FERMILAB
AD/Mechanical Support Department

November 7, 2011

1.3 GHz Cryomodule (CM2) Coldmass Transport to Industrial Center Building (ICB)

(MSDN-ME-000109)

Michael W. McGee

Summary

The duration of the transport of CM2 coldmass from its support at MP9 to the support at ICB spanned 2 hours, 3 minutes and 18 seconds. The CM2 coldmass assembly traveled 2.4 miles in 16 minutes and 28 seconds with an average speed of 9.8 mph. During the transport of the CM1 coldmass from MP9 to ICB on October 15th, 2007, a benchmark maximum acceleration of 2.43 g (vertical) on base frame and 0.25 g (vertical) on any cavity was measured. The goal was to limit maximum acceleration experienced by the coldmass to 0.5 g, during the CM2 coldmass assembly transport from MP9 to ICB.

Assembly Setup and Instrumentation

The CM2 Coldmass transport assembly shown in Figure 1 consists of a cryomodule coldmass weighing 4-tons, a strong-back fixture weighing 2.69-tons and base frame weighing 1.4-tons. In total, the CM2 coldmass assembly weight found above the isolators (not including the base frame) is approximately 6.69-tons. Four helical coils in a compression-roll (45 degree) configuration attenuate shock between the base frame and isolation fixture. The isolators, manufactured by Isolator Dynamics Corp. (IDC), part # M24A-400-08 each have a static spring constant of 7,000 lb/in and dynamic constant of 3,000 lb/in[1]. The isolator design considers a frequency ratio of 3:1, providing 80% isolation between the base frame and isolation fixture.

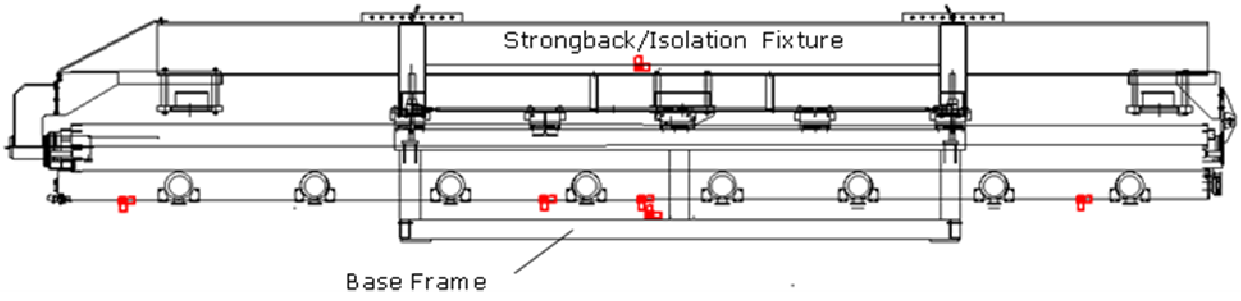

Figure 1. Elevation view of CM1 transport assembly with instrumentation locations.

In Figure 2, the center of gravity is shown, roughly in-line with the center of the isolators (therefore maximizing stability). The downstream (DS) end of the assembly is

loaded slightly more due to the relative position of strong-back fixture and cryomodule. This slight off-set was necessary in order to keep the load centered or level transversely and longitudinally, when lifting with a crane.

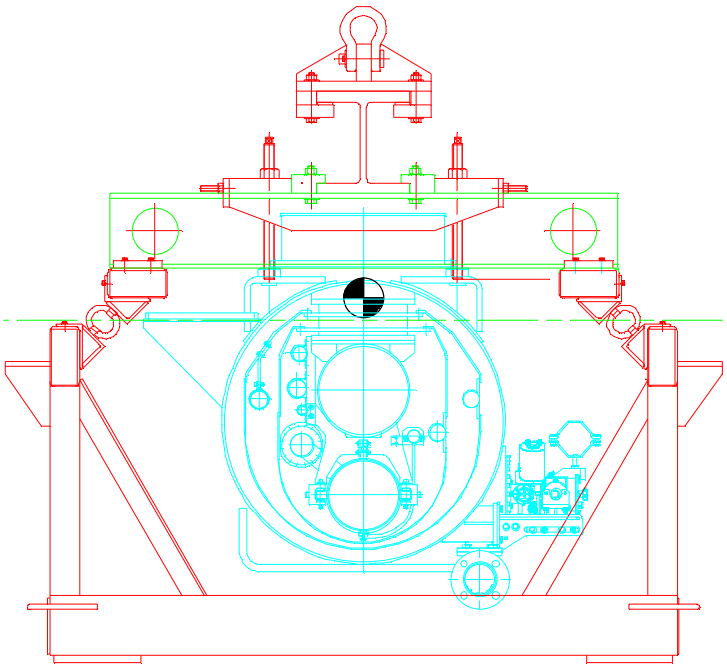

Figure 2. Center of gravity of CM2 Coldmass assembly versus isolator center.

A total of (20) Geospace HS-1 geophone devices in block sets of 3 (x, y and z-direction) were attached to the isolation fixture, Cavities #1, #4, #5, #8 (see Figure 3) and base frame as shown in Figure 1[2]. All geophones were connected to five National Instruments (NI) NI-9233 4-channel, 24-bit ADC modules found within an NI chassis sampled at 2K/s, and the data was recorded to a laptop hard-drive.

Figure 3 Instrumentation mounted near Cavity #5.

Shock Response

The movement of CM2 Coldmass from MP9 to ICB was divided into three phases; loading at MP9, over-the-road transport and unloading at ICB.

Loading at MP9

Initially, the base frame with four isolators attached was loaded and secured onto the 48' air-ride trailer. All loading was completed using a 30-ton overhead crane. After activating the geophones, the CM2 Coldmass assembly was then carefully loaded onto the base frame as shown in Figure 4.

Figure 4. Loading CM2 Coldmass assembly onto base frame at MP9.

Table 1 provides a summary of maximum acceleration loads experienced during the crane operation and subsequent attachment to the base frame. Figures 5, 6 and 7 show the geophone data while loading at MP9, in the vertical, transverse and longitudinal direction, respectively. The crane acceleration loads are quite low as compared to loads experienced during connection of the transport assembly. Maximum acceleration values from the cavities were designated as "Cavities" in each summary table.

Table 1. MP9 summary of maximum acceleration of geophone devices.

Location	Vertical Acceleration (g)	Transverse Acceleration (g)	Longitudinal Acceleration (g)
Cavities	0.07	0.2	0.17
Base	---	---	---
Isolation	**0.59**	0.2	0.26

Bold face font indicates absolute maximum acceleration of coldmass and *italic* absolute for base.

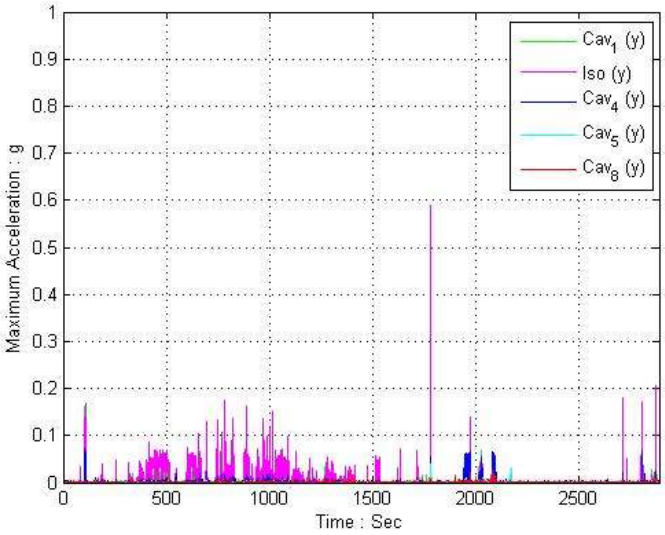

Figure 5. Vertical geophone acceleration loads at MP9.

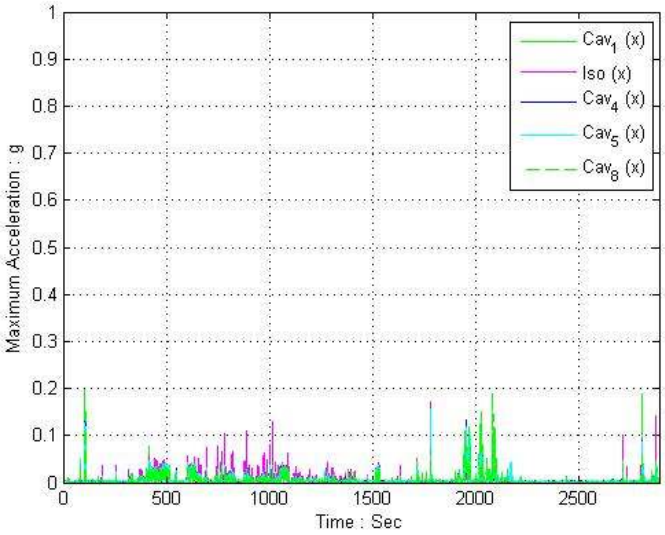

Figure 6. Transverse geophone acceleration loads at MP9.

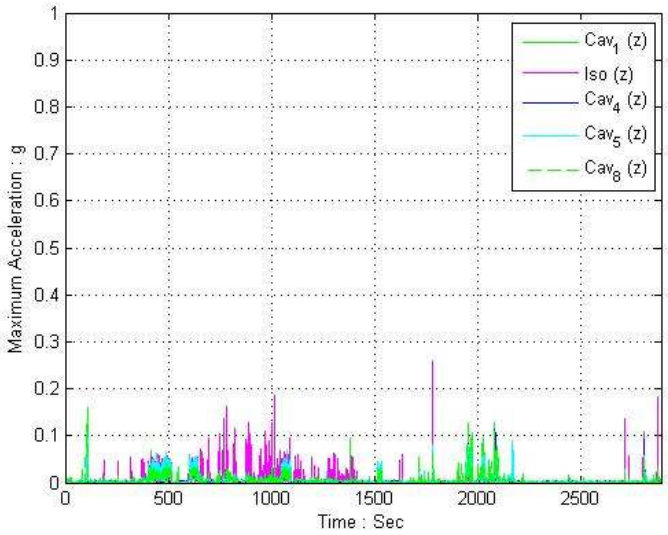

Figure 7. Longitudinal geophone acceleration loads at MP9.

Over-the-road Transport

Precautions were taken to limit longitudinal acceleration/deceleration by transporting at a continuous speed under Security escort. A summary of maximum accelerations experienced during the transport phase is given in Table 2. The maximum accelerations found during the transport in the vertical, transverse and longitudinal direction are shown in Figures 8, 9 and 10, respectively.

Table 2. Over-the-road phase summary of maximum acceleration of geophone devices.

Location	**Vertical Acceleration (g)**	**Transverse Acceleration (g)**	**Longitudinal Acceleration (g)**
Cavities	0.03	0.15	0.07
Base	0.06	*0.17*	0.1
Isolation	0.03	0.14	0.07

Bold face font indicates absolute maximum acceleration of coldmass and *italic* absolute for base.

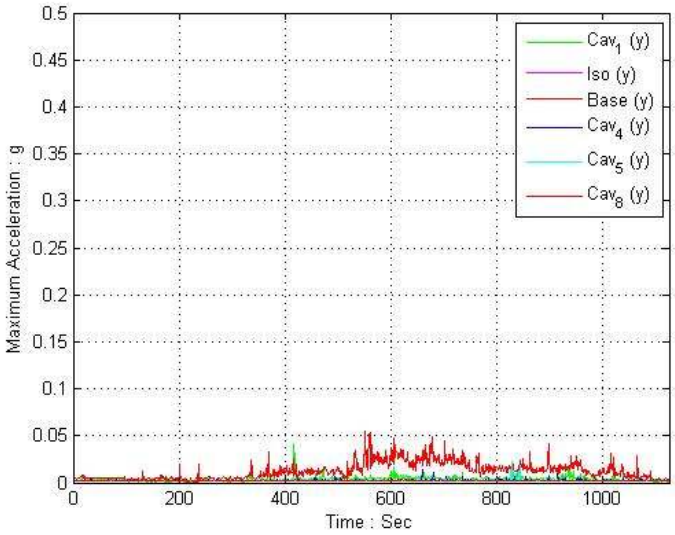

Figure 8. Vertical geophone acceleration loads during over-the-road transport.

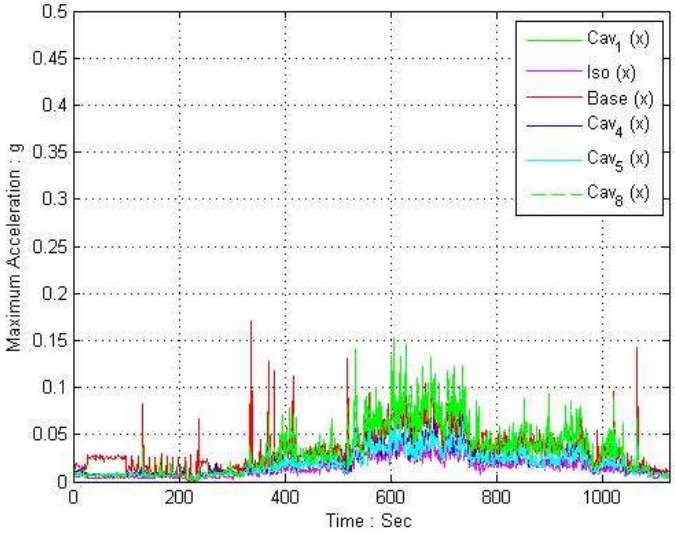

Figure 9. Transverse geophone acceleration loads during over-the-road transport.

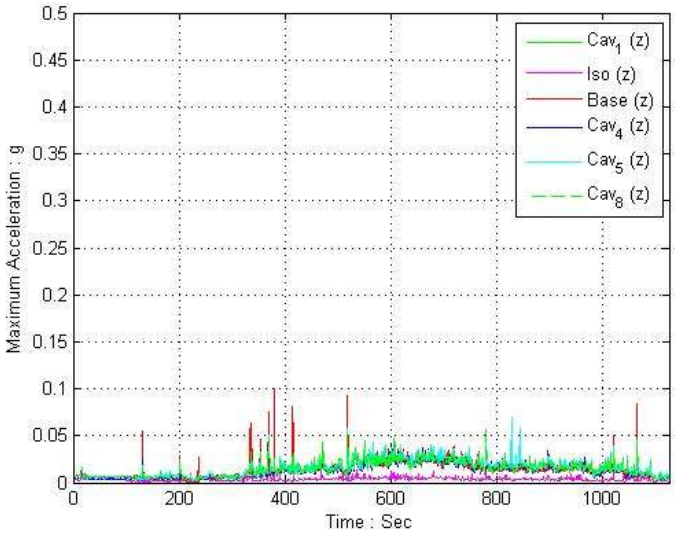

Figure 10. Longitudinal geophone acceleration loads during over-the-road transport.

Unloading at ICB

After arriving within the ICB highbay, the CM2 Coldmass assembly was supported by the overhead crane and the isolators were disconnected. Table 3 provides the maximum acceleration results during unloading and crane transport onto the coldmass supports as shown in Figure 11.

Figure 11. Unloading CM2 coldmass onto the coldmass support at ICB.

Table 3. ICB summary of maximum acceleration of geophone devices.

Location	Vertical Acceleration (g)	Transverse Acceleration (g)	Longitudinal Acceleration (g)
Cavities	0.07	0.12	0.18
Base	---	---	---
Isolation	0.52	0.3	0.36

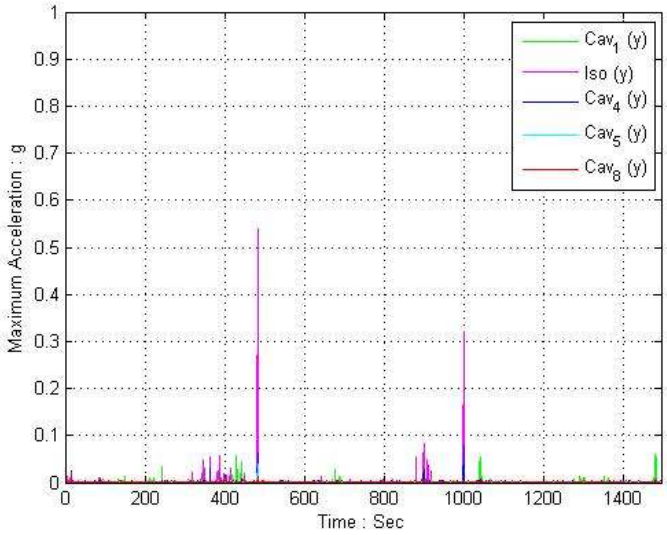

Figure 12. Vertical geophone acceleration loads during unloading.

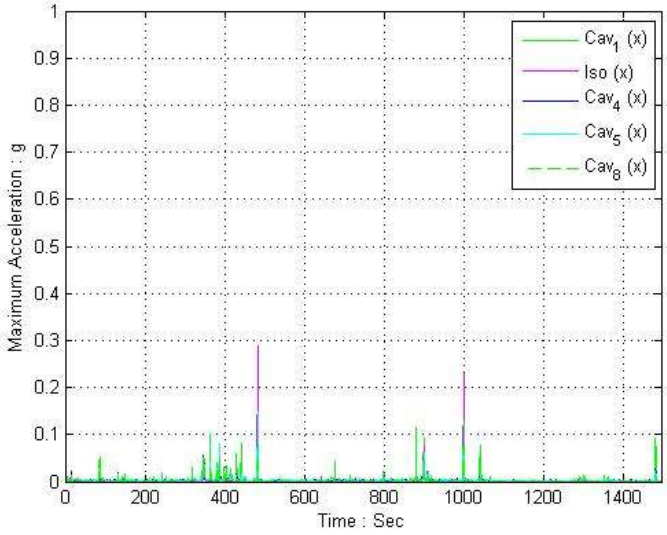

Figure 13. Transverse geophone acceleration loads during unloading.

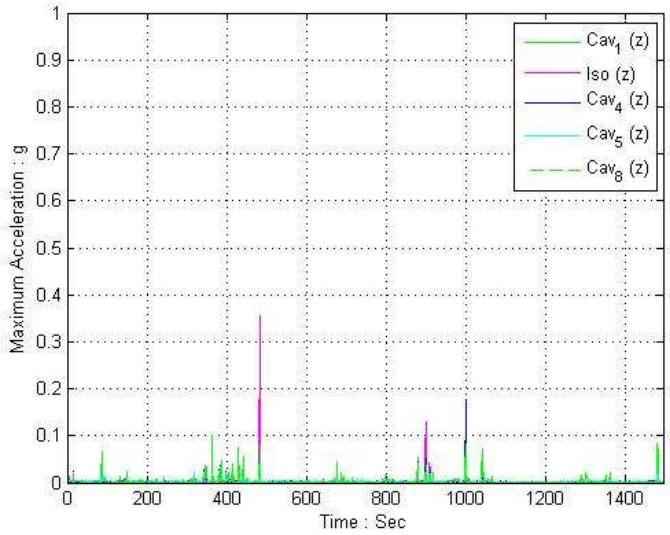

Figure 14. Longitudinal geophone acceleration loads during unloading.

Results

Maximum measured acceleration loads over all three transport phases on the CM2 coldmass is shown in boldface in Table 1. The maximum acceleration vertically was 0.59 g, however the maximum acceleration measured for the cavities was 0.2 (transverse). The cavity maximum accelerations were beneath the goal value of 0.5 g. The transverse acceleration load maximum of 0.17 g for the base (italicized in Table 2) was measured during the over-the-road phase.

References

[1] www.isolator.com

[2] www.geospacelp.com