Low-Latency Telerobotics From Mars Orbit:
The Case for Synergy Between Science and Human Exploration

Based on Findings from:
“The First Symposium on Space Exploration via Telepresence:
A New Paradigm for Human-Robotic Cooperation”

Symposium Briefing on May 2-3, 2012
NASA Goddard Space Flight Center

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http://telerobotics.gsfc.nasa.gov/
The First Exploration Telerobotics Symposium

http://telerobotics.gsfc.nasa.gov/

Participants were a diverse group of key stakeholders to understand the challenges and future opportunities using telepresence as a productive strategy for human space and scientific exploration.

~100 participants among

• planetary scientists
• space robotic engineers
• human space flight experts
• terrestrial robotics users

• academia
• NASA (incl HQ), and CSA, ESA, JAXA
• industry
• policy/press

Findings and observations currently being compiled in a report and will be submitted to NASA HQ, and posted on symposium web site.
Explore inaccessible and hazardous regions of other planetary bodies via “proximity” robotic operations from planetary orbit.

- Humans remain in locations where control of robots on planetary surfaces is limited by round-trip light-travel time $< 500$ ms (low latency)
- Extend human cognition to the surface of Moon, Mars, and other bodies without the challenges, expense and risk of putting humans on hazardous surfaces or within gravity wells
- Achieve synergy between human and scientific exploration of other planetary bodies by surface telepresence of “astronaut” scientists
Cognitive Horizon

• Putting human cognition (relevant human senses and dexterity) at a remote site requires:
  – Low communication latency: < 200-500 ms (~30,000km: cognitive horizon)
  – High bandwidth (human eye performs at 10Mb/s)

• For the Moon, humans work at EM L1/2 or LLO
• For Mars, humans work at Mars orbit, Phobos, Deimos
Experience to Apply...

Supervised Robotic Exploration of Titanic (1990's): deep ocean

Multi-robot operations at Deep Water Horizon well (2010)

2033: humans in Mars orbit with surface robots
Highlights of Symposium: Day 1

Mindell (MIT): Archeological Discovery via Precision Mapping of Ocean Floor

Whitcomb (JHU): 50 years of Deep Ocean Telerobotics Exploration

Hodges (ASU): Collaborative Field Geology

Vertesi (Princeton): Telerobotics Sociology
Highlights of Symposium: Day 1

- Kazanzides (JHU): Telerobotics in Medicine
- Whittaker (CMU): Terrestrial Robotics
- Schiele (ESA): METERON
Highlights of Symposium: Day 2

Preliminary SCIENCE Findings

• Discussions on science scenarios for Moon, Mars, SBs, and Venus and relevance to the priorities of the decadal survey
• Low-latency human-robot collaborative work in surface geological exploration of Mars
• On-orbit telerobotic sample recovery and return to the crewed orbiting facility for immediate analysis by resident astronauts (e.g. may enable rapid analysis of volatile bearing samples without requiring long-term cryogenic storage)
• Areas that precludes human access can particularly be explored via telepresence
• Keeping humans away from sites where extant life may exist could be a compelling rationale
Highlights of Symposium: Day 2

Preliminary HUMAN SPACE FLIGHT Findings

• Proven value of terrestrial telepresence technologies in industry, commercial, and research endeavors – improving safety, saving lives, saving costs, improving operational efficiency, and enhancing science return.

• Synergistic science and human exploration activities via low-latency telerobotics:
  - **Science operations on Mars** controlled from orbit or Lagrange point, or on the surface
  - **Assembly operations of large structures** from orbit or Lagrange point
Highlights of Symposium: Day 2

Preliminary TECHNOLOGY Findings

• A few areas that need development and testing with proximity in mind (cf, NASA OCT Robotics, Telerobotics & Autonomy Roadmap (TA04)):
  – Sensing and Perception
  – Mobility
  – Manipulation
  – Human-System Integration
  – Autonomy

• Sample return technologies e.g. canister rendezvous, acquisition and return to the orbiting station needs to be demonstrated.

• High-fidelity analog missions with authentic science to test a range of operational concepts and telerobot control modes
Next Steps

• Engage the scientific community in topical workshops to **develop specific low-latency telepresence scenarios** for scientific exploration of Mars tied to the NRC Decadal survey goals.

• **Operations feasibility assessment** needed at analog field sites (some already in development e.g. from ISS and were presented at GLEX 2012).

• **Investments in key robotics technologies** such as sensing, perception, mobility, manipulation, human systems integration and autonomy are needed.

• **Foster international collaboration** and public/private partnership.