A helicopter is going to Titan. Could an airplane be next?

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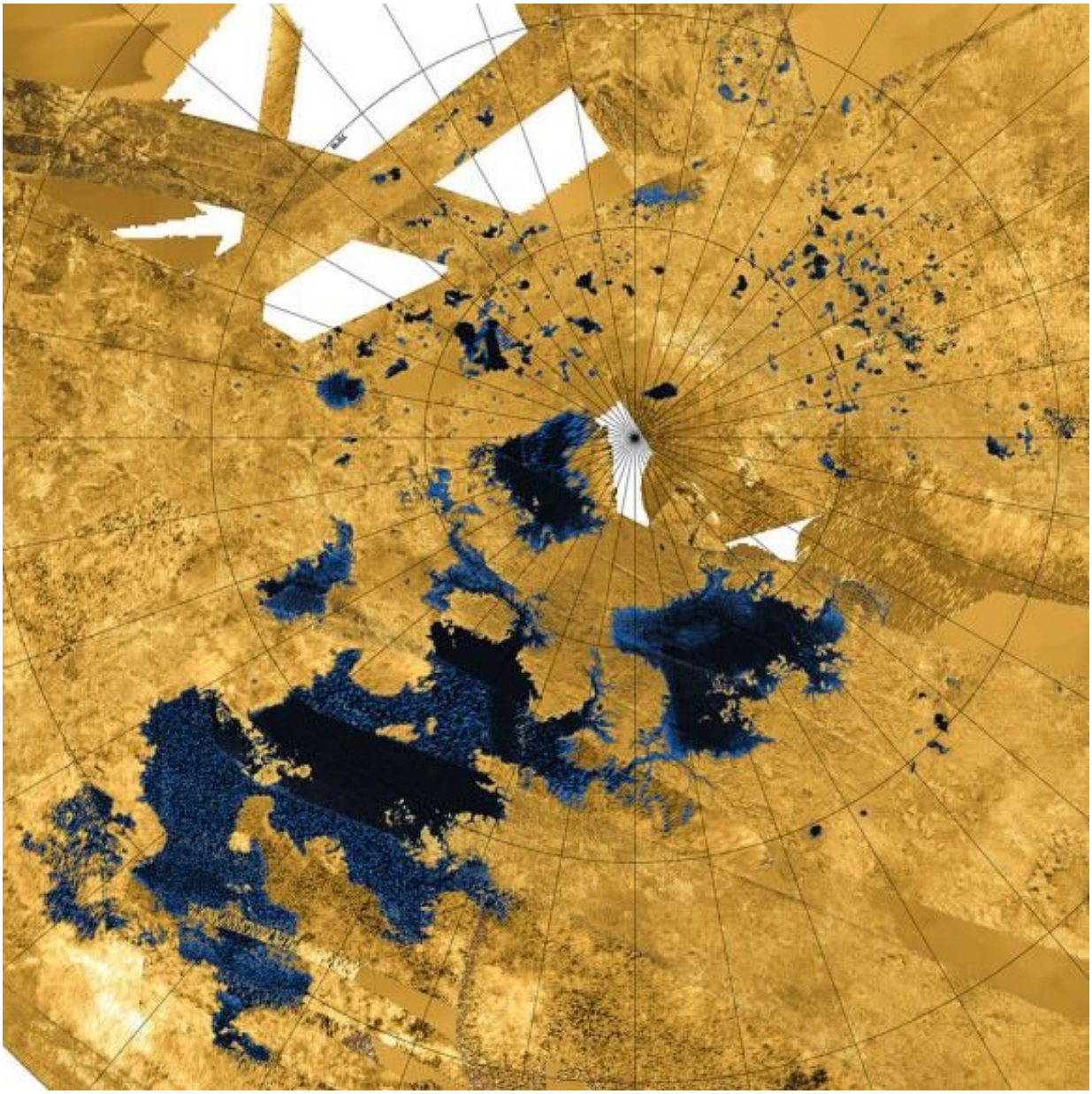

This colorized mosaic from NASA's Cassini mission shows the most complete view yet of Titan's northern land of lakes and seas. Credit: NASA / JPL-Caltech / Agenzia Spaziale Italiana / USGS

What are the hydrocarbon seas on Titan really like? While the upcoming Dragonfly helicopter mission to Saturn's hazy and frigid moon should arrive by 2034 to explore Titan's atmosphere, the need remains for a mission that could study the moon's mysterious seas and lakes, filled with liquid hydrocarbons.

But how about an aircraft that could study both the seas and skies of Titan?

A new mission concept that received funding from NASA's Innovative Advanced Concepts (NIAC) Program is called "TitanAir," and features a flying boat, known as a laker. The laker would be outfitted with numerous instruments to sip and taste both air and liquid, all while soaring and sailing, seamlessly transitioning between navigating through Titan's atmosphere and gliding across its lakes, much like a seaplane on Earth.

TitanAir is one of 14 different visionary ideas that received NIAC's Phase I funding of $175,000, which provides backing to help flesh out potentially breakthrough concepts that could transform future missions.

TitanAir is the brainchild of Quinn Morley and his company Planet Enterprises. Morley has 15 years' experience working for Boeing and is currently pursuing a bachelor's degree in mechanical engineering. This is Morley's second NIAC award, as in 2021 he won another Phase 1 grant to investigate the development of low-cost robotic, self-driving "borebots" capable of deep drilling on Mars. This concept is currently

under consideration for a Phase II NIAC grant.

"I mix a pretty ridiculous sense of creativity with a knack for technical writing and a strong aerospace fabrication background," Morley wrote on his website, adding that he is the first undergrad to be named a NIAC Principal Investigator.

The idea for TitanAir is that the laker would be able to "drink" in methane condensation and organic material through a permeable section on the leading-edge of the wings. Passive capillary features on the inside of the wing would bring the liquids to science instruments, much like how plants pull up water from their roots to the leaves, or how the "quicker picker upper" paper towels work. This is also how fuel tanks for rockets are designed to be able to reignite in a weightless environment, as the veins in the tank will wick the fluids into the suction port.

"I've had a fascination with capillary effects in everyday life ever since I was a kid," Morley wrote on his LinkedIn account, "but what really got me was Don Pettit's coffee cup on the International Space Station."

Back in 2008, astronaut Don Pettit wanted to enjoy his morning brew on the ISS in a coffee cup instead of a bag, so he invented a cup that works in microgravity by using capillary action to control the flow of liquid. The cross section of the cup looks like an airplane wing, and the narrow angle wicks the liquid up.

"Somehow I took an idea inspired by the space coffee cup and a messy spill in the refrigerator, convinced a team of amazing people to work with me, and mixed it all into a winning NIAC concept over summer break," Morley said. "I'm not sure how I was inspired to bring liquid in through a permeable wing skin. I remember dwelling on the idea for a while though, not knowing what to do with a wing bullnose full of

liquid."

The impressive team Morley put together includes Dr. Narasimha Boddeti, Dr. Steven Collicott, Laura Forczyk, and Dr. Peter Buhler.

Titan is the only body in the solar system—apart from Earth—known to possess surface lakes and seas. But at Titan's frigid surface temperatures—roughly -180 degrees Celsius (-292 degrees Fahrenheit)—liquid methane and ethane dominate Titan's hydrocarbon equivalent of Earth's water.

An illustration of NASA's Dragonfly rotorcraft on Titan. Credit: NASA

TitanAir would land and takeoff from the lakes, and could fly and soar at low altitudes for about an hour every day.

Like NASA's upcoming Dragonfly, any airborne mission to Titan would get a boost from the moon's atmosphere, which is about four times as dense as Earth's atmosphere. Combined with Titan's low gravity (13.8% that of Earth), Morley told Universe Today, it is about 27 times easier for any powered flight on Titan, but only if the aircraft's wings were very long and thin.

"The advantage to airplanes is 'soaring flight'—so you can cruise along in level flight with way less power than on Earth," Morley said via email. "So, if you want to slowly gain altitude you could potentially do that with 20x less power than stable flight on Earth."

As for the design of the TitanAir craft, Morley cautioned that his current investigation is focused on determining the feasibility of the liquid-ingestion technologies for an aircraft on Titan.

"So, the airplane is kind of a stand-in or strawman," Morley explained. "NIAC calls this the mission context."

But currently, Morley and his team are basing the size of the craft on typical general aviation aircraft on Earth, such as a small Cessna airplane. In their white paper, the team lists their context weight of about a ton with a 10-meter (30 ft) wingspan. The wings would have to be inflatable in order to fit inside the spacecraft that would bring TitanAir to the Saturn system.

"To be honest, the size of the laker is not constrained right now, because the requirements of floating on a lake and flying in the air are kind of at odds," Morley told Universe Today. "If we sized the whole craft for the laker case, the wings may be prohibitively long. The inflatable wings are really to give us the longer wings that we need to support a large fuselage, and get us a reasonable efficiency while performing long-duration flights, while still being able to fit in a second stage fairing."

As for the instruments, under consideration are next generation Urey-type instruments that would include an integrated suite designed to search for biomarkers that "would be well suited to the analysis of complex organics." In total the instruments would have a mass of less than 20 kg, but could be adapted to a wide range of aircraft sizes.

Another instrument that Morley and team are considering is based on Dragonfly's sampling system called DrACO (Drill for Acquisition of Complex Organics), which will extract material from Titan's surface and deliver it to a mass spectrometer. If a drill was mounted on the wingtips of the laker, it could sample shoreline materials.

"The laker could swing a wing over the shoreline and perform sampling activities from the safety of the lake," Morley wrote, adding that this may be a perilous task for a craft like Dragonfly given the potential for getting stuck. "This could amplify the science return and unlock access to hard-to-reach evidence of the hydrological cycle."

While the team lists several challenges to overcome, such as having materials for the wings and fuselage that could withstand the extreme cold of Titan and stand up to the toxic hydrocarbons, the benefit of the TitanAir concept is that it could support many of the recommendations in the Decadal Survey to study Titan and understand its mysterious methane cycle. It would also contribute to the understanding planetary atmospheres that otherwise would require multiple missions and spacecraft, leading to lower costs.

"Few options exist that can contribute to all of these questions in a meaningful way, but we feel that this concept has the potential to change the conversation about the climate science, prebiotic atmospheric chemistry, lake composition and habitability of the planet Titan," Morley and team concluded in their paper.

More information: The white paper is available online: www.planet.enterprises/_files/ … 934cba43ef2058c2.pdf

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