Telehealth in the United States

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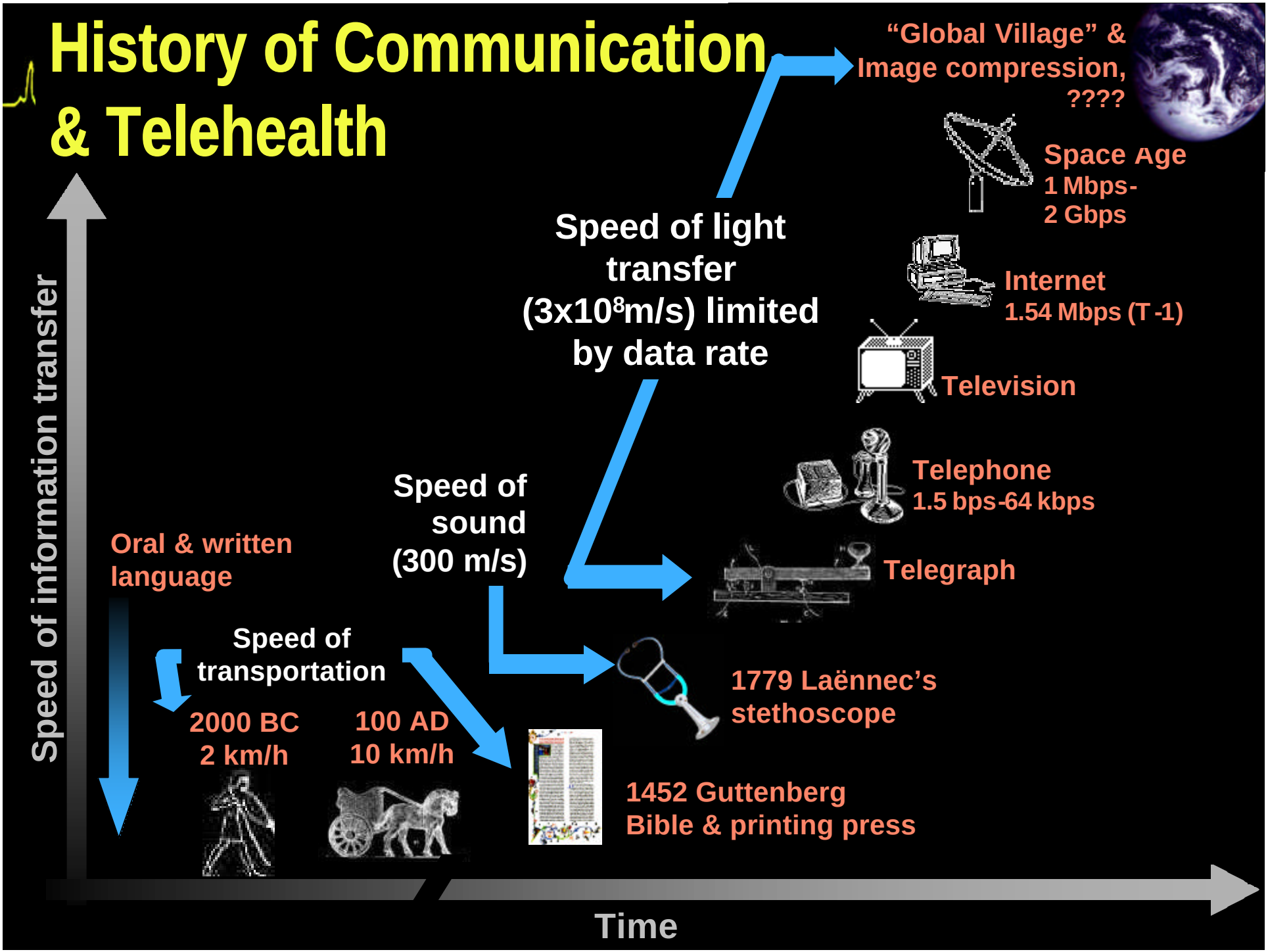
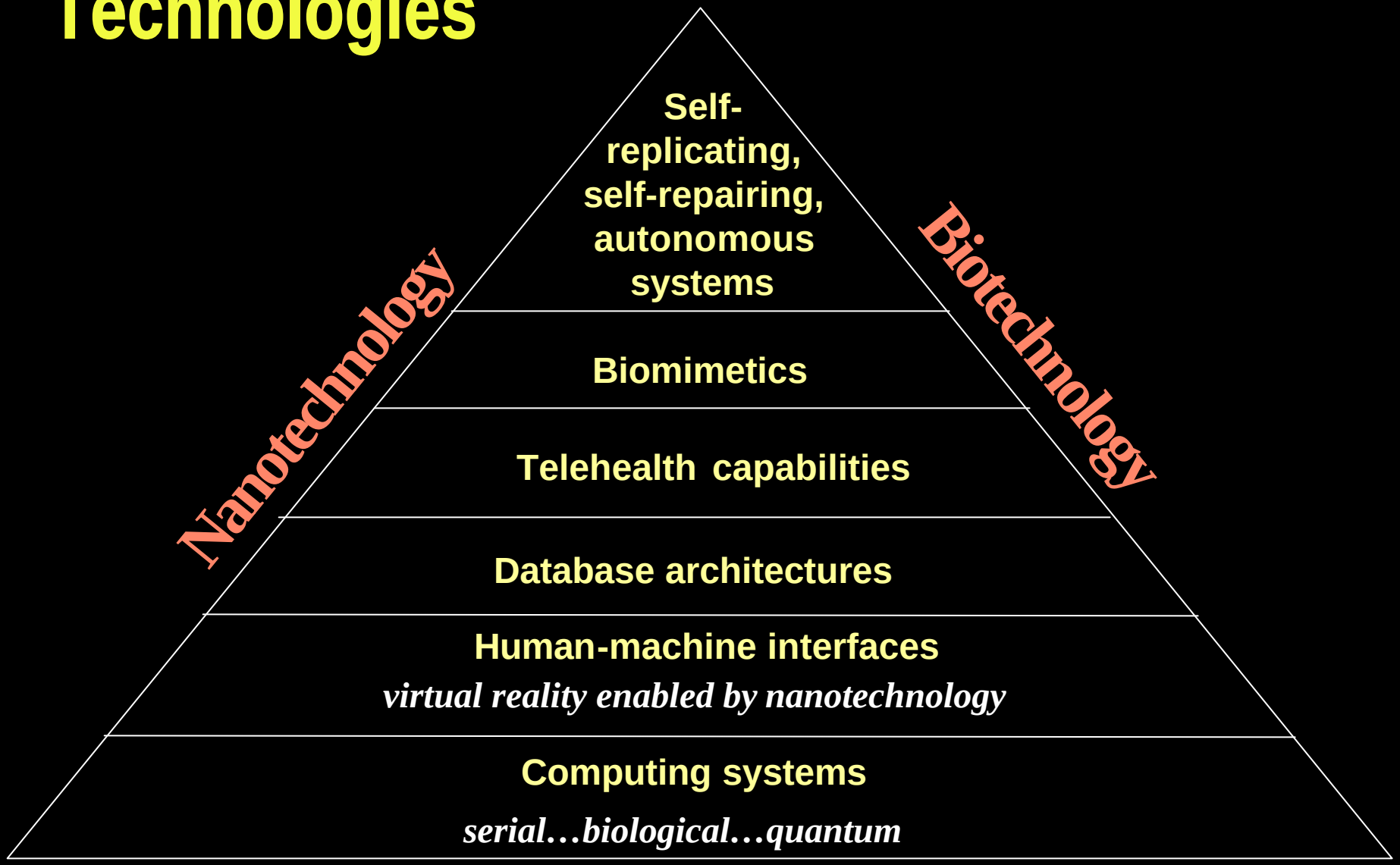
  - Department of Defense (DoD)
  - National Aeronautics and Space Administration (NASA)
- The future of telehealth in the U.S. space program

History of Communication & Telehealth

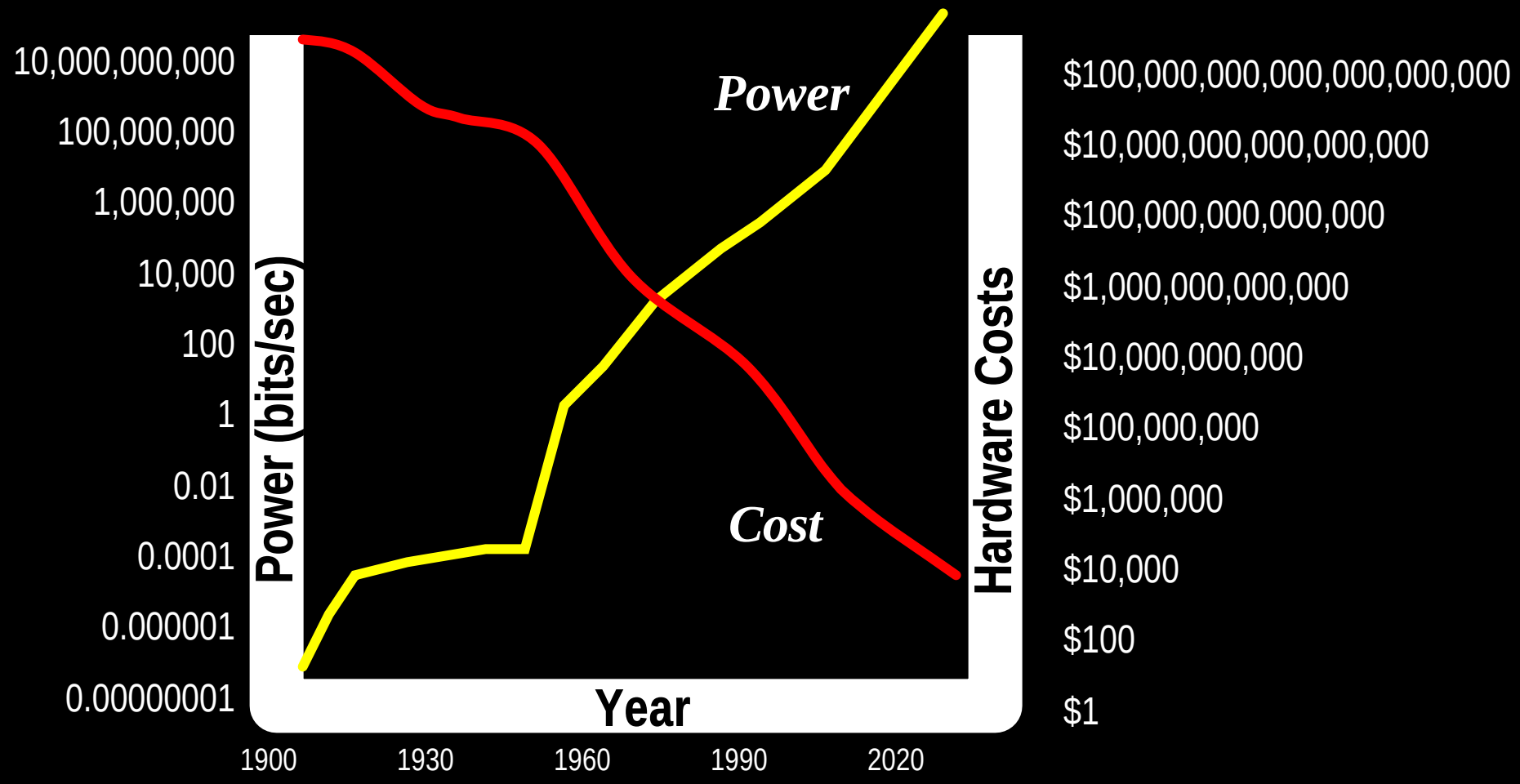


Hierarchy of Medical Technologies



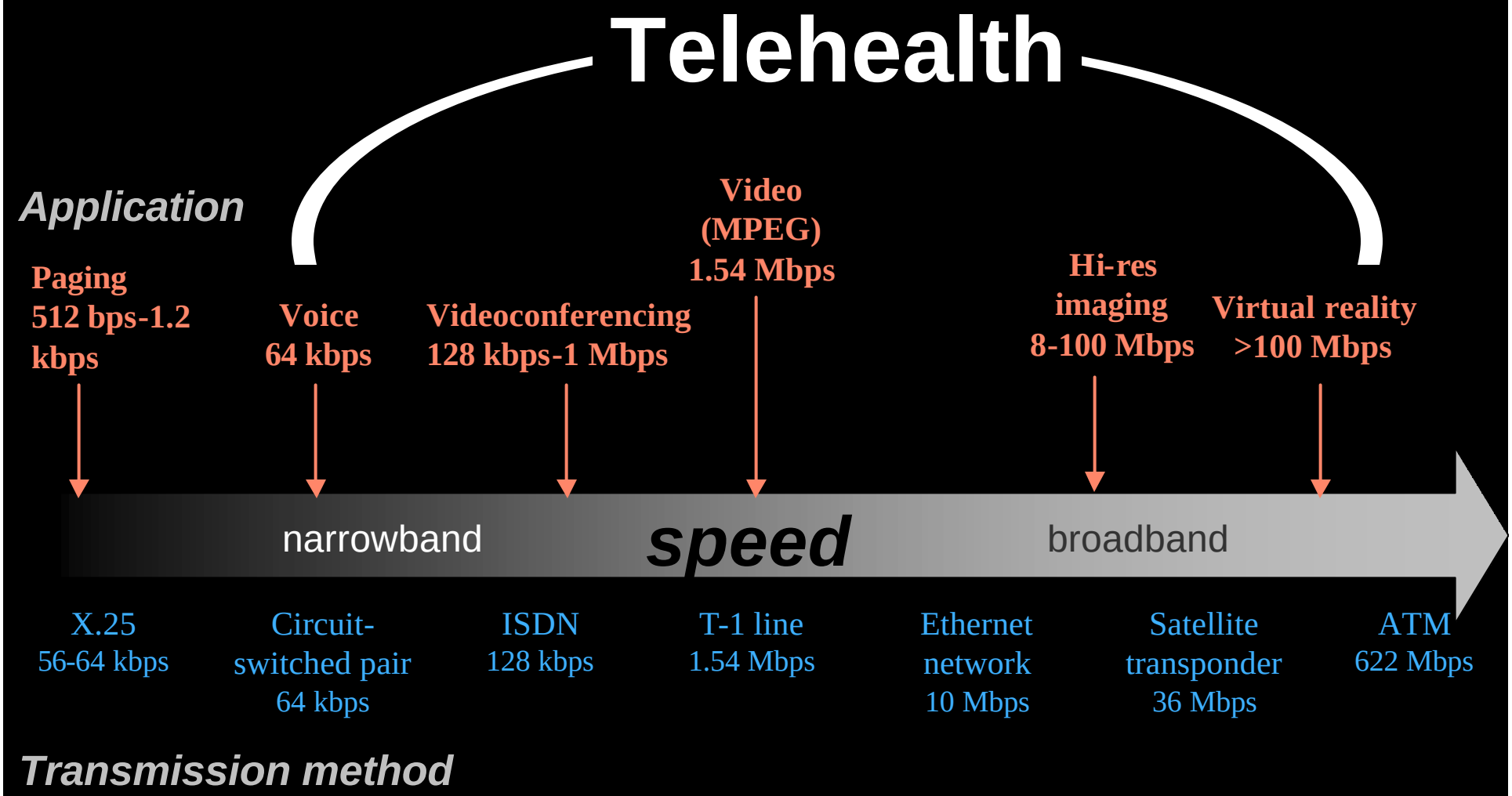
Information

Power vs. Cost of Computing



*Adapted from Hans Moravec, Mind Children:The Future of Robot and Human Intelligence (Cambridge, MA: Harvard University Press, 1988).

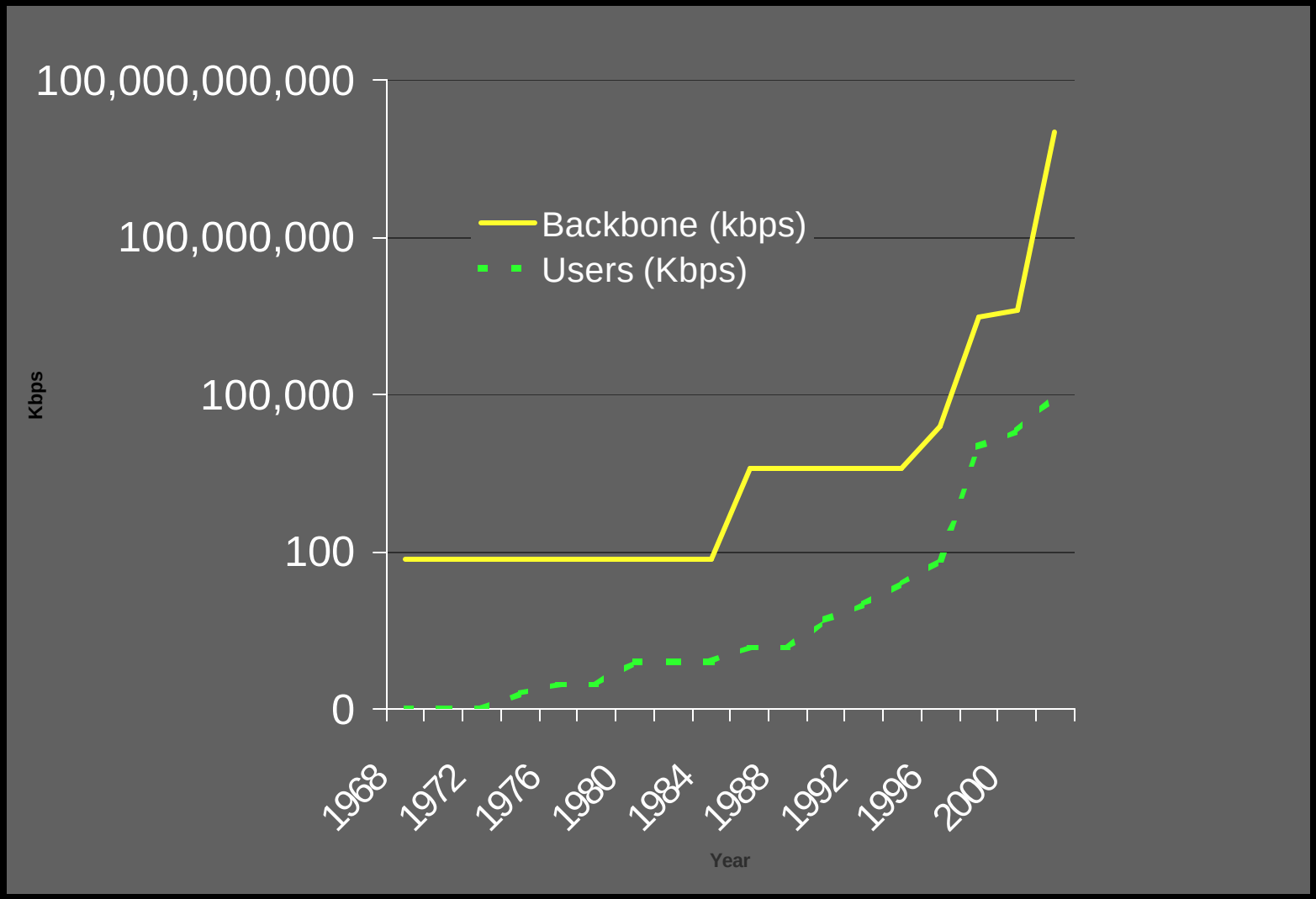
How Fast Can Data Move Today?



1 Gigabit (Gb) = 1,000,000,000 bits
1 Megabit (Mb) = 1,000,000 bits
1 kilobit (kb) = 1,000 bits

Source: Futron Corporation, 1999

Growth of the Internet

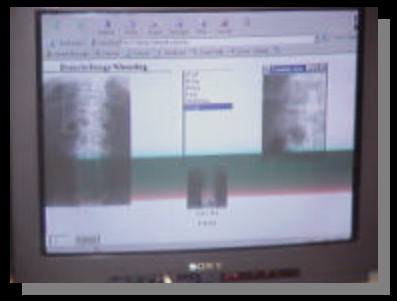


*Adapted from Vinston Cerl, “Beyond the Millennium: The Internet,” http:www.mci.com/mcisearch/aboutyourinterests/technology/ontechcertreport0697.shtml, 1997.

Telehealth Philosophy

MONITOR

PREVENT



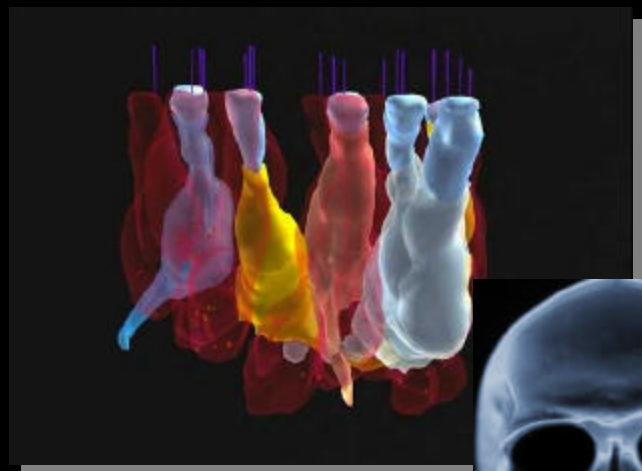
TREAT

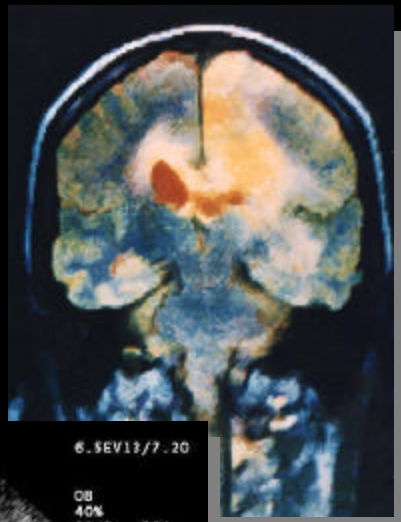
Telehealth Requirements

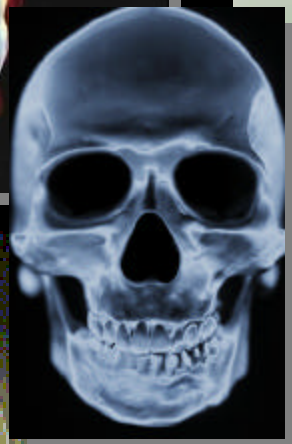
- Improve traditional tools
- Minimize geographic inequality
- Enhance the quality of care
- Contain expenditure/ infrastructure cost

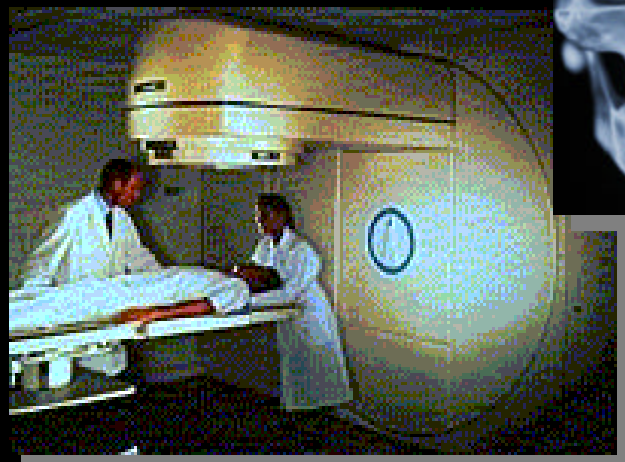
Telehealth Requirements

Improve traditional tools



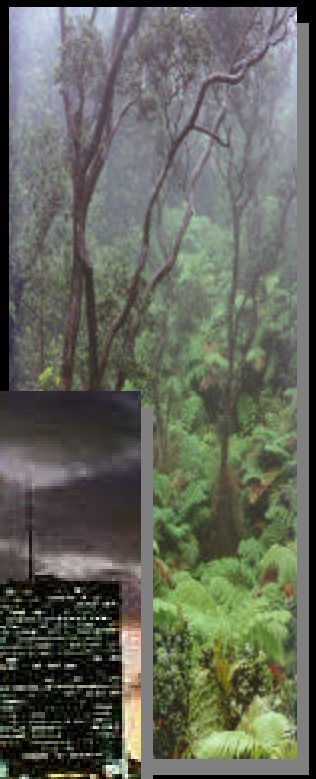






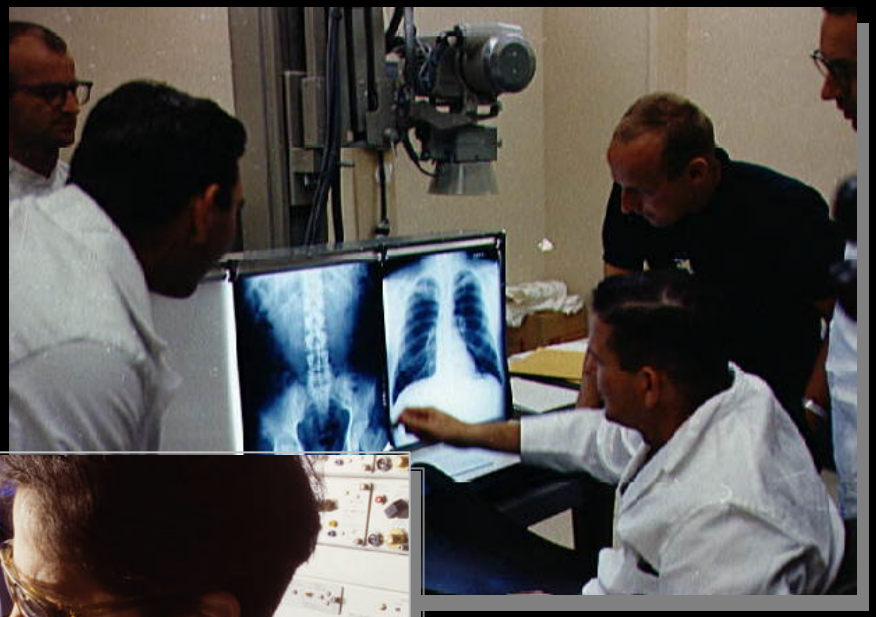
Telehealth Requirements

Minimize geographic inequality



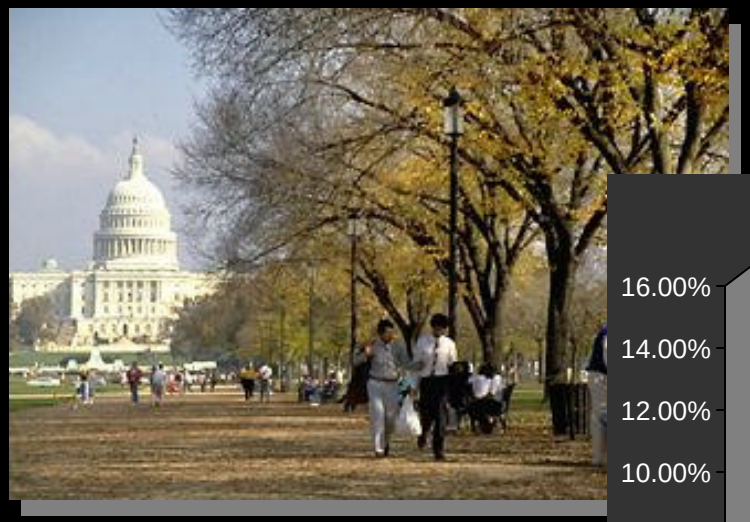
Telehealth Requirements

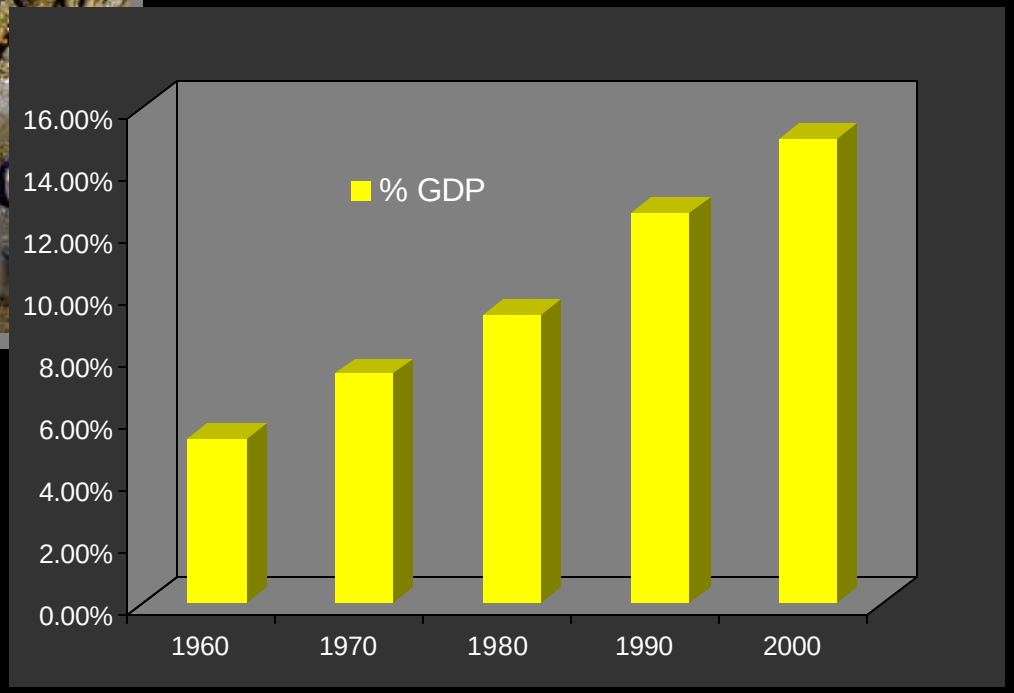
Enhance the quality of care



Telehealth Requirements

Contain expenditure/infrastructure cost

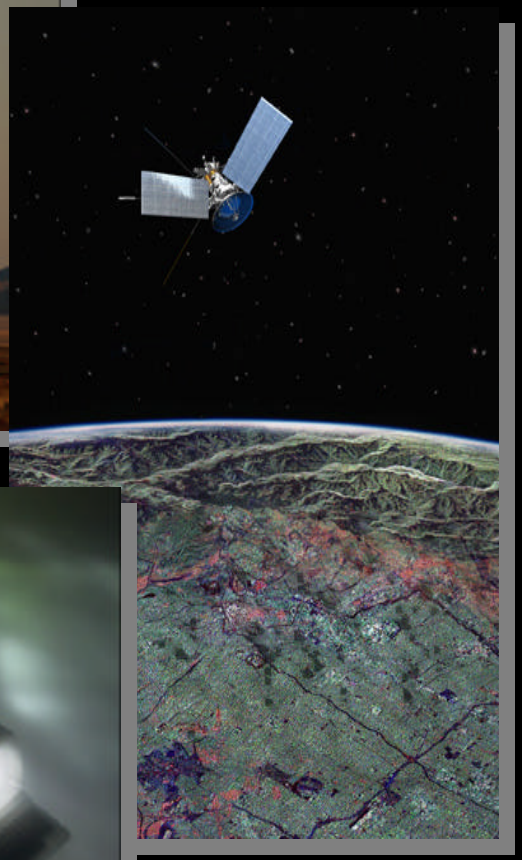




Historical U.S. Healthcare Expenditures

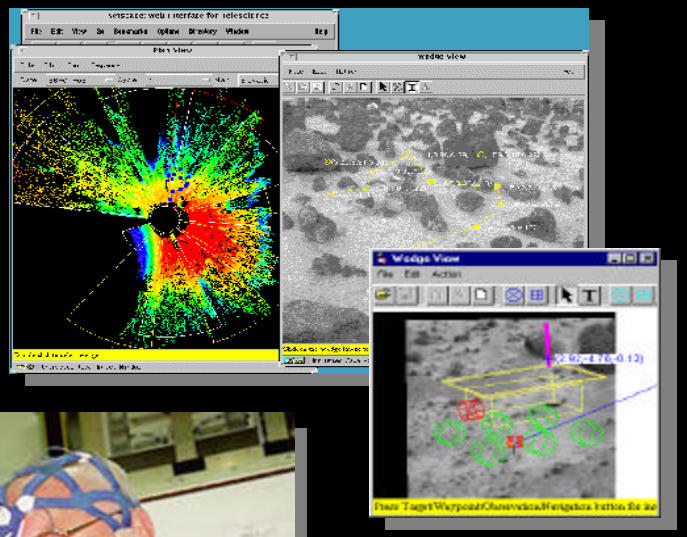
Telehealth Requirements

End-user infrastructure



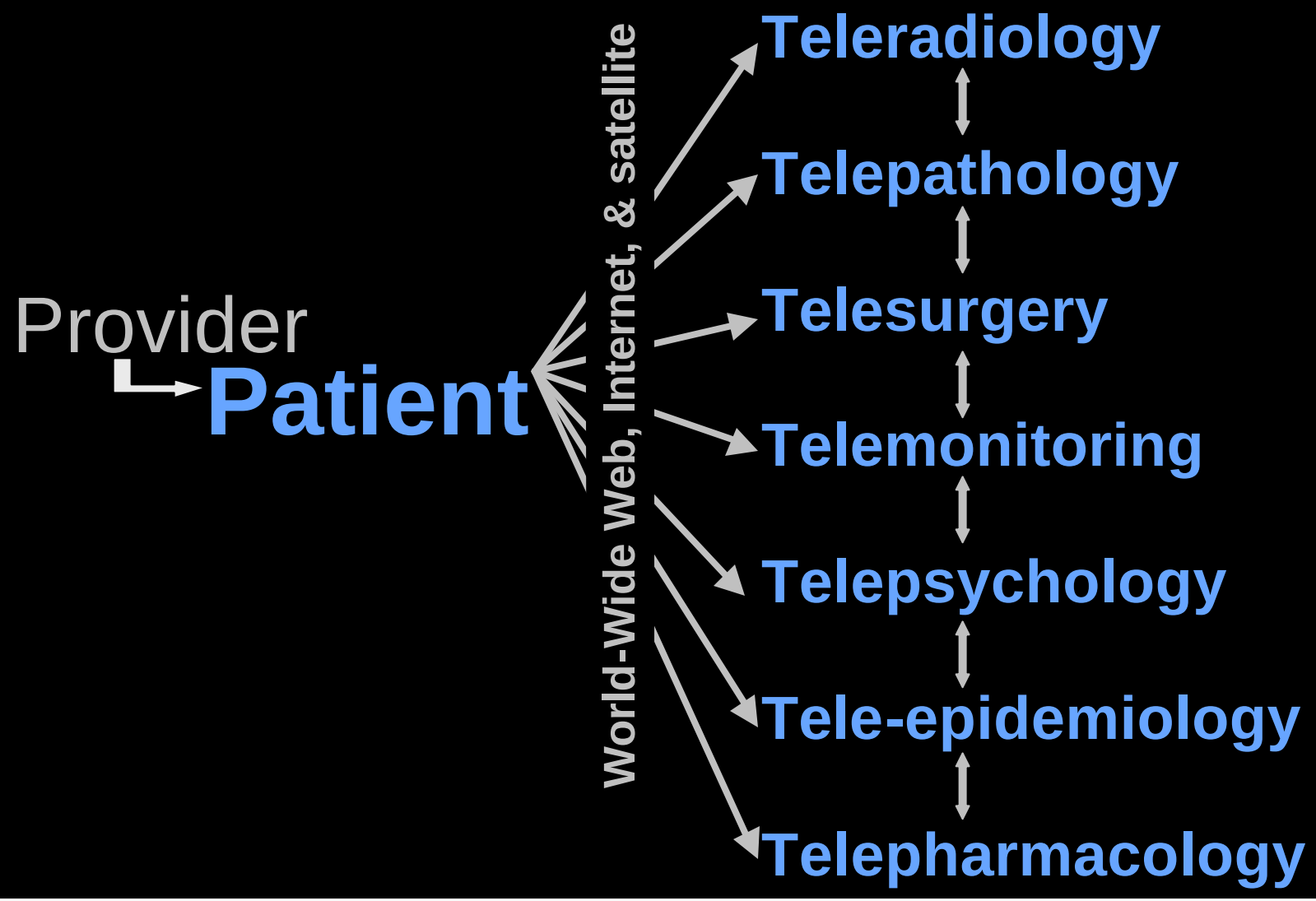
Telehealth Requirements

Applications



Telehealth

…moves bits, not patients.



U.S. Telehealth: the Civil Sector

- Applications
  - EMS/rescue
  - Education (“Dot-Com” companies)
  - Teleimaging
  - Outpatient care/ home care
  - Maritime telecare
  - Prison telemedicine
  - Automated patient record systems
  - Disaster relief/humanitarian efforts
- Barriers
  - Security
  - Insurance reimbursement/liability
  - Medical licensure (across states)
  - Technology (bandwidth)

U.S. Telehealth: Dept. of Defense

- 1976: digital tooth
- 1985: digital x-rays
- 1990's: telepathology
- 1990's: teledermatology
- TATRIC (Army/NASA)
- Maritime telehealth (Navy)
- Deployments
  - Bosnia
  - Somalia
  - Persian Gulf
- Disaster relief

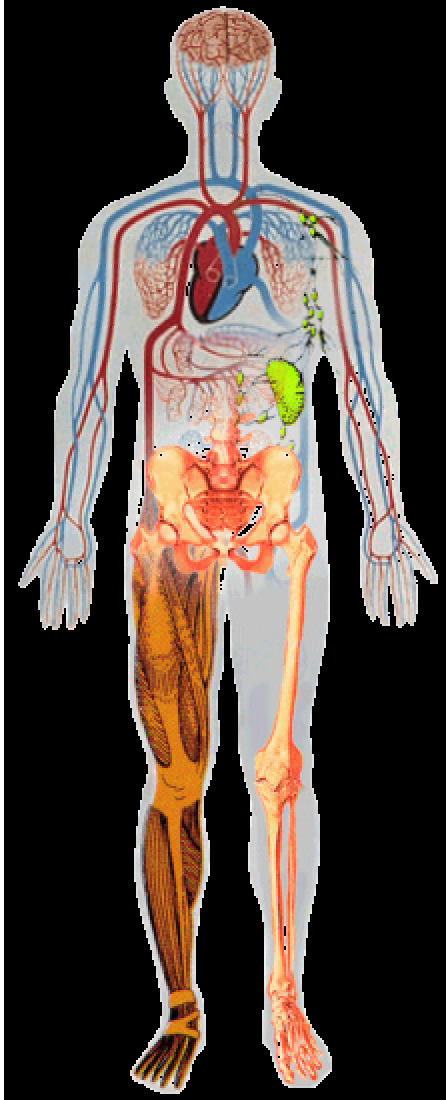
Lessons Learned from the DoD

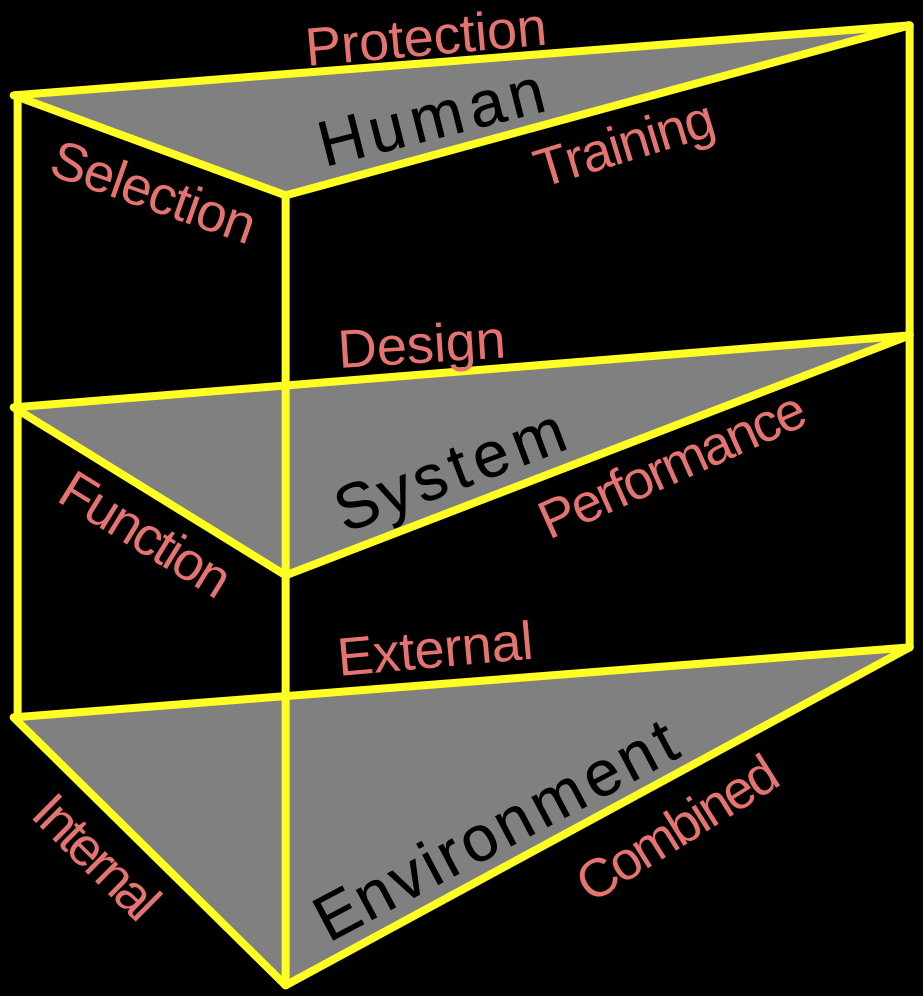
- Telehealth works best with...
  - Full-time support
  - Reliable, mobile, user-friendly communications
  - Easy coordination
  - Information security
- Future considerations
  - Changes in health care patterns
  - Medical business reengineering
  - New technology

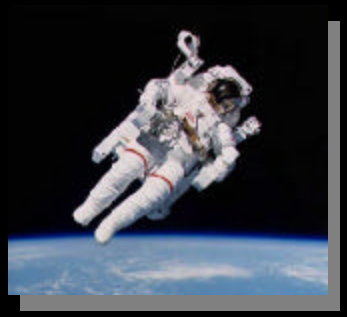
A Comparison: Who Does What?

	NASA	Civil Sector	DoD
Teleradiology	✓	✓	✓
Telecare/Telediagnosis	✓	✓	✓
Telepathology	✓	✓	✓
Telecardiology	✓	✓	✓
Teledermatology	✓	✓	✓
Tele-education	✓	✓	✓
Teleconsultation	✓	✓	✓
Telemonitoring	✓	✓	✓
Humans	✓		✓
Systems	✓		
Environment	✓		
Telescience	✓		
Testbeds	✓	✓	✓

NASA Mission Success







NASA Health Care Models

microgravity

Adaptation

- Red blood cell loss
- Fluid loss
- Cardiovascular adjustment
- Changes in neural control (blood pressure)

hypo-volemic syndrome

Pathophysiology

- Radiation
- Bone & muscle loss
- Immunology

degenerative diseases

Inflight

- *Human*
- *Systems*
- *Environment*

return to gravity

Post-flight

- Neurosensory motor control dysfunction
- ↓cardiovascular reserve
- ↓immune response
- Dehydration

cardiovascular & neurological compromise

- Regional osteopenia
- ↓ muscle endurance & strength
- ↑risk of kidney stone(s)
- Radiation career dose exposure

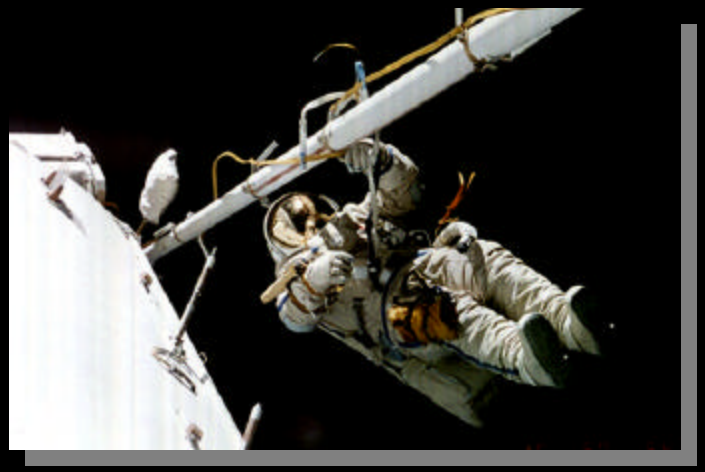
health risks

NASA Health Criteria

- Maintain health and well-being before, during, and after mission
- Ensure rapid re-adaptation to gravitational forces

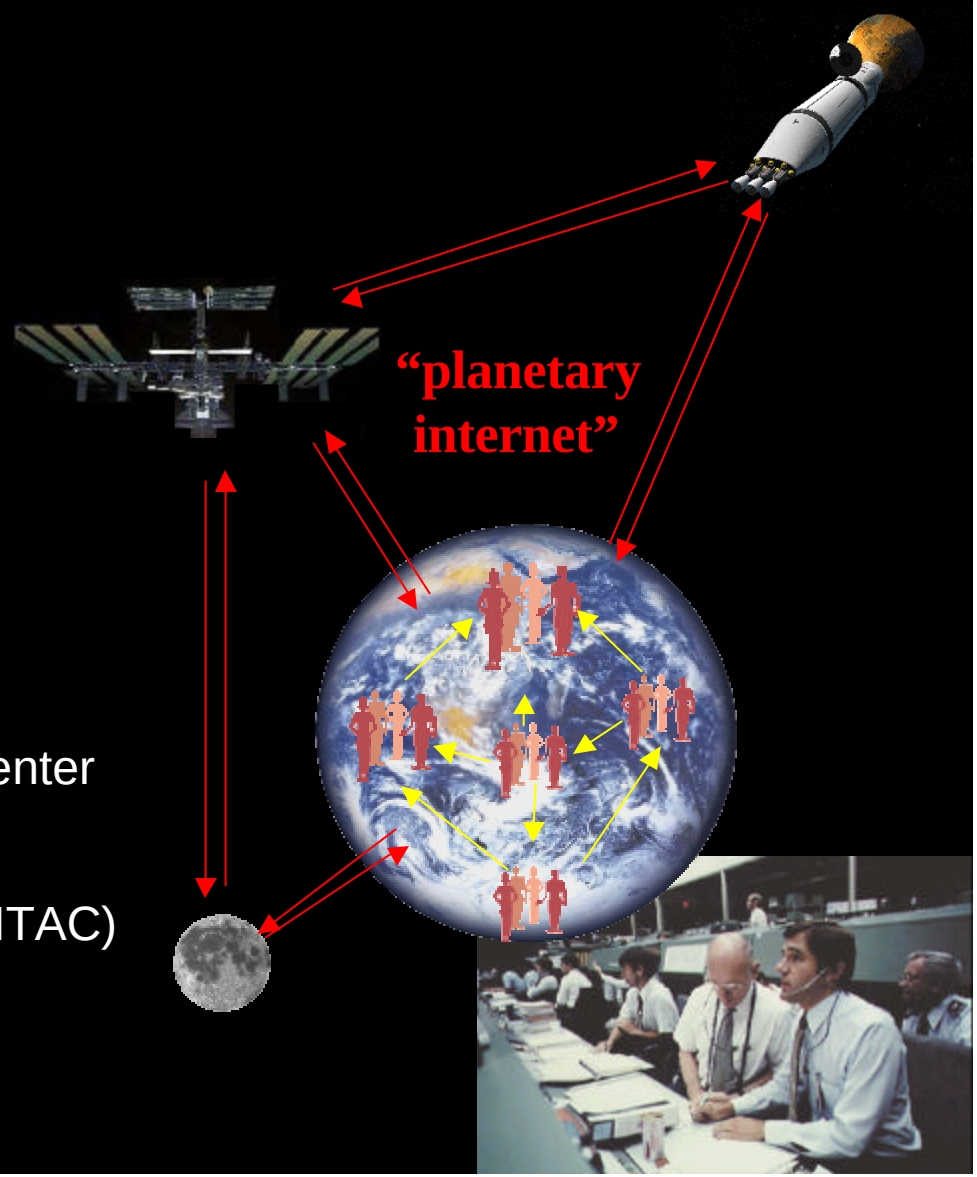
NASA Care Criteria

- Ability to treat crew members and return them to duty
- Minimize impact on remainder of crew
- Provide for stabilization and evacuation (in LEO)
- Provide for crew safety
- Provide for remote consultation



NASA Testbeds

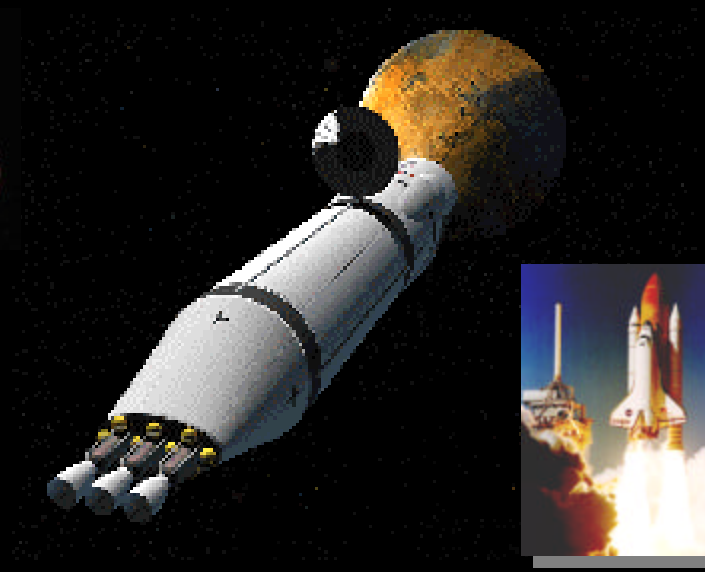
- **Ground-to-ground**
  - Broadband
    - Satellite-based
    - Higher quality, higher cost
    - Spacebridge to Moscow
  - Narrowband
    - 5 kbs-45 Mbs
    - T-1 line
    - Good quality, lower cost
    - East-West Space Science Center
    - International public health
    - Telepathology in Ecuador (MITAC)
- **Ground-to-flight**



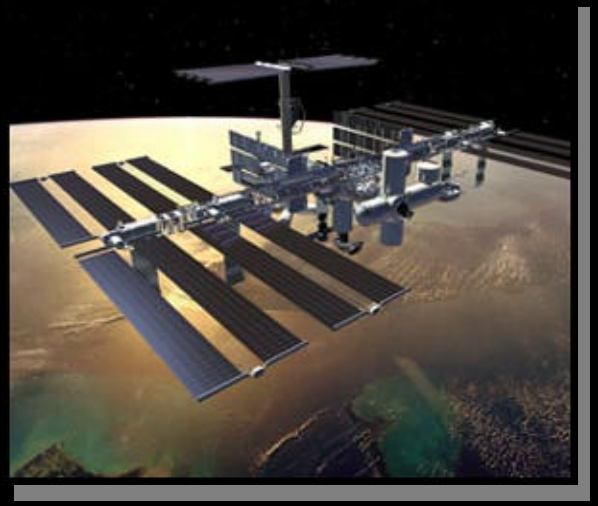
NASA Communications Infrastructure

NASA Telehealth Applications

- 1961-1972
  - Monitoring
  - Automation
  - Minimal command

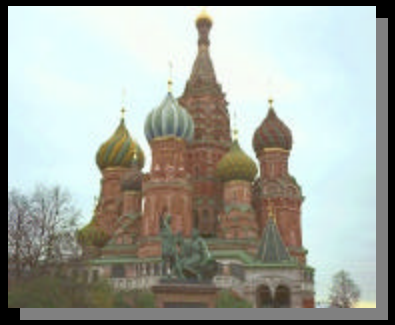


- 1981-present
  - Telemonitoring
  - Telescience
  - Teleimaging
- 2000+
  - Telemonitoring
  - Telescience
  - Telecare
  - Teleimaging
  - Teleconsultation
  - Telediagnosis



NASA Telehealth Applications

- **1972-3**
  - ✓ STARPAHC
- **1975**
  - ✓ Applied Technology Satellite
  - ✓ COSPAS/SARSAT
  - ✓ PEACESAT
- **1985**
  - ✓ Mexico City earthquake
- **1989**
  - ✓ Spacebridge to Armenia/Ufa
- **1993**
  - ✓ ACTS demonstrations
  - ✓ Spacebridge to Moscow
- **1994**
  - ✓ GHNet (WHO/USAID)
  - ✓ Pan-American Health Organization (PAHO)
  - ✓ Spacebridge to Russia (through 1997)



✓*completed*

NASA Telehealth Applications

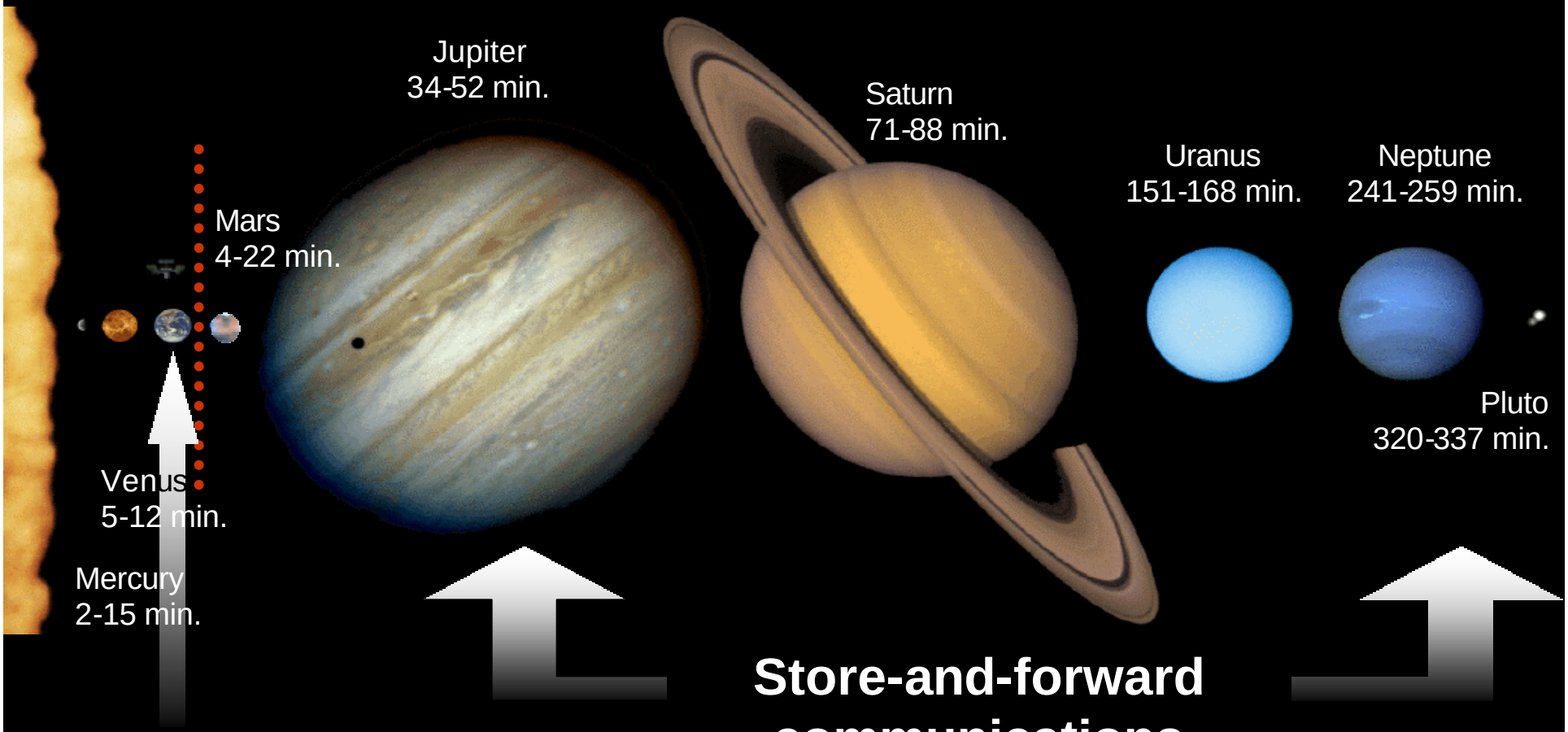
- **1995**
  - ✓ ARC telemed demo with Trident & Mt. Sinai Medical Center
- **1997**
  - NASA-MITAC established
  - East-West Space Science Training Center

- **1998**
  - ✓ Ecuador “keyhole” surgery
  - ✓ Everest Extreme Expedition I
- **1999**
  - ✓ Virtual Hospital demo with ARC, Stanford, Salinas
  - ✓ Everest Extreme Expedition II
  - ✓ TIP demonstration in Texas and Montana

- **2000**
  - Low-bandwidth telemonitoring in Ecuador
  - Low bandwidth telemonitoring in Dominican Republic
  - Kosovo disaster response
  - Devon Island telemedicine

✓*completed*

Communications Challenge: Time and Space



Store-and-forward communications

Real-time communications

+ Air/ground & EVA/IVA

Future of Telehealth & the U.S. Space Program

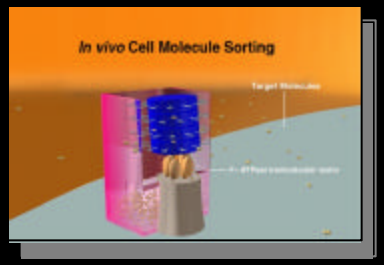
From telecare to autonomy and teleconsult...

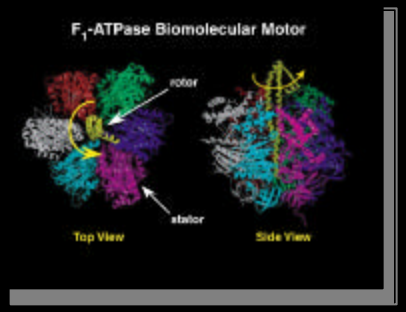
- Adaptive Automation
- Multipurpose Tactile Interface
- Maintaining Spacecraft Operator Alertness
- Performance Measurement, Evaluation, and Modeling
- Non-Invasive Video Motion Capture of Astronaut Activity

- Cognitive Prostheses
- Biologically-Inspired Robots
- Manipulation & Locomotion
- Functionally-Adaptive Biomimetics
- Wireless Biosensor
- Medical informatics
- Smart/haptic systems
- Telescience

Hair cell sensors

Biomotors





NASA Telehealth

Initial NASA telehealth efforts monitored survivability in microgravity.

Today, all aspects of NASA telehealth--communications, capabilities, and applications--improve health care in space and on Earth.

Conclusion

1924

1969

2000+

The insight we have gained from U.S. telehealth, combined with tomorrow's nanotechnology and informatics, will allow NASA to send astronauts on safe, productive long-term explorations.

Backup

NASA's Health Criteria

Medical standards are tailored to meet the specific needs of each class: pilot (I), mission specialist (II), or payload specialist (III).

Evaluation approach

- Selection criteria
  - Medical history and physical
  - Lab & functional testing
- Retention criteria
  - Health maintenance
  - Acceptance of certain risks with changes

Areas of Emphasis

- Short-duration mission
  - Neurosensory
  - Neuromotor
  - Cardiovascular/ cardiopulmonary
  - Fluid & electrolyte
- All missions
  - Performance
  - Psychosocial suitability
  - Survival
- Long-duration mission
  - All short-duration concerns
  - Musculoskeletal
  - Radiation exposure
  - Metabolic/endocrine
  - Hematology/immunology