Juno's Jupiter mission a quest to find 'recipe for planet-making'

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Even for scientists versed in the grand scale of astronomy, it's never been easy to grasp the scope of Jupiter.

After all, you could fit every piece of the solar system other than the sun inside Jupiter - all the other planets, moons and asteroids - with plenty of room to spare. Jupiter has cannibalized 20 moons over the years and still has at least 63, one bigger than Mercury. Jupiter's "spot" is actually a hurricane, which has lasted for hundreds of years and is more than twice the diameter of Earth.

But Jupiter isn't just a forbidding ball of gas. Somewhere in there are the clues, scientists believe, to the origin of the solar system - and Earth. Starting the morning of Aug. 5, NASA will enter the launch period for the spacecraft Juno, which will begin an unprecedented exploration of Jupiter's profound secrets.

"We are after the recipe for planet-making. To get the list of ingredients - this is the place," said Scott Bolton, the mission's principal investigator and the director of space science at San Antonio's Southwest Research Institute.

Roughly four and a half billion years ago, the sun formed when a giant cloud of gas and dust collapsed under its own gravity. The sun sucked up virtually all of it, but there were leftovers. Those leftovers formed the solar system, and most of them wound up inside Jupiter.

Unlike other planets that shed their elements over time and undergo sweeping change, Jupiter's sheer girth has allowed it to retain most of its original features. Contained inside, said William Hubbard, a University of Arizona professor of planetary sciences and one of the mission's top scientists, is a record, essentially, of the birth of the planets.

"It ties right back to us," Bolton said. "These are the elements of life, the elements that Earth is made out of. How Jupiter managed to get enriched in these elements is right at the essence of how we got here. Where did we come from? That's what it comes down to."

Juno can launch any time during a 22-day period, hitching a ride on an Atlas V rocket from Cape Canaveral in Florida.

Juno's solar panels, configured like three spokes of a Ferris wheel, will supply power to the craft as it journeys across 1.8 billion miles of space. The trip will take five years. By the fall of 2017, Juno is expected to have completed 34 elliptical, polar orbits around Jupiter. Its task complete, Juno will then be plunged, in a final hurrah, into Jupiter's depths, where it will disintegrate.

The Jet Propulsion Laboratory in La Canada Flintridge, Calif., is managing the $1.1 billion mission.

With the recent end of the space shuttle program, NASA has faced questions about an approach to manned space exploration that critics have called aimless. On the other hand, this year marks a bustling period in unmanned exploration, particularly on deep-space missions.

Juno's launch will follow NASA's Dawn spacecraft arriving into orbit around the protoplanet Vesta, the first prolonged encounter with an object in the main asteroid belt between Mars and Jupiter.

In September, twin spacecraft will lift off to fly in coordinated orbits around the moon. That project is expected to yield the most complete gravitational map of the moon and also help scientists understand the origins of the Earth.

Also this fall, the new Mars rover, Curiosity, is scheduled to launch from Cape Canaveral, and is expected to continue the search for water and evidence of life.

"In all the time I've been working, I can't think of one time that has had so many launches, so fast," said Bolton, who was a scientist at JPL from 1980 until 2005. "It's an exciting time."

Juno's orbits have been spaced with precision to cover the entire planet. The result, scientists believe, will be the first comprehensive mapping of Jupiter's gravitational and magnetic fields.

Scientists will also be able to determine whether there is a solid core underneath Jupiter's massive bands of gas. That discovery will help to reveal the timeline of the formation of the solar system.

If Jupiter has no core, then it probably formed as the sun did - by inhaling, in a sense, during a gravitational instability. If Jupiter does have a solid core, then its rocky elements would have needed time to form before being surrounded by the bands of gas that circle the planet.

Despite those potential leaps - and though scientists have dreamed of studying Jupiter at this level of detail since the 1970s - Juno was, for many years, not a sure thing.

Spacecraft dating back to Pioneer 10 in the early 1970s have studied Jupiter, "but just kind of looking out the car window," said Jan Chodas, a JPL engineer and the Juno project manager. Jupiter's hostile

environment, particularly its crippling doses of radiation, was an impediment.

Juno, too, will be subjected to an enormous amount of radiation - the equivalent of 100 million dental X-rays. That level of radiation can fry a spacecraft's electronics in an instant, and was among the reasons that Jupiter missions were initially passed over in NASA competitions to obtain launch approval.

Then, in the late 1990s, Bolton was working on Cassini-Huygens, the first spacecraft to go into orbit around Saturn.

One morning - after spending the previous day in a series of meetings about measuring radiation in deep space - Bolton was standing in the shower. He had an epiphany.

He would need a specific instrument loaded onto Juno - a microwave radiometer, which could probe the planet's atmosphere with less interference. The spacecraft would also need to orbit Jupiter's poles, not its equator, thereby reducing the information "noise" that would come from the planet's radiation belts.

The combination, he believed, would yield the first solid reading of water and oxygen on Jupiter. It would be a critical step in understanding the distribution of heavy elements during the formation of the planets. There would be implications far beyond our solar system; hundreds of "Jupiter-class" planets have been discovered in recent years in further reaches of the galaxy.

"The rest is history," Bolton said.

To complete such a promising and demanding set of calculations during its orbits, Juno will fly little more than 3,000 miles above Jupiter's poles,

far closer than any spacecraft has ever managed.

Engineers have equipped it with a protective titanium box, 500 pounds and roughly three square feet, to shield what engineers call Juno's brain and heart - its data components and the electronics that control its power and send its science back to Earth. Chodas said Juno is essentially "an armored car in space."

"Now we just have to wait five years until we get to Jupiter," Bolton said. "You have to have a lot of patience in this business."