

Life Support Systems validation: from space to ground, and back

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Space
Infrastructure
Systems
Innovation Lead

Expert
Life Support & Habitability

Domain
Exploration & Science Italy



Moon Exploration

Deep Space Gateway
Orion ESM

Universe Exploration

Euclid, Integral

Solar System Exploration

Exomars 2016 and 2020,
BepiColombo, Mars Sample Return

Exploring the Universe

Human Spaceflight in LEO

International Space Station and
Future LEO Stations Modules

Re-entry Vehicles

IXV, Space Rider

OUR JOB, OUR MISSION

2

ISEF 2018, March 2, 2018

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A challenging environment for humans & systems



Cosmic Rays

Meteoroids



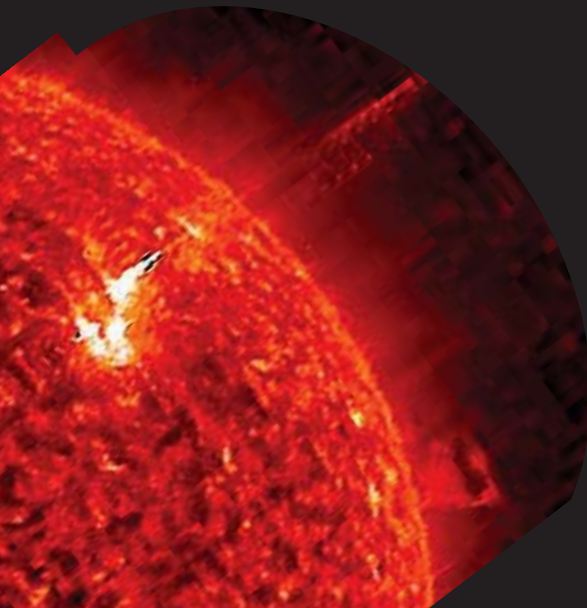
Vacuum

Atmospheres

Altered g



Dust

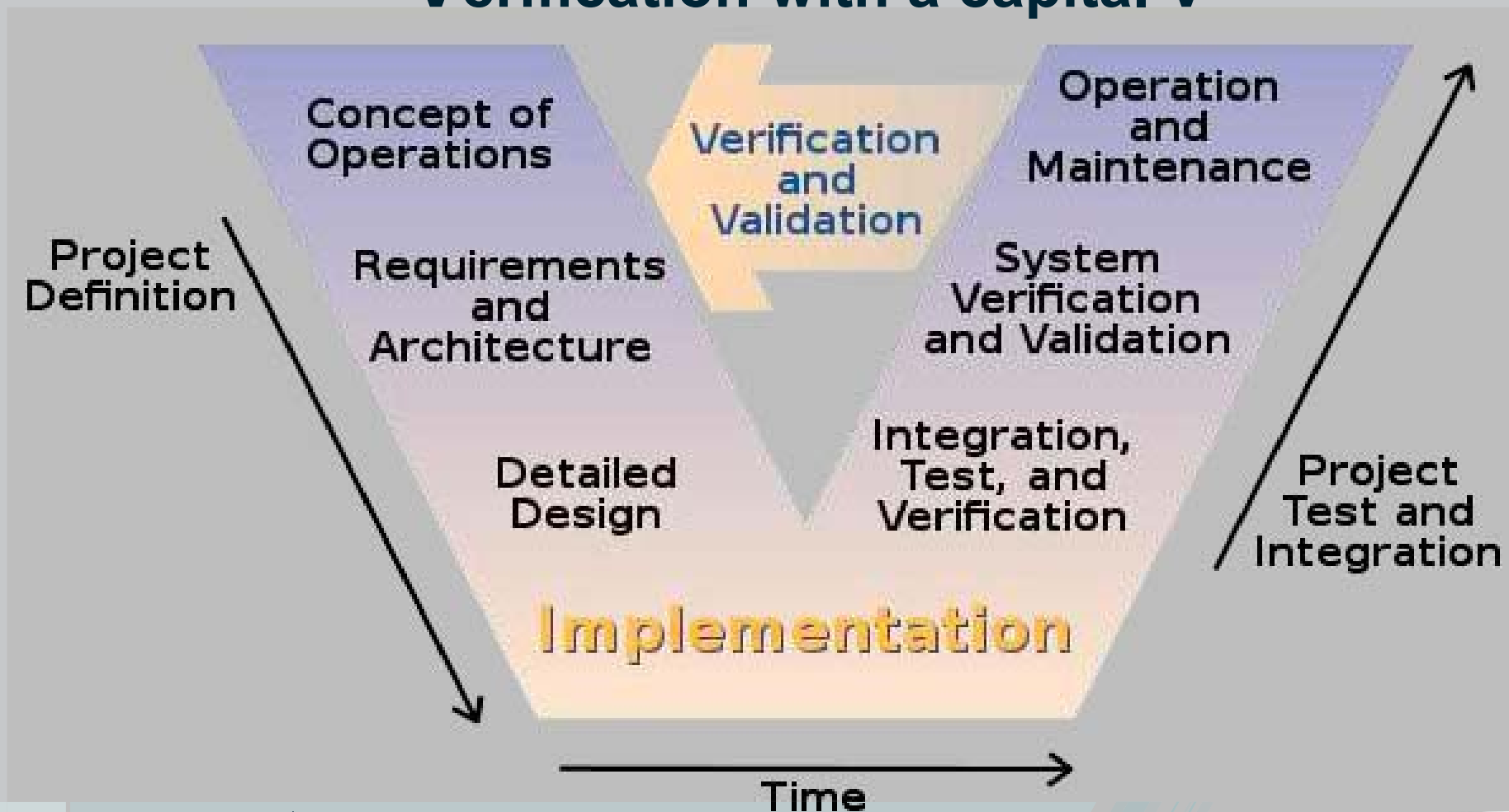


Solar Particles

Plasma

Extensive VERIFICATION

Verification with a capital V



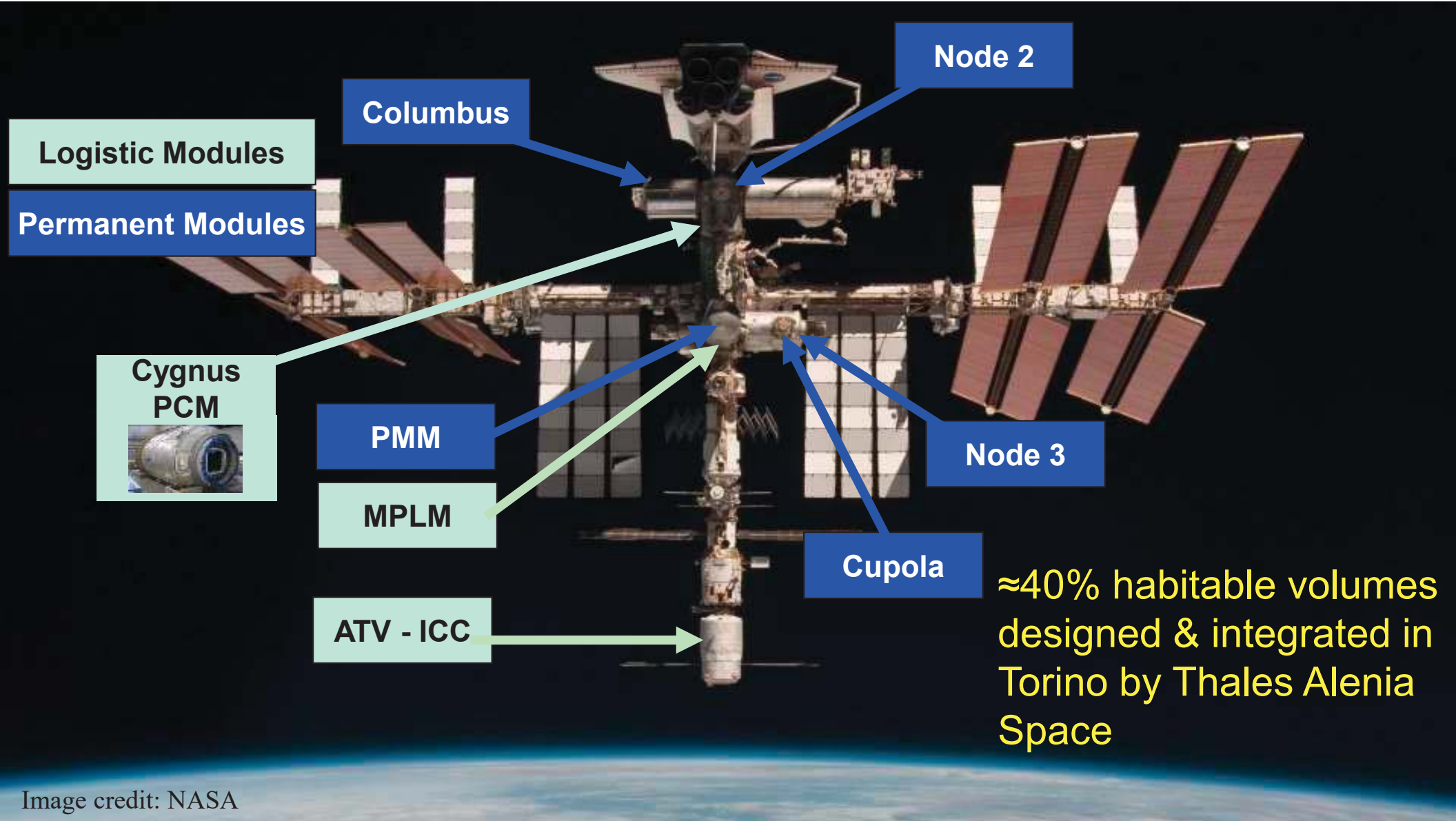


Image credit: NASA

The Nodes: the most complex ISS modules

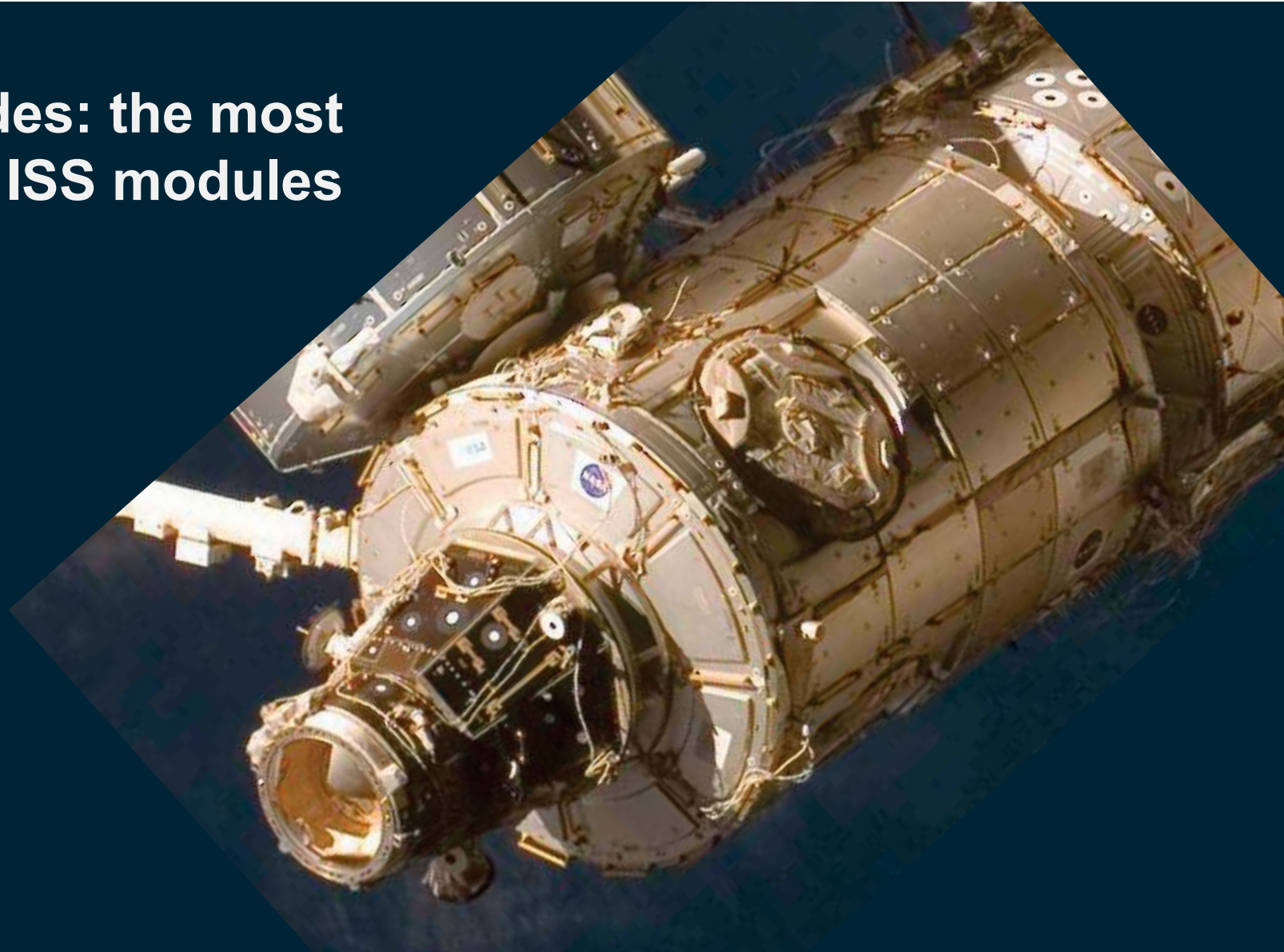


Image credit: NASA

Pressurized Module – structures, passive thermal elements

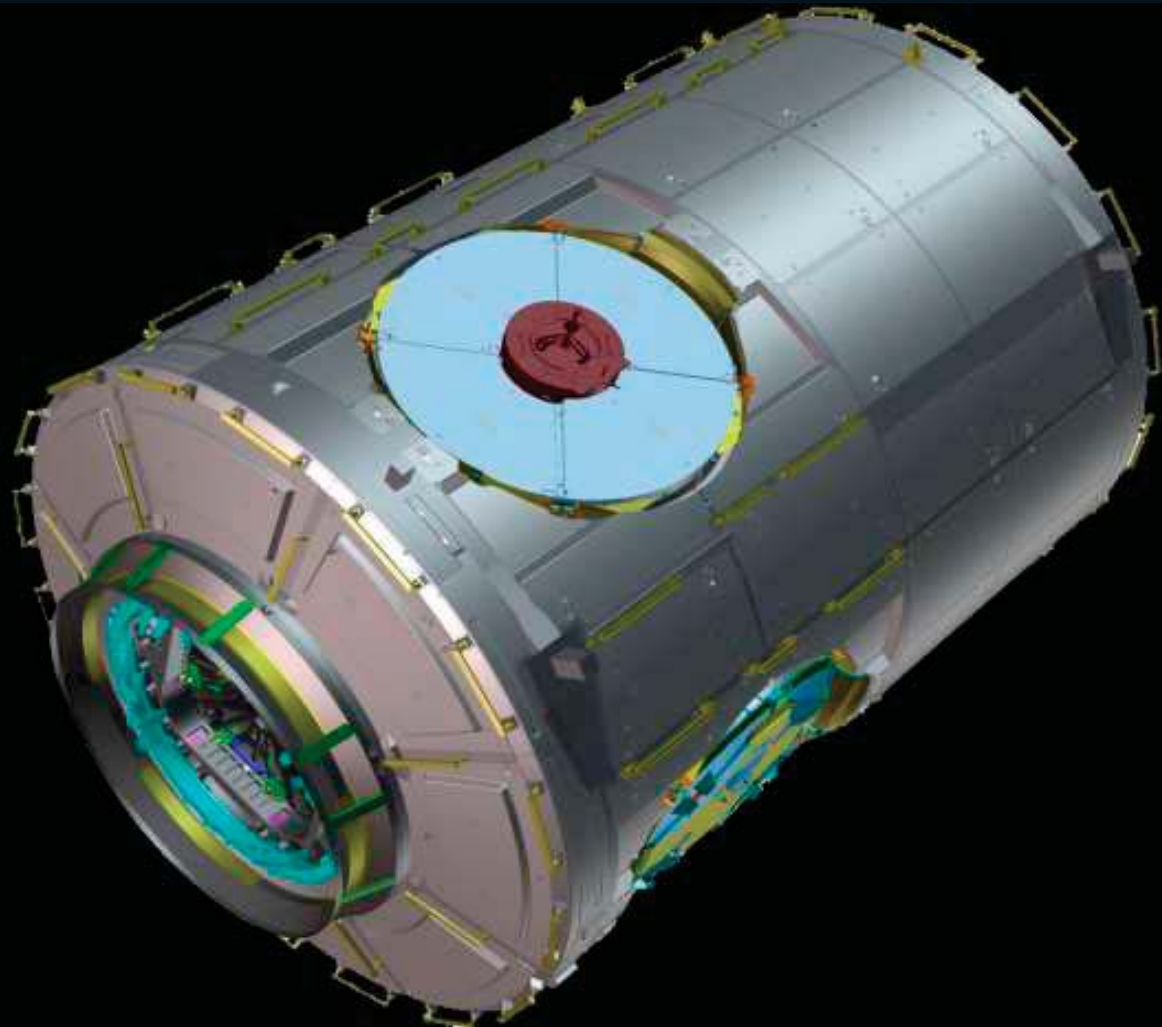
Micro-meteoroid & Orbital Debris Shielding

Passive Thermal Insulation

Primary Structure Pressurized w/ Hatches

Secondary structures and racks

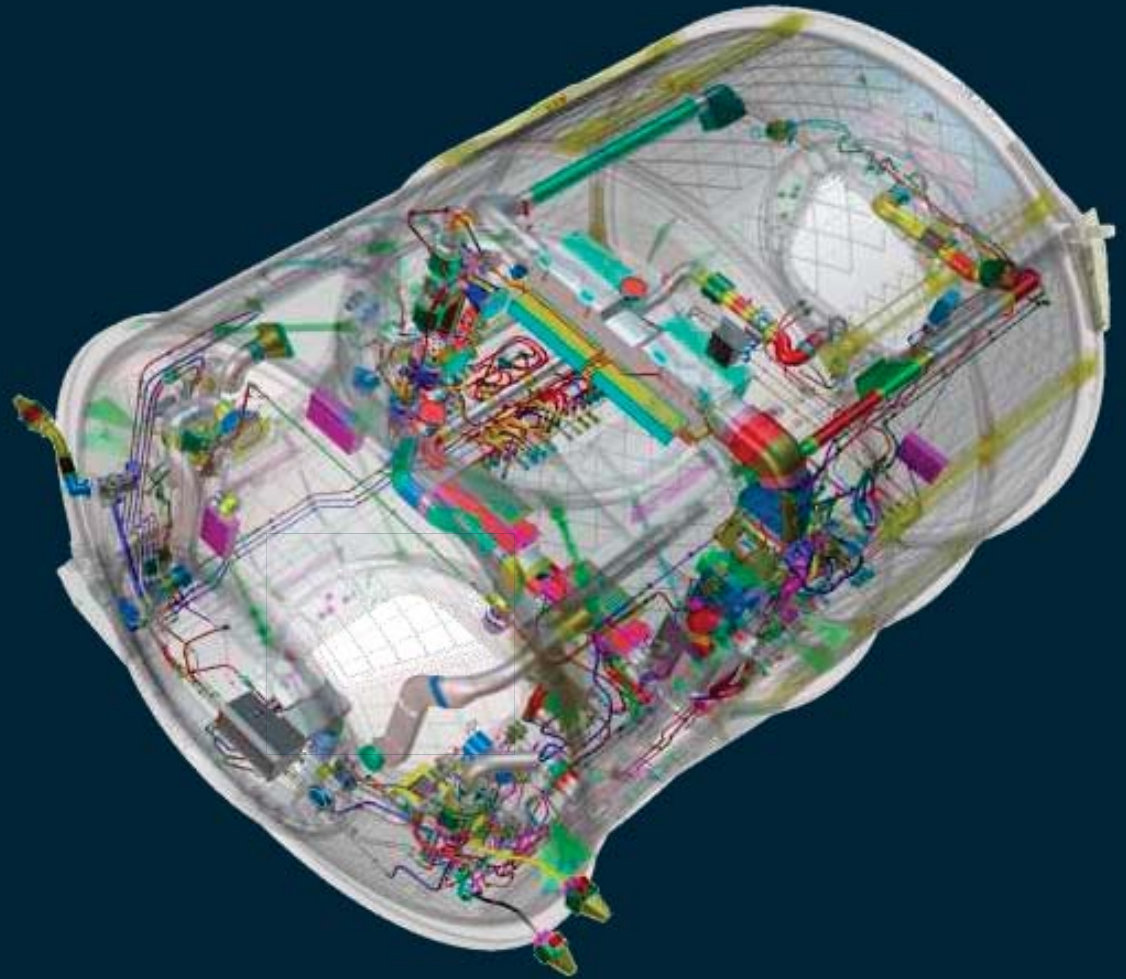
To accommodate equipment and experiments



Pressurized Module – internal active systems

Environmental Control & Life Support System

- Cabin Pressurization
- Temperature & Humidity Control
- Atmosphere purification
- Water Management
- Fire Detection & Suppression
- *Integration of NASA Regenerative LS Racks (Node 3)*

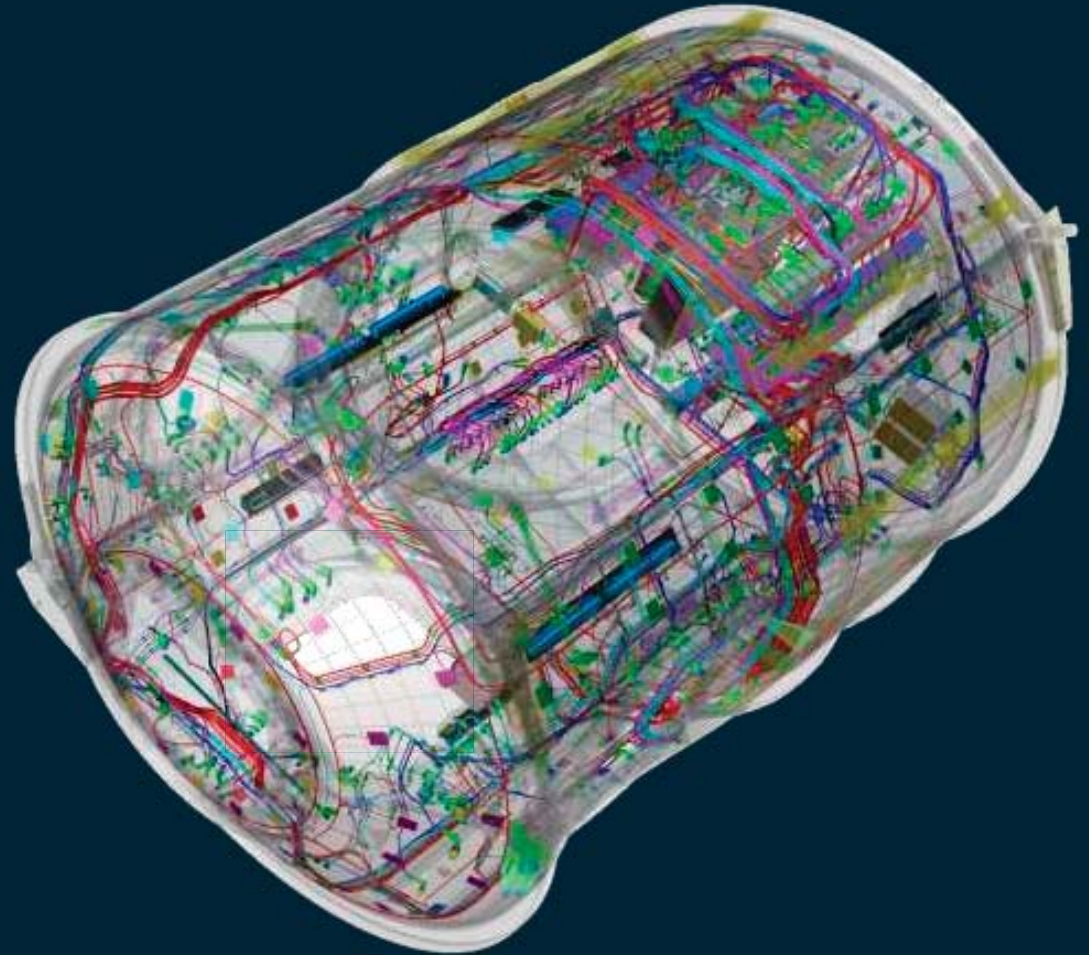


Pressurized Module – internal active systems

Active Thermal Control

Avionics

- Computers
- Audio & video
- Power distribution
- Harness



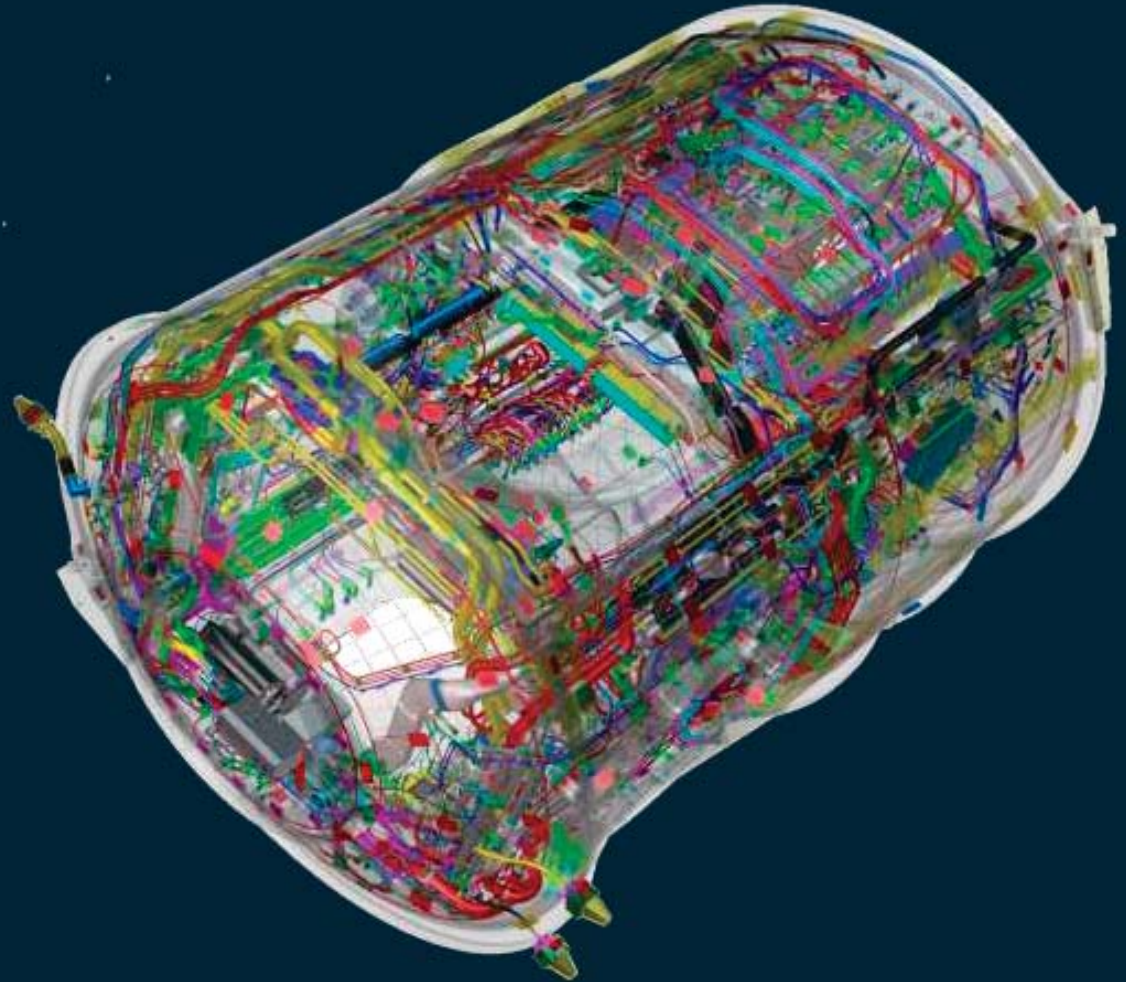
Pressurized Module – internal active systems

Integrated Design

Digital mock-up
virtual reality

Verification:
From component to element
levels (on ground)

Validation:
by users (crew) on orbit




NODE 2 HARMONY, 23 october 2007... > 10 years on orbit!



Image credit:
NASA

enia
space

A photograph of an astronaut inside a spacecraft, looking out of a large window at the Earth. The astronaut is wearing a dark shirt and has their hand resting on the window frame. The Earth is visible as a bright blue and white sphere against the black background of space. The interior of the spacecraft is dark, with some equipment and structural elements visible.

On orbit human habitats The Cupola

**Controlled p, T,
RH, O₂, N₂, CO₂,
contaminants**

Image credit: NASA

All perfect and ready then?

Well...

05/07/2018

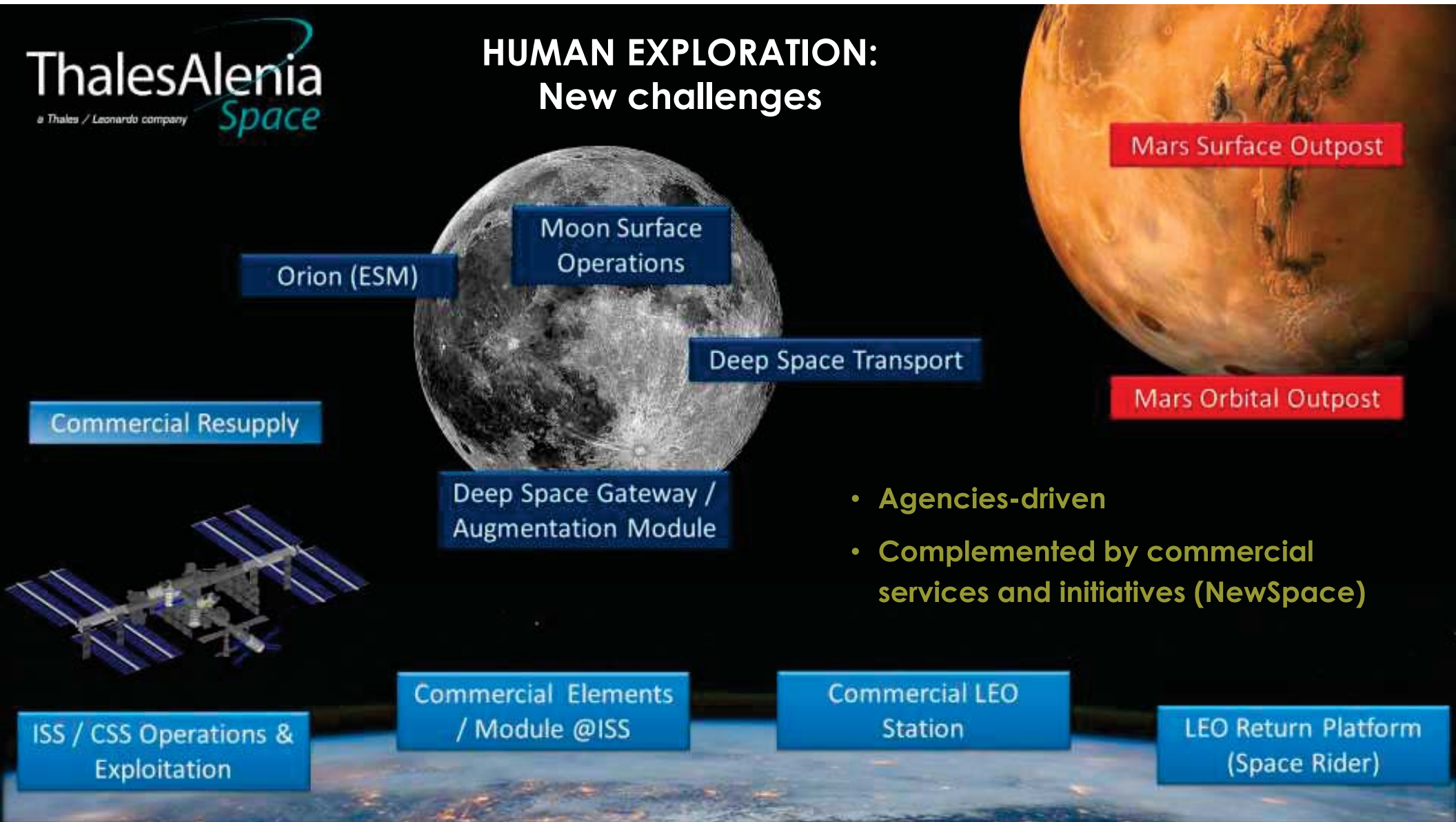
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A Thales / Finmeccanica Company
Space

HUMAN EXPLORATION: New challenges



- **Agencies-driven**
- **Complemented by commercial services and initiatives (NewSpace)**

edizione italiana di **SCIENTIFIC AMERICAN**

del geco

Missione impossibile?

Humans in deep space / planets:

many technical challenges!

- **radiation**
- **vital resources**
 - **distance**
- **habitat volume**



New approaches needed:

Project → Product

Program → Product Line

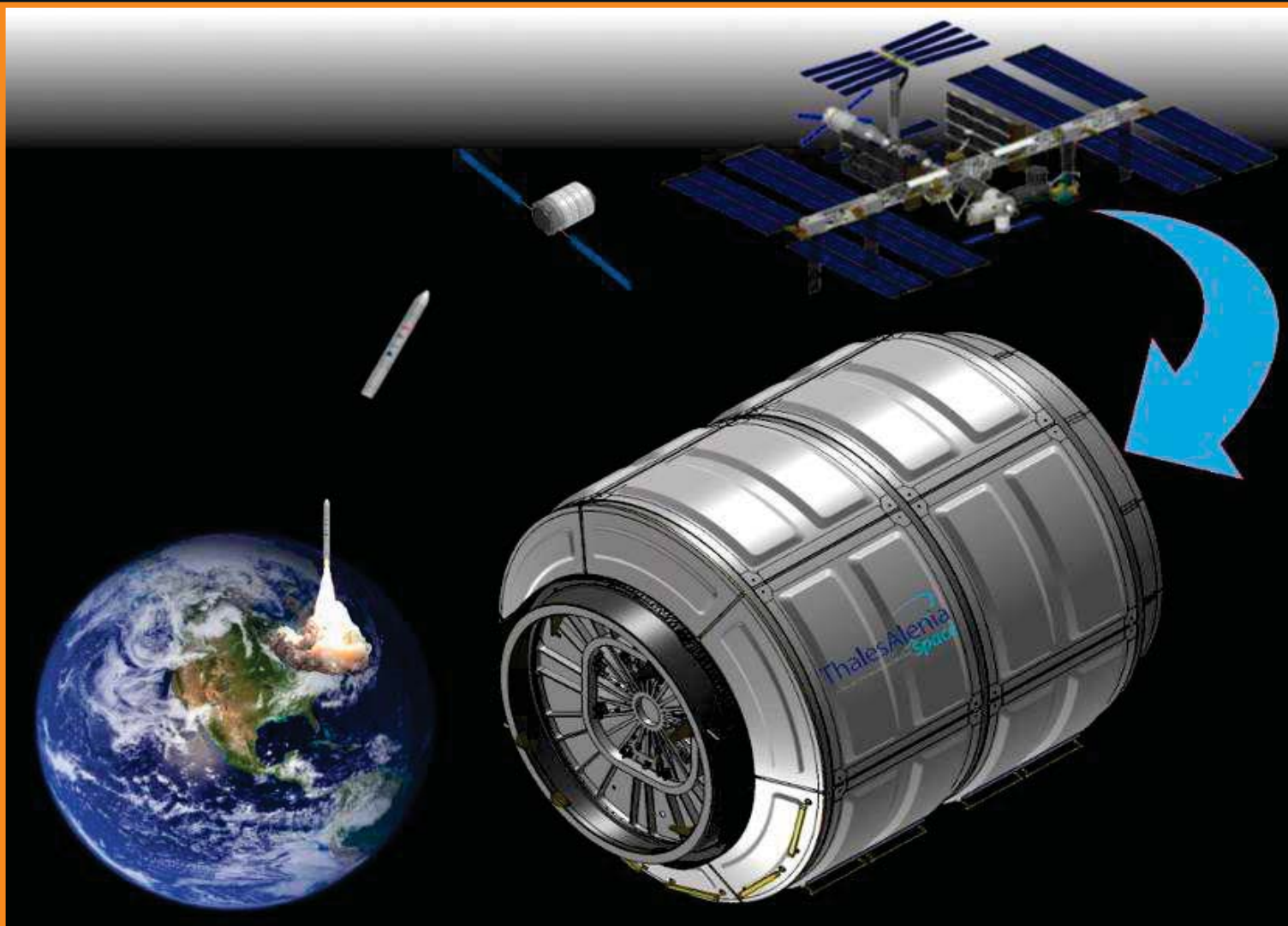
→ Service

Silo mode → Agile, Lean

Build – Measure – Learn

More demo in-space and analogues

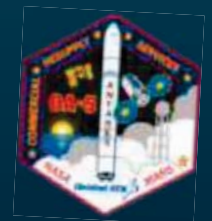
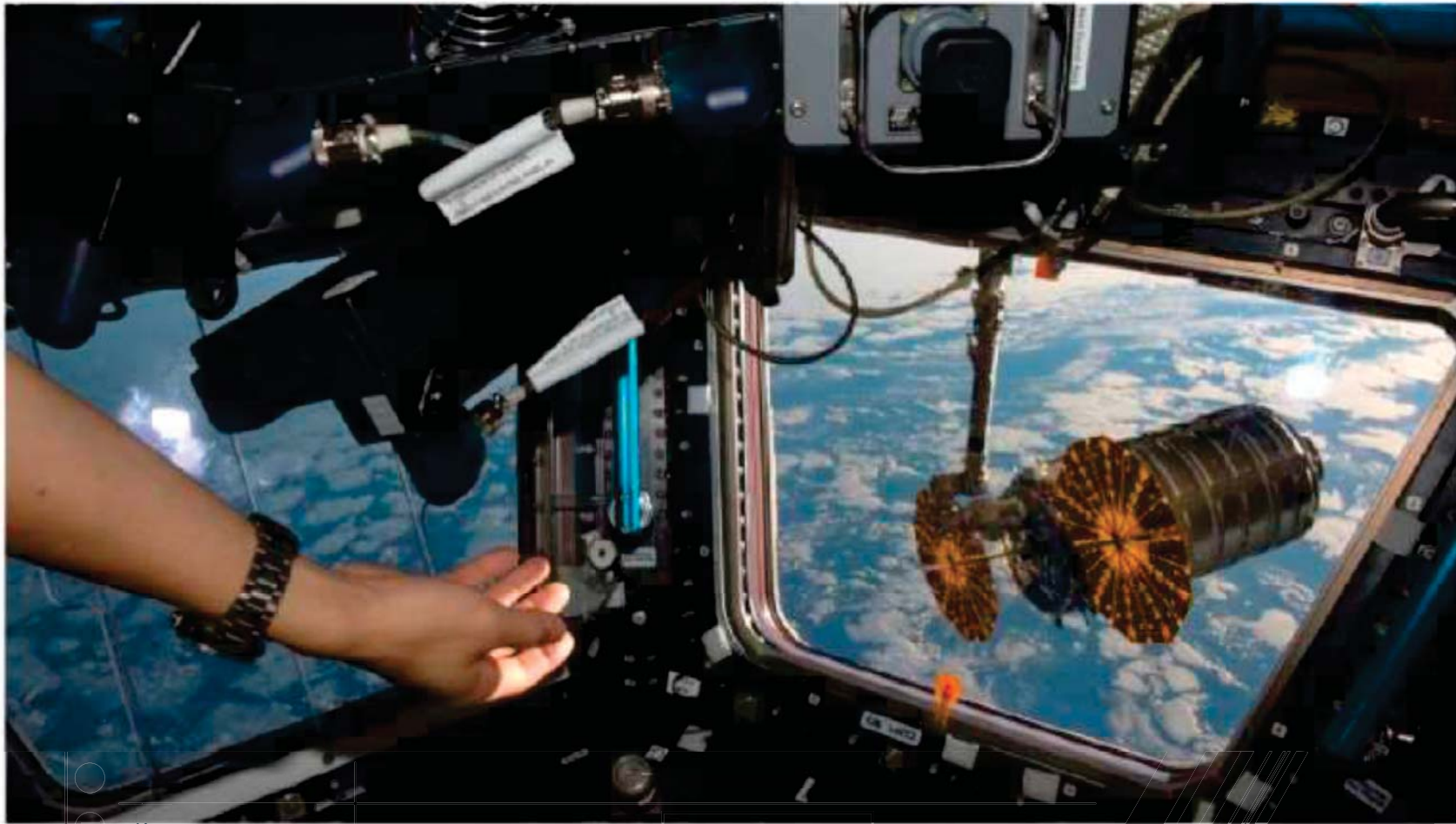
Product / Service: Commercial Resupply Service



Cygnus PCM



Cygnus at ISS



alesAlenia
Space

Image credit: NASA

Cygnus for Cargo Resupply – many flight tests!

COTS-1

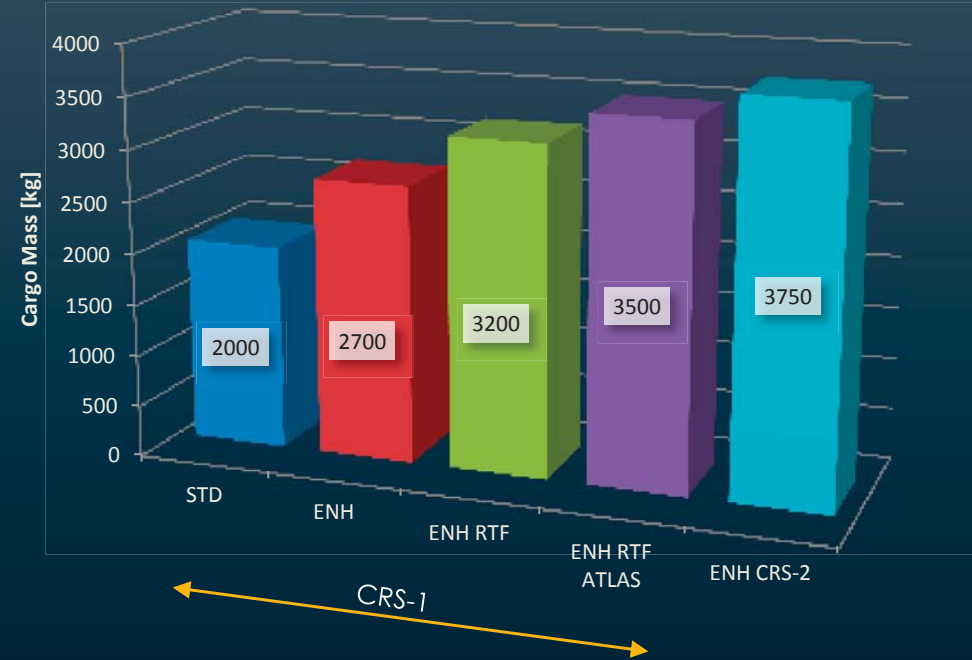
1 Flight unit
Flown Sept. 2013

CRS-1

11 Flight units
9 units completed & delivered
1st mission in Jan. 2014 / Last flown in Nov. 2017
Next planned in Mar. 2018

CRS-2

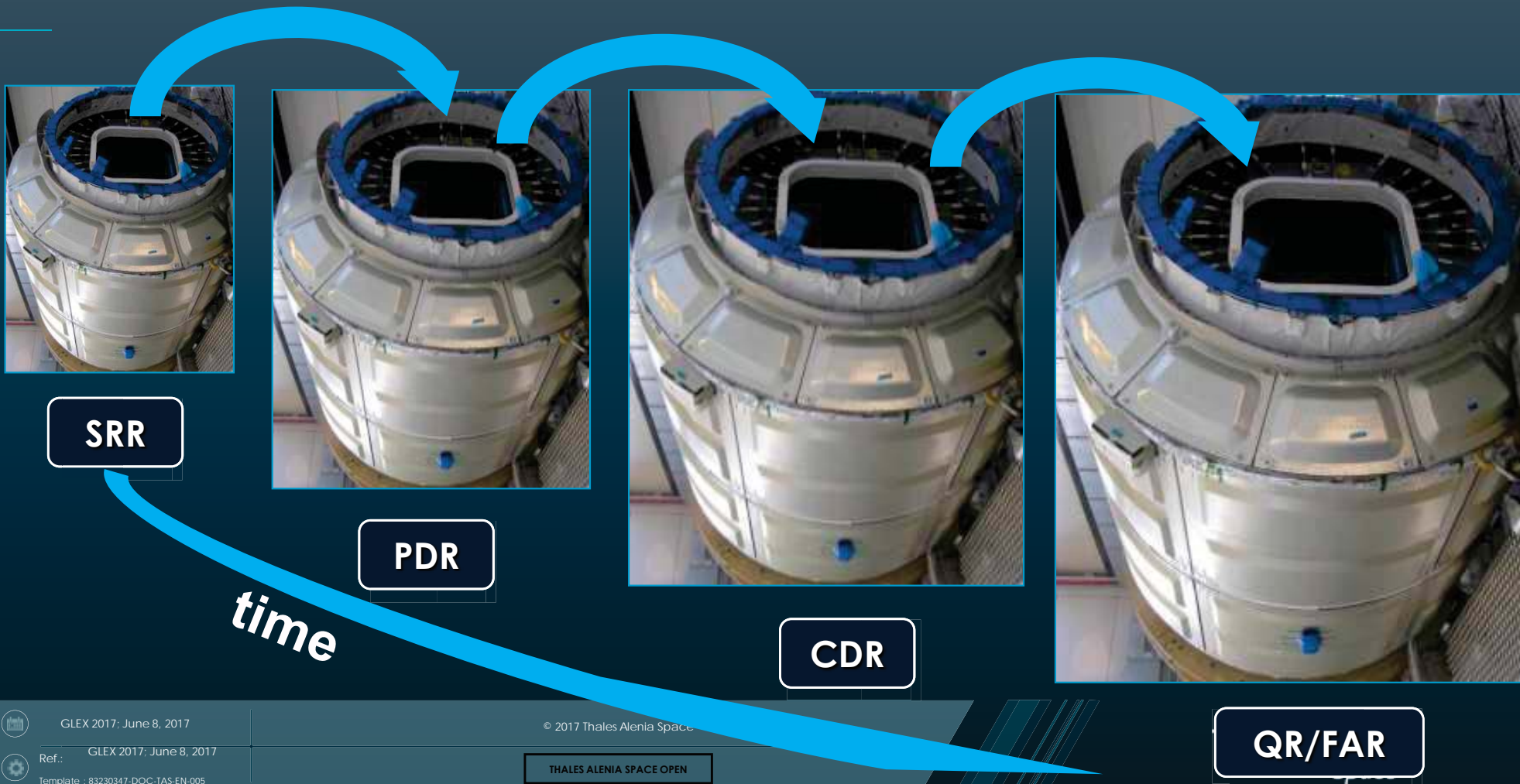
6 Flight units
Primary structure welding in progress



Constant Cargo Capability Improvement



We are good at making “space silo” but... BEWARE!



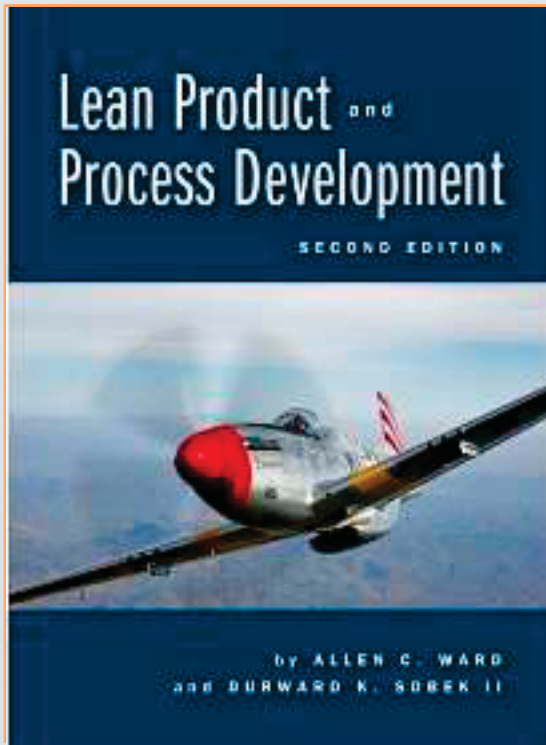
Need to get agile, **LEAN**

Innovation

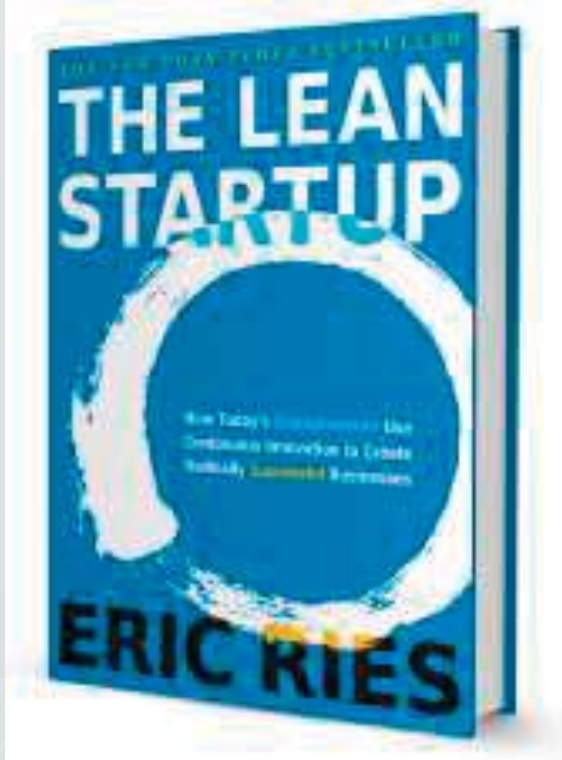
Execution



Need to get agile, **LEAN**, ambidextrous



Innovation



Execution

Lean Start-up – Minimum Viable Product

HOW TO BUILD A MINIMUM VIABLE PRODUCT

NOT LIKE THIS



LIKE THIS

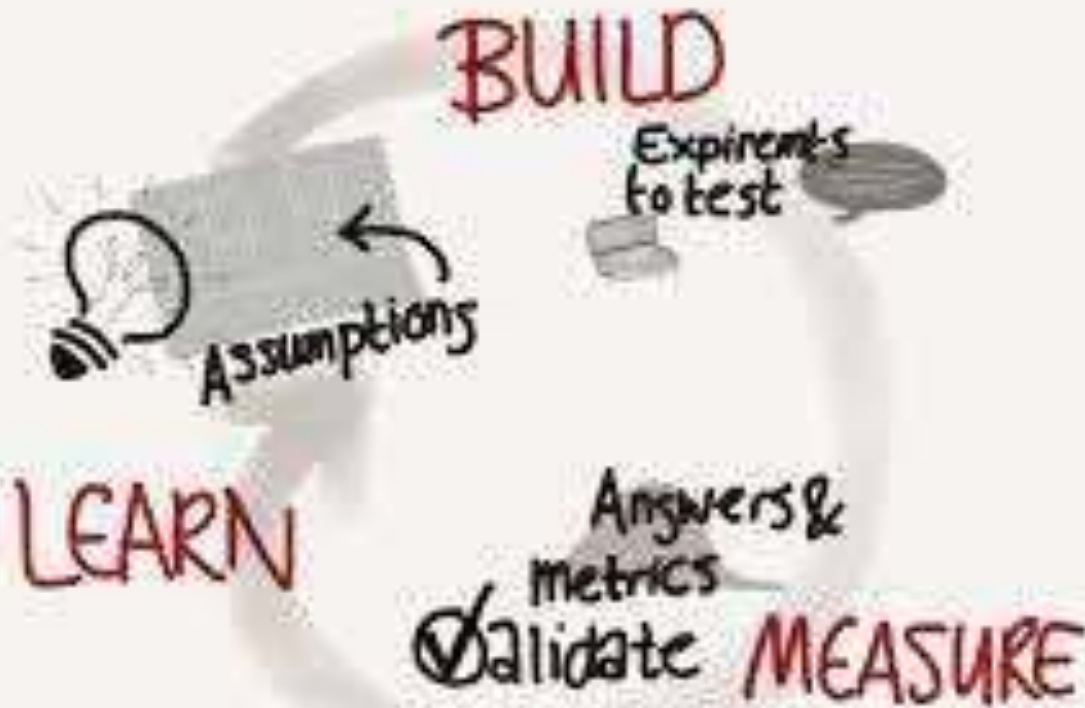


image by blog.fastmonkeys.com original idea: spotify product team

Figure out the smallest element of functionality that delivers value to your users, then build and test that. Refine and iterate.



Lean Start-up: Build – Measure – Learn



Lean Start-up for overcoming the “TRL Death Valley”

TRL 4

TRL 6/7

**More affordable
demonstration in
space and
analogue
environments**

Platforms for On-orbit R&D, Demonstration, Verification

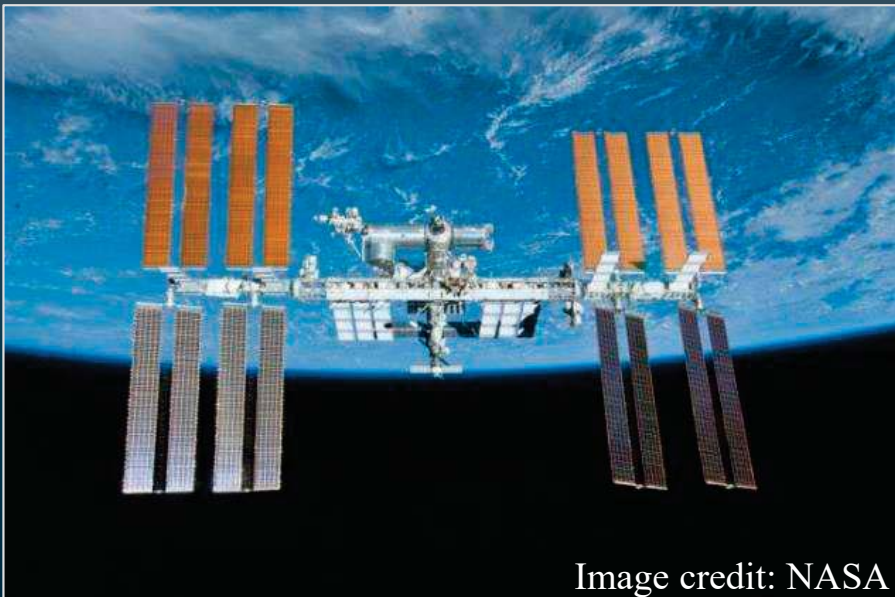


Image credit: NASA

Exploration Technology Validation @ ISS

(ESA, ASI)

Demonstrations in preparation of deep space exploration
(PERSEO for crew radiation protection, advanced closed loop environmental control, food production,...)

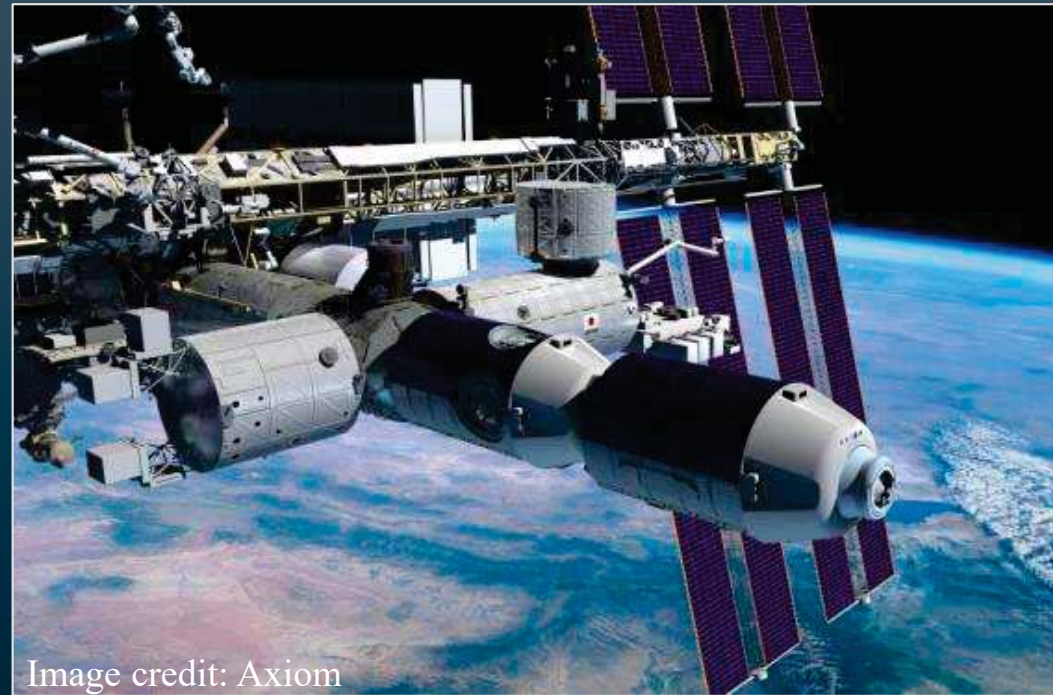


Image credit: Axiom

Commercial LEO Station (Axiom)

Pressurized elements under design by Thales Alenia Space



PERSEO - Personal Radiation Shielding for intErplanetary missiOns

Paolo Nespoli on ISS, November 7th 2017: mission accomplished!



Credit: NASA



Space Station



April 13, 2018

Veggie

Image credit: NASA

Space Station Science Highlights: Week of April 9, 2018

Future: PFPU

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Destiny, the U.S. Laboratory aboard the space station.
The pink glow from the Veggie plant growth facility in Columbus can be seen ahead in Node 2.

Credit: NASA

Future platforms for On-orbit R&D, Demonstration, Verification

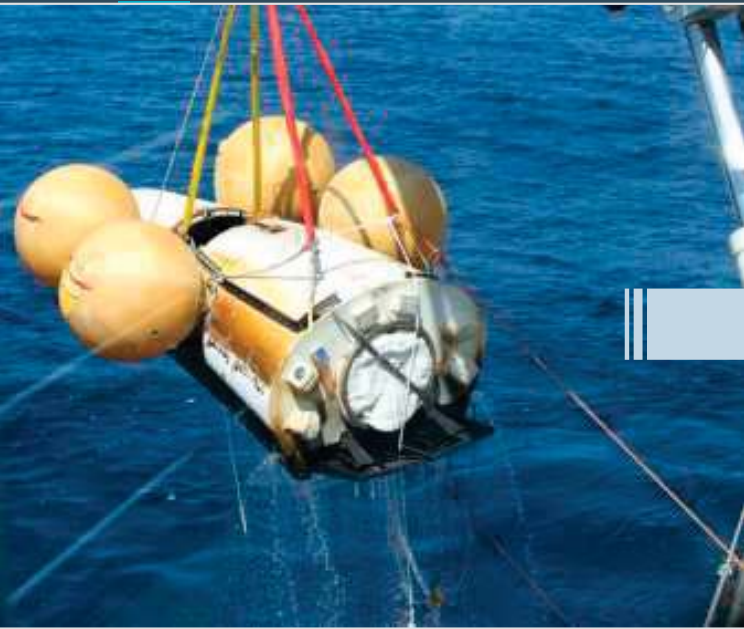
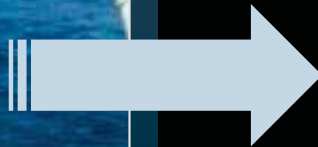


Image credit: ESA



**IXV successful demo
(Feb 2015)**

SpaceRider (ESA)
Orbital and re-entry platform, under development
by Thales Alenia Space and AVIO



Exploration of moon and Mars surface



Image credit: NASA

Resupply mass / cost / distance



Stock resources

Regenerate air and water via phys/chem tech

Produce food Bioregenerative



Exploit analogue environments





The PIUME product line



Thanks for your attention!



Credit: superstarfloraluk.com