“Failure is Always an Option”

- Various launch vehicle failures (video only)
- STS 51-L - Challenger
- STS 107 - Columbia
- AMROC SET-1

© 2022 David L. Akin - All rights reserved
http://spacecraft.ssl.umd.edu

Atlas Launch Failure

Titan 34D Failure

SpaceX CRS-7 Launch

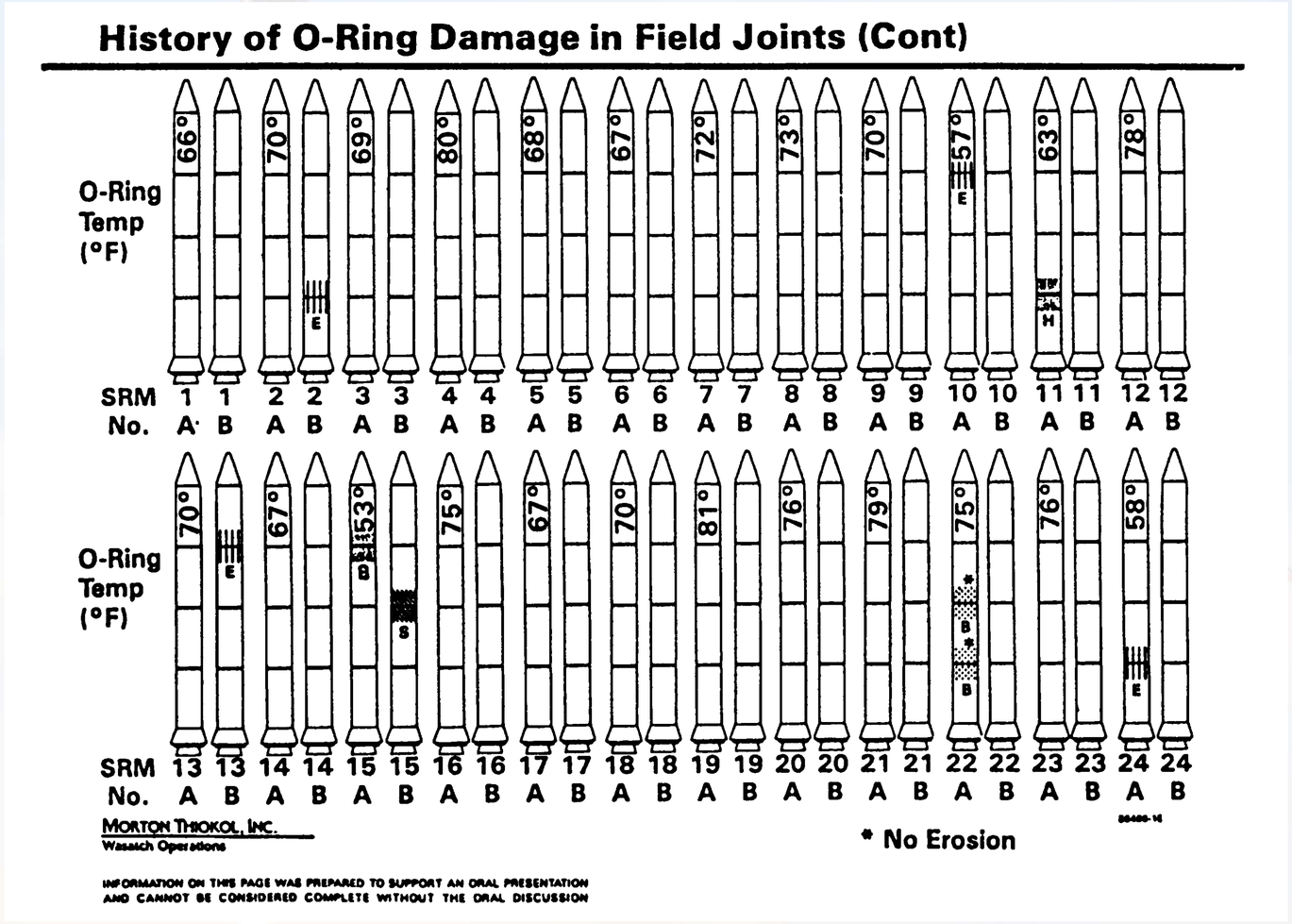
Antares OA-3 Launch

SpaceX AMOS-6 Static Test Fire

“How Not to Land an Orbital Rocket”

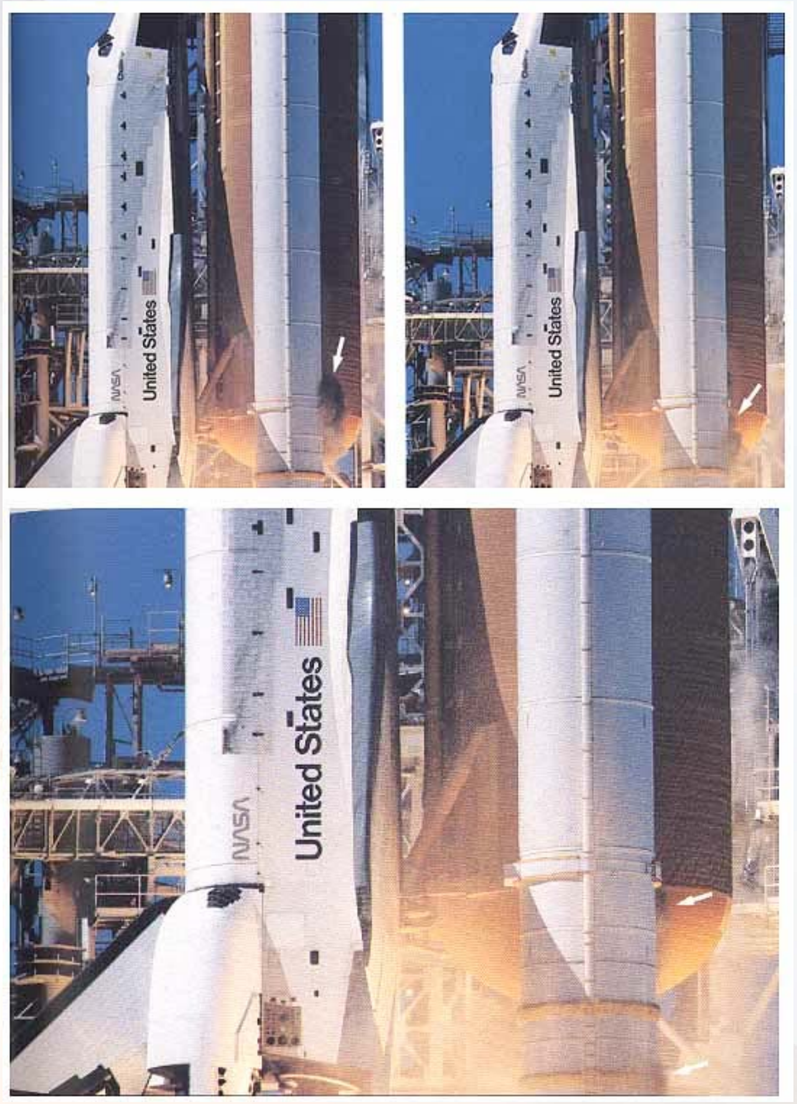
January 28, 1986

Review Slide - STS-51L L-1 FRR

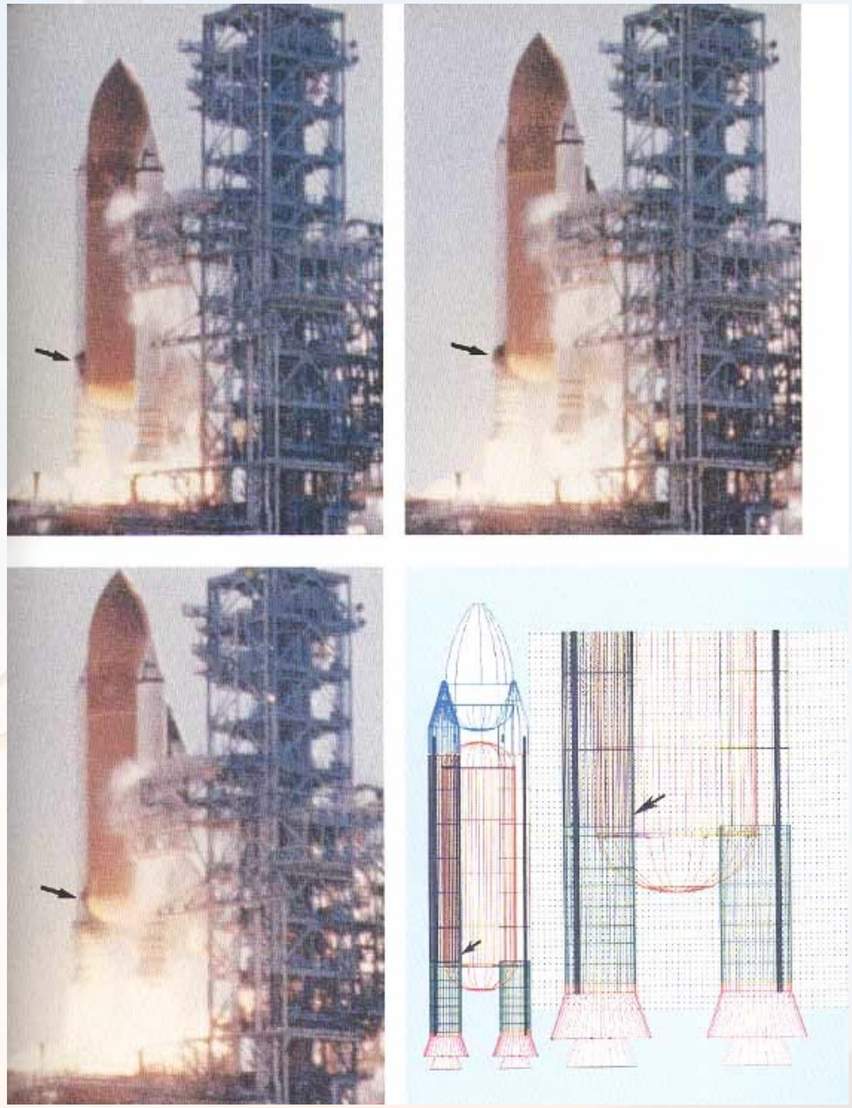


From Edward R. Tufte, Visual and Statistical Thinking: Displays of Evidence for Making Decisions
Graphics Press, 1997

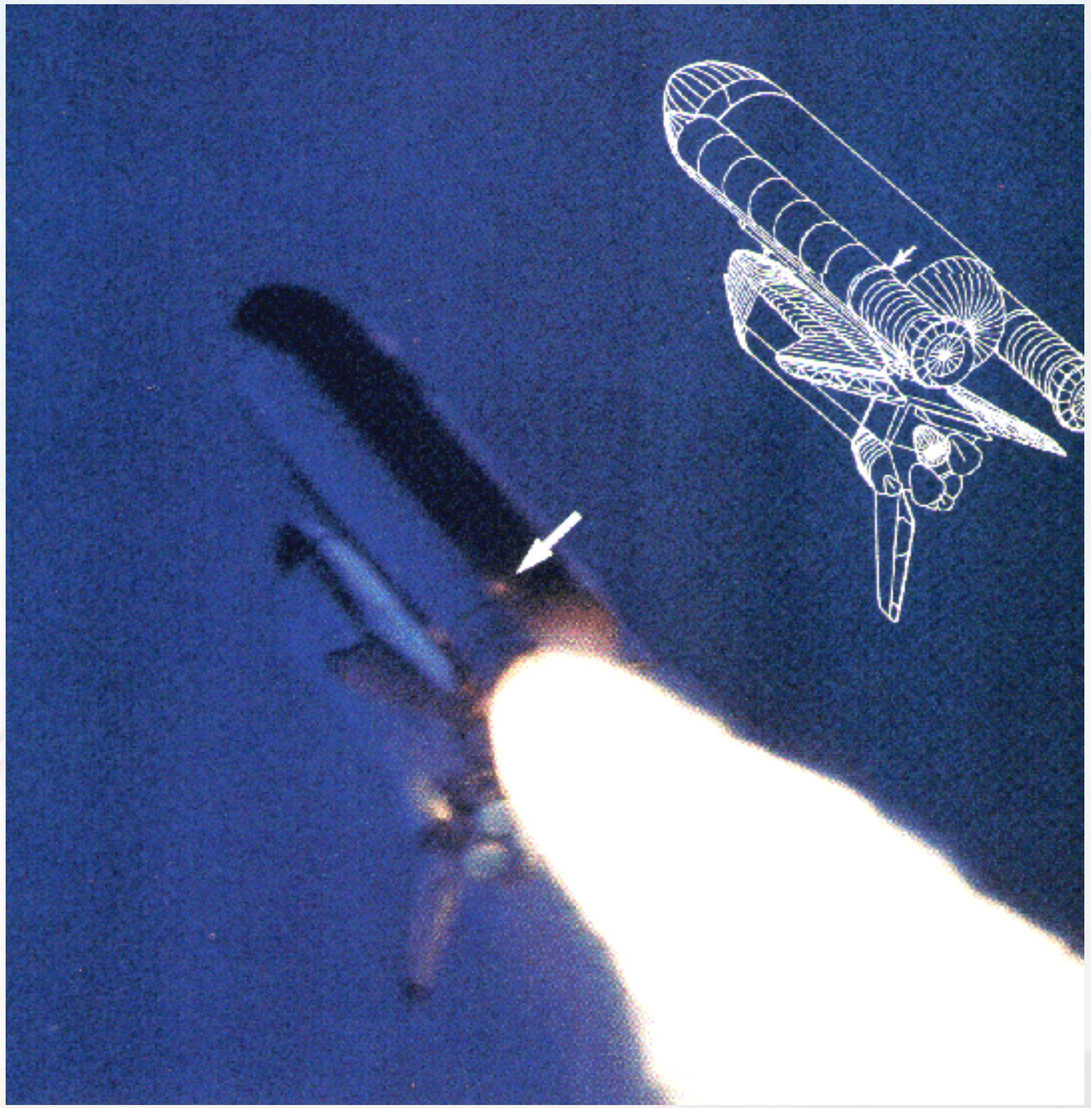
Black Smoke Plumes from Aft Field Joint


United States
NASA
United States
NASA
United States
NASA

Photographic Evidence

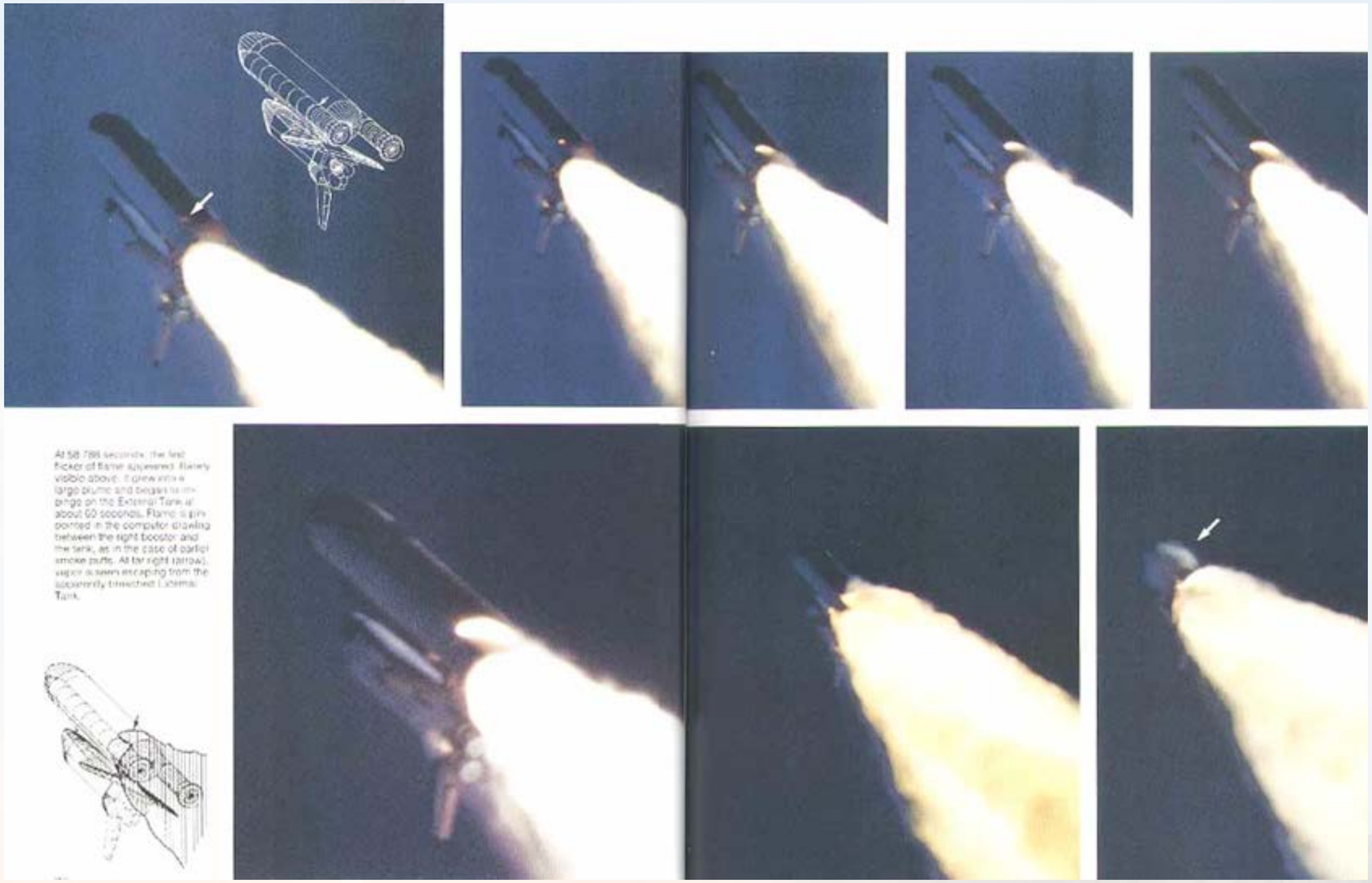


T+58 sec - Appearance of External Flame



Flame Hitting Aft Attach Fixture and ET

Progression of SRB Burn-through



Original SRB Field Joint Design

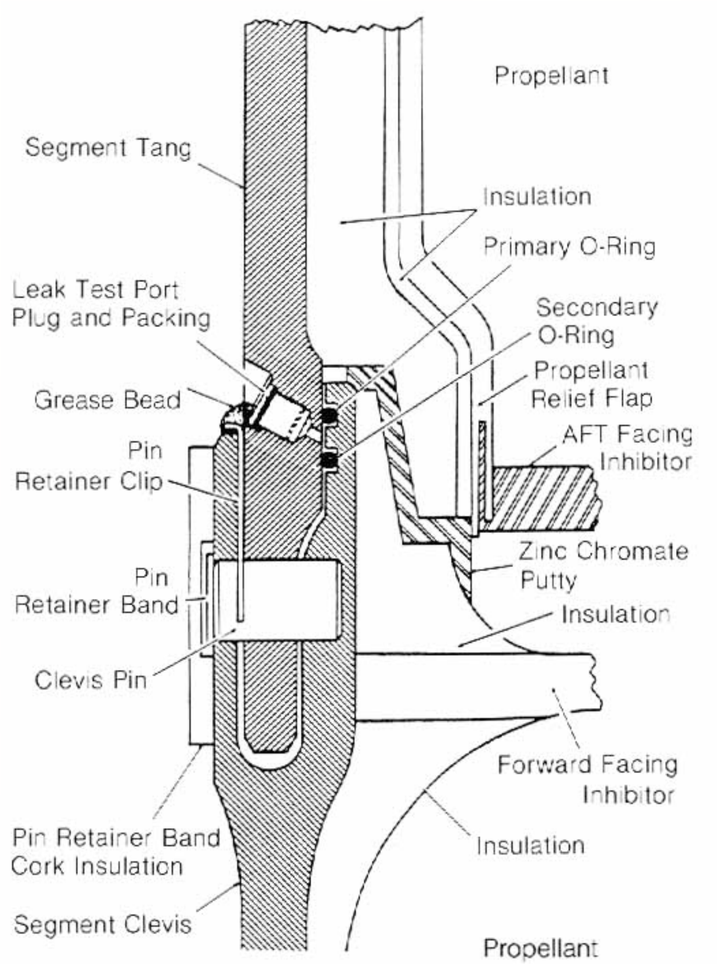
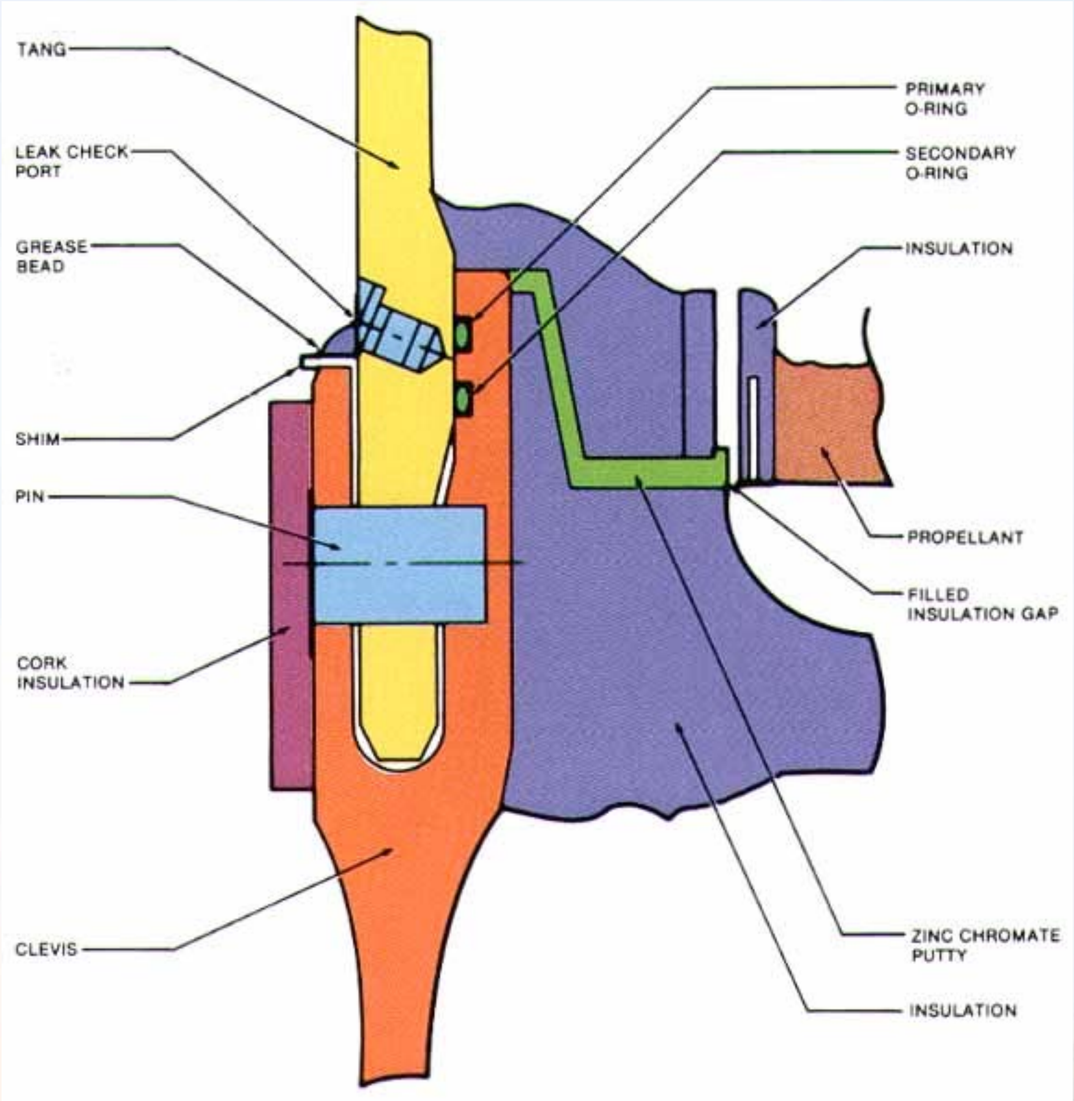
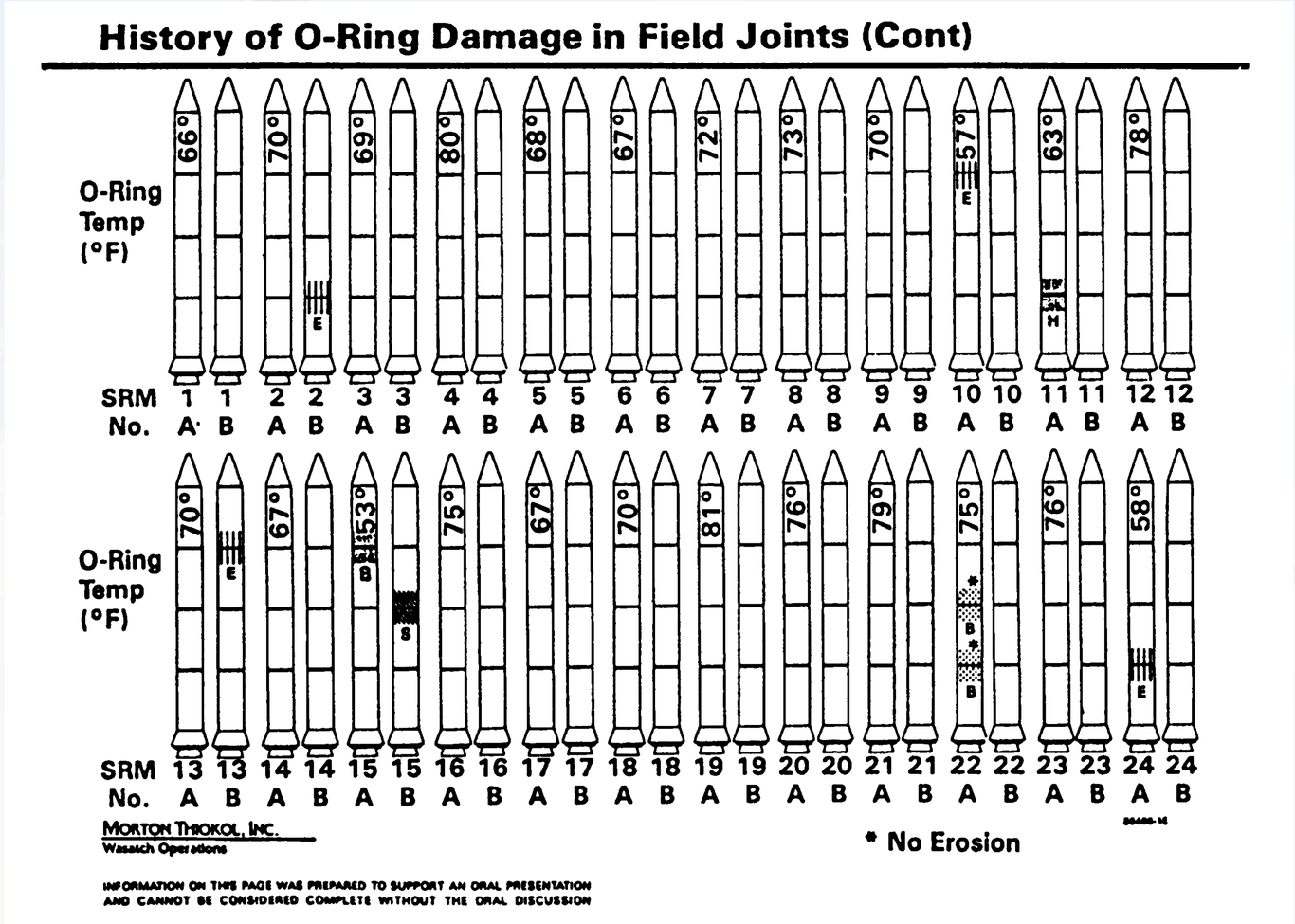


Figure 14
Solid Rocket Motor cross section shows positions of tang, clevis and O-rings. Putty lines the joint on the side toward the propellant.

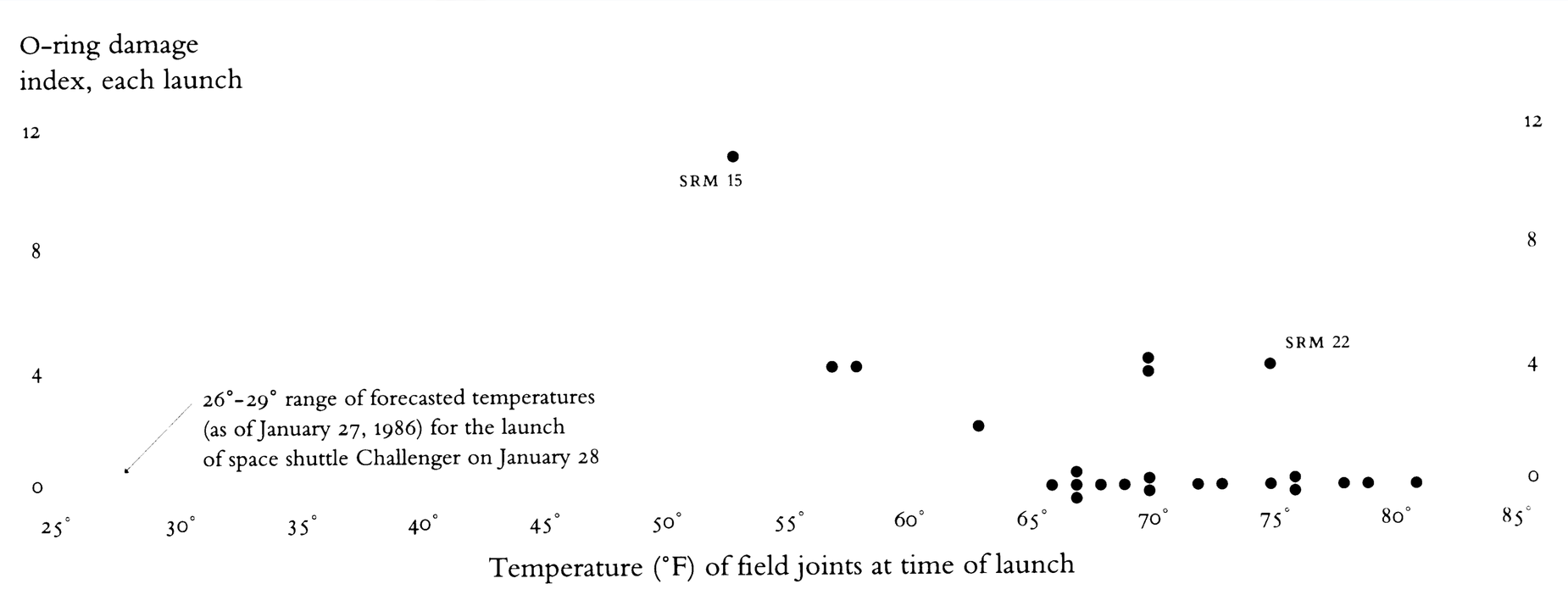


The Slide That Was Presented



From Edward R. Tufte, Visual and Statistical Thinking: Displays of Evidence for Making Decisions Graphics Press, 1997

The Slide That Should Have Been...



From Edward R. Tufte, Visual and Statistical Thinking: Displays of Evidence for Making Decisions
Graphics Press, 1997

Clearance Effects on O-Ring Seating

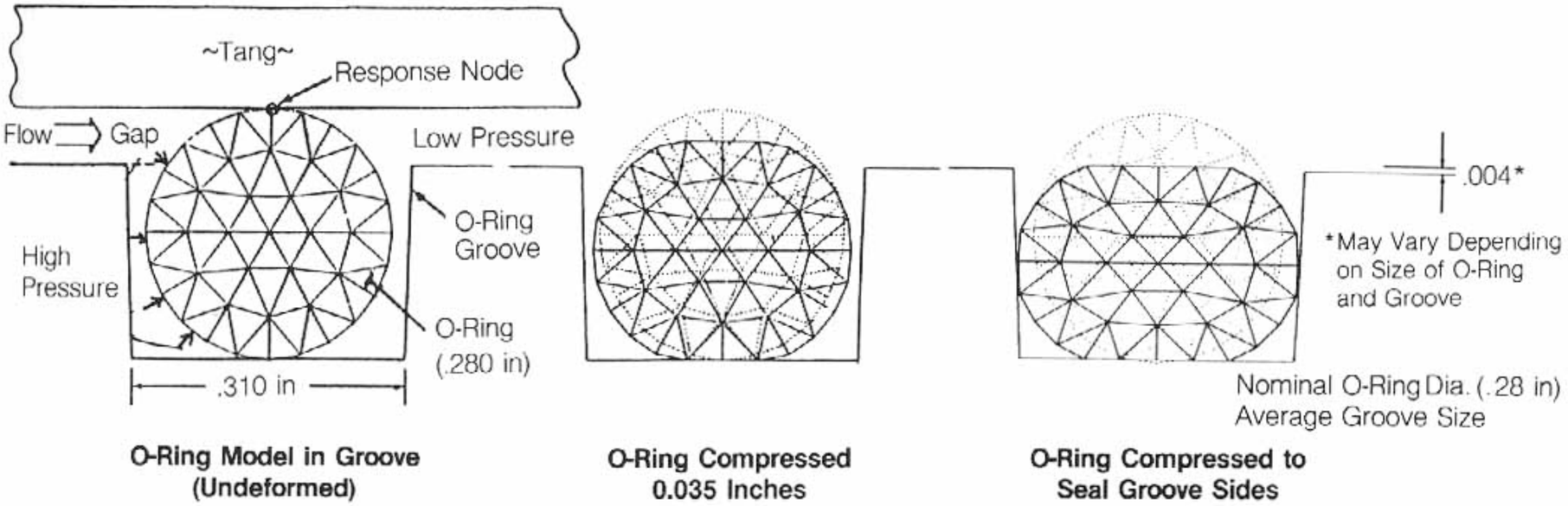


Figure 18
Drawings show how progressive reduction of gap between tang and clevis can inhibit and eventually block motor cavity's high-pressure flow from getting behind O-ring.

Dynamic Motion of O-Ring Seals

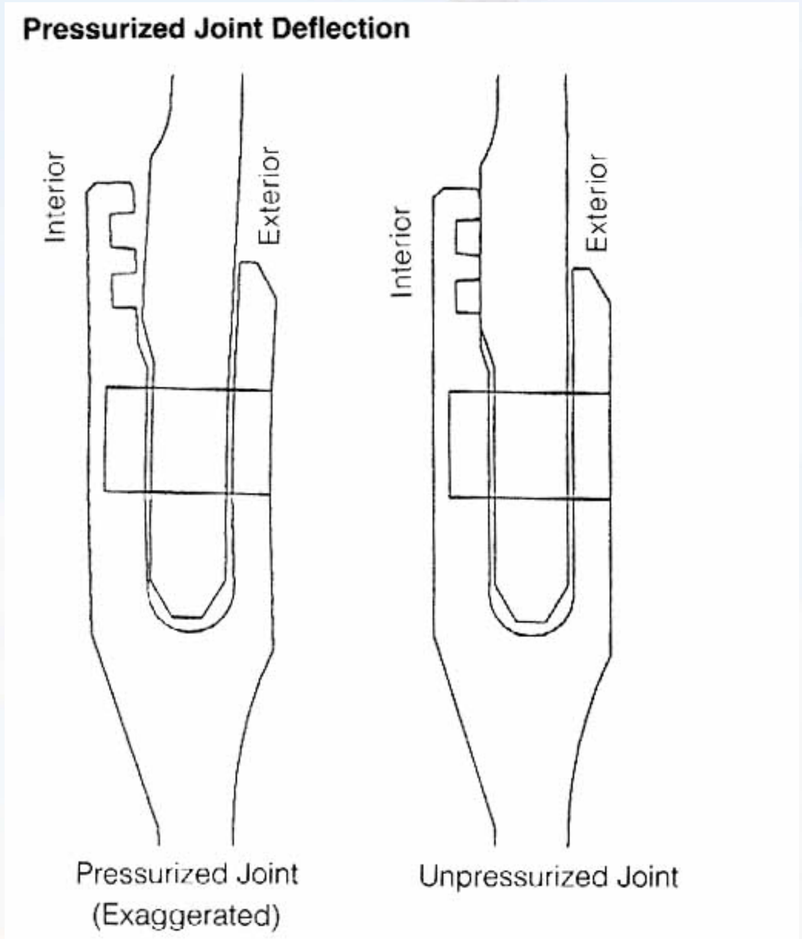


Figure 16
Drawings show how tang/clevis joint deflects during pressurization to open gap at location of O-ring slots. Inside of motor case and propellant are to left in sketches.

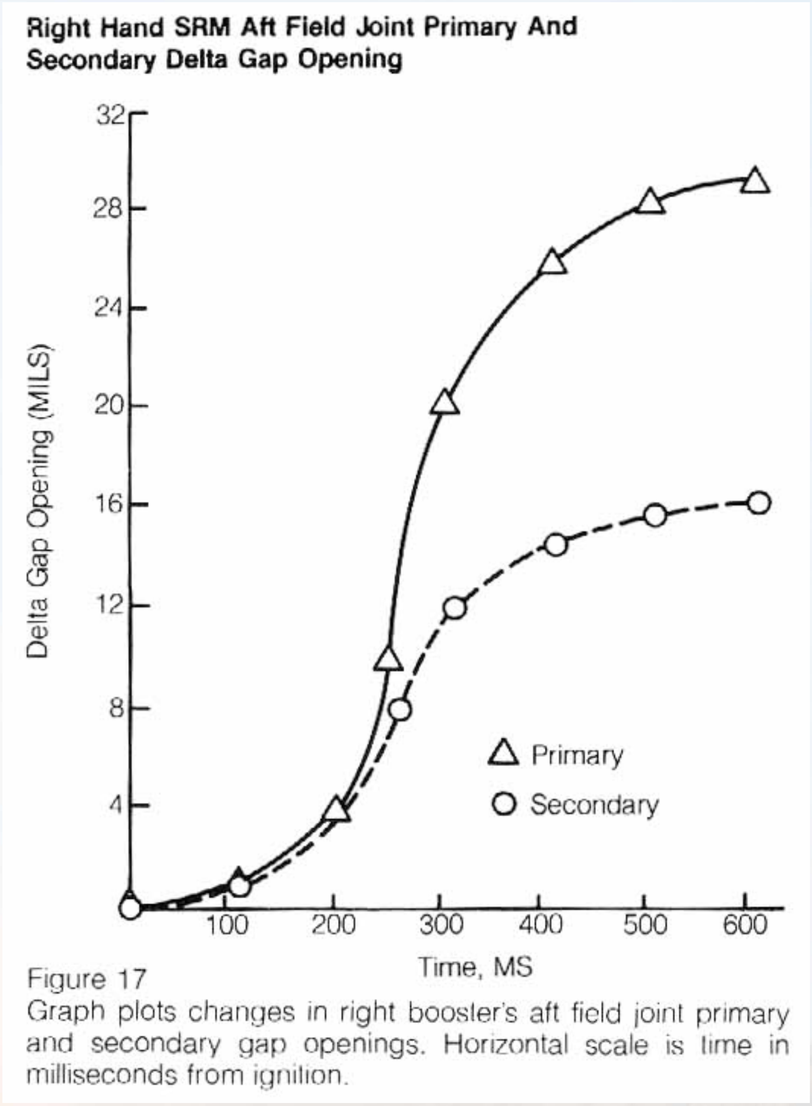
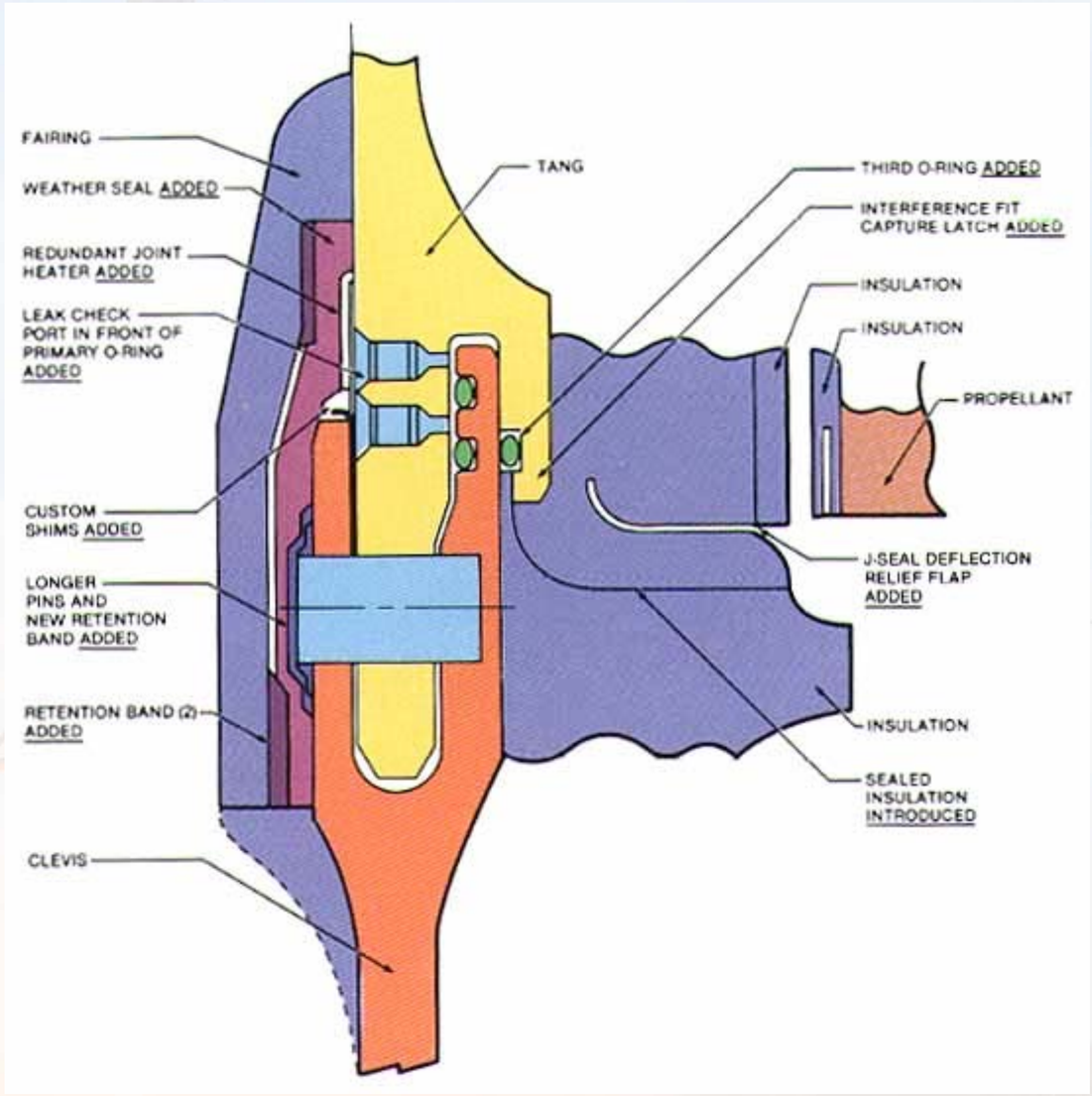
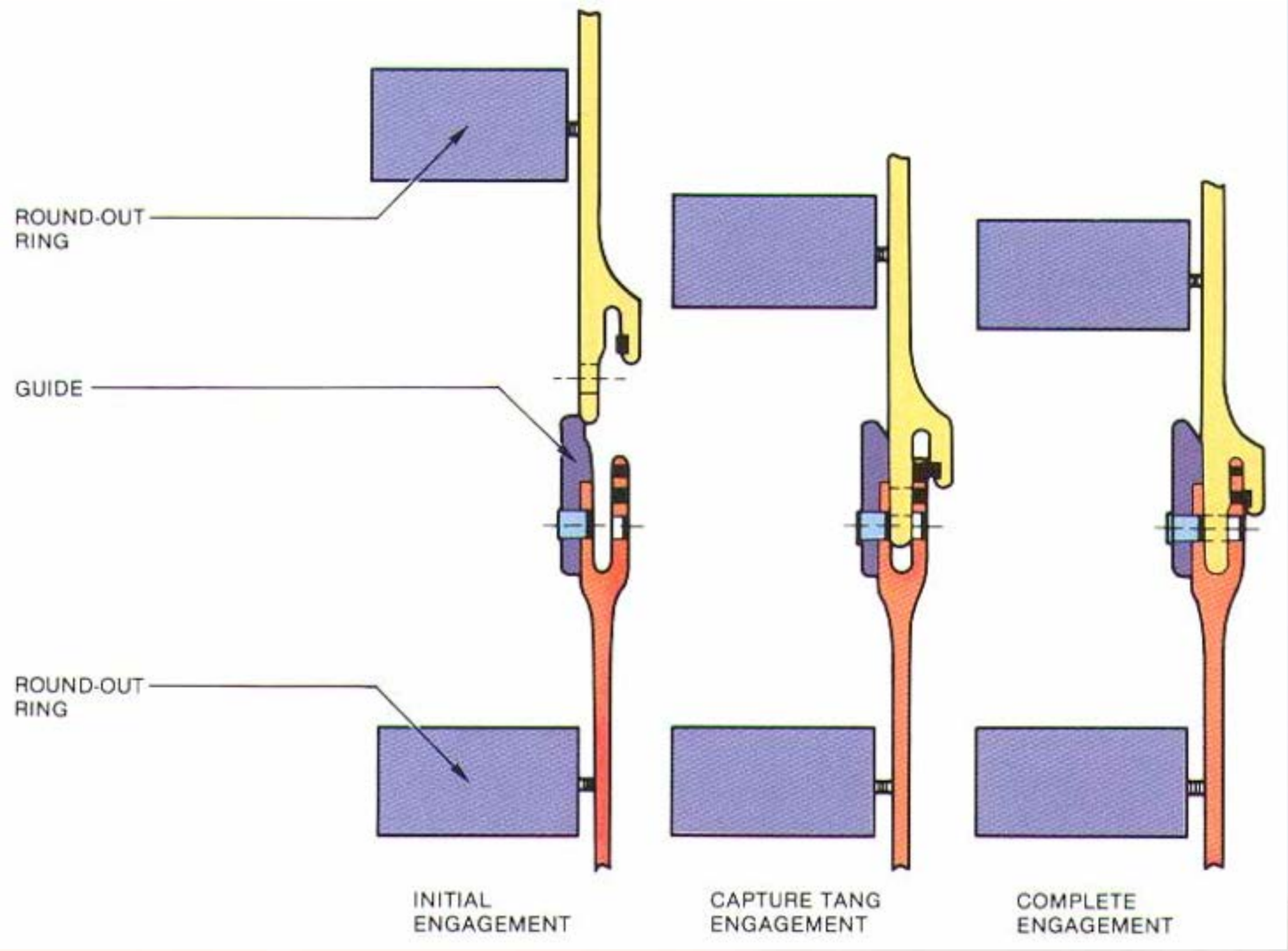


Figure 17
Graph plots changes in right booster's aft field joint primary and secondary gap openings. Horizontal scale is time in milliseconds from ignition.

Redesigned SRB Field Joint

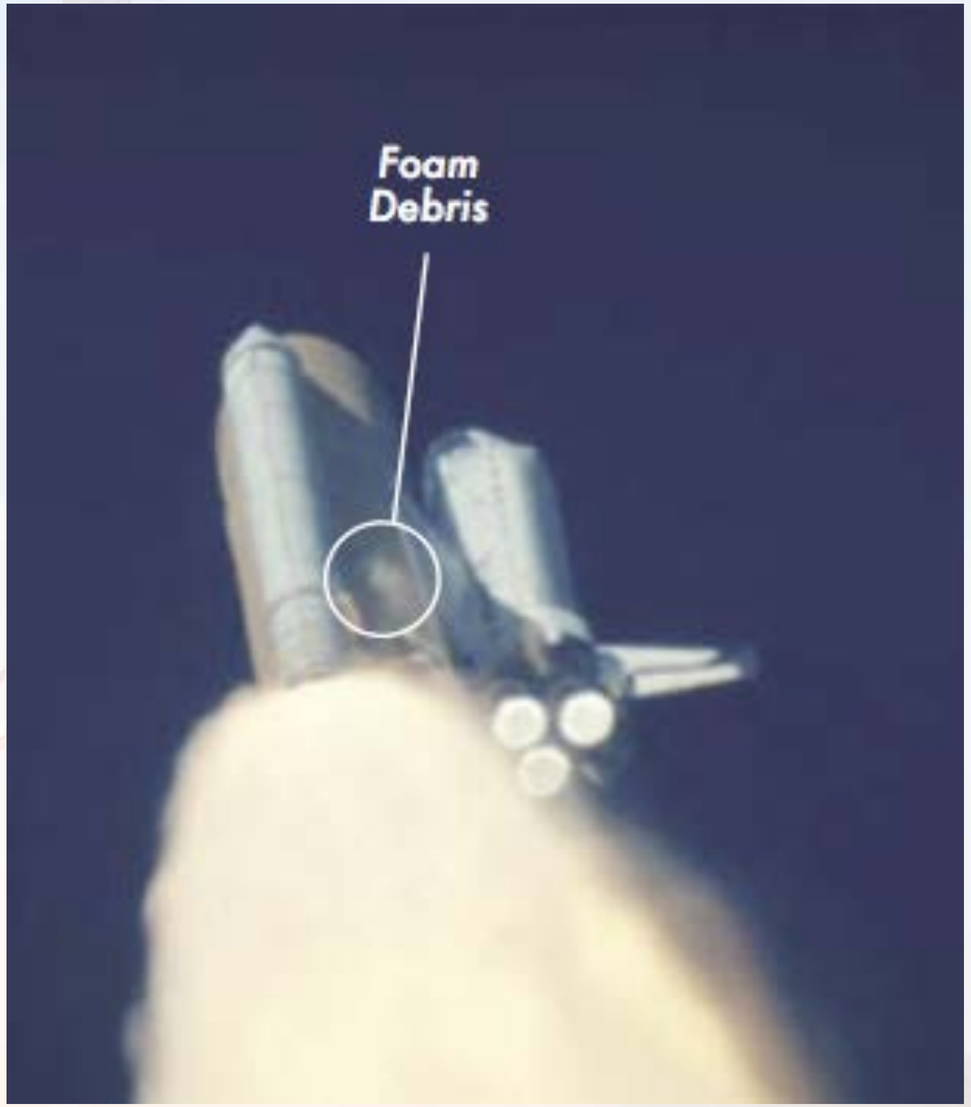


Revised SRB Assembly Technique



Columbia Launch - STS-107

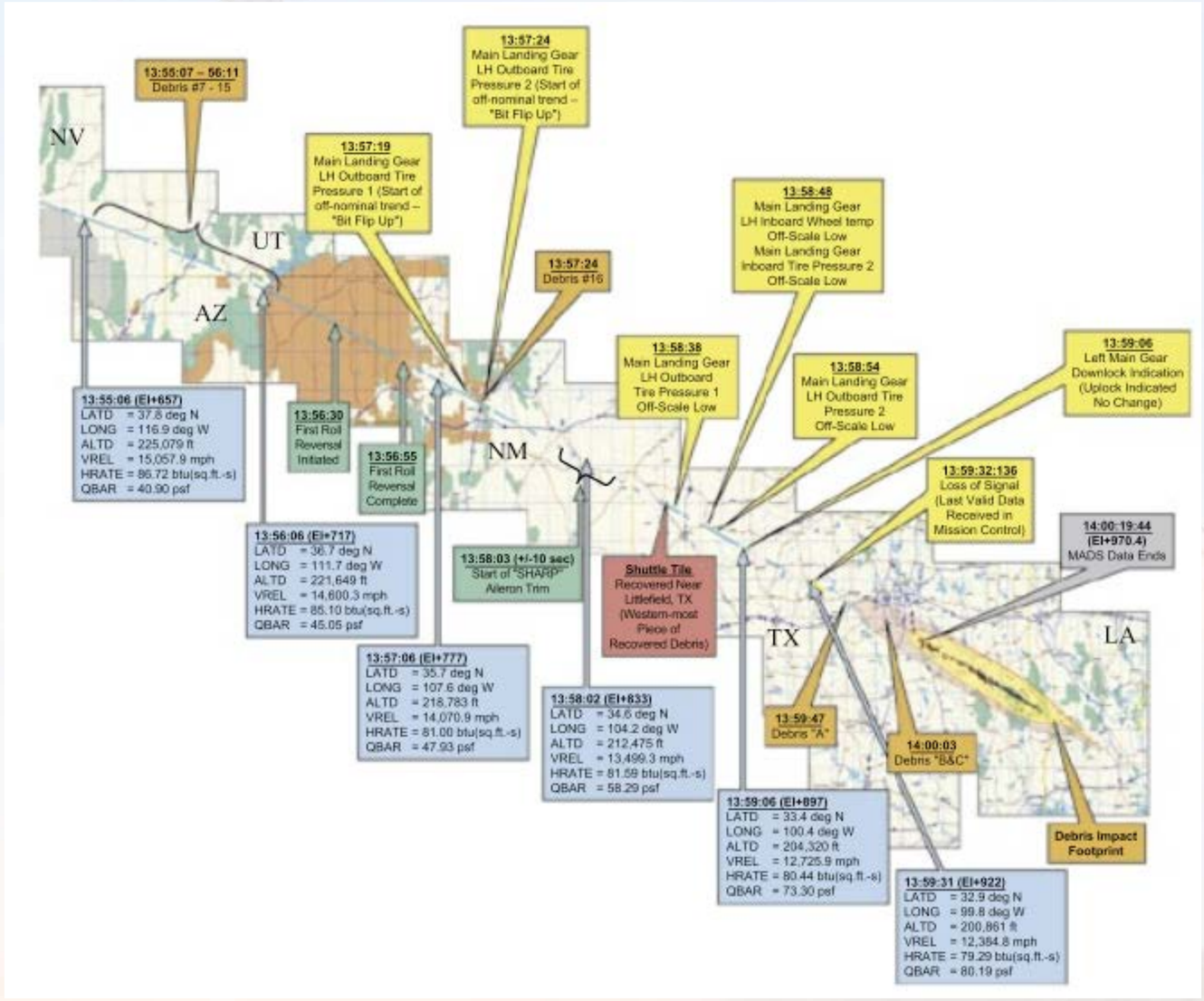
L+81.9 sec



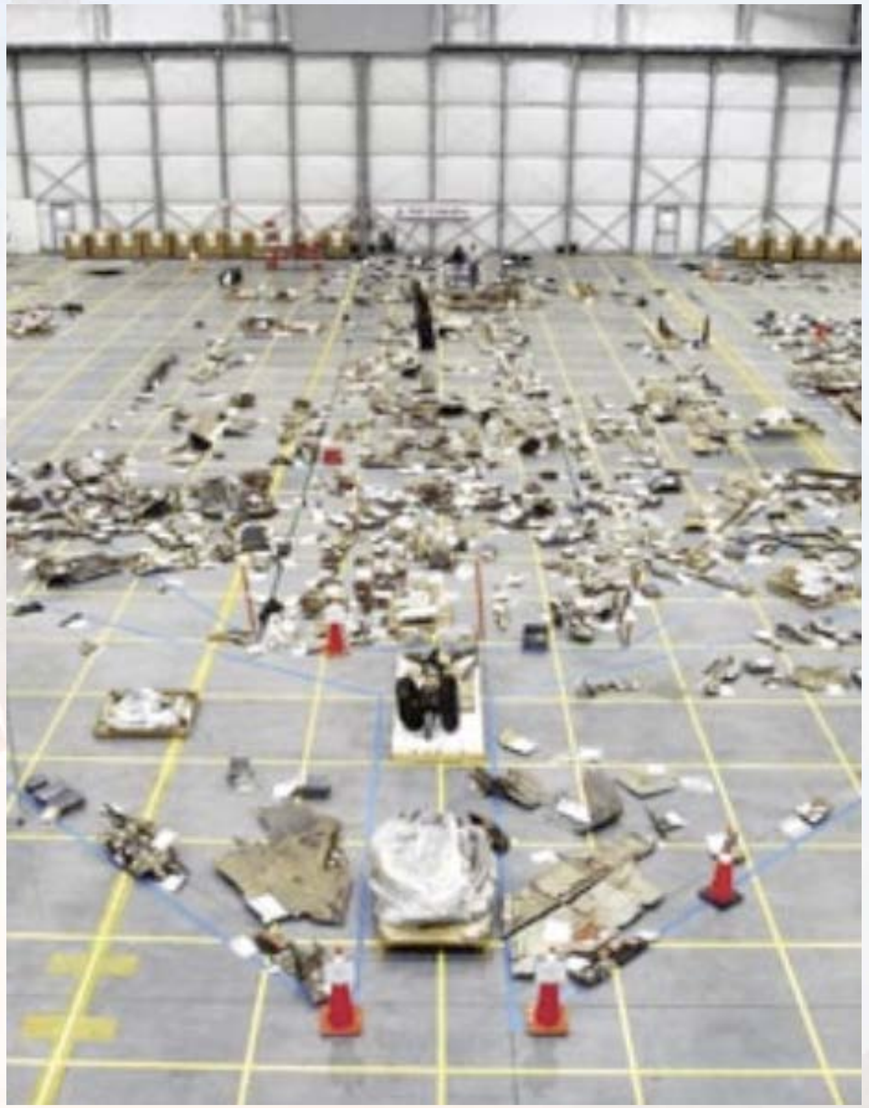
Columbia Entry Break-up

In-Flight Breakup

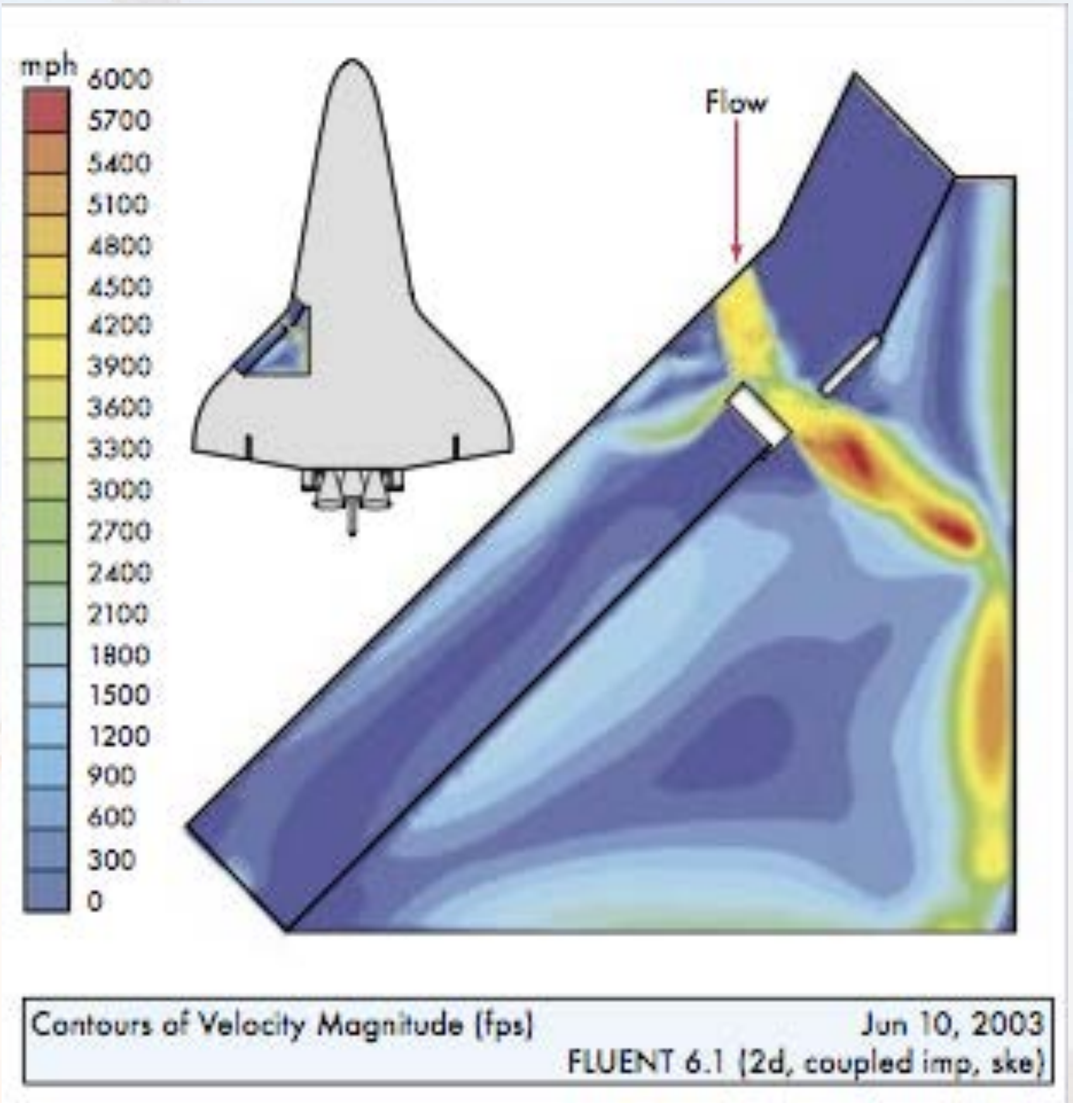
Events Along Flight Path



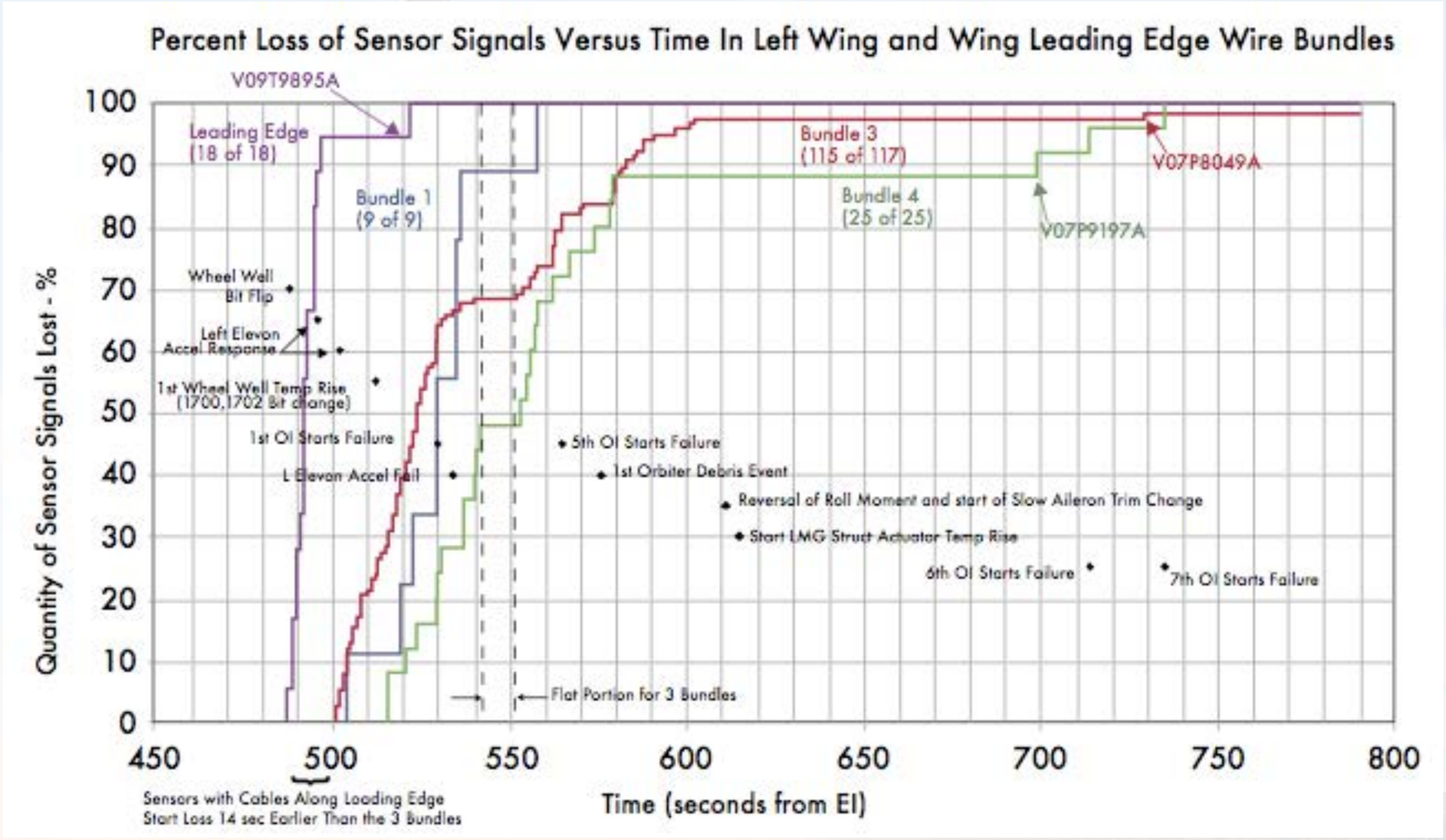
Columbia Debris Reconstruction



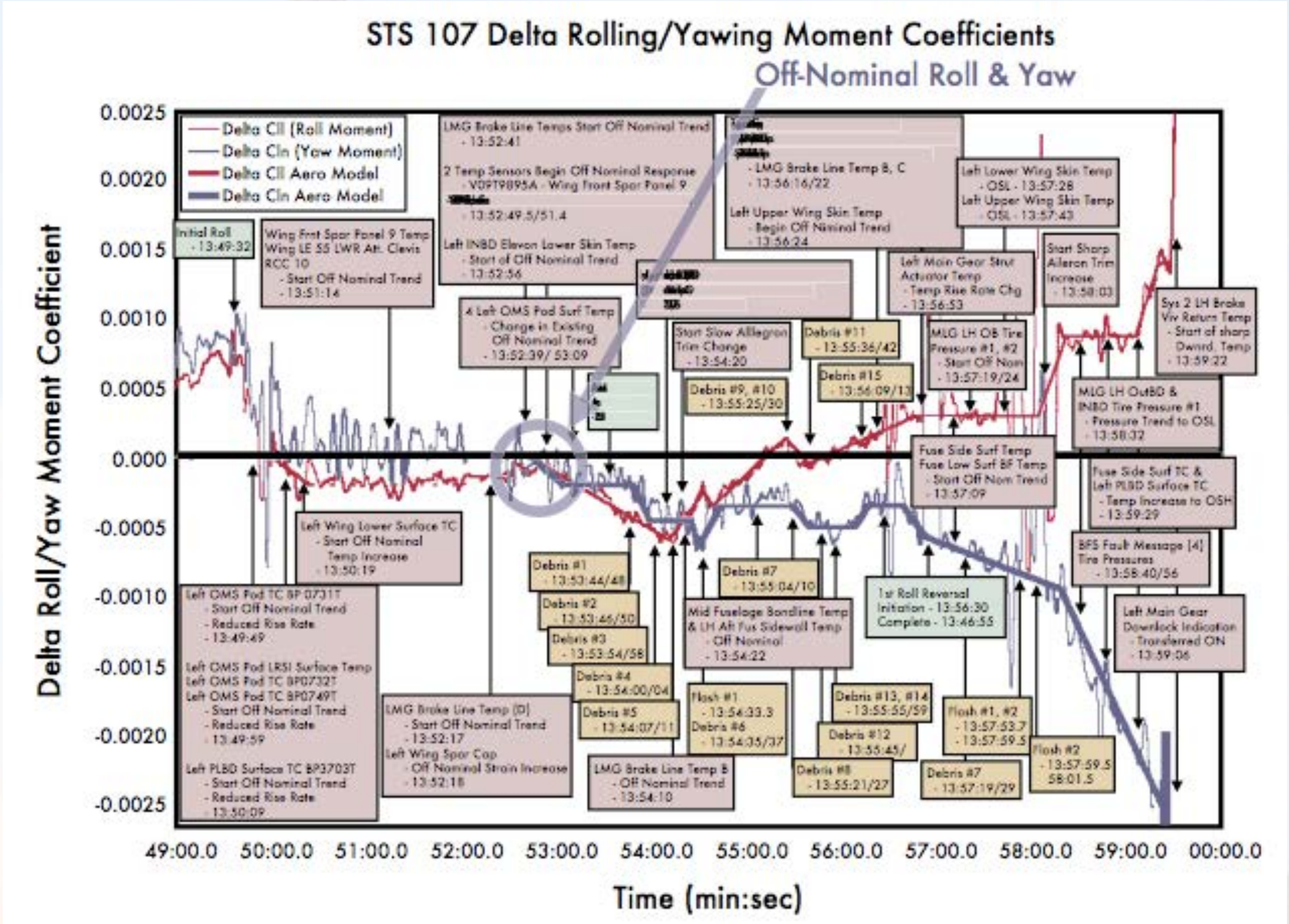
CFD Analysis of Internal Airflow



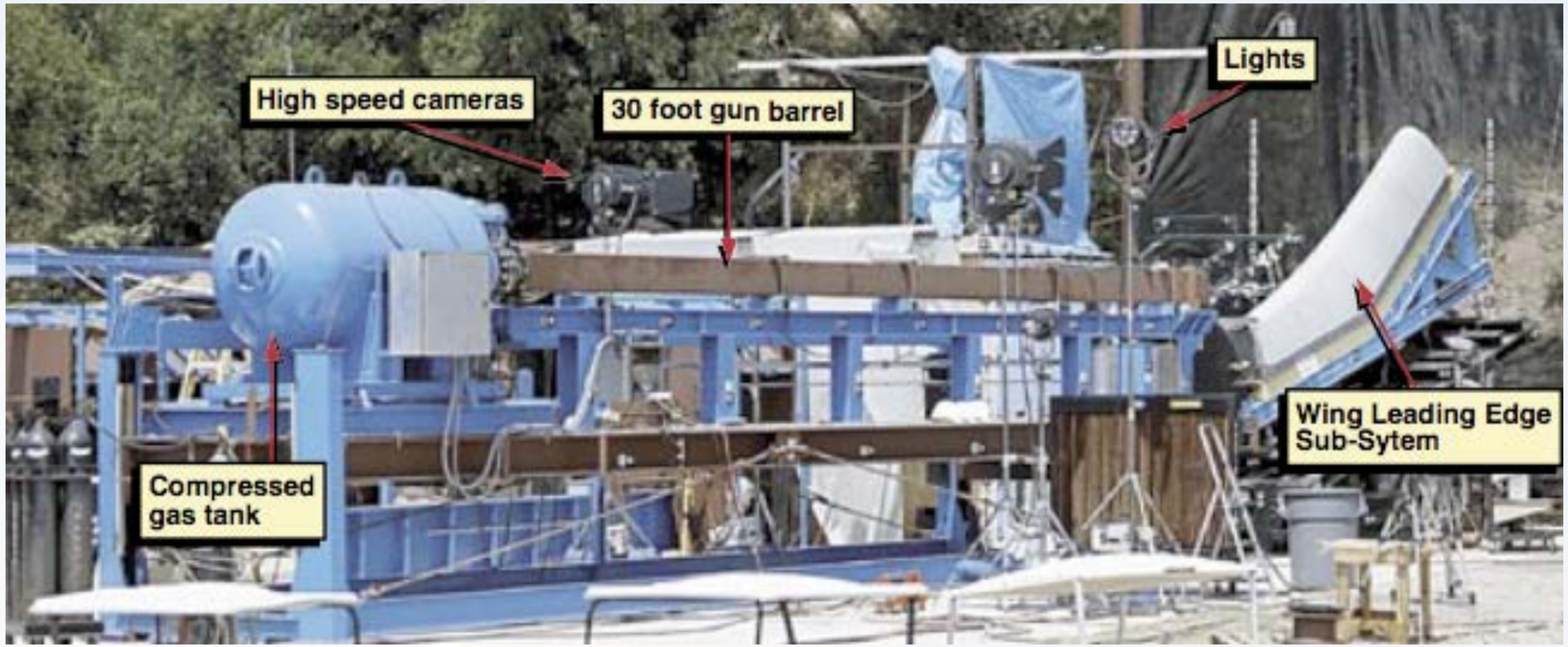
Failure Rates of Sensor Wiring Bundles



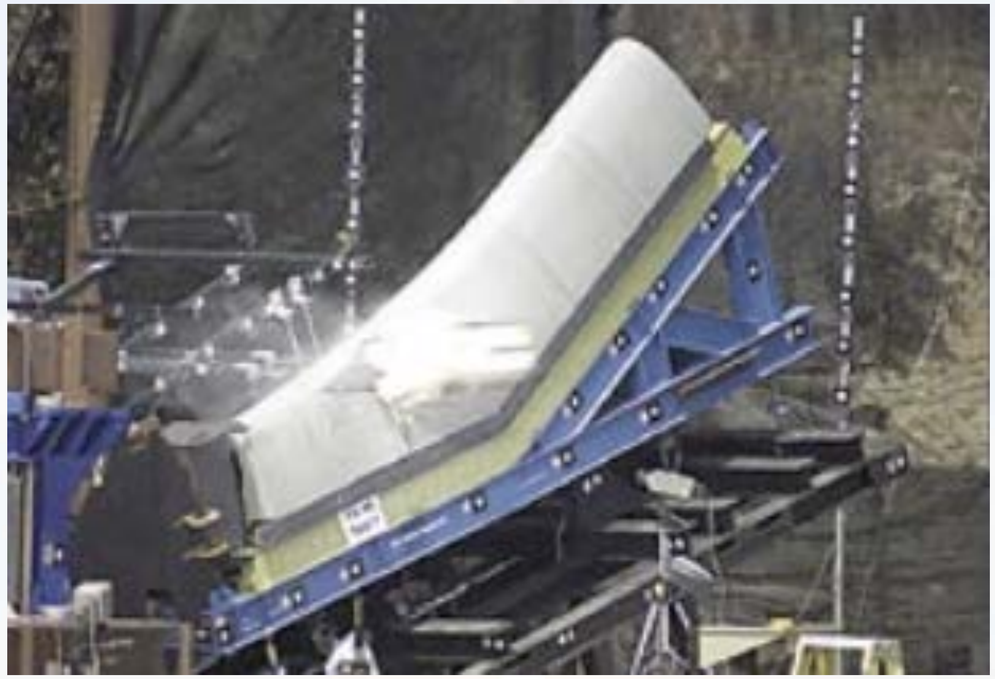
Divergence of Roll/Yaw Angles



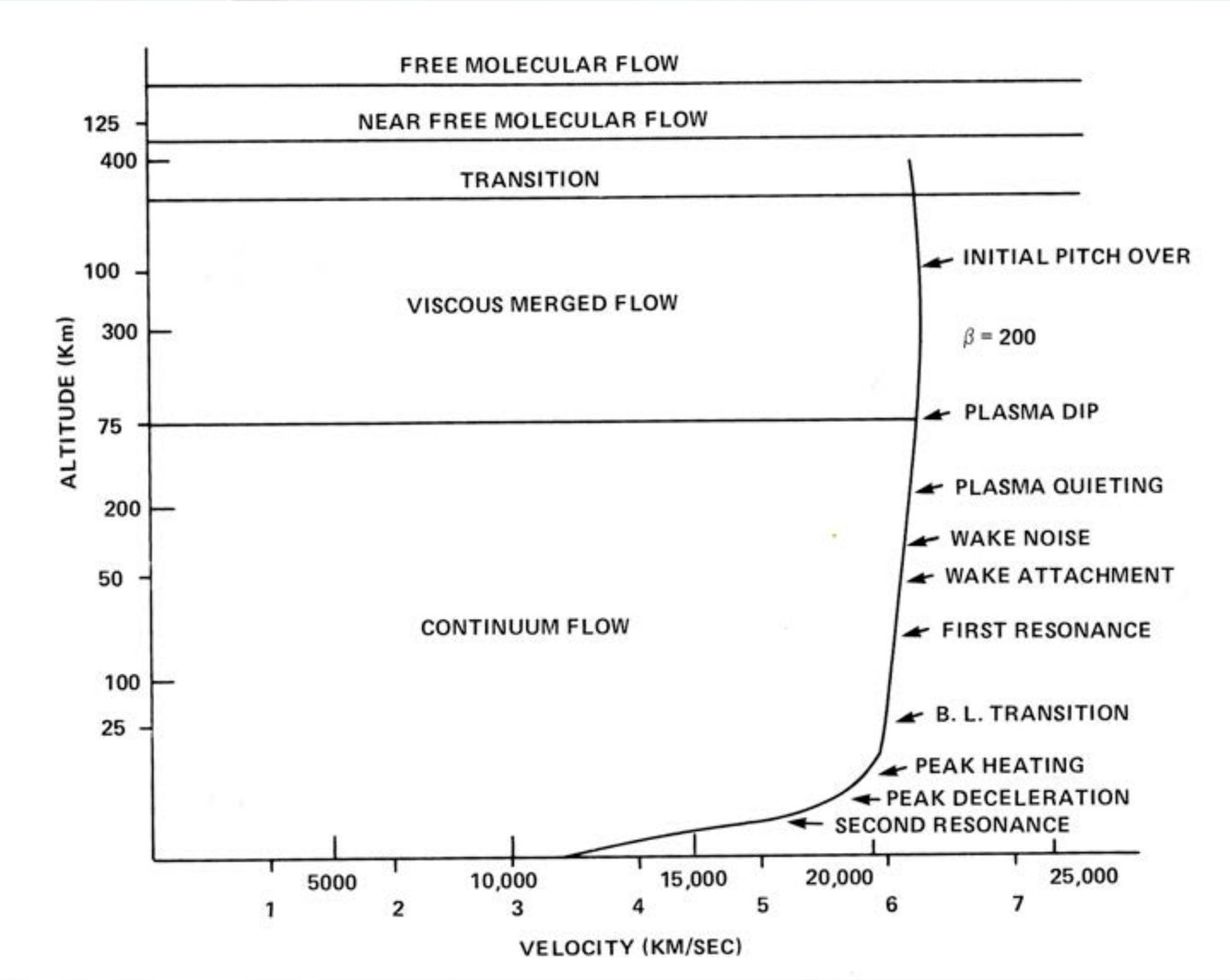
High-Velocity Impact Testing of RCC



Results of Impact Tests on RCC



Entry Flow Regimes



ref: Frank J. Regan, Reentry Vehicle Dynamics AIAA Education Series, NY, NY 1984

AMROC SET-1 Launch Attempt

October 5, 1989 - T+2 sec

October 6, 1989 - Aftermath