The Value of Simple Checks

Conference on Quality in the Space and Defense Industries

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Simple Checks Can Be Very Effective

- **Frequently, engineers believe that "checking" anything complex always requires potentially costly or time-consuming testing**
- **Sometimes, just a simple check would be adequate to uncover a problem**
- **But such checking requires a knowledge of how a system really works, as well as understanding of the "real world" physics behind the complicated mathematics**

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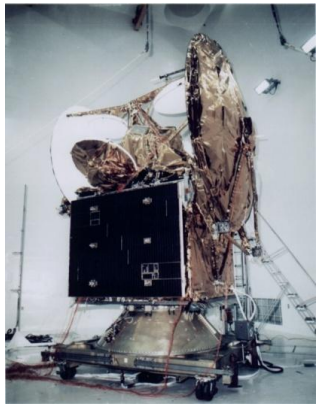
STS-51 TOS/ACTS Separation Band Anomaly

- **Underlying Issue:** Design error made it to flight
- **Problem:** STS-51 Orbiter damaged by debris from ruptured separation joint upon ACTS/TOS deployment (9/12/93)
- **Why:** Improper design of Super Zip firing circuits. ***No simple electrical interface drawing check performed.***
- **Impact:** Damage to Orbiter
  - Nearly impacted flight/crew critical equipment:
    - One piece penetrated Orbiter aft bulkhead blanket and caused a 1/8 x 1/2 inch hole in bulkhead
  - Other debris caused:
    - At least 9 tears in cargo bay insulation blankets
    - 3 gouges in wire tray covers
    - Possibly a gouge in a TPS tile



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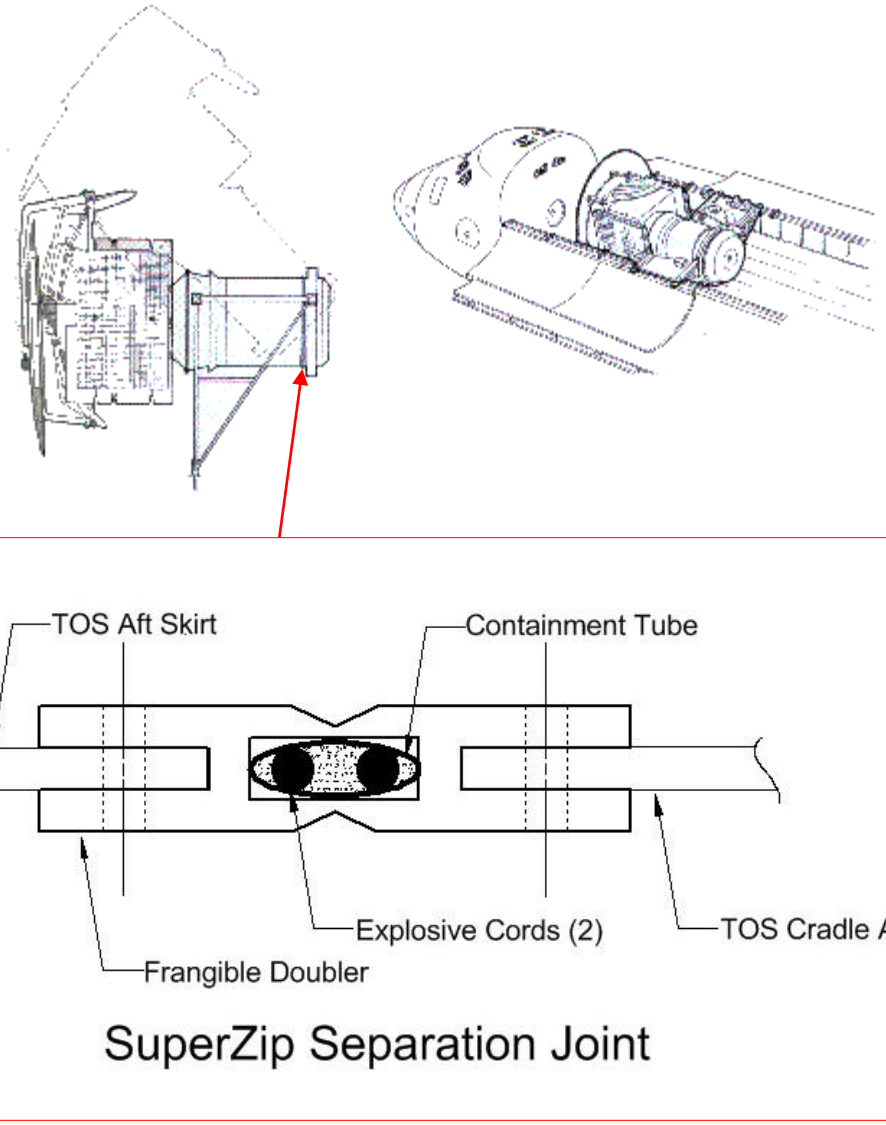
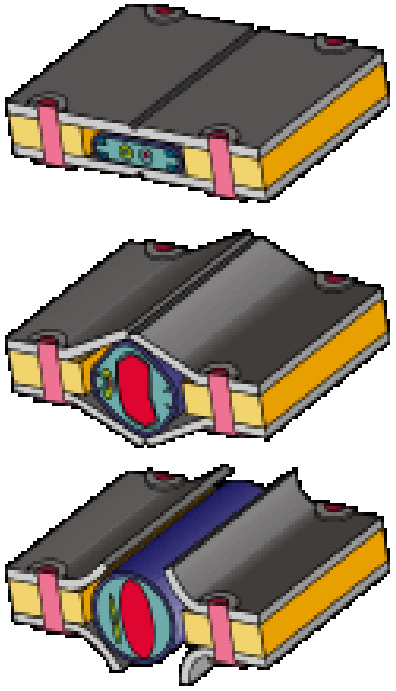
STS-51 TOS/ACTS Separation Band Anomaly (cont'd)





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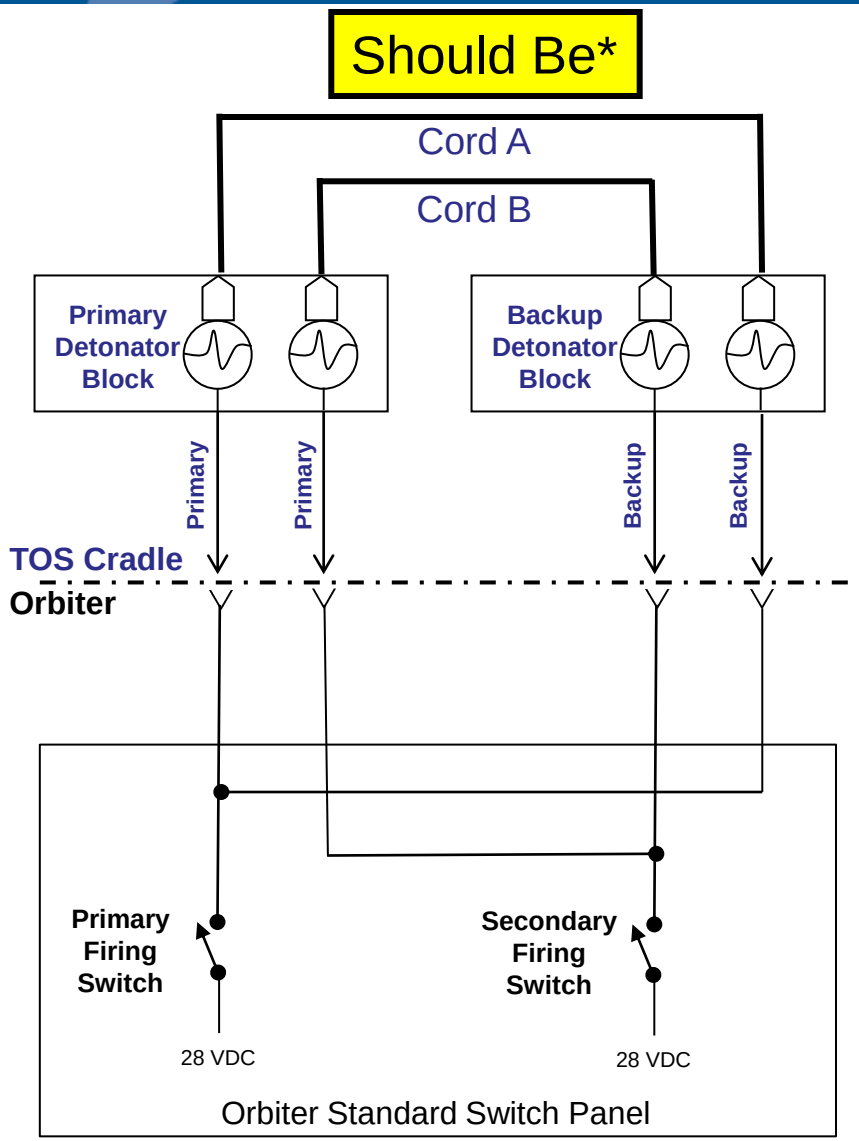
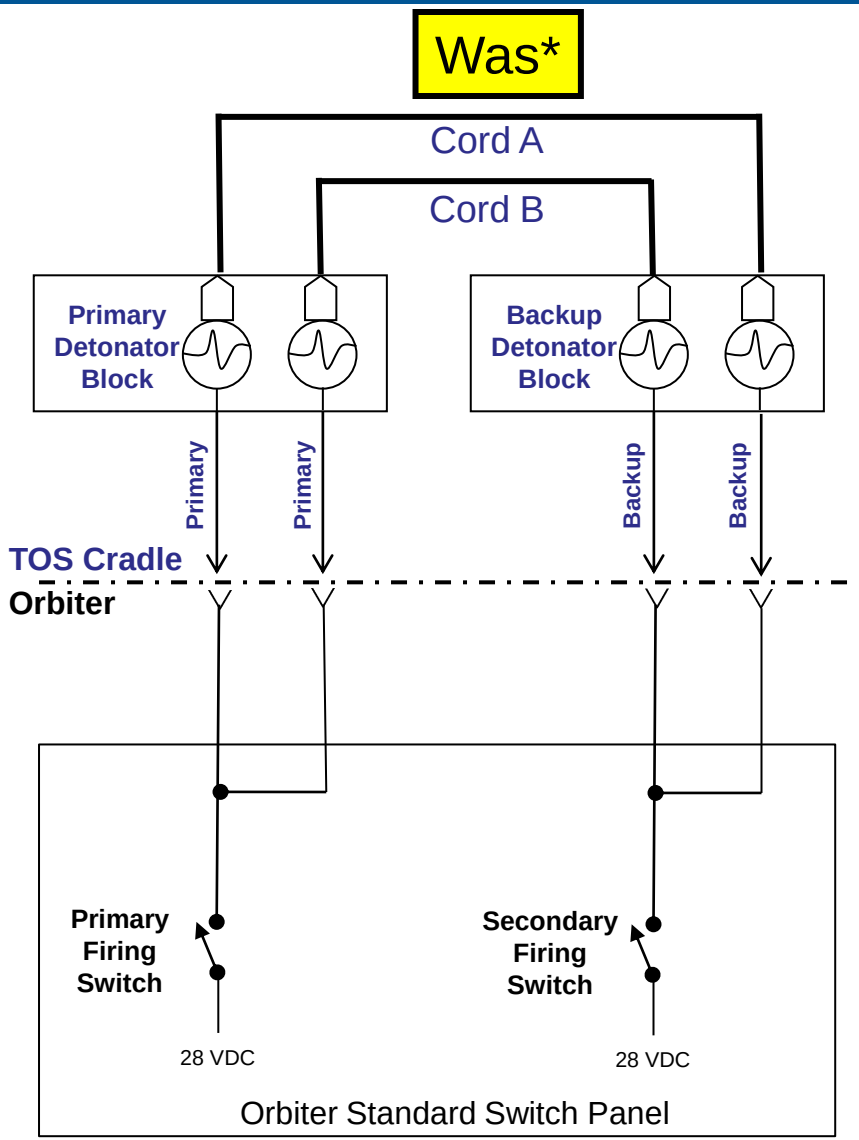
STS-51 TOS/ACTS Separation Band Anomaly (cont'd)





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* Details courtesy of Dan Tani, NASA JSC Astronaut, who previously served as the ACTS/TOS Flight Operations Lead for the Orbital Sciences Corporation.

Pyro Testing

NASA Glenn Research Center
Pyro Testing
Rigorous Configuration Control
Safety First!

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STS-51 TOS/ACTS Separation Band Anomaly (concluded)

LESSONS:

- **Never implement an electrical interface based on nomenclature**
  - **Verify compliance with design intent by examining the entire circuit**
  - **Produce end-to-end (cross interface boundaries) schematics for all electrical systems**
- **Test procedures should be based on functional requirements whenever possible**
  - **Not just to verify "built to print"**
- **Be extremely vigilant when implementing any interface – historically, this is a "hot spot" for mistakes!**

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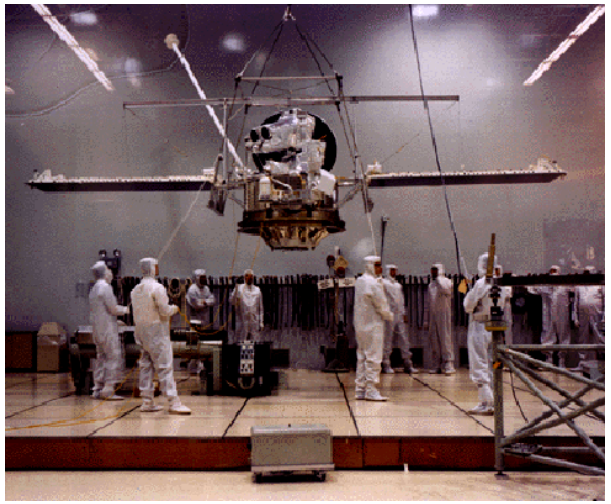
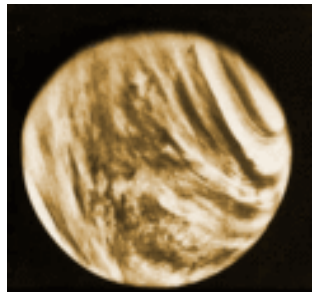
AC-34: Mariner Venus/Mercury - Mariner 10

- **Launched successfully:** November 3, 1973
- **Underlying Issue:** Error in implementing spacecraft interface to launch vehicle
- **Problem:** Spacecraft X-axis polarity reversed in launch vehicle ascent trajectory simulation
  - *Caught by simple check 3 years before launch*
- **Potential impact if undetected:** Damaged spacecraft instruments
- **Actual impact:** None – Mission successful
  - Ended March, 1975, after one Venus and three Mercury passes
  - First dual planet mission - 12,000 images
    - First clear pictures of Venusian clouds
    - First use of gravity assist
    - First mission to Mercury



Venus in real color

Venus in ultraviolet



Mercury in real color

Source: Subject matter expert: J. Nieberding, lead launch vehicle mission analyst

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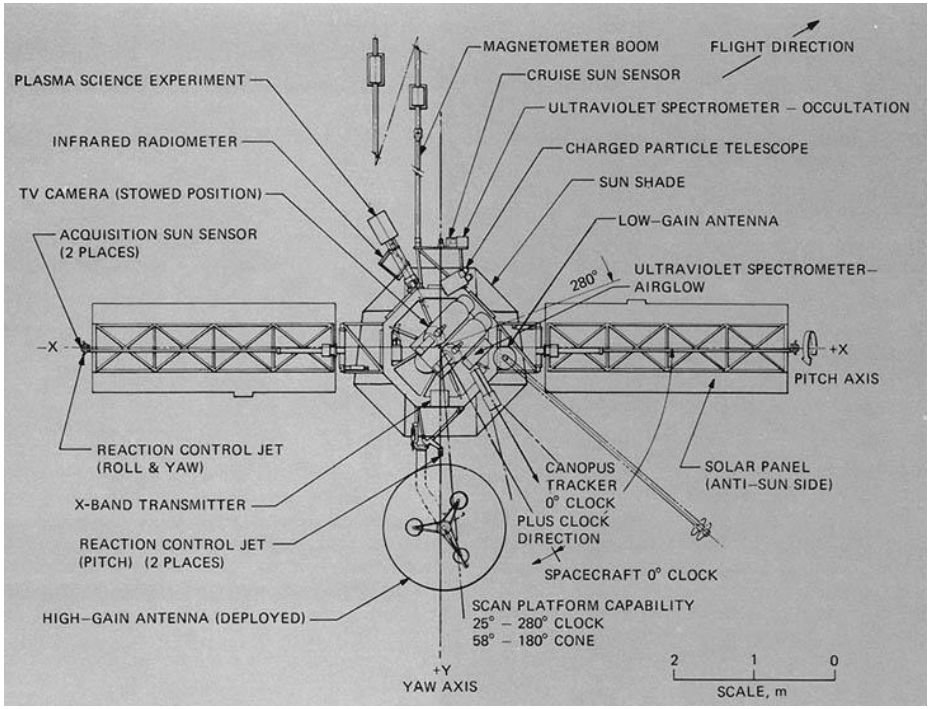
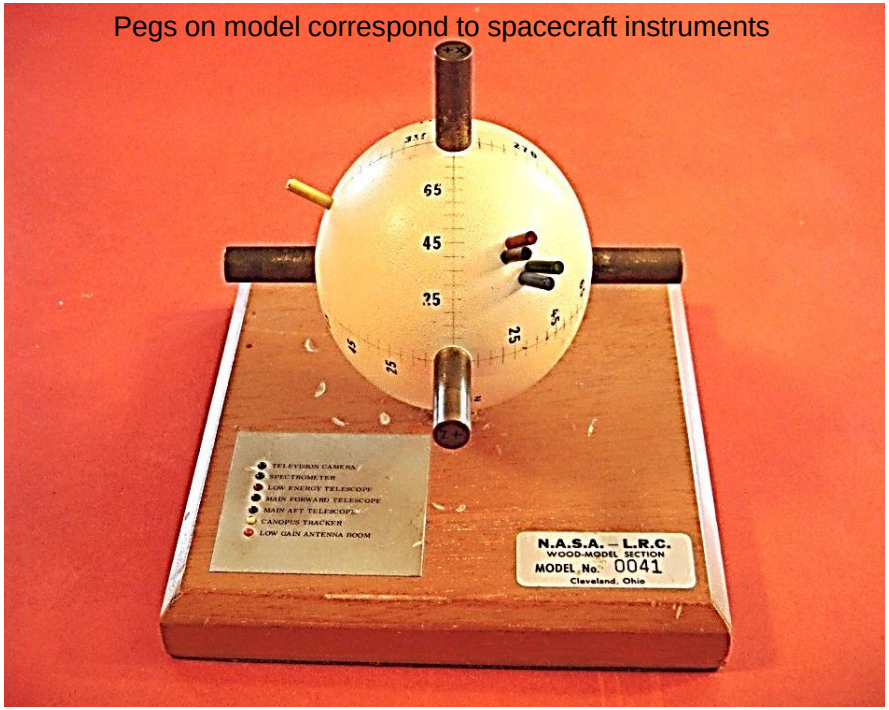
AC-34: Mariner Venus/Mercury - Mariner 10 (cont'd)

Simple spacecraft model





Complex → Simple

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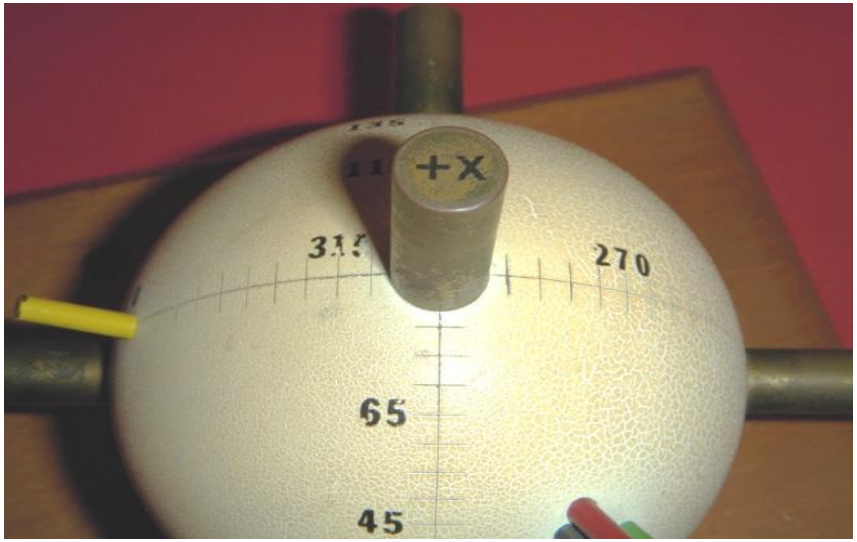
AC-34: Mariner Venus/Mercury - Mariner 10 (cont'd)

- **Spacecraft instruments must not point toward sun**
  - Centaur coast phase roll attitude so programmed
- **Trajectory listing reviewed**
  - Listing attitude was manually compared with expected attitude as determined through observation of model and globe relative geometry
  - Comparison revealed problem
- **Trajectory simulation code had the spacecraft X-axis polarity reversed!**
  - If undetected, serious spacecraft damage likely



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AC-34: Mariner Venus/Mercury - Mariner 10 (concluded)

LESSONS:

- **Be extremely vigilant when implementing any interface (between systems, NASA centers, contractors, etc.) – historically, this is a "hot spot" for mistakes!**
- **Simple checks can be very effective**
- **Must understand the real world physics, not just the mathematics**

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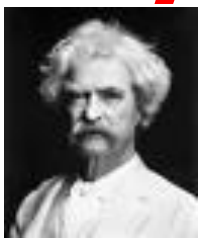
Conclusion

- Look for ways to perform simple checks
- If “it” doesn’t pass a simple test, “it” may be wrong
- Remember, as Mark Twain once said:

“It ain’t what you don’t know that gets you into trouble. It’s what you know for sure that just ain’t so.”



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MISSION

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