DEM Structural Model Technical Notes
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Two separate areas will be covered in the technical discussion of the Structural model of the DEM:

1. Mechanical configuration/design description with assumptions taken to verify the structure
2. Description of Structural-Thermal model and its design criteria

1 Mechanical Configuraton/Design Description

The DEM structure consists of four basic pieceparts:

1. Module Box - the main box structure into which all electronics modules are placed. The box is machined from a solid piece of aluminum and is the only load bearing member of the structure assembly. The mounting lugs which attach the DEM to the S/C platform are integrally machined as part of the box and meet all design criteria as outlined in EID-A. Average material thickness of the box is 1.3mm with a center top section of up to 6mm in thickness for radiation protection of certain suceptible electronics modules within the DEM. Stiffening webs are also machined into the surfaces to increase rigidity.
2. Motherboard Frame - holds the motherboard (electronic backplane) in place and attaches to one end (+Zu) of the Module Box. The motherboard is clamped in between the box and the frame with screws holding the frame to the box. The motherboard frame is slightly elevated from the S/C platform so that it bears no structural load other than its own mass, which is supported by the 16 or so screws which hold it to the box. Screws are #2-56 (approximate M2 size) with the large number being chosen for distributed clamping force rather than load support.
3. Front Cover - wraps around three surfaces (top and two sides) of the front (-Zu) face of the module box. The cover is single piece machined aluminum with average material thickness of 1.3mm, though a center section which covers those modules more suceptible to radiation as discussed above, has thickness of up to 6mm. Slots are machined in the front face of the cover where all interface connectors are located. Interface connectors (J01 - J05) are right-angle PC board mount "D-Type" and are mounted directly to the module frames/pc boards within the DEM. Connection to the cable harness (OM 3) is easily made. The front cover attaches to the module box along four separate surfaces (shown on ICD #R39988). In addition, two screws attach the front face of the cover to each of the 19 electronics modules inside the DEM. This attachment increases the thermal conductivity from the modules to the front face of the cover, which acts as the primary radiator for the assembly.

4. Rear Cover - wraps around three surfaces of the motherboard frame located at the +Zu end of the module box. It is similar in design to the front cover, but without additional radiation shielding thickness. This cover is solely meant to protect the back surface of the motherboard from the environment. Currently, the design calls for minimum material thickness of 1.3mm on this cover, dependant upon the placement of the two DEM assemblies "back to back", with the rear covers facing each other, with a maximum separation distance that allows only for clearance of screwheads and (if required), MLI. The intent is to minimize additional mass requirements for radiation protection on this surface, by allowing the two DEMs to shield each other.

Within the DEM are housed 19 (includes 1 spare) electronics modules as well as two "slide in" radiation shields. Each module is mounted in a separate module frame, either aluminum or Ryton R-4, and inserted separatly into the module box. Grooves are machined into the inner top and bottom surfaces of the module box and act as guides for insertion and alignment of the modules to the motherboard. Each module has either a 74 or 95 pin connector mounted on one end which interfaces to a socket connector of the same type on the motherboard. Insertion force required to mate the two is fairly substantial and once assembled, the installation of the front cover, as discussed above, prevents any demating under vibration. Previous modal testing on modules of the same size and basic design, indicate a first global resonance of about 250 Hz.

The two radiation shields also are installed in the same manner as the modules and are held in place with screws through the top and bottom surfaces of the module box. These two inner shields, along with the shielded areas on the top and front faces of the assembly, surround the seven modules most sensitive to radiation with a minimum effective shield of 6.7mm.

2 Mechanical Design Assumptions and Verification

As is mentioned previously, the primary load bearing component (other than analysis of the PC board designs themselves), is the module box. As the box is machined from solid material, no joints or interfaces present themselves as a matter of concern except that of the mounting lugs and the interface of the box to the S/C platform. Two areas of analysis can be looked at:

1. the material chosen for the box and
2. the adequacy of the number of bolts and their strength given the loading and factor of safety.

The material chosen for the structure is Aluminum, 6061-T6, a wrought alloy with the following properties:

1. Ultimate Tensile Strength - 45 kpsi (310 MPa)
2. Yield Strength - 40 kpsi (276 MPa)
3. Ultimate Shear Strength - 30 kpsi (207 MPa)

* A multiplication conversion factor of 6.89 MPa/kpsi was used

Worst case loading occurs in shear, as this is where the material has the lowest strength. Tearing of the "margin", that area of the mounting lug outward from the M4 mounting bolts, will be analyzed. Stress concentration at the hole itself, due to tension, will also be considered, though typically if the bolt preload is applied correctly and maintained, the stress concentration at the hole is nullified. Preliminary calculations indicate that the material of the box, along with the mounting lug design, are more than adequate to withstand the loading. As the DEM module box is the only structural element and is fairly straightforward to analyze mathematically, it is not intended that a finite element analysis be done. All mathematical calculations and assumptions will be provided. A finite element analysis, due to cost constraints at SNL, is not deemed necessary at this time.

In analyzing bolt adequacy, the following assumptions are made:

1. M4 Socket Head bolts are to be used
2. Mat'l: Corrosion Resistant type 304 Stainless Steel Anti-Magnetic
3. Property Class 70 / Grade A2
4. Tensile Strength Area At = 8.78mm^{-2}
5. Tensile Strength: 700 Nmm^{-2} (100,000 psi)
6. Breaking Torque: 3.8 N.m (33.6 in.lb)

* Information taken from Metric and Multistandard Corp. Catalog

Additional criteria used to calculate load on the bolts is taken from the National Aerospace Standard (NAS) catalog. Though information available is for American National Standard bolt sizes, values are conservative and felt to be applicapable at this time. An M4 bolt is 0.157 in (DIA) with the closest American Standard size being a #8 (0.164 in (DIA)). Data for corrosion resistant steel socket head bolts indicates a breaking strength of 1,120 lb (4984 N) and At = 9 mm^2. This corresponds to a breaking stress of 80,000 psi, below the limit shown for the M4 bolts (smaller in size). It is therefore felt that using the breaking strength for the #8 bolts will yield conservative design values.

Using the criteria outlined in the EID-A; 5.5.5, with a worst case factor of safety = 3, the following margin is shown:

1. Mass of Unit = 18.6 lb (8.4 kg)
2. Allowable Load = 1120 lb /bolt x 6 bolts = 6720 lbf (30,000N)
3. Limit Load = 18.6 lbf x 25g = 465 lbf (2000 N)
4. Factor of Safety = 3

Using the above values still gives a positive margin of safety of 3.8. Consideration must be given to the capability reduction of the inserts in the platform as well.

3 Description of Structural / Thermal Model

The Structural / Thermal model delivered to the S/C will have the following properties simulated:

1. All external features, including mounting lug and connector locations, will be indicative of the flight units.
2. Mass and CG will be within the tolerance specified in the EID-A.

3. Thermal dissipation, either through the use of heaters or resistors, will be simulated.

4. External coatings; paint, alodine, MLI?; will be applied as in the flight units.

The STM unit will be subjected to vibration and thermal vacuum testing at the spacecraft level. A cable harness check will also be performed.