Humans to Mars: The Technical Expertise and Political Initiative Needed for Human Exploration of the Red Planet

2002 NASA Astrobiology Academy

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Astrobiology Academy Colloquium

July 11, 2003

NASA Ames Research Center

Our Analysis: We propose that

NASA and international space agencies adopt a human mission to Mars as a clear and articulated goal of the international space program.

- Mission-focused, driven by science

Accompanying Document: http://www.umich.edu/~tmarzull

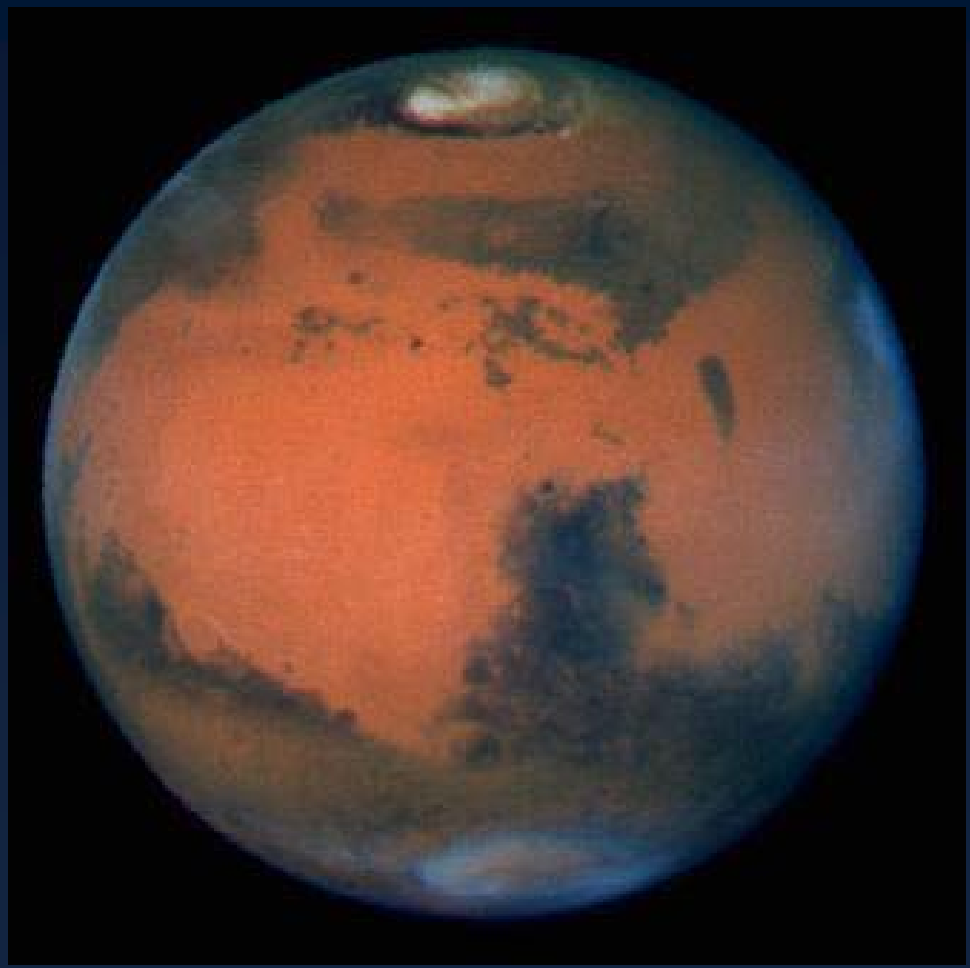
OVERVIEW

- I. Why Go?
- II. Enabling Factors
- III. Conclusions

WHY GO NOW?

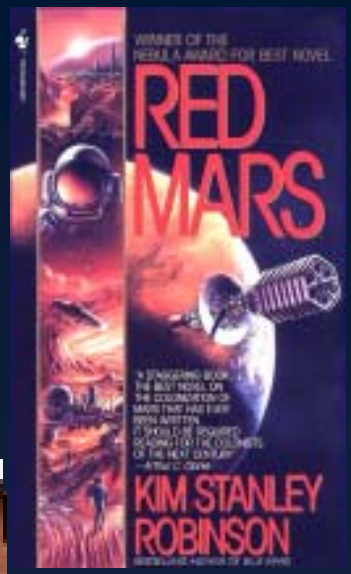
- Exploration
- Education
- Economics

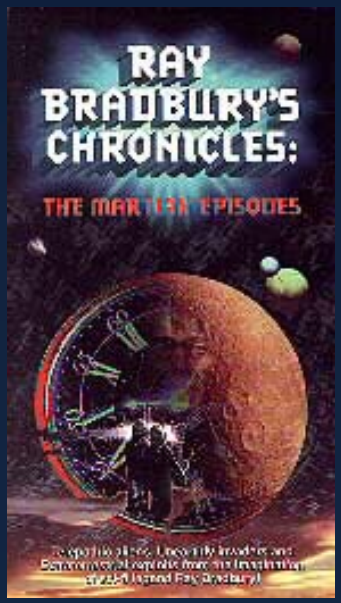
Why Mars?



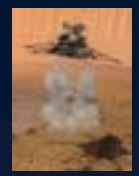
- A feasible destination
- Mars as an Analogous System to Earth
  - Past history and evolution
  - Climate modeling
- Astrobiological questions…
  - How did we get here?
  - Are we alone?

Fascinating . . .





Past Robotic Exploration

Images suggesting history of water

Absence of surface life

Confirmation of water associated geological features

Detection of large reservoirs of shallow water ice

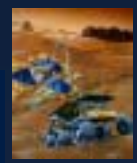
Future:
Hyperspectral Imaging
Sample Return
A Human Mission?

1960s
Mariner 4
Mariner 6
Mariner 7
Mariner 9

1975
Viking 1
Viking 2

1992
Mars Observer

1997
Pathfinder



1998
Climate Orbiter
Polar Lander

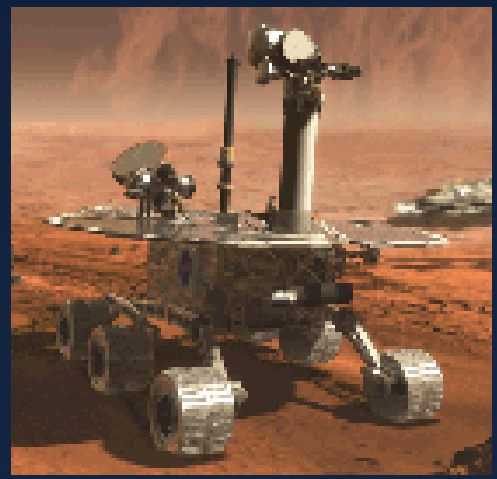
2001
Odyssey

2003
Mars Express
Mars Exploration Rovers

Why Humans?

- Ability to modify plans and adapt to new conditions
- High Volume, Accurate Context Scientific Return

or



How does sending a few people to Mars help the billions of people on Earth?

Education:

- Inspiring the Next Generation

Economics

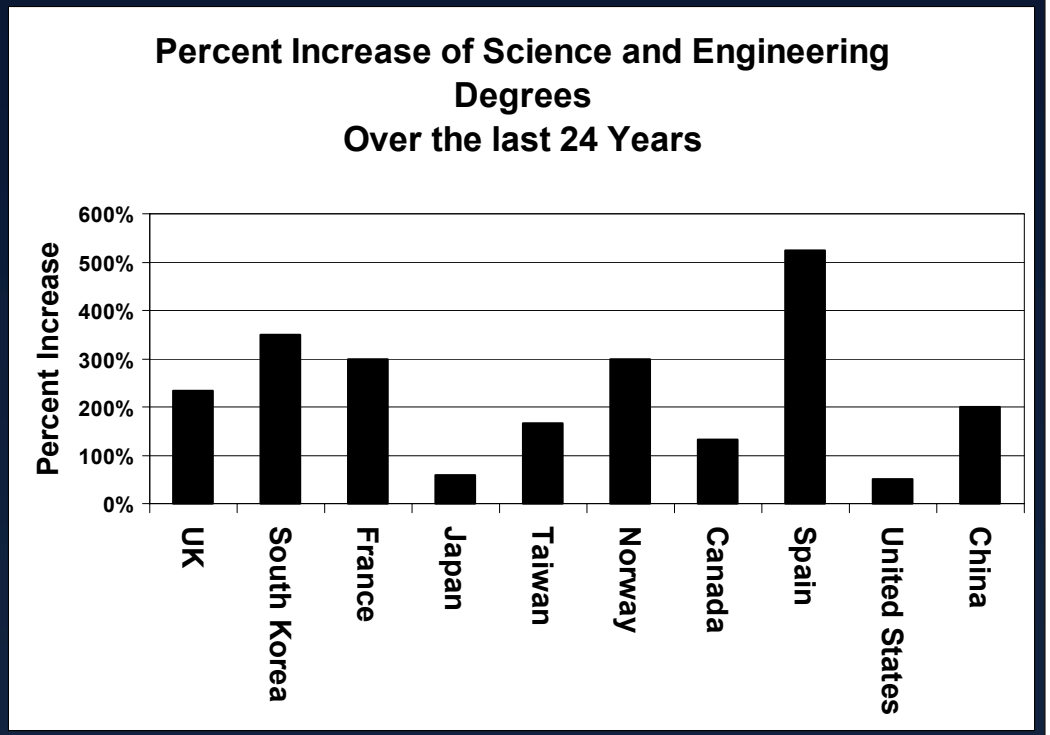
Why is "Inspiration" Important?

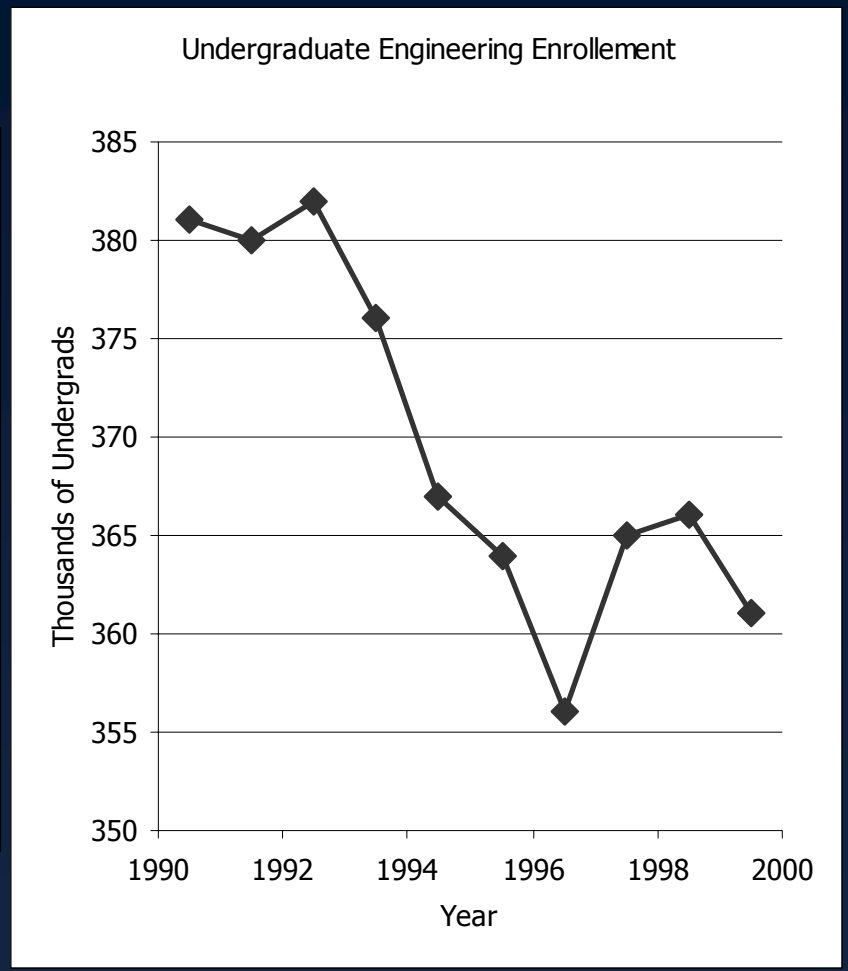
Science and Engineering Education

- Industrialized countries rely on highly technical workforce to maintain its technological and economic position.
  - CASE STUDY: UNITED STATES
  - In the next 10 years, an estimated 15% increase in demand for physical scientists and a 20% increase in demand for engineers in the United States

National Science Foundation (US)—Science and Engineering Indicators, 2000

Failing to meet the need

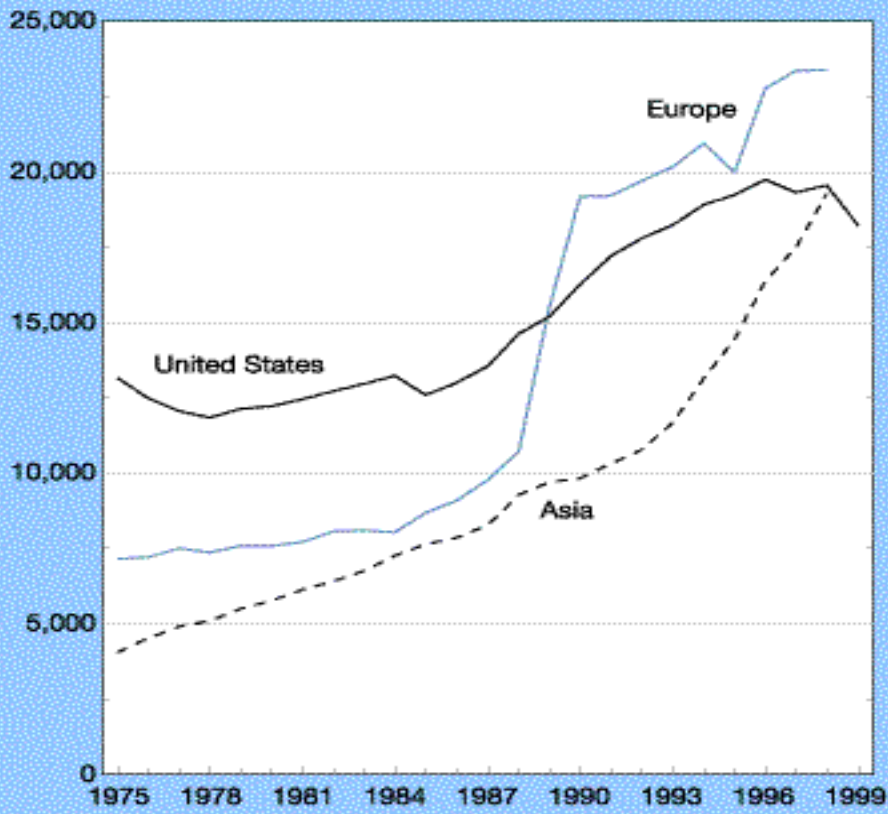




National Science Foundation (US)—Science and Engineering Indicators, 2000
Hart-Rudman Commission Report (2000)

What About the Rest of the World?

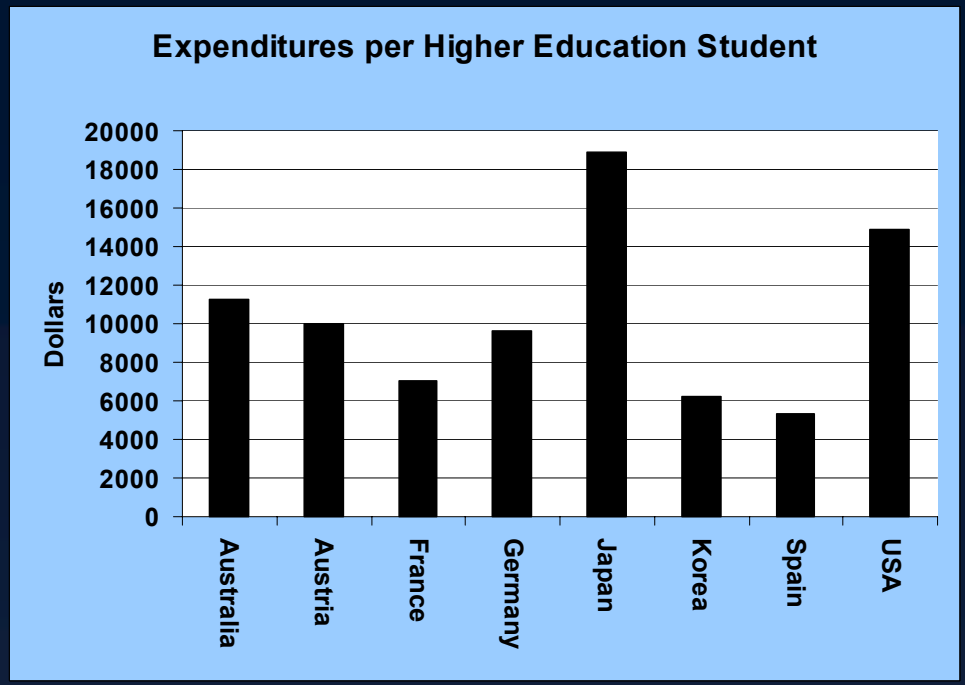
Figure 2-33.
Doctoral NS&E degrees in the United States, Europe, and Asia: 1975–99

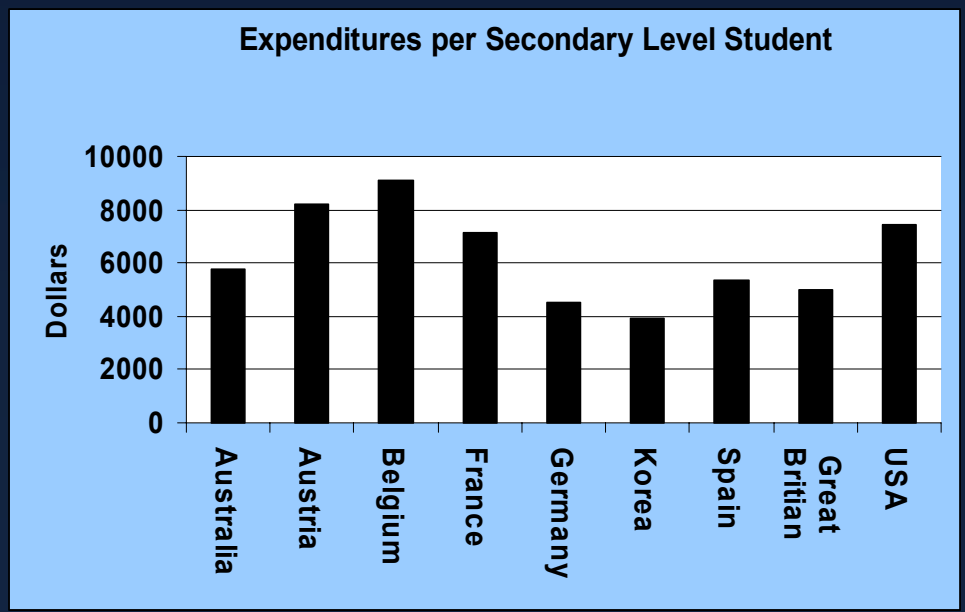


NOTES: Natural sciences include physics, chemistry, astronomy, and biological, agricultural, earth, atmospheric and ocean sciences, as well as mathematics and computer sciences. Europe includes France, Germany, and the United Kingdom. Asia includes China, India, Japan, South Korea, and Taiwan.

See appendix tables 2-39, 2-40, and 2-24.

Science & Engineering Indicators – 2002



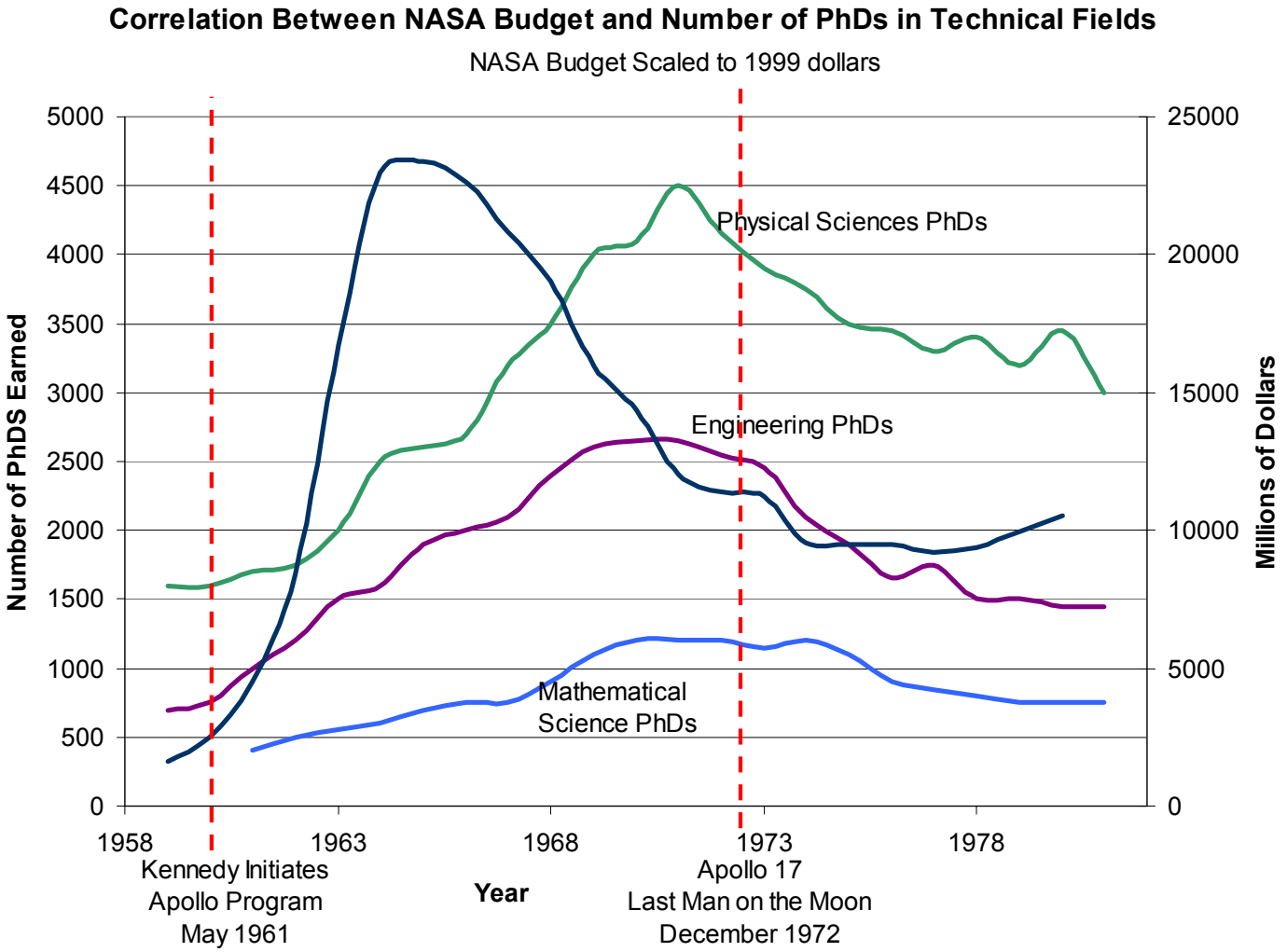


Why Not Just Put the Money Directly into Education?

- That's good for creating a generally well-educated population, but not for Ph.D.s in technical fields
- United States is a top spender in education yet suffers from a decline in technical graduate studies.

National Science Foundation (US)—Science and Engineering Indicators, 2000
Hart-Rudman Commission Report (2000)

Can a Human Mission to Mars Change this Trend?



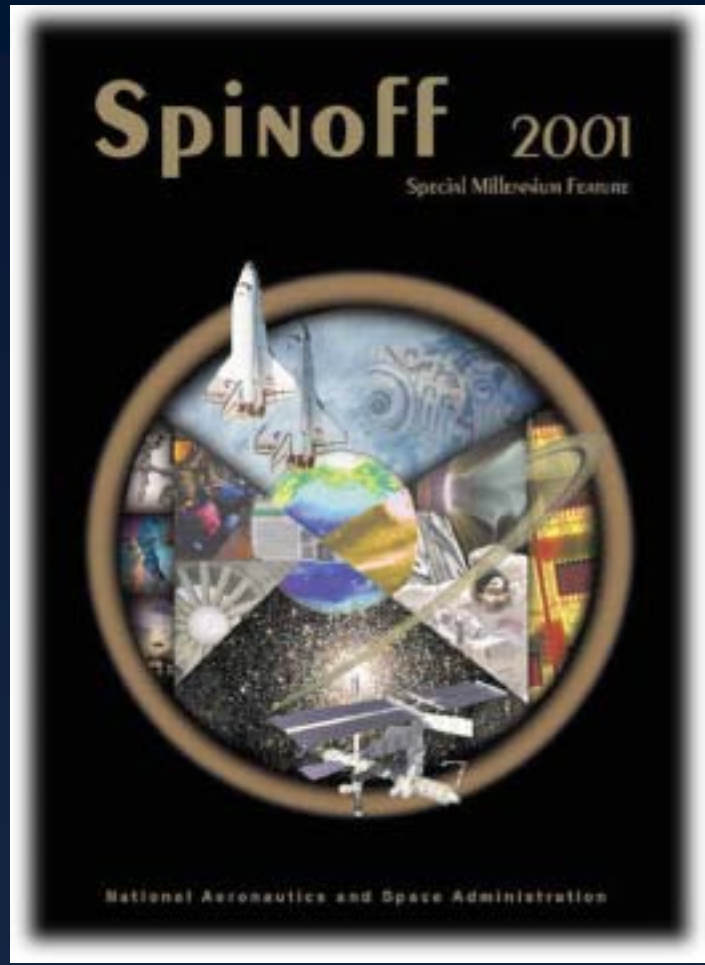
*Office of Management and Budget, "Space Activites of the US Government", http://history.nasa.gov/presrep00/pdf_files/appndx_e1b.pdf, 2000

Economics

- Economy is a measure of investment in research and development in science and engineering.
- High tech industries enable high wage nations to compete alongside low wage countries.
- Space exploration drives advancements in science and technology that allow for development and creation of high tech industries.

Technological Spin-offs

- Areas of development:
  - Health care and Medicine
  - Environmental and Ecological
  - Energy
  - Automation and Robotics
  - Transportation and Propulsion
  - Communications and Navigation
  - Construction and Manufacturing



Mars Technology Advances

Areas of development:

- Health care and Medicine
- Environmental and Ecological
- Energy
- Automation and Robotics
- Transportation and Propulsion
- Communications and Navigation
- Construction and Manufacturing

Space improving life on Earth

FRIDAY, MARCH 7, 2003

Space technology helping fight osteoporosis on earth

'Good vibrations' counter bone loss in astronauts

VERONIQUE MANDAL
CanWest News Service
WINDSOR

Russian space technology has landed in a Windsor rehab centre where it is being used for the first time in Canada to fight osteoporosis.

Vibe, is offering what some see as new hope for people who suffer the effects of bone loss.

While most experience bone loss due to aging, leaving the pull of gravity and experiencing prolonged weightlessness can age the bones of cosmonauts and astronauts as much as 20 years.

Long flights on Mir in the 1990s caused irreversible, 20-per-cent bone loss in one cosmonaut. NASA devised many varieties of workout programs for its astronauts but none solved the problem of muscle and bone loss.

Russian scientists, investigating the negative effects of vibrations on cosmonaut's bodies, realized some vibrations had a po-

ple vibrating plate for cosmonauts to stand on, and discovered that gentle, controlled vibrations can ward off, or reverse bone loss.

Further experiments in the U.K. on sheep showed that by standing their hind legs on a vibrating platform for 20 minutes every day for a year, the density of spongy bone in the animals' thighs was 34 per cent higher than in sheep not receiving the treatment.

Jasper Sidhu, a chiropractor and owner of a rehab centre in Windsor, said vibration therapy is now being investigated by NASA and is used by professional athletes, including Toronto Maple Leafs goalie Eddie Belfour.

The biggest benefit, said Sidhu, may eventually be for the millions of baby boomers rapidly reaching 50.

"It has tremendous benefit without any increase in blood pressure or heart rate," said Sidhu. "It also helps chronic back pain, and can be used after arthroscopic surgery and for bad circulation.

"A patient can exercise the entire muscular system within 10 minutes without any strain on

take more than an hour with conventional strengthening," Sidhu said.

"If your body feels sore at the beginning, it feels great afterwards. I've recommended it to my friends because if you have something wrong it's a great benefit."

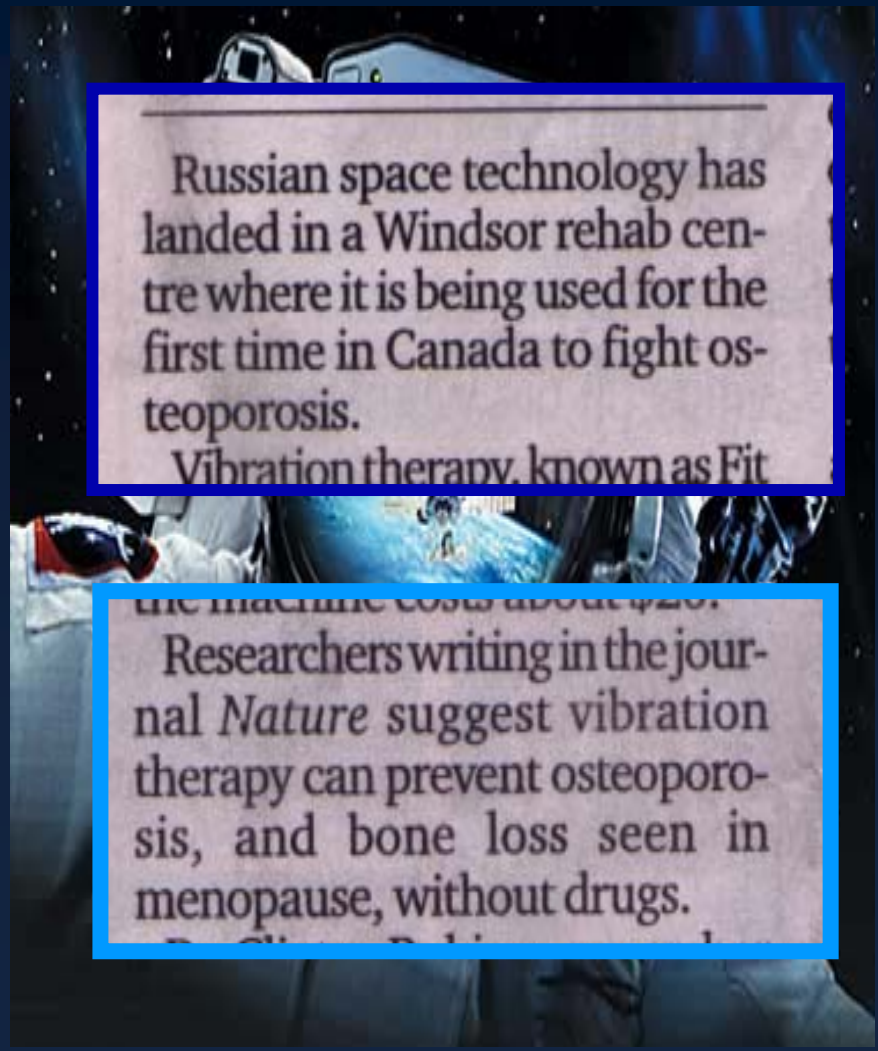
The Fit Vibe, a $20,000 piece of equipment, has a rectangular plate to step on, with an attached handle just above waist level. For applications not covered by health insurance, a session on

Researchers writing in the journal *Nature* suggest vibration therapy can prevent osteoporosis, and bone loss seen in menopause, without drugs.

at Stoney Brook University in New York state, believes there is great potential in vibration therapy.

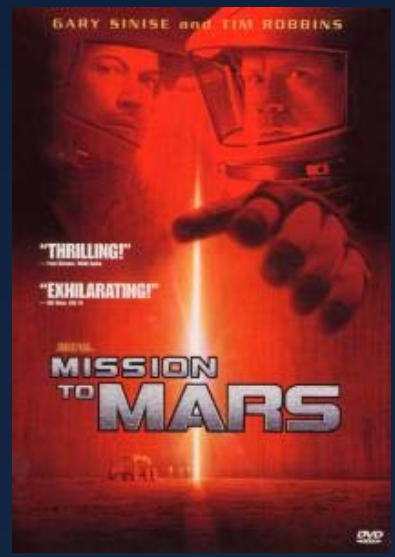
"This is a real departure from the accepted theory of how mechanical signals control bone, and it is certainly controversial," Rubin said.

"Nevertheless, it might work. Good vibrations — unexpected and controversial — could be the key to healthy bones on Earth and beyond."



Feasible: Can we do it ?

- Economic Feasibility
  - Can we afford it ?
- Technical Feasibility
  - Human Factors
    - Radiation
    - Microgravity
  - Propulsion



Fact

vs.

Fiction

Economic Feasibility

- Cost depends on specific mission architecture:

  low-end high-end

  $30 billion < Human Mars Mission < $300 billion

- NASA's FY2003 Budget is $15 billion, $450 million of which is for Mars Exploration

- *Comparisons*
  - Assuming the low number and a 10 year spread
    - 20% of the NASA budget each year
  - Assuming a 30 year spread, the higher number is
    - Equal to the annual cigarette advertising expenditures
    - 2% of the DoD budget

Human Factors

Microgravity

- Effects Muscular-skeletal weakening, cardiovascular health and blood chemistry
- Solutions:
  - Further study on ISS
  - Countermeasures
    - Artificial gravity
    - Exercise and conditioning
    - Pharmaceuticals
    - "Penguin Suits"

Radiation

- MARIE results suggest that radiation is "not a show-stopper"—exposure over a Mars mission timeframe would not exceed career does limits (Zeitlin, 2003)
- Solutions:
  - Shielding

International Cooperation

- Greatest endeavor in history of mankind - naturally space goes beyond borders
- Challenges require the expertise and specialties of different nations.
- Sharing of costs and risk

CONCLUSIONS

- Benefits of a human Mars mission
  - Exploration - solar system, water, life?
  - Education - young people into science
  - Economics - reinforce high technology
- Acts as an "Umbrella Program"
  - Channels funds to important research projects
  - Sheer bang for your buck because it involves many programs at a fraction of the national budget

Accompanying document available for download at:

http://www.umich.edu/~tmarzull

Acknowledgements

2002 Astrobiology Academy

Ames Research Center

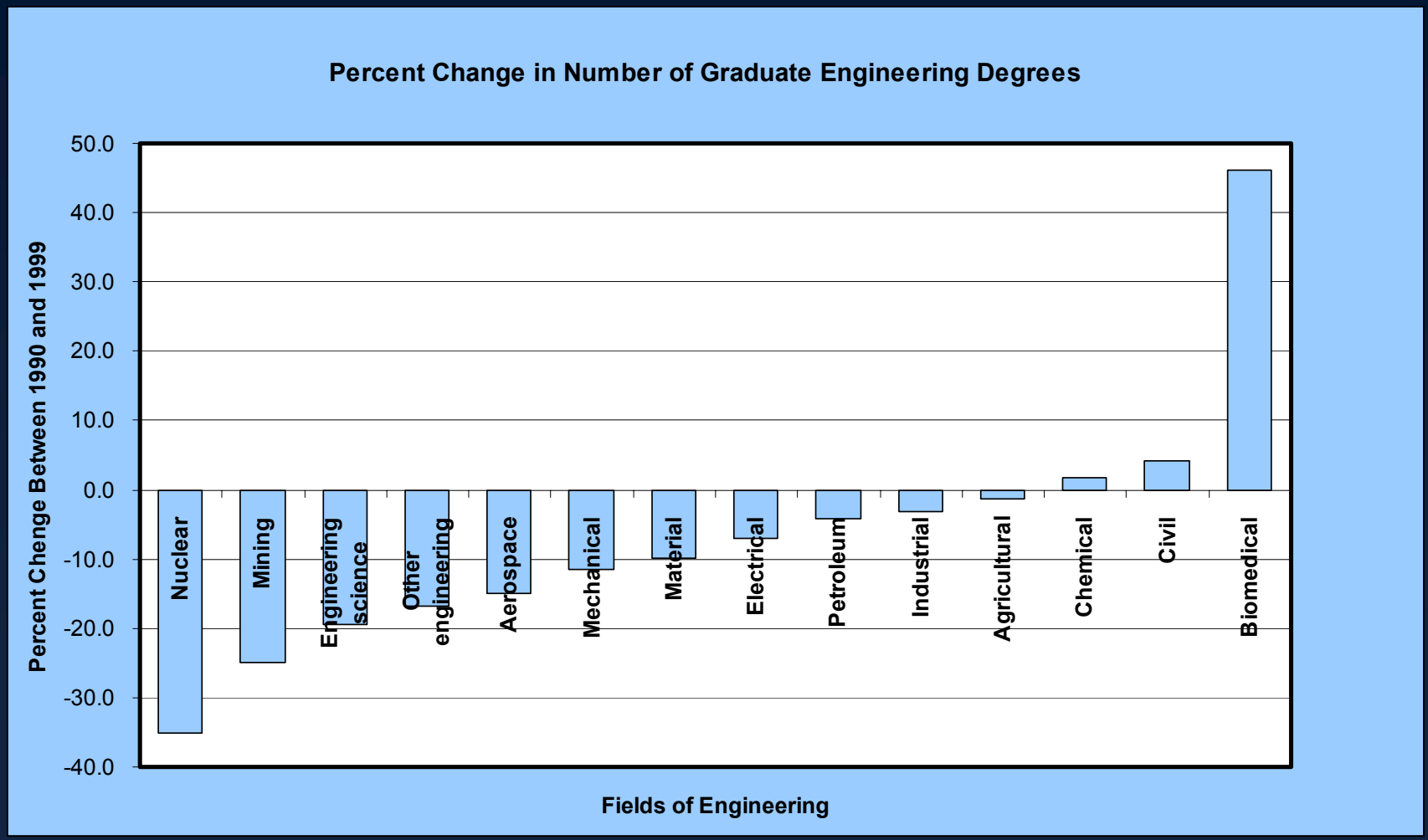
Full presentation: http://www.umich.edu/~tmarzull

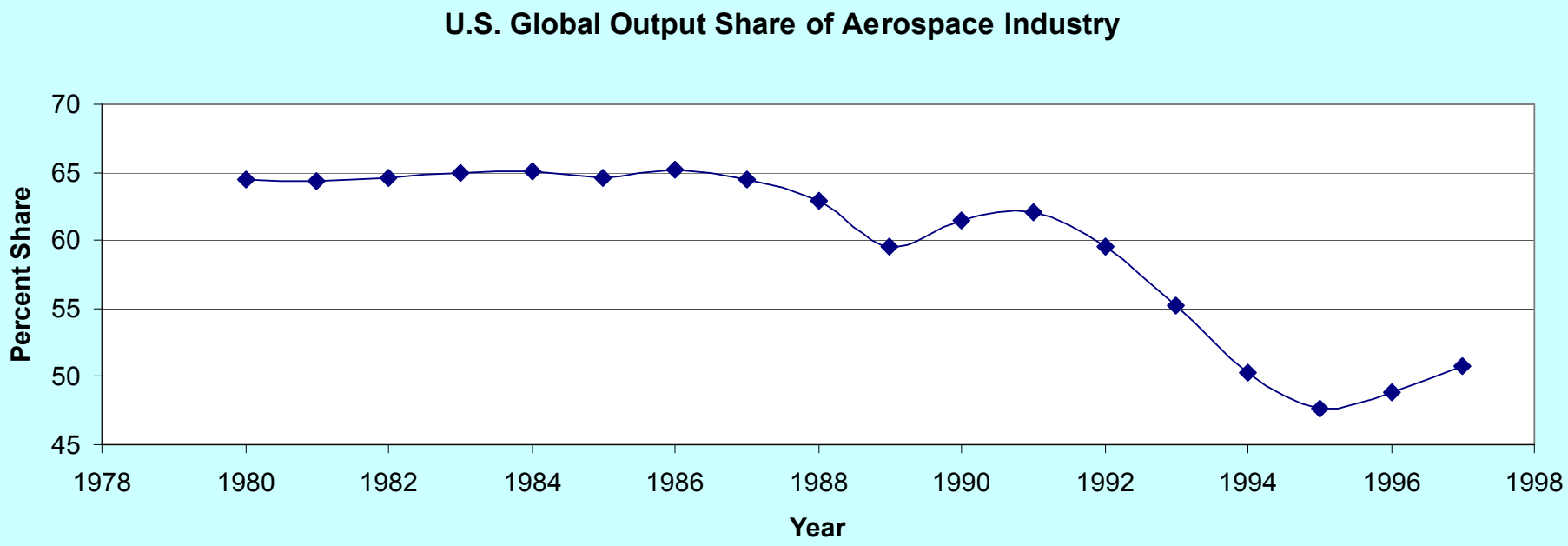
EXTRAS

"We chose to go to the Moon in this decade and do other things not because they are easy but because they are hard." (JFK)

- Tremendous amount of research completed and still more ongoing
- Many reports during SEI days could not even consider some of the advanced technologies we have today: computing power, internet, inflatables, ISRU
- NRC, 1967—If we fail to include man in our plans for exploration, we inevitably exclude him because we have not undertaken the necessary planning

Decline is even offset by interest in Biomedical Engineering





2001 Science & Engineering Indicators, National Science Foundation

While US share of the world aerospace market has dropped 15% since the 1980s, the Chinese have increased their world aircraft shipments by nearly 80%.

Propulsion

- The faster we go the less exposure to microgravity and radiation
- Trade off between stored power and mass