SAMPLE

Solar System Missions: Perseverance and Ingenuity

The New Mars Mission

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Conclusion

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Introduction

The Mars 2020 mission, consisting of the rover Perseverance and helicopter Ingenuity, was launched on July 30, 2020, and landed in Jezero crater on Mars on February 18, 2021. As of September 3, 2026, Perseverance has been on the planet for 1969 sols (2023 total days; 5 years, 197 days).

Ingenuity operated for 1042 sols (1071 total days; 1 year, 341 days) until its rotor blades, possibly all four, were damaged during the landing of flight 72 on January 18, 2024, causing NASA to retire the craft. Current weather data on Mars is being monitored by the Curiosity rover and had previously been monitored by the Insight lander. The Perseverance rover is also collecting weather data.

In 2017 the three sites (Jezero crater, Northeastern Syrtis Major Planum, and Columbia Hills) were chosen as potential landing locations, with Jezero crater selected as the landing location, and launched on July 30th, 2020, from Cape Canaveral. After arriving on February 18, Perseverance focused on validating its systems. During this phase, it used its science instruments for the first time, generated oxygen on Mars with MOXIE, and deployed Ingenuity.

Ingenuity began the technology demonstration phase of its mission, completing five flights before transitioning to the operations demonstration phase of its mission. The Cratered Floor Campaign was the first science campaign. It began on June 1, 2021, with the goal of exploring the Crater Floor Fractured Rough and Séítah geologic units. To avoid the sand dunes of the Séítah unit, Perseverance mostly traveled within the Crater Floor Fractured Rough geologic unit or along the boundary between the two units.

Chapter 1: The Discovery of Perseverance and Ingenuity

While Perseverance embarked on its first science campaign, Ingenuity continued to travel alongside the rover as part of its operations demonstration campaign. Ingenuity's sixth through twenty-fifth flights were completed during this phase, achieving an at-the-time speed record of 5.5 meters per second. The Delta Front Campaign was the second science campaign of the Mars 2020 mission.

The campaign opened with Ingenuity still flying escort for the rover, in its operations-demonstration role, and Perseverance leaving the rapid traverse mode it had entered at the end of the last mission to rapidly reach the delta. During the campaign, Perseverance would take a further nine samples, in addition to two further witness tubes. Ingenuity would make its 41th flight during this mission.

An incident occurred in which Ingenuity was unable to sufficiently charge during the night, leading to a change in how Ingenuity manages its heaters. The MOXIE experiment continued to run, generating a record amount of oxygen-per-hour on Mars. The campaign concluded with Perseverance reaching the top of the delta and the completion of its first sample depot. The Upper Fan Campaign, also called the Delta Top Campaign, was the third science campaign of the Mars 2020 mission.

Whereas prior campaigns investigated areas that are believed to have been submerged in an ancient lake, this campaign investigated one of the riverbeds that used to feed into the lake. The MOXIE experiment completed its 16th, and final, oxygen generation test during this campaign. Ingenuity completed its

54th flight during this campaign.

The helicopter experienced an anomaly that caused it to land outside the range of the rover, but this was ultimately resolved when the rover moved into a position that allowed contact to be restored. The campaign ended with Perseverance reaching the margin carbonate geologic unit, after having taken three further rock samples (and 21 overall). The Margin Campaign was the fourth of the Mars 2020 mission.

The campaign was expected to last around 8 months, although it lasted closer to a year, after which point Perseverance began the Crater Rim Campaign. The campaign gets its name from the geological unit it aims to explore - the margin carbonate unit. Rocks in this unit are capable of containing traces of life, and their formation is tied to the presence of liquid water.

During the campaign, Ingenuity achieved several records, including a max altitude of 24 meters (flight 61) and a maximum groundspeed of 10 meters per second (flight 62). Unfortunately, due to a failure on the 72nd flight, the helicopter blades became too damaged to fly. On January 25th, 2024, NASA declared the end of Ingenuity's mission - the helicopter's final resting place was named Valinor Hills, after a location in the Lord of the Rings franchise.

Despite the loss of Ingenuity's blades, the core of the helicopter remained intact; it will continue to monitor atmospheric conditions for as long as it is able. Perseverance took four further rock samples during this campaign (25 overall). The campaign overlapped with solar conjunction, interfering with the ability to communicate with the rover from Earth.

Engineers from NASA's Jet Propulsion Laboratory in Southern California and AeroVironment are completing a detailed assessment of the Ingenuity Mars Helicopter's final flight on January 18, 2024, the first of its kind on an extraterrestrial planet, concluding that the inability of Ingenuity's navigation system to provide accurate data during the flight likely caused a chain of events that ended the mission. The helicopter's vision navigation system was designed to track visual features on the surface using a downward-looking camera over well-textured (pebbly) but flat terrain.

This limited tracking capability was more than sufficient for carrying out Ingenuity's first five flights, but by Flight 72 the helicopter was in a region of Jezero Crater filled with steep, relatively featureless sand ripples. One of the navigation system's main requirements was to provide velocity estimates that would enable the helicopter to land within a small envelope of vertical and horizontal velocities.

Data sent down during Flight 72 shows that, around 20 seconds after takeoff, the navigation system couldn't find enough surface features to track. Photographs taken after the flight indicate the navigation errors created high horizontal velocities at touchdown. In the most likely scenario, the hard impact on the sand ripple's slope caused Ingenuity to pitch and roll.

The rapid attitude change resulted in loads on the fast-rotating rotor blades beyond their design limits, snapping all four of them off at their weakest point — about a third of the way from the tip. The damaged blades caused excessive vibration in the rotor system, ripping the remainder of one blade from its root and generating an excessive power demand that resulted in loss of communications.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.