

Future of Drones

PROFILE: AeroVironment's Wahid Nawabi talks about the Mars helicopter and the industrial uses for unmanned aircraft.

By **MARK R. MADLER** Staff Reporter

While there are other companies in the world that make drones and ground robots, none of those companies just focus on those technologies. That's according to **Wahid Nawabi**, chief executive of **AeroVironment Inc.**, the Simi Valley robotics company that made history this spring as the inventor of Ingenuity, the first aircraft to fly on another planet, in this case Mars. At AeroVironment, the focus is only on robots – originally drones, and increasingly ground robots and even underwater robots, said Nawabi, who joined the company in 2011 and took the top job five years ago. AeroVironment recently announced it would relocate its headquarters from Simi Valley to Arlington, Va. effective June 15. In a statement Nawabi said that the move was done to put the company closer to key customers. "Expanding our presence in the region will further our access to decision makers, influencers and talent," Nawabi said. He spoke to the Business Journal about the drone market, what he likes about his job and the technical challenges of developing the Ingenuity Mars helicopter.



Wahid Nawabi

Question: How did the company get the contract for the Mars helicopter?

Answer: We have had a fairly long-standing relationship with JPL (Jet Propulsion Laboratory) and NASA for many years. This took several years to come to fruition primarily because there were lots of skeptics – including within NASA and JPL – about whether you can even fly in the atmosphere of Mars. ... So we proved it in a pressurized chamber that was mimicking the atmosphere of Mars here on Earth. Once we achieved that, folks became believers and after that they decided to pursue that mission because the benefits in the future and the possibilities would dramatically increase in terms of human missions in the Martian atmosphere and even on other planets besides Earth. It took several years to get to that stage. Early on, NASA and JPL were convinced we were the right company given our capabilities and our experience in this area.

When did the Mars helicopter project start?

Around 2013 is when we initially engaged JPL and NASA on this specific program for Mars 2020.

What were some of the technical challenges of the project?

Ingenuity had to be not only a spacecraft that has to achieve all the expectations and the requirements of being a spacecraft and flying in space, but also being an aircraft. The combination of those requirements is tremendously difficult. To give some examples, it had to fit in a specific size, weight and power envelope

underneath the belly of the Perseverance rover. That size and weight requirement was constraining. In terms of how it had to be designed, it had to be like a helicopter to fit there. We had to figure out how it could withstand the vibrations and the shocks in terms of the launch mechanism. Then it has to travel for millions of miles for a few months until it got to Mars.

And after arrival?

Once it arrives it has to meet all the stringent conditions of entry and landing into the Martian surface. Then it has to dismount from the belly of Perseverance, it has to open up its legs, the solar system has to work. It had to operate in extreme temperatures, extreme dusty conditions and extreme radiation for the time it is actually in the Martian atmosphere. The atmosphere of Mars is about 1/100th of the density of the Earth's atmosphere. So trying to actually achieve flight require incredibly higher speeds on the propellers, much lighter weight and much more precision controls.

Why is that?

It is not like an operator hits a joystick every millisecond or so. It has to be computerized so it flies itself and does that in the Martian atmosphere without any interventions throughout the flight.

What were the space flight requirements?

Every single piece of wire is custom designed, custom placed and custom connected. It requires microscopic-level attention to detail and precision and workmanship. The other thing is you have to design it so there is not a single point of failure and no room for a single mistake or defect. Once you launch it, there is no way for you to touch it again.

What was the human resources commitment for this aircraft?

It was weeks and weeks and weeks and months and years, literally years of exhaustively difficult work to get it done. The speeds the blades rotate at are incredibly high speed because that is the only way they can achieve lift. Therefore, they have to be super light but at the same time super rigid and strong, in terms of the material strength. If you hold it in your hand, it weighs almost nothing. But it has layers and layers of meticulously designed and layered composites and foam structure to be able to achieve that. Once a blade starts to rotate under incredibly

high speeds the centrifugal forces push the blades to want to come apart from the rotor shaft. The higher the speed of rotation, the more it wants to escape the actual shaft. Basically, it wants to break up. So, designing something that is incredibly strong but extremely lightweight is very difficult.

Do you foresee additional NASA contracts for AeroVironment?

We do foresee that. This is a massive accomplishment for mankind. This is the equivalent to the Kitty Hawk moment with the Wright Brothers more than 100 years ago here on Earth. Who would have thought at that time that aviation was going to change the fabric of our society and have such an incredible impact on human society as a whole? This could be a similar moment 100 years from now. The fact that you could actually achieve flight on Mars, it dramatically opens the prospects of other ways to achieve missions on Mars.

Can you give any examples?

There are soil samples right now being collected on the Martian surface by Perseverance with the expectation that on another mission, another spacecraft is going to collect those and bring them back. All those concepts were thought out to be done by a ground robot. What if they had a break down? There are risks involved with every single pick up and drop off with a rover. The helicopter can open up a lot of new possibilities. (NASA) could conceptualize Martian missions where the next helicopter flies further and collects samples so therefore the sample set in the future could be dramatically different based on the capabilities of a flying machine on Mars.

Does the company make money from the Mars helicopter?

This is not a significant revenue generator for us. We are not doing this because we want to make a lot of money or generate a lot of revenue from JPL and NASA. This is something that is good for humanity, good for a great cause. ... It is an achievement that our team wants to do as part of the identity of the company.

Do you have a favorite moment during the project?

There are numerous different events and milestones that were important. ... Nothing can top the last moment when we got the signal back at 3 a.m. Pacific time when we received the video

WAHID NAWABI

Position: Chief Executive

Organization: AeroVironment Inc.

Age: 52

Education: BS Electrical Engineering, University of Maryland - College Park

Most Admired Person: Imam Ali, one of the early leaders of the Islam religion.

Personal: Married with three children

Interests: Golf, poetry, music, soccer, cooking, mentoring

that showed the Ingenuity achieving flight.

Were you awake when confirmation of the first flight happened?

I wasn't the only one. There were a ton of our employees and pretty much all of the engineers and scientists from our team and NASA and JPL that worked on it and who were awake and watching it and keeping our fingers crossed. We also had a team deployed at JPL on standby to be there ready if anything were to go wrong and we would have to interpret some information if we got information that was inconsistent with our expectations.

Why the move to Virginia?

We acquired a business called Progeny Intelligent Systems that is based in Northern Virginia/D.C. Metro. The timing was right for us to consider moving our company headquarters as we have to expand our presence in the D.C. area.

What does this mean for the operations in Simi Valley and Moorpark?

Our current operations and presence in Simi Valley and Moorpark will not be affected by this move. We continue to stay committed to the Simi Valley and Moorpark area and we intend to keep our operations here in Southern California. This is just a corporate HQ move. We are a growing company and we already had plans to continue growing our presence in the D.C. area because majority of our customers are in the D.C. area.

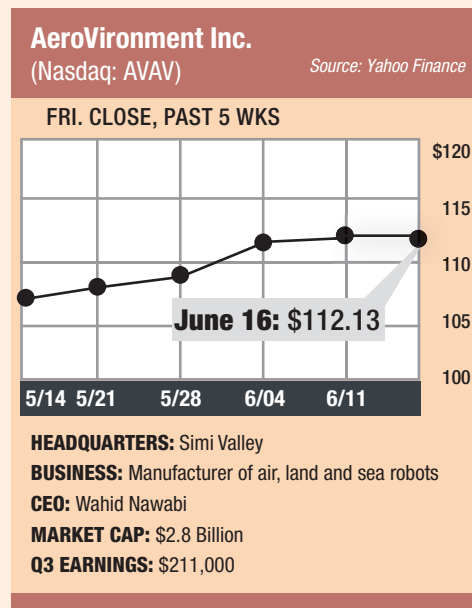
Will you and the rest of the executives move to Virginia?

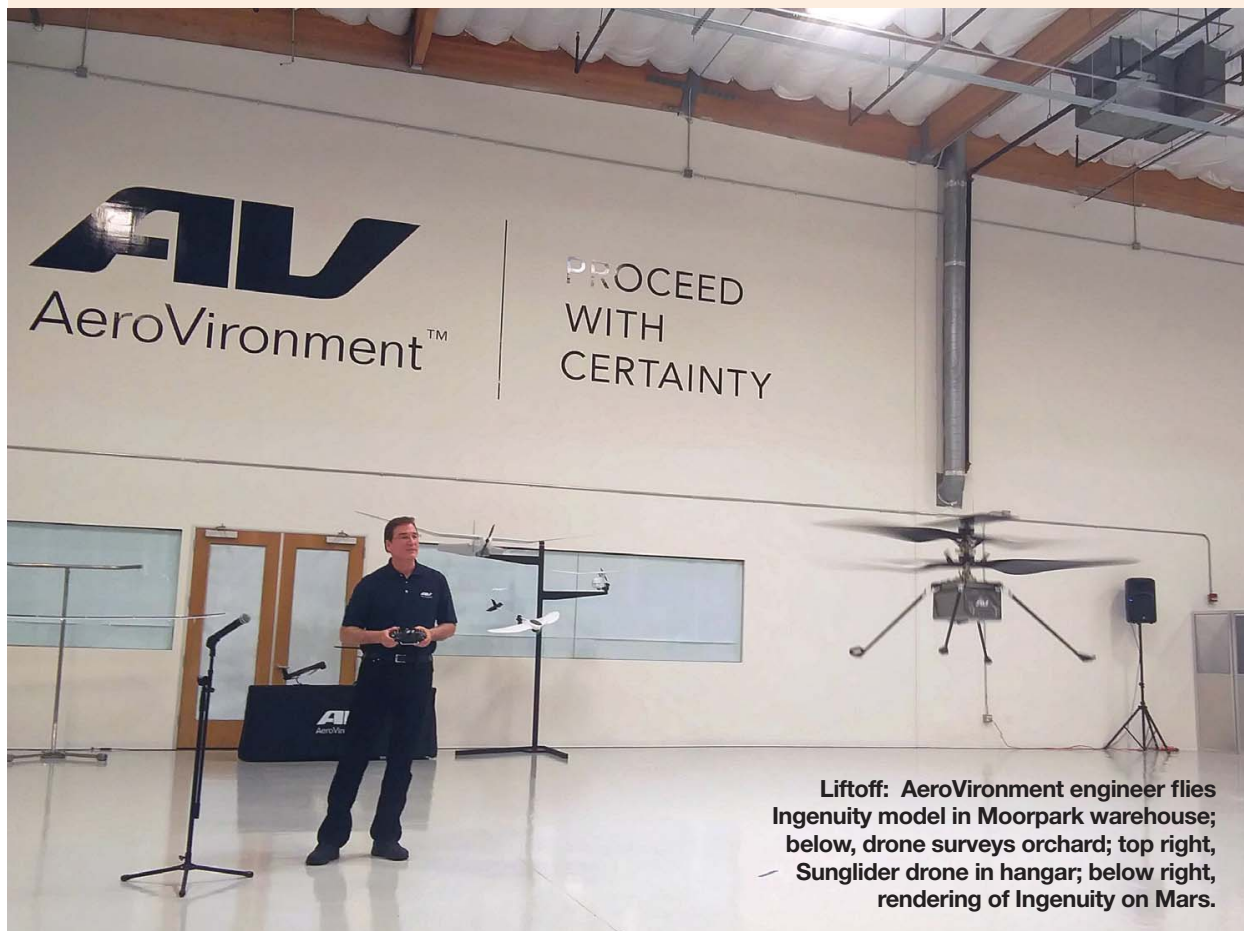
No. We already travel to D.C. area quite frequently. Very few of our executives may have to move or have dual residency, but nothing significant. Again, our commitment and presence in Simi Valley and Moorpark area remains the same and we will continue to maintain our engineering, operations, production and other capabilities here in Simi Valley. We will also not require any of our current employees to move, either. ... We always intended to grow our customer-facing organization in the D.C. area and this is consistent with that strategy and intent.

Let's switch gears – where is the drone market going?

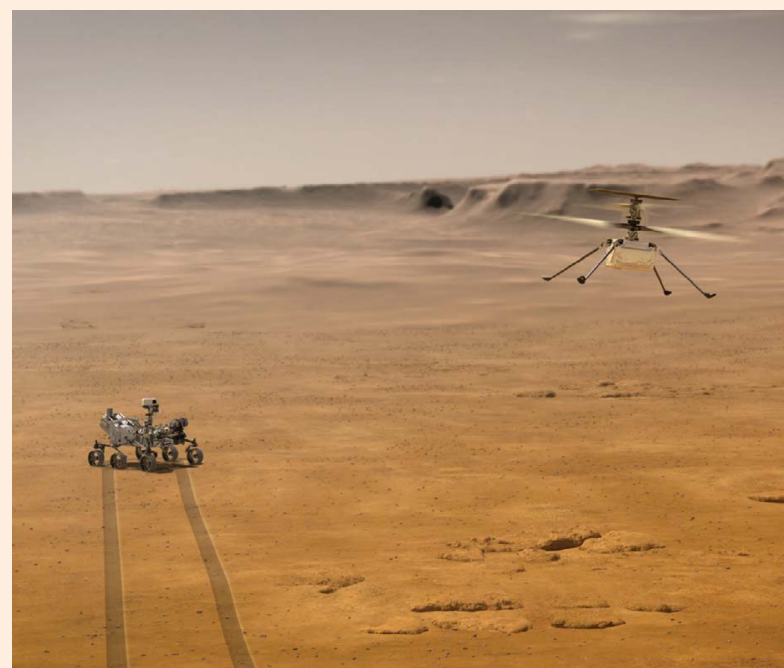
We've already seen the drone market transform various industries. We started this thing in the defense market. Small drones are a capability that AeroVironment invented for defense applications and the military back 20-plus years ago. We continue to be a leader in that space. We are one of the leading providers of small, unmanned aircraft systems and robotic systems for not only the DoD now but also 50 allied countries around the world. We design and manufacture that all here in California.

What about new industries that use



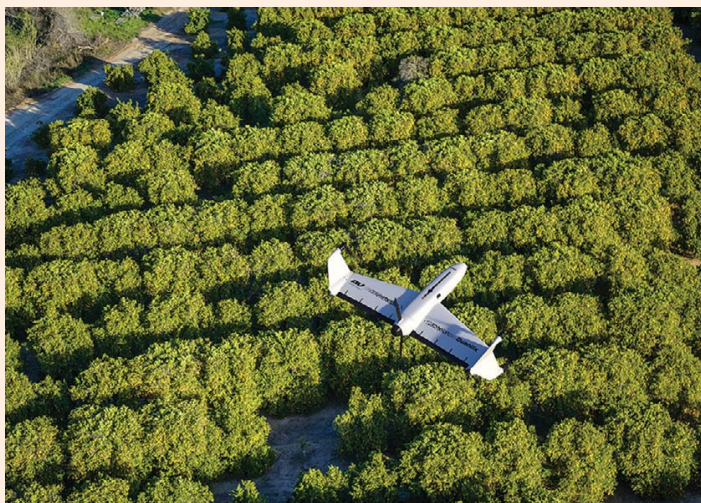


Liftoff: AeroVironment engineer flies Ingenuity model in Moorpark warehouse; below, drone surveys orchard; top right, Sun glider drone in hangar; below right, rendering of Ingenuity on Mars.



drones?

There are other industries that are emerging, like agriculture. We launched a solution a couple of years ago called Quantix. It essentially allowed farmers to become drone pilots. They can put up a map and tell the drone to go survey their land. In less than an hour, the UAV will take off by itself, achieve the flight, collect imagery and come back and land and image a 400-acre piece of agricultural land in less than an hour. We have several pilot projects with utilities. We have several projects with the oil and gas industry. If you look at this thing in the next decade or so, it is going to change many of these industries in a positive way. The benefits are tremendous. And AeroVironment is at the forefront of that.



Do customers want larger or smaller drones?

It all depends on the mission. There is an application and use case for all different sizes, shapes and forms of UAVs, drones and robotic systems. AeroVironment is now more than a drone company. We have assembled the world's leading portfolio of multi-domain empowered robotic systems. There are specific reasons we use those words. "Multi-domain" means UAVs on the ground, air robots, stratospheric robots, in-the-water robots and underwater robots. All are integrated together. They are intelligent; it means they have AI (artificial intelligence) machine learning algorithms that we have developed at our company and that others are developing that we integrate with these systems so they can conduct missions more intelligently and with less cognitive load on the operator.

How about big drones?

Our Sun glider is a drone with a wingspan a couple of feet longer than an Airbus A380. But it weighs as much as an SUV and is 100 percent solar powered. It flies on the edge of the atmosphere, the stratosphere level which is about 60,000 feet above sea level. Twice as high as where commercial airliners fly. Our portfolio solutions span a very wide range of size, endurance, weight, power, sensor capability, software capability, analytics and AI. There

are use cases for all of them.

Can you give an example?

A very tiny drone is very useful. We introduced one called the Snipe a couple years ago. It is basically a drone that is pocketable for a soldier. It is for very small environments. It can actually go through a window or door and inspect a room or a building. There are drones that you hand launch for a small squadron or a farmer. Other drones take off vertically and fly for 20 hours and can go 100 kilometers in terms of its range and can carry 20, 30 pounds worth of payload. Also the Sun glider, which is a solar stratospheric airplane, is a massively large airplane in terms of its wingspan.

What is the status of the Sun glider?

We demonstrated that last October. It takes off from a runway, unmanned, gets to 60,000 feet above sea level. It carries 5G payload that acts like a cell tower. I actually conducted a Zoom call this last October from Spaceport New Mexico with an Android smart phone and through (Sun glider), we connected Washington, D.C. with New Mexico to Silicon Valley to Tokyo, Japan. It was a four-way Zoom call, no latency whatsoever using a standardized handset.

How did the acquisition of German

robotics company Telerob come about?

All of the acquisitions that we have done, including the last three we've done this year, they were intentionally, proactively approached and selected by us to achieve our future state.

Our future state is intelligent multi-domain integrated robotics systems. The ground robot is an area that we had not played in before. There are lots of missions where the cooperation and the integration of a flying robot like a drone and a ground robot can do a lot of things effectively for our customers.

Again, an example?

Imagine a bomb squad or first responders, and they are getting a call for a domestic threat. What they can do is go to an area where somebody brought a car and they think it's got a bomb inside of it or something. A UAV can survey this space and find out if they are looking for a specific type of vehicle. That is a much cheaper effort than a manned helicopter or airplane and it is a lot safer for public safety to fly a much smaller device that is far safer and a lot more reliable than a manned helicopter. The cost is also significantly lower. Once you identify a suspect vehicle or bag or some asset, you can dispatch a ground robot and ask the ground robot to inspect it further.

What do you like most about your job?

The people. It is truly an amazing company with amazing people. It is not a dull day here in terms of innovation and excitement. These brilliant, cutting-edge scientists, experts in

their field, and how they take on these daunting challenges and come up with solutions.

How would you describe your management style?

Servant leadership is a concept and philosophy I really believe in. You have to really believe that I am here to help others and unleash their potential. It always involves a team. These are very complex and sophisticated system solutions. We have to be able to design the motors, the propulsion system, the battery system, the electronics, the software, the analytics, the avionics, the structures, the composites – the list goes on and on. All of that requires expertise in various areas. You have to be able to develop a team and an organization capability that can do all those things effectively as a team.

Is there an example that illustrates that?

Ingenuity is a tremendous example of that. We had to work effectively with ourselves, but we had to be an incredible team with our colleagues at JPL. You have to rely on them for things and they have to rely on us. That is a tremendous example of teamwork. Another example is the stratospheric airplane Sun glider. It is an airplane as I said with a wingspan of an Airbus A380, weighs less than an SUV and has to take off from a regular runway. It has no person on board and is 100 percent solar powered. We have to work with our Japanese partner, **Softbank**. We have to work with **Alphabet Inc.**, or Google, who provided the payload. We have to work with flight teams and local suppliers on the latest and greatest battery technology and solar cells and propulsion system for the electric motors. We have to design the software and then make it work. That is a massive effort to do during COVID.