During the countdown for launch of a spacecraft, there is an automatic hold at T-4 minutes. That’s a natural spot when everything on the rocket is stable, and it can wait there for hours if necessary for weather or technical issues to clear up. As the Principal Investigator for the MAVEN mission, I was at my console in the control room for the countdown on November 18, 2013. During the T-4 minute hold, I listened to the final poll of two-dozen people representing all key systems to make sure they were ready for launch. As the countdown was about to resume, I texted my wife who was watching from the nearby causeway: “Go for launch. Here we go!” At that point, it was four minutes of second-by-second waiting. I was so anxious that I couldn’t sit still. When I stood up, I immediately understood why there was a bar across the top of the console – it was something to grab on to!

The countdown reached the last ten seconds. The rocket ignited. At T = +0.3 seconds, the Atlas V carrying the MAVEN spacecraft lifted off in a fury of smoke and noise. It was a flawless countdown and a picture-perfect launch.

Right now, MAVEN is more than half way along its ten-month journey to Mars. The science instruments have all been turned on and tested and are working as anticipated. The spacecraft systems are performing nominally, a word that sums up literally volumes of plans and expectations as well as years of development, integration, and testing on the ground prior to launch. During what might be thought of as a quiet cruise to Mars, the spacecraft team is now working hard to get ready for Mars orbit insertion on September 21 and for the five-week transition phase when the spacecraft will be prepared for the one-year science mission.

MAVEN stands for the Mars Atmosphere and Volatile EvolutioN
mission. It is the first spacecraft devoted to studying the upper atmosphere of Mars and its interactions with the solar wind. The goal of MAVEN’s mission is to understand how the Sun and the solar wind can strip gas off of the top of the planet’s atmosphere.

The essential questions MAVEN is trying to answer are: Where did the water go? Where did the carbon dioxide from an early thicker atmosphere go? Evidence from previous spacecraft missions tells us that ancient Mars had liquid water flowing over it. We believe this required the presence of a thicker atmosphere to provide the greenhouse warming needed to allow liquid water to be stable on the Martian surface. That early warm environment is in contrast to Mars’ thin atmosphere and cold, dry surface today. Although there is evidence that some atmospheric carbon dioxide has been sequestered into the subsurface, the amounts identified to date cannot account for the total that must have once been in the atmosphere.

There also is strong evidence that the Sun and solar wind have stripped away some of the gas from the upper atmosphere over time. MAVEN’s job is to understand the processes that lead to escape to space, and determine how much total gas has been lost. This will tell us whether these loss processes have been a significant (or possibly dominant) driver in changing the planet’s climate.

I have been researching the Mars surface and atmosphere since 1976. As an undergraduate at UCLA, one of my professors, Hugh Kieffer, hired me to work with him on the two Viking Orbiters that flew to Mars that year. My interests were to understand the seasonal cycles in the Martian atmosphere and on its surface and in exploring the long-term history of the atmosphere. I became intrigued by the possibility of life existing on Mars, and realized that this question was the most fundamental and important one that we could ask about Mars, the planets in our solar system, and the planets orbiting other stars.

Life requires liquid water, the availability of “biogenic” elements, and an energy source to drive metabolism. To explore the potential for life on Mars, one needs to examine the surface geology, analyze data from the atmosphere, and study the planet’s deep interior to find evidence that these three essential resources for the development of life exist. Evidence for the existence of liquid water in Mars’ distant past comes from the geology of the surface that shows distinctive features that had to be carved by liquid water. It also appears that the history of liquid water on the Martian surface is connected to the loss of the Martian atmosphere to space. Thus, an “aeronomy” mission that explores the upper atmosphere of the planet could help us learn about the history of the Martian surface and what controls whether it was once possible to be a habitat for
simple forms of life like microbes.

I thought it would be important to fly this type of exploration mission that would integrate knowledge gained about the upper atmosphere with the other components of the Mars environmental system. Knowing that an opportunity to propose a mission to NASA would be coming up, I called two colleagues at the University of California at Berkeley’s Space Sciences Laboratory, Janet Luhmann and Bob Lin. We discussed the science thrust of a MAVEN-like mission and whether it could be competitive with other mission concepts in a world that often seemed to more strongly value surface exploration. We agreed that it was worth a try and that a collaboration between my institution (University of Colorado’s Laboratory for Atmospheric and Space Physics) and theirs would provide the ideal core for the science team and for building the science instruments. I became the Principal Investigator and Bob became the Deputy Principal Investigator. Janet would be one of the senior interdisciplinary scientists on the team; after Bob’s death in 2012, she became the Deputy PI. We put together a science team that identified the measurements that were needed to answer our science questions and the science instruments required to make them. We met with Lockheed Martin to discuss the spacecraft, and eventually agreed to partner on this mission. We also agreed to partner with NASA’s Goddard Space Flight Center (GSFC) as our management partner. A mission the size of MAVEN was too big to manage from one of...
our university laboratories, and GSFC had the breadth and depth to provide a project manager and the rest of a project office that would be needed to provide oversight of the entire endeavor. Remarkably, all the different institutions with their different responsibilities and roles came together as an integrated, coherent team, with everybody pulling in the same direction.

Being project PI carries tremendous responsibility for all aspects of the mission. This includes technical implementation and success, cost control and scheduling, risk management, and science. We have a project manager who does the day-to-day management of these activities, David Mitchell from GSFC. He has experience in implementing spacecraft missions, and can take my scientist’s view of our goals and turn them into reality.

Being PI also has given me the exciting opportunity to shape the mission with what I thought were the most important science directions and necessary measurements. Although you can’t tell going in whether the activity of solving all of the challenges that come up over ten years will end up being enjoyable or sheer drudgery, I’ve been lucky — it’s been tremendous fun.

After our selection to move forward to flight in 2008, we had five years until launch. We used the first year to develop the team and get our processes in place. Over the next four years, our team had to define the requirements to be met by the spacecraft and instruments (about 10,000 of them over all). We designed the spacecraft and its instruments, built the components, integrated them onto the spacecraft, then tested every aspect of the completed observatory. Listing these activities makes them sound easy, but an incredibly skilled team of hundreds of people worked incredibly hard to make all of this come together properly, on schedule, and on budget.

The completed spacecraft was shipped to Florida in August, 2013, for launch from Cape Canaveral. That last three months was a flurry of activity to complete final testing, load the fuel and pyrotechnic devices, install the spacecraft into the fairing (the “nosecone” on top of the rocket) that would protect it while it went through the Earth’s atmosphere, then mount it on top of the rocket for launch.

At the same time, we had our final reviews to ensure that we were ready for launch. From concept to launch, we had a total of more than 200 formal reviews to ensure that we were doing everything we could to be successful. The last couple of reviews, during the week leading up to launch, are etched most strongly into my mind. They primarily involved the launch team, which was responsible for the rocket and for the launch itself. I learned that that group is composed of incredibly professional and competent people, giving me confidence that they would do everything possible to ensure a safe ride to space.

Now that we’re on our way to Mars, the science team and I are

MAVEN Principal Investigator Bruce Jakosky (left) and Project Manager David Mitchell, at the pre-launch press conference at NASA Headquarters. [NASA]
focused on getting ready to carry out mission operations and to “do science” when we get there. We have to be sure that we’ve planned out how we’re going to observe the planet (that is, exactly what observations will be made during the spacecraft’s 5 orbits per day), how the data will flow back to the Earth and into the computers of the instrument teams, and how the data will be processed, reduced, calibrated, and then distributed to the rest of the science team.

With only a one-year primary mission, every day is precious and we have to be ready to go on the first day of science observations. Most importantly, we have to know at the start how we’re going to go from taking measurements to reaching science conclusions about Mars.

After we go into orbit on September 21, it will take us about five weeks to get the spacecraft ready to do science. We have to get into our final science-mapping orbit, deploy the booms that hold some of the science instruments away from the effects of the spacecraft, and test the instruments again to make sure they’re functioning properly.

Because nothing is ever easy, a comet discovered only last year, Comet Siding Spring, will pass within about 140,000 kilometers of Mars during the middle of our commissioning phase. This means that it’s possible that we’ll get pelted with dust released from the comet, at speeds of 56 km/sec! If we survive this encounter and it’s possible to do so safely, we will also make some science observations relating to the comet. Only then will we be able to carry out our original science mission.

MAVEN is one spacecraft mission in a series of missions that are exploring Mars. They include spacecraft from the United States, from the European Space Agency and Russia, and from India. MAVEN fits into the broader context of the overall exploration of Mars because we are exploring the history of the Martian climate and volatiles that will improve our understanding of the planet’s potential for life. We look forward to future missions that will explore other aspects of Mars and to programs that eventually result in returning samples back to Earth to look for evidence that the planet might once have supported life. MAVEN also is helping us prepare for eventual human missions to Mars by studying the radiation environment that can be harmful to people.

But MAVEN is a science mission whose potential contribution to
our understanding of Mars stands on its own merit. We will explore the upper atmosphere of Mars and its interactions with the solar wind, and we will examine in great detail an important aspect of the larger Mars environmental system. We look forward to starting the science mission that we’ve been planning for more than ten years.

About the Author

Bruce Jakosky is a professor in the Laboratory for Atmospheric and Space Physics and Department of Geological Sciences at the University of Colorado in Boulder. He is Principal Investigator for the MAVEN mission to Mars.

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