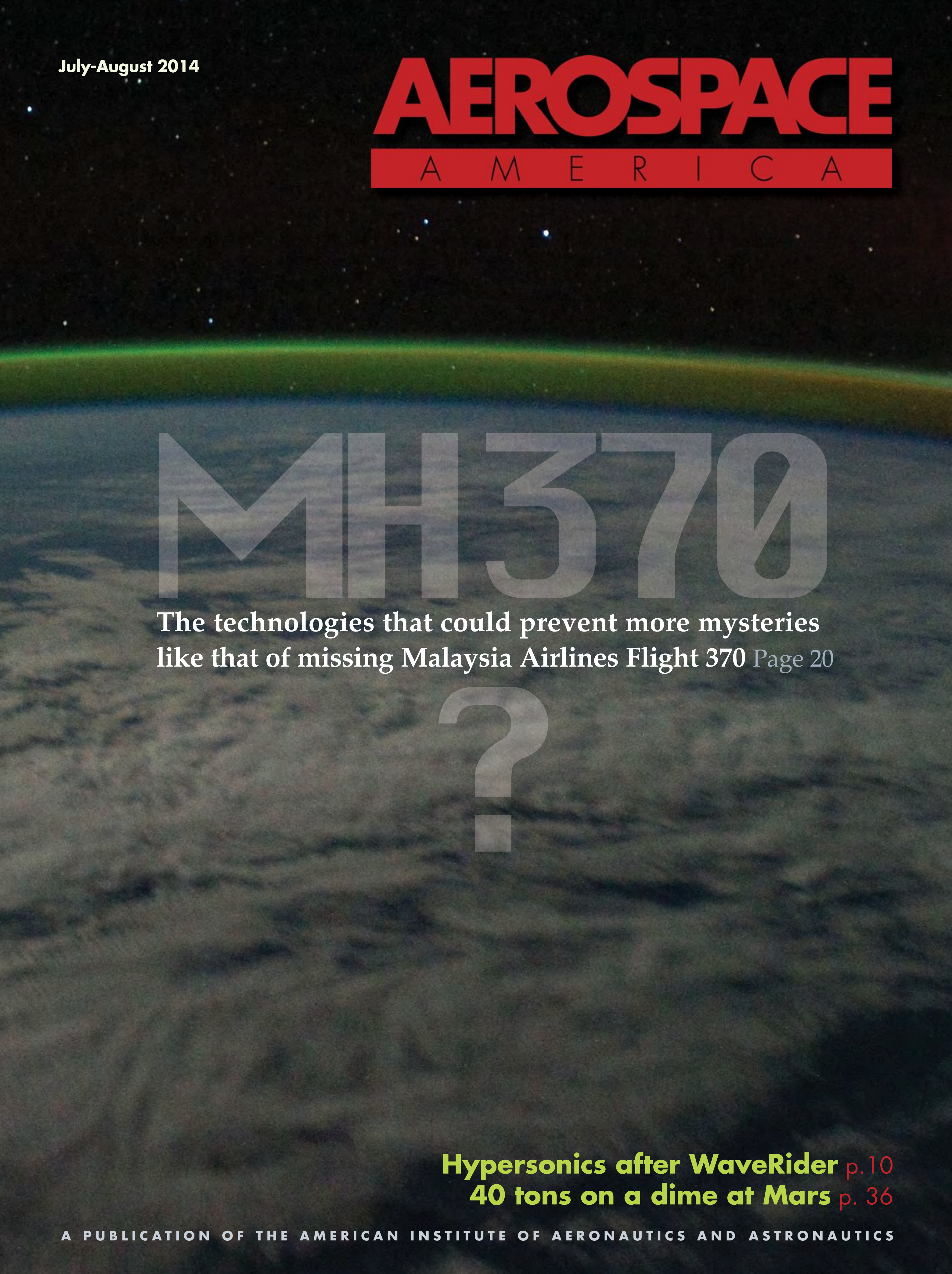

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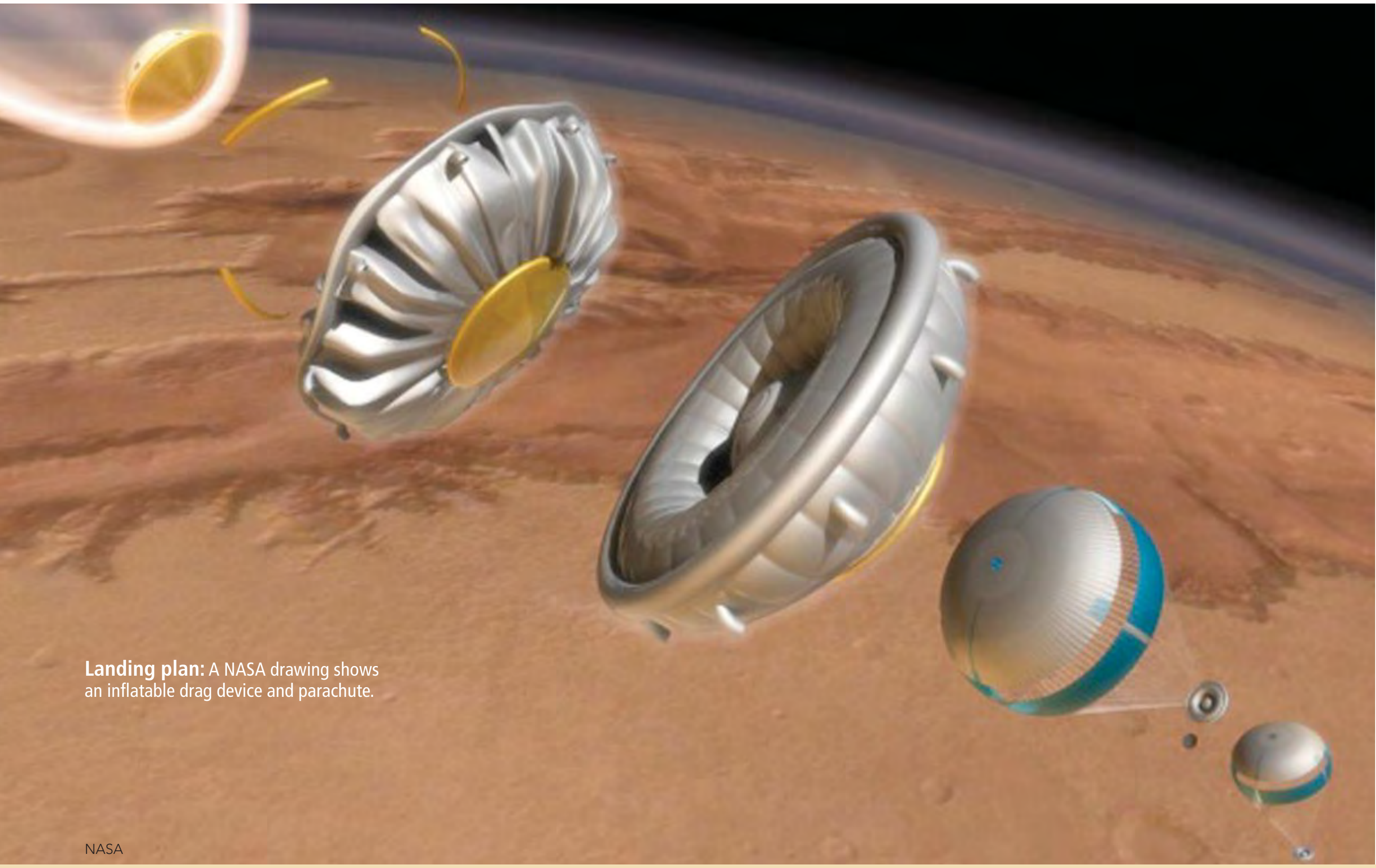
MARS BRAKING TECH



Landing plan: A NASA drawing shows an inflatable drag device and parachute.

NASA

NTED

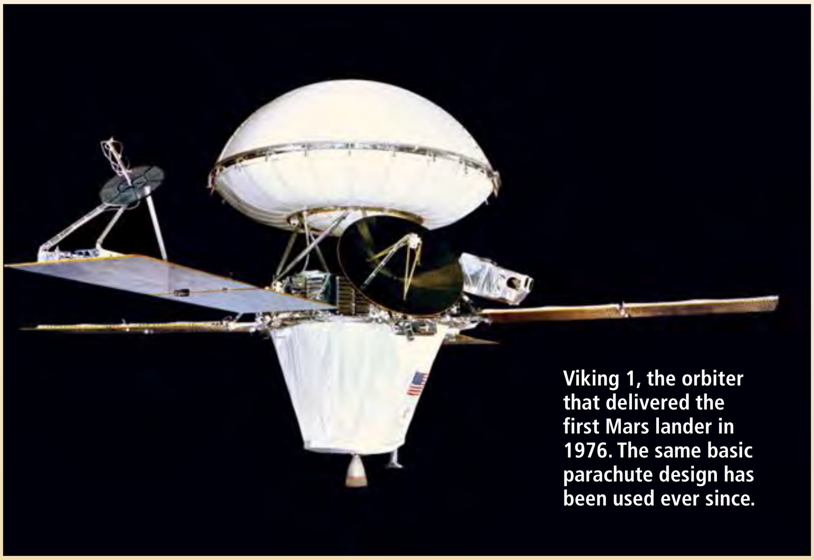
NASA has entered the test phase of an ambitious program to develop inflatable drag devices and mammoth parachutes for landing heavier things on Mars, including the many tons of life-support equipment human explorers would require. Leonard David examines NASA's efforts.

By Leonard David

One of NASA's greatest triumphs of innovation came when the Curiosity rover dangled to the surface of Mars from its Sky Crane module. As impressive as those moments were, other parts of the descent could have been mistaken for the Viking spacecraft landings of 1976.

Curiosity used a Viking-era parachute design. That was fine for the one-ton rover. NASA knows that stronger atmospheric braking technology will be required to land heavier robots and hardware to sustain human explorers on Mars. An inflatable drag vessel will surely have to be added to the entry vehicle, and a larger parachute—perhaps several—will be required.

With that on their minds, engineers at NASA's Jet Propulsion Laboratory in Pasadena are coming to the crucial flight test phase of a five-year, $200 million plan to develop and evaluate new braking technologies. The initiative is called the Low Density Supersonic Decelerator project, with low density referring to the challenge of slowing down a heavy object in the thin Martian atmosphere. At stake is whether



Viking 1, the orbiter that delivered the first Mars lander in 1976. The same basic parachute design has been used ever since.

NASA

Clean room: At the Jet Propulsion Laboratory, NASA workers prepare the saucer-shaped low-density supersonic decelerator for shipment to Hawaii, where it will be launched into near-space for testing. NASA JPL

NASA will be able to check a key box on the list of breakthroughs that might convince skeptics about the feasibility of sending people to the red planet. To be sure, there are questions about the design of the rocket to get there and the ability of humans to survive the radiation environment on Mars. Those questions are moot if the agency can't land heavier things.

The Viking landers were launched four decades ago, and "Since that time we have not done any tests of supersonic flight of these things, and we just relied on test data," says Mark Adler, project manager for the braking technology work at JPL.

"With Curiosity we landed a ton on Mars. To land humans it's something like in the 40-ton range. You can't go from one to 40 tons in one fell swoop. You have to take some steps in-between," says Adler. "So we're taking the first steps along that path, also increasing the Mach number."

Creating drag

Adler's team began the project in 2010, and so far it has devised a 30.5 meter-diameter parachute – almost twice the width of the 16-meter chute that slowed Curiosity — and two different versions of inflatable drag devices, known as SIADs, short for Supersonic Inflatable Aerodynamic Decelerators, or SIADs. A SIAD would be inflated around the periphery of the entry vehicle to slow it to less than Mach 2 from speeds greater than Mach 3.5 The giant parachute or parachutes would be unfurled after the SIAD does its job of slowing the capsule enough that the chute wouldn't be ripped apart.

The engineers are glad to be ending the long test hiatus after the Viking missions. "We have been standing on the shoulders of those tests for all of our Mars parachutes used since. What makes this [test program] much more challenging than those early tests is the larger size and mass of the systems we are testing," says Rob Manning, chief engineer for the low-density braking project.

So far, NASA has tested the big parachute and a SIAD at the Navy's China Lake, Calif., range using a rocket sled designed to roar across the desert floor. To test the parachute, a rope was run through a ground pulley and attached to the sled. The parachute was released and once fully opened, the sled's rockets were fired. As the sled raced ahead it pulled the parachute toward the ground and imparted the desired loads — some 90,000 pounds of force. More parachute and SIAD tests at China Lake are planned for later this year.

JPL engineer Mike Meacham says that the quest for much larger supersonic parachutes has, in the past, relied on wind tunnel data. However, the parachutes were getting so large that they no longer could fit into wind tunnels.

"We needed a way to apply this same type of wind in a controlled way and we had to get outside the building," Meacham says. "You want to go to Mars. You want to go big…then you've got to test big here on Earth," he says, so "You got to be a little crazy sometimes if you want to do crazy things."

The engineers set out to make a larger chute with a new shape, called a supersonic disk sail parachute. Proving the capability of such a large diameter parachute is not to be underestimated. Supersonic parachutes are "fickle devices," says Ian Clark, the principal investigator for the Low Density Supersonic Decelerator work at JPL.

"When we have to use them like we do at Mars, it's behind a very large, blunt vehicle. That vehicle is screaming through the atmosphere. It's punching a hole in the atmosphere. All the air is rushing in behind it to fill the vacuum that it's creating," he says. "That creates a very turbulent, very unsteady environment for the parachute to live in. You need a particular kind of parachute."

Simulating a Mars descent

The sled tests were a good start, but the team needed a way to more realistically simulate the forces that the parachute and SIAD would encounter during the descent to the surface of Mars. The engineers decided to attach cameras to a test article of the size and shape of an entry vehicle and send it up to the stratosphere. A plan was drawn up to slowly loft the vehicle to an altitude of 120,000 feet using a 34-million cubic foot research balloon to be released from a tower at the Navy's Pacific Missile Test Range on the island of Kauai. At that altitude, pyrotechnics will release the vehicle and a split second later, four solid rocket motors are to stabilize the capsule's attitude. This ensures it is pointed correctly when an ATK Star-48 solid motor kicks on to blast the vehicle up to the top of the stratosphere — 160,000 to 180,000 feet — and a velocity of Mach 4. At that point, the vehicle should be positioned approximately horizontally.

"Then the vehicle is ready to conduct the technology experiments at the proper Mars-flight-like conditions," Adler says.

As the vehicle plunges back toward the ocean the SIAD inflates at Mach 3.8 to decelerate it to Mach 2.7, at which point a small chute called a ballute pulls out the 30.5-meter parachute. The craft splashes down about 40 minutes after it was released from the balloon and is recovered.

The need to accelerate the vehicle created an engineering challenge. "The Star 48 motor plume will be releasing a huge amount of radiative heat, so we have lots and lots of blankets to protect the vehicle," Adler says.

"With Curiosity we landed a ton on Mars. To land humans it's something like in the 40-ton range. You can't go from one to 40 tons in one fell swoop. You have to take some steps in between, so we're taking the first steps along that path, also increasing the Mach number."

— Mark Adler, NASA JPL

"It's much, much more complicated than the steel structure we put on the rocket sled," he adds. "But what we did learn is how to integrate SIAD onto the vehicle and make sure we knew how to interface it with the inflation devices. We showed that it deployed properly."

Last month, the team was waiting for the winds to ease enough at Kauai to conduct the first of three planned stratospheric tests — one this year and two in 2015. The team expects a rich bonanza of information once the vehicle is recovered. How did the SIAD survive the event? Did it start to rip and is there thermal damage?

NASA

Rocket power: A deceleration device on a rocket sled test fixture at China Lake, Calif. NASA wants to go to the stratosphere next.

How did the parachute fare?

Adler will consider the first flight a success if the test vehicle is launched to the proper speed and altitude. He describes it as a "shakeout flight" to see how the test approach works. Any information about the SIAD and parachute he considers a "bonus." Lessons will be applied to the flights next year.

One version of the inflatable device is called SIAD-R, with R short for robotic. This version is six meters across and is the version that Adler was trying to test from Kauai in June. It is meant to be paired with the next version of the Curiosity rover, which would be a bit larger than a ton. It would be inflated with pressurized hot gas. The second version is called SIAD-E, with E short for exploration. It's for payloads in the 3-ton, 5-ton or 10-ton class. Scoops on its side would pull air in at 2,000 miles per hour, inflating the SIAD to the proper shape.

"They are somewhat competitive, but it is the 6-meter that will be brought to Technical Readiness Level (TRL-6)" — meaning a prototype or representational model — "and ready for use in a project," Adler says.

The exploration version is more experimental and is planned to be brought to TRL-5, meaning a less-refined breadboard technology.

"They have similar mass, so the 8-meter would be more efficient," Adler explains.

Good to be testing again

The flight tests will mark the first time since the 1970's that NASA has tested large deceleration devices at supersonic speeds.

The tests from Kauai would be the most ambitious steps yet to go beyond that technology.

"It's been quite a while getting to this point," Adler says, comparing the work to "a spacecraft development."

An optimistic Adler says the technologies tested now might be used as early as NASA's proposed 2020 Mars rover mission, which is now being scoped out.

But his team has even greater ambitions. One idea that's blossoming would be to use a cluster of three to five of the 30.5 meter diameter parachutes to place perhaps 15 tons on Mars.

"Getting the humans down on Mars doesn't require that much mass. But it's not going to do them much good to land…and not have a place to live," Adler notes.