ORSAT Modelling and Assessment

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NASA Orbital Debris Program Office

4th International Workshop on Space Debris Reentry,
Darmstadt, 1 March 2018

Outline

- **ORSAT Models**
  - Aerodynamics
  - Aerothermodynamics
  - Trajectory
  - Heat transfer & conduction
  - Casualty Area
  - Risk calculation
- **ORSAT Assessment Workflow**
  - Fragment list
  - Input generation
  - Input visualization
  - Running ORSAT
  - Reconciling independent analyses
- **Conclusions and Future Work**

ORSAT Overview

- ORSAT has six modules (trajectory, atmosphere, aerodynamics, aerothermodynamics, thermal, debris casualty area/risk)
- Basic method of input is to obtain trajectory data at entry interface and component data (dimensions, mass, & material) before starting analysis
- Central theme is that integrated heat load or absorbed heat is computed over time during entry; when this value exceeds material heat of ablation, object is considered to demise
- If object survives, ORSAT predicts debris casualty area and risk to humans on ground
- Parent body breakup altitude is assumed (normally 78 km - based on Aerospace observations) but can be varied

ORSAT Overview (Cont'd.)

- **Aerothermal, ablation-only code**

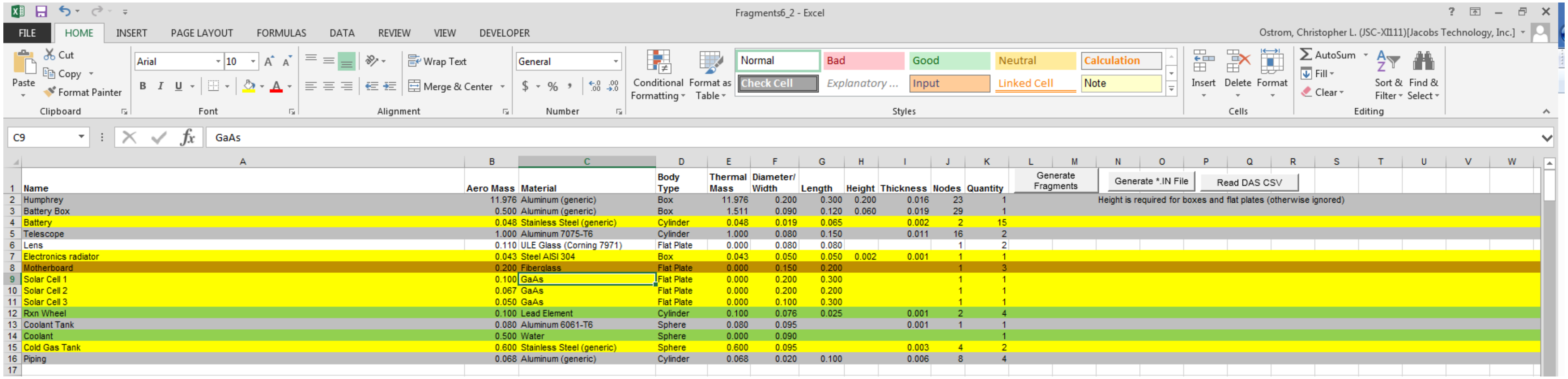
- **Conventional material models**
  - Currently no charring, cracking, or pyrolysis modules

ORSAT Overview (Cont'd.)

- Hierarchy of components is critical to input
- Components are modelled using a set of 10 shape primitives and 80+ aerospace materials
- Key output in ORSAT analysis is plot of demise altitude vs. downrange of all components
- Sample plot of sample spacecraft component demise altitudes shown in next slides
- For targeted entry, ORSAT can provide ground track of latitude vs. longitude

Preprocessing

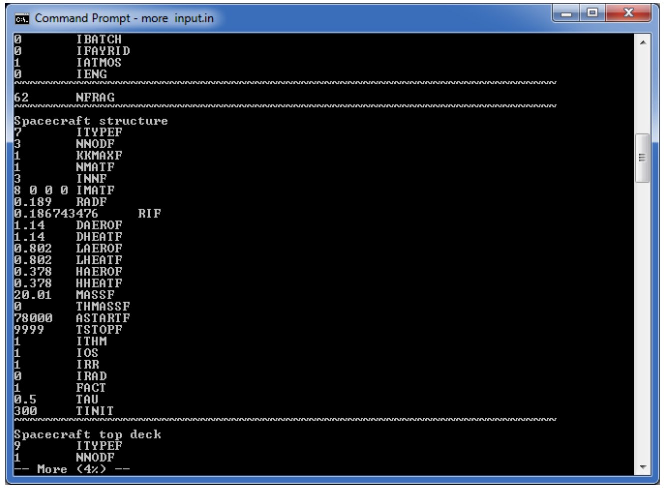
- Automatic generation of ORSAT input file from parts list
- Color coding by 'demise score'
- Non-standard materials easily incorporated

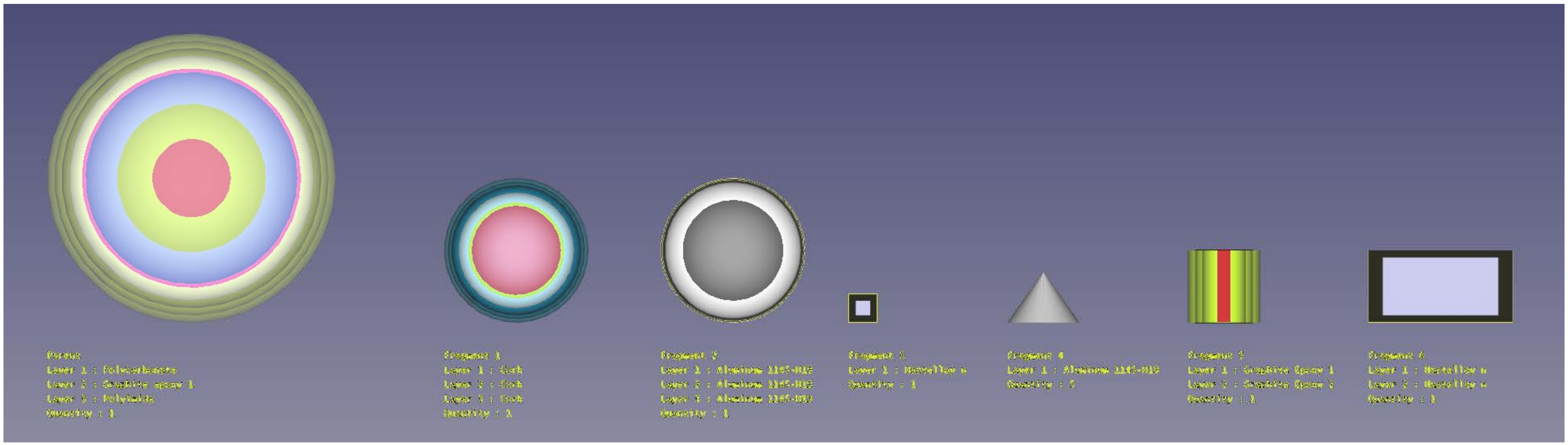


Name	Aero Mass	Material	Body Type	Thermal Mass	Diameter/ Width	Length	Height	Thickness	Nodes	Quantity
Humphrey	11.976	Aluminum (generic)	Box	11.976	0.200	0.300	0.200	0.016	23	1
Battery Box	0.500	Aluminum (generic)	Box	1.511	0.090	0.120	0.060	0.019	29	1
Battery	0.048	Stainless Steel (generic)	Cylinder	0.048	0.019	0.065		0.002	2	15
Telescope	1.000	Aluminum 7075-T6	Cylinder	1.000	0.080	0.150		0.011	16	2
Lens	0.110	ULE Glass (Corning 7971)	Flat Plate	0.000	0.080	0.080			1	2
Electronics radiator	0.043	Steel AISI 304	Box	0.043	0.050	0.050	0.002	0.001	1	1
Motherboard	0.200	Fiberglass	Flat Plate	0.000	0.150	0.200			1	3
Solar Cell 1	0.100	GaAs	Flat Plate	0.000	0.200	0.300			1	1
Solar Cell 2	0.067	GaAs	Flat Plate	0.000	0.200	0.200			1	1
Solar Cell 3	0.050	GaAs	Flat Plate	0.000	0.100	0.300			1	1
Rxn Wheel	0.100	Lead Element	Cylinder	0.100	0.076	0.025		0.001	2	4
Coolant Tank	0.080	Aluminum 6061-T6	Sphere	0.080	0.095			0.001	1	1
Coolant	0.500	Water	Sphere	0.000	0.090					1
Cold Gas Tank	0.600	Stainless Steel (generic)	Sphere	0.600	0.095			0.003	4	2
Piping	0.068	Aluminum (generic)	Cylinder	0.068	0.020	0.100		0.006	8	4

Input Visualization

- **New visualization tool allows us to see what ORSAT thinks each object looks like (in piece-by-piece view):**





Running ORSAT

- **Standard initial conditions are used to begin simulation**
  - 0.1-deg. FPA at 122 km reentry interface
  - 78 km breakup altitude for parent objects

- **Objects propagated until demise or ground impact**

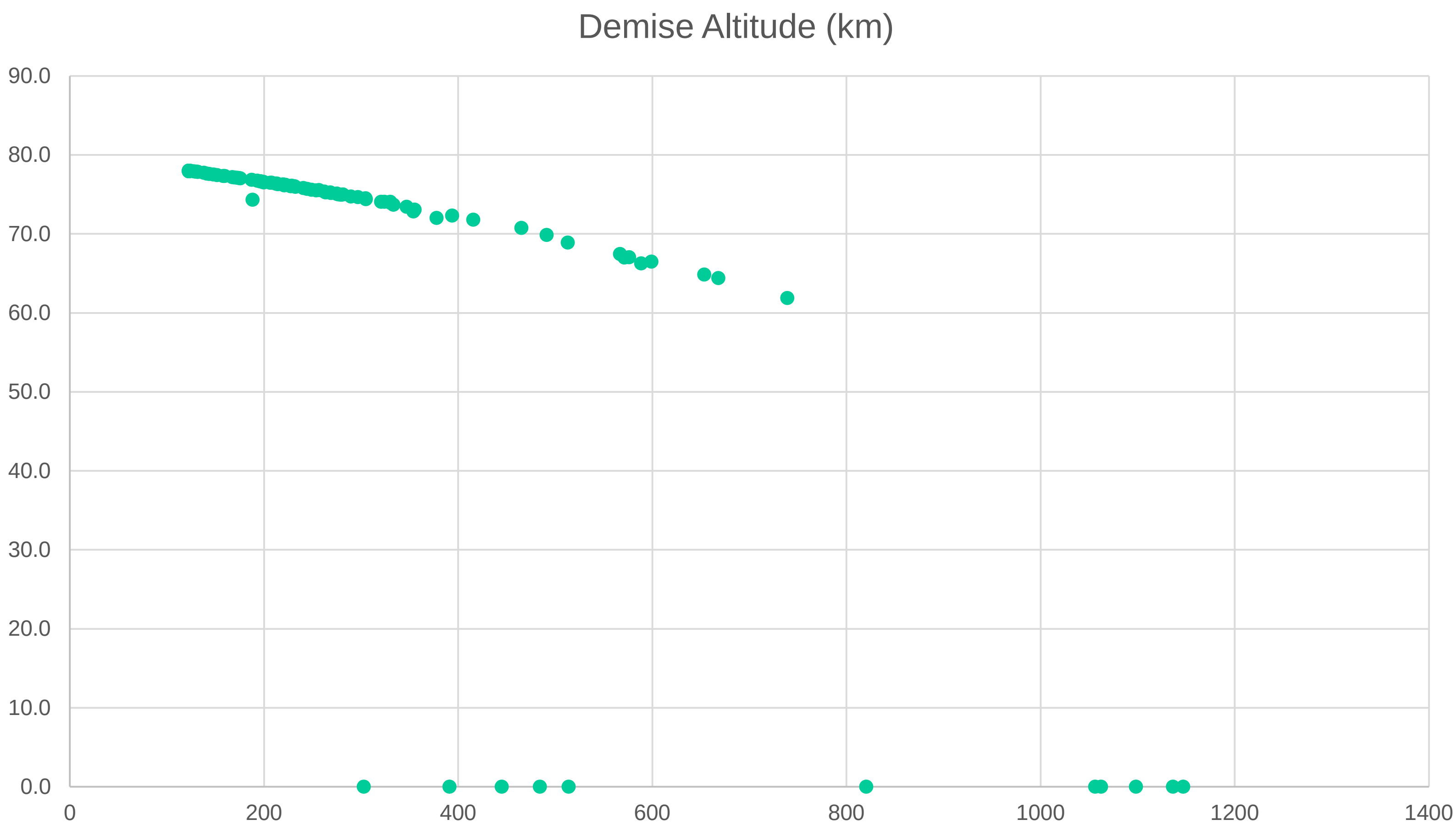
- **Fragments that show low-altitude demise, or high total thermal load typically re-run, varying initial conditions to determine most likely outcome**

Independent Analyses

- **Each ORSAT project is assessed by two analysts**
  - End-to-end independent analysis to ensure most accurate outcome

- **Results are compared, differences reconciled, and finalized**
  - Modelling assumptions challenged and defended
  - Analyzed geometry examined for similarity to as-built components
  - Any differences and rationale are archived for future review and reference

Demise Altitude vs. Downrange for Example Spacecraft



Future Work

- **ORSAT and DAS updates**
  - Updated NS 8719.14, Process for Limiting Orbital Debris
    - **Currently under revision by NASA**
  - Increased automation of ORSAT process
    - **Develop database of sample object reentries to estimate likelihood of survival prior to any analysis**
  - Probabilistic risk assessment and Parametric Studies

Future Work (Cont'd.)

- **Adding new aerospace materials to database**
- **Continue Latitude Bias research**
  - Distribution of FPA at entry interface
- **New CFRP and GFRP model development**
  - Supported by plasma and arcjet testing in 2018
- **Characterizing high-altitude pyrolysis effects**