Masters Forum #17
International Partnering

European Space Agency (ESA)
Organisation, Programmes, Ambitions

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Content

- Introduction to ESA
- Outlook to the Ministerial Conference 11/2008
- Principles/Motivation for International Partnering
- Program aspects
  - Space Science
  - ISS Program
  - Exploration

What is ESA ?

An inter-governmental organisation with a mission to provide and promote - for exclusively peaceful purposes -

- Space science, research & technology
- Space applications.

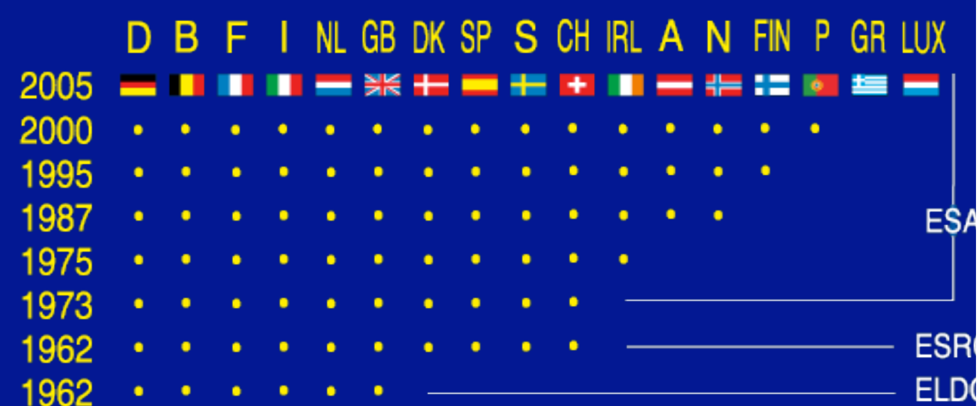
ESA achieves this through:

- Space activities and programmes
- Long term space policy
- A specific industrial policy
- Coordinating European with national sp programmes.

ESA Member States

ESA has 17 Member States :

- Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Norway, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom.
- Hungary, the Czech Republic and Romania are European Cooperating States.
- Canada takes part in some projects under a cooperation agreement.



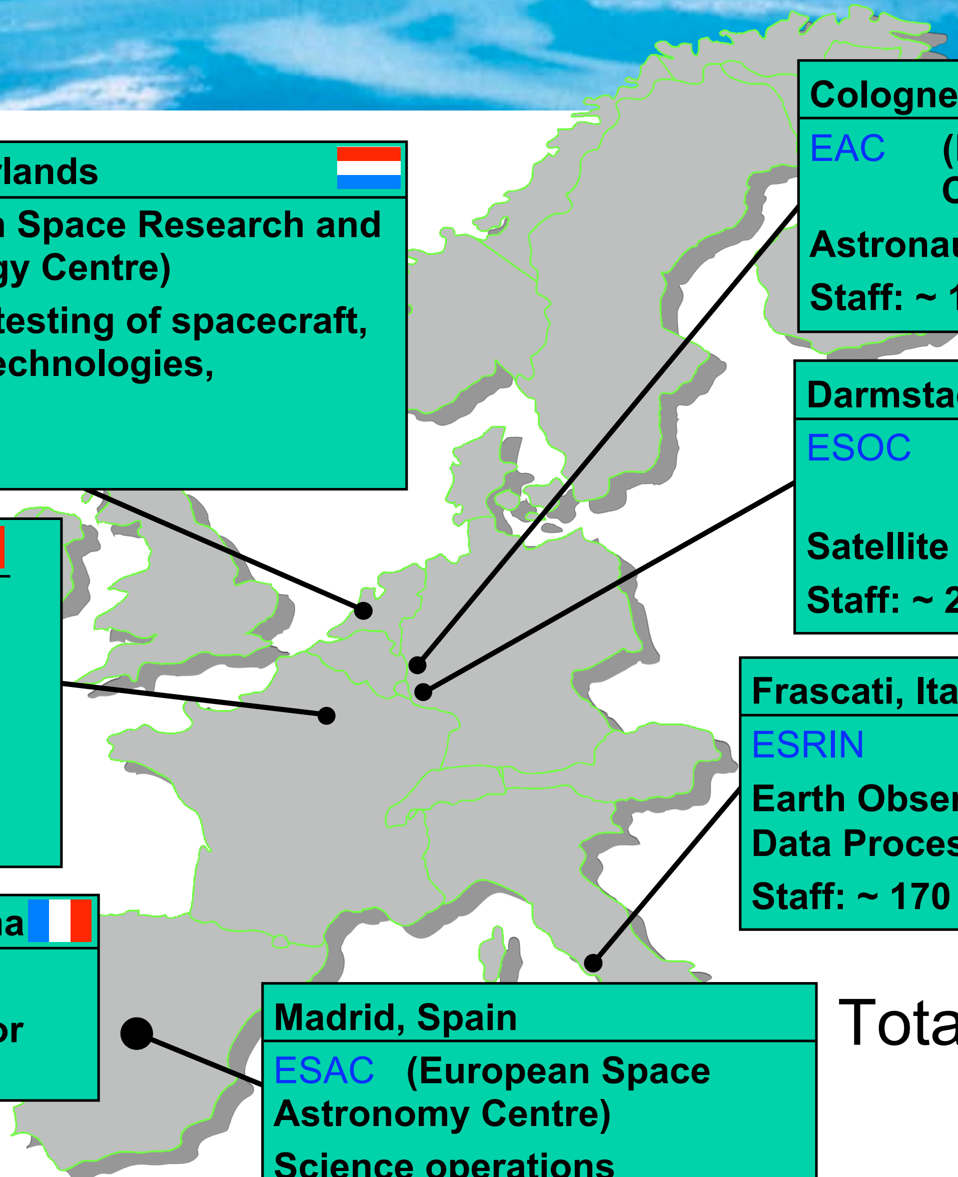
ESA is responsible for research and development o space projects.

- On completion of qualification, these projects are handed over to outside bodies for the production/exploitation phase.

Operational systems are transferred to new or specially established organisations:

- Launchers: Arianespace
- Telecommunications: Eutelsat & Inmarsat
- Meteorology: Eumetsat

Establishments



Noordwijk, The Netherlands

ESTEC (European Space Research and Technology Centre)

Project management, testing of spacecraft, development of new technologies, space science

Staff: ~ 1000

Paris, France

Headquarters

Space Policy,

Administration

Staff: ~ 370

Kourou, French Guiana

CSG

Europe's Spaceport for Ariane launches

Cologne, Germany

EAC (European Astronaut Centre)

Astronaut training

Staff: ~ 15

Darmstadt, Germany

ESOC (European Space Operations Centre)

Satellite operations

Staff: ~ 250

Frascati, Italy

ESRIN

Earth Observation, Data Processing and Distribution

Staff: ~ 170

Madrid, Spain

ESAC (European Space Astronomy Centre)

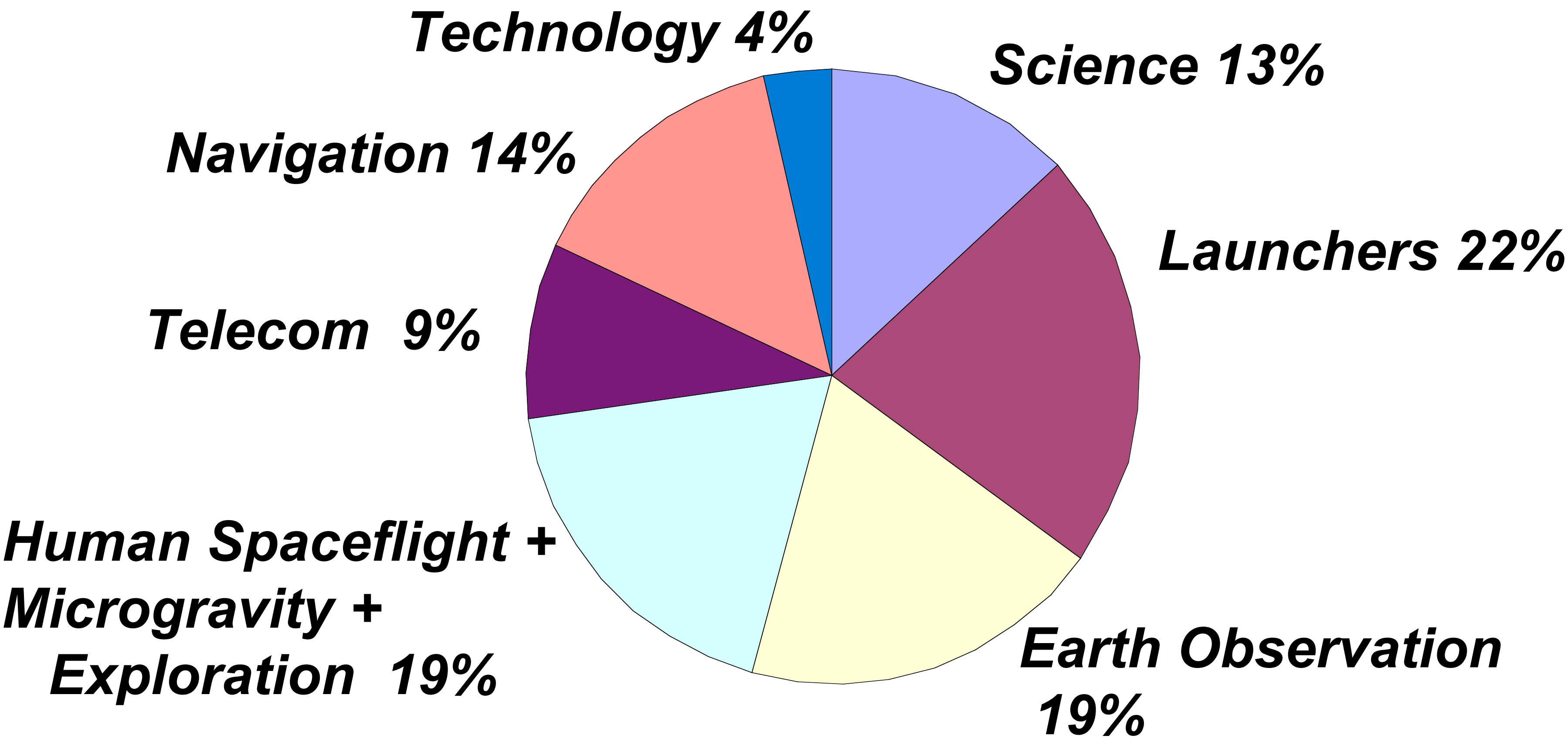
Science operations

Staff: ~ 40

Total staff: ~1900

(Status: 12/2007)

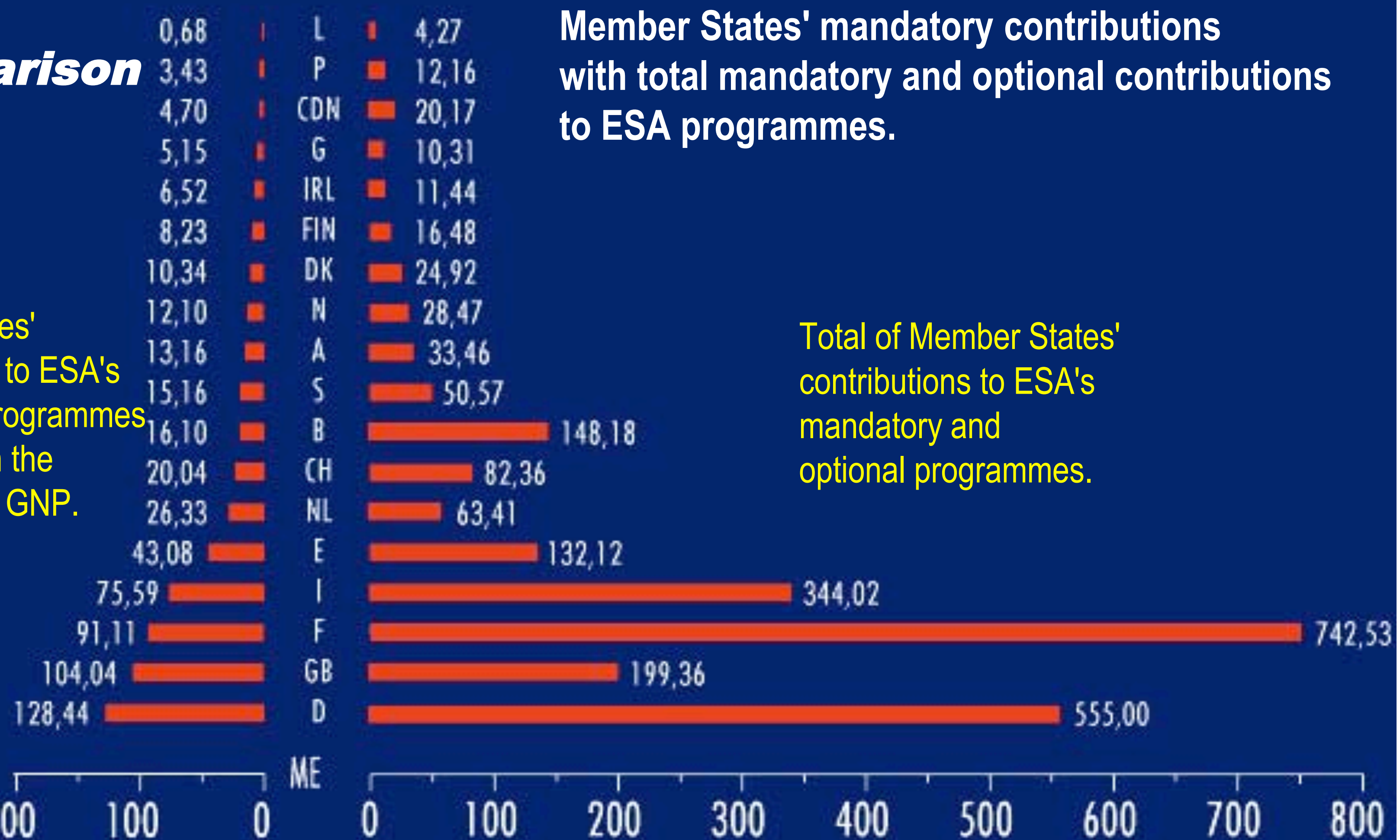
Total Budget 2008: ~3200 M€



Comparison

Member States' mandatory contributions with total mandatory and optional contributions to ESA programmes.

Member States' contributions to ESA's mandatory programmes calculated on the basis of their GNP.



Total of Member States' contributions to ESA's mandatory and optional programmes.

M€ : Million of Euro

Governance of European Space Activities

ESA

- **ESA Ministerial Council (next: 11/2008) -> ESA program**
- **lead in science, launchers, technology, human spaceflight, exploration**

EU

- **Space Council -> European Space Policy (political guideline)**
- **representation of Europe regarding Galileo and GMES/Kopernikus**
- **(co)funding major programs: Galileo, GMES/Kopernikus**

Member States

- **national space programs (in particular F, D, I)**

European Space Policy

Flagship projects: Galileo, GMES

new priorities (2008)

- **Space and Climate Change**
- **Contribution of Space to the Lisbon Strategy**
- **Space and Security**
- **Exploration**

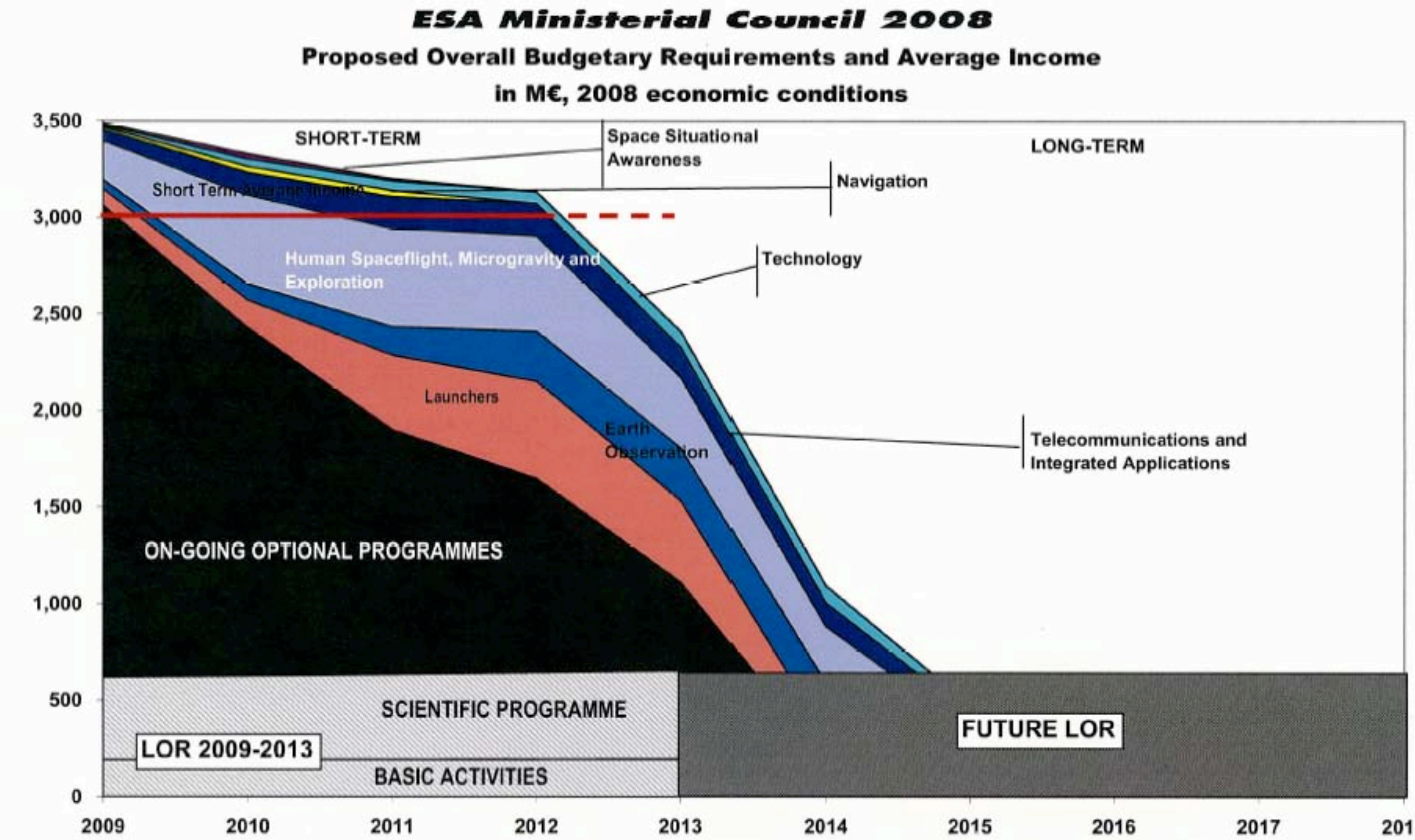
Outlook to the Council at ministerial level

- Continuation of ongoing programs
  - ISS (exploitation, utilisation)
  - Science (incl. robotic Mars Exploration)
  - Application Programs (EO, Telecom, Navigation)
  - Access to Space
  - Technology

- Perspectives for Europe in space exploration

- Space situational awareness
  (core element: space debris + space weather)

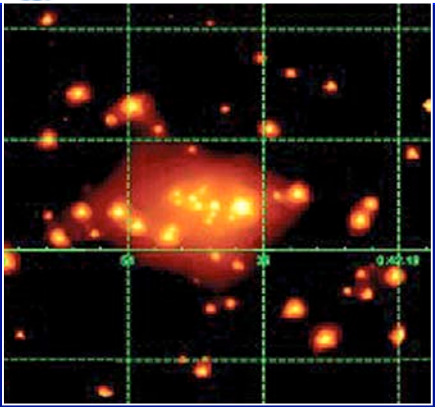
- Evolution of ESA
  (e.g. decision making process, balanced infrastructure)


ESA Ministerial Council 2008
Proposed Overall Budgetary Requirements and Average Income
in M€, 2008 economic conditions
3,500
3,000
2,500
2,000
1,500
1,000
500
0
SHORT-TERM
Space Situational Awareness
LONG-TERM
Navigation
Short Term Average Income
Human Spaceflight, Microgravity and Exploration
Technology
Launchers
Earth Observation
Telecommunications and Integrated Applications
ON-GOING OPTIONAL PROGRAMMES
SCIENTIFIC PROGRAMME
FUTURE LOR
LOR 2009-2013
BASIC ACTIVITIES
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

ESA Principles/Motivation for international partnering

- Support to ongoing and planned space projects (technical, operational, financial reasons)
- Support to reaching policy objectives (e.g. European integration, development policies)
- Affirmation of Europe’s presence in international context

- **Space Science**



Past missions

ISO [1995

Hipparcos [1989]
Giotto [1985]
Exosat [1983]
IUE [1978]
COS-B [1975]

Operations

INTEGRAL [2002]
Cluster [2000]
XMM-Newton [1999]
SOHO [1995]
Hubble [1990]
Ulysses [1990]
Double Star [2003]
Rosetta [2004]

Implementation

COROT [2005]
Venus Express 2006
Herschel [2007]
Planck [2007]
LISA Pathfinder 2008

Definition

Gaia
JWST
LISA
BepiColombo

Assessment

Darwin
Hyper
Solar Orbiter
XEUS

- **ISS Programme**

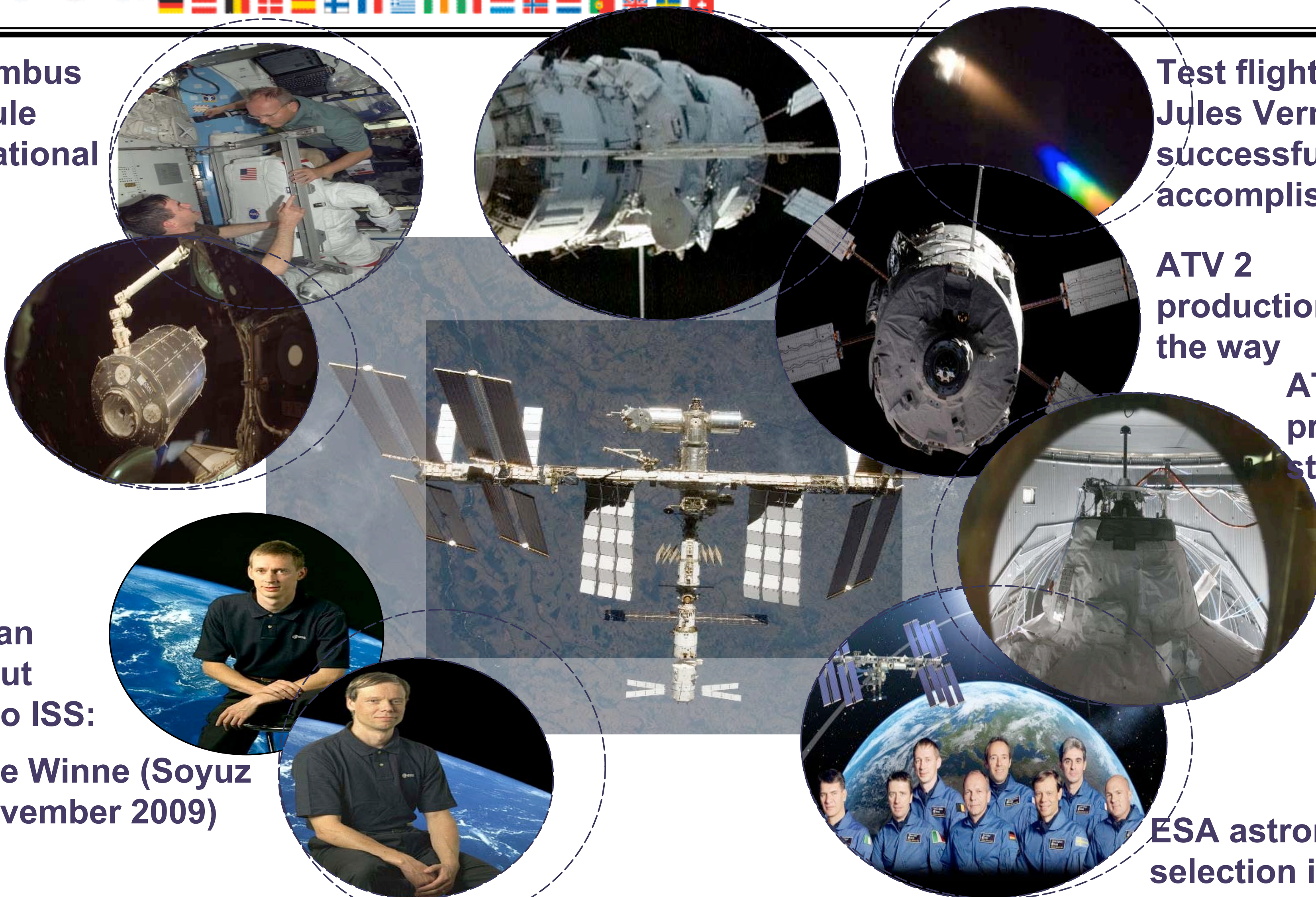
Current status of European ISS program

Columbus module operational

Test flight of A
Jules Vernes successfully accomplished

ATV 2 production on the way

ATV 3 produc
started



European astronaut flights to ISS:

Frank de Winne (Soyuz May-November 2009)

Christer Fuglesang (STS-128 July/August 2009)

ESA astronaut selection in fina
round

Current ISS status
Main European ISS developments

Data Management for Svezda
Launched Jul 2000

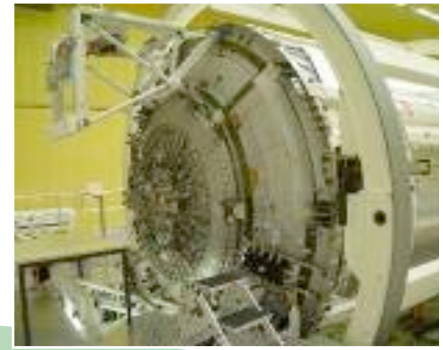
Microgravity Science Glovebox (NASA)
Launched Jul 2002

EMCS
Launched Jul 2006

2000

Minus 80 degree Freezer (MELFI)
Launched Jul 2006

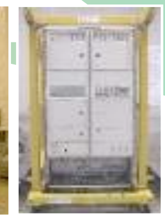
Node 2
Launch Oct 2007



Columbus
Launch Feb. 2008
With payload racks + external paylo

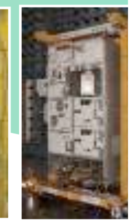
Fluid Science Laboratory

European Transport Carrier

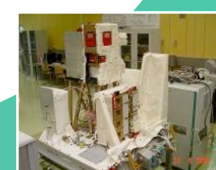


European Drawer Rack

Biolab



Europea Physiol Module



EuTEF

Solar

2010

ERA
Launch late 2011 tbc

Node 3 (NASA)
Launch Jan 2010

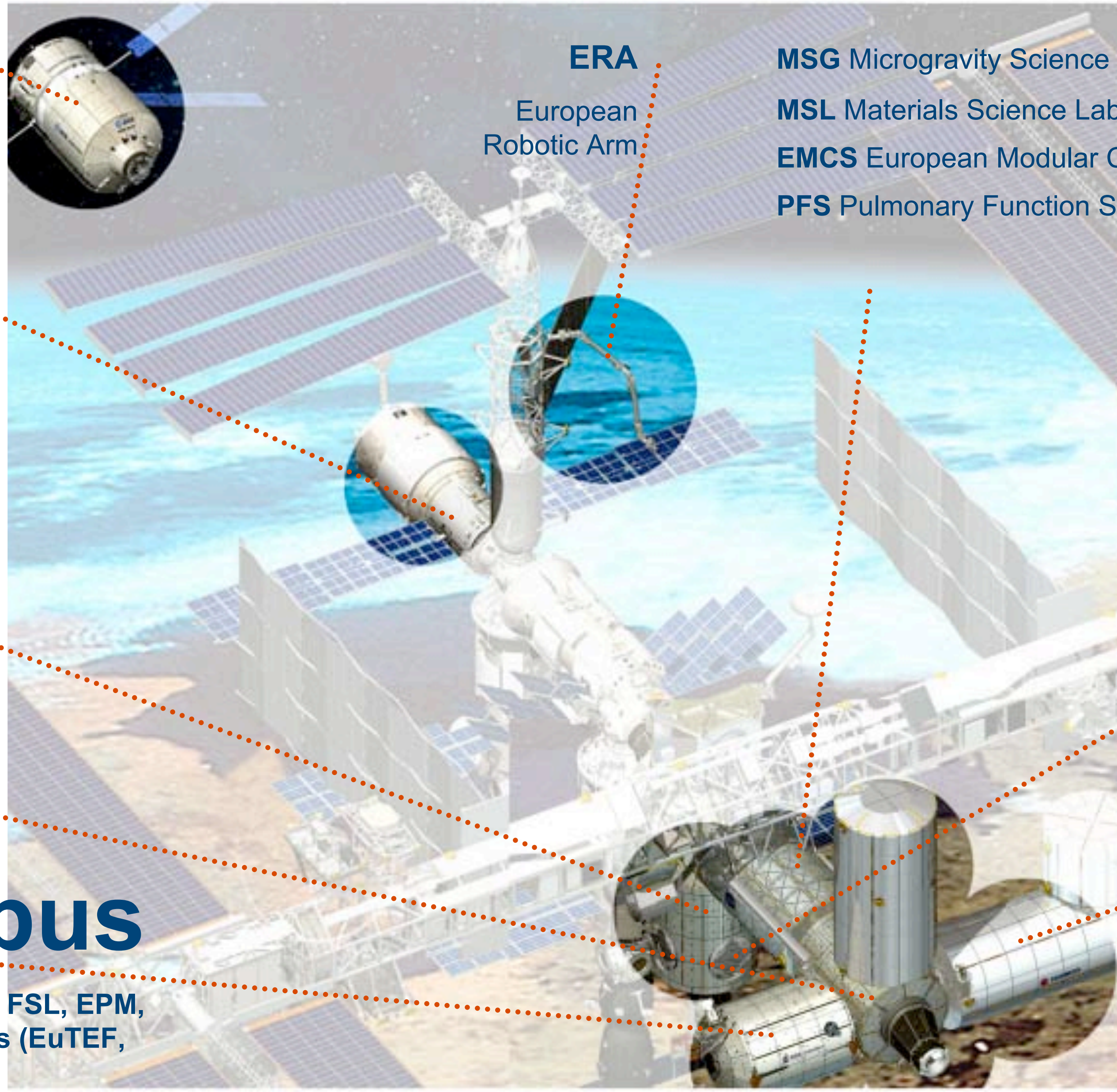
Cupola
Launch Jan 2010

ATV
Launch March 2008

Material Science Laboratory
Launch tbd

Crew Refrigerator Rack (NASA
Launch tbd

ESA Elements on ISS



ATV

Automated Transfer Vehicle

DMS-R

ESA's Data Management System for the Russian Segment of the ISS. Located in service module Zvezda.

Node 3
Connecting Module

Node 2
Connecting Module

Columbus

(Internal Racks (Biolab, FSL, EPM, EDR), External payloads (EuTEF, SOLAR))

ERA

European Robotic Arm

MSG Microgravity Science Glovebox

MSL Materials Science Laboratory (in MSRR-1

EMCS European Modular Cultivation System

PFS Pulmonary Function System (in HRF-2)

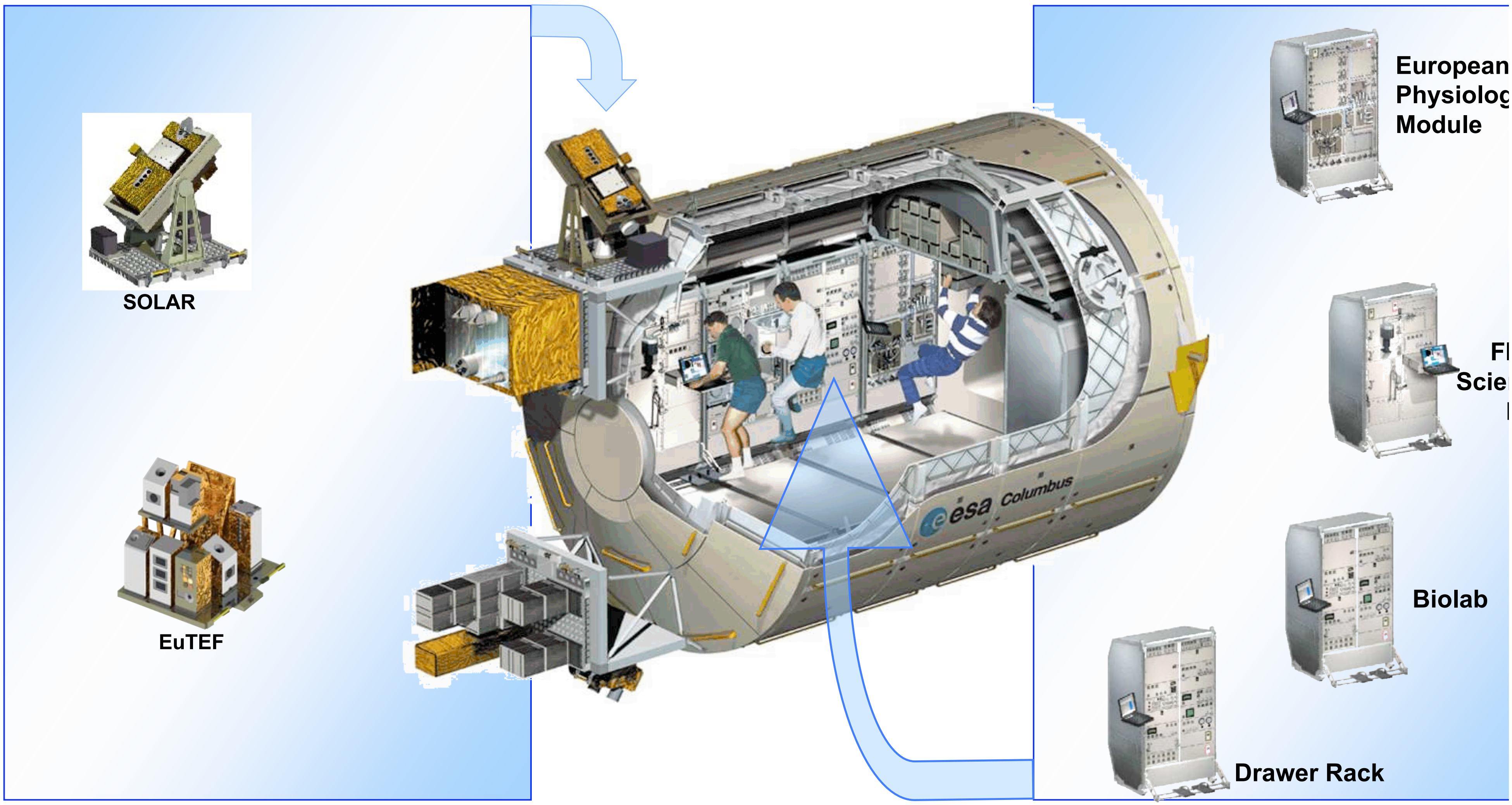
Cupola
Pressurised observation and work area

MELFI
- 80°C Freezer f
research specin
Located in Dest
Kibo

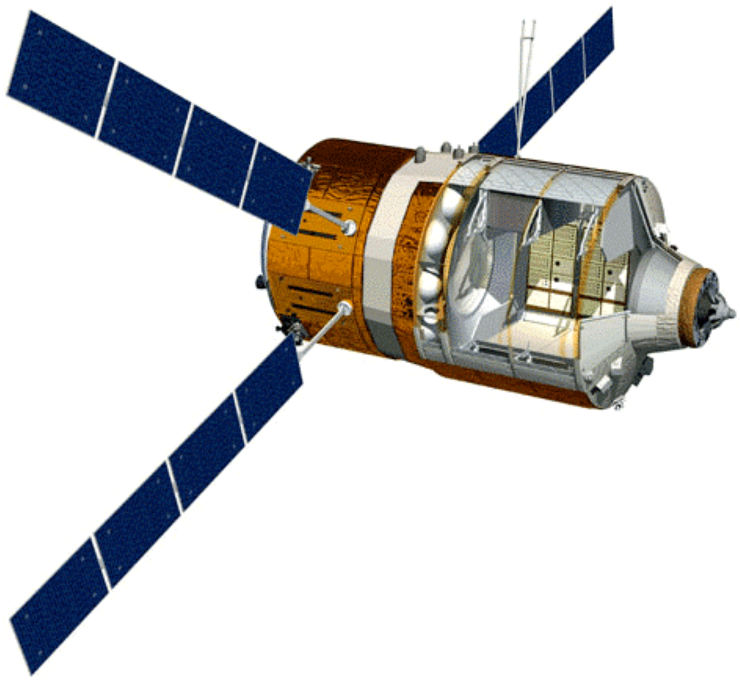
Columbus' European Payloads

External Payloads

Internal Payload Facilities



The Automated Transfer Vehicle, ISS supply spaceship for ISS consumables, ISS payloads and food for the ISS crew



Main Features

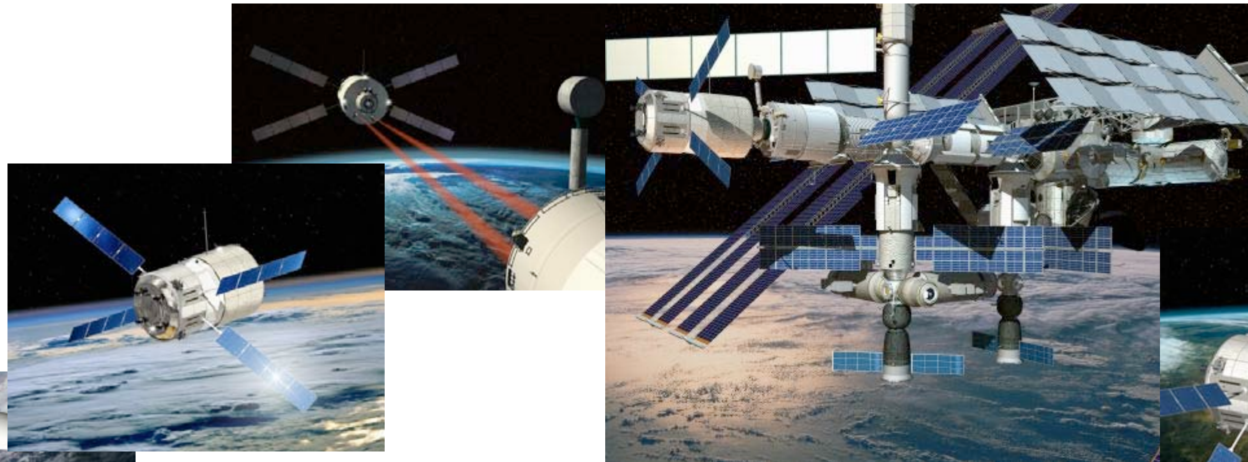
• Overall length	9 m
• Maximum diameter	4.5 m
• Span of deployed solar wings	22.3 m
• TOTAL Launch mass	20.7 tons

Payload (Net Cargo Capability)

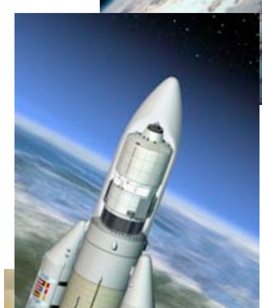
• Dry cargoes	1,500 - 5,500
• Water	up to 840 kg
• Gas (O_2, N_2, air)	up to 100 kg
• Propellant for refueling	up to 860 kg
• Propellant for reboost	up to 4.9 tons
• Total cargo upload capability	up to 7.7 tons

Automated Transfer Vehicle

Mission Characteristics



Docked with the Russian Segment of the ISS, the ATV serves as a supply vehicle, …

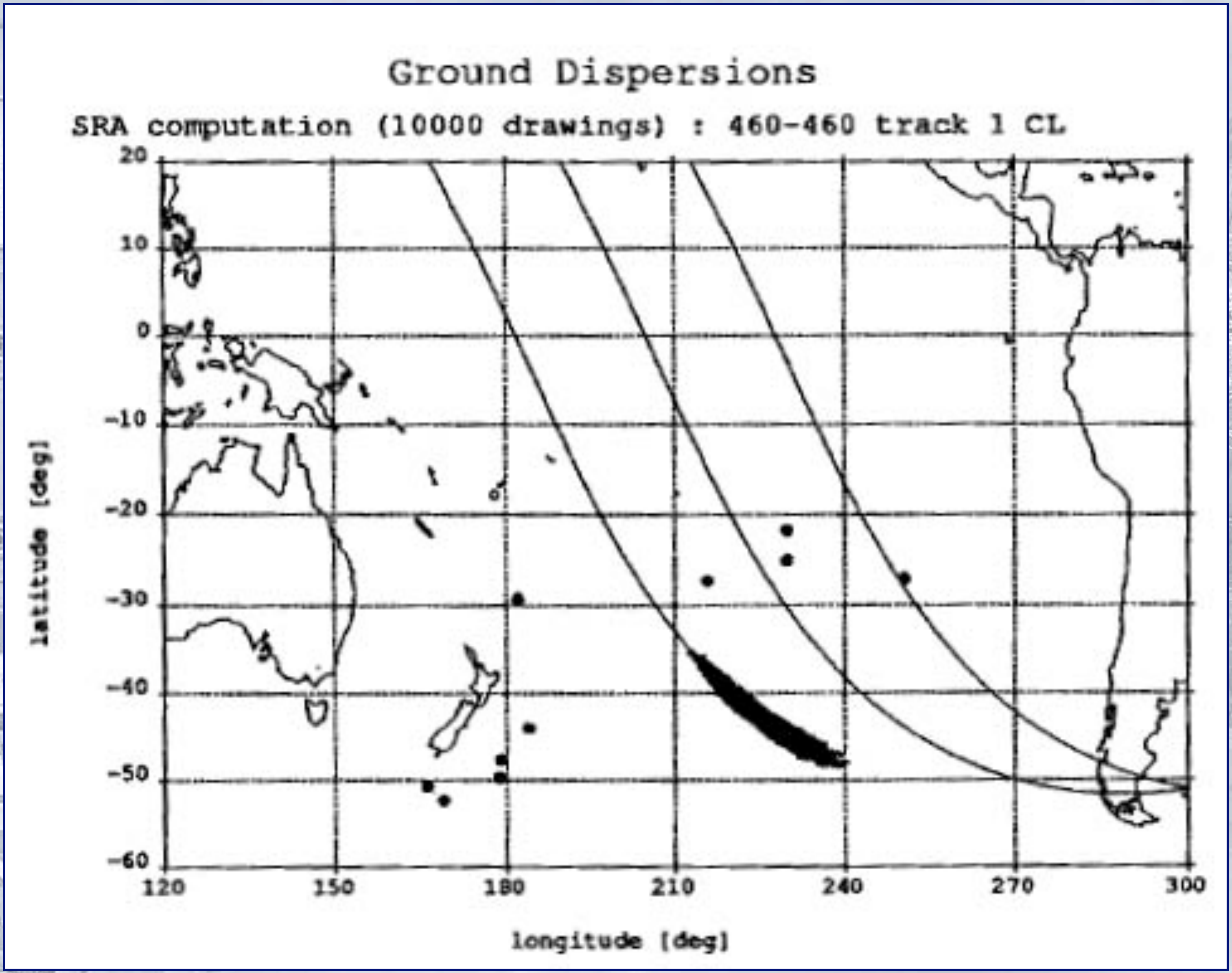


… the ATV's flight to, and docking with, the ISS is fully automated.

… re-boosts the Station to a higher altitude,…

Launched by a European Ariane 5 launch vehicle ….

… and removes waste, burning-up in the Earth's atmosphere.



Ground Dispersions
SRA computation (10000 drawings) : 460-460 track 1 CL
20
10
0
-10
-20
-30
-40
-50
-60
latitude [deg]
120
150
180
210
240
270
300
longitude [deg]

Additional European Contributions

Barter Elements

Under these Barters, ESA delivers :

Data Management for Russian Service Module (RSA)

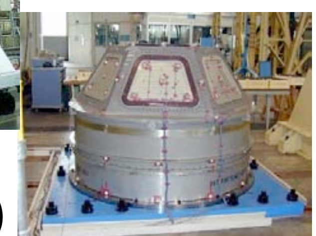
Super Guppy (NASA)

Microgravity Science Glovebox (NASA)

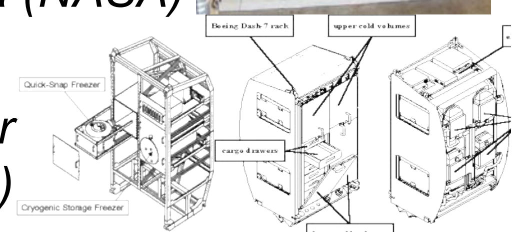
Minus 80 degree Freezer (NASA and NAS

Hexapod (NASA)

Nodes 2 + 3 (NASA)



Cupola (NASA)



Refrigerator/Freezer
Cryo System (NASA)

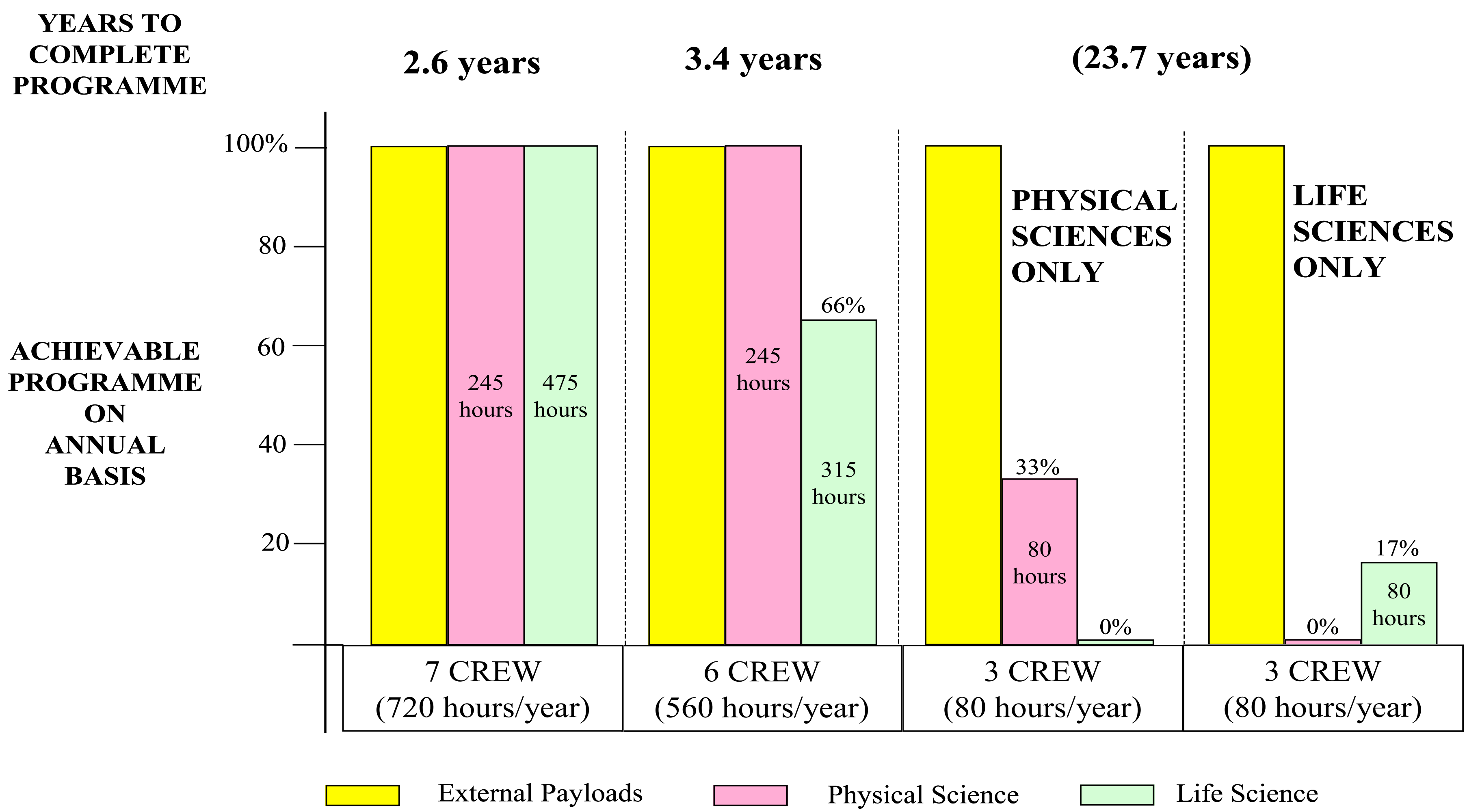
In Return, ESA receives :

FROM NASA :
Columbus launch on Shuttle
Early utilisation on US Segment
Shuttle ISS Payload up and down mass allocations
2 Astronaut opportunities

FROM Roscosmos:
2 Docking Systems for the ATV

FROM JAXA :
ISS Standard Payload Racks

Crewtime required to execute ESA's prioritized Utilisation Plan for the initial phase: 1900 hours



Lessons Learned

The ISS program faced challenges due to

- the long duration of the programme before assembly complete
  - sustainability of political support over long time (across several government periods)
  - changed geopolitical environment (Russia as new partner)
  - change of programmatic priorities (Exploration)
  - technical solutions/pillars become obsolete (Space Shuttle)

- the size/dimension of the programme
  - consumption of large fraction of national space budgets
  - high visibility for public and political decision makers, requiring good arguments for (long-lasting) programme priority

- the specific set-up of cooperation scheme
  - clear dominance/leadership of initially 1 (later 2) Partner(s) with corresponding influence on programme evolution
  - contributions of small partners are welcome but not essential for programme success

Lessons Learnt

- Different management cultures can successfully interact
- Strong political commitment is essential for program robustness
- Redundancy for key technical solutions/pillars proved essential (positive and negative examples)
- From ESA perspective: basis of cooperation shall be inter-dependency rather than dependency
- Barter arrangements proved to be efficient tool – but provision of hardware for services bears risks
- In Europe: no significant stakeholder community outside space sector

- **Exploration**

ESA’s mid-term plans for space exploration:

- **Support international exploration architecture building (GES, ISECG)**
- **Make full use of the ISS (testbed, astronaut flight opportunities);**
- **Continue robotic Mars exploration (ExoMars, MSR)**
- **Add robustness to global exploration undertaking:**
  - **Starting the development of a new transportation system providing cargo return capabilities (ARV) (phase 0/A)**

    (growth potential towards crewed system)
  - **Prepare technologies for Moon exploration and propose a Lunar cargo lander (definition study).**

Advanced Reentry Vehicle (ARV)

Step 1: Cargo Transportation from LEO

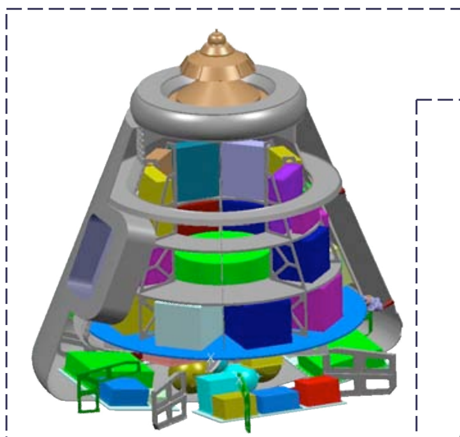
- **logistics capability for ISS with download capability, (responding to stop of STS operations)**

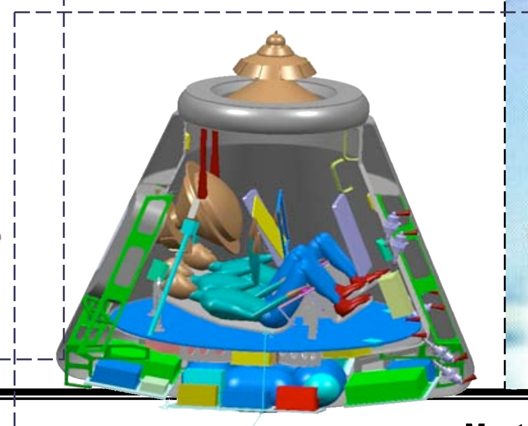
Step 2: Human Spaceflight in LEO

- **Fly crew of 3 between Earth and ISS or any orbital infrastructure succeeding ISS**

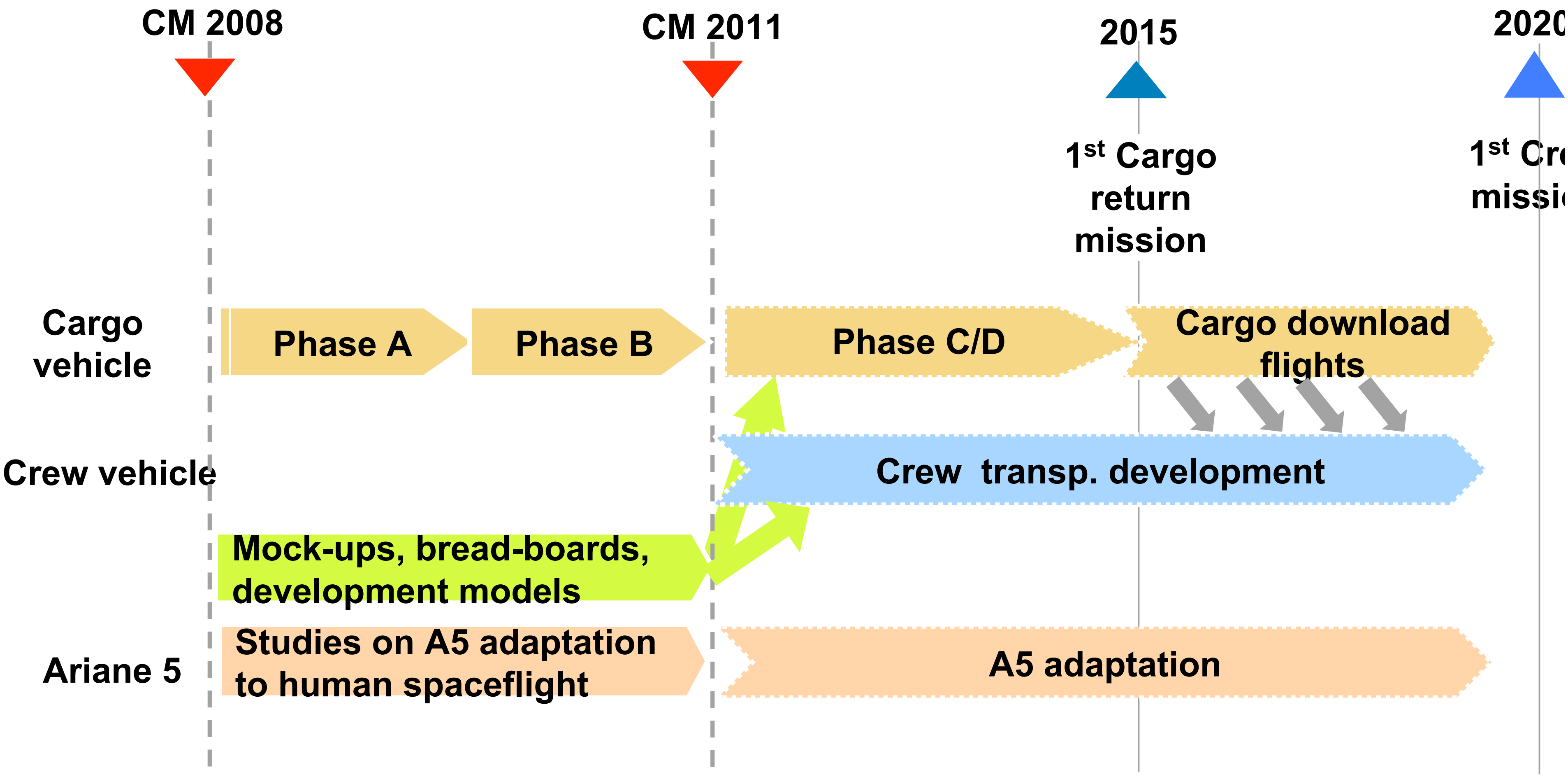
Step 3: Human Solar System Exploration

- Vehicle design not excluding its use in lunar missions



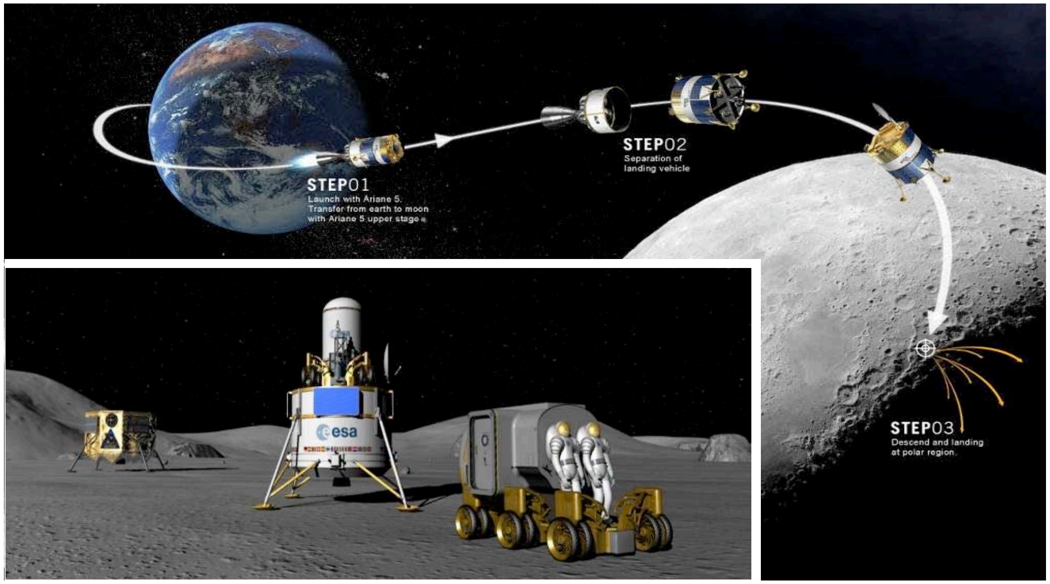


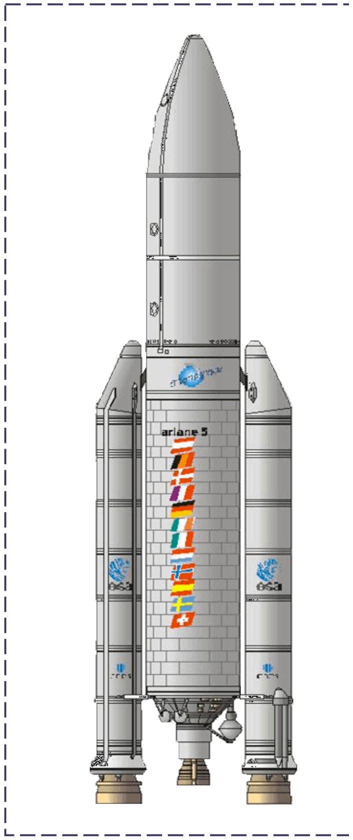
Preliminary Schedule



Lunar Cargo Lander

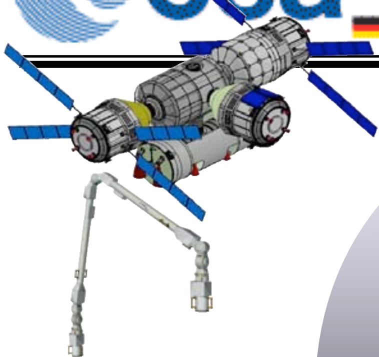
- **Use the full Ariane 5 performance capability**
- **Deliver payloads to any location on the lunar surface**
- **Perform soft precision landing (500m)**
- **Deploy payloads on lunar surface**
- **Provide resources to the P/L (power, comm's etc)**

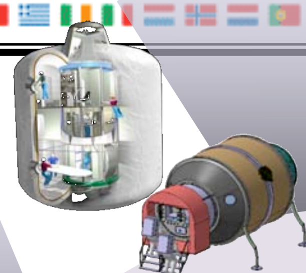




- Gross payload performance (A5 ECA) ~1.2 ton

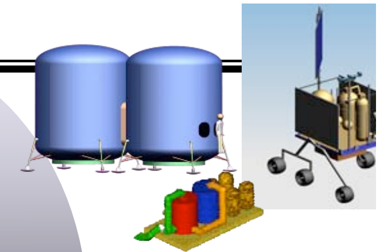
Future Programmatic Proposa





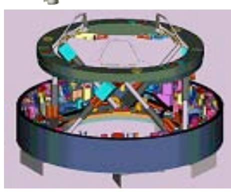
Habitation

- Improvement of life in urban environments
- Waste management



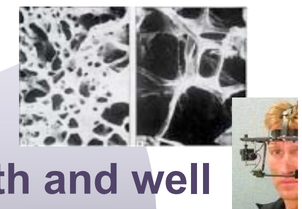
Resource, Energy Management

- Innovative and efficient energy use and management
- Development of new energy resources
- Efficient use of natural resources



Servicing – Space Operations

- Multipurpose robotic aids
- Automation



Human Health and well being in space

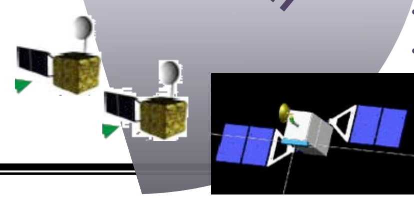
- Teleoperations
- telemedicine
- Fast and improved medical diagnostic

Space Environment

- Dust and radiation research
- Understanding hazardous environments
- Development of counter measurements

Communication and Navigation

- Daily tele connectivity and communication
- Positioning and tracking systems
- Safety and life guarding systems



Transportation Propulsion

- **Backup**

Applications

- GMES/Kopernikus
- Meteosat Third Generation
- European GNSS Evolution Programme (2nd generation EGNOS p/l in 2011)
- Integrated Applications Programme

Meeting Europe's Security Needs

- Space Situational Awareness
- European Data Relay Satellite (replace Artemis) (focused on GMES)

Competitive and innovative industries

- Telecommunication Programmes
- General Support Technology Programme

Contributing to the knowledge-based society

- Mandatory Science Programme (Cosmic Vision 2015-2025)
- ELIPS
- Enhanced ExoMars
- Mars Robotic Exploration Preparation Programme
- Climate Change Initiative (mainly analysis of existing data)

Access to Space

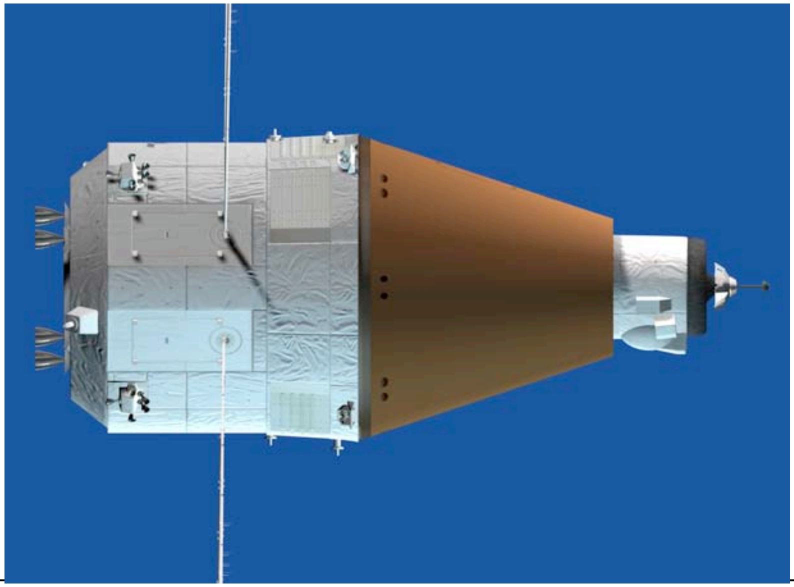
- Ariane 5 and Vega Accompaniment
- Ariane 5 Evolution (Vinci engine; new cryogenic upper stage)
- Future Launchers Preparatory Programme (next generation launcher concepts; technology development and demonstration)

Human Spaceflight and Exploration

- ISS Exploitation (20….)
- European Transportation and Human Exploration Preparatory Activities
  - ARV (phase 0/A) and continuation of cooperation with Russia
  - Moon Lander (definition study)
  - Post-ISS infrastructure in LEO (study) (in 2010)

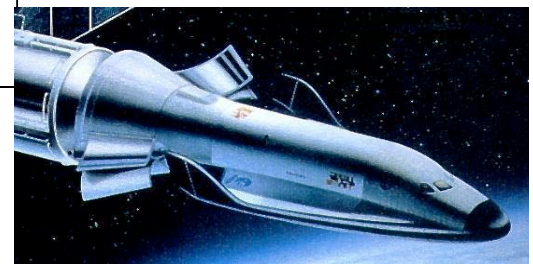
Other

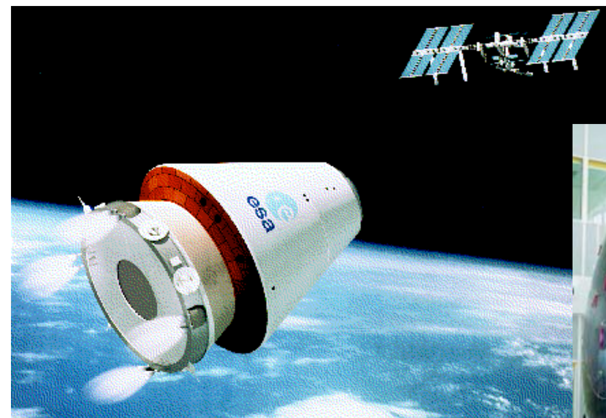
- General Studies Programme
- Technology Programmes
- Education

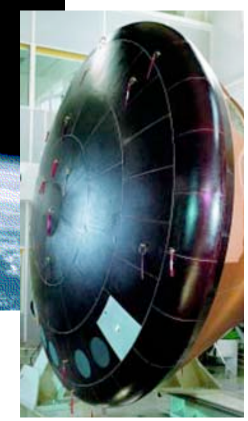


Advanced Re-entry Vehicle (ARV) Perspectives

The European background







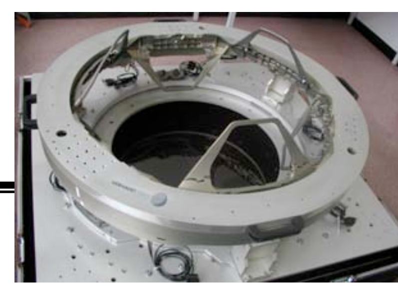
- Since the 80’s Europe has considered the development of an autonomous crew transportation system with the Hermes vehicle.

- Several attempts have been made in 90’s to achieve a European human transportation capability, autonomous (Hermes, MSTP, CTV) or in cooperation (X-38/CRV), but no operational system has been developed, although considerable competence at system and subsystem level has become available.

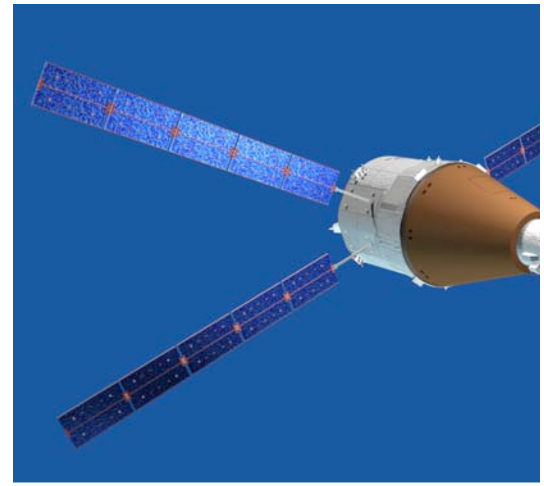
- In the field of human spaceflight, the next important step for Europe would be to enter the area of crew transportation.

- The increased industrial experience in this field, allow Europe to consider such a development, which would rely on the achievements of programmes such as Columbus, ATV and Ariane 5.

- European industry has achieved good understanding of the re-entry systems and technology's aspects through technology and demonstration programmes performed in the last twenty years, including the successful ARD flight in 1998.



- The progressive acquisition of additional strategic capabilities, such as atmospheric re-entry, fully European orbital rendezvous and docking, astronaut extra-vehicular activities is required.

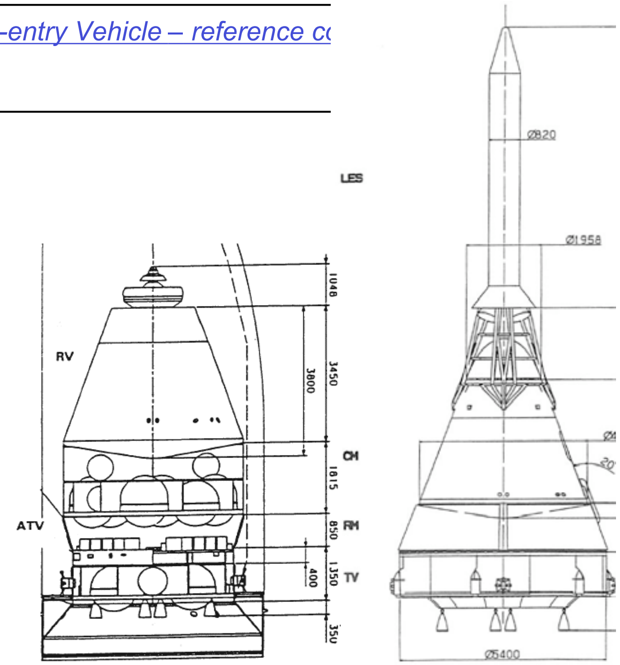


- ARV will be designed since the beginning to allow finally an operational crew system, but an initial step based on un-crewed flights will be implemented for:
  - Validation of the design techniques and collection of flight data
  - Ensuring an early operability of the system in a cargo transportation and return function in support to the ISS;
  - Progressive verification of the design and operations;
  - Allowing the necessary time for the adaptation of the Ariane 5 system to human spaceflight.

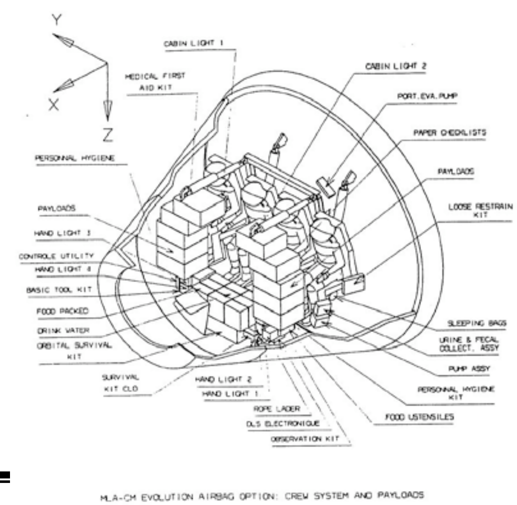
- The objective is to achieve the crew flight capability around 2020.

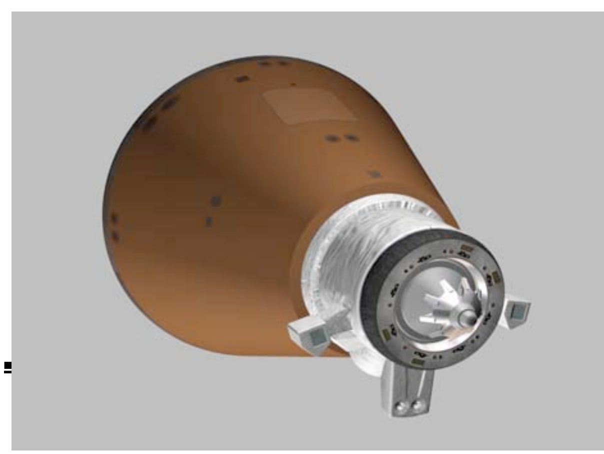
- The trade-offs performed in 1997 for CTV and recent studies, including CSTS and CTSE have converged towards a transportation system concept based on 2 modules
  - Service module
  - Re-entry module

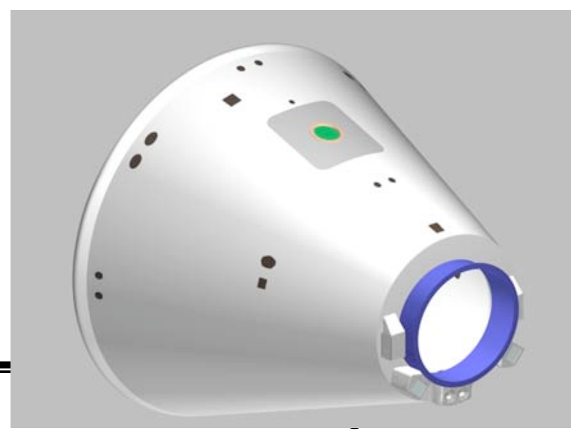
  plus the Launch Escape System (for the crew version)
- The re-entry vehicle will be based on an expendable capsule of conical type (cone inclination angle of 20°). A trade-off between spherical and a Viking type heat shield will be performed. The diameter of the capsule will be around 4.4 m, allowing a crew of 4.
- The re-entry module will be compatible with both, the Russian Docking System (RDS) and the IBDM.



Crew Transport Vehicle



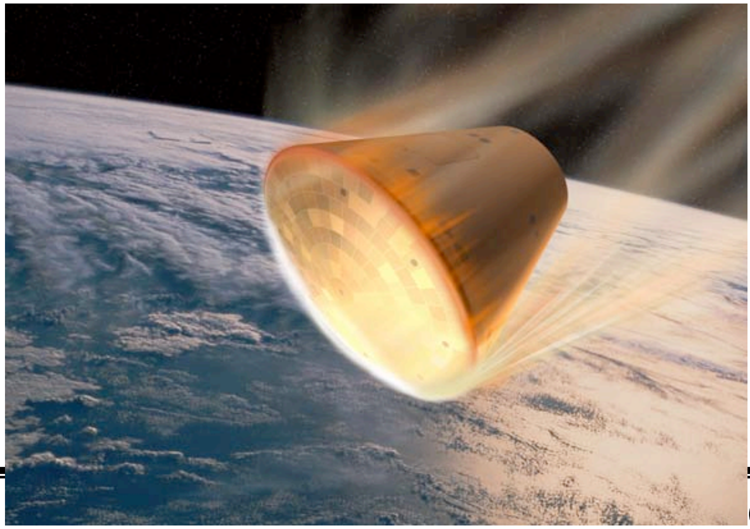


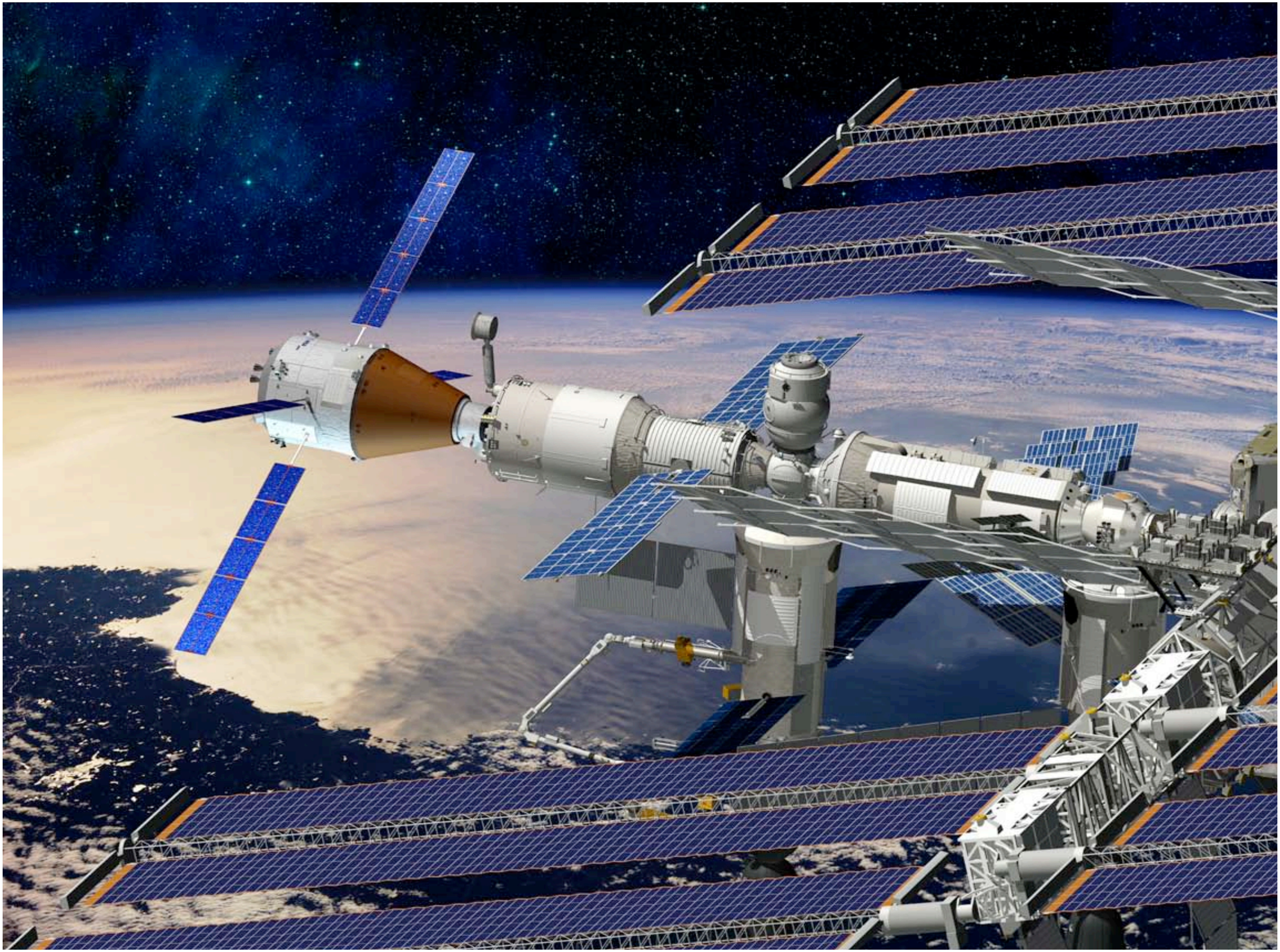


ARV proposal for ESA Ministerial Council 2008

- **The ESA Proposal to the Member States reflects the defined stepwise approach w the following programme components in the period 2008-2011:**

  - **A Cargo and Crew Transportation System definition component for the implementation of the Phase and cooperative activities with Russia at subsystem and component level;**
  - **An Early Activities component, dedicated to early bread-boarding activities, development models an demonstrators of a comparable financial envelope;**
  - **A tbd amount is earmarked for the ARV Phase B and continuation of the hardware development activities, to be un-blocked in 2010 (pending i.a. more clarity about ISS lifetime extension).**





Enhanced ExoMars Mission

ExoMars Industrial Day
Torino – 29 May 2008

D. McCoy and the ExoMars Project Team

Mission Objectives

- **Main Technology Demonstration Objectives:**
  - Entry, Descent and Landing (EDL) of a large payload on the surface of Mars;
  - Surface mobility via a Rover having several kilometres of mobility range;
  - Access to sub-surface via a Drill to acquire samples down to 2 metres;
  - Automatic sample preparation and distribution for analyses of scientific instruments.

- **Main Scientific Objectives (in order of priority):**
  - To search for signs of past and present life on Mars;
  - To characterise the water/geochemical environment as a function of depth in the shallow subsurface;
  - To study the surface environment and identify hazards to future human missions;
  - To investigate the planet's subsurface and deep interior to better understand the evolution and habitability of Mars

Enhanced Baseline Overview

Launcher

Prime

or

Back-up

Spacecraft Composite

Descent Module

Carrier Module

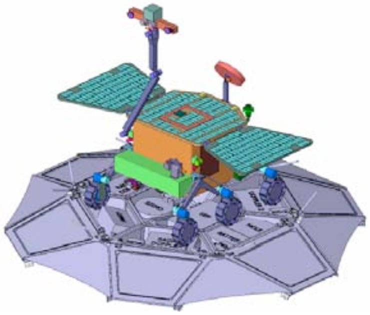
Data Relay

NASA DSN

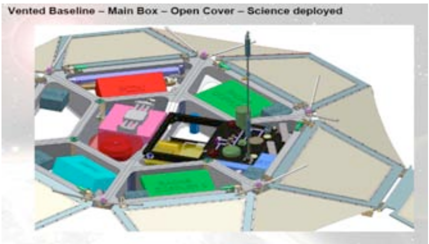
Phobos-Grunt (TBC)

ESA DSN

Payload Elements



ExoMars Rover Module with Pasteur Payload



Lander with Geophysics and Environmental Payload

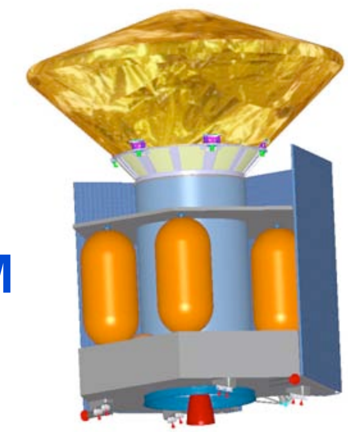
Spacecraft Composite

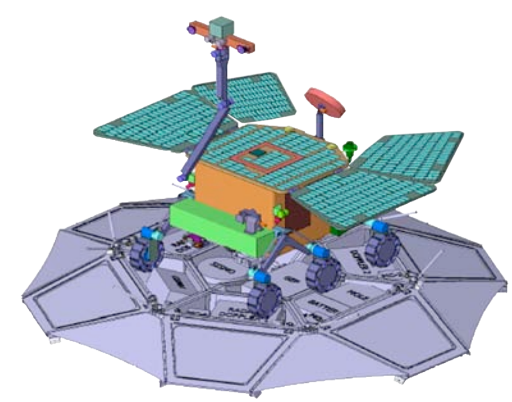
- **Launched by Ariane 5 ECA, in Nov-Dec 2013, into interplanetary transfer (T2) trajectory, arrival Sept 2014**
  - **Mission design shall be compatible with the back-up launch date in Jan 2016**

- **Consists of large Carrier Module and large (1.2 tons) Descent Module with Vented Airbags technology**

- **DM released from Mars parking orbit to avoid Global Dust Storm Season. Landing accuracy: 100 km (target 50 km) -3 sigma**

- **DMC contains Lander with Rover Module**
  - **Rover Module (RM) has ~ 16.5 Kg of Pasteur Payload (PPL) Instruments**
  - **Lander carries about 8.5 kg Humboldt Payload Instruments**

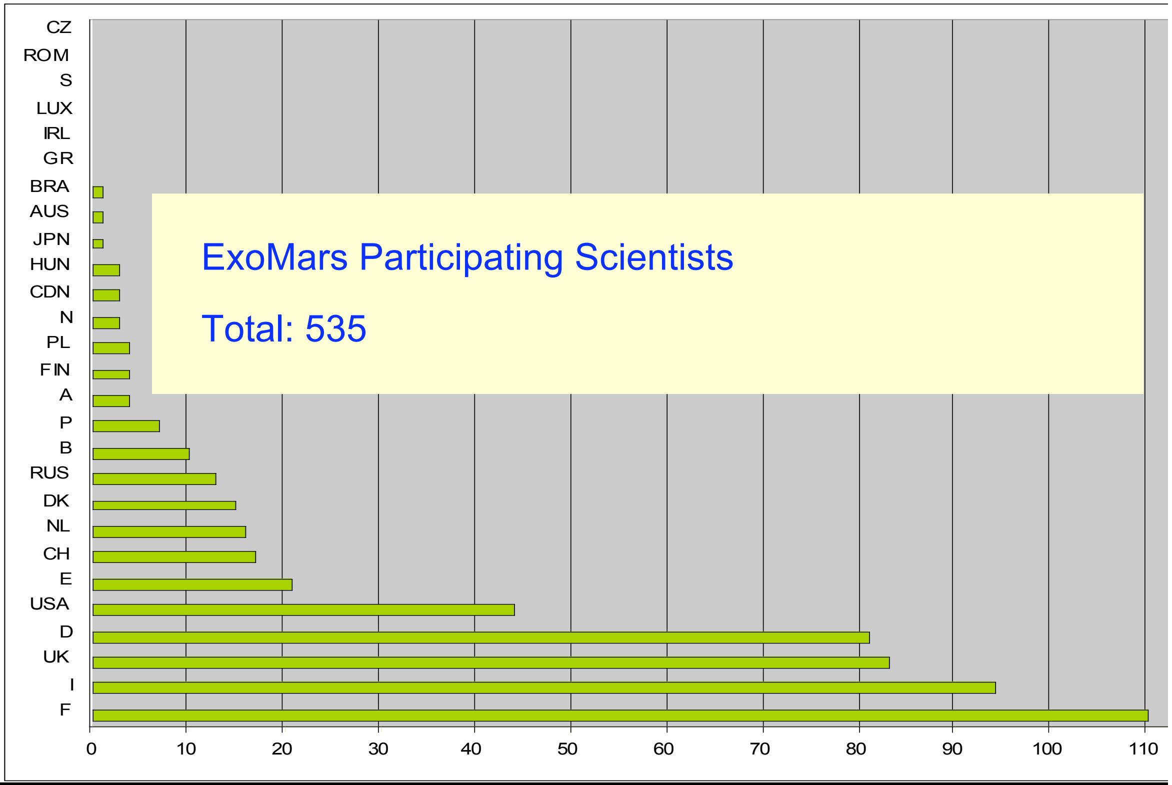




Lander and Rover

- The Enhanced ExoMars mission flies 23 instruments
  - **Rover: Pasteur Payload = 12 instruments**
  - **Lander: Humboldt Payload = 11 instruments**

- Instruments are funded by national agencies similar to Science approach



United States

- ESA – NASA Mars Program Interface:
  - Mars Proximity Communications using NASA orbiters
  - Provision of instruments in Pasteur Payload
  - Other technical exchanges
  - Letter of Agreement approved by ESA and NASA

Russia

- ESA– Roscosmos Interface:
  - Science cooperation with Phobos-Grunt
  - RHU support for procurement in Russia
  - Communications support with Phobos-Grunt from ESA stations
  - Possibility of Mars Proximity Communications using Phobos-Grunt
  - Proton support to secure back-up launcher
  - ExoMars & Phobos-Grunt Cooperation Agreement approved by ESA and awaiting Roscosmos approval anticipated in June 08

- **Major Achievements in 2007 - 2008**
  - Phase B2/C/D/E1 industrial proposal submission in October and evaluation completed 20 December 2007
  - Programme Board limited authority to use 80 Meuro for Phase B2 and activities necessary to maintain 2013 launch while awaiting C-Min decision.
  - Baseline Consolidation Review successfully closed the pending System Requirements Review establishing technical baseline
    - Successful testing of Vented Airbags proving a critical enabling technology for ExoMars
    - Manufacturing of breadboards for drill, and sampling system with first tests
  - IPC approval to proceed with Phase B2 and Advanced C/D procurements to maintain 2013 launch date
  - Phase B2 and Advanced C/D activities start in Feb. 08

Current Activities

- Final Negotiations with ExoMars industrial team for Phase B2 and Advanc C/D contract
- Planning for allocation of the advanced C/D activities balancing available resources with need to maintain 2013 launch date
- Preparation for industrial and system PDR
- Commitment Confirmation submission to ESA in September 08
- Ministerial Council 2008 in November for final approval
- System PDR by end 2008

- **Future Milestones**
  - Phase B2 PDRs for Prime Contractor through 2008
    - Maximum of 1 year to complete Agency level PDR
  - Commitment Confirmation of total mission cost in September 2008 by industry to ESA as input to C-Min
  - Council of Ministers Nov 2008
    - Confirmation of new mission envelope increase to ~ 1 billion euros
      - i.e. industrial costs (incl. rover operation), launcher, spacecraft & p/l operations, ESA, etc
  - Phase C/D start by 1 April 2009 latest, pending positive outcome of the Ministerial Conference
  - Launch 2013

Mission Schedule