

Industrial implementation of fracture control on payloads

ESA Workshop on Fracture Control of Spacecraft, Launchers and their Payloads and Experiments, 9-10 February 2009

Astrium Space Transportation

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All the space you need

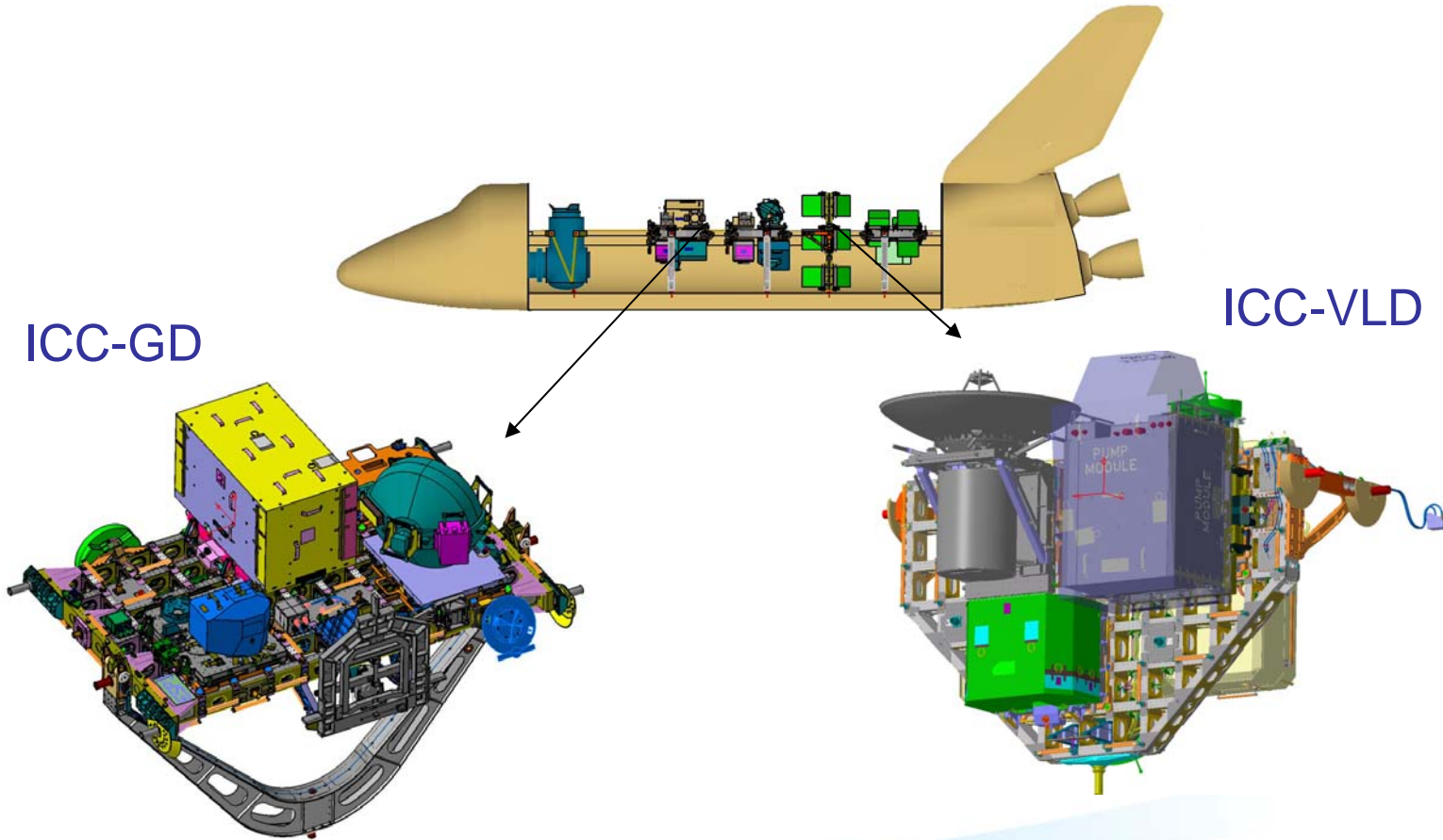


Outline

- Presentation of analysed payloads
- Fracture control requirements for payload
- Principal tasks in fracture control verification
 1. Identification of PFCI
 2. Definition of load spectrum
 3. Analysis (safe life, fail safe & containment)
- Specific payload issues
- Conclusion

Presentation of Payloads (1)

Space Shuttle - Integrated Cargo Carrier

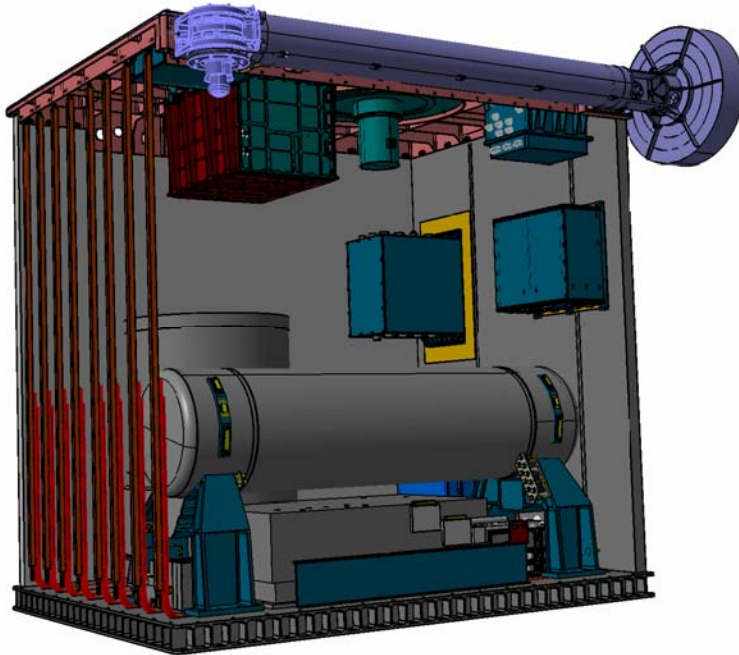


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Presentation of Payloads (2)

Experimental laboratories / Racks

Atomic Clock Ensemble in Space (ACES)



Microgravity Science Glovebox (MSG)



Fracture control requirements for Payload

Fracture Control requirements for payload shall be compliant with

- ISS requirements (SSP 30558)
- Launcher / capsule requirements
 - Space Shuttle (NASA-STD-5003),
 - Progress / Soyuz (TEC-MCS/2004/1080/IN/RK, ECSS-E-30-01A),
 - ATV (ATV-AS-SSS-1100),
 - HTV (NASDA-ESPC-2857)...

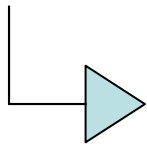
Fracture Control requirements shall already be considered in the design:

- Access for NDI,
- Material requirements wrt SCC,
- Availability of material data,
- Geometry ...

Identification of PFCI – specific payloads

Failure of an item would:

- Result of the release of any element with a mass > 113.5 grams
- Result in the release of any tension pre-loaded part with a mass > 13 grams if $K_{IC}/YS < 1.66\text{mm}^{1/2}$
- Result in the release of any tension pre-loaded part with mass > 13 grams if steel bolt with UTS $> 1240\text{MPa}$
- Result in the release of hazardous substance
- Prevent configuration from safe descent from orbit
- Release of any mass during zero gravity flight with $v > 10.7\text{m/s}$ or Momentum $> 1.21\text{Ns}$



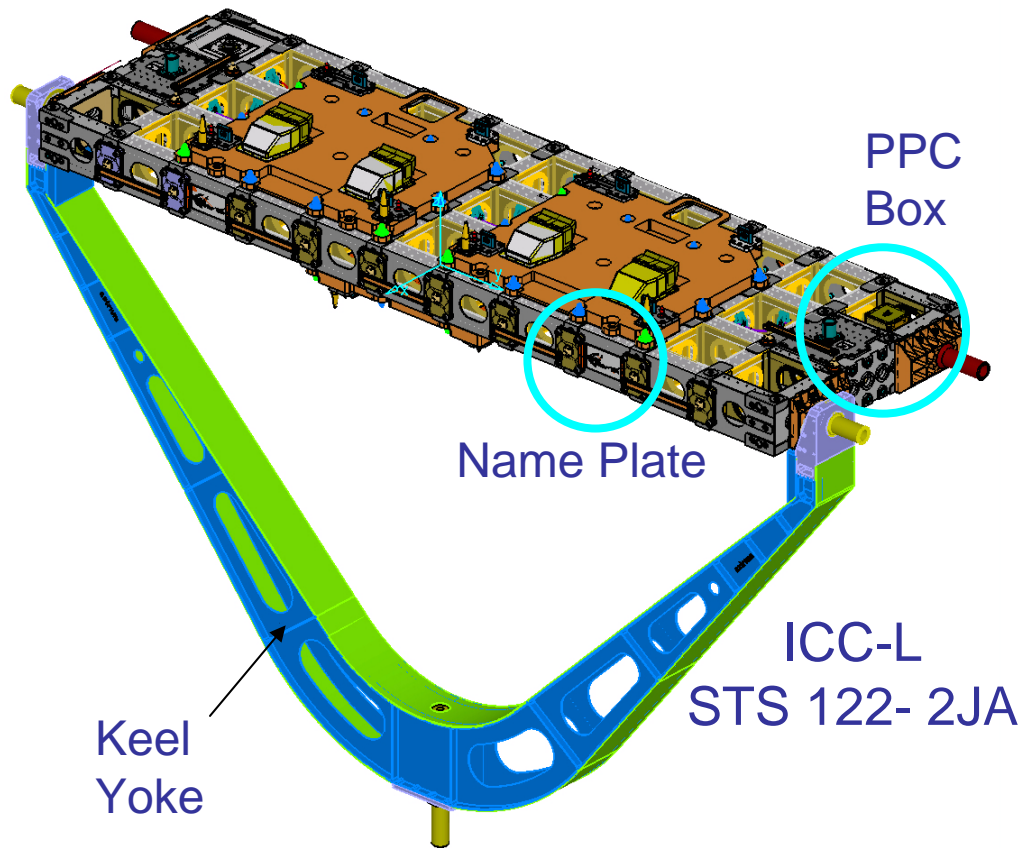
**Potentially Fracture Critical Item
(PFCI)**

Task 1 - Determination of PFCI – screening

Composite? → No
Pressurised items? → No
Welding? → No
Casting? → No
Structural element? → Yes

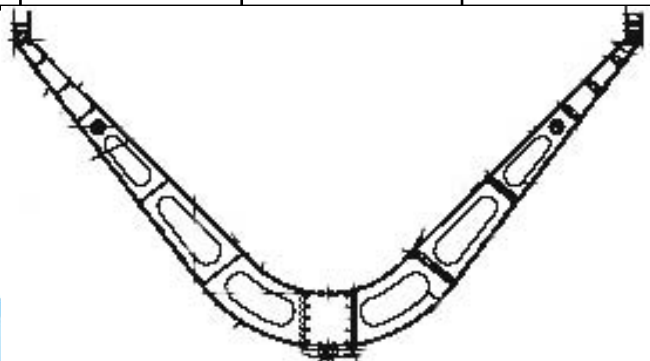


- e.g. 1. Keel Yoke
- 2. PPC Box
- 3. Name Plate (m = 385g > 113g)



Task 1 - PFCIL - ICC-L mission STS 122

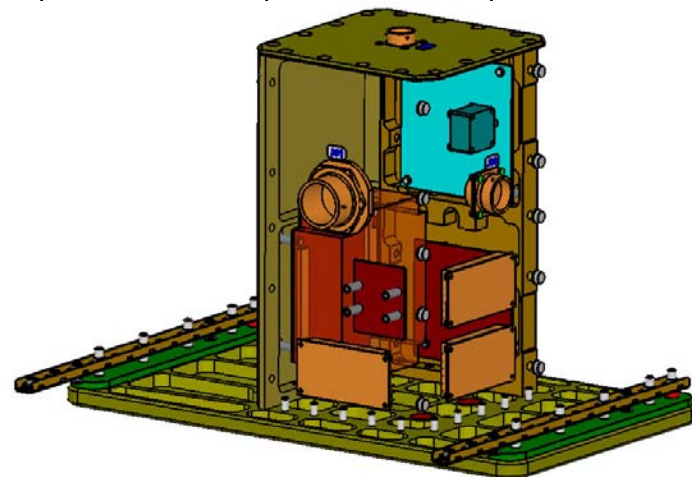
PFCI	Item	Material	Design philosophy			NDI	Remark
			Fail safe	Safe life	Containment		
1.	Keel Yoke Assembly						
1.1	Keel Yoke Structure						
1.1.1	Bracket XY	AA 7075 T73		X		DP	
1.1.2	Screw	In 718 STA		X		EC	Aerospace standard



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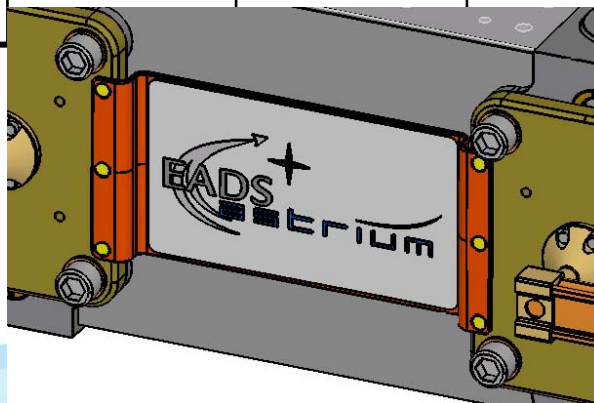
Task 1 - PFCIL - ICC-L mission STS 122

PFCI	Item	Material	Design philosophy			NDI	Remark
			Fail safe	Safe life	Containment		
1.	Keel Yoke Assembly						
2.	PPC Box						
2.1	Panel	AA 7075 T7351		X		DP	
2.2	Screw	A286	X			LA	Aerospace standard
2.3	PPC electrical components				X		

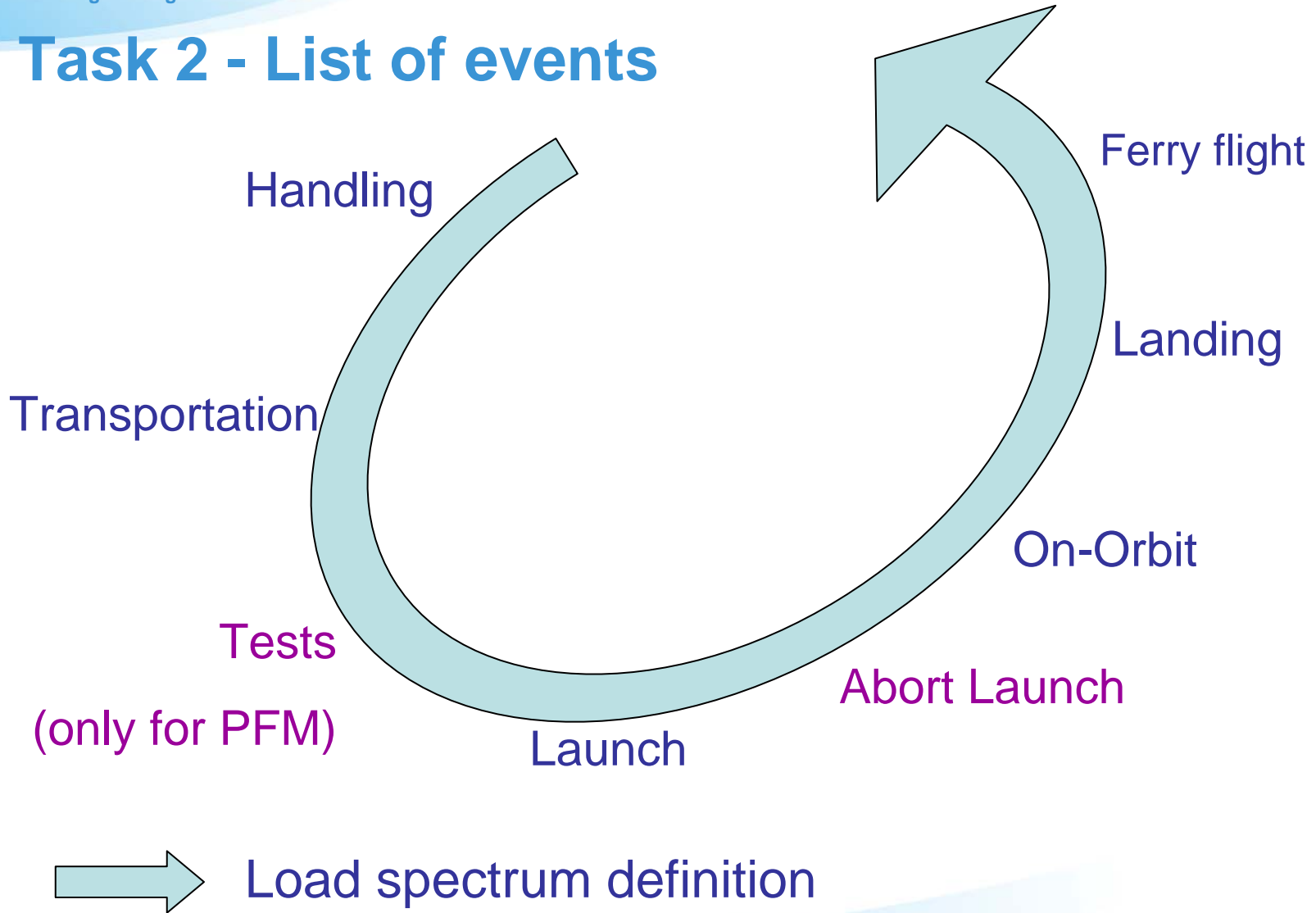


Task 1 - PFCIL – ICC-L mission STS 122

PFCI	Item	Material	Design philosophy			NDI	Remark
			Fail safe	Safe life	Containment		
1.	Keel Yoke Assembly						
2.	PPC Box						
3.	Name Plate						m > 113g
3.1	Name Plate	AA 7075 T7351		X		DP	
3.2	Screws	Ti6Al4V STA	X			LA	Aerospace standard



Task 2 - List of events

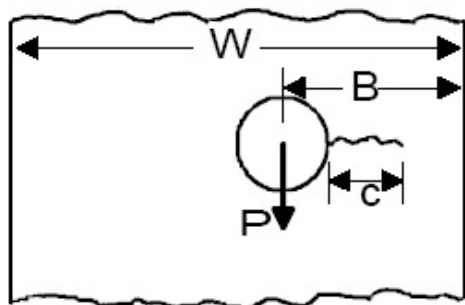


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Task 3 - Analyses

Safe life verification

- NDI performed on complete part



e.g. CC02



CCS, No. of Missions

- Several locations per PFC Item analysed

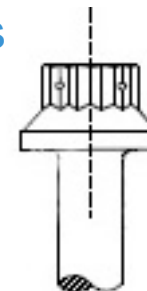
Fail safe verification

Identification of critical load path after removal of a structural item

- ⇒
- New MoS
 - Damage accumulation sum (Miner)
 - Zero gravity release criterion

⇒ $\geq M8$: sometimes difficulties

- Preferred Safe life verification



Containment verification

Minimal required wall thickness calculated with the punch equation

Specific payloads issues

Some parts are:

- made of glass,
- pressurised items,
- composites items.



Fracture Control Verification performed by proof test

Example of welded tube verification:

- X-ray of welded tube
- Proof pressure test of sub-component (level: $1.5 \times$ MDP including design acceleration)
- Eddy current NDI before and after proof test

Preferred method

- X-ray of welded tube
- crack growth calculations
- derivation of material data (strength, da/dN vs ΔK)
- Eddy current NDI of welds

Conclusion

- Fracture control verification to be considered in the design from first review (Verifiable design)
- Fracture control verification:
 - Structural screening - PFCI
 - Load spectra
 - Analyses
- Summary report to be issued containing all analysis results & inspection certificates
- Verification by proof test for glass, pressurised components, composite