HERRO: A Science-Oriented Strategy for Crewed Missions Beyond LEO

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Prior to the end of the Apollo program, NASA's approach to space exploration took two distinct paths. A debate over their comparative merits has raged ever since. One path sees the extension of human presence into the solar system – regardless of whether it is done for science, economic development, national prestige or sheer destiny – as the overarching goal of the space program. The German rocketeer, Werner Von Braun, aggressively promoted this view, and it has become the rallying cry for human spaceflight ever since, most recently with President Bush's 2004 Vision for Space Exploration (VSE). The other path embraces robotic, unmanned missions as a more practical, less costly way of exploring space. This view was reinforced by the tremendous successes of these missions (e.g., Hubble, Voyager, Galileo, Cassini) and their unprecedented contributions to our understanding of the universe. Although many advocates of this path recognize the value of hands-on field research on the surfaces of other worlds, they see human spaceflight as being too difficult, risky and expensive for exploration beyond Low Earth Orbit (LEO) at this time.

The debate would be moot if NASA's budget could increase and accommodate the desires of both communities. This is obviously not the case, and NASA's limited resources will continue to force a balancing that inevitably leaves one camp feeling short-changed. Now with the advent of an Administration that values new ideas, it makes sense to ask the question: is there an approach to exploration that mitigates the competition between these two visions – a new strategy that (1) increases the scientific return at destinations of interest to the space science community, (2) contributes to the more visceral goal of extending human presence beyond low earth orbit (LEO), and (3) fits within the limitations of NASA's budget?

This paper presents an exploration strategy that does this by combining the best features of human and robotic spaceflight into a single architecture. Called **H**uman **E**xploration using **R**eal-time **R**obotic **O**perations (**HERRO**), the strategy abstains from placing humans on the surface of Mars, at least in the near-term. Rather, it focuses on deploying crews of scientists in orbit about Mars and other planetary bodies within the inner solar system. From this vantage point, the science teams would conduct extensive exploration of the surface using telerobots and remotely controlled systems. By eliminating the up to 40-minute round-trip communications delay with Earth, teleoperation would give scientists real-time control of rovers, aerobots and other sophisticated instruments, thus greatly expanding the scientific return at these destinations. Upon completion of a mission, the crews would return to Earth, and with appropriate maintenance and outfitting in LEO, HERRO spacecraft could be reused for later missions. This approach to exploration is akin to how modern-day oceanographers in submersibles use telerobots to explore inaccessible regions of the ocean.

The main advantage of HERRO is that the propulsive energies required to go to many destinations within the inner solar system, such as Mars orbit, Lagrange points, near Earth asteroids and even Venus orbit, are quite similar. This means that a single interplanetary vehicle design could be used for missions to a variety of destinations. Surprisingly, the conventional approach of sending crews all the way to the Mars surface would nearly double the mission's total energy requirement. In addition to requiring more propellant, such a mission would be complicated by the need for robust man-rated ascent and descent stages, habitats, surface power units, communication systems and support infrastructure, all of which drive up cost. The HERRO approach avoids the need for these additional elements, and frees up resources to augment science activities on the surface, such as development of robotic landers, long-duration rovers and mobile laboratories, and sophisticated instrument packages.

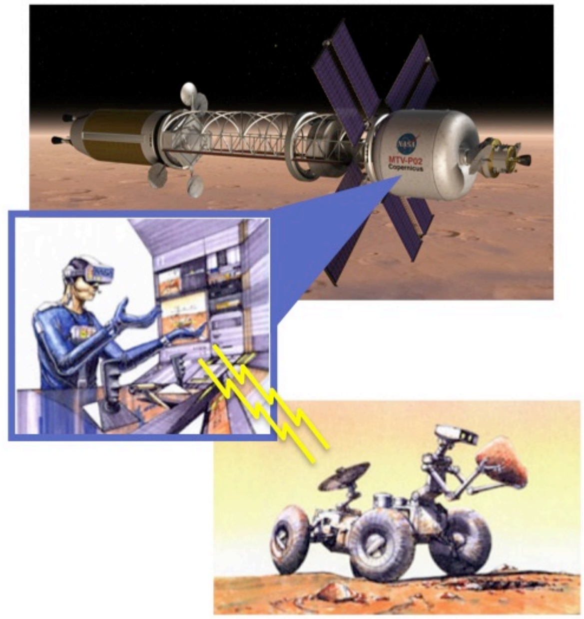

Figure 1: Real-time control of telerobotic elements on planetary surfaces is central to the HERRO strategy

HERRO also allows scientists to be much more interactive and involved at the research site, while still maintaining planetary protection standards. This is particularly important for Mars exploration, where detecting signs of indigenous life is a key science objective. Avoiding crew presence on the surface, at least until several missions have thoroughly evaluated the environment, protects the planetary environment from contamination by hearty Earth-originating microbes, and prevents human exposure to potential alien pathogens.

HERRO offers considerable benefits to space science. In addition to providing direct real-time control of operations on the surface, it opens the way for missions of much greater capability. One example is the Mars Sample Return Mission, which could be conducted as part of an HERRO deployment. The only unique hardware for this mission would be a small ascent vehicle that could take samples from the Mars surface to the orbiting HERRO spacecraft, where the material could be evaluated, discarded or kept for further study on Earth. Another is a long-duration Venus rover mission, which could be facilitated by offloading temperature-sensitive electronics, which provide high-order control functions, to the crew and computers aboard the orbiting HERRO spacecraft.

A key benefit of HERRO is that it enables the use of much more sophisticated robotic systems and remote-controlled laboratories on the surface. Many of these designs could be standardized, and multiple units could be deployed at different locations on the planet. Finally, the "hands-on" field research desired by some scientists would be possible at near Earth asteroids, the Martian moons and small planetary bodies, since their negligible gravitational fields make their surfaces readily accessible to HERRO spacecraft.

HERRO is a departure from the conventional view of human exploration, and does represent a compromise. A common response by skeptics is, 'why wouldn't you go to a planet's surface, when you've spent so much time and energy to get there?' This is certainly not true for Mars, since traveling to low Mars orbit requires only half the energy as traveling to the surface. HERRO missions also offer a big advantage in terms of safety. The crew stays aboard a single vehicle for the entire mission, and it is likely that the orbital phase of most missions could be completed in a three-month period. This would enable use of faster, opposition-class missions that would last only one year – within the human duration limits demonstrated on Mir and the International Space Station (ISS). In fact, much of the knowledge gained from the ISS program would be directly applicable to HERRO, and ISS would be an important test bed for the development of HERRO spacecraft systems and equipment.

Although HERRO bypasses many of the initial steps that have been historically associated with human space exploration, it opens the door to many new destinations that may be better candidates for future resource utilization and human settlement. HERRO should be viewed as a first step, one that takes humans to exciting destinations beyond LEO while solidly expanding our ability to conduct science within the inner solar system. In fact with appropriate advancements in propulsion and life support technology, it is reasonable to consider extending the HERRO approach to missions into the main asteroid belt and destinations in the outer solar system. Finally, advocates for human exploration should understand that HERRO does not replace eventual human missions to the surfaces of other worlds. The technologies developed for HERRO are directly relevant to later human surface missions. When the nation decides to develop the systems needed to send crews to the surfaces of the Moon and Mars, a good portion of the technological infrastructure will already be in place.