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oly to Attn of:

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To: 421/EOS-AM Project Manager

From: 543/EOS-AM Observatory Manager

Subject: EOS-AM Transportation Dynamic Environment

1.0 Summary

The overall dynamic environment was benign with the road segment dominating the responses. Axial and lateral responses were all under .5g. The maximum dynamic vertical acceleration was 1.2g at the end of the Observatory. The maximum response during the C5A segment of the trip occurred at landing and was measured at .5g. All responses are well below test verified limits.

2.0 Background

2.1 EOS Transportation

The EOS-AM Observatory was shipped over the road from the Lockheed-Martin Valley Forge facility to Dover AFB. The transporter was then backed into a C5A and flown to Vandenberg AFB. After unloading at VAFB the transporter was driven over the road about a mile to the Astrotech launch processing facility. The Observatory has been successfully unloaded at Astrotech and launch processing is currently underway.

The EOS-AM Observatory utilized a custom transportation system. The Observatory was cantilevered to a strongback, which in turn was isolated, using a series of rubber blocks, from the floor of the center section of the transporter. A detachable set of front and rear bogies, and an aluminum cover, converted this into a custom trailer. The center section also contained air-bearing pads, castors, and jacks for handling at both Valley Forge and Astrotech.

2.2 Instrumentation

A total of 15 accelerometers were used to monitor the dynamic environment during transport. Two IST, model EDR3D, data acquisition systems were custom built for this application. These systems each included an internal triaxial accelerometer as well as an

external triaxial set hardwired directly to the analog-to-digital converter. The lack of connectors between the external accelerometers and the ADC was intended to eliminate any false triggers due to movement of the connectors.

LMMS developed two mounting plates, which were used to mount the external triaxial units to node fittings near the spacecraft center of gravity and close to the end of the cantilever. One data acquisition unit was mounted below the vertical strongback on the isolated side of the center section and another was mounted on the center section floor near the rear access door. When bench testing showed intermittent failures in the Y channel of one of the external triaxial accelerometers IST provided an additional EDR3C unit. This unit provided an additional triaxial accelerometer, which was mounted on the plate on the end of the spacecraft. This gave a redundant set of data at the plate on the spacecraft tip. The block with the questionable accelerometer channel was mounted to put the "bad" channel in the spacecraft axial direction and the triggers were disabled for this channel. There were no accelerometer problems noted in the data acquired for this, or any other channel.

The following data acquisition settings were used on all channels:

Sample rate:	250 Hz.
Anti-alising filters:	60 Hz.
Number of samples/event:	8192
Number of pre-trigger samples:	1024
Sample Duration:	32.8 seconds
Trigger level:	0.4 g
Full-scale range:	10 g
ADC resolution:	10 bits, (about .03g measured)
Number of events:	100 before overwrite

The triggers were set so that any channel within an individual EDR unit would trigger acquisition of the remaining channels in that unit. No attempt was made to cross-strap the triggers between EDRs. The only exception was that the trigger for the "bad" channel mentioned above was disabled. It should be noted that IST performed a separate test to ensure that over 97% of the full level was reached at 40 Hz with the filters set at 60 Hz. The intent of the lower frequency filter settings was to eliminate the influence of any high-frequency noise on the results.

3.0 Results

The results are presented in the following table. The table presents a total of 43 events assembled from all the events acquired. The relatively long sample period and low filter frequency made the data assembly task fairly easy as the same "bounce" tended to trigger all units at close to the same time. There were no "bad" events acquired with the EDR3D units and only two anomalous triggers on the EDR3C unit. All events but one were from the initial road transportation phase, with the two largest around the time we pulled over

to fix the ECS system. The guess is that the trailer hit a pothole or soft spot as it pulled off the road.

The table presents results in the spacecraft coordinate system. Xsc pointed toward the rear of the trailer, Ysc pointed vertically, and Zsc was lateral. The directions indicated for the individual channels are in the local channel coordinates. All responses are dynamic so that the Ysc results do not include the 1g static bias.

Results showed the maximum response of 1.22g at the tip of the spacecraft. Axial and vertical response were below .4g during this event and below .5g overall. The next highest level recorded was .75g at the spacecraft tip and was recorded just before the maximum. The C5A landing was the only event triggered after arrival at Dover AFB. The landing was very gentle with the accelerometer on the plane reading 1.2g, including the static 1g contribution. The measured landing response peaked at .5g in the vertical direction on the trailer floor with similar values, in both the vertical and lateral directions, at the spacecraft tip. Both accelerometer sets, on the tip mounting plate, agreed to within a bit or two, providing an additional check of the validity of the data.

4.0 Conclusion

The EOS-AM transportation was completed successfully. All responses are well below the design limits and no areas of concern have been identified.

		Xs/c					Ys/c					Zs/c				
		2067a	2066a	2067b	2066b	3c	2067a	2066a	2067b	2066b	3c	2067a	2066a	2067b	2066b	3c
		trailer	strgbck	s/c cg	s/c tip	s/c tip	trailer	strgbck	s/c cg	s/c tip	s/c tip	trailer	strgbck	s/c cg	s/c tip	s/c tip
time	note	Peak X	Peak X	Peak X	Peak Y	Peak X	Peak Z	Peak Z	Peak Y	Peak Z	Peak Y	Peak Y	Peak Y	Peak Z	Peak X	Peak Z
g		g	g	g	g	g	g	g	g	g	g	g	g	g	g	g
4/15/99 16:49			0.14		0.17	0.15		0.17		0.46	0.45		0.08		0.29	0.29
4/15/99 21:40	Depart LMMS-VF		0.08		0.12	0.12		0.10		0.52	0.52		0.08		0.25	0.25
4/15/99 21:44			0.08		0.14	0.12		0.33		0.44	0.42		0.15		0.25	0.25
4/15/99 21:48		0.08	0.08	0.11	0.19	0.17	0.32	0.33	0.38	0.46	0.45	0.08	0.08	0.12	0.23	0.23
4/15/99 21:53			0.12		0.19	0.19		0.24		0.44	0.43		0.28		0.29	0.30
4/15/99 21:54		0.10	0.10	0.09	0.14	0.13	0.48	0.40	0.36	0.40	0.42	0.15	0.24	0.12	0.29	0.30
4/15/99 21:55		0.08	0.10	0.09	0.10	0.10	0.46	0.37	0.40	0.48	0.47	0.08	0.10	0.10	0.25	0.25
4/15/99 21:57			0.08		0.12	0.10		0.33		0.42	0.42		0.15		0.25	0.25
4/15/99 21:59			0.08		0.12	0.12		0.33		0.42	0.42		0.19		0.19	0.18
4/15/99 22:04	overpass		0.12		0.23	0.22		0.31		0.46	0.47		0.24		0.40	0.41
4/15/99 22:05	overpass					0.22					0.36					0.41
4/15/99 22:06	overpass	0.13	0.12	0.17	0.17	0.24	0.32	0.28	0.40	0.58	0.57	0.15	0.24	0.18	0.46	0.48
4/15/99 22:07	overpass					0.17					0.42					0.32
4/15/99 22:09	RT 1		0.12		0.17	0.17		0.30		0.46	0.43		0.22		0.34	0.35
4/15/99 22:12	RT 2	0.13	0.16	0.21	0.23	0.22	0.25	0.21	0.42	0.65	0.66	0.13	0.13	0.14	0.27	0.27
4/15/99 22:12	overpass				0.19	0.19				0.50	0.50				0.44	0.46
4/15/99 22:12			0.16					0.28					0.28			
4/15/99 22:13		0.15		0.23	0.28	0.26	0.32		0.40	0.46	0.45	0.19		0.18	0.38	0.41
4/15/99 22:13		0.13	0.12	0.15			0.34	0.31	0.38			0.13	0.17	0.14		
4/15/99 22:14		0.15	0.18	0.43	0.41	0.40	0.51	0.49	0.58	0.75	0.72	0.10	0.17	0.18	0.27	0.44
4/15/99 22:15	stop for ECS fix	0.17	0.21	0.37	0.39	0.39	0.83	0.78	1.02	1.22	1.21	0.22	0.33	0.18	0.30	0.32
4/15/99 22:42	underway - stop for ECS fix		0.14		0.14			0.24		0.42			0.22		0.29	
4/15/99 22:44		0.08	0.08	0.11	0.14	0.12	0.58	0.51	0.47	0.56	0.57	0.10	0.15	0.10	0.25	0.23
4/15/99 22:45		0.08	0.12	0.11	0.14	0.13	0.43	0.37	0.40	0.48	0.49	0.08	0.17	0.14	0.30	0.30
4/15/99 22:46		0.08	0.08	0.09	0.14	0.12	0.34	0.31	0.42	0.46	0.47	0.06	0.08	0.08	0.19	0.18
4/15/99 22:49			0.18		0.21	0.19		0.31		0.52	0.52		0.22		0.27	0.27
4/15/99 22:52			0.14		0.17	0.15		0.28		0.48	0.47		0.15		0.25	0.27
4/15/99 22:56	RT 14/131				0.19					0.42					0.19	
4/15/99 22:57		0.10	0.08	0.13	0.16	0.13	0.43	0.40	0.42	0.60	0.57	0.13	0.17	0.12	0.34	0.35
4/15/99 22:58	to 195	0.10	0.10	0.17	0.19	0.17	0.58	0.51	0.47	0.56	0.57	0.08	0.13	0.10	0.27	0.27

4/15/99 22:59					0.17					0.42					0.46	
4/15/99 23:00	overpass		0.10			0.17		0.21			0.31		0.22			0.48
4/15/99 23:14			0.08		0.12	0.10		0.28		0.52	0.50		0.10		0.29	0.30
4/15/99 23:19	underway - stop for ECS fix		0.08		0.16	0.15		0.21		0.50	0.50		0.08		0.21	0.20
4/15/99 23:24	over new bridge	0.13	0.16	0.17	0.23	0.21	0.36	0.33	0.40	0.52	0.50	0.19	0.31	0.18	0.36	0.37
4/15/99 23:25		0.10	0.16	0.23	0.28	0.26	0.29	0.28	0.42	0.52	0.52	0.15	0.24	0.14	0.40	0.42
4/15/99 23:27		0.29	0.29	0.27	0.32	0.31	0.46	0.42	0.31	0.48	0.49	0.22	0.33	0.23	0.40	0.42
4/15/99 23:28		0.10	0.14	0.15	0.16	0.13	0.55	0.49	0.59	0.71	0.68	0.08	0.10	0.10	0.21	0.22
4/15/99 23:49	underway - cop stop		0.14		0.17	0.17		0.35		0.44	0.45		0.08		0.23	0.23
4/15/99 23:51			0.10		0.26	0.24		0.24		0.46	0.47		0.15		0.30	0.32
4/15/99 23:51			0.10		0.14	0.15		0.28		0.42	0.42		0.10		0.25	0.23
4/15/99 23:54	road travel	0.13	0.10	0.17	0.17	0.15	0.46	0.39	0.31	0.50	0.49	0.08	0.10	0.08	0.29	0.30
4/16/99 14:41	Landing at VAFB	0.15	0.16	0.17	0.17	0.17	0.50	0.44	0.26	0.46	0.43	0.17	0.22	0.23	0.46	0.46