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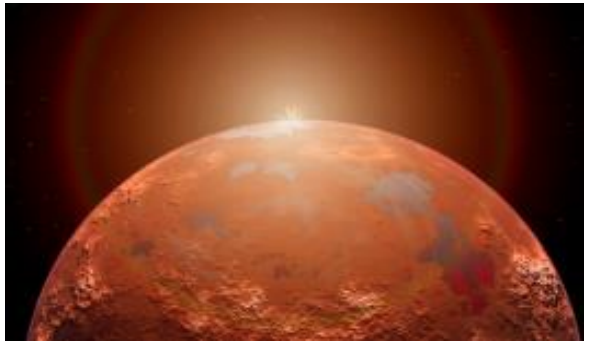
Safety Process Evolution for Space Stations: From ISS Heritage to Commercial Era Challenges

Adriana Aiello – Lorenzo Fava

11-12 NOVEMBRE 2026 TORINO







ALTEC

Space Engineering & Mission Services

Aerospace engineering, logistics and mission operations for human and robotic exploration.

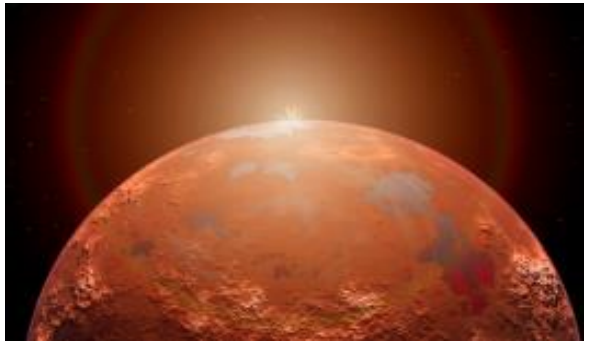
- ***Low Earth Orbit***
- ***Space Exploration***
- ***Space Big Data***
- ***Space Gate***
- ***International Presence***

Turin, Cologne, Munich, Houston NASA liaison offices

ALTEC - Aerospace Logistics Technology Engineering Company







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Space Engineering & Mission Services

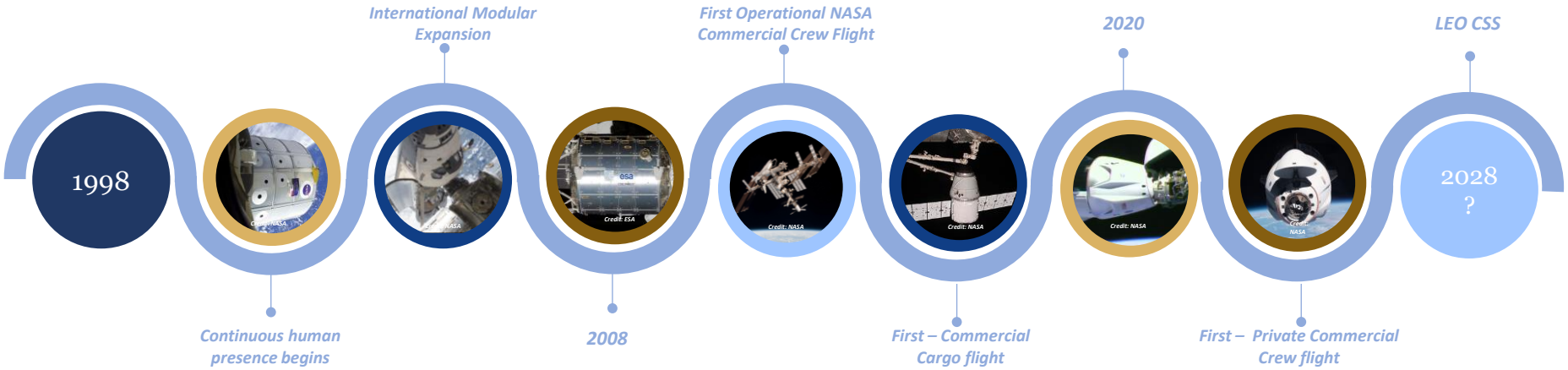
Aerospace engineering, logistics and mission operations for human and robotic exploration.

- ***Low Earth Orbit***
  - *ISS Sustaining Engineering*
  - ***ISS exploitation***
  - *ISS operations support activities*
  - *ISS European Logistic Centre*
  - *Crew Training*
  - *Columbus Flight Control Team*
  - ***Human Space Flight***
- ***Space Gate***
  - *Unmanned/Manned vehicles*
  - ***ISS Payloads***
  - *Suborbital flights*
  - *Microsats&Cubesats*
  - *Stratosferic Baloons*

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ISS Safety Heritage: A Knowledge Base, not Just a Set of Requirement

25+ years of continuous human presence



ISS Safety Heritage

- Established hazard analysis processes
- Safety requirements for crewed systems
- Integrated Safety of payloads, systems and operations
- A culture of verification, traceability and lessons learned

Payload Safety Across Mission Lifecycle

Safety by Design:

Hazard analysis · Design controls · Verifications

- *Identify and control hazards through design choices and verify the effectiveness of the controls.*

Safety by Operations:

Procedures · Monitoring · Operational response

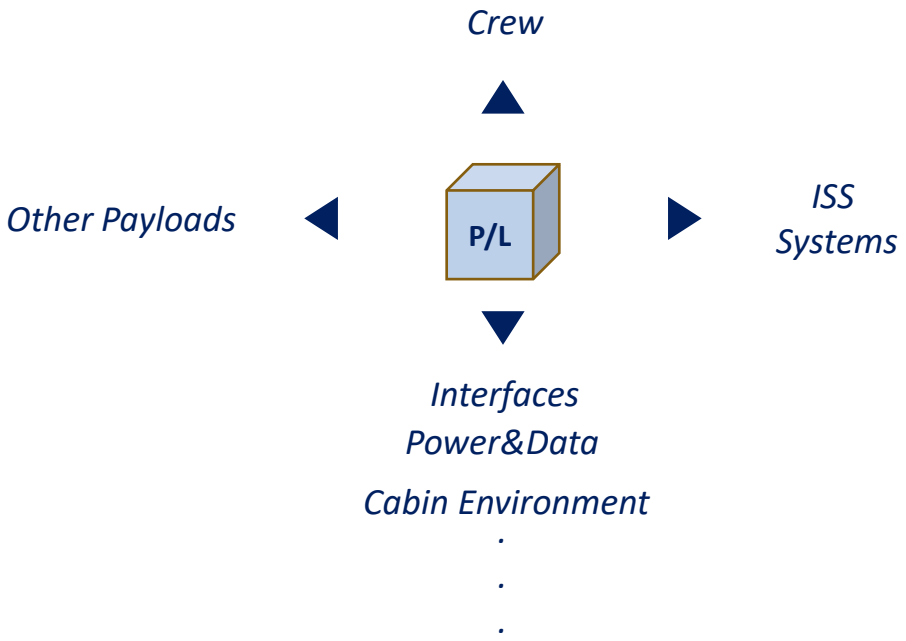
- *Maintain safe conditions throughout preparation and on-board execution of operations via operational products and real-time monitoring.*



Safety begins by design and continues through operations.

Safety by Design: The ISS Integrated Perspective

❖ *A payload may be safe in isolation, yet unsafe when integrated into the station environment station environment.*



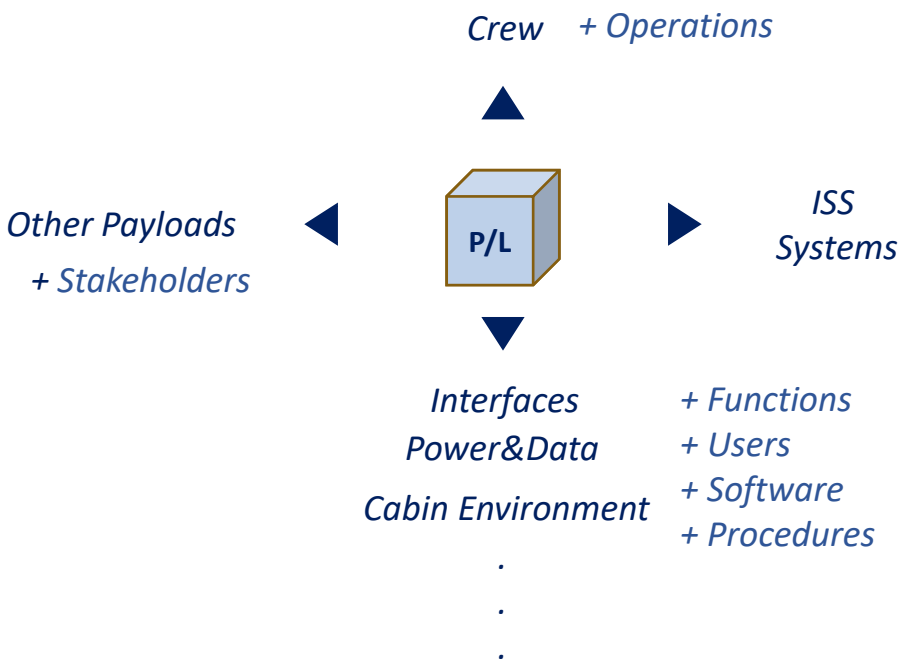
Key Safety Questions

1. *What hazards can the payload introduce?*
2. *How can those hazards affect crew, vehicle and operations?*
3. *How are the hazards controlled and how are the controls verified?*

From a functioning payload to a safely integrated payload.

Safety by Design: The ISS Integrated Perspective

❖ *As payload complexity grows, the challenge extends beyond the payload itself to the broader system in which it operates.*



Hazard Identification

- More Functions, Interfaces & Hazard Sources

Impact Assessment

- More Stakeholders, Users & Operational Scenarios

Control & Verification

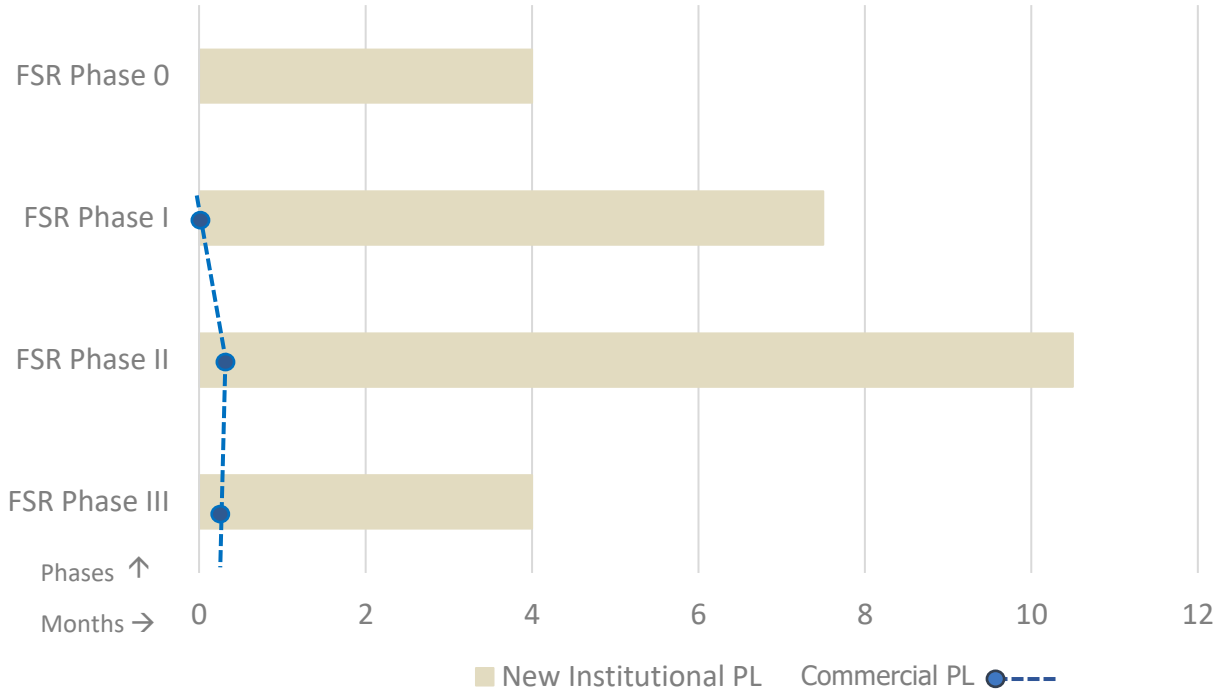
- More Evidence, Coordination & Safety Reviews

As integration complexity grows, safety assessment expands from hardware to interfaces , operations and organizational interactions, extending project lead times.

Flight Heritage changes the Starting Point

New Institutional Payload	***Commercial Payload***
New Design	Existing Design
New Hazards	Known Hazards Baseline
New Analysis	Existing evidence
New Verification	Assessment of changes
Longer Lead Time	Shorter Lead Time

ISS Safety Review Process Timeline

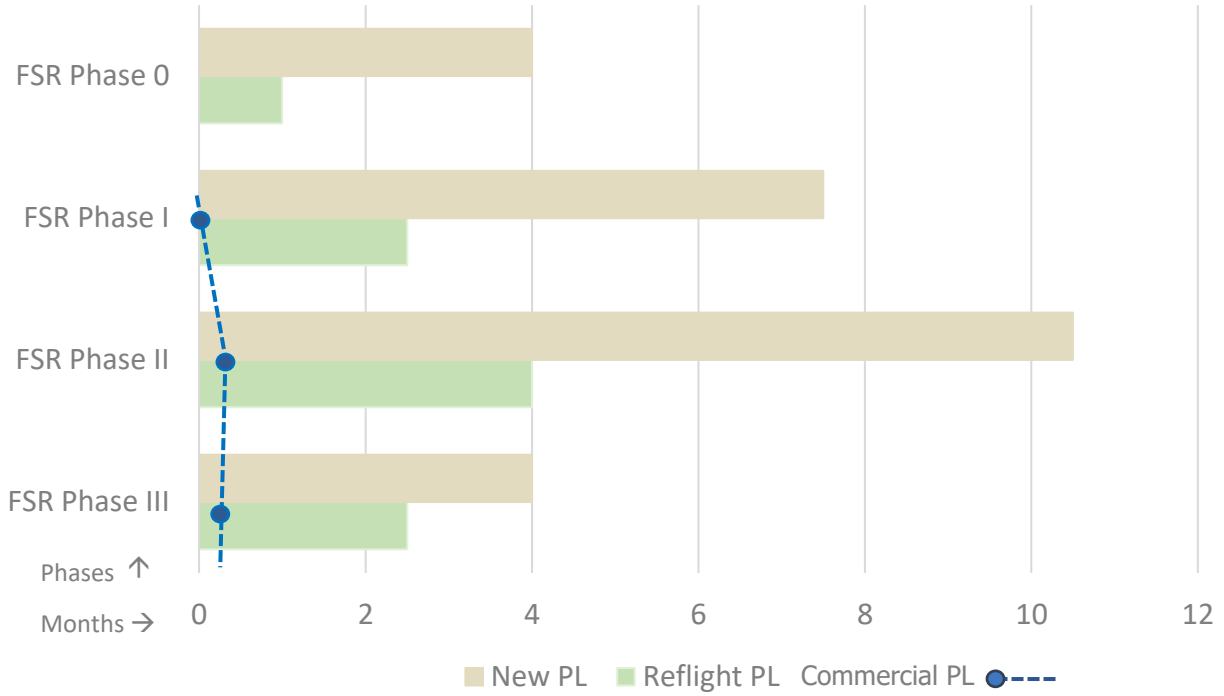


Flight heritage becomes a key enabler when preparation time is severely constrained.

Flight Heritage changes the Starting Point

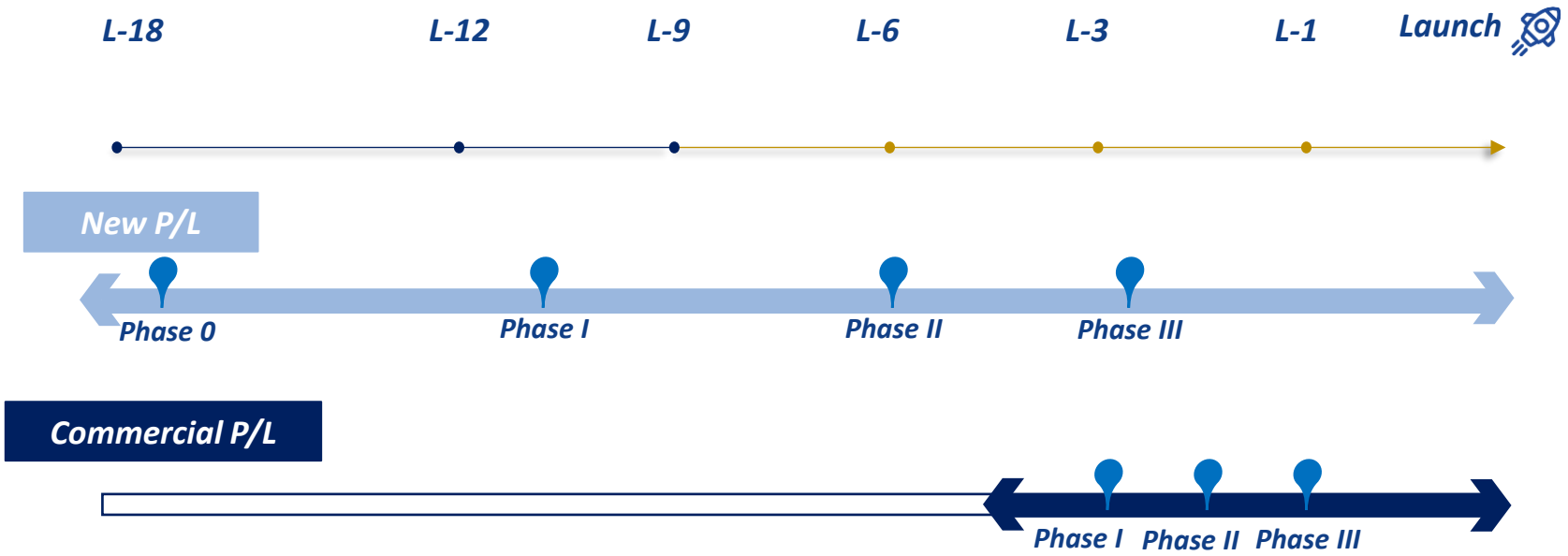
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ISS Safety Review Process Timeline



Flight heritage becomes a key enabler when preparation time is severely constrained.

Same safety objectives, different preparation windows.



Commercial missions compress the available preparation window without reducing safety expectations.

↓

*Flight heritage becomes a **key enabler**.*

A short preparation window leaves little room for late discovery of safety issues.

Key Challenges Observed in Commercial Payload Campaigns

Knowledge & Evidences

- Broader Assessment Scope
- More interfaces to evaluate
- Greater Verification effort



Process & People

- Limited process awareness
- Complex Stakeholder Coordination
- Organisational continuity risks



Time Constrains

- Longer Safety Lead times
- Low tolerance for late issues
- Risk to flight opportunity

Flight Heritage ≠ Flight Readiness

Flight heritage provides a starting point, but readiness still depends on evidence, coordination and execution within the available preparation window.

Commercial Mission Experiences from an Ops perspective: allocation approach

Driving parameters for manned missions:

- Mission duration
- Crew time availability
- Commercial & scientific objectives
- Crew members

Hours per objective comparable for both

Commercial mission objectives complexity < ***Institutional mission objectives complexity***

	Duration	Objectives	Complexity
Institutional	↑	↑	↑
Commercial	↓	↑	↓

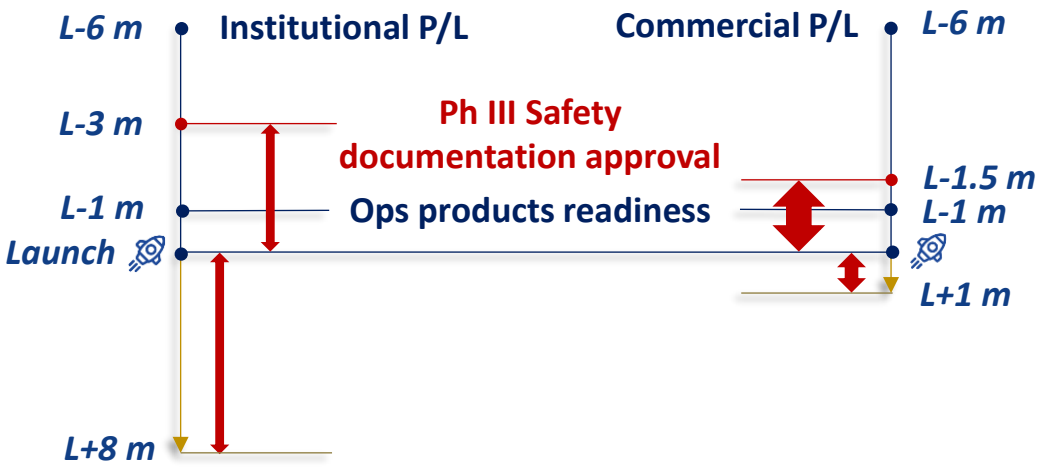
	Institutional	Commercial	
Duration [~ days]	220	18	
Objectives #	50	40	
USOS Crew #	4	0	
Private Astronaut Mission Crew Member #	0	2	
Crew Time [hours]	180	140	
	↓	↓	
Hours per objective	3,6	3,5	≈
Crew Time per day [h]	0,82	7,7	↑↑ × 9
Objective per day	0,23	2,22	↑↑ × 9

Please note that the values in the tables are estimated.

High amount of commercial objectives is currently managed through lower complexity to maximize the mission success

What are the challenges for Ops Safety in the frame of ISS operations?

Main driver during PREPARATION PHASE → ***Operational Products***



INSTITUTIONAL MISSION
Pro
Fewer objectives
Experienced developers
Cons
Higher complexity

COMMERCIAL MISSION
Pro
Lower Complexity
Shorter mission duration
Cons
Less experienced developers
More Objectives

MISSION PHASES

OPS PRODUCTS	Preparation	Execution
Operational Data File (i.e. procedures)	✓	✗
Flight Rules / PL Regulations	✓	✗
Chits (Requests among agencies)	✓	✓
Columbus Flight Notes	✓	✓
Anomaly Reports	✗	✓

PREPARATION

EXECUTION

CRITICAL TIMEFRAME

CRITICALITIES
- **Increased workload;**
- **Higher pressure on teams;**
- **Higher risk of errors;**
- **Risk of overlooking or omitting key aspects.**

Same processes to be used over a shorter timeframe → MORE EFFORT & FOCUS

What are the challenges for Ops Safety in the frame of ISS operations?

Main driver during EXECUTION PHASE → ***Anomaly Reports***

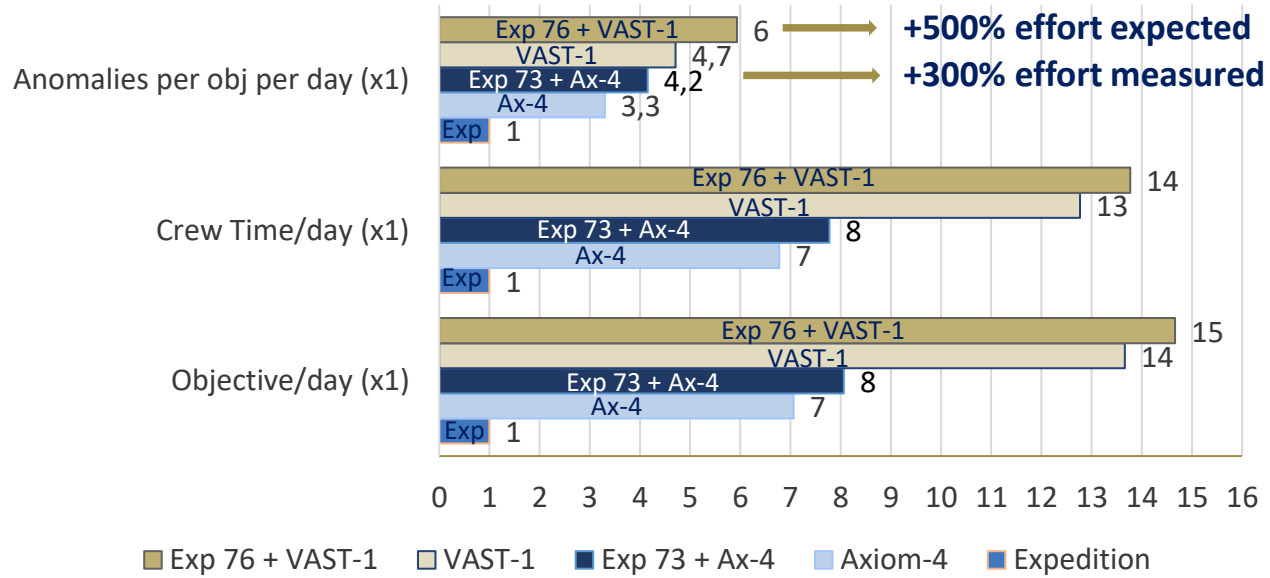
Anomaly reports (similar to NCR, SPR or incident reports)

	Institutional	Commercial
Duration [days]	220	14-21
Anomaly Reports	200	40
Objectives	50	40
Anomaly per day	1	2,2 ↑ × 2

INSTITUTIONAL MISSION
Pro
More time for troubleshooting
Experienced support
Cons
Higher complexity
More anomalies overall

COMMERCIAL MISSION
Pro
Lower complexity
Cons
More anomaly reports
Less time for troubleshooting
Unexperienced support

Safety Team effort – Institutional VS Commercial VS Combined



+500% effort expected
+300% effort measured

CRITICALITIES
- **Increased workload over a very short period;**
- **No chances to reschedule objectives in case of anomalies;**
- **Faster response required to accomplish mission objectives;**
- **No additional team members during execution.**

More Anomaly Reports per day in a shorter timeframe → ***MORE EFFORT & FOCUS***

Key Challenges Observed in Commercial Payload Campaigns: Industry perspective

DESIGN PHASE

- Increased assessment scope;
- More Interfaces & Stakeholders;
- Greater verification effort;
- Increased evidence generation;
- Longer safety lead times;
- Limited margin for late design changes and late findings
- Underestimation of safety and integration activities;

OPERATIONAL PHASES

- Increased workload during preparation;
- Higher pressure on teams during execution;
- Higher risk for mistakes during the overall mission;
- Oversight/Omission of safety key aspects;
- No chances to reschedule objectives → no replanning;
- Faster response needed to accomplish mission objectives;
- Higher pressure to accomplish commercial objectives.



ISS Heritage is not the past of Human Spaceflight. It is the foundation of its Commercial future.

Thank You

Adriana Aiello – Lorenzo Fava

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