Symposium envisions golden age of space travel

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The SpaceX Dragon cargo craft is pictured just prior to being released by the International Space Station's Canadarm2 robotic arm on May 31 to allow it to head toward a splashdown in the Pacific Ocean. Credit: NASA

A symposium on space this past week was abuzz with talk of a new golden age of space travel.

Amazon.com CEO Jeff Bezos, who also heads private space firm Blue Origin, compared the advent of reusable rockets to the Internet and the

national highway system, opening the door to an explosion of commercial space activity.

Underlying the optimism is a new space race: to cut launch costs. Reusable rockets are just one part of it.

Hawthorne-based SpaceX already offers launch vehicles at half the price of its competitors' rockets. Adding reusable rockets to the mix would step the challenge from SpaceX and other companies to longtime launch provider United Launch Alliance, a joint venture of aerospace giants Boeing. and Lockheed Martin.

"I think they do indeed feel threatened," John Logsdon, professor emeritus at George Washington University's Space Policy Institute, said of United Launch Alliance. "They have been used to a noncompetitive situation, and that is not a recipe for innovation. So all of a sudden, they have these shiny, new companies threatening what they're used to doing, and it's hard for old organizations to respond."

United Launch Alliance CEO Tory Bruno said his company welcomes more competition and said an increased launch market from sectors other than national security is important.

"It's always healthy to have competition," he said in an interview. "By SpaceX entering the field as a certified and competitive provider, it allows all of us now to go and be competitive in that larger market."

Driving much of the innovation is a competition to replace the Russian RD-180 rocket engines that have been used to launch U.S. government and commercial satellites since 2000. After the Russian annexation of Crimea in 2014, Congress mandated that a U.S.-made alternative be built by 2019.

Two technologies could be key to disrupting the launch business:

-Flying on methane: The leading candidate to replace the Russian engine will be powered by a new type of fuel: liquefied natural gas.

The BE-4 engine is the brainchild of Blue Origin. When fully developed, it will be powered by staged combustion of liquid oxygen and liquefied natural gas to produce 550,000 pounds of thrust. Blue Origin says the engine will be flight-qualified by next year and could fly as early as 2019.

Experts say liquefied natural gas, which is a commercially available form of methane, could have several advantages as a rocket fuel.

Blue Origin has said its wide availability and low cost would enable an "extended engine development test program."

Methane is also clean, meaning it's less likely to clog fuel lines inside the engine. That would reduce the type of rigorous cleaning needed to clear those particulates and make it easier for reusability, said Ann Karagozian, UCLA professor of mechanical and aerospace engineering.

The gas also self-pressurizes, which could eliminate the need for tank-pressurization systems.

"If this combination for the BE-4 gives them a simple, reliable design that is easy to manufacture, then it could be a game changer," said G. Scott Hubbard, professor of aeronautics and astronautics at Stanford University and former director of NASA's Ames Research Center at Moffett Federal Airfield in Silicon Valley.

Blue Origin is competing against legacy Sacramento manufacturer Aerojet Rocketdyne to develop an engine for United Launch Alliance's

Vulcan rocket. Aerojet is developing a liquid-oxygen-and-kerosene-powered engine called the AR1, which is slated for completion and flight qualification in 2019.

"We are very confident that we're going to qualify this engine in 2019, certify it, as well as have a factory to build it," said Julie Van Kleeck, vice president of Aerojet's advanced space and launch business unit.

Analysts have said the competition could come down to cost versus reliability. Aerojet's traditional technology is less risky than Blue Origin's, but could end up being more expensive.

"I think Aerojet is going to have a really hard time competing with Jeff Bezos and his company on cutting-edge technology that could dramatically increase the power of the engine versus the weight, and thus have a much lower cost," said Marco Caceres, senior space analyst at the Teal Group, an aerospace and defense research firm.

"The onus is really on Blue Origin to do what they supposedly say they can do. And if they do, there's nothing that Aerojet can do than say, 'We tried.'"

SpaceX is also developing a liquid-oxygen-and-methane staged combustion engine called Raptor, which company President Gwynne Shotwell has said could be flown on "orbital trajectories and beyond Earth missions," according to her statement last year to the House Armed Services Committee.

This could be a factor in the company's plans for Mars, as SpaceX has said methane could be synthesized in the Martian atmosphere. "Methane has those advantages for reusability," UCLA's Karagozian said. "But it is not standard. It's not a sure thing by any means."

-3-D printing: Additive manufacturing, commonly known as 3-D printing, can substantially reduce the time and cost of producing rocket parts.

Take the main oxidizer valve body in one of the SpaceX Falcon 9 rocket engines, for example. The part, which controls the flow of oxygen into the engine, was produced through 3-D printing in less than two days and launched on a Falcon 9 in 2014. That marked the first time that SpaceX flew a 3-D printed part. Normally, that process would have taken months, the company said in a blog post at the time.

SpaceX said that compared with a traditionally cast part, the printed valve body had "superior strength, ductility and fracture resistance." After undergoing a rigorous test program, the 3-D printed part was qualified to fly interchangeably with cast parts on all Falcon 9 missions, the company said.

Additive manufacturing has been used for individual parts and components up to SpaceX's SuperDraco engine chamber for the Dragon Version 2 spacecraft and Aerojet's demonstration rocket engine. The SuperDraco engine chamber was printed in Inconel, a superalloy. The engines will power a launch escape system.

"I could see that a lot of the cost of very specialized parts could come down substantially," Stanford's Hubbard said. "And that can contribute to a lower-cost overall vehicle."

Parts made through additive manufacturing can also be much lighter than their traditional counterparts, though reinforced to maintain strength, said John Parsey, professor of practice at Arizona State University. Lighter parts can increase a rocket's payload.

These parts and their manufacturing process will be especially

important for missions deeper into space, Hubbard said.

The 32nd Space Symposium was held in Colorado Springs, Colo.