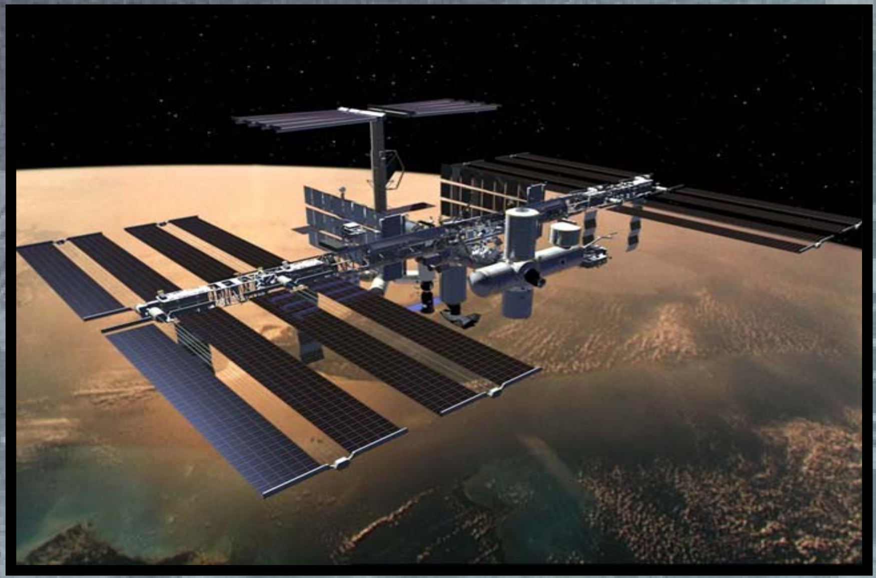
International Space Station



Today, the International Space Station is operating as a multi-room space hotel and research facility orbiting the Earth at an average altitude of 400 km.

Space Station circles the Earth every 90 minutes. That means the crew will see 16 sunrises each day.

Having People Live in Space Helps People on Earth

- **Learn about long-term effects of space on people and other living things so we can explore further into space**
- **Research without gravity opens a unique window into how things work**
- **New products for U.S. companies**

- **Learn to play well with people who come from different countries and speak different languages**
- **Enrich our lives through the excitement of learning**
- **Gain a better view of the world for seeing and solving our problems**

Human Exploration Begins with the International Space Station

Space operations for 30 days
• we can go to the Moon


International Space Station

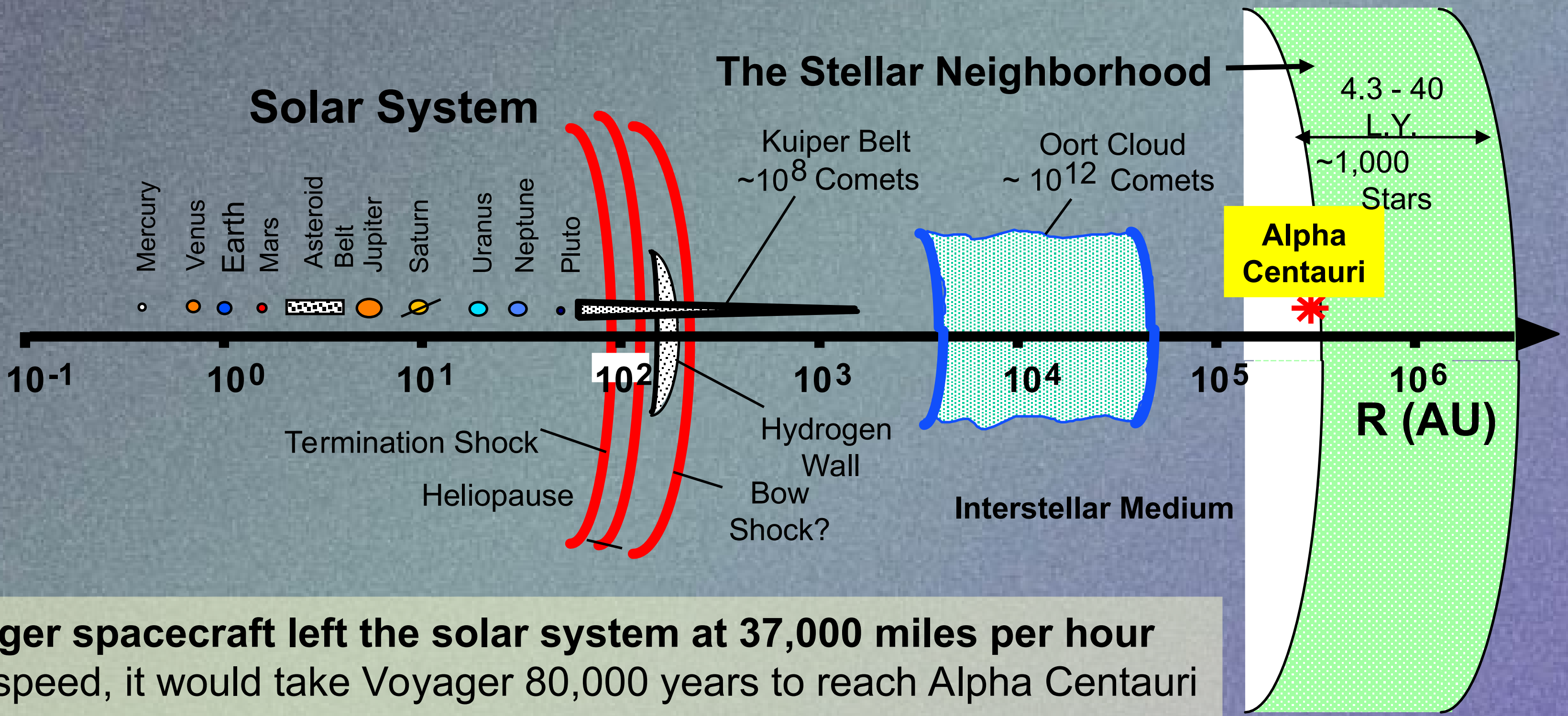
Space operations for 3 years
• We can go to another planet


Lunar Outpost

Humans on Another Planet


Just How Big Is Space?

Or: The Challenge of Time and Distance



The Voyager spacecraft left the solar system at 37,000 miles per hour

- At that speed, it would take Voyager 80,000 years to reach Alpha Centauri —our nearest star

For humans to explore the distant universe, we need:

- Propulsion methods that eliminate or drastically reduce propellant needs
- Dramatic increases in transit speeds

Joint Shuttle/*Mir* Program with Russia

Nine Missions to *Mir*

- First was STS 71—June 1995
- Final was STS 91—June 1998

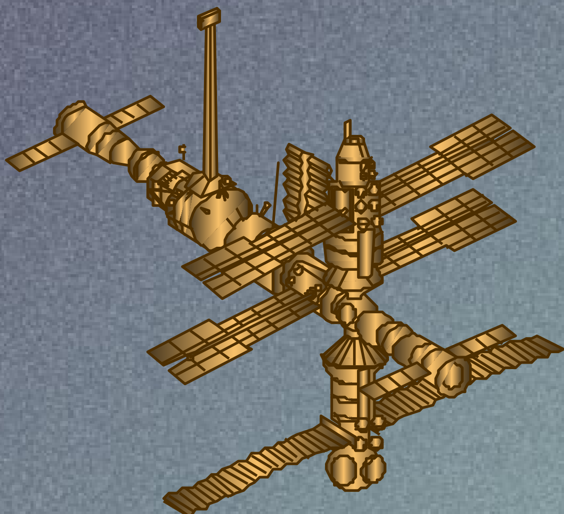
Four Main Objectives

- Learn to work with Russia
- Reduce International Space Station construction and operations risks
- Gain operational experience with long-duration missions
- Conduct research

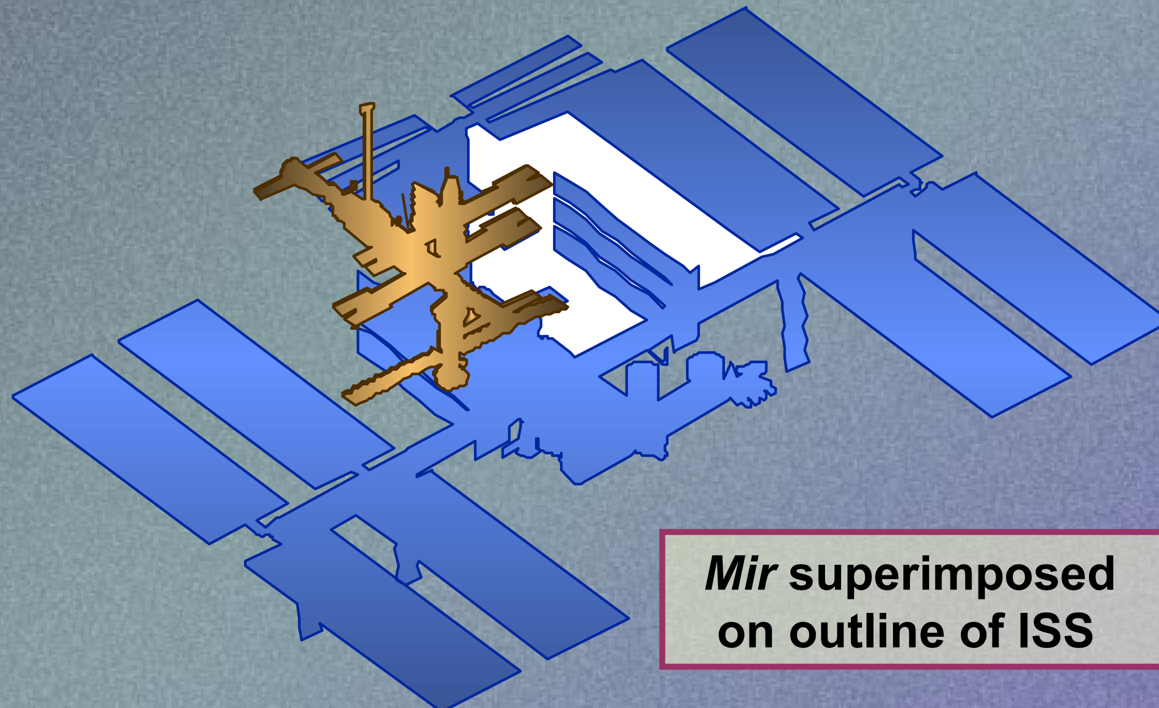
We learned a lot from unexpected on-orbit experiences

- **On-orbit fire in the *Mir* Core**
- **Progress vehicle collided with *Mir* while docking**
- **Interior and exterior space walks to make repairs**
- **Variety of system failures**

ISS–*Mir* Size Comparison



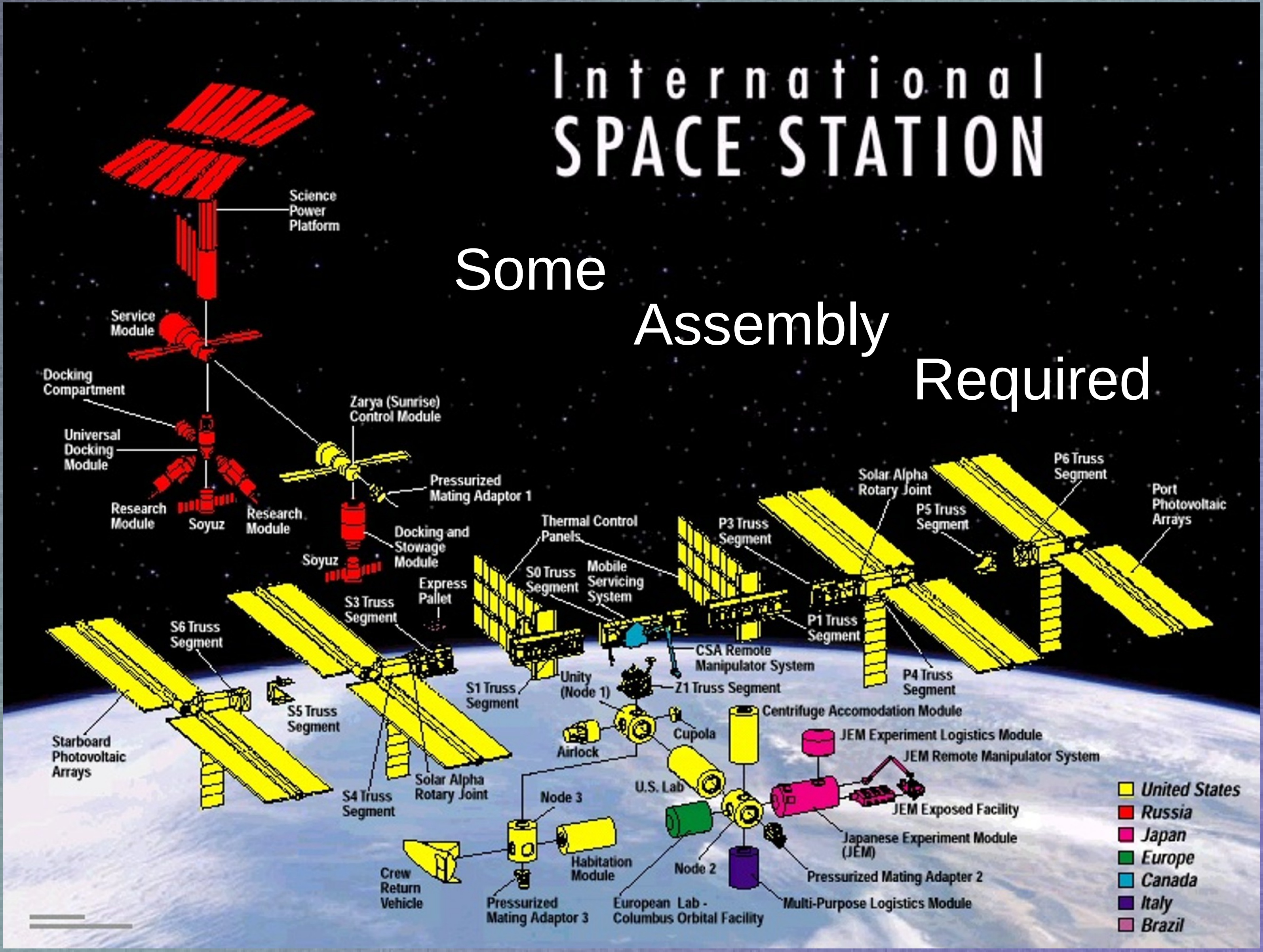
Mir **Space Station**



Mir **superimposed on outline of ISS**

	Length	Width	Height	Weight
Mir	108 ft.	98 ft.	89 ft.	90 metric tons
ISS	290 ft.	356 ft.	131 ft.	454 metric tons

International Space Station

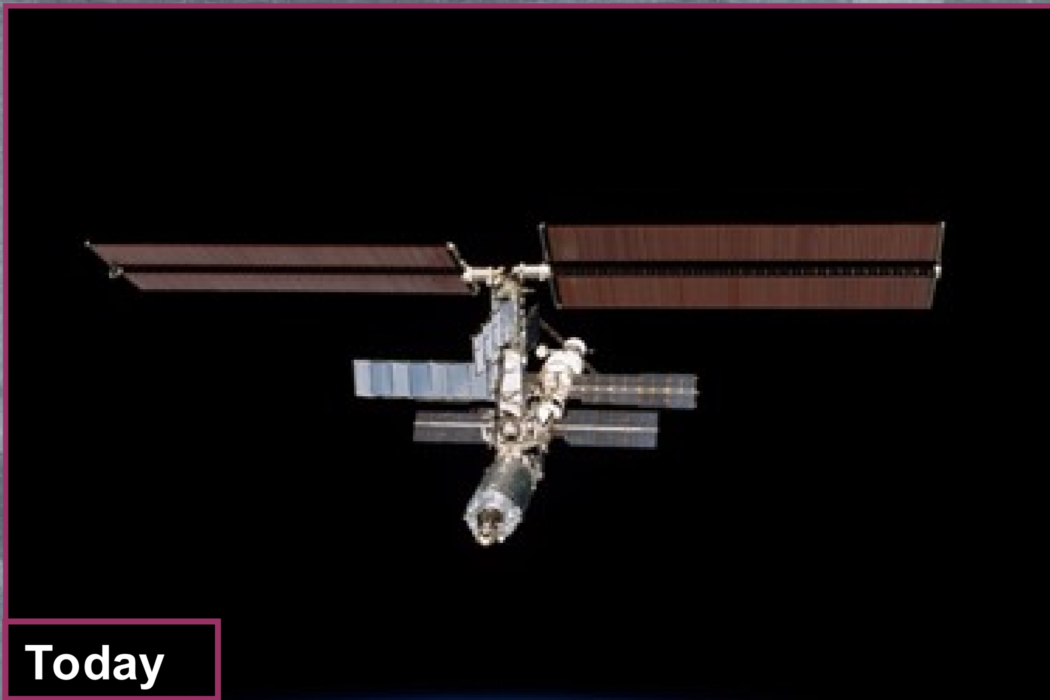


Some

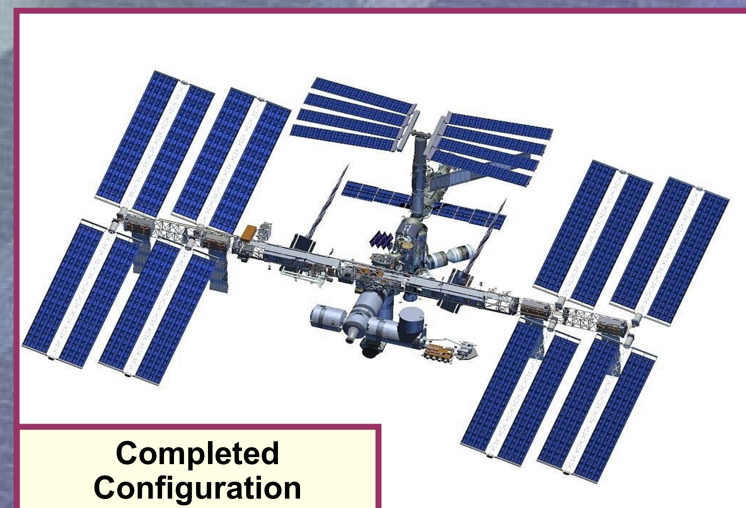
Assembly

Required

International Space Station
How Does It Get Assembled?



Today



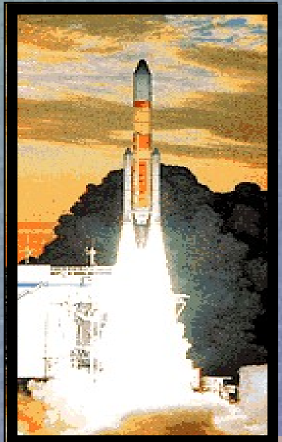
Completed Configuration

How Will Space Station Be Launched and Maintained?

America's Space Shuttle

Russia's Proton, Soyuz, and Progress vehicles

Europe's Ariane 5



Japan's H2

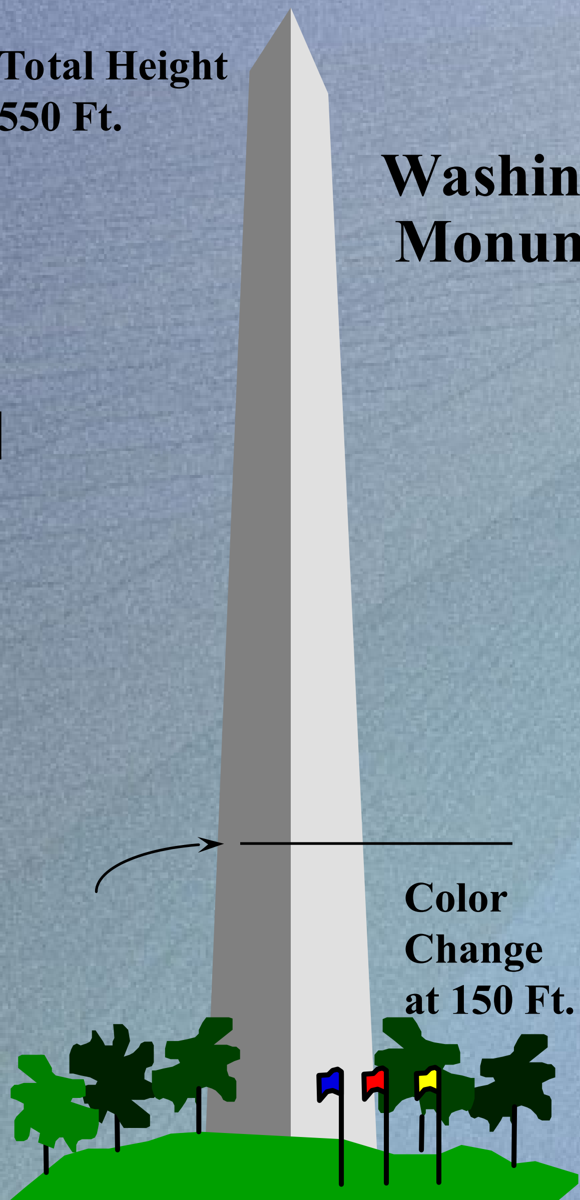
An international fleet of space vehicles will

- Rotate crews (Shuttle and Soyuz)
- Deliver propellant and supplies
- Replenish science experiments

How Big Is the Space Station?

Total Height
550 Ft.

Washington
Monument

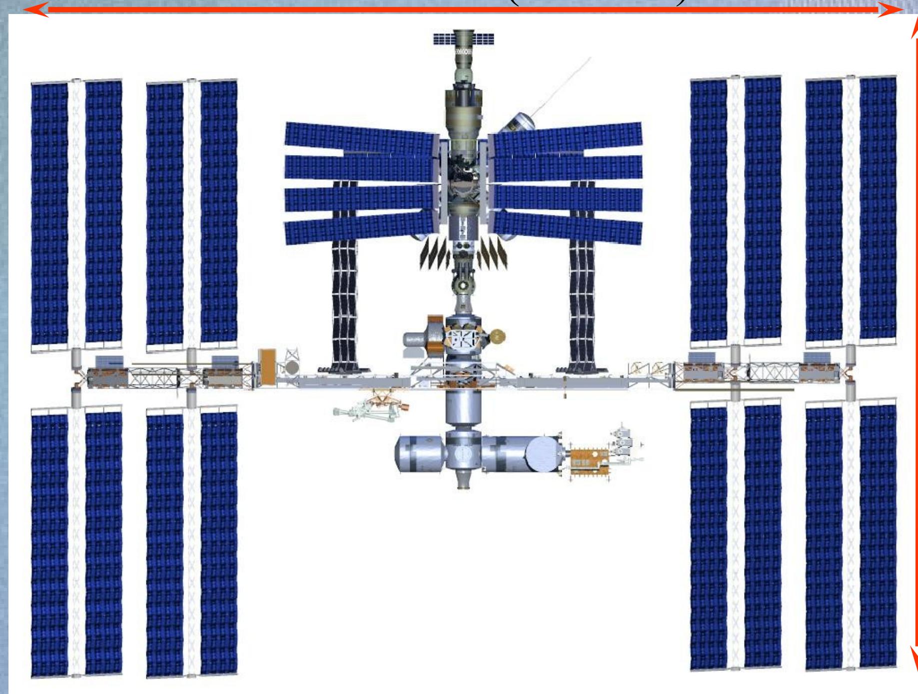


Color
Change
at 150 Ft.

International Space Station
Largest Structure Ever Built in Space

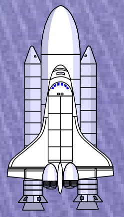
International Space Station

109 meters (356 feet)

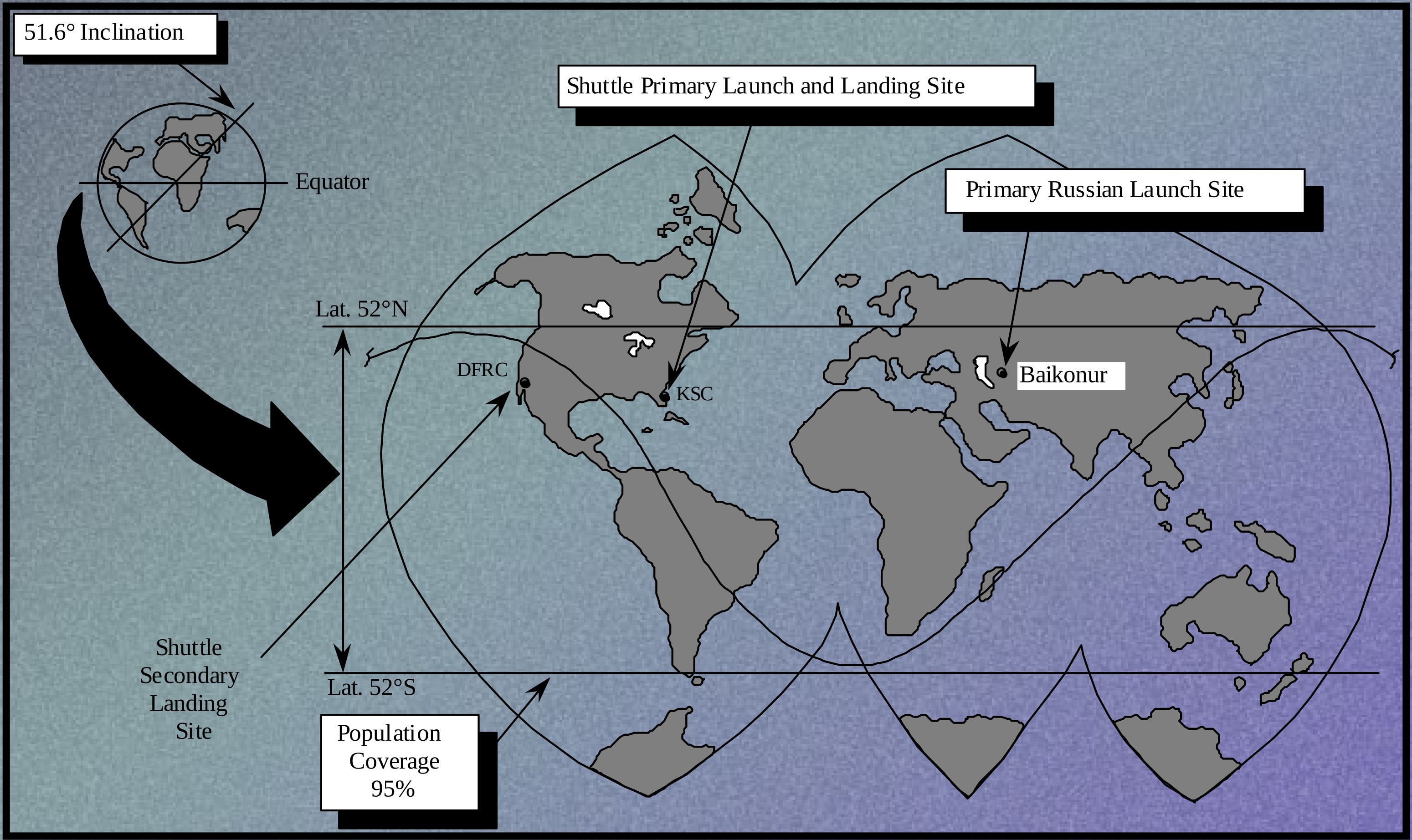


88 meters (290 feet)

**Space
Shuttle**



How Much of Earth Can You See from the Space Station?



ISS will fly over the same spot approximately every three days.

Hey—Who's Got the Remote?

Ground Operations Supporting All U.S. and Russian ISS Missions

Mission Control Center—Houston

Mission Control Center-Houston (MCC-H): Responsible for flight command and control of overall vehicle

Mission Control Center—Moscow

MCC-M: responsibility for flight command
and control of Russian Segment.

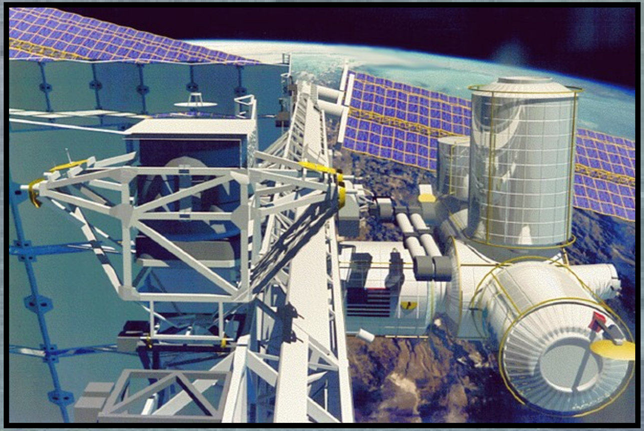
Payload Operations and Integration Center

Marshall Space Flight Center manages execution of on-orbit research

Space Station Research

What's Unique

A Microgravity Laboratory
- Use of low gravity as a research probe
- Long experiment run times
- Repeated access to experiments



A Long Term Observatory
- Unique view of earth and universe
- Long observing times
- Repeated visits to observatory

This research can't be done on Earth

Space Station Research

An Investment in Our Future

Improving Industrial Processes

Combustion Science
Fluid Physics
Materials Science

Increasing Fundamental Knowledge

Fundamental Physics
Fundamental Biology
Earth Science
Space Science

Looking After Our Health

Biomedical Research
Crew Care and Countermeasures
Protein Crystal Growth Research
Cell and Tissue Science
Advanced Medical and Life Support Technologies

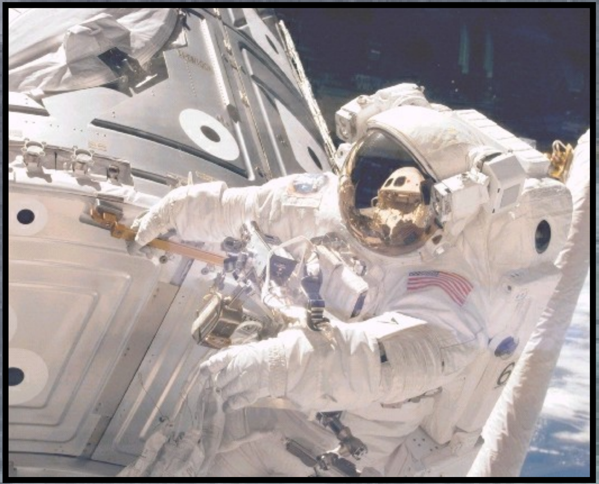
Enabling Exploration

Engineering Research
Scientific Research

Researching Tomorrow's Products Today

Commercial Cooperative Research
Testbed for New Commercial Processes, Products, and Services

Space Station Research

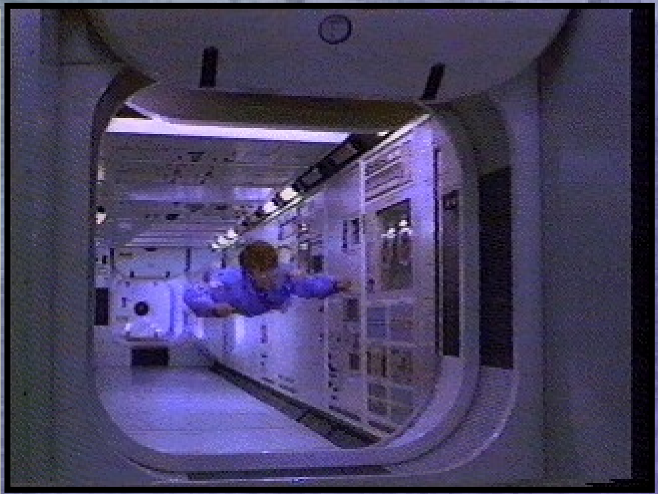


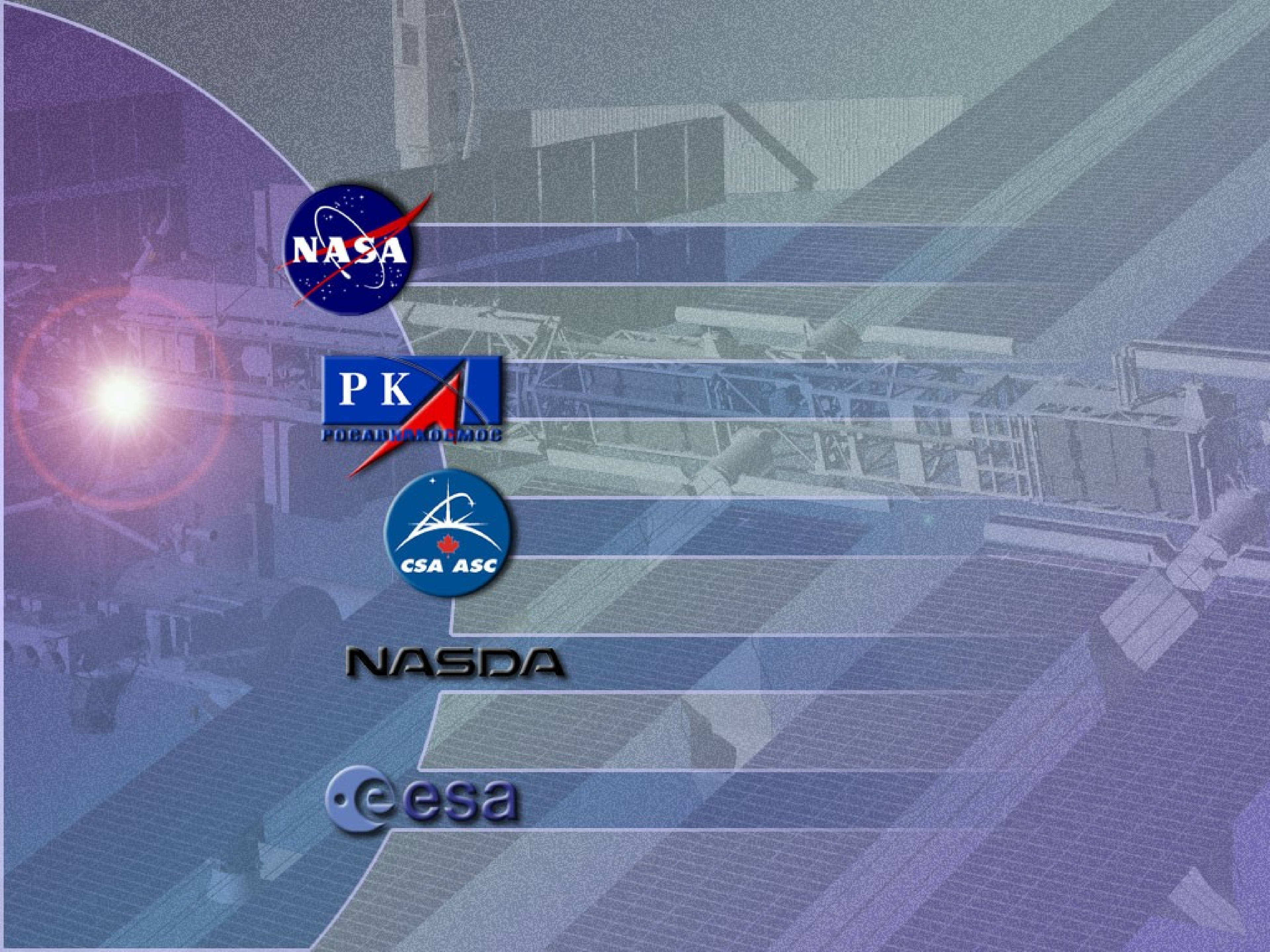
Unpressurized Research Capabilities:

- Express Pallet
- Technology Experiment Facility
- Low Temperature Microgravity Physics Facility
- Attached Payload Sites

Pressurized Research Capabilities:

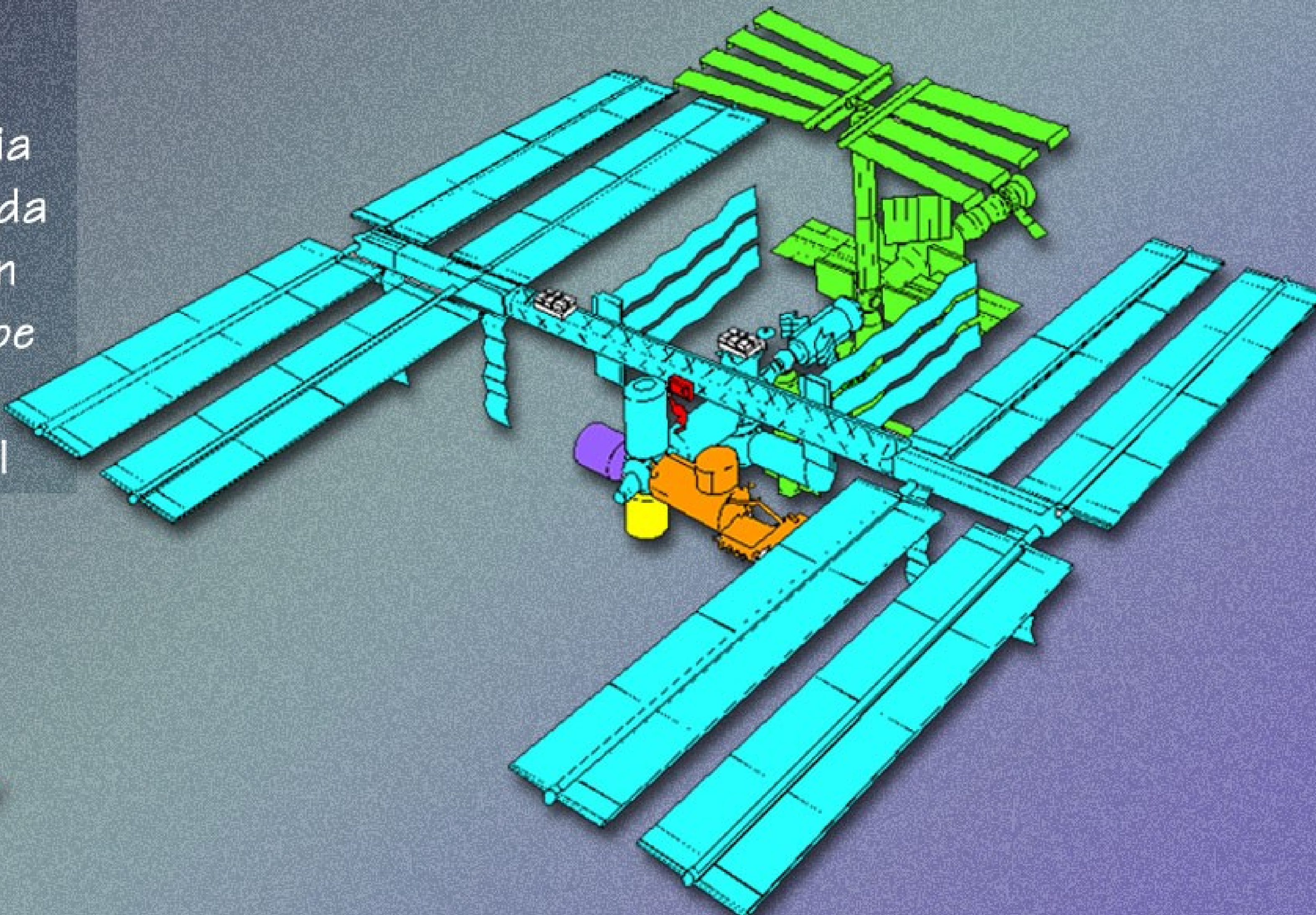
- Express Rack
- Cold Stowage
- Gravitational Biology Facility
- Human Research Facility
- Microgravity Sciences Research Facility
- Fluids and Combustion Facility
- X-ray Diffraction System
- Window Observational Research Facility



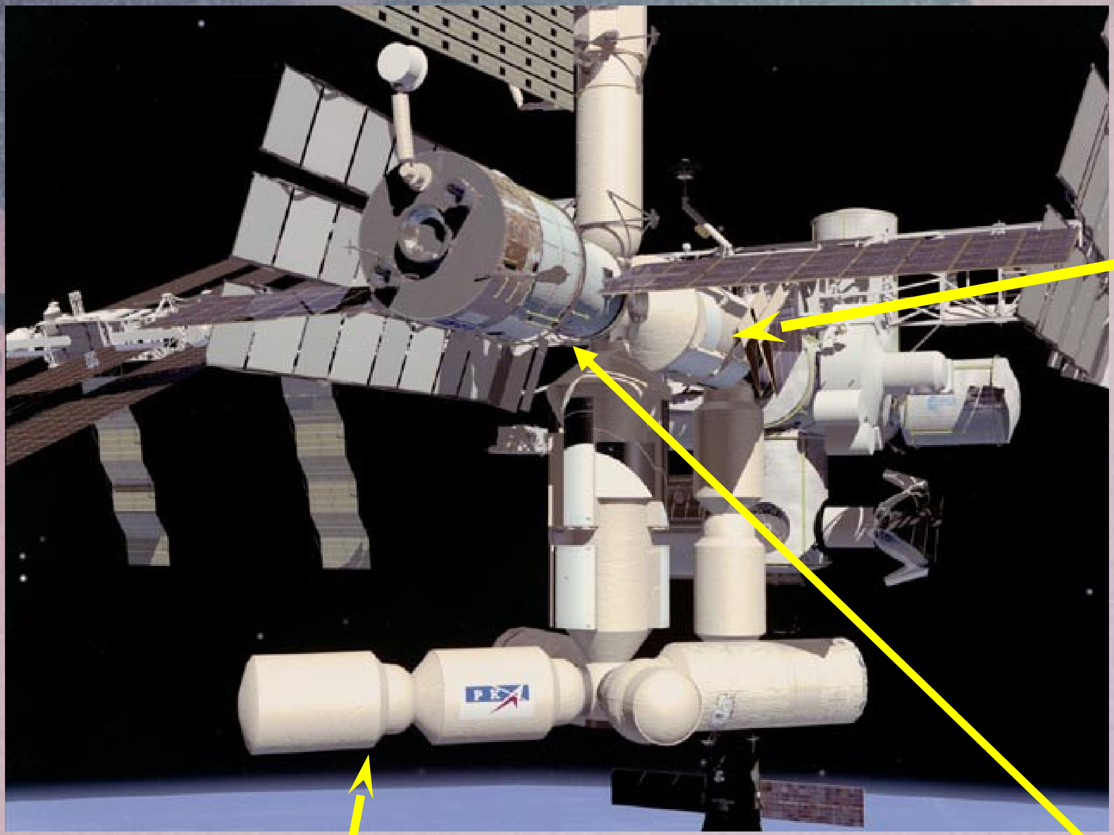

NASA
PK
CSA ASC
NASDA
esa

International Space Station Partner Participation

- U.S.
- Russia
- Canada
- Japan
- Europe
- Italy
- Brazil



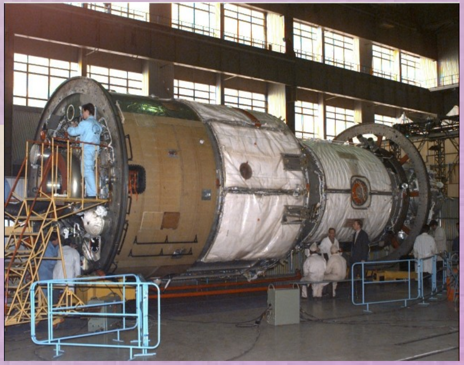
What Are the Russians Building?



Zarya (Dawn)
Control Module
Russian-built U.S.
Hardware

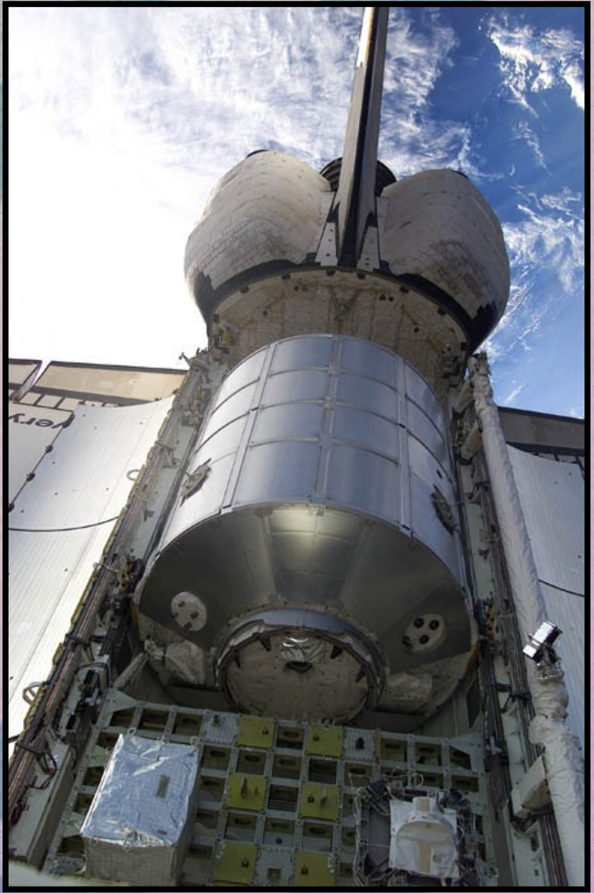
Research
Modules

Zvezda (Star)
Service Module



What Are the Europeans Building?

European Space Agency (ESA)
Columbus Orbital Facility (COF)



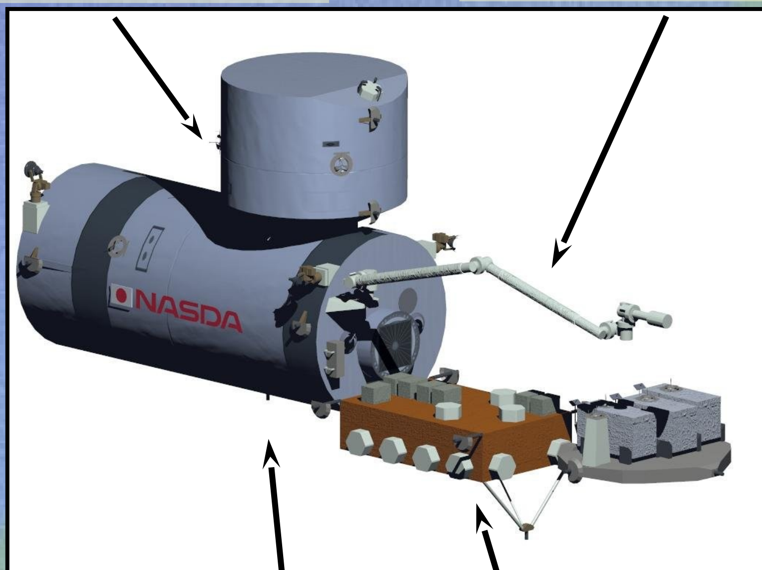
Italian
Mini-Pressurized Logistics Module (MPLM)
(U.S. Hardware Built in Italy)

What Is Japan Building?

Japan has named its part of the ISS "Kibo," which in English means "hope"; it stands for something that is expected and desired to be accomplished in the future.

Experiment Logistics Module (ELM-PS)

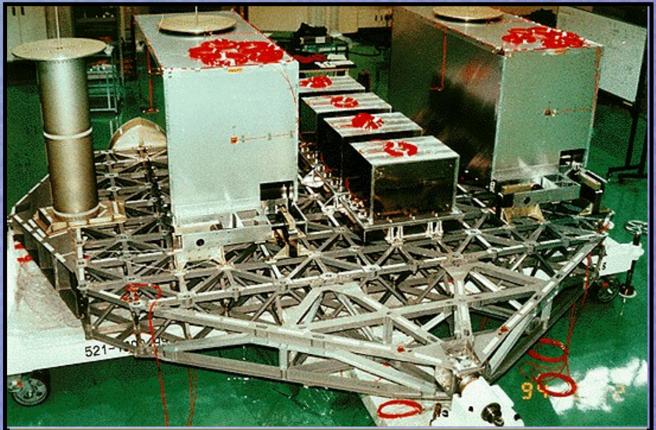
Remote Manipulator System (JEM-RMS)



Pressurized Module (PM)

Exposed Facility (EF)

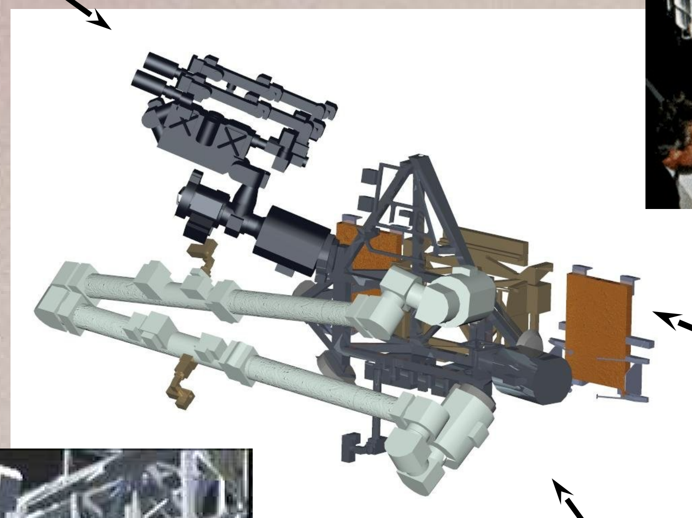
Japanese Experiment Module

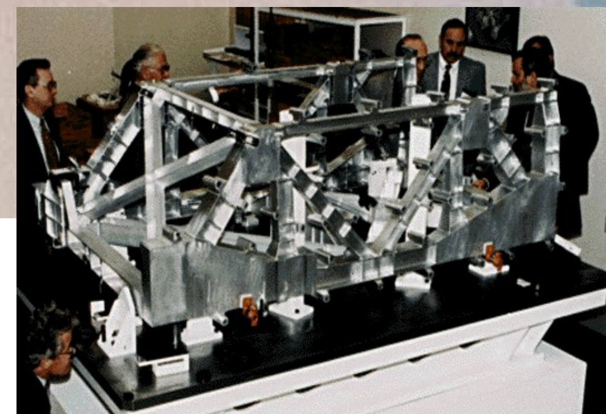


Japanese Experiment Facility (JEF)

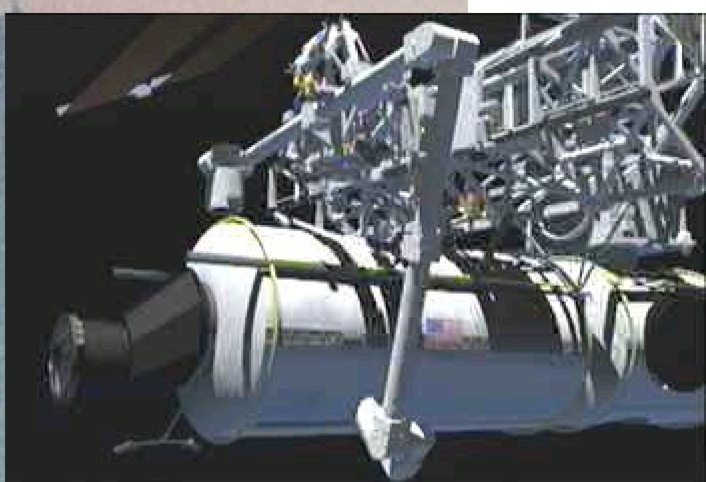
What Is Canada Building?

Dexterous Manipulator





Mobile Transporter



Remote Manipulator System

What Is Brazil Building?

Unpressurized Logistics Carrier (ULC)

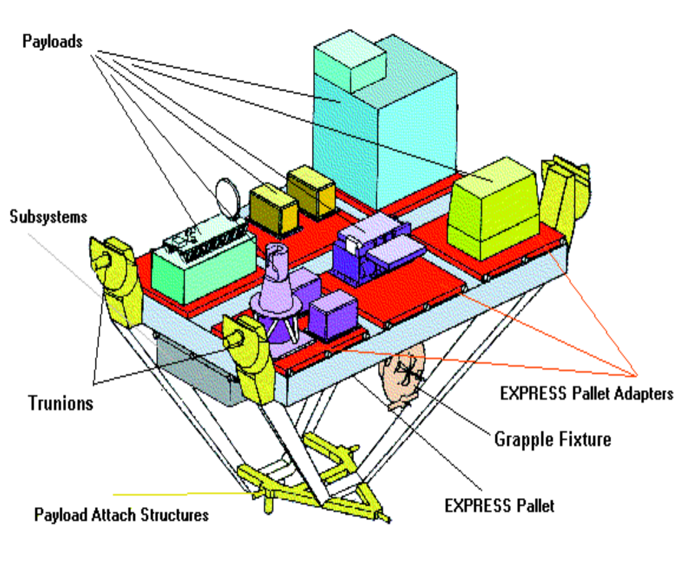
EXPRESS Pallet

Z1 Attachment Site

Cargo Handling Interface Assemblies (CHIA)

Window Observation Research Facility (WORF 2)

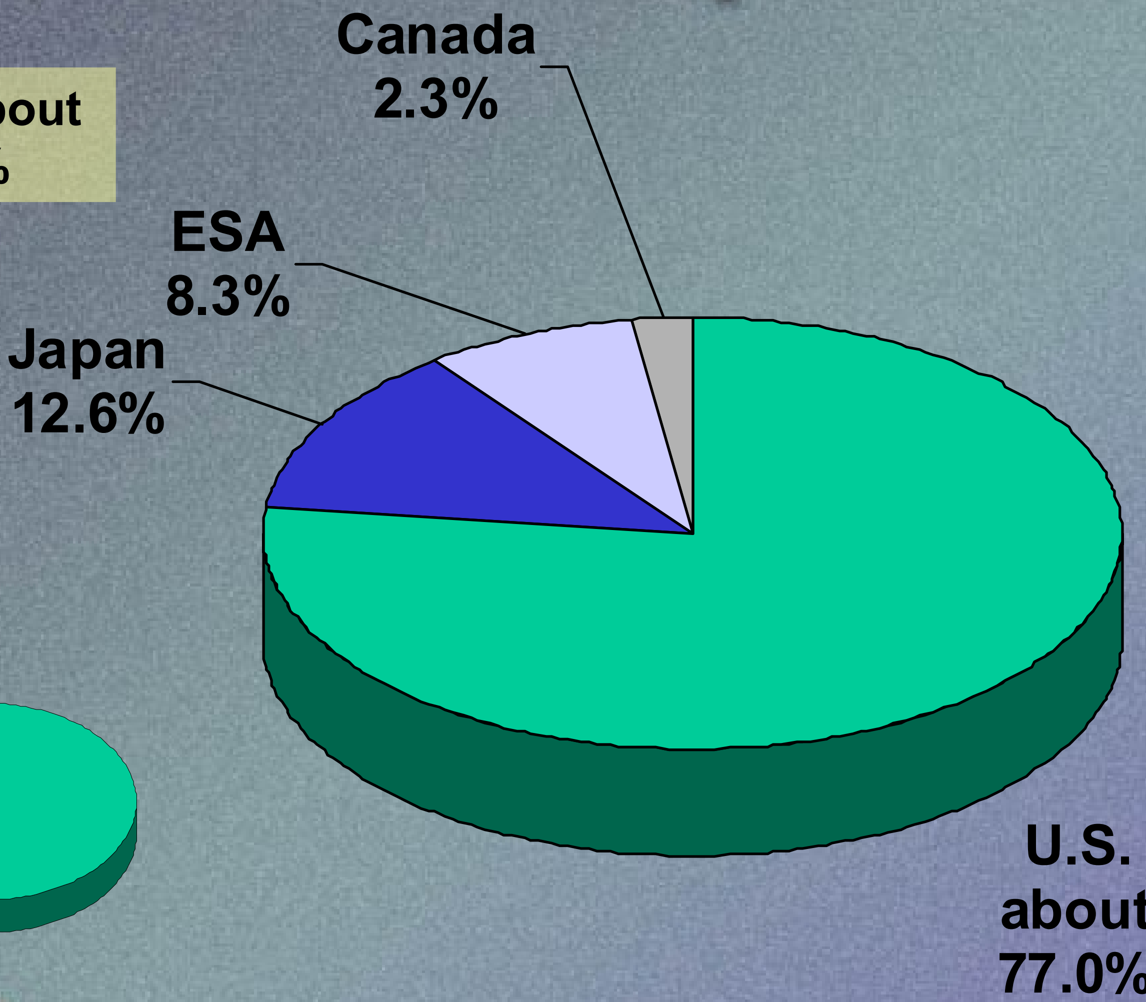
Technology Experiment Facility (TEF)



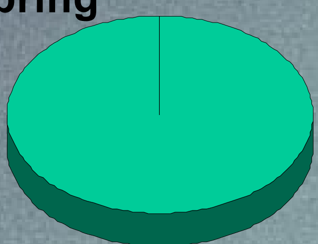
Drawing: EXPRESS Pallet

Who Gets to Use the Space Station?

IP's About 23%



Russia 100% of what they bring



U.S. Allocations:

- Life Sciences 30%
- Microgravity 30%
- Commercial 30%
- Other* 10%

Note:

Other U.S. includes OSF, Other U.S. Gov, Education, Public Affairs, International Barter

Space Station will have seven orbiting laboratories:
The U.S. Lab, ESA's Columbus Orbital Facility (COF), Kubo. Japan's Experimental Module (JEM), the Centrifuge Accommodations Module (CAM), and three Russian research modules.**

International Space Station Expedition-1 Crew

First ISS Crew

- **Bill Shepherd, Station Commander, U.S. Astronaut**
- **Yuri Gidzenko, Soyuz Commander, Russian Cosmonaut**
- **Sergei Krikalev, Flight Engineer, Russian Cosmonaut**

Nearly five months on orbit

- **Launched October 31, 2000, aboard a Soyuz from Baikonur**
- **Returned March 20, 2001, aboard the Space Shuttle**

ISS Begins a New Era of Permanent Operations in Space

International Space Station Expedition Crews

Expedition-2 Crew

- Docked March 10 2001 via the Space Shuttle
- Yuri Usachev, Jim Voss, Susan Helms
- Return on STS-105 (Flight 7A.1)

Expedition-3 Crew

- Flight 7A.1—STS-105
- Vladimir Dezhurov, Mikhail Turin,Frank Culbertson
- Return on STS-109 (Flight 8A)

Expedition-4 Crew

- Flight 8A—STS-109
- Yuri Onufrienko, Carl Walz, Dan Bursch
- Return on Soyuz #4

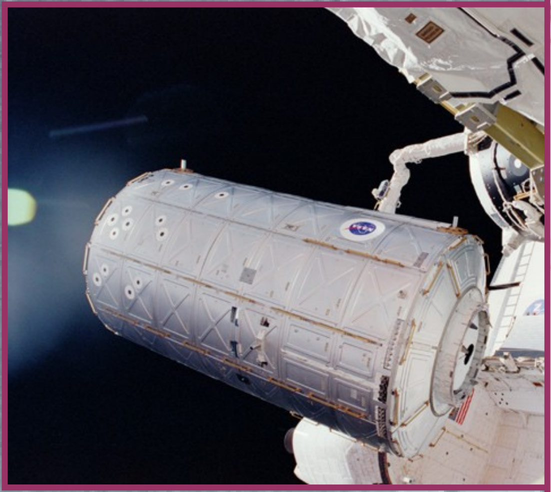
Expedition-5 Crew

Valeri Korzun, Commander/Pilot/RSA
Elena Kondakova, Flight Engineer/RSA
Peggy Whitson, Flight Engineer/NASA

Expedition-6 Crew

TBD, Commander/NASA
Yuri Malenchenko, Pilot/RSA
TBD, Flight Engineer/NASA

U.S. Laboratory Module



The Space Station is the largest structure ever built in space.

- Pressurized volume will be about the size of 3 average American homes (approximately 43,000 cubic feet).
- Six labs with 24 experiment racks (about the size of a refrigerator) and 11 vibration isolation racks for experiments that require quiescent environment.

I Gotta Get Home—Quick!

Picture: Test-drop from an Airplane

Crew Return Vehicle

- Returns an injured crew member
- Returns the whole crew if Station becomes uninhabitable or cannot be resupplied
- Accommodates up to 7
- Parafoil deploys after vehicle slows to subsonic speed and lands at about 35 knots
- CRV can be guided to land within a one-mile space—just about anywhere

This New House

Constructing the ISS is like building a small house,

moving in a family of three,

asking them to finish building the house while living in it,

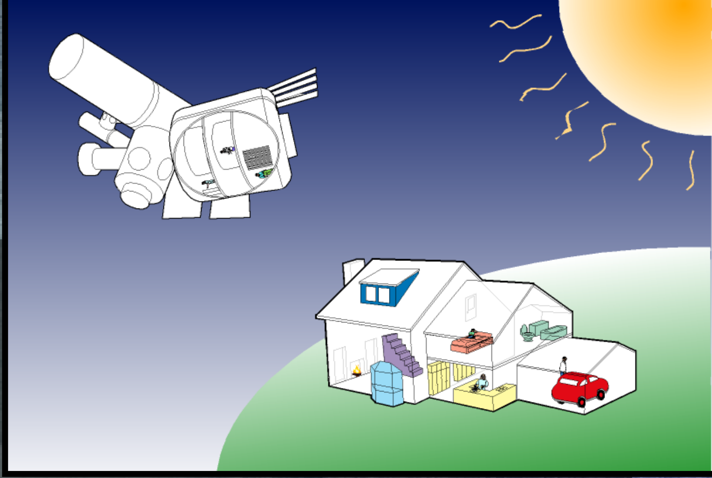
and, of course, working full-time from home.

By the way,

the house is in Antarctica,

and the dogsled delivers
supplies only once
every three months.

Structural Consideration



Lightweight Materials

- Delivery costs—$10,000/lb

Structural Strength

- High launch loads
- Pressurized container in the vacuum of space creates stress

Unpredictable Environment

- Outer shell protected with Kevlar
- A few very thick windows

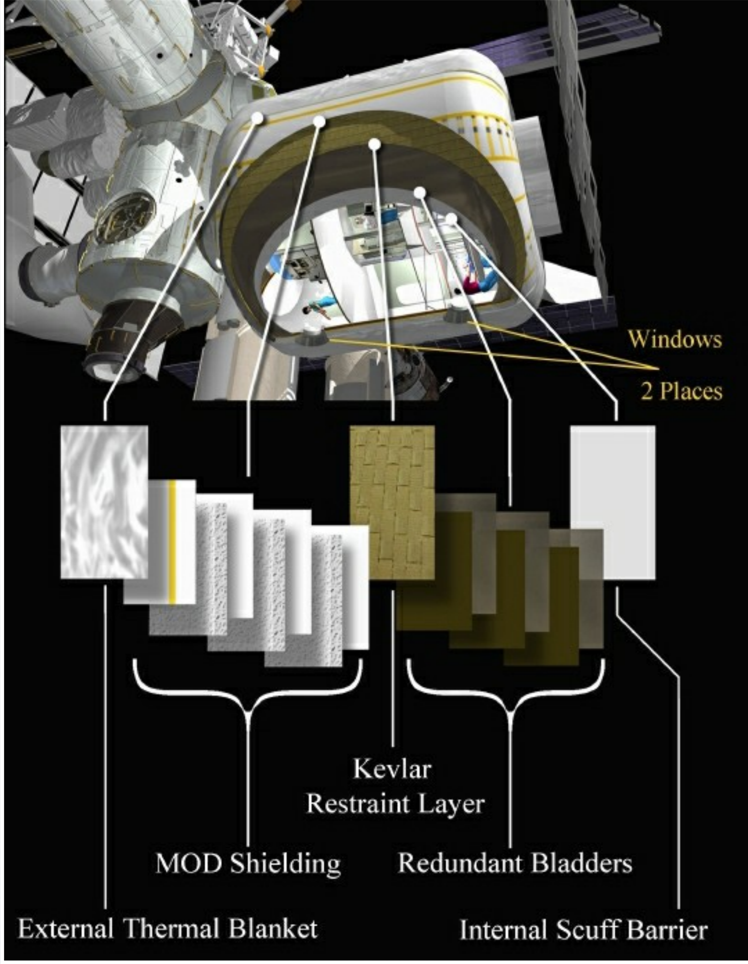
Onsite Assembly

- Spacesuits make detail work difficult
- Connections must be reliable, strong, yet easy to connect

Structure

Bad weather in space means tiny meteors and man-made debris.

The ISS requires special shielding—a "bulletproof vest."



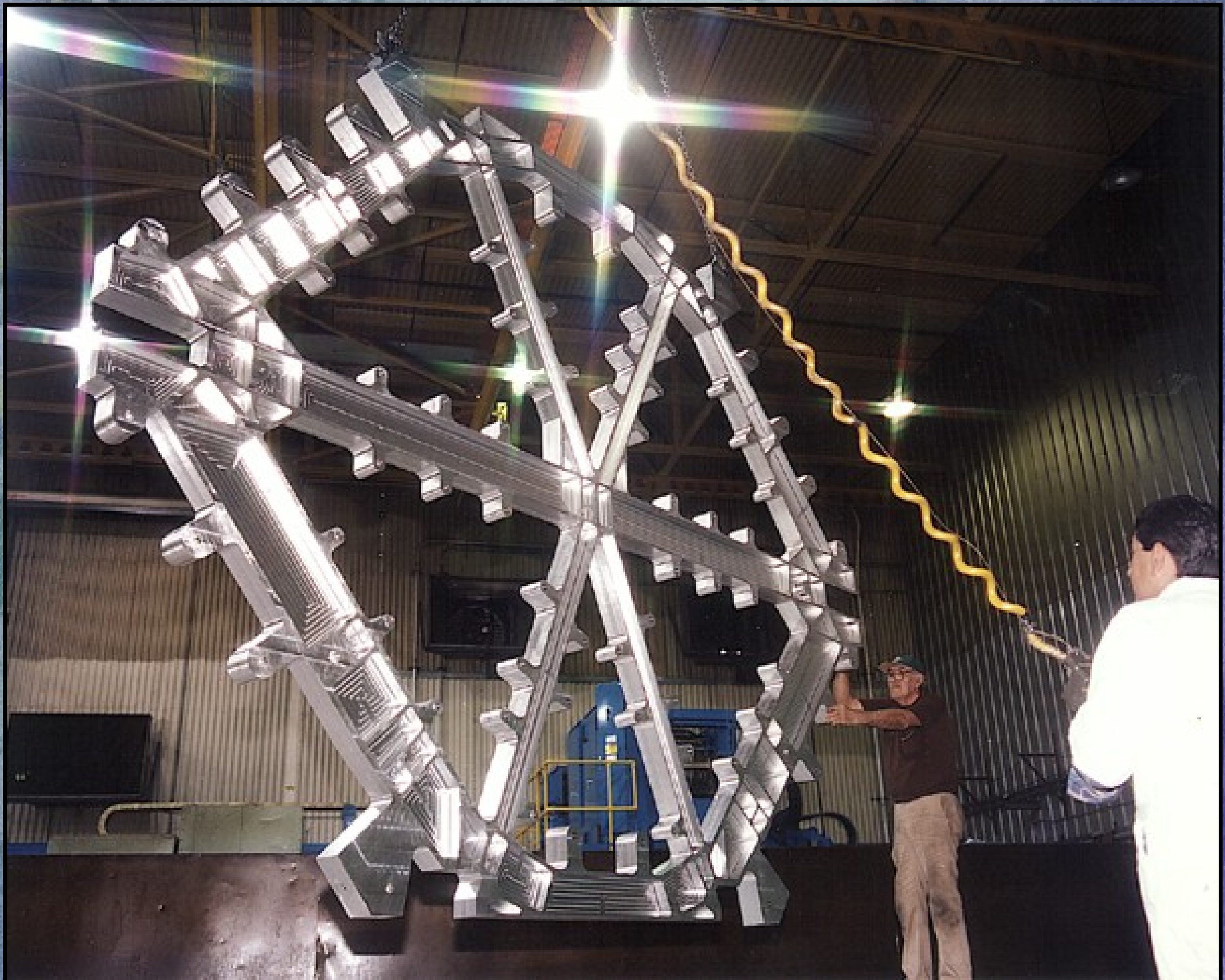
Windows are needed but are more than five times as thick as on Earth.

Structure

Principal force on modules in orbit is pressure of air inside—about 15 psi.

During launch, hardware will "weigh" three times its normal weight.

Strong and lightweight, aluminum makes up most of the structure.



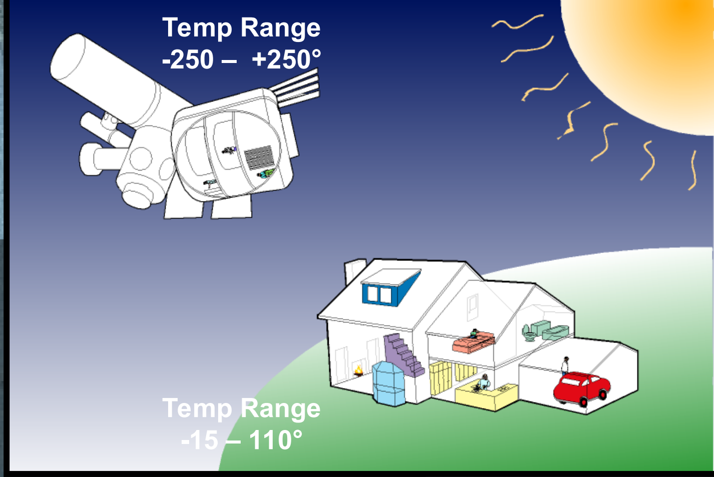
Structure

Common Berthing Mechanism links the modules together.

Berthing Mechanism links modules using 16 bolts tightened to 19,000 lbs each.

A huge force is needed to counteract internal air pressure wanting to push modules apart.

Heating and Cooling



ISS Is Super-insulated

- Multi-layer Mylar insulation
- Window frame heaters

Powered Equipment Produces Heat

Internal Heat-transfer System Required

- Cold water piped through interior walls
- Heat exchanger controls humidity
- Ammonia system transfers heat to external radiators

Earth Systems

- Based on gravity-induced convective heat transfer

Primary difference between Earth and space is how heat is dissipated

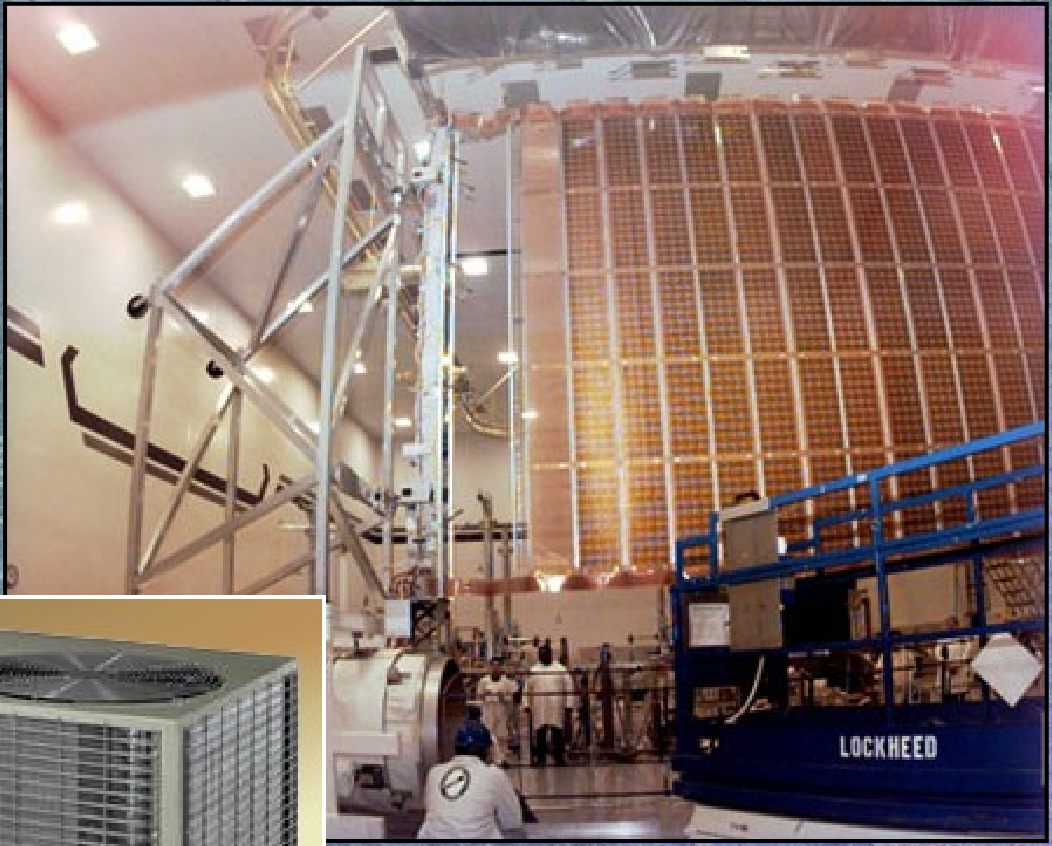
Heating and Cooling

The purpose of insulation on Earth is to limit the convection and conduction of heat.

In space, external insulation reflects the Sun's heat away.

Heating and Cooling

Without air, heat from the Space Station must be dissipated through radiators.



On Earth, heat exchange is usually achieved through air flow.

Habitat

Work Day

- 14 hours work
- 1.5 hours meals
- 8.5 hours sleep

Living in Space—Day to Day

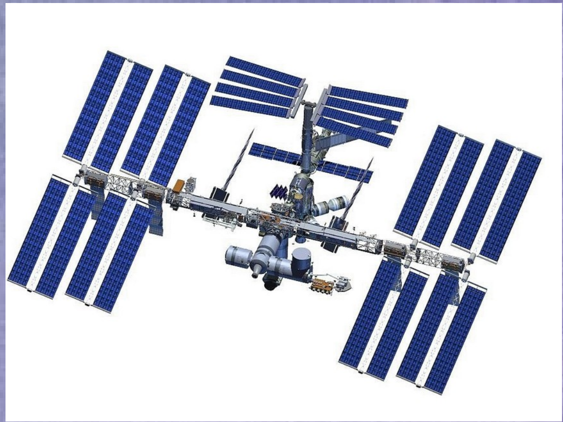
- Design criteria
- Materials
- Cooking and cleaning
- Personal hygiene

How Much Space Is There on the International Space Station for People?

The average American house is about 1,800 square feet. With an 8-foot ceiling, that's about 14,400 cubic feet.

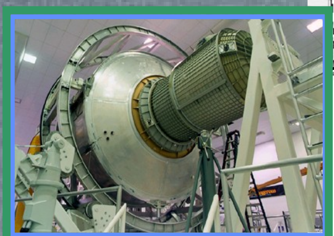
Space Station has about 43,000 cubic feet of pressurized volume. About how many average houses would this be?

√ About 3

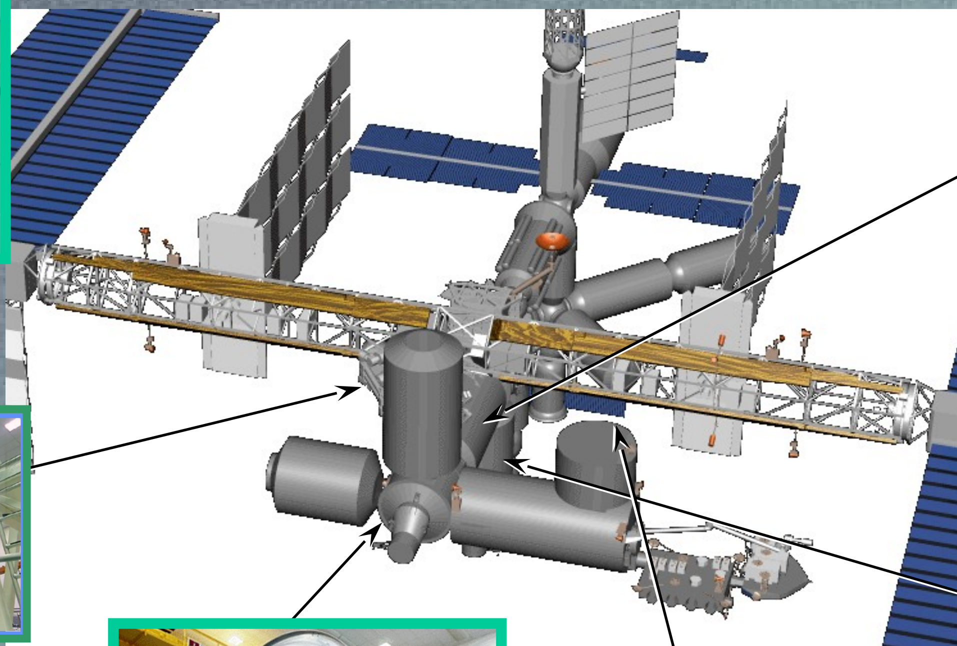


Places People Live, Work, and Breathe

System Racks
(placed in HAB/LAB Modules)



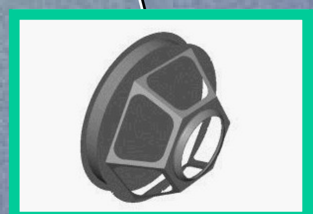
Airlock and High-Pressure Gas
(underneath Truss)



U.S. Lab Module

U.S. Hab Module

Node Structure



Cupola
(underneath)

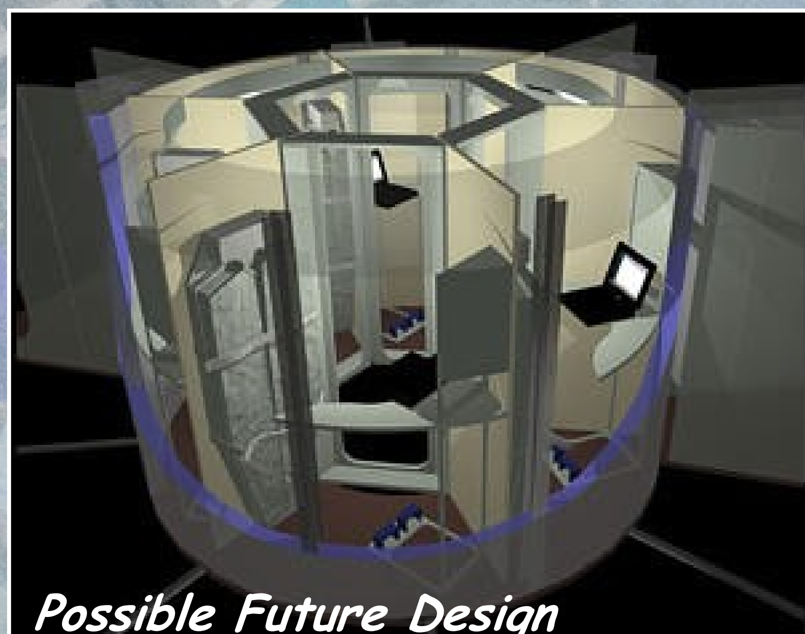
Habitat

These racks make up the kitchen, or "galley."
The wardroom table will function as the main food preparation area.

Table with Earth viewing window

Habitat

Sleeping quarters are small, and the crew sleep vertically in sleeping bags strapped to the wall.

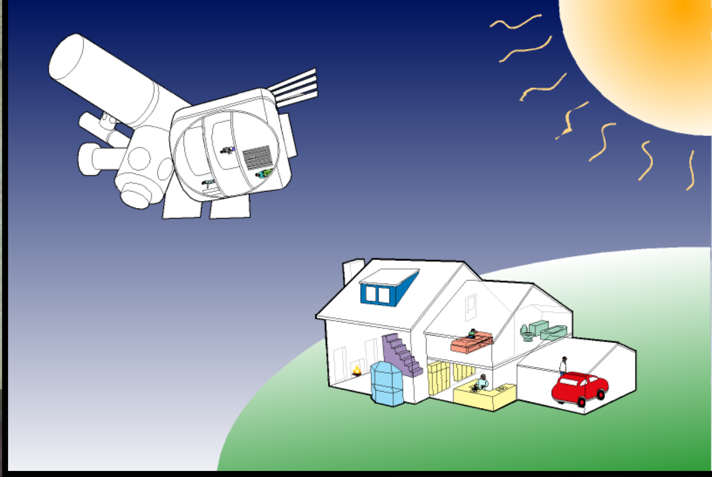


Possible Future Design

Habitat

In bathrooms on the ISS, unlike bathrooms on Earth, air moves waste through the system. Solid wastes are compressed and stored onboard.

Power



Solar Arrays Produce Electric Power

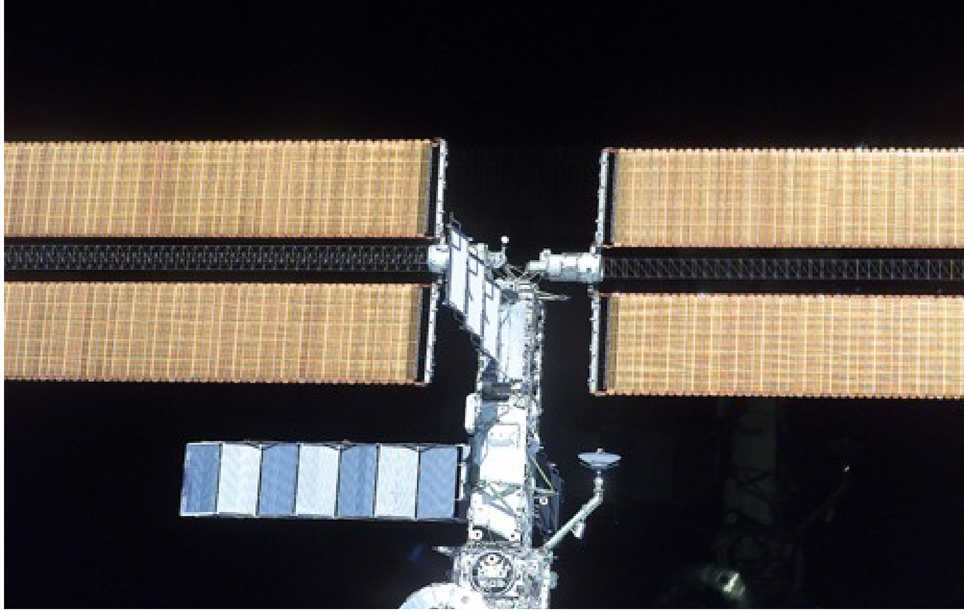
- ISS serves as both the local power company and the consumer
- Equivalent to power used by about 50 homes
- Fifty percent for systems—50 percent for experiments

Power System Is Direct Current (DC)

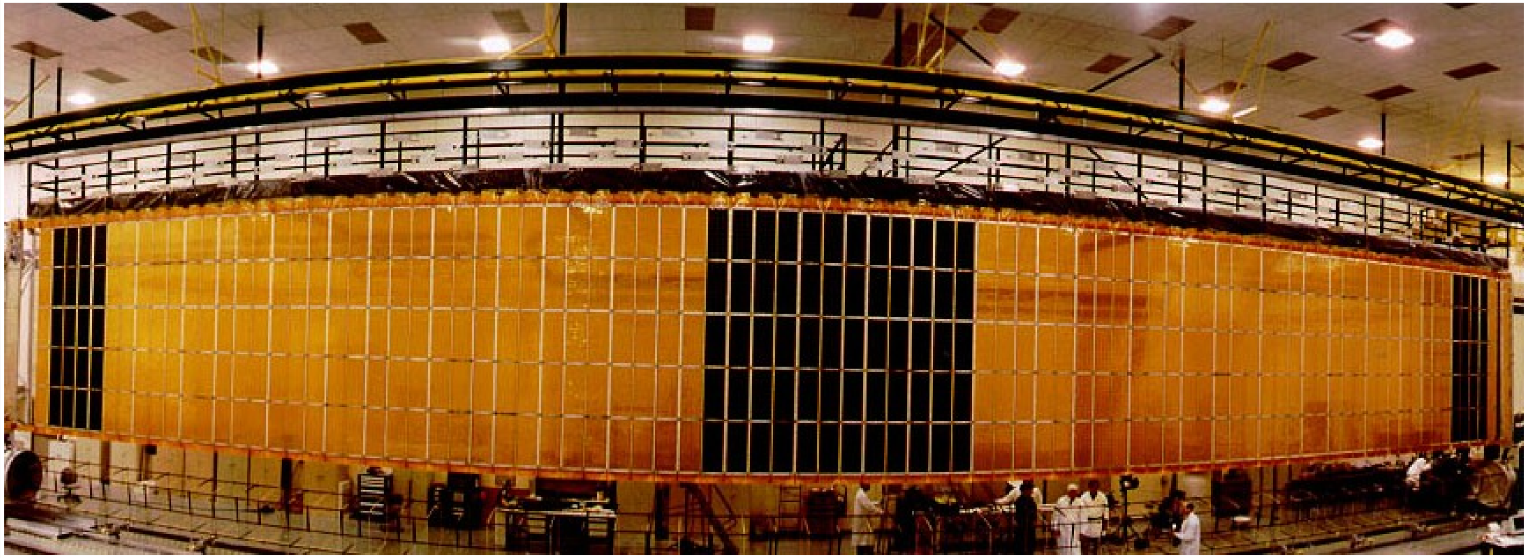
- Homes on Earth are AC—better for long-distance power transmission
- DC better suited for use with batteries (consistent with output)

Power

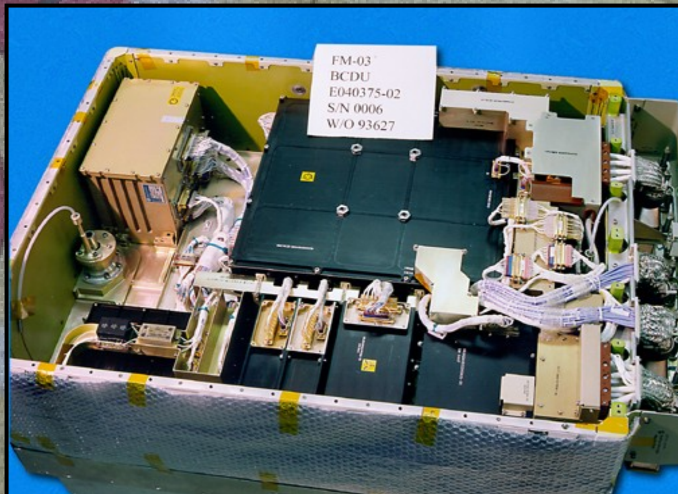
Orbiting at 17,500 mph, arrays constantly track the Sun.

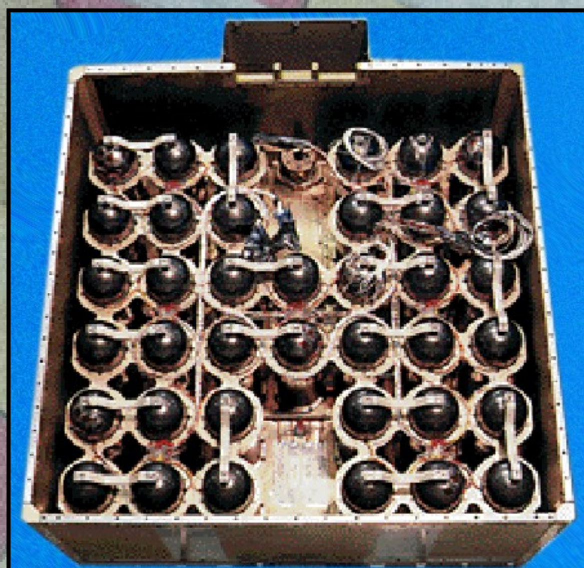


ISS seeks direct sunlight—similar to summer on Earth.



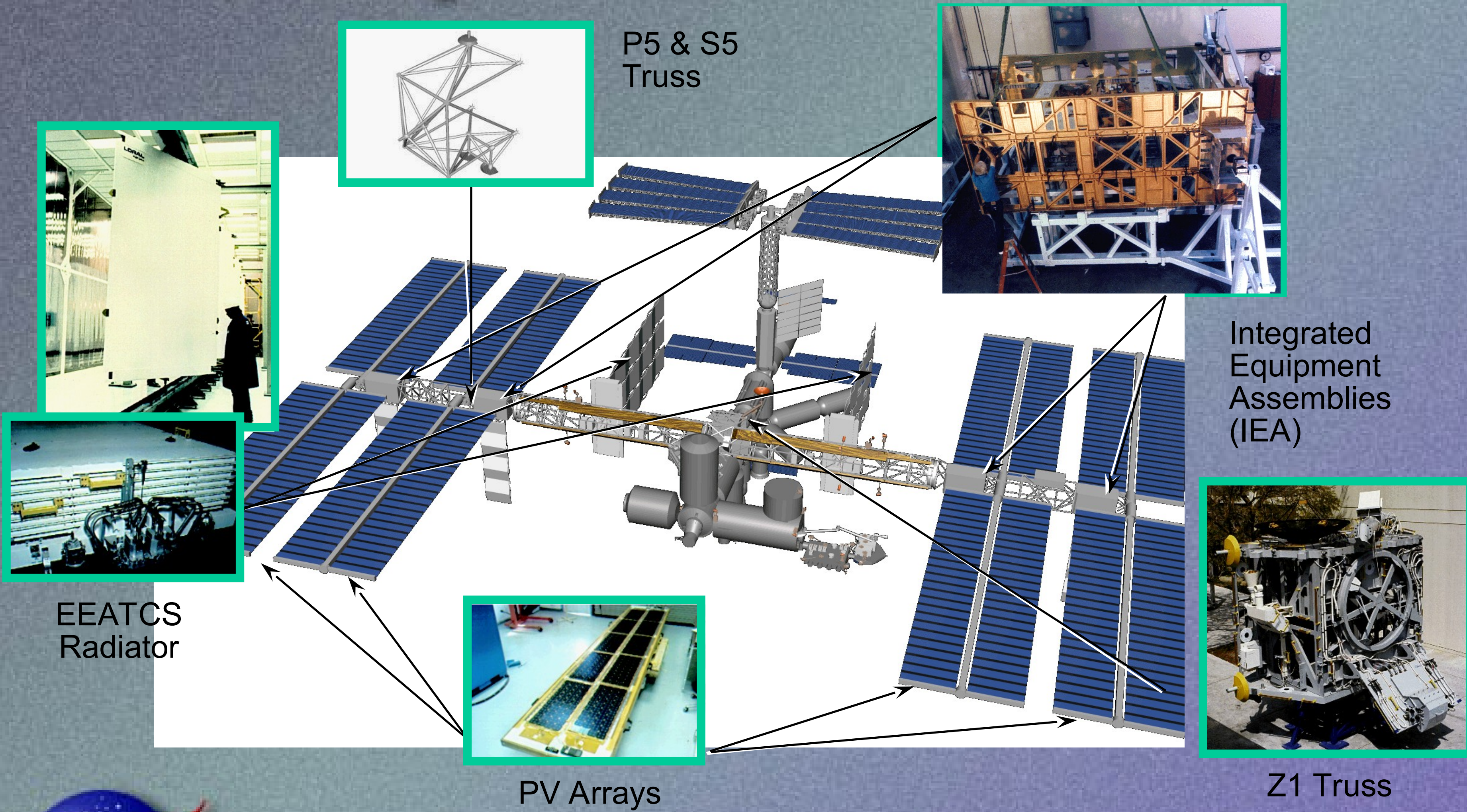
Power





Solar power is stored in batteries and then used during eclipse periods, which usually last about 30 minutes.

The Power System



Power is generated from four sets of solar arrays on the truss. Alpha joints provide sun tracking.

Thermal radiators dissipate heat that is transported through an internal water cooling loop system.

Join us in the excitement of exploration!

spaceflight.nasa.gov
education.nasa.gov