SAMPLE

Solar System Missions: MAVEN

Mars Atmosphere and Volatile Evolution

Aira Astralis

Free sample: Introduction & Chapter 1

putrabooks.github.io

Buy the full book:

Carousell carousell.sg/p/solar-system-missions-maven-ebook-pdf-1467856782

ElevenReader

Payhip

Contents

Introduction

Chapter 1: The Science Goals of MAVEN

Chapter 2: The MAVEN Spacecraft

Chapter 3: The Launch and Journey to Mars

Chapter 4: The Upper Atmosphere of Mars

Chapter 5: The Solar Wind and Atmospheric Escape

Chapter 6: The History of Water on Mars

Chapter 7: Mars' Changing Climate

Chapter 8: The Aurora on Mars

Chapter 9: The Magnetic Field of Mars

Chapter 10: Dust in the Martian Atmosphere

Chapter 11: The Moons of Mars - Phobos and Deimos

Chapter 12: Fun Facts and Trivia About MAVEN

Chapter 13: The Future of Mars Exploration

Chapter 14: The Comet's Gift - Siding Spring at Mars

Chapter 15: Deep Dips - Sampling the Escape Zone Up Close

Chapter 16: From Drawing Board to Launch Pad - Building MAVEN

Chapter 17: A Decade of Records - MAVEN's Long Service

Chapter 18: Conclusion: The Legacy of MAVEN

Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

On November 18, 2013, an Atlas V rocket rose from Cape Canaveral carrying a spacecraft whose name was both a wish and a confession. MAVEN stands for Mars Atmosphere and Volatile Evolution, and the confession was in the second word: Mars has an atmosphere worth studying only because it once had a much better one. The planet that today shows us a cold desert, with air so thin that liquid water cannot last on its surface, was once warm enough for rivers, lakes, and perhaps a shallow sea. Something carried the water and the thick carbon dioxide blanket away, and the leading suspect was never a suspect at all so much as a certainty: the planet bled its air into space, molecule by molecule, for billions of years, stripped by sunlight and by the wind from the

Sun. MAVEN was built to catch that process in the act.

The mission was the first spacecraft sent to another planet whose entire purpose was the study of an atmosphere's escape rather than its presence. Earlier orbiters had mapped the surface of Mars and landers had touched its soil; MAVEN instead spent its days high above the planet, riding an elliptical orbit that dipped through the upper atmosphere and then climbed far above it, sampling the region where Mars loses its grip on its own air. Its eight instruments, built by teams at the University of Colorado, the University of California at Berkeley, and NASA's Goddard Space Flight Center, measured the escaping gas directly, watched the solar wind arrive, and recorded what happened when the two met.

The spacecraft entered orbit on September 22, 2014, after a ten-month cruise of 711 million kilometers, and it has been working at Mars ever since, long past the end of its two-year primary mission. Its findings have been decisive. Mars is losing its atmosphere to space today, at rates that vary with the Sun's moods, and the loss was far greater in the past, when the young Sun was a stormier star. The escape measured over the whole of Martian history, extrapolated from the rates MAVEN has recorded, is enough to account for the disappearance of a thick early atmosphere and for the drying of a once habitable world.

This book follows MAVEN from the question that defined it to the engineering that answered it, through the launch and the arrival, and into the discoveries: the measured escape, the metal ion layer, the aurora that spreads across the whole planet, the invisible dust that puzzles its discoverers, and the March 2015 solar storm that let the spacecraft watch the planet's air torn away in real time. It closes with the mission's long twilight, a spacecraft built for one question now serving as a relay, a sentinel, and the keeper of a record that no

other instrument at Mars can replace.

Chapter 1: The Science Goals of MAVEN

Every mission to Mars has had to choose what it is about. Rovers choose rocks. Orbiters choose maps. MAVEN chose a process, and the process was loss. Its primary science goal, stated in the plainest words the team could manage, was to determine the role that the loss of atmospheric gas to space has played in changing the Martian climate through time. It is a question that had been waiting for a spacecraft since the days when the Mariner probes first showed a cratered, dessicated world, because the only way to answer it is to go to the place where the loss happens and measure it.

The mission broke that goal into four objectives, and the four together form a complete accounting. First, MAVEN would determine the current state of the upper atmosphere and ionosphere: what gas is up there, at what temperature and density, and how it is structured. Second, it would identify the physical processes that drive gas out of the atmosphere and into space, one at a time. Third, it would measure the rates at which those processes remove atmosphere today. Fourth, it would use models of the Sun's history to project those rates backward, and so estimate the total amount of atmosphere Mars has lost over the past four billion years. The logic is an auditor's logic: know the inventory, watch the withdrawals, and read the ledger backward to learn what the account once held.

The withdrawals come through several channels. Thermal escape, the classic route, is a matter of speed: in the thin upper atmosphere, a fraction of atoms are always moving faster than the planet's escape velocity, and those atoms leave, one by one, never to return. Photochemical escape is more violent, chemistry weaponized by sunlight; ultraviolet photons break apart molecules in the upper atmosphere and dump the fragments' energy into their motion, so that newborn oxygen atoms can fly away at several kilometers per second. Ion escape is theft on a grand scale: the solar wind, a supersonic stream of charged particles from the Sun, picks up freshly ionized gas and carries it downstream past the planet like a river taking a bank's soil.

Sputtering adds insult to injury, as solar wind particles slam into the atmosphere and knock loose atoms into space the way a cue ball scatters a rack. Each process leaves a different signature, in a different place, at a different energy, and MAVEN's instrument suite was assembled to catch every signature.

The mission also had to watch the weather, because the loss is not steady. The Sun's output rises and falls on scales of hours and decades, and the escape rates rise and fall with it. A single measurement of atmospheric loss on a quiet

day would be like judging a coastline's erosion from one calm afternoon. So

MAVEN was designed to operate for a full Martian year, through all seasons, and to keep measuring long enough to see the Sun's own cycle turn, recording how the escape responds to solar storms, seasonal change, and dust storms that shroud the whole planet.

The stakes were never merely meteorological. A warm early Mars needs a thick atmosphere, and there are only two ways to lose one: lock it away in the ground as carbonate and ice, or bleed it upward into space. The surface record suggests some of the first, but the chemistry of the remaining air, light with noble gases, points strongly at the second. If escape was the killer, then the story of Mars is in good measure an astrophysical story, of a small planet with a weak magnetic shield sitting downstream of a tempestuous young star.

MAVEN went to Mars to read that story where it is still being written.

The region where all of this happens was chosen with care, and it is worth saying plainly why the upper atmosphere is the only place the loss can be seen. Below about 100 kilometers, the Martian air is well mixed: collisions keep every species moving together, and the composition at the top of the mixed layer is the same as at the surface. Above the homopause, the layer where mixing gives way to sorting, the atmosphere separates by mass like a centrifuge, and the light atoms, hydrogen above all, come into their own, spreading upward into the exosphere where a molecule's next collision may simply never occur. Every escaping atom, whatever process eventually frees it, must pass through this sorted zone first. A spacecraft that measures the well-mixed air learns what the atmosphere contains; a spacecraft that measures the sorted zone learns what the atmosphere is losing; MAVEN's orbit was drawn through the sorted zone, twice every five hours, for exactly that reason.

It also matters that the zone is a moving target. The upper atmosphere of Mars swells in daylight and shrinks at night by tens of kilometers, breathes with the seasons as the southern summer inflates it, and storms at the Sun can double its temperature within hours. A single dip through it measures weather; only repeated passages at every local time, through whole Martian years, measure climate. The mission's observing program was therefore built as a decade-long campaign from the beginning, with the instruments gathering continuously rather than in targeted snapshots, so that whatever the Sun or the planet did, the record would contain it. Some of the mission's best results, the response of escape to the solar cycle and the 2018 storm's water loss, came from data taken years before anyone knew they would be needed.

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.