FINAL REPORT

FOR

IMAGE DISSECTOR CAMERA SUBSYSTEM, ASSOCIATED GROUND SUPPORT EQUIPMENT, AND INTEGRATION SUPPORT FOR APPLICATIONS TECHNOLOGY SATELLITE

Contract NAS 5-10200

May 17, 1965 to November 17, 1968

Prepared by

ITT Aerospace/Optical Division
Electro-Optical Operations
Fort Wayne, Indiana

Formerly

ITT Industrial Laboratories
Fort Wayne, Indiana

For

NASA Goddard Space Flight Center
Greenbelt, Maryland

ITTIL 68-043 December 3, 1968

FINAL REPORT

FOR

IMAGE DISSECTOR CAMERA SUBSYSTEM,

ASSOCIATED GROUND SUPPORT EQUIPMENT,

AND

INTEGRATION SUPPORT FOR APPLICATIONS

TECHNOLOGY SATELLITE

Contract NAS 5-10200

May 17, 1966 to November 17, 1968

Prepared by

ITT Aerospace/Optical Division
Electro-Optical Operations
Fort Wayne, Indiana

Formerly

ITT Industrial Laboratories
Fort Wayne, Indiana

For

NASA Goddard Space Flight Center
Greenbelt, Maryland

E. W. Koenig, Manager
Applied Electronics
Department

E. L. Byer
Director of Engineering

R. J. Gans, Vice President
and General Manager

ABSTRACT

This report presents a chronological review of activities conducted by ITT Industrial Laboratories in the fabrication and testing of a flight model image dissector camera for the Applications Technology Satellite; the design, fabrication, test, and installation of two sets of ground station equipment; and the field service support of these equipments through integration, pre-launch, launch, and post-launch activities.

TABLE OF CONTENTS

1.0 INTRODUCTION

Contract NAS5-10200 provided for the fabrication of a flight model copy of the Image Dissector Camera (IDC) for ATS developed by ITT Industrial Laboratories (ITTIL) under contract NAS5-9671. It further required the design and fabrication of two ground support equipments as well as service support for the system throughout the integration, launch, and post-launch phases.

Under this contract the flight model camera was delivered to Hughes Aircraft Company for integration and test and was subsequently launched from Cape Kennedy and inserted into orbit. Two sets of GSE were developed and delivered and were used successfully to process pictures from the satellite. Field service support was provided throughout the integration, pre-launch, launch, and post-launch periods. The IDC has been operational for 1 year and is still providing high quality pictures from space. This report traces the activities, from May 17, 1966 to November 1968.

This report is not intended as a complete technical record of the image dissector camera and the GSE. Those details are recorded in the operation and maintenance manuals for those units.

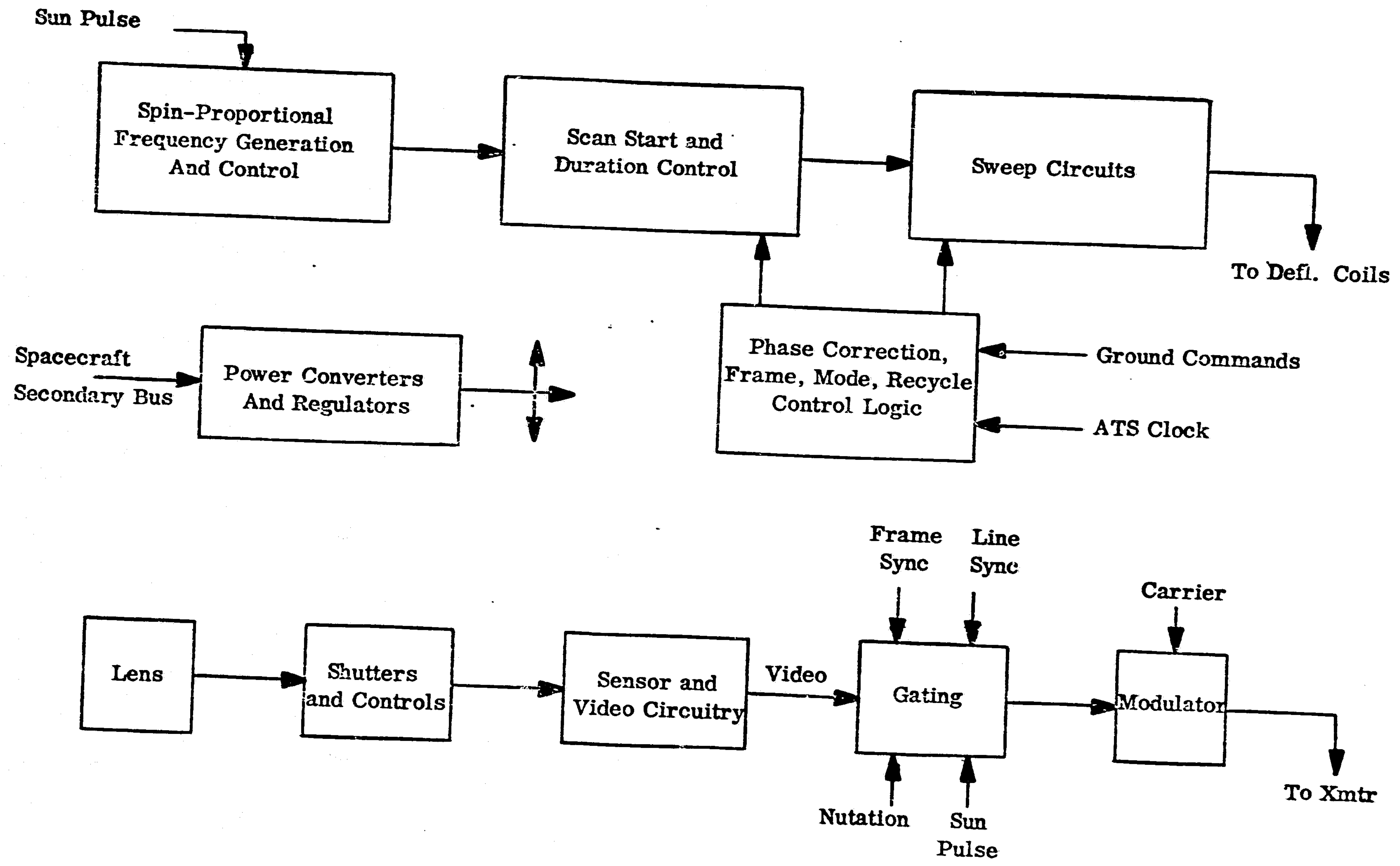
2.0 BACKGROUND AND INITIAL STUDY

Under Contract NAS5-9671, the ITT Industrial Laboratories (ITTIL) had developed an Image Dissector Camera System (IDCS) for operation aboard ATS-C, a spin stabilized, synchronous altitude spacecraft in the Applications Technology Satellite series. Built under the technical direction of the Systems Branch of NASA's Goddard Space Flight Center, this experiment will collect high resolution images of Earth's cloud cover during daylight hours for realtime transmission to ground recording terminals. The system utilizes a built-in sun sensor and a voltage-controlled crystal oscillator to generate precise spin-proportional timing pulses which permit a primary operating mode employing north-south scanning. The camera delivers a composite output signal containing frame sync, line sync, sun pulse, and nutation data in addition to the scene video information. These signals permit the use of a much simplified ground station and also allow the removal of nutational distortions from longitudinally scanned images by simple ground station processing.

Prior to the award of contract NAS5-9671 ITTIL performed a study (Contract NAS5-3770, Amendment 5) to determine the feasibility of developing a continuous scanning camera for use on a spin-stabilized satellite. This study evaluated the performance characteristics of the ITT Vidissector sensor tube under the operating conditions encountered at synchronous altitude and considered possible limitations which this sensor might impose on the orbital characteristics of a spacecraft. It also considered image distortions which could result from satellite motions and misalignments and from the spherical earth as viewed from synchronous altitude. The findings of this previous study indicated the feasibility of development of the camera system described herein.

The initial 2-month study effort under this contract resulted in the Phase I Study Report (PISR) of December 10, 1965 which presented a general description of system electronics, sensor analyses, optical design and selection criteria, and the intended construction and packaging techniques. The system block diagram of Figure 2-1 was developed and, except for the subsequent addition of the sun sensor as an integral system component, has remained unchanged and in use throughout the program as an overall representation of system functions and interrelationships.

The most demanding and significant effort during the study was the conceptual design of a frequency generation unit which would provide the system with a suitable spin-proportional timing reference. System specifications dictated a highly stable and accurate clock source while the wide tolerance (100 ± 40 rpm) on satellite spin rate necessitated a frequency deviation of nearly 3 to 1. Jitter in the sun sensor signal, providing spin rate data, which equalled many camera resolution elements further complicated the timing problem. Consideration of these factors led to the development of a frequency synchronization unit employing closed loop control of a voltage controlled crystal oscillator (VCXO). An adaptive sampled-data feedback system with deadband was devised and implemented with high speed integrated circuit logic elements and a digital-to-analog converter to exert precise control of the VCXO. The discussion of the theory and implementation of this system as well as the related diagrams in paragraph 4.2 of the PISR remains valid for the finalized configuration.



Sun Pulse
Spin-Proportional Frequency Generation And Control
Scan Start and Duration Control
Sweep Circuits
To Defl. Coils
Spacecraft Secondary Bus
Power Converters And Regulators
Phase Correction, Frame, Mode, Recycle Control Logic
Ground Commands
ATS Clock
Lens
Shutters and Controls
Sensor and Video Circuitry
Video
Frame Sync
Line Sync
Gating
Nutation
Sun Pulse
Carrier
Modulator
To Xmtr

Figure 2-1

The scan modes and their formats, area coverage, and lens characteristics remain essentially as described in the PISR, although a special lens with a focal length of 49 mm was procured to ensure full field coverage for the cathode of the 1 inch Vidissector. The 1 inch tube was selected with an S-11 photocathode and 0.0007 inch aperture.

While the operations and signal interactions needed for system timing and control are properly described in the PISR, several changes in logic design and signal derivation were made in this portion of the system. The M+1 counter is phased for the correct look angle only at the beginning of each frame by parallel loading from the TOD counter. Extra pulses are then inserted at a 2.64 second rate to update the M+1 counter throughout each frame. The scan period for latitudinal mode is determined by a sense gate on the M+1 counter rather than by a delay circuit as initially planned. The line sync pattern is changed to 16 alternate 1-0 element intervals followed by a 32 element fixed delay before video. Otherwise, the line timing, frame timing, and output data format diagrams are proper.

3.0 FIRST QUARTER ACTIVITIES (5-17-66 to 8-17-66)

3.1 Image Dissector Camera

Awaiting test of the camera prototype, camera activities for this period were limited to parts procurement.

3.2 Integration and Support Services

No field service has been required up to this time; however, integration requirements and procedures have been studied and training of service personnel in theory and operation of the IDC has been performed.

3.3 Ground Support Equipment

Design studies have been initiated to define the interface requirements of the GSE which will constitute the ground recording terminal for the ATS-IDC when coupled between government-furnished receiver and photofacsimile units. The GSE will input the composite video waveform from the spaceborne IDC as an AM subcarrier output from the GFE receiver. Through appropriate detection and manipulation of this data, the GSE will derive sync, clock, and video signals for exercising the photo-recorder to reproduce the sensed image. Most of the design concepts for GSE operations and circuits will be drawn directly from the BCU. The primary new design effort relates to the nutation correction capability required in the GSE, although compatible interfaces with the photo-recorder must also be developed.

4.0 SECOND QUARTER ACTIVITIES (8-17-66 to 11-17-66)

4.1 Image Dissector Camera

The flight model IDC will be an exact duplicate of the prototype unit which is currently in the final fabrication processes. Modifications and improvements resulting from EM testing are being incorporated into it and some preliminary module testing is underway. The aluminum housing for the flight unit has been fabricated and is awaiting final painting. Some of the logic cards have also been fabricated and assembled, although testing will not begin until all prototype cards have been checked out.

4.2 Integration and Support Services

Field service activities are still limited to in-house study and familiarization of the system by the support personnel.

4.3 Ground Support Equipment

During the second quarter, the GSE block diagram was completed, as shown in the Second Quarterly Report, as well as many of the clock extraction, sync recognition, demodulation, and video amplification circuits. A large effort was expended on the nutation correction circuitry.

First efforts were directed toward synthesizing a circuit having the inverse of the nutation sensor characteristic. This approach, resulted in an elaborate network which was judged to be impractical. Efforts were then applied to synthesis of a circuit to duplicate the sensor and amplifier characteristic. This circuit is to be applied in the configuration shown in Figure 3-3 of the Second Quarterly Report. The level shifter, comparator, and logarithmic converter circuits were developed during this quarter as well as some of the logic circuits.

5.0 THIRD QUARTER ACTIVITIES (11-17-66 to 2-17-67)

5.1 Image Dissector Camera

During this quarter most flight model circuit boards have been completed. Relay problems have caused some delay.

Circuit cards have been tested individually and in functional groups. Testing is about 50 percent compl .

Cabling within the flight model housing is also 50 percent complete.

5.2 Integration and Support Services

Two ITTIL representatives established residence in El Segundo, California, to provide full time support of the IDC system at the facility of the spacecraft contractor, Hughes Aircraft Company. Initial activities there have included the receipt and setup of the engineering model camera and a bench checkout unit (from contract NAS5-9671) at HAC to check system interface compatibility and to undertake preliminary system testing on the EPC, an experimenters console equivalent to a rack-mounted spacecraft.

5.3 Ground Support Equipment

Assembly of GSE unit No. 1 was completed and checkout was started.

The nutation correction circuits were completed and more detailed calibrations were performed. The sample-and-hold circuit was completed and the block diagram is shown in the Third Quarterly Report.

Processing data through the GSE to the EIS photofax was accomplished after clock pulse transitions were improved in the GSE drivers.

6.0 FOURTH QUARTER ACTIVITIES (2-17-67 to 5-17-67)

6.1 Image Dissector Camera

During this report period, all modules and subassemblies of the flight model camera, with the exception of the tube and coil assembly, have received final fabrication, assembly, and functional test. In addition, all available units have been installed in the completed camera housing and have undergone a system level checkout and thermal test cycle with dummy loads simulating the tube and coils. During preliminary checkout, intermittent response to frame start commands was noted with the problem eventually traced to a faulty relay. Replacement of this relay rectified the problem and no further difficulties were experienced. The defective unit was returned to the manufacturer for analysis.

A variety of processing and performance difficulties have continued to plague the tube fabrication effort. After several weeks of cathode processing difficulties, a few tubes which appeared very promising after initial burn-in were rejected when loose particles were discovered following their vibration tests. A re-examination of vibration test procedures, levels, and equipments was then conducted by ITTIL which resulted in the fabrication of a new shake fixture, the discontinuation of tube vibration testing at ITTIL, and the modification of test levels to flight level, random vibration only. Having ascertained that the particles loosened during vibration of these later tubes were flakes of antimony, tube engineers revised the evaporator ring holding the antimony processing beads so as to increase its separation from both aperture plate and drift tube. Tubes processed with this modification are currently undergoing burn-in and vibration testing so that an acceptable tube for the flight camera should be selectable in the very near future.

6.2 Integration and Support Services

Support activities have continued throughout this period primarily through the efforts of the two ITTIL technical personnel in resident service at Hughes Aircraft Company. Their attention to assuring proper system interfacing and testing of compatible operation was shifted from the engineering model to the prototype model camera following its arrival at HAC in early April. One minor problem with the prototype unit was found in that the alignment mirror affixed to the camera was not of sufficient flatness and did not have distinct enough crosshairs to allow accurate positioning with an autocollimator. A new mirror is being fabricated.

Other effort has been applied to the reorganization and clean up of test procedures, definition of allowable variations in telemetry data, and other documentation and procedural areas.

6.3 Ground Support Equipment

During this period, the first GSE unit has been carried through final assembly, alignment, and checkout and is currently receiving full-scale performance test for NASA approval. The construction of the second GSE has also been completed but its checkout remains to be completed before acceptance testing can be accomplished.

Late additions or revisions to the circuit complement of the GSE units include a low pass input filter for reducing high frequency receiver and transmission link noise. The IDCS requires a maximum data bandwidth of approximately 125 khz while data transmission is accomplished over a 5 mhz bandwidth link. The input filter consists of a single stage amplifier followed by a two stage active R-C filter. This filter has a high frequency roll-off rate of 24 db per octave with its upper 3 db point at 150 khz.

Also finalized during this period was the nutation correction portion of the GSE. Several modifications were made to these circuits which required printed circuit card rework. The circuits as finally configured are contained on three printed circuit cards which are described in detail in the Fourth Quarterly Report. The first of these has the D/A converter for nutation correction which contains a five stage up-down counter, a five-stage buffer register, and a five-bit digital-to-analog conversion network. This unit determines a number (final counter contents) which corresponds to the magnitude and polarity of nutation present on each line of camera data. This number is derived by comparing a nutation voltage sample (demodulated video level just prior to line sync) to the D/A converter output voltage. Starting from an all-zero condition in the up-down counter, clock pulses are allowed to up step the counter until comparison of the two voltages is sensed, at which time no further clock pulse inputs to the counter are allowed. The number of counts accumulated by the counter is then the number of clock pulses needed to delay the start of video after line sync to compensate for the nutation effect.

The analog portion of the nutation correction circuitry is on the second card and consists of the sample and hold circuit, operational amplifiers which function primarily as level shifters, and an amplifier having a logarithmic transfer characteristic which closely approximates that of the nutation sensor amplifier on board the satellite. This amplifier transforms the linear output voltage of the D/A converter into the log scale necessary to perform the desired comparison. Since the accelerometer and amplifier in the actual nutation sensor are frequency sensitive and since nutation frequency is a function of satellite spin rate, control is provided for spin rate changes, hence compensating for nutation frequency changes.

The third card assembly in the nutation correction circuitry is the nutation correction control. This unit provides the necessary timing pulses and logical control levels for properly sequencing the functions involved in the correction process.

Whenever the camera is scanning in the latitudinal mode, the nutation correction data received will not be used.

Considerable testing of the GSE was performed in conjunction with a Mincom tape recorder to determine the camera signal recording technique which resulted in the better signal-to-noise ratio during data playback. The camera output was applied simultaneously to the BCU, the GSE, and to a Mincom track (x) through an AM record amplifier having a 300 khz bandwidth at 60 ips. The output of the GSE was applied both to the Fax and to a Mincom track (y) through an FM record amplifier having a measured 27 khz bandwidth at 60 ips. Thus at the end of a given camera frame, a BCU-produced photo and a Fax photo were available for comparison.

On tape playback the AM signal from track (x) was applied to the GSE which extracted clock and sync for Fax timing and also produced demodulated video. The Fax photo could be produced, however, with the video information derived from either the GSE or from the FM track (y). Results of these tests showed that:

1. With a properly aligned and degaussed recorder, the AM record-playback data was nearly as good as the original.

2. If the recorder was noisy or not properly aligned and clean, the FM record-playback procedure gave a somewhat better signal-to-noise ratio with fewer apparent tape dropouts.

The disadvantages of the second technique are that two tracks are needed, one AM channel for timing signals and one FM channel for video. Also, when using a 1328 line resolution signal into the FM channel, the playback signal started to degrade at 55 khz carrier frequency. There was also some phase shifting between the peak amplitude resolution signal and the Fax clock from the AM channel and GSE which caused degraded resolution in the photograph produced.

7.0 FIFTH QUARTER ACTIVITIES (5-17-67 to 8-17-67)

7.1 Image Dissector Camera

Full system testing of the flight camera was begun in early June immediately following the preparation and installation of the Vidissector tube into the system. By mid-July, this camera had successfully passed all qualification tests and was delivered to the spacecraft contractor.

The qualification test cycle involved two environments: thermal-vacuum and vibration. Additionally, extensive testing was performed to verify proper camera operation in the continuous spinning mode and to check the aging characteristic of the tube. Several "second generation" problems encountered during the early portions of flight model test were isolated and corrected. One failure occurred as a result of environmental stresses. The camera tube developed an effective short between two dynodes when subjected to a vibration test and had to be replaced.

7.1.1 Camera Resolution

Initial flight system testing revealed that camera resolution was not as good as had been expected from the bench testing of the tube. The tube was then removed from the camera and after further investigation, the reason for this discrepancy became apparent. The ability of the tube to resolve detail in a scene was found to depend on the direction of scan referenced to the scene, that is, a definite astigmatic-effect was present. Rather than continue working with this particular tube, a new tube was selected, bench tested and installed in the camera.

Results of resolution tests showed considerably improved camera performance over either the engineering or prototype models of the IDC. Where previous camera response to nominal 700 line optical input had not exceeded about 40 percent modulation, the flight model camera achieved 75 percent modulation under these conditions. Part of this improvement can be credited to an improved tube. However, a significant factor in obtaining better resolution was the operation of the lens system at a slightly higher f number than previously. Whereas both early models of the IDC had operated at iris settings of f/2, flight model tests showed that a more optimum setting for maximum resolution without signal-to-noise degradation was about f/2.5; hence, the lens was stopped down accordingly.

7.1.2 Operational Spin Test

A formal operational test in the acceleration environment was not officially required for qualification of the flight model camera; however, to provide additional confidence in the proper function of critical camera components and parameters by operating the flight IDC under conditions that would simulate the spinning spacecraft environment the camera was taken to GSFC where it was mounted on a centrifuge equipped with slip rings. Pertinent outputs and test points of the camera were monitored while the unit was spun at rates simulating spacecraft spin rates.

All commands were exercised and proper camera response to these commands was monitored. No camera malfunctions or parameter degradation of any type were experienced during this test.

7.1.3 Vibration Test

One of the environmental qualification tests conducted on the flight model camera was the three-axis sine and random vibration test. The camera was taken to GSFC in mid-June where it was subjected to these tests at specified flight levels. Following a shake test in the X-axis (transverse to tube axis) the camera video output was seen to be considerably reduced. Additional testing upon return to the ITTIL facility verified that the video amplitude was less than 50 percent of its pre-vibration level and that this reduction was due to an internal tube short which had occurred between the eleventh and twelfth dynodes. Complete examination of the tube revealed that an internal tube bleeder resistor between these two dynodes had failed.

This failure, of course, necessitated the replacement of this tube with one which had just completed component life test, and after the necessary bench testing to define external shading resistor values, this tube was potted and installed in the camera.

In mid-July, following completion of the thermal-vacuum test, the flight camera was returned to GSFC for a final flight level vibration test. No failures were experienced as a result of this test.

7.1.4 Thermal-Vacuum Test

Preliminary testing of the flight model camera in the thermal-vacuum environment was conducted just prior to the vibration test run in mid-June. This test sequence, which spanned approximately 30 hours, resulted in none of the problems with optical focus which had been experienced by the prototype camera. A significant decrease in video amplitude was seen, but this was later determined to be not a camera fault, but rather due to deposition of a film of oil on the collimator lens. No other malfunctions were experienced.

Following replacement of the tube which failed in vibration test, a full thermal-vacuum test covering a period of 200 hours was conducted early in July. During this test, the high brightness shutter was incorporated in the vacuum chamber test set-up to allow operation of the camera at up to full 10,000 foot-lambert brightness levels. Except for a recurrence of condensation on the collimator lens and a malfunction in the artificial sun simulator, no difficulties of any type were experienced during thermal-vacuum testing. Camera performance was monitored by a series of three test sequences conducted at approximately 3 hour intervals throughout each 12 hour operating period. For the remainder of each period, the camera was run at 4000 foot-lambert brightness input for the purpose of further aging the tube to stabilize cathode response.

7.1.5 Tube Aging and Photometric Calibration

An important portion of flight model system testing involved operating the tube for long periods of time under shuttered input light conditions for the purpose of checking its aging characteristic. To implement this so-called "burn-in" or aging test, the camera was operated, in addition to its normal test periods, for approximately 120 hours at 4000 foot-lambert 4 percent duty cycle shuttered input. These tests were conducted both inside and outside the vacuum chamber, with a continuous series of photographs being made of camera output video levels at regular intervals. Some difficulty was experienced with the test collimator light source over the relatively long operating periods involved. Especially while operating in the vacuum chamber, problems with a slowly decreasing light output from the collimator gave an erroneous indication of the stability of the tube. When the collimator was cleaned and recalibrated and comparisons were made with original tube output levels, very good stability was being obtained with the tube. The entire aging cycle of 120 hours plus all normal test time, amounting to perhaps 50 hours of tube loading, resulted in a decrease of only about 10 percent in tube sensitivity. Indications also were that in the later stages of the aging period, the sensitivity curve was leveling off as expected.

Shortly after the final in-plant acceptance test on the flight model camera and just before its shipment to the ATS spacecraft contractor, a final photometric calibration of the camera was made.

Use was made of a NASA supplied light source which had been developed for use with AVCS cameras. This source simulated accurately the color temperature of the earth scene. The final video gain setting was made so that a small amount of clipping would occur at the 10,000 foot-lambert brightness level. Final gray scale data was taken using the AVCS light source.

7.1.6 Flight Model Performance Characteristics

NASA accepted the flight model IDCS for integration into the spacecraft on July 18, 1967. The following table summarizes the performance of this camera:

Center Resolution	20% modulation at 1000 lines (2000 TV lines/inch)
	70% modulation at 700 lines (1400 TV lines/inch)
Dynamic Range	100:1 (thirteen $\sqrt{2}$ steps)
Signal-to-Noise Ratio	35 db at 10,000 ft-L highlight brightness
Shading	± 20%
Power Consumption	18.0 watts

7.2 Integration and Support Services

Integration test activity has increased at the spacecraft contractor facility during this quarter. Both the prototype model IDC and the flight model have undergone shakedown testing to verify their performance and compatibility with the ATS-C spacecraft. Both cameras have been mated with the spacecraft -- the prototype early in the period and the flight model later when it became available after completion of its qualification and acceptance tests at ITTIL.

Shortly after it was received at the spacecraft contractor facility, the flight model IDCS was tested on the bench check unit and with the Experimental Package Console (EPC). At the conclusion of these tests, the prototype camera was removed from the spacecraft and the flight model installed in its place. Performance tests were made with the flight model camera to verify its correct operation aboard the spacecraft.

Environmental testing of the entire spacecraft began early in August. Individual experiments were tested before and after exposure to sine and random vibration levels in two axes. No operational problems were encountered with the IDC after this test series. By mid August, spacecraft thermal-vacuum testing began and is presently in progress.

7.3 Ground Support Equipment

Formal acceptance of GSE No. 1 was made by NASA following the completion of its acceptance testing on May 23, 1967. The unit was then shipped to HAC on May 31, 1967 to be mounted in a mobile test van with an EIS photofax recorder. The second GSE system also received its final checkout and testing, was accepted by NASA on June 29, 1967, and shipped to GSFC on July 5, 1957. An ITTIL engineer went to both GSFC and HAC to assist in the field set up of these units and to check out their interfacing and operation with the EIS units.

Before the shipment of the second unit, tests were conducted to determine the effectiveness of the GSE input noise filter. This filter had been slightly modified from the circuit shown in the previous quarterly report in that the input coupling capacitor had been decreased in value to 0. 05 microfarad. This change had the effect of raising the lower 3 db point on the response curve to about 600 hz, thereby affording greater rejection to 60 hz and its low harmonics. In tests, a General Radio 1340A noise generator with a spectrum of 30 hz to 5 mhz was connected to add noise to a 1 volt peak to peak maximum modulated GSE test signal. The GSE line sync recognition circuit was adjusted to properly sense line sync bursts whenever the demodulated signal level fell in the range from 1. 1 volts peak (for maximum white level) to 0. 8 volt peak. Line sync was not detected for demodulated signal levels below this value. With this set-up, the input noise amplitude was increased until the line sync recognition threshold was reached, this threshold being arbitrarily defined as being the condition when one sync burst in ten was not detected. The noise generator indicated 300 millivolts RMS amplitude when this recognition threshold was encountered.

Initial design has also begun on the development of the AGC circuit to be retrofitted into the GSE units. This circuit is primarily intended for use during tape playback operation to reduce the effects of any line to line amplitude variations which might result as the recorder becomes somewhat noisy or misaligned.

8.0 SIXTH QUARTER ACTIVITIES (8-17-67 to 11-17-67)

8.1 Image Dissector Camera

Integration testing of the flight model IDC with the ATS-C spacecraft was conducted throughout nearly the entire quarter both at Hughes Aircraft and at Kennedy Space Center. Final environmental tests were conducted on the complete spacecraft system at HAC during September. While undergoing the thermal-vacuum portion of this test cycle, the IDC developed a failure after experiencing several days of intermittent difficulty. The unit was returned to ITTIL where the problem was immediately traced to a defective -8 volt regulator flatpack. Replacement of this component restored normal IDC operation. Following temperature cycling and vibration testing of the repaired card assembly and 52 hours of thermal-vacuum testing of the IDC system, the unit was returned to HAC where it successfully negotiated the balance of spacecraft system testing. Only one further apparent difficulty was noted, that being the occasional establishment of an anomalous operating mode with only sun pulse and minimum level carrier output. This condition was determined to be the response when two consecutive start commands were applied and was the proper and normal result of a non-normal command sequence.

8.2 Integration and Support Services

Approximately 1 month prior to launch of ATS-C, the spacecraft with all experiments and associated ground support equipment was transported from the spacecraft contractor's facility to the launch site. During the period before launch, ITTIL technical personnel remained at the Cape Kennedy test site and conducted the required pre-launch testing on the IDC. In addition, ITTIL engineering personnel were present shortly before launch at both GSFC and at Rosman Data Acquisition Facility to make preparations for initial data reception and processing.

On November 5, 1967 the spacecraft was launched from Cape Kennedy and the desired synchronous equatorial orbit at approximately 50 degrees longitude was achieved. The IDC was turned on for the first time on November 7, 1967 and returned a sequence of six high quality pictures of the earth scene. An improper look angle initially established for this sequence was corrected and later found to be the result of an error in the tabulation of look angle corrections versus GMT in the IDC handbook.

Camera performance has continued normal during the balance of this report period with no operational problems encountered. Engineering support presently continues at GSFC where the ground station is operating on a daily basis receiving and processing IDC data.

8.3 Ground Support Equipment

Several design changes were incorporated in the ground support equipment (GSE) during this quarter. These modifications were wired and field-tested in the GSE at GSFC. Also during this period, the wide band transmission link between the Roman Data Acquisition Facility and GSFC was tested utilizing the Engineering Model IDC as the signal source at Rosman with the ground station receiving the data at GSFC.

The test of the transmission link was conducted to assure that no signal degradation would occur between the receiver and the ground station readout. The signal was received at the video input to the GSE and pictures generated on the photorecorder. The only degradation noted was a slight distortion in the amplitude-modulated line sync waveform. However, proper sync recognition was maintained by the GSE and no detrimental effects were apparent in reproduced pictures at the photorecorder.

One of the design changes involved the GSE bandpass noise filter lower cut-off frequency. This frequency was raised from 500 hz to approximately 3000 hz to reduce the possibility of low frequency noise affecting the reproduced picture. The 3000 hz cut-off point is still adequately below the minimum lower bandwidth frequency for no loss of video information at the GSE.

An AGC circuit was designed during this quarter which maintains a constant amplitude GSE output signal on a line-to-line basis even though the input might vary. The AGC circuit is an amplifier, the gain of which is varied by a control voltage derived from peak detecting the demodulated line sync pulses. AGC gain is set at the end of the line sync interval and remains constant until the next line sync pulses are detected. Thus the gain is adjusted at the start of each video line based on a constant reference signal, correcting for any slow undesired input signal amplitude changes over one or more lines. The AGC circuit may be switched on or off by a front panel control switch.

To facilitate the evaluation of reproduced pictures received from the IDC, it was desired to insert a timing reference signal in the normal video for print-out on the photorecorder. The actual sun pulse present in the IDC composite output is an ideal timing reference, but it occurs outside the active video portion of each line interval. Thus it is necessary either to delay the received sun pulse or to derive an artificial marker at the appropriate time. The latter method was implemented since means for generating such a signal were available.

The digital voltmeter-counter instrument contained in the GSE had previously been wired at an external programming connector for counting the number of clock pulses between alternate sun pulses. When so operating, this instrument's decade counter outputs maintain particular phase relationship with the received sun pulse.

It is therefore possible to select a decade output which will definitely occur during the active video period of 1328 clock times. Since all counter outputs are accessible at the programming connector, only interfacing circuitry is needed to adapt this source of timing marker data to the video channel. The 900 count output was chosen to drive a pulse generator circuit whose output is then mixed with the demodulated scene video. The result is a fine white marker on alternate lines of the image which shows the timing relationship of sun pulse and line sync throughout the framing period.

Both before and after the successful launch of the ATS-C satellite, ITTIL personnel were present at GSFC to control the operation of the GSE in reproducing the pictures from the IDC experiment. All aspects of GSE operation were normal, including the generation of "sunline" pictures as described above.

9.0 SEVENTH QUARTER ACTIVITIES (11-17-67 to 2-17-68)

9.1 Picture Analysis

The pictures as received from the IDC and printed out by the ground station show definite skew as the frame progresses. This skew varies from picture to picture and also varies during the picture. Variation in the clock frequency of the IDC appear to be the cause of this picture skew. Since the alignment of the horizontal lines is dependent upon the timing of the line sync pulses and the timing of line sync is dependent upon clock frequency, any variation in clock frequency will result in a slight misalignment of the scan lines. This in turn produces a skewed picture.

9.2 Ground Station Equipment

Some modifications were made to the ground station equipment during this quarter to facilitate ease of operation and to allow the pictures to be printed out without the skew apparent in the earlier pictures. Also the length of the line gate was increased to allow observation of the east and west horizon of the earth.

To remove the skew in the pictures, the camera is operated in the latitudinal mode and the ground station equipment is operated so that each scan line is referenced to the sun pulse.

The ground station video controls were modified to enable the operator to adjust the video to the internal GSE circuits and to the photorecorder independently of each other. This allows the operator to change the appearance of the picture without upsetting the sync circuits.

In an effort to further improve the usefulness of the pictures, the length of the video line gate was increased from 1328 to 1728 elements. The result is that the east and west horizons of the earth appear in the photograph.

9.3 Operations Support

Personnel from ITT were involved in the ATS ground station operations during this period and their primary effort was in training the Nimbus ground station personnel at GSFC to operate and maintain the ATS ground station equipment. Included in this training was the basic theory of operation of the Image Dissector Camera.

Phasing of the responsibility for operation of the ground station from ITT personnel to GSFC personnel was accomplished during the period.

10.0 EIGHTH QUARTER ACTIVITIES (2-17-68 to 5-17-68)

Activity during the period included the construction of a permanent modification kit to replace the temporary modifications made to the ground station at GSFC last quarter. The circuitry necessary for the "sun sync" mode of operation was placed on printed circuit boards and these boards were installed at GSFC. Other temporary modifications to the sun pulse detector and to the video level adjustment controls were cleaned up and put in their finalized form.

In addition to the activity at GSFC, the ground station at the Goldstone Tracking Station in the Mojave Desert was also modified. The permanent modification kit was installed and an operational check of the system was performed using live video from the Image Dissector camera. Also a formal training session was held to acquaint the STADAN personnel with the theory of operation and maintenance aspects of the IDC ground station.

11.0 NINTH QUARTER ACTIVITIES (5-17-68 to 8-17-68)

During this period, ITT personnel traveled to GSFC for periodic maintenance of the Image Dissector camera ground station. The operational circuits were checked and some minor adjustments made to the equipment. A check of the ground station during reception of live video from the IDC proved the equipment to be in satisfactory operating condition.

12.0 TENTH QUARTER ACTIVITIES (8-17-68 to 11-17-68)

During this quarter, personnel from ITT again traveled to GSFC to perform preventive maintenance on the IDC ground station and to provide backup operator and maintenance support for the IDC system during the flight of Apollo VII. The IDC was used to provide up-to-date information on the status of hurricane Gladys for the weather bureau during this flight.