

*Exploring Space and Investing in the Future:
Perceptions and Experiences of a
Retired NASA Astronaut*



Bonnie J. Dunbar, PhD NAE

University of Houston

Professor, Mechanical Engineering

Director, UH STEM Center

Director, Aerospace Grad. Pgm





The Milky Way: Inspiring Dreams



Wright 1903 Flyer (replica)

Robert Goddard 1882 - 1945



"It was one of the quiet, colorful afternoons of sheer beauty which we have in October in New England, and as I looked toward the fields at the east, I imagined how wonderful it would be to make some device which had even the **possibility** of ascending to Mars, and how it would look on a small scale, if sent up from the meadow at my feet."

"I was a different boy when I descended the tree from when I ascended, for existence at last seemed very purposive." 1899

October, 1957



Sputnik Launched by the Soviet Union:

Soviet Union--Yuri Gagarin: First Human to Orbit the Earth: April 12, 1961



United States: May 5, 1961
Alan Shepherd launched Sub-orbital



Mercury 7

United States: John Glenn launched into orbit Feb 20, 1962



Flies again on Space Shuttle at age 77

President Kennedy Commits the Nation

Rice University, Houston, TX - 9/12/62

- *“...This generation does not intend to founder in the backwash of the coming age of space. We mean to be a part of it – we mean to lead it.”*

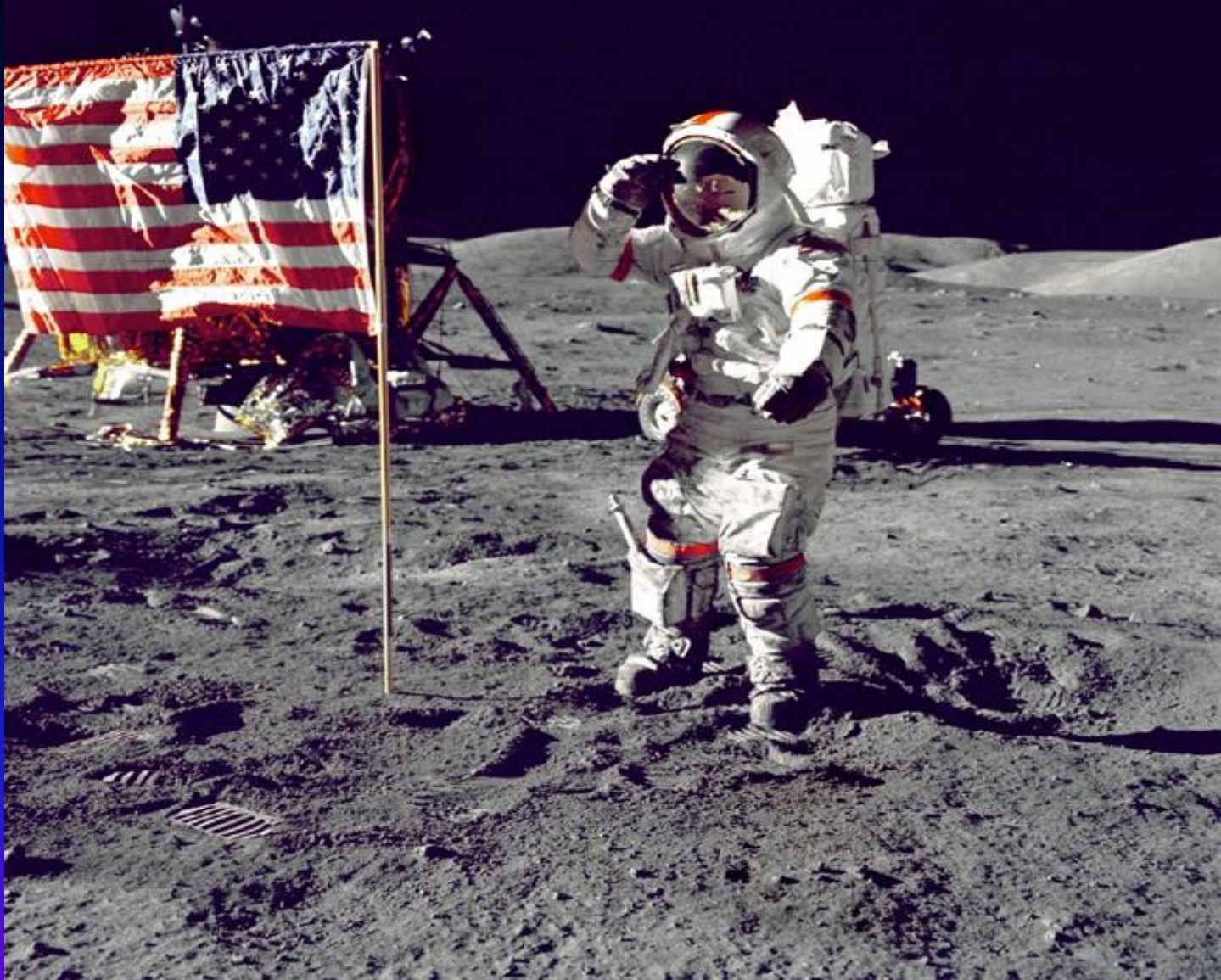


President Kennedy Commits the Nation

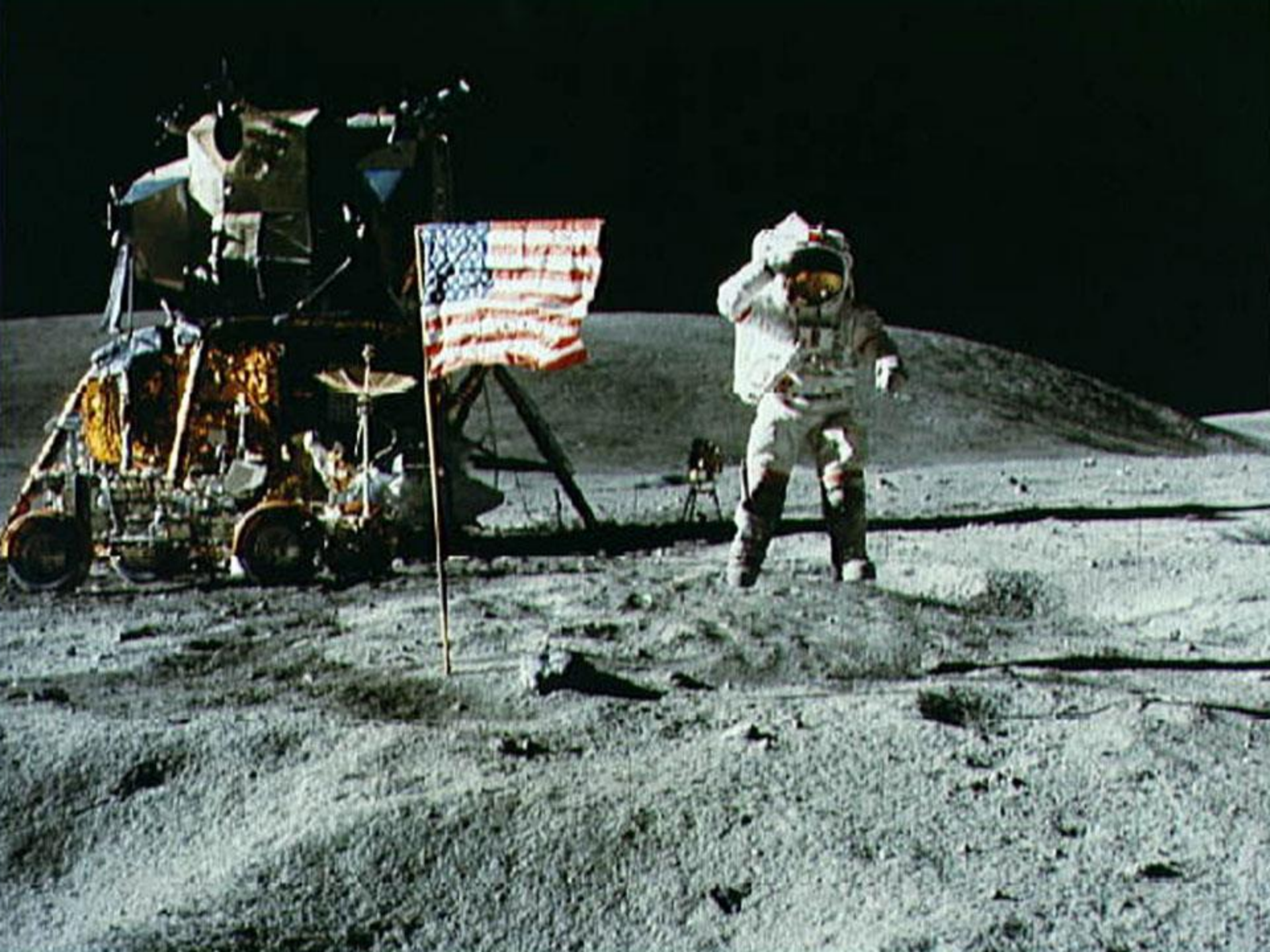
Rice University, Houston, TX - 9/12/62

- *...This country was conquered by those who moved forward—and so will space...We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard...The growth of our science and education will be enriched by new knowledge of our universe and environment....*





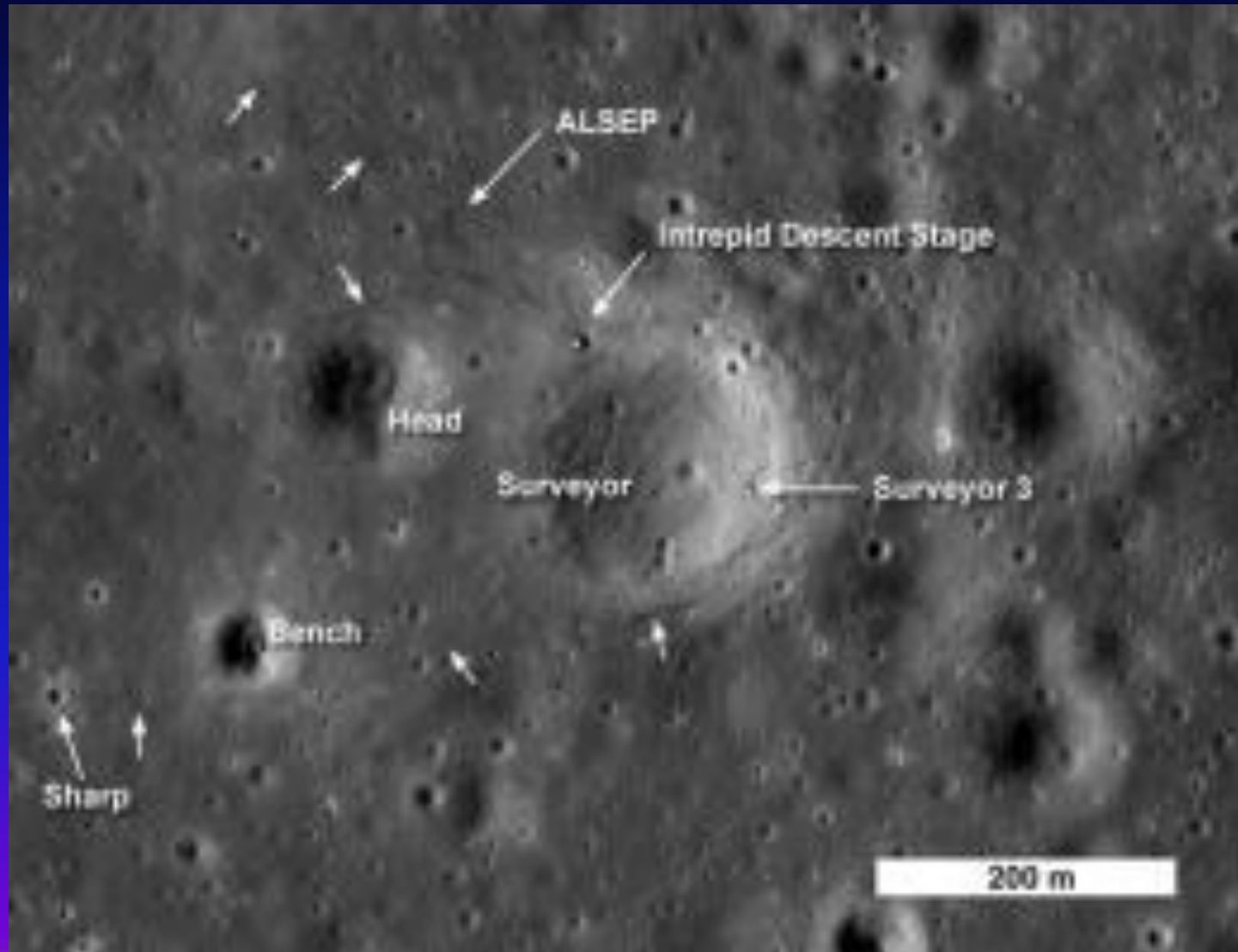
July 20, 1969: Neil Armstrong walked on the Moon

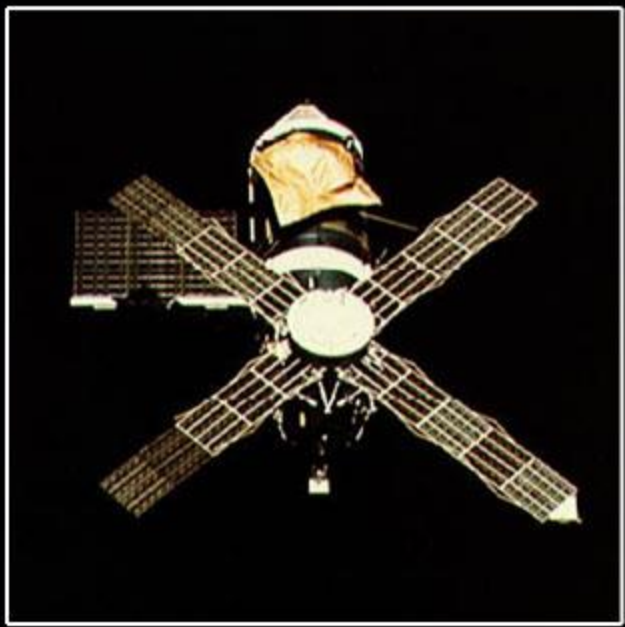






Lunar Reconnaissance Orbiter (LRO) Viewed Apollo 12 (1969) and Surveyor (1967) 40 years after









S-82-01840A

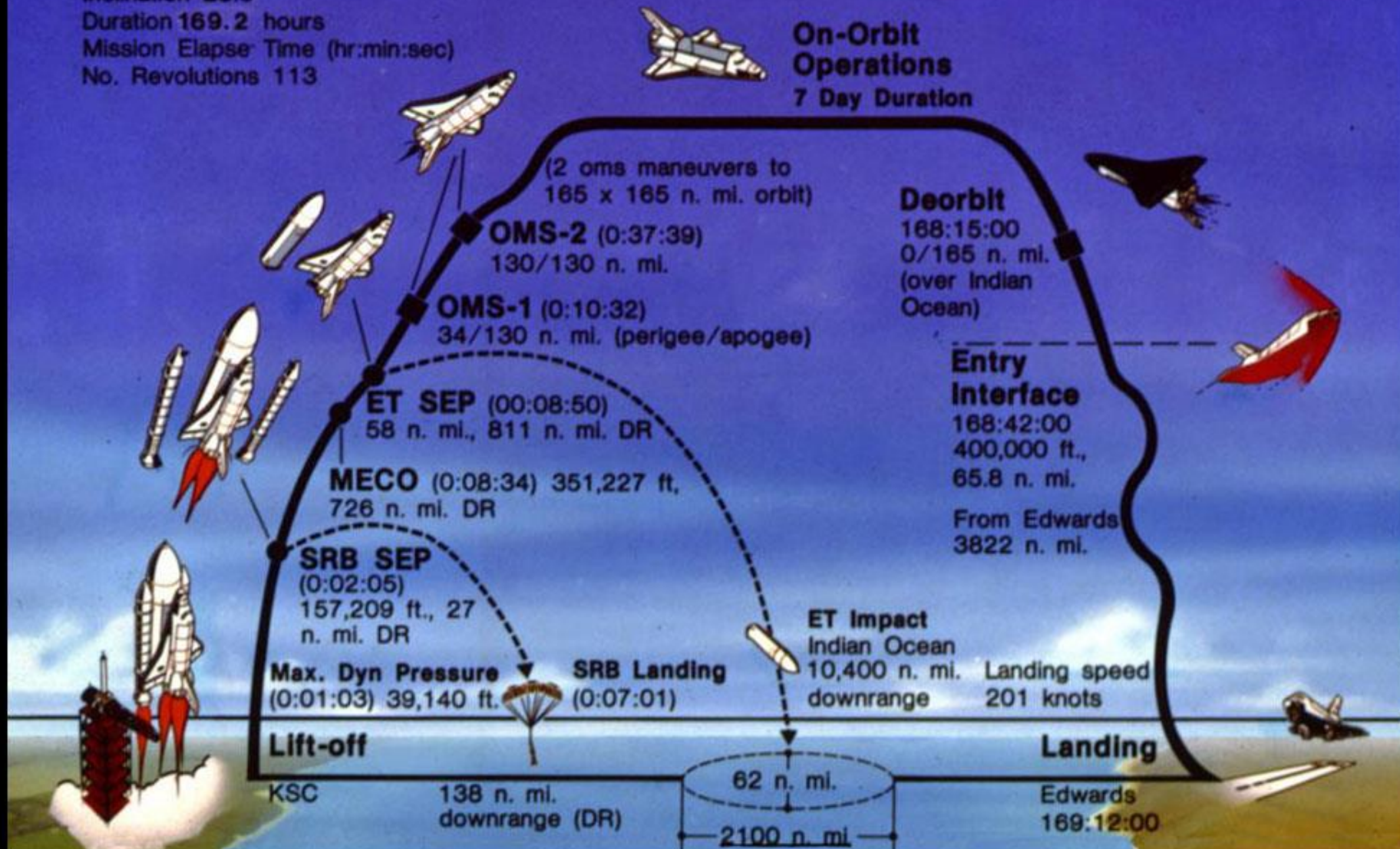
Nominal Orbit 165/165 n. mi.
Inclination 28.5
Duration 169.2 hours
Mission Elapse Time (hr:min:sec)
No. Revolutions 113

Space Shuttle Nominal Mission Profile for STS-4

LA/FM2/L. DAVIS
AS OF 8-23-82

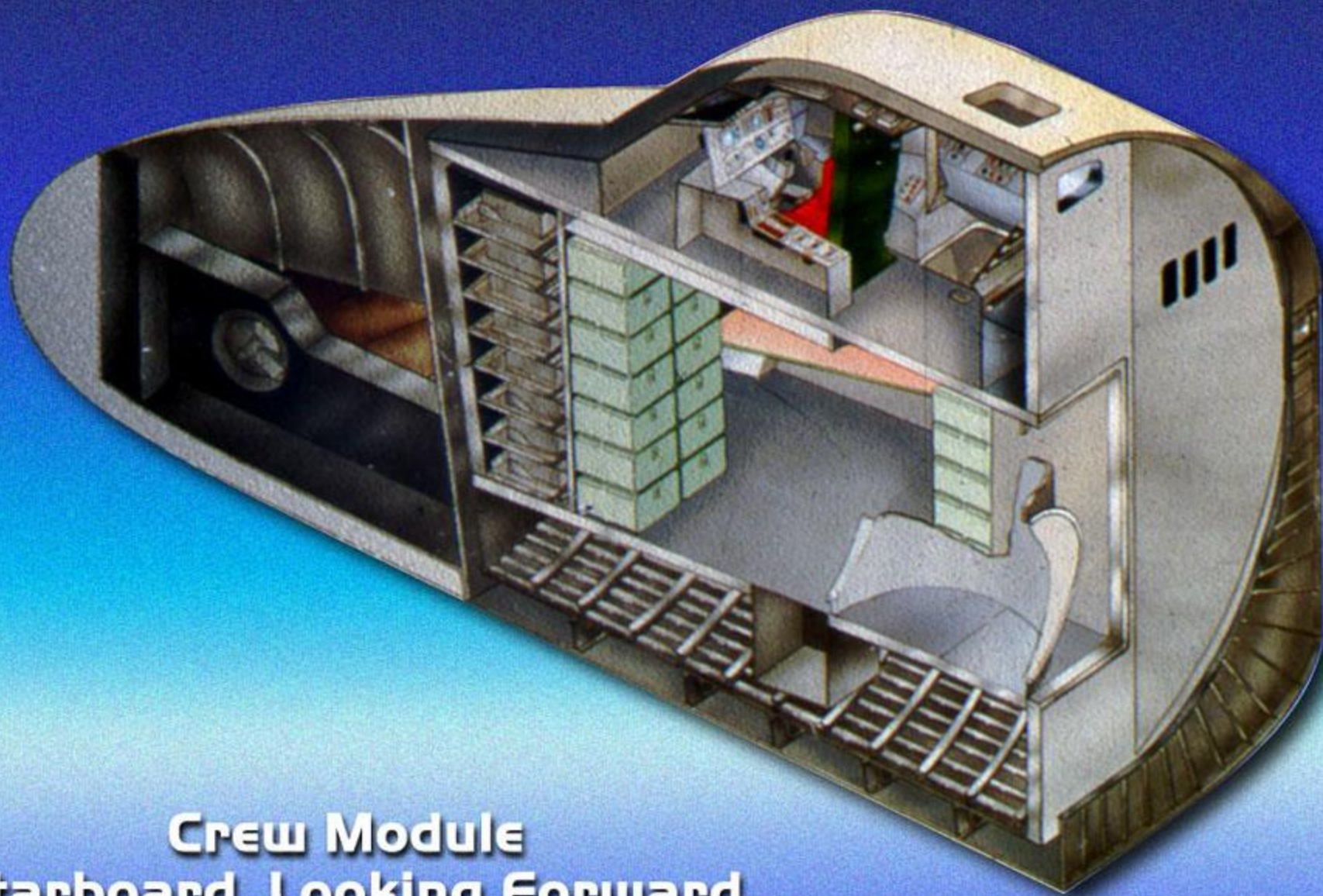


**On-Orbit
Operations**
7 Day Duration

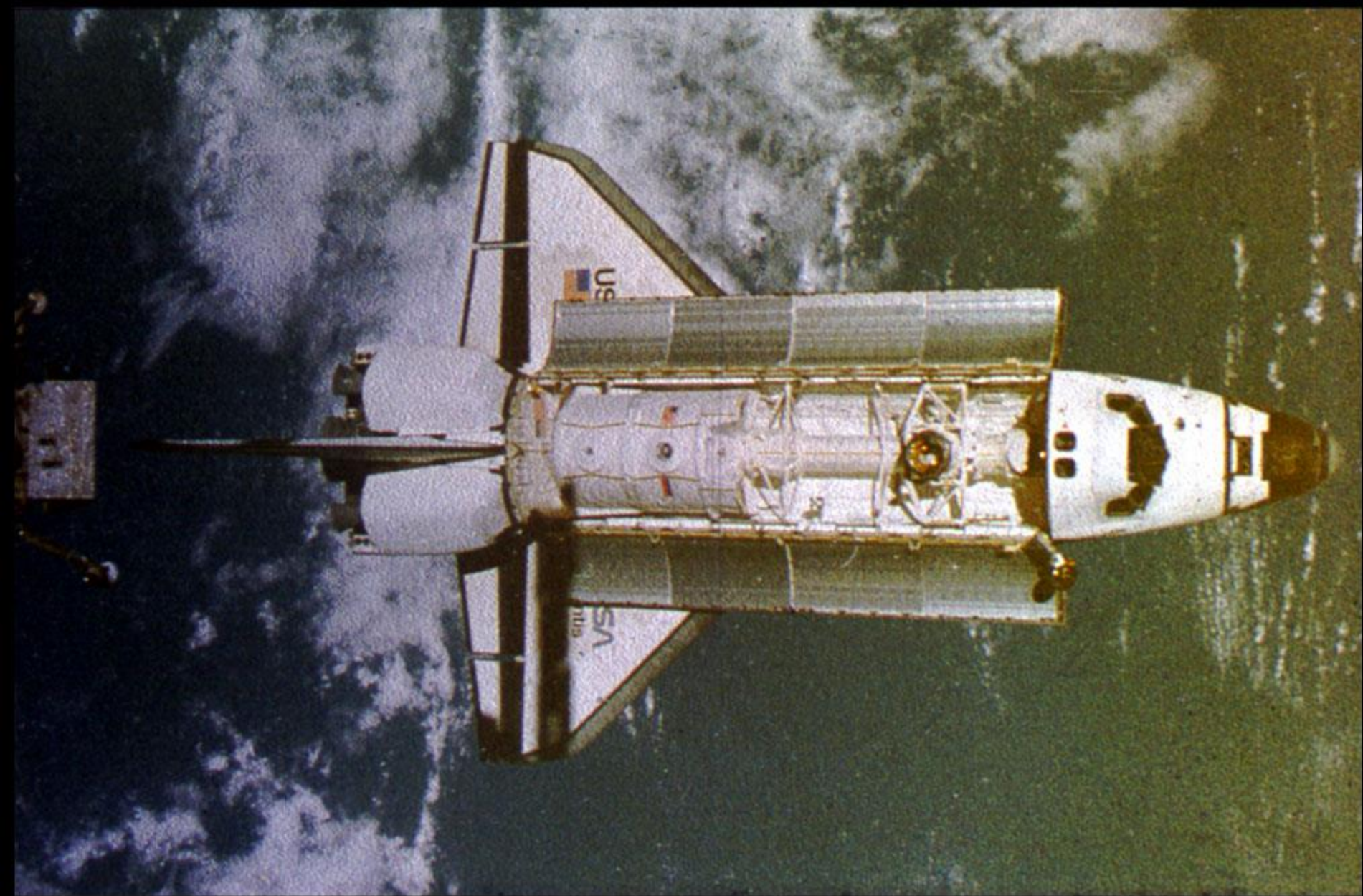








Crew Module
Starboard, Looking Forward



Reentry (Artist Concept c.1968)



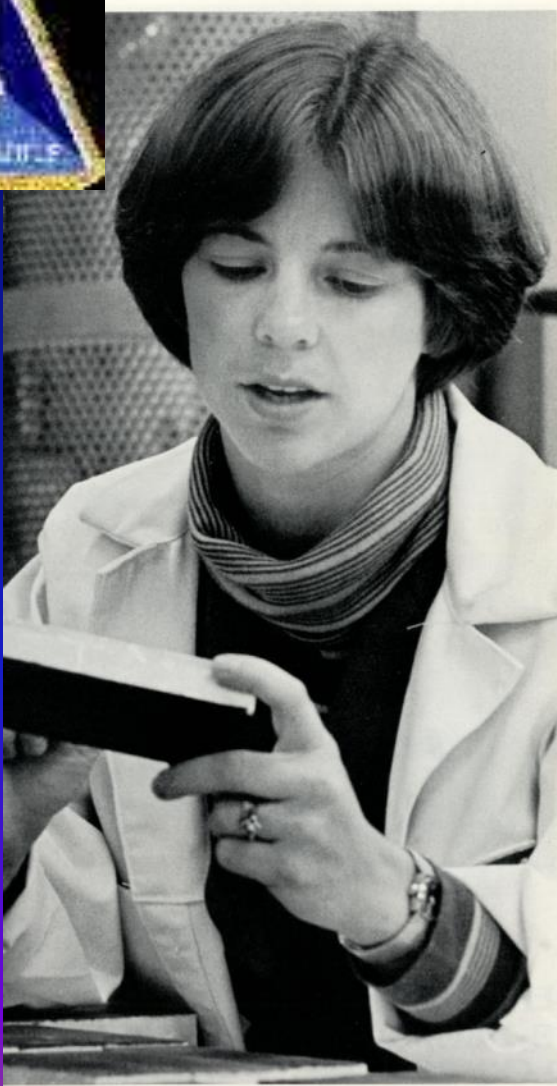
Dr. James I. Mueller (Doc)

University of Washington

Mining, Metallurgical and Ceramic Engineering



Rockwell International Space Division 1976-78



Bonnie Dunbar Has Her Sights On the Stars

"I'm helping to build the Space Shuttle. Now I want to fly in it," says Bonnie Dunbar, a research ceramic engineer working on the Orbiter's thermal protection system at Downey.

"Everyone feels that there is something they want to do, and even though I love my job, space travel fascinates me. I want to be an astronaut," she declares decisively.

Suiting her dreams to action, Bonnie has been taking flying lessons. She soloed last February. She has been selected as one of about 200 astronaut applicants for the individual interviews and physical exams—out of 8000 who applied.

"I know what the odds are," she says, "but I'm young and I feel I'm prepared." In January NASA will select as many as 20 candidates as mission specialists who in mid-1978 will begin two years of training and evaluation.

Raised on a farm in Yakima Valley, state of Washington, Bonnie earned her master's degree in 1975 in Ceramic Engineering, which she puts to work on developing the tiles which will protect the Orbiter during re-entry into Earth atmosphere.

"The field of ceramics is exciting because there are so many new applications," she explains.

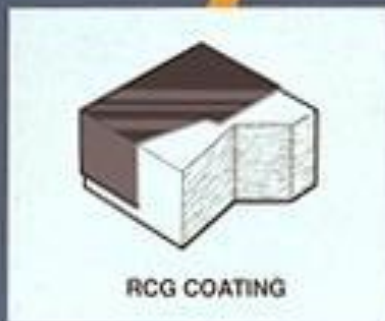
One of those applications will be out of this world, and that's where an astronaut-hopeful named Bonnie would like to go.



Rockwell International



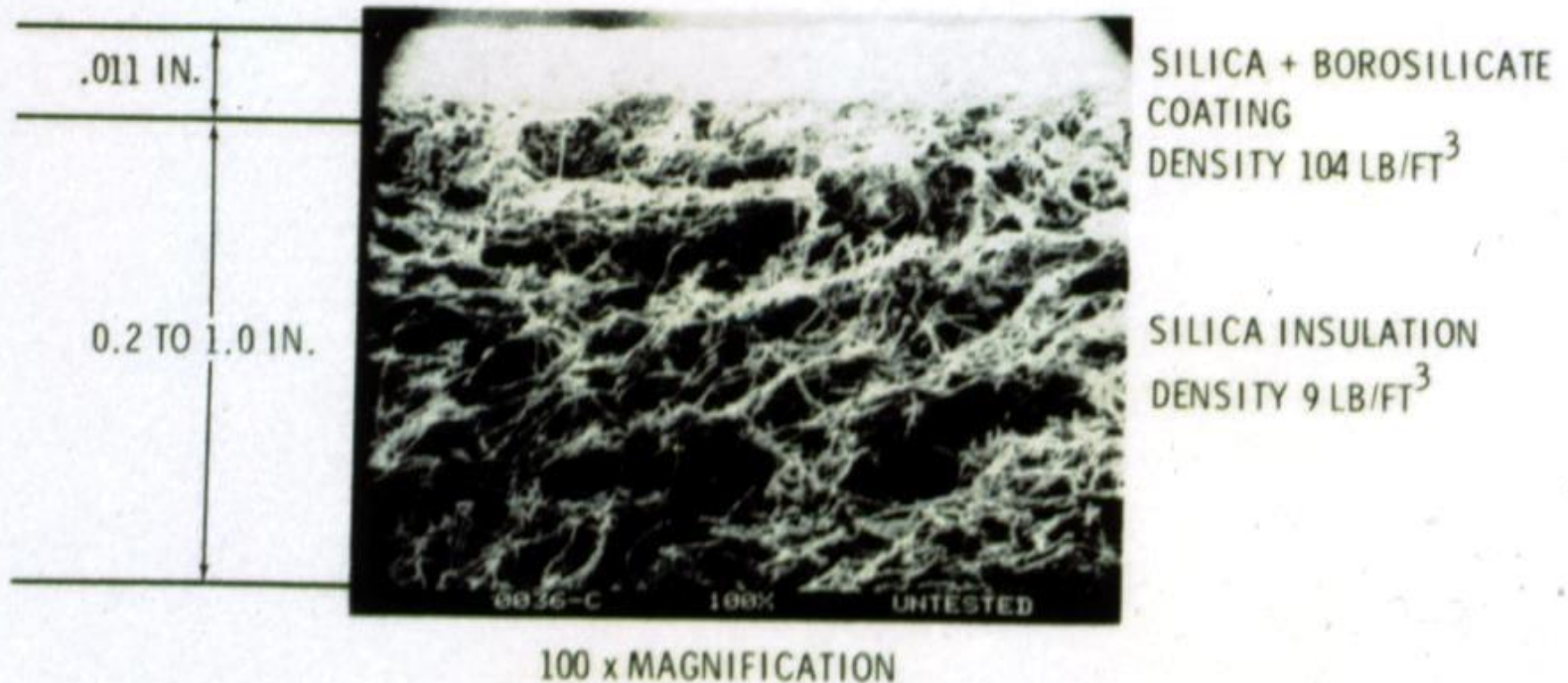
Thermal Protection Materials



Shuttle Thermal Protection Tiles

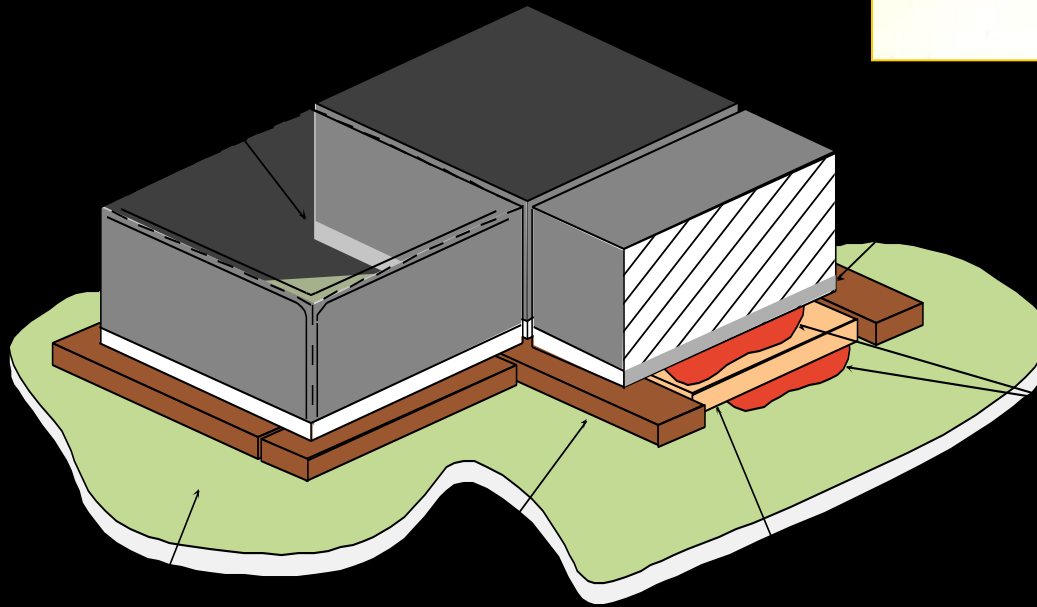
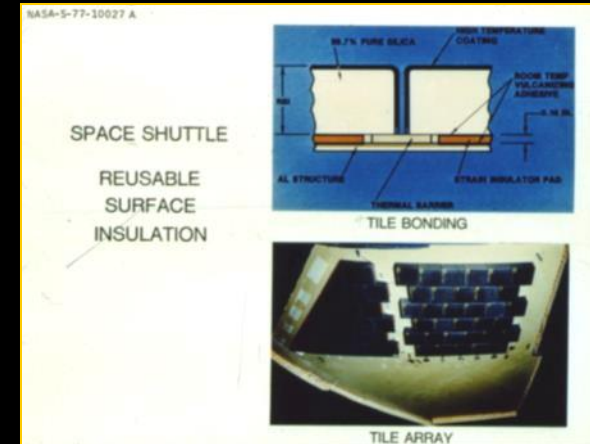
NASA-S-78-12437

LOW TEMPERATURE REUSABLE SURFACE INSULATION

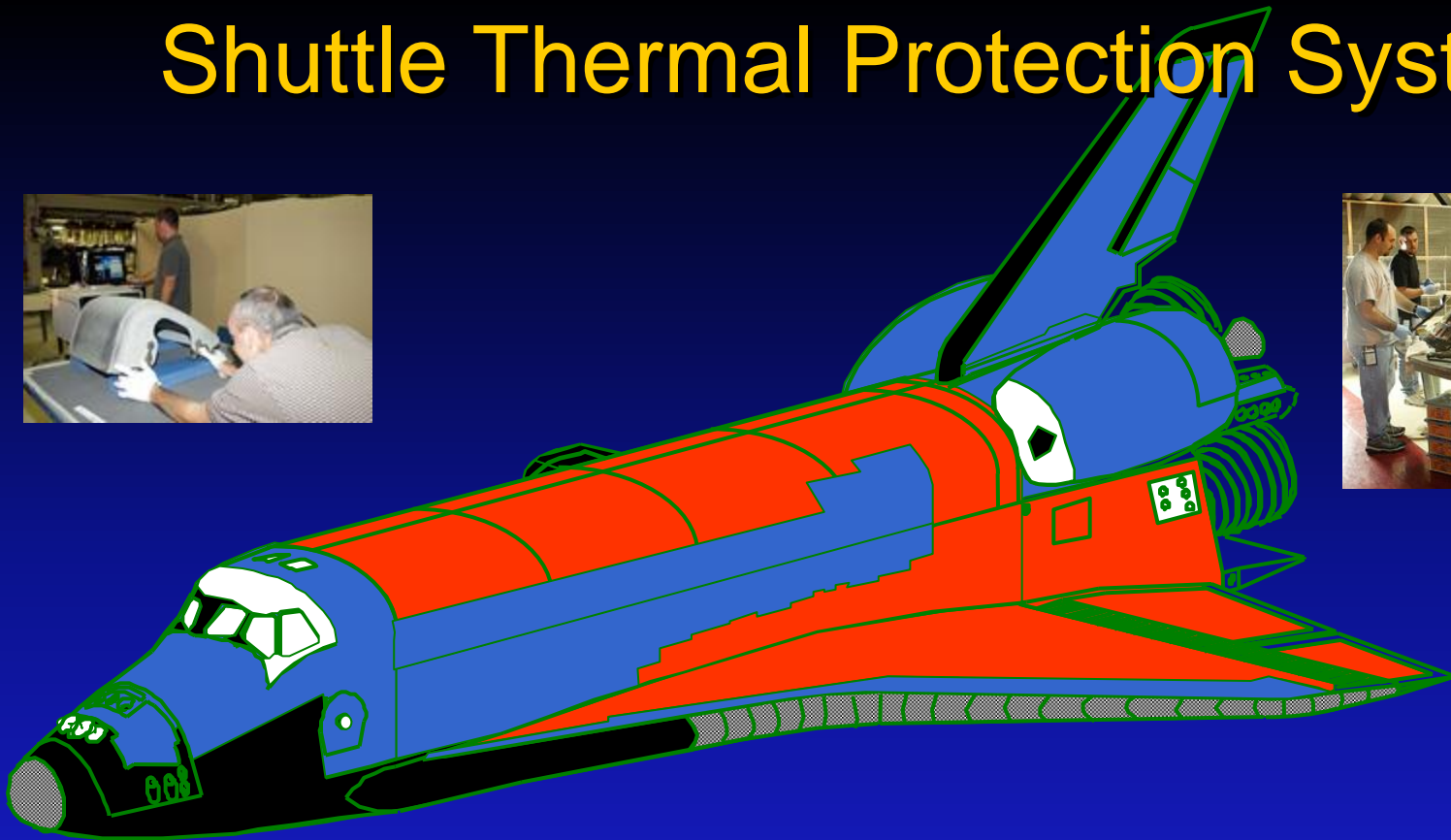
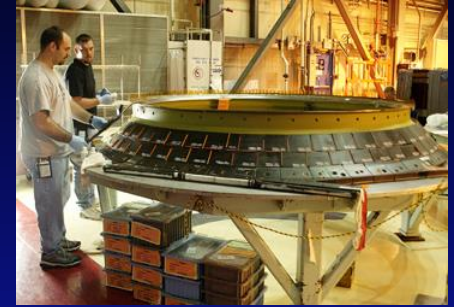


Note: all fibers waterproofed: e.g. hydrophobic silane

High Temperature Reusable Surface Insulation (HRSI) Tile System



Shuttle Thermal Protection System



RCC - Re-inforced Carbon-Carbon

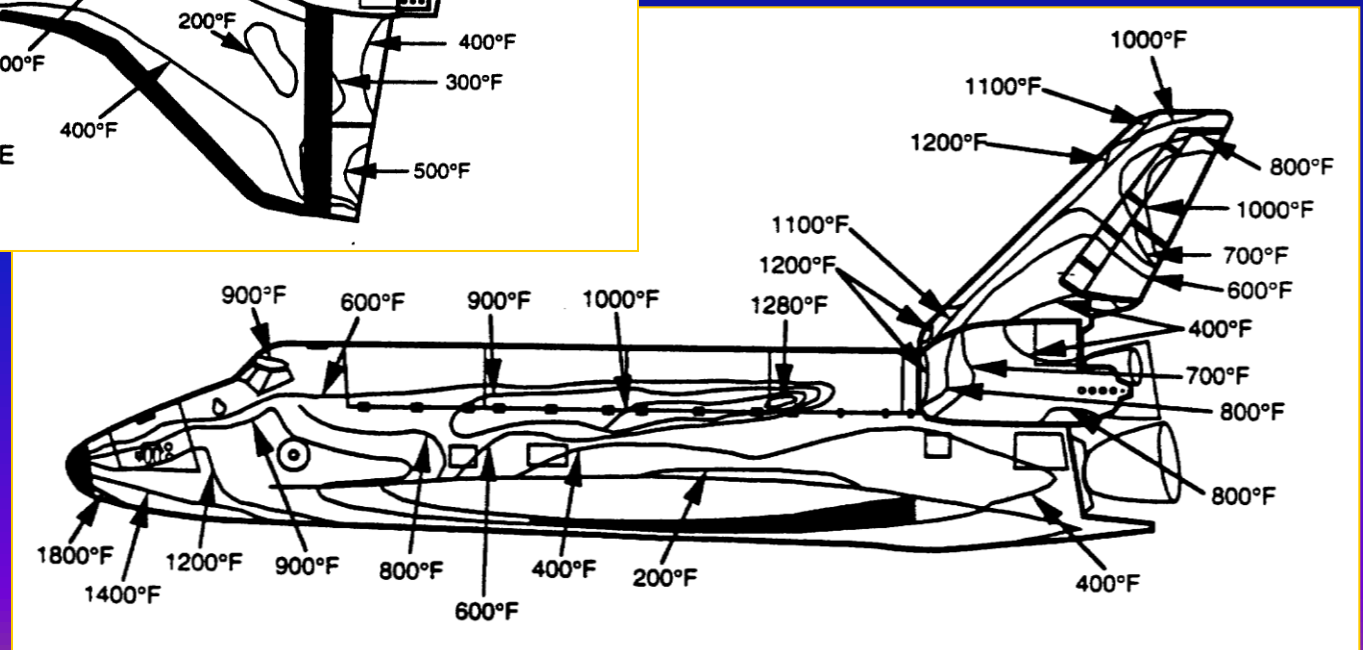
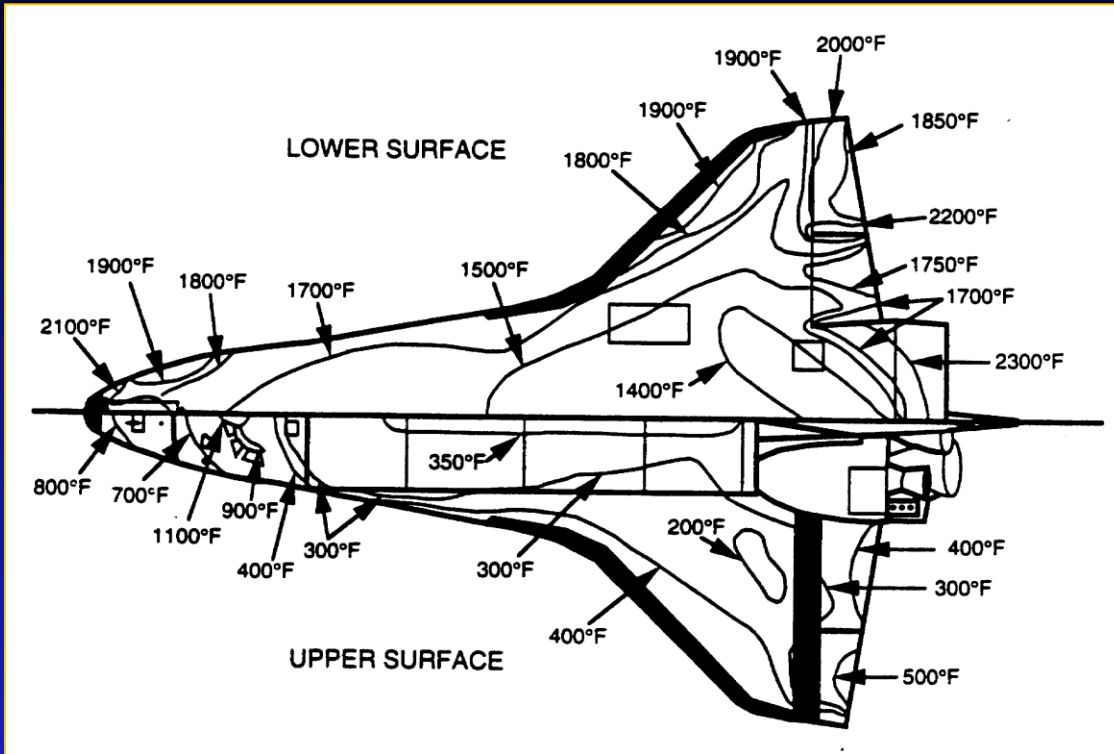
HRSI - High-temperature
Reusable Surface Insulation

LRSI - Low-temperature
Reusable Surface Insulation

AFRSI (FIB) - Advanced Flexible
Reusable Surface Insulation

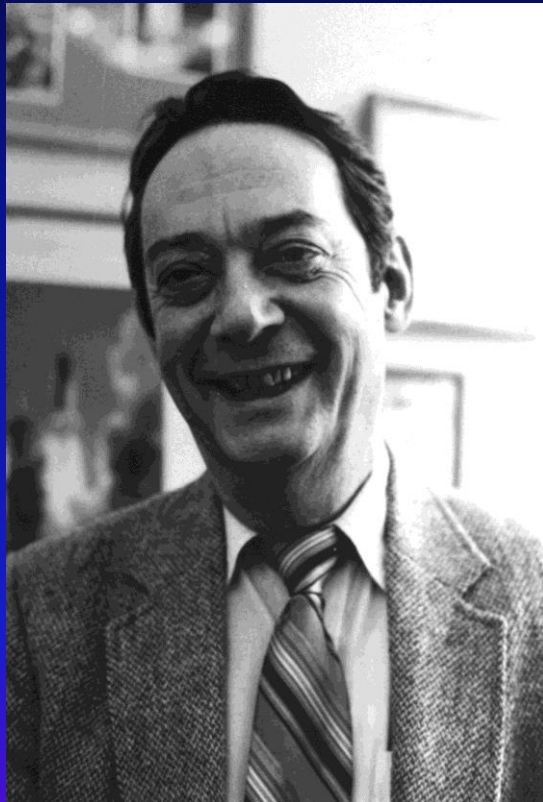
FRSI - Flexible Reusable
Surface Insulation

Maximum Recorded OML Surface Temperatures - STS-1 through STS-5



Dr. James I Mueller (“Doc”)

“I will introduce you to NASA Engineers.....”



University Of Washington
Chair, Mining, Metallurgical and Ceramic Engineering (Materials Science and Engineering)

Astronaut Class 1980



Five Space Shuttle Flights: 50 Days

Columbia (x2), Challenger, Atlantis, Endeavor



STS-61A, D-1 10-30-1985

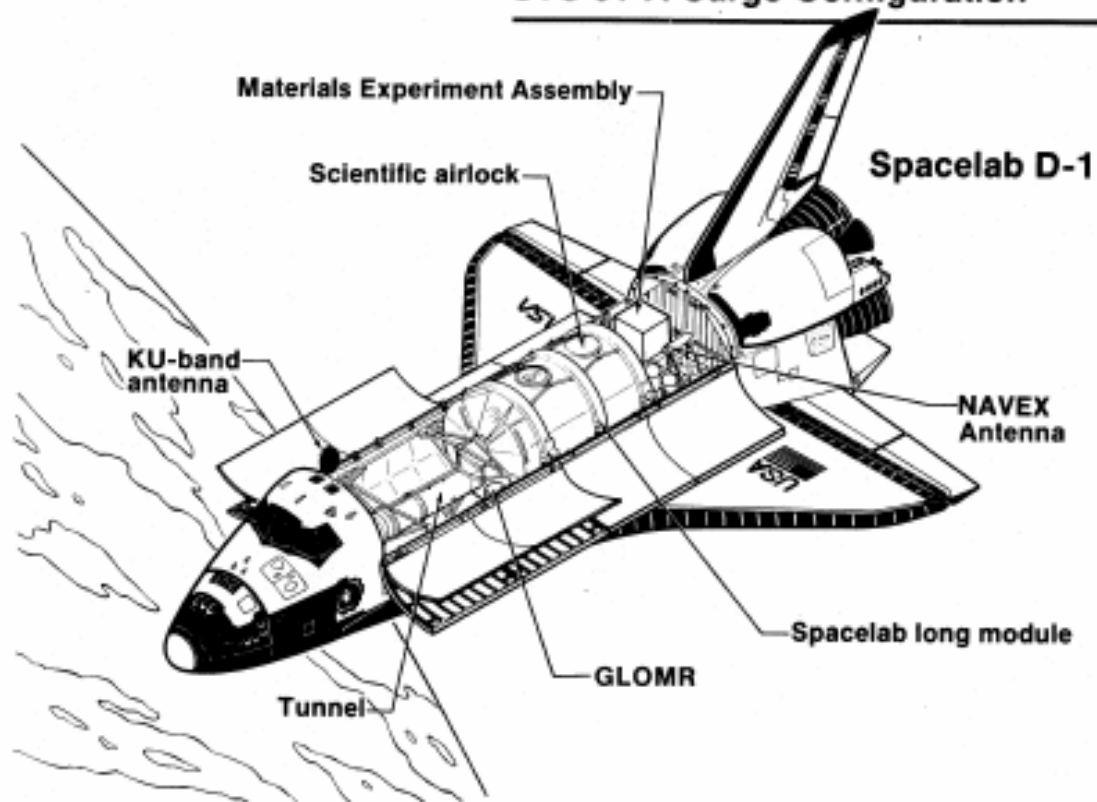
7 Days Challenger





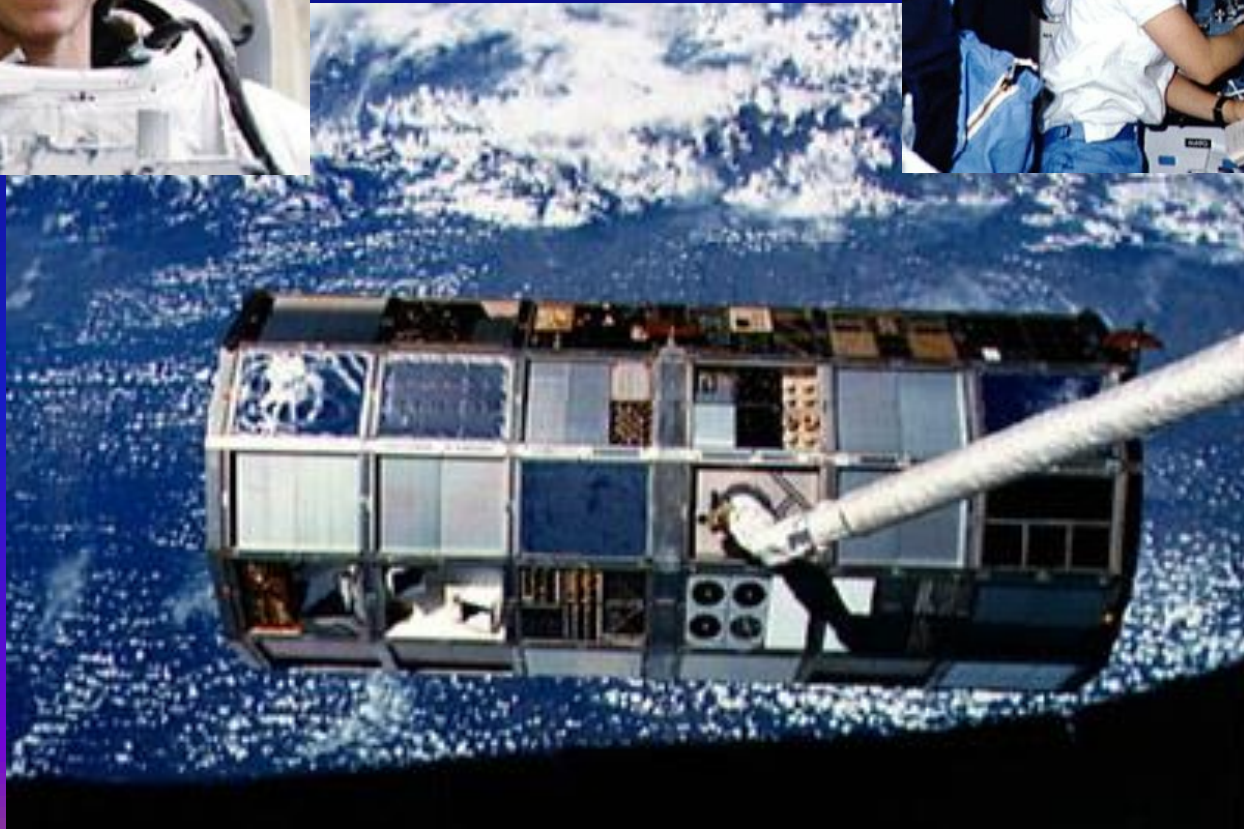
NASA
S-85-01691C

National STS Program STS 61-A Cargo Configuration



STS-32 January 1990

Columbia 11 days



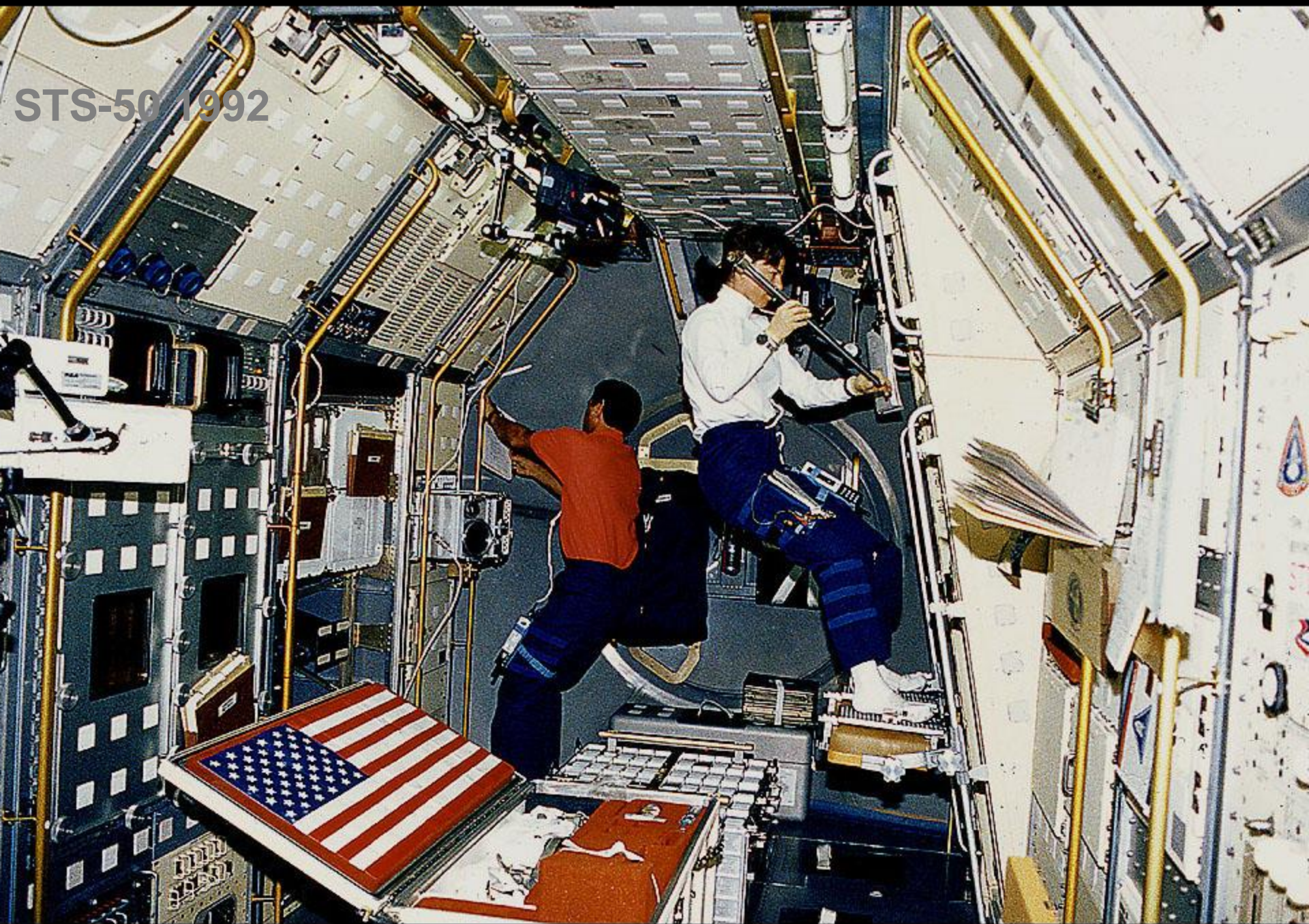


STS-50 USML-1

(United States Microgravity Lab)
June 1992 13 Days



STS-50 1992



Back-up To First Shuttle-MIR Crew, 1995

Anatoly Solovyev
Bonnie J. Dunbar
Nicolai Budarin



Training in Russia



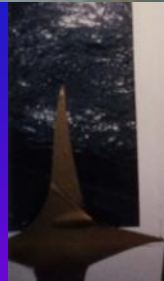


Valentina Tereshkova (USSR)
Roberta Bondar (Canada)
Mary Cleave (USA)

Svetlana Saviskaya (USSR)
Bonnie J. Dunbar (USA)
Helen Sharman (UK)

Meeting international pioneers in Russia

Winter Survival in Siberia



STS-71 First Shuttle-MIR Docking Mission June 1995

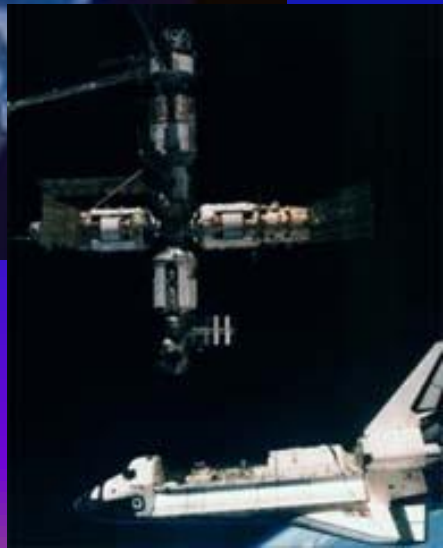


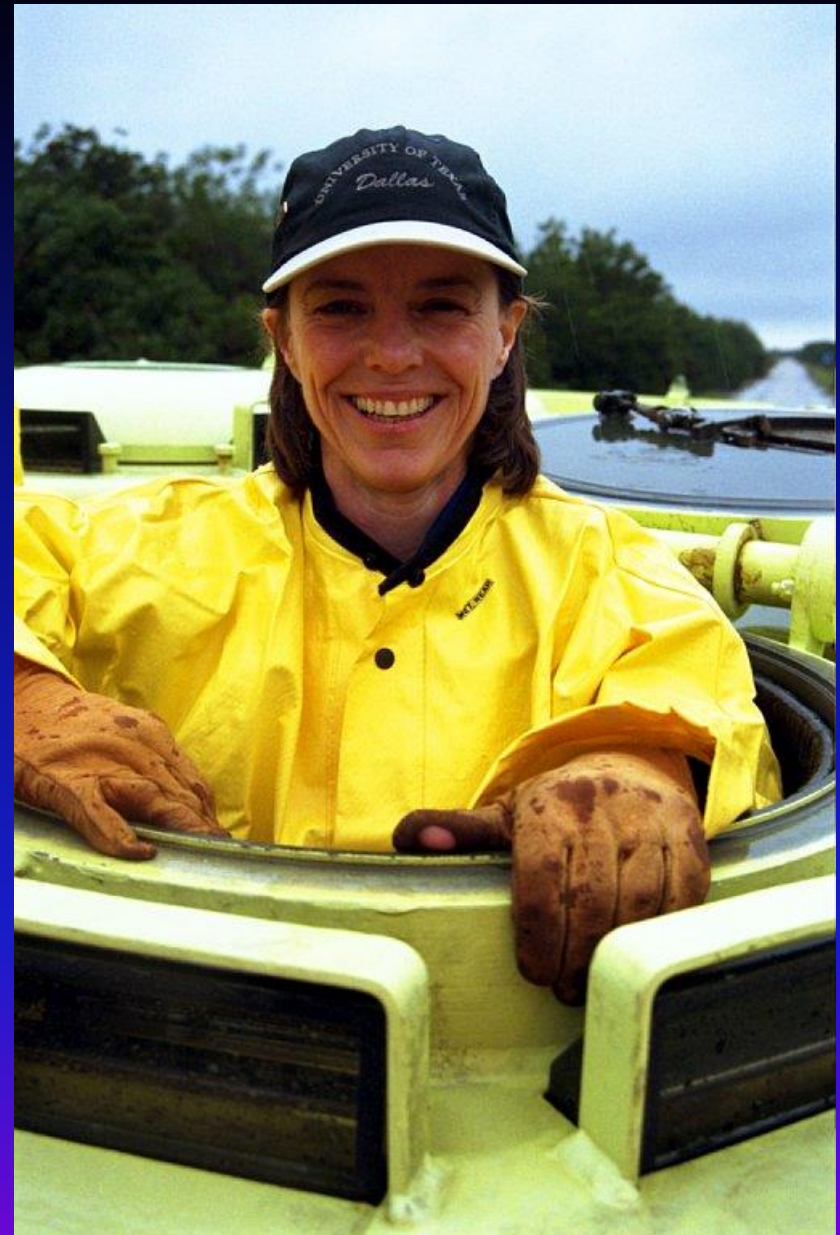


Medical Experiments in
the Spacelab

Singing in the MIR











STS-89

January 22, 1998

Terrence W. Wilcutt, Commander

Joe F. Edwards, Jr., Pilot

Bonnie J. Dunbar, Payload Commander, MS

Michael P. Anderson, Mission Specialist

James F. Reilly, II, Mission Specialist

Salizhan S. Sharipov, Mission Specialist

Andrew S. W. Thomas, Mission Specialist



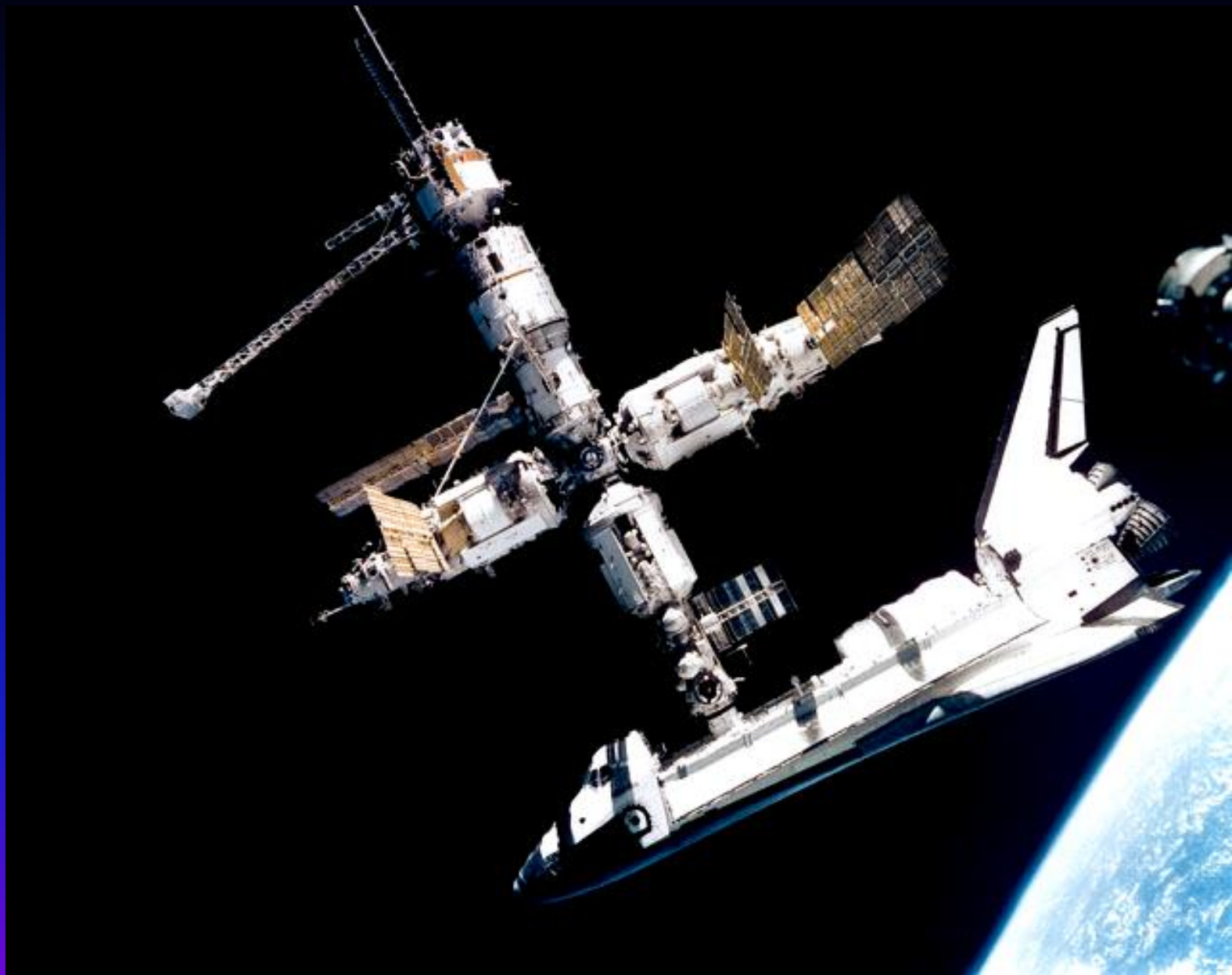


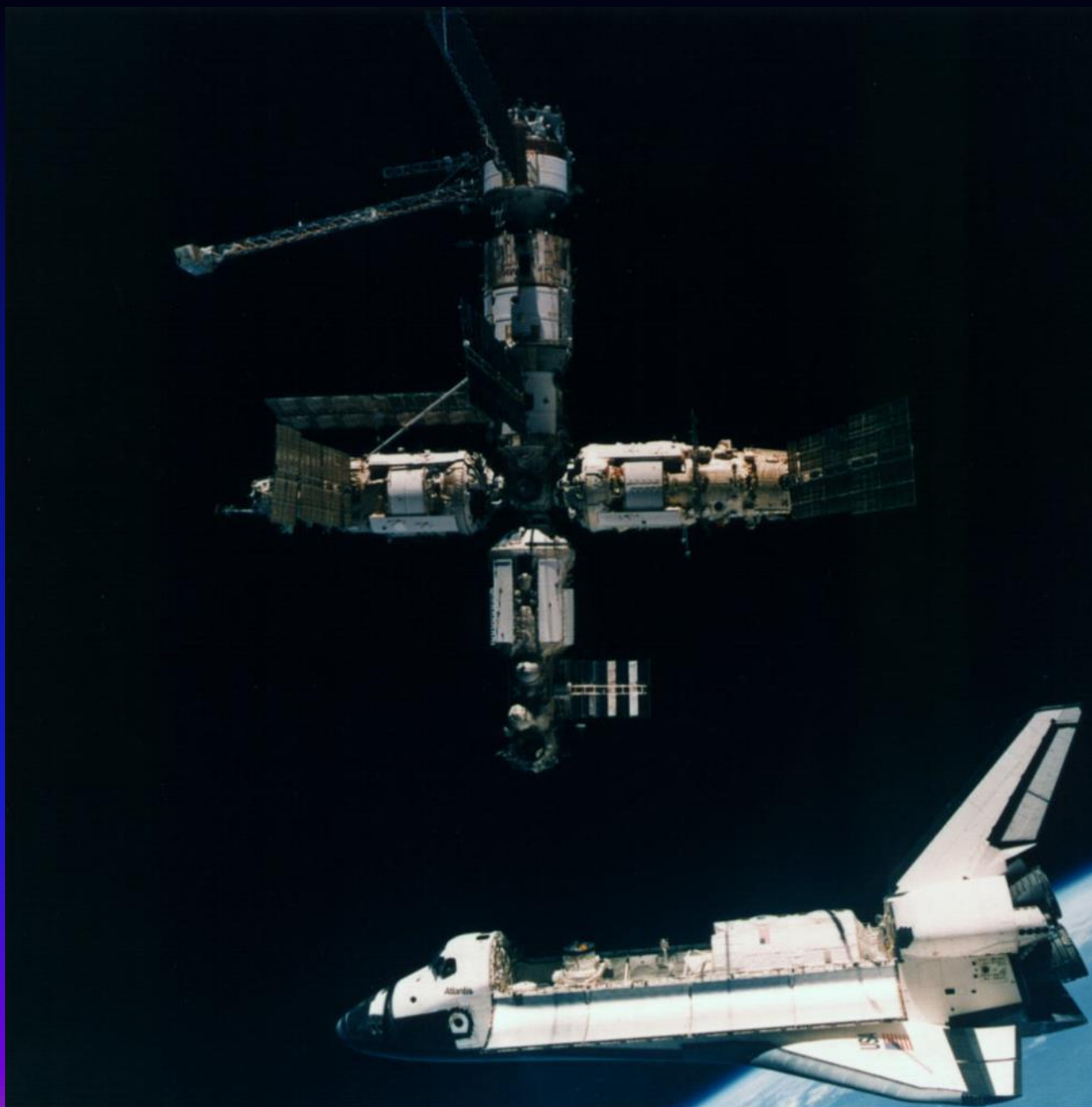
































USA

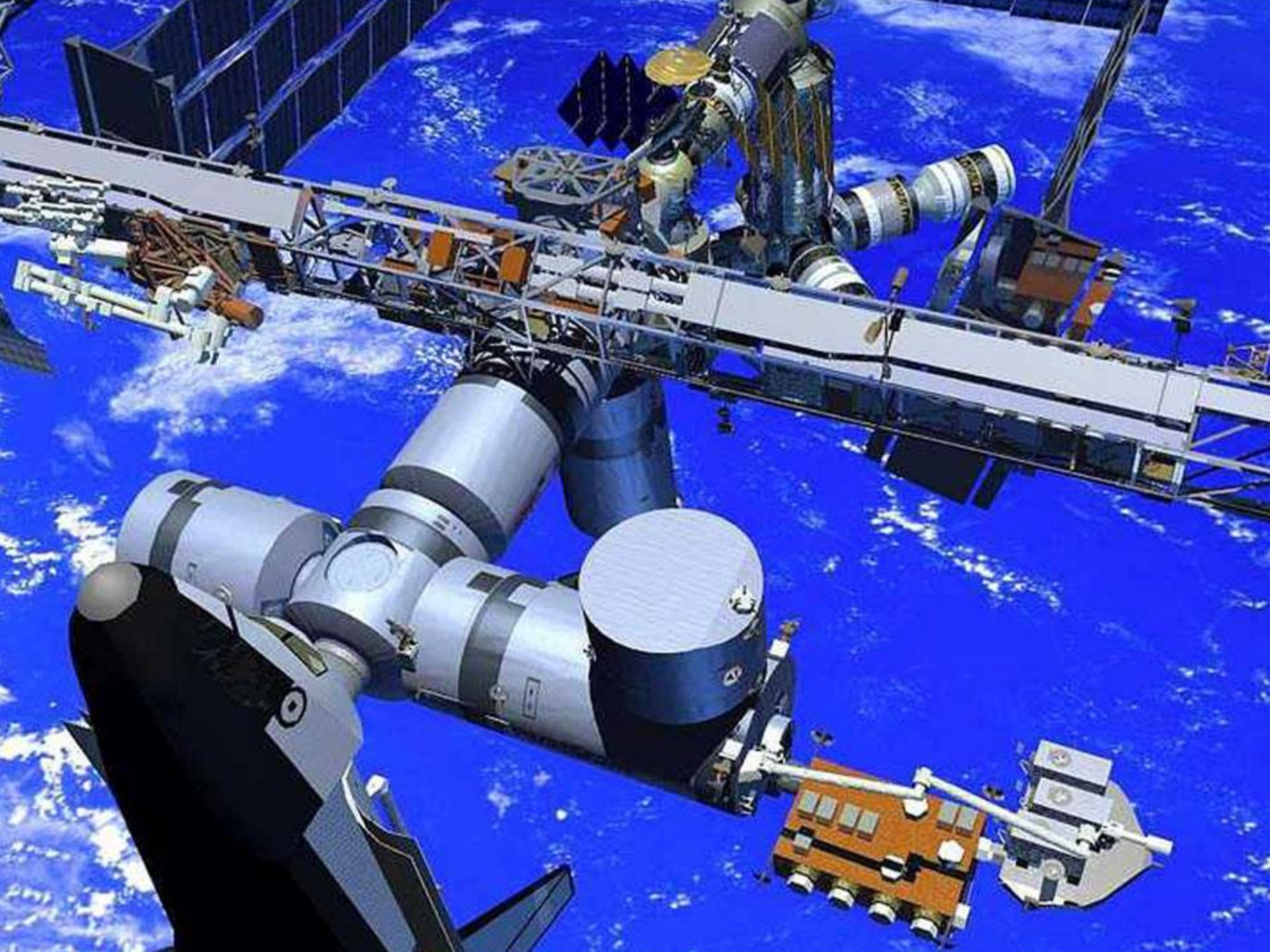
Russia

Japanese Space Agency

Canadian Space Agency

European Space Agency (except UK)

Brazil





*"I'm not afraid of storms...
for I am learning to sail my ship."*

Louisa May Alcott











*"Wheresoever you go...
go with all your heart."*

Confucius







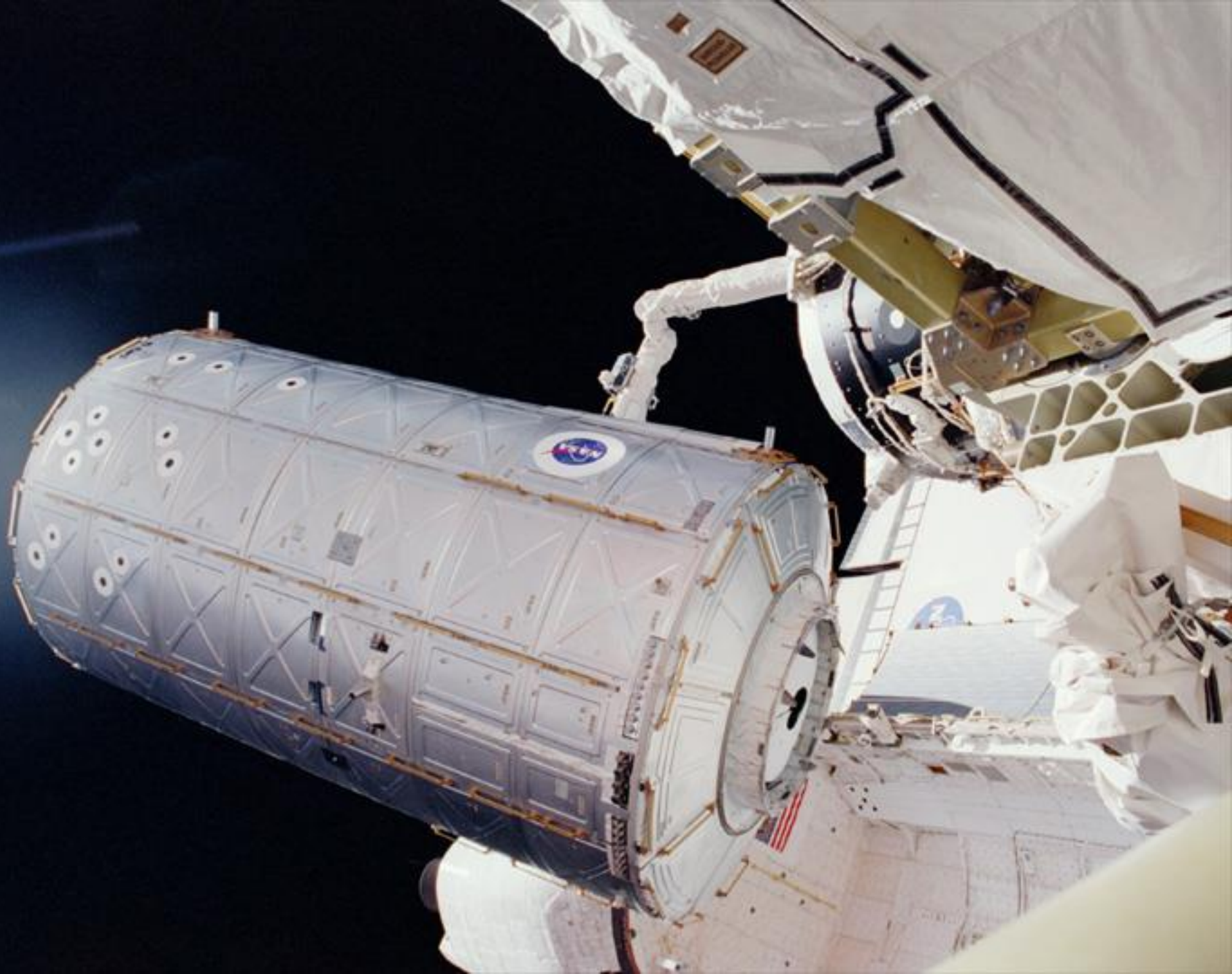




*"I never see
what has been done..."*

*I only see
what remains to be done."*

Marie Curie





*"Every great
advance in science
has issued from
a new audacity...
of the imagination."*

John Dewey









*"What makes
the desert beautiful",
said the little prince,
"is that somewhere
it hides a well..."*

Antoine De Saint Exupery





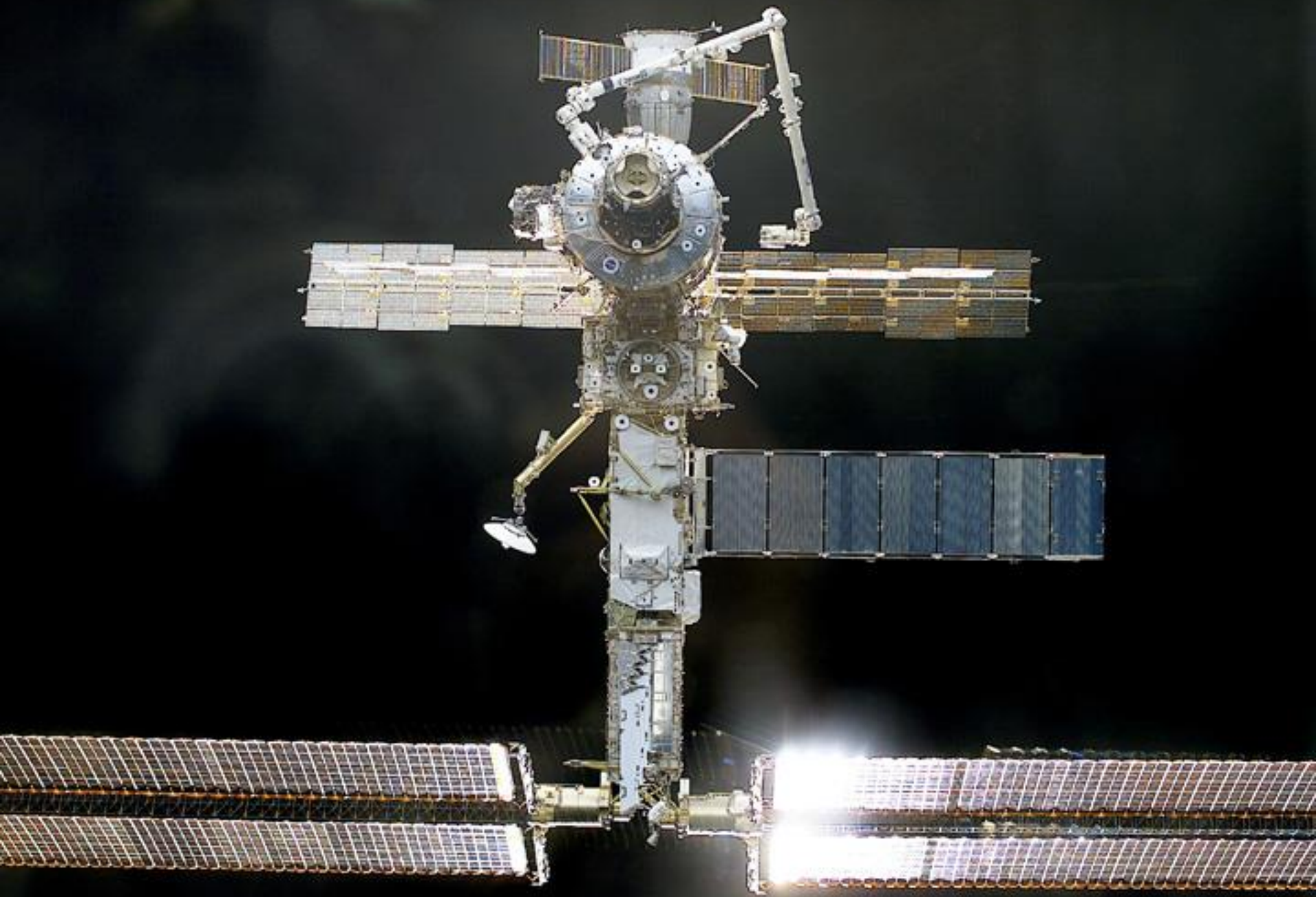




"Am I not destroying
my enemies

when I make friends
of them?"

Abraham Lincoln







A first-person perspective shot from inside a space helmet, looking out at an astronaut in a white space suit floating in space. The astronaut's helmet is in the center, and their arms are visible. The background is a bright blue sky with white clouds. The quote "We must become the change we want to see." is overlaid in white text at the bottom.

"We must become the change we want to see."

Gandhi



International Space Station (ISS)...



<http://www.spaceflight.nasa.gov>











aurora

lightning

Minneapolis/St. Paul

Chicago

Appalachians

Des Moines

St. Louis

Omaha



THE INTERNATIONAL SPACE STATION: OVER TEN YEARS OF CONTINUOUS HUMAN OCCUPATION



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Michael Barratt



Frank De Winne



Roman Romanenko



Gennady Padalka



Koichi Wakata



Bob Thirion



"It is truly an historic moment aboard the International Space Station. For the first time, the station will have six crew members, while also marking the first time all five partner agencies are represented by



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Page Editor: Scott Hanger
NASA Official: Brian Dunbar

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- USA.gov
- ExpectMore.gov
- Open Government at NASA
- Help and Preferences



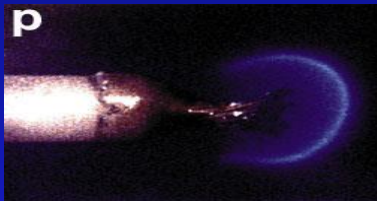
Discovery Rolls to Pad for Last flight: February, 2011



Spaceflight and “micro” gravity – How Do Things Work or Don’t Work?

In microgravity, there is no.....

Convection



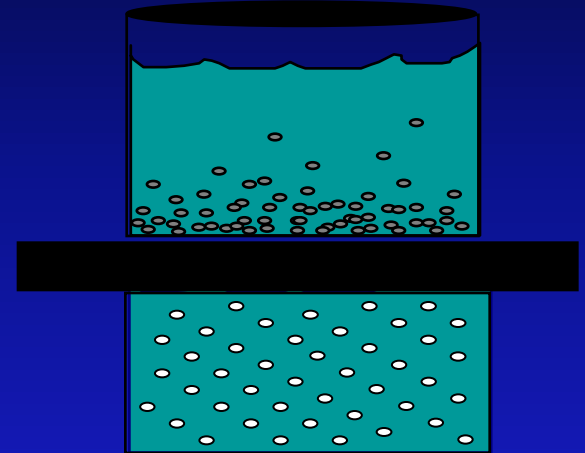
A candle burns on Earth (top) & in microgravity (bottom).

Buoyancy

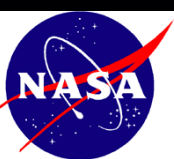


Fluid flows through a pipe in Earth's gravity (top) and in microgravity (bottom).

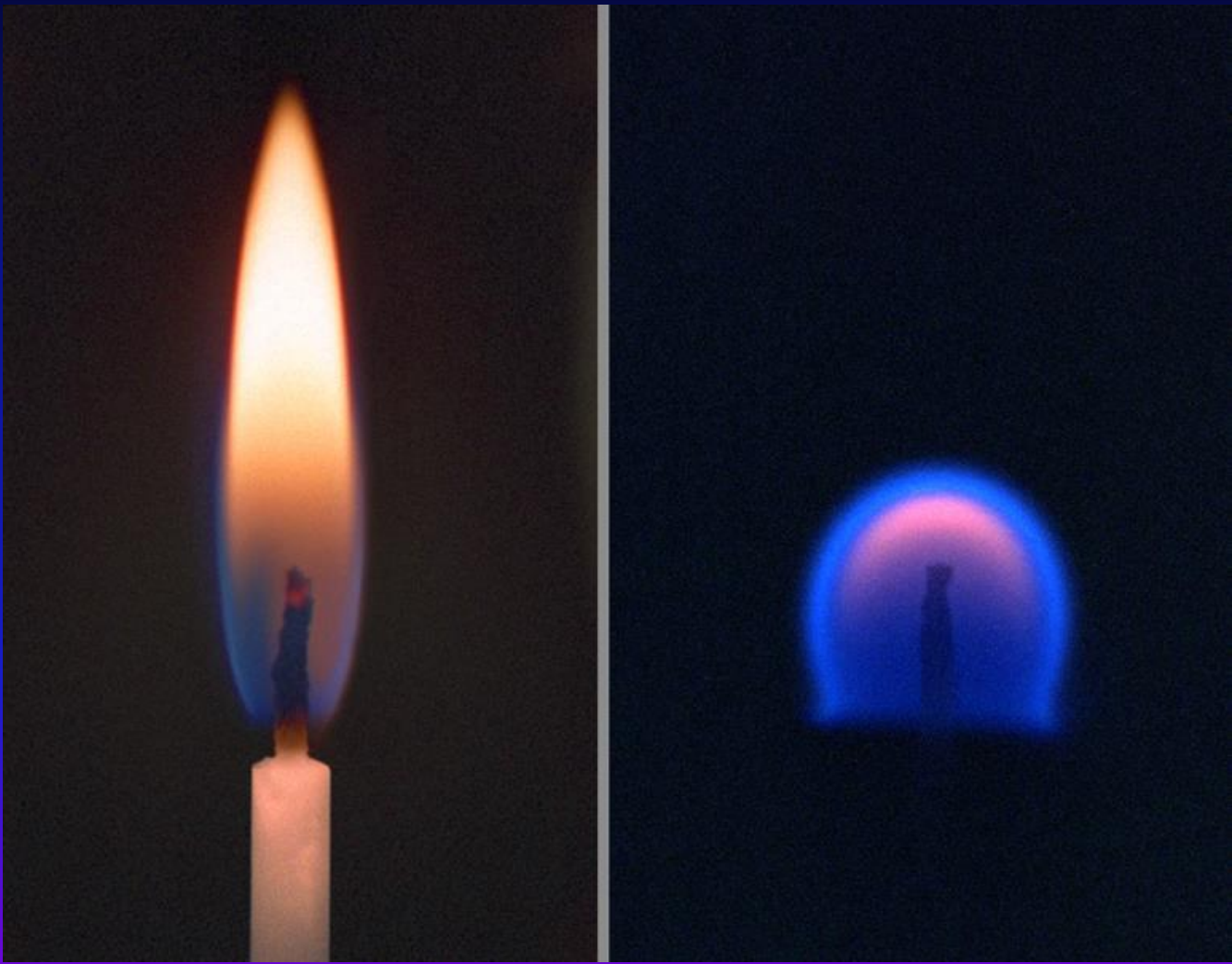
Sedimentation



On Earth, particulates settle out of a liquid (top), but in space, particulates are suspended evenly (bottom).



Combustion in Micro-g



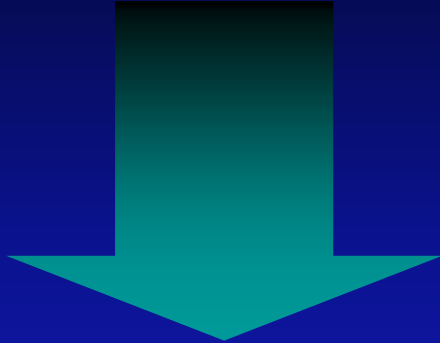
Bioastronautics Elements

All elements of Bioastronautics rely upon development and integration of enabling technologies. (<http://www.nsbri.org>)



Summary of Known Space Flight Medical Risks To the Human System and Subsystems

Astronauts experience a spectrum of adaptations during space flight and even post flight



Behavioral Changes
Balance disorders
Cardiovascular deconditioning
Decreased immune function
Muscle atrophy
Bone loss

Additional influences include the unique Radiation environment and Nutritional/Food Limitations

Behavioral

Neurovestibular System

(Neurosensory, Neuromotor)

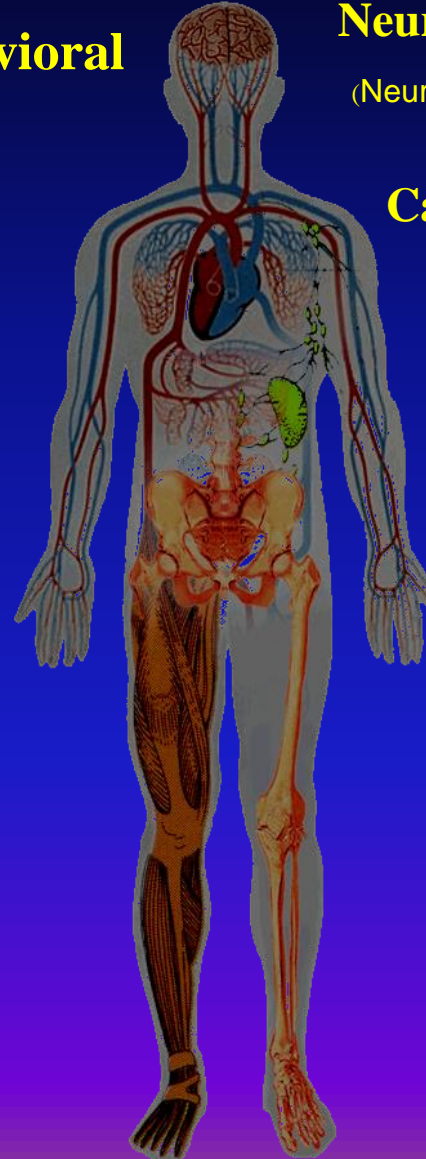
Cardiovascular System

Immune System

(Endocrine)

Bone and Muscle Systems

(Musculoskeletal)



NSBRI

Research to pave the way for
human exploration of space

National Space Biomedical Research Institute

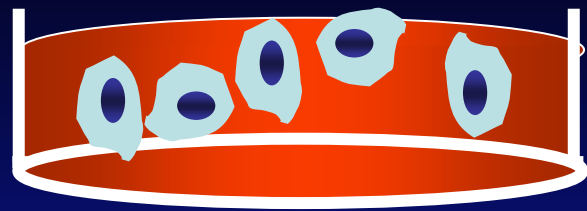
[Research Areas](#) [Earth Benefits](#) [Education and Outreach](#) [Research Announcements](#) [News/Public Outreach](#) [Industry Forum](#) [About NSBRI](#) [Search/Site Map](#) [myPORTAL](#) [Intranet](#) 

NSBRI research seeks solutions to health concerns facing astronauts on long missions. Patients on Earth suffering from similar conditions will benefit from these advances.

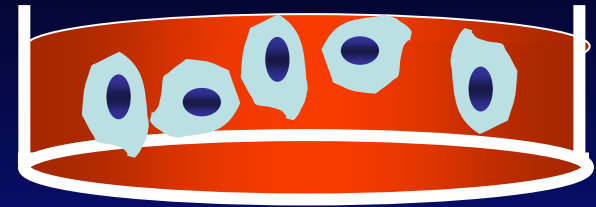
National Space Biomedical Research Institute
One Baylor Plaza, NA-425, Houston, TX 77030
713-798-7412 (phone), 713-798-7413 (fax)
For more information contact info@www.nsbri.org

Microgravity Cell Culture

Micro-G

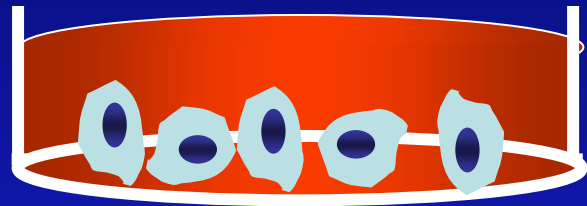


TIME
(min) (Hrs)



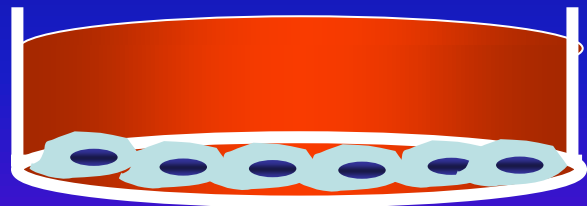
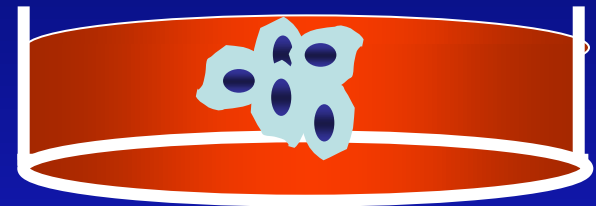
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10

10

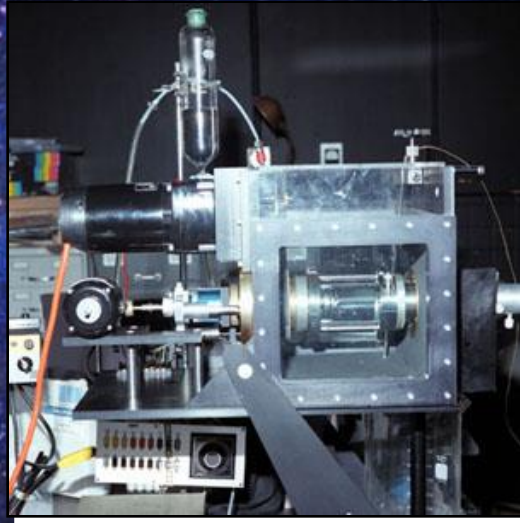


60

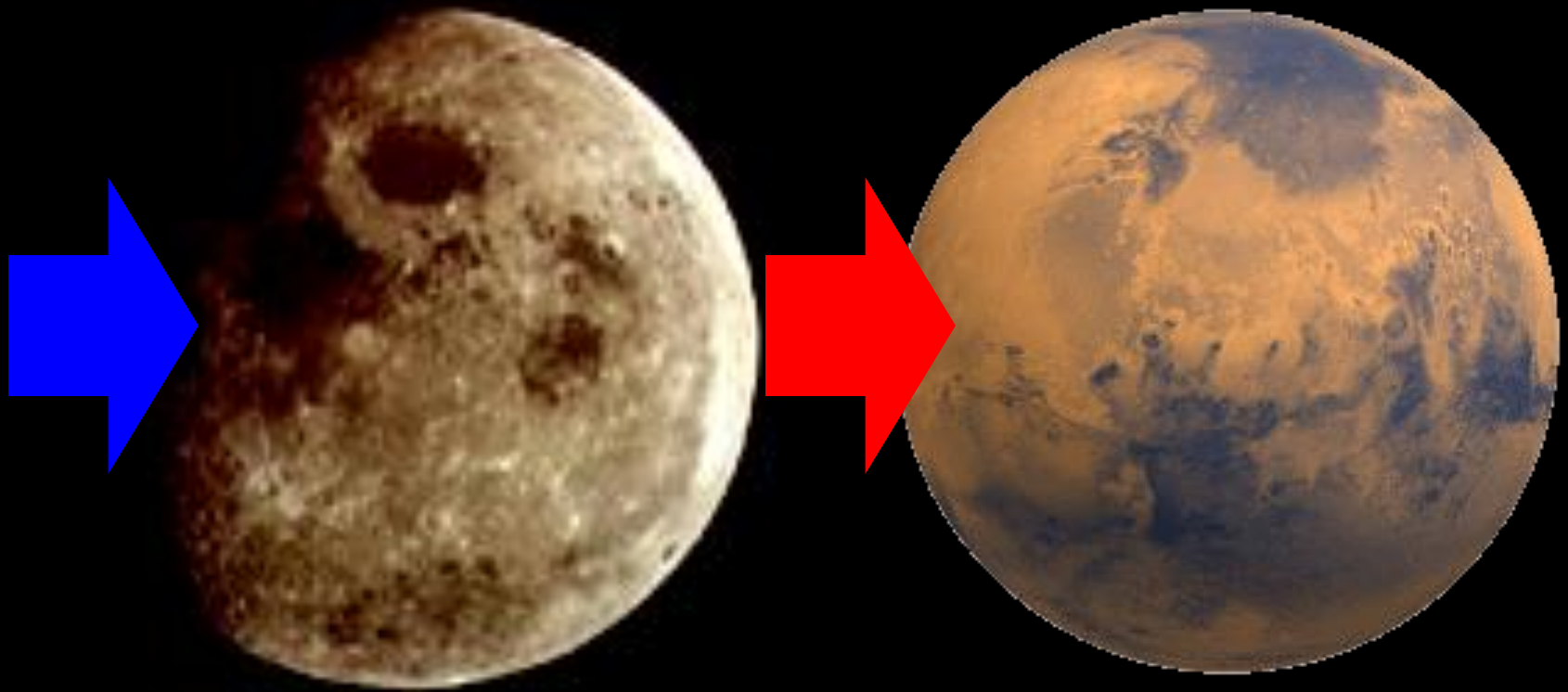
60



Cellular Biotechnology



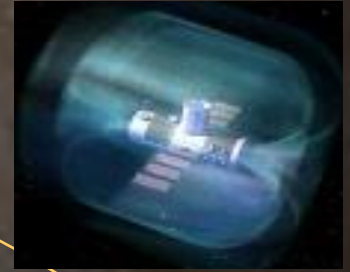
What's Next?



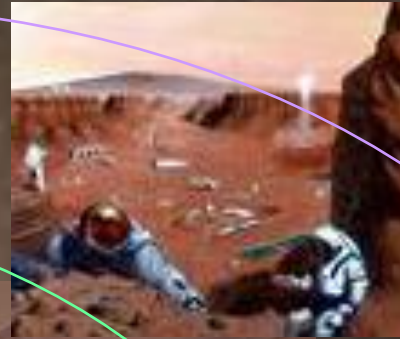
Exploration Vision

Humans & Robots

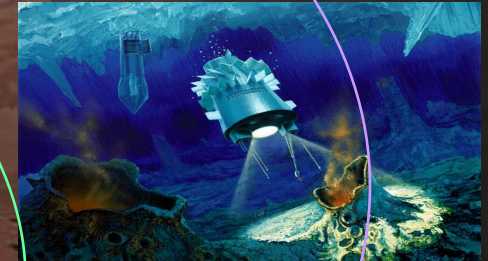
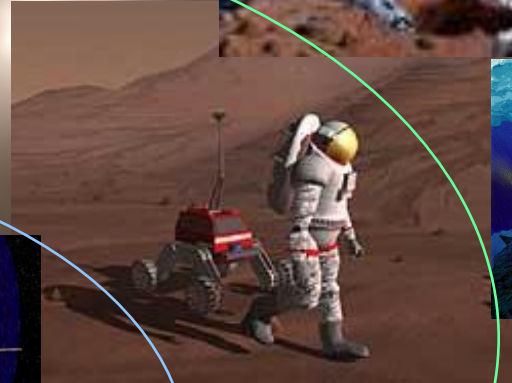
Go anywhere, anytime



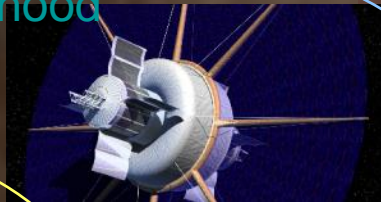
Sustainable Planetary
Surfaces



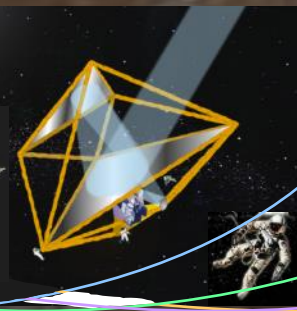
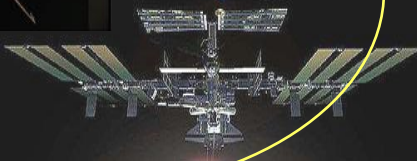
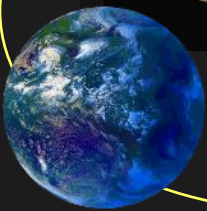
Accessible Planetary Surface



Earth's
Neighborhood



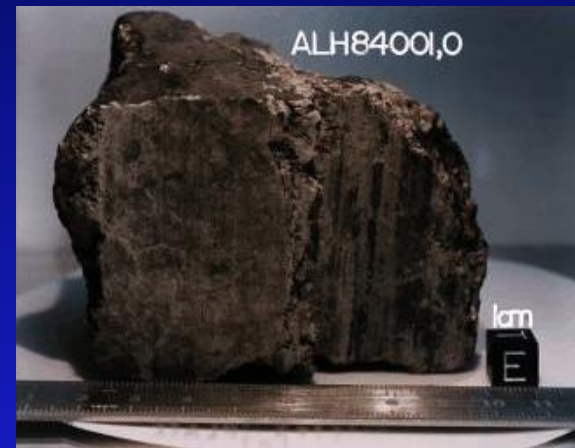
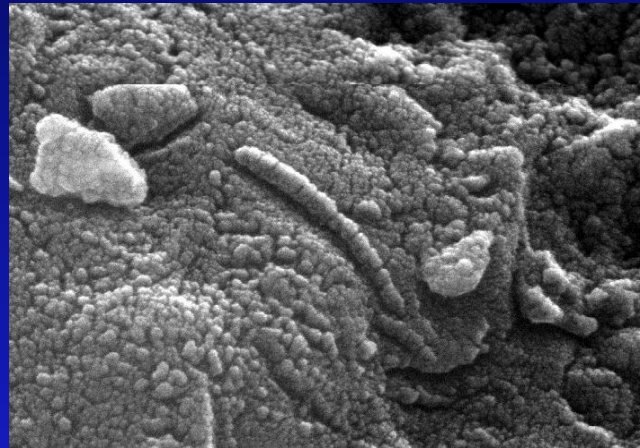
Earth
and LEO





Center of Excellence:

Astromaterials collection, curation, and analysis



Lunar Base



DAVIDSON



Martian Base



Pat Rowings '95

Original 2010 Budget: Constellation Program Components

Ares V:
Heavy Lift
Launch
Vehicle



Earth Departure
Stage



Orion: Crew
Exploration Vehicle



Ares I: Crew
Launch
Vehicle

Lunar
Surface
Access
Module
(LSAM)



Original 2010 Budget: Constellation Program Components

Ares V:
Heavy Lift
Launch
Vehicle

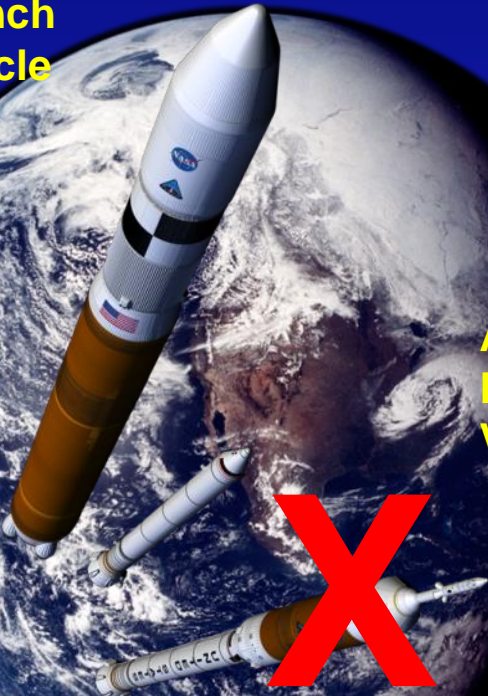


Earth Departure
Stage

Orion: Crew
Exploration Vehicle



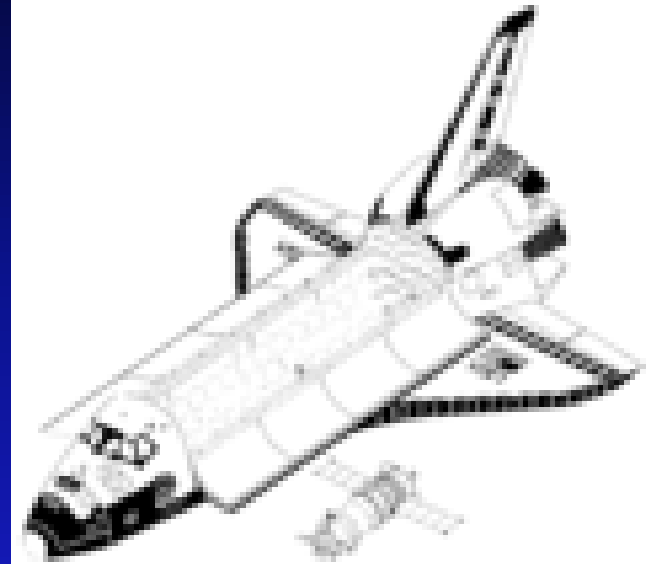
Ares I: Crew
Launch
Vehicle



Lunar
Surface
Access
Module
(LSAM)



Russian Soyuz: Only method of reaching ISS after 9/2010



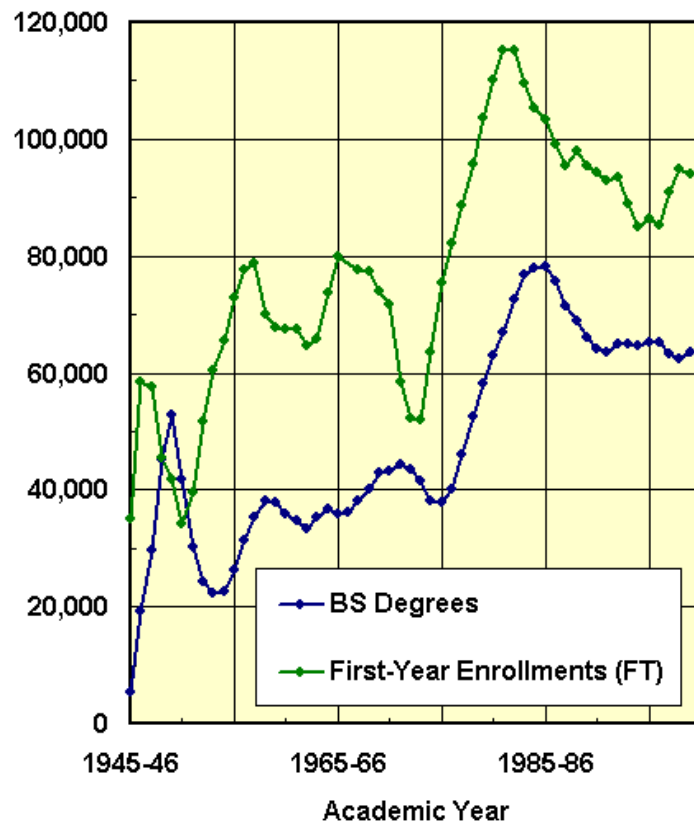
- Crew Transport Vehicle (3 crewmembers)
- Launches from Kazakhstan



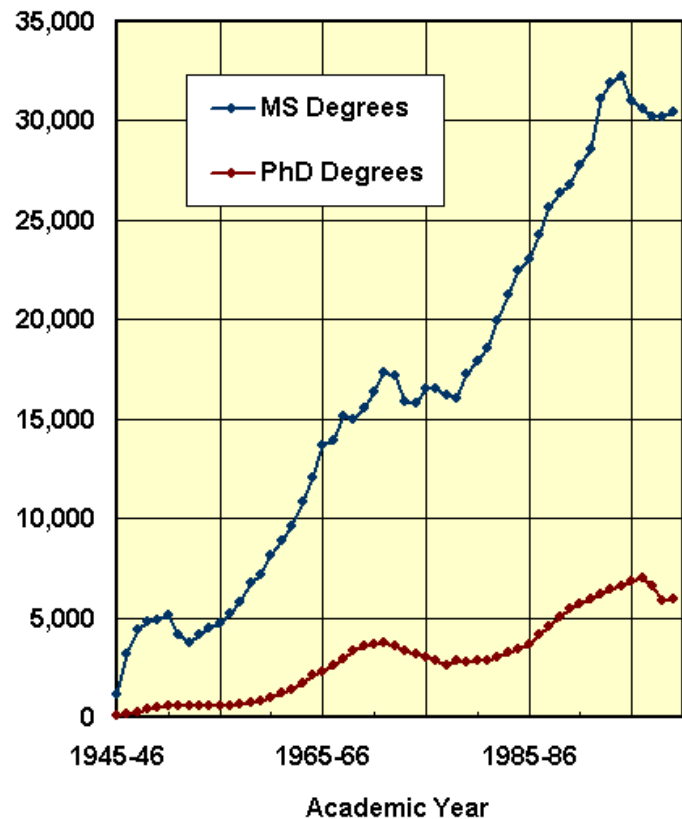
National Engineering Education Challenge

Engineering Degrees 1945-2001

First-Year Enrollments
and BS Degrees



MS and PhD Degrees



The U.S. Engineering and Physical Sciences *Workforce “Crises”* (*Not new News*)

- 1945 – 2012: National Science Foundation “Indicators”:
- 1989 Space Policy Institute Report on Origins of Scientists and Engineers
- 2001 Hart Rudman: Commission on National Security/21st Century
- 2002 Walker Aerospace Commission Report:

2005: National Academy of Engineering

Norman R. Augustine

Craig Barrett

Gail Cassell

Stephen P. Chu

Robert M. Gates

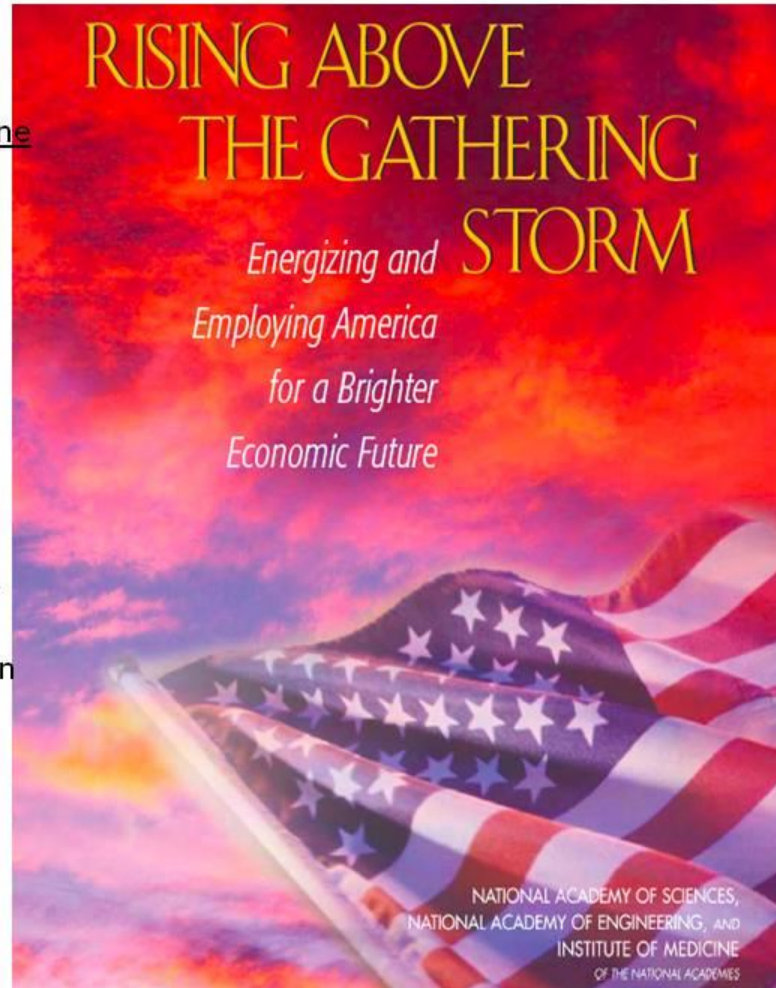
Nancy Grasmick

Charles Holliday, Jr.

Shirley Ann Jackson

Anita K. Jones

Joshua Lederberg



Richard Levin

C. D. (Dan) Mote

Cherry Murray

Peter O'Donnell, Jr.

Lee R. Raymond

Robert C. Richardson

P. Roy Vagelos

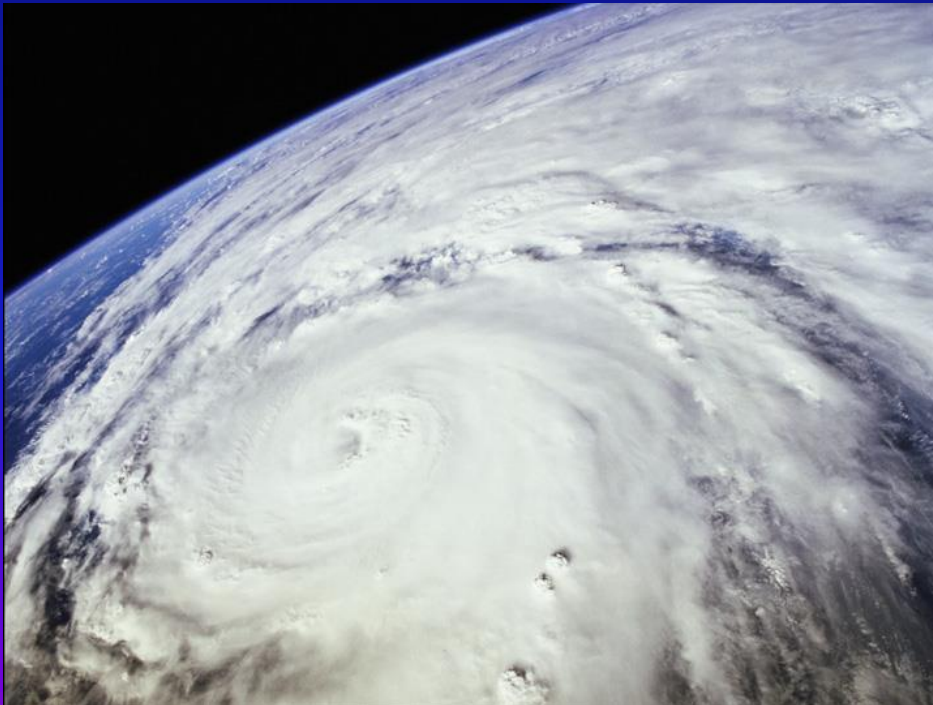
Charles M. Vest

George M. Whitesides

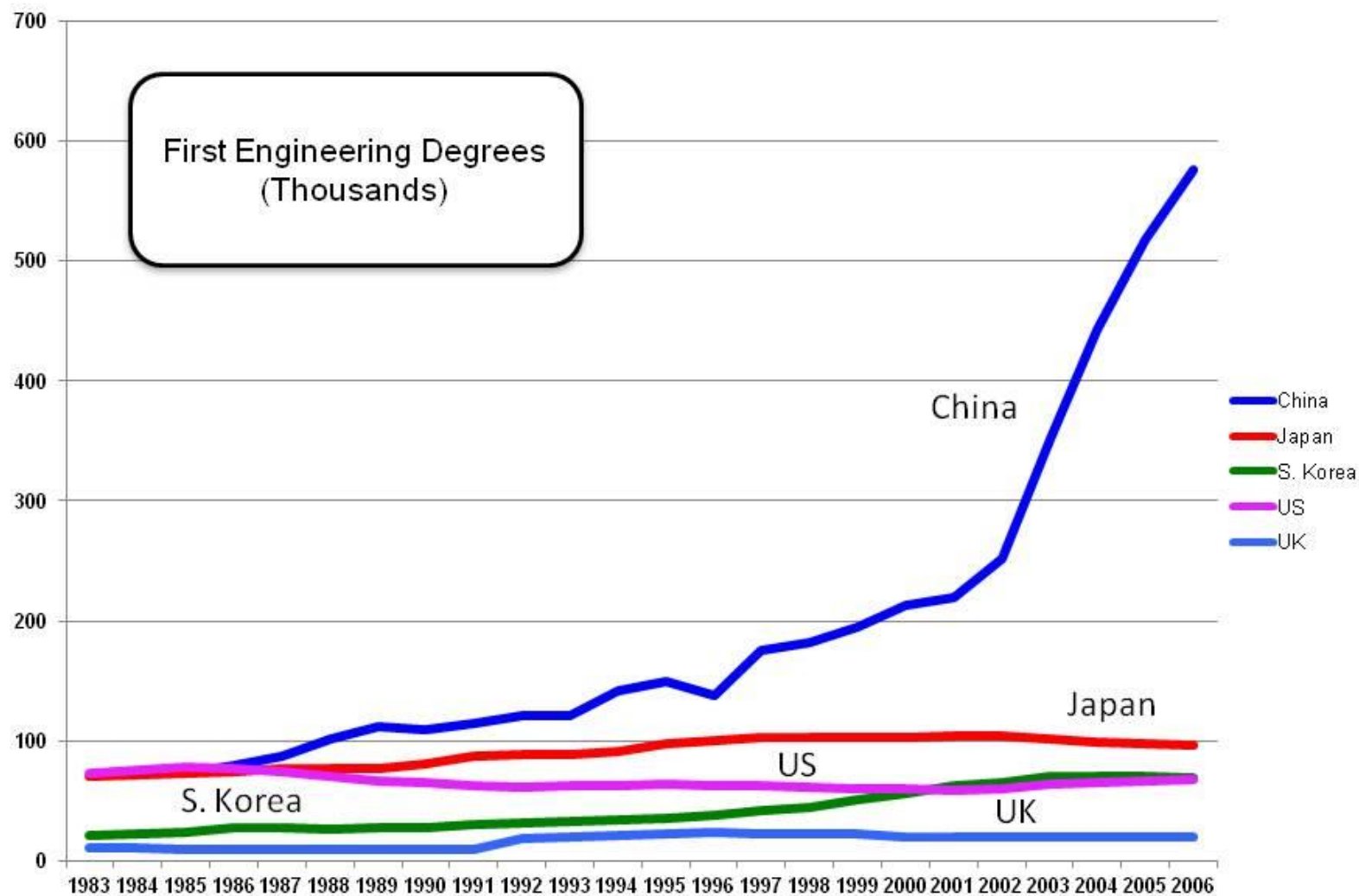
Richard N. Zare

NAE 2010

Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5



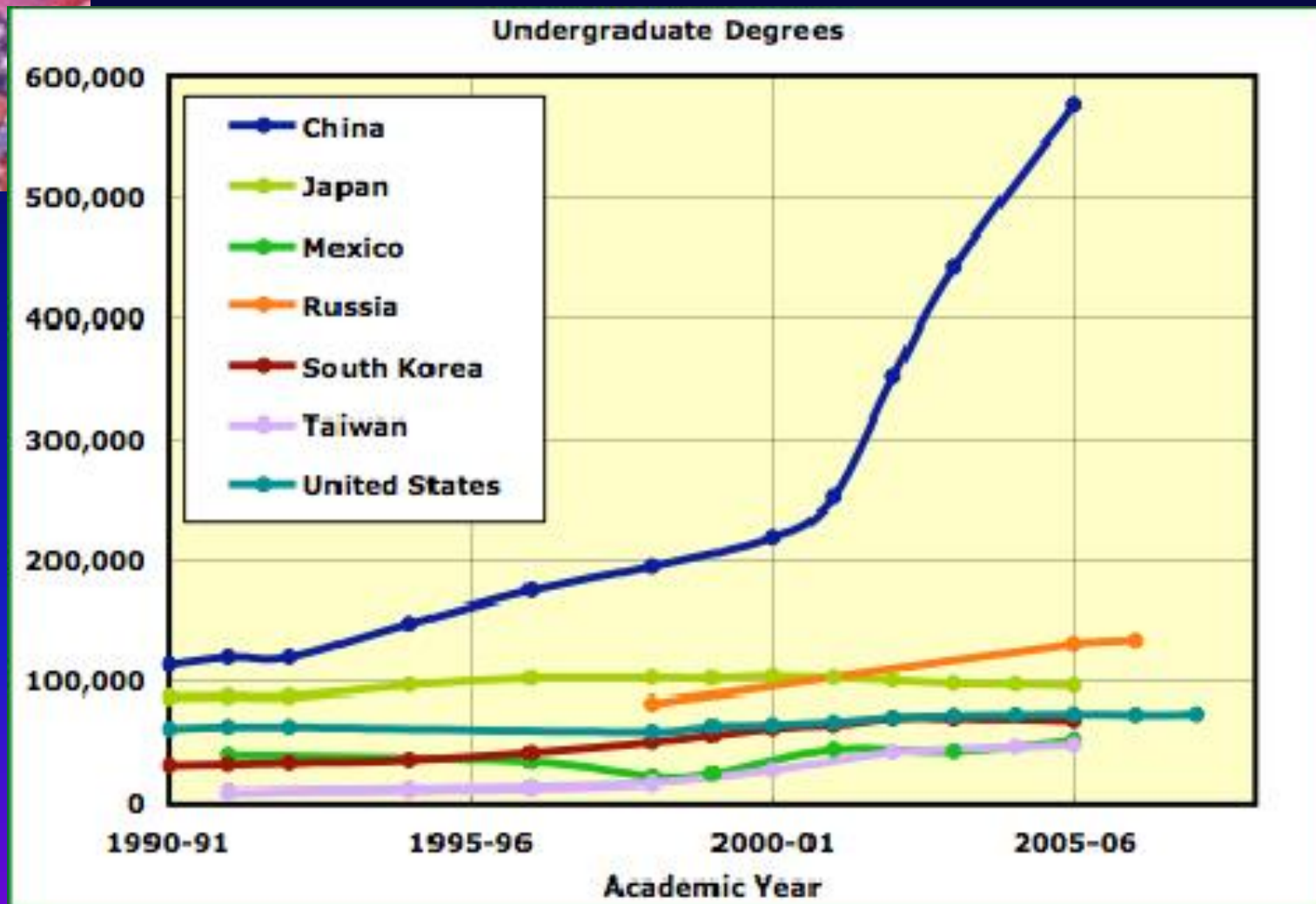
China Rises



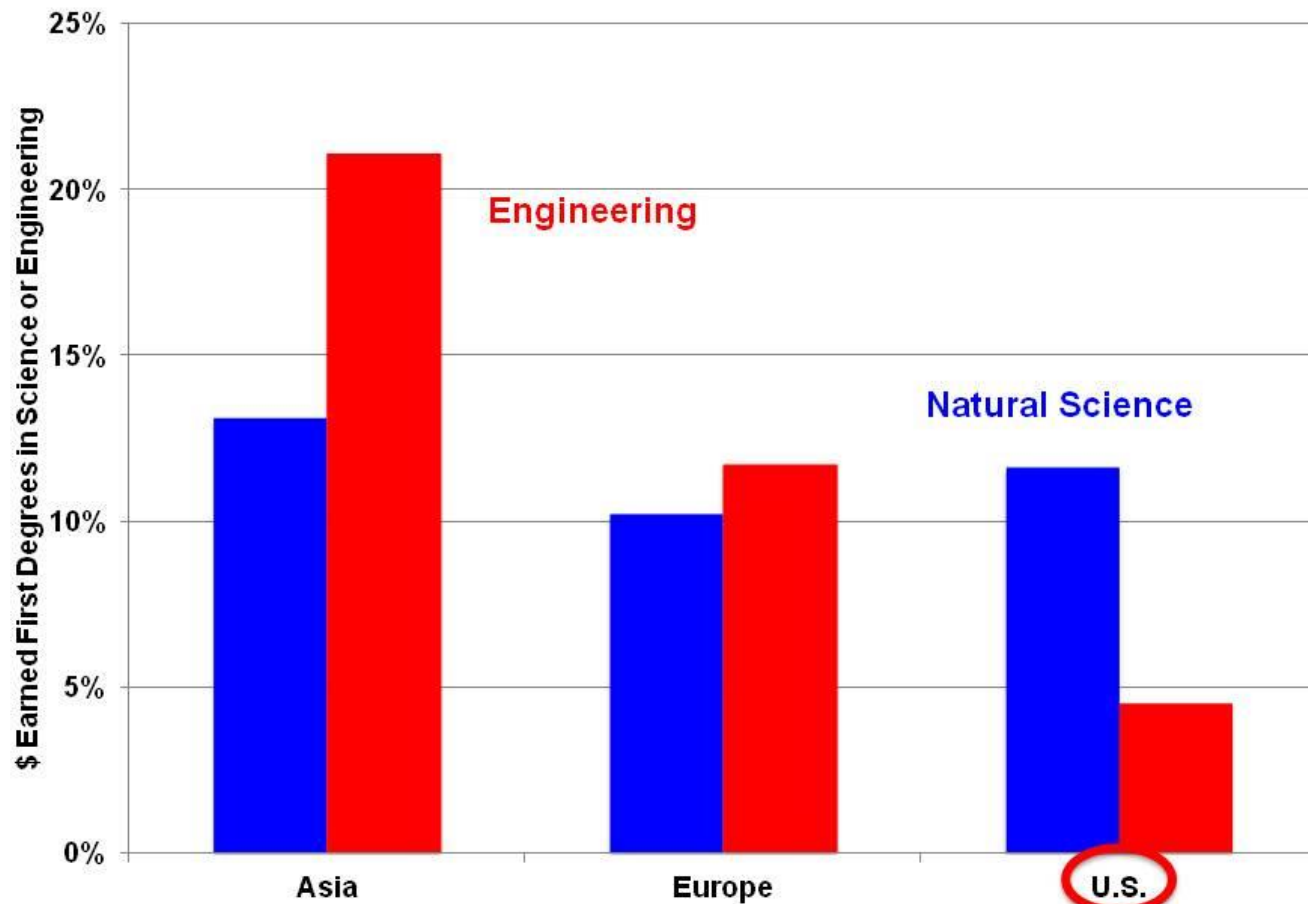
Source: NSF Science and Engineering Indicators, 2010



Undergraduate Engineering Degrees

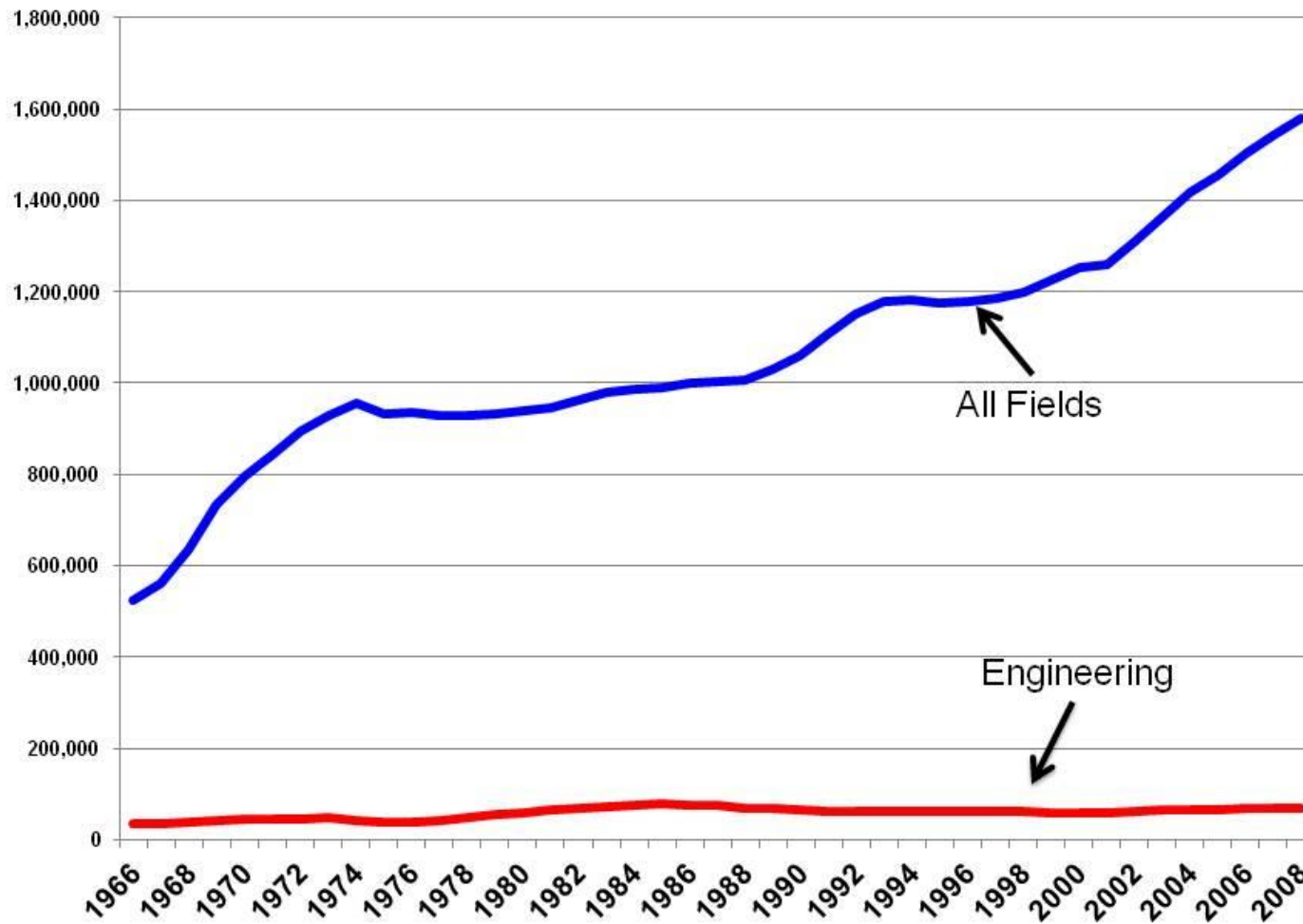


Fraction of First Earned Degrees in S&E



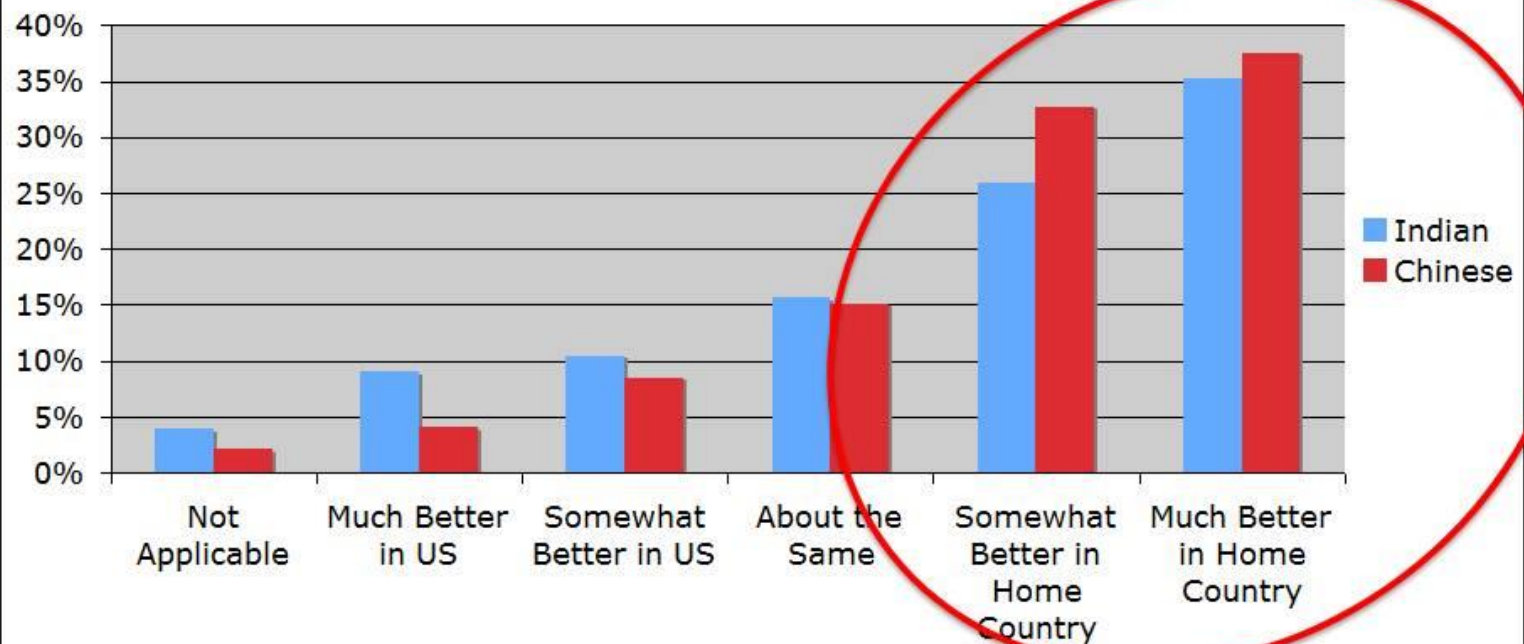
Source: NSF Science and Engineering Indicators, 2010

U.S. Bachelors Degrees Awarded



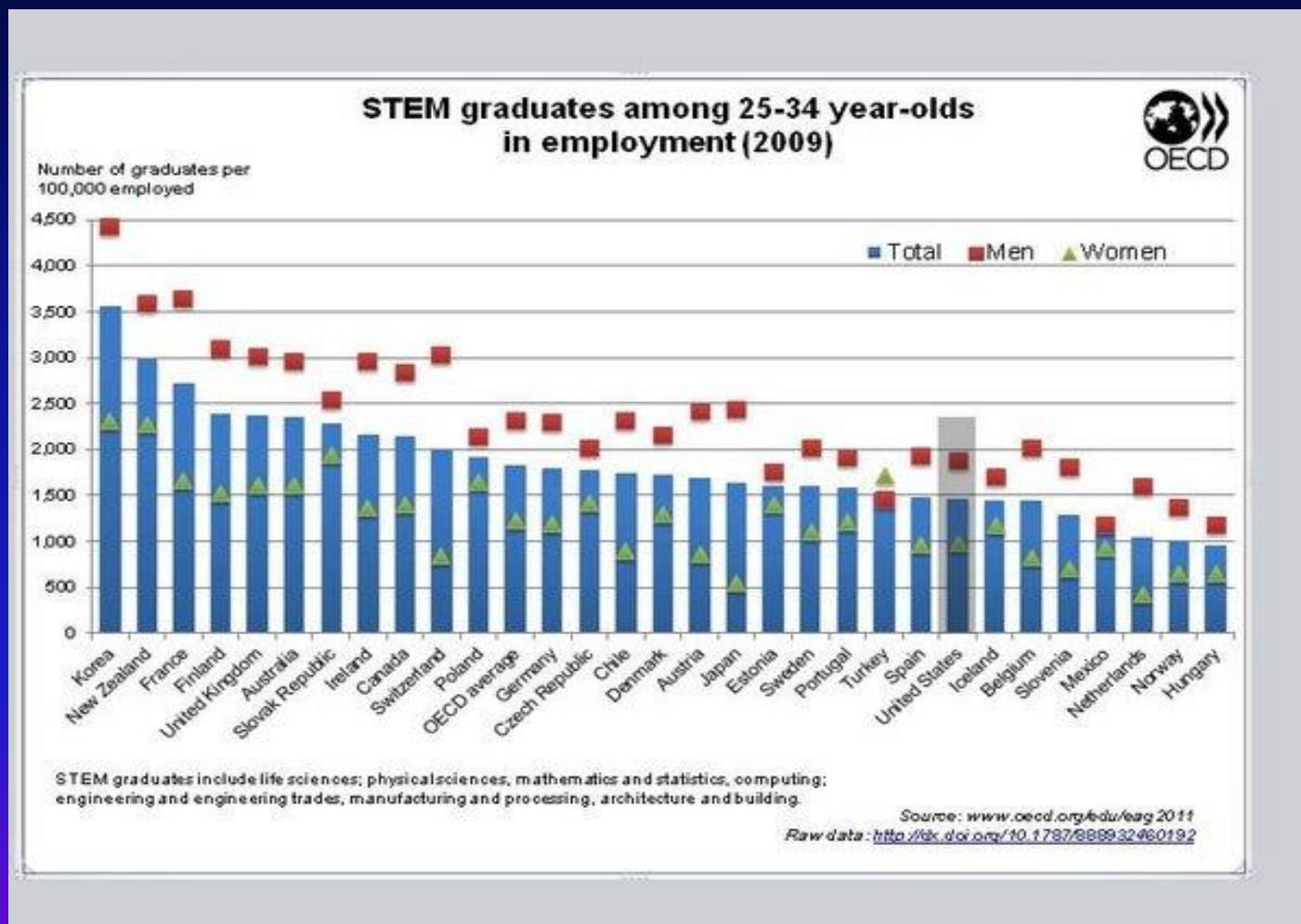
Source: S&E Degrees: 1966-2008, NSF 11-316, June 2011

Why I Returned Home: Speed of Professional



source: V. Wadhwa, et al, *America's Loss is the World's Gain*, Kauffman Foundation, March 2009

US workers behind Korea, UK, Germany, 19 others in Employed STEM graduates (between Spain and Iceland)



April, 2013: Brookings Report “STEM DEMAND”

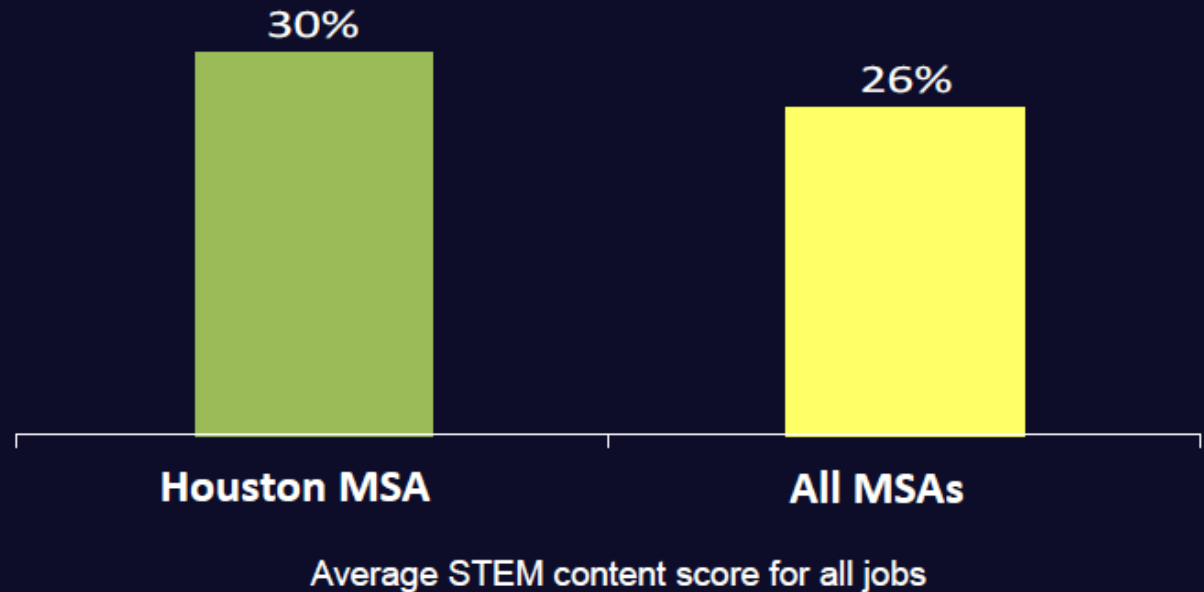
About one third of Houston’s jobs are in STEM-focused fields

Share of jobs with above-average STEM content, 2011

Source: Brookings analysis of
Bureau of Labor Statistics
data

Houston Rank
(among 100 metro areas)

5



April, 2013: Brookings Report: “STEM SUPPLY”

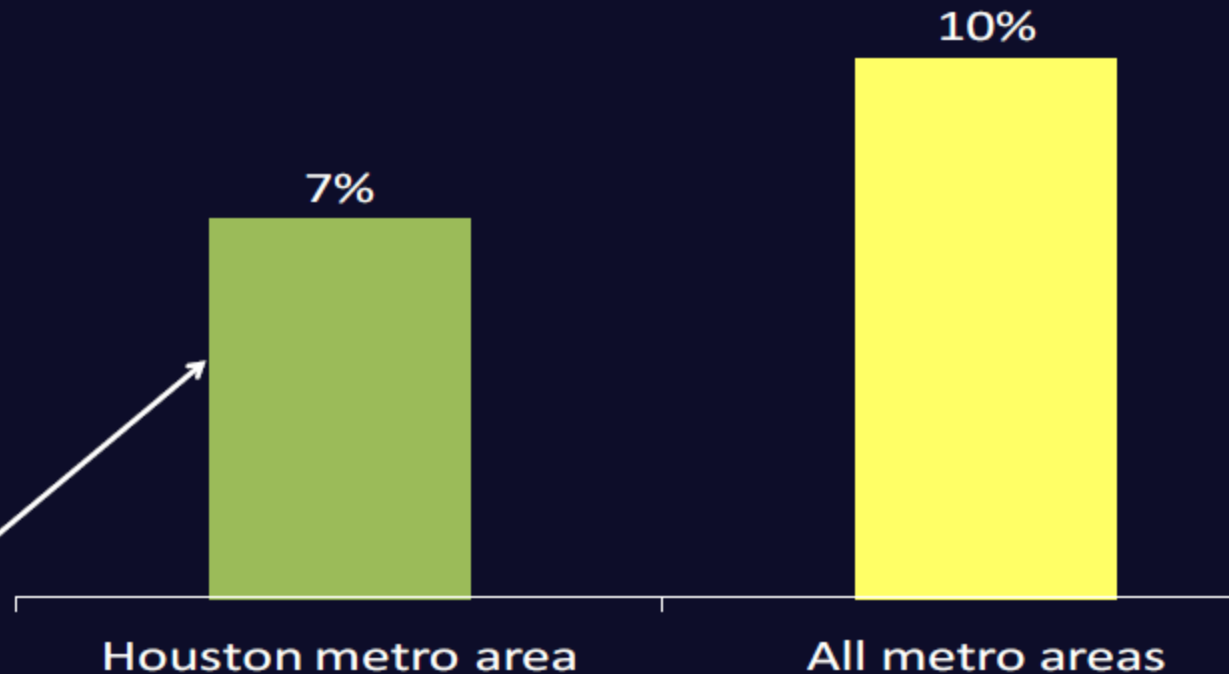
Houston's young adults are less highly educated than those elsewhere

Share of 18 to 24 year-olds
with bachelor's degree,
Houston MSA versus metro
average, 2011

Source: Brookings analysis of
U.S. Census Bureau data

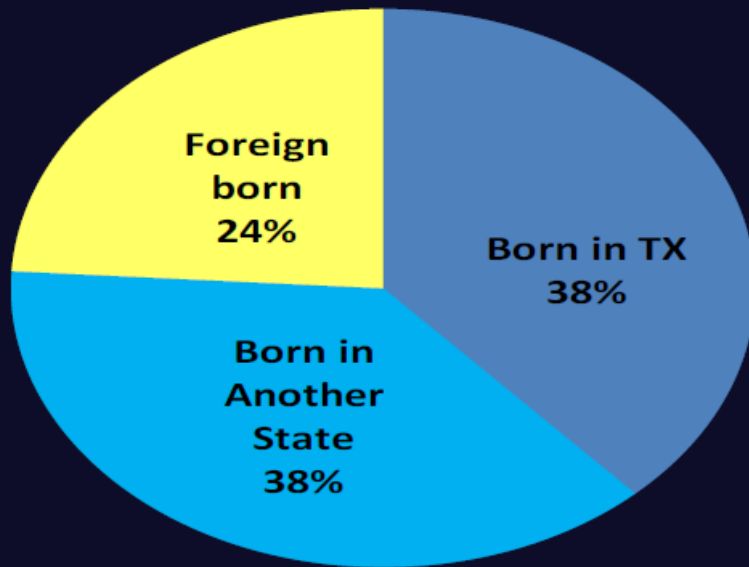
Houston Rank
(among 100 metro areas)

72



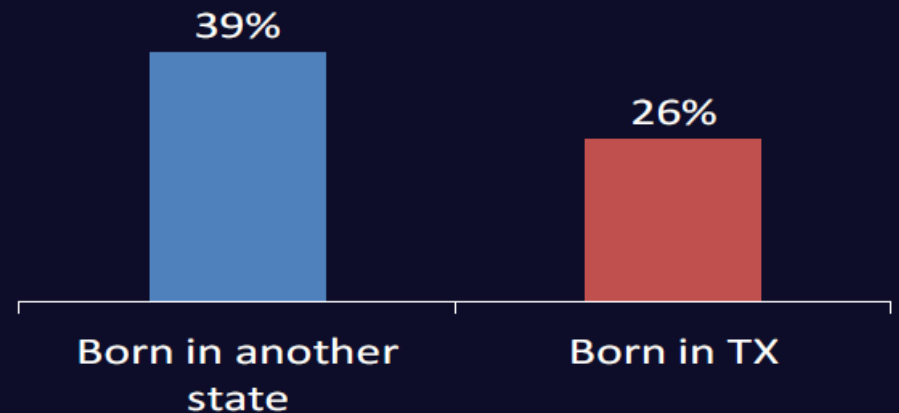
April, 2013: Brookings Report

Almost two-thirds of Houston's highly educated residents are from outside TX



Birthplace of Bachelor's Degree Holders, Houston MSA, 2011

Houston's in-migrants are more highly educated than its TX-born residents



Share of residents with Bachelor's Degree by Birthplace, Houston MSA, 2011

UH STEM Center: College of Engineering STEM Outreach

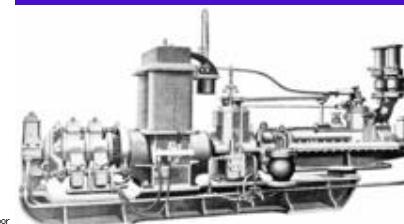
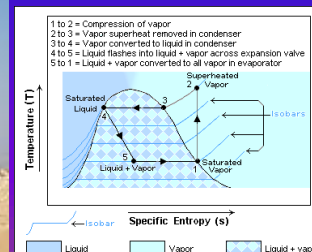


GK-12
GRADE Camp
STEP Forward Camp
PROMES Outreach
RET (Teachers)
REU (Undergraduates)
ISIP (Industrial Interns)
Science and
Engineering Fair,
Houston
National Engineers
Week



From The Pyramids to Mars Exploration

A great nation's health and prosperity depends upon its technological innovation, solutions to the problems of supporting life, and inspiration of its youth. It will depend upon the production and development of its scientists, mathematicians, engineers, chemists, and physicists.....



Inspiring and Teaching the Next Generation

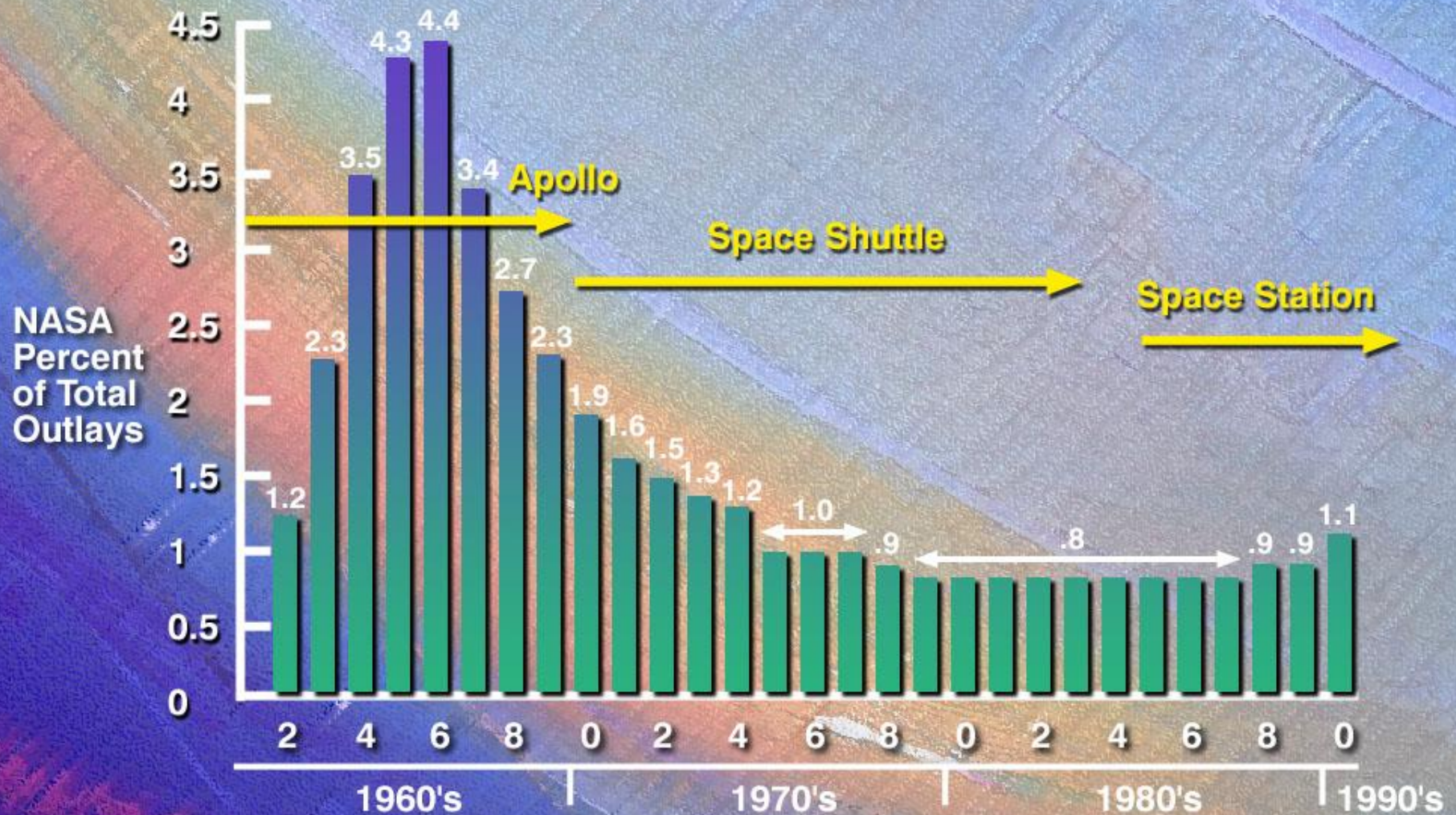


Math, Chemistry and Physics are the languages of the Natural World --





NASA Historical Percent of Budget Outlays



WHAT WE SPEND



Revisiting Viking 1 and II: Not IF--



First Robotic Lander on Mars

United States of America, 1976

-but When and Who?

Russia still looks to Mars as their long term goal.

China launched its first Taikonaut Oct 15, 2003, launched 2 in 2005, launched again in 2008, 2012, and plans a space station and mission to the moon

India is interested in a “Human Space Flight” program

Europe Publishes “Aurora” plan for Moon and Mars exploration, 2002

Japan discusses independent efforts with Hope Shuttle and Lunar Landings

First Robotic Lander on Mars

United States of America, 1976





It is difficult to say what is impossible. For the dreams of yesterday become the hopes of today, and the realities of tomorrow.

Dr. Robert Goddard