

# Testing Operational strategies for the Mars 2020 Helicopter using a UAV

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## Abstract

We utilized a commercial drone to test operational strategies for the Mars Helicopter Scout (MHS), which is expected to be part of the payload for the upcoming NASA Mars 2020 mission. Using the reported capabilities of MHS, we demonstrate that a 3-min flight time at an elevation of 100 m is enough to attain a spatial coverage of  $10^4$  m<sup>2</sup> (assuming a FOV of  $\sim 80^\circ$ ) at an image overlap that is acceptable for building full mosaics and digital terrain models. Despite the apparent short daily flight time, careful planning of the scout path can also result in substantial ground-track coverage of  $\sim 200$  m, which would be enough to provide reconnaissance data for 3–4 sols of rover operations (assuming daily traverse distances similar to that of the Mars Science Laboratory).

## 1. Introduction

Unmanned Aerial Vehicles (UAVs), commonly referred to as “drones”, are fast becoming essential tools in geosciences with variable applications including surveys and mapping, atmospheric and archeological studies, and various monitoring activities. The NASA Mars 2020 mission is expected to include a drone-sized helicopter scout [1]. The drone may aid in mission operations, offer scientific context to the landing site area at higher spatial resolution than what is available from orbit [1], or simply act as a technological proof of concept for future missions. While our results here may be directly relevant to some aspects of the Mars 2020 mission, our main aim is to explore in a general sense optimal operational strategies for utilizing UAV-like instruments in different settings for future planetary missions. During a GeoHeuristic Operational Strategies (GHOST) field test - the latest in a series of field tests organized to test different operational

strategies for martian and lunar rover missions [2, 3] we used a commercial drone to test a number of operational strategies for a hypothesized drone utilized in concert with a mobile platform on Mars.

### 1.1 Study site

The field site that was chosen for the GHOST campaign [4] is located in the Uinta Basin of the Colorado Plateau province in northeastern Utah ( $39.8058^\circ\text{N}$ ,  $109.0759^\circ\text{W}$ ). The main testing area was a canyon cutting through a 500 x 500 m study region where rock layers are well exposed on both sides of the canyon. The site was chosen because it displays evidence for paleo-habitability that can be detected by in-situ measurements, thereby consistent with being a potential analogue site for ancient Mars in accordance with current goals of the NASA Mars Exploration program.

## 2. Methods

We used as published capabilities of the MHS as originally proposed for Mars 2020 a baseline [1]. Daily flights would be limited to a short duration of approximately 3 minutes due to power constraints, but it would attain  $\sim 100$  m altitude and  $\sim 600$  m ground track [1]. To simulate these parameters, we used a DJI Mavic Pro drone (<https://www.dji.com/mavic/info>). The main approach was to carry out multiple 3 minute-flights, each simulating possible MHS constraints for a single sol on Mars to gain better understanding of the nature and extent of scientific reconnaissance that can be carried out on a daily basis. To test reconnaissance capabilities, we used reported data for MHS to design a flight plan that would simulate a 3-min flight. We used Drone Deploy (<https://www.droneDeploy.com/>) to construct a simulated reconnaissance flight plan with MHS

activity constraints. For our flight simulations, we planned for a side overlap (the percentage of overlap between each leg of flight) of 65%, and a front overlap (the percentage of overlap between one image and the next) of 75%. Finally, we tested additional strategies with no time constraint where we focused on testing methods by which the drone would be able to complement daily rover science operations as opposed to being used as a reconnaissance tool.

## 3. Results

### 3.1 Reconnaissance capabilities

Simulated flight plans on drone mapping software demonstrated that an area roughly  $10^4$  m<sup>2</sup> can be imaged within 3 minutes (assuming a wide-angle FOV of 78.8°, similar to the Mavic Pro), including take-off and landing time, with enough overlap to construct an image mosaic and a DTM.

### 3.2 Scientific capabilities

In this mode, we utilized the drone to trace vertically stratigraphic packages that would normally be inaccessible to a rover. This would be particularly beneficial in a canyon setting but also applicable for 10s of meter-high outcrops, impact crater walls, etc. In one particular example, the GHOST teams identified an interesting float rock with fossilized ripple marks. The drone was then utilized to trace its stratigraphic origin on the cliff wall.

We also tested an optional mode using the drone's gimbal capabilities to assess the benefits of having such a system in the future, or alternatively two cameras: one nadir-, and another horizon pointing. Our operational plan for a single sol consisted of first launching to maximum height (100m) to take a reconnaissance image, then decreasing the elevation to 20–30 m. The drone would then travel along a potential rover route for 30–50 m, acquire a set of horizontal images over at least a FOV of 180° for panoramic stitching, then repeat the sequence of travelling ahead and acquiring images until there were 30 seconds remaining for the drone to land and finish its simulated martian sol traverse. This mode provided a context image as well as the opportunity to detect a number of regions of interest (e.g., float rocks, interesting outcrops) that would be potential targets for detailed investigation by the rover. Using

this technique, we were able to cover a ground track of 150–200 m per operational planning period (i.e., 3 minutes).

## 4. Implications for future planetary missions

Our analysis is directly applicable to MHS and possibly future missions to Mars. However, certain aspects of our work could be applicable as well to future missions to other planetary bodies. Our testing of having a gimbal system or at least two cameras is directly applicable to the Dragonfly mission proposal to investigate Titan [5, 6]. In particular, our tests here could be applicable to operational strategies of the camera suite [6].

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