# European Manned Space Projects

## and related Technology Development

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# European Projects - Overview










# European Projects - Overview









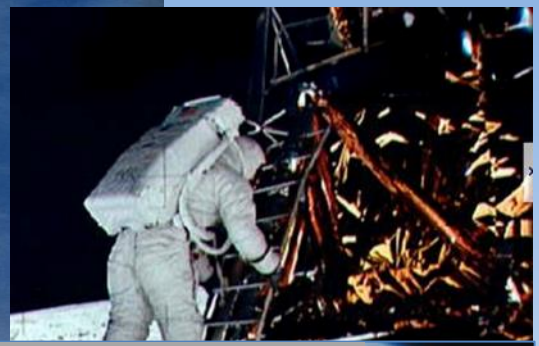

# V. Braun-Origin of the US manned Space Program

Werner v. Braun and his team in Huntsville

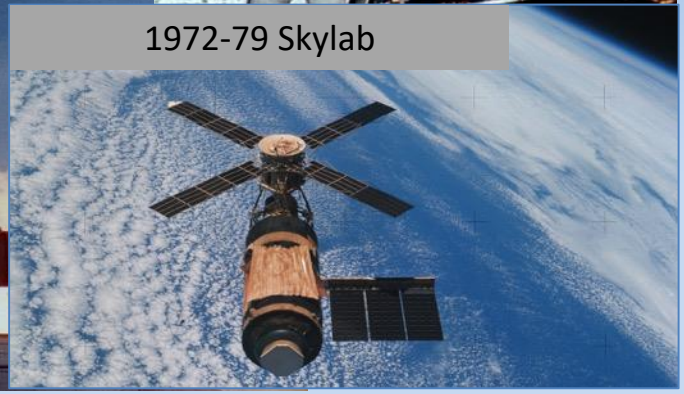
1967 in front of Saturn 5

1969 1st launch of men to the moon

1969-72 On the Moon



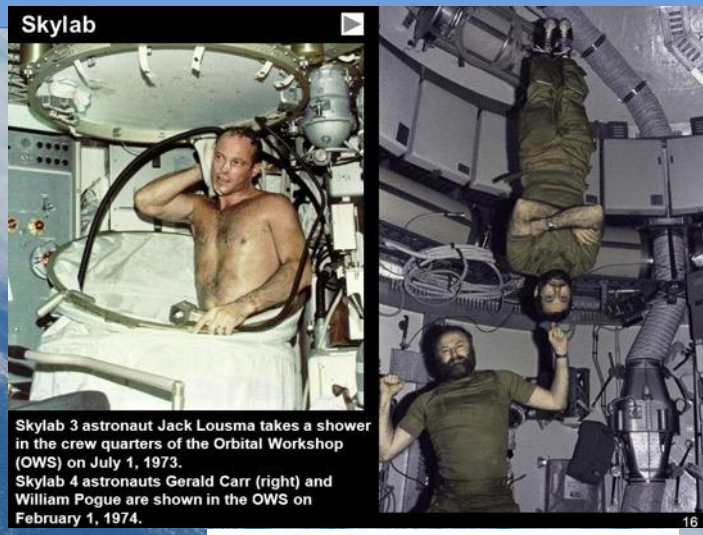
1972-79 Skylab

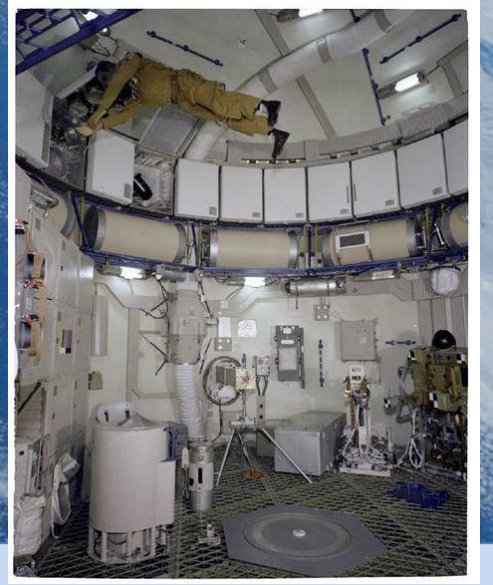


# Skylab – the largest Space Habitat so far

## Hundreds of scientific experiments with European Participation

- Use of left-over Saturn 5 and Saturn 1B
- 2 launches (Saturn 5 and Saturn 1B)

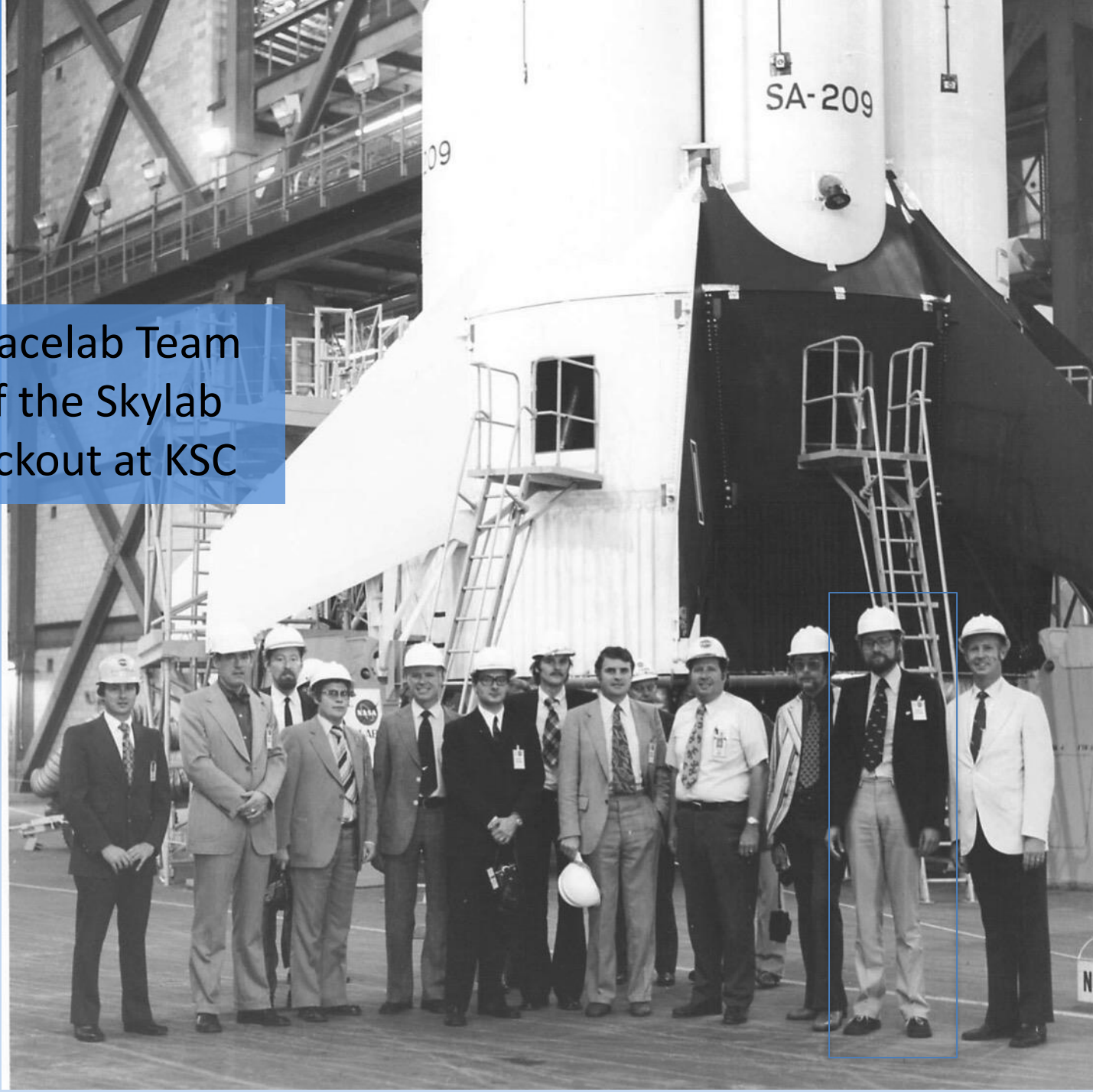


Use of Saturn 1B as habitat

Damaged during launch
- 2nd solar array torn of
- Micrometeorite protection (repaired)

ESA/Industry Spacelab Team 1973 in front of the Skylab during final checkout at KSC

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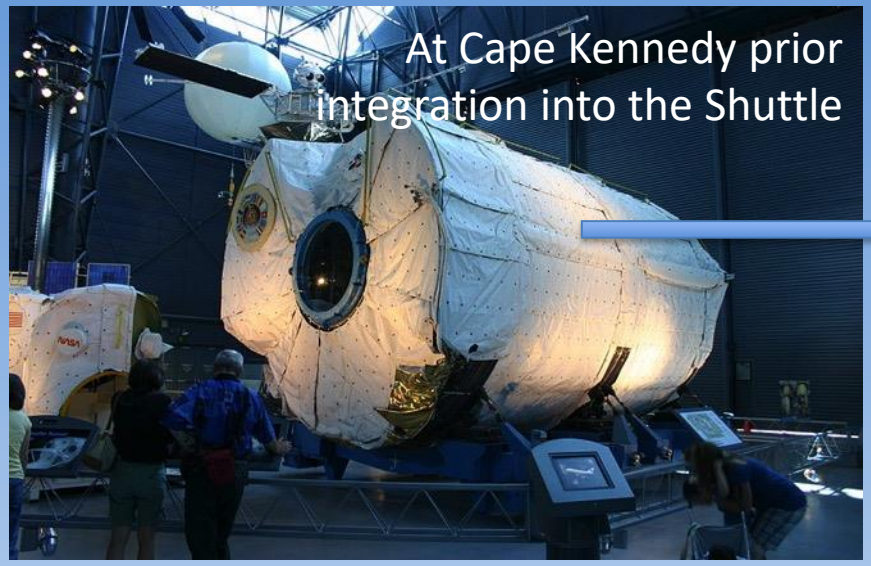
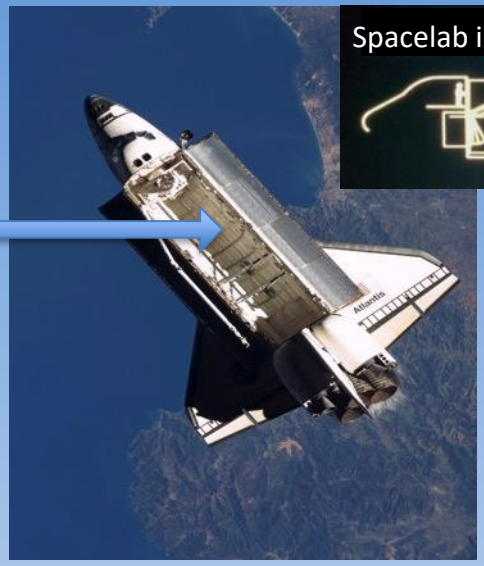
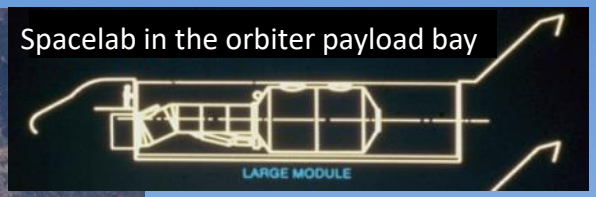
# Spacelab - Europe in the Shuttle Program







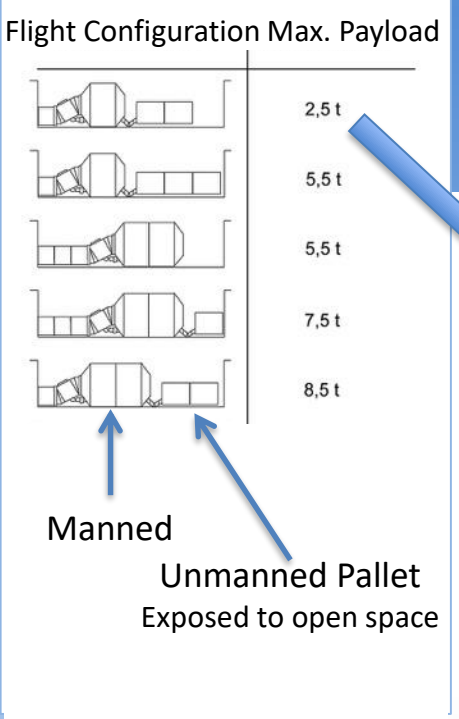
- Main Shuttle payload
  - 22 manned missions 1983-1989
- Developed 1974-81
- 2nd SPACELAB: Direct NASA contract
- Participation of 10 countries
- Scientific research in micro-gravity
- More than 100 different scientific experiment racks/drawers

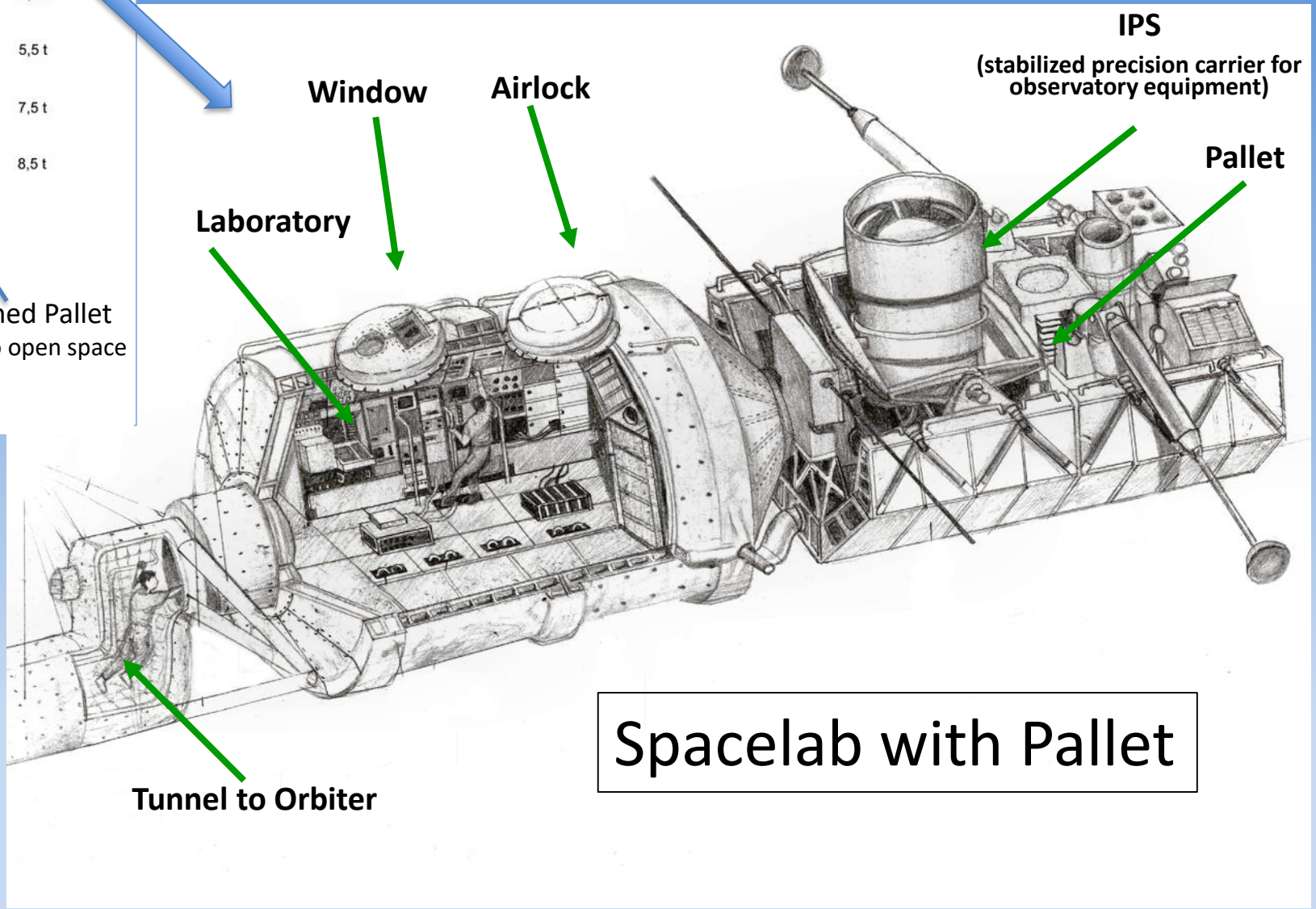
# Microgravity Science on SPACELAB

1. Material Sciences
   - Better and new materials
2. Biology and Biotechnology
   - Progress in protein research
3. Human medicine
   - Better knowledge of diseases
   - Better medicaments
4. Astronomy
   - Free sight outside the Earth‘s atmosphere
5. Plants
   - Better knowledge on growth and diseases


SPACELAB was the „Blueprint“ for the ISS for
- Life in the microgravity environment
- Laboratory construction
- Microgravity research

# Spacelab Configurations




Spacelab with Pallet

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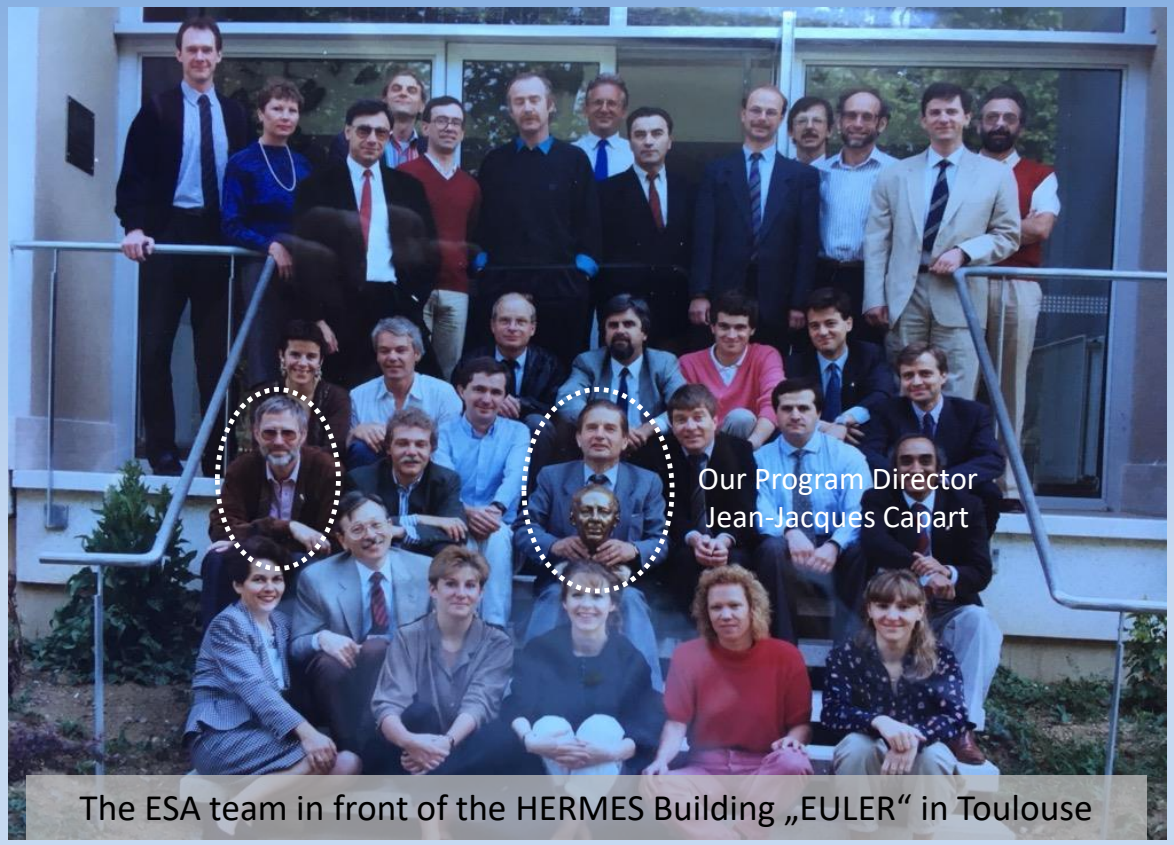
# HERMES Spaceplane Program

## Manned Space Transport for Europe

# Joint ESA/CNES Program Management

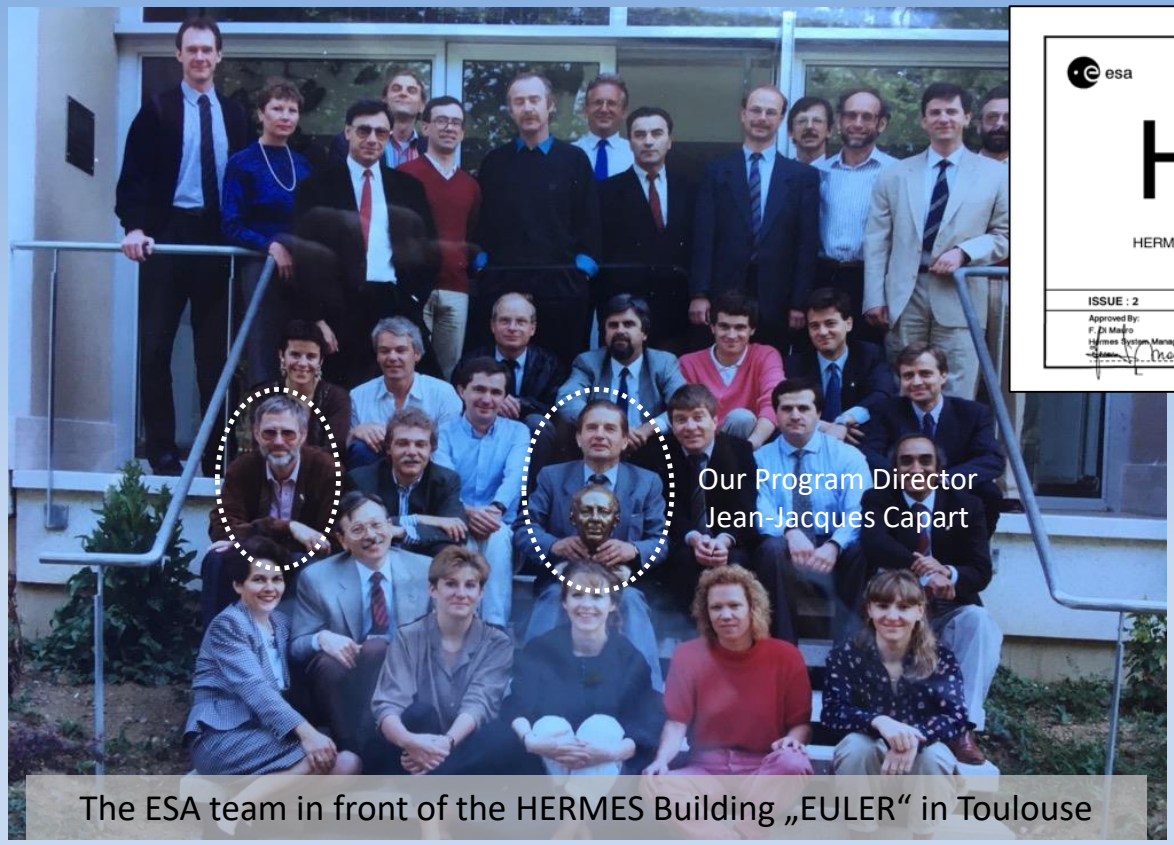
- ESA team introduces manned system experience




The ESA team in front of the HERMES Building „EULER“ in Toulouse

# Joint ESA/CNES Program Management

- ESA team introduces manned system design experience
- Establishment and control of HERMES system requirements

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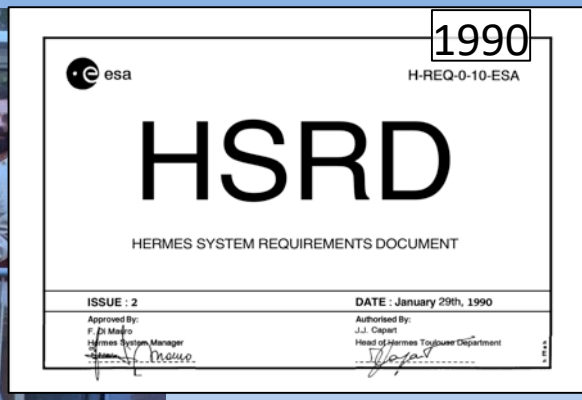

1990

esa

H-REQ-0-10-ESA

HSRD

HERMES SYSTEM REQUIREMENTS DOCUMENT

ISSUE : 2

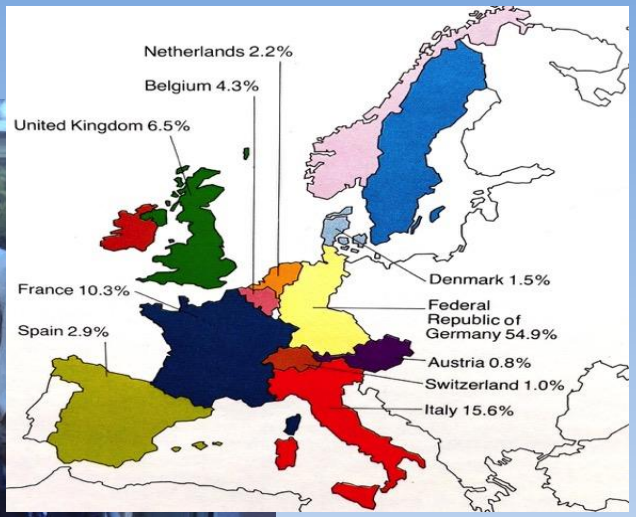
DATE : January 29th, 1990

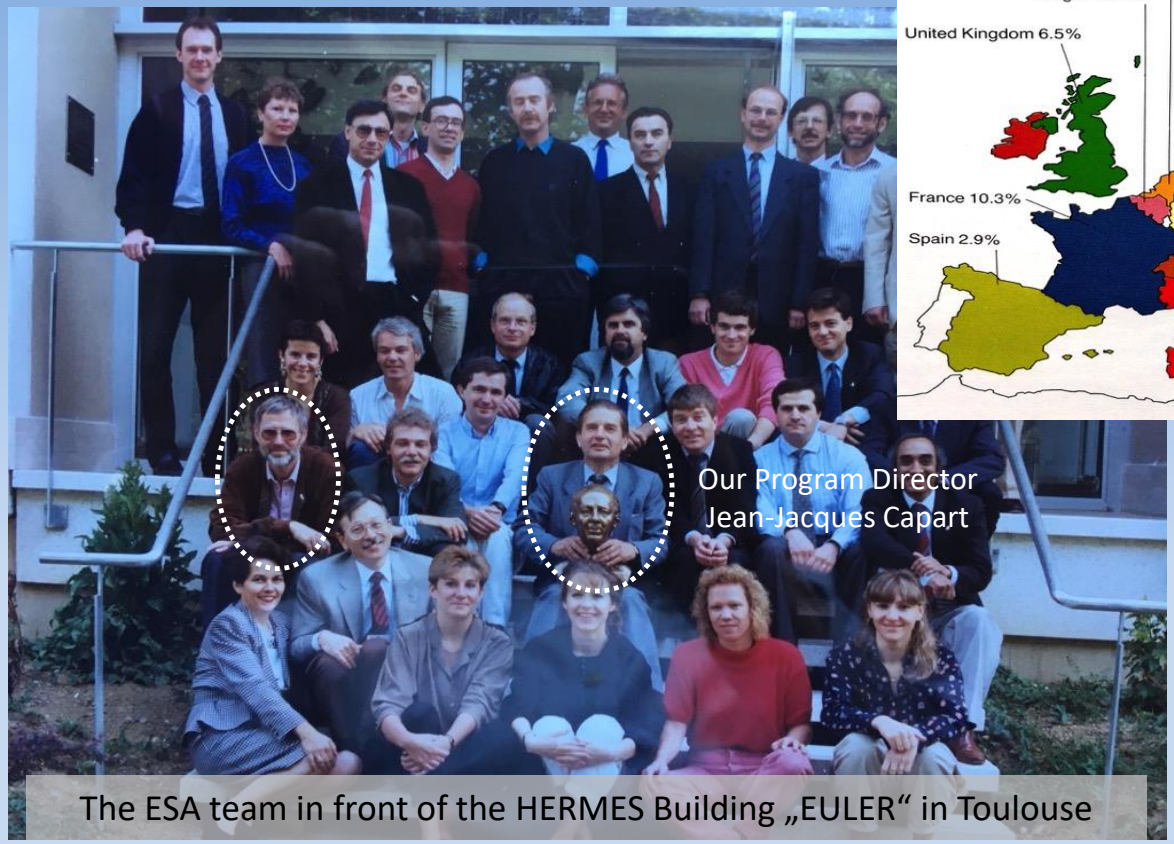
Approved By:
F. Di Mauro
Hermes System Manager

Authorised By:
J.J. Capart
Head of Hermes Toulouse Department

# Joint ESA/CNES Program Management

- ESA team introduces manned system design experience
- Establishment and control of HERMES system requirements
- Establishment, conclusion and control of contracts in 10 countries

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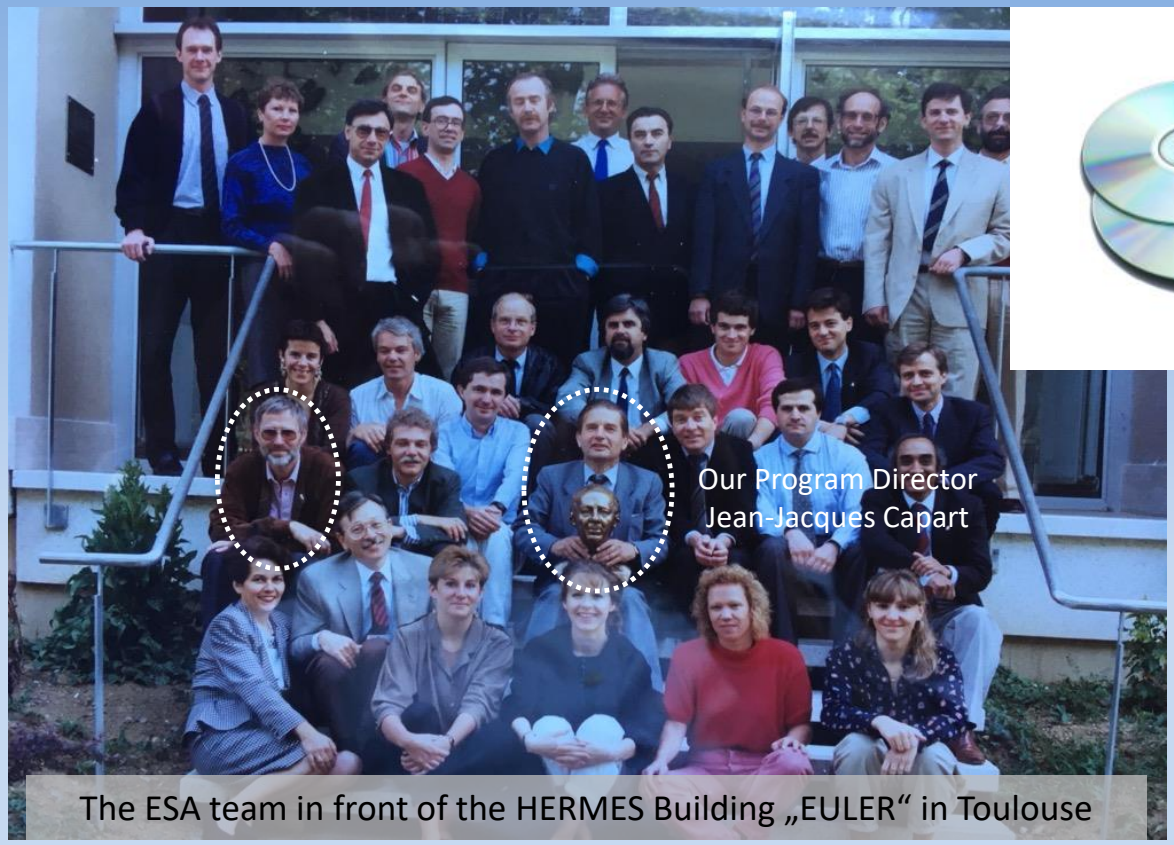
# Joint ESA/CNES Program Management

- ESA team introduces manned system design experience
- Establishment and control of HERMES system requirements
- Establishment, conclusion and control of contracts in 10 countries
- Program results documented 1993 on more than 40 CD‘s




The ESA team in front of the HERMES Building „EULER“ in Toulouse

# HERMES Spaceplane - 1986

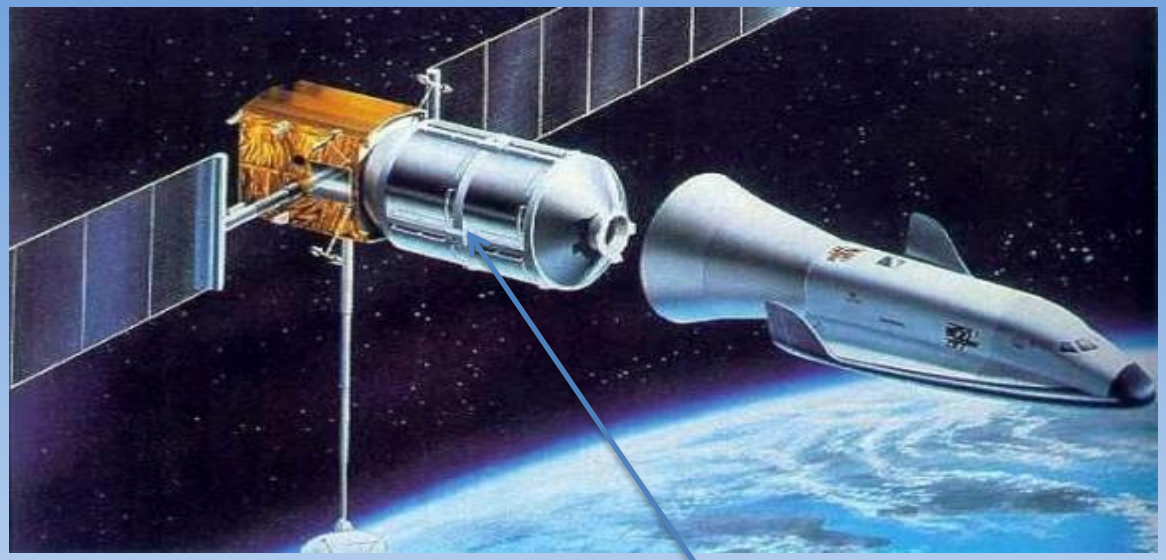

- Fully reusable
- 15 t
- > 3 t payload up and down
- 1 week mission duration

# HERMES Spaceplane - 1986

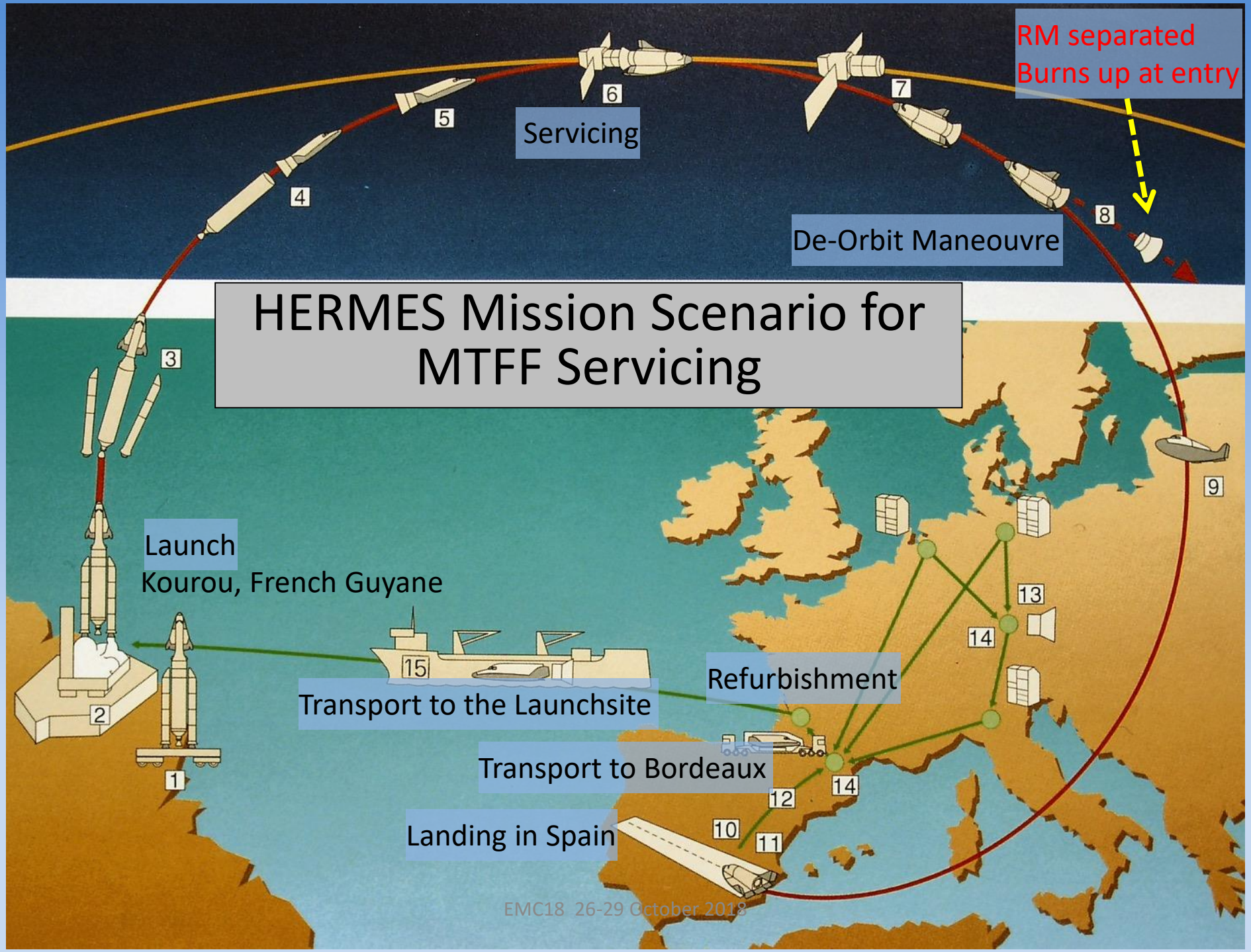

- Launch with Ariane 5
- Landing on dedicated airport

# HERMES Mission - 1986

Servicing the European laboratory MTFF



Derived from SPACELAB


RM separated
Burns up at entry
Servicing
De-Orbit Maneouvre
HERMES Mission Scenario for MTFF Servicing
Launch
Kourou, French Guyane
Transport to the Launchsite
Refurbishment
Transport to Bordeaux
Landing in Spain
1
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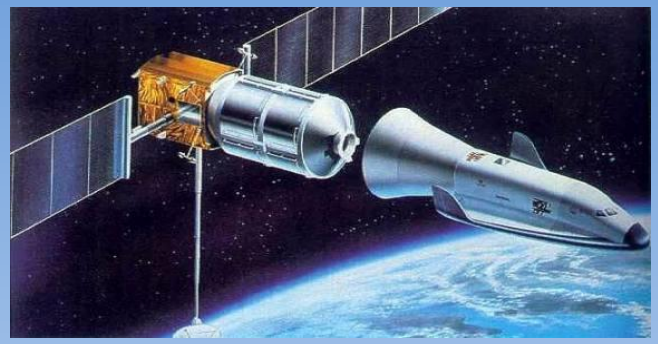
15

# HERMES Spaceplane - 1992

## Largely extended mission requirements



MTFF Servicing

\+

ISS Servicing

\+

MIR Servicing

\+

EURECA Servicing

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- Alternative landing sites
- 3000 km crossrange
- Mission duration up to 4 weeks

# HERMES Spaceplane - 1992

## Adaptation of HERMES Configuration

Additional „Resource Module“


- Partially reusable
  - 8 t of equipment in the Resource Module
  - Resource Module lost at entry
- 23 t
- 3 t payload up and 1.5 t down

# Why a Resource Module ?


Aerodynamic lateral load during ascent

- Lateral force destabilizes the launcher
- Maximum allowable wing area = 86 m2

- Maximum spaceplane mass for 86 m2 wing area = 15 t *

* Determined by HERMES entry and landing conditions

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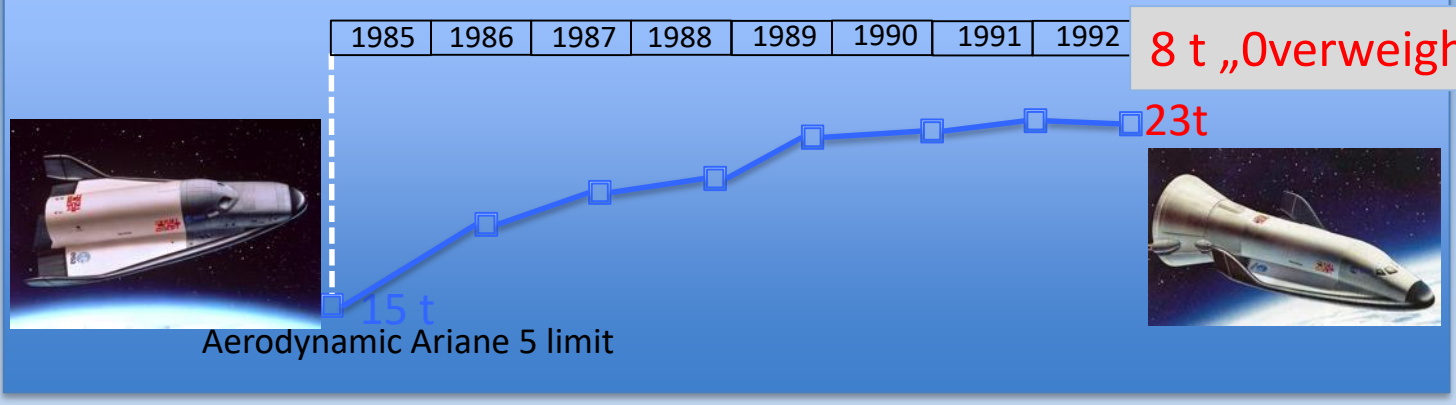
Mass increase between 1985 and 1992



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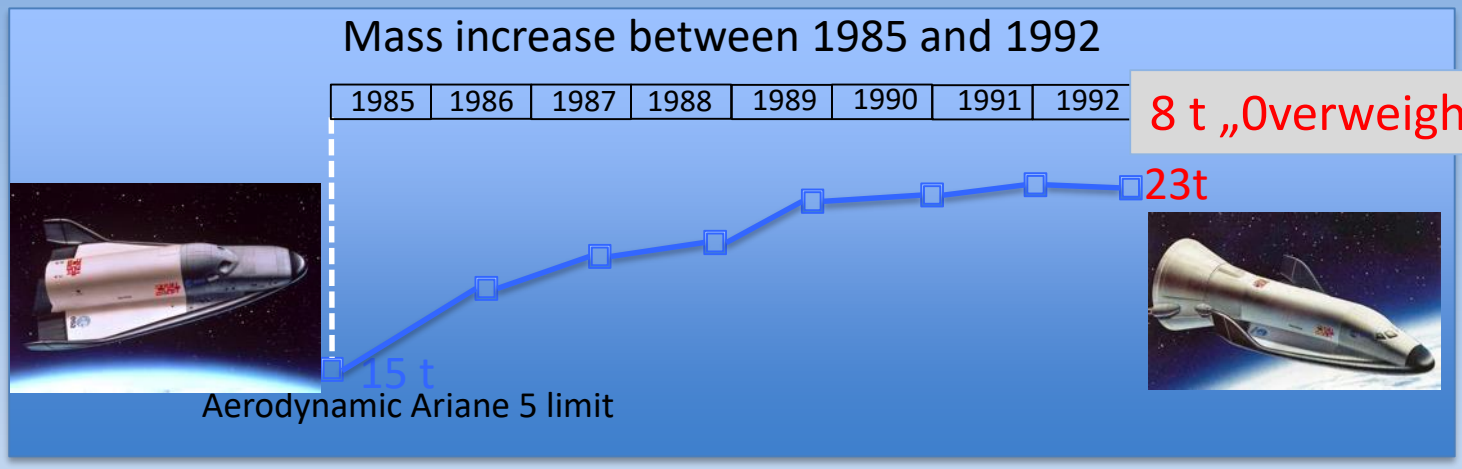
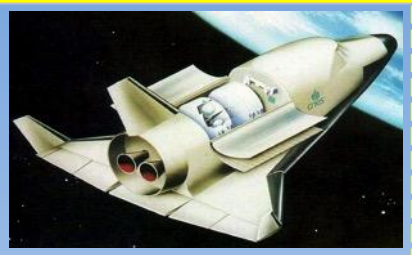



- 8 t of HERMES mass to be transferred to the Resource Module
  - Orbit injection propulsion system
  - Equipment no more needed for entry and landing after Resource Module separation

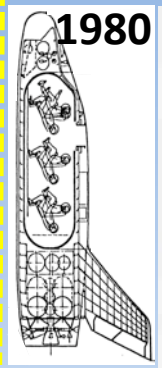
# HERMES Program Evolution 1980-1995

1980 — 1985 — 1992

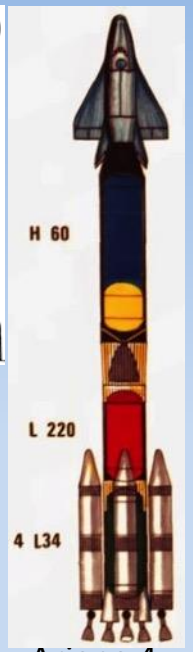
CNES/French Industry Studies | ESA/CNES Development Program



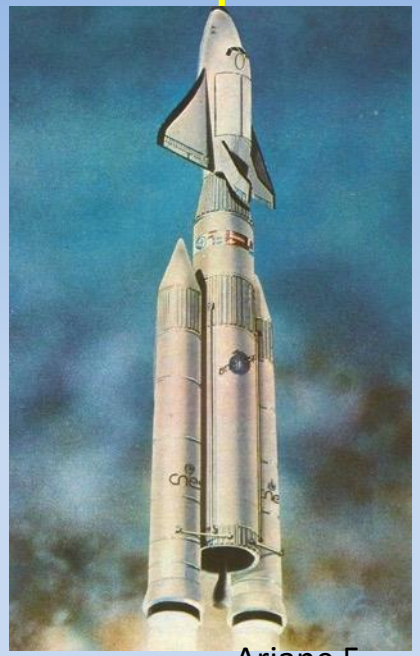
1983



1980




Ariane 4



Ariane 5

# HERMES Program Evolution 1980-1995

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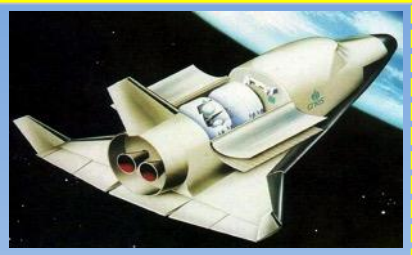

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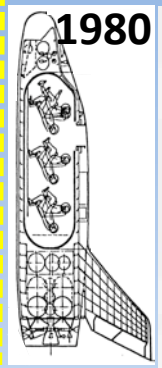

1980


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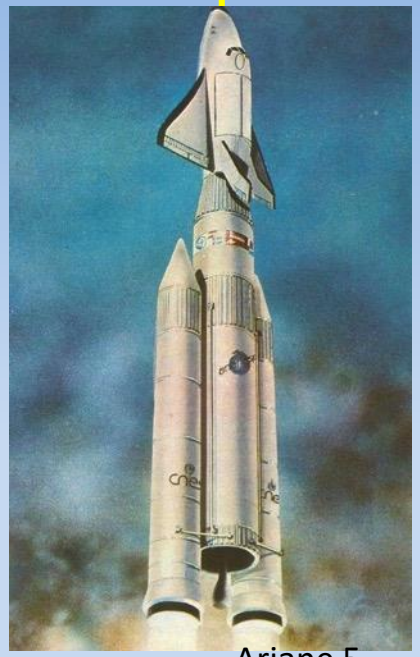

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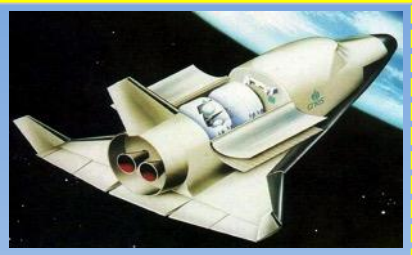

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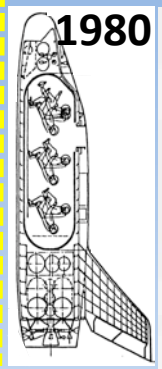


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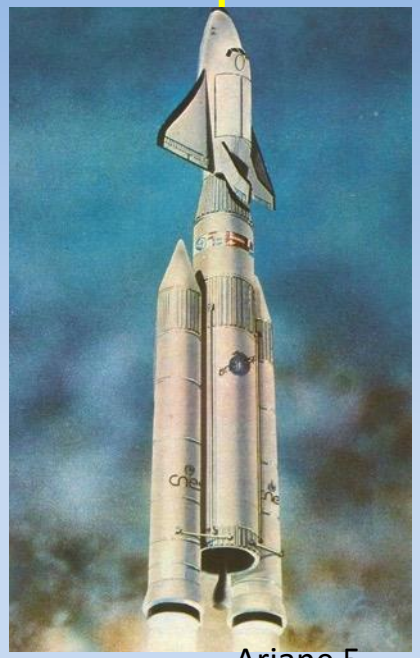

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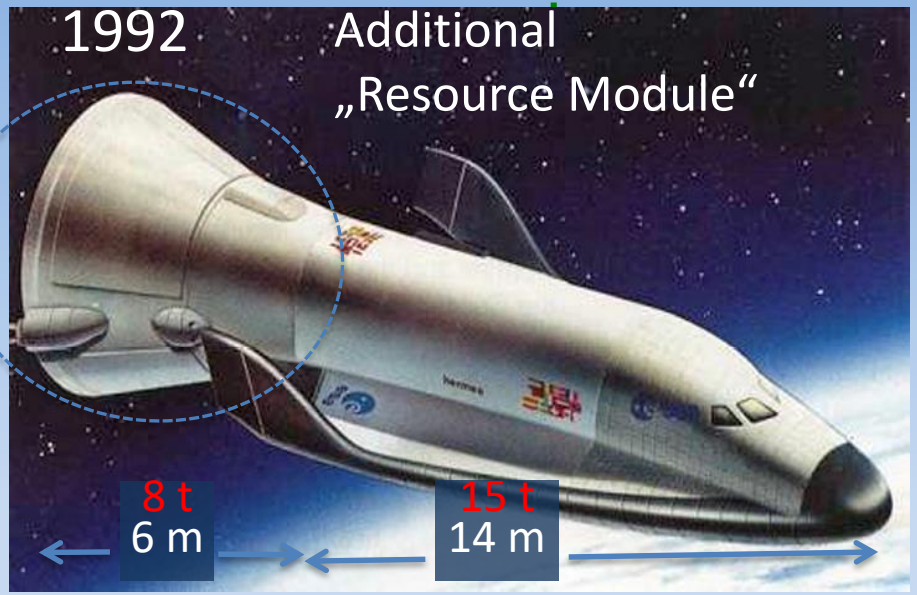


# HERMES Program Evolution

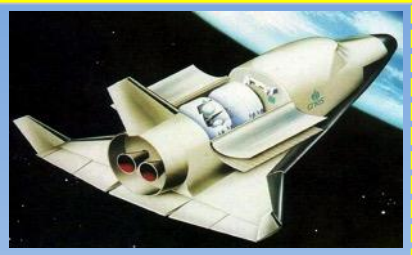
70 different configurations analyzed

Development Program terminated
Continuation with Technology Program

ESA Conference at Ministerial Level

1980 | 1985 | 1992 | 1995

CNES/French Industry Studies | ESA/CNES Development Program | Technology Program



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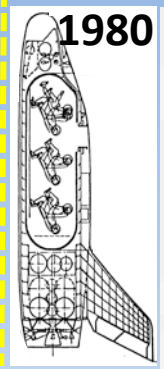

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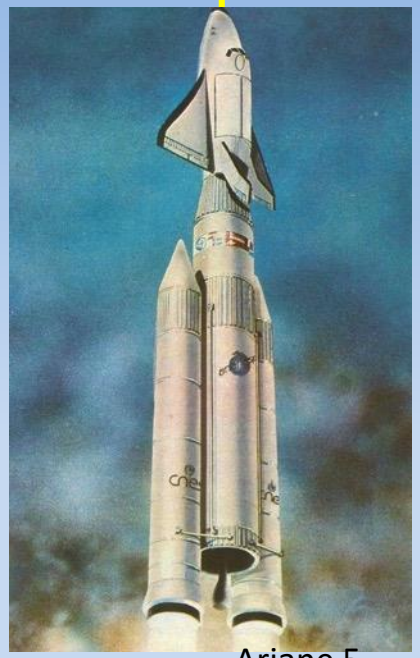

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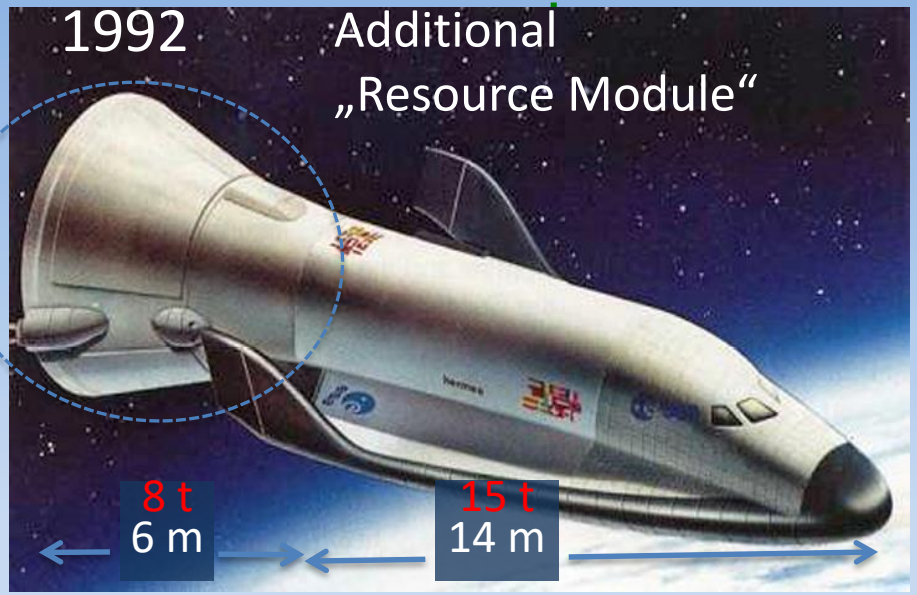
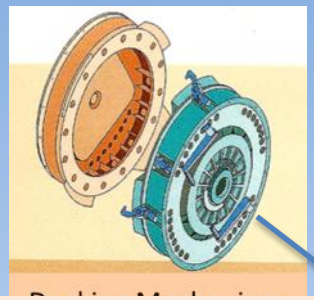


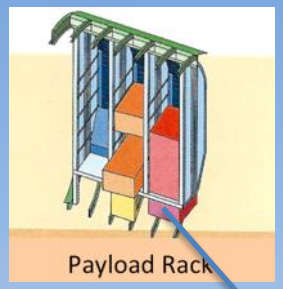
# HERMES Technology Program 1992-95

End of Development program ESA Conference at Ministerial Level

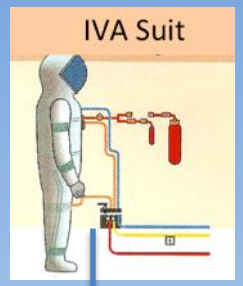
1992 — 1995

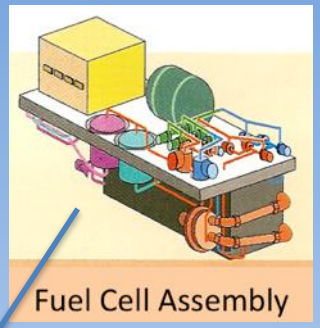
Technology Program

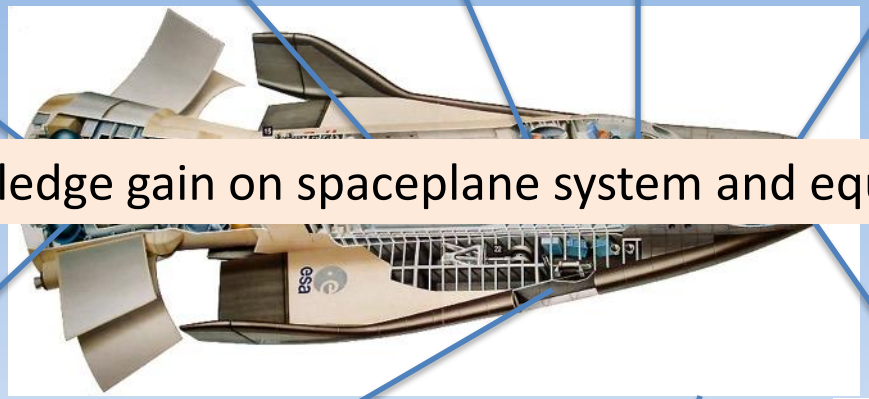






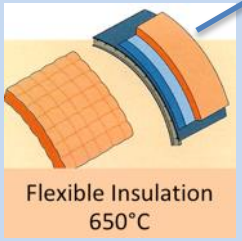


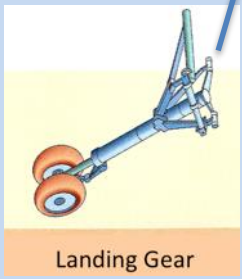



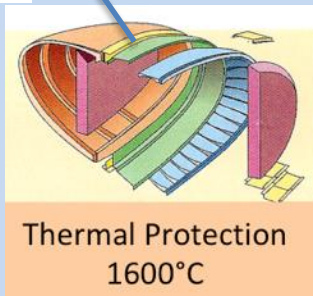



Important knowledge gain on spaceplane system and equipment design

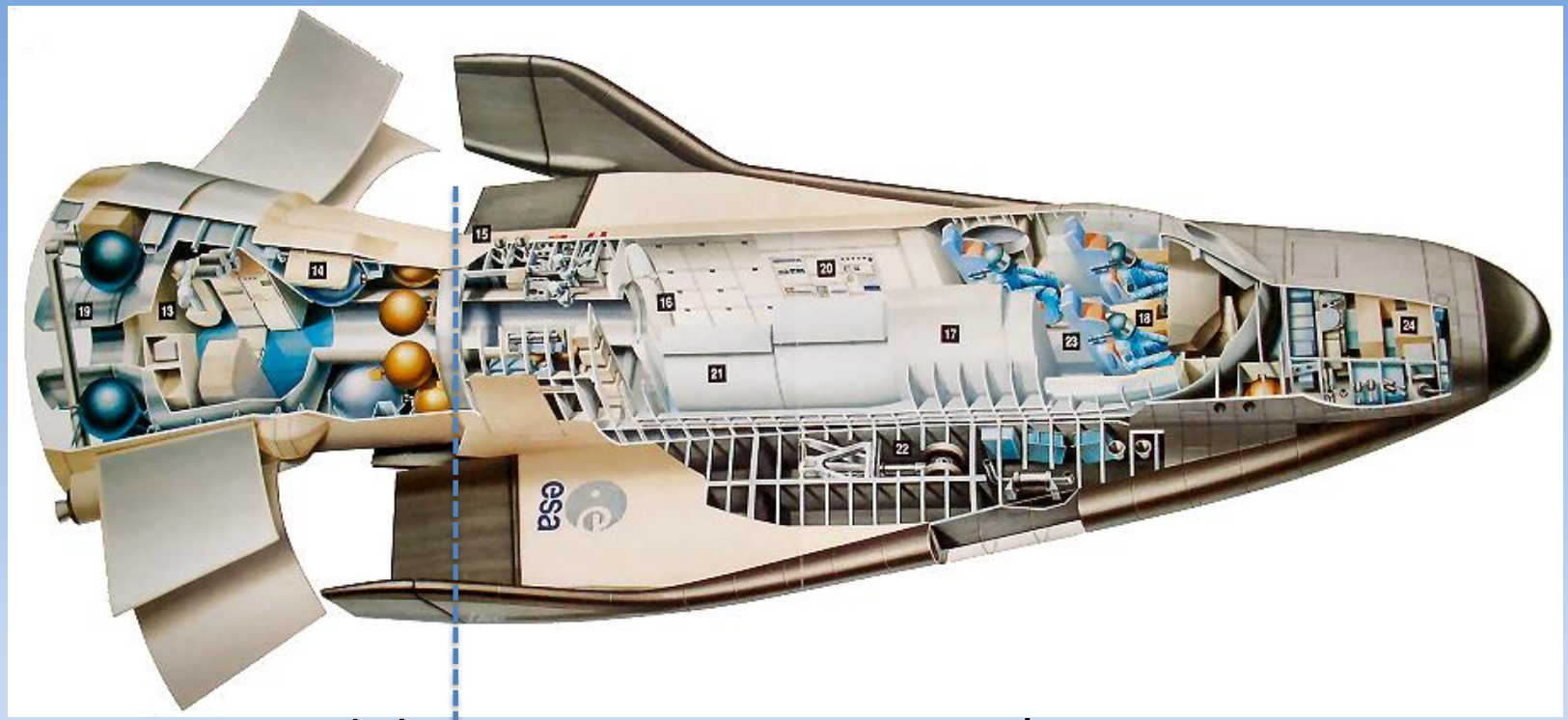




# Final HERMES Configuration



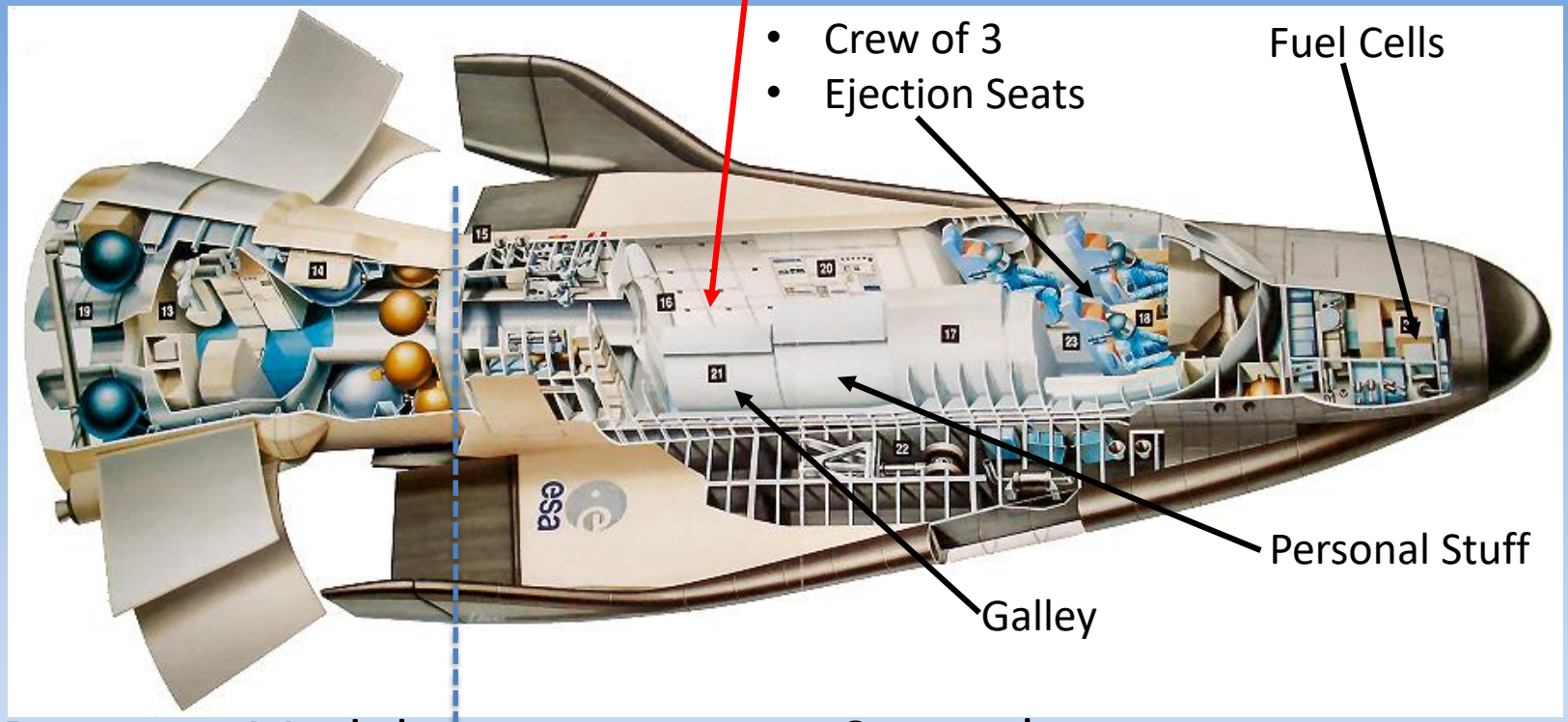

Resource Module

Spaceplane

- Burns in the atmosphere

- Fully reusable 100 times
- 30 missions in 15 years

# Final HERMES Configuration



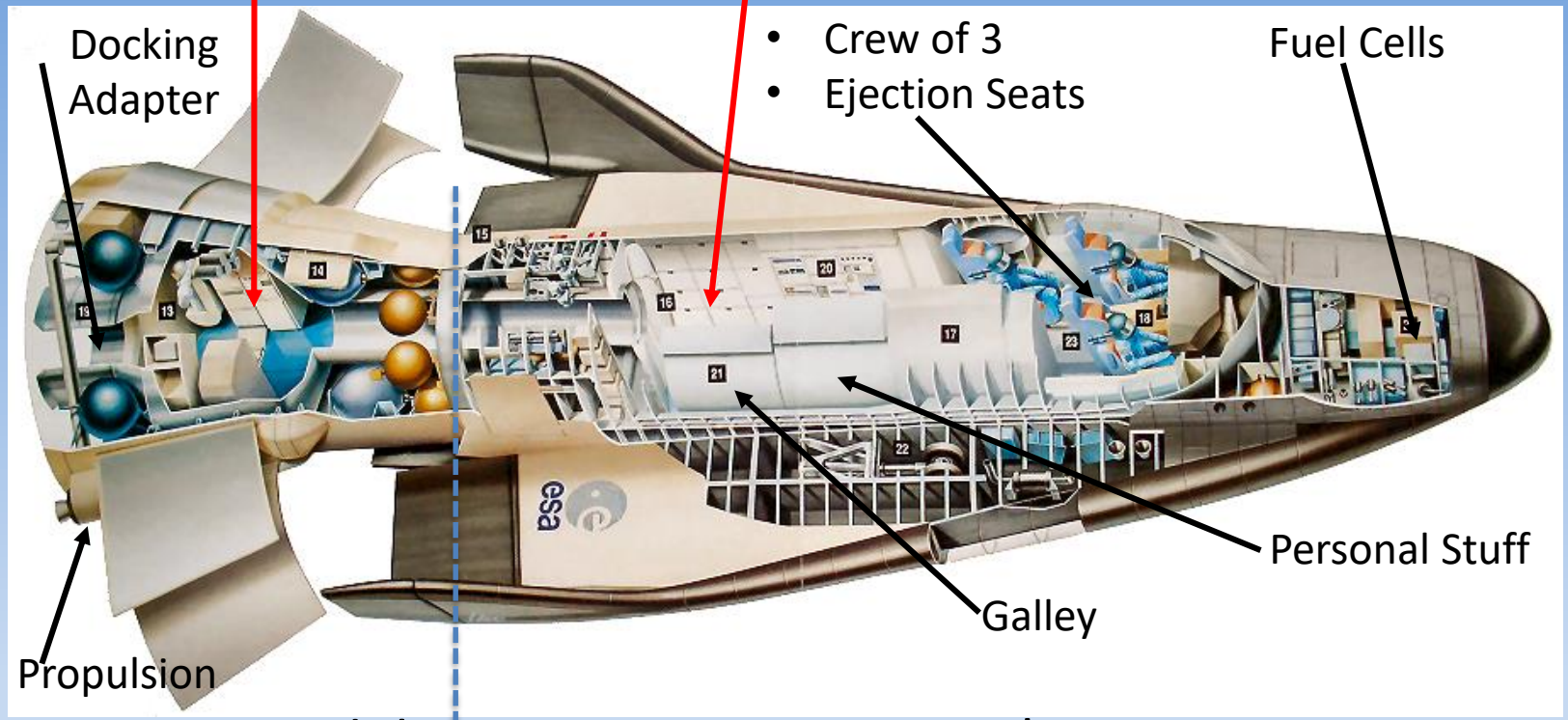

- Burns in the atmosphere

- Fully reusable 100 times
- 30 missions in 15 years

# Final HERMES Configuration

- Up: 1.5 t cargo / experiments
- Down: up to 1.5 t garbage

Up & down: 1.5 t cargo / experiments




- Burns in the atmosphere

- Fully reusable 100 times
- 30 missions in 15 years

# Reasons for HERMES Development Termination

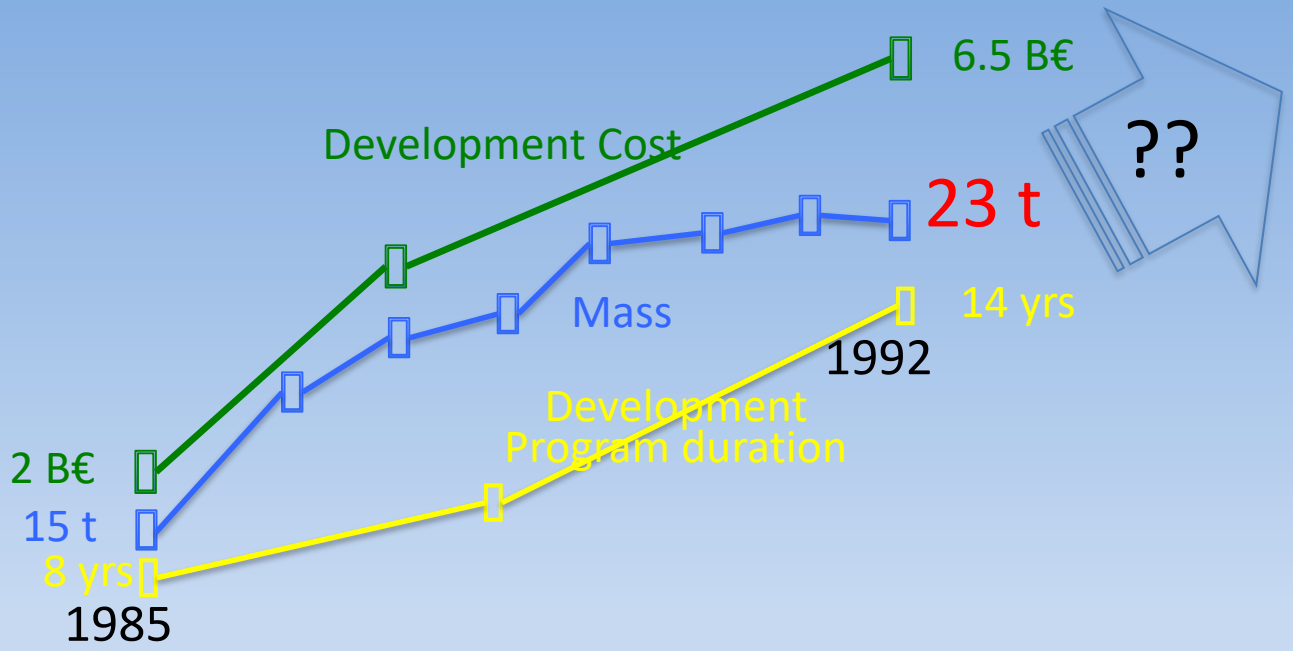
- Political changes 1990-91 (German reunification)

# Reasons for HERMES Development Termination

- Increased program complexity/cost with the „Resource Module“

# Reasons for HERMES Development Termination

- Mass, cost and schedule increase / uncertainty
  - HERMES mass exceeding Ariane 5 capacity



# Evolution of Requirements leading to Mass, Schedule and Cost Increase

- Mission requirements
  - 1985: servicing of the MTFF
  - 1992: Multiple mission scenarios
- Lessons learned
  - Design complexity (e.g. CoG/CoP)
  - Safety requirements
    - Crew Rescue (ejection seats / ejectable cabin)
    - Additional redundancies
- Operations requirements
  - Meeting multiple mission operations requirements
  - Maintainability requirements
  - Access to equipment for inspection and repair

# Why HERMES was important for EUROPE

- Application of existing design and test know-how
  - Windtunnel simulation
  - Aero-Thermodynamics design
  - Thermal protection design
- Gain of expertise for manned systems
  - Design of complete manned on-orbit and ground systems
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HERMES could probably be realized today considering the technical progress since 1985

Example: DREAM CHASER

# Dream Chaser

- ISS servicing
- Unmanned


- 9 m long
- 9 t
- 5 t cargo up / 3t down
- launched on top of a Falcon or Ar5 type rocket under a fairing with foldable wings
- Shall later transport 6 passengers + cargo to the ISS

# Dream Chaser


- ISS servicing
- Unmanned
- Comparison: HERMES
- 9 m long 20 m
- 9 t 23 t
- 5 t cargo up / 3t down 3 t up/1.5 t down
- launched on top of a Falcon or Ar5 type rocket under a fairing with foldable wings
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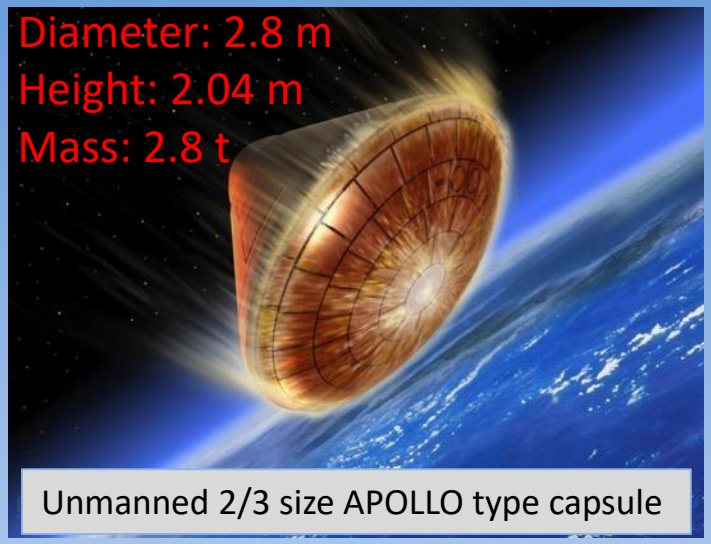
➢ Man-Rating impact on mass / schedule / cost ?

# The Atmospheric Reentry Demonstrator

## Taking Advantage of HERMES Achievements




- „Low Cost“ program
  - Application of commercial, AR5&HERMES design
  - Only 2 years development
  - Total cost < 45 million $

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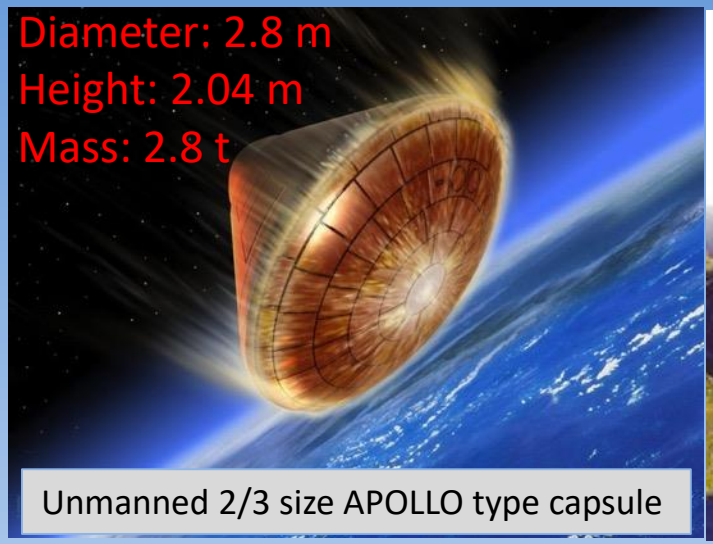



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- 1998: successful mission
  - Launch on Ariane 5
  - Ariane 5 mission control

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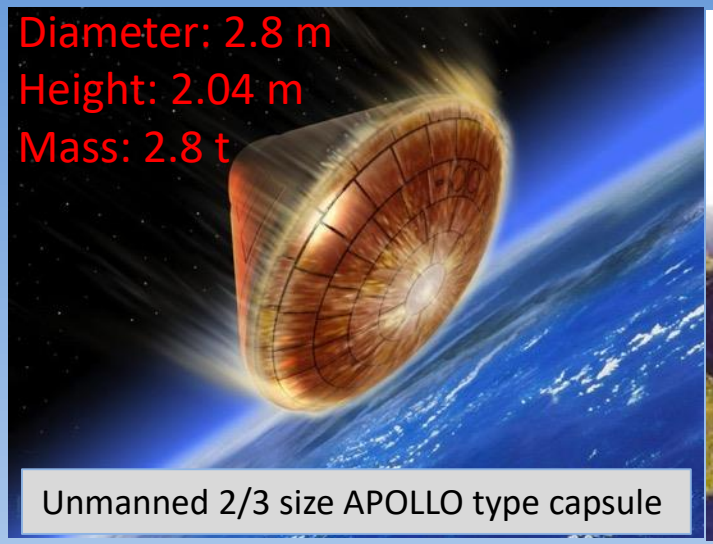


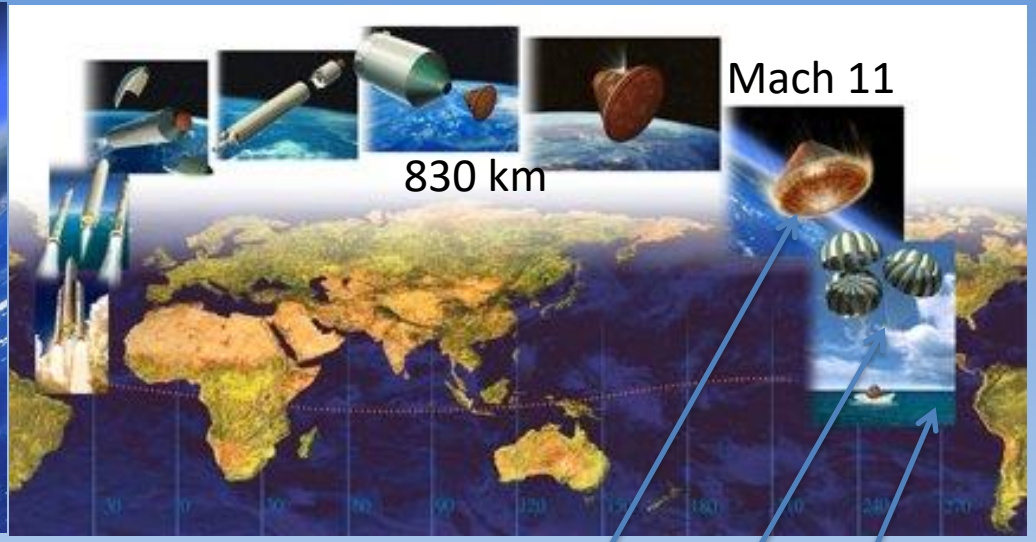


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New for Europe

- Entry
- Parachute System
- Sea recovery

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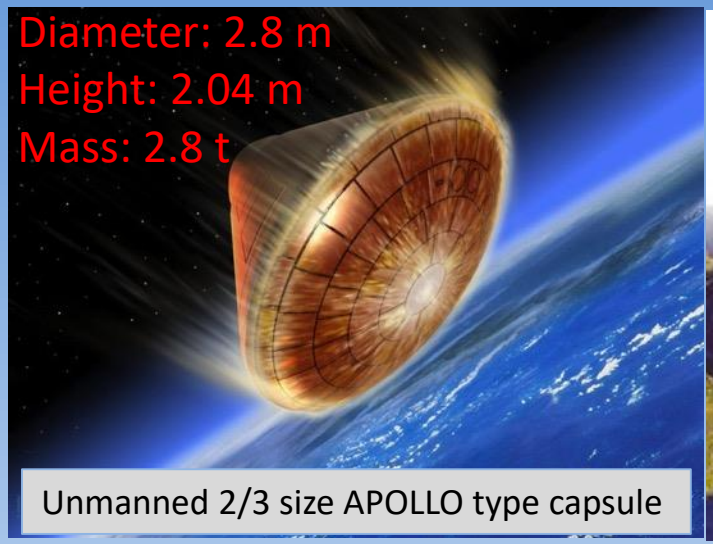


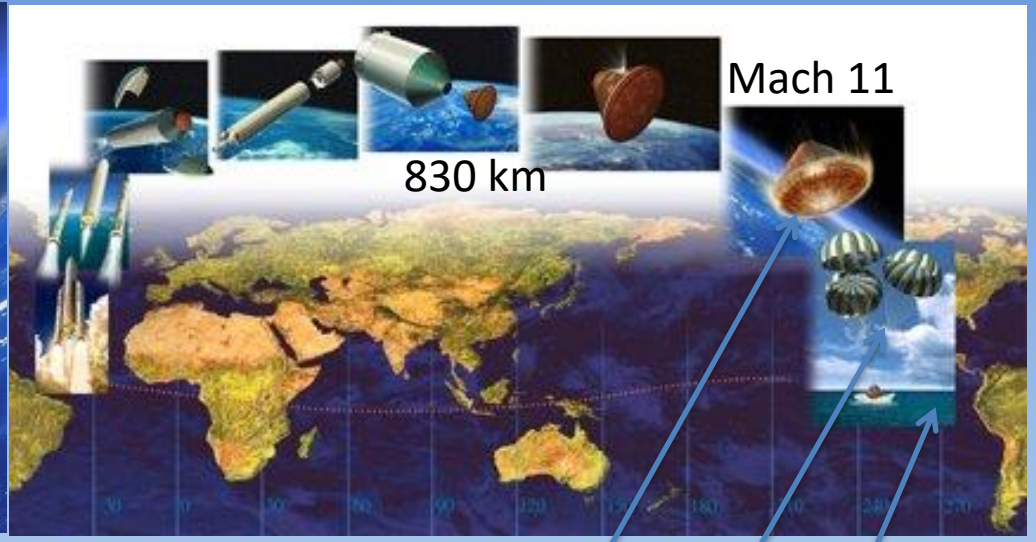


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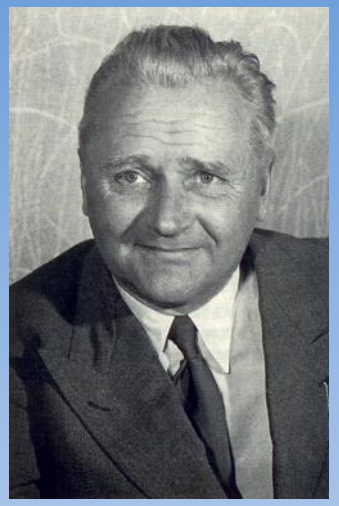
Important knowledge gain on entry and recovery technologies

# Sänger - A Hypersonic Spaceplane

## Study for the German Ministry of Research, 1985-95

2 stages

- Horizontal takeoff and landing on airports
- 1st stage suborbital
- 2d stage into LEO (ISS)
- Lifetime: 100 missions

Eugen Sänger
1905-1964
Space Pioneer

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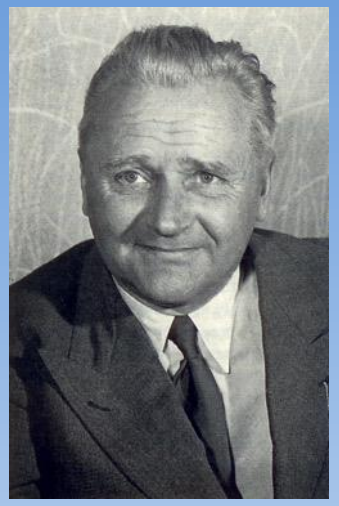

Eugen Sänger
1905-1964
Space Pioneer

- Cost (1992 PB in Mio $)
  - Development: 20.000
  - Production: 500
  - Operations: 20 Mio $ refurb&ops cost at >10 missions/year
- Development time: 15 years

# Various Flight Configurations

1st stage

- Passenger Transport
  - Up to 135 passengers over 16.000 km
  - Mass: 260 t

or

- Booster for 2nd stage

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- Passenger Transport
  - Up to 135 passengers over 16.000 km
  - Mass: 260 t

or

- Booster for 2nd stage

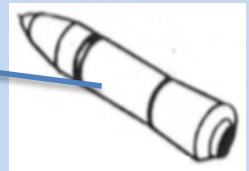
2nd stage

Transport into ISS orbit

- 7 passengers + 7t payload
- Or 20 t cargo
- Mass: ~55 t
- HERMES design heritage

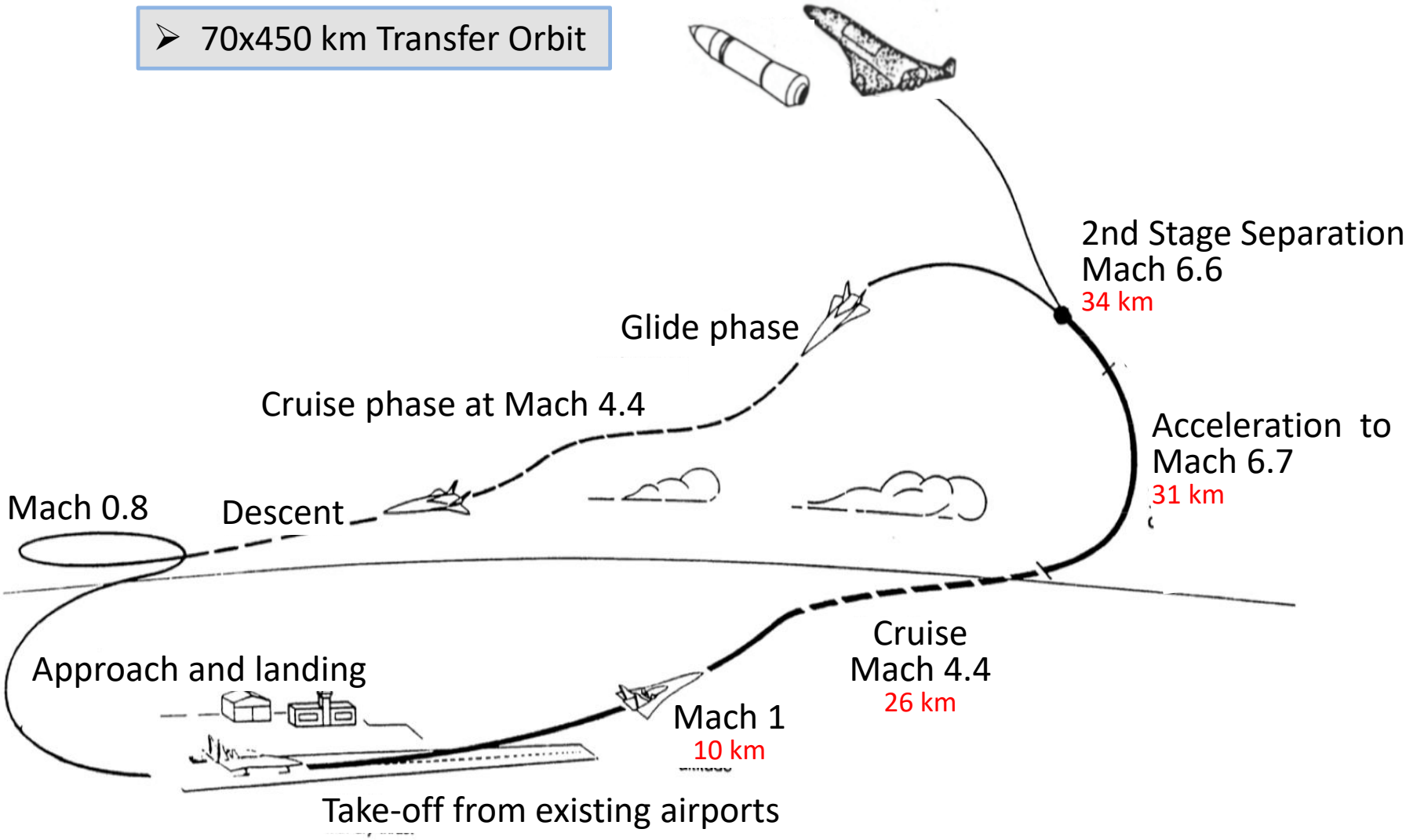
manned

unmanned



# ISS Servicing Scenario

- 70x450 km Transfer Orbit



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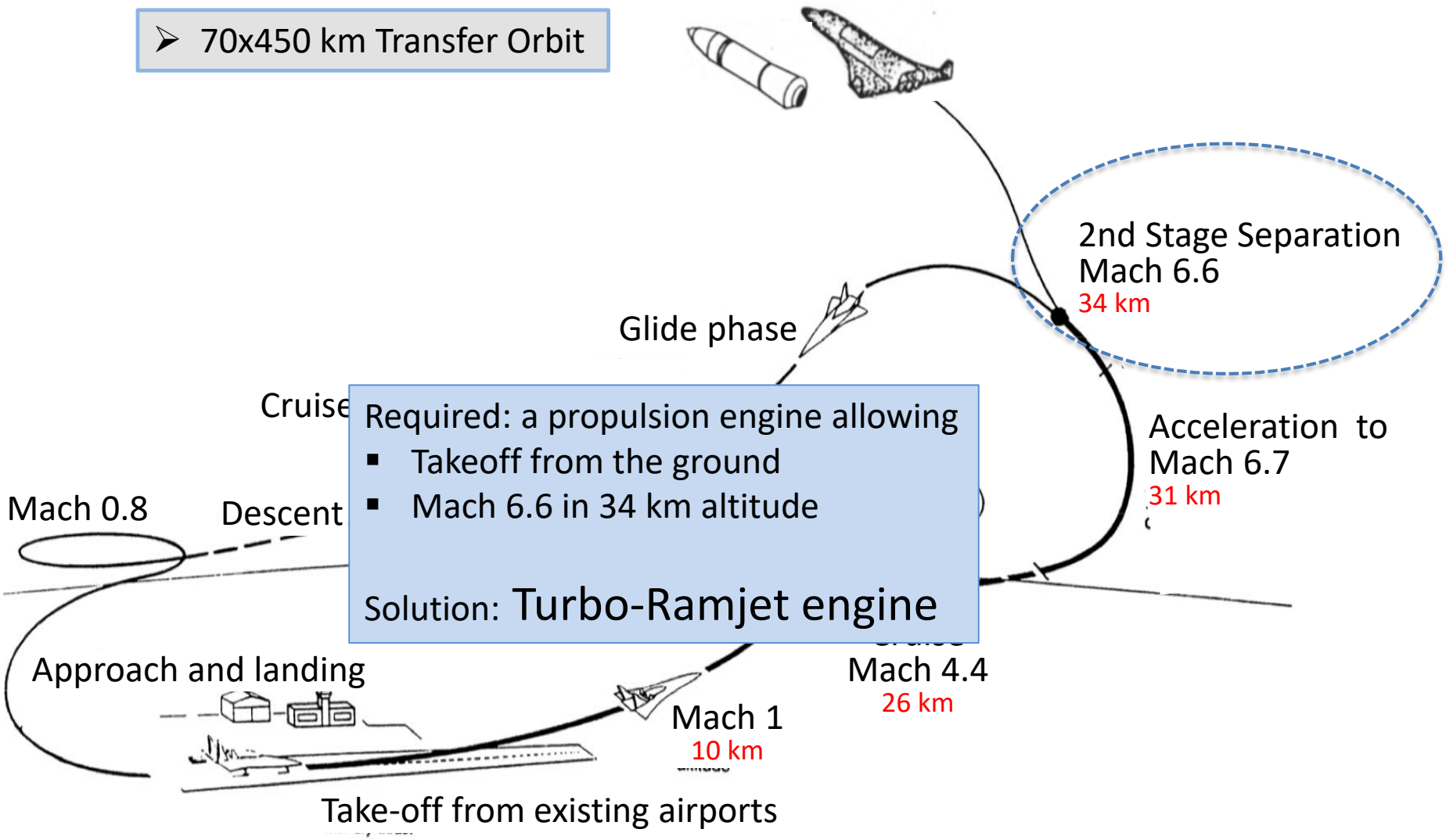

# Turbo Ramjet – From the Ground to Mach 6


Turbo Ramjet: Ramjet plus aircraft-like turboengine

# Sänger Summary

- Development cost estimate (20 B$) based upon completed HERMES development
- Program termination 1992
  - Financial and political situation 1991
  - Cancellation of the HERMES development
  - Limited development cost estimate credibility
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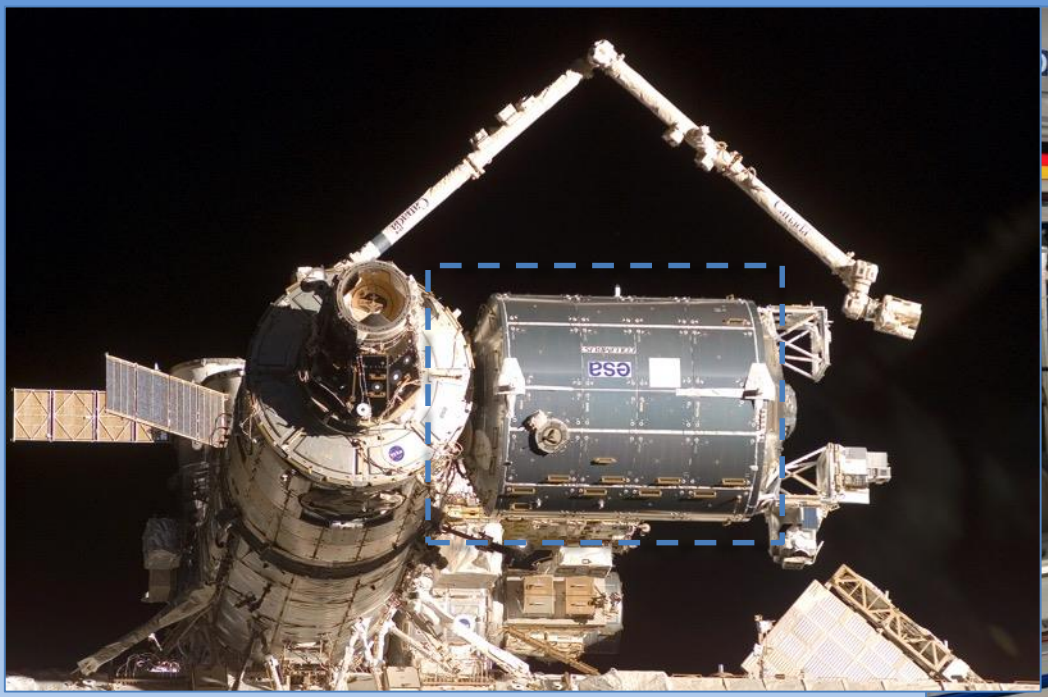
Open areas

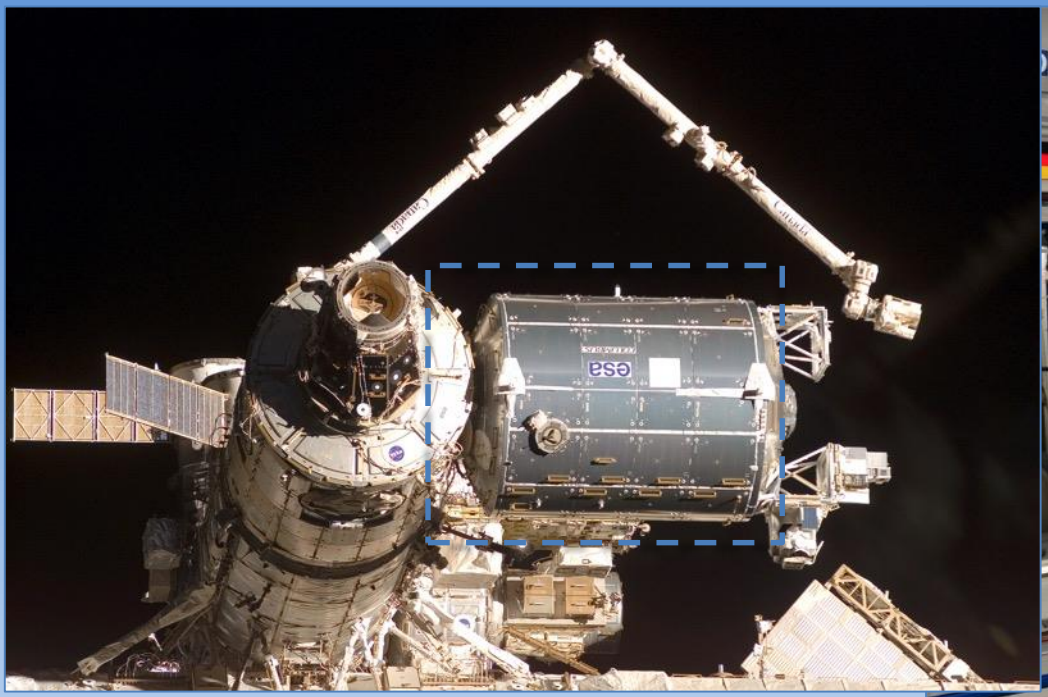
- Development and operations cost estimates ?
- Impact of manned safety requirements ?
  - No passenger rescue in case of catastrophic failure

# COLUMBUS




- 10.3 t launch mass
- Launched 2008 by the Shuttle
- Scientific research laboratory

# COLUMBUS




- Equipped with scientific Payload
- Derived from SPACELAB
  - Construction
  - Scientific Reseach domains

- So far 110 experiment racks/drawers
  - Involving 500 scientists
  - Replaced by the Shuttle

# ATV-Advanced Transport Vehicle

- Launch by Ariane 5
- Launch mass: 20.8 t


5 missions to the ISS 2008-2015

- Supply of the ISS with up to 7.7 t of cargo
  - Food, water, propellant

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End of mission:

- Filled with garbage
- Burned at atmospheric entry

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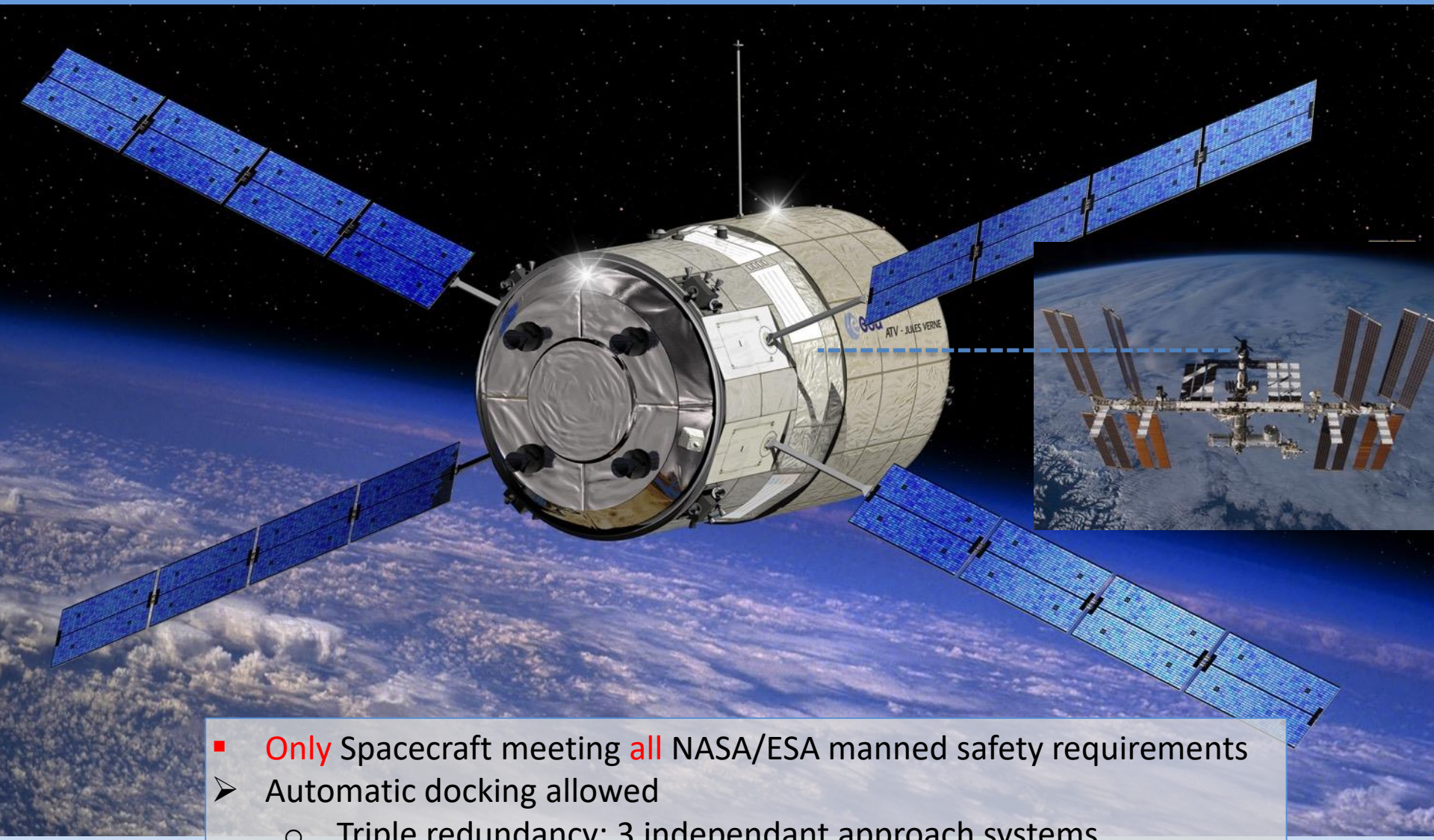
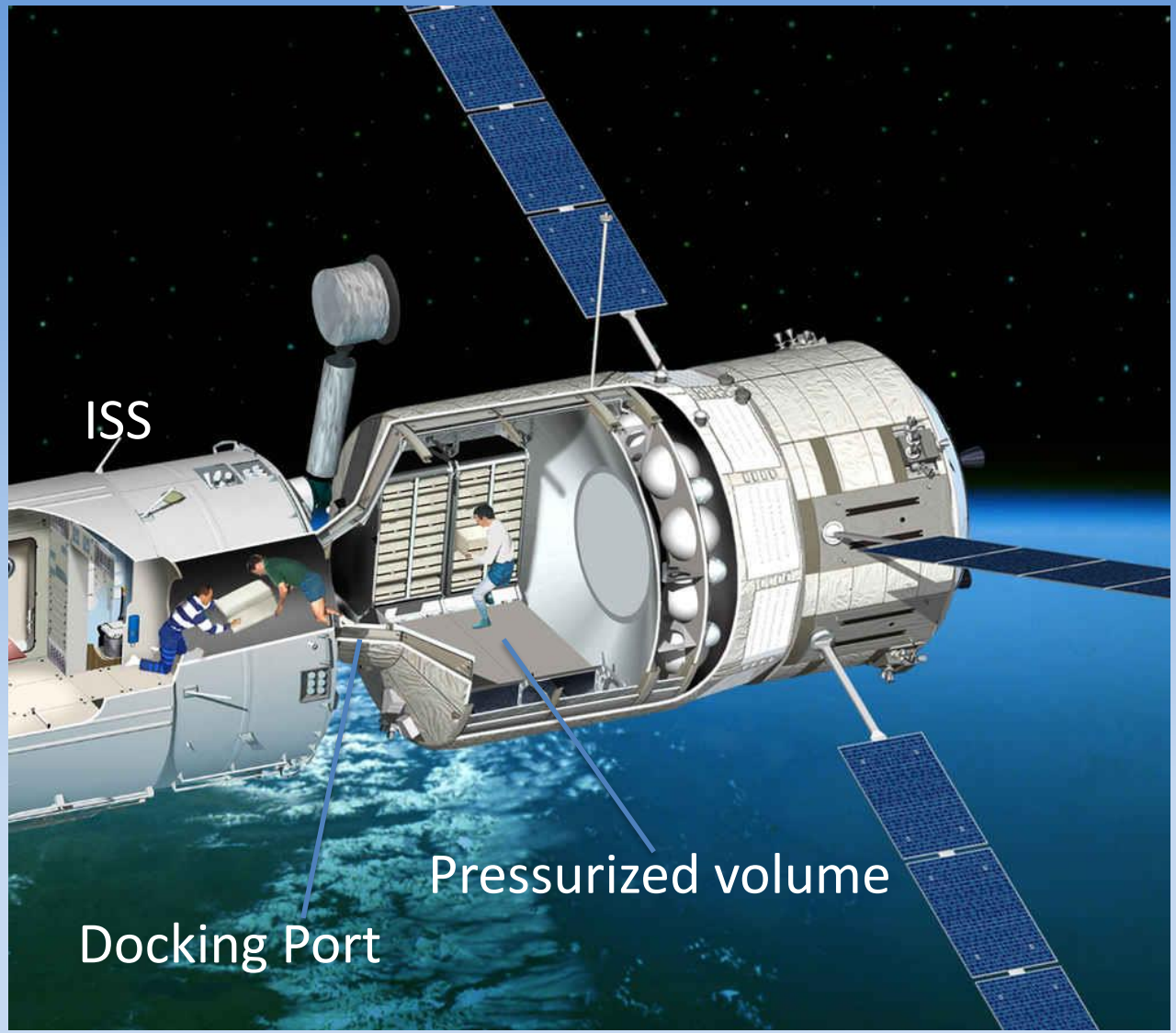



- Only Spacecraft meeting all NASA/ESA manned safety requirements
- Automatic docking allowed
  - Triple redundancy: 3 independant approach systems


ISS
Pressurized volume
Docking Port

# SHEFEX

- Hypersonic research vehicle
  - Developed by the German Space Agency DLR
  - Technology Demonstrator
  - Innovative shape using easy-to-fabricate thermal protection
- Successfuly tested in 2017
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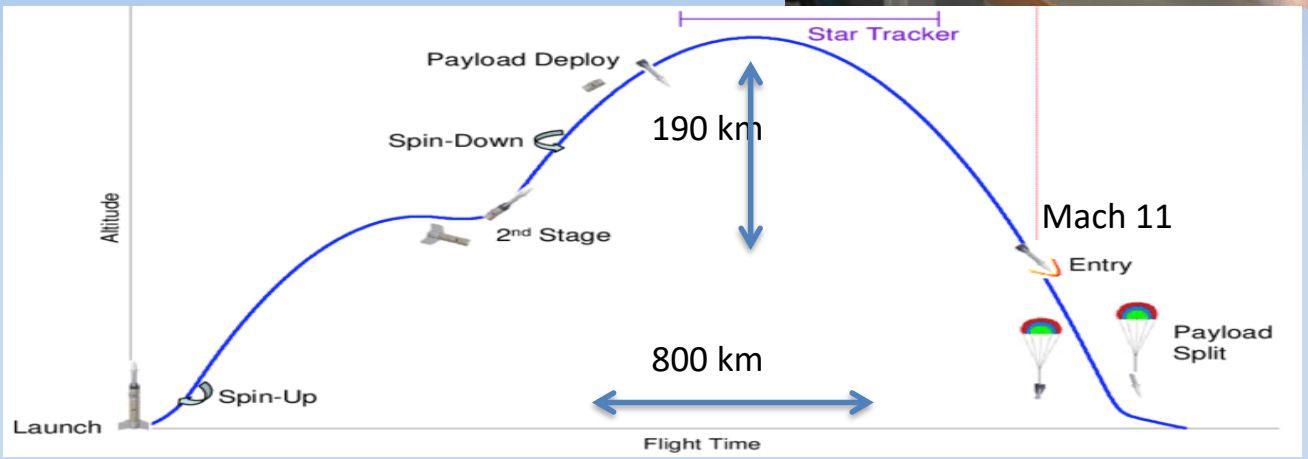

# SPACELINER – Ongoing DLR* Study since 2001

*German Space Agency DLR

- Fully reusable
- Fully rocket driven
  - ➢ Available rocket technology

# SPACELINER – Ongoing DLR* Study since 2001

*German Space Agency DLR

- 1 st stage
  - Return to launch site and horizontal or vertical landing (tbd)

# SPACELINER – Ongoing DLR* Study since 2001

*German Space Agency DLR

- 2nd stage
  - ~100 passengers from Europe to Australia in less than 2 hours
  - Or 30 t to LEO (ISS orbit)
  - Landing on airports
  - Passenger rescue with ejectable cabin

# SPACELINER – Ongoing DLR* Study since 2001

*German Space Agency DLR

- Annual workshops on design progress

# SPACELINER – Ongoing DLR* Study since 2001

*German Space Agency DLR

- Main challenges
  - Safety standard: commercial air transport
  - Ejectable cabin design
  - Launch and landing sites and procedures

# SKYLON (UK)

SSTO (Single-Stage-To-Orbit) spaceplane studied since 1981

7-8 ton payload from normal airport into low Earth orbit

- Turbo-Ramjet plus rocket in a single engine

# SKYLON (UK)

SSTO (Single-Stage-To-Orbit) spaceplane studied since 1981


- To date no breakthrough in key technologies
- Payload capacity too limited for passenger transport
  - ➢ Low flight frequency = high operations cost

# European Service Module (ESM) for ORION

around the moon in 2020

- European contribution to the ORION Program providing
  - Propulsion
  - Thermal Control
  - Power
  - Consumables
- Based on ATV

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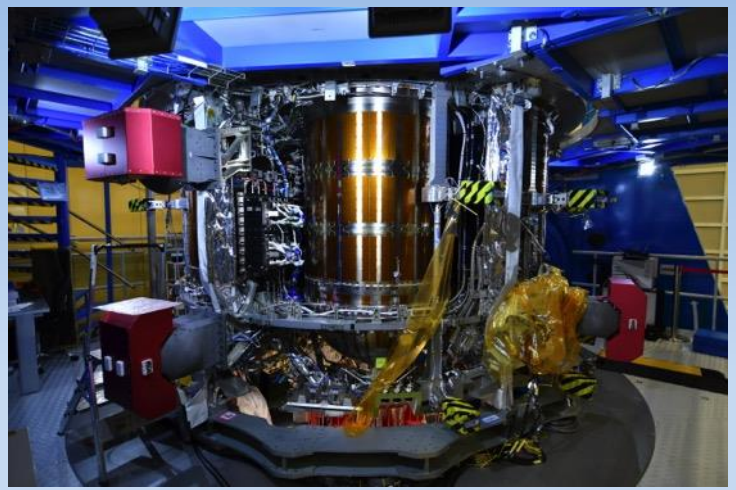


The ORION Service Module during Integration in Bremen

# Conclusions

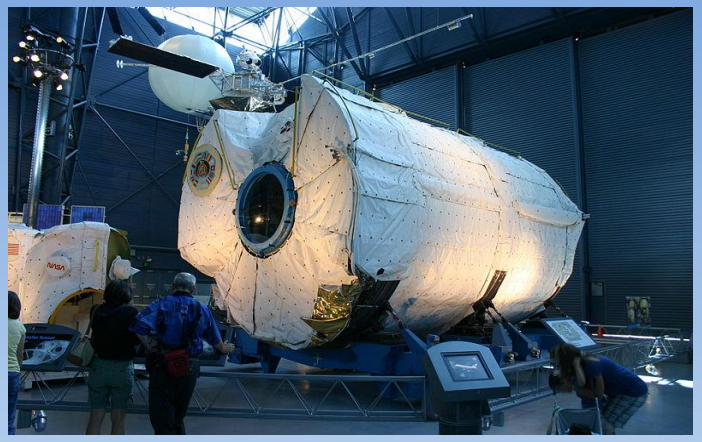
Technologies for manned spacefaring are available in Europe

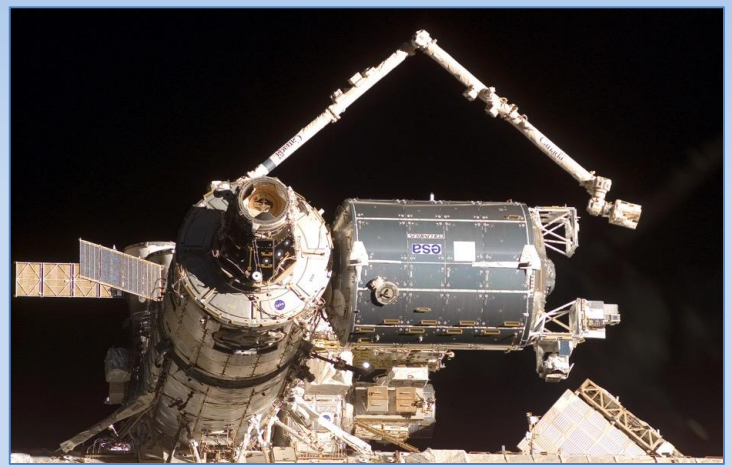
- Windtunnel testing

# Conclusions

Technologies for manned spacefaring are available in Europe

- Manned systems - Spacelab, Columbus, ATV

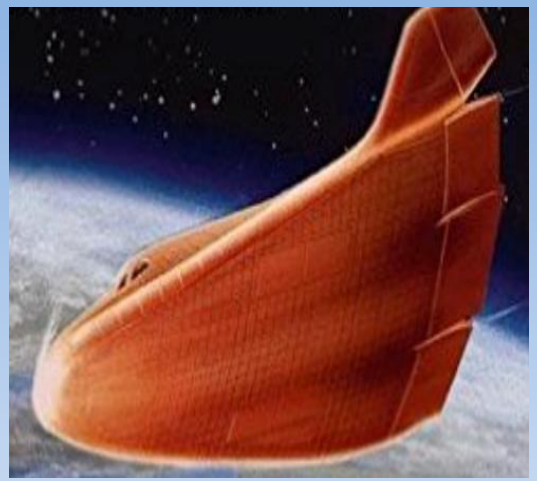


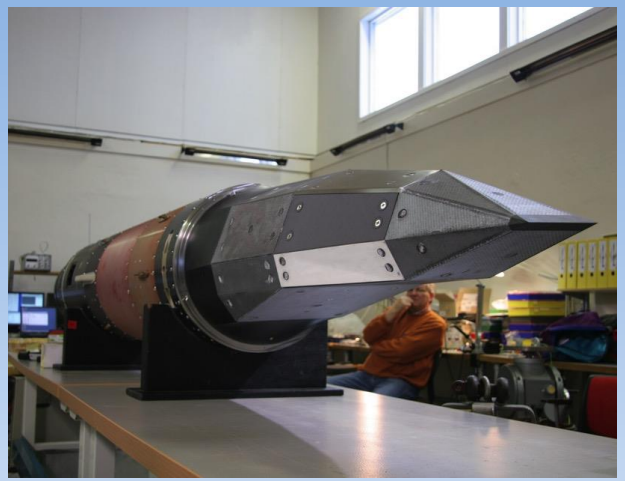


# Conclusions

Technologies for manned spacefaring are available in Europe

- Hypersonic entry - HERMES, ARD, SHEFEX





# Conclusions

Technologies for manned spacefaring are available in Europe

- ESM - Participation in the NASA ORION program

# Conclusions

Technologies for manned spacefaring are available in Europe

- SpaceLiner - Study of a large space transportation system

# Conclusions

## Technologies for manned spacefaring are available in Europe

- Next generation Life Support System for the ISS

Astronaut Alexander Gerst installing ESA‘s next generation Life Support System on the ISS


ESA‘s next Generation Life Support System on the ISS

# Conclusions

Technologies for manned spacefaring are available in Europe

- Moon basis - ESA studies

# Thank you for your attention!

Dipl.Ing. Jürgen Herholz
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*marssociety.de*
*jherholz@yahoo.de*

MARS SOCIETY
DEUTSCHLAND E.V.