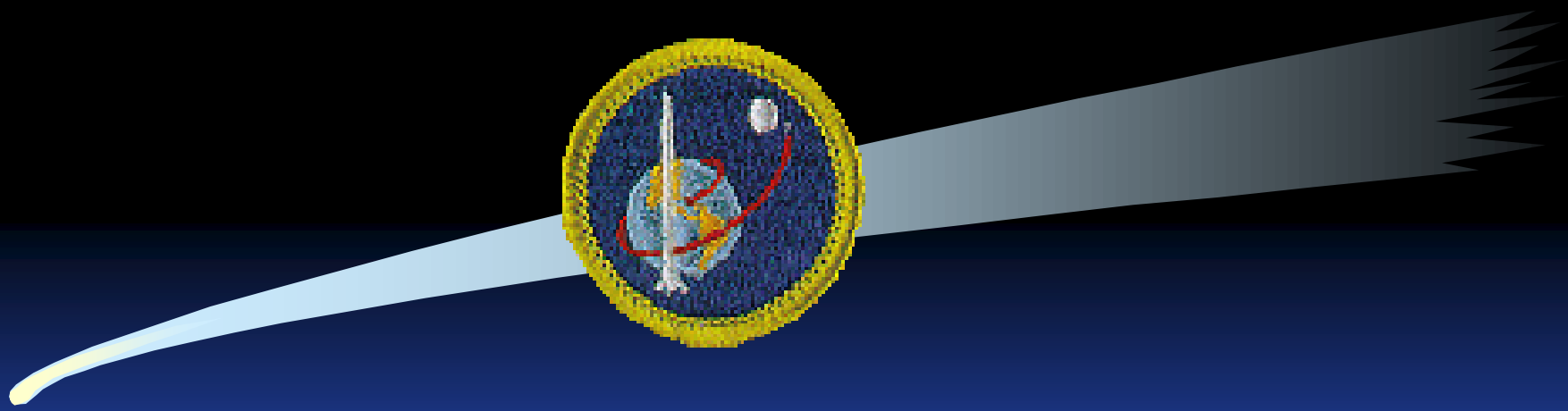
Space Exploration Merit Badge
April 2009



Vincent Needham

Physics Department

Kansas State University

http://jrm.phys.ksu.edu/Scouts/

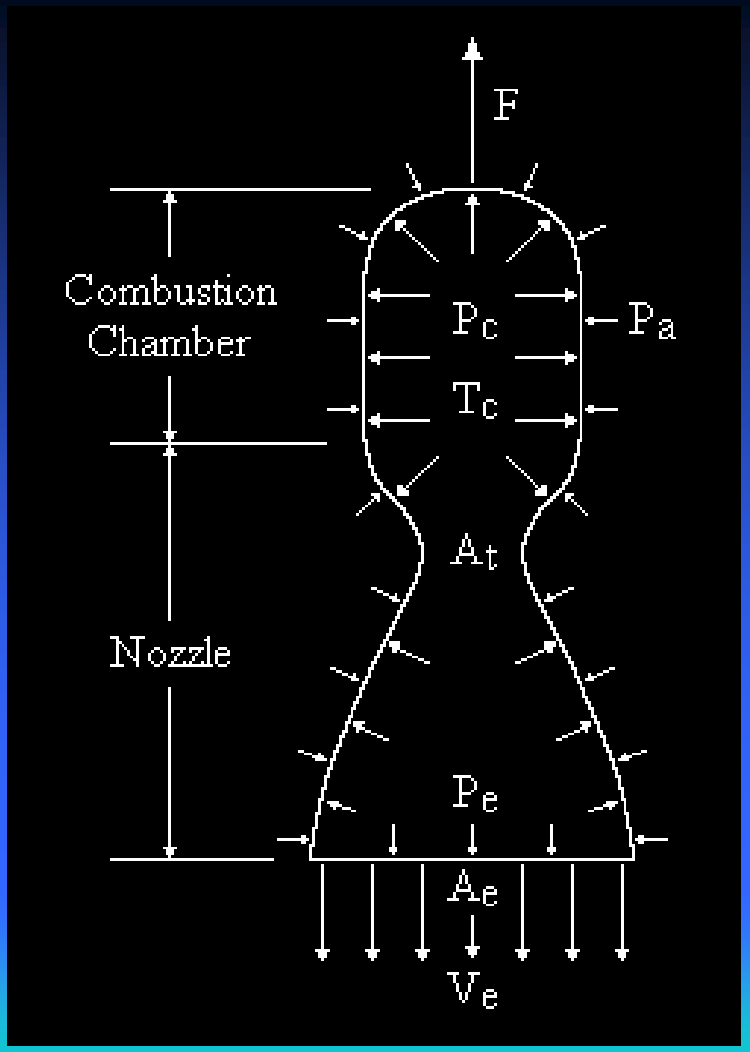
Summary of Course

- Describe the Space Shuttle & ISS
  - Explored in context of a shuttle mission
- Examine manned & unmanned missions to the Moon, Mars and Beyond.
- Review some history of space exploration
- Discuss careers in space exploration
- How to learn more...
- Launch and recover model rockets

First Controlled Powered Flight
Orville & Wilbur Wright
10:35 a.m. 17 December 1903
Kitty Hawk, North Carolina

120 feet in 12 seconds!

Basic Rocketry

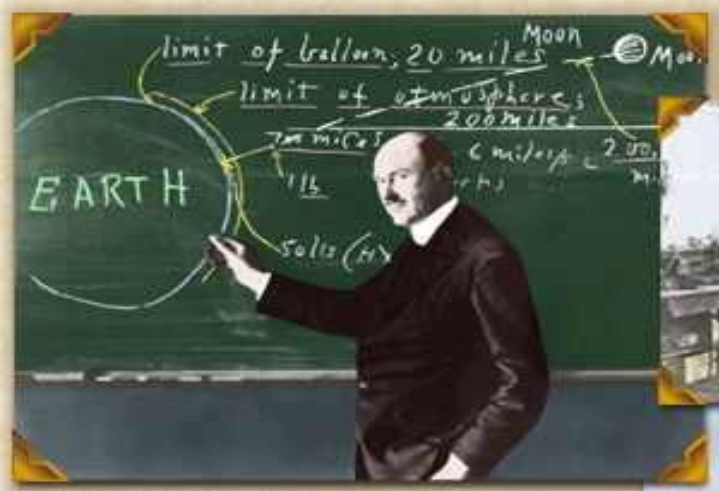


Reaction

Action

2001: Anniversary of Goddard's Launch

75th Anniversary of the 1st Liquid Fuel Rocket Launch



CLARK UNIVERSITY, 1924

DR. GODDARD
CHECKING FUEL PUMPS

DR. ROBERT GODDARD
WITH ONE OF HIS LATER
ROCKETS

GODDARD'S FIRST ROCKET, 1926

About
Events
History
Contact
Photos

Robert Goddard Retrospective - Quicktime Movie
GSFC Home

"Professor Goddard does not know the relation between action and reaction and the need to have something better than a vacuum against which to react. He seems to lack the basic knowledge ladled out daily in high schools."

1921 New York Times editorial

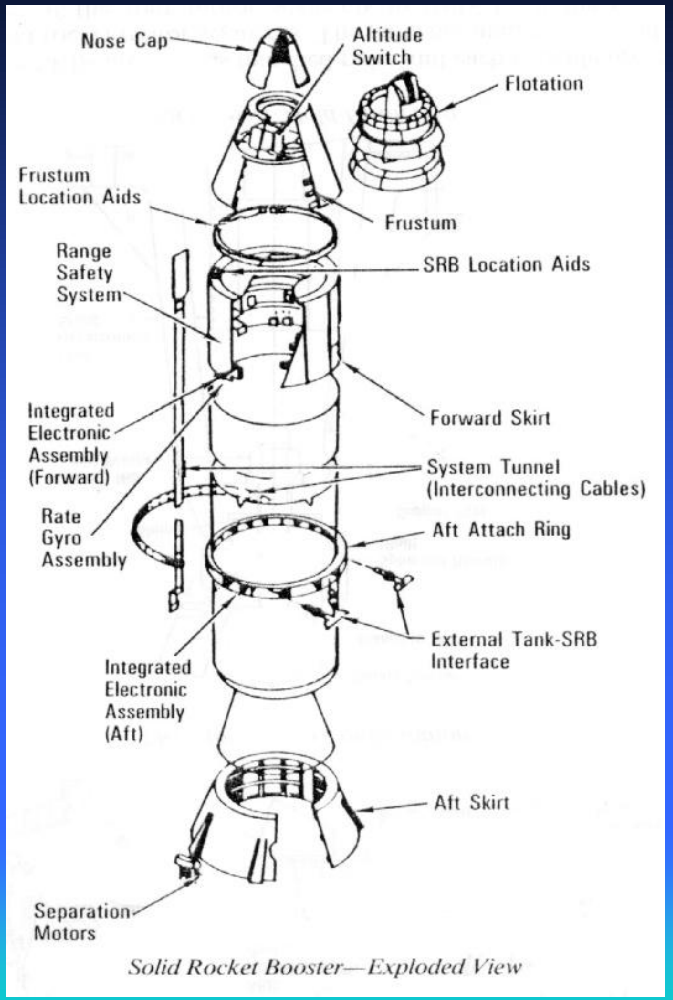
"Further investigation and experimentation, have confirmed the findings of Isaac Newton in the 17th century, and it is now definitely established that a rocket can function in a vacuum as well as in an atmosphere. The Times regrets the error."

1969 New York Times retraction

The Space Shuttle
(First Launch 12 April 1981)

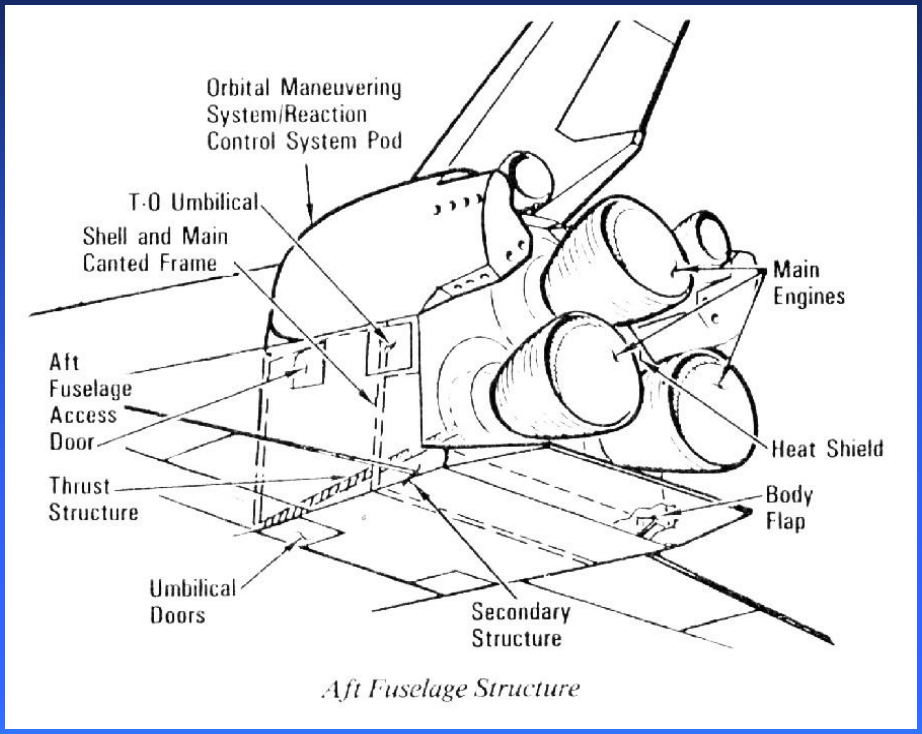
- Manned spacecraft
- Orbiter
- LH/LOX Main Engines (SSME)
- Solid Rocket Boosters (SRB)

Solid Rocket Boosters (SRB)

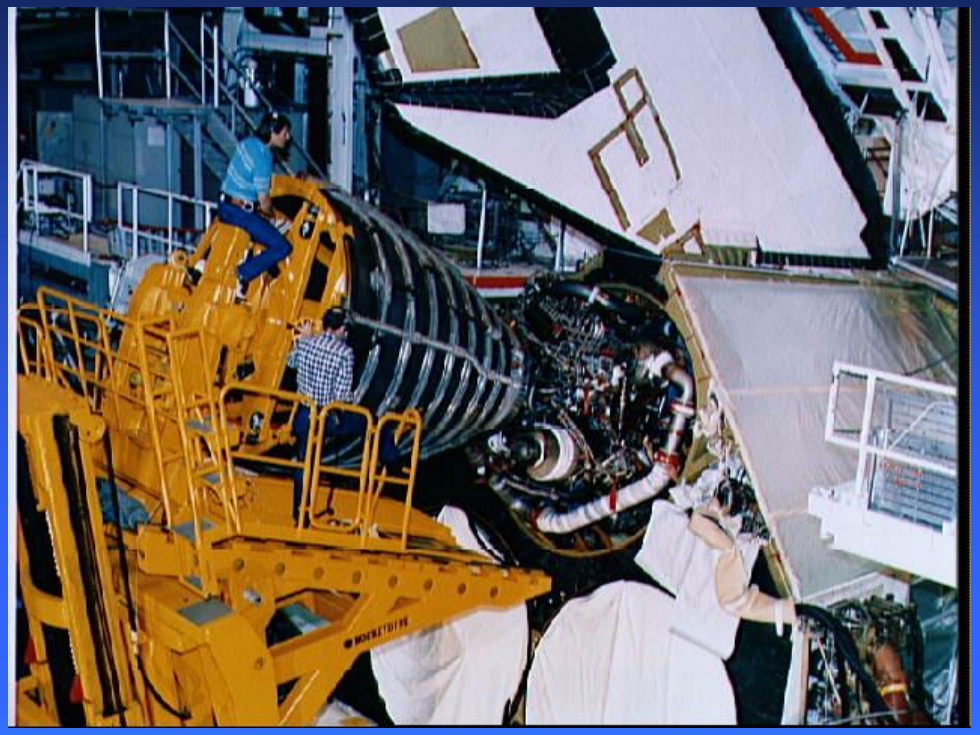


Solid Rocket Booster—Exploded View

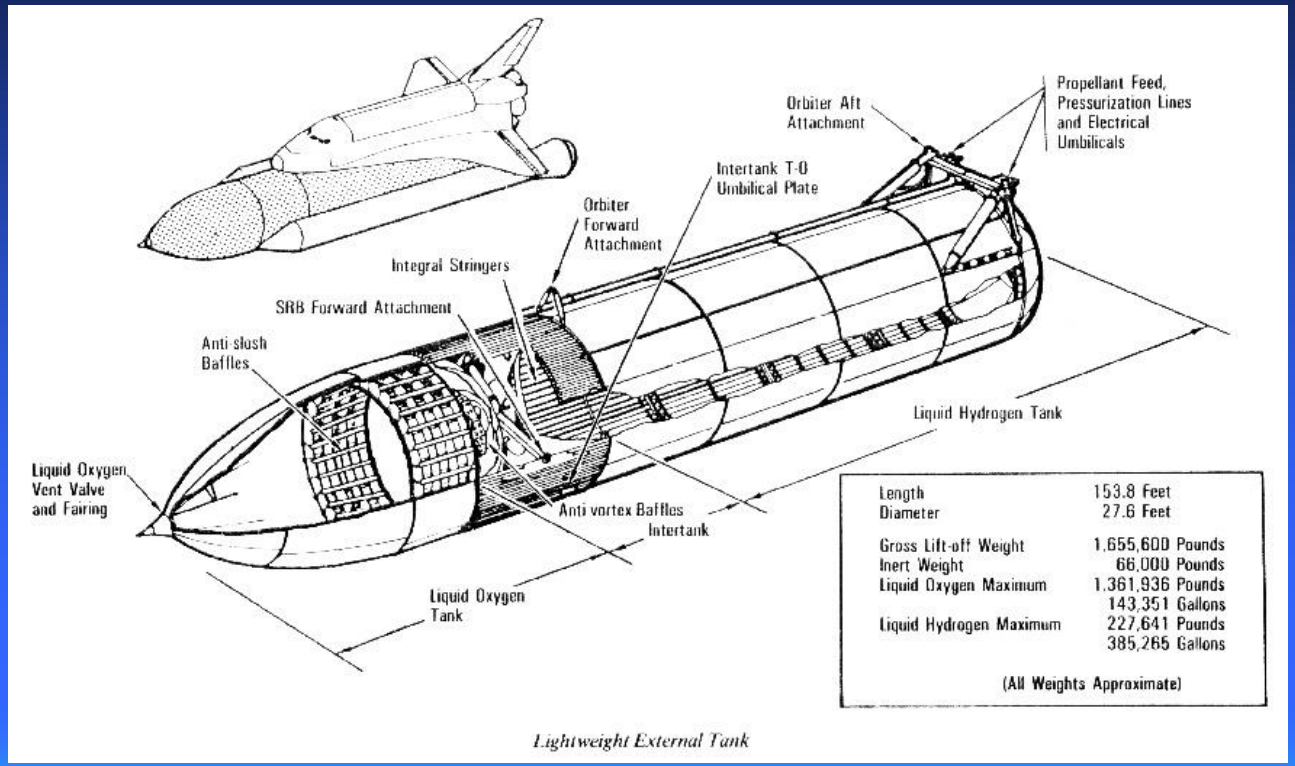
Space Shuttle Main Engines (SSME)



Aft Fuselage Structure

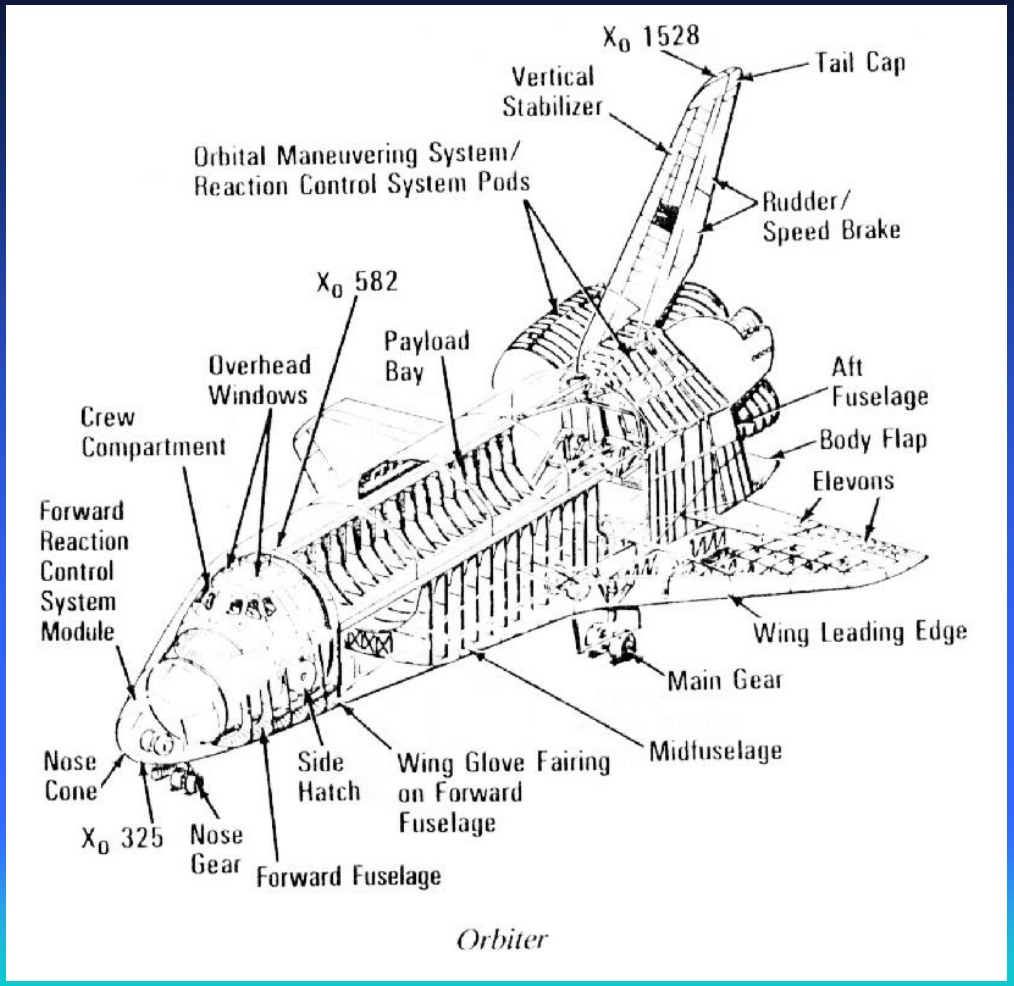


External Tank (ET)



Lightweight External Tank

Orbiter



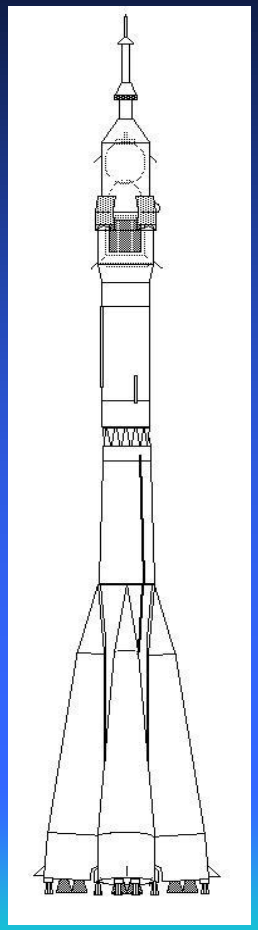
Orbiter

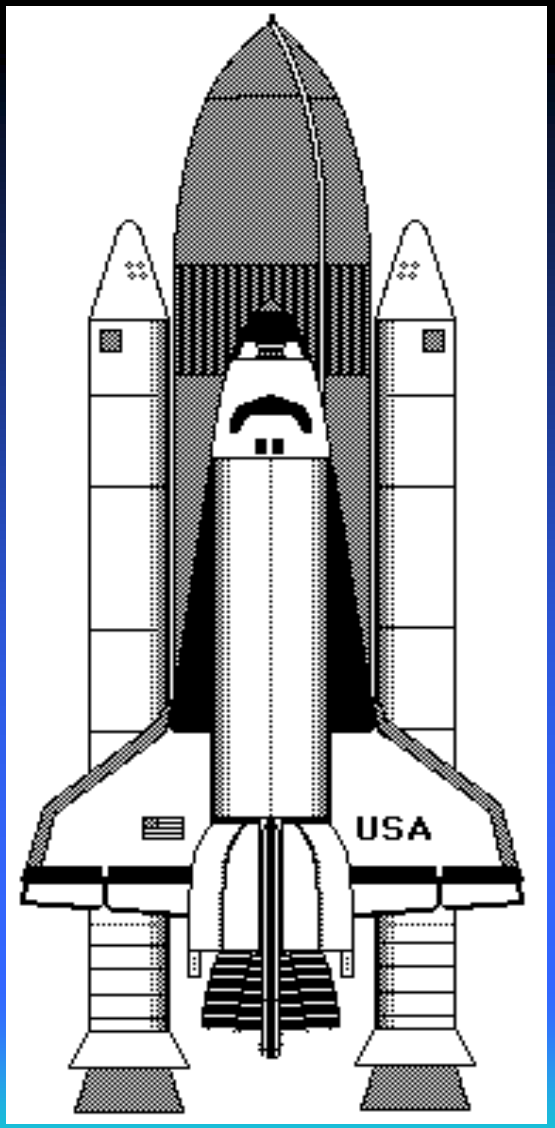
Российская Система
Russian Systems

- SL-4 Launcher
- Soyuz Spacecraft
- Progress Ferry
- Mir Space Station
  1986 - 2001
- ISS

SL-4/Soyuz Launcher

- Old (1963), but…
- Reliable
- Rugged
- Cheap

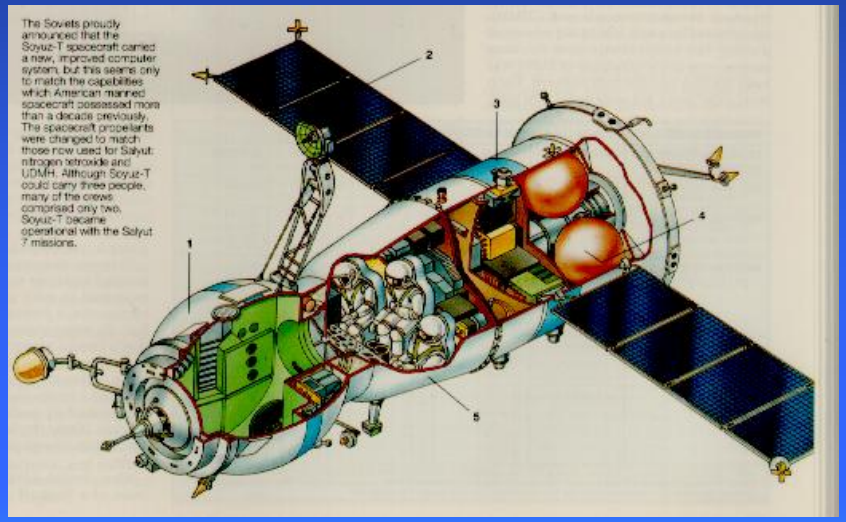


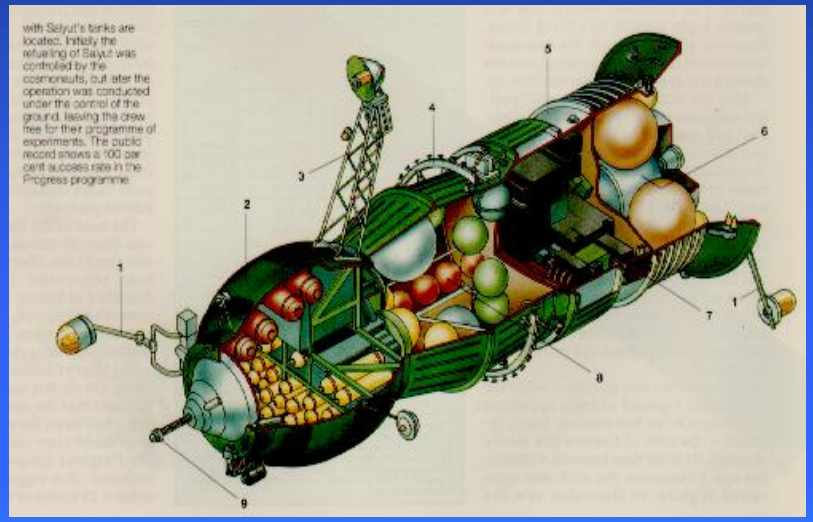


12 April 1961
Yuri Gagarin Launched on Vostok 1
First Man in Space

Soyuz & Progress

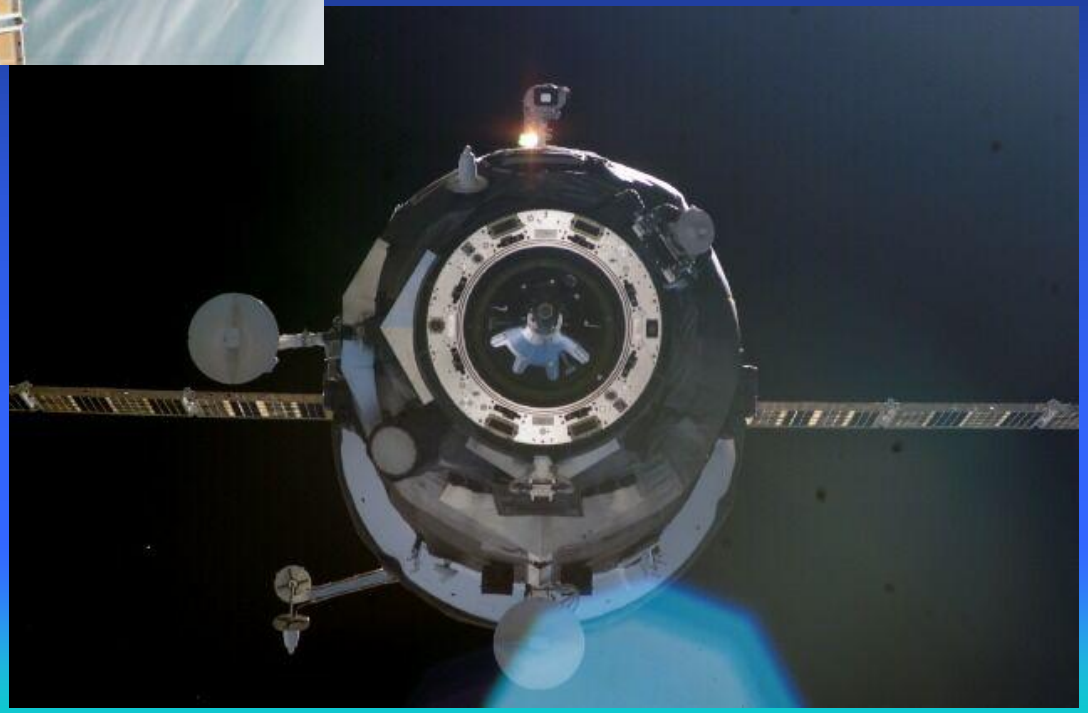
- Soyuz
  - 3 Cosmonauts
  - Station Rescue
- Progress
  - Modified, Unmanned Soyuz
  - Supply Ferry for Mir & Station





Soyuz TMA-6 arrives
🡐 at ISS in 2007

Business end of a
Progress ferry, arriving
Christmas 2006 🡒



First Chinese Manned Spacecraft

Shenzhou (神舟號) spacecraft launched on *Long March* CZ-2F with Yang Liwei, 15 Oct 2003. Next flight may be in 2010?

Shuttle Flight Profile

MAIN ENGINE CUTOFF, EXTERNAL TANK SEPARATION

Altitude: 59 nmi (68 miles); velocity: 7,796 mps (25,581 fps, 17,440 mph) about 8 minutes after launch (just before orbit insertion)

ORBIT INSERTION AND CIRCULARIZATION

Altitude varies according to mission

ORBITAL OPERATIONS

Mission from 7 to 30 days; 100 to 600 nmi (115 to 690 miles) orbits; 7,743 mps (25,405 fps, 17,321 mph)

SRB SEPARATION

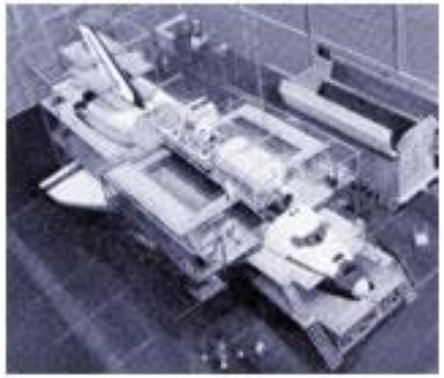
Altitude: 24 nmi (28 miles); velocity: 1,383 mps (4,538 fps, 3,094 mph) 2 minutes after launch

DEORBIT

Velocity decreased nominal 91 mps (300 fps, 204 mph) from earth orbit operations

LAUNCH

Maximum dynamic pressure at 10,241 meters (33,600 ft); about 60 seconds after launch



MAINTENANCE

LANDING

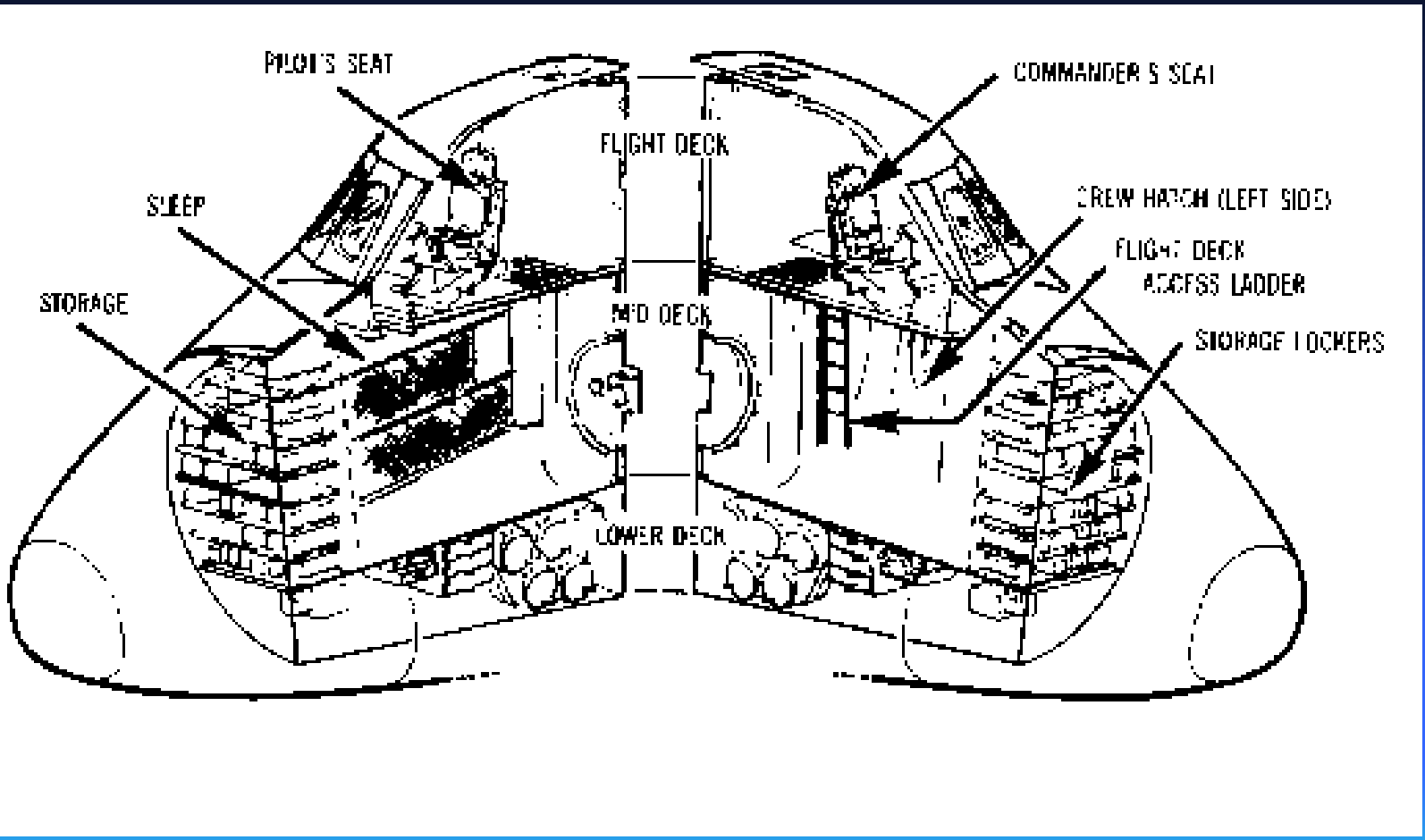
Touchdown speed 184 to 196 knots (213 to 226 mph)

Shuttle Launch

STS-119 *Discovery*

28 March 2009

Inside the Shuttle



Flight Deck

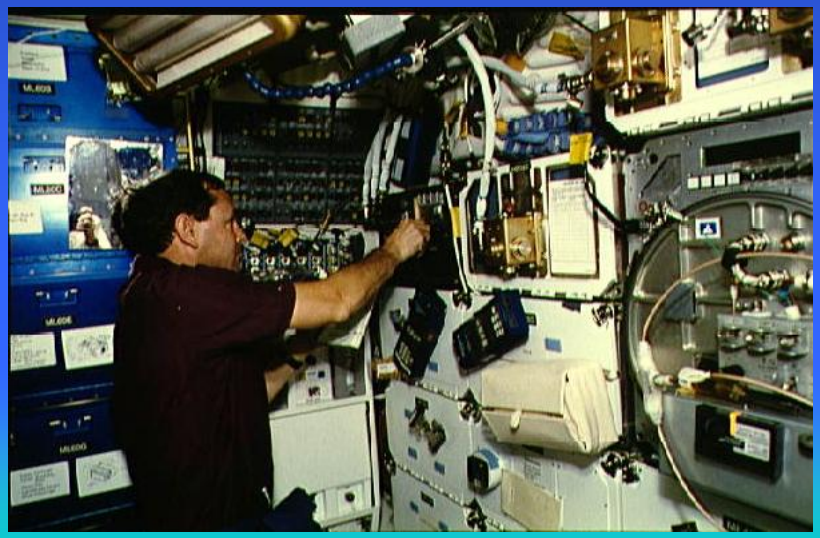
- Flight Controls

- Payload Systems

Avionics Upgrade

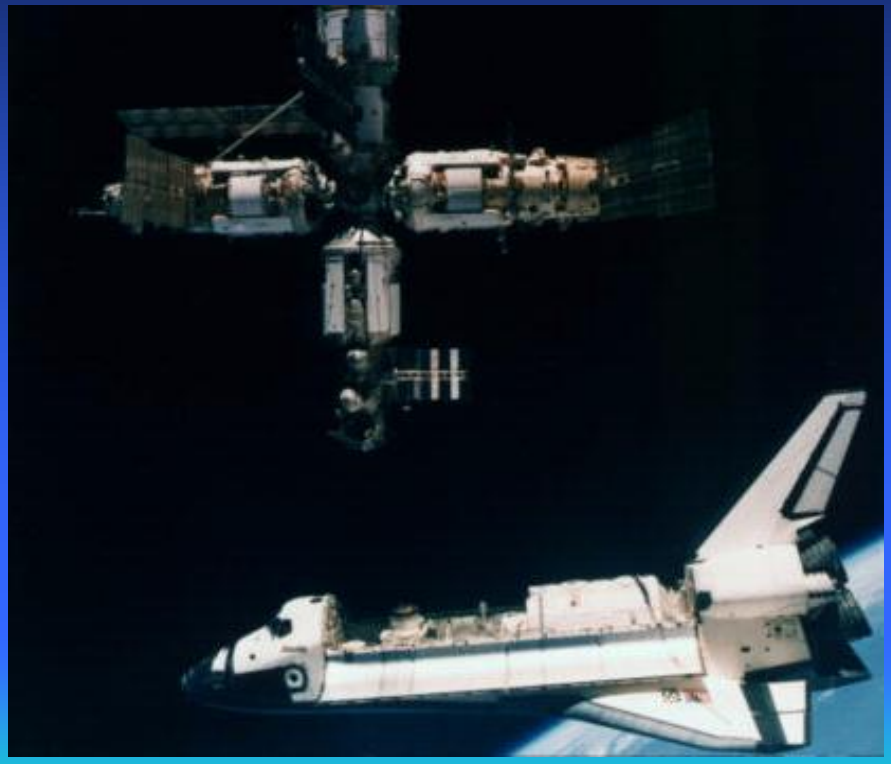
Mid-Deck

- Crew quarters
- Experiments
- Supplies
- Extended by
  - SpaceHab Module
  - SpaceLab

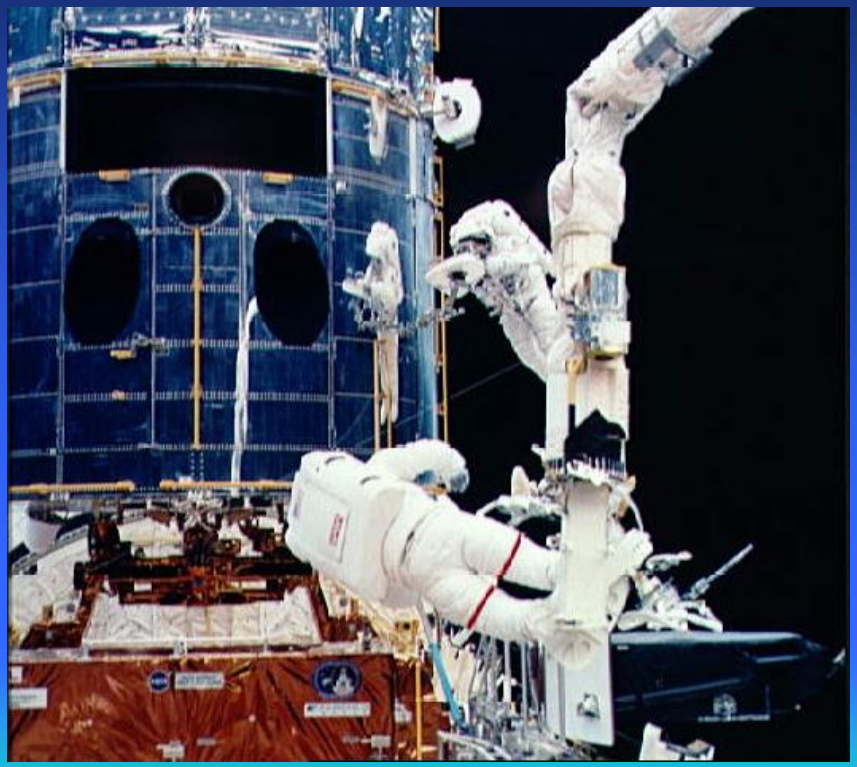


Payloads

- SpaceLab/Space Station



- Satellites & Space Probes (Delivered & Repaired!)



STS-124/*Discovery*

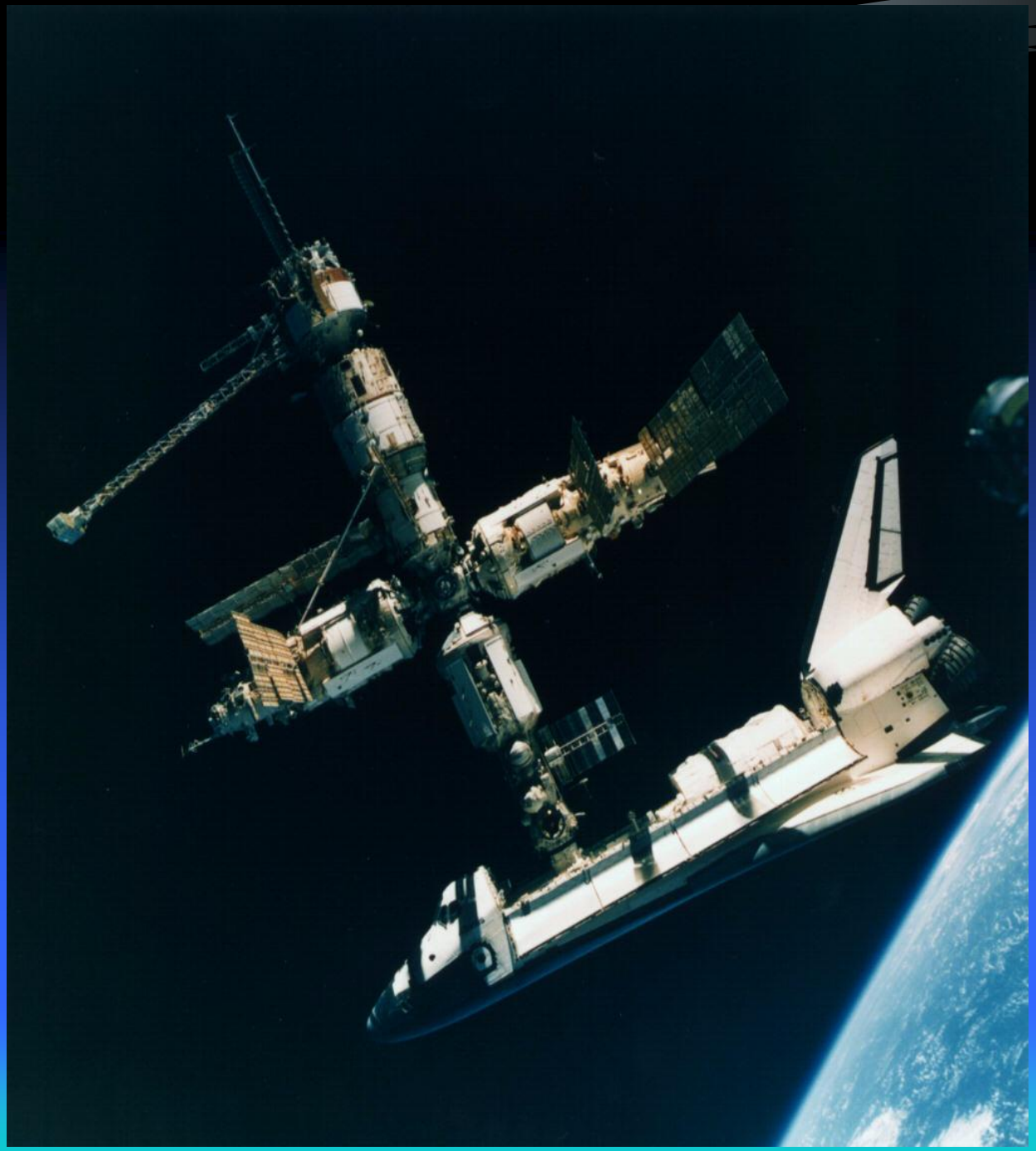
Kibo Module for ISS
(31 May 2008)

- Mark Kelly (Cmdr, USN)
  - CDR, MS, Aero Eng
- Kenneth Ham (Cmdr, USN)
  - PLT, MS, Aero Eng
- Karen Nyberg
  - MS1, PhD, Mech Eng
- Ronald Garan (Col, USAF)
  - MS2, MS, Aero Eng
- Michael Fossum
  - -MS3, MS, Sys Eng/Phys Sci
  - Eagle Scout
- Akihiko Hoshide (JAXA)
  - MS4, MS, Aero Eng
- Gregory Chamitoff
  - PhD, Aeronautics
  - Arriving Exp 17 Flt Eng
- Garrett Reisman
  - PhD, Mech Eng
  - Returning Exp 16 Flt Eng

STS-124 *Discovery* Crew

International Space Station

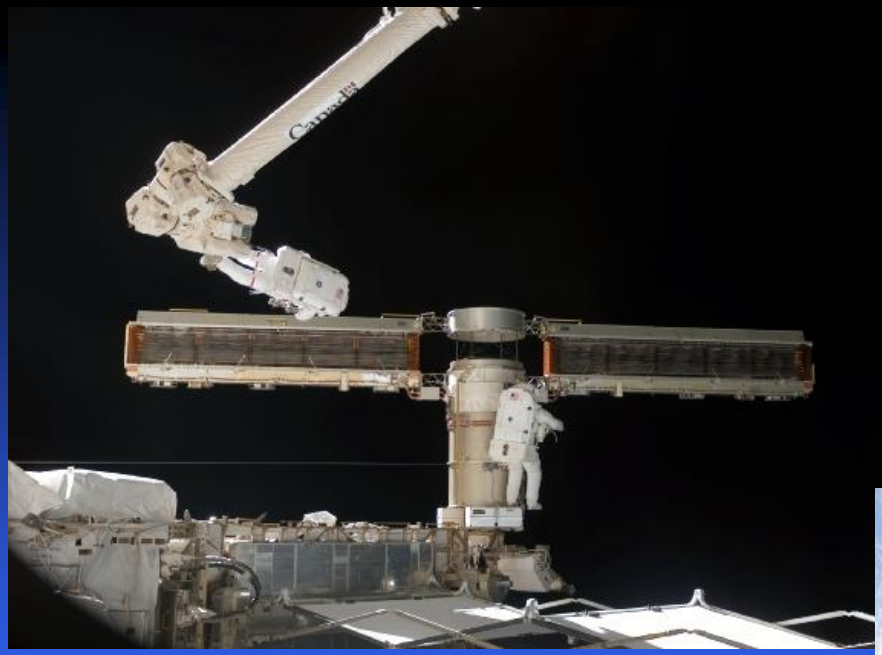
- USA
- Russia
- Europe
- Japan
- Canada



Mir

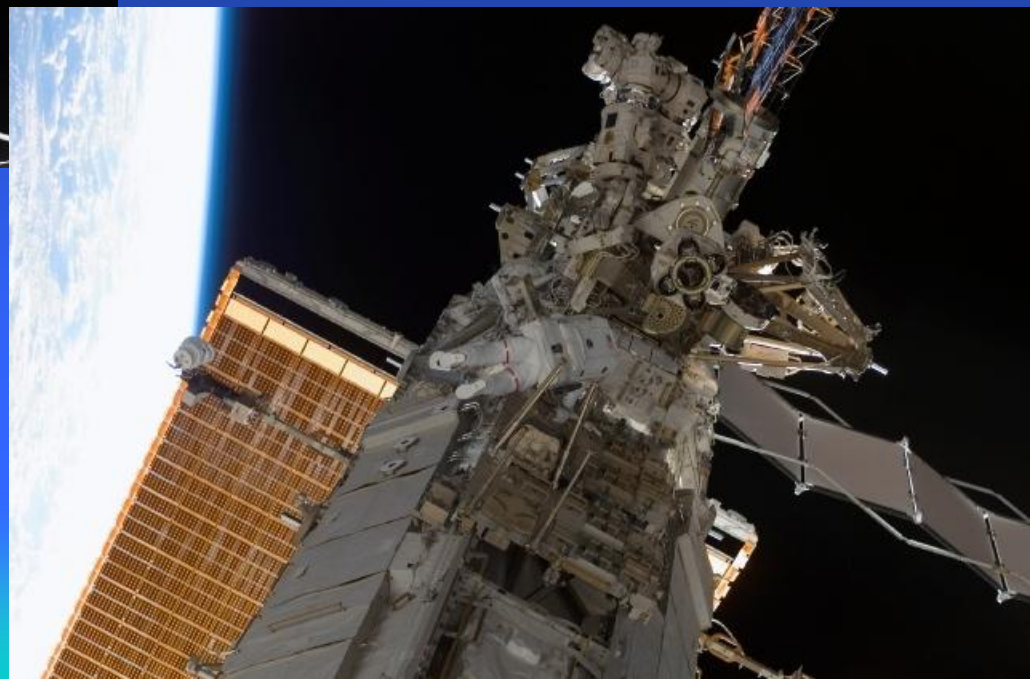
- Core module launched in 1986
- Phase 1 of the International Space Station
- Last visiting U.S. astronaut was Andy Thomas
- Final Shuttle-Mir mission was by *Discovery* on 28 May 1998.
- *Mir* re-entry on 23 March 2001

Recent Station Assembly



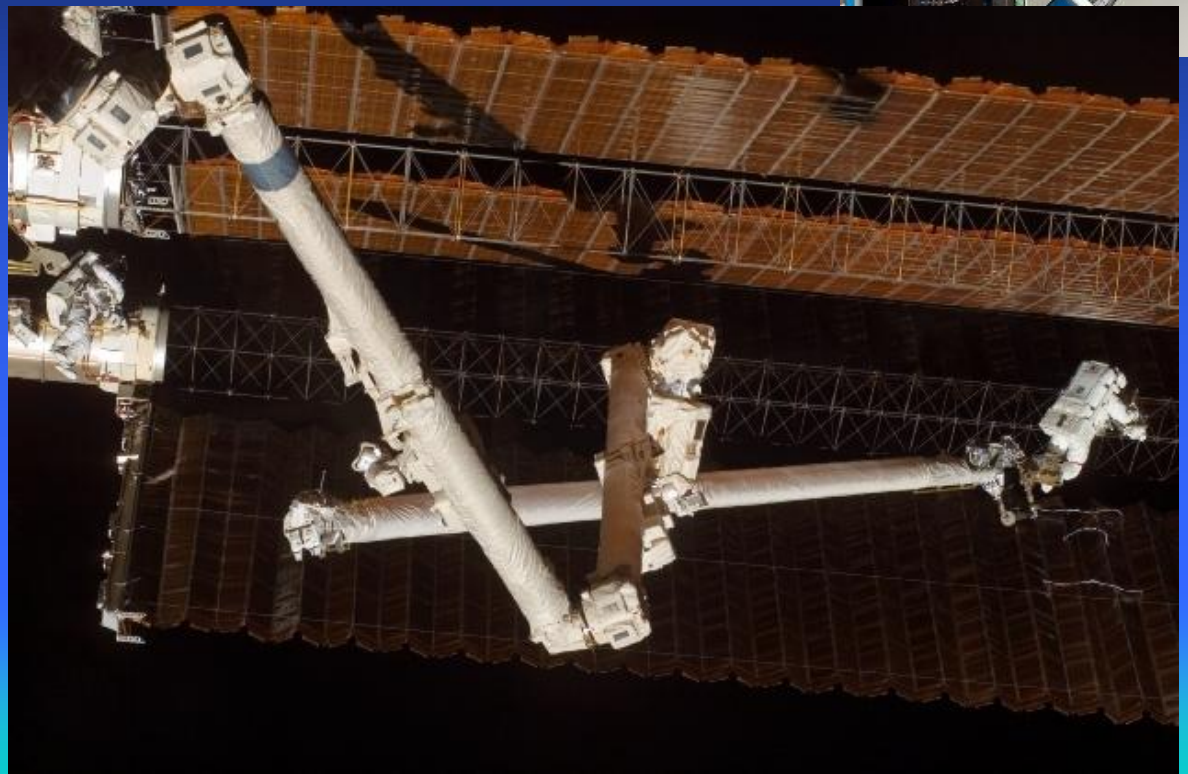
←June 2007:
STS-117/*Atlantis* delivers S3/S4 truss, juggles solar arrays

August 2007:
STS-118/*Endeavour* brings S5 truss, rewires ISS →



November 2007:

STS-120/*Discovery* installs Harmony node…

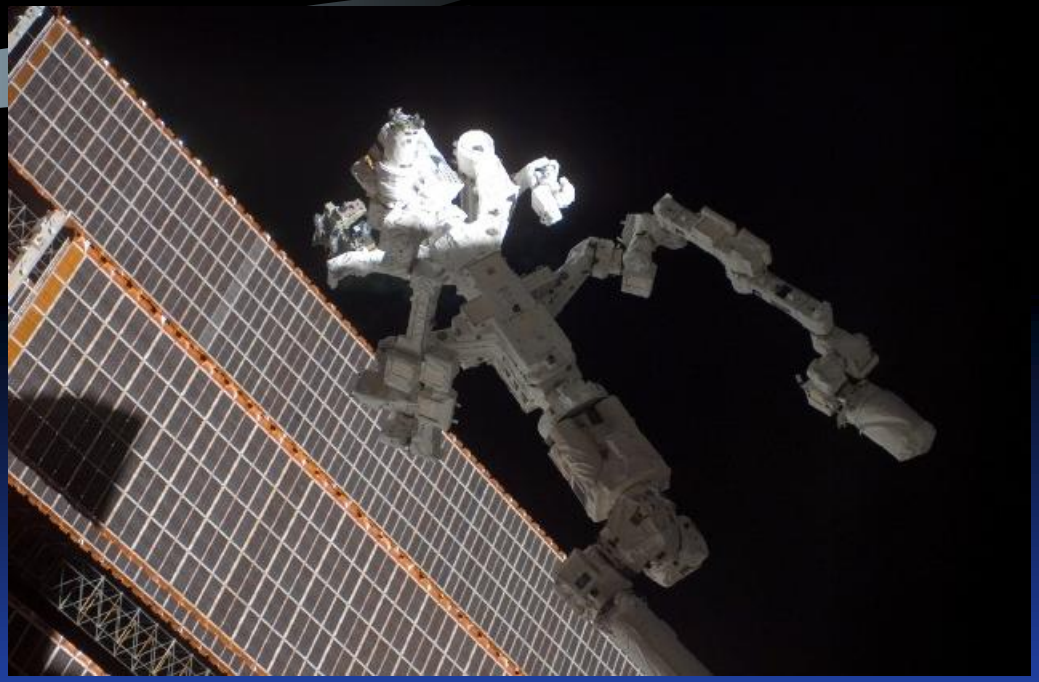


…and then redeploys and fixes a torn solar array

February 2008 – STS-122/*Atlantis* attaches European *Columbus* laboratory

March 2008 – STS-123/*Endeavour* begins 3-part *Kibo* delivery

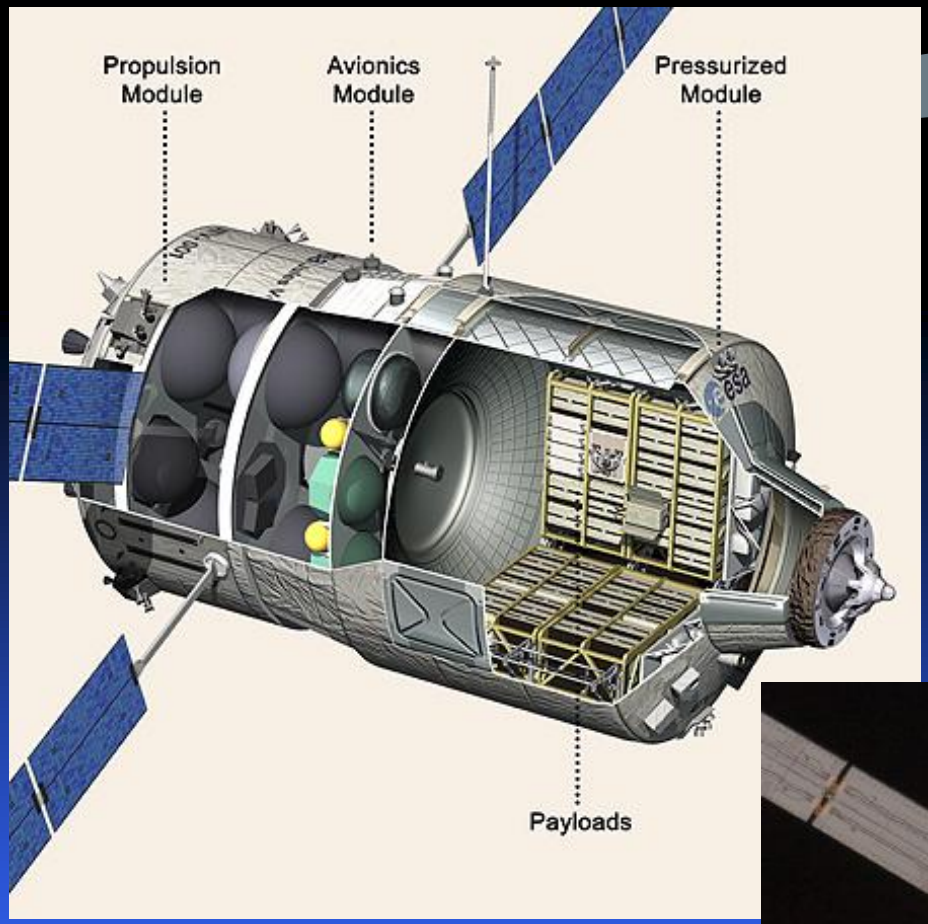
March 2008 – STS-123/*Endeavour* also assembled Canadian *Dextre* robot



May 2008 – STS-124/*Discovery* and the main Japanese Kibo laboratory

ESA *Jules Verne* ATV

Like Progress, autonomously delivers supplies to ISS



First docking was on 03 April 2008; still there…

Space Station Tour

At Home on the Station

- Astronauts must be safe, happy & productive

ISS Expedition 16 Crew Launched 07 April 2007

Charles Simonyi, Oleg Kotov, Fyodor Yurchikhin, (comm.)

ISS Expedition 17 Crew

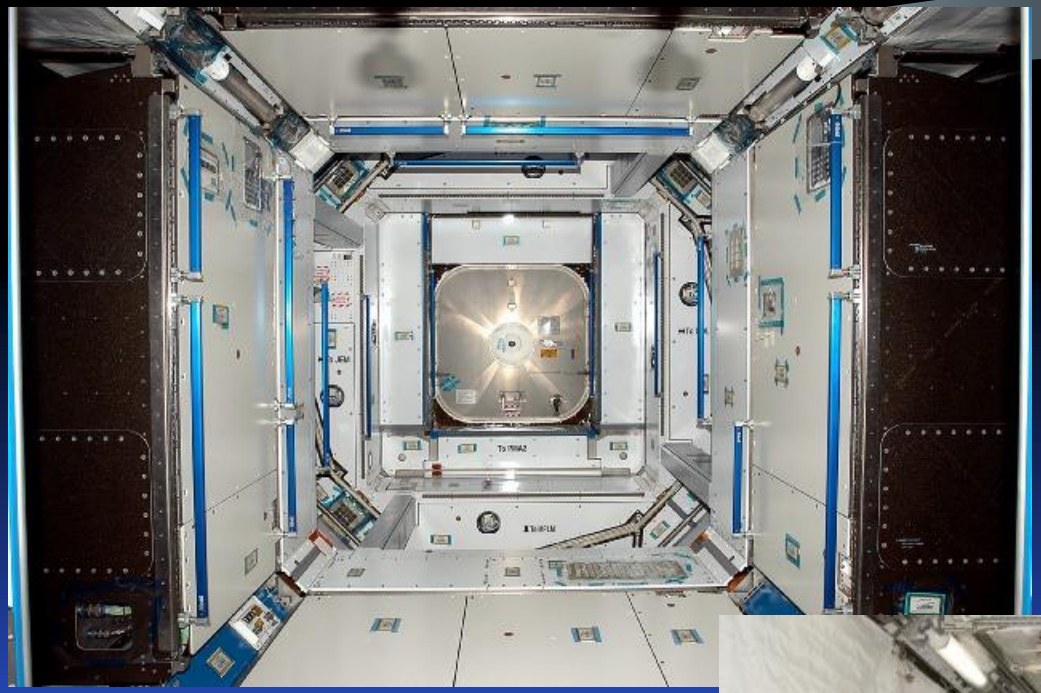
- Sergey Alexandrovich Volkov
  - -Lt. Col, RFAF
  - - Pilot/Eng, Tambov AF Academy
- Oleg Dmitrievich Kononenko
  - - ME, Kharkov Aviation Institute
- Garrett Reisman
  - - PhD, Mech Eng
  - - Returning from ISS
- Gregory Chamitoff *(not shown)*
  - - PhD, Aeronautics
  - - Remains on ISS

Zarya ➔

➔ Zvezda

Unity ➔

Destiny ➔



Harmony node

Columbus laboratory, with shuttle and station crews

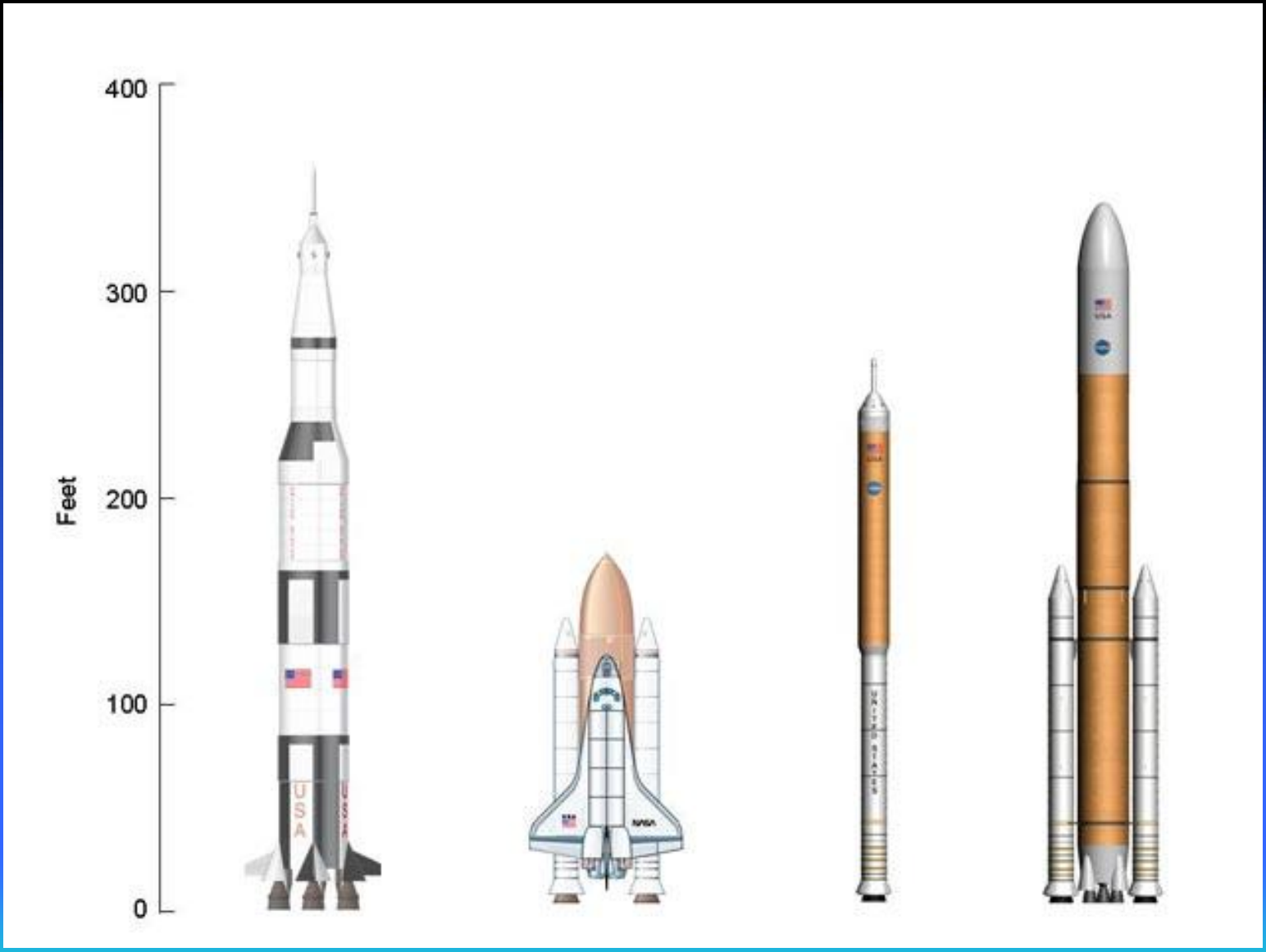
Moon, Mars & Beyond

Goals of the President's initiative:

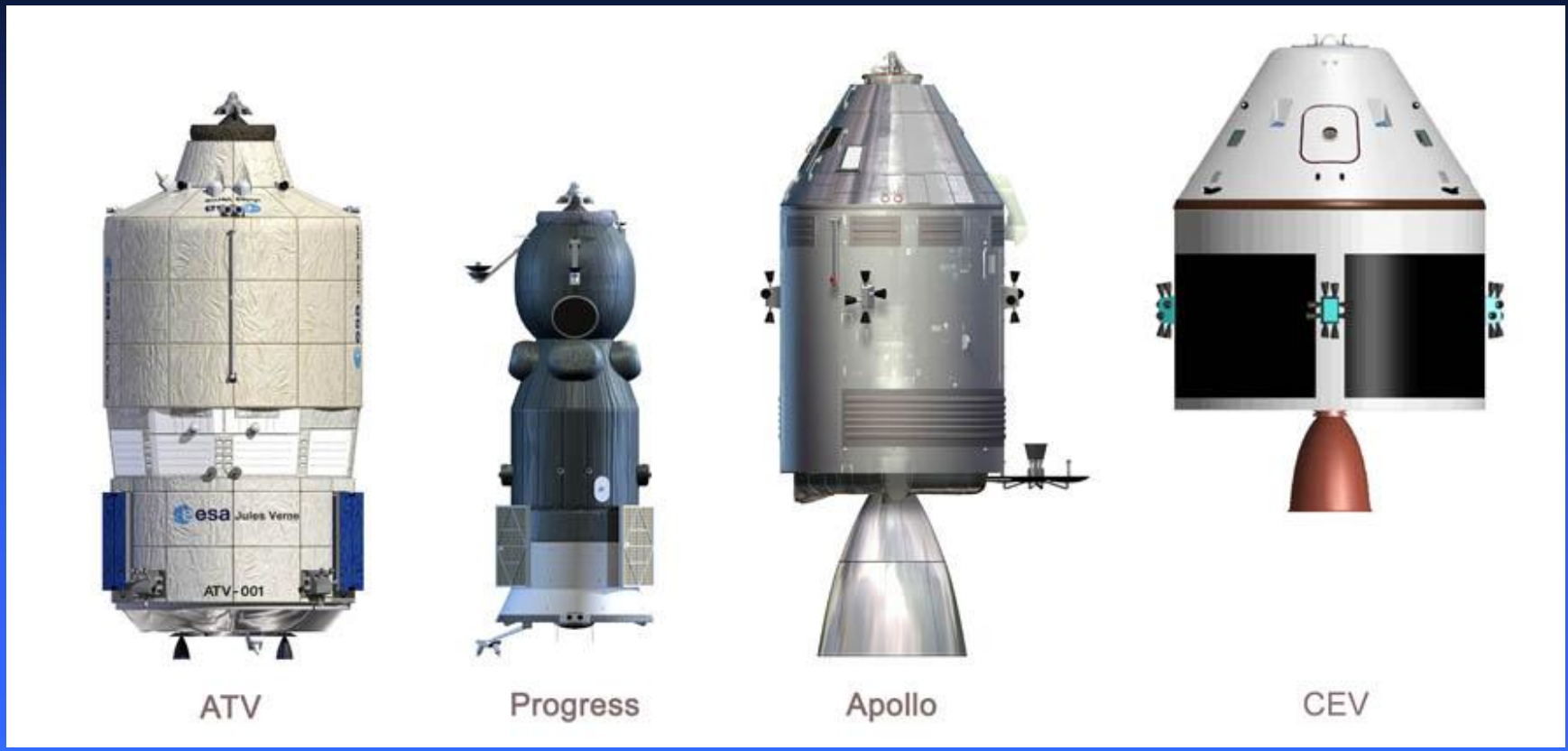
- Complete the International Space Station
- Create a new Crew Exploration Vehicle
- Return humans to the Moon
- Ultimately, launch human missions to Mars

Exploration of the solar system is the central theme

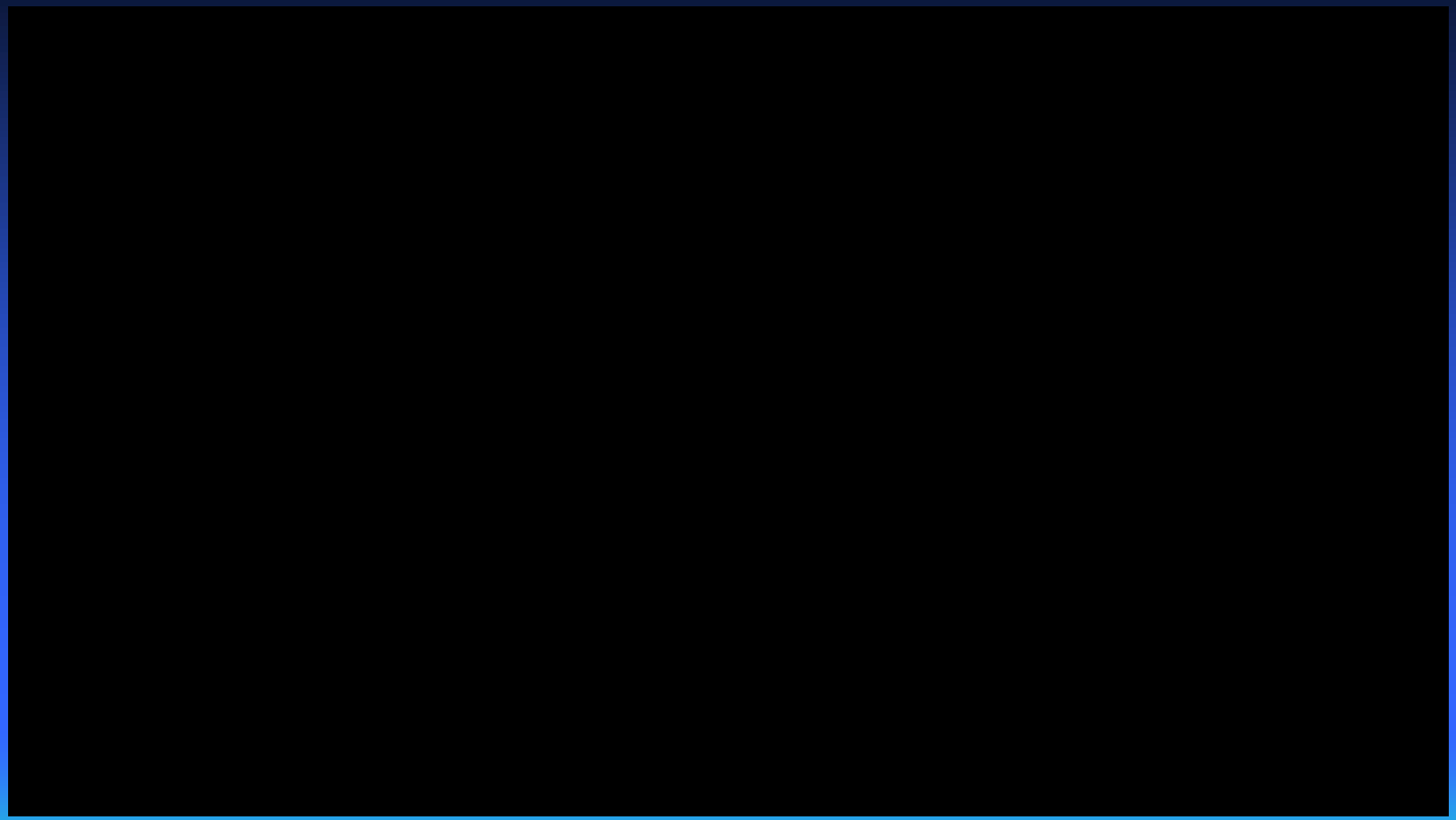
Saturn, Shuttle and New Aries Rockets

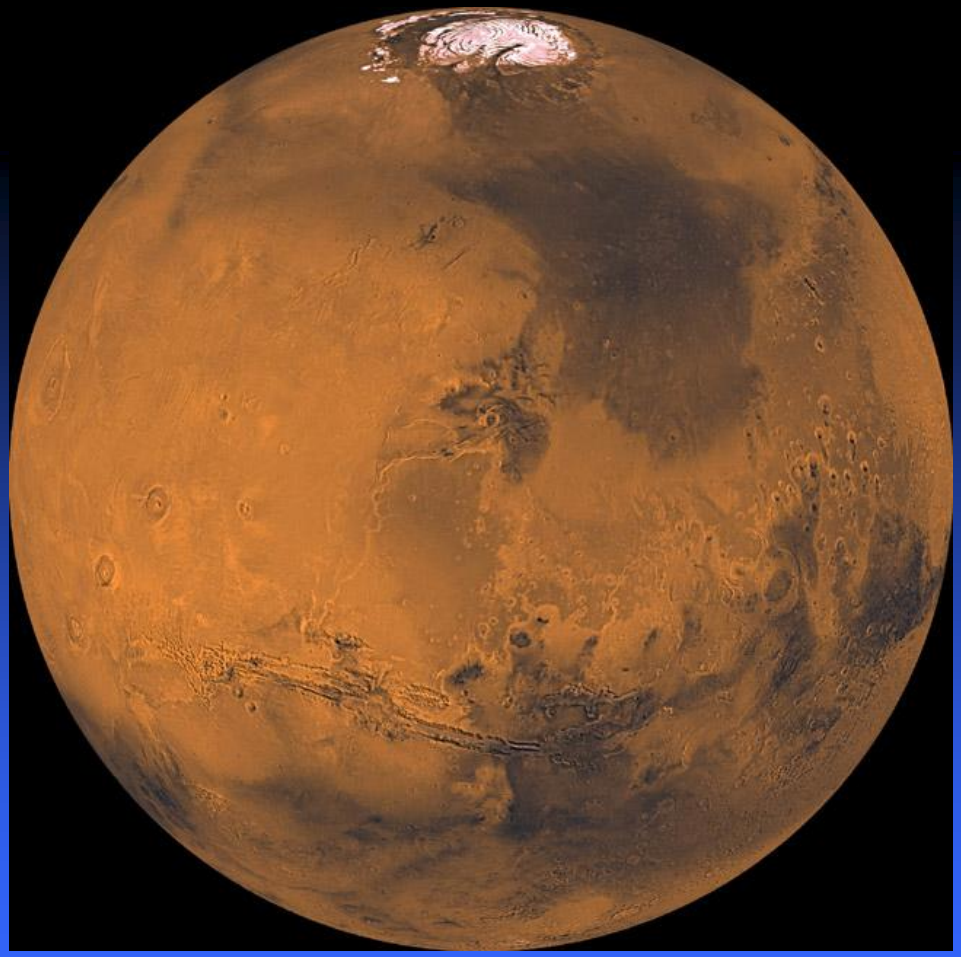


Orion Crew Exploration Vehicle (and more!)



Back to the Moon!

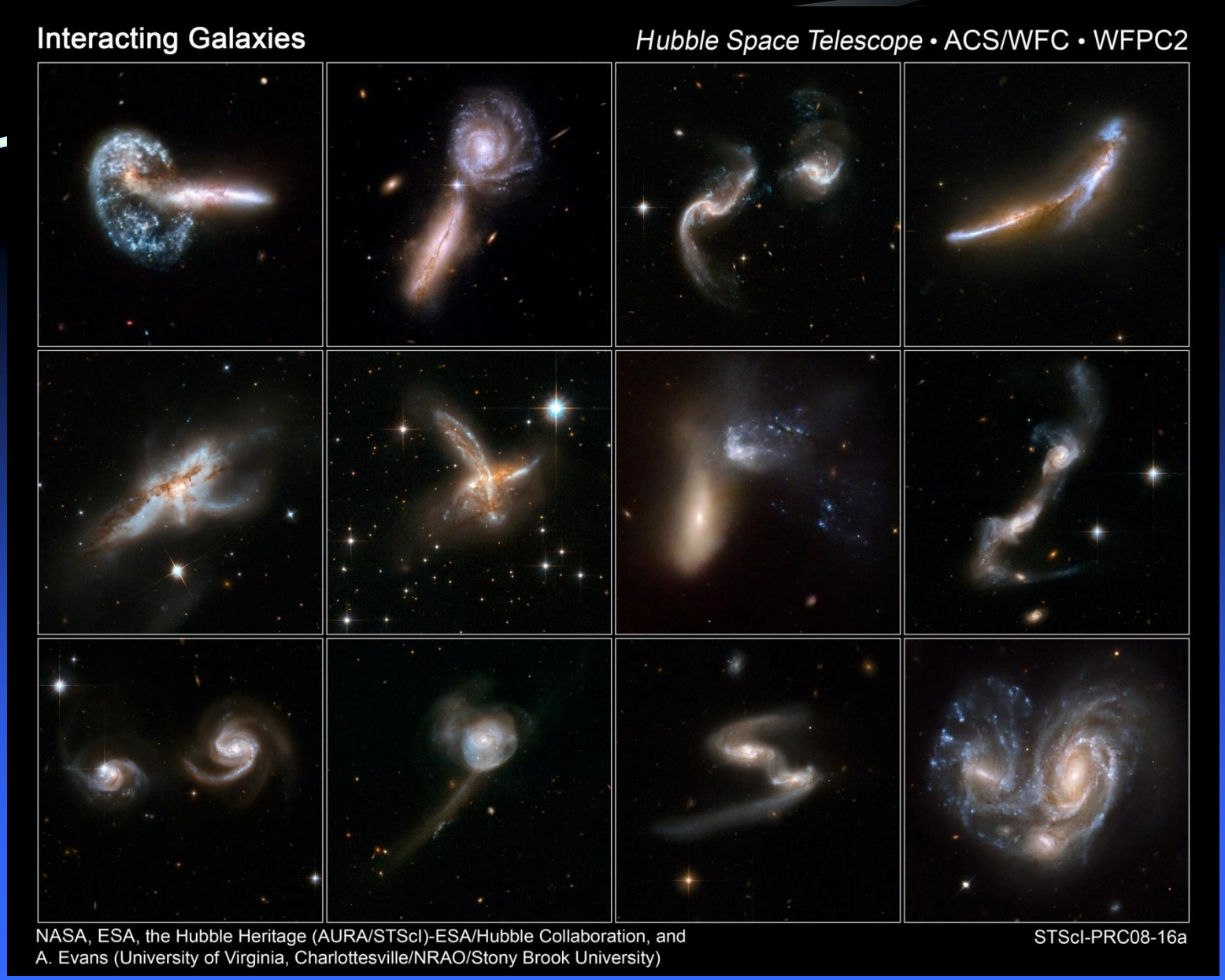




Towards Mars

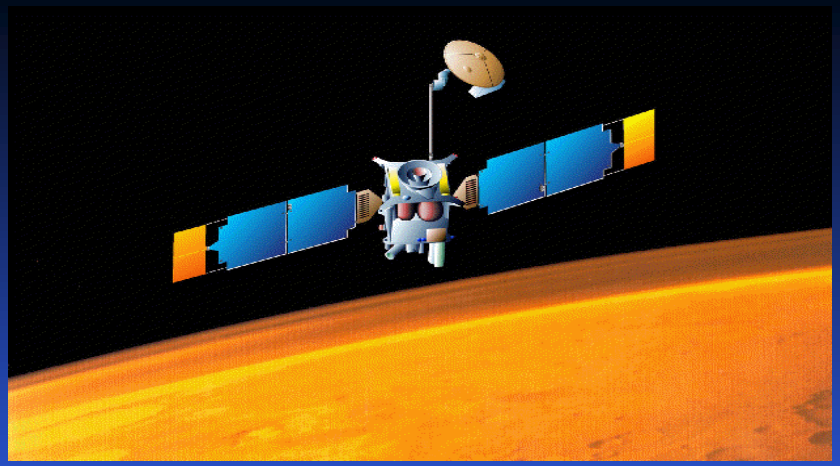
Hubble Space Telescope

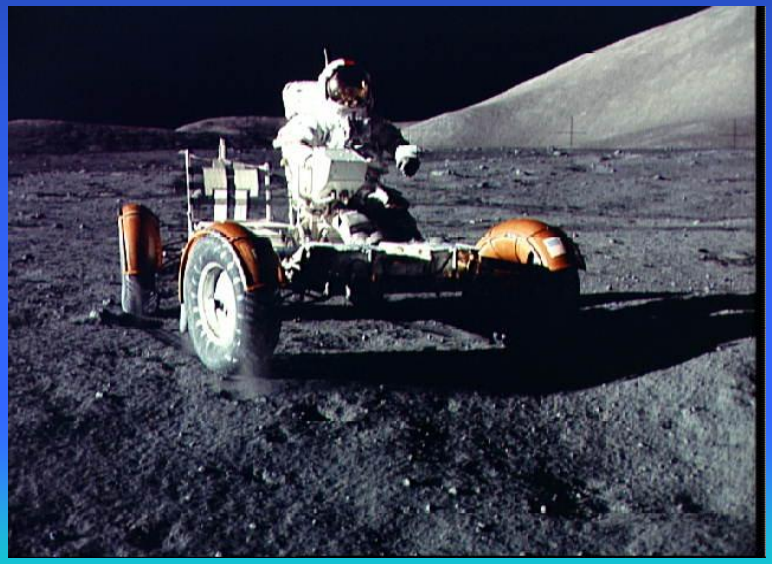
- Launched on 24 April 1990
- Shuttle service calls in:
  - December 1993
  - February 1997
  - October 1999
  - March 2002
  - Sept. 2008 (STS-125)

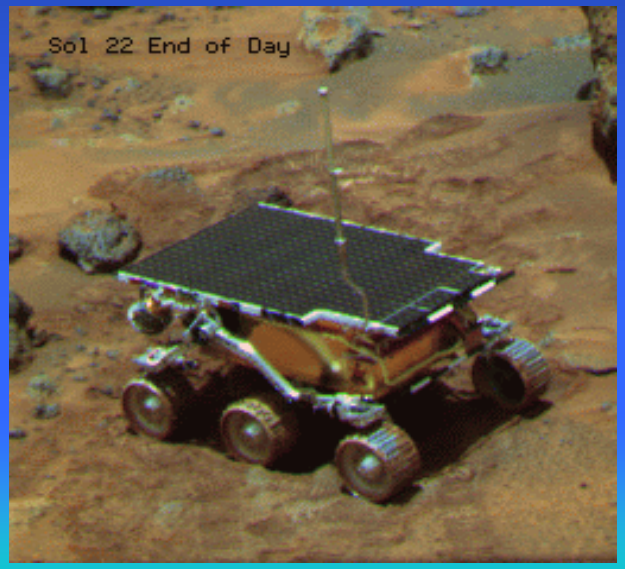


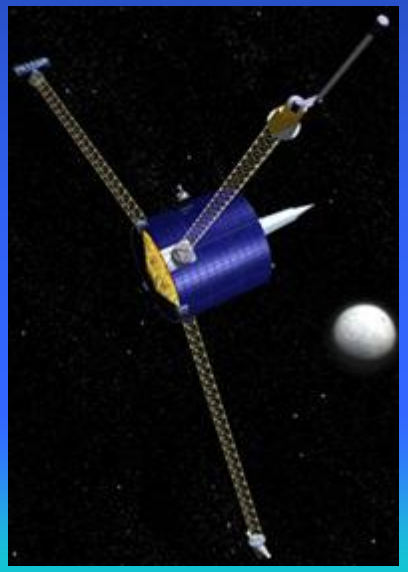
Hubble's 18th Birthday

Planetary Exploration





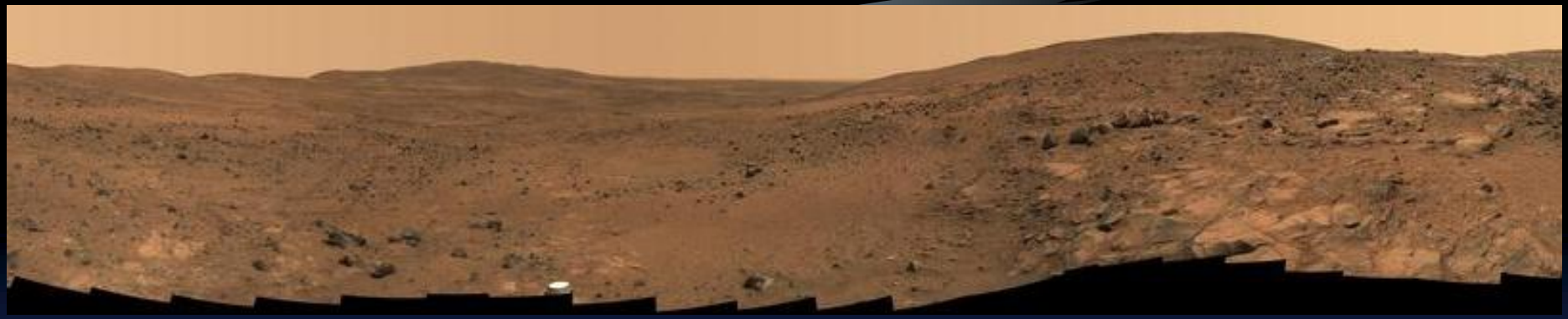




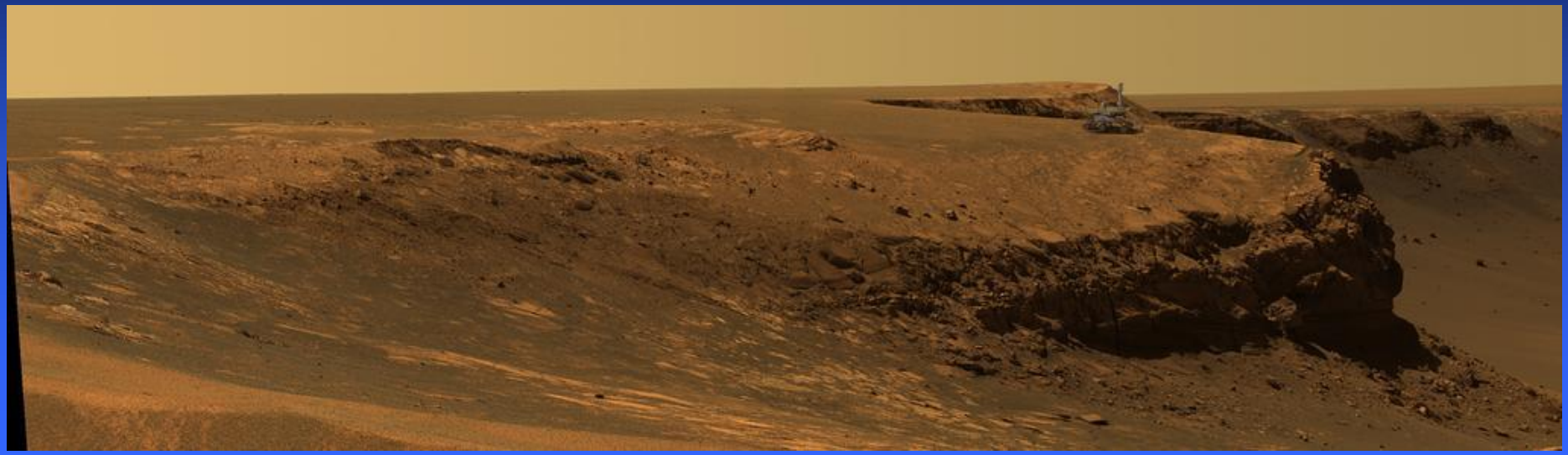
Mars Exploration Rovers (MER)

Two rovers:

- Launched June ‘03
- Landed Jan ‘05
- Spirit at Sol 1533; Opportunity at 1513
- They keep going, and going…

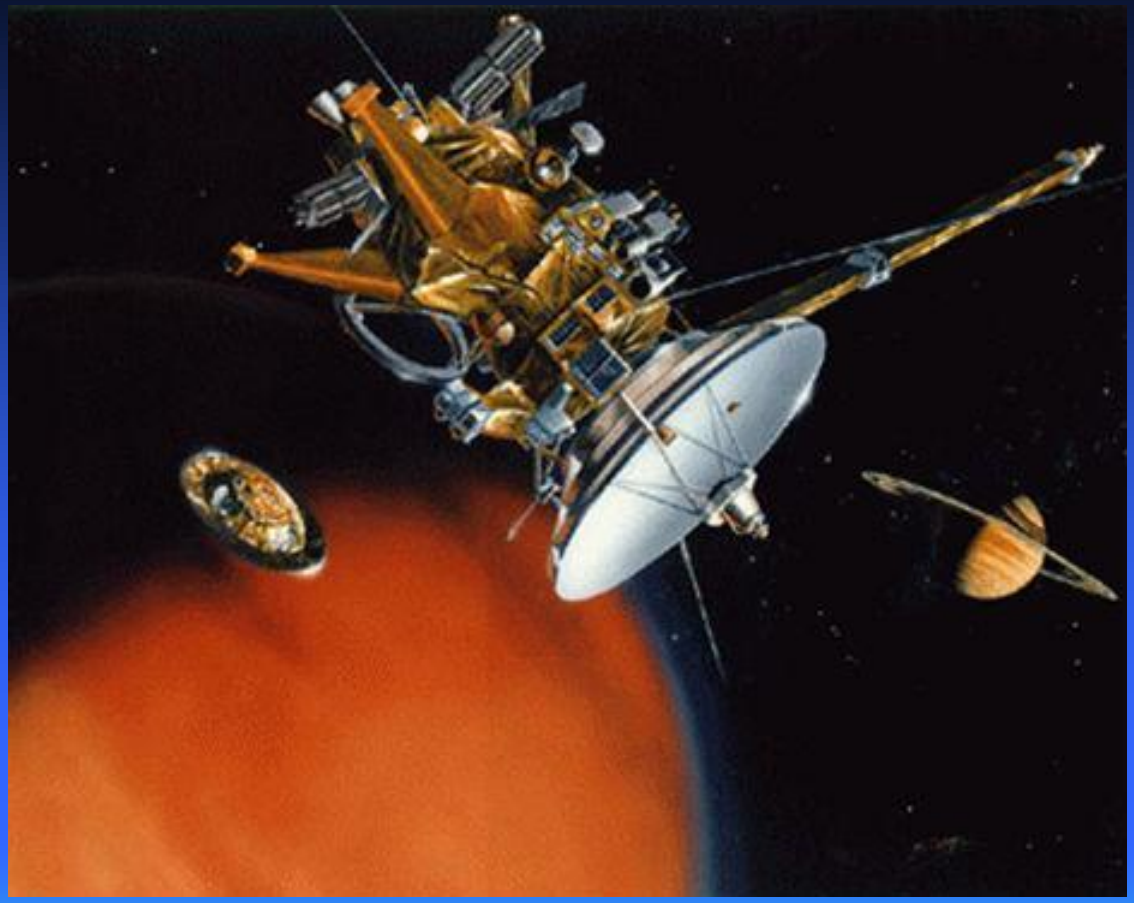


Spirit, from the top of Husband Hill within the enormous Gusev crater



Opportunity, “photoshopped” onto the rim of Victoria Crater

Cassini-Huygens at Saturn



- Launched Oct ‘97
- Arrived Jun ‘04
- Huygens landed on Titan, Jan ’05
- Prime mission ends in July; approved for two year extension

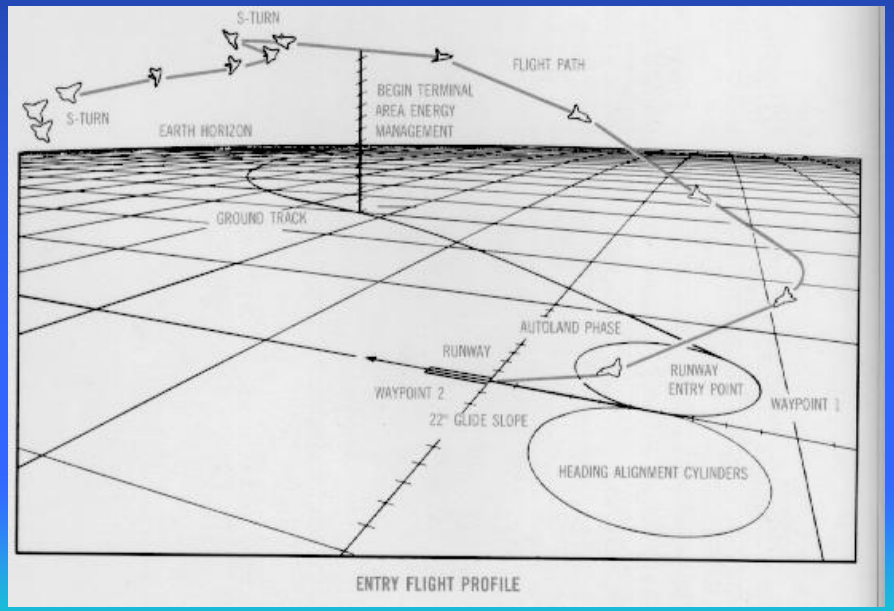
← Titan from the air & Titan from the ground →

Saturn on approach ↓

Re-entry & Approach

- Thermal tiles absorb extreme heat

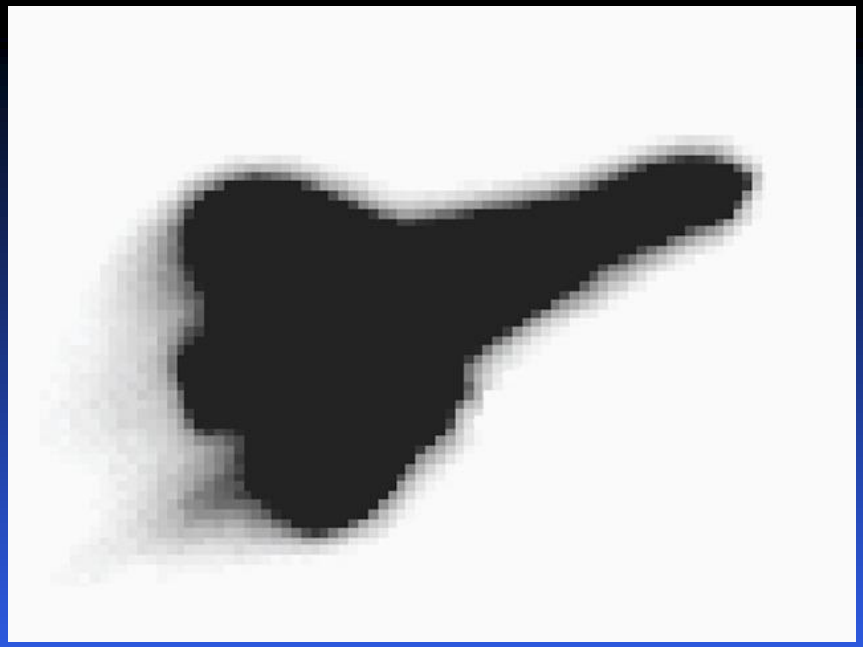
- Dead-stick landing
- Energy management is critical



ENTRY FLIGHT PROFILE

Thermal Protection System (Up Close)

STS-107/*Columbia*
Lost 01 Feb 2003



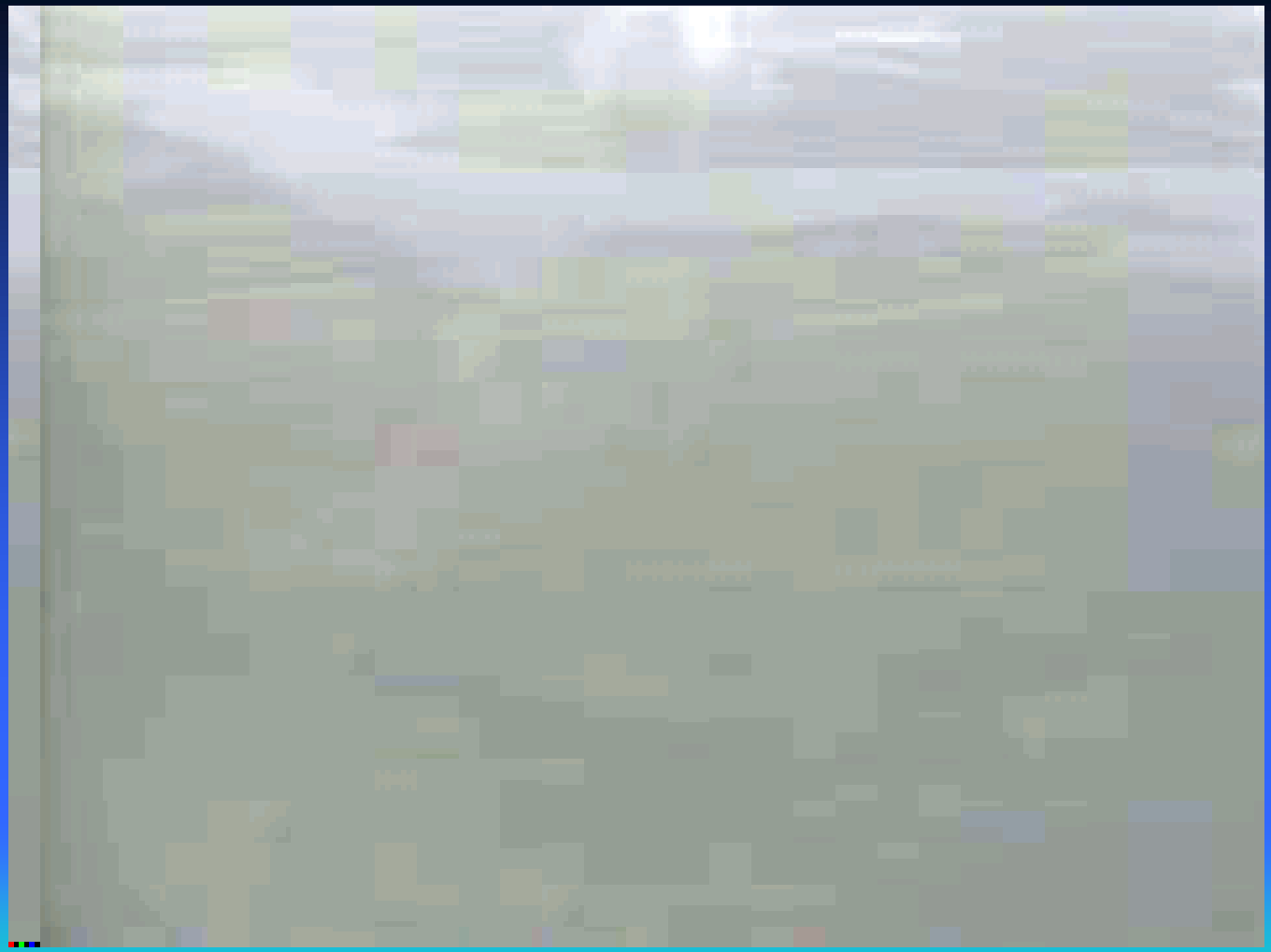
Amateur astronomers' video image may show wing trouble

Columbia breaks up over Texas

Landing

- KSC is preferred spaceport
- Edwards AFB is backup
- White Sands, NM used once

Pilot's Eye View



Rutan/Scaled Composites *SpaceShipOne* wins the X-Prize!

- Privately finances, builds & launches a spaceship, able to carry three people to 100 kilometers (62.5 miles)
- Returns safely to Earth
- Repeats the launch with the same ship within 2 weeks

Blue Origin

Astronaut Qualifications

How can I become an astronaut?

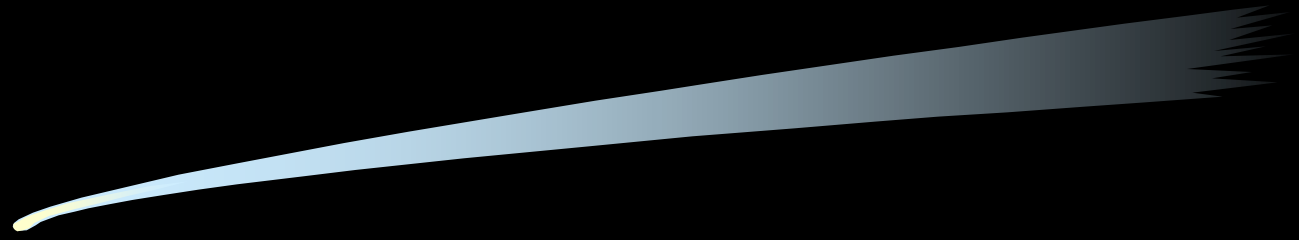
Any adult man or woman in excellent physical condition who meets the basic qualifications can be selected to enter astronaut training.

For mission specialists and pilot astronauts, the minimum requirements include a bachelor's degree in engineering, science or mathematics from an accredited institution. Three years of related experience must follow the degree, and an advanced degree is desirable. Pilot astronauts must have at least 1,000 hours of experience in jet aircraft, and they need better vision than mission specialists. Competition is extremely keen, with an average of over 4,000 applicants for about 20 openings every 2 years.

Astronaut recruiting occurs periodically. For more information, write to the Astronaut Selection Office, NASA Johnson Space Center, Houston, TX 77058.

Where to get more information

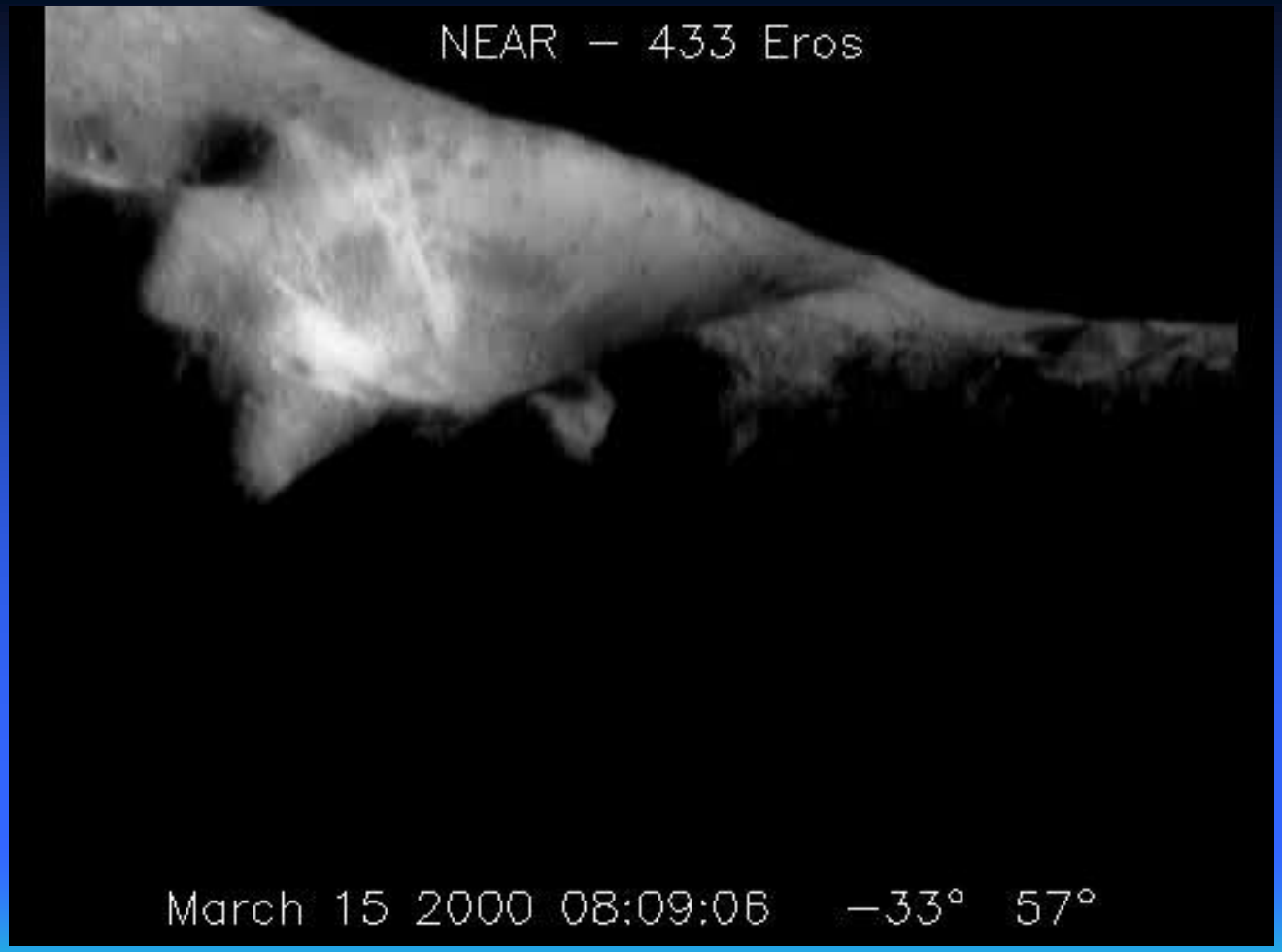
- Your local library
- The World Wide Web
  - Most of this presentation was prepared from WWW resources!
    - http://jrm.phys.ksu.edu/Scouts/
    - http://spacelink.nasa.gov/
    - http://www.yahoo.com/Science/Space/ (1531 listings!)



Delta II Launch Cam

Space Shuttle Cam!

Near Earth Asteroid Rendezvous



Roton Test Flight