DC4EU

54th European Space Science Committee Plenary Meeting

22-24 November 2017

German Aerospace Centre – DLR

Obepfaffenhofen, Germany

Presenter: Dr. Marco Berg

esa

OHB

SNC SIERRA NEVADA CORPORATION

TELESPAZIO a LEONARDO and THALES company

SPACE SYSTEMS

Dream Chaser® for European Utilization (DC_4EU):

We. Create. Space.

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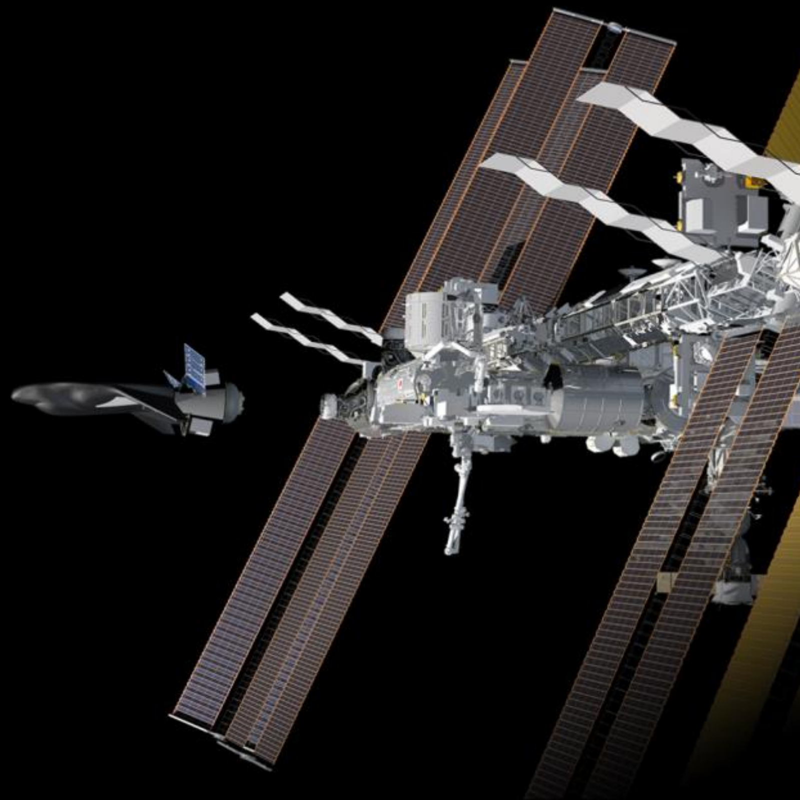
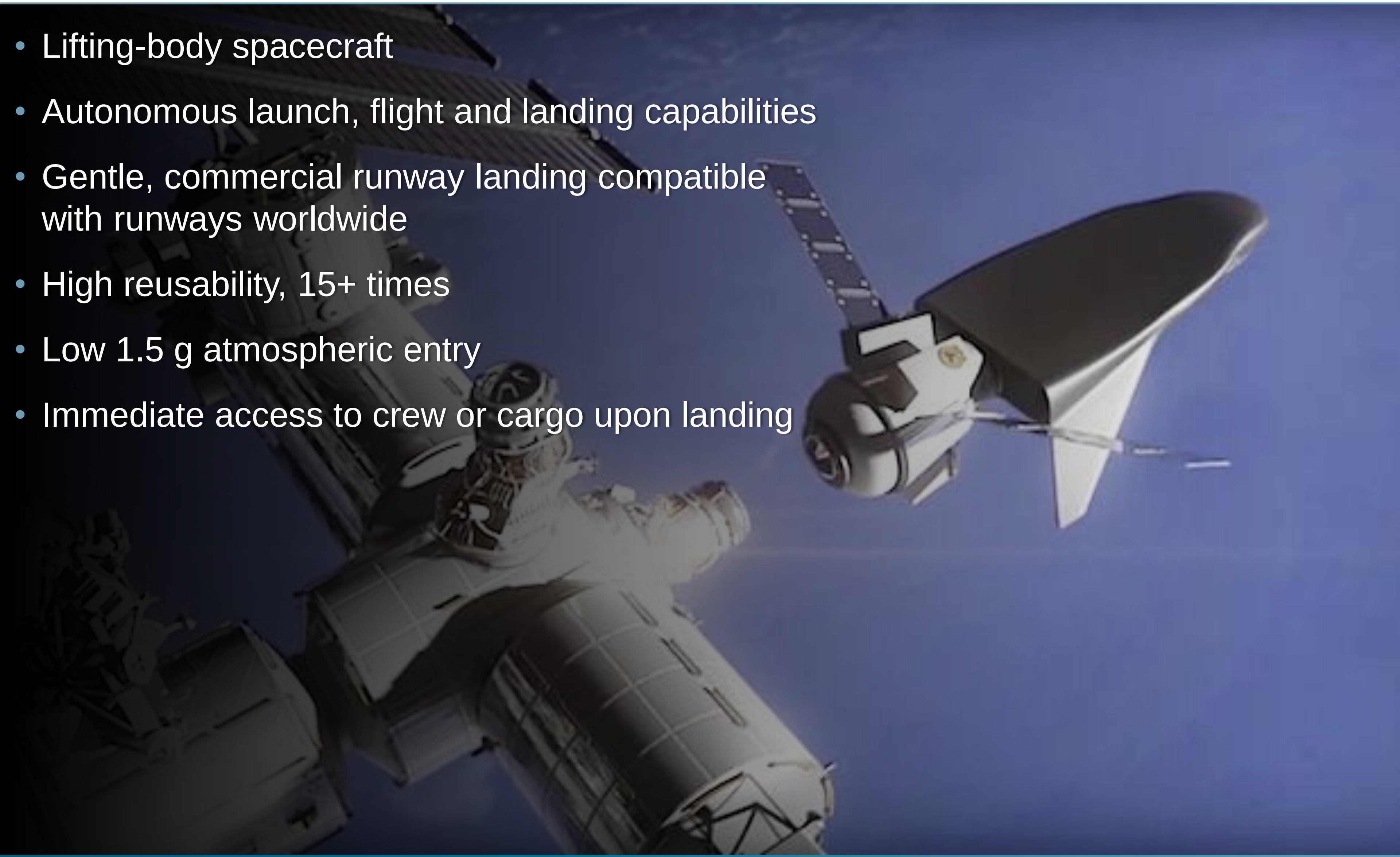
Dream Chaser heritage and CRS2 contract

- The Dream Chaser spacecraft has been in development by the Sierra Nevada Corporation(SNC) for more than 10 years, including six years as part of NASA's Commercial Crew Program
- It leverages more than 40 years of X-vehicle and NASA space shuttle heritage.
- In 2016, Dream Chaser was selected by NASA under the Commercial Resupply Services 2 (CRS2) contract for minimum six missions to transport in pressurized and unpressurized cargo to and from the ISS with return and disposal services.

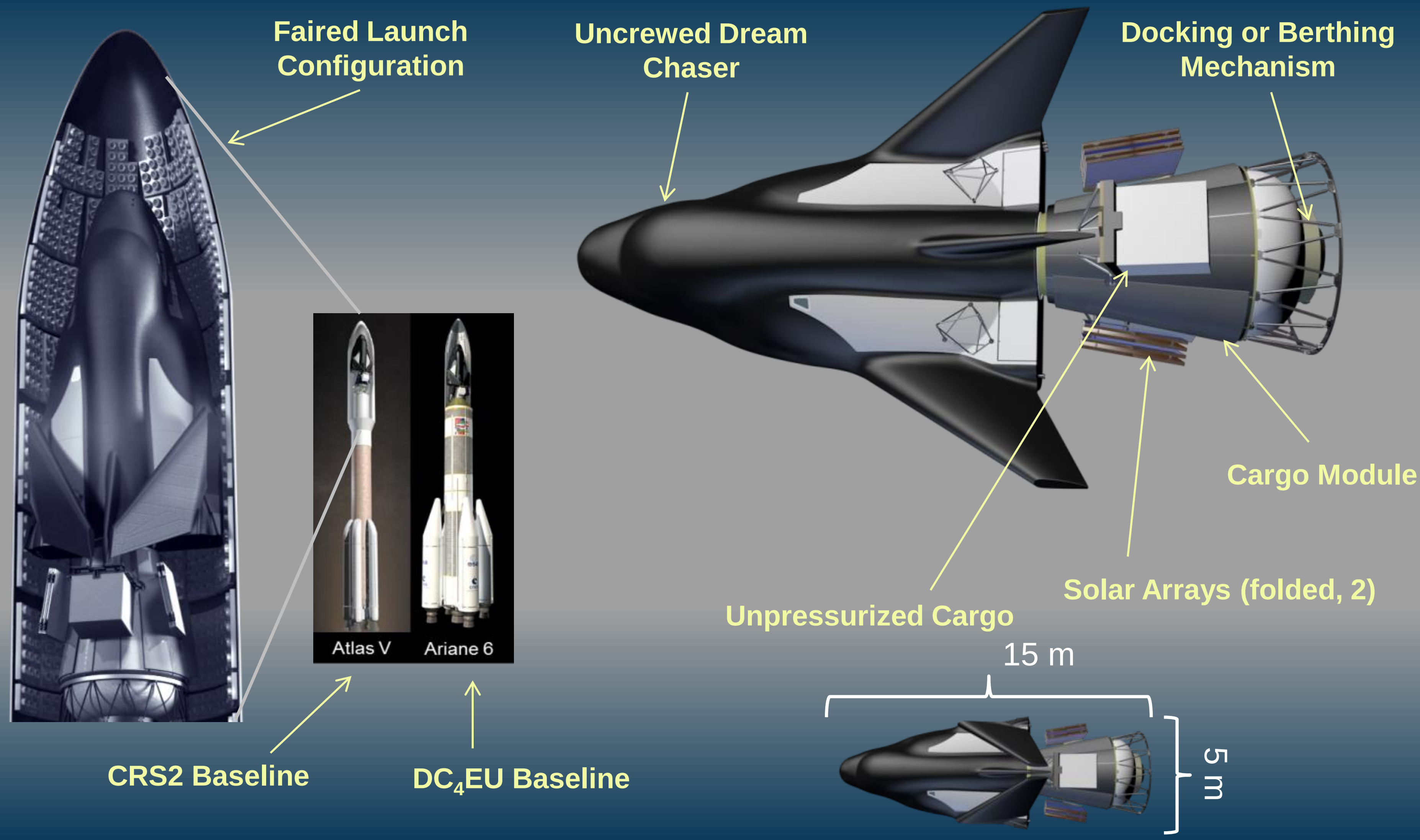


Dream Chaser features include

- Lifting-body spacecraft
- Autonomous launch, flight and landing capabilities
- Gentle, commercial runway landing compatible with runways worldwide
- High reusability, 15+ times
- Low 1.5 g atmospheric entry
- Immediate access to crew or cargo upon landing



Dream Chaser Cargo System



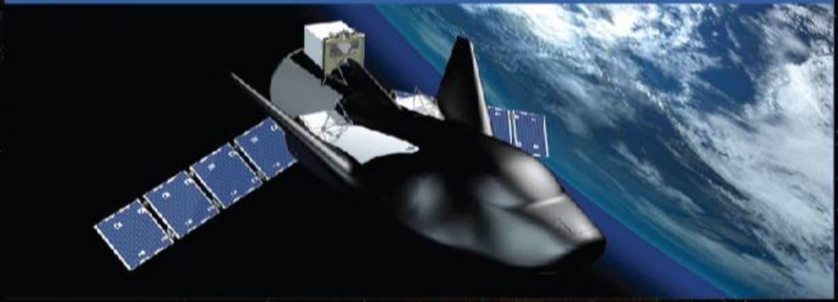
Multi-Mission Capabilities

Servicing and Debris Removal

- LEO satellite servicing, deployment, and retrieval
- Debris removal and de-orbit

Science and Technology Test Bed

- Free flight, micro gravity missions used for research and test objectives
- Low g entry and global runway landing for rapid access



Remote Sensing

- Reuseable platform for eath observation instrumentation

Path to Crew Capability

- 2-7 crew
- Crew support to a variety of mission concepts, including EVA

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ESA Call for Space Exploration Ideas

In 2015 esa has released a Call for Ideas:
Space Exploration as a driver for growth and competitiveness: opportunities for the private sector

Consistent with the ESA Space Exploration Strategy, potential partnership idea themes were introduced:

Low Earth Orbit (LEO) Infrastructures
- Improved and sustained (post 2020 and post-ISS) access for European user community to research infrastructures in LEO
- New ideas for utilization of ISS

Joint Research and Development
- Enhancement of the technological capabilities of Europe in the priority fields identified in the ESA Space Exploration Strategy

Exploiting the inspiration potential
- New means and mechanisms for fully exploiting the potential of Space Exploration to inspire society, in particular the young generations to expand the limits of our knowledge
- New approaches for engaging new stakeholder communities in the conduct of Space Exploration and the exploitation of the inspirational value gained

Lunar and Mars Exploration
- Increased knowledge of Moon (and possibly Mars) in preparation of future human missions
- Access to the lunar surface for the European community
- Services in support of future exploration missions such as e.g. those related to transportation to the Moon, communications at the Moon, navigation and logistics.

Dream Chaser for European Utilization Team, Objectives and Goals

The DC_4EU consortium, created to answer to the ESA CFI, consists of OHB System AG (Germany), Sierra Nevada Corporation (USA) and Telespazio SpA (Italy), in partnership with the European Space Agency (ESA).

The objective is to provide a European on-demand low Earth-orbit operational capability based on reliable and flexible space services and missions.

Its main goals are:

- Ensure that first class research facilities for science remain available, even after the ISS is decommissioned
- Enable a flight application of developed European transportation technologies (IBDM, simulators, cockpit, displays and MMI, operational SW, thermal protections, rendezvous and re-entry GNC, navigation sensors, etc.) and capabilities (launch and landing).
- Allow new technology validation in relevant environment (robotics, grappling, re-fuelling, etc.) and generate spin-off to other areas of space activities (space exploration, active debris removal, in-orbit servicing, assembly in space, etc.).

The DC_4EU program has been selected by ESA for the implementation of a pilot phase

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Mission based on existing/planned European infrastructures/technologies/services

- Baseline Dream Chaser from the NASA Cargo Resupply Service 2 (CRS2) to ISS
- Implement European Technologies, Services and Infrastructures
  - Ariane 6.4 Launcher
  - Licensed landing sites in Europe (Dream Chaser able to land wherever a B737 or A320 lands)
  - Ground Segment, enhancing the existing infrastructures
  - European Technologies, e.g. enhanced communication

DC_4EU Pilot Phase scope, goals, and activities

Pilot Phase: Dream Chaser for European Utilisation End-to-End Mission		
Scope	**Technical Assessment**	**Objective**
Preliminary assessment of the key elements to perform the first European end-to-end mission with Dream Chaser implementing all the key technologies and resources for the user needs requirements. The feasibility assessment, both technical and programmatic, will be refined based upon the feedback and outcomes of the User day (as part of this Pilot Phase)	• Ariane 6 accommodation • European ATC and landing evaluation • P/L communication • Ground segment assessment • Identify enabling kits for minimum 3-week autonomous mission **Programmatic Aspects** • User requirements survey • European Industry contributions • Business plan • Cost and risk assessment • Dossier for the Evaluation Panel	• Proof of the complete end-to end scenario • Evaluate the scientific mission interest and opportunities for institutional and non-institutional payload hardware • Target technology readiness level (TRL) increases for European key technology for LEO and beyond LEO application • Understand the socio-economic benefit and initiate public engagement • Refine the partnership model

Role of each partner

The DC_4EU consortium consists of OHB System AG (Germany), Sierra Nevada Corporation (USA), and Telespazio SpA (Italy).

- OHB and SNC co-lead the investigation and assess the suitable end-to-end mission portfolios and conduct feasibility assessments.
- Telespazio SpA sets up ground segment capabilities for selected services.
- ESA focuses on the launch vehicle interface, flight regulations and landing scenarios in Europe.

Technologies and Infrastructures as enablers of DC_4EU

- Launch accommodation on the Ariane 6.4 launch vehicle, including full integrated stack and requirements analysis, plus flight environments and mission profile flight assessments
- Assessment and accommodation for Dream Chaser launch, entry, and landing at suitable European runways, including consideration of European flight regulations, Air Traffic Control, Environmental Assessment, and other considerations for landing at European airports and spaceports.
- Enhanced payload communications capability: Key equipment, capabilities, and features that must be added to the current Dream Chaser baseline configuration to meet user data, and video communications requirements
- Additional mission-specific kits or capabilities: Initially focus on an early definition of interface requirements for mission-specific kits, subsystems and technologies required to enable at least Dream Chaser free-flight mission lasting three or four weeks.
- European ground segment interfaces, coverage areas, uplink/downlink locations, operations support capabilities, and data storage/transfer

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Identification of User Needs

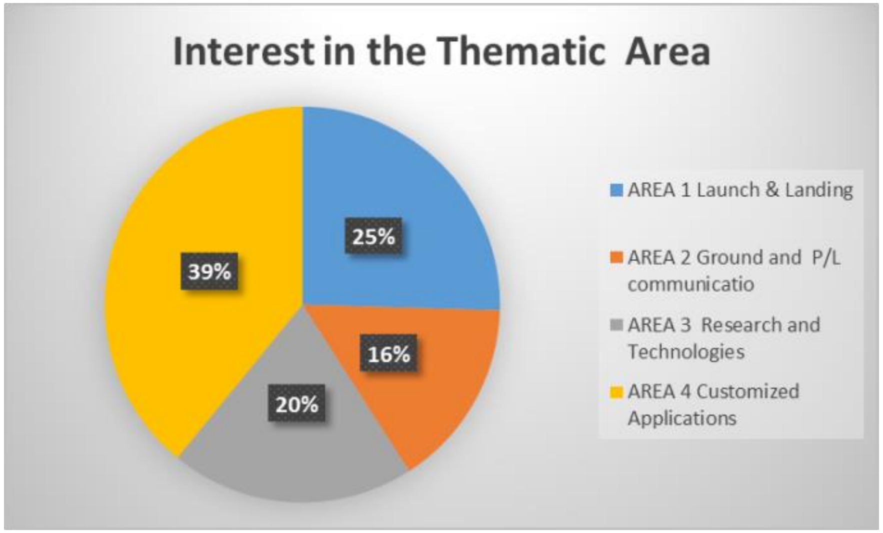
The DC_4EU is a user driven initiative, and understanding how such project can fit within the current European environment is of crucial importance to determine the feasibility of the idea.

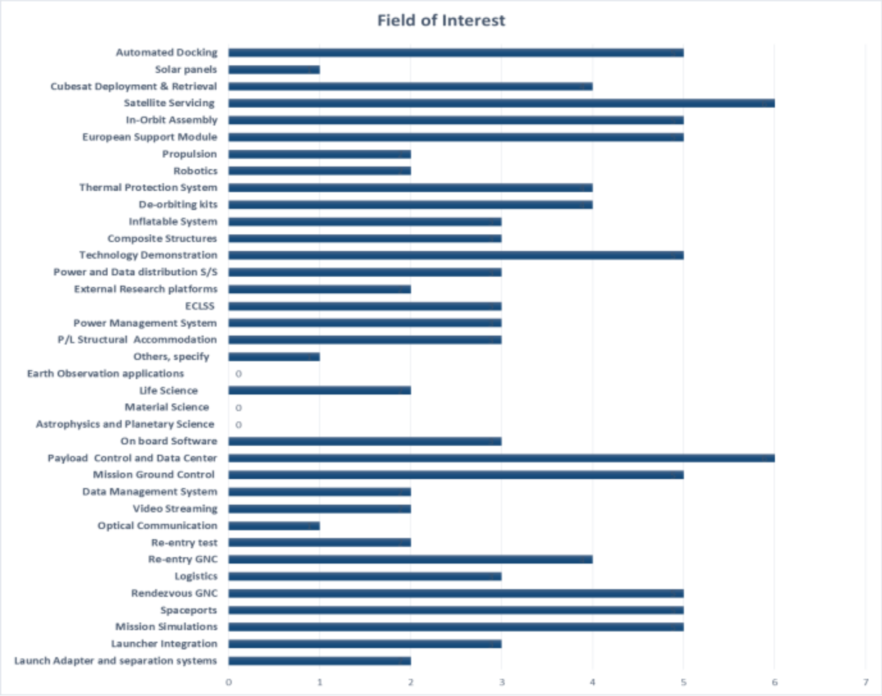
Through a general analysis of the current and future LEO utilization the User Needs have been identified in the following events:

- DC_4EU Industry Days was organised in ESRIN, Frascati, Italy
  - 22^{nd}-23^{rd} June 2016
- ESA's Stakeholder Day, held at ESTEC, The Netherlands
  - 10th November 2016.
- Users' information day at the OHB System site in Oberpfaffenhofen, Germany.
  - 22nd June 2017

One of the DC$_4$EU objectives is to strengthen European competitiveness in LEO, and this is done by opening a wide range of new potential activities and upgrades to be carried out in Europe.

After the DC$_4$EU Industry Days 24 Letters of Interest have been submitted to the Consortium by European industries which aim to cooperate and contribute to the pilot phase with own products, technologies and services to the European mission, on a self-funded basis.





Identification of ESA interest
ESA stakeholder workshop

The ESA stakeholder workshop aimed to raise at ESA a cross-directorates awareness of the potential of the European version of the Dream Chaser as a market-driven offer.

ESA personnel from different programme and technical departments were invited to actively participate in identifying potential opportunities for technology demonstration, scientific payloads, vehicle-related elements and education & outreach purposes and services.

Fields of interest
Life Support Scientific Payload
3D printing using plastics in Space
Impact Protection - Debris Monitoring - Testing
Shadow GNC Experiment
Hybrid Navigation Experiment
Science Payloads
External critical instrumentation for in-situ atmospheric re-entry measurements
Additive manufacturing and manufacturing in Space
Theater Testing
De-orbitation capsule experiment
Exobiology
Biology
New propellant component in Zero-g
Life Support Technology Demonstration
Inflight refuelling
NanoSat deployment for IOD - Retrieval & Return
Manufacturing of high aspect ratio structure in orbit/space
Control of Dream Chaser and Robot Experiment
Dream Chaser Vehicle green propellants NOFB, LMP-103S, Lox Methane
Inflight system identification
Routine docking concept
Novel GNC concepts
Detachable external platform for testing propulsion & other components
TPS Testing
Life support technology long-term effect of microbial contamination

- The DC_4EU User's information day, has mainly targeted the scientific community in order to present the vehicle capabilities, resources, payload accommodation and potential mission scenarios. At the same time information has been acquired on existing payloads ready to launch, areas of interest or lessons learned from previous experiences to build upon.
- Several user questionnaires have been collected, which shall be the basis to establish reference missions and identify enhanced Dream Chaser capabilities.
- The collected information helps to identify the range of potential mission applications and to assess the prioritized interest by the user communities in these areas.

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Optimizing for Powered Payloads

- SNC additional payloads identified areas, which to require design modifications or operational constraints to optimize for payload needs
  - Power, harnessing, switching
  - Heat removal
  - Commanding and telemetry
  - Data recording
  - Secondary structure
  - Mass and volume allocation (assumed standard MDL)
  - Updated payload integration processing and payload CONOPS
- Changes can be made incrementally, in an evolutionary way

Defining Missions on an Enhanced CRS2 Configuration

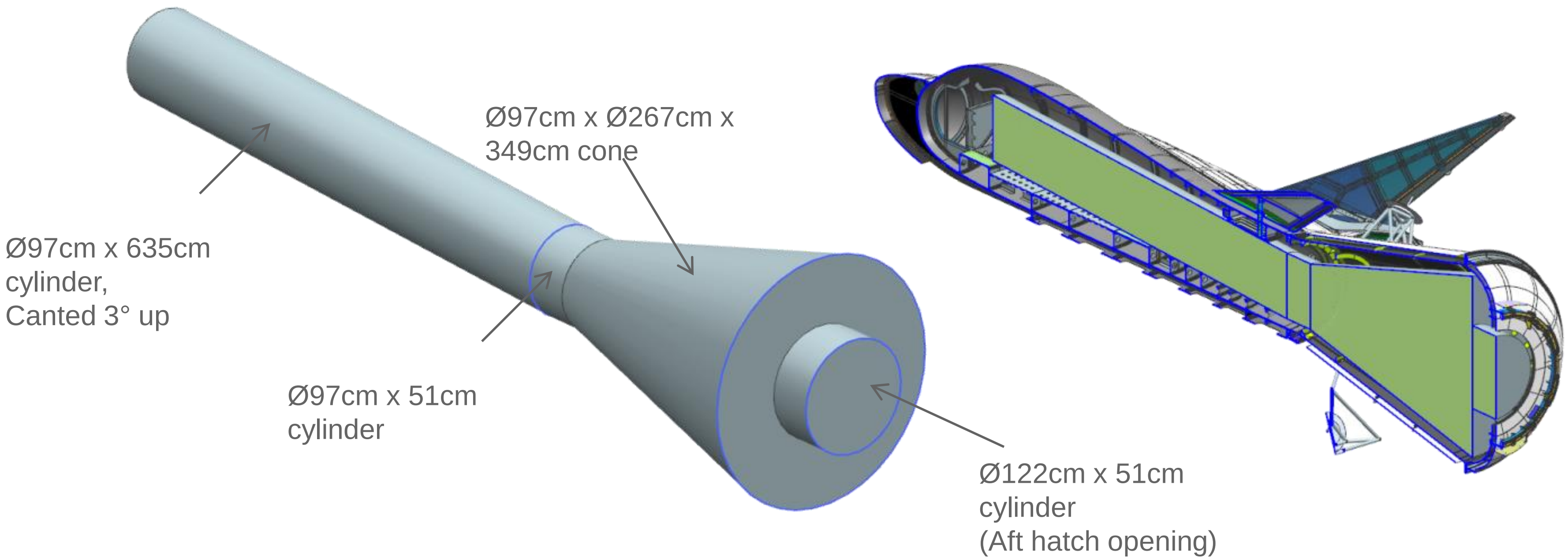
Enhanced CRS2 configurations expand service offerings and mission capabilities from basic CRS2 capabilities.

- Payloads
  - 35+ total standard payloads
- Payload power
  - Larger solar arrays
  - Additional batteries to support payloads
- Cooling
  - Kits to increase heat exchanger capabilities and radiator area
- Data
  - Comm kit to increase real-time data from payloads
- Hatch options
  - Could change out Dream Chaser aft hatch to support mission kits
  - Windows and observational modifications
- Delta v: ~270 m/s
- Max duration: order of months
- Automation/Transportation Kit options
- Additional landing site options available

Dream Chaser Cargo System Capability (no payload outfitting)	
Pressurized Upmass (Dream Chaser and Cargo Module)	Up to 5000Kg
Unpressurized Upmass (Cargo Module)	Up to 1500Kg
Maximum Combined Upmass	5500 kg
Return/Disposal	
Pressurized Return Mass (Dream Chaser)	Max 1,750 kg
Pressurized Disposal Mass (Cargo Module)	Max 3,250 kg
Unpressurized Disposal Mass (Cargo Module)	Max 1,500 kg

Payload Volume

- Internal Volume shown = ~540 ft^3 = 15,2 m^3
  – Additional “sand” volume is available
- Items inside the Cargo Module are disposed of during entry and are not returned.



Why Do Research on Dream Chaser?

Designed for Science Missions

Biotech and Pharmaceuticals | Biology and Life Science | Material and Fluid Science | Technology Demonstration

- **Selection of:**
  - Launch Vehicle
  - Desired Landing Site
  - Orbit and Inclination
  - Mission Duration
  - Standard or Customized Hardware
  - Crewed, Uncrewed, or Tele-operational
- **Frequent Flight and Re-Flight Opportunities**
- **Expedited and Cooperative Payload Integration**
- **Flexible Operating Requirements and Environments**
- **IP Control**

CIM-025.1

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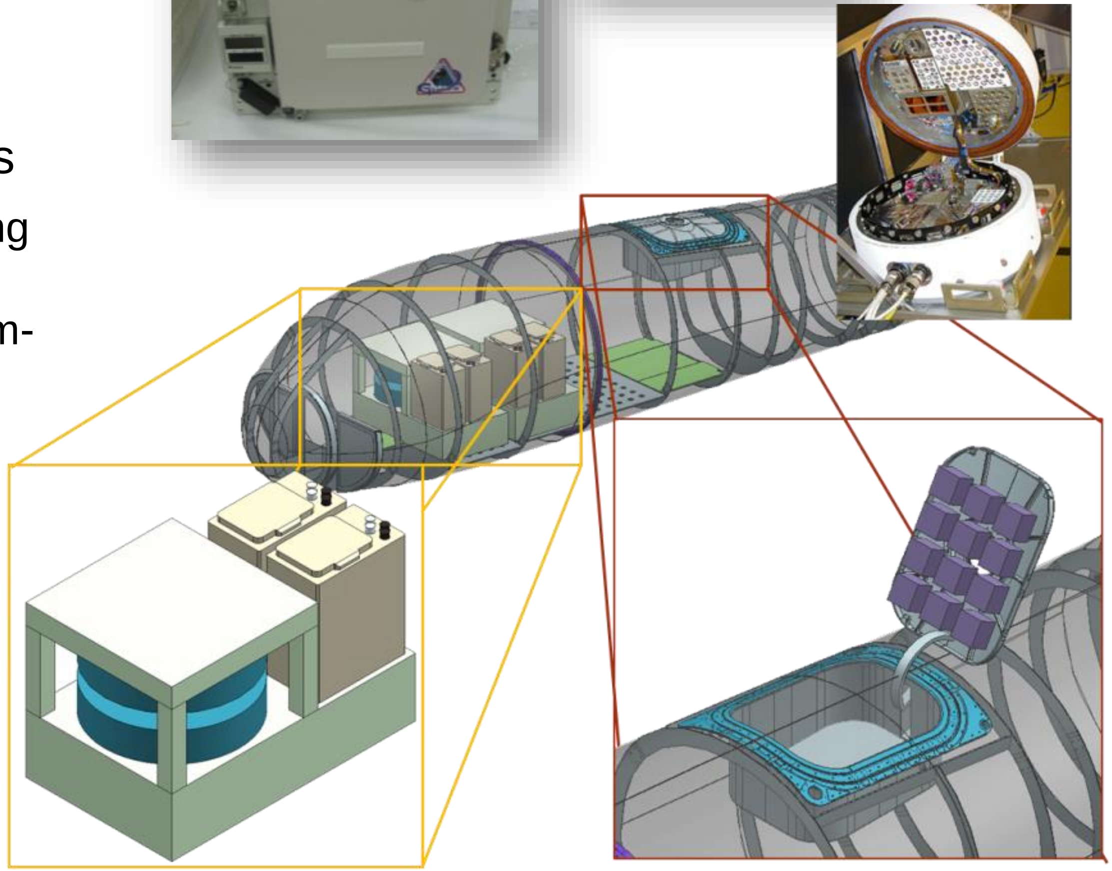
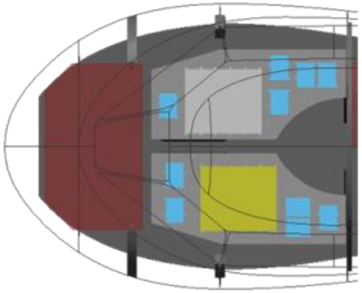
Accommodation of Standard and Non-Standard Payloads

- Standard Payload based on standard "Mid-Deck Locker equivalents" (MLEs)
  - Double & Single MDL →

- Non-Standard Payload Examples
  - Custom structures and mounting
  - Rodent habitat
  - BIOPan like experiments accommodated in hatch modifications

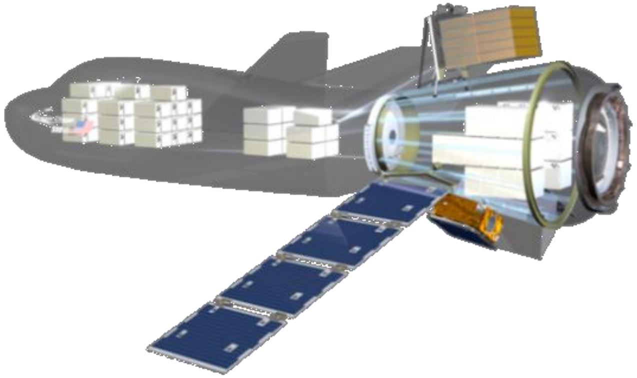




Pressurized Payload Services

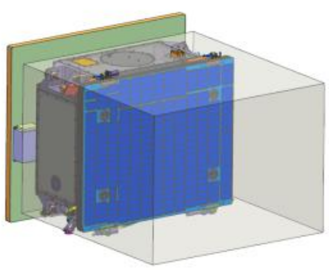
- Install a suite of payloads (samples on previous slides) to be autonomously executed
  - 35 standard payloads (75 W each)
- Available services:

Electrical Power Subsystem	• 28V power • 2.6 kW
Thermal Control Subsystem/ECLSS	• 2.6 kW heat rejection
Comm & Instrumentation	• Real-time downlink > 100 Mbps • Data recorders
Structures	• 35 standard accommodations

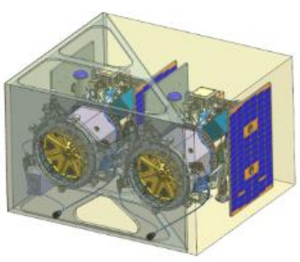


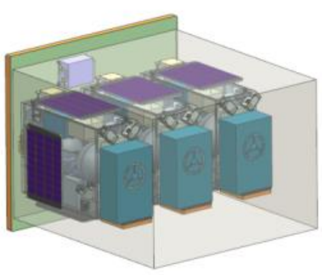
External Payload Examples

- Cargo Module supports three external, unpressurized payloads that attach via standard Flight Releasable Attachment Mechanism (FRAM)
- External Volume = ~ 256 ft^3 = ~7,3 m^3
  - 102”x81”x35” at upper location
  - 49"x34"x46“ at each of 2 lower locations
- FRAM power and data interfaces can be used to support a secondary satellite deployment mechanism
  - 120 V
  - Up to 150 W per location, 450 W total
- Multiple small sat / cube sat configurations that meet FRAM mass/volumetric constraints

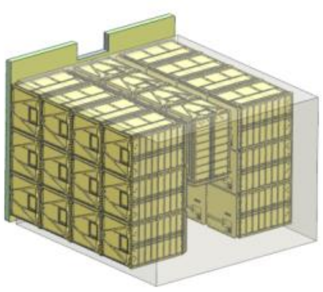


Single satellites up to 500 kg





Multiple 100 – 200 kg satellites



28x 12U Cubesats
~18 x 12U Mass (24 kg each)

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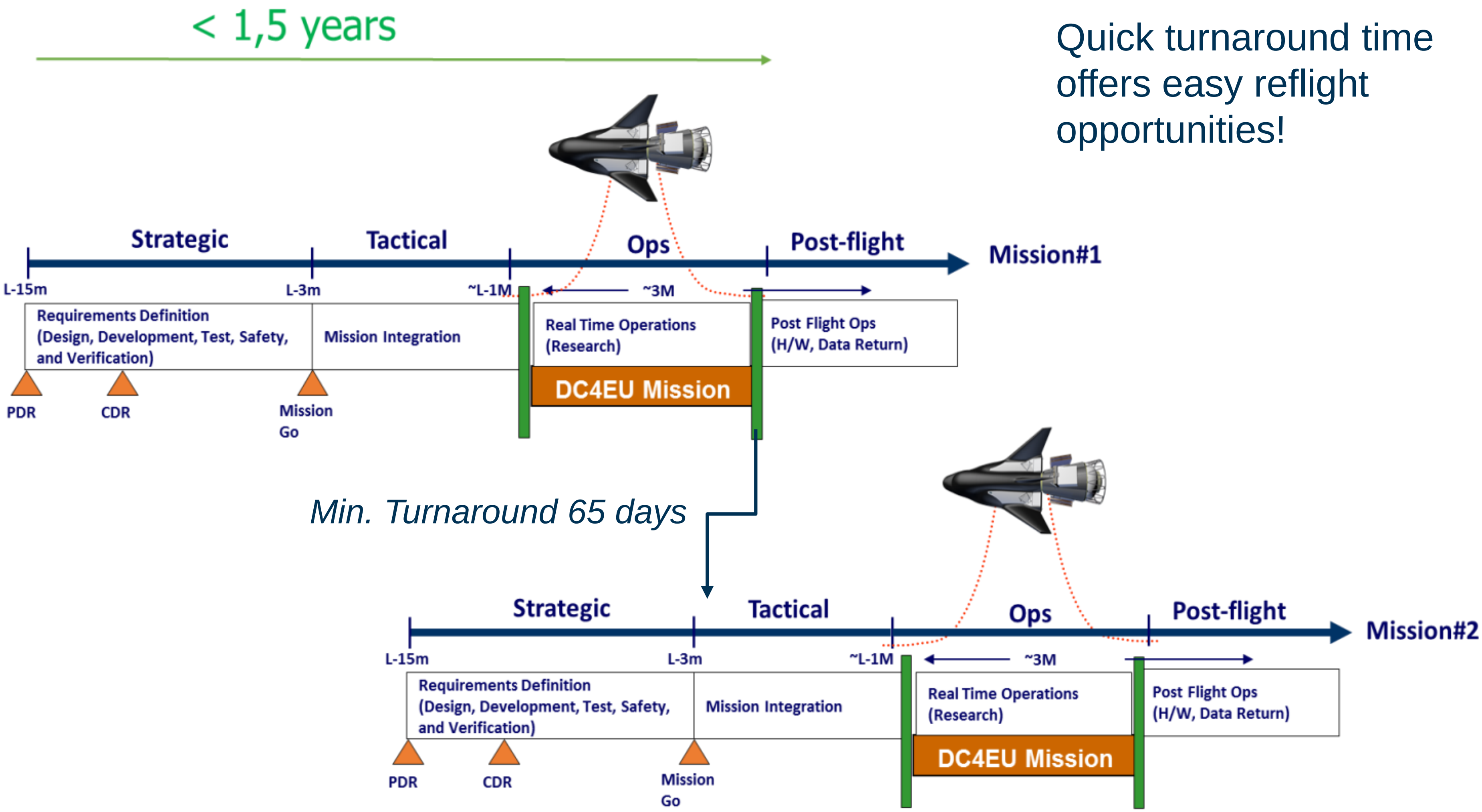
Conceptual Mission

Integration and Processing



Quick turnaround time offers easy reflight opportunities!

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Benefits of Dream Chaser for Free-Flying Science Missions

Key Points of the Dream Chaser

- Increased mission flexibility tailored to smaller set of PI needs
- Driven primarily by payload requirements, not ISS schedule or cargo vehicle manifest
- Broader orbit possibilities enable more flexibility in space science mission set
- Minimal risk to payload operations caused by payload transfer and checkout on ISS
- Mission emphasis on payloads focuses priorities. Immediate operation enhances science return

- Payloads return uncompromised, returning rapidly to laboratory environment
- More flexible interface for PI either in-person or via telepresence
- Payload drives launch and landing requirements
- Lower cycle time speeds results and, if applicable, time to market
- Mission emphasis on payloads focuses priorities. Immediate operation enhances science return

DC_4EU Summary

- Provide affordable, reliable, and flexible space services for independent European access to LEO, e.g. for science, technology demonstration, or on-orbit satellite service missions.
- Provide a full end-to-end mission capability using the unique attributes of the Dream Chaser spacecraft, compatibility with the Ariane 6 launch vehicle and the ability to land on suitable runways in Europe.
- The DC_4EU initiative is now in its Pilot Phase to develop an independent end-to-end access scenario to LEO for multiple European missions. The feasibility and commercial viability of the DC_4EU partnership model is being assessed.
- Inputs from different potential users in Europe representing scientific research and technology have been collected and analysed to identify user needs. The results so far show that the DC_4EU service is able fulfil the majority of LEO Mission User needs.
- European technologies and infrastructures that will enable Dream Chaser free-flight missions has been identified and are being assessed.


DC4EU
Where European Dreams
Take Flight!