MARS HOVERCRAFT. E. Hanna, Aaron, G. Blando, , Jet Propulsion Laboratory, California Institute of Technology. Ehanna@jpl.nasa.gov , Guillermo.D.Blando@jpl.nasa.gov, Kim.M.Aaron@jpl.nasa.gov

Objective: The first objective is to develop technologies leading to a small autonomous rotorcraft for use in the Martian atmosphere to extend the exploration range of surface rovers. Martian rovers to date have had limited range and speed. An autonomous rotorcraft could rapidly explore a much greater area with high resolution imaging systems or other remote sensing instruments to provide views not available from the rover itself. This would provide a synergistic capability to the system. The rover could do the "heavy lifting" without spending most of its time seeking targets, whereas the rotorcraft, with its greater speed and mobility could be the "eyes" for the system, seeking targets for the rover. Together, they would have far greater capability than either in isolation.

A second objective isto propose a multi-craft system, to which this unit would belong, that would enable the collection of surface soil samples and ultimately facilitate human flight to Mars. This rotorcraft vehicle would fly close to surface and be the sample collector/remote eyes, for other crafts. By hovering over the surface it would enable the ability to collect soil samples, extending the reach of the current MSL mission and possibly connecting with an orbiting human-carrying craft. The rotorcraft would be a rover-based, deployable, high-performance electrical powered mini-rotorcraft aerial vehicle.

The rotorcraft would carry a lightweight drill to collect samples from different sites. These samples could be "delivered" to MSL for analysis and/or carried back to a space vehicle for return to Earth.

Preliminary concept of the rotor-craft: a) 1 to 5 kg of mass, b) minimal volume when retracted, c) mission profile: 20 minutes of cruise flight, 5 minutes of hovering, 100 m radius autonomy, 20 m altitude, d) payload: (at minimum) hi-resolution micro-camera, comm system,e) programmable flight computer, f) power source.

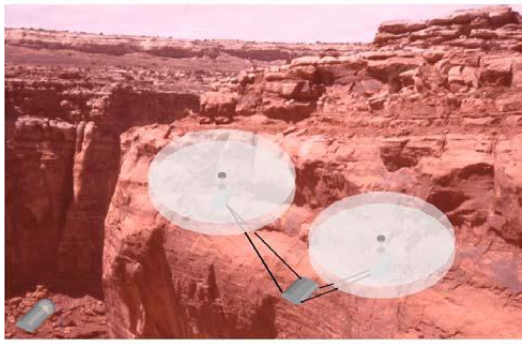
The major Advantages to NASA/JPL are:

a) Be part of a module or a system of space crafts that could collect soil sample for return, communicate/engage with human-carrying space craft: Space exploration has multiple objectives (Ex: Human exploration and soil return). Eventually we may have an orbiting space craft, a surface to space unit, and another "collector" craft. This would be the "collector" craft that would interface with other vehicles. The attached picture shows a possible transportation copter for humans, as shown in Young/Lee/Briggs's study. Reference [2].
b) Extend the reach of the existing Mars Science Laboratory that has a limited range and slow speed. The rotor-craft could fly further to get more samples and deliver to MSL thus taking advantage of current investment.
c) Freedom from slow moving mobility wheels: All rovers currently on MARS have mobility restricted and hampered by relying on the MARS surface for movement. It's time for a new technology to get rid of this restriction and open new frontiers for analysis and sampling.
d) Confirming existing observation of known sites: Aerial observation of some sites is based on gas analysis, assumptions and similarities. This method would provide actual samples for analysis and eventually return to Earth.
e) Get a larger sampling of MARS for better undertstanding of the whole planet.

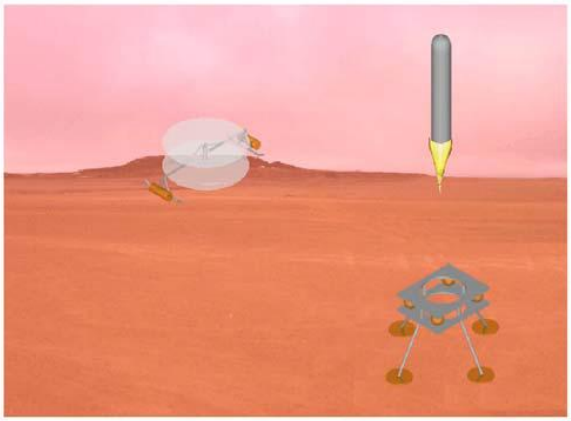
The major technological challenges/new technology is:

1) Aerodynamic performance of rotor blades and the possibility of jet assist. A trade of weight versus performance is needed.
2) Ultra-light power system: Electrical, Solar, and Nuclear sources are options. The battery should be capable of powering the rotorcraft for the mission profile proposed, and operate heaters for proper operation.
3) Communication and interface with other vehicles, rover or space craft.

Approach: These challenges would be addressed by JPL multiple disciplines: Aerodynamics, Propulsion, Mechanisms, Guidance, Robotics..



Picture showing a concept of a rotor craft, taken from Young's proposal, ref. [2]



Picture showing Rotary-Wing Mobility Coupled with Sample collection and Return to Earth, from Young'sproposal, ref. [2].

References:

[1] Blando, Aaron and Ghandchi. (2011) *Rover-based Deployable Mini-Rotorcraft for Mars Exploration*[2] Young, Aikin. et al. (2004) *Mars Rotorcraft: Possibilities, Limitations, and Implications for Human/Robotic Exploration*.