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SPACE SHUTTLE ENGINEERING AND OPERATIONS SUPPORT

DESIGN NOTE NO. D0410-008

TWO-IMU FDI PERFORMANCE OF THE SEQUENTIAL PROBABILITY RATIO TEST DURING SHUTTLE ENTRY

MISSION PLANNING, MISSION ANALYSIS AND SOFTWARE FORMULATION

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PREPARED BY: T. M. Rich
T. M. Rich
Engineer
488-5660, Ext. 293

APPROVED BY: W. J. Mason
W. J. Mason
Task Manager
488-5660, Ext. 293

APPROVED BY: Peggy M. Dugge
P. M. Dugge
MPB Work Package Manager
488-5660, Ext. 222

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1.0 SUMMARY

This design note presents 2-IMU FDI performance data for the sequential probability ratio test (SPRT) during shuttle entry. Also included are current modelling constants and failure thresholds for the full mission 3B entry through landing trajectory. FDI results are presented in a "raw data" tabular format in order to furnish the reader with as much data tracking test detection and isolation performance data as is possible, with a minimal amount of data processing. Minimum 100% detection/isolation failure levels and a discussion of the effects of failure direction are presented. Finally, a limited comparison of failures introduced at trajectory initiation shows that the SPRT algorithm performs slightly worse than the data tracking test (Reference 1).

2.0 INTRODUCTION

Last September the SPRT algorithm was baselined at the Level B OFT Entry SDR to perform the onboard 2 and 3 IMU FDI testing with skewed IMU's. In order to both develop and verify the method, a subroutine incorporating the 2-IMU SPRT was added to the IMUFDI triple string IMU simulation program on the JSC Univac 1110. This report contains an evaluation of the present SPRT formulation (Reference 2) in detecting and identifying soft IMU failures.

3.0 DISCUSSION

The 2-IMU SPRT performance data presented in section 4.0 were generated by the IMUFDI program, version 18.C, interfaced with the 2-IMU SPRT subroutine, as described in Reference 2. The following paragraphs contain error modelling data, guidelines, and other constants specifying the exact conditions under which the enclosed failure test case results were generated.

3.1 Guidelines

- Reference Mission 3B entry
- Simulation begins at entry interface (400 Kft.), and ends at touchdown, 1945 sec. after entry interface
- Only IMU #1 and IMU #2 are ON; IMU #3 is downmoded throughout all test cases
- All failures are introduced into IMU #1 at time t=0 (400 Kft.)
- First detection/isolation tests are performed at time t=10 sec., subsequent tests are performed every 5 sec. thereafter
- Each failure case is tested through 30 Monte Carlo cycles
- The 11° nav base pitch is modeled
- The Kearfott IMU gimbal sequence is used (ZYX-inner middle outer)

The following limitations of the IMUFDI program should be mentioned:

- All IMU's are assumed collocated.
- No tangential or centripetal forces are modeled.
- A 3 gimballed IMU error model is used, error in the 4th (inner roll) gimbal is unmodeled.
- This is an open loop simulation

3.2 Filter Constants

The first order whitening filter is characterized by the following constants:

Autocorrelation time

τ_{GYRO} = 120 sec.

τ_{ACCL} = 120 sec.

Gains

K_{GYRO} = .54

K_{ACCL} = .084

3.3 Base Failure Thresholds

The base failure thresholds are plotted in Figures 1 and 2, together with the 100 Monte Carlo cycle envelopes of nominal data before filtering. The gyro threshold is a 3rd order polynomial function of time, specified by the following coefficients:

$TGYRO_0$ = 3.7 E-4

$TGYRO_1$ = 3.4967 E-6

$TGYRO_2$ = -1.1786 E-10

$TGYRO_3$ = -5.8263 E-13

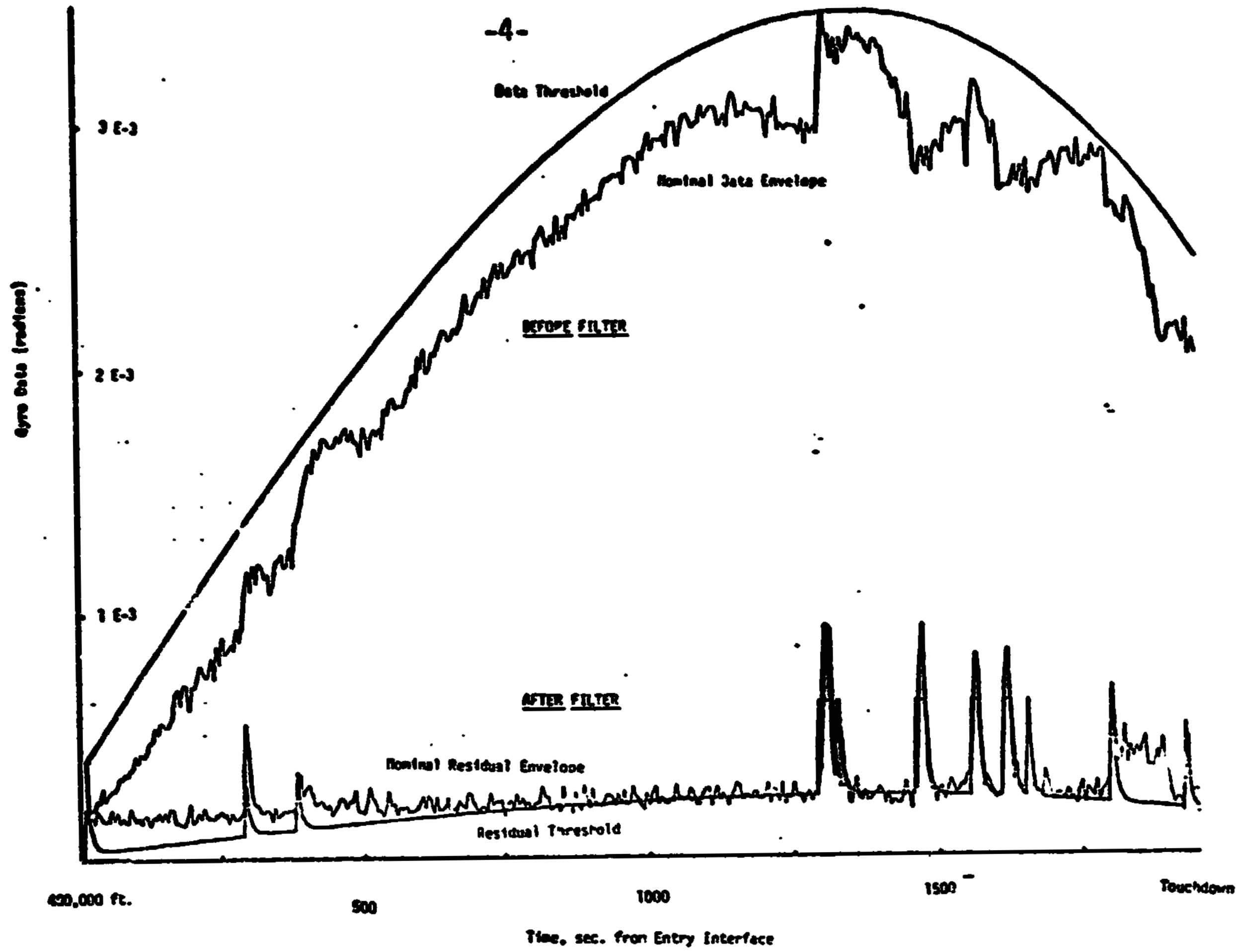

Figure 1. Total Relative Misalignments

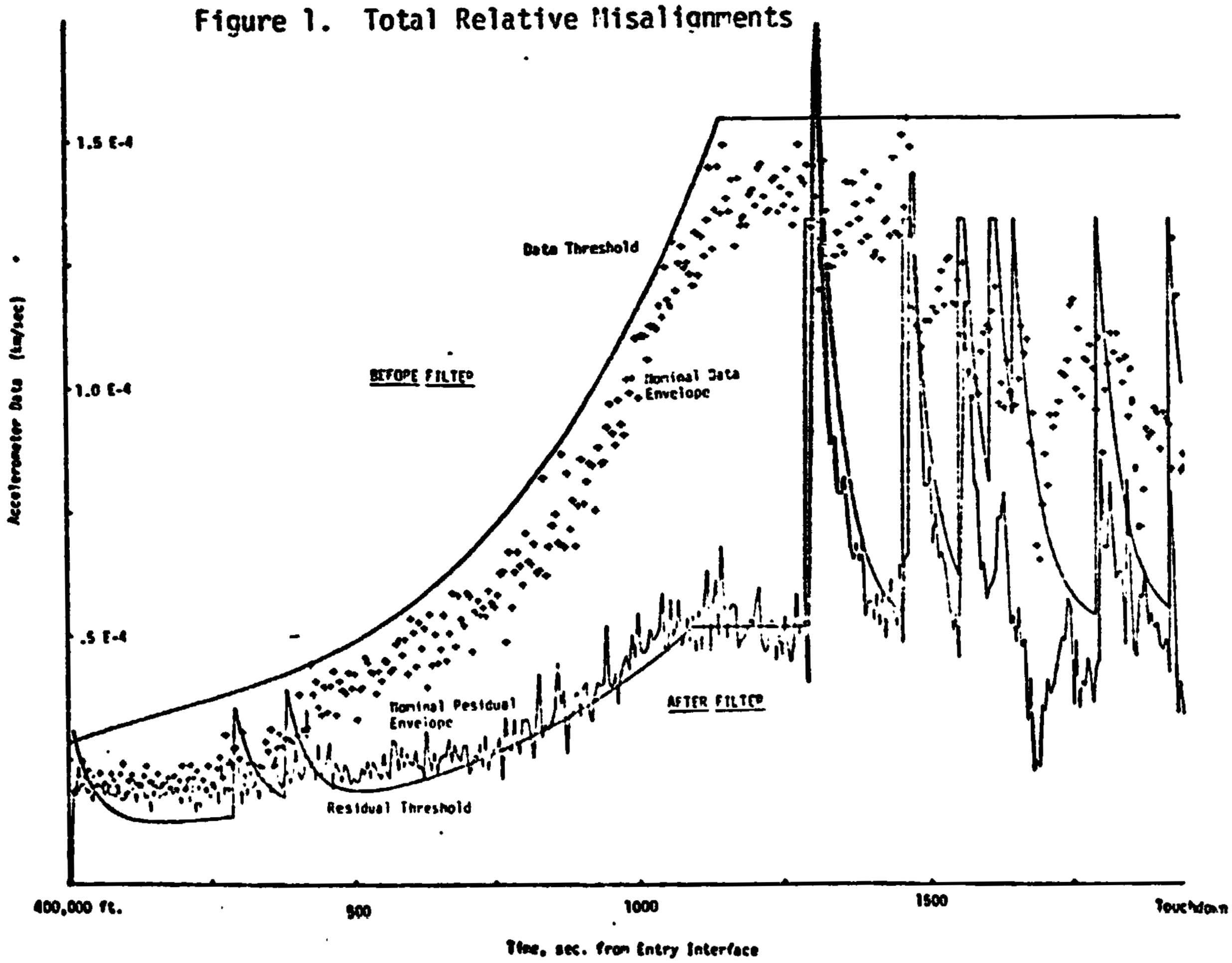

Figure 2. Incremental ΔV Differences

The accelerometer threshold is a 3rd order polynomial which latches to a constant level at t=1145 sec. Before 1145, the threshold is specified by the following coefficients:

$TACCL_0$ = 2.83 E-5

$TACCL_1$ = 4.3503 E-8

$TACCL_2$ = -5.3665 E-11

$TACCL_3$ = 9.7743 E-14

3.4 Log Likelihood Ratio Constants

The failure thresholds on the residuals *after* filtering are also plotted in Figures 1 and 2, together with envelopes of 100 Monte Carlo cycle nominal residuals. These thresholds are calculated from the base failure thresholds as described in Reference 1 using the following constants:

Attitude Transient Percentage

$P_{NB,\ GYRO} = .15$

$P_{NB,\ ACCL} = .80$

Attitude Transient Detect Level

Δ_{GIM} = .226 radians

Residual Standard Deviation

σ_{GYRO} = 2.4E-4 rad

σ_{ACCL} = 1.2E-5 Km/sec

Mean False Alarm Rate

$ALPHA = \Delta t/T = 5/5000 = 10^{-3}$

Where T = 5000 sec., mean time between false alarms

3.5 Skew Matrix

The ideal skewed transformation from IMU #1 to IMU #2 stable platform coordinate frames is given by:

$$T_{12} = \begin{bmatrix} -.5000000000 & .8090169944 & -.3090169944 \\ -.8090169944 & -.3090169944 & .5000000000 \\ .3090169944 & .5000000000 & .8090169944 \end{bmatrix}$$

3.6 IMU Platform to Nav Base Euler Matrix

The Kearfott IMU stable platform to navigation base transformation matrix is given by:

$$\begin{bmatrix} C\psi C\theta & C\psi S\theta & -S\psi \\ -C\phi S\theta+S\phi S\psi C\theta & C\phi C\theta+S\phi S\psi S\theta & S\phi C\psi \\ S\phi S\theta+C\phi S\psi C\theta & -S\phi C\theta+C\phi S\psi S\theta & C\phi C\psi \end{bmatrix}$$

where S=sine, C=cosine, ϕ, ψ, θ are the X, Y, Z gimbal angles, respectively.

3.7 IMU Entry Error Model

	Engineering Values	Program Values
ACCELEROMETER ERRORS (1σ) per axis		
bias	50 ug	.490333369-006 $\frac{\text{Km}}{\text{sec}^2}$
scale factor	100 PPM	.0001
input axis misalignment	15 arc sec	.727220522-004 rad.
quantization	1×10^{-5} km/sec	1×10^{-5} Km/sec
GYRO ERRORS (1σ) per axis		
bias drift	0.035 deg/hr	.169684788-006 $\frac{\text{rad}}{\text{sec}}$
g-sensitive drift-input axis	0.025 deg/hr/g	.123592917-004 $\frac{(\text{rad/sec})}{(\text{Km/sec}^2)}$
g-sensitive drift-spin axis	0.025 deg/hr/g	.123592917-004 $\frac{(\text{rad/sec})}{(\text{Km/sec}^2)}$
g^2-sensitive drift-input/spin axis	0.025 deg/hr/g^2	.125826815-002 $\frac{(\text{rad/sec})}{(\text{Km/sec}^2)^2}$
scale factor	200 PPM	.0002
mounting alignment	60 arc sec	.290888209-003 rad
IMU ERRORS (1σ)		
IMU to nav. base	42.4 arc sec	.2056890249-003 rad
gimbal non-orthogonality	50 arc sec	.2424068405-003 rad
resolver bias term	0.	0
resolver sinusoidal term	30 arc sec	.1454441043-003 rad
resolver multiplicative speed	2	2
gimbal quantization	20 arc sec	.9696273622-004 rad
INITIAL ALIGNMENT ERRORS (1σ)		
each axis	132 arc sec	.6399540589-003 rad

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4.0 RESULTS

Detection and isolation sensitivities of the 2-IMU SPRT algorithm were tested on failures in gyro drift, accelerometer bias, and accelerometer scale factor, introduced into IMU #1 at t=0 (400,000 ft). Failure levels were selected to correspond with the cases tested in Reference 2 so that performance of the SPRT and data tracking test could be compared under similar conditions. Failures in the following orientations were examined:

Single axis: X, Y, and Z axes
Dual axis: -45° and +45° in XY plane

Finally, for the sake of completeness, SPRT performance in the presence of no failure is summarized.

Each failure case is summarized in a six column table. The first column is the Monte Carlo cycle number. The second is the time (sec. from entry interface) of the first detection; this number will be equal to zero if there has been no detection during the cycle. The third column is the type of detection, ACCL or GYRO; this field will be blank if there has been no detection. Columns 4 and 5 are the same as columns 2 and 3, except that they pertain to the first isolation instead of the first detection. The sixth column is the IMU configuration control flag AFAIL, which is set after the first isolation. This number should be equal to 5 for all IMU #1 failures; it would be equal to 6 if the isolation logic indicated an IMU #2 failure.

4.1 Gyro Drift

Tables 1, 2, and 3 contain FDI performance summaries for .5°/hr, 1°/hr, and 2°/hr failures, respectively. The following observations are made on the basis of these data:

- .5°/hr detection was high but never 100%, ranging from 83% in the Z axis case to 97% in the -45° case
- 1°/hr isolation was 100% in only the +45° case, falling to 97% in the Y and Z cases, to 43% in the X case and 3% in the -45° case
- 2°/hr isolation was 100% in all but the -45° case. Average isolation times were sharply reduced from the 1°/hr cases. For example, Y axis average isolation time fell from 1515 sec. to 479 sec.

4.2 Accelerometer Bias

Tables 4, 5, and 6 contain FDI performance summaries for 1000μg, 1200μg, and 2000μg failures, respectively. The following observations are made on the basis of these data:

- 1000μg detection was high but never 100%, ranging from 87% in the -45° and Y cases to 93% in the X axis case
- 1200μg detection was 100% in all cases. 1200μg isolation ranged from 0% in the -45° and X cases to 50% in the +45° case
- 2000μg isolation was 100% in the +45°,Y, and Z cases, falling to 20% in the X case and 3% in the -45° case.

4.3 Accelerometer Scale Factor Error

Tables 7, 8, and 9 contain FDI performance summaries for 3000ppm, 5000ppm, and 8000ppm failures, respectively. The following observations are made on the basis of these data:

- The 100% detection level lies between 3000ppm and 5000ppm
- 5000ppm isolation was at best 90% in the X axis case

- 8000ppm isolation was 100% in the -45°, Y, and Z cases, falling to 97% in the +45° case, and to 63% in the X axis case.

4.4 Nominal

Table 10 contains the FDI performance summary in the nominal case. In a separate run (not included) the algorithm was tested during 100 nominal Monte Carlo cycles with no false detection or isolation.

5.0 CONCLUSIONS

The following conclusions are made on the basis of the data contained in section 4.0.

- For all cases run with the SPRT, there were no false detections in a 100 Monte Carlo cycle nominal case, and no incorrect isolations in the failure cases.
- Failure detection was sensitive, for all failure orientations, with the following 100% detection levels

  gyro drift ≃ .6°/hr
  accelerometer bias ≃ 1100μg
  accelerometer scale factor ≃ 4000ppm
- For the IMU pair tested (#1, #2), the best isolation geometry holds for the +45°, Y, and Z axis cases. Best geometry 100% isolation levels were found to be:

gyro drift	1°/hr
accelerometer bias	1400μg
accelerometer scale factor	6000ppm

- -45° and X axis failures in gyro drift and accelerometer bias exhibited poor isolation geometry, since they were closest to the ambiguity line at -31.7° in the XY plane discussed in the appendix of Reference 3. In the -45° case, 1°/hr isolation fell to 3%, and 2000μg isolation fell to 3%.

Reference 1 presented the following 100% levels for the tracking test:

Detection: .5°/hr, 800μg, 4000ppm

Isolation: 1°/hr, 1200μg, 5000ppm

Comparing these levels with those above for SPRT, the tracking test is slightly more sensitive than the SPRT. A comparison of response times shows the tracking test to be slightly faster in detection/isolation than the SPRT.

6.0 REFERENCES

1. T. M. Rich, "Performance Results of the Data Tracking Test for 2-IMU FDI," MDTSCO Working Paper No. E914-8A-026, 27 Feb. 1976.
2. T. M. Rich, "A Detailed Description of the Sequential Probability Ratio Test for 2-IMU FDI", MDTSCO Design Note No. D0410-007, 24 March 1976.
3. T. M. Rich, "Performance of the version 17.B Two IMU Single Axis FDI Logic in Detecting and Isolating Dual Axis Gyro Failures", MDTSCO Working Paper No. E914-8A-003, 18 Oct. 1974.

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1835	GYRO	0		0
2	1835	GYRO	0		0
3	1830	GYRO	0		0
4	1455	GYRO	0		0
5	435	GYRO	0		0
6	1775	GYRO	0		0
7	1870	GYRO	0		0
8	1780	GYRO	0		0
9	1755	GYRO	0		0
10	535	GYRO	0		0
11	1765	GYRO	0		0
12	1835	GYRO	0		0
13	1780	GYRO	0		0
14	1735	GYRO	0		0
15	1780	GYRO	0		0
16	1785	GYRO	0		0
17	1745	GYRO	0		0
18	1855	GYRO	0		0
19	1845	GYRO	0		0
20	0		0		0
21	1880	GYRO	0		0
22	1720	GYRO	0		0
23	1860	GYRO	0		0
24	1195	GYRO	0		0
25	1840	GYRO	0		0
26	1720	GYRO	0		0
27	530	GYRO	0		0
28	1840	GYRO	0		0
29	1745	GYRO	0		0
30	1430	GYRO	0		0
	46990		0		

a) -45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1855	GYRO	0		0
2	0		0		0
3	1830	GYRO	0		0
4	1845	GYRO	0		0
5	1845	GYRO	0		0
6	1745	GYRO	0		0
7	1870	GYRO	0		0
8	0		0		0
9	0		0		0
10	1845	GYRO	0		0
11	1385	GYRO	0		0
12	1855	GYRO	0		0
13	1810	GYRO	0		0
14	1840	GYRO	0		0
15	1840	GYRO	1875	GYRO	S
16	0		0		0
17	960	GYRO	0		0
18	1540	GYRO	0		0
19	1870	GYRO	0		0
20	1715	GYRO	0		0
21	1750	GYRO	0		0
22	1845	GYRO	0		0
23	1250	GYRO	0		0
24	965	GYRO	0		0
25	1555	GYRO	0		0
26	1640	GYRO	0		0
27	465	GYRO	0		0
28	1820	GYRO	0		0
29	610	GYRO	0		0
30	1825	GYRO	0		0
	41575		1875		

b) X axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1855	GYRO	0		0
2	0		0		0
3	1855	GYRO	1900	GYRO	S
4	1845	GYRO	1875	GYRO	S
5	1865	GYRO	0		0
6	1840	GYRO	0		0
7	1740	GYRO	1870	GYRO	S
8	1775	GYRO	0		0
9	0		0		0
10	1840	GYRO	1905	GYRO	S
11	1445	GYRO	0		0
12	1905	GYRO	0		0
13	0		0		0
14	1845	GYRO	0		0
15	1845	GYRO	1860	GYRO	S
16	0		0		0
17	1770	GYRO	0		0
18	1765	GYRO	0		0
19	0		0		0
20	1730	GYRO	0		0
21	1860	GYRO	0		0
22	1895	GYRO	0		0
23	1885	GYRO	0		0
24	1055	GYRO	1550	GYRO	S
25	1865	GYRO	0		0
26	1855	GYRO	0		[illegible]
27	475	GYRO	0		
28	1840	GYRO	1890	GYRO	
29	1740	GYRO	0		0
30	1835	GYRO	1885	GYRO	S
	43245		14735		

c) +45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1760	GYRO	0		0
2	1715	GYRO	0		0
3	1550	GYRO	0		0
4	1870	GYRO	0		0
5	1910	GYRO	0		0
6	1840	GYRO	0		0
7	410	GYRO	1785	GYRO	S
8	1750	GYRO	0		0
9	1775	GYRO	0		0
10	1860	GYRO	0		0
11	1785		0		0
12	1735		0		0
13	0		0		0
14	1895	GYRO	0		0
15	1865	GYRO	0		0
16	[illegible]	GYRO	0		0
17	1630	GYRO	0		0
18	1440	GYRO	0		0
19	1710	GYRO	0		0
20	1720	GYRO	0		0
21	1725	GYRO	0		0
22	1860	GYRO	0		0
23	780	GYRO	0		0
24	0		0		0
25	1730	GYRO	0		0
26	1855	GYRO	0		0
27	1410	GYRO	0		0
28	1780	GYRO	0		0
29	1795	GYRO	0		0
30	1775	GYRO	0		0
	46845		1785		

d) Y axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1745	GYRO	0		0
2	1775	GYRO	0		0
3	1715	GYRO	1715	GYRO	S
4	1455	GYRO	1850	GYRO	S
5	1780	GYRO	0		0
6	1890	GYRO	0		0
7	1395	GYRO	0		0
8	1440	GYRO	1910	GYRO	S
9	1865	GYRO	0		0
10	900	GYRO	0		0
11	0		0		0
12	1775	GYRO	1875	GYRO	S
13	1455	GYRO	0		0
14	1845	GYRO	0		0
15	1735	GYRO	1860	GYRO	S
16	1575	GYRO	1795	GYRO	S
17	1905	GYRO	0		0
18	0		0		0
19	1265	GYRO	1870	GYRO	S
20	1770	GYRO	1910	GYRO	S
21	1890	GYRO	0		0
22	0		0		0
23	0		0		0
24	1215	GYRO	1855	GYRO	S
25	1875	GYRO	1915	GYRO	S
26	1550	GYRO	1875	GYRO	S
27	1870	GYRO	0		0
28	1790	GYRO	0		0
29	0		0		0
30	1860	GYRO	0		0
	41335		20430		

e) Z axis

Table 1. .5 °/hr Gyro Drift, IMU #1

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	405	GYRO	0		0
2	315	GYRO	0		0
3	540	GYRO	0		0
4	525	GYRO	0		0
5	765	GYRO	0		0
6	545	GYRO	0		0
7	920	GYRO	0		0
8	325	GYRO	0		0
9	690	GYRO	0		0
10	225	GYRO	0		0
11	565	GYRO	1900	GYRO	S
12	635	GYRO	0		0
13	410	GYRO	0		0
14	1055	GYRO	0		0
15	735	GYRO	0		0
16	930	GYRO	0		0
17	630	GYRO	0		0
18	655	GYRO	0		0
19	1060	GYRO	0		0
20	655	GYRO	0		0
21	760	GYRO	0		0
22	425	GYRO	0		0
23	575	GYRO	0		0
24	490	GYRO	0		0
25	930	GYRO	0		0
26	530	GYRO	0		0
27	310	GYRO	0		0
28	555	GYRO	0		0
29	560	GYRO	0		0
30	475	GYRO	0		0
	16245		1900		

a) -45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	460	GYRO	1940	GYRO	S
2	1140	GYRO	0		0
3	1155	GYRO	1890	GYRO	S
4	1415	GYRO	1865	GYRO	S
5	560	GYRO	0		0
6	525	GYRO	0		0
7	475	GYRO	1735	GYRO	S
8	430	GYRO	1720	GYRO	S
9	565	GYRO	0		0
10	890	GYRO	1870	GYRO	S
11	475	GYRO	0		0
12	435	GYRO	1900	GYRO	S
13	495	GYRO	0		0
14	675	GYRO	0		0
15	765	GYRO	1840	GYRO	S
16	645	GYRO	1810	GYRO	S
17	480	GYRO	0		0
18	425	GYRO	0		0
19	555	GYRO	0		0
20	520	GYRO	0		0
21	535	GYRO	0		0
22	285	GYRO	0		0
23	620	GYRO	0		0
24	480	GYRO	1290	GYRO	S
25	630	GYRO	0		0
26	1425	GYRO	1920	GYRO	S
27	245	GYRO	0		0
28	1135	GYRO	1885	GYRO	S
29	310	GYRO	0		0
30	1135	GYRO	1570	GYRO	S
	20295		23555		

b) X axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1015	GYRO	1440	GYRO	S
2	1175	GYRO	1290	GYRO	S
3	1095	GYRO	1170	GYRO	S
4	1705	GYRO	1755	GYRO	S
5	1385	GYRO	1440	GYRO	S
6	550	GYRO	1720	GYRO	S
7	375	GYRO	490	GYRO	S
8	635	GYRO	1150	GYRO	S
9	540	GYRO	1790	GYRO	S
10	1450	GYRO	1700	GYRO	S
11	570	GYRO	1720	GYRO	S
12	440	GYRO	1225	GYRO	S
13	1245	GYRO	1275	GYRO	S
14	560	GYRO	1755	GYRO	S
15	925	GYRO	1120	GYRO	S
16	625	GYRO	1455	GYRO	S
17	445	GYRO	1755	GYRO	S
18	515	GYRO	1720	GYRO	S
19	895	GYRO	965	GYRO	S
20	650	GYRO	1420	GYRO	S
21	520	GYRO	1755	GYRO	S
22	320	GYRO	1450	GYRO	S
23	620	GYRO	1750	GYRO	S
24	495	GYRO	1335	GYRO	S
25	645	GYRO	1000	GYRO	S
26	1440	GYRO	1450	GYRO	S
27	285	GYRO	935	GYRO	S
28	1135	GYRO	1290	GYRO	S
29	420	GYRO	1435	GYRO	S
30	1145	GYRO	1545	GYRO	S
	24330		42015		

c) + 45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1555	GYRO	1710	GYRO	S
2	610	GYRO	1550	GYRO	S
3	810	GYRO	1290	GYRO	S
4	770	GYRO	1730	GYRO	S
5	1155	GYRO	1715	GYRO	S
6	1155	GYRO	1760	GYRO	S
7	245	GYRO	650	GYRO	S
8	1060	GYRO	1725	GYRO	S
9	450	GYRO	1615	GYRO	S
10	915	GYRO	1725	GYRO	S
11	375	GYRO	0		0
12	565	GYRO	1545	GYRO	S
13	1025	GYRO	1395	GYRO	S
14	[illegible]	GYRO	[illegible]	GYRO	S
15	560	GYRO	1250	GYRO	S
16	355	GYRO	1710	GYRO	S
17	320	GYRO	1825	GYRO	S
18	525	GYRO	1740	GYRO	S
19	545	GYRO	1375	GYRO	S
20	625	GYRO	1720	GYRO	S
21	455	GYRO	1860	GYRO	S
22	1215	GYRO	1750	GYRO	S
23	430	GYRO	1920	GYRO	S
24	715	GYRO	1090	GYRO	S
25	250	GYRO	1165	GYRO	S
26	650	GYRO	1745	GYRO	S
27	475	GYRO	1730	GYRO	S
28	645	GYRO	1720	GYRO	S
29	615	GYRO	1760	GYRO	S
30	740	GYRO	1850	GYRO	S
	19490		45450		

d) Y axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	695	GYRO	1100	GYRO	S
2	325	GYRO	735	GYRO	S
3	535	GYRO	585	GYRO	S
4	475	GYRO	[illegible]	GYRO	S
5	535	GYRO	[illegible]	GYRO	S
6	890	GYRO	1275	GYRO	S
7	350	GYRO	1450	GYRO	S
8	535	GYRO	1735	GYRO	S
9	1010	GYRO	1710	GYRO	S
10	455	GYRO	670	GYRO	S
11	915	GYRO	1720	GYRO	S
12	285	GYRO	1700	GYRO	S
13	670	GYRO	730	GYRO	S
14	1060	GYRO	1400	GYRO	S
15	340	GYRO	1420	GYRO	S
16	930	GYRO	1155	GYRO	S
17	1150	GYRO	1780	GYRO	S
18	545	GYRO	0		0
19	365	GYRO	1700	GYRO	S
20	650	GYRO	1785	GYRO	S
21	1390	GYRO	1735	GYRO	S
22	770	GYRO	1540	GYRO	S
23	595	GYRO	1725	GYRO	S
24	310	GYRO	1820	GYRO	S
25	505	GYRO	1705	GYRO	S
26	650	GYRO	1730	GYRO	S
27	330	GYRO	1160	GYRO	S
28	720	GYRO	975	GYRO	S
29	670	GYRO	1840	GYRO	S
30	440	GYRO	1930	GYRO	S
	19155		36525		

e) Z axis

Table 2. 1 °/hr Gyro Drift, IMU #1

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SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	190	GYRO	0		0
2	180	GYRO	0		0
3	210	GYRO	0		0
4	175	GYRO	0		0
5	160	GYRO	0		0
6	190	GYRO	0		0
7	270	GYRO	0		0
8	195	GYRO	0		0
9	250	GYRO	1730	GYRO	S
10	155	GYRO	0		0
11	245	GYRO	1775	GYRO	S
12	230	GYRO	0		0
13	200	GYRO	1915	GYRO	S
14	235	GYRO	0		0
15	240	GYRO	0		0
16	260	GYRO	0		0
17	245	GYRO	1705	GYRO	S
18	240	GYRO	1860	GYRO	S
19	260	GYRO	0		0
20	250	GYRO	0		0
21	235	GYRO	1790	GYRO	S
22	190	GYRO	1910	GYRO	S
23	250	GYRO	1875	GYRO	S
24	265	GYRO	0		0
25	275	GYRO	1845	GYRO	S
26	170	GYRO	0		0
27	185	GYRO	1915	GYRO	S
28	205	GYRO	0		0
29	215	GYRO	1920	GYRO	S
30	190	GYRO	1760	GYRO	S
	6500		22080		

a) -45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	200	GYRO	1245	GYRO	S
2	290	GYRO	1160	GYRO	S
3	215	GYRO	915	GYRO	S
4	255	GYRO	1435	GYRO	S
5	215	GYRO	1220	GYRO	S
6	205	GYRO	1430	GYRO	S
7	200	GYRO	485	GYRO	S
8	200	GYRO	770	GYRO	S
9	210	GYRO	1410	GYRO	S
10	205	GYRO	1420	GYRO	S
11	190	GYRO	1445	GYRO	S
12	215	GYRO	455	GYRO	S
13	210	GYRO	1270	GYRO	S
14	230	GYRO	1730	GYRO	S
15	215	GYRO	1640	GYRO	S
16	220	GYRO	1310	GYRO	S
17	215	GYRO	1445	GYRO	S
18	205	GYRO	715	GYRO	S
19	240	GYRO	815	GYRO	S
20	220	GYRO	1170	GYRO	S
21	200	GYRO	1720	GYRO	S
22	170	GYRO	1395	GYRO	S
23	210	GYRO	1420	GYRO	S
24	175	GYRO	930	GYRO	S
25	215	GYRO	990	GYRO	S
26	250	GYRO	1415	GYRO	S
27	150	GYRO	570	GYRO	S
28	235	GYRO	1195	GYRO	S
29	185	GYRO	1415	GYRO	S
30	225	GYRO	1245	GYRO	S
	6380		35020		

b) X axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	200	GYRO	310	GYRO	S
2	480	GYRO	510	GYRO	S
3	250	GYRO	330	GYRO	S
4	560	GYRO	570	GYRO	S
5	225	GYRO	505	GYRO	S
6	215	GYRO	495	GYRO	S
7	205	GYRO	260	GYRO	S
8	205	GYRO	330	GYRO	S
9	220	GYRO	290	GYRO	S
10	275	GYRO	530	GYRO	S
11	215	GYRO	485	GYRO	S
12	215	GYRO	225	GYRO	S
13	235	GYRO	450	GYRO	S
14	240	GYRO	345	GYRO	S
15	225	GYRO	235	GYRO	S
16	235	GYRO	285	GYRO	S
17	210	GYRO	595	GYRO	S
18	215	GYRO	300	GYRO	S
19	240	GYRO	255	GYRO	S
20	220	GYRO	295	GYRO	S
21	245	GYRO	505	GYRO	S
22	195	GYRO	290	GYRO	S
23	215	GYRO	345	GYRO	S
24	195	GYRO	230	GYRO	S
25	225	GYRO	230	GYRO	S
26	285	GYRO	380	GYRO	S
27	175	GYRO	280	GYRO	S
28	250	GYRO	590	GYRO	S
29	200	GYRO	280	GYRO	S
30	265	GYRO	625	GYRO	S
	7335		11540		

c) +45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	265	GYRO	360	GYRO	S
2	230	GYRO	540	GYRO	S
3	215	GYRO	425	GYRO	S
4	250	GYRO	675	GYRO	S
5	370	GYRO	600	GYRO	S
6	245	GYRO	600	GYRO	S
7	150	GYRO	290	GYRO	S
8	250	GYRO	445	GYRO	S
9	195	GYRO	540	GYRO	S
10	375	GYRO	610	GYRO	S
11	190	GYRO	620	GYRO	S
12	185	GYRO	260	GYRO	S
13	245	GYRO	565	GYRO	S
14	195	GYRO	655	GYRO	S
15	195	GYRO	265	GYRO	S
16	190	GYRO	355	GYRO	S
17	195	GYRO	795	GYRO	S
18	190	GYRO	365	GYRO	S
19	185	GYRO	300	GYRO	S
20	185	GYRO	480	GYRO	S
21	200	GYRO	605	GYRO	S
22	210	GYRO	310	GYRO	S
23	195	GYRO	440	GYRO	S
24	180	GYRO	260	GYRO	S
25	155	GYRO	255	GYRO	S
26	230	GYRO	580	GYRO	S
27	235	GYRO	320	GYRO	S
28	205	GYRO	765	GYRO	S
29	190	GYRO	320	GYRO	S
30	220	GYRO	780	GYRO	S
	6465		14380		

d) Y axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	215	GYRO	410	GYRO	S
2	230	GYRO	270	GYRO	S
3	250	GYRO	300	GYRO	S
4	250	GYRO	255	GYRO	S
5	240	GYRO	305	GYRO	S
6	205	GYRO	330	GYRO	S
7	195	GYRO	735	GYRO	S
8	200	GYRO	320	GYRO	S
9	215	GYRO	570	GYRO	S
10	255	GYRO	260	GYRO	S
11	230	GYRO	330	GYRO	S
12	165	GYRO	635	GYRO	S
13	215	GYRO	430	GYRO	S
14	220	GYRO	280	GYRO	S
15	190	GYRO	445	GYRO	S
16	200	GYRO	455	GYRO	S
17	210	GYRO	905	GYRO	S
18	215	GYRO	610	GYRO	S
19	190	GYRO	280	GYRO	S
20	215	GYRO	565	GYRO	S
21	220	GYRO	670	GYRO	S
22	190	GYRO	495	GYRO	S
23	200	GYRO	440	GYRO	S
24	190	GYRO	440	GYRO	S
25	175	GYRO	360	GYRO	S
26	265	GYRO	265	GYRO	S
27	195	GYRO	715	GYRO	S
28	215	GYRO	285	GYRO	S
29	195	GYRO	975	GYRO	S
30	255	GYRO	305	GYRO	S
	6375		14030		

e) Z axis

Table 3. 2 °/hr Gyro Drift, IMU #1

```
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE     1ST DETECTION                 1ST ISOLATION

   1          30   ACCL            0                   0
   2           0                   0                   0
   3          10   ACCL            0                   0
   4          25   ACCL            0                   0
   5          60   ACCL            0                   0
   6  [illegible]  ACCL            0                   0
   7         115   ACCL            0                   0
   8  [illegible]  ACCL            0                   0
   9  [illegible]  ACCL            0                   0
  10          15   ACCL            0                   0
  11          25   ACCL            0                   0
  12          40   ACCL            0                   0
  13          20   ACCL            0                   0
  14          20   ACCL            0                   0
  15         125   ACCL            0                   0
  16          25   ACCL            0                   0
  17          30   ACCL            0                   0
  18          40   ACCL            0                   0
  19          45   ACCL            0                   0
  20          20   ACCL            0                   0
  21           0                   0                   0
  22          25   ACCL            0                   0
  23          20   ACCL            0                   0
  24          20   ACCL            0                   0
  25          25   ACCL            0                   0
  26          25   ACCL            0                   0
  27          30   ACCL            0                   0
  28          25   ACCL            0                   0
  29           0                   0                   0
  30           0                   0                   0
          ------              ------
             900                   0
```

a) -45° in XY plane

```
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE     1ST DETECTION                 1ST ISOLATION

   1          30   ACCL            0                   0
   2          75   ACCL            0                   0
   3          40   ACCL            0                   0
   4          15   ACCL            0                   0
   5          20   ACCL            0                   0
   6          15   ACCL            0                   0
   7          20   ACCL            0                   0
   8          20   ACCL            0                   0
   9          20   ACCL            0                   0
  10           0                   0                   0
  11          25   ACCL            0                   0
  12          25   ACCL            0                   0
  13          15   ACCL            0                   0
  14          25   ACCL            0                   0
  15          25   ACCL            0                   0
  16          15   ACCL            0                   0
  17          20   ACCL            0                   0
  18          50   ACCL            0                   0
  19          40   ACCL            0                   0
  20          20   ACCL            0                   0
  21          30   ACCL            0                   0
  22          20   ACCL            0                   0
  23           0                   0                   0
  24          15   ACCL            0                   0
  25          20   ACCL            0                   0
  26          20   ACCL            0                   0
  27          15   ACCL            0                   0
  28          15   ACCL            0                   0
  29          30   ACCL            0                   0
  30          20   ACCL            0                   0
          ------              ------
             720                   0
```

b) X axis

```
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE     1ST DETECTION                 1ST ISOLATION

   1          60   ACCL            0                   0
   2          45   ACCL            0                   0
   3          45   ACCL            0                   0
   4          25   ACCL            0                   0
   5          45   ACCL            0                   0
   6          40   ACCL            0                   0
   7          45   ACCL            0                   0
   8          50   ACCL            0                   0
   9          30   ACCL            0                   0
  10           0                   0                   0
  11          45   ACCL            0                   0
  12          55   ACCL            0                   0
  13  [illegible]  ACCL            0                   0
  14          35   ACCL            0                   0
  15  [illegible]  ACCL            0                   0
  16           0                   0                   0
  17          35   ACCL            0                   0
  18         105   ACCL            0                   0
  19          60   ACCL            0                   0
  20          30   ACCL            0                   0
  21          30   ACCL           50   ACCL           5
  22          40   ACCL            0                   0
  23           0                   0                   0
  24          20   ACCL            0                   0
  25          25   ACCL            0                   0
  26          40   ACCL            0                   0
  27  [illegible]  ACCL            0                   0
  28          20   ACCL            0                   0
  29  [illegible]  ACCL            0                   0
  30          20   ACCL            0                   0
          ------              ------
            1065                  50
```

c) +45° in XY plane

```
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE     1ST DETECTION                 1ST ISOLATION

   1          35   ACCL            0                   0
   2          15   ACCL            0                   0
   3          30   ACCL            0                   0
   4          55   ACCL            0                   0
   5          20   ACCL            0                   0
   6          15   ACCL            0                   0
   7          20   ACCL            0                   0
   8          20   ACCL            0                   0
   9          40   ACCL            0                   0
  10           0                   0                   0
  11           0                   0                   0
  12          25   ACCL            0                   0
  13          15   ACCL            0                   0
  14  [illegible]  ACCL            0                   0
  15          15   ACCL            0                   0
  16           0                   0                   0
  17          25   ACCL            0                   0
  18          20   ACCL            0                   0
  19          20   ACCL            0                   0
  20          35   ACCL            0                   0
  21          15   ACCL            0                   0
  22          30   ACCL            0                   0
  23          40   ACCL            0                   0
  24           0                   0                   0
  25          20   ACCL            0                   0
  26          25   ACCL            0                   0
  27          20   ACCL            0                   0
  28          15   ACCL            0                   0
  29          15   ACCL            0                   0
  30          15   ACCL            0                   0
          ------              ------
             630                   0
```

d) Y axis

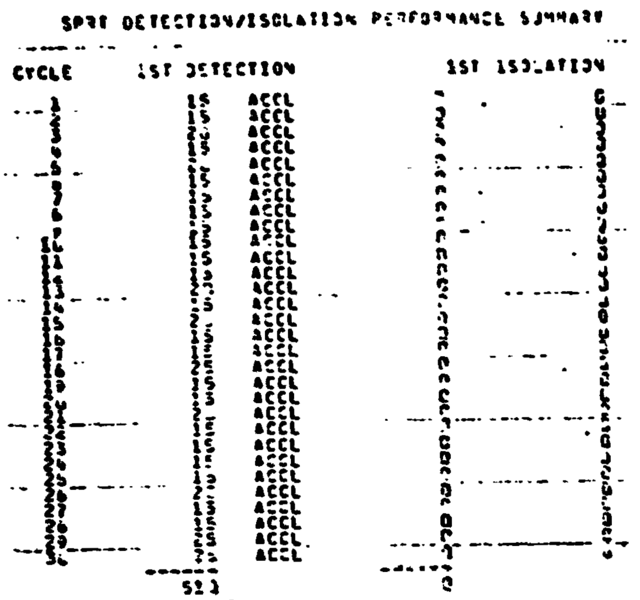
```
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE     1ST DETECTION                 1ST ISOLATION

   1          20   ACCL            0                   0
   2          35   ACCL            0                   0
   3          15   ACCL            0                   0
   4          20   ACCL            0                   0
   5          40   ACCL            0                   0
   6          25   ACCL            0                   0
   7          15   ACCL            0                   0
   8           0                   0                   0
   9          15   ACCL            0                   0
  10          20   ACCL            0                   0
  11          25   ACCL            0                   0
  12  [illegible]  ACCL            0                   0
  13          15   ACCL            0                   0
  14          20   ACCL            0                   0
  15          15   ACCL            0                   0
  16          20   ACCL            0                   0
  17          15   ACCL            0                   0
  18          15   ACCL            0                   0
  19          70   ACCL            0                   0
  20          50   ACCL            0                   0
  21          15   ACCL            0                   0
  22          25   ACCL            0                   0
  23           0                   0                   0
  24          20   ACCL            0                   0
  25          15   ACCL            0                   0
  26          25   ACCL            0                   0
  27          15   ACCL            0                   0
  28           0                   0                   0
  29          15   ACCL            0                   0
  30          30   ACCL            0                   0
          ------              ------
             630                   0
```

e) Z axis

Table 4. 1000 μg Accelerometer Bias, IMU #1



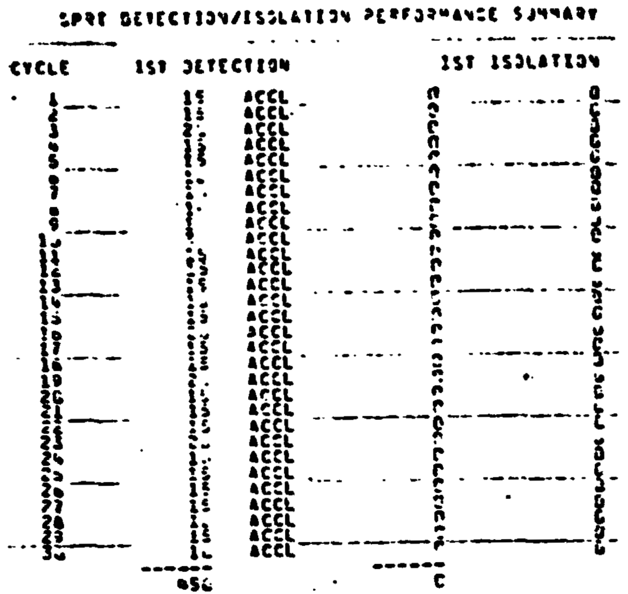
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

523

0

a) -45° in XY plane



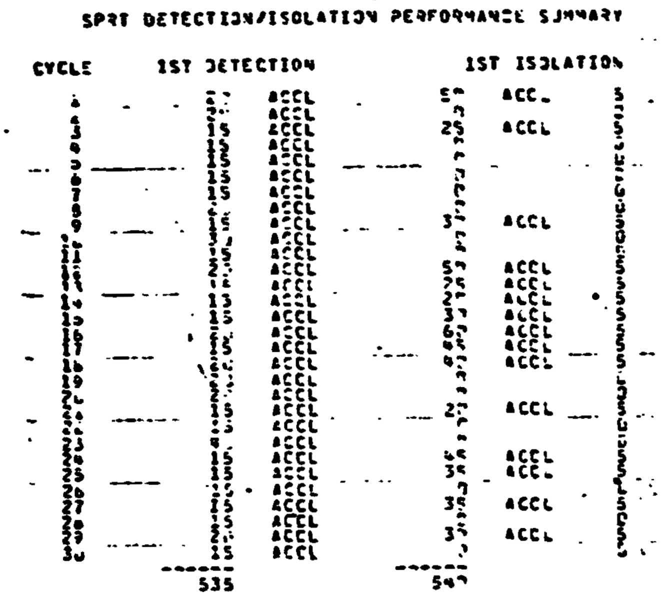
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

456

0

b) X axis



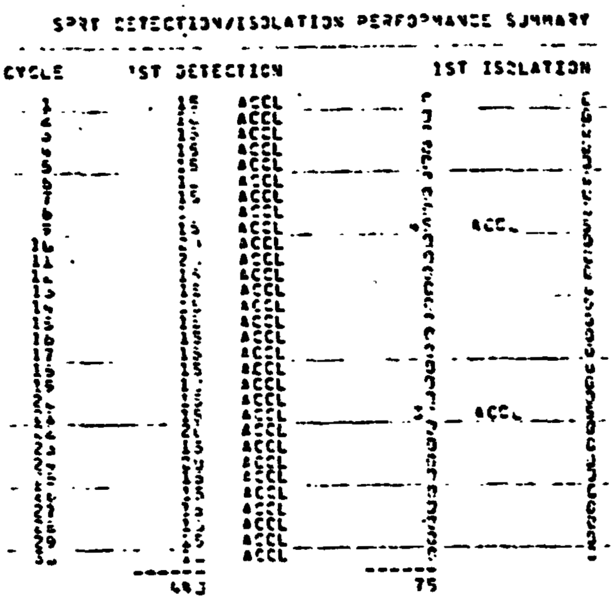
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

535

54?

c) +45° in XY plane



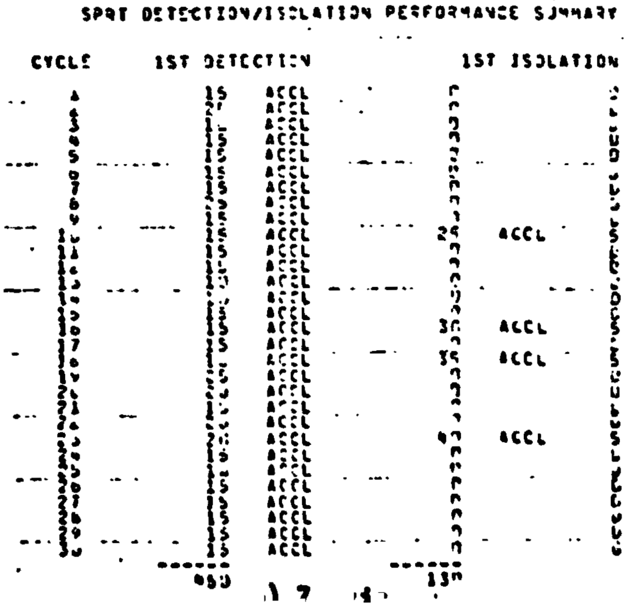
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

483

75

d) Y axis



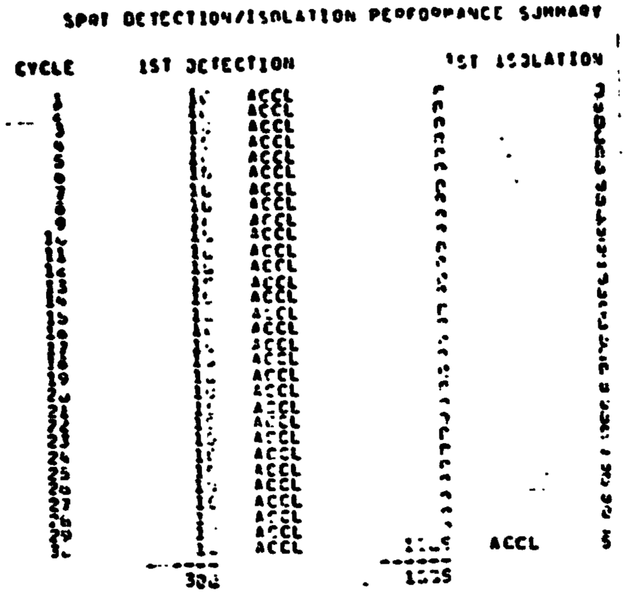
SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

453

13?

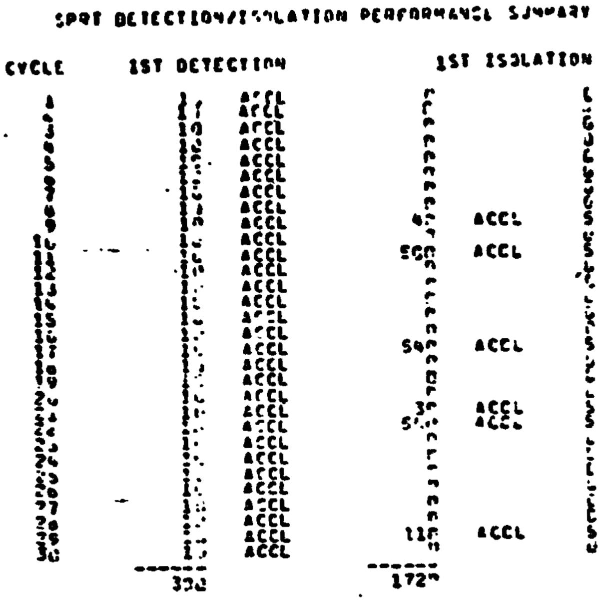
Table 5. 1200 µg Accelerometer Bias, IMU #1



SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

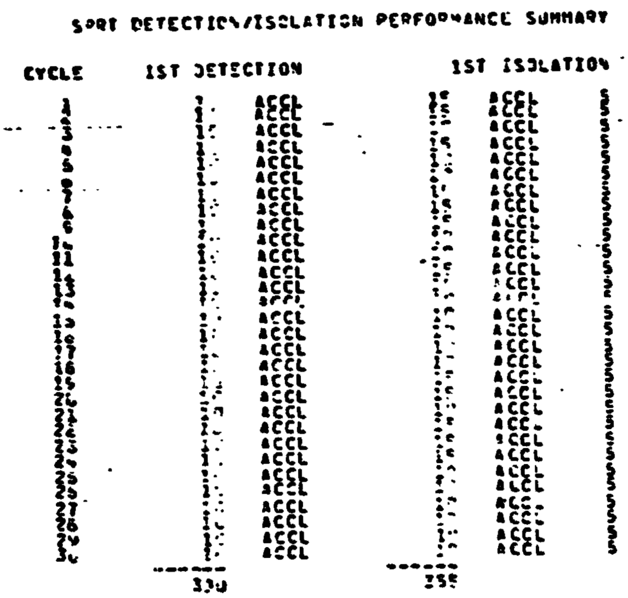
a) -45° in XY plane



SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

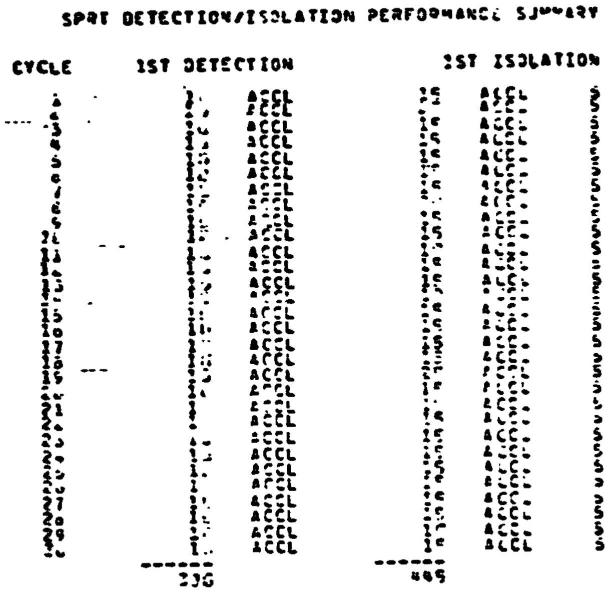
b) X axis



SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

c) +45° in XY plane

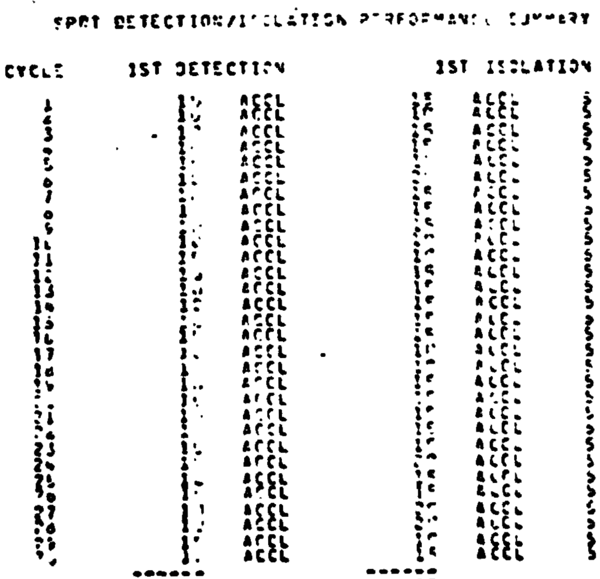


SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

d) Y axis

Table 6. 2000 µg Accelerometer Bias, IMU #1



SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE 1ST DETECTION 1ST ISOLATION

e) Z axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1270	ACCL	0		0
2	820	ACCL	0		0
3	790	ACCL	1135	ACCL	5
4	965	ACCL	1015	ACCL	5
5	1130	ACCL	0		0
6	1075	ACCL	0		0
7	1020	ACCL	0		0
8	1135	ACCL	0		0
9	1090	ACCL	0		0
10	975	ACCL	1045	ACCL	5
11	1035	ACCL	0		0
12	1315	ACCL	0		0
13	935	ACCL	1135	ACCL	5
14	1045	ACCL	0		0
15	1055	ACCL	0		0
16	1020	ACCL	0		0
17	1005	ACCL	0		0
18	990	ACCL	0		0
19	1010	ACCL	0		0
20	1145	ACCL	0		0
21	1015	ACCL	0		0
22	1170	ACCL	0		0
23	1145	ACCL	0		0
24	0		0		0
25	975	ACCL	0		0
26	1135	ACCL	0		0
27	0		0		0
28	1000	ACCL	0		0
29	1320	ACCL	0		0
30	680	ACCL	0		0
	29160		4330		

a) -45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1445	ACCL	0		0
2	1365	ACCL	0		0
3	1475	ACCL	0		0
4	1255	ACCL	0		0
5	0		0		0
6	1265	ACCL	0		0
7	1385	ACCL	0		0
8	1435	ACCL	0		0
9	1295	ACCL	0		0
10	1370	ACCL	1455	ACCL	5
11	1425	ACCL	0		0
12	1475	ACCL	0		0
13	1265	ACCL	0		0
14	1435	ACCL	0		0
15	1475	ACCL	0		0
16	1385	ACCL	0		0
17	1695	ACCL	0		0
18	1380	ACCL	0		0
19	1475	ACCL	0		0
20	1455	ACCL	0		0
21	0		0		0
22	1410	ACCL	0		0
23	0		0		0
24	1445	ACCL	0		0
25	1365	ACCL	0		0
26	1285	ACCL	0		0
27	1475	ACCL	0		0
28	0		0		0
29	1480	ACCL	0		0
30	1365	ACCL	0		0
	36610		1455		

b) X axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	930	ACCL	0		0
2	1130	ACCL	0		0
3	1345	ACCL	0		0
4	1310	ACCL	0		0
5	975	ACCL	0		0
6	1105	ACCL	0		0
7	895	ACCL	1020	ACCL	5
8	920	ACCL	0		0
9	985	ACCL	1055	ACCL	5
10	1315	ACCL	1415	ACCL	5
11	965	ACCL	1315	ACCL	5
12	960	ACCL	0		0
13	960	ACCL	0		0
14	1310	ACCL	0		0
15	960	ACCL	0		0
16	0		0		0
17	1000	ACCL	0		0
18	985	ACCL	0		0
19	990	ACCL	0		0
20	1310	ACCL	0		0
21	1310	ACCL	0		0
22	970	ACCL	990	ACCL	5
23	995	ACCL	0		0
24	1005	ACCL	1310	ACCL	5
25	930	ACCL	0		0
26	930	ACCL	0		0
27	945	ACCL	990	ACCL	5
28	1310	ACCL	0		0
29	915	ACCL	965	ACCL	5
30	1305	ACCL	0		0
	30605		9095		

c) +45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	775	ACCL	0		0
2	535	ACCL	0		0
3	920	ACCL	0		0
4	945	ACCL	0		0
5	885	ACCL	0		0
6	665	ACCL	910	ACCL	5
7	765	ACCL	900	ACCL	5
8	790	ACCL	0		0
9	885	ACCL	910	ACCL	5
10	980	ACCL	0		0
11	530	ACCL	925	ACCL	5
12	650	ACCL	955	ACCL	5
13	535	ACCL	0		0
14	950	ACCL	965	ACCL	5
15	[illegible]	ACCL	0		0
16	930	ACCL	1005	ACCL	5
17	575	ACCL	975	ACCL	5
18	760	ACCL	1310	ACCL	5
19	880	ACCL	1310	ACCL	5
20	940	ACCL	1310	ACCL	5
21	915	ACCL	0		0
22	515	ACCL	685	ACCL	5
23	840	ACCL	1310	ACCL	5
24	945	ACCL	1315	ACCL	5
25	770	ACCL	1310	ACCL	5
26	680	ACCL	0		0
27	760	ACCL	855	ACCL	5
28	830	ACCL	0		0
29	745	ACCL	795	ACCL	5
30	490	ACCL	0		0
	23530		17920		

d) Y axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1745	ACCL	0		0
2	790	ACCL	0		0
3	890	ACCL	0		0
4	995	ACCL	0		0
5	0		0		0
6	0		0		0
7	1305	ACCL	0		0
8	0		0		0
9	0		0		0
10	1320	ACCL	0		0
11	1345	ACCL	0		0
12	1305	ACCL	0		0
13	995	ACCL	0		0
14	0		0		0
15	1135	ACCL	0		0
16	1735	ACCL	0		0
17	1925	ACCL	0		0
18	0		0		0
19	1730	ACCL	0		0
20	1425	ACCL	0		0
21	1745	ACCL	0		0
22	0		0		0
23	1445	ACCL	0		0
24	1305	ACCL	0		0
25	1305	ACCL	0		0
26	1555	ACCL	0		0
27	1305	ACCL	0		0
28	1275	ACCL	0		0
29	0		0		0
30	815	ACCL	0		0
	29390		0		

e) Z axis

Table 7. 3000 ppm Scale Factor Error, IMU #1

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	[illegible]	ACCL			
2	375	ACCL			
3	[illegible]	ACCL			
4	49	ACCL	1445	ACCL	S
5	[illegible]5	ACCL	11[illegible]	ACCL	S
6	46.	ACCL	79.	ACCL	S
7	465	ACCL	915	ACCL	S
8	[illegible]	ACCL			
9	[illegible]25	ACCL	935	ACCL	S
10	6.[illegible]	ACCL	1265	ACCL	S
11	495	ACCL	[illegible]	ACCL	S
12	5 5	ACCL	96[illegible]	ACCL	S
13	38	ACCL			
14	465	ACCL	99[illegible]	ACCL	S
15	49	ACCL			
16	47	ACCL	1[illegible]	ACCL	S
17	[illegible]	ACCL	[illegible]	ACCL	S
18	4[illegible]5	ACCL	1[illegible]35	ACCL	S
19	47.	ACCL	1[illegible]15	ACCL	S
20	53.	ACCL	[illegible]	ACCL	S
21	38.	ACCL	[illegible]	ACCL	S
22	45.	ACCL	635	ACCL	S
23	[illegible]	ACCL	[illegible]7	ACCL	S
24	51	ACCL	1[illegible]7	ACCL	S
25	39	ACCL	[illegible]15	ACCL	S
26	47	ACCL	[illegible]4	ACCL	S
27	38.	ACCL	69	ACCL	S
28	[illegible]	ACCL			
29	47	ACCL	[illegible]	ACCL	S
30	375	ACCL			
	1421		2268		

a) -45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	38	ACCL	955.	ACCL	S
2	36.	ACCL	[illegible]	ACCL	S
3	375	ACCL			
4	465	ACCL			
5	37.	ACCL	95[illegible]	ACCL	S
6	38.	ACCL	[illegible]	ACCL	S
7	365	ACCL	98	ACCL	S
8	37.	ACCL	9[illegible]	ACCL	S
9	37.	ACCL	[illegible]65	ACCL	S
10	49.	ACCL	[illegible]9	ACCL	S
11	37.	ACCL	[illegible]	ACCL	S
12	37	ACCL	[illegible]	ACCL	S
13	365	ACCL	1[illegible]	ACCL	S
14	375	ACCL	[illegible]65	ACCL	S
15	37[illegible]	ACCL	96[illegible]	ACCL	S
16	495	ACCL	[illegible]	ACCL	S
17	38	ACCL	[illegible]	ACCL	S
18	365	ACCL	[illegible]	ACCL	S
19	37	ACCL	97[illegible]	ACCL	S
20	375	ACCL	[illegible]	ACCL	S
21	365	ACCL	[illegible]	ACCL	S
22	375	ACCL	[illegible]15	ACCL	S
23	365	ACCL	[illegible]	ACCL	S
24	375	ACCL	[illegible]	ACCL	S
25	365	ACCL	87	ACCL	S
26	365	ACCL	[illegible]55	ACCL	S
27	36	ACCL	[illegible]	ACCL	S
28	37[illegible]	ACCL	[illegible]5	ACCL	S
29	36[illegible]	ACCL	49.	ACCL	S
30	36.	ACCL			
	11410		20165		

b) X axis

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	5[illegible]	ACCL	955	ACCL	S
2	495	ACCL	9[illegible]	ACCL	S
3	48	ACCL	99.	ACCL	S
4	5[illegible]	ACCL	79[illegible]	ACCL	S
5	55	ACCL	9[illegible]	ACCL	S
6	67.	ACCL	[illegible]	ACCL	S
7	5[illegible]	ACCL			
8	55.	ACCL	[illegible]65	ACCL	S
9	465	ACCL	1[illegible]	ACCL	S
10	465	ACCL	[illegible]	ACCL	S
11	77	ACCL			
12	495	ACCL	1[illegible]	ACCL	S
13	58.	ACCL	[illegible]65	ACCL	S
14	6[illegible]	ACCL	[illegible]	ACCL	S
15	78[illegible]	ACCL	[illegible]	ACCL	S
16	79.	ACCL	1[illegible]	ACCL	S
17	[illegible]	ACCL	[illegible]	ACCL	S
18	435	ACCL	[illegible]	ACCL	S
19	45	ACCL	[illegible]5	ACCL	S
20	81[illegible]	ACCL	92[illegible]	ACCL	S
21	67.	ACCL	1[illegible]1[illegible]	ACCL	S
22	5[illegible]5	ACCL	[illegible]	ACCL	S
23	4[illegible]5	ACCL	[illegible]	ACCL	S
24	72	ACCL	99	ACCL	S
25	5[illegible]	ACCL	95	ACCL	S
26	525	ACCL	97	ACCL	S
27	535	ACCL			
28	8[illegible]	ACCL	85	ACCL	S
29	55.	ACCL			
30	57.	ACCL	92[illegible]	ACCL	S
	16875		2526[illegible]		

c) +45° in XY plane

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	1235	ACCL	127[illegible]	ACCL	S
2	975	ACCL	1975	ACCL	S
3	57.	ACCL	121[illegible]	ACCL	S
4	12[illegible]5	ACCL	121[illegible]	ACCL	S
5	1255	ACCL	1355	ACCL	S
6	12[illegible]	ACCL			
7	445	ACCL			
8	12[illegible]	ACCL			
9	435	ACCL			
10	1225	ACCL	12[illegible]	ACCL	S
11	1225	ACCL			
12	[illegible]	ACCL			
13	122[illegible]	ACCL	1975	ACCL	S
14	12[illegible]	ACCL			
15	1445	ACCL			
16	1215	ACCL			
17	1225	ACCL			
18	4[illegible]	ACCL			
19	43.	ACCL			
20	12[illegible]	ACCL			
21	12[illegible]	ACCL			
22	123[illegible]	ACCL			
23	445	ACCL			
24	135	ACCL			
25	43.	ACCL			
26	12[illegible]5	ACCL	[illegible]213	ACCL	S
27	43	ACCL			
28	12[illegible].	ACCL			
29	465	ACCL			
30	126[illegible]	ACCL	121[illegible]	ACCL	S
	2[illegible]295		12255		

d) Y axis

Table 8. 5000 ppm Accelerometer Scale Factor Error, IMU #1

SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE	1ST DETECTION		1ST ISOLATION		
1	59.	ACCL			
2	67	ACCL	[illegible]	ACCL	S
3	765	ACCL	[illegible]	ACCL	S
4	[illegible]65	ACCL	[illegible]9.	ACCL	S
5	98	ACCL	1[illegible]	ACCL	S
6	1[illegible]9	ACCL	123[illegible]	ACCL	S
7	1[illegible]	ACCL			
8	[illegible]	ACCL	1[illegible]	ACCL	S
9	[illegible]	ACCL	1735	ACCL	S
10	94	ACCL	[illegible]	ACCL	S
11	1[illegible]	ACCL			
12	1[illegible]	ACCL	1[illegible]	ACCL	S
13	95	ACCL	1[illegible]5	ACCL	S
14	1135	ACCL	[illegible]5	ACCL	S
15	9[illegible]	ACCL	170.	ACCL	S
16	11[illegible]	ACCL			
17	1255	ACCL			
18	[illegible]	ACCL			
19	9[illegible]5	ACCL	199	ACCL	S
20	995	ACCL			
21	1[illegible]	ACCL			
22	13[illegible]5	ACCL	1[illegible]	ACCL	S
23	9[illegible]	ACCL	1[illegible]5	ACCL	S
24	1135	ACCL	1[illegible]	ACCL	S
25	1[illegible]15	ACCL	1[illegible]	ACCL	S
26	995	ACCL	11[illegible]	ACCL	S
27	13[illegible]	ACCL			
28	9[illegible]	ACCL	955	ACCL	S
29	1[illegible]	ACCL			
30	695	ACCL	1[illegible]	ACCL	S
	3[illegible]7 5		[illegible]35		

e) Z axis

```
          SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE      1ST DETECTION                    1ST ISOLATION

  1          775     ACCL          [illegible]    ACCL      [illegible]
  2    [illegible]   ACCL          [illegible]    ACCL      [illegible]
  3    [illegible]   ACCL          [illegible]    ACCL      [illegible]
  4          755     ACCL          [illegible]    ACCL      5
  5   37[illegible]  ACCL         [illegible]5    ACCL      5
  6   [illegible]5   ACCL          [illegible]    ACCL      5
  7    [illegible]   ACCL         59[illegible]   ACCL      5
  8   37[illegible]  ACCL          [illegible]    ACCL      5
  9          375     ACCL          [illegible]    ACCL      5
 10   [illegible]5   ACCL          [illegible]    ACCL      5
 11   37[illegible]  ACCL          [illegible]    ACCL      5
 12    [illegible]   ACCL          [illegible]    ACCL      5
 13   [illegible]5   ACCL         [illegible]5    ACCL      5
 14          755     ACCL          [illegible]    ACCL      5
 15    [illegible]   ACCL         64[illegible]   ACCL      5
 16   75[illegible]  ACCL         54[illegible]   ACCL      5
 17    [illegible]   ACCL         [illegible]7    ACCL      5
 18    [illegible]   ACCL          [illegible]    ACCL      5
 19   37[illegible]  ACCL          [illegible]    ACCL      5
 20    [illegible]   ACCL          [illegible]    ACCL      5
 21   33[illegible]  ACCL          [illegible]    ACCL      5
 22   [illegible]5   ACCL             395         ACCL      5
 23  [illegible]55   ACCL         [illegible]7    ACCL      5
 24    [illegible]   ACCL        [illegible]75    ACCL      5
 25    [illegible]   ACCL             555         ACCL      5
 26          375     ACCL   [illegible]9[illegible] ACCL    5
 27   37[illegible]  ACCL          [illegible]    ACCL      5
 28   37[illegible]  ACCL             465         ACCL      5
 29    [illegible]   ACCL         37[illegible]   ACCL      5
 30    [illegible]   ACCL             425         ACCL      5
          ------                     ------
          11130                      25503
```

a) -45° in XY plane

```
          SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE      1ST DETECTION                    1ST ISOLATION

  1   81[illegible]  ACCL     11[illegible]5      ACCL      5
  2    [illegible]   ACCL          993            ACCL      5
  3          815     ACCL          915            ACCL      5
  4   8[illegible]   ACCL     1[illegible]5       ACCL      5
  5   8[illegible]   ACCL     1[illegible]        ACCL      5
  6   8[illegible]   ACCL     1[illegible]        ACCL      5
  7   6[illegible]5  ACCL
  8          815     ACCL     135[illegible]      ACCL      5
  9   81[illegible]  ACCL         1255            ACCL      5
 10          815     ACCL     13[illegible]5      ACCL      5
 11   84[illegible]  ACCL
 12   8[illegible]   ACCL
 13    [illegible]   ACCL     115[illegible]      ACCL      5
 14   8[illegible]   ACCL
 15    [illegible]   ACCL         1975            ACCL      5
 16          815     ACCL
 17   6[illegible]   ACCL
 18   [illegible]5   ACCL         1455            ACCL      5
 19   [illegible]5   ACCL
 20   8[illegible]   ACCL
 21   8[illegible]   ACCL         1475            ACCL      5
 22    [illegible]   ACCL         1235            ACCL      5
 23    [illegible]   ACCL
 24   8[illegible]5  ACCL
 25    [illegible]   ACCL
 26    [illegible]   ACCL      [illegible]        ACCL      5
 27    [illegible]   ACCL      [illegible]        ACCL      5
 28   86[illegible]  ACCL         1475            ACCL      5
 29    [illegible]   ACCL      [illegible]        ACCL      5
 30   82[illegible]  ACCL   [illegible]7[illegible] ACCL    5
          ------                     ------
       12[illegible]                 23435
```

b) X axis

```
          SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE      1ST DETECTION                    1ST ISOLATION

  1   35[illegible]  ACCL      [illegible]        ACCL      5
  2    [illegible]   ACCL      [illegible]        ACCL      5
  3          355     ACCL     115[illegible]      ACCL      5
  4   35[illegible]  ACCL      [illegible]        ACCL      5
  5          355     ACCL          995            ACCL      5
  6    [illegible]   ACCL      [illegible]        ACCL      5
  7   35[illegible]  ACCL      [illegible]        ACCL      5
  8          355     ACCL      [illegible]        ACCL      5
  9          355     ACCL     7[illegible]        ACCL      5
 10          355     ACCL          995            ACCL      5
 11          355     ACCL      [illegible]        ACCL      5
 12          355     ACCL     7[illegible]        ACCL      5
 13   35[illegible]  ACCL    1[illegible]75       ACCL      5
 14   35[illegible]  ACCL    [illegible]535       ACCL      5
 15          355     ACCL     1[illegible]        ACCL      5
 16    [illegible]   ACCL      [illegible]        ACCL      5
 17   35[illegible]  ACCL     [illegible]35       ACCL      5
 18          355     ACCL     95[illegible]       ACCL      5
 19          355     ACCL     99[illegible]       ACCL      5
 20          355     ACCL          955            ACCL      5
 21          355     ACCL          245            ACCL      5
 22   35[illegible]  ACCL          375            ACCL      5
 23   35[illegible]  ACCL     97[illegible]       ACCL      5
 24          355     ACCL          825            ACCL      5
 25    [illegible]   ACCL     9[illegible]5       ACCL      5
 26    [illegible]   ACCL     7[illegible]5       ACCL      5
 27   35[illegible]  ACCL     53[illegible]       ACCL      5
 28    [illegible]   ACCL          955            ACCL      5
 29    [illegible]   ACCL     57[illegible]       ACCL      5
 30   [illegible]5   ACCL      [illegible]        ACCL      5
          ------                     ------
          13626                      24275
```

c) +45° in XY plane

```
          SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE      1ST DETECTION                    1ST ISOLATION

  1          356     ACCL     35[illegible]       ACCL      5
  2          355     ACCL          935            ACCL      5
  3          365     ACCL      [illegible]        ACCL      5
  4          385     ACCL      [illegible]        ACCL      5
  5          385     ACCL          355            ACCL      5
  6          385     ACCL      [illegible]        ACCL      5
  7          345     ACCL          375            ACCL      5
  8   38[illegible]  ACCL          375            ACCL      5
  9          385     ACCL          375            ACCL      5
 10    [illegible]   ACCL      [illegible]        ACCL      5
 11   35[illegible]  ACCL   [illegible]7[illegible] ACCL    5
 12          345     ACCL      [illegible]        ACCL      5
 13   35[illegible]  ACCL     37[illegible]       ACCL      5
 14    [illegible]   ACCL      [illegible]        ACCL      5
 15    [illegible]   ACCL      [illegible]        ACCL      5
 16   35[illegible]  ACCL     [illegible]5        ACCL      5
 17   [illegible]5   ACCL     [illegible]5        ACCL      5
 18    [illegible]   ACCL     [illegible]55       ACCL      5
 19    [illegible]   ACCL      [illegible]        ACCL      5
 20          385     ACCL     [illegible]35       ACCL      5
 21   38[illegible]  ACCL      [illegible]        ACCL      5
 22   34[illegible]  ACCL      [illegible]        ACCL      5
 23    [illegible]   ACCL      [illegible]        ACCL      5
 24   38[illegible]  ACCL      [illegible]        ACCL      5
 25   33[illegible]  ACCL          375            ACCL      5
 26    [illegible]   ACCL     [illegible]5        ACCL      5
 27    [illegible]   ACCL      [illegible]        ACCL      5
 28          385     ACCL     [illegible]75       ACCL      5
 29          335     ACCL     [illegible]5        ACCL      5
 30          335     ACCL          835            ACCL      5
          ------                     ------
       1[illegible]320            [illegible]
```

d) Y axis

Table 9. 8000 ppm Accelerometer Scale Factor Error, IMU #1

```
          SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

CYCLE      1ST DETECTION                    1ST ISOLATION

  1          795     ACCL      [illegible]        ACCL      5
  2   61[illegible]  ACCL      [illegible]        ACCL      5
  3   57[illegible]  ACCL     1[illegible]        ACCL      5
  4          725     ACCL      [illegible]        ACCL      5
  5   79[illegible]  ACCL      [illegible]        ACCL      5
  6   9[illegible]   ACCL          595            ACCL      5
  7   1[illegible]   ACCL     1[illegible]        ACCL      5
  8          775     ACCL      [illegible]        ACCL      5
  9   99[illegible]  ACCL     11[illegible]       ACCL      5
 10   76[illegible]  ACCL   [illegible]9[illegible] ACCL    5
 11   1[illegible]   ACCL     1[illegible]        ACCL      5
 12   99[illegible]  ACCL      [illegible]        ACCL      5
 13          725     ACCL      [illegible]        ACCL      5
 14          925     ACCL      [illegible]        ACCL      5
 15   7[illegible]5  ACCL   [illegible]47[illegible] ACCL   5
 16    [illegible]   ACCL     75[illegible]       ACCL      5
 17          915     ACCL     1[illegible]5       ACCL      5
 18   79[illegible]  ACCL      [illegible]        ACCL      5
 19   7[illegible]   ACCL      [illegible]        ACCL      5
 20   79[illegible]  ACCL      [illegible]        ACCL      5
 21    [illegible]   ACCL   [illegible]55[illegible] ACCL   5
 22   1[illegible]   ACCL     1[illegible]        ACCL      5
 23          715     ACCL     1[illegible]        ACCL      5
 24   85[illegible]  ACCL     1[illegible]        ACCL      5
 25  [illegible]15   ACCL     1[illegible]        ACCL      5
 26   6[illegible]   ACCL      [illegible]        ACCL      5
 27  111[illegible]  ACCL     1[illegible]        ACCL      5
 28   7[illegible]   ACCL      [illegible]        ACCL      5
 29 1[illegible]1[illegible] ACCL 11[illegible]   ACCL      5
 30          635     ACCL      [illegible]        ACCL      5
          ------                     ------
          25195                  3194[illegible]
```

e) Z axis

```
          SPRT DETECTION/ISOLATION PERFORMANCE SUMMARY

----CYCLE-------1ST-DETECTION-------------- 1ST-ISOLATION --
      1            0                  0          0
      2            0                  0          0
----- 3 ---------- 0 ---------------- 0 -------- 0 --
      4            0                  0          0
      5            0                  0          0
      6            0                  0          0
----- 7 ---------- 0 ---------------- 0 -------- 0 --
      8            0                  0          0
      9            0                  0          0
     10            0                  0          0
---- 11 ---------- 0 ---------------- 0 -------- 0 --
     12            0                  0          0
     13            0                  0          0
     14            0                  0          0
---- 15 ---------- 0 ---------------- 0 -------- 0 --
     16            0                  0          0
     17            0                  0          0
     18            0                  0          0
---- 19 ---------- 0 ---------------- 0 -------- 0 --
     20            0                  0          0
     21            0                  0          0
     22            0                  0          0
---- 23 ---------- 0 ---------------- 0 -------- 0 --
     24            0                  0          0
     25            0                  0          0
     26            0                  0          0
---- 27 ---------- 0 ---------------- 0 -------- 0 --
     28            0                  0          0
     29            0                  0          0
     30            0                  0          0
-------------------------------------------------------
                   0                  0
```

Table 10. Nominal IMU's #1 and #2