Space Shuttle Debris Transport

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Debris Sources

Liftoff Debris
rust, uncontained hardware, etc.

Ascent Debris
Foam, ice, gap fillers, ceramic inserts, many other smaller and lower likelihood sources.

Orbital Debris
> 3 km/sec
> 9,800 ft/sec

National Aeronautics and Space Administration
www.nasa.gov
Probabilistic Debris Process

\[ Pr(\text{failure}) = Pr(E_1 \cap E_2 \cap E_3) \]
\[ = Pr(E_1) Pr(E_2 | E_1) Pr(E_3 | E_1 \cap E_2) \]

- \(E_1\): Debris Released
- \(E_2\): Debris Impacts Surface
- \(E_3\): Impact Exceeds Capability

Void distributions, material properties, heating, etc.

Flowfield, mass, drag coefficient, crossrange, etc.

RCC, tile, windows, ...

\[ f(\text{mass, velocity, angle, material, ...}) \]
Eliminating Debris Sources

STS-1 thru 4 many modifications
Return To Flight & subs modifications
Multiple ice/frost ramp redesigns
LH₂ flange process changes
Airloads reviews
Aerothermal support

RCS Tyvek® covers
Bipod Ramp Removal
±Z Aero-Vent Modification

Modified Aft Longeron
LO₂ feedline bracket redesigns
STS-121 PAL Ramp Removal
Prelaunch Iceball Assessment Tools
Inflight Damage Assessments

STS-118
Tile Damage

$M_\infty = 18$
$\alpha = 35^\circ$

Post flight Image

Insight into local flow properties

AIAA 2008-4246
Inflight/Postflight Debris Assessments

Mach 3 Simulation of tile ceramic insert debris

Reaction Control System cover trajectory reconstruction