Solar Probe Plus

A NASA Mission to Touch the Sun

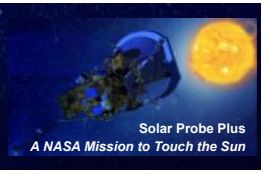
Integrated Science Investigation of the Sun
Energetic Particles

Preliminary Design Review
05 – 06 NOV 2013

ISIS Structural

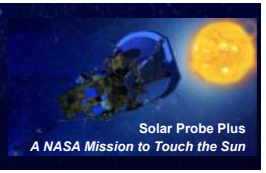
Nick Alexander

Outline



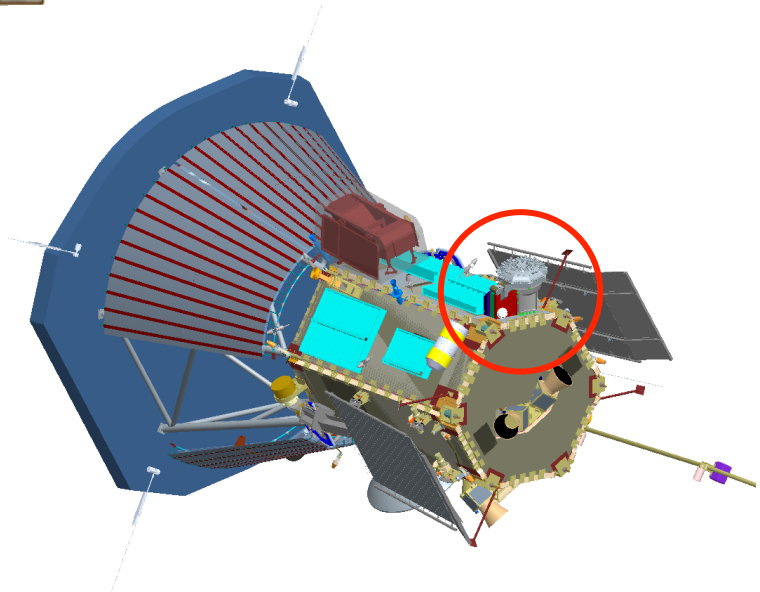
- Summary of mechanical design/structural requirements
- Description of the ISIS overall mechanical configuration
- Description of plans for fabrication of mechanical/structural items
- Description of the finite element models (FEMs) and load cases used to demonstrate structural integrity of applicable components
- Information on structural design margins as well as plans for strength verification

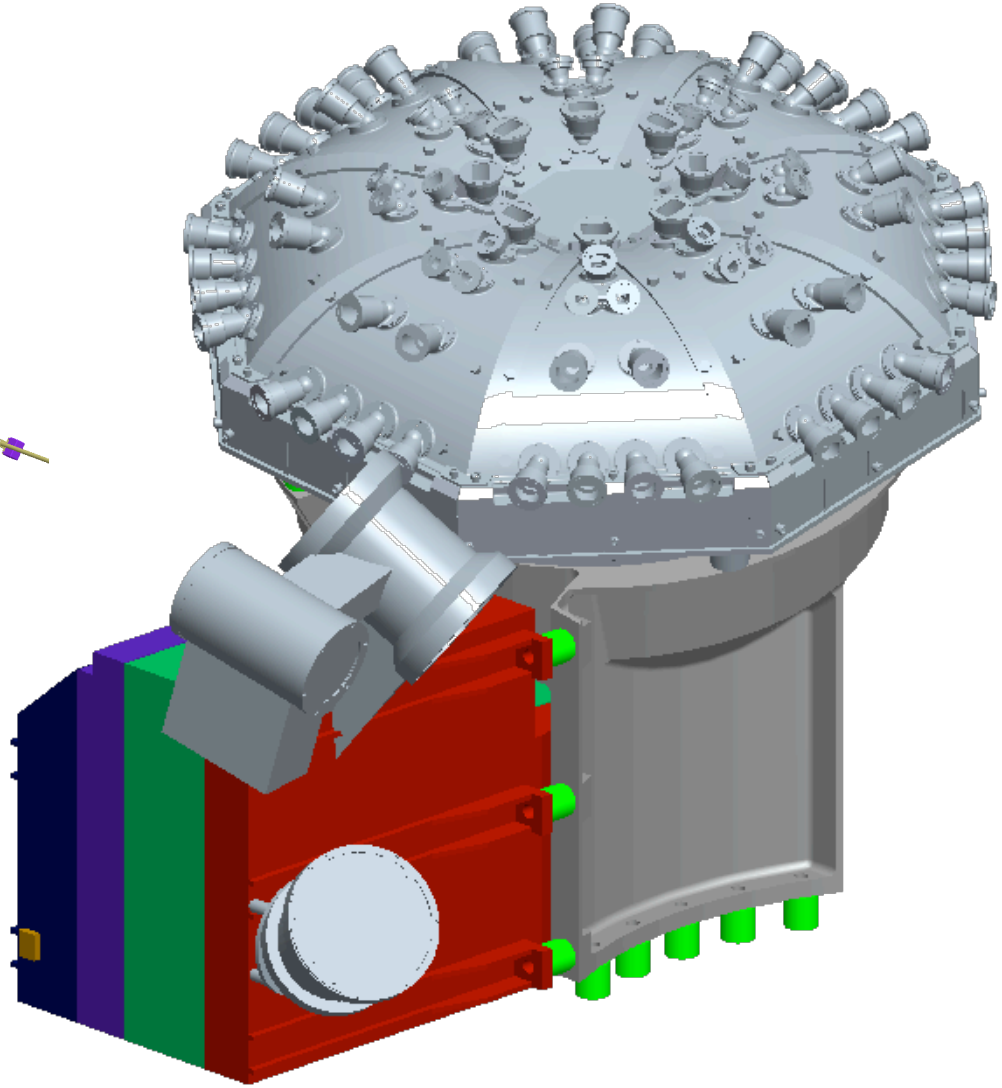
Mechanical Design Requirements



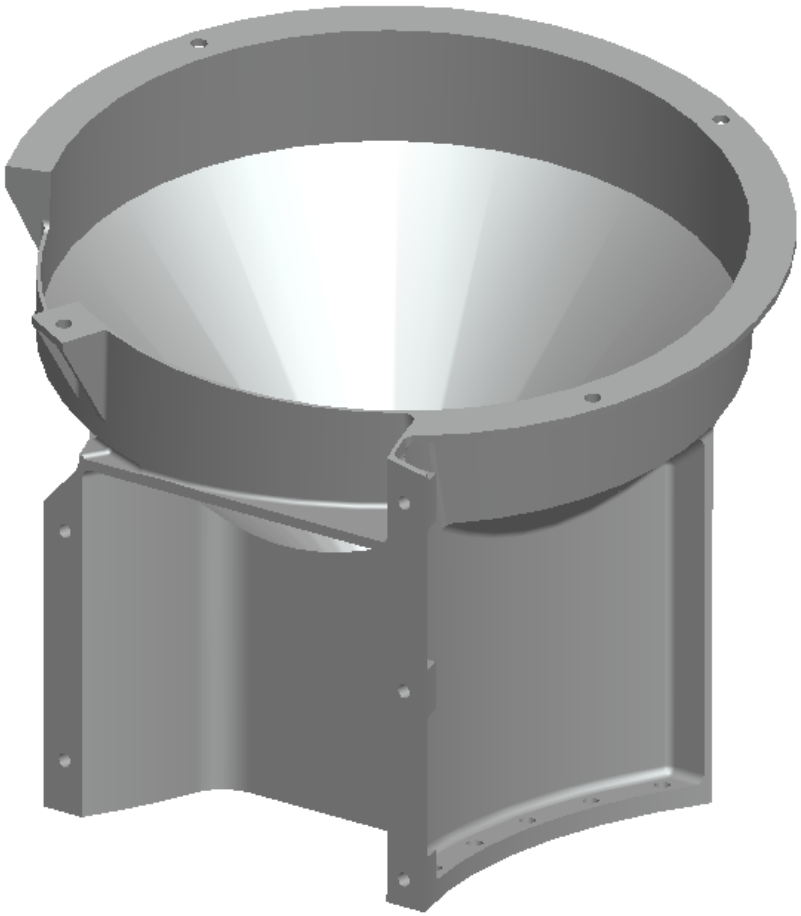
- ISIS bracket must hold EPI-Hi & EPI-Lo in position on the SPP deck
- ISIS bracket must be capable of independently removing EPI-Hi & EPI-Lo, in either order
- ISIS bracket must survive all environments for deck mounted components
  - Minimum resonant frequency >80 Hz
  - Quasi-static loads
  - Random vibration
  - Sine vibration
  - Shock
- All ISIS suite testing shall be performed on the bracket, with instruments or instrument analogs as appropriate

Mechanical Design Overview (1/2)

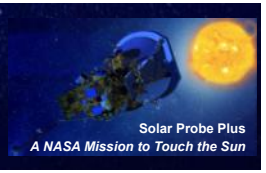




Mechanical Design Overview (2/2)



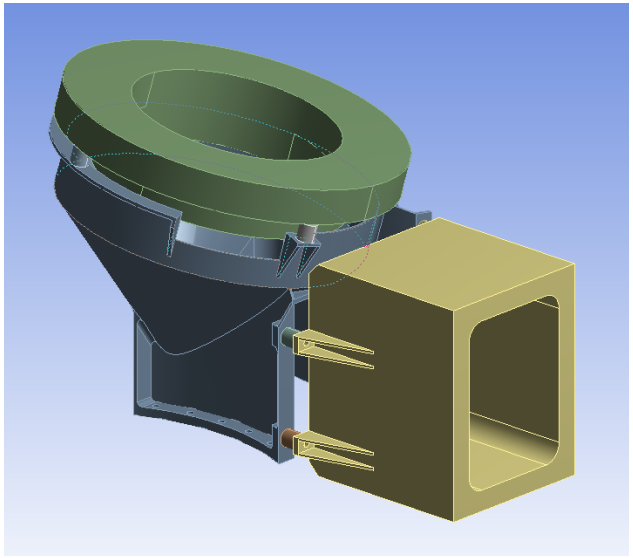
Bracket Fabrication

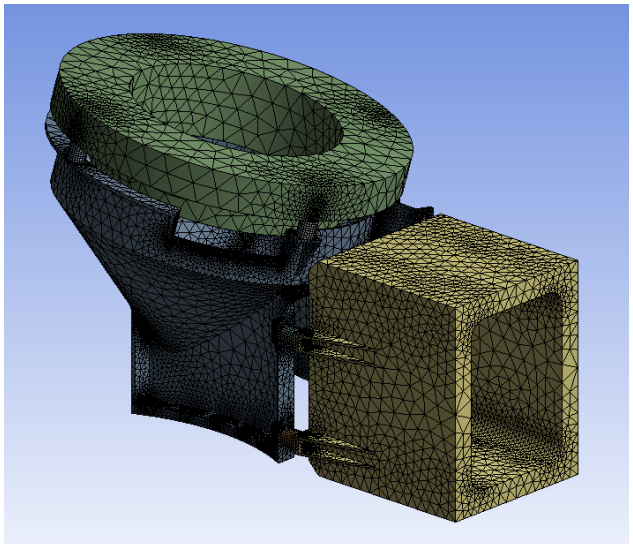


- The ISIS bracket can be machined using conventional machining processes
  - Monolithic design, will be machined from a single block
  - All operations can be performed on conventional machines (i.e. lathe, mill, etc.)
- Thermal isolators & mass models will also be fabricated to be used during structural testing
  - G10 isolators will be machined to flight-like quality
  - Mass models to reflect instrument mass properties with flight-like mounting interfaces
- Bracket height increase due to TPS shift can easily be accommodated as needed
  - Working with S/C mechanical team; any shift in the TPS only requires translation normal to the deck to remain adjacent to the umbra

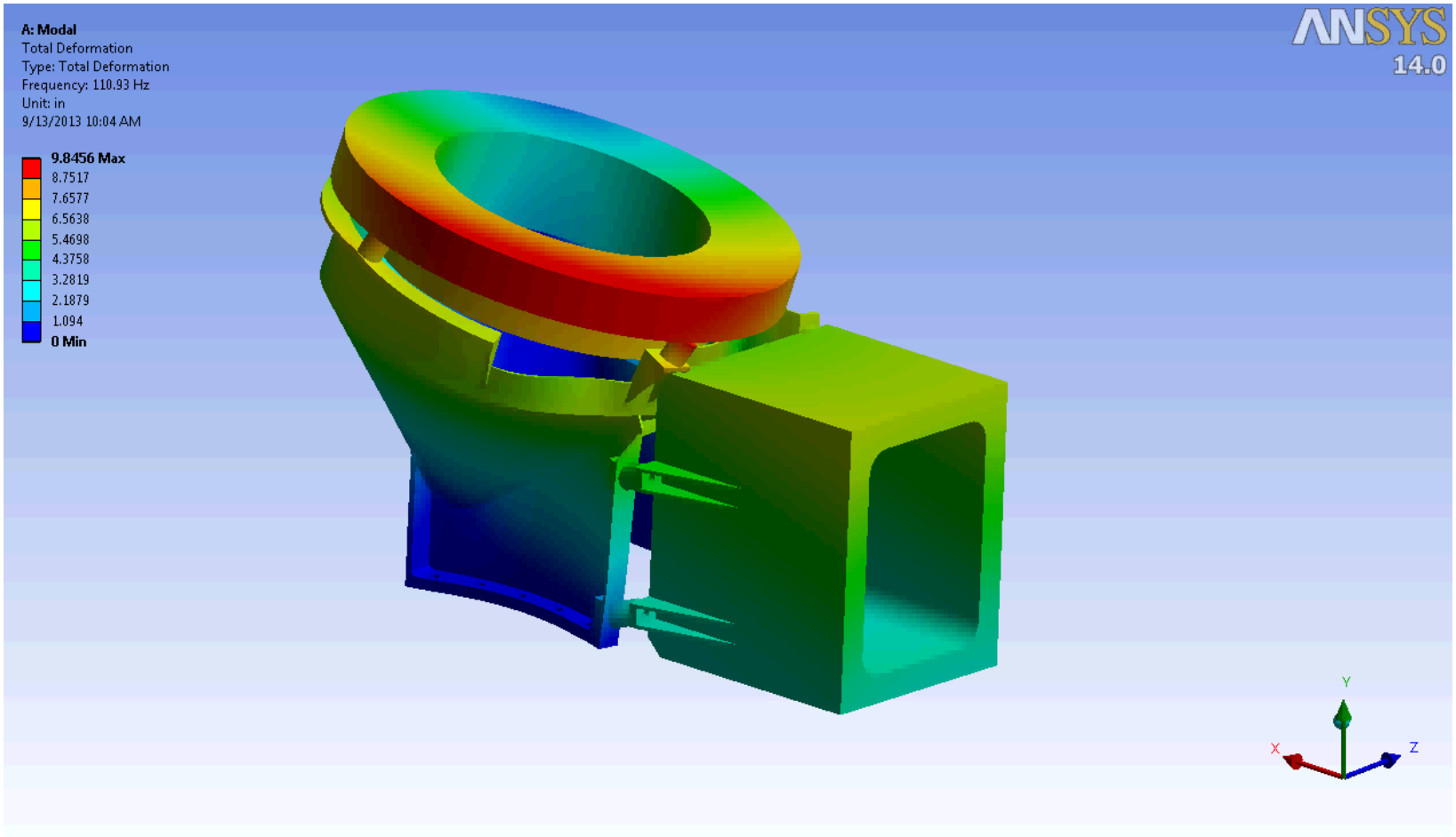
FEM - Setup

- Model includes bracket, EPI-Hi & EPI-Lo mass models (at max allocation) and thermal isolators
  - Bracket & mass models assigned Aluminum 6061-T6 material properties
  - Thermal isolators assigned G10 material properties
- Mass models represent accurate mass & CG properties
  - Test results will be easy to compare to model
  - Mass models are stiff enough to not introduce modes
- Edge to surface connections for all mounting interfaces
- Fixed supports on all 10 bracket mounting holes





FEM - Modal Results



FEM - Structural Setup

- PSD G acceleration applied uni-axially, all 3 major axes
  - 2 direction lateral to panel, 1 direction normal to panel
- PSD input from EDTRD
  - Section 4.4.3, Tables 4-8 & 4-9

Frequency (Hz)	Qualification (G^2/Hz)	Protoflight (G^2/Hz)	Acceptance (G^2/Hz)
20	0.01	0.01	0.01
60	1.25	1.25	0.63
200	1.25	1.25	0.63
350	0.04	0.04	0.04
500	0.04	0.04	0.04
2000	0.01	0.01	0.01
Overall Grms	16.4	16.4	12.6
Duration (mins)	2	1	1

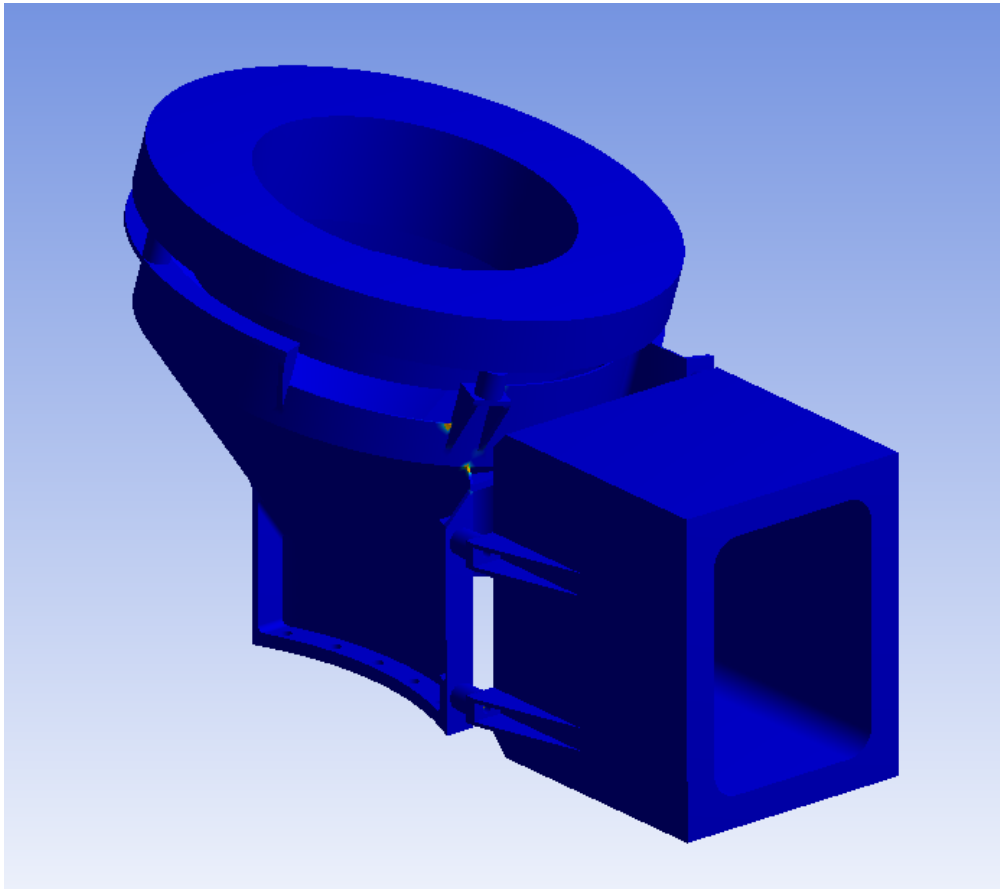
Table 4-8: Side Panels Mounted Components Normal to Panel

Frequency (Hz)	Qualification (G^2/Hz)	Protoflight (G^2/Hz)	Acceptance (G^2/Hz)
20	0.01	0.01	0.01
35	0.04	0.04	0.04
500	0.04	0.04	0.04
2000	0.01	0.01	0.01
Overall Grms	6.8	6.8	6.8
Duration (mins)	2	1	1

Table 4-9: Side Panels Mounted Components Lateral to Panel

FEM - Structural Results (Preliminary)

- Still running stress cases
  - Deck-lateral cases are well within necessary safety margins
  - Refining model to mitigate high stress concentrations in deck-normal case
- Need to perform bolt analysis for bracket mounting bolts
  - Baseline is QTY:10 10-32 SHCS (A286)



Structural Design Margins

- Structural results must meet Safety Factors per EDTRD
  - Section 4.4.2.2, Table 4-5 for Metallic Structures (Tested)
    - Ultimate: 1.40 (Aluminum 6061-T6 F_{TU} = 42 ksi*)
    - Yield: 1.25 (Aluminum 6061-T6 F_{TY} = 35 ksi*)
- Margin of Safety must always be positive
  - MS = Allowable/(FS x Applied) – 1.0
  - Maximum Allowable Stress (Ultimate) = 30 ksi
  - Maximum Allowable Stress (Yield) = 28 ksi
- ISIS bracket will be exposed to random vibration with mass models attached for verification prior to EPI-Hi & EPI-Lo testing

*Per MIL-HDBK-5J

Structural Testing

- ISIS bracket will be tested at SwRI facilities with EPI-Hi & EPI-Lo mass models
  - G10 thermal isolators will be included
  - Mounted using flight quality mounting hardware
- Tests will check natural frequency, random vibe response, sine vibe response
  - Natural frequency must be >80 HZ (EDTRD_0095)
  - Must survive random vibration loads (EDTRD_0111) per tables in EDTRD 4.4.3
  - Must survive sine sweep loads (EDTRD_0114) per sine environment (TBD) given in EDTRD 4.4.4
  - Pre & post test low-level sine sweeps used to identify any change in fundamental frequency