InSight

A Brief History of the Development and Acceptance of a “Build-to-Print” Parachute

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"the parachute is identical [to PHX]" – InSight Step 2 Proposal
Initial plan:
- “identical” = design, materials, construction, test program, etc…
- Include healthy schedule margin to accommodate any setbacks during development and test
Parachute Plan, Revision 2 (Requirements Creep)

Design load increase has minor impacts to parachute design:
- Strengthen suspension lines: Kevlar $\rightarrow$ Technora w/hybrid joints
- No changes to other materials $\rightarrow$ slight reduction in structural margins

Test venue change enables test campaign improvements:
- Better control/repeatability of test conditions
- Better instrumentation and video of deployment/inflation
Incorporated multiple lessons learned:

- Sensitivity to dimensional variation
  - Augmented inspection, some re-work
  - Augmented LS-DYNA analysis

- Supersonic inflation stress > subsonic inflation stress
  - Augmented NFAC testing to include higher loads
Discovered previously unobserved twisting phenomenon in NFAC:

- Confirmed that twisting is linked to parachute packing method
- Developed alternate packing method which eliminated twist
- Performed ‘fly-off’ of parachutes packed using both methods
Closely followed post-flight investigation:

- InSight parachute already built and qualified, so limited ability to react
- All findings and recommendations could be reasonably addressed by InSight with no additional activities
Parachute Plan, Revision 6 (Launch Slip)
Discovered that InSight broadcloth nylon is not the same as heritage material:

- Identified different material response after exposure to high temperature / high duration DHMR
- Different vendor, different additives, different response to DHMR environment (PIA-7020 is a spec, not a recipe)
- Performed enhanced material testing to range of flight-like environments where we had leveraged heritage
- Demonstrated InSight environments do not result in reduced performance
Watched ASPIRE flights anxiously:

- Opportunity for new learning (e.g. risk discovery), but very limited time to react
- Some advance planning to prepare contingency options
- Two successful tests!

Nominal Plan
Not in Plan
Non-Project Activity
Parachute Advisory Group
Summary

• Another case study exposing the fallacy of “build to print:”
  – Flight chute nearly identical in design and construction but..
    • Requirements creep impacted design, manufacturing, and test
    • Internal and external activities exposed multiple unknown unknowns
    • Heritage broadcloth material no longer available

• More time spent on unplanned activities than planned ones:
  – Why? Not many flights of supersonic parachutes (N≈20)
    • every new flight can expose unknown unknowns
    • any chute failure induces lots of questions
  – Initial schedule well margined to accommodate unplanned effort

• High confidence in InSight parachute:
  – Parachute broadcloth tested more extensively than any mission since Viking
  – Flight lot chute tested subsonically to >2x the flight limit load
  – Retain very strong heritage basis for successful supersonic deployment on Mars