Martian VTOL Research Studies

JPL and the entire Mars Helicopter team should be applauded for moving the idea of flying a helicopter on Mars from concept to reality. But a lot of notable research was done long before the Mars 2020 Rover mission was announced.

One of the earliest studies for aircraft to fly on Mars was completed for JPL in 1978 by Developmental Sciences Inc.: "A concept study of a remotely piloted vehicle for Mars exploration" (NASA-CR-157942). The study was contracted after initial discussions had begun at JPL January 1977 on using high-altitude drone technology in the thin atmosphere of another planet; future AHS Alexander Klemin Award winner Abe Karem was one of the project leaders.

Over the years, the idea of sending an aircraft to Mars to survey larger and more varied geography of the Red Planet continued to return. In the 2000s, NASA's Ares (Aerial Regional-scale Environmental Survey of Mars) project studied a foldable Mars Flyer glider designed by Aurora Flight Sciences, with a half-scale Mars Flyer released for a successful test flight from a high-altitude balloon at 103,500 ft (31.55 km).

More recently, a flying wing based on the Preliminary Research Aerodynamic Design to Land on Mars (Prandtl-m), was designed to deploy from a 3U CubeSat miniature satellite in the aeroshell of a future Mars rover. An aircraft was tested extensively between 2015 and 2017. However, one issue was that a glider could only make one flight and would only have one shot to take photos.

What appears to be the first paper on Mars rotorcraft, "An autonomous flying robot for Mars exploration," was published in October 1993 by G. Savu, C. Oprisiu, and O. Trifu of the Institute of Fluid Mechanics and Flight Dynamics, Bucharest, Romania; this was followed by another paper, "Photovoltaic Rotorcraft for Mars Missions," in 1995.

In Summer 1999, the Sikorsky Aircraft and NASA Ames Research Center-sponsored request for proposals for the 17th Annual Student Design Competition was released, for the "Development of Rotary-Wing Technologies for Use in Mars Exploration." Larry Young (NASA Ames) and Chris Van Buiten (Sikorsky) were the authors of, and points of contact for, the RFP.

In 2000, Pennsylvania State University won the undergraduate competition, while the Georgia Institute of Technology and the University of Maryland won graduate categories: Maryland won first place in the Vehicle Design category, while Georgia Tech, with its "GTMARS" proposal, won second in Vehicle Design, but placed first in the Propulsion System and Flight Computer Design category.

A team led by Datta (then a graduate student at UMD) designed the Maryland proposal, the Martian Autonomous Rotary-wing Vehicle (MARV). Maryland's design was significantly heavier than JPL's current design at 110 lb (50 kg), said Datta, but it was designed to fly for 39 minutes and travel 15.5 miles (25 km) to meet the specified design requirements. This allowed a payload of 23.8 lb (10.8 kg).

In 2000, NASA Ames personnel, including Larry Young and Ed Aiken, presented four different technical papers related to extraterrestrial rotorcraft at three different AHS conferences, and additional papers at AHS and other conferences over the following two years. The winning student designs were presented in May 2001 at Forum 57, and a synopsis of the Maryland proposal was published in the Journal of Aircraft in 2003.

In 2000, the University of Maryland and George Tech won the AHS Student Design Competition, sponsored by NASA and Sikorsky, for Mars helicopters. (University of Maryland image)

Later, after working as a scientist at Ames Research Center, Datta also consulted on the NASA Mars Helicopter development (2015–2017). "I certainly credit my expertise on Mars and my involvement in this project to that design," he recalled.

Similarly, in 2016, NASA selected Georgia Tech's Innovative Mars Exploration Education and Technology (IMEET) program as part of a three-year, $1.25M project to promote science, technology, engineering and math (STEM) engagement with high school and college students. "The idea is for IMEET team to develop and coordinate the control of aerial and ground robots on Mars, either autonomously or under astronaut control," said Prof. Daniel Schrage at Tech.

NASA organizations continue to research alternative designs for Mars explorations such as the Mars Electric Reusable Flyer — a vertical takeoff and landing (VTOL) tailsitter that was designed to nose over to fly as an airplane in cruise for longer range. A large-scale model was flown outdoors, but the unique efficient hover capabilities of a low disk-loading helicopter design in the thin Martian atmosphere was seen as the key discriminator, at least for this initial mission.

The Mars Electric Reusable Flyer was a higher disk-loading VTOL approach to exploring the Red Planet from the air.

As development of the Mars Helicopter has progressed over the past five years, the aircraft has captured the imagination of the public — including landing on the cover of the November 2016 issue of *Popular Mechanics* magazine and receiving broad coverage by the trade press.

And within the past three years, publications on Mars helicopter research have also increased in frequency. At the AHS Aeromechanics Technical Meeting in January in San Francisco, three papers on Mars rotorcraft design and testing were presented, with authors from NASA Ames Research Center, Georgia Tech and the University of Maryland, respectively. At Forum 74, two follow-on papers from NASA Ames and UMD, respectively, were presented.

At the January 2017 AHS Unmanned VTOL Technical Meeting, Georgia Tech's Dr. Schrage delivered the banquet presentation, "Why Helicopters Can and Should Fly on Mars." If the Mars 2020 rover lands safely on the Red Planet, and the Mars Helicopter flies as it was designed to, the vertical flight community will finally prove that claim true — helicopters can and should fly on Mars.

More on Mars helicopter research and references:
www.vtol.org/mars