## STS-4 GNC Postflight Report

The enclosed STS-4 ENC postflight report is limited in scope to analysis of systems anomalies and discussion of topics which we believe need attention.

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1.1 TACAN

1.1.1 Preflight Self-Test - during the L-1 day crew briefing, we were informed of a number of TACAN anomalies which were discovered during nav aid self-test (L-72 hrs).

a. Following a successful self-test, TACAN #1 failed to lock onto the KSC TACAN station 059% when its rotary switch was returned from the GPC to the T/R position. A repeat of this operation, including another self-test, resulted in a successful lock onto 059%. This procedure was repeated 10 times in an attempt to duplicate the anomaly, but with no success. There is, as yet, no explanation for this anomaly; however, E&D personnel feel that the LRU was not at fault, in as much as it exhibited normal search characteristics during the anomalous period and subsequently behaved normally during further testing. This would suggest that the LRU never received a command to search for 059%, although telemetry suggested otherwise. In the VAB a spectrum analyzes could have determined what frequency the TACAN was outputting, but unfortunately this was not feasible on the pad. (IPR 4V-535 was written against this unit).

. b. Duirng one of the ten subsequent self-tests, the T/R bit in the control word dropped to the "O" state when moding from T/R to GPC with TACAN #1 rotary switch. This condition was duplicatable by slowly rotating from T/R to GPC, much slower than normal rotation rate. The following explanation suggests this is not an anomaly, but rather an unlikely condition, and one that has no impact to system operation. Where in the GPC position the MDM will command the TACAN to the word coming from the GPC (completely disregards the current control panel inputs). However, if the SOP is inactive and no new command word is coming from the GPC (which is the condition we were in), then the MDM will revert back to the last command it had received from the control panel (just prior to receiving the GPC position indication). In the case where the rotary slowly moves from T/R to GPC position, it is possible that the  $\pm 5V$  signal representing T/R could drop to a "O" state (detectable by the MDM) before the GPC position indication is sensed by the MDM, thus representing the receive position. This situation has no real impact to the TACAN system operation since the T/R bit will return to the "1" state when the TACAN SOP becomes active.

c. Duirng another of the 10 self-tests, TACAN #2 range output a value of 296.14 NM, where an acceptable value is between "0.0 and 0.5 NM." This anomaly did not repeat itself on any of the subsequent tests. E&D has suggested the following scenario, which might have created this condition, but would be near impossible to duplicate statistically. Bearing data is updated within the TACAN output buffer on a cyclic basis; however, range data is updated only after a change in computed range of greater than 0.05 NM. If the first value range (following the random search value of 296.14 NM) of data reached the output buffer a few micro-seconds behind a bearing update, it is possible that no range update took place. And if subsequent data out of the range computation circuitry remained within 0.05 NM of the previous valid range output, then no attempt to further update the output buffer would occur, thus freezing the range test value at 296.14 NM. This condition has never been recorded as a self-test anomaly (within our failure history reports), representing an obviously rare, however feasible situation. (IPR 4V-539 was written against this unit).

Bearing Oscillation - following many hours of lock-on to the channel 1.1.2 059Y KSC ground station (approximately 24 hrs), TACAN #2 bearing began to exhibit random fluctuation around the correct value. KSC explained this phenomenon as the effects of tanking operations in the vicinity of the TACAN #2 antenna, causing multipath problems. However, a few hours later this fluctuation became cyclic, repeating every 7-8 seconds, with a total variation of approximately  $\pm 20$  degrees. We recommended a special TACAN self-test, but KSC disagreed, as their criteria for an acceptable LRU (Successful self-test at L-72 hrs and subsequent power status) was not being violated. A plot of bearing data during the 70 seconds of ascent lock-on suggests that the oscillations were present and would very likely have been declared failed by RM, had it been active during that period. Although KSC insisted this phenomenon is similar to data seen on previous missions (multipath effects due to environmental conditions, structural reflections, etc.), both E&D and the TACAN vendor are of the opinion that an anomaly existed. E&D will recommend removal of TACAN #2 for test and analysis, although no failure reports were generated by KSC. Subsequent operation of this unit during the flight (including self-test, on-orbit tracking, and entry) showed no evidence of the preflight anomaly, albeit the longest period of operation did not exceed 5-6 hrs.

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FOD STS PROBLEM ENTRY FORM (PAGE 1) DATE FILED NC. STS 06127182 CLOSED \_ \_ \_ \_ \_ VEHICLE( 7) DISCIPLINE( 10) REV\_\_\_\_ 11SS10N(3) GNC/SNSRS 01-102 STS - 004 1-4 MAJOR COMPONENT( 15) SUBSYSTEM( 20) GNAC TACAN SERIAL NUMBER(20) S/N 34 MINOR COMPONENT( 15) \_ ERD- DON RHOADES ED LIEBMAN CONTACT: FOD- -MAILCODE/PHONE \_CF6/5595 OTHER-RIC- -MAILCODE/PHONE PROBLEM IDENT: FAIL MODE( 12) CAUSE( 8) CYCLIC DATP HDW GMT RECOGNIZED GMT OCCURRED MISSION PHASE( 12) ~178:10:00:00 178:10:20:00 PRE-LAUNCH PROBLEM DESCRIPTION: (1092) : 059 Follows 111 tota 3 6.1.4

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1.2 IMU 3 Cage Fail - the azimuth gimbal of IMU 3 did not drive to the zero position in response to the operate command. Preflight alignment performance was normal. It was determined that all of the possible failure points that would produce a cage fail, but permit preflight align would not affect operation of the IMU. Unless testing planned by E&D and KSC to locate the failure turns up new concern for significantly increased risk of further related failures affecting operation, we recommend flying this IMU again as is.

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DAP Auto PBI Contact RM Fail - the forward, orbital DAP, auto control mode PBI (panel C3A6, switch 3) contact A (V72K2840X) failed RM while the crew was expanding from a single G2 GPC to a dual G2 GPC redundant set. The PBI was depressed and held during the expansion when the crewman's finger slipped such that there was uneven pressure exerted on the PBI without the switch being fully released or depressed. As a result, the B and C switch contacts were closed while the A contact remained open and caused a miscompare for 3 consecutive cycles (6.25 Hz) of orbit switch FDI processing. The FAIL discrete for contact A (V90X7814X) (figure 1.3.1) was set and the contact was deselected by RM. Subsequently, the PBI was checked by the crew by depressing the switch and observing, on the ground, the A, B, and C contacts close then open when the switch was released. This indicated there was no actual hardware failure only a transient signal type failure, which caused RM deselection of the contact due to insufficient contact closure.

The PBI's have a small amount of mechanical play in the socket which makes it difficult to protect RM from this failure mode. Switch FDI can be inhibited via the RM switch spec function but this will cause loss of protection if there is an actual hardware failure. A memory read/write can be done to reset the logic and make the contact available to RM again, but the potential impact here is well known.

This RM failure was the result of the physically awkward procedure of holding depressed all 3 DAP mode PBI's while expanding the GPC set. Simultaneously holding depressed multiple PBI's greatly increases the probability that at least one will be relaxed enough to break one or two sets of contacts for the one-half second required to trip RM. The purpose of this procedure is to prevent erroneous PRCS jet fails from occurring because of upmoding to NORM during the GPC reconfiguration. It is necessary to hold depressed only the VERN PBI to accomplish this. In this case the SELECT and CONTROL modes were already selected to the upmode position, but even if this were in different positions these controls can be reconfigured after the GPC set expansion/collapse is completed.

We recommend that crews be specifically trained to apply this procedure to the VERN PBI only and to hold it firmly depressed.

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#### 2.0 IMU Performance

#### 2.1 Discrepencies in Star Align Data

Introduction - During the first three flights, we observed that the star alignment data, namely the misalignment angles for each IMU axis, varied as the star pair on which they were based varied. This was most notably observed on STS-3, but has also been seen on STS-1 and STS-2.

Description of the Problem - If the star alignment system was perfect, the IMU misalignment angles (torquing angles) would be exactly the same for different star pairs (which means different vehicle attitudes), discounting the effects of platform drift. The phenomena observed on STS-3 demonstrated that our system is certainly less than perfect, and occasionally outside of the 3 or spec performance limits. On STS-3, the thermal attitudes flown allowed the star trackers to sweep large portions of the sky and acquire many stars of opportunity. Torquing angles generated by a star pair were computed by the onboard software. As the vehicle continued to rotate, a new star pair was acquired and new torquing angles were generated. Even though these sets of data were computed only a few minutes apart, the variation between the two angles for a given axis was as large as .09 deg. The 10 specification for the process of measuring the torquing angles is .02 deg. If we assume errors on both measurements, then the 30 spec would be .075 deg.

STS-4 Performance - Unfortunately, the attitudes flown during STS-4 were not favorable for the acquisition of stars of opportunity; therefore, we don't have the data base we had on STS-3. In addition to the unfavorable attitudes, we were also hamstrung by the star tracker's shutters being latched shut by the target suppress bit in the tracker. The attitudes being flown on STS-5 look more favorable for stars of opportunity and the target suppress bit should no longer be a problem because of a software change.

Conclusion and Recommendations - Although there is a wide disparity of opinion concerning the variations in torquing angles. We believe that they are caused by errors in the IMU resolver reads of the gimbal angles. This is substantiated by the enclosed plots which show a sinusoidal behavior of the IMU attitude differences (figures 2.1.1, 2.1.2, 2.1.3) during a period on STS-2 where the vehicle was flying a -ZLV attitude. The period of the oscillations match the orbital period (90 min), which says that as the gimbals rotate with the vehicle, a non-linear attitude is output by the IMUs. This type of behavior will cause the variations we see in the torquing angles. Also enclosed is 30 minutes of data (figure 2.1.4) during a PTC period of STS-4. Although there is not enough data to be conclusive, the same sinusoidal behavior is suggested. Because of these variations in torquing angles and the sinusoidal nature of the attitude outputs, we are considering a recommenation to E&D that the IMUs on OV-102 be tested in the JSC ISL lab. Since OV-102 will be down for mods, this will be an excellent opportunity to try to correlate ground testing with the type of behavior observed during the five flights.

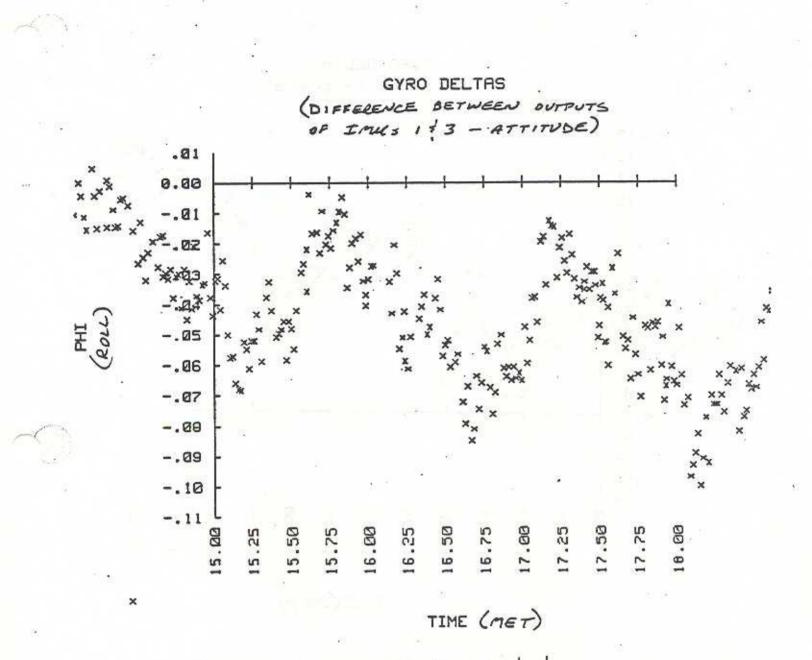
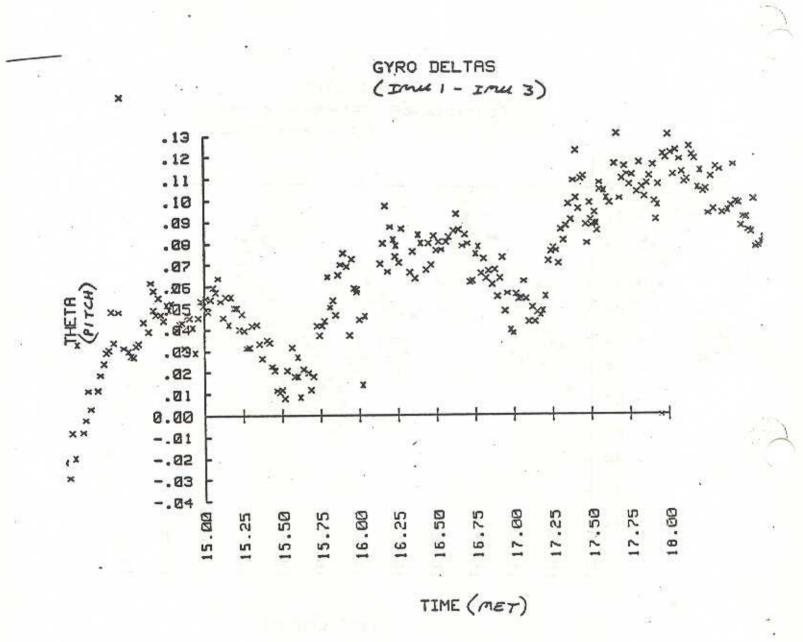
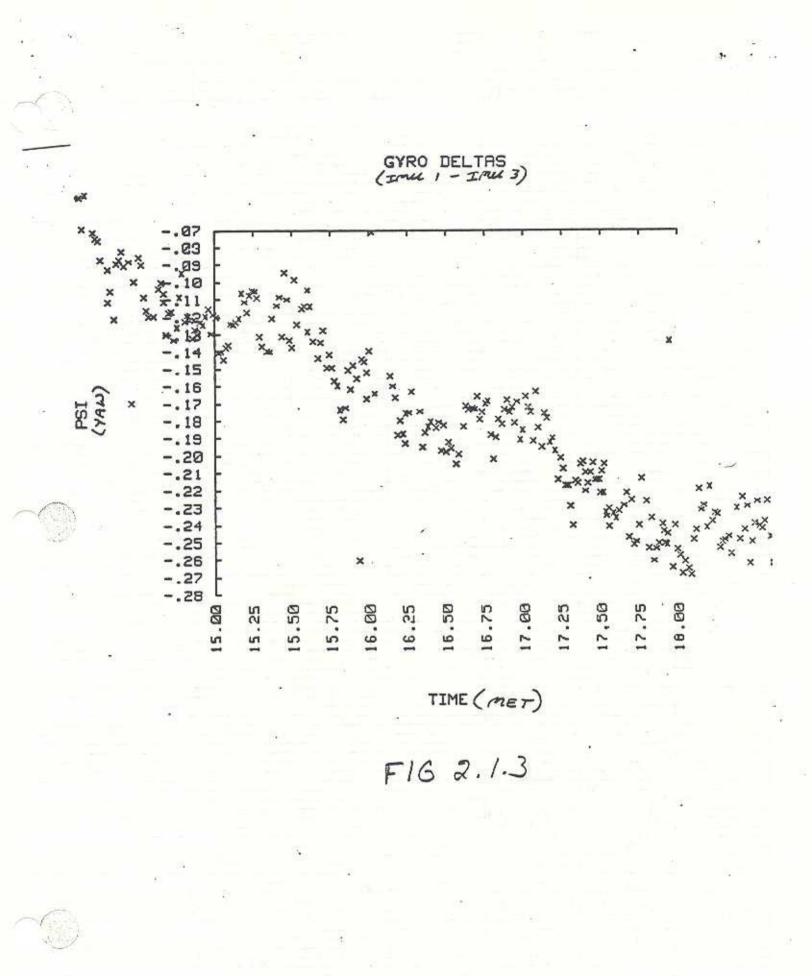


FIG 2.1.1

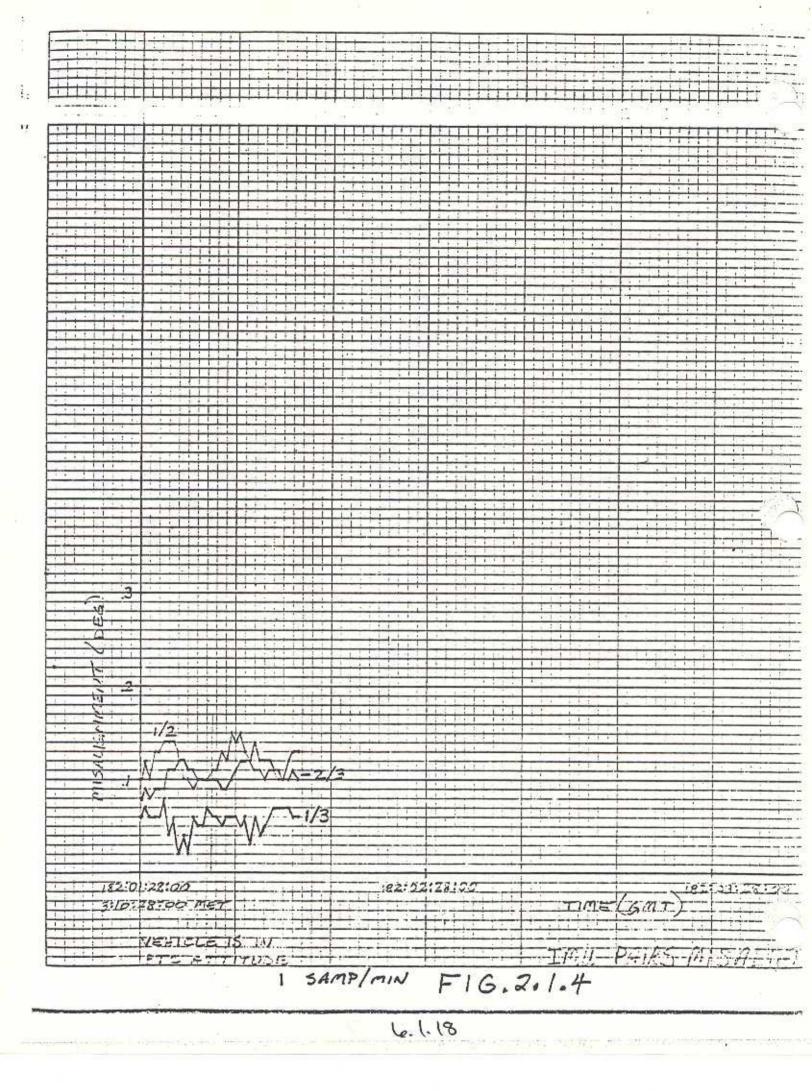
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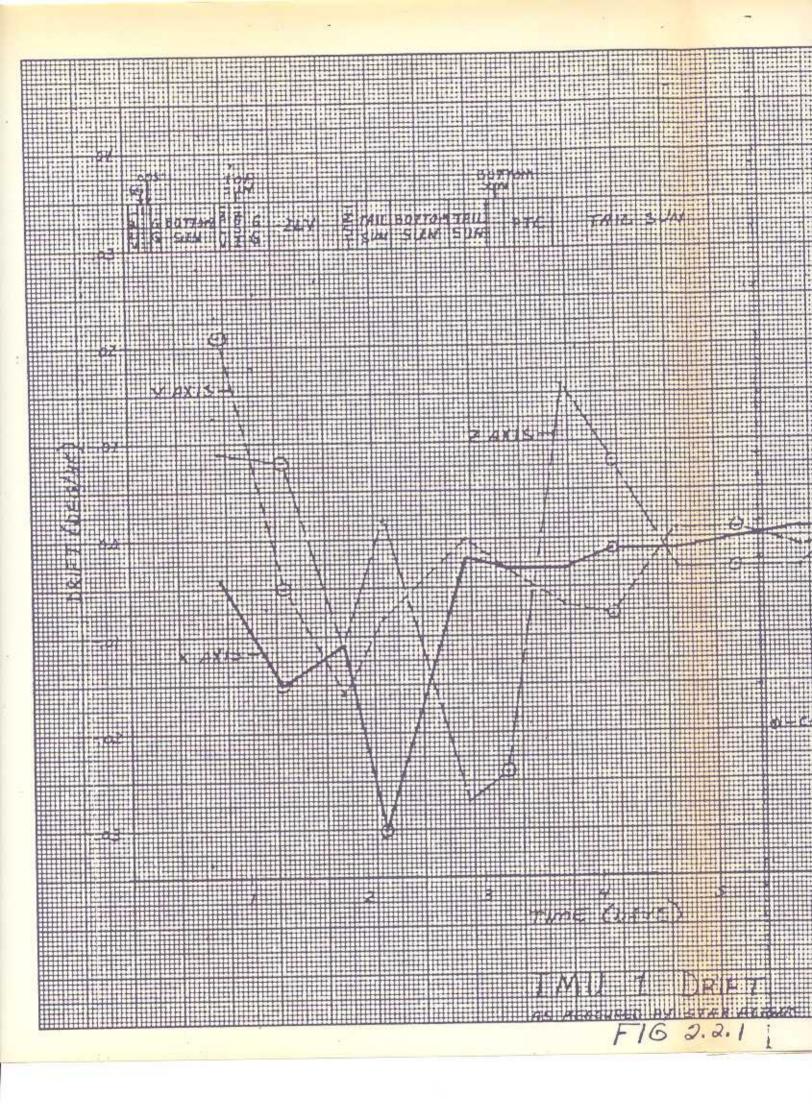
#### 2.2 Attitude Dependency of IMU Drifts

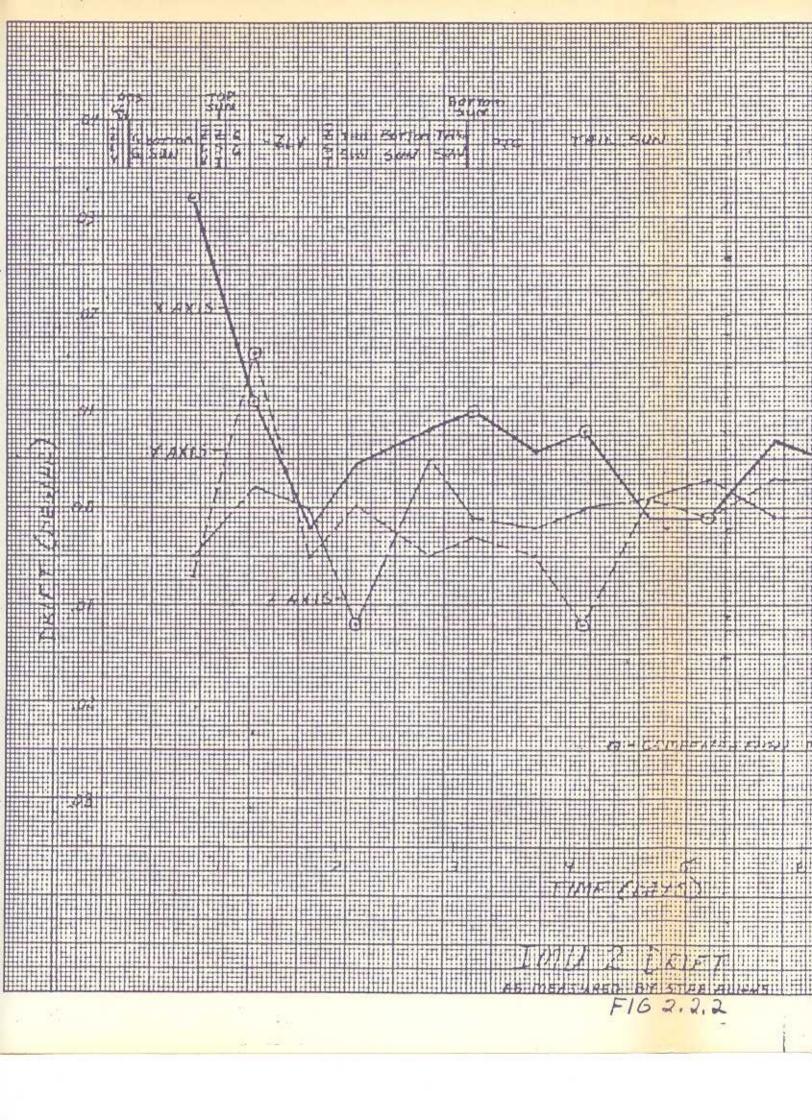
<u>Introduction</u> - During the first three flights we noted that the drift characteristics of the IMUs changed during the course of the flight. STS-1 and STS-2 were such short flights that we really could not draw any conclusions about the nature of the drift. On the subsequent flights, though, we were able to observe that as the predominant attitude of the Orbiter changed, so did the IMU drifts.

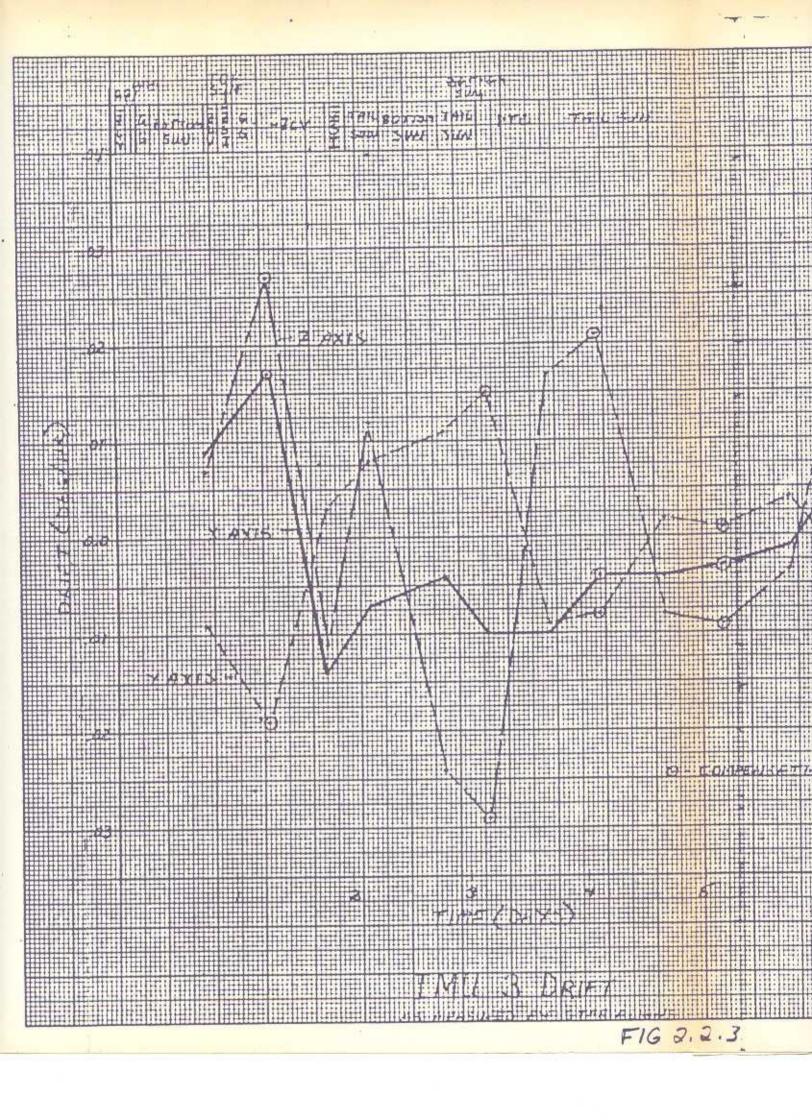
Description of the Problem - The on-orbit drift performance of the IMUs has been outstanding ( </ar) when the vehicle has flown in the same orientation for long periods of time. For example, on STS-3 when the vehicle flew the nose sun attitude for such a long period of time, we were able to calibrate the drift so well that we went 27 hours without an alignment. When we changed from the nose sun attitude to the top sun attitude, though, almost every axis of the 3 IMUs required compensation to negate the new drifts. IMU 3Z was most susceptible to this "orientation sensitivity," the magnitude of the drift change being .06 deg/hr.

<u>STS-4 Performance</u> - As shown on the enclosed plots (figures 2.2.1, 2.2.2, 2.2.3), the measured IMU drift did vary and several updates were necessary to maintain the drift at a less than 1° level. IMU 1 Z shifted by .03 deg/hr when the attitude changed from a tail sun to bottom sun attitude in the 2-3 day MET time period. During this same period IMU 3 Z shifted by .04 deg/hr. These two shifts were the largest observed, although several other smaller attitude dependent shifts were observed. During the long tail sun period, the IMU drifts were extremely small, once again showing that the drift performance is excellent when the vehicle stays in a given attitude for an extended period.

<u>Conclusions and Recommendations</u> - The IMUs do demonstrate an orientation sensitivity which can cause drift changes as high as  $3\sigma$  (.06 deg/hr/axis). These changes necessitate continual monitoring of IMU drifts and many gyro bias compensation updates per flight. Given some dedicated ground testing, this orientation sensitivity could be measured and compensated for in the software. To this end, we are again considering this problem as part of the justification for testing them here at JSC. We are hoping to understand the significance of this orientation sensitivity and we also hope to determine its repeatability/predictability.







#### 2.3 Onboard Navigation Errors at MECO

<u>Introduction</u> - On the first three flights, the navigation state has been biased in the negative crossrange position direction at MECO. On flights 1 and 2 this was thought to be due to an I-load error which affected the IMU azimuth alignment accuracy. This situation was corrected on STS-3 such that the azimuth alignment done in preflight was felt to be near perfect. The same crossrange errors occurred on STS-3, however, so the I-load correction was not the only error source.

Description of the Problem - The accuracy with which the azimuth axis of the IMUs can be aligned is directly correlated to the accuracy of of the crosstrack position component of the nav state. When the azimuth alignment is thought to be near perfect and a nav state error is still present, one has to suspect other platform errors. Since the sensed velocity vector (which is fed to nav) is selected on a component by component basis (i.e., it could be that an axis from each IMU is used), it is unlikely that a random error source would produce the same errors on all flights. The thinking has been, however, that IMU drifts on the pad were a random process. But with three flights of data showing a bias in the same direction in nav, we started to question the randomness of the preflight drift about the Up axis.

Figures 2.3.1 through 2.3.18 are plots of the position and velocity errors for STS-2 and STS-3. The plots show the nav errors for the downrange (U), vertical (V), and crossrange (W) positions and the corresponding velocity errors.

STS-4 Performance - We would like to report that STS-4 showed a different signature than the first three flights, but that is not the case. The position and velocity errors during ascent looked identical to the errors on the first three flights, as shown in the enclosures.

<u>Conclusions and Recommendations</u> - The nav state errors are apparently due to a drift about the Up axis on all three IMUs. We realized that the platforms would drift about Up since we can't calibrate that axis as well, but we felt the drift would be random. The data from the first four flights appears to indicate that the platforms drift in the same direction and at roughly the same rate each flight. We are assessing the performance impact of this error.

A CR has been submitted which will allow an I-loaded number to be used as compensation for Up axis drift during the time from T-20 min to T-12 sec (tuned inertial mode of the IMUs). If the CR is approved, the vendor would have to provide the number for this I-load which would mean further factory calibration and therefore more cost. The Up axis drift is much larger than the drifts on the other axis and therefore is our major source of error in preflight. To eliminate the nav errors and increase the allowable hold time on the pad, this CR should be approved.

#### 3.0 Gravity Gradient

- Performance Attempts to establish a gravity gradient attitude were 3.1 initiated on two separate occasions. The first gravity gradient period was at 178:20:41:00 on the first day of the fourth mission. The second gravity gradient period was at 179:16:23:00 of the second day. The general guidelines for the establishment of gravity gradient are that the crew must release the Orbiter with as small a rate of movement as possible. Additionally, excessive movements within the vehicle by the crew or venting of any type during the period is prohibited. The general Orbiter attitude to accomplish gravity gradient is with its nose pointed to the center of the earth and its +Z axis pointed generally toward the velocity vector. Violations of these general guidelines can prevent establishment of a successful gravity gradient equilbrium. Below are the gravity gradient period results and a synoposis of the data gathering procedures.
- 3.1.1 Day One The day one gravity gradient (gg) test was started at 178:20:41:00 at a pitch, yaw, omicron of 357.51, 0.97, and 249.18 degrees respectively. This test was unsuccessful. There were unknown forces much greater than gravity gradient forces acting on the vehicle and all three axes were divergent. The initial attempt was terminated at 178:21:10:00 with maximum attitude errors in roll, pitch, yaw of 117 degres, -13.6 degrees, and 18.9 degrees respectively. The maximum rate errors seen in roll, pitch, yaw were -0.196 degree/sec., 0.055 degree/sec., and 0.085 degree/sec respectively. (See figures 3.1, 3.2, 3.3).

A restart of gg was performed at 178:21:29:00 with a change in omicron to 244 degrees and leaving pitch and yaw the same at 357.51 and 0.97 respectively. The omicron change was based on the orbit being 161 n miles versus 165 n miles. This attempt was somewhat more stable in pitch and yaw for the first 50 minutes before the same magnitude of force caused a divergent condition. Roll on this second attempt still was not acting stable as it had drifted off 40 degrees in the first 50 minutes before the divergent condition was apparent. This second attempt was terminated at 178:22:42:00 with maximum attitude errors in roll, pitch, yaw of 262 degrees, 4.6 degrees, and -20.7 degrees respectively. The maximum rate error seen in roll, pitch, yaw were -0.279 degrees/sec., -0.087 degrees/sec., and 0.099 degrees/sec., (see figures 3.4, 3.5, 3.6).

There was an apparent correlation between the force acting upon the Orbiter and the sunlight striking the vehicle. The first attempt to establish gravity gradient was started at sunrise and was immediately divergent. The second attempt was started at sunset with less divergence noted through the night pass. However, at sunrise the Orbiter diverge immedidately (see figure 3.7, 3.8). At this point there was a suspected vent occuring on the vehicle which became more active as the vehicle entered sunlight. Venting of any sort violates the general guidelines for establishing gravity gradient equilibrium. The DAP errors were monitored throughout the sleep period with the same correlation noted between a venting force and sunlight. Attempts to isolate the location of the venting force were undertaken. It seems that the venting force provided a roll torque of approximately 1.76 ft/lbs, and was located in a plane through the center of gravity containing a body vector pitch of 13  $\pm$  10 degrees and a yaw of 76  $\pm$  10 degrees. The approximate location of the venting force would be located near the center of gravity in the

payload bay. At no time during the planning phase of this mission was there any indication of a venting problem originating from this location.

- 3.1.2 Day Two The day two gg test was changed from 12 hours period to a 5½ hour test late in the day. The large unknown forces appeared to have become significantly smaller. The gg test was started at 179:16:23:00 at a pitch, yaw, omicron of 357.51, 0.97, and 245 degrees respectively. This test can be considered successful with a stable gg attitude biased off slightly in the negative error direction. The maximum attitude errors seen in roll, pitch, yaw were -25.19, -3.33, and -7.93 degrees respectively. The period of oscillations was 56 minutes in pitch and yaw and 109 minutes in roll. Looking primarily at the roll axis, the first 2 hours of data is under the influence of the gg release conditions. After 2 hours, roll appears to be stabilizing around a new reference point (-4 degree error), but there is only 1½ cycles of data on which to make that conclusion. Both pitch and yaw look stable around slightly negative errors of -0.5 and -1.5 degrees respectively. Using these errors a new gg start attitude was determined to be pitch, yaw, omicron of 357.58, 1.14 and 249 degrees respectively (see figures 3.9, 3.10, 3.11).
- 3.1.3 Ground Evaluation Procedure The following is a discussion of the procedures utilized to obtain and plot the gravity gradient data for analysis. The team which performed this task consisted of 3 people per shift plus 1 overall gravity gradient monitor. The console representative hardcopied MSK 2023, universal digital display, which had 10 data parameters on it consisting of total attitude errors, ADI rates, LVLH attitudes for roll, pitch, and yaw, and onboard GMT. Hardcopies were taken realtime and from playback data at 1 minute intervals. The console representative kept a log of the time interval. when data was hardcopied. Coordination with the Data Integrator was initiated, if any time intervals were missing. The other two individuals retreaved the hardcopies, placed them in chronological order, ploted the total attitude erros and ADI rate information for each 4 minute interval, and coordinated with the console operator on missing data. The gravity gradient monitor insured that status reports, copies of plots, and any other information requests were provided as required. This procedure seemed to work smoothly; however, there were instances where information did not reach the correct source in a timely manner.
- 3.1.4 <u>Summary</u> The day one gravity gradient period was unsuccessful due to an unknown vent originating from the payload bay area. Two attempts to start gravity gradient were made during the day one period. Both attempts were unsuccessful. The first attempt lasted 29 minutes before it was terminated because the total roll attitude error was 117 degrees. The second attempt was for 73 minutes and the total roll attitude error reached 262 degrees. The unknown vent experienced during day one was not as evident during the shortened day two gravity gradient period. Gravity gradient was started during day two and was not divergent. The maximum roll error was 25.19 degrees. The conclusion can be made that, if the general guidelines for establishment of gravity gradient are followed; i.e., no vents allowed, a stable gravity gradient attitude can be established

using vernier RCS while in a circular orbit.

### 3.2 Recommendations

1. Gravity gradient periods less then 3 hours are not adequate for data gathering efforts.

2. Gravity gradient needs to be proven ! using the primary RCS system.

3. Gravity gradient for elliptical orbits needs to be tested for its effects on the Orbiter.

4. It is critical that all vents be known and deleted prior to any gravity gradient period.

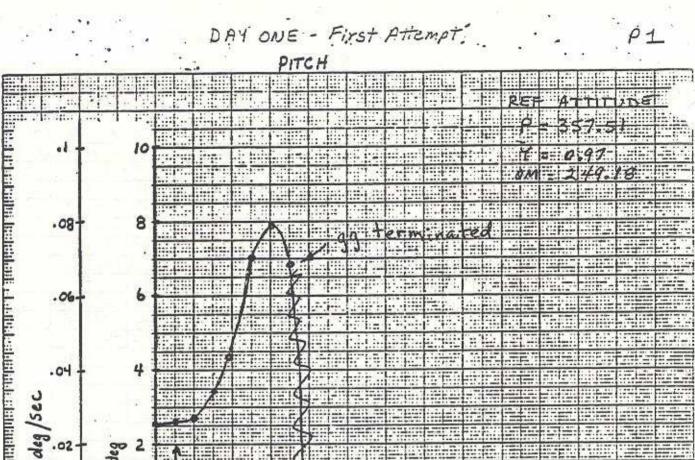
5. The gravity gradient data gathering team can be decreased from 3 to 2 individuals--a console representative and a plotter.

6.. Hardcopies should only be taken at the beginning and end of a real time pass or playback interval plus only at 5 minute intervals in between.

7. Plotted data should be at 5 to 10 minute intervals except at maximum/ minimum points where the interval should be increased.

8. Offices to receive gravity gradient results during the mission should be better defined so that timely and correct distribution of gravity gradient material can be made.

DAY ONE - First attempt. ROLL .026 26 6 ilen. •ii.liin 6.1 : i. REHAT LDET 1. 1. 3 11.03 .... T .024 24 el= 14-1 -1 Ret. Hirt. :: |: 1 .... r HELL 1. 1..... .... 1 4 1 357-15 F..... :ł:., 14 11 - VI = 0.97 in the l 1.11 : .::: 1. 1 11 ....... .022 22 is'y .htm in the OM = 249 18 . trade .... 11 H-feeli ..... ..... 11-17-1 ..... - 111-1 .... H. 1 ------. 020 20 like dat. da. .... in the ..... 36 ..... 11. 19 I. ·...... · · · · · · · 7 Her.) ..... : ..... ..... 1 .018 18 11 \*\*\*\* Liquin 1: 1: Test ...... ...... 1.1.1.1 ...... dilleril ...... din: L. ..... 1.:.... ---------.016 160 hµi. Hi Pak :::**:**::: **Haller** (1. 5. 6 - Fiin ..... F. 1. .... antes. · ... 1994. Las li tita 1100 1.128 .014 140 11 6014 ..... i dell' ..... -----E. ..... ·† :... ..... 4.11 . - 1 11.11 Part . P. Think 3.944 ···· ··· ..... 1.... 1 1 ...... ..... . 012 120 M I II II III CHI CIPINIII the later. 11 ...... E1.1 1 ...... · · · · · · 1 14912 **m P** . : 100112 .010 100 . ..... Tr. 4. 11 ... 5.97 ". iz :: . . . - ister. 14.7 111 i · Headline in 1.1.1 1 21 1....1 -1.1 1.... 1 1-11 1..... . in. 13 .008 80 Hilling and the 1.1.1 . an Eth and in ..... bear at. .... 90 i Ellini 14.4. 182-6.88 tritte 14.11 .......... 2 Feil -h :+1 ..... . . .... dre 60 006 Inual I .... ...... 1. H. H. H. H. L. H. ..... 777 F. m .... e. Fra littlere birdror it if a feature in 1.1 intri THE 1 11 Rog 40 .004 iperstation for fre free ...... t sig: it. 1217 .... RA. 1011-01-08 ERI Per la la la .1 1.71. .002-20 12-16-16 aper la state **H**H **H** 1.1.1 - Harter . au r. inder die Palita heidele der . ROLL 2-1----1011 2 Their. ROLL · . . ------0 0 ...... 4646407 H4. WEADALC | ALEAALL. Dulland State Durk · · • • • • ..... 91.---arlini d h. .52\* -20 0 -. 002 31-10-10 4.... .alatti tanın LEASE REF. LOT 10.1.5 13% TFT 11.1 ..... 1.1.1 -40 .04 AND LONGING S OF THE MANAGEMENT -.004 0 11.77 [.+ TES dellais: \* THUR. .... - 13 -. 006-.CL And the V le altriget -t-anti-1.4 ..... aladi i politikatoria (n. papi (n. p \*\*. . t: \*\*. ! Piete la constante de la const -08 -80 P.008 2h., 1.1.1 - has been a lot to deal of the lot of the grade of the second second second second second second second second 11 .... 114 141 104.00 1 : 1: .. .... Partial. de la contra la constru--. 010 -- 10 -100 「日本」というの 1. ..... triant interit 100000.000 1. **The U** · . Hand Andrew Property and a second - 4--.012 + 7.12 -120 i. . i. 31... ÷ 1... 'n. Latter al a far 1.20 ----101.0 1 .... 1. . t' i 11 ..... -014 -.14 -140 i. : •f Contraine produced a second ----stal etta ( tee a 1. . in the first of th н 1.55 E - 174F . 1.1.1.1.1 -.016 - .16 -160 ub. an and date of 2 1 with induition of the -1...... .1....... LTL1.1217 1.1. · . 4: 1. j. . : ni hiti 1.1 and the first of t 1. ..... in the second second -.018 - . /8 -130 de te instituti en len hunder Ŀ. -.020 - .20 -20 . . . . 1.14 \$ .... ..... .... n.t. -+ 24 1 ----ii. -----..... terta. nilin' 1 1.... - **1** - <del>1</del> ..... willing 19.00 1.11 · · · · · little dariele's de bed is hitte h. h. 12.2047 de the state of the s --· ....... .024 -24 45 \$ 53 5" 01 05 07 13 G 2 (STOP) 178/20:41:00 GMT TART 6.1.46



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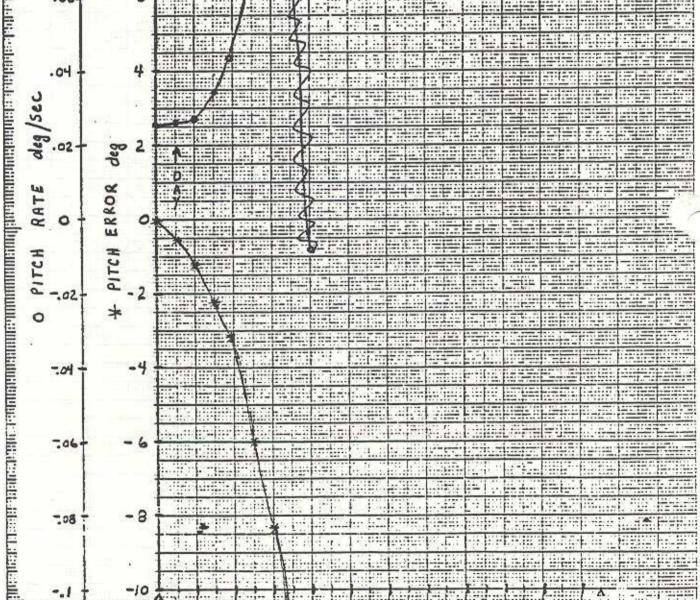
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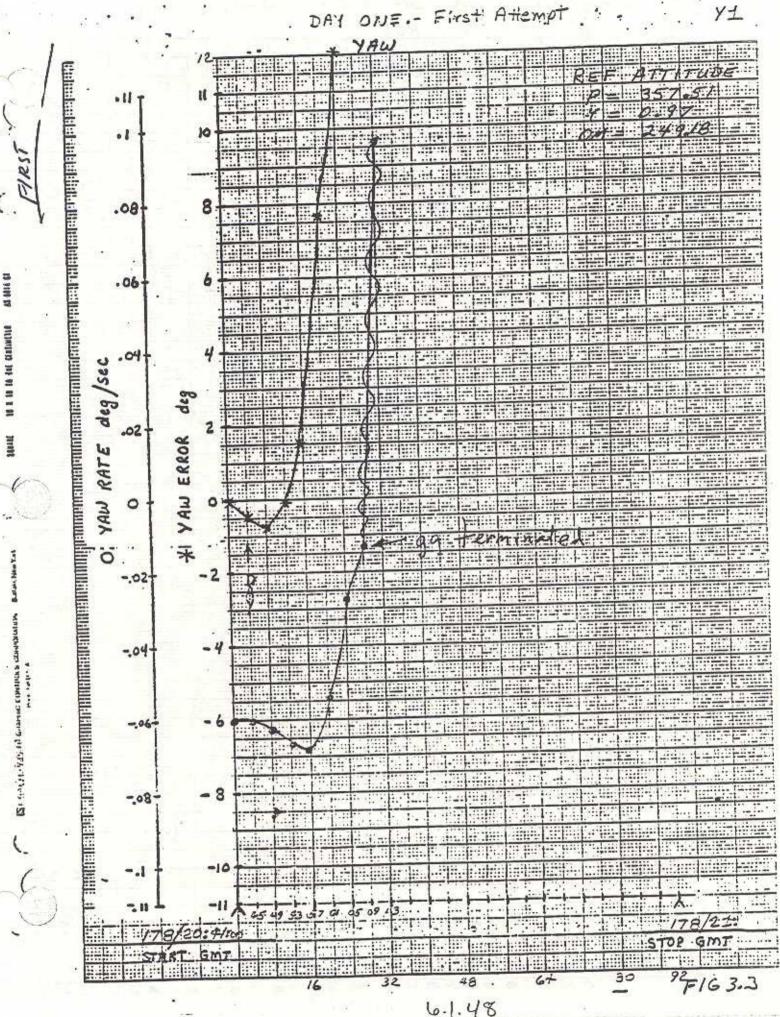
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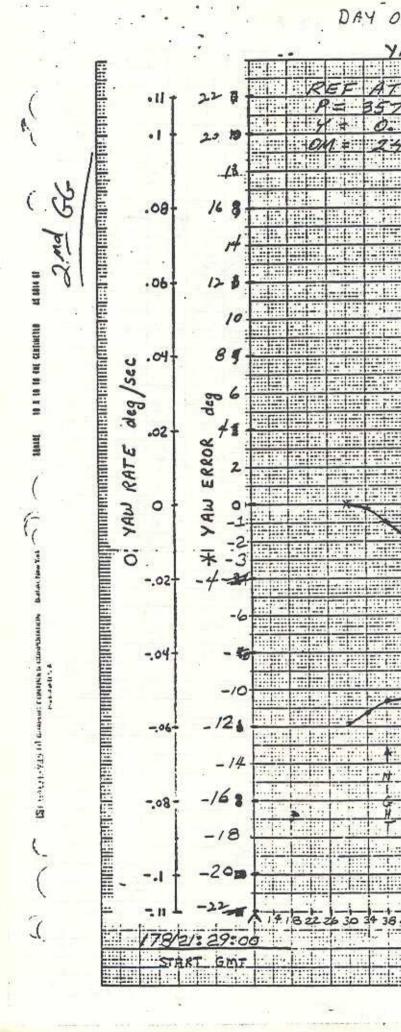
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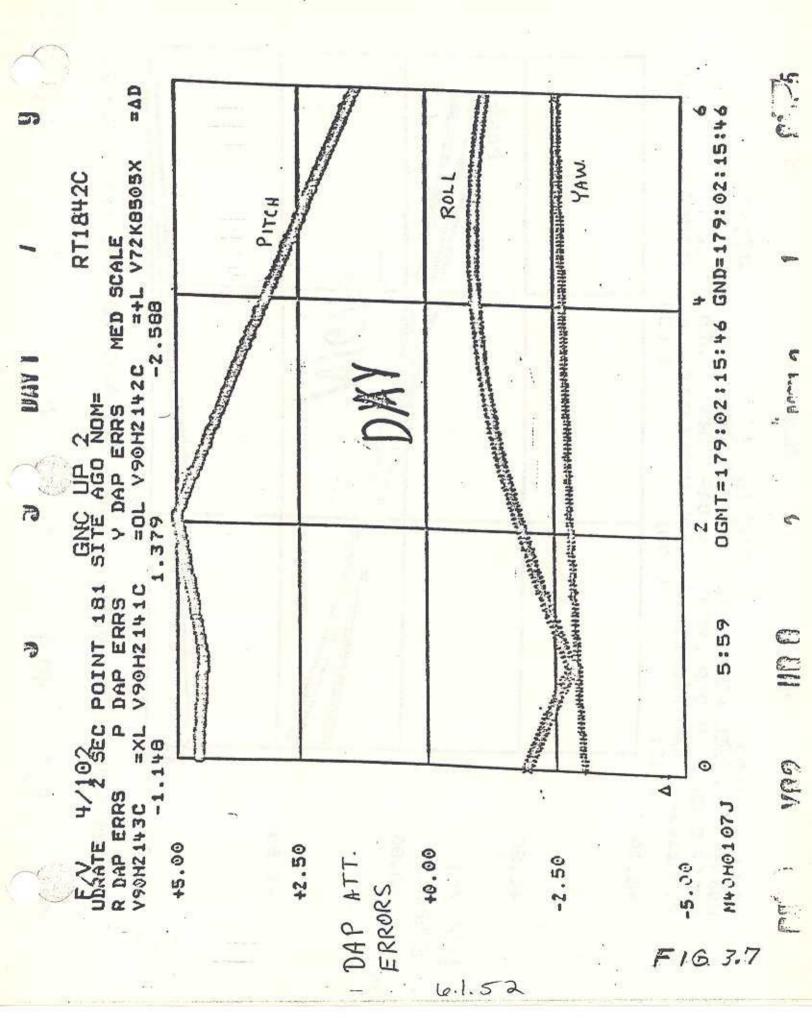
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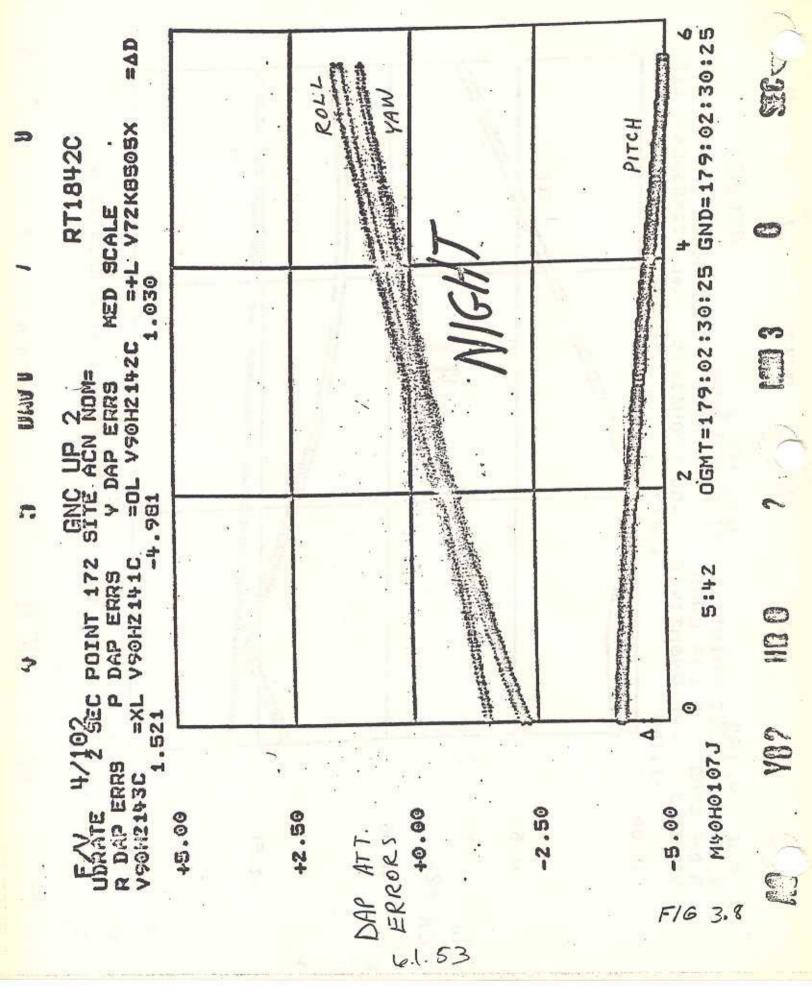
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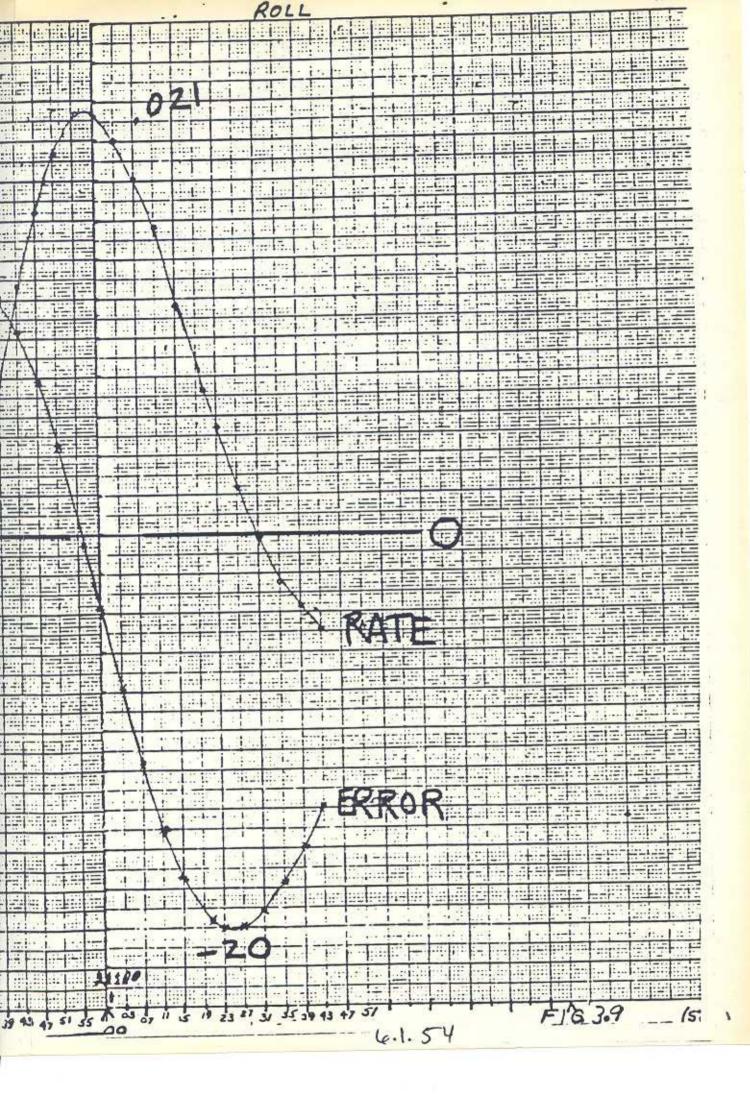
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	붱뼺뺘뺘듏相뉑썲볞랦뢨뿂귏놂뀰붱콎뭑썦꾿뉟놰슻렠얁곀뺘 뗿볢삨游뎦뿡 <b>퐼땩뜕볛</b> 뻝귾퐄귕쀪궳궒롐랻뚬봔릠泪泪웉뵹둗雪
	뗿몖뼈쁈뎝뿤难드뜕웲괕귾퐄귐놂챓웲몍귿훕뀰귐붱탥뮏끒 휭쨔몡꺥텬뤙쭨몡뎡쀻륟꺍캩껆꺌왥뭑듺뀰귐붱탥뮏끒쁙윩
	방법 김 김 왕의 연원 연원 전원 조망 김 영양 지원을 가지 않았다. 탄생 왕의 김 김 영양 분위를 한번 전쟁 문제를 통해할 것이 같은 것이 있는 것이 같은 것이 있는 것이 같은 것이 있는 것이 있다. 이 있는 것이 있 같이 있는 것이 있 같이 있는 것이 있 것이 있는 것이 있다. 이 있는 것이 있 것이 것이 있는 것이 있다. 것이 있는 것이 있는 것이 있는 것이 있는 것이 없다. 것이 없는 것이 없는 것이 없는 것이 없는 것이 없다. 것이 없는 것이 없는 것이 없는 것이 없는 것이 없다. 것이 없는 것이 없는 것이 없는 것이 없는 것이 있 것이 것이 것이 없는 것이 없는 것이 없는 것이 없는 것이 없는 것이 없다. 것이 없는 것이 없는 것이 없는 것이 없는 것이 있는 것이 없다. 것이 없는 것이 없는 것이 없는 것이 없다. 것이 없는 것이 없는 것이 없는 것이 없다. 것이 없는 것이 없는 것이 없다. 것이 것이 없는 것이 없는 것이 없다. 것이 없는 것이 없는 것이 없는 것이 없다. 것이 않은 것이 않은 것이 않은 것이 않이 않이 않이 않아? 것이 않는 것이 없다. 것이 않은 것이 않이 않이 않이 않이 않이 않이 않이 않아? 것이 않이 않이 않이 않이 않 않이 않이 않아? 것이 않아? 않이 것이 않아? 것이 않아? 것이 않아? 것이 않아? 것이 않아? 것이 있 않아? 것이 않아? 것이 않아? 것이 않아? 것이 않아? 것이 않아? 않아? 것이 않아? 것이 않아? 것이 않아? 않아? 것이 않아? 않아? 것이 않이 않 않 않이 않이 않이 않이 않아? 것이 않아? 않아? 않아? 것이 않이 않 않 않 않 않이 않이 않아? 않 않이 않
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## 4.0 DAP Performance

4.1 Introduction - The orbit DAP performed well the 6 days on-orbit. No software anomalies were noted. Some of the control parameters, namely maneuver rate and attitude deadband, caused an excessive amount of VRCS activity and prop usage. The resulting lengthy firings of L5D and R5D are probably the cause of tile damage located on the upper surface of the bodyflap. These control parameters should be changed (via crew input) for future flights as outlined in this report.

Also, a crew induced contact failure occurred which can be attributed to non-specific FDF terminology. The contact was determined to be functioning properly.

- 4.2 <u>Tests Performed on the System</u> The only test performed relative to the orbit DAP was the PRCS narrow deadband test. A .1<sup>o</sup> deadband was used. Preliminary data indicates the PRCS system was able to control to this tight constraint. Several jet firings occurred in the 2 minute period. The prop usage has not been determined, but it will probably be high.
- 4.3 <u>Anomalies</u> Strictly speaking, there were no DAP anomalies. There were, however, areas of concern:
- 4.3.1 Excessive VRCS Activity This concern was expressed post STS-3 after a DAP maneuver rate of .5°/s was used in conjunction with a 1° deadband during several maneuvers. This combination caused unacceptable VRCS activity due mainly to phase plane overshoots. On STS-4 the rate was lowered to a maximum of .3°/s. The resulting activity was still unacceptable. For example, during the RMS/PRCS test a .3°/s VRCS rate was used in conjunction with a 5° deadband after each PRCS doublet to take out the residual rates and return the vehicle to the desired attitude. Jets L5D and R5D had continuous ON times of 45 sec and 27 sec respectively. This activity must be considered excessive and illustrates the VRCS inability to effectively handle "high" vehicle rate demands.

In addition, several of the tiles on the upper surface of the bodyflap were damaged during the flight. The damage is believed to be due to L5D/R5D plumes.

The rate/deadband combination also induced excessive VRCS activity when DAP B2 was used for a maneuver. The rate was .2°/s and the deadband was .1°. This rate is not considered excessive for the verniers, but the deadband is too small to allow phase plane capture without overshoots.

4.3.2 <u>Transition Moding</u> - On two occasions while expanding/collapsing the G2 redundant set, the VERN pb was not depressed during the OPS 201 PRO. In both instances the DAP upmoded to NORM. Since the RJDs were off erroneous jet fail offs occurred and the vehicle was in free drift. The problem is the failure of the FDF to be specific. That is, DAP is all that is called for following the 201 PRO. During another set expansion an erroneous contact fail occurred. This problem is described in paragraph 1.3.

6.1.57

## 4.4 Recommendations

- 4.4.1 Since the VRCS is so sensitive to rate <u>demand</u>, all maneuvers at a rate greater than 2<sup>0</sup>/s should be done with the PRCS jets. RMS constraints must be recognized when using PRCS.
- 4.4.2 To avoid the situation where a maneuver is done with a DAPLDAD intended for an FTO, as was the case on this flight, it is recommended that DAP A be set up for maneuvers. Only DAP B should be reconfigured to support FTO and payload requirements. DAP A should be reconfigured only if a specific FTO or payload requirement demands repeated cycling between 2 different DAP loads. In such a case DAP A should be returned to the maneuver configuration as soon as possible. Flight crews can thus be trained to do all normal manuevers in DAP A virtually eliminating the possibility of manuevering in improper configuration.

Definition of the best DAP configuration for manuvers is dependent upon propellant consumption, jet lifetime, and manuever time. It is the subject of continuing analysis, but we recommend that until this analysis produces a better one the following configuration be used for DAP A.

	RATE	DEADBAND
NORM	.5°/s	3 <sup>0</sup>
VERN	.2 <sup>0</sup> /s	1°

There has been no consistent philosophy concerning DAP A/B management for the first Rour flights. Based on the events on STS-4 it is time to start.

6.1.58

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	RMU+01		APPROXIMATELY 400 TILES SHOW SOME EVIDENCE OF HAILSTONE IMPACT DUE TO HAIL THAT OCCURRED ON PAD DURING THUNDERSTORM. TILES AFFECTED ARE LOCATED ON RH OUTBOARD BOTTOM WING AND ELEVON, RUDDE SB AND VERTICAL STABILIZER. MANAGEMENT DIRECTION	CL
		9 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	IS TO REPAIR TILE THAT CAN BE ACCESSED IN TIME AVAILABLE AND NOT DELAY LAUNCH. TPS TEAM HAS REVIEWED LAUNCH FILM AND REPORTS NO TILE IMPACT CR TILES LEAVING VEHICLE.	
			DUE TO THE TILES BEING SOAKED WITH RAIN THE ATTITUDE TIMELINE WAS ALTERED GOING TO A BOTTOM-SUN ATTITUDE FOR APPROXIMATELY 24 HOURS TO "BAKE OUT" THE TILES AND REMOVE ANY WATER THAT COULD FREEZE WITHIN THE TILE AND CRACK THEM. AFTER APPROXIMATELY 16 HOURS IN	
	. –		BOTTOM-SUN THE TILES APPEARED TO BE DRY. THE ATTITUDE WAS CONTINUED IN ORDER TO MEET THE THERMAL DTO REQUIREMENT OF APPROXIMATELY 34 HOURS OF BOTTOM-SUN.	
Contraction of the second	GNC+01		IMU 3 AZ GMEL DIDN'T CAGE AT POWER UP. SUSPECT STUCK RELAY. NO IMPACT SINCE CAGING NOT REQUIRED IN FLIGHT.	CL

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	L OMS FU TK PRES LESS THAN THE H	SSURE C&W LIMIT: PURGE RESULTED IN SSURE READING 1 PSIA	CL
	WAS NOT AN OPTI BFS GMEM PROCED TO ADJUST THE T THE GMEM WILL N UNLESS THERE IS VIOLATING THE P DURING PRELAUNC GMEM CHANGES SO 288 PSIA TO 290 C&W HAS ALREADY 296 PSIA. NO B AND CREW CHANGE 288 PSIA AT MET	OF 288 PSIA. DECREASING THE THE HOT AIR PURGE ON. CONSEQUENTLY, A URE HAS BEEN WEITTEN K PRESS UPPER LIMIT. OT BE UTILIZED A POSSIBILITY OF RESENT UFPER LIMIT H AND ASCENT OPS. FTWARE LIMIT FROM PSIA. HARDWARE BEEN CHANGED TO FS UPDATE WAS REQUIRED D HARDWARE C&W BACK TO 0/.045.	
32 178/	.020 TACAN 2 BEARING OSCILLATION OF ADVISED BUT PLA BEARING CONSIDE WHEN PERFORM DT TACAN 2 PASSED GUIDANCE & GNC	CHANNEL SHOWS CYCLIC ABOUT 25 DEGREES. KSC NS NO ACTION. TACAN 2 RED SUSPECT. WILL EVALUATE O'S AND SELF TEST. SELF TEST. OK FOR USE. REPORT TACAN 2 BEARING	CL
-@2 178/	COVERS FOR FIL, LAUNCHED WITH T FIF SHOWED INDI CHAMPER AS EVIC CCOL DOWN FURIN	F3D, F1F, F2F, F3F. HIS CONDITION. F3D, CATIONS OF WATER IN THE EMCED BY INJECTOR TEMP G ASCENT. NO JET PROELEMS	CL
M-01 178/			CL
	-@2 178/J	TO ADJUST THE T THE GMEM WILL N UNLESS THERE IS VIOLATING THE P DURING PRELAUNC GMEM CHANGES SO 288 PSIA TO 290 C&W HAS ALREADY 296 PSIA. NO B AND CREW CHANGE 288 PSIA AT MET 288 PSIA AT MET 0SCILLATION OF ADVISED BUT PLA BEARING CONSIDE WHEN PERFORM DT TACAN 2 PASSED GUIDAMCE & GNC SOLID DURING TA -02 178/1343 KSC OESERVED WA COVERS FOR FIL, LAUNCHED WITH T FIF SHOWED INDI CHAMPER AS EVID COL DOWN PURIN OBSERVED DUE TO M-01 178/1409 THERMAL EVAP MS	C&W HAS ALREADY BEEN CHANGED TO 296 PSIA. NO BFS UPDATE WAS REQUIRED AND CREW CHANGED HARDWARE C&W BACK TO 288 PSIA AT MET Ø/•045. 02178/1020 TACAN 2 BEARING CHANNEL SHOWS CYCLIC OSCILLATION OF ABOUT 25 DEGREES. KSC ADVISED BUT PLANS NO ACTION. TACAN 2 BEARING CONSIDERED SUSPECT. WILL EVALUATE WHEN PERFORM DTO'S AND SELF TEST. TACAN 2 PASSED SELF TEST. OK FOR USE. GUIDANCE & CNC REPORT TACAN 2 BEARING SOLID DURING TACAN TEST.

С

6.2.3

-	July o, is		07/0100 STS-4 ANOMALY LIST	Page 10
7	ANOMALY	TIME	DESCRIPTION/IMPACT/RESOLUTION	ST
X	GNC-Ø3	Ø3/2125	RM HAS DESELECTED CONTACT A ON FWD DAP AUTO PUSHBUTTON. NO IMPACT AT THIS TIME. IF ONE OF THE OTHER TWO CONTACTS WERE TO FAIL, WOULD NOT BE ABLE TO SELECT AUTO FROM FWD STATION. MEMORY READ/WRITE IS IN WORK TO RE- GAIN THIS CONTACT IN RM SOFTWARE. THE RM FAILURE, WHICH HAPPENED DURING AN OPS TRANSITION, LOOKS LIKE A TRANSIENT, SINCE THE SWITCH SUBSEQUENTLY SHOWEF 3 GOOD CONTACTS. MEMORY READ/WRITE WAS DISAPPROVED. IF GET ANOTHER FAILED CONTACT, CREW WILL FLY MANUAL TRANS DAP (OR MM301 THROUGH MM303).	CL
	RMU-28	Ø3/2155	APU NO. 3 SEAL CAVITY DRAIN PRESSURE IS DECREASING IN "STEP DROPS" SPREAD OVER SEVERAL HOURS. THE EXACT MECHANISM IS NOT UNDERSTOCD BUT IS NOT CONSIDERED ANY IMPACT TO PROCEDURES OR ENTRY. ON STS-3, APU SEAL DRAIN PRESSURE DROPPED COMPLETELY TO ZERO PSIA WITH NO SUB- SEQUENT PROELEMS.	CL
	PROP-08	04/0411	R5D FU INJECTOR TEMP BIASED 25 DEGREES LOW. SAME CHARACTERISTICS AS F5L (REF. PROP-06 ANOMALY). NO IMPACT.	CL
	EECOM-06	Ø4/1655	EECOM CONFIRMER PCS #2 N2 LK AT LOW TEMPERATURES (<50 DEGREES) INTO VACUUM VENT LINE. LK RATE IS APPROXIMATELY 3 LES/HR. SWITCH TO SYSTEM 1.	CL



## FLIGHT TEST PROBLEM REPORT

NO. STS-4-14

Statement of problem: Orbital DAP (Digital Autopilot) control auto select switch contact "A" failed.

Discussion: During STS-4, the contact "A" of the forward orbital DAP (digital auto pilot) control auto select pushbutton switch (switch 3 on panel C3A6) contact "A" failed when the switch was activated. Subsequent activations indicated the contact had cleared, however, the RM (redundancy management) flag remained latched as there is no preprogrammed reset capability for this switch. The problem was duplicated after the flight by slowly depressing (teasing) the switch while monitoring the output of each contact. One or two contacts could be activated while the other(s) remained open. This is normal operation for this type of switch. The crew reported that extra care was necessary to insure that firm pressure was applied to push button switches while in zero g.

A switch review showed that the orbital DAP control auto and manual select switches are the only three contact push button switches used in zero g without a backup or item reset capability. A software change is being requested to provide backup switch capability during entry phase or to clear the RM flag if it remains latched.

Conclusions: The contact failure was caused by applying gentle pressure to the switch during zero g operation.

Corrective action: The crew will insure that firm pressure is applied to all pushbutton switches for proper operation during zero g. A software change is being requested to provide either backup or reset capability for the orbital DAP control auto and manual pushbutton select switches. Fly as is for STS-5. Implement the Software Control Board decision for future flights.

APPROVED Date

Effect on subsequent missions: None.

arkas/EH5; Personnel assigned: Maa \$/31/82 Resolution: CLOSED 09/01/82

FLIGHT TEST PROBLEM REPORT

NO. STS-4-29

Statement of problem: Upper Body Flap Tile Degradation Caused by Aft Vernier RCS Plumes.

Discussion: The orientation of the two aft vernier RCS thrusters results in direct plume impingement on the upper body flap tiles. High aft vernier usage during STS-3 and STS-4 caused degradation of the HRSI (high temperature reusable surface insulation) tiles on the upper body flap. Erosion or roughening of the tile surface was first noted after STS-3. Accumulated degradation during STS-4 resulted in severe erosion of several tiles on the upper surfaces of the body flap.

Testing indicates that RTV (room temperature vulcanizing) material will still be elastic after ascent and should provide adequate protection from the thruster plumes. Verification of RTV-coated tiles is planned at White Sands on August 20, 1982, during thruster life testing. An AFRSI (advanced flexible reusable surface insulation) blanket will also be tested as a long-range solution.

Conclusions: High usage of the two aft vernier RCS thrusters resulted in continued degradation of HRSI tiles on the upper surfaces of the body flap and tile refurbishment or replacement was required.

Corrective action: Nine tiles on the upper left body flap and three on the upper right have been coated with RTV. One tile on the upper left has been replaced. Potential long-term solutions include thruster re-orientation, scarfing or plume deflectors for the aft vernier thrusters as well as an AFRSI blanket for the upper body flap tiles. FOD will limit vernier RCS usage to under 0.2°/second rates.

APPROVED Aldrich Date top abde

Effect on subsequent missions: None. Repair and/or replacement of several upper body flap tiles may be required after each flight until a long range solution is implemented.

the 3/13/82 Robert Q. Ward 8/18/82 Dotts/ES3: R. J. Ward/WAJ Personnel assigned:

Resolution: CLOSED for STS-5 08/25/82

6.3.2