Rapid High Fidelity Radiation Shielding Analysis: An Enabler for Responsive Space Applications

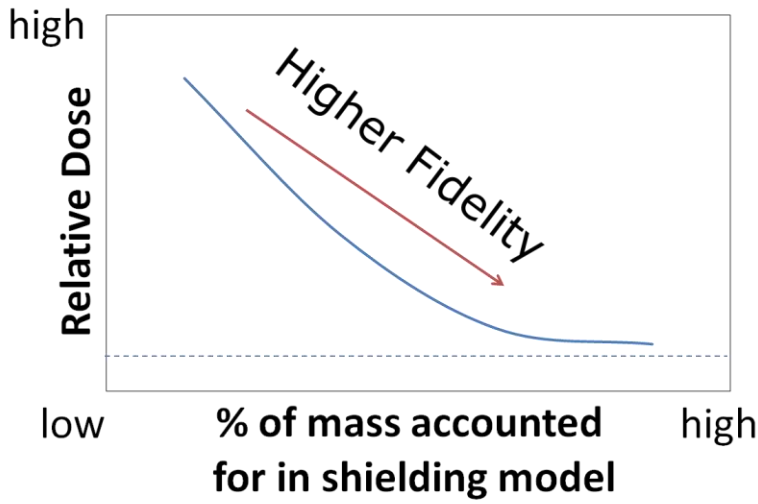
Steve Manson, Ray Laning, Eric Williams – Raytheon Missile Systems, Tucson, AZ

Kurt Ketola, James Chow, Barry Willits – Raytheon Space & Airborne Systems, El Segundo, CA

Raytheon

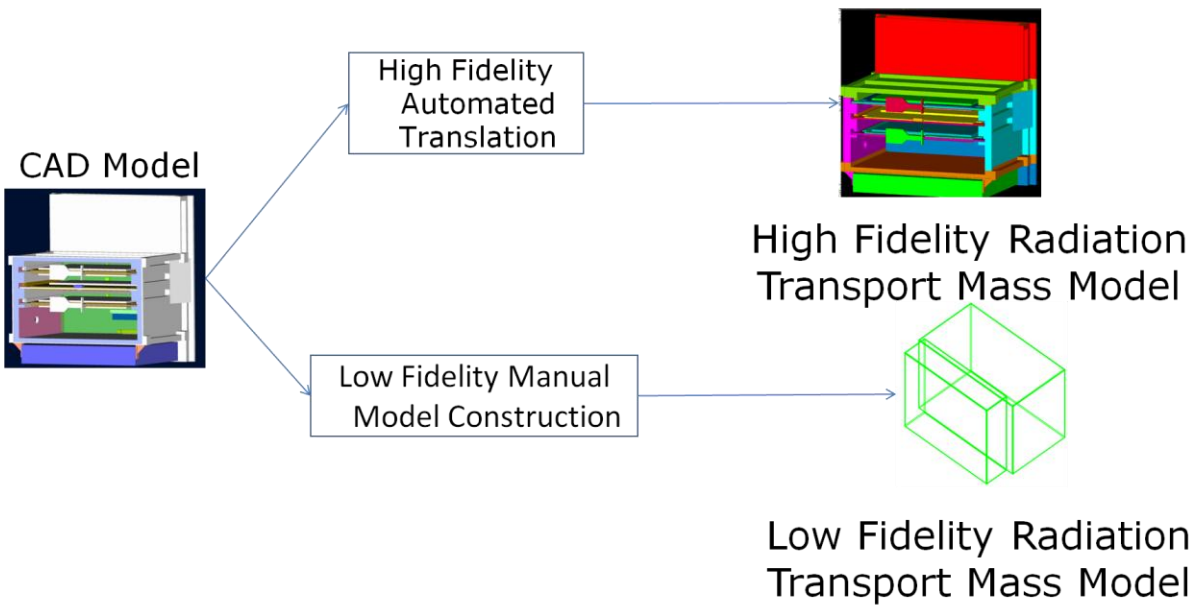
Enabling Responsive Space:

- Need to rapidly and accurately assess radiation requirements for proposed missions.
- Increased percentage of mass included in the analysis reduces overly conservative margins.
- This expands choice of COTS parts which reduces schedule and cost.



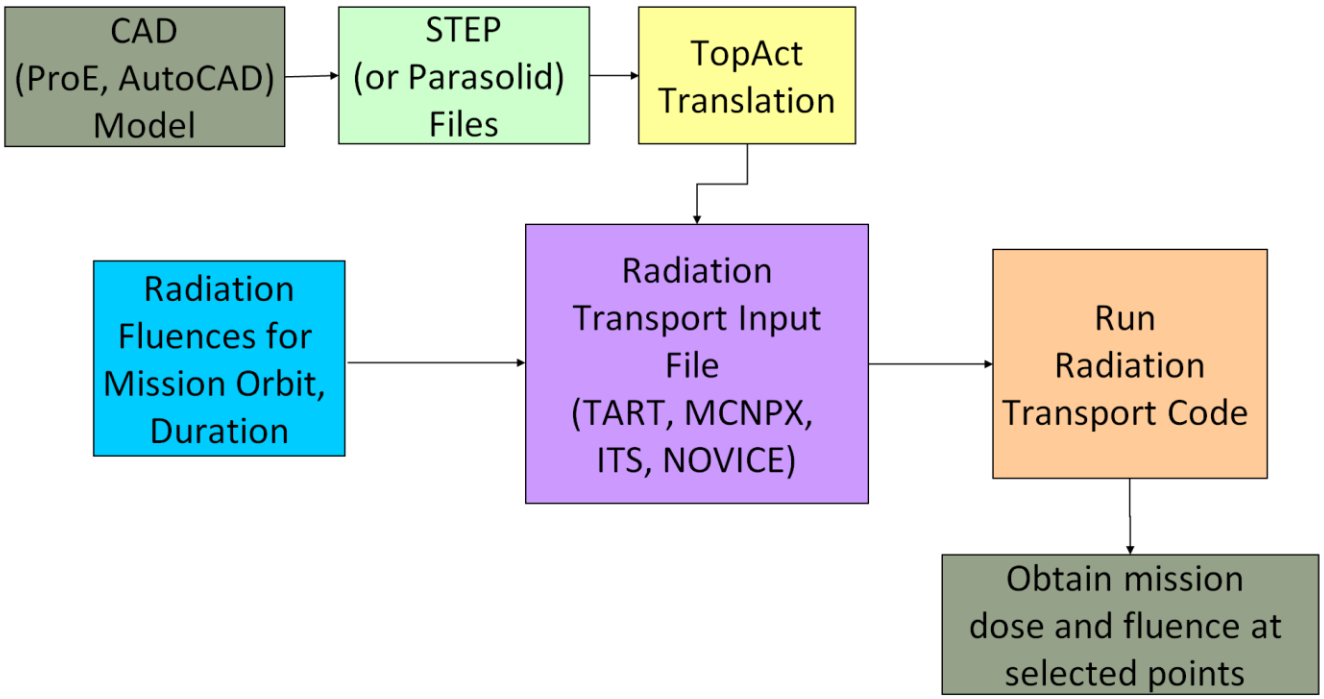
High Fidelity Radiation Shielding Analysis Solution

- Manual construction of high fidelity mass models is prohibitively expensive.
- Need to build tools for automated assembly of accurate radiation transport mass models .

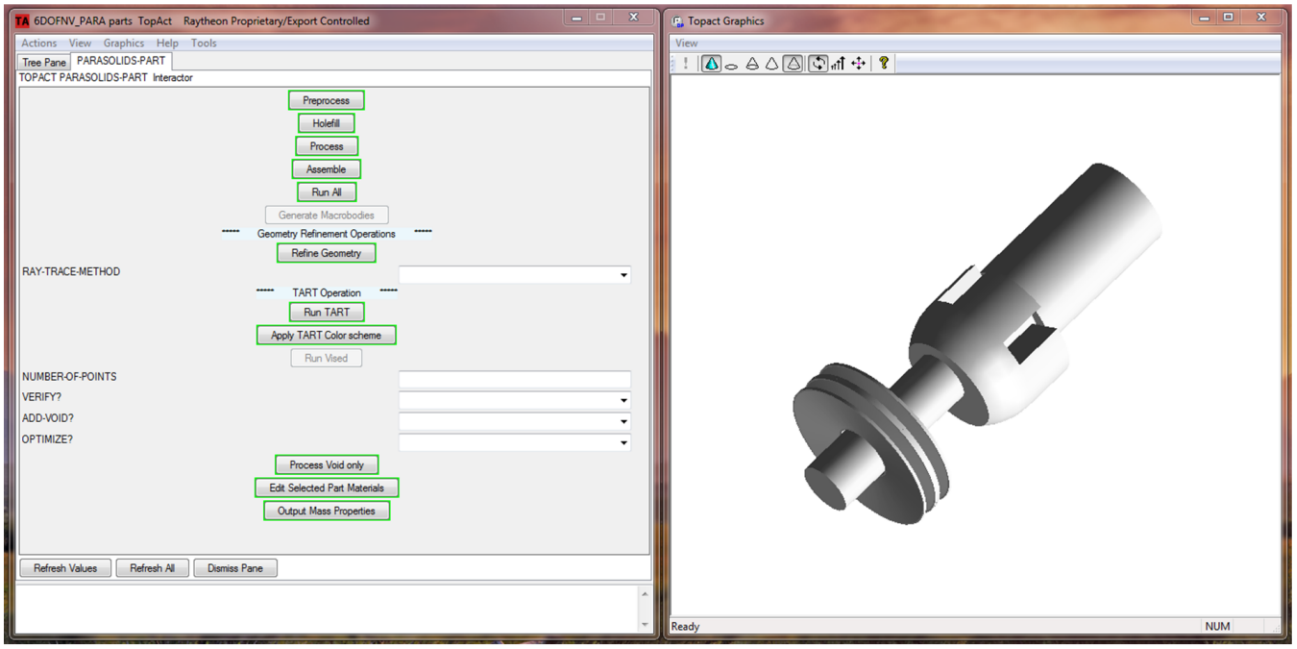


Raytheon Developed TopAct Translation Tool

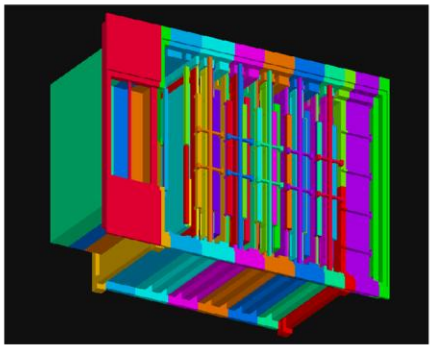
- TopAct: **T**ranslation **O**ptimization for **P**art-wise **A**daptive **C**ombinatorial **T**ransport
- Translates parasolid or step files generated from the CAD model into a variety of radiation transport mass model formats such as TART, MCNP, ITS, NOVICE.



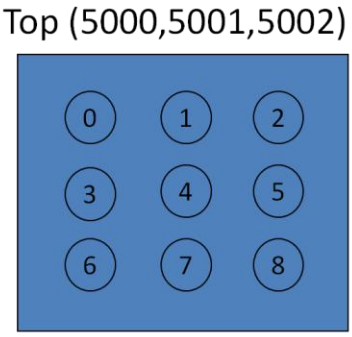
TopAct Translation Tool GUI



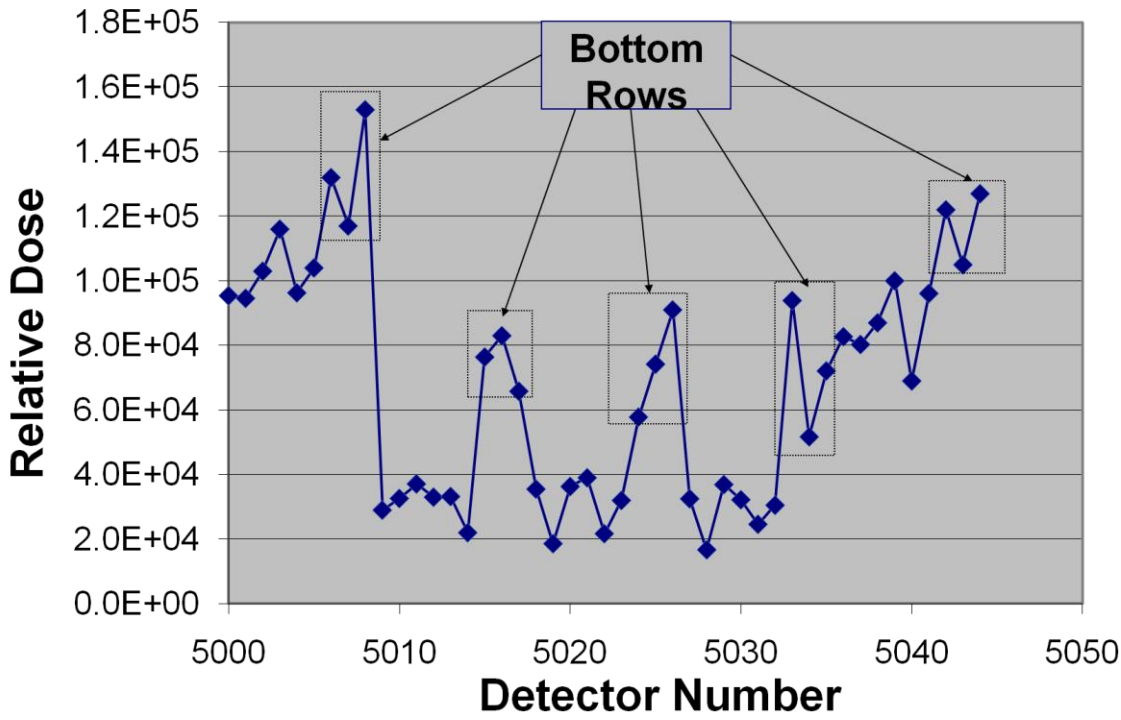
High Fidelity MCNPX model can be used to map out fine scale variations in dose and fluence.



radiation transport model of electronics box translated from CAD with TopAct

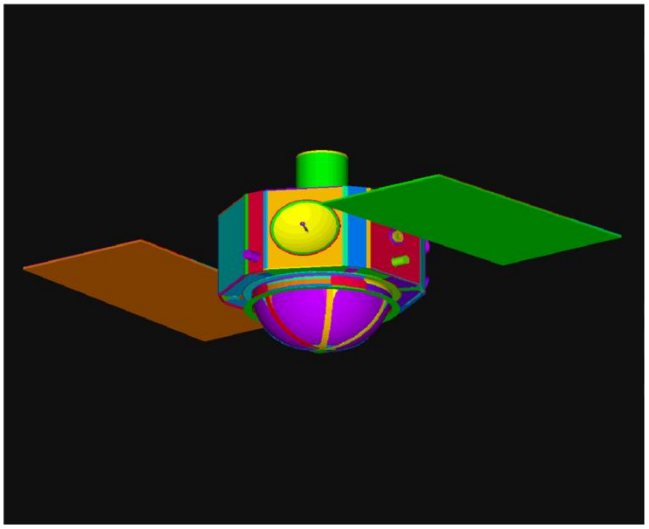


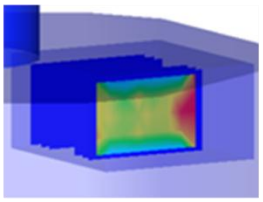
3 x 3 array of detectors located on 5 boards in box



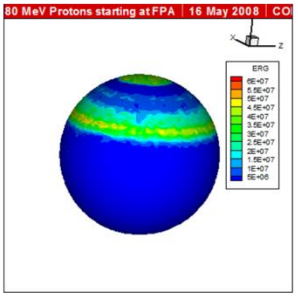
- 2x variation between comparable points on boards
- Max variation is ~7x
- Analysis Enables Positional Shielding

Analysis demonstrated on complex systems from electronic boxes to sensors to satellites.





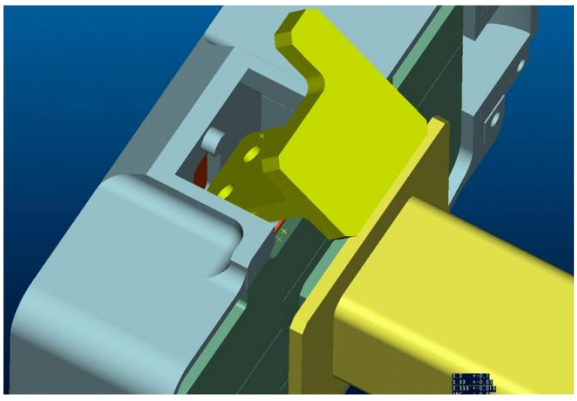
PWB Dose Map



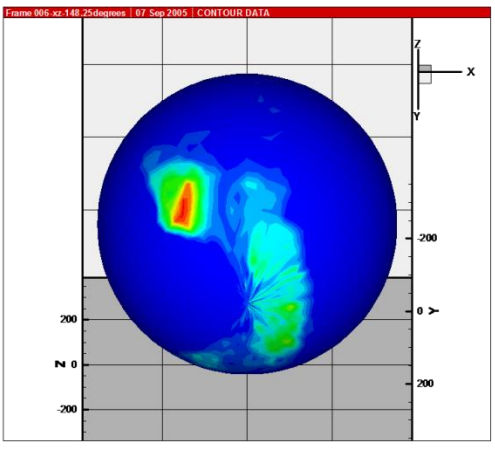
Shielding Map Relative to Critical Points

radiation transport model of satellite translated from CAD with TopAct

High Fidelity MCNPX model can be used to find design flaws such as small streaming holes.



Streaming Hole to Radiation Sensitive Part (mitigated by adding shielding mass)



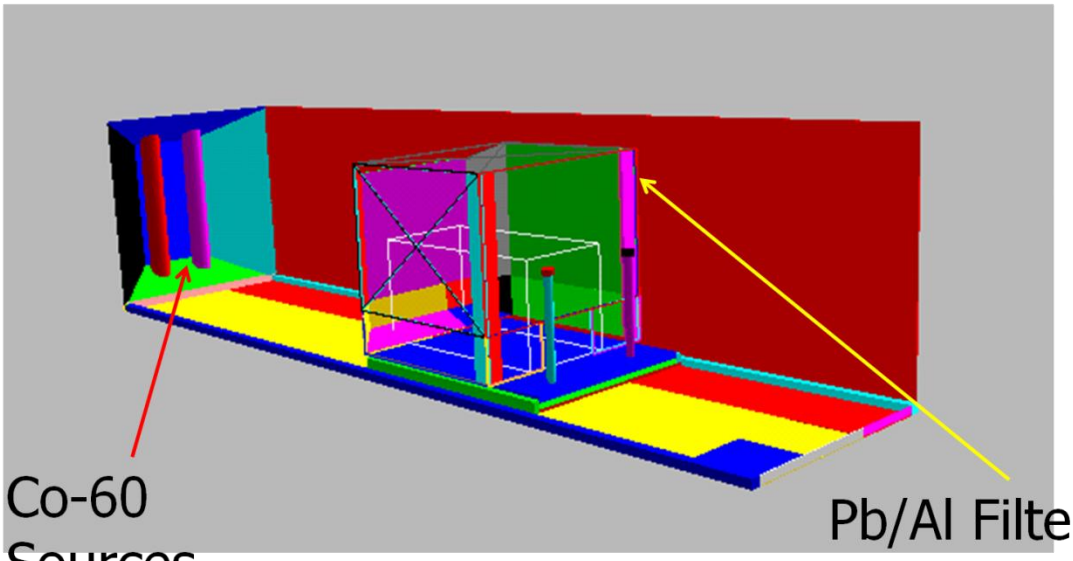
Shielding map from proton exposure vs. angle

TopAct / MCNPX Validation Experiment

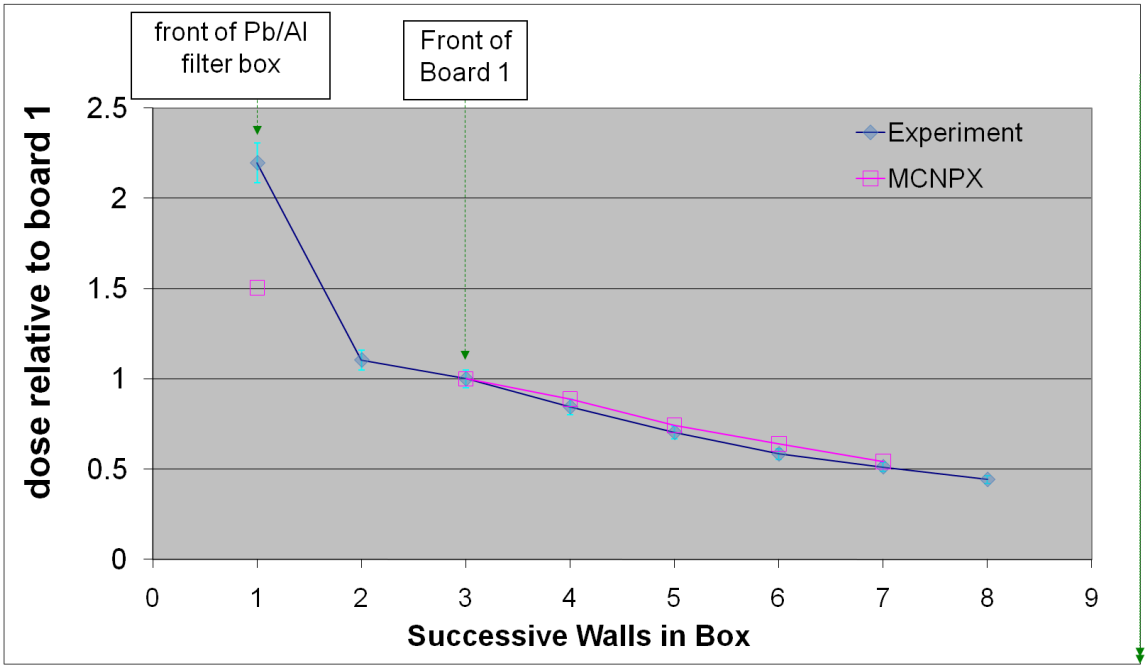
- Measure dose in simple metal box from Co-60 gammas using thermo-luminescent dosimeters.
- Use TopAct to generate MCNPX mass model.
- Compare results of experiment to those from MCNPX model.

Gamma rays

Shepherd 484 Irradiator



Comparison of Experiment to Model



- Scale dose relative to the dose on the front side of copper sheet #1.
- Excellent agreement except for dosimeters on front of Pb/Al filter box.
- Difference at this location could be due to nonlinearity in TLD response in the low energy region.

How Rapid High Fidelity Radiation Shielding Analysis Enables Responsive Space

- Quickly assess radiation hardness requirements with a greater degree of accuracy.
- Include much more of the mass in the shielding analysis which will reduce predicted dose levels.
- Allows for greater use of COTS parts with reduced radiation hardness.
- Enhanced ability to optimize shielding based on location.
- Pre-translate standard modules for plug-n-play shielding analysis.
- Point of contact:

Steve Manson (sjm@raytheon.com, 520.794.2610)