly resonant with the sum total of distributed capacity at 400 MHZ. This was the only change required to stabilize the base circuit of Q3. The advantages gained are as follows:

1. Unconditional stability at its base input
2. Increase of gain (.75 DB)
3. Stability, independent of temperatures

The gain loss versus temperature extremes, speaking now of the "collector circuits" of Q1, Q2, and Q3 was directly proportional to the parameter sensitive select at test components. For example, a Radiation transmitter at nominal room temperature, tuned to deliver 15.0 watts into a .50 ohm load, and subjected minus 20°F, would lose approximately 6.0 DB of power (below spec). This loss of power was distributed rather evenly between the collector circuits of Q2 and Q1.

It was necessary to remove from the Radiation transmitters the following components:

|        |         |         |         |
|--------|---------|---------|---------|
| 1. R3  | 10. R1  | 19. C4  | 28. C83 |
| 2. C36 | 11. C14 | 20. L2  | 29. L39 |
| 3. C22 | 12. C11 | 21. C3  | 30. C84 |
| 4. C19 | 13. C12 | 22. L1  |         |
| 5. C79 | 14. L3  | 23. C1  |         |
| 6. C13 | 15. C8  | 24. C2  |         |
| 7. C15 | 16. C7  | 25. C81 |         |
| 8. L6  | 17. C6  | 26. C82 |         |
| 9. C16 | 18. C5  | 27. L38 |         |



After the redesign of the collector circuits, the updated transmitter, the unit was placed in the temperature chamber, and results are listed below:

- A. R.F. output power at R.T. = 12.5 watts
- B. R.F. output power at minus 45° - 14.0 watts (2.5 hours)
- C. All harmonic contents better than specs. Note Figure No. 1

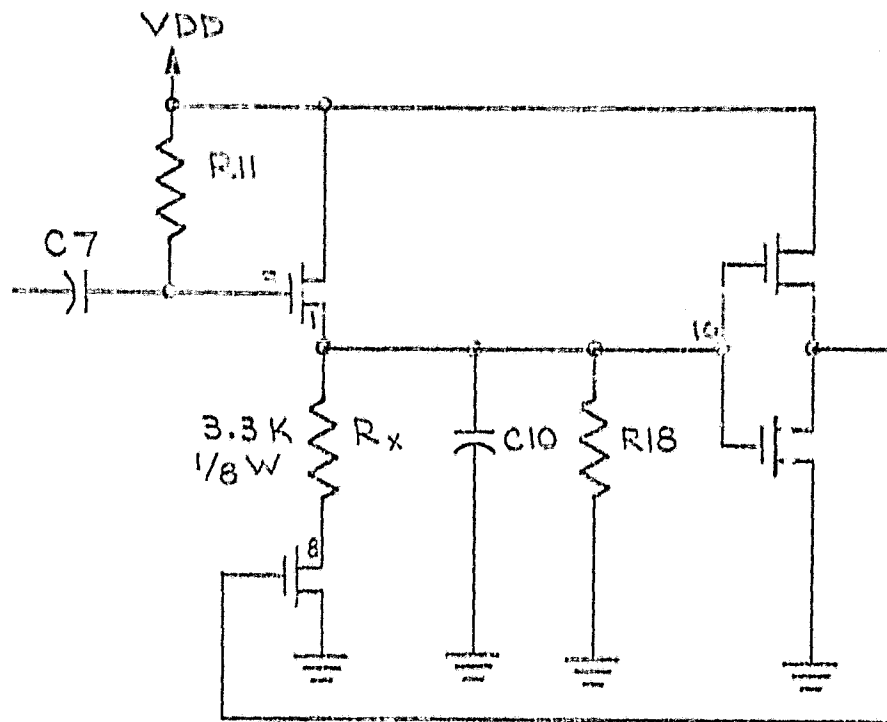
Thirteen of the 50 Radiation DCP's which had failed the cold temperature test were rebuilt as per the redesigned transmitter. Each was tested and its performance under temperature versus power output and harmonic content was identical with the first modified unit. When the tests were completed, GE submitted a request for approval of changes to NASA. The remaining 36 transmitters were modified and tested. Their individual performance exceeded specification. However, one problem remained, and that was to eliminate the effect of a low Q  $\frac{1}{4}$  wave cavity inherent within the DCP chassis and back cover. This was successfully eliminated by shielding the power amplifier circuits from the undesirable cavity effects.

#### Programmer Board Changes

In April 1972 the Integrated Circuit Component CD4007AE which provide timing pulses within the DCP presented problems. The devices were hand selected to insure circuit performance. The threshold and impedance characteristics of the CD4007AE were parameters effecting the circuit application. RCA admitted that the internal characteristics of the device had been changed by a production process change and no longer matched their application data.

In view of this, the circuit was analyzed by design engineering. It was apparent that the addition of a resistor added between the input and output gates would insure that the necessary threshold was reached in all cases.

The circuit change involved adding a resistance (3.3K, 1/8 watt) between pins 1 and 8 as follows:



This was substantiated by breadboarding the circuit and performing tests with a number of devices which would not work in the present programmer. These tests included temperature cycling as well as ambient conditions. All devices performed across the range of temperature and voltages and waveshapes were satisfactory.

A&GS implemented the recommended design change in all component applications

by first removing the IC in U2 and U7 and adding a resistor across pins 1 and 7 instead of the jumper wire.

In July additional problems were experienced with the Programmer Board. Seven units were either non-operational or marginally operational. These units had all failed during temperature humidity cycling.

All units manifested the same malady - low voltage "test-in" signals. It was determined excessive leakage currents were flowing in the "test-in" gate circuit (U6). After removing the COS-MOS integrated circuit of a typical board and inserting a new device, it was concluded that the leakage currents were somehow distributed around the P.C. card.

Rather than pursue the location and source of the leakage currents, it was felt that the problem could be solved by lowering the circuit impedance. In addition, other alternatives to this approach were discussed such as applying an external current to offset the degrading current (apply 24 volts through 8.2 mohm to the "test-in" terminal).

Even though tests on the other input gates, 90 sec enable, 180 sec enable and test enable did not show the large amount of leakage current of the "test-in" terminal, it was decided to lower the impedance of R6, R5 and R3 from 1 megohm to 240K as insurance for future unknown leakage paths.

Also, because there was a history of wide variations in the current drawn by the COSMOS elements, with resulting VDD variations, it was decided to lower the impedance of dropping resistor R20 from 82K to 33K and add a zener diode IN4099 across filter capacitor C12. This design will increase the "idle power" by approximately 8 MW but will maintain VDD at a nominal 6.8 volt value for wide variations in the current requirement of the COS MOS chips.

### Antenna Unit

Antennas for the DCP's were produced per GE drawing 63E901402. Antenna qualification tests were performed at the General Electric's Heavy Military Electronics Division's antenna test range in Cazenovia, New York.

On March 17, 1972 the first antenna qualification test was run per GE test procedure 56137-21-163, "DCP Antenna Qualification Testing Requirements," dated July 25, 1972. The following discrepancies were noted during that test:

1. Antenna polarization was left hand circular instead of right hand circular.
2. Antenna gain measurements were not within the specified values.
3. Antenna axial ratio measurements are not within the specified values.

Upon notification of these anomalies, GE-SSO sent an antenna specialist to Cazenovia for an independent evaluation of the problem. The following dispositions resulted for each of the discrepancies noted:

1. The error that caused this switch in polarization was in Radiation Inc. drawing 613059, Revision B, and was transferred to the GE drawing system. Revision A of these drawings was correct; Revision B incorporated the error. Radiation Inc. antenna was built to Revision A and GE's to Revision B. Drawing changes were made to change the antenna to right hand circular polarized. All units were then modified to the updated drawings. The test was then rerun successfully to verify the proper polarization.
2. A waiver was issued by GE with NASA's concurrence to accept the gain at  $20^{\circ}$  to be 0.5 db rather than the specification value of 1.5. As it turns out, the same problem was encountered with original testing of the Radiation Inc. antenna.

3. A change was made to specification SVS 7848 dated 19 April 1971, paragraph 3.2.8.2 to allow the axial ratio to be "less than 6 db" at 20° elevation. This problem was also encountered during original testing of the Radiation Inc. antenna.

After these changes were made, another antenna was completely tested to verify the DCP antenna performance. Production and testing of subsequent antennas occurred without significant problems.

IV. FIELD TEST SET (FTS)

To help meet the production schedule of the FTS, design was begun before final contract go-ahead by design engineers at the General Electric facility in Valley Forge, Pa. A breadboard FTS was built, using available off-the-shelf production components where practicable. A breadboard FTS was then tested, documented, and accepted by NASA. Specification SVS 7925 was issued on 20 September 1971. As a result of these activities, preliminary drawings of the FTS were delivered to A&GS in Daytona Beach by November 1, 1971 to be used in manufacturing planning, parts list generation, and producibility reviews. By 1 December 1971, all production FTS drawings under top assembly number 47E225158 were delivered to A&GS. A&GS then implemented and documented drawing control procedures that did not allow any FTS design changes without written approval of the cognizant design engineer at Valley Forge. A&GS then began production of the prototypes FTS.

The prototype was originally scheduled for qualification testing per A&GS test specification 56137-21-190 in the last week of December 1971. (This procedure was an update of the same procedure used to verify the operation of the FTS breadboard at Valley Forge.) Due to shortages and discrepancies between the breadboard design and drawings, the actual qualification test was completed on 1 March 1972. During this period, the FTS designer spent considerable time at Daytona Beach verifying the production design.

Production of the Field Test Sets proceeded from this point with a minimum of problems.

It had been noted during production testing that in some cases, the maximum operating voltage had reached unsafe values. This was considered to be detrimental to operating life due to overcharging or high temperatures. To solve this, a Voltage Regulator Unit was designed. This Voltage Regulator Unit was sent to the FTS User as a Field Modification kit together with installation instructions. A description of the voltage regulator and the installation instructions follows.

## FIS VOLTAGE REGULATOR UNIT

### I. INTRODUCTION

The Field Test Set utilized for testing the DCP's consists of an electronic unit and a battery pack.

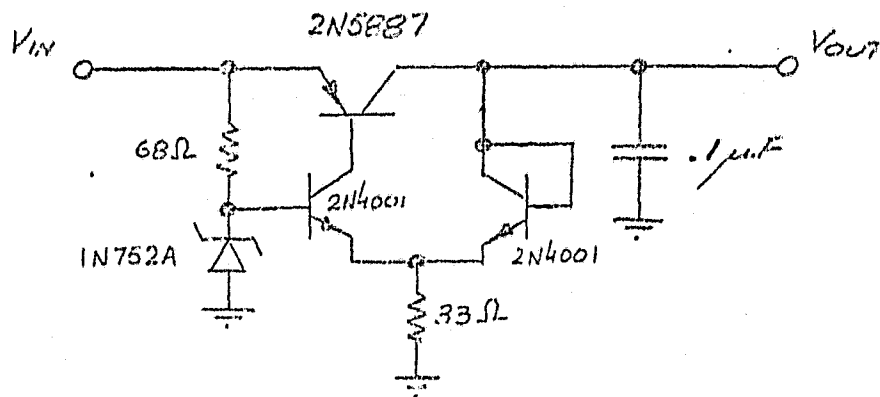
As pertinent to the battery pack, it has been noted that in some cases the maximum operating voltage has reached unsafe values, i.e., excess charge, unusual temperatures, aging, etc.

In order to prevent any problems or failures that may occur due to those circumstances, General Electric has developed and manufactured a Voltage Regulator Unit which is recommended to be installed in every FIS.

### II. DESCRIPTION

The Voltage Regulator Unit is a modular assembly, easy to attach to the present FIS.

The circuit is a simple series regulator referenced to a Zener diode, with the provision of self-saturating capability in event the battery voltage degrades below the minimum regulating voltage.





### III. INSTALLATION PROCEDURE

#### A. Tools and Materials

- (1) Drill motor with No. 28 drill bit
- (2) Screwdriver
- (3) Soldering Iron
- (4) Ohmmeter
- (5) Three pieces - 1 ft. long of AWG #22 wire
- (6) Plastic Tape
- (7) Solder

#### B. Instructions

- (1) Disconnect the FTS from the 115 VAC line
- (2) Disconnect the FTS from battery (remove black plug from battery pack jack)
- (3) Remove battery pack unit from the FTS by disengaging its hinges
- (4) Position the section with the front panel horizontally

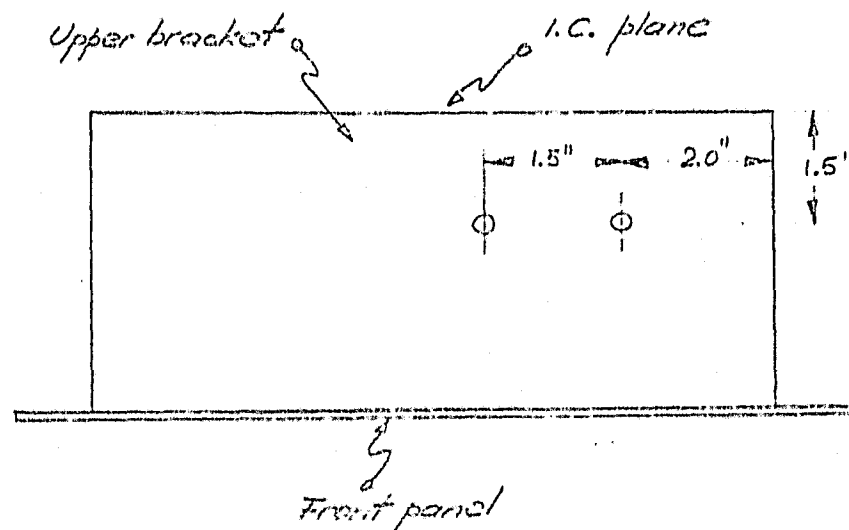
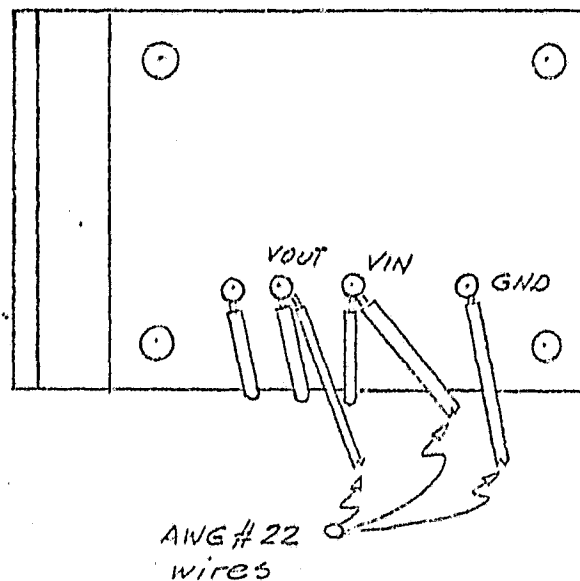


fig. 1

- (5) Unfasten all six "quick look" screws and remove the unit from its housing
- (6) Drill two holes in the upper bracket of the unit as shown in the Figure 1.

NOTE: Observe caution to avoid metal chips from falling into the wire wrap plane.

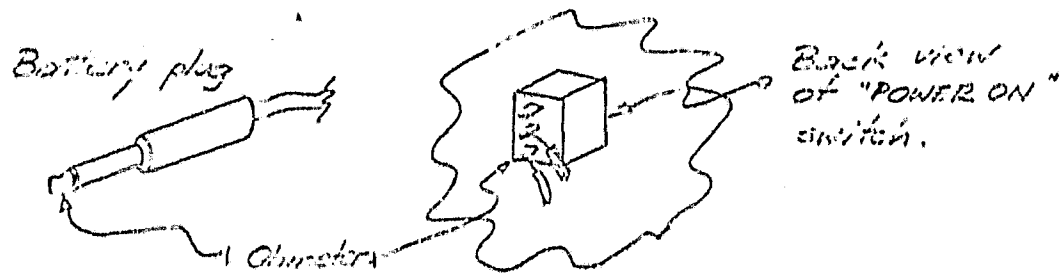
- (7) Solder a one foot long, AWG #22 wire to the terminals of the Voltage Regulator Unit as indicated in Figure 2. Mark those wires as shown.



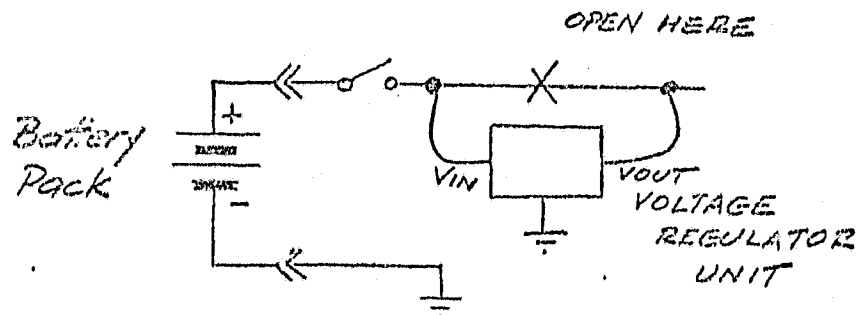
- (8) Install the Voltage Regulator Unit under the FTS's upper bracket using the #6 hardware supplied. The power transistor side must face the back of the display panel.

- (9) Verify that the FTS power switch is in the OFF position.

Determine with the aid of an ohmmeter which wired terminal shows continuity to the tip of the battery plug. Disconnect the wire from the switch terminal that does not show continuity.



- (10) Solder the wire marked "IN" in Step #7 to the switch terminal individualized in Step #9.
- (11) Solder the wire marked "OUT" in Step #7 to the wire individualized in Step #9.
- (12) Solder the wire marked "GND" to terminal #12 of the FTS terminal board located between the front panel and the wire wrap plane.
- (13) Electrically the connection should be:



- (14) Reassemble the entire FTS. It is now ready for use.

V. DCP/FTS Logistics and Spares

The requirements for manufacture and delivery of spare parts for the Data Collection Platforms and the Field Test Sets are defined in this section.

Data Collection Platform spare cards were provided on the basis of one set per 100 DCP units. The total number of cards delivered under the contract was:

- 16 Analog Cards
- 20 Parallel Digital Cards
- 24 Transmitter Cards
- 24 Programmer Cards

Field Test Set spares were manufactured as one set with each Field Test Set delivered. The list of spares provided per CDRL Item #9 under the General Electric A&GS subcontract is as follows:

DCP/PLATFORM TESTER SPARES

| <u>ITEM NO.</u> | <u>PART NO.</u>   | <u>DESCRIPTION</u>   | <u>QUANTITY</u> |
|-----------------|-------------------|----------------------|-----------------|
| 1               | SN5400N           | Integrated Circuit   | 1               |
| 2               | SN5404N           | Integrated Circuit   | 1               |
| 3               | SN5405N           | Integrated Circuit   | 1               |
| 4               | SN5410N           | Integrated Circuit   | 1               |
| 5               | SN5420N           | Integrated Circuit   | 1               |
| 6               | SN5430N           | Integrated Circuit   | 1               |
| 7               | SN5454N           | Integrated Circuit   | 1               |
| 8               | SN5474N           | Integrated Circuit   | 1               |
| 9               | SN5486N           | Integrated Circuit   | 1               |
| 10              | SN54L86N          | Integrated Circuit   | 1               |
| 11              | SN5495N           | Integrated Circuit   | 1               |
| 12              | SN54121N          | Integrated Circuit   | 1               |
| 13              | SN54L164N         | Integrated Circuit   | 1               |
| 14              | SSL-22L           | Light Emitting Diode | 1               |
| 15              | CLP-25            | Led Clip             | 1               |
| 16              | 41B004-<br>FD15G1 | Battery              | 1               |
| 17              |                   |                      |                 |
| 18              |                   |                      |                 |
| 19              | 312-001           | Fuse                 | 1               |
| 20              | 1N5059            | Diode                | 1               |

VI. FIELD MANUALS AND DEPOT MANUALS

General Electric produced and delivered a two-volume set of Installation, Operation and Maintenance Manuals for the Data Collection Platform and the Field Test Set. A total of 225 copies of Field Manual, Volume I, and 45 copies of Depot Manual, Volume II, were required.

The manuals provide clear and complete instructions for the DCP's and FTS's once implemented. Volume I is intended for field use and contains a summary theory of operation for the system as well as the details of DCP and FTS operations.

Volume II is for Depot use where tools and standard electronics test equipment are available for troubleshooting and repair. It includes schematics, parts lists, procedures and reference drawings.

The Depot Manual provided the schedule pace since the detailing of the technical data into a satisfactory form for user application in troubleshooting with minimum test equipment was a rigorous task.

The Field Manual Volume I was completed and 41 copies transmitted to experimenters per E. Painter's Letter 14752, dated 4 April 1972, for advanced data on detail design of sensor interface packages.

Due to the transmitter design change the Depot Manual Volume II was slipped in order to incorporate necessary changes and detail maintenance of the DCP.

The Depot Manual, Volume II, was completed June 12, 1972. The delay in this delivery was caused by the incorporation of the modifications to the DCP and the resultant test changes as well as the Field Test Set modification. This revised date is in accord with NASA Letter #16355 dated 5/2/72.

VII. Advisory Services

GE provided advice to DCS Users by mail, TWX, and telephone on the subjects of DCS theory of operation, detailed technical discussions of DCP design and operations, installation and interfacing, environmental factors and protection, failure analysis and troubleshooting and other areas of advisory assistance to promote successful use of the ERTS DCS.

GE helped the users identify and develop sources for devices, material, and techniques of value as required in the utilization of their DCP's.

The advisory services continue at present since many DCP's have yet to be activated in the system and support is assured until September 1973.



VIII. On Site Assistance and Applications Development

GE provided aid to Users in the implementation and use of the DCP at the field sites. On-site assistance was provided to field sites in the U.S.

A summary of the on-site support through October 1972 is as follows:

1) U.S. Corps of Engineers - Waltham, Massachusetts

The U.S.C.E. had implemented a software number generator to simulate a random serial input to the DCPs in order to pre-evaluate its reliability.

The implementation consisted of a mini-computer initialized by the DCP enable signal and the output data transferred to an output register before the subsequent clock transition.

The problem existed since the set of instructions were given in a high level language rather than machine, thus requiring too much time for its execution.

Help was given to the user in shortening the computer execution time, by modifying the program, to a time compatible with the DCP internal clock.

The system thus modified was then checked in site and through the data recovered by NASA/GSFC, proving to be satisfactory.

2) U.S. Geological Survey - Menlo Park, California

The problem that existed at this location appeared to the users as DCP failures, however, it was due to inadequate DCP batteries and some DCP-FTS interface mismatch.

In detail: the batteries used in supplying power to the DCPs were too small, acting as an equivalent lame capacitor being charged through a relative high resistance by a battery; this caused the DCP's to transmit the preamble and address adequately, but degraded the message towards the last words, since this equivalent capacitor was being discharged by the heavy current drain of the transmitter.

When these DCPs, so connected, were checked out by means of the FTS, this latter device became voltage sensitive checking correctly or not the DCPs depending on its internal battery ability to fortuitously track a given discharge curve.

The problem was identified and all DCPs checked out correctly using the adequate power source.

In the troubleshooting process one of the FTS failed and had to be repaired.

3) Washington, Navy Yard

This user intends to employ the DCPs in a very unique fashion on board of a buoy, therefore, a number of recommendations were given related to the proper environmental measures to be taken.

Also a misunderstanding of the FTS checkout procedure was explained. The FTS presented a malfunction that had to be corrected.

IX. DCP System Evaluation

During the first 90 days of ERTS-1 operation, the DCS system was evaluated for performance. A full report was written and submitted 2 January 1973. The report was entitled Data Collection System Performance Evaluation for the Earth Resources Technology Satellite (ERTS-1).

Major system parameters considered include:

- Range: System Threshold
- Reception Probability
- Error rates/DCP Messages
- Grazing Angle Effects
- Adjacent Transmission System

A complete discussion on resulting evaluation is presented in Section 5 of the subject report.