TOPIC

FRIDAY, MARCH 21, 1969

9. VDP COMPONENT DESCRIPTION (LH AND RH)  
   SMITH  8:30 AM

10. DRIVE K BRASSBOARD TEST STATUS  
    NAVON  9:00 AM

11. DESCRIPTION OF PLANNED TESTS AND TEST METHODS AND PARAMETERS THAT ARE TO BE VERIFIED:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>DSS-1</td>
</tr>
<tr>
<td>---</td>
<td>-------</td>
</tr>
<tr>
<td>SUB A</td>
<td>DISANTO</td>
</tr>
<tr>
<td>VDP</td>
<td>(60 MIN.)</td>
</tr>
<tr>
<td>MDKE</td>
<td>NAVON</td>
</tr>
<tr>
<td>ADKE</td>
<td>NICOLINI</td>
</tr>
<tr>
<td>LHS</td>
<td>NICOLINI</td>
</tr>
<tr>
<td>GYRO</td>
<td>NICOLINI</td>
</tr>
<tr>
<td>LMMC</td>
<td>NICOLINI</td>
</tr>
</tbody>
</table>

(INCLUDE ANY SPECIFIC COMPONENT TEST PROBLEM AND THE CURRENTLY PLANNED SOLUTION OR PLAN TO OBTAIN A SOLUTION)

12. CRITICAL OPEN INTERFACE ITEMS  
    NICOLINI  1:00 PM

----- LUNCH -----

13. ALPHA ALIGNMENT DESCRIPTION AND STATUS  
    KOPANSKI  1:15 PM

14. STATUS OF DYNAMIC MODEL  
    SCHWARTZ  2:00 PM

15. STATUS OF JANUARY TD ACTION ITEMS  
    SCHWARTZ  2:30 PM

16. ALPHA SUBSYSTEM SPECIAL MODES  
    KARP  3:00 PM

17. REPORT ON THERMAL MEETING  
    KARP  3:15 PM
### ALPHA SUBSYSTEM TEM

**THURSDAY, MARCH 20, 1969**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>PRESENTER</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ALPHA S/S MILESTONE SCHEDULES (DC, DSS, 114)</td>
<td>DISANTO</td>
<td>8:30 AM</td>
</tr>
<tr>
<td>2. ALPHA S/S FUNCTIONAL DESCRIPTION ELECTRICAL BLOCK DIAGRAM</td>
<td>MANLEY</td>
<td>9:00 AM</td>
</tr>
<tr>
<td>INCLUDING INTERFACE WITH CONSOLE CONTROLLER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. DRIVE K FUNCTIONAL DESCRIPTION CIRCUIT AND PACKAGING BLOCK</td>
<td>HOOKER/BILLINGS</td>
<td>9:30 AM</td>
</tr>
<tr>
<td>DIAGRAMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PREDICTED S/S AND COMPONENT PERFORMANCE AS RELATED TO CEI</td>
<td>MONTGOMERY/CHEESEMAN/MANLEY</td>
<td>11:00 AM</td>
</tr>
<tr>
<td>REQUIREMENTS (INCLUDE ANY SPECIFIC COMPONENT DEVELOPMENT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROBLEM AND THE PLANNED SOLUTION OR PLAN TO OBTAIN A SOLUTION)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----LUNCH----</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. ALPHA INTERNAL MECHANISMS DESCRIPTION AND DESIGN STATUS</td>
<td>KOPANSKI</td>
<td>2:00 PM</td>
</tr>
<tr>
<td>6. ALPHA EXTERNAL COMPONENT DESCRIPTION AND DESIGN STATUS</td>
<td>GOOSS/STEARNS</td>
<td>3:00 PM</td>
</tr>
<tr>
<td>7. SUN SENSOR DESIGN STATUS</td>
<td>SCHWARTZ</td>
<td>4:15 PM</td>
</tr>
<tr>
<td>8. COMPONENT WEIGHT AND POWER STATUS (INCLUDE SUB A UPDATE)</td>
<td>MANLEY/MAYER</td>
<td>4:30 PM</td>
</tr>
</tbody>
</table>
AGENDA FOR THERMAL MTG.

THURSDAY, MARCH 20, 1969

1. ENVIRONMENTAL CONSTRAINTS
   A. VARIATION OF θ ANGLE
   B. RANGE OF OPERATING VARIABLES
      1. DOOR OPEN TIME
      2. USAGE DENSITY
      3. ENVIRONMENTAL FLUXES
   C. ACTS THRUSTER FIRING - IMPACT ON THERMAL COATINGS
   D. TIME AVAILABLE TO EQUALIZE SYSTEM AFTER LIFT-OFF

2. SYSTEM THERMAL REQUIREMENTS
   A. TEMPERATURE LEVEL
   B. TEMPERATURE GRADIENTS

3. CONCEPTS
   A. HEATERS + PARTIALLY INSULATED DESIGN
      1. POWER PENALTY - EXTERNAL AND INTERNAL
   B. BAS CONCEPT

4. STATUS OF MDAC THERMAL MODEL

5. QUAL. TESTING PROBLEM
   A. SYSTEM DESIGN MARGIN
   B. IMPLICATIONS OF MEETING ORIGINAL REQUIREMENTS OF DR1100
ALPHA SUBSYSTEM

COMPONENT STATUS

3-19-69
LAST 60 DAYS

- Module breadboard testing completed
- 70% module drawings issued: fabrication initiated
- Preliminary weight, thermal, and worst case analysis completed
- Parts for 3 units ordered
- Independent packaging/requirements review held
- 60% of module test requirements issued
- Envelope drawings issued

NEXT 90 DAYS

Major tasks are related to detail design and release to manufacturing for DC-1, DSS-1, and 114 units

- Complete release of module drawings (Mar 21)
- Complete fabrication and testing of modules (Jun 6)
- Release PC boards (Mar 15-Apr 15)
- Release test equipment design (Apr 30)
- Design review (Apr 15)
- Issue block diagrams (Mar 22)

PROBLEMS

- Tight schedule (100% success)
LAST 60 DAYS
- Engineering Spec. Issued
- Breadboard Tests Completed
- Preliminary Packaging, Weight, and Thermal Analysis Completed
- 40% Module Drawings Completed (7 of 18 Cordwood)
- 3 of 18 Module Test Requirements Issued
- Advance Order of Parts for ADKE and Test Equip. Placed

NEXT 90 DAYS
- Major Tasks are related to Detail Design and Release to Manufacturing for DC-1, DSS-1, and 114 Units
- Conceptual/Breadboard Design Review (Mar 25)
- Complete Module Design, Fab., and Test (June 6)
- Complete P.C. Boards Design and Fab. (June 15)
- Complete Design and Begin Fab. of Test Equip. (May 27)

PROBLEMS
- Tight Schedule (100% Success)
LEFT-HAND CONTROL STICK — (LHC)

LAST 60 DAYS

○ 42 DETAIL DRAWINGS ISSUED (GRIP DEFINITION, 2 TRANSITION ARMS, AND TOP ASSEMBLY ARE ONLY OUTSTANDING ITEMS FOR DC-1, DSS-1, AND 114 RELEASE)

○ LONG LEAD ITEMS ORDERED (SWITCHES ORDERED; OUT FOR QUOTES ON HERMETICALLY-SEALED POTS; OUT FOR QUOTES ON GRIP)

○ EMI ANALYSIS COMPLETE

○ INTERFACE AND SCHEMATIC COMPLETE

NEXT 90 DAYS

○ EVALUATE QUOTES FROM THREE GRIP VENDORS (MAR 20—MAR 27)

○ SELECT GRIP VENDOR (MAR 28)

○ COMPLETE DRAWING RELEASE (APR 10)

○ DESIGN REVIEW (APR 11)

○ DESIGN AND FAB. TEST EQUIPMENT (APR. 24—JULY 26)

○ DSS-1 AND 114 RELEASE (JUNE 6)

○ ADDITIONAL SUPPORTING ANALYSES (STRESS, WEIGHT, PACKAGING, RFMA, FMEA) (APR 11)

PROBLEMS

○ DSS-1 AND 114 RELEASE PRIOR TO ENVIRONMENTAL TESTS ON DC UNIT

○ INITIAL RESPONSES OF 26 WEEK LEAD-TIME ON GRIP JEOPARDIZES SCHEDULE FOR ENGINEERING UNITS.
LAB MODULE MODE CONTROLLER (LMMC)

LAST 60 DAYS
- SPEC. DRAFT WRITTEN
- PRELIMINARY ANALYSIS ISSUED (PACKAGING, WEIGHT, POWER)
- SCHEMATIC ISSUED
- LONG LEAD ITEM ORDER PLACED (JAN 15)

NEXT 90 DAYS
- COMPLETE PRELIMINARY ANALYSIS (APR 11)
- DESIGN REVIEW (APR 15)
- COMPLETE DESIGN/ISSUE TOP ASSEMBLY DRAWING (APR 30)
- DESIGN TEST EQUIPMENT
- ISSUE TEST PLANS (ACCEPTANCE, DC) (FOR DSS-1, 114) (APR 22) (APR 29)
- START FAB AND ASSEMBLY
  DC/DSS-1 (MAY 22)
  114 (MAY 24)
VISUAL DISPLAY PROJECTOR (VDP)

VISUAL DISPLAY MODULE (VDM)

BUILT BY LEA SIEGLER INC., PER WS 1307

LAST 60 DAYS

- Top assembly drawings started
- Block diagram issued
- New optical assembly and prescription issued (preliminary)
- Film format changed to aid in fine positioning
- Test film subcontract awarded to Data Corp.
- New 3-filament projector lamp survived 150% of shock and qual. vib. levels; survived 72 hours, 2 atms, helium operation without noticeable degradation; and is presently in life test
- New optical design tests indicate that both resolution and brightness requirements will be met.

G.E.

- Thermal requirements added to spec.
- 30 min. thermal-vacuum requirement added to spec.
- Telemetry requirements added to spec.
- Worked console 2 interference problem
- Update film format in CEI spec.
NEXT 90 DAYS

LSI
- Complete part procurement and start all phases of assembly for two development units (both console 8 versions)
- Start CEI specs.
- Complete exercise design and begin procurement
- Issue top assembly drawings

G.E.
- Analyze new optical design (May 7)
- Establish mounting interface definition (May 14)
- Resolve console 2 interference (issue direction by Mar. 27)

PROBLEMS
- Console 2 interference
  - Problem, trade-offs, resolution - part of CEI pitch previously given -- mockup tour
  - Impact on VDP and VDM - later (Fri. Morn.)
DRIVE-K SCANNER

PROGRESS WITHIN LAST 60 DAYS

- DETAIL DESIGN REVIEW (EMK)
- DETAIL DRAWING RELEASE (EMK)
- INITIATE PROCUREMENT (EMK)
- RELEASE DRAWINGS AND SPEC.
  - ENCODER (EMK)
  - TORQUERS (EMK)
- INITIATE LONG-LEAD PROCUREMENT (EM-1)

MILESTONE SCHEDULE

- EM1 PEDESTAL DESIGN RELEASE (6-1)
- EMK TEST PLAN (6-9)
- EMK ASSEMBLY COMPLETE (6-15)
- EMK TEST START (7-15)
- DELIVER DSS-1 (11-1)
- DELIVER 114 (12-1)
SCANNER PROCUREMENT STATUS

THE EMK SCANNER PROCUREMENT, AS OF 3/14/69, BREAKS DOWN AS FOLLOWS:

1.0 MIRROR BEZEL PHASE

1.1 BEZEL - AMERICAN BERYLLIUM CORPORATION - COMPLETE SARASOTA, FLORIDA (5-23)

1.2 HONEYCOMB END PLATE - PARSONS CORPORATION - COMPLETE STOCKTON, CALIFORNIA (5-16)

1.3 BEZEL/END PLATE INTEGRATION - AMERICAN BERYLLIUM - 4/9/69 (6-18)

2.0 PITCH GIMBAL PHASE

2.1 YOKE ASSEMBLY - BARDEN LEEMATH - COMPLETE WOODBURY, NEW YORK (5-23)

THIS PROCUREMENT INCLUDES THE TORQUER AND ENCODER HOUSINGS

2.2 TORQUE MOTORS - AEROFLEX CORPORATION - PLAINVIEW, NEW YORK (4-20)

2.3 ENCODER - WAYNE-GEORGE - 5/1/69 (8-8)

3.0 ROLL AXIS PHASE

3.1 ROLL HOUSING - BARDEN LEEMATH - 3/24/69 DESIGN CHG.

3.2 PEDESTAL - BARDEN LEEMATH (COMPLETE) WOODBURY, NEW YORK DESIGN CHG.

3.3 ROLL HOUSING/PEDESTAL INTEGRATION - BARDEN LEEMATH - 3/28/69 

3.4 TORQUE MOTOR - AEROFLEX CORPORATION - 4/20/69 (4-20)

3.5 ENCODER - WAYNE-GEORGE - 5/1/69 (5-1)

THE EMK ASSEMBLY AND TEST PHASE IS AS FOLLOWS:

1.0 ROLL AXIS ENCODER ASSEMBLY

ASSEMBLY COMPLETED. DATA REDUCTION IS IN PROCESS.

(JUNE 1)
DRIVE-K TELESCOPE

PROGRESS WITHIN LAST 60 DAYS

- BENCH TEST DESIGN COMPLETE
- FAB BENCH TEST ELEMENTS:
  - OBJECTIVE END COMPLETE
  - EYEPiece ELEMENTS IN WORK
- DETAIL DESIGN (EMK) COMPLETE
- RELEASE DESIGN (EMK)
- LONG-LEASE ITEM (EMI) RELEASED
- INITIAL THERMAL ANALYSIS COMPLETED

MILESTONES SCHEDULE

- INITIAL BENCH TEST (3-11)
- COMPLETE BENCH TEST (4-27)
- FINAL BENCH TEST REPORT (5-10)
- INITIATE EMK ASSEMBLY (4-21)
- EMK ASSEMBLY COMPLETE (7-30)
- EMK TEST PLAN (8-1)
- DELIVERY DSS-1 UNIT (9-15)
- DELIVERY 114 UNIT (12-1)
PROCUREMENT STATUS

THE EMK TELESCOPE PROCUREMENT AS OF 3/14/69 BREAKS DOWN AS FOLLOWS:

1.0 OBJECTIVE TUBE - BUDD COMPANY 4/27/69
   FORT WASHINGTON, PA. (5-23)

2.0 INTERMEDIATE TUBE - LUDWIG HONOLD 5/30/69
   FOLCROFT, PA. (6-30)

3.0 ELBOW CASTING - ANADITE CORPORATION 7/15/69
   SOUTH GATE, CALIFORNIA (9-25)

4.0 ZOOM CASTING - UNI CAST, INCORPORATED 6/1/69
   DERRY, NEW HAMPSHIRE (6-23)

5.0 PERIPHERAL DISPLAY - LA POINTE INDUSTRIES
   5/1/69 ROCKVILLE, CONNECTICUT (5-1)
PROGRESS WITHIN LAST 60 DAYS

- CONCEPTUAL DESIGN COMPLETE
- MECHANICAL LAYOUTS IN PROGRESS

MILESTONES

- COMPLETE DESIGN LAYOUTS (4-15)
- COMPLETE THERMAL DESIGN (5-15)
- COMPLETE DETAIL DESIGN (EMK) (5-25)
- PDR (6-24)
- EMK TEST PLAN (10-1-69)
- CDR (11-24-69)
- DELIVER DSS-1 (12-1-69)
- DELIVER 114 (12-10-69)
- DELIVER ELECTRONIC SENSORS FOR DSS-1 TESTING (10-15-69)
PROGRESS WITHIN LAST 60 DAYS

- CONCEPTUAL LAYOUTS INITIATED
- THERMAL ANALYSIS INITIATED

MILESTONE SCHEDULES

- COMPLETE DETAIL LAYOUTS (5-1)
- COMPLETE THERMAL ANALYSIS (5-15)
- PDR (6-10)
- CDR (12-16)
- RELEASE DETAIL DRAWINGS FOR ENGINEERING MODELS (7-23)
- DSS-1 DELIVERY (10-15)
- 114 DELIVERY (11-22)
- EMK TEST PLAN (9-1)
DRIVE-K GYRO & ELECTRONICS
BUILT BY HONEYWELL INC. PER WS1717

LAST 60 DAYS

HONEYWELL
- CDR JAN 29-30
- CDR ACTION ITEMS
- DELIVERED 1 PROTOTYPE UNIT TO G.E. FOR S/C "A" DEV. UNIT MAR 4

G.E.
- CDR
- CDR ACTION ITEMS
- TESTED PROTOTYPE UNIT & DELIVERED TO S/C A MAR 7

NEXT 90 DAYS

HONEYWELL
- COMPLETE CDR ACTION ITEMS APR 15
- DELIVER SECOND PROTOTYPE UNIT TO G.E. FOR S/C A DEV. UNIT
- RESOLVE MECHANICAL PROBLEMS

G.E.
- TEST SECOND PROTOTYPE UNIT AND DELIVER TO S/C A MAY 1
- ISSUE DC TEST REPORT MAY 16

PROBLEMS
- GYRO FAILED LATEST VIBRATION REQUIREMENTS - FIX REQUIRES REDESIGN TO ELIMINATE SHAFT NOTCH
Servo Requirements

Errors (Gimbal)

\[< 0.84 \text{ rad}\]
\[< 0.01 \text{ deg/sec}\]

Time

Pitch \(\left(\frac{\Delta \theta}{15} + 1\right)\) sec

Roll \(\left(\frac{\Delta \theta}{30} + 1\right)\) sec
SLEW MODE BLOCK DIAGRAM

SERVO RESPONSE IN SLEW
Roll Slew Performance

θ = 2 rad/sec²
θ_MAX = 45 deg/sec

SPECIFICATION

SERVO PERFORMANCE

SETTLING TIME ~ SEC

COMMENDED POSITION CHANGE (Δθ) ~ Deg
Pitch Slew Performance

\[ \dot{\theta} = 1 \text{ rad/sec} \]
\[ \dot{\theta} = 45^\circ/\text{sec} \]

- SPECIFICATION

- Servo Performance

SETTLING TIME - SEC

COMMAND POSITION CHANGE (\(\Delta \theta\)) - Deg
SLEW PROCESSOR

Position vs. Time

\[ \theta_e = \theta_c + T \dot{\theta}_c - \frac{a}{2} T^2 \]

\[ (\theta_e - \theta_d) = \frac{(\dot{\theta}_d - \dot{\theta}_c)^2}{2a} \]

\[ \dot{\theta}_d - \dot{\theta}_c \]

Square Plane Plot
RATE LIMIT $|\dot{\theta}_c| \leq 45\, \text{deg/sec}$.

ACCELERATION RESPONSE
SLEW INTO BACK STOP - PITCH

SLEW INTO FRONT STOP - PITCH
POSITION SETTLING RESPONSE AT THE END OF SLEW

TIME SETTLING CONSTRAINT ($s^2 + 1$)

POSITION ERROR - (Units) GIMBAL

TIME IN SECONDS

ROLL GIMBAL

PITCH GIMBAL

POSITION SETTLING CONSTRAINT ($\pm 244$ Units)
Servo Transfer Functions

Pitch

\[ GH = \frac{3200 \left( \frac{5}{40} + 1 \right)}{s \left( \frac{5}{1} + 1 \right) \left( \frac{5}{600} + 1 \right)^2 \left( \frac{5}{1000} + 1 \right) \left( \frac{5}{5000} + 1 \right)} \]

Roll

\[ GH = \frac{2800 \left( \frac{5}{25} + 1 \right)}{s \left( \frac{5}{0.02} + 1 \right) \left( \frac{5}{550} + 1 \right)^2 \left( \frac{5}{1000} + 1 \right)^3 \left( \frac{5}{5000} + 1 \right)} \]
### Table II

Recommended Servo Configurations

<table>
<thead>
<tr>
<th>Source</th>
<th>Pitch Axis</th>
<th>Roll Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Noise</td>
<td>0.0325</td>
<td>0.0265</td>
</tr>
<tr>
<td>Gyro Noise</td>
<td>0.0360</td>
<td>0.0345</td>
</tr>
<tr>
<td>Input Noise</td>
<td>0.0176</td>
<td>0.0155</td>
</tr>
<tr>
<td>Electronic Noise</td>
<td>0.0146</td>
<td>0.0125</td>
</tr>
<tr>
<td></td>
<td>0.0529</td>
<td>0.0478</td>
</tr>
<tr>
<td></td>
<td>0.1058</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.1160</td>
<td></td>
</tr>
<tr>
<td>2σ</td>
<td>0.232 sec</td>
<td></td>
</tr>
</tbody>
</table>
### Table III

**Recommended Servo Configurations Present Estimated Performance**

<table>
<thead>
<tr>
<th>Source</th>
<th>Pitch Axis</th>
<th>Roll Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Noise</td>
<td>0.0290</td>
<td>0.0207</td>
</tr>
<tr>
<td>Gyro Noise</td>
<td>0.0247</td>
<td>0.0299</td>
</tr>
<tr>
<td>Input Noise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 Buffer</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>DAC Sources</td>
<td>0.014</td>
<td>0.014</td>
</tr>
<tr>
<td>Electronic Noise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amplifiers</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>RPM I</td>
<td>0.010</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>0.0418</td>
<td>0.0363</td>
</tr>
<tr>
<td></td>
<td>0.0836</td>
<td></td>
</tr>
</tbody>
</table>

\[ 2 \alpha = 0.1822 \text{ rad} \]

*Assumes Bearing Noise Requirements will be met.*
### Error Allocation

<table>
<thead>
<tr>
<th>Source of Noise</th>
<th>Pitch</th>
<th>Roll</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Noise</td>
<td>0.041</td>
<td>0.030</td>
</tr>
<tr>
<td>Gyro Noise</td>
<td>0.035</td>
<td>0.0345</td>
</tr>
<tr>
<td>Input Noise</td>
<td>0.0175</td>
<td>0.0155</td>
</tr>
<tr>
<td>Electronic Noise</td>
<td>0.0145</td>
<td>0.0125</td>
</tr>
</tbody>
</table>

| | 0.0585 | 0.0498 |

| LOS (10) | 0.1262 | 0.2529 |
| LOS (20) |        | 0.2529 |

### Estimated Error

<table>
<thead>
<tr>
<th>Source of Noise</th>
<th>Pitch</th>
<th>Roll</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Noise</td>
<td>0.0365</td>
<td>0.0236</td>
</tr>
<tr>
<td>Gyro Noise</td>
<td>0.0247</td>
<td>0.0244</td>
</tr>
<tr>
<td>Input Noise</td>
<td>0.0141</td>
<td>0.0141</td>
</tr>
<tr>
<td>Electronic Noise</td>
<td>0.011</td>
<td>0.011</td>
</tr>
</tbody>
</table>

| | 0.0475 | 0.0333 |

| LOS (10) | 0.1024 |
| LOS (20) | 0.2048 |
Figure (2)  
Allocated Errors  

Rich Axis Noise Errors as a Function of Bandwidth,  

\[ G \omega e = \frac{k \left( \frac{s}{\omega_c + 1} \right)}{s} \left( \frac{1}{1 + \frac{s}{\omega_0} + \frac{s}{\omega_0^2}} \right) \]

\( \omega_c \) = Crossover frequency of recommended servo configuration

We = RMS Gimbal Error

Gyro Noise

Input Noise

Electronic Noise

Bearing Noise

Bandwidth  Rad/Sec

40
Estimated Performance

Roll Axis Noise Error As A Function of BANDWIDTH

\[ \text{Error} = \frac{k \left( \frac{2}{s} \right)}{s \left( \frac{2}{s} + 1 \right) \left( \frac{s}{5000} + 1 \right) \left( \frac{s}{1000} + 1 \right)} \]

\( \omega_c \) = Crossover Frequency of recommended servo configuration

- Bearing Noise
- Gyro Noise
- Input Noise
- Electronic Noise

RMS Gimbal Error vs. Bandwidth (Rad/Sec)
Figure 4
Estimated Performance

Pitch Axis Noise Errors As A Function of Bandwidth

\[ GH = \frac{K \left( \frac{W_c}{10^4} \right)}{5 \left( \frac{W_c}{10^4} \right)^2 \left( \frac{W_c}{10^4} \right)^2} \]

\( W_c \) - Crossover frequency of recommended servo configuration
Figure (3) of the document illustrates the roll axis noise errors as a function of bandwidth. The equation for calculating the roll axis noise errors is given by:

$$\text{Gain} = \frac{K (s + 1)}{s (s + 10)(s + 50)(s + 100)^3}$$

where $w_c$ represents the crossover frequency of the recommended servo configuration.

The graph shows the relationship between the roll axis noise errors and the bandwidth, with the x-axis representing bandwidth in rad/sec and the y-axis representing the RMS gimbal error. The curves demonstrate the effect of various noise sources, including gyro noise, bearing noise, and electronic noise, on the overall noise performance as the bandwidth changes.
Figure 110
Phase Margin Degrees

Roll Axis Worst Case

2800 (5/200+V100 000) / (5/250+V100 000)}

A = 0.0003
B = 0.0005
Figure 611

Phase Margin Degrees

A: \( \delta = 0.003 \)
B: \( \delta = 0.001 \)
C: \( \delta = 0.005 \)

Pitch Axis

\[
\frac{3200 \left( 5 \% + 1 \right) \left( 5/100 + 1 \right)}{5 \left( 5 \% + 1 \right) \left( 5/100 + 1 \right) \left( 5/100 \% + 1 \right) \left( 5/500 \% + 1 \right)_{\text{rad/sec}}}
\]

- \( 176 \text{ rad/sec} \)
- \( 230 \text{ rad/sec} \)
- \( 331 \text{ rad/sec} \)
- \( 560 \text{ rad/sec} \)
- \( 995 \text{ rad/sec} \)

GAIN DB

1349 rad/sec

20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500

0 10 20 30 40 50 60 70 80

NRO APPROVED FOR RELEASE 1 JULY 2015

SECRET/DORIAN
**Table III**

Stability Margins for Recommended Roll Configuration

<table>
<thead>
<tr>
<th>Mode Frequency</th>
<th>Mode Amplitude</th>
<th>Worst Case Stability Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>176 rad/sec</td>
<td>2db Z-P</td>
<td>17.5 db</td>
</tr>
<tr>
<td>331 rad/sec</td>
<td>&gt;1db Z-P</td>
<td>13db</td>
</tr>
<tr>
<td>580 rad/sec</td>
<td>12db P-Z</td>
<td>9db, 100 Degrees</td>
</tr>
<tr>
<td>1260 rad/sec</td>
<td>44db Z-P</td>
<td>60 Degrees</td>
</tr>
</tbody>
</table>

Assumptions

15% Tolerance on Mode Frequency
10% Amplifier and Torquer Gains
10% Time Constants

3 o Worst Case
### Table VIII

Stability Margins for Recommended Pitch Configuration

<table>
<thead>
<tr>
<th>Mode Frequency</th>
<th>Mode Amplitude</th>
<th>Worst Case Stability Margins</th>
</tr>
</thead>
<tbody>
<tr>
<td>176 rad/sec</td>
<td>$\frac{1}{1} \text{db}$ $z-p$</td>
<td>{12 db, 20 degrees}</td>
</tr>
<tr>
<td>230 rad/sec</td>
<td>$\frac{1}{1} \text{db}$ $z-p$</td>
<td>{9 db, 20 degrees}</td>
</tr>
<tr>
<td>331 rad/sec</td>
<td>$\frac{1}{1} \text{db}$ $p-z$</td>
<td>9 db</td>
</tr>
<tr>
<td>580 rad/sec</td>
<td>4db $z-p$</td>
<td>12 db</td>
</tr>
<tr>
<td>945 rad/sec</td>
<td>12db $z-p$</td>
<td>10 db</td>
</tr>
<tr>
<td>1349 rad/sec</td>
<td>$\frac{1}{1} \text{db}$ $p-z$</td>
<td>{8 db, &gt;100 degrees}</td>
</tr>
</tbody>
</table>
\[ N = \text{GEAR RATIO} \times 2 \]

\[ O_I = \text{IMAGE POSITION} \]

\[ O_T = \text{TRANSDUCER POSITION} \]

\[ O_C = \text{COMMAND SIGNAL (STEP INPUT)} \]

**Figure 2.2-49. Image Orientation Control Loop**
Requirements

Reposition in

\((\frac{A\theta}{30} + 1)\) sec

Servo Accuracy

\(\leq 0.5\) Degrees
SECRET/DORIAN

FIG. 3

LINEAR MODEL OF R-3 SUBSYSTEM

\[
\frac{k_v (1 + Ts)}{(1 + Ts)}
\]
OPTICAL ERRORS

PRESENT SPEC.*

HI  
127 X +5
  -3

LO  
16 X ± 1

CHANGE TO *

HI  
127 X +0
  -2

LO  
16 X ± 1

EXPECTED PERFORMANCE (0.1% E.P. DIAMETER MEASUREMENT ERROR)*

HI  
127 X +0
  -.127X

LO  
16 X ± .016X

*PENDING VENDOR CONFIRMATION
SERVO AND INSTRUMENTATION ERRORS

<table>
<thead>
<tr>
<th>Error Description</th>
<th>POT REF.</th>
<th>CAM REF.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHC Pot Alignment &amp; Noise (e1)</td>
<td>6 min.</td>
<td>22 min.</td>
</tr>
<tr>
<td>ADKE Shaper Scale Factor (e2)</td>
<td>8.2</td>
<td>36.6</td>
</tr>
<tr>
<td>ADKE Feedback Buffer (e3)</td>
<td>8.2</td>
<td>36.6</td>
</tr>
<tr>
<td>F.B. Pot Alignment (e6)</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>RSS</td>
<td>14.3 min.</td>
<td>52.6 min.</td>
</tr>
<tr>
<td>Servo Standoff (e4)</td>
<td>60 min.</td>
<td>220 min.</td>
</tr>
</tbody>
</table>
# Mechanism Errors (e_5)

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference to Pot</th>
<th>Reference to Cam</th>
</tr>
</thead>
<tbody>
<tr>
<td>POT WIND-UP</td>
<td>0.5 min.</td>
<td>1.83 min.</td>
</tr>
<tr>
<td>Gear Tooth Tolerances</td>
<td>2.</td>
<td>7.34</td>
</tr>
<tr>
<td>Shaft Straightness</td>
<td>2.</td>
<td>7.34</td>
</tr>
<tr>
<td>Gear Decenter</td>
<td>2.</td>
<td>7.34</td>
</tr>
<tr>
<td>Gear to Shaft Coupling</td>
<td>3.</td>
<td>11.01</td>
</tr>
<tr>
<td>Bearing to Bore</td>
<td>3.</td>
<td>11.01</td>
</tr>
<tr>
<td>Shaft to Bearing</td>
<td>3.</td>
<td>11.01</td>
</tr>
<tr>
<td>POT Repeatability</td>
<td>0.5</td>
<td>1.83</td>
</tr>
<tr>
<td>Shaft Wind-Up</td>
<td>0.</td>
<td>0.</td>
</tr>
<tr>
<td>Cam Torsional Wind-Up</td>
<td>0.</td>
<td>0.</td>
</tr>
<tr>
<td>Cam Follower Backlash</td>
<td>0.</td>
<td>0.</td>
</tr>
<tr>
<td>Cam Follower to Rail Pin Deflection</td>
<td>0.</td>
<td>0.</td>
</tr>
<tr>
<td>Gear Deflections</td>
<td>0.</td>
<td>0.</td>
</tr>
<tr>
<td>Performance (RSS)</td>
<td>5.72 min.</td>
<td>20.9 min.</td>
</tr>
</tbody>
</table>
## ZOOM ERROR SUMMARY

<table>
<thead>
<tr>
<th>ERROR DESCRIPTION</th>
<th>SOURCE MAGNITUDE</th>
<th>LOW RANGE MAGN ERROR</th>
<th>HI RANGE MAGN ERROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTICS</td>
<td>± 1(^{+0}_{-2})</td>
<td>1.0</td>
<td>+0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-2</td>
</tr>
<tr>
<td>MECHANISMS</td>
<td>20.9 MIN.</td>
<td>0.00349</td>
<td>0.087</td>
</tr>
<tr>
<td>SERVO RANDOM</td>
<td>52.6 MIN.</td>
<td>0.00876</td>
<td>0.218</td>
</tr>
<tr>
<td>RSS</td>
<td></td>
<td>1.0</td>
<td>+0.235</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-2.01</td>
</tr>
<tr>
<td>SERVO BIAS</td>
<td>220 MIN.</td>
<td>0.0367</td>
<td>0.916</td>
</tr>
<tr>
<td>COMPOSITE</td>
<td>± 1.0367</td>
<td>+1.151</td>
<td>-2.926</td>
</tr>
<tr>
<td>CEI</td>
<td>± 1</td>
<td>+5</td>
<td>-3</td>
</tr>
</tbody>
</table>
LINE OF SIGHT DEFINITION

ALIGNMENT PURPOSES - LINE OF SIGHT IS THE LINE CONNECTING THE SPACECRAFT TO THE PROJECTION OF THE TELESCOPE RETICLE ON THE TARGET PLANE.

JITTER PURPOSES - LINE OF SIGHT IS THE LINE CONNECTING THE SPACECRAFT TO A GROUND OBJECT IN THE CENTER OF THE TELESCOPE FIELD OF VIEW.
UNRESOLVED SOFTWARE PROBLEM

STOW/UNSTOW APPROACHES

I.  5°/SEC. SLEW FROM STOW
   • WORD SYNCHRONIZATION AT 0° ROLL, 56.25° PITCH
   • SYSTEM READY FOLLOWING SLEW

II.  WIRED SYNCHRONIZATION WORD AT STOW POSITION
    • SLEW FROM STOW
DRIVE K BEARINGS

- REQUIREMENTS
- GE/SUBCONTRACTOR AGREEMENT
- RESULTS OF DEVELOPMENT TESTS
- RESULTS OF ANALYSIS
- DESIGN SOLUTION
- FUTURE STEPS TO COMPLETION
REQUIREMENTS

- LOW TORQUE RIPPLE PERFORMANCE
- LAUNCH SURVIVABILITY
- SPACE ENVELOPE CONSTRAINTS
- STIFFNESS
- AVERAGE RUNNING TORQUE
- THERMAL ENVIRONMENT
- INSTALLATION-INDUCED DEGRADATION
GE/SUBCONTRACTOR A AGREEMENT

- Drive a bearing technology directly transferable - capability existed at GE for bearing development.

- Final responsibility for design remains at SUB A because of overall subsystem requirements and trades.

- GE performs development tests, analysis

- Outputs from GE to SUB A include test data, design analysis, mechanical performance data, specification definition, installation requirements. Also supplied EM-K bearings. Future procurements to be decided.
BACKGROUND

- THIN-SECTION PITCH AXIS BEARINGS ON DRIVE-K RETAINED AS HIGH-RISK, LOW-COST APPROACH. - JUNE '68

- ALLOCATION NOT MET BY DEVELOPMENT TEST DATA (AS PREDICTED), EVEN WITH NO INSTALLATION OR THERMAL MARGIN. - NOV. '68

- RATHER THAN IMMEDIATE REDESIGN TO FULL-SECTION BEARINGS, DRIVE-K HIGH-PERFORMANCE PROGRAM EXPANDED. - DEC. '68

- INITIAL RESULTS OF HIGH-PERFORMANCE PROGRAM INDICATE CERTAIN NECESSARY COURSES OF ACTION.
THERMAL ANALYSIS

- GRADIENT AND TOTAL TEMPERATURE EXCURSION EQUATIONS FORMULATED.

- CHANGES IN NORMAL APPROACH CALCULATED AS FUNCTIONS OF GRADIENT OR TOTAL TEMPERATURE.

- NORMAL APPROACH CHANGES CONVERTED TO PRELOAD.

- RMS AND DCT AS FUNCTIONS OF PRELOAD COMBINED WITH ABOVE TO PRODUCE CONSTRAINT ENVELOPES
FIGURE 11: DRIVE K REAR ENVELOPE FOR PRESSED AND UNPRESSED CONDITIONS

THERMAL ENVELOPE
FOR K-21 BEARING
FIGURE 10: DRAFT K BEARING THRESHOLD ENVELOPES FOR POTTED AND UNPOTTED CONDITIONS
HIGH-PERFORMANCE PROGRAM

• SUPERFINISHES PRODUCED BY SBB EFFECT UP TO 30% DECREASE IN RMS WITH NO CHANGE IN FREQUENCY CONTENT. BARDEN SUPERFINISH SHOULD DO EQUALLY OR BETTER. THE PRACTICAL LIMIT FOR THIN RACE BEARINGS HAS BEEN REACHED.

• MOLOIL. HIGH-VISCOSITY SILICON FLUID LUBRICANT CAN, WITH PROPER APPLICATION, PRODUCE DRAMATIC PERFORMANCE INCREASES WHICH WILL LIKELY PERMIT THE USE OF THE EXISTING THIN-SECTION BEARINGS. DEVELOPMENT IS WARRANTED.
SUMMARY

- DEVELOPMENT TEST BEARINGS WERE OUTSIDE ALLOCATION

- HIGH PERFORMANCE PROGRAM HAS PRODUCED A DESIGN SOLUTION WHICH IS IN EXECUTION
SCANNER ASSEMBLY DESCRIPTION

TWO AXIS GIMBAL SYSTEM

- PEDESTAL
- ROLL HOUSING
- YOKE ASSEMBLY
- BEZEL ASSEMBLY
- MIRROR

BEARINGS

GYROS AND ELECTRONICS

INCREMENTAL ENCODERS

TORQUE MOTORS

OTHER FEATURES

- CABLES AND HARNESS
- STOW LOCK AND STOPS
- ALIGNMENT MIRRORS
- BALANCED GIMBALS
SCANNER COMPONENTS

ENCODERS
- SPECIFICATIONS SUBMITTED FOR APPROVAL
- EMK ASSEMBLY STARTED
- WAYNE-GEORGE BEING MONITORED CLOSELY
- STATIC ACCURACY TEST LATE APRIL
- PSEUDO-RATE TESTS THIS SUMMER

TORQUERS
- AEROFLEX DELIVERED LOW TORQUE UNITS
- REDESIGN MAY RESULT IN INCREASED WEIGHT
- POWER TRADE-OFF POSSIBLE

BEARINGS
- COVERED SEPARATELY
- GENERAL ELECTRIC TESTING THROUGH JUNE, 1969
- STATIC TORQUE AND RIPPLE TESTS TO BE DONE ON SINGLE AXIS TESTER THIS SPRING

GYROS
- HONEYWELL HANGAR QUEENS FURNISHED BY GENERAL ELECTRIC
- PRIME UNITS INSTALLED AT GENERAL ELECTRIC
- HONEYWELL AND GENERAL ELECTRIC RUNNING TESTS
- VALIDATION TESTS TO BE PERFORMED BY ITEK ON SATS CONSOLE
- HANGAR QUEENS WILL BE USED TO MEASURE TORQUE TRANSMISSIBILITY AND POSSIBLY MECHANICAL NOISE

CABLES/HARNESS
- WIRE SPECIFICATIONS SUBMITTED FOR APPROVAL
- DESIGN LIMITED BY TORQUE REQUIREMENT
- THROUGH-BORE DESIGN IS SPACE LIMITED
- REQUIRE GROUND STRAP WAIVER
- TORQUE AND RIPPLE TESTS ON ACROSS-THE-GIMBAL CABLES BEING RUN THIS SPRING
EMK SCANNER ASSEMBLY
- DRAWINGS AND ASSEMBLY PROCEDURES COMPLETE
- ALL COMPONENTS ON ORDER
- PROCUREMENT TO BE COMPLETE EARLY MAY
- DEVELOPMENT TEST PROCEDURES DUE EARLY JULY
- FULL DEVELOPMENT TESTS TO START AUGUST
- ENVIRONMENTAL TESTING FOLLOWS PERFORMANCE BASELINE TEST

THERMAL TEST (TDT-1A)
- SCANNER REPRESENTED BY MIRROR POTTED INTO BEZEL
- TESTING TO BE PERFORMED IN MAY

SINGLE AXIS TESTER (GAS BEARING)
- BROAD BANDWIDTH DESIRED POSES SERVO/NOISE PROBLEM
- DESIGNED TO MEASURE CABLE SPRING RATE AND TORQUE RIPPLE
- USE EXTENDED TO TEST BEARINGS
- CURRENTLY OPERATING SUCCESSFULLY WITH PSD PROGRAM

SCANNER TEST STAND (STS)
- TO BE USED WITH DEVELOPMENT AND PRIME UNITS
- PERMITS BALANCING AND "ZERO-G" TESTING
- DUE FROM PALO ALTO IN AUGUST

SCANNER TEST CONSOLE (SATS)
- GYRO RATE LOOP ONLY OUTSTANDING PROBLEM
- FULL CAPABILITY TO EXERCISE SCANNER
- DUE FROM PALO ALTO IN JUNE
SCANNER PROBLEM AREAS

BEARING NOISE PERFORMANCE

BERYLLIUM ENCODER FLEXURE

PITCH GIMBAL MAINTAINABILITY

CDR DATE VS. TEST SCHEDULE

GYRO INSTALLATION AND BALANCE

SCANNER INSTALLATION AND ALIGNMENT

SCANNER REPLACEABILITY ON LAUNCH PAD
POWER GROUND

- WAIVER IN PROCESS FOR MAIN TORQUERS
- PLAN WAIVER REQUEST FOR DEROTATION AND ZOOM MOTORS
OPTICAL FILTERS

A filter wheel is required that employs four different filters any one of which can be used at a given time. Generally, the filters will include a clear glass filter, neutral density, and haze filters. The clear glass filter, of which only one is needed, serves as a dummy optical element to maintain system aberration balance and focus when no functional filters are being used. To determine the requirements of the other filters, the content of the viewed scene must be analyzed.

Carman and Caruthers\(^1\) made a study of the distribution of scene luminance and luminance differences for a variety of terrain types as viewed from an aircraft flying at 4000 ft. altitude. The recording photometer scanned the terrain with a spot diameter of 3 feet. In every case, the luminance distribution was very nearly normal. The following table describes the scene content in terms of an assumed normal distribution.

<table>
<thead>
<tr>
<th>Sun Altitude</th>
<th>Weather</th>
<th>Illumination</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 64°</td>
<td>Clear or Light Haze</td>
<td>- 10965 lumens/ft.(^2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TERRAIN TYPE</th>
<th>MEAN LUMINANCE (FT.-LAMBERTS)</th>
<th>3(\sigma) LUMINANCE DIFF. (FT.-LAMBERTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>1000</td>
<td>2.5</td>
</tr>
<tr>
<td>Small Town</td>
<td>1000</td>
<td>2.5</td>
</tr>
<tr>
<td>Orchard &amp; Cultivated Land</td>
<td>1585</td>
<td>2.5</td>
</tr>
<tr>
<td>Heavily Wooded</td>
<td>891</td>
<td>1.8</td>
</tr>
</tbody>
</table>

The table indicates the luminance levels to be expected without the addition of the atmospheric haze associated with an orbital mission. On a clear day the maximum addition due to haze is about 750 foot-lamberts. Sunlit clouds\(^2\), however, reach levels of 10,000 ft.-lamberts, snow 5000 ft.-lamberts and sea glint much higher than either. Neglecting the latter phenomenon (because it is analyzed and found to be of minor effect in another study), let us assume that the mean scene luminance level that is to be attenuated is 3000 ft.-lamberts.
Introducing the system transmission of 35% this quantity becomes very nearly 1000 ft.-lamberts. The previous reference lists minimum illumination levels for various activities varying from 2500 lumens/ft.² for a hospital operating table to 3 lumens/ft.² for candle light dining. Perhaps the activity nearest to that of the system function is that of engineering drafting. The recommended level for drafting room work is 100-200 lumens/ft.². A white piece of drawing paper on a drafting table would have a luminance of roughly the same numerical value, 100-200 ft.-lamberts. Let us assume that the system image should have a mean luminance of 100-ft.-lamberts. The required neutral density filter must attenuate by a factor of 10:1. Its density is 1.0. Because of the constancy of mean scene luminance, as evidenced by the above table, it is recommended that only one neutral density filter be used. Haze, on the other hand, is quite variable. It is therefore recommended that the other two filters be used for cutting two relatively different levels of haze.

The spectral content of the scattered light making up the haze varies with the amount of haze. When haze is very low, on a relatively clear day, scattering is predominantly at the shorter visible wavelength, the blue end of the spectrum. Scattering is then proportional to $\lambda^{-4}$. For heavier haze, such as that of an overcast day, the scattered light is primarily white indicating that the scattering is then ideally proportional to $\lambda^0$.

Any haze spectral filter, in order to be of any use, according to the above analysis must be one that filters out the shorter wavelengths. Typical minus blue filters, such as these, transmit very little blue light, cutting on (50% level) at about 470 m/μ. With heavier haze, light begins scattering at even longer wavelengths requiring that the cut-on wavelength must also be longer. In order to preserve some transmission, and for want of any other sources of definition, let us recommend a filter that cust on at 510 m/μ. Both of the above can be represented by Kodak Wratten Filters #6 and #9.
<table>
<thead>
<tr>
<th>ACTION ITEM</th>
<th>COMPLETE</th>
<th>INCOMPLETE</th>
<th>PLANNED COMPLETION DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SHRD - New Time</td>
<td>GE-ACTION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. 1703 Noise</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. EMI Noise</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Pressure Start-Stop</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Pressure Slew Rate</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. K Gyro Vibration Study</td>
<td>YES - CEL #31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Power Supply-Start Res.</td>
<td>YES - CEL #30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Power Darlington</td>
<td>YES - CEL #28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Heater Inhibit</td>
<td>YES - CEL #32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Large CAPS</td>
<td>YES - CEL #29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Inhibit Bridge</td>
<td>YES - CEL #33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. 1717 Ripple</td>
<td>YES - Honeywell Letter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Thermal Analysis</td>
<td>YES - CEL #36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Thermal Resistance - Mounting Ring</td>
<td>YES - CEL #30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. 1703 Freq. Response</td>
<td>YES - CEL #28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Humidity</td>
<td>YES - CEL #35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. EMI</td>
<td>YES - Data Submittal by 3-21-69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG2000</td>
<td>(mailed)</td>
<td>not received yet</td>
<td></td>
</tr>
<tr>
<td>GG2001</td>
<td><strong>X</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Reliability</td>
<td>YES - CEL #27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Gyro Failure Rates</td>
<td>In Duplicating Now</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Parts Failure</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Error Removal</td>
<td>YES - CEL #37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Crystal Stability</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Circuit Analysis</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. External Effects Scale Factor</td>
<td>YES - CEL #30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Welded Module Potting</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STATUSES OF GYRO CDR ACTION ITEMS

5  FULLY ACCEPTED
1  GE ACTION - IN PROCESS
3  HONEYWELL TO RESUBMIT
4  SUBMITTED BY HONEYWELL NOT YET REVIEWED BY GE
4  INCOMPLETE (HONEYWELL)

---

17
<table>
<thead>
<tr>
<th>IFS/ICD</th>
<th>TBD/R</th>
<th>ICN</th>
<th>TITLE</th>
<th>ASSOC</th>
<th>SIGNED BY</th>
<th>SCHEDULED SIGN-OFF DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>S003</td>
<td>D119-1</td>
<td>D</td>
<td>AO Component Areas and Heat Capacities <strong>Tolerances</strong></td>
<td>G</td>
<td>TSOM 10</td>
<td>2 June 69</td>
</tr>
<tr>
<td></td>
<td>D119-2</td>
<td>D</td>
<td>Radiator Temperatures, Prelaunch</td>
<td>D</td>
<td>TSOM 10</td>
<td>2 June 69</td>
</tr>
<tr>
<td></td>
<td>D119-3</td>
<td>D</td>
<td>Film Coefficients, Boundary Temperatures, Prelaunch</td>
<td>G/D</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D119-4</td>
<td>D</td>
<td>Film Coefficients, Ascent and Early Orbit</td>
<td>D</td>
<td>TSOM 10</td>
<td>2 June 69</td>
</tr>
<tr>
<td></td>
<td>D119-5</td>
<td>D</td>
<td>Film Coefficients and Boundary Temperatures, On-Orbit, Pressurized</td>
<td>D</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D119-6</td>
<td>D</td>
<td>Boundary Temperatures, On-Orbit, Depressurized</td>
<td>D</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D119-7</td>
<td>D</td>
<td>Film Coefficients and Boundary Temperatures, ACTS Translation</td>
<td>D</td>
<td>TSOM 10</td>
<td>2 June 69</td>
</tr>
<tr>
<td></td>
<td>D119-9</td>
<td>D</td>
<td>Heat Rates, Telescope</td>
<td>G</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D119-10</td>
<td>D</td>
<td>Area Tolerance, Penetration Fitting</td>
<td>D</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D119-11</td>
<td>D</td>
<td>Pedestal Conductance</td>
<td>D</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D119-12</td>
<td>D</td>
<td>Boundary Temperatures, Launch, Ascent &amp; Early Orbit</td>
<td>D/G</td>
<td>2 June 69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D119-13</td>
<td>D</td>
<td>Penetration Fitting Temperature, Prelaunch Thru Ascent</td>
<td>D</td>
<td>2 June 69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R119-1</td>
<td>D</td>
<td>Emissivity Tolerances, AO Components</td>
<td>G</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R119-2</td>
<td>D</td>
<td>Air Temperature Inside Aerodynamic Pairing, Prelaunch</td>
<td>D</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R119-3</td>
<td>D</td>
<td>Electrical Cable, Thermal Properties</td>
<td>G</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R119-4</td>
<td>D</td>
<td>Net Interchange Factor, Window/Cell <strong>Tolerances</strong></td>
<td>G</td>
<td>TSOM 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R119-16</td>
<td>D</td>
<td>Radiator Temperature excursions</td>
<td>D/G</td>
<td>TSOM 10</td>
<td></td>
</tr>
</tbody>
</table>
CRITICAL OPEN INTERFACE ITEMS

- **LM SHELL STIFFNESS**
  - ICN 144 ANTICIPATED SIGN-OFF BY TSOM 9.5

- **THERMAL**
  - ICN 119 SIGNED OFF AT TSOM #9 WITH 19 TBD/TBR
  - ACTION PLAN TO RESOLVE TBD/TBR BY JUNE 1969

- **SHROUD FOOT PRINT**
  - NEED TO RESOLVE:
    - SHROUD SUPPORT -- 2 PIECE -- 1 PIECE
    - BOOT TIE DOWN
114 DEVELOPMENT TEST ARTICLE

EQUIPMENT

- Mission module aft and forward sections and transportation fixture to which are mounted consoles 2 and 8
- Transportation fixture to provide mounting points for telescope, scanner, fixed fold and shroud
- Console 2 side following completion DSS-1 tests
- Console 8 side with prime glass

OBJECTIVES

- Establish mechanical compatibility
- Establish electrical compatibility between AVE subsystems
- Determine system functional performance characteristics
- Verify the system EMC characteristics
- Develop and verify ground test procedures to be used for acceptance testing
114 PLANNED TESTING FOR ATS

- SLEW MODE
- TRACKING MODE
- ZOOM CONTROL
- MAGNIFICATION STEP CONTROL
- IMAGE DEROTATION
- SOLAR BLANKING
- PERIPHERAL DISPLAY
- CUE RETRIEVAL (AUTO)
- LAMP INHIBIT
- MANUAL CUE RETRIEVAL
- SINGLE FRAME STEP
115 SYSTEMS QUALIFICATION TEST ARTICLE

EQUIPMENT

- HOLDING FIXTURE SAME AS 114
- PRIME UNITS FOR CONSOLE 2 AND 8

OBJECTIVE

- DEMONSTRATION OF PERFORMANCE TO AVE CEI REQUIREMENTS

TESTING FOR ATS

- SLEW MODE
- TRACKING MODE
- ZOOM CONTROL
- MAG STEP CHANGE
- IMAGE DEROTATION
- SOLAR BLANKING
- SHROUD
- PERIPHERAL DISPLAY
- CUE RETRIEVAL (AUTO)
- CUE AVAILABILITY
- LAMP INHIBIT
- MANUAL CUE RETRIEVAL
- SINGLE FRAME STEP
- FILM MODULE REPLACEMENT TIME
- MAGNIFICATION CONTROL STICK FUNCTIONS
- FILTERS

TA
TA
T
T
TA
T
T
T
T
T
T
T
T
EDCTU (GD-5)

- Equipment from DSS-1 to be used on 114 - will not be shipped as GD-5
- K brassboards will be shipped as GD-5

LMOTV (GD-6)

**Equipment**
- Prime units for consoles 2 and 8

**Objective**
- Demonstration of performance to AVE CEI requirements
- Thermal vacuum testing similar to 115
THERMAL DESIGN - SUMMARY

• THERMAL DESIGN REQUIREMENTS

• TELESCOPE -
  VARIATION IN TEMP. FROM ASS'Y TEMP. ±12°F

AXIAL GRADIENT (OBJECTIVE WINDOW - ELBOW) ±3°F

TUBE CIRCUMFERENTIAL GRADIENT ±7°F

OBJECTIVE WINDOW RADIAL GRADIENT ±1°F

OBJECTIVE ELEMENT #1 RADIAL GRADIENT ±1°F

OBJECTIVE ELEMENT #2 RADIAL GRADIENT ±1°F

• SCANNER ASSEMBLY

TEMP. VARIATION 50-90°F

BEARING GRADIENTS <5°F
PROPOSED DESIGN CONCEPT

TOTALLY INSULATED SHROUD
UMBRA COOLING
HEATED LENS CELL + FIXED FOLD HOUSING

ANALYTICAL CONCLUSIONS

SCANNER ASS'Y TEMP. VARIES BETWEEN 47° - 90°F

BEARING GRADIENTS LESS THAN 5°F

HEATER POWER REQ. ~ 13 WATTS.

AXIAL GRADIENT 11.2°F (1.3 diopters, smooth to focal)

AMBIENT VAR. OF TELESCOPE +9°F - 8

CIRCUMFERENTIAL GRAD. 1.5°F

OPTICAL ERROR BUDGET FOR SCAN MIRROR MET.
**ALTERNATE DESIGN CONCEPT**

PARTIALLY INSULATED SHROUD
NO UMBRA COOLING REQ.
HEATED SCANNER ASS'Y OR SHROUD
HEATED LENS CELL + FIXED FOLD HOUSING

SCANNER ASS'Y TEMP. VARIES BETWEEN 50°F - 130°F.

BEARING GRADIENTS - 10° (ROLL TORQ) & 18° (PITCH MOTOR) W/O HEATER.

AXIAL GRADIENT 11.2°F

AMBIENT VAR. OF TELESCOPE +9°F -8°F

CIRCUMFERENTIAL GRAD. 1.5°F

HEATER POWER 33 WATTS+
(ASSUMES HEATERS MTDB ON)

OPTICAL ERROR BUDGET FOR SCAN MIRROR NOT MET.
QUAL. TESTING PROBLEM

REQUEST WAIVER TO SAFSL 10003.

SAFSL10003 REQ.

**INTERNAL COMPONENTS** -
TEMPERATURE CYCLE BETWEEN 10°F TO 140°F
PERFORMANCE TEST AT HIGH AND LOW TEMP. EXTREMES.

**EXTERNAL COMPONENTS** -
ADJUST ENVIRONMENT SIMULATOR TO YIELD COMPONENT TEMPERATURES 30°F ABOVE THE MAX. AND 30°F BELOW MINIMUM.

RATIONALE FOR WAIVER REQUEST -
OPTICAL PERFORMANCE CAN NOT BE MET UNDER ABOVE ARBITRARY ENVIRONMENTAL EXTREMES

1. EXCEEDS PERMISSABLE TEMP. VAR. FOR TELESCOPE.

2. MAKE GRADIENT PROBLEMS AND SEVERE CONSEQUENTLY TORQUE AND JITTER REQ CANNOT BE MET.

3. CREATES ADD'L GRADIENTS IN SCAN MIRROR - OPTICAL ERROR BUDGET WOULD NOT BE MET.
GE/MDAC INTERFACE SPEC. STATUS.

RESULTS FROM EARLIER MODEL

±6°F VAR. IN PRESSURE WALL TEMP.

11°F OF MAX. AXIAL GRADIENT.

UPDATED MODEL.

PRESSURE WALL I. F. TEMP.

OPERATING TEMP.

TELESCOPE TEMP.

MDAC

GE

ORBITAL DATA - DUE TSO/M # 10.

ASCENT, & ACTS DATA - JUNE 2.

PROBLEM AREAS (MAJOR)

1. DEFINITION OF PRESSURE WALL TEMP. - NEED VARIATION HELD TO ±2°F TO ELIMINATE LENS CELL HTR.

2. MORE REALISTIC DEFINITION OF CONSOLE AREA BOUNDARY TEMPERATURES.
OPERATIONAL & ENVIRONMENTAL CONSTRAINTS

• BETA ANGLE \( -60° \leq \beta \leq 60° \)

• ENVIRONMENTAL Fluxes (BTUS/HR, FT²)

<table>
<thead>
<tr>
<th></th>
<th>SOLAR</th>
<th>ALBEDO</th>
<th>EARTH</th>
<th>MOLECULAR HTG.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX.</td>
<td>460</td>
<td>202</td>
<td>75</td>
<td>71.4 BTUS/HR FT²</td>
</tr>
<tr>
<td>NOM.</td>
<td>440</td>
<td>167</td>
<td>67</td>
<td>28.6</td>
</tr>
<tr>
<td>MIN.</td>
<td>425</td>
<td>136</td>
<td>61</td>
<td>0</td>
</tr>
</tbody>
</table>

• DOOR OPEN TIME - 0-40 MIN./REV. CUMULATIVE TIME 250 MIN./DAY.

• TARGET DENSITY
  - NON-OPERATING: 0
  - MINIMUM OPERATING: 0.5 TARGETS/MIN.
  - MAXIMUM OPERATING: 4.0 TARGETS/MIN.
  - NOMINAL: 1.6 TARGETS/MIN.

IMPACTS TORQUER HEAT DISSIPATION - HEAT DISSIPATION DURING SLEWING MANEUVER ~ 100\% THAT DURING TRACKING MANEUVER.

• TRANSLATION THRUSTER FIRING
  - ON-ORBIT - MAX. DURATION 900 SEC.
  - NOM. DURATION 205 SEC.
  - HIGH TEMPERATURE PROB.
  - FORCES COATING SELECTION
     CREATES CONTAMINATION PROBLEM.

• GYRO MOUNTING SURFACE - MAINTAIN BETWEEN 0-100°F
• READY TIME - AFTER LIFTOFF

10 HRS. PER CE1 SPEC.
• SYSTEM THERMAL REQUIREMENTS

• BEARINGS -

INCREASING OR DECREASING THE TEMPERATURE FROM THE ASS'Y TEMP. INCREASES THE BEARING PRELOAD

TEMPERATURE GRADIENTS ON BEARINGS WILL RESULT IN AN INCREASE IN PRELOAD OR A DECREASE DEPENDING ON THE DIRECTION OF THE GRADIENT.

CURVES SHOWN GIVE PERMISSABLE RANGE OF TEMPERATURE GRADIENT WITH CHANGES IN THE AVERAGE BEARING ASS'Y TEMP.

• THERMAL/OPTICAL CONSTRAINTS.

SCANNER - ERROR BUDGET
SURFACE DISTORTION - PEAK TO VALLEY - 0.56 μin.

SENSITIVITY COEFF. (THEO.),
AMBIENT VAR. - .0007 μin./°F
RADIAL GRADIENTS - .009 μin./°F
AXIAL GRADIENTS - .316 μin./°F
POTTING GAP GRAD. - .01125 μin./°F.
**FIXED FOLD ERROR BUDGET**

Surface Distortion - .24 μin. Peck to Valley

Sensitivity Coeff. (Theor.):
- Amb. Var. - .0007 μin./°F
- Rad. Grad. - .009 μin./°F
- Axial Grad. - .3/6 μin./°F
- Potting Gap Grad. - .0125 μin./°F

**OBJECTIVE WINDOW ERROR BUDGET.**
Surf. Dist. - 1.04 μin. Peak to Valley

Sensitivity Coefficients:
- Radial Grad. - 1.348 μin./°F
- Axial Grad. - .00012 μin./°F
- Pressure Difference - .0004 μin./Psi

**TELESCOPE THERMAL REQUIREMENTS.**
- Objective Ambient Var. ± 12°F
- Axial Gradient ± 3°F
- Circumferential Grad. ± 7°F

Radial Gradients -
- Objective Window -
  - Element #1 10°F
  - Element #2 10°F
THERMAL DESIGN CONCEPTS

EXTERNAL ASS'Y - SCANNER

- Passive - Partially Insulated Shroud. Heaters to maintain scanner ass'y above minimum temp.
  White coating on shroud. Possible patchwork on yoke and other select areas of scanner ass'y.

- Active - (BAS) - Big Aperture Shutter. Totally insulated shroud. White coating on shroud. Possible patchwork on yoke and other areas. Umbra cooling.
  Partially insulated shroud using BAS concept.

INTERNAL ASS'Y - TELESCOPE

- Passive - Low Emittance Shell.
  - Insulated Shims.
  - Heaters on objective lens cell & fixed fold mount.

OTHER CONCEPTS EXAMINED

- Coolant loop built into telescope

![Diagram of a telescope system with a coolant loop and regenerative heat exchange.]
- Low emittance coating on objective window.

- Increase wall thickness of telescope.

- Provide forced air circulation around telescope.

- Heat telescope to uniform temperature.

**Analytical Conclusions**

**Scanner Ass'y** -

- **Passive Design** - Scanner ass'y temp. varies between -30°F to +125-130°F (Q/P = .125/1.125).

- **Use of Heaters to Increase Minimum Temp.** Potentially could create larger gradients in scan mirror and in bearings.

- **Optical Error Budget Exceeded.**
  - .725 mm in - .56 allowable.

- In order to achieve req. pitch and roll torque values, scanner must be maintained between 50°F-90°F.

- ≈20 watts max. req. to maintain scanner ass'y above 50°F at cold cond. ( Assumes heaters mounted on scanner ).
$Q_{HTT2} = \varepsilon_1 \varepsilon_2 A_1 \left[ \alpha T_1^4 (\varepsilon_2 A_2 F_{23} + \varepsilon_2 A_2 F_{25}) - \varepsilon_3 A_2 F_{23} 0 T_3^4 
- \varepsilon_2 A_2 E - \alpha_5 A_2 \bar{A} \right] \
\div \varepsilon_1 \varepsilon_2 A_1 + \varepsilon_2 \varepsilon_3 A_2 F_{23} + \varepsilon_2 A_2 F_{25}$

**Note:** Assumes insulated portion of shroud acts as an adiabatic wall.
BEARING GRADIENTS - WORST CASE -

ROLL TORQUER -
  INBOARD - 10°F
  OUTBOARD - 10°F

PITCH MOTOR - 18°F.

ADDITIONAL WORK REQ. TO OPTIMIZE BOTH TEMP. LEVEL & TEMP. GRAD.

BAS-

SCANNER ASS'Y TEMP. VARIES BETWEEN 47°F TO 62-90°

OPTICAL ERROR BUDGET MET - .530 VS. .56 ALLOWABLE

BEARING GRADIENTS - WORST CASE

ROLL TORQUER -
  INBOARD - 5.0°F
  OUTBOARD - 2.5°F

PITCH MOTOR - 5.0°F.
OBJECTIVE LENS CELL.

- Use of thin film gold coating (ε ≈ 0.1) yields radial gradients < 1°F.
- Transmittance is marginal. 25% req.
- Proposed sol'n consists of HTG lens cell to even out temp. cycling. (Est. pic power ≈ 3 watts). Also heat fixed fold mount to match lens cell temp. (Est. pic power ≈ 10w).
- Heating telescope to eliminate axial gradients aggravates the radial gradient problem in the obj. window & lens cell.

<table>
<thead>
<tr>
<th>Grad. W.</th>
<th>W/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT25</td>
<td>HT25</td>
</tr>
<tr>
<td>Obj. Window</td>
<td>3.5</td>
</tr>
<tr>
<td>Ele. # 1</td>
<td>3.5</td>
</tr>
<tr>
<td>Ele. # 2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

TELESCOPE

Amb. Var. \{ +18°F, -10°F \} \{ +9, -8 \}

Axial Grad 3°F 11.2
Circ. Grad 1.5°F 1.5

Reticle/Scene Defocus . . 1.3 diopters.
G.E./MDAC Thermal Interface Model.
PRESSURE WALL TEMP. AT PENETRATION FITTING

TEMPERATURE, °F

TIME, HRS.

MAX. TEMP.

57 MIN. TEMP.