TELEVISING MARS MISSIONS

Real-time Television Quality Full Motion Video for Mars Missions

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Televising Mars Missions

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Televising Mars Missions

- *MPEG-1 and MPEG-2 Software Decoders (Windows, Unix, and Macintosh)*
- *Still and digital video quality metrics*
- *Perceptual optimization of JPEG compression.*
- *Video system design for Mars Airplane*

Outline of Talk

- *Why Video for Mars Missions*
- *Obstacles to Video for Mars Missions*
- *Radiation Hardened Video Systems are Now Possible*
- *Near Earth Applications*

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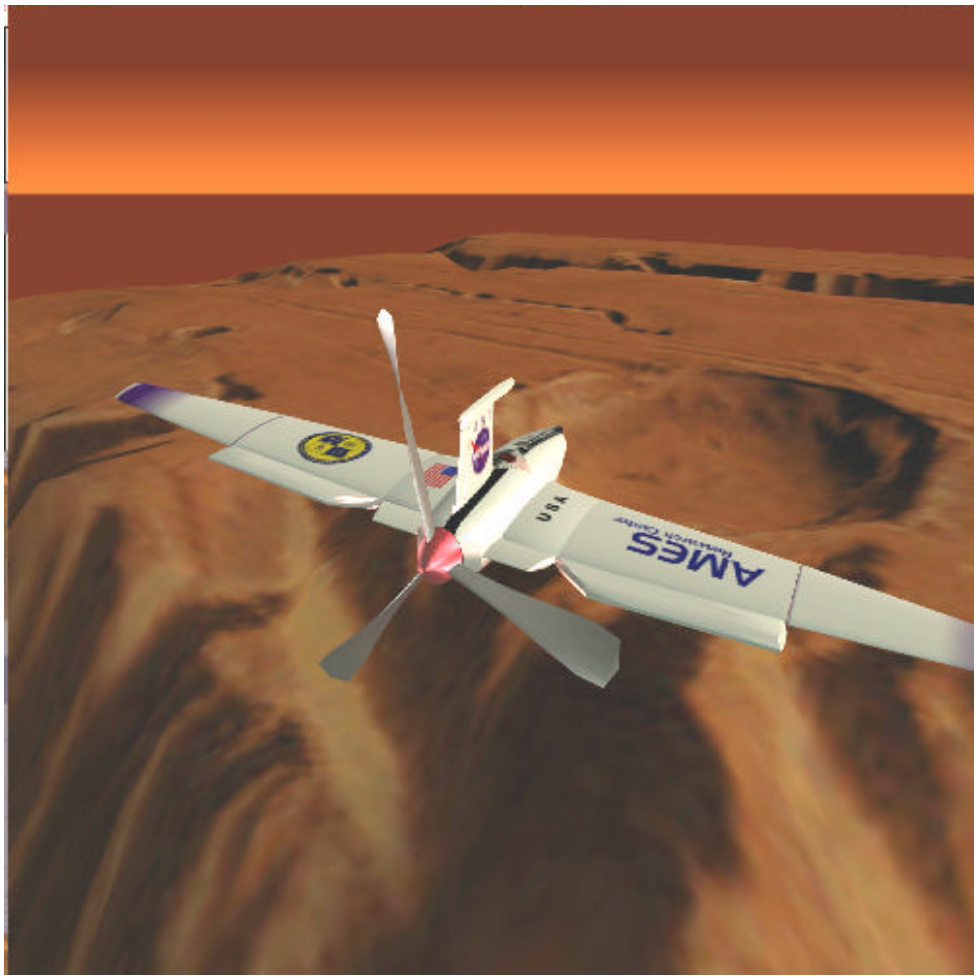
Televising Mars Missions

- *Build and maintain public support*
- *Video from mobile probes - airplanes, balloons, and rovers - will be dramatic!*
- *Airplane in Valles Marineris (NASA Year 2000 Budget Proposal)*

Televising Mars Missions



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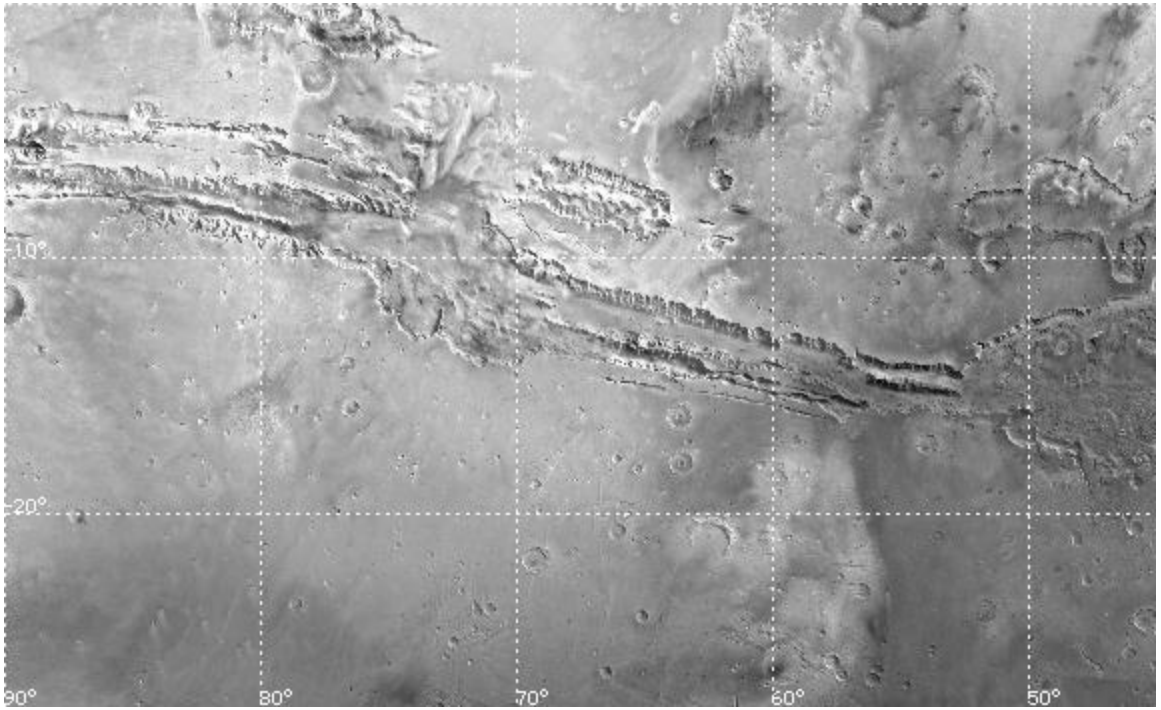

Valles Marineris

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- *Life detection*
- *Unambiguous detection of life has proven difficult (Viking Labeled Release)*
- *Directly observe microorganisms reproducing under a microscope.*
- *Directly observe motion by microorganisms (swimming or crawling)*

Televising Mars Missions

- *Failure Analysis and Prevention*
  - *Video of landing, e.g. Mars Polar Lander*
  - *Video of final approach, e.g. Mars Climate Orbiter*
  - *Visual inspection of probe during long journey from Earth*

Televising Mars Missions

- *Mobile probes such as airplanes, balloons, or high-speed rovers will benefit from video.*
- *Video provides multiple successive overlapping images for better interpretation of ambiguous surface features.*

Televising Mars Missions

- *Detection and study of releases of subsurface water.*
- *Geysers, hot springs, or eruptions of water from collapsing crater or mountain walls.*
- *Evidence of recent groundwater seepage (Malin and Edgett)*

Televising Mars Missions

- *Seepage of gases or fluids at the Martian surface.*
- *Methane and other gases from subsurface life.*
- *Columbia River Basalt Group SLIME produces large amounts of methane (natural gas).*

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- *Oil or natural gas on Mars?*
- *Seepage of methane, natural gas, or oil are possible.*
- *Trace gas detectors are best but video may assist especially for eruptions or bubbling activity.*

Televising Mars Missions

- *Known past volcanic activity on Mars*
- *Is there current activity?*
- *Video can directly observe eruptions or other volcanic or seismic activity.*

Televising Mars Missions

- *Many gases of interest, such as methane or hydrogen sulfide, and some liquids are transparent to visible light.*
- *Gases or liquids from beneath the surface will probably be warmer than surface, especially volcanic gases.*
- *Infrared video may easily detect seepage, eruptions, or active volcanism.*

Televising Mars Missions

- *Video for atmospheric phenomena such as dust storms, dust devils, snow, lightning, and so forth.*
- *Still images have problems detecting or studying many transient atmospheric phenomena.*

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- *Animals seem unlikely.*
- *Video will better be able to detect animals, especially if camouflaged or quite small.*
- *Unexpected discoveries. New physical phenomena. Functioning mobile probes from extraterrestrial civilizations.*

Televising Mars Missions

- *COTS MPEG-1 or MPEG-2 components*
- *800 cm^3*
- *2 KG*
- *20 Watts (probably < 6.5 Watts)*
- *1 Megabit/second for MPEG-1 SIF*
- *Bit Error Rate: 10^{-6}*

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- *352 by 240 pixels*
- *Frame Rate of 30 fps (NTSC video)*
- *Peak Signal to Noise Ratio: 30 dB*
- *"VCR" Quality*

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Televising Mars Missions

- *Bit rate requirements are substantial*
- *Minimum of about 1 Megabit/second for "VCR" quality video.*
- *6-8 Megabits/second for Broadcast or Studio Quality Video*
- *Current Mars to Earth is less than 100 Kilobits/second with line of sight.*

Televising Mars Missions

- *Mars Communication Relay Networks*
- *JPL is studying*
- *Possible bit rates of 1-10 Megabits/second*
- *Solar or Nuclear Powered*
- *Low Mars Orbit or Mars Geosynchronous Orbit (or both)*

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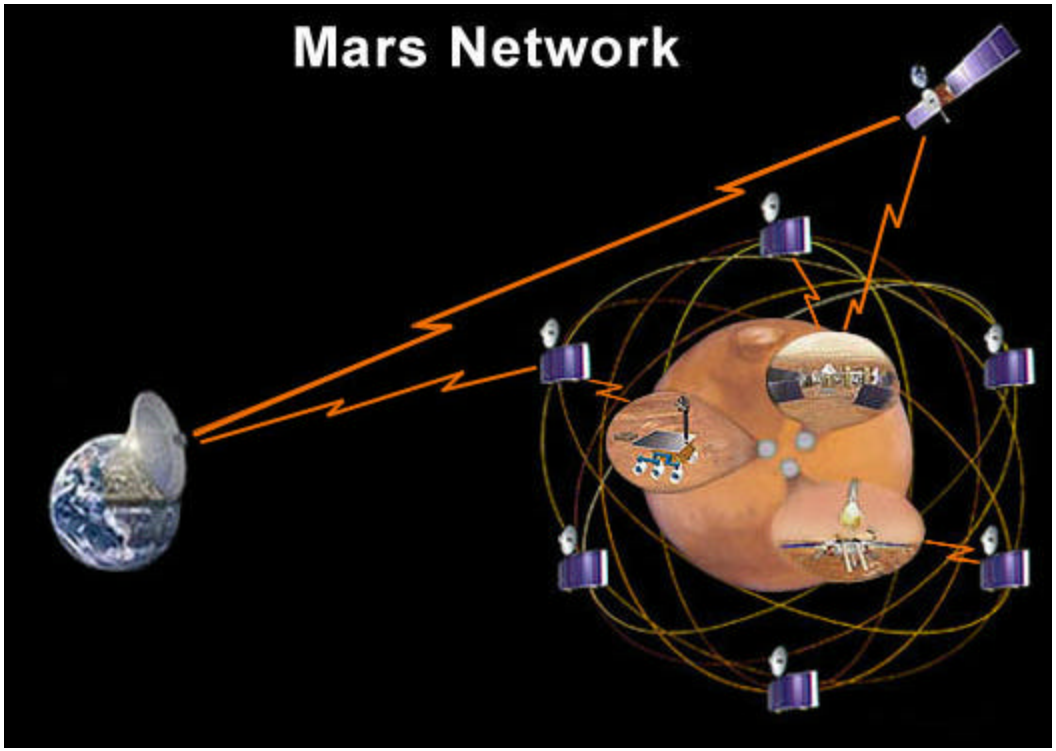

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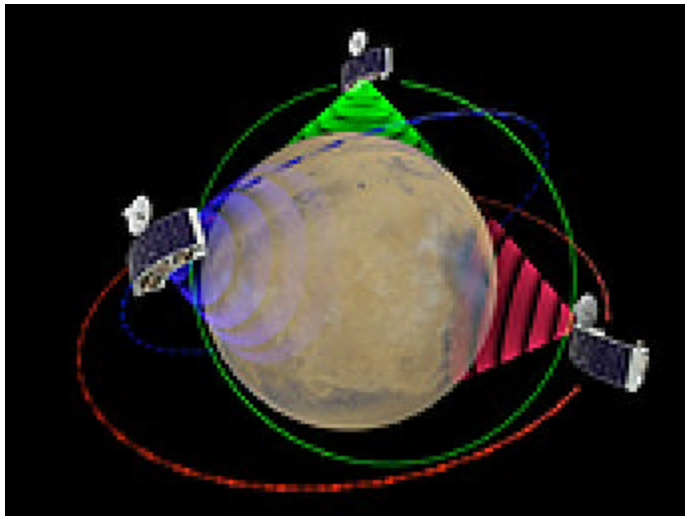

Constellation of Three Microsats

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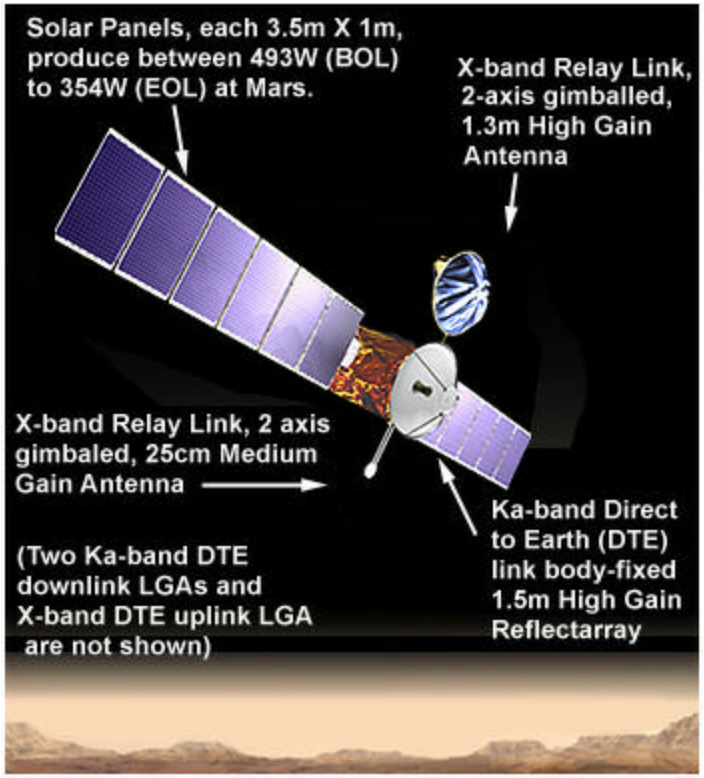

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- *Relays are infrastructure, no immediate return on investment.*
- *All current relays coupled to a planetary exploration probe with a camera.*
- *High bandwidth relays can carry video cameras.*
- *Dust storms! Global Circulation Models*

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Televising Mars Missions

- *Propose sending high bandwidth relay satellites to Mars with video cameras to justify missions.*
- *These can return both still images and video of Martian weather.*
- *Martian Dust Storm web site?*

Televising Mars Missions

- *Other obstacles*
- *Vibration and jitter on mobile probes may interfere with efficient digital video compression.*
- *Multipath interference in canyons such as Valles Marineris.*

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- *Radiation Hardening*
- *10-20 Krad Total Ionizing Dose (TID)*
- *Shielding fine for TID*
- *Reset software for Single Event Upsets*
- *Single Event Latchup (SEL) may force radiation hardened video processing chips!*

Televising Mars Missions

- *Rad hard CMOS processes have achieved system clock speeds and levels of integration needed for single or few chip MPEG-1 or MPEG-2 Video Encoders.*

Televising Mars Missions

- *MPEG-2 Main Profile at Main Level (720 by 480 pixels at 30 fps)Video Encoder*
- *54 MHz clock speed*
- *3-5 million transistors (0.75 - 1.25 gates)*
- *720 by 480 at 30 fps*

Televising Mars Missions

- *MPEG-1 SIF (352 by 240 pixels at 30 fps) Video Encoder*
- *27 MHz (probably 13.5 MHz)*
- *1 million transistors (250,000 gates)*
- *352 by 240 pixels at 30 fps*

Televising Mars Missions

- *Honeywell RICMOS-V Silicon on Insulator (SOI)*
  - *400 MHz maximum clock rate*
  - *1.2 million usable gates*
  - *single event latchup immune*

Televising Mars Missions

- *UTMC UT 0.6 Micron CRH Commercial RadHard Gate Array Family*
  - *400 MHz*
  - *600,000 usable equivalent gates*
  - *126 MeV/cm^2/mg (80 is often considered immune to single event latchup)*

Televising Mars Missions

- *Lockheed Martin Federal Systems 5M (0.5 micron, 3-5 metal layer CMOS)*
  - *at least 33 MHz (above 27 MHz)*
  - *1,100,000 usable gates*
  - *single event latchup immunity unclear. This used for RAD6000 processor on Mars missions!*

Televising Mars Missions

- *Lockheed Martin ASIC RAD-LITE 0.25 Micron ASIC Family (vaporware?)*
  - *>500 MHz*
  - *up to 7,500,000 usable gates*
  - *latchup immune*

Televising Mars Missions

- *Sandia National Laboratory 0.6 Micron CMOS6R*
  - *100 MHz*
  - *1,700,000 transistors*
  - *latchup immune, reportedly never observed in tests*

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Televising Mars Missions

- *MPEG-1 or MPEG-2 Video Encoders are possible in current technologies with from 1-5 chips.*
- *Package in multichip modules or other techniques to reduce size and weight of encoder chips.*
- *NO SHOW STOPPER*

Televising Mars Missions

- *Video has many potential applications near Earth where market is larger. Near Earth market can drive development.*
- *Robots to service satellites in Earth orbit.*
  - *Now requires costly Space Shuttle missions.*
  - *Video cameras for remote piloted service robots.*

Televising Mars Missions

- *Many Earth Observing Applications*
  - *Ships*
  - *Traffic*
  - *Weather and Climate*
  - *Fires and other disasters*
- *Constellations of video satellites for continuous coverage of Earth?*

Conclusion

- *Compact, light-weight, low power, radiation hardened video systems are possible for missions to Mars and other missions in space.*
- *Many uses for video on Mars*
- *Universal television coverage of all space missions near Earth may be possible.*

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