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(Cover Story) Blue Origin successfully and safely completes second human flight to space and back

by Gradatim Ferociter, Blue Origin, 2021 October 13 (with permission) (Photo credit: Blue Origin / Brett Griffin)

Blue Origin successfully completed its second human spaceflight on board New Shepard on Wednesday, October 13, 2021. The flight included four astronauts, Dr. Chris Boshuizen, Glen de Vries, Audrey Powers, and William Shatner, as well as thousands of postcards from Blue Origin’s foundation, Club for the Future.

The crew of NS-18. Pictured left to right: Dr. Chris Boshuizen, William Shatner, Audrey Powers, and Glen de Vries.

Now official astronauts, the crew was welcomed back from space with a celebration in the West Texas desert with family, friends, and the Blue Origin team.
(Cover Story) Blue Origin successfully and safely completes second human flight to space and back

“At Blue Origin, we are motivated by the dreamers that inspire us and the builders who turn those dreams into reality. Today’s crew represented both dreamers and builders. We had the honor of flying our very own Audrey Powers, Vice President of New Shepard Operations, who fulfilled a lifelong dream to go to space and has been an integral part of building New Shepard. Our two customers, Chris Boshuizen and Glen de Vries, have built their own successful ventures and have now realized their own dreams of space travel. And, as everyone knows, William Shatner has played an important role in describing and imagining the wonders of universe and inspired many of us to pursue a career in the space industry,” said Bob Smith, CEO Blue Origin. “This flight was another step forward in flying astronauts safely and often. It’s an incredible team and we are just getting started.”

Blue Origin is planning one more crewed flight this year, with several more crewed flights planned for 2022. If you are interested in flying on New Shepard, please visit our website. If you are interested in purchasing a commemorative patch or other merchandise, head to the Blue Origin Shop.

Key Mission Statistics:

- Crew capsule apogee: 347,539 ft AGL / 351,186 ft MSL (106 km AGL / 107 km MSL)
- Booster apogee: 347,160 ft AGL / 350,807 ft MSL (106 km AGL / 107 km MSL)
- Official launch time: 9:49 AM CDT / 14:49 UTC
- CC Landing Time: 9:59 AM CDT / 14:59 UTC
- Mission elapsed time: 10 min 17 sec
- Max ascent velocity: 2,235 mph / 3,597 km/h

You can also watch a full replay of today's flight below. [https://www.youtube.com/watch?v=uEhdI1or-do](https://www.youtube.com/watch?v=uEhdI1or-do)
(Cover Story) Blue Origin successfully and safely completes second human flight to space and back

Blue Origin NS18 Lift Off

Booster Landing

Inside the Capsule at Apogee

Audrey Powers at Apogee

William Shatner at Apogee
(Cover Story) Blue Origin successfully and safely completes second human flight to space and back
NEW SHEPARD

Named after astronaut Alan Shepard, the first American in space, New Shepard is Blue Origin's fully reusable, suborbital rocket system built for human flight from the beginning. During the 11-minute journey, astronauts soar past the Kármán Line (100 km/62 miles), the internationally recognized boundary of space, experiencing several minutes of weightlessness and witnessing life-changing views of Earth through windows that take up more than one-third of the capsule's surface area. Every person on board is a crew member—there are no pilots.

New Shepard's historic first human flight took place on July 20, 2021 with four private citizens onboard. The crew included Jeff Bezos, his brother, Mark Bezos, aviation pioneer Wally Funk, and Oliver Daemen, Blue Origin's first paying customer.

New Shepard's second human flight (NS-18) took place on October 13, 2021. The crew included a former NASA engineer and co-founder of Planet Labs Dr. Chris Boshuizen, Life Sciences & Healthcare, Dassault Systèmes and co-founder, Medidata Glen de Vries, Vice President of Mission & Flight Operations Audrey Powers, and actor William Shatner.

All the learnings from the New Shepard program are applied to Blue Origin's orbital launch vehicle, New Glenn, and the Blue Moon lunar lander. Both vehicles leverage New Shepard's autonomy, guidance, vertical landing architecture, powerful and throttleable liquid engines, and lean operations.

FLIGHT HISTORY
To date, New Shepard has completed 18 consecutive successful launches, 17 consecutive successful booster landings, 3 successful crew capsule escape tests and 19 consecutive successful crew capsule landings, including a pad escape test in 2012. Every New Shepard flight since the beginning has been integral to verifying and proving out the capabilities of the vehicle with the first and foremost focus on safety.

SPECIFICATIONS
- 60-feet-tall, fully reusable, autonomous rocket with a crew capsule measuring 530 cubic feet with room for up to six people or research payloads.
- Launches from Blue Origin's Launch Site One in Van Horn, TX. at 3,700 feet mean sea level (MSL).
- Booster is powered by the BE-3MP liquid oxygen/liquid hydrogen rocket engine with 110,000 lbf (489 kN) of thrust. The engine is also environmentally friendly, the only byproduct of New Shepard's engine combustion is water vapor with no carbon emissions.
- Accelerates to more than Mach 3 and experiences forces equal to three times Earth's gravitational force.

FLIGHT PROFILE
The capsule and booster take off vertically. The capsule separates near space at about 250,000 feet (76 km) and continues to space to reach an apogee of 350,000 feet (106 km). The booster autonomously makes its way back to Earth for a pinpoint landing on the pad about two miles away from where the vehicle lifted off.

The capsule then enters a stable freefall back to Earth. To slow down the vehicle for landing, three drogue chutes are deployed several thousand feet above Earth prior to the capsule's three main chutes. Just before touchdown, a retro-thrust system expels a cloud of air beneath the capsule to create a gentle landing around 1 mph (1.6 kph) in the West Texas desert.
(Cover Story) Blue Origin successfully and safely completes second human flight to space and back

CUSTOMER ASTRONAUT PROGRAM MILESTONES

- October 13, 2021: Blue Origin successfully completed New Shepard’s second human flight (NS-18) with four private citizens onboard. The crew included William Shatner, Audrey Powers, Dr. Chris Boshuizen and Glen de Vries, who all became astronauts when they passed the Kármán Line. Upon completion of the flight, William Shatner, 90, became the oldest person to fly in space.

- July 20, 2021: Blue Origin successfully completed New Shepard’s first human flight with four private citizens onboard. The crew included Jeff Bezos, Mark Bezos, Wally Funk and Oliver Daemen, who all became astronauts when they passed the Kármán Line. Upon completing the flight, Funk, 82, at the time, she became the oldest person to fly in space, while Daemen, 18, became the youngest.

- May 5, 2021: Blue Origin announced the opportunity to bid on the very first seat on New Shepard. The winning bid was $28 million, announced on June 12, 2021. Blue Origin donated the winning bid to its foundation, Club for the Future, which then awarded 19 space-focused charities $1 million each to inspire future generations to pursue careers in STEM and help invent the future of space.

- April 14, 2021: Blue Origin personnel standing in as astronauts entered the capsule prior to launch for the first time. The astronauts conducted a series of tests from within the capsule, including a comms check with the Capsule Communicator (CAPCOM), procedures for entering and exiting the capsule, and pre-launch preparations within the capsule.

- November 23, 2015: New Shepard became the first fully reusable, vertical take-off/vertical landing space vehicle. That booster successfully flew five times before retirement.

SYSTEM SAFETY

New Shepard’s initiated crewed operations once its extensive test and safety program concluded in April 2021 following 15 consecutive successful missions. The vehicle’s core safety components include:

- **Crew Escape System**: Drawing from the Mercury and Apollo programs, New Shepard is equipped with a crew escape system which pushes the capsule away from the booster in the unlikely event an issue is detected. The system has been tested three times successfully from the launch pad, mid-flight and in the vacuum of space, demonstrating the system can activate safely in any phase of flight.

- **Redundant Landing Systems**: A robust landing safety design with multiple redundancies engineered into the capsule from the beginning and tested throughout the program. The capsule can land with two of its three chutes out, and the seats have been designed to flex and absorb g-forces in the unlikely event of an off-nominal landing.

VEHICLES IN SERVICE

Blue Origin has two fully reusable New Shepard vehicles in service today to support astronaut and payload customer operations. The vehicle dedicated to astronaut customer operations debuted on January 14, 2021, and has flown three times. The vehicle dedicated to operational payloads entered service on December 12, 2017, and has flown eight times. Additional New Shepard vehicles are currently in production to meet the demand of astronaut and payload customer operations. Minimal refurbishment is required between flights. Full reusability is essential to lowering the cost of access to space.
NASA, ULA Launch Lucy Mission to ‘Fossils’ of Planet Formation

2021 October 16


(Left) A United Launch Alliance Atlas V rocket with the Lucy spacecraft aboard is seen in this 2 minute and 30 second exposure photograph as it launches from Space Launch Complex 41, Saturday, Oct. 16, 2021, at Cape Canaveral Space Force Station in Florida. Lucy will be the first spacecraft to study Jupiter’s Trojan Asteroids. Like the mission’s namesake – the fossilized human ancestor, "Lucy," whose skeleton provided unique insight into humanity's evolution – Lucy will revolutionize our knowledge of planetary origins and the formation of the solar system. Credits: NASA/Bill Ingalls

NASA’s Lucy mission, the agency’s first to Jupiter’s Trojan asteroids, launched at 5:34 a.m. EDT Saturday on a United Launch Alliance (ULA) Atlas V rocket from Space Launch Complex 41 at Cape Canaveral Space Force Station in Florida.

Over the next 12 years, Lucy will fly by one main-belt asteroid and seven Trojan asteroids, making it the agency’s first single spacecraft mission in history to explore so many different asteroids. Lucy will investigate these “fossils” of planetary formation up close during its journey.

“Lucy embodies NASA’s enduring quest to push out into the cosmos for the sake of exploration and science, to better understand the universe and our place within it,” said NASA Administrator Bill Nelson. “I can’t wait to see what mysteries the mission uncovers!”

About an hour after launch, Lucy separated from the second stage of the ULA Atlas V 401 rocket. Its two massive solar arrays, each nearly 24 feet (7.3 meters) wide, successfully unfurled about 30 minutes later and began charging the spacecraft’s batteries to power its subsystems.

“Today’s launch marks a genuine full-circle moment for me as Lucy was the first mission I approved in 2017, just a few months after joining NASA,” said Thomas Zurbuchen, associate administrator for the Science Mission Directorate at the agency’s Headquarters in Washington. “A true mission of discovery, Lucy is rich with opportunity to learn more about these mysterious Trojan asteroids and better understand the formation and evolution of the early solar system.”
NASA, ULA Launch Lucy Mission to ‘Fossils’ of Planet Formation

Lucy sent its first signal to Earth from its own antenna to NASA’s Deep Space Network at 6:40 a.m. The spacecraft is now traveling at roughly 67,000 mph (108,000 kph) on a trajectory that will orbit the Sun and bring it back toward Earth in October 2022 for a gravity assist.

Named for the fossilized skeleton of one of our earliest known hominin ancestors, the Lucy mission will allow scientists to explore two swarms of Trojan asteroids that share an orbit around the Sun with Jupiter. Scientific evidence indicates that Trojan asteroids are remnants of the material that formed giant planets. Studying them can reveal previously unknown information about their formation and our solar system’s evolution in the same way the fossilized skeleton of Lucy revolutionized our understanding of human evolution.

“We started working on the Lucy mission concept early in 2014, so this launch has been long in the making,” said Hal Levison, Lucy principal investigator, based out of the Boulder, Colorado, branch of Southwest Research Institute (SwRI), which is headquartered in San Antonio. “It will still be several years before we get to the first Trojan asteroid, but these objects are worth the wait and all the effort because of their immense scientific value. They are like diamonds in the sky.”

Lucy’s Trojan destinations are trapped near Jupiter’s Lagrange points – gravitationally stable locations in space associated with a planet’s orbit where smaller masses can be trapped. One swarm of Trojans is ahead of the gas giant planet, and another is behind it. The asteroids in Jupiter’s Trojan swarms are as far away from Jupiter as they are from the Sun.

The spacecraft’s first Earth gravity assist in 2022 will accelerate and direct Lucy’s trajectory beyond the orbit of Mars. The spacecraft will then swing back toward Earth for another gravity assist in 2024, which will propel Lucy toward the Donaldjohanson asteroid – located within the solar system’s main asteroid belt – in 2025.

Lucy will then journey toward its first Trojan asteroid encounter in the swarm ahead of Jupiter for a 2027 arrival. After completing its first four targeted flybys, the spacecraft will travel back to Earth for a third gravity boost in 2031, which will catapult it to the trailing swarm of Trojans for a 2033 encounter.

“Today we celebrate this incredible milestone and look forward to the new discoveries that Lucy will uncover,” said Donya Douglas-Bradshaw, Lucy project manager at NASA’s Goddard Space Flight Center in Greenbelt, Maryland.

NASA Goddard provides overall mission management, systems engineering, plus safety and mission assurance. Lockheed Martin Space in Littleton, Colorado, built the spacecraft. Lucy is the 13th mission in NASA’s Discovery Program. NASA’s Marshall Space Flight Center in Huntsville, Alabama, manages the Discovery Program for the agency.

For more information about NASA’s Lucy mission, visit:

https://www.nasa.gov/mission_pages/lucy/overview/index
(October 20) Poetry of the Night: A Nightwatchman’s Journey,
by Dr. David H. Levy (Comet and Asteroid Hunter, Co-Discoverer, Shoemaker-Levy 9)
(Screenshots Only) [https://engage.aiaa.org/losangeles-lasvegas/viewdocument/2021-october-20-poetry-of-the-nig]

Dr. David H. Levy has a Ph.D. and (his lifetime passion) in Literature and Astronomy. Right: Shoemaker Levy - 9 impacting Jupiter in 1994.

This lecture is the 2180th of Dr. Levy’s since his first in the 1960s. It’s the magic number.

Upper Right: Prof. Madhu Thangavelu introducing Dr. Levy & moderating Q&A; Bottom: Dr. Nahum Melamed (Planetary Defense Project Lead in Aerospace Corporation) asking questions.
A few weeks ago, I received a message from Cameron Gillis, an amateur astronomer who wrote that he liked galaxies. Just for fun, I decided to take the opposite approach, a philosophical reversal. If he likes galaxies, then I hate them. As we prepared for our meeting I began to explain the various reasons why I hate them. When, for example, I am observing with a telescope and the Andromeda galaxy enters my field of view, I quickly leave the telescope and ride my bicycle to the end of our driveway and back. The more I stretch the story the greater the laughter becomes. I especially get annoyed by the dark Hydrogen-II regions that stretch across its hideous girth. The cluster of galaxies in the Virgo cluster, particularly Messiers 84 and 86, are so bland that I sometimes have to leave the telescope altogether!

The worst galaxy is our own. When I look up at the evening sky, the Milky Way obstructs my view as it straddles the night from Cassiopeia all the way down to Sagittarius. The stars are so thick that I can hardly see black sky between them. Except of course, when I come across Baade’s window. This area of sky rattles me because there, some darkness appears. Discovered by Walter Baade, this window allows us to see almost to the center of our galaxy. It is an awful sight. The majesty of the night is nowhere more apparent than when I am viewing the center of our galaxy, in Scorpius and in Sagittarius, through my telescope. It is wondrous. So wondrous that I still hate it. Because it wastes my time when I am mesmerized by it, the emotion of viewing the galaxy from my backyard is so strong that it strengthens my heart and pierces my soul.
Galaxies, just for the sake of argument

The worst part of seeing our own galaxy on a clear autumn night is that the dark lanes of hydrogen dust straddle its length. Dark areas are called giant molecular clouds. They are not lit by nearby stars; they just are there. In the far distant future, they will generate new systems of stars and planets like our Earth. They are called giant molecular clouds or Hydrogen (H II) regions.

In distant external galaxies, dark clouds like these can straddle their whole length. The Andromeda galaxy has several of these H II regions that one can observe through a small telescope if one looks carefully enough.

Deep in the southern sky, but still visible from most of North America, lies Caroline Herschel’s galaxy. It is No. 253 in the NGC, the New General Catalogue. Under a bright sky it is hardly anything, but from a dark site it resembles a long resting caterpillar. It has a most prominent dark hydrogen lane running across its length.

Along with globular star clusters, those round conglomerations of hundreds of thousands of stars that orbit the outskirts of galaxies, including our own, galaxies are the oldest structures in the Universe. The oldest ones started to build within half a million years of the Big Bang, when the Universe was in its infancy.

So much for hating galaxies. When I say that I hate them, I write merely for the sake of argument and humor. Galaxies are almost like people, each one different, each one with its special characteristics. One way of looking at them is to compare their gigantic sizes with our puny selves. But there is another way. Small as we may be, each of us is unique. Galaxies are huge, but aside from their differing shapes, they are still much alike. But in all this Universe, among all these galaxies, there is just one, only one, of each of us. Our ideas, our personalities, are precious.
THE GREAT ‘WHAT-IFS’ OF USC ENGINEERING

Six alternate scenarios that might have reshaped the Trojan engineer-iverse

by Adam Smith, Viterbi Magazine, Fall 2021 (with permission)

https://magazine.viterbi.usc.edu/fall-2021/features/the-great-what-ifs-of-usc-engineering/

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1) What if Zohrab Kaprielian had been left behind as a baby?

One of the most transformational deans in USC Viterbi’s history, Zohrab A. Kaprielian — who also served as USC’s provost and executive vice president during the 1970s — galvanized the school into a major research institution.

After convincing the U.S. Department of Defense in 1962 to award USC one of the coveted Joint Services Electronics Programs, Kaprielian assembled the school’s renowned “Magnificent Seven” communications faculty: Solomon Golomb, Bob Scholtz, Irving Reed, Charles Weber, William Lindsey, Lloyd Welch and Bob Gagliardi. Kaprielian also supported visionary projects like the Distance Education Network (DEN@Viterbi) and the USC Information Sciences Institute.

But it almost never happened.

Zohrab Kaprielian, USC Viterbi’s fourth dean, played a pivotal role in the school’s evolution as a top 10 ranked program. However, as the child of Armenian refugees, he was almost left behind by his parents in southeastern Turkey.
THE GREAT ‘WHAT-IFS’ OF USC ENGINEERING

Six alternate scenarios that might have reshaped the Trojan engineer-iverse

Born in 1923, Kaprielian, the son of Armenian refugees, was left behind in his crib when his childhood home was attacked by marauders. His family fled in panic, only to remember the missing baby several hours later. When his parents returned to the Turkish city of Aintab (present-day Gaziantep), they discovered the infant Zohrab still in his crib, “surrounded by a hail of bullets,” according to Archbishop Vache Hovsepian in his 1982 memorial remarks for Kaprielian. Resettling in Syria, young Kaprielian attended primary school in rags. Despite this, he was always first in his class — though his primary school trustees nearly refused to let such a destitute student deliver the valedictory speech.

He earned his bachelor’s and master’s degrees in applied physics in 1942 and 1943 from the American University of Beirut. According to his niece, Arpine Deraney, Kaprielian may have been aided by AUB or UC Berkeley in coming to the United States after World War II, where, at Berkeley, he received his Ph.D. in electrical engineering in 1954. He came to USC in 1957, and the rest is Trojan history.

2) What if Judith Love Cohen hadn’t worked for the space program?

Judith Love Cohen, B.S. ’57, M.S. ’62, was a celebrated author of children’s books like “You Can Be a Woman Engineer.” She was the mother of Neil Siegel, a member of the National Academy of Engineering and a USC Viterbi faculty member, as well as the actor and musician, Jack Black. But perhaps her proudest achievement, according to Cohen’s son, Neil, was working on the Apollo space program.

As an engineer for TRW (Thompson Ramo Wooldridge Inc.), a subcontractor on the Apollo missions, Cohen was a member of the team that created the abort guidance system, or AGS, an early digital computer that had a very important job. Much of the maneuvering and flight of the Apollo spacecraft was planned and computed well in advance. But in the event of an aborted moon landing, the AGS could provide the necessary calculations to allow the lunar lander, with its two astronauts on board, to safely return to the command module, where a third astronaut awaited in lunar orbit.
THE GREAT ‘WHAT-IFS’ OF USC ENGINEERING
Six alternate scenarios that might have reshaped the Trojan engineer-iverse

During the Apollo 13 mission in 1970, the oxygen tank exploded, destroying the ship’s engine, life support and power systems, and forcing the three astronauts, Jim Lovell, Jack Swigert and Fred Haise, to use the lunar lander as a “lifeboat.” With no power for the command module’s primary navigation computer, the crew relied entirely on the lander’s AGS to plot 238,000-mile trip back to Earth, including two course corrections. In addition, Cohen was part of TRW’s “orbitology” team that designed the trajectory paths to get the astronauts from the Earth to the Moon and back. Without this, the AGS would have been useless.

Cohen’s son, Neil Siegel, recalled: “After they returned to Earth, the Apollo 13 astronauts came to TRW in Redondo Beach to thank the three TRW teams — orbitology, LEM descent engine and LEM abort guidance system — that also helped get them home. I was just a teenager, but my mom took me to that event.”

3) What if Charlie Bolden hadn’t watched “Men of Annapolis”?

Growing up in segregated South Carolina, 12-year-old Charles Bolden fell in love with the sharp suits and tradition of the U.S. Naval Academy through the 1957 television series “Men of Annapolis.” Every episode opened with the words: “These are their stories, full of their laughter, their heartache, their tragedies and triumphs … the stories of the Men of Annapolis!”

Inspired, Bolden wrote to both his senators and to Lyndon Johnson, then vice president of the United States, seeking a necessary appointment in the academy. Said Bolden, “I wanted them to know, early on, who I was and that I was really serious about this.” Unfortunately, the responses from his congressmen, which included the segregationist Sen. Strom Thurmond, made it clear they were “not going to appoint a Black to the academy,” Bolden said. Still, he was hopeful that LBJ would appoint him. That is, until November 22, 1963, when he learned — on the way to Charleston to play for the state football championship — that John F. Kennedy had been assassinated, and Johnson was now the president.

“My world stopped,” Bolden told the “Consider the Cosmos” podcast in 2020, “and it was selfish. Not only had we lost the president we all loved, but I had lost any hope of going to the Naval Academy. Johnson was going to become president, and I wasn’t eligible for a presidential appointment.”
Undeterred, Bolden wrote to the new president. Within weeks, a Navy recruiter was knocking on Bolden’s door, leading to an appointment from U.S. Rep. William L. Dawson from Chicago.

After graduating from the Academy, Bolden became a Marine aviator and test pilot, eventually earning his master’s in systems management from USC in 1977. In 1980, Bolden got the call from NASA and replaced a crisp Marine Corps Nomex flight suit for a spacesuit, which he wore on four Space Shuttle missions from 1986 to 1994. In 2009, Bolden received one more presidential appointment: President Obama nominated him to become the 12th Administrator of NASA. With his Senate confirmation, he became the only African American to hold that post in the agency’s 63-year history.

4) What if Mike Gruntman had not escaped the Soviet Union?

Mike Gruntman, USC Viterbi professor of astronautics and aerospace and mechanical engineering, has helped build one of the largest academic space engineering programs in the United States. It’s the lifeblood of private space companies like SpaceX and Virgin Galactic. It’s the home of the USC Rocket Propulsion Laboratory, which in 2019 launched the first student-built rocket to outer space. It’s the first and only university to offer a B.S., M.S. and Ph.D. in astronautical engineering.
THE GREAT ‘WHAT-IFS’ OF USC ENGINEERING
Six alternate scenarios that might have reshaped the Trojan engineer-iverse

It’s perhaps no exaggeration to say the department would not exist without Gruntman. But what if he had never escaped the Soviet Union?

In an alternate world, Gruntman should have been a favorite son of the Soviet space program. As a 3-year-old raised in Tyuratam — a secret location deep in present-day Kazakhstan — he was one of the world’s few witnesses to the launch of Sputnik in 1957, the first man-made satellite. His father was the chief engineer who built the cosmodrome, or Russian spaceport, from which Sputnik launched.

But though he earned his Ph.D. in physics from the Space Research Institute of the USSR Academy of Sciences and worked as a researcher for the IKI and IPM institutes, Gruntman turned anti-communist at an early age. In 1984, he tasted tear gas for the first time, aiding the Polish Solidarity movement against riot police imposing martial law in Gdansk. When the “cracks developed in the Iron Curtain,” Gruntman found himself in a Dutch airport in March 1990. Three days later, with 80 in his pocket, Gruntman walked into a new office and new life at USC.

Though Gruntman is not ready to share the exact details of his complex escape plan, he relied heavily on the support of colleagues and friends from six countries on three continents. One of these was Darrell Judge ’63, Ph.D. ’65, professor emeritus of physics and astronomy and astronautical engineering at the USC Dornsife College of Letters, Arts and Sciences. Judge, Gruntman recalled, helped him escape from the former Soviet Union and make the transition to the scientific community at USC.
THE GREAT ‘WHAT-IFS’ OF USC ENGINEERING
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“Darrell’s generosity, hospitality and friendship have touched the lives of many people, including mine,” Gruntman said. “As I started my life from scratch in the U.S., he warmly welcomed me to his group at USC and offered the hospitality of his home during my first week in Los Angeles.”

Gruntman would go on to map the interstellar frontier of our solar system in 2008 (a project he began at age 24!) as part of the IBE spacecraft team. But none of it would’ve been possible without first reaching a new terrestrial frontier in Southern California.

5) What if A.C. “Mike” Markkula did something else on Mondays?

“A lot of people wouldn’t invest in Apple, wouldn’t even talk to Apple, because Steve Jobs was so odd,” recalled venture capitalist Don Valentine, founder of Sequoia Capital.

Nolan Bushnell, founder of Atari (where Jobs worked) said no. Tom Perkins, co-founder of Kleiner Perkins, said he “very foolishly didn’t even look at Steve and Apple co-founder Steve Wozniak.” Although Valentine dismissed Jobs and Wozniak as “renegades from the human race,” he did refer them to an old colleague from his Fairchild days.

That colleague was A.C. “Mike” Markkula Jr., who was arguably the first to recognize the full potential of the Apple II.

Markkula, B.S. EE ’64; M.S. EE ’66, a millionaire from stock options as an Intel marketing manager, spent his days teaching himself to read music for guitar and building custom wood furniture for his A-frame cabin in Lake Tahoe.

“Every Monday, I’d help people write business plans and find financing to start companies. I thought it was fun. But I only did it Mondays,” Markkula said.

One Monday, he pulled into the driveway of Paul and Clara Jobs’ home in Los Altos. Markkula entered the garage, looked past their unkempt 22-year-old son, Steve, and his buddy, Steve Wozniak, and pondered the machine on the workbench.
THE GREAT ‘WHAT-IFS’ OF USC ENGINEERING
Six alternate scenarios that might have reshaped the Trojan engineer-iverse

Markkula, the USC trained engineer, knew it was “a massive achievement.” He came out of retirement and wrote Apple’s original business and marketing plans. He made the original 250,000 investment that launched Apple and leveraged his professional experiences and relationships to help build Apple into a Fortune 500 company in less than five years. For over 20 years, Markkula led Apple in various capacities, from CEO to chairman of the board, leading to Jobs’ ultimate return in 1997.

“Steve and I get a lot of credit, but Mike Markkula was probably more responsible for our early success, and you never hear about him,” Steve Wozniak told Failure Magazine in July 2000.

Today, with a market capitalization of 2.1 trillion, Apple is the biggest company in the world. But it might never have existed as the behemoth we know today without Markkula, its lesser-known co-founder.

6) What if UCLA had moved faster the day Keith Uncapher had called?

In 1972, technology maverick Keith Uncapher received an unusual offer. His work at Santa Monica, California-based think tank RAND Corp., where Uncapher directed the computer science division, had drawn the attention of the United States’ Defense Advanced Research Projects Agency (DARPA). Create and lead a center for emerging technologies, said DARPA officials, and the agency would provide financial support.

Uncapher initially approached the University of California at Los Angeles, where he was told it would take 15 months to receive approval from the UC Board of Regents. But given DARPA’s interest, Uncapher felt he had no time to waste.
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He appealed to George Bekey, chair of electrical engineering systems at USC and a consultant to RAND. Bekey helped arrange for Uncapher to meet with USC’s dean of engineering, Zohrab A. Kaprielian, who wielded considerable influence — and who thought Uncapher’s concept had tremendous promise.

USC’s Board of Trustees authorized the center just five days later. In less than a month, the Information Sciences Institute, or ISI, launched operations as a largely autonomous arm of USC’s School of Engineering. At Uncapher’s insistence, the new center was located off campus to maximize its entrepreneurial bent.

From its 12-story, oceanfront building in Marina Del Rey, ISI conceived wonders. In 1972, ISI designed an interface for ARPANET, which later becomes the basis of the internet. In 1981, Danny Cohen created MOSIS, probably the world’s first e-commerce site. Two years later, Paul Mockapetris created the internet’s Domain Name System (DNS), enshrining .com, .gov and .edu, among others. In 2011, ISI established the USC-Lockheed Martin Quantum Computation Center, the first academic research center in quantum computing. In 2016, Pegasus software, whose development is led by Ewa Deelman, was instrumental in detecting gravitational waves, contributing to a recent Nobel Prize.

Today, ISI is USC’s crown jewel research institute. But nearly 50 years ago, it might have been UCLA’s.
Hubble Captures Mesmerizing Detail of Two Galaxies on a Collision Course

by Michelle Starr, Senior Journalist at ScienceAlert, 2021 October 11 (with permission)

https://www.sciencealert.com/two-galaxies-on-a-collision-course-have-been-captured-by-hubble

Around 100 million light-years away, two galaxies are giving astronomers a sneak preview of the fate of the Milky Way.

So close that they are categorized under a single name, Arp 91, the spiral galaxies NGC 5953 and NGC 5954 are in the process of merging, with material from the latter extending towards and into the former. Details of this merger are visible in a new image from the Hubble Space Telescope.

Gradually, the two galaxies will join together, becoming one big elliptical galaxy, according to our models of these colossal cosmic interactions. That's how we expect the Milky Way to end up, too, when it eventually merges with our own closest galactic neighbor, the spiral galaxy Andromeda.

Arp 91. (ESA/Hubble & NASA, J. Dalcanton; Acknowledgement: J. Schmidt)
Hubble Captures Mesmerizing Detail of Two Galaxies on a Collision Course

Actually, galactic mergers are not uncommon in the Universe. Space is large, and you might think that things wouldn't bump into other things terribly often, but galaxies are not adrift in a sea of nothing. They're often connected by vast filaments of intergalactic gas, which can act as matter highways along which galaxies are drawn together across the void.

We've spotted many such galactic collisions, but they take place on a time scale of around a billion years, so any one collision in isolation won't reveal the entirety of the process. However, each one is a snapshot of one moment in the process; by studying the collisions collectively, we can piece together the sequence of events, as seen in the 2016 simulation below.

Arp 91 is at a stage where the two galaxies haven't yet been significantly disrupted; their spiral structures are still largely intact. However, their interaction has triggered a burst of star formation in both galaxies, as inflowing gas generates shocks in clouds of molecular star-forming gas, pushing it into denser clumps that collapse under their own mass to form baby stars.

In addition, both galaxies have active galactic nuclei; that is, the supermassive black holes at their centers are actively devouring material. This process generates powerful black hole winds that push out into the surrounding gas, which – you guessed it – generates shocks that trigger star formation. So the two galaxies are very busy places indeed.
Hubble Captures Mesmerizing Detail of Two Galaxies on a Collision Course

Eventually, the two will merge, their spiral structures dissolving into a bright, nearly featureless type of galaxy called an **elliptical galaxy**. That, however, is at least a few hundred million years away. Whether humanity will be around to see it is an open question.

The merger between the Milky Way and Andromeda is even further. Scientists predict that it will start taking place around **4.5 billion years from now**. We have very little to worry about, however; by that time, humanity will almost certainly be dead, gone, or unrecognizable.

But isn't it nice to know what will happen to the place after we're gone?

You can download Hubble's image of Arp 91 in full resolution or wallpaper versions from the ESA Hubble website.

**About the author:**

Michelle Starr is a Senior Journalist at ScienceAlert; her deep love and curiosity for the cosmos has made the publication a world leader in reporting developments in space research.

She is an award-winning journalist with over 15 years of experience in the science and technology sectors. Prior to joining the ScienceAlert team in 2017, she worked for seven years at CNET, where she created the role of Science Editor.

Her work has appeared in The Best Australian Science Writing 2018 and 2020 anthologies, and in 2014, she was awarded the Best Consumer Technology Journalist in the Optus IT Journalism Awards.

She absolutely adores orcas, corvids, and octopuses, and would be quite content to welcome any one of them as the new overlords of Earth.
Blue Origin and Sierra Space developing commercial space station
by Blue Origin, 2021 October 25 (with permission)

New Orbital Destination Opens Up Space For Business And Travel, Creating New Ecosystem

Blue Origin and Sierra Space today announced plans for Orbital Reef, a commercially developed, owned, and operated space station to be built in low Earth orbit. The station will open the next chapter of human space exploration and development by facilitating the growth of a vibrant ecosystem and business model for the future. Orbital Reef is backed by space industry leaders and teammates including Boeing, Redwire Space, Genesis Engineering Solutions, and Arizona State University.

Designed to open multiple new markets in space, Orbital Reef will provide anyone with the opportunity to establish their own address on orbit. This unique destination will offer research, industrial, international, and commercial customers the cost competitive end-to-end services they need including space transportation and logistics, space habitation, equipment accommodation, and operations including onboard crew. The station will start operating in the second half of this decade.

Orbital Reef will be operated as a “mixed use business park” in space. Shared infrastructure efficiently supports the proprietary needs of diverse tenants and visitors. It features a human-centered space architecture with world-class services and amenities that is inspiring, practical, and safe. As the premier commercial destination in low Earth orbit, Orbital Reef will provide the essential infrastructure needed to scale economic activity and open new markets in space. Reusable space transportation and smart design, accompanied by advanced automation and logistics, will minimize cost and complexity for both traditional space operators and new arrivals, allowing the widest range of users to pursue their goals. The open system architecture allows any customer or nation to link up and scale to support demand. Module berths, vehicle ports, utilities, and amenities all increase as the market grows.
Blue Origin and Sierra Space developing commercial space station

The Orbital Reef business model makes it easy for customers and is strategically designed to support a diverse portfolio of uses. The team has all the services and systems to meet the needs of emergent customers, including researchers, manufacturers, and visitors. Orbital Reef offers standard interfaces at all levels – locker, rack, and module. Seasoned space agencies, high-tech consortia, sovereign nations without space programs, media and travel companies, funded entrepreneurs and sponsored inventors, and future-minded investors all have a place on Orbital Reef.

- The Orbital Reef team of experts brings proven capabilities and new visions to provide key elements and services, including unique experience from building and operating the International Space Station:
  - Blue Origin – Utility systems, large-diameter core modules, and reusable heavy-lift New Glenn launch system.
  - Sierra Space - Large Integrated Flexible Environment (LIFE) module, node module, and runway-landing Dream Chaser spaceplane for crew and cargo transportation, capable of landing on runways worldwide.
  - Boeing – Science module, station operations, maintenance engineering, and Starliner crew spacecraft.
  - Redwire Space – Microgravity research, development, and manufacturing; payload operations and deployable structures.
  - Genesis Engineering Solutions – Single Person Spacecraft for routine operations and tourist excursions.
  - Arizona State University – Leads a global consortium of universities providing research advisory services and public outreach.
Blue Origin and Sierra Space developing commercial space station

“For over sixty years, NASA and other space agencies have developed orbital space flight and space habitation, setting us up for commercial business to take off in this decade,” said Brent Sherwood, Senior Vice President of Advanced Development Programs for Blue Origin. “We will expand access, lower the cost, and provide all the services and amenities needed to normalize space flight. A vibrant business ecosystem will grow in low Earth orbit, generating new discoveries, new products, new entertainments, and global awareness.”

“Sierra Space is thrilled to partner with Blue Origin and provide the Dream Chaser spaceplane, the LIFE module and additional space technologies to open up space for commercial research, manufacturing, and tourism. As a former NASA astronaut, I’ve been waiting for the moment where working and living in space is accessible to more people worldwide, and that moment has arrived,” said Dr. Janet Kavandi, former three time NASA astronaut and Sierra Space president.

“This is exciting for us because this project does not duplicate the immensely successful and enduring ISS, but rather goes a step further to fulfill a unique position in low Earth orbit where it can serve a diverse array of companies and host non-specialist crews,” said John Mulholland, Boeing VP and program manager for the International Space Station. “It calls for the same kind of expertise we used to first design and then build the International Space Station and the same skills we employ every day to operate, maintain and sustain the ISS.”

“The Orbital Reef represents the next evolution of the commercial space paradigm by creating the first ever crewed private sector platform in low Earth orbit. The Orbital Reef will carry forward the singular legacy of the ISS, supporting innovative microgravity research, development, and manufacturing activities which will advance fields as diverse as communications and biotechnology,” said Mike Gold, Executive Vice President for Civil Space and External Affairs at Redwire. “The microgravity environment presents an entirely new arena for commercial and scientific development, making Orbital Reef the platform that will launch new technologies and capabilities dramatically improving life on Earth while enabling humanity’s journey to the stars.”

“The Single Person Spacecraft will transform space walking,” said Brand Griffin, Program Manager for Genesis Engineering Solutions. “Space workers and tourists alike will have safe, comfortable, and quick access outside Orbital Reef. Shirtsleeve environment, great visibility, automated guidance, and advanced precision manipulators will make external operations cost-effective and routine.”

“ASU’s Interplanetary Initiative is honored to be leading the university consortium that is supporting Orbital Reef,” said Lindy Elkins-Tanton, Vice President of ASU’s Interplanetary Initiative and Principal Investigator of the NASA Psyche mission. “We’ve brought together an international group of more than a dozen universities to work on the ethics and guidelines of research — on how we can bring to bear all our expertise in science and research and manufacturing in low gravity, to help nations, corporations and groups that want access to Orbital Reef. It’s about collectively believing in our future and bringing science and engineering to bear on a better future – hugely exciting.”
Blue Origin and Sierra Space developing commercial space station

Orbital Reef University Advisory Council

Arizona State University (ASU) leads a global consortium of universities, the Orbital Reef University Advisory Council. Comprising more than a dozen leading academic institutions with expertise in space and microgravity research, the University Research Advisory Council will focus academic community needs, stimulate research, advise novice researchers, evolve standards of conduct, and lead STEM outreach.

• University Advisory Council members include:
  • Arizona State University
  • Colorado School of Mines
  • International Space University
  • Oxford University
  • Purdue University
  • Southwest Research Institute
  • Stanford University
  • University of Central Florida
  • University of Colorado at Boulder
  • University of Florida
  • University of Michigan
  • University of Texas at El Paso
  • University of Texas Medical Branch
  • Vanderbilt University
Dr. Dittmar talked about Space Policy 101 and the U.S. Space Policy, with the first enacted by Pres. Eisenhower's administration.

Dr. Dittmar explaining the U.S. Space Policy, with the examples of Commercial Space and the Human Space Flight.

Dr. Dittman talking briefly about Axiom Space and it's plan. She also answered many great questions, as well as giving great recommendations and suggestions for AIAA on Space policy.
Attendees taking turns chatting about interesting topics like the Psyche Mission, James Webb Space Telescope update (arrival at the French Guiana), and COVID-19 booster shot/surge in UK, Russia, Singapore, etc., and the Delta Plus variant........

Attendees discussing also on some books, shown by Dr. Ken Saunders, from general relativity/cosmology, The Race Theory, and others.
(October 9) From geometry concerns to radar absorbing materials (RAM) inside Electronic Warfare: Improving aircraft tactics and survivability by Radar Cross Section (RCS) management (Screenshots Only)


Mr. Renan Richter showing the importance of air combat survivability, and the needs for Electronic Warfare, and RCS

RCS BASIC PRINCIPLES

Mr. Renan Richter explaining the RCS basic principles.

CASE OF STUDY

The speaker showing case studies, and addressing interesting questions (during Q&A).

Thank you!

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aiaa-lalv.org | aiaa-lasvegas.org
engage.aiaa.org/losangeles-lasvegas
(October 12) Space Agencies and Global Collaboration for Planetary Defense
(Screenshots Only)  

Those exciting speakers/panelists from around the world speaking out and discussing their efforts in their space agencies and the existing and future collaboration and its importance.

The speakers answering questions and discussing additional issues after individual brief presentations.

Here is the link to the Poll questionnaire (3 poll questions) mentioned during the event (the voting/survey site):

https://www.aiaa-lalv.org/2021_october_12_aiaa-la-lv_planetary_defense_polls/#

The details descriptions are listed there, as well as in the PDF file posted here on the AIAA LA-LV Engage Public Library for easy reference:

https://engage.aiaa.org/losangeles-lasvegas/viewdocument/october-12-poll

It is open for voting right now, and the poll will be for a month.
Airbus Zephyr Solar High Altitude Platform System (HAPS) reaches new heights in its successful 2021 summer test flights

by Airbus (with Permission) (2021 October 11)


- Achieved 36 days of stratospheric flight, across two 2021 flights, proving Zephyr’s status as the only HAPS able to perform at length in the stratosphere

- Set a new world record for absolute altitude for this class of UAS at 76,100ft.

- Secured and exercised FAA flight approvals operating inside the US National Airspace System (NAS)

- Demonstrated successful flight with multiple payload integrations and tested new OPAZ payload, streaming Earth observation data

- Proved Zephyr can operationalize the stratosphere, achieving some 2,435 total flight hours and demonstrating precise stratospheric manoeuvrability and station-keeping over points on the ground.

Munich, 11th October 2021 – The Airbus Zephyr S completes a successful 2021 test flight campaign in the United States. The final Airbus solar-powered High Altitude Platform System (HAPS) flight touched down on 13th September in Arizona, USA, ending the most ambitious and successful Zephyr flight campaign to date.

The flight campaign had a clear customer focus - to demonstrate how Zephyr could be used for future operations, flying outside of restricted airspace and over airspace shared with commercial air traffic. Carrying an Optical Advanced Earth Observation system for Zephyr (OPAZ) payload, Zephyr proved its operational value to provide instant, persistent, and improved situational awareness.
Airbus Zephyr Solar High Altitude Platform System (HAPS) reaches new heights in its successful 2021 summer test flights

“Working with Airbus and the Zephyr team during the 2021 flight campaign, significant progress has been made towards demonstrating HAPS as a capability. This summer’s activities represent an important step towards operationalising the stratosphere” said James Gavin, Future Capability Group Head at Defence Equipment & Support, the procurement arm of the UK Ministry of Defence.

“Defence investment in cutting edge technology is key to the development of world-leading military capabilities. Zephyr is an important programme within UK Strategic Command and the recent successful flight has required many innovative technical solutions. This represents a significant milestone for Zephyr which is informing the development of new concepts and ways of enabling military operations, particularly in the context of Multi-Domain Integration.” Said Major General Rob Anderton-Brown, Director Capability and MDI Change Programme at Strategic Command.

The campaign consisted of six flights in total, four low level test flights and two stratospheric flights. The stratospheric flights flew for around 18 days each, totaling more than 36 days of stratospheric flight in the campaign. This adds a further 887 flight hours to the 2,435 stratospheric flight hours for Zephyr to date, marks significant progress for fixed wing HAPS and is a step towards making the stratosphere an operational reality for its customers.

“Credible and proven ultra-persistence, stratospheric agility, and payload interoperability underscore why Zephyr is the leader in its sector. It is a sustainable, solar powered, ISR and network extending solution that can provide vital future connectivity and earth observation to where it is needed.” said Jana Rosenmann, Head of Unmanned Aerial Systems at Airbus.

Such an innovative and potentially game-changing capability is part of Airbus ambition to rapidly move towards operationalizing the stratosphere. “Carbon Neutral”, Zephyr uses sunlight to fly and recharge its batteries, using no fuel and producing no carbon emissions.

With its ability to remain in the stratosphere for months at a time, Zephyr will bring new see, sense and connect capabilities to both commercial and military customers. Zephyr will provide the potential to revolutionise disaster management, including monitoring the spread of wildfires or oil spills. It provides persistent surveillance, tracing the world’s changing environmental landscape and will be able to provide communications to the most unconnected parts of the world.
A proposed design for radiation shielding in interplanetary travel is presented with primary shielding created by a superconducting split toroid magnetic field and unconfined magnetic fields created by two deployable superconducting loops. The split toroid’s shielding effectiveness is analyzed with calculations of mass, field, particle path, and synchrotron radiation provided. The creation of plasma regions is also taken into consideration. The design has a wire mass of \(8.08 \times 10^4\) kg, which creates a 0.47 T shielding field, and a field less than \(2.17 \times 10^{-4}\) T in the crew area. Calculations show the shielding field deflects associated with particles of solar wind, solar flares, and high energy, high atomic number particles found in galactic cosmic radiation. This design might also be used to generate power and thrust from the radiation to create a potentially self-sufficient mobile station.

**Keywords:** Radiation Shielding, Interplanetary Travel, Magnetic Shielding

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### 1 INTRODUCTION

Interplanetary travel requires radiation shielding to protect astronauts and electronics. The radiation of most concern is that from the solar wind and solar flares, which produce solar energetic particles (SEP) and the radiation produced in galactic events such as supernovae known as galactic cosmic radiation (GCR). SEP radiation consists mainly of protons and electrons. GCR consists of ionized H, He, as well as high atomic number energetic particles (HZE) such as Fe^{26}, O^{18}, and C^{16}[1]. To shield these particles both their maximum energy and the energy of maximum flux need to be taken into consideration [2], as well as secondary radiation that might be produced during shielding.

Passive methods that have been considered include mass shielding [3], and active methods considered include creating plasmas [4], electric fields[5], and magnetic fields [6-11] surrounding the system. No one of these systems seems to be enough to sufficiently reduce radiation exposure. Ongoing research in new passive materials such as BNNT [3] is very promising as is the application of superconducting materials and new designs for fields [12-13].

This work proposes a combination of both passive mass shielding and active magnetic shielding with consideration of trapped plasma as a design. The focus of this paper is on the magnetic field created by the design and calculations of particle trajectories through the field with consideration of the secondary radiation the particles produce.

### 2 PROPOSED DESIGN

A shielding method consisting of a split toroid wire configuration, two deployable wire loops, and passive shielding using Boron Nitride Nanotubes (BNNT) is proposed. The crew area is a cylindrical shape with a 10 m radius, and a 10 m height as seen in Fig. 1. Its surface is constructed from BNNT to minimize any radiation that might make it through the fields and any produced secondary radiation from reaching the crew area. The thickness of this BNNT wall can be adjusted based on shielding effectiveness of the material and weight, but it is shown as 1m in Fig. 1.

Superconducting wire is necessary to sustain a \(B\)-field during interplanetary travel. Ti-MgB\(_2\) superconducting tape has a high current to mass ratio as Musenich et al. and Buzea and Yamashita demonstrate [12-13]. Tables 1-2 show the limits of the Ti-MgB\(_2\) superconducting tape according to both articles.

Tables 1-2 have data differing by about one order of mag-
This difference comes from the titanium sheath used by Musenich et al., which allows the avoidance of helium cryogenics and maintains stability of the tape [12]. Table 2 shows the potential MgB₂ superconductors have as wire for B-fields as radiation shields in space. Until more work is done, this paper will assume the values from the data of Musenich et al. as the limits for MgB₂ superconductors. The Ti-MgB₂ superconducting tape will be referred to as a wire for the rest of this paper for simplicity.

A split toroid made from Ti-MgB₂ superconducting wire creates a roughly uniform, 5 m thick, B-field of 0.47 T that surrounds the crew area. The inner loops have a radius of 10 m while the outer loops have a 15 m radius as shown in Fig. 2.

The superconducting wires of the split toroid carry a current of 800 A at a temperature of 16 K, with a wire density of 600 wires per meter extending vertically 10 meters, surrounding the crew area. A wire density of this magnitude will have significant wire repulsive forces associated with the toroidal loops and will need to be optimized in a final design by adjusting the distance between each wire. Toroidal caps deflect particles at the top and bottom of the split toroid with the same current and wire density making the split toroid a nearly confined B-field, however, their shape is adjustable as shown in Fig. 3.

A deployable wire loop of radius 100 m, current 800 A, and \( n_s = 90 \) superconducting loops of wires carrying a total combined current of \( n_s I = 72,000 \) A surrounds the split toroid and produces a B-field with similar magnitude to that of Earth. As demonstrated by the SR2S project [10], a plasma of trapped particles forms surrounding the deployable loops similar to that of the Van Allen belts, Fig. 4.

A smaller wire loop of 15 m radius, current 800 A, and \( n_s = 20 \) superconducting wires loops carrying a total combined current of \( n_s I = 10,800 \) A will cancel out the B-field in the crew area as seen in Fig. 5.

The adjustable toroidal caps have potential of producing thrust from redirected radiation spiraling down at the top and bottom of the crew area as shown in Fig. 6. The direction of thrust can be adjusted by manipulating the shape of the caps to change the direction of deflection of the particles.

Produced synchrotron radiation may be harnessed for energy with the incorporation of photovoltaic cells [14].

While there are many parts to this design, this paper focuses on the shielding effectiveness of the B-field created by the split toroid and the two deployable wire loops.

### 3 CALCULATIONS

Before any simulations were run, highly energetic "test parti-
Fig. 6 Particle Redirection at Caps.

particles were Fe$^{+26}$, C$^{+6}$, He$^{+2}$, and H$^+$ with kinetic energies of 84 GeV, 18 GeV, 12 GeV, and 1.5 GeV respectively [2].

A B-field simulation was created using MATLAB coding with the Biot-Savart law in Eq. 1.

$$\mathbf{B} = \frac{\mu_0 I}{4\pi} \oint \frac{\mathbf{r} \times \mathbf{F}}{r^2} \, ds$$

(1)

The following information was input into the code: Matrix dimensions, split toroid dimensions and specifications, and deployable loop currents and dimensions. The code outputs a 3-dimensional vector field using matrices. The B-field vector was calculated, from each wire in the split toroid and the deployable loops, at each point in the matrix.

A second MATLAB code was used to send virtual particles into the B-field from various directions and observe their path. This code has inputs of particle mass, charge, initial kinetic energy, and the B-field matrix created by the toroid and deployable loops. The relativistic particle’s path is plotted using the particle’s trajectory, the total produced synchrotron radiation in electron volts, and change in kinetic energy before moving onto the next time step and continues in this fashion until the particle leaves the vector field. We used a timestep of 0.1 m/|v| where |v| is the magnitude of the initial velocity of the time step which gives a reasonable estimate of the particle’s path. The particle’s path is calculated based on the value of the nearest B-field vector to provide an accurate trajectory as the particle travels through the field. The code outputs the total produced synchrotron radiation in electron volts, and visual plots of the particle’s trajectory, the B-field, and the toroidal and deployable wires.

Calculations performed to update variables are given by Eq. 2 for acceleration $\mathbf{a}$, Eq. 3 for velocity $\mathbf{v}$, Eq. 4 for position $\mathbf{r}$, and Eq. 5 for the synchrotron radiation power $P$. In what follows, $m$ represents the rest mass of the particle, $t$ the time that has passed, $c$ the speed of light in vacuum, $q$ the charge of the particle, and

$$\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}$$

(2)

$$\mathbf{a} = \frac{q}{m v^2} (\mathbf{v} \times \mathbf{B})$$

(3)

$$\mathbf{v} = \mathbf{v}_0 + \mathbf{a} t$$

(4)

$$P = \frac{q^2 \gamma^4 c}{6\pi\varepsilon_0 \gamma^2}$$

(5)

The total energy lost per particle due to synchrotron radiation was calculated by summing over the total time the power radiated multiplied by the time step.

To calculate the B-field, a 200 × 200 × 200 matrix was created with each vector representing one square meter. A minimum toroidal radius of 10 m and a maximum radius of 15 m was input as the dimensions of the split toroid to create the toroid seen in Fig. 2. A current of 800 A was sent through the toroidal loops using 6000 layers of wire over a vertical distance of 10 m to give an estimate of the field produced. A deployable loop of 90 wires was added with a radius of 100 m. A second deployable loop of opposite current and a radius of 15 m was added to cancel out the B-field in the center from 20 wires creating the configuration seen in Fig. 5.

Fe$^{+26}$, C$^{+6}$, He$^{+2}$, H$^+$, and e$^-$ particles were sent into the B-field in groups of ten of each particle type from the bottom left corner at the matrix points [1 1 101] to [10 1 101]. The particle’s velocity is directed towards the center of the crew area to maximize the amount of B-field traversed. Due to the unconfined toroidal B-field in the simulation, the particles are initially redirected to a tangential path along the toroid and some are pulled into the toroid as grazing particles. In a final design, this effect will not occur to this extent due to the toroid being a nearly confined field. Different kinetic energies were input until a maximum kinetic energy for a grazing particle was found that would not enter the crew area. The values of synchrotron radiation produced were also calculated.

The B-field was then multiplied by 1/4, 1/2, 2, and 4 to calculate its shielding effectiveness for a total of 5 different configurations. These values will be called B-field Multipliers in this paper. The corresponding mass was also calculated for each B-field Multiplier. The shielding effectiveness of each B-field Multiplier is calculated in the following section.

To calculate the total mass of the wires, the dimensions of the Ti-MgB$_2$ superconductors were used and a mass per length of 0.037 kg/m [12]. The total length of wire of the deployable loops and split toroid was added up to calculate a wire mass of 4.15 × 10$^4$ kg. The total mass, including an estimate of the toroidal caps, is calculated to be 8.08 × 10$^4$ kg by doubling the mass of the toroid wires.

4 RESULTS

The resulting B-field from the deployable loops is similar in magnitude to Earth’s geomagnetic field, but spread out over a smaller volume. This was calculated based on representing Earth’s outer core with the larger deployable wire loop and choosing a current to produce the same B-field magnitude at a distance of 220 m from the center of the loops representing...
Earth's surface. The resulting field is shown in Figs. 7-9.

The maximum $B$-field produced by the deployable loops inside the crew area's 10 m radius is $2.17 \times 10^{-4}$ T with the center not exceeding $8.63 \times 10^{-5}$ T. These are acceptable values according to the International Standards of static $B$-field prolonged exposure from the World Health Organization[15].

The split toroid $B$-field was then calculated without the addition of caps and added to the deployable loop's $B$-field. Because the caps were not added to this calculation, the resulting $B$-field for the toroid is not fully confined. The additional field in the crew area, created from the split toroid, is neglected in the total $B$-field of the crew area since the final design will be nearly fully confined. This combined $B$-field can be seen in Figs 10-12.

Particles in groups of ten were sent into this field from the bottom left corner from 1-10 m on the x-axis as previously...
described, and their paths were plotted in red as seen in Figs. 13-14. Note that MATLAB has a tendency to connect the final positions of each particle with a straight line to each other. This MATLAB artifact does not obscure the path of the particles. When only one particle is sent through, no extra lines appear to create a clearer picture of the particle's path as seen in Fig. 15.

Particles grazing the outer deployable loop were simulated to demonstrate that they are also shielded as shown in Fig. 16.

The paths of Fe$^{+26}$, C$^{+6}$, He$^{+2}$, H$,^+$, and e$^-$ particles for different B-field multipliers strength as described earlier were calculated. The results are shown in Tables 3-8.

In Table 3, the B-field Multiplier is the number multiplied to each vector in the created field. For instance, a B-field Multiplier of 1 is no change in the magnitude of the vectors from the initial parameters. A B-field Multiplier of 2 is twice the magnitude of each vector in the B-field created from the necessary wires.

In Table 4, “Max KE Fe$^{+26}$” is the maximum grazing particle kinetic energy in GeV that the B-field for the given multiplier can deflect. The Synchrotron Radiation is the total produced synchrotron radiation during the particles' path.

Table 3 The integer multiples of the B-field with corresponding wire mass and wire length at 16 K

<table>
<thead>
<tr>
<th>B-field Multiplier</th>
<th>Mass of Wires (kg)</th>
<th>Length of Wire (km)</th>
<th>Critical Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1.73×10^4</td>
<td>5.45×10^3</td>
<td>936</td>
</tr>
<tr>
<td>0.5</td>
<td>3.63×10^4</td>
<td>1.09×10^3</td>
<td>890</td>
</tr>
<tr>
<td>1</td>
<td>8.08×10^4</td>
<td>2.18×10^3</td>
<td>800</td>
</tr>
<tr>
<td>2</td>
<td>2.10×10^5</td>
<td>4.36×10^3</td>
<td>617</td>
</tr>
<tr>
<td>4</td>
<td>1.02×10^6</td>
<td>8.72×10^3</td>
<td>253</td>
</tr>
</tbody>
</table>

Table 4 Data for Fe$^{+26}$, including the particle's kinetic energy, energy of synchrotron radiation produced

<table>
<thead>
<tr>
<th>B-field Multiplier</th>
<th>Max KE Fe$^{+26}$ (GeV)</th>
<th>Synchrotron Radiation (eV)</th>
<th>Plasma Effect Percentage Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>12.0</td>
<td>4.99×10^4</td>
<td>85.7%</td>
</tr>
<tr>
<td>0.5</td>
<td>34.5</td>
<td>1.45×10^7</td>
<td>58.9%</td>
</tr>
<tr>
<td>1</td>
<td>116</td>
<td>7.58×10^6</td>
<td>none</td>
</tr>
<tr>
<td>2</td>
<td>229</td>
<td>2.80×10^4</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>504</td>
<td>2.00×10^2</td>
<td>none</td>
</tr>
</tbody>
</table>

Table 5 Data for C$^{+6}$

<table>
<thead>
<tr>
<th>B-field Multiplier</th>
<th>Max KE C$^{+6}$ (GeV)</th>
<th>Synchrotron Radiation (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>12.0</td>
<td>4.99×10^4</td>
</tr>
<tr>
<td>0.5</td>
<td>34.5</td>
<td>1.45×10^7</td>
</tr>
<tr>
<td>1</td>
<td>116</td>
<td>7.58×10^6</td>
</tr>
<tr>
<td>2</td>
<td>229</td>
<td>2.80×10^4</td>
</tr>
<tr>
<td>4</td>
<td>504</td>
<td>2.00×10^2</td>
</tr>
</tbody>
</table>

Table 6 Data for H$^{+2}$

<table>
<thead>
<tr>
<th>B-field Multiplier</th>
<th>Max KE H$^{+2}$ (GeV)</th>
<th>Synchrotron Radiation (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.981</td>
<td>3.99×10^4</td>
</tr>
<tr>
<td>0.5</td>
<td>2.92</td>
<td>9.87×10^3</td>
</tr>
<tr>
<td>1</td>
<td>7.90</td>
<td>4.32×10^3</td>
</tr>
<tr>
<td>2</td>
<td>17.9</td>
<td>3.10×10^4</td>
</tr>
<tr>
<td>4</td>
<td>39.0</td>
<td>1.79×10^4</td>
</tr>
</tbody>
</table>

Table 7 Data for H$^+$

<table>
<thead>
<tr>
<th>B-field Multiplier</th>
<th>Max KE H$^+$ (GeV)</th>
<th>Synchrotron Radiation (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.690</td>
<td>3.04×10^9</td>
</tr>
<tr>
<td>0.5</td>
<td>1.96</td>
<td>9.75×10^8</td>
</tr>
<tr>
<td>1</td>
<td>4.47</td>
<td>7.91×10^7</td>
</tr>
<tr>
<td>2</td>
<td>9.76</td>
<td>4.67×10^6</td>
</tr>
<tr>
<td>4</td>
<td>22.1</td>
<td>2.35×10^5</td>
</tr>
</tbody>
</table>

Table 8 Data for e$^-$

<table>
<thead>
<tr>
<th>B-field Multiplier</th>
<th>Max KE e$^-$ (GeV)</th>
<th>Synchrotron Radiation (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1000+</td>
<td>1000×10^9</td>
</tr>
</tbody>
</table>

*percentage of the test particle's kinetic energy that would require some other method, such as plasma considerations, to deter the particle
An accurate idea of how much plasma is induced from the deployable loops is not achievable without real world experimentation. When a particle enters a plasma, its kinetic energy will change. The Plasma Effect Percentage Needed in Table 4 is the percentage decrease of the initial kinetic energy of the particle after it traverses the plasma. So, an 84 GeV Fe\(^{+26}\) particle must decrease its kinetic energy to 34.5 GeV in the plasma, which is a 58.9% decrease from 84 GeV, to be fully shielded with a B-field Multiplier of 0.5. If no plasma is induced from the deployable loops, a Multiplier of one is required to fully shield the particle. This table gives an idea of the induced plasma’s shielding power required to stop the test particle for each B-field Multiplier.

C\(^{+4}\), He\(^{+2}\), H\(^{+}\), and e\(^{-}\) particles were sent into the same B-field multipliers to find their maximum kinetic energies and produced synchrotron radiation. The results are in Tables 5-8.

Electrons lose considerably more energy to synchrotron radiation when traveling at higher kinetic energy through a B-field. No electron kinetic energies were found that could make it through the B-field. At 1000 GeV, the particle was still shielded from the crew area since energy is lost quicker due to the y’ term. Because of this, even with a B-field Multiplier of 0.25, the crew area is a forbidden region for all electrons traveling through the toroidal field. This suggests a second plasma made of electrons may form inside the split toroid which would cause unwanted heating of the wires and a greater power requirement to keep the wires cool. This plasma, however, has a potential to be used as a power source, but this requires further consideration. Some particles may make it through the split in the toroid, but only if they are incident tangential to the toroid at the slit. The orientation of the ship to the Sun will drastically reduce the solar wind particles that make it through the slit.

The effectiveness of this shielding method can be seen when compared to Miller and Zeitlin’s data [2]. Miller and Zeitlin show a graph of differential flux vs. kinetic energy per nucleon of Fe\(^{+26}\), C\(^{+6}\), He\(^{+2}\), and H\(^{+}\) particles. Estimates from the graphs in Miller and Zeitlin’s paper for most probable particle and maximum kinetic energy are provided in Table 9.

Using the data from Miller and Zeitlin [2], the most probable kinetic energy GCR particles can be fully deflected using a B-field Multiplier of 1. Additionally, Mewaldt[16] notes SEP-proton kinetic energy has not exceeded much higher than 1 GeV during the past few major solar flares from 1956-1989. According to Cline and McDonald, the kinetic energy of electrons during solar flares are 3-12 MeV [17]. Even with a B-field multiplier of 0.5, the most probable kinetic energies of GCR particle that was simulated can be fully deflected, along with every observed proton and electron from recent solar flares. There will be some particles that cannot be deflected, but they have significantly less flux than the average GCR particle and may be deflected by a combination of plasma, B-field, and BNNT shielding. The produced synchrotron radiation may be partially absorbed by photovoltaic cells and used as power for onboard equipment [14]. The rest will have to be deflected or absorbed by the BNNT structure housing the crew area [3].

It is important to understand how high energy particles will interact with this design when unshielded. Fig. 17 shows 5 Fe\(^{+26}\) with energies increasing to and including 2800 GeV.

Fig. 17 shows that some high energy particles are not shielded. Furthermore, substantial synchrotron radiation will be produced and needs to be considered. These values are in Table 10. With the addition of a plasma surrounding the ship and BNNT around the crew area, these very high energy particles may become shielded from the crew area. Knowing the characteristics of the induced plasma and the shielding effectiveness of BNNTs is essential to finding the limit of this method’s shielding ability.

Additionally, a lightweight method to keep the wires under their critical temperature will be required. The addition of well-designed sunshields may reduce the energy required to keep the wires below their critical temperature.

5 CONCLUSION

The simulation shows significant shielding effectiveness of this design. A wire mass of 8.08 × 10\(^4\) kg is a reasonable mass considering this is less than the mass of the ISS. Although the mass of the cooling system required to keep the Ti-MgB\(_2\) wires under their critical temperature is not included in this calculation, it is important to note the potential of producing thrust from rea-

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**TABLE 9** Estimates of the probable kinetic energies and maximum kinetic energies

<table>
<thead>
<tr>
<th>Particle</th>
<th>Most probable KE</th>
<th>Maximum KE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe(^{+26})</td>
<td>42 GeV</td>
<td>2800 GeV</td>
</tr>
<tr>
<td>C(^{+6})</td>
<td>9.0 GeV</td>
<td>12,000 GeV</td>
</tr>
<tr>
<td>He(^{+2})</td>
<td>6.0 GeV</td>
<td>4000 GeV</td>
</tr>
<tr>
<td>H(^{+})</td>
<td>0.75 GeV</td>
<td>5000 GeV</td>
</tr>
</tbody>
</table>

**TABLE 10** Synchrotron radiation from Fe\(^{+26}\) particles traveling through a B-field Multiplier of 4

<table>
<thead>
<tr>
<th>Fe(^{+26}) KE (GeV)</th>
<th>Synchrotron Radiation (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>560</td>
<td>1.82×10(^4)</td>
</tr>
<tr>
<td>1120</td>
<td>1.26×10(^4)</td>
</tr>
<tr>
<td>1680</td>
<td>8.59×10(^3)</td>
</tr>
<tr>
<td>2240</td>
<td>6.12</td>
</tr>
<tr>
<td>2800</td>
<td>6.65</td>
</tr>
</tbody>
</table>
rected radiation may make this mass acceptable. A space station similar to the ISS could be designed to move between orbits of Earth, the Moon, Mars, or many other bodies using this shielding method without the need for chemical propellants by using the momentum from redirected radiation. The induced electron plasma fields and photovoltaic cells have the potential of powering the systems onboard the ship making it a self-sufficient mobile station. Its cylindrical crew area also has potential to be spun simulating a gravitational field and so reduces problems arising from prolonged exposure to the absence of gravity. This Magnetically Shielded Self-Sufficient Space Station (M5S) holds potential to be a more practical method for interplanetary travel.

These results are promising, but more considerations need to be made. The induced plasma and its added shielding must be studied further. Since calculations of induced plasma are roughly estimated based on knowledge of the plasma trapped in Earth’s magnetic field, a real-world experiment may be needed to get an idea of the plasma’s characteristics. This could be accomplished using a CubeSat with a deployable wire loop. Considerations must be made of the time required for the plasma to form in the solar wind, the heating of the wires due to the plasma and synchrotron radiation, the produced neutrons from the collision of radiation with any mass on the ship, and the effectiveness of BNNT as a passive shielding method.

REFERENCES

2. J. Miller & C. Zeitlin, "Twenty years of space radiation physics at the BNL AGS and NASA Space Radiation Laboratory", in Life Sciences in Space Research, 9, 12-18, 2016.
Mitigating Lunar Dust: Masten Completes FAST Landing Pad Study

by Masten Space Systems (with Permission) (2021 September 22)

https://masten.aero/blog/mitigating-lunar-dust-masten-completes-fast-landing-pad-study/

Landing on the Moon (and staying on the Moon) is no easy task. The lunar surface has limited sunlight, extremely cold temperatures, and lots and lots of dust (a.k.a. lunar regolith). But the good news is, Masten is up for the challenge!

We’re building the technologies and infrastructure to enable sustainable access and utilization of our solar system, starting with the Moon. Our goal is to accelerate ecosystems on the Moon, Mars, and beyond to unlock the value in space for humans on Earth. But first we have to solve for the challenging lunar environment, and one of the most pressing hurdles faced by the industry is mitigating lunar dust.

Why is lunar dust so hazardous?

Lunar dust is made up of tiny grains of crushed rock formed by meteorite impacts, effectively creating fragments of glass and mineral. This razor-sharp regolith has always been an issue (lunar dust tore the spacesuits of Apollo astronauts!), but the challenge is amplified for upcoming missions, such as Artemis. Why? Today’s lunar landers proposed for human missions are significantly larger and have more powerful engines.

Artemis landers will have a landed mass of approximately 20 to 60 metric tons compared to approximately 10 metric tons of landed mass during the Apollo era. Engine plumes from these larger landers will create a deep crater and kick up high-velocity regolith that can travel up to 3,000+ meters per second! This regolith can damage the lander, nearby infrastructure, orbital assets, and even endanger astronauts. It can also impact smaller lunar landers carrying important scientific instruments and payloads.
Mitigating Lunar Dust: Masten Completes FAST Landing Pad Study

The good news? Masten’s near-instant landing pads can help solve this challenge using an in-Flight Alumina Spray Technique (FAST). Following our Phase 1 [NASA Innovative Advanced Concepts award](#), we’ve spent the last year studying and advancing the FAST concept in collaboration with Honeybee Robotics, Texas A&M University, and the University of Central Florida. And we just wrapped up our initial research, proving the solution is feasible in the lunar environment! You can find a summary of the report below.

But first… what exactly are FAST Landing Pads?

One approach to mitigate dust damage would require building a landing pad prior to each mission. This traditional approach would be both costly (we estimate more than $120 million per landing pad mission) and subject to a “chicken and egg” dilemma: how do you emplace the pad without landing something in the area first?

In contract, Masten’s FAST Landing Pad approach utilizes ceramic particles injected into rocket plume to form a coating over lunar regolith as a lander descends on the lunar surface. The particles impact the surface and solidify to build up a hard landing pad with greater thermal and ablation resistance.

This approach can significantly reduce deep cratering and prevent regolith ejecta from impacting the surrounding environment. That means spacecraft can safely land anywhere on the Moon without the need for a precursor pad construction mission.

The FAST Landing Pads can also maintain their structural integrity to minimize plume effects during an ascent back into lunar orbit.

What did we study in Phase I?

With our partners at Honeybee Robotics, Texas A&M University, and the University of Central Florida (including the renowned plume expert Dr. Phil Metzger!), we fine-tuned our approach during Phase I of the study, which included the following investigations.

- Calculating the optimal landing pad thickness based on the plume effects and pad spalling (i.e., chips, flakes) using data from flying Masten’s vertical takeoff and vertical landing rockets.
- Analyzing materials and particle sizes to ensure they’re the right temperature to adhere to each other on impact and build up layers of landing pad.
- Modeling how the particles absorb and reject heat inside the engine and during travel to the surface.
- Optimizing the deposition rate and required cooling time so the layers can harden into a solid pad while minimizing loiter time of the lander.
- Modeling material adhesion to the regolith to optimize impact velocity and material selection.
- Assessing performance of the solidified material and its effectiveness at mitigating blown dust and deep cratering effects.
- Testing candidate materials with a hot fire rocket engine test that simulates a lunar landing.
Mitigating Lunar Dust: Masten Completes FAST Landing Pad Study

Hot fire test using an alumina plate and Masten’s rocket engine test stand in Mojave, CA; engine camera (left), FLIR thermal camera (right).

Testing plume scouring effects with a lunar regolith simulant and Masten’s Xodiac rocket in Mojave, CA.
Mitigating Lunar Dust: Masten Completes FAST Landing Pad Study

What did we learn from the study?

Our analysis determined the FAST concept is feasible for building near-instant landing pads during a lunar descent, even when utilizing an Artemis-scale human lander.

The exact landing pad thickness and material properties will be based on the size and temperature of the engine plume and can be optimized to meet a diverse set of missions.

As an example, a large-scale Artemis human landing system would require alumina particles of approximately 0.5 millimeters diameter to pass through the engine without melting. The particles would impact the lunar surface at approximately 1,500 meters per second to create an initial base layer on the lunar surface that’s approximately 1 millimeter thick.

After the base layer is deposited, alumina particles of approximately 0.024 millimeters in diameter would be required to heat up and liquify as they pass through the engine. These particles would impact the surface at approximately 650 meters per second and create additional layers that build up and strengthen the landing pad. The full deployment would take 10 seconds to release 186 kilograms of alumina at up to 30 meters above the lunar surface, creating a 6-meter diameter landing pad. The pad would then require 2.5 seconds to cool before the vehicle touches down for a safe landing.

What’s next? To the Moon, Mars, and beyond!

In Phase I, we advanced the technology readiness and laid the groundwork for future development. In the next phase, our goal is to further mature the landing pad technology by testing it in a lunar environment. Looking even further ahead, the FAST concept can be applied to other planetary bodies like Mars where loose regolith also poses risks to human and robotic missions.

By mitigating plume effects on the Moon, Mars, and beyond, FAST Landing Pads can keep astronauts, infrastructure, and spacecraft safer while increasing the number of potential landing locations. This technology is also the key to significantly lower total program costs that would be required to build landing pad infrastructure.

In short, FAST Landing Pads can greatly expand accessibility and affordability to planetary bodies, unlocking new scientific discoveries and commercial applications.
Abstract

The importance of outer space satellites and their supporting systems cannot be overstated. Their use in the civil and commercial world to provide communications, weather, navigation, timing, and Earth resources monitoring provides major advantages to those who employ the information generated by these systems. However, due to the global reach of these space systems, advantages are provided to both friendly and adversary militaries. Beginning with the use of space systems to support military operations during the Arab–Israeli conflicts, and in Operation Desert Storm, both major and minor players are considering how denial of space capabilities to their adversaries will be a force multiplier on terrestrial battlefields.

Based on the author’s extensive experience in this theoretical area, he has developed essential “rules” by which he feels the next space war will be conducted. These are based on his unclassified analyses of past military history, and of classical military principles of war¹ and Sun Tzu’s Art of War² applicability to space warfare (see author’s additional papers). Since a full-up space war has not yet occurred, all these concepts are notional and unproven, much like air warfare doctrine was only theoretically understood prior to World War II. Nonetheless, it is very important to better understand how a future space war might be conducted to ensure favorable outcomes for the more prepared country, and for better outcomes for the world, in general, post space conflict.

Introduction

The future of space warfare is rapidly approaching. There is significant buildup of space warfare capabilities by some major countries that rely on space systems for their defense or perceive that their potential adversaries depend too much on space capabilities to conduct terrestrial warfare. Because of the lack of significant experience by countries in this new military domain, it is difficult to fully understand what the best doctrine, strategies, and tactics are to win the next space war. Based on the author’s study of military history for over 50 years and his direct involvement with space warfare

¹ I would like to acknowledge the great military thinkers of the last few thousand years, from ancient Greek and Roman generals, to ancient Chinese military philosophers such as Sun Tzu, for their philosophies that continue to inspire me to translate these concepts into theories and doctrine impacting present and future space warfare.
programs for the past 43 years, he has developed general rules by which the next space war will be conducted. These “Top Rules” are an extrapolation of well-established principles of war for terrestrial conflicts applied to the unique space environment, where orbital dynamics restrict what is possible for antisatellite (ASAT) weapon systems attack profiles.

Due to the large distances (tens of thousands of kilometers) between the Earth and military satellites, it is difficult to track and fully image these systems to assess their abilities as potential threats to national security. In addition, very few countries possess the worldwide space surveillance assets to track movements of suspicious space objects that may be maneuvering toward critical national assets. Even for those few countries that possess significant space sensor systems, it is very difficult to continuously track satellites that initiate their maneuvers in areas with no sensor coverage (i.e., Antarctica). A recent unclassified computer simulation by the author showed that 95 percent of possible space attacks could be completed within 24 hours, which is before any reactions on the ground can be contemplated, approved, or executed. Thus, one of the conclusions of this “Top Rules” study is that space warfare favors the offense. Another conclusion of this article is that, due to the remoteness of space, countries that take actions against an adversary’s satellites can do so under a cloud of secrecy, without the general population of the world becoming aware of these aggressive actions. Thus, space warfare adds new and subtler rungs on the conflict escalation ladder, where countries can express intent and resolve to their adversaries without necessarily inducing terrestrial conflict.

Figure 1. Competing in Space: Possible Space Systems Attacks Modes.
1. **Preconflict Positioning**: Since it is very difficult to change orbits at the last minute (especially changing orbital inclination), immediate space combat can only be fought with the current resources on hand in the local area. There will be no transconflict redistribution of space forces to help those forces under immediate attack. Thus, preconflict positioning of space assets is possibly the most important aspect of space strategies. This principle is related to the other fundamental principle of maximizing high maneuvering abilities of space assets. Dominating and survivable preconflict satellite positioning and extensive satellite on-board maneuvering fuel is of most importance.

2. **Space Situational Awareness and Weapons Range**: It does not matter how plentiful or how brilliant your adversary space weapon systems are if they cannot find or reach your critical space systems. If you are constantly maneuvering so that he cannot find you, or your satellites are in hard to reach orbits, or have low observables, or you possess many believable satellite decoys, then he can never dominate you. Perceptive space situational awareness (SSA) and predictive battlespace awareness (PBA) will dominate any offensive weapons capabilities. Because of the inherent instability of offense vs. defense in space warfare, the most important tool for senior military and political space leaders is space surveillance and identification sensors with corresponding automated assessment algorithms, particularly those that provide PBA.

3. **Decisive Political Will**: Having space forces that are superior in numbers and technological quality are useless if there is not the political will to fully and quickly use them. This principle may imply dictatorships are more at an advantage than democracies. Hesitation and uncertainty can rapidly lead to failure in space warfare. Effective doctrine and decisive political will is most necessary to counter adversary military actions in the space environment.

4. **Maneuver**: A satellite’s ability to frequently conduct large, small, or continuous maneuvers, especially just before and during a space conflict, might be the best capability to keep your adversaries guessing as to your space control intentions and planning, besides complicating his targeting solutions, especially when said adversary may lack worldwide space surveillance sensor coverage.

5. **Unusual Orbits**: Unusual orbits increase the difficulty of your adversaries to determine your intentions or target you quickly.

6. **Value of Space**: Due to the newness of space warfare, your adversary probably does not fully understand the value of space both to himself and to his adversaries. This complicates his ability to prioritize his targeting plans, and may contribute to him wasting precious maneuvering fuel and limited “shots” from space weapons going against low-value satellites, along with ceding time and tempo advantages to the other side.

7. **Political Consequences**: Due to the newness of space warfare, our adversary and probably ourselves do not fully understand the political, diplomatic, economic,
and international ramifications of employing space weapon systems, especially post conflict.

8. **Effective Doctrine**: Due to the newness of space warfare, our adversary and probably ourselves do not fully understand the best theory, doctrine, strategies, tactics, and techniques for conducting optimized space warfare. Big mistakes will be made by both sides.

9. **Mistakes Will Be Made**: Due to the newness of space warfare, most carefully laid plans, doctrines, strategies, tactics, techniques, political, technological, and correlation of forces assumptions will prove false and be immediately thrown out (or worse, be so dearly held, they lead to immediate defeat). This rule equally applies to both sides of the conflict, unless one side is lucky enough to have gotten space doctrine slightly more correct than the opposing side.

10. **Vary Space Weapon Types**: Due to the newness of space warfare, it might be best to possess different phenomenology space weapon systems with varied basing options to increase the chance you developed your preplanning and space doctrine right for a type of conflict that has never occurred before. Remember, in all previous wars the first casualties are most, if not all, of the preconflict plans.

11. **Define Winning**: The concept of “winning” in space warfare is not clearly defined. Its definition may be made by political leadership with limited technological or military knowledge and may be based on purely political, propagandistic, or failed doctrinal principles. Your adversary will certainly have a very different definition of winning, which means both sides may perceive they have “won” the space conflict and derive quite different conclusions that will dominate their military, political, diplomatic, and economic (commercial and procurement strategies) thinking for decades to come. One’s space strategies employed during the conflict should take this into consideration to place your nation into a favorable position post conflict.

12. **Space Debris**: Creation of too much space debris during space conflicts may make losers out of all sides after the conflict, in the long term.

13. **Future Political Impacts**: You may be assured that after the conduct of a major space war, national and international protocols, treaties, rules of conduct, and alliances will be radically changed for space. One’s space strategies employed during the conflict should take these into consideration to place your nation into a favorable position post conflict.

14. **Adversary Postconflict Reactions**: You may be assured that after the conduct of a major space war, your adversaries and other nations will learn from this war and probably build up their own space weapon capabilities, even if necessarily covertly. One’s space strategies employed during the conflict should take these into consideration to place your nation into a favorable position post conflict.

15. **Space Escalation Ladder**: Due to the remote nature of space systems, the world’s populace may be kept in the dark (especially for low-level space conflicts)
of what is truly happening, which provides additional, more subtle rungs on the conflict escalation ladder, allowing nations to privately exhibit resolve and to send determined political messages.

16. **Space Warfare Inherently Conflict Destabilizing**: Because a small, relatively inexpensive space mine can take out a large billion-dollar satellite critical to the conduct of your military operations and actual satellite point defense is problematic due to probable ASAT hypervelocity closing speeds, offense is better than defense in space warfare, making it inherently unstable for conflict escalation.

17. **Quick Space Attacks Possible**: Due to the remote nature of satellites in space, small-scale space attacks may be initiated, executed, and completed before the recipient even knows he is under attack, who is attacking, what are their attack strategies and goals (end states), and when an uncomprehending senior political leadership can validate the attack and respond in a military, political, diplomatic, or economic manner. Large-scale space attacks may be initiated, executed, and completed within 24–48 hours. Without adequate and timely SDA/SSA and determined political will, an adversary can easily get within your Observe, Orient, Decide, Act (OODA) command-and-control loops for space and shock and confuse you.

18. **Space Exhibits Escalation Imbalances**: Due to the remote nature of satellites in space and the difficulty for space surveillance assets to determine the true nature of space attacks, and because space attacks may be initiated, executed, and completed within 24–48 hours, there is a good chance that the side that initiates space attacks first will be the side that wins the space war.

19. **Covertness and Surprise of Prime Importance**: Due to the remote nature of satellites in space and the difficulty for space surveillance assets to determine the true nature of space attacks, and because space attacks may be initiated, executed, and completed within 24–48 hours, covertness and surprise will significantly contribute to winning the space war.

20. **Joint Military and Commercial Space Use**: Mixing military and commercial systems on the same satellites increases the chances of space conflict escalation due to the general populace immediately becoming aware of the effects of satellite loss and placing pressure on political leadership to take precipitous actions. Thus, the nuances of steady and reasoned escalation control are lost.

21. **Space Only Benefits Terrestrial Systems**: Space conflict is all about denying satellite support to military forces or civilian populations on Earth—not simply the elimination of satellite systems for destruction sake or as a space “scorekeeper.”

22. **Small Space Forces Can Beat Larger**: As in many other conflicts past and present, having space forces that appear superior in numbers and technological quality on paper does not guarantee a “win” under all circumstances. There are many examples throughout thousands of years of military history of numerically
inferior forces beating their “betters.” Many times, it is the forces with better doctrine, planning, morale (political will), or positioning that win. This can only be truer for a new area of conflict in space that has little, if any, past military examples and experiences.

23. **Public Opinion Will Limit Military Options:** Even though space wars entail very few, if any, human casualties, international public opinion values space wars as more politically unacceptable compared to terrestrial destruction and loss of human life from traditional warfare on Earth. In addition, space wars will fire the imaginations, good or bad, of your citizens, along with much of the rest of the world that is not actively participating in the conflict.

24. **Allies Count Little Militarily for Space Wars:** Due to the limited number of countries with future space weapons systems and their attendant need for covertness along with international political sensitivities, each adversary will probably have to go it alone, and his allies cannot or will not significantly help him openly in the coming space conflict. In addition, more than likely, allied space systems will be in the wrong space defense regions, and incapable of maneuvering closer for mutual defense in a timely manner.

25. **Space Treaties Will Be Violated:** Most space treaties will be violated in the first few hours of the coming space war. International treaties have usually been violated in most previous major terrestrial conflicts, and due to the remoteness of space, treaties concerning the military use of space are easier to ignore, especially when the world populace may not even be aware of this ongoing space conflict.

26. **Data Relay Satellites Are Prime Targets:** Possibly the most important space targets will be those satellites that relay data and commands directly to other satellites in remote orbits, making them choke points for critical space systems. This is particularly true for those countries without extensive worldwide satellite ground control stations.

27. **Defense vs. Offense:** Those nations that have more space systems being used by their military also have more space systems to defend and probably must emphasize defense over offense in their technology developments and in their military planning. If your adversary has few space systems, then there are fewer targets for your offensive space weapons, and you must emphasize defense, unless you believe that you have perfect SDA/SSA and you know all your adversaries’ and their allies’ offensive space weapons and believe you can target and neutralize these early in the space conflict before he can fully implement his offensive space warfare plans.

28. **Space Warfare Systems Are Untested:** If your adversaries’ space warfare systems are untested in real, sustained combat, then their true abilities against you are uncertain and probably possess “cracks in their armor.” Unfortunately, the same is probably true of your space warfare systems (whether you believe this or not), but the true vulnerabilities and failure points of both sides may not be obvious or believable. However, be assured, due to the new nature of space warfare, they do exist in plenitude.
29. **Differing Cultures and Military Traditions**: Because your adversaries probably come from different cultures and military traditions than your own, they have a higher probability of detecting your space warfare systems nonobvious "cracks in their armor" than you do, and vice versa.

30. **You Are Always Vulnerable**: As in all military matters since time immemorial, due to the cleverness of human beings, especially under stressful combat conditions, your adversaries will ultimately find your vulnerabilities and get through any defenses you may fool yourself into thinking are "invulnerable.”

31. **Decisive Commander**: For those countries at war with roughly equal space warfare forces, the main decisive factor would be which country may be lucky enough to discover and believe in the one decisive commander who is a genius in space warfare organization, doctrine, strategies, and tactics. This is especially true for the nontraditional nature of space warfare. In addition, those countries with the least meddling in military matters by their politicians might be the decisive factor in winning the war (though possibly “losing” the peace afterward).

32. **Little to No Human Casualties**: Because space warfare involves little to no human casualties, commanders can be particularly decisive and coldhearted in their planning and execution compared to terrestrial warfare. As the late Maj Gen Roger G. DeKok, USAF, stated, “Satellites have no mothers.” In addition, morale and courage on the battlefield is of less importance, though command decisiveness remains a critical factor.

33. **Low-Cost Offensive Weapons**: Due to the hypervelocities of space orbits, one cannot adequately armor your spacecraft, and a small, relatively inexpensive space mine can take out a large billion-dollar satellite critical to the conduct of your military operations.

34. **Space “Fog of War”**: The potential for confusion known as the “fog of war” is well-documented for terrestrial battlefields; it will be even worse for space warfare, due to the newness of this theater for conflict, the tremendous distances involved, and the global nature of space.

35. **Commercial Satellites Are on Their Own**: Commercial satellite operators whose expectations are that the military will protect their space systems during conflicts will have a rude awakening.

36. **Checklist Vulnerability**: Operators who are trained to respond to unusual situations by “checklist” actions can be easily spoofed and manipulated by a clever adversary, especially in a contested environment with denied or degraded communications to higher headquarters (rule suggested by Paul Day).

**Conclusion**

The future of space warfare is upon us, but the theory, doctrine, strategies, and tactics are uncertain. A quote from Leon Trotsky is appropriate here: “You may not be interested in war . . . but war is interested in you.” Whether you believe in space
warfare or are desperately trying to prevent it, conflicts in space will happen
nevertheless, as space is far too important to remain a sanctuary while major military
conflicts are raging on Earth. Space warfare remains far too important to the ultimate
outcome of the terrestrial battlefield and may indeed cause fewer casualties than
extended conflicts on the ground.

Most importantly, before any major military conflict is initiated on the Earth, a
smart adversary would position his space assets at key jumping-off points in space
(choke points) to better enable surprise attacks. If countries invest in SDA/SSA sensor
networks (RADAR, optical and SIGINT) on the ground and in space, they can be
prewarned of impending space attacks and are presented with the opportunity to
confront the adversary at the United Nations and possibly prevent the ensuing
terrestrial conflict.

I will leave you now with two more quotes:

General George S. Patton: “If everyone is thinking alike, then somebody isn’t
thinking.”

General Hugh Trenchard: “The great captains are those who think out new
methods and then put them into execution. Anybody can always use the old method.”

Paul S. Szymanski

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He currently manages a private discussion group consisting of 17,856 hand-picked
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General officers and Admirals, 58 current and former Under/Assistant Secretaries of Defense
(including one former Secretary of Defense), 278 from the Joint Chiefs of Staff (including two
former Chairmen of the Joint Chiefs of Staff) past and current Commanders of the 4th, 6th,
Pacific, and Korea Naval fleets, 604 Congressional House & Senate staffers, 178 diplomats, 293
from the White House and National Security Council staffs, and 57 astronauts, among others.


2 Sun Tzu, The Art of War (Minneapolis: Filiquarium Publishing LLC, 2006).
DARPA’S Hypersonic Air-breathing Weapon Concept (HAWC) Achieves Successful Flight (Test advances goal to transfer technology to U.S. Air Force as program of record)

by DARPA (with Permission) (2021 September 22) [https://www.darpa.mil/news-events/2021-09-27]

DARPA, in partnership with the U.S. Air Force, completed a free flight test of its Hypersonic Air-breathing Weapon Concept (HAWC) last week. The missile, built by Raytheon Technologies, was released from an aircraft seconds before its Northrop Grumman scramjet (supersonic combustion ramjet) engine kicked on. The engine compressed incoming air mixed with its hydrocarbon fuel and began igniting that fast-moving airflow mixture, propelling the cruiser at a speed greater than Mach 5 (five times the speed of sound).

The HAWC vehicle operates best in oxygen-rich atmosphere, where speed and maneuverability make it difficult to detect in a timely way. It could strike targets much more quickly than subsonic missiles and has significant kinetic energy even without high explosives.

"The HAWC free flight test was a successful demonstration of the capabilities that will make hypersonic cruise missiles a highly effective tool for our warfighters," said Andrew "Tippy" Knoedler, HAWC program manager in DARPA's Tactical Technology Office. "This brings us one step closer to transitioning HAWC to a program of record that offers next generation capability to the U.S military."

Goals of the mission were: vehicle integration and release sequence, safe separation from the launch aircraft, booster ignition and boost, booster separation and engine ignition, and cruise. All primary test objectives were met.

The achievement builds on pioneering scramjet projects, including work on the X-30 National Aero-Space Plane as well as unmanned flights of NASA’s X-43 vehicles and the U.S. Air Force’s X-51 Waverider.

“HAWC’s successful free flight test is the culmination of years of successful government and industry partnership, where a single, purpose-driven team accomplished an extremely challenging goal through intense collaboration,” Knoedler added. “This historic flight would not have been possible without the dedication of industry, U.S. Air Force, and Navy flight test personnel who persevered through the pandemic to make the magic happen.”

The HAWC flight test data will help validate affordable system designs and manufacturing approaches that will field air-breathing hypersonic missiles to our warfighters in the near future.

Image Caption: Artist’s concept of Hypersonic Air-breathing Weapons Concept (HAWC) missile (Courtesy: Raytheon Missiles & Defense)
China’s quest for hypersonic arms

by Holmes Liao, Taipei Times (with Permission) (2021 October 17)

https://www.taipeitimes.com/News/editorials/archives/2021/10/17/2003766241

Hypersonic weapons are defined as armaments capable of traveling at speeds faster than Mach 5 and can be broadly classified into two types: hypersonic glide vehicles (HGV) and hypersonic cruise missiles. The former are launched into the upper atmosphere by ballistic missiles. The vehicle is then separated from the booster to maneuver, or glide, toward its target. The latter can be launched from a jet plane or rocket to reach supersonic speed before igniting a scramjet engine to achieve hypersonic speeds.

As the US engages in a great-power competition with China and Russia, all three countries are racing to field hypersonic weapons. While the US was busy with its “war on terror” over the past 20 years, Beijing seized the opportunity to gain an edge in this contest. China has reportedly fielded DF-17 missiles mounted on DF-ZF HGVs and is making progress on its Starry Sky-2 hypersonic cruise missile.

To aid research and development into hypersonic technology, the Chinese Academy of Sciences’ Institute of Mechanics (IMECH) launched the JF-12 “shock tunnel reproducing hypersonic flight conditions” program in 2008. It became operational in 2012. The JF-12 tunnel is reportedly being used to develop Starry Sky, which can carry nuclear warheads and travel at six times the speed of sound.

The JF-12 can duplicate flight conditions from Mach 5 to 9 speeds and altitudes from 25km to 50km. The tunnel can sustain test times of more than 130 milliseconds, which is enough to support the data collection of flow field, shock structure and other high-speed aerodynamic parameters to help design hypersonic weapons.
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The China Aerodynamics Research and Development Center’s Hypersonic Aerodynamics Institute in Mianyang is responsible for the Chinese People Liberation Army’s (PLA’s) research and development of hypersonic weapons. Given China’s military-civil fusion approach to defense technology, it is highly likely that IMECH supports the center’s simulation and engineering tasks.

Chinese media reports have frequently claimed that the JF-12’s performance is superior to NASA’s hypersonic tunnel facility. Such claims appear dubious in light of contemporaneous emphasis on the JF-12 tunnel’s cutting-edge five degrees of freedom mechanism, a technology that NASA has had since the 1980s. The claim that a 130 millisecond testing time is a world record is also false; NASA’s shock tunnel for the X-43A experimental vehicle can sustain similar test conditions for longer durations.

In March 2018, IMECH began work on the JF-22 “detonation-driven ultra-high-speed and high-enthalpy shock tunnel.” The JF-22 can reportedly achieve higher speeds and altitude conditions than the JF-12. The program passed a major milestone in December last year. IMECH claims that the JF-12 and JF-22 combined can cover all hypersonic flight profiles, although the timeline for the JF-22 to achieve initial operational capability is uncertain.

In addition to powerful wind tunnels, hypersonic vehicle design requires sophisticated computational fluid dynamics simulations. US and Chinese computational fluid dynamics communities frequently interact in open academic conferences. Chinese experts have subsequently acquired much-needed knowledge from such events. The powerful computer simulations, which require computation-intensive algorithms, are run on indigenous supercomputers built with US-designed graphical processing units, central processing units and memory chips. The kind of knowledge diffusion is not preventable under existing national security safeguards such as the US Economic Espionage Act.

In 2012, the China Aerospace Science and Industry Corp (CASIC) Academy of Defense Technology proposed a method capable of defending against hypersonic weapons. The first component of the proposed defense architecture is an efficient and optimized detection network comprised of sensors covering 800km to 1,000km. The second is a high-speed information center capable of processing large amounts of heterogeneous data and discriminating against noise and other interference in real-time. The third element is a high-performance command and control system to support an integrated air picture with rapid sensor-to-shooter cycle.

The fourth component is a mixture of fast response airborne and near space-based interceptors. CASIC advocates air-to-air missiles for this purpose, but hypersonic cruise missiles also pose significant technical challenges for low-angle detection and tracking over long distances, and the 2012 proposal does not seem to have solutions to this problem.

Researchers from the China Air-to-Air Missile Research Institute recommended a similar architecture in 2016. They also advocate implementing airborne interceptors using kinetic and direct energy, because of their low risk, and low research and development and deployment costs, as well as their rapid response ability with maximum operational flexibility. One challenge with air-to-air interceptors is their ability to deploy powerful airborne fire control radar to lock onto targets hundreds or even thousands of kilometers away. Whether China has fully developed this technology is unknown.

Researchers from the Space Engineering University, under the command of the PLA Strategic Support Force, indicated that they could use existing surveillance assets consisting of early warning aircraft and ground radars for early detection. For combat, they envisage “forward deployment” of air-to-air missiles for head-on intercept, although due to the HGV’s high maneuverability, the deployment area would need to be quite large, and the rate of success would likely be small.
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Two engineers from PLA Strategic Support Force units No. 31002 and No. 32032 propose deploying layered global networks for early warning and kinetic interception. They indicate that although an infrared sensor cannot render precise 3D target coordinates, it can still effectively provide early warning capabilities.

The PLA Rocket Force University of Engineering, previously known as PLA Second Artillery Engineering University, recommend shortening a long chain of command to build a flat command and control organization that optimizes information flow and reduces response time.

Researchers at the First Aircraft Institute of Aviation Industry Corporation of China recognize that laser weapons can be valuable in hypersonic defense because they can illuminate a target instantaneously. However, such weapons are susceptible to vibration and noise, which creates technical difficulties for beam control, high-precision aiming, tracking and rapid damage assessment. Additionally, hypersonic vehicles are typically shielded by ceramic matrix composites, which protect their structures from extreme heat, especially in the nose cone section, but the ceramics would be naturally effective at diffusing heat from laser beams for a prolonged period, rendering them less effective.

In general, Chinese strategists assess that hypersonic defense systems based on airborne platforms are advantageous due to their flexible deployment and high initial launch speed of kinetic interceptors, and the relatively weak maneuverability of incoming targets in the glide phase. Some Chinese researchers believe these limitations can be remedied by the use of uncrewed aerial systems.

China’s Air Force Engineering University has studied the feasibility of deploying a cluster of widely spaced uncrewed aerial systems to intercept hostile hypersonic strikes. The conceptual design makes use of high-altitude, long-endurance systems that can loiter in the forward theater. Because payloads on such systems are smaller than crewed aircraft, Chinese researchers envisage that a drone cluster would be divided between two missions: early warning and interception.

To provide effective early warning, the systems involved need collaborative decisionmaking, networked target acquisition and beyond-visual-range communications to provide long-range detection and tracking capabilities. Per the Air Force Engineering University’s conceptual design, the uncrewed aerial systems interceptor would carry six 250kg, 200km range airborne missiles.

The researchers divide combat into four stages: patrol and combat readiness, early warning, target acquisition and intercept capabilities. They have conducted systems analysis to determine the optimal deployment strategy for early warning and interceptor uncrewed aerial systems.

Hypersonic vehicles are not subject to arms control treaties on ballistic missiles. The US in February extended the bilateral New Strategic Arms Reduction Treaty with Russia, and hopes to persuade China to join strategic weapons negotiations.

China has little incentive to be encumbered by any arms control treaty as it lags behind the US and Russia in long-range intercontinental ballistic missiles and nuclear warhead stocks, while maintaining a vast stockpile of short and intermediate-range ballistic missiles that could potentially give it an edge in a regional contingency in the western Pacific.
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China is not a signatory of the Missile Technology Control Regime, a multilateral export control authority. Consequently, Beijing is not bound by missile nonproliferation obligations and has provided missile technologies to Iran, North Korea, Pakistan, Saudi Arabia and Syria.

The current situation, which is characterized by China’s long-range missile disadvantage vis-a-vis the US and Russia, and huge advantage in short and medium range missiles, might be beginning to shift. In August 2019, the US withdrew from the Intermediate-Range Nuclear Forces Treaty because of repeated Russian contraventions and Chinese arms buildup in the Pacific and the South China Sea. The withdrawal has introduced the possibility of new US land-based, conventional, intermediate-range and hypersonic missiles deployments in Asia.

US deployment (or the risk thereof) of hypersonic weapons to the region, along with revisions to the Missile Technology Control Regime to assist allies and partners such as Taiwan, Australia and Japan to build long-range, land-based offensive capabilities, could combine to alter Beijing’s strategic calculus on arms control. George Schultz, secretary of state under former US president Ronald Reagan, believed that the US deployment of short-range nuclear missiles in western Europe was what drove the former Soviet Union to the Intermediate-Range Nuclear Forces Treaty negotiation.

Given that the PLA Rocket Force sees hypersonic weapons as a deterrence unmatched by nuclear weapons, and can alter the strategic balance and affect an opponent’s intent and determination, US deployment of hypersonic weapons on one of the western Pacific island chains could induce Beijing to perceive a change in the strategic balance to its disadvantage, and compel it to participate in arms control negotiations with the US, Russia and potentially other nuclear states.

Holmes Liao has more than 30 years of professional experience in the U.S. aerospace industries and previously served as an adjunct distinguished lecturer at Taiwan’s War College. The full version of this article was published by the Jamestown Foundation in its China Brief publication on October 8, 2021 and can be found here: https://jamestown.org/program/chinas-development-of-hypersonic-missiles-and-thought-on-hypersonic-defense/
America is highly vulnerable to a missile attack

China, Russia and Iran all now have the projectile means to penetrate America's porous GBI-reliant missile defenses by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 September 28

https://asiatimes.com/2021/09/america-is-highly-vulnerable-to-a-missile-attack/

Despite spending billions of dollars, the US still lacks a credible ballistic missile defense to protect its territory from Russia, China or Iran. The US does have some defenses against a possible missile strike from North Korea but even these systems require billions of dollars in new investment for needed improvements.

A good interim solution for the US would be to adopt Israel’s Arrow-3 for homeland security defense, buying time to develop a new and capable ballistic missile defense system.

The US has three land-based missile defense systems and one sea-based system. Of the land-based systems, the Ground Based Midcourse Interceptor (GBI) is potentially the most important to protect US territory from an ICBM launch.

Yet the GBI has performed poorly in tests. So much so, in fact, that the Pentagon decided to drop Boeing, the GBI’s main contractor, and award an “interim” contract to Northrop and Lockheed to build 20 interceptor missiles. The new contracts are valued at US$3.7 billion.

Lockheed is partners with Aerojet Rocketdyne and Northrop with Raytheon Missiles and Defense.

Today, GBI launchers and radars are located at Fort Greely, Alaska and Vandenberg Air Force Base near Lompoc in Santa Barbara County, California. The US currently has only 44 interceptor missiles and none that can protect against a possible Chinese, Russian, or even Iranian attack.

The US has some other systems for missile defense, but none are capable against sophisticated ballistic missiles. A sophisticated ballistic missile is one that flies at hypersonic or near hypersonic speed and that can carry multiple warheads and various decoys and other masking devices.
Russia has had MIRV’d (multiple independently targeted re-entry vehicles) on its intercontinental ballistic missiles since about 1973. The US introduced them earlier, in 1968, on the Minuteman III.

China came late to the party, but today it has several long-range missile types with MIRV capability. Other countries including France, the UK and India reportedly have missiles that can carry more than one warhead; whether they are independently targetable isn’t so clear. Iran is working on a long-range rocket with at least two and possibly more warheads. North Korea also says it is working on hypersonic missiles with MIRV capability.

Defeating and destroying a ballistic missile is not easy, and virtually all tested systems have had difficulty even shooting down simulation drones that lacked multiple warheads or deception devices such as decoys.

The GBI is perhaps the worst of all in this regard. In an entirely optimistic assessment, the probability to kill rate for a single launch of an interceptor missile at a single target is put at 56%. To achieve anything like acceptable kills against a relatively unsophisticated ballistic missile threat, it would take four missiles to achieve a 97% kill rate probability.

Given there are only 44 missiles in Alaska and Vandenberg, the chances would be low of stopping a threat of more than 10 attacking missiles.

China has between 50 and 75 ICBMs and is said to be expanding the number as well as hardening the missiles in silos in new locations. North Korea, according to US assessments, has about 12 ICBMs but the number and sophistication are growing.

Right now, North Korea could successfully bypass US defenses on the West Coast and hit US targets. Russia has approximately 310 deployed ICBMs that can carry up to 1,189 warheads.
America is highly vulnerable to a missile attack

The Aegis Ashore anti-missile system in a file photo. Photo: US Defense Department

The US has deployed three other systems outside of the country. These are the THAAD (Terminal High Altitude Air Defense) system, the Patriot PAC 3 and the AEGIS sea and land-based system featuring relatively new interceptor missiles, the SM-3 and SM-6, to intercept midcourse and terminal ballistic missiles.

Aegis at sea is used by the US and by Japan. The US has a total of 47 ships that carry the ballistic missile defense version of Aegis. The land-based Aegis Ashore is now deployed in Deveselu, Romania, with another site under construction in Redzikowa, Poland.

Japan, which had earlier planned to buy Aegis ashore, changed its mind and decided to rely on Aegis at sea. Recent tests of Aegis SM-6 missiles for terminal defense against submarine-launched ballistic missiles failed.

THAAD is deployed in South Korea and has recently been deployed in Saudi Arabia, the UAE, Guam, Israel and Romania. There is also a THAAD unit in Hawaii. Saudi Arabia has also purchased its own THAAD system but it has not yet been delivered.

THAAD has a single-stage solid-fueled interceptor with a downrange of about 200 kilometers and a service ceiling of some 93 miles, allowing it to operate in the exo-atmosphere. Anything below 100 kilometers, or 60 miles, is considered the endo-atmosphere.

Unfortunately, THAAD tests have often failed. The interceptor is not designed to handle sophisticated missile threats and is intended to be used against short- and medium-range missiles. To appease Iran, the Biden administration has ordered the removal of its THAAD and Patriot systems from the UAE and Saudi Arabia.

Patriot PAC-3 – the most sophisticated version of the Patriot – can be used against short-range ballistic missiles and supersonic aircraft. Many countries rely on Patriot as their primary missile defense system, including Japan, South Korea, Taiwan, NATO and various countries in the Middle East.

The US does not deploy the Patriot on its home territory. The Patriot has intercepted a number of Houthi (really Iranian) short-range ballistic missiles. In many cases, Patriot has managed to hit incoming missiles but often too late to stop them from impact on or near their targets.
America is highly vulnerable to a missile attack

A Patriot PAC-3 anti-missile air defense unit. Photo: AFP / The Yomiuri Shimbun

The Patriot appears to lack the ability to differentiate between a missile body and a missile warhead, and it has trouble dealing with heavier threats.

Given that the only system the US has for homeland defense is GBI, and that GBI is waiting for new missiles, where does this leave the nation? Rather than waiting for a new GBI interceptor, the US should consider taking the existing US-Israeli Arrow 3 interceptor and use it as an interim replacement for the old GBI interceptor missiles.

Arrow 3 was funded significantly by the US, and Israel’s Missile Defense Organization (IMDO) is partnered with the Pentagon’s Missile Defense Agency (MDA).

About half the Israeli system is built in the US. In July 2019 over a 10-day period, the Arrow 3 was tested at the Pacific Spaceport Complex-Alaska (PSCA) in Kodiak, Alaska.

The Arrow system was integrated with the AN/TPY2 radar, the same one used for GBI. In Alaska, the Arrow 3 system fired three interceptors on three separate occasions against ballistic missile targets, destroying each one.

Arrow 3 does not have the same range as GBI but it still has considerable reach – 2,400 kilometers, or almost 1,500 miles. Unlike GBI, the Arrow 3 is a single-stage interceptor with thrust vector controls and a gimbaled electro-optical seeker.

Like GBI, it is a hit-to-kill system. The main advantage of Arrow-3 is that it is effective and can deal with North Korean threats for now. Arrow-3 is much smaller and more compact than GBI.
America is highly vulnerable to a missile attack

The launch of an Israeli Arrow 3 missile at an undisclosed location in southern Tel Aviv. Photo: AFP / Israeli Defense Ministry

A GBI interceptor is 1.28 meters in width, compared to Arrow-3, which is .53 meters and fits in a 21-inch standard launch tube.

The US would gain a lot by using Arrow-3 as an interim GBI solution. It would buy time for the US to build a new and really effective ballistic missile defense system, something that has been lacking for decades. It would also save billions from being wasted on another attempt to salvage a flawed system.

The US MDA is also partnered with Israel on a next step project dubbed Arrow-4. Few details are known about Arrow-4, but it appears it is designed to deal with MIRV’d threats.
How will US respond to China’s hypersonic threat?

China's hypersonic vehicle test showed it can deliver a nuclear weapon from space in violation of its 1967 Outer Space Treaty commitments

by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 October 29

https://asiatimes.com/2021/10/how-will-us-respond-to-chinas-hypersonic-threat/

China flaunts its hypersonic prowess in the Dongfeng-17 hypersonic glider during a military parade in Beijing in a file photo. Photo: AFP

China tested a [hypersonic glide vehicle in August](https://asia-times.com/2021/10/how-will-us-respond-to-chinas-hypersonic-threat/) launched from an orbiting spacecraft, qualifying the Chinese vehicle as a Fractional Orbit Bombardment (FOB) System.

The launch was [confirmed by the Chairman of the Joint Chiefs of Staff](https://asia-times.com/2021/10/how-will-us-respond-to-chinas-hypersonic-threat/), General Mark Milley, who called it “very close to a Sputnik moment.” He also said the launch was “very concerning.”

FOBs are nothing new. But what makes the Chinese system different is that instead of launching a nuclear warhead mounted on a small rocket in space orbit against a ground target, China has shown it can launch a hypersonic glide vehicle with a nuclear warhead from space.

Russia already has an ICBM hypersonic glide vehicle called [Avangard](https://asia-times.com/2021/10/how-will-us-respond-to-chinas-hypersonic-threat/), which is now deployed. Unlike the Chinese FOB, Avangard sits atop a missile launched from an underground silo. When within range of its target, it releases the Avangard hypersonic glide vehicle.

It is not currently an orbital vehicle or technically a fractional orbital vehicle. It is said to carry a 2 megaton, relatively small, nuclear warhead.

Going back in time, Russia built at least three different FOB platforms starting in 1960. One of them, called the R-36O, was first flight-tested in 1965. After 20 tests and many problems, the first Russian FOBs were deployed in 1971 in Kazakhstan, then part of the USSR, but were not equipped with nuclear warheads until the following year.

The R-36O was a fractional orbit system and was not intended to circle the earth entirely. For example, it might be launched from Russia, head down over the South Pole, and then head north to the United States following a partial orbiting path. In range of its target, it would launch a small rocket from space with a nuclear warhead.
How will US respond to China’s hypersonic threat?

Initially, the reason for FOBs for Russia was to overcome US anti-ballistic missile systems (ABMs). At the time of development, the US had only one such system called Sentinel (later called Safeguard), a system that would come to have 480 Spartan and 192 Sprint missiles, but Russia’s reasoning is that a FOB could be launched either over the North or South poles.

The world’s most powerful thermonuclear bomb, up to 100 megawatts, on display in the museum of nuclear weapons in the Russian Federal Nuclear Center in the Nizhny Novgorod Region. Much smaller warheads are needed for hypersonic missiles. Photo: Supplied

The US had an early warning system (BMEWS) in North America, Canada and in the UK covering launches over the North Pole. But a FOB, which could circle the earth many times in a low earth orbit, could equally be launched over the South Pole.

The US had no south-facing radars like the BMEWS. But in 1972, the US and the USSR signed the ABM Treaty, limiting both sides to two ABM sites – one to protect its capital and the other to protect an ICBM launch site. In 1974, the ABM treaty was amended with a protocol limiting both countries to one ABM site.

The US shut down the Sentinel system in 1976 and the US never built an ABM system to protect Washington, DC. The Russians deployed an ABM around Moscow, initially the A-35 (Galosh), in 1971, which later was replaced by the A-135.

In 2001, the US withdrew from the ABM treaty in order to build the Ground Based Interceptor – today limited to 44 launchers based in Alaska and California. Demolition of the old BMEWS system began in 2016.

By 1983, the Soviets decided to remove all its FOBs from service. By that time the US began deploying space-based radars, so a key advantage of the Russian FOBs to evade US ground radars was defeated by the radars and additional satellite-based sensors that were able to detect missile launches.

China, of course, was never a party to the ABM treaty, or any other bilateral or trilateral arms control agreement. However, China is a signatory to the 1967 Outer Space Treaty.
How will US respond to China’s hypersonic threat?

That treaty includes the following provision: “Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction … ”

The latest Chinese launch directly violates the terms of the Outer Space Treaty because the Chinese system orbited the earth. However, the UN, which is the treaty’s manager and repository, has said nothing about the Chinese launch.

China says it did not launch an FOB with a hypersonic vehicle but instead was testing a reusable space vehicle. If that was the case, why was this particular launch kept secret by the Chinese?

However, the belated US confirmation of the launch indicates that the US successfully tracked China’s hypersonic glide vehicle FOB test.

One of the troubling questions on the US side is why the Chinese launch was not reported at the time, as nearly three months passed before the Financial Times reported the news, probably based on a government leak.

d additional satellite-based sensors that were able to detect missile launches.

Was the Pentagon covering up the Chinese launch in order to avoid difficulties with China?

China’s vehicle clearly did not meet all expectations and will require more tests and a longer development cycle. One indication is that it appears the Chinese hypersonic glider missed its target by more than 20 miles, suggesting that accuracy and vehicle control remain major challenges.

And, because hypersonic glide vehicles can carry only small nuclear warheads – just as the predecessor Russian FOBs carried warheads one third smaller than could be put on ICBMs – accuracy is all-important to have a credible weapon.
How will US respond to China’s hypersonic threat?

An open and unanswered question is whether the US will decide to develop strategic defenses against hypersonic threats, whether launched from space, from sea, or by aircraft. Milley’s characterization of the Chinese hypersonic vehicle as “very close to a Sputnik moment” suggests that the Pentagon is deep in debate on how to respond to this new Chinese challenge.

One approach is to kill any low earth orbiting system before it can release a hypersonic vehicle. This probably would require a system that is space-based, has sophisticated sensors that can pick out a threatening hypersonic platform, and has the means to quickly destroy it.

Such a system would be quite different from classical ground-based ABMs, which are incapable of intercepting hypersonic threats. The US and Israel are jointly working on a system that addresses hypersonic space-based threats under the aegis of a new system called [Arrow 4](#).

The US contractor is Lockheed and the Israeli prime is Israel Aerospace Industries (IAI). Sponsorship is through the US Missile Defense Agency and the Israel Missile Defense Organization. Whether Arrow 4 is intended as an intercept of a space launched glider or whether it is intended to attack the launching platform is not clear.

Meanwhile, there is little doubt that China’s secret platform launch is the start of a new competition and global nuclear missile threat. The US will have to come up with an answer to China’s new threat, either with an effective defense against hypersonic weapons or a means to knock out FOBs before they release their weapons, or possibly both.
Commentary

Would the United States win the battle to save Taiwan from China? Not according to a series of Pentagon simulations and war games. In an effort to figure out what would happen should U.S. forces come to the defense of Taiwan, the Pentagon has determined that the U.S. might be defeated and certainly would suffer heavy losses of personnel and equipment.

Among military strategists, there is even debate about whether American aircraft carriers, generally thought to be critical for the relief of Taiwan, are vulnerable today to Chinese missiles and could be destroyed from long distances —perhaps as far as 1,000 miles or more.

It wasn’t always this way.

In 1996, China conducted a massive missile “exercise” and began to mass troops, suggesting that the “exercise” was a cover for an invasion of Taiwan.

Stephen Bryen was in Taipei along with R. James Woolsey, former head of the Central Intelligence Agency early in the Clinton administration, and Admiral Leon “Bud” Edney, who only four years before had been Vice Chief of US Naval Operations. They felt the fear and anxiety rapidly spreading on the island.

They wondered what Washington was doing, and the three of them hit the phones to push the Pentagon and the White House to act. Up to that point, President Bill Clinton, along with the National Security Council, had been unwilling to respond mostly because they were all about improving ties with China and enlarging mutually advantageous trade. As the danger grew and loomed, and the situation was approaching a dire point, Clinton finally sent in two carrier task forces.
A New Way to Defend Taiwan

But from that situation, China understood that to take over Taiwan it needed to significantly improve its navy and air force, acquire defensible landing vessels, and find a way to kill the American aircraft carriers. China has had 25 years to fix these problems and has done so by building very modern fighter planes (including the stealthy J-20) and nuclear bombers, landing ships such as the Type 075 Yushen Class large deck amphibious ships that can carry troops, helicopters, and armored vehicles, and carrier killer missiles.

In the carrier killer category is the Dong Feng (East Wind) DF-21D, a two stage solid fuel anti-ship missile with a range of 900 miles or more. This ship can be guided to its target by satellites and by drones. It is said to have a maneuverable reentry vehicle (warhead) making it difficult to defeat. Future versions of the DF-21D may also have multiple independently targeted warheads (MIRVs), adding to the DF-21Ds lethality and making it even more difficult to kill.

The United States is deploying AEGIS cruisers and new types of interceptor missiles such as the SM-3 (RIM-161 Standard Missile 3) and SM-6 (RIM-174 Standard Extended Range Active Missile), and the AEGIS radars have been improved. These newer systems are usually included with carrier task forces and may be able to stop a DF-21D attack, but whether it can stop a swarming DF-21D attack is unclear.

China is preparing on the one hand and watching the United States on the other. It isn’t clear at what point, using what strategies, China would reach the conclusion it could successfully attack U.S. aircraft carriers. Unfortunately, the same is true on the American side: it isn’t clear that the United States could stop a Chinese anti-carrier missile attack and we won’t really know until it happens.

But even if the carriers could get through, the Chinese Air Force is far more capable than it was 25 years ago. China is working to improve its stealth capabilities and match the American F-22 even more than the F-35, which is more of a tactical aircraft and is less stealthy than the F-22.

Unlike the United States, China is not a democratic country with a free press and free social media. If Chinese planners are willing to lose 400 aircraft and dozens of ships in what they believe will be a successful mission to defeat the United States, that will be part of their calculus.

But when the president asks Pentagon planners what to expect if we came to support Taiwan, he will get some bad news that could cause serious domestic pushback. He may be told a carrier could go down, or we could lose 50 to 75 fighter aircraft. This means the president has to consider the possibility of a public response to thousands of casualties and billions in lost hardware.

Much depends on the courage, political and moral, of the president. But the instinct in Washington would likely be an urgent attempt to push Taiwan into a negotiation with China that would end with Taiwan becoming Chinese. In effect, surrendering. That would get the United States off the hook but would be a dire warning to our friends in Asia that the sky was indeed falling and there was no hope or help to be had from the Americans.

Unless another formula is found.

Appeasement will, in the end lead to world war; it is impossible to believe that China would be satisfied just swallowing Taiwan. It should not be forgotten that China has an insatiable anger about Japan and what Japanese forces did to China in the 1930’s and 1940’s—the millions who were slaughtered, and the use of germ and chemical warfare by Japan against civilians, mainly Chinese.
A New Way to Defend Taiwan

The 1937-38 Rape of Nanjing/Nanking or the Nanjing Massacre, which may have killed as many as 300,000 Chinese, mainly civilians, is one of the many unavenged atrocities China remembers. Once China has chased away the Americans, Japan is the next target and the Japanese know it, that is why Japan calls a possible invasion of Taiwan an “existential threat.”

Allies in the Pacific can prevent this only with an entirely new strategy to deter China from attacking Taiwan. Instead of relying on far off carriers and waiting for the Chinese to create an incident or provocation to trigger a conflict, we need to take steps to change the game now by reinforcing Taiwan.

The best and fastest way would be to create a single Taiwan Military Command that includes Japan, the United States, and Taiwan. There is no coordination command mechanism today with Taiwan or Japan. The current American approach—to do it ourselves—is not viable. Japan has F-35s and F-15s, a small but good navy, and excellent submarines. Taiwan has modernized F-16’s and CK-F-1 home built fighters. All of these have to be used to block China, but they need to operate in a coordinated manner. For example, we must coordinate Identification Friend or Foe (IFF) assets so we can operate efficiently against the enemy and not kill each other.

A single command structure would let China know it has a significantly larger problem on its hands than just Taiwan, and that the United States and Japan and Taiwan have access and support from multiple bases on Taiwan, on Okinawa, and in Japan. With that sort of challenge, China cannot hope to isolate Taiwan and frighten away the Americans.

In addition, in a conflict, the air and naval bases, particularly in Japan and Okinawa (including American, Japanese, and Joint bases) should be available to Taiwan’s Air Force and Navy. This changes the game in two ways: Taiwan could operate from bases outside the island, meaning that Chinese attacks directed at Taiwan will not ensure a Chinese victory, and China would be confronted with threats from multiple bases and significant coordinated air and naval assets of the allies.

With a multi-base and support system to confront China and a common command, China’s strategy crumbles.

The Pentagon should run new simulations with a single military command and multiple bases mutually supporting the effort to block a Chinese invasion of Taiwan. Given the potential game-changing nature suggested here, China would understand that it is contained, much as NATO successfully contained the USSR from 1949 until its collapse in 1991.

The current administration needs to turn around its policy approach of global retreat and appeasement, which will ultimately lead to war, and adopt a new strategy to deal with China before it is too late.

*Views expressed in this article are the opinions of the author and do not necessarily reflect the views of The Epoch Times or the AIAA Los Angeles - Las Vegas Section.*

*Dr. Stephen Bryen is regarded as a thought leader on technology security policy, twice being awarded the Defense Department’s highest civilian honor, the Distinguished Public Service Medal. His most recent book is “Technology Security and National Power: Winners and Losers.”*

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(October 27) e-Happy Hour on AIAA LA-LV Virtual Starship Enterprise
(Screenshots Only)

Attendees gathering in the command deck of the virtual Starship Enterprise to chat, role-playing for Star Trek characters, and sharing excitement and thoughts of the recent aerospace development.

Max Trest, the high school student who designed the graphics of this Virtual SS Enterprise, sharing his recent progress in developing 3D rocket launch/landing game with professional attendees, who cheered for him. Lots of fun! Well done, Max! (Max is a High School Member of AIAA.)
(October 30) The Little Things that go Bump in the Night:
Space Debris from the Bottom Up... , by Dr. Henry B. Garrett (AIAA Fellow)
(Screenshots Only)

Dr. Henry Garrett opening the lecture by showing a fun TV show in the '70s "Sanford and Son" about a family of father-and-son junk dealer, and also urging attendees to visit the rocket museum in the town where he was born, Roswell, NM, also the birthplace of Robert H. Goddard (instead of visiting the UFO Museum in the same town ...).

(Left) The shield that Dr. Henry Garrett's designed and experimented has been in display in Smithsonian; (Right) The Kessler Syndrome, the main issue that so many people have been concerned about for the growth of space debris.

Dr. Henry Garrett answering questions and engaging in delightful conversations with the enthusiastic attendees. More exciting lectures/talks by the speaker will be arranged as it goes soon when his schedule allows again.
Hispanic Heritage Month is celebrated from September 15 to October 15. Meant to recognize and honor the histories, cultures and contributions of American citizens whose ancestors came from Spain, Mexico, the Caribbean and Central and South America, it was created by President Ronald Reagan in 1988. The starting date of this unique “month” was chosen because it’s the anniversary of independence for Latin American countries Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua, while Mexico and Chile celebrate their independence days on September 16 and September 18, respectively. Citizens of Hispanic heritage have a long history of contributing to American science, literature and the arts, from motion pictures, the stage, architecture, music, dance and the fine arts. One American artist who was proud of his Hispanic heritage was space artist Chesley Bonestell (1888-1986).

Photo: Robert E. David
Chesley Bonestell in his studio in Carmel, CA
¡Viva Señor Chesley Bonestell! (Hispanic Heritage Month)

Chesley’s family roots trace back to Mexico and further back to Spain. Young Chesley’s mother, Jovita Ferrer, was one of the fifteen children of Manuel Y. Ferrer, a prominent musician who was considered to be one of the best virtuoso guitarists in America. Manuel was born in Baja Sur California (Mexico) to parents who had emigrated from Spain.

Chesley, unfortunately, never really got to know his mother. Jovita developed pneumonia after falling overboard during a yachting party and died when Chesley was nine months old.

Chesley, and his sisters, Blanche and Lura, were raised by their father, Chesley Sr., and grandfather, Louis Bonestell, along with the help of other relatives.
Jovita’s godfather had been **General Mariano Guadalupe Vallejo** (1807-1890). Chesley’s own godfather was **Eusebius J. Molera** (1846-1932). Besides being a military commander, a town founder and politician, Molera had once been arguably the most powerful man in northern California. After the United States took over California in 1848, he worked on the state constitution and became a member of the first legislature. He was adamant in his efforts to preserve the history of Spanish and Mexican California.
¡Viva Señor Chesley Bonestell! (Hispanic Heritage Month)

“The Ferrers, Vallejos, and Moleras,” Bonestell wrote later, “were close friends. At my baptism, Mr. Molera presented me with a silver porringer (a shallow bowl with a handle), but it was lost in the 1906 earthquake and fire. Mr. Molera did not assiduously pursue his duties as godfather, however, as I did not see him again for 26 years, until I happened to sit opposite him at a dinner given for architects, painters and sculptors of the 1915 Panama Pacific Exposition. When I told him who I was, he exclaimed: ‘is this the little baby who was baptized at the Yglesia de Nuestra Senora de Guadalupe?’”

Bonestell did many paintings celebrating the history of his native San Francisco but perhaps the most personal tribute he paid to his Hispanic heritage was a series of more than twenty paintings in which he meticulously recreated classic California missions as they would have looked in their heyday. Twenty-one of them are found in the book, “The Golden Era of the Missions, 1769-1834,” with a text by historian, Paul C. Johnson.
¡Viva Señor Chesley Bonestell! (Hispanic Heritage Month)

Mission San Jose painted by Chesley Bonestell circa 1971-73

Mission San Miguel Arcangel painted by Chesley Bonestell circa 1971-73
¡Viva Señor Chesley Bonestell! (Hispanic Heritage Month)

Before he passed away in 1986, Chesley Bonestell expressed his desire that these paintings be kept together in one collection. He also wanted them to remain in California and displayed where the public could see them. He even built special velvet-lined, wooden boxes to store them until that happened. The collection was eventually acquired at auction by Bonestell enthusiast Brad Paul, who gifted them to the California Historical Society in 2018. Fellow enthusiast Gerson Smoger donated additional funding for necessary cleaning and preservation. Plans are being made by the California Historical Society to display these remarkable paintings to the public sometime in the near future.

You can find out more about Chesley Bonestell by watching the award-winning film, Chesley Bonestell: A Brush With The Future. It’s the only documentary ever made about the life and works of this remarkable artist and architect. This film is available to stream and for purchase on DVD and Blu-ray. All versions include subtitles in Spanish and in French. For more information, please click on the link below.

www.chesleybonestell.com
Rocket Lab to Recover Electron Rocket, Introduce Helicopter Operations During Next Launch

by Rocket Lab (with Permission) (2021 October 19)


Image Caption: Artist’s concept of Hypersonic Air-breathing Weapons Concept (HAWC) missile (Courtesy: Raytheon Missiles & Defense)

• The mission is the latest in Rocket Lab’s program to make Electron the first reusable orbital launch vehicle dedicated to small satellites.
• After splashing down in the ocean, Electron’s first stage will be recovered by ship and transported back to Rocket Lab’s production complex for analysis.
• For the first time, a helicopter will track and observe Electron’s descent in preparation for future missions which aim to use helicopters to intercept and capture returning rocket boosters mid-air as they return to Earth under parachute.

Long Beach, California. 19 October – Rocket Lab USA, Inc (“Rocket Lab” or the “Company”) (Nasdaq: RKLB) has today revealed it will attempt a controlled ocean splashdown and recovery of the first stage of an Electron rocket during the company’s next launch in November. The mission will be Rocket Lab’s third ocean recovery of an Electron stage; however, it will be the first time a helicopter will be stationed in the recovery zone around 200 nautical miles offshore to track and visually observe a descending stage in preparation for future aerial capture attempts. The helicopter will not attempt a mid-air capture for this mission but will test communications and tracking to refine the concept of operations (CONOPS) for future Electron aerial capture.
Rocket Lab to Recover Electron Rocket, Introduce Helicopter Operations During Next Launch

The ‘Love At First Insight’ mission is scheduled to lift-off from Launch Complex 1 in New Zealand during a 14-day launch window that opens on November 11, 2021 UTC. The mission’s primary objective is to deploy two Earth-observation satellites for global monitoring company BlackSky, with the secondary objective to splash down and recover Electron’s first stage to further validate Rocket Lab’s recovery operations and hardware.

“As one of only two companies to recover an orbital-class booster from space, we’ve proven it’s possible to make Electron the world’s first orbital-class reusable small launch vehicle,” says Peter Beck, Rocket Lab founder and CEO. “We’ve perfected Electron’s controlled descent, demonstrated flawless parachute deployment, and successfully plucked stages from the ocean. Now we’re gearing up for the next stage – preparing to use a helicopter to catch a rocket as it descends to Earth from space. It’s ambitious, but with each recovery mission we’ve iterated and refined the hardware and processes to make the impossible ordinary. I’m excited to take what we learn from this launch and put it into practice with aerial capture missions in future.”

Rocket Lab will be tracking the stage’s descent from space and as it approaches 19,000 ft (5.7 km) from the ocean surface, a helicopter will be dispatched to conduct reconnaissance of the returning booster. The ‘Love At First Insight’ mission will also include new recovery hardware developments to Electron including an advanced parachute to be deployed from the first stage at a higher-altitude, allowing for a slower drift back to Earth to test communications and tracking for future aerial recovery. Electron also features improvements to the first stage heat shield which protects its nine Rutherford engines while they endure up to 2200 °C heat and incredible pressure on the descent back to Earth. A team of Rocket Lab engineers and technicians will again be stationed at sea with their purpose-built Ocean Recovery and Capture Apparatus (ORCA) to retrieve the stage from the ocean and return it to Rocket Lab’s production complex in New Zealand for analysis and inspection.

The ‘Love At First Insight’ mission follows two previous ocean splashdown recovery missions; the ‘Return to Sender’ mission in November 2020, and the ‘Running Out of Toes’ mission in May 2021.

A livestream of the launch and real-time updates of recovery operations for ‘Love At First Insight’ will be available on Rocket Lab’s social media channels and website.

Note: ‘Love At First Insight’ launch and recovery operations timeline:

- Approximately two and a half minutes after lift-off, the nine Rutherford engines on Electron’s first stage will shut down and Electron’s first and second stages will separate. Electron’s second stage will continue with the customer’s payload to space, where the Kick Stage will separate and deploy the satellites.
- Following stage separation, Electron’s first stage will begin its descent. A cold-gas reaction control system will position the stage on an ideal angle to re-enter the atmosphere.
- While descending, Electron’s first stage is expected to experience intense heat and pressure while travelling up to eight times the speed of sound before significantly decelerating to enable a drogue parachute to be deployed.
- At approximately seven and a half minutes into the mission, Electron’s drogue parachute will be deployed at around 43,000 ft (13 km) altitude. This drogue parachute both increases the booster’s drag and stabilizes its descent as it approaches the ocean.
Rocket Lab to Recover Electron Rocket, Introduce Helicopter Operations During Next Launch

Earlier and higher than on previous flights, the large main parachute will be deployed less than a minute after the drogue, at an altitude of 19,000 ft (5.7 km) to further slow the stage and enable a controlled splashdown. A key objective of this mission is to increase the drift-time of Electron’s first stage to test communications and tracking for future aerial recovery efforts.

Upon receiving the all-clear from the recovery team stationed at sea, a nearby helicopter will be deployed to sight the returning stage and observe its descent to record data that will help refine Electron aerial capture CONOPS.

Once in the ocean, Rocket Lab engineers will attempt to retrieve the stage onboard their vessel with their purpose-built Ocean Recovery and Capture Apparatus (ORCA), a specialised cradle and winch system manufactured to Electron specifications and dimensions, before transporting the stage back to Rocket Lab’s production complex for analysis and inspection.

Further mission information

https://www.rocketlabusa.com/missions/next-mission

Images and video content


Live launch webcast

The live launch webcast will be available approximately 15 minutes prior to lift-off at:

www.rocketlabusa.com/live-stream

About Rocket Lab

Founded in 2006, Rocket Lab is an end-to-end space company with an established track record of mission success. We deliver reliable launch services, spacecraft components, satellites and other spacecraft and on-orbit management solutions that make it faster, easier and more affordable to access space. Headquartered in Long Beach, California, Rocket Lab designs and manufactures the Electron small orbital launch vehicle and the Photon satellite platform and is developing the Neutron 8-ton payload class launch vehicle. Since its first orbital launch in January 2018, Rocket Lab’s Electron launch vehicle has become the second most frequently launched U.S. rocket annually and has delivered 105 satellites to orbit for private and public sector organizations, enabling operations in national security, scientific research, space debris mitigation, Earth observation, climate monitoring, and communications. Rocket Lab’s Photon spacecraft platform has been selected to support NASA missions to the Moon and Mars, as well as the first private commercial mission to Venus. Rocket Lab has three launch pads at two launch sites, including two launch pads at a private orbital launch site located in New Zealand, one of which is currently operational, and a second launch site in Virginia, USA which is expected to become operational by the end of 2021. To learn more, visit www.rocketlabusa.com.
Stennis Space Center Helps Commercial Partner Launcher Reach Milestones
(2021 October 6) (with Permission from Launcher Space, CEO Mr. Max Haot)

When Launcher successfully completed a thrust chamber assembly hot fire at NASA’s Stennis Space Center in late August, it was just the latest in a string of testing milestones for the small satellite launch company.

For the past two years, Launcher has partnered with Stennis near Bay St. Louis, Mississippi, to conduct testing for its 3D-printed Engine-2 (E-2) rocket engine. Launcher is developing the 22,000-pound-thrust engine in the midst of a new space race, which has rocket designers and engineers thinking small.

Launcher hot fire: Commercial space company Launcher conducts a hot fire test for its 3D-printed Engine-2 rocket engine in the E Test Complex at NASA’s Stennis Space Center. Credits: Launcher/John Kraus Photography

The Hawthorne, California, company is one such startup vying to lead in what is known as the “small satellite launcher class” of rockets. With information collected from its Stennis test campaign, the company is seeking to develop the world’s most efficient rocket capable of delivering small satellites to orbit around Earth.

“The opportunity to work with a world-class team and facility at Stennis has allowed us to achieve major milestones in the development of E-2,” Launcher Lead Engineer Andre Ivankovic said. “The Stennis team works hard to meet our testing needs, and the facility can provide us with large quantities of high-pressure gases and propellants, as well as a data acquisition system. These capabilities have been critical for us to achieve multiple test campaigns within the first year of becoming a commercial tenant.”
The August milestone for Launcher followed a string of testing achievements in the E Test Complex at Stennis. In October 2020, Launcher conducted its first full-scale test fire of the Launcher E-2 engine injector and combustion chamber. In April 2021, the team successfully tested its E-2 liquid oxygen turbopump. The turbopump test series consisted of liquid nitrogen cold flow testing on April 21, with a total of seven tests for a combined 211.2 seconds (including a 120-second full duration test), and liquid oxygen cold flow testing on April 22, with a total of eight tests for a combined 162.6 seconds (including a 60-second full duration test). On Aug. 20, the company successfully completed a 5-second hot fire of its latest thrust chamber assembly.

The Launcher E-2 and the first testing campaigns at Stennis were funded, in part, through a U.S. Space Force Small Business Innovation Research (Phase II) award.

“As we scaled from 1,000-lbf thrust liquid rocket engine tests at our own test site to 22,000-lbf thrust engines, we partnered with NASA Stennis due to the surprisingly low cost and incredible facilities we could leverage,” Launcher Founder and CEO Max Haot said. “At the start, we were wondering if the government organization would be able to work at our startup speed and with our culture. Since then, we have been shocked at how great and easy it has been to work with the NASA team – to the point we nicknamed Stennis E complex ‘rocket engine testing paradise.’”

The Launcher team was attracted to Stennis due to its nearly 60 years of expertise and flexibility in testing both full-scale rocket engines and components, as well as its competitively priced lease agreement, highly secure facilities, easy accessibility, and a 125,000-acre acoustic buffer zone allowing 24/7 test operations without disruptions to nearby communities.

“There’s sometimes a misperception that working with the government is expensive,” said David “Skip” Roberts, a NASA senior project engineer overseeing the Launcher test partnership on the Stennis E-1 Test Stand. “However, by choosing to test at Stennis, commercial tenants like Launcher can reduce testing risk, speed up their developmental process, and incur cost-savings.”

Another major advantage in testing at Stennis is access to high-pressure propellant tanks and gases. “One of the main reasons Launcher decided to come to Stennis was because of our test infrastructure and ability of our High Pressure Gas Facility to deliver needed propellants and gases,” Roberts said.

For Launcher, the testing at Stennis is focused on efficiency. According to the company, the engine’s combustion chamber is the world’s largest, single-part, 3D-printed chamber of its kind for a liquid rocket engine and will produce the largest thrust, yield the lowest propellant consumption, and offer the lower cost-per-pound of thrust in the small satellite launcher class.

Launcher’s E-2 engine is designed to produce 22,000 pounds of thrust at sea level using RP-1 (a highly refined form of kerosene) and liquid oxygen as its propellants. A single E-2 engine will power the first stage of the Launcher Light vehicle, which the team claims will be capable of delivering payloads of up to 330 pounds to low-Earth orbit. Its first launch is planned for 2024.

In the meanwhile, Launcher plans to conduct longer duration tests of the entire thrust chamber assembly in the weeks ahead. By the middle of next year, the team aims to conduct full-duration, full-scale testing of the E-2 engine with its integrated turbopump at Stennis.

As the nation’s premier rocket propulsion test facility, Stennis offers nearly six decades of expertise, specialized and versatile infrastructure, cryogenic propellant and high pressure gas facilities, laboratories and shops, and advanced data-gathering technologies to ensure the success of commercial tenants, government partners, and academia.
Integrated Avionics on the Structure of Avionics Systems Architecture

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Abstract

There is a need for an avionics operation that implements several avionics functions within a single LRU. In an individual embodiment, the method incorporates a software-configurable RF assembly, interfaces to allow links to aircraft electronics and data loaders, and multipurpose antennas. Integrated Modular Avionics (IMA) systems, hostile to conventional avionics systems, promote the execution of varied aircraft functions on the same hardware modules. This contributes to reductions, for example, of price and weight, but it develops into also testing for the design space exploration, in specific, because of many process distribution choices. The process management concept of IMA systems gives the authority in advance for manually subdivide the process into a hierarchical system, comprising groups (or clusters) of jointly associated system components. Therefore, the departure to certain structure of the program design, such as IMA systems, it based on a program of performances mining techniques. The modular avionics process may likewise organize one or more linked processing line-replaceable units (LRUs), the rationalized handling LRUs covering at least one multi-core computer processor, one or more multi-function display (MFD) systems constructed to get imagery messages from the integrated handling LRUs and present the image data on a display device. Leading to beneficial effects regarding network load at the deployment level. We define a process to cut points on the resultant clustering, to resolve the final number of clusters, thus, the partitioning of the system.

Keywords: Avionics System, Clustering, Line-replaceable units (LRUs), Multi-function display (MFD), Software Architecture, System Modelling.
Fig. 1: Data mining-based automated architecture partitioning.

https://doi.org/10.1145/3270112.3270133 [6]

Fig. 2: ASAAC hierarchy

https://doi.org/10.1007/978-3-642-33826-7_14 [7]

Fig. 3: Assembly  https://doi.org/10.1007/s13272-015-0156-1 [2]
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Autonomous Tracking and Navigation for a Long-Range Autonomous Underwater Vehicle

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Abstract

It manifested discoveries in a study to find out the practicability of growing and displaying a long-range autonomous underwater vehicle. Based on a genuine war scale plan need, the technology advancement and ability of illustration programs describe. Interpreting the computing aspirations needed to prove the basis counting expected process performance efficiencies with activity program for the manifestation process. A sensor technique for exploration, interference avoidance, passive detection, vehicle motion, and vehicle health, is expressed in the study. Special attention/perception is drawn towards consideration of the hardware and software plan for the system, with an insistence on presenting as much top-down guidance as workable. The investigation of the software includes the operation of a system competent in supporting parallelism. In its knowledge, expert modules and a coordinated collection of perceptual and navigation modules linked through a blackboard. The report portrays the database/communication system, the Autonomous Underwater Vehicles (AUV), simultaneously with the releases which are essential in organizing the various sensors of the system. Simulations of a proposed vehicle, including six degrees of freedom, in a marine environment, contoured in the record. The progression of the AUV system from simulation through unit checking to the at-sea demonstration is marked out as a perk in the article.

Keywords: Autonomous Underwater Vehicles (AUV), communication system, database system, long-range AUV, six degrees of freedom, underwater vehicle.
Fig. 1: Two Tethys vehicles observing the oceanic environments [5]


Fig. 2: A glider is moving up and down by transitioning between two water current layers. [6]


Fig. 3: Diagram of LRAUV’s control mechanism for isotherm tracking. [7]

https://www.researchgate.net/publication/334623055
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Here Is Why The U-2 Plane Is Still In Service While SR-71 Is Not
by Aniqa Ajmal (with Permission) (2019 April 5)

On a hot sunny day, if you decide to fuel up an SR-71 plane while it is on the ground, the fuel won’t stay inside the plane and will leak out on the field. To start the engine, you can not use a standard airport start cart. Instead, you have to use a pair of V8 muscle car engines. Now to get fuel ignited, you must have to inject a rocket propellant-like particular, toxic, high-temperature hypergolic chemical.
Here Is Why The U-2 Plane Is Still In Service While SR-71 Is Not

Even after all that, the plane cannot get in the air with a full tank. Neither can it fly for too long without one. Therefore, a tanker must be ready to take the plane in the air. The leaks mentioned earlier only get sealed up when the plane reaches its cruising speed and gets heated up. After getting re-fueled a few times, the plane becomes ready to get deep inside the enemy’s territory at its full speed. SR-71 can achieve speeds up to Mach 1.5. At this speed, if you touch the glass with your bare hands, your hands would get burned.

In the scenario of engine shutting down, you have only three tries to get it restarted because starting this plane is not like turning the key. You have to carry that hypergolic restart mix on board enough to not make the plane a bomb. Flying an SR-71 plane is very dangerous and very expensive at the same time. As soon as the military realized that they could get the job done without this plane, they grounded it. This a shame as well because the SR-71 was the closest thing to a space plane ever made. However, U-2 still flies still it doesn’t have the drawbacks which SR-71 was bringing with it.

That is why the U2 is still in service but the SR-71 has been grounded.
NASA’s Webb Space Telescope Arrives in French Guiana After Sea Voyage

NASA RELEASE 21-132 (2021 October 12)


After the custom-built shipping container carrying Webb is unloaded from the MN Colibri, Webb will be transported to its launch site, Europe’s Spaceport in Kourou, French Guiana. Credits: NASA/Chris Gunn

NASA’s James Webb Space Telescope successfully arrived in French Guiana Tuesday, after a 16-day journey at sea. The 5,800-mile voyage took Webb from California through the Panama Canal to Port de Pariacabo on the Kourou River in French Guiana, on the northeastern coast of South America.

The world’s largest and most complex space science observatory will now be driven to its launch site, Europe’s Spaceport in Kourou, where it will begin two months of operational preparations before its launch on an Ariane 5 rocket, scheduled for Dec. 18.

Once operational, Webb will reveal insights about all phases of cosmic history – back to just after the big bang – and will help search for signs of potential habitability among the thousands of exoplanets scientists have discovered in recent years. The mission is an international collaboration led by NASA, in partnership with the European and Canadian space agencies.

“The James Webb Space Telescope is a colossal achievement, built to transform our view of the universe and deliver amazing science,” said NASA Administrator Bill Nelson. “Webb will look back over 13 billion years to the light created just after the big bang, with the power to show humanity the farthest reaches of space that we have ever seen. We are now very close to unlocking mysteries of the cosmos, thanks to the skills and expertise of our phenomenal team.”

After completing testing in August at Northrop Grumman's Space Park in Redondo Beach, California, the Webb team spent nearly a month folding, stowing, and preparing the massive observatory for shipment to South America. Webb was shipped in a custom-built, environmentally controlled container.
NASA’s Webb Space Telescope Arrives in French Guiana After Sea Voyage

Late in the evening of Friday, Sept. 24, Webb traveled with a police escort 26 miles through the streets of Los Angeles, from Northrop Grumman’s facility in Redondo Beach to Naval Weapons Station Seal Beach. There, it was loaded onto the MN Colibri, a French-flagged cargo ship that has previously transported satellites and spaceflight hardware to Kourou. The MN Colibri departed Seal Beach Sunday, Sept. 26 and entered the Panama Canal Tuesday, Oct. 5 on its way to Kourou.

The ocean journey represented the final leg of Webb’s long, earthbound travels over the years. The telescope was assembled at NASA’s Goddard Space Flight Center in Greenbelt, Maryland, starting in 2013. In 2017, it was shipped to NASA’s Johnson Space Center in Houston for cryogenic testing at the historic “Chamber A” test facility, famous for its use during the Apollo missions. In 2018, Webb shipped to Space Park in California, where for three years it underwent rigorous testing to ensure its readiness for operations in the environment of space.

“A talented team across America, Canada, and Europe worked together to build this highly complex observatory. It’s an incredible challenge — and very much worthwhile. We are going to see things in the universe beyond what we can even imagine today,” said Thomas Zurbuchen, associate administrator for NASA’s Science Mission Directorate in Washington. “Now that Webb has arrived in Kourou, we’re getting it ready for launch in December — and then we will watch in suspense over the next few weeks and months as we launch and ready the largest space telescope ever built.”

After Webb is removed from its shipping container, engineers will run final checks on the observatory’s condition. Webb will then be configured for flight, which includes loading the spacecraft with propellants, before Webb is mounted on top of the rocket and enclosed in the fairing for launch.

"Webb’s arrival at the launch site is a momentous occasion,” said Gregory Robinson, Webb’s program director at NASA Headquarters. “We are very excited to finally send the world’s next great observatory into deep space. Webb has crossed the country and traveled by sea. Now it will take its ultimate journey by rocket one million miles from Earth, to capture stunning images of the first galaxies in the early universe that are certain to transform our understanding of our place in the cosmos.”

For more information about the Webb mission, visit: https://www.nasa.gov/webb
Northrop Grumman Signs Cooperative Agreements with Korean Aerospace and Defense Industry Leaders for JSTARS-K

Demonstrates continued commitment to delivering advanced defense solutions to the Republic of Korea

by Northrop Grumman (2021 October 19) (with Permission)


Northrop Grumman’s JSTARS-K will leverage the company’s 30+ years of BMC2 mission domain expertise as a prime systems integrator combined with the G550 platform. Cooperative agreements with Korean aerospace and defense businesses will enhance interoperability with existing Republic of Korea systems.

The cooperative agreements are memoranda of understanding to deliver airborne battle management command and control (BMC2). Northrop Grumman is bringing its expertise in advanced technology, software, prime systems integration, advanced sensors and mission domain to deliver a low risk airborne BMC2 capability. Northrop Grumman’s JSTARS-K will incorporate the unique capabilities and talents of each cooperative organization to deliver the best value solution.

“Northrop Grumman has more than 30 years of leadership in advanced airborne BMC2 capability and mission expertise; we have continued to develop and deliver new technologies to outpace evolving threats,” said Janice Zilch, vice president, multi-domain command and control programs, Northrop Grumman. “With these cooperative agreements, we will deliver industry-leading capability powered with local content and talent to the Republic of Korea.”

Northrop Grumman is a technology company, focused on global security and human discovery. Our pioneering solutions equip our customers with capabilities they need to connect, advance and protect the U.S. and its allies. Driven by a shared purpose to solve our customers’ toughest problems, our 90,000 employees define possible every day.
(Oct. 16) China tests new space capability with hypersonic missile

(Oct. 17) China surprises U.S. with nuclear-capable hypersonic missile test, FT reports

(Oct. 19) What about China’s hypersonic missile? (Center for Security Policy)

(Oct. 27) China’s hypersonic weapon test close to ‘Sputnik moment’, says top US general.

(Oct. 16) International Space Station tilted after thrusters on a Russian craft fired unexpectedly

(Oct. 17) Now, Go Where No Man Has Gone Before (WSJ), by Dr. Buzz Aldrin

(Oct. 23) NASA targets February launch for Artemis 1 mission on its first moon rocket since Apollo

(Oct. 17) Space Station Astronauts Spot Strange Glow Over Europe

(Oct. 21) Jupiter hit by another space rock in rare views captured by Japanese skywatchers

(Oct. 25) General Dynamics, Epirus team up to integrate counter-drone swarm system on combat vehicles

(Oct. 21) Earth may be trapped inside a giant magnetic tunnel

(Oct. 20) NASA Announces Winners of Deep Space Food Challenge

(Oct. 26) IAC 2021: Dubai Kicks Off 72nd Edition Of 5-day International Space Event

(Oct. 25) NASA: Mars helicopter Ingenuity successfully completes 14th flight

(Oct. 30) Weather Delays SpaceX Launch of Crew-3 Astronauts for NASA (Nov. 3)

(Mar. 23) DC-X: The Rocket That Beat SpaceX by 20 Years

(Oct. 9) Space Station Astronauts Spot Strange Glow Over Europe

(Oct. 25) A Sample of Asteroid Ryugu

(Oct. 30) Geomagnetic storm watch in effect this Halloween following intense solar flare

(Oct. 26) Here’s a rare look at an Air Force F-117 stealth jet flying over California - Vintage airpower back in black.

(Oct. 20) NASA Announces Winners of Deep Space Food Challenge
Photography Gallery: The Cygnus Loop - Remnants of a Supernova

by Dr. Robert Q. Fugate, Speaker/Lecturer of the AIAA Space 2015 von Kármán Lecture
Photography Gallery: The Cygnus Loop - Remnants of a Supernova
by Dr. Robert Q. Fugate, Speaker/Lecturer of the AIAA Space 2015 von Kármán Lecture

Some stars explode - astronomers call the biggest of these cataclysmic events a supernova. They are (next to the merger of supermassive black holes) the largest releases of energy in the universe - some $10^{44}$ to $10^{46}$ joules - I know, an incomprehensible number. It is of the order of converting the entire mass of the sun into pure energy (light and heat) in accordance with Einstein’s $E=mc^2$ law.

Supernovae are the end point of the life cycle of very massive stars. The star collapses when it runs out of hydrogen and the internal pressure can no longer balance the force of gravity. The collapse onto the core of the star then increases the pressure creating new thermonuclear reactions that result in a supernova explosion, ejecting stellar material outward at up to 30,000 km/s and temperatures of over 1 million degrees. This shock wave interacts with the interstellar medium (ISM). The supernova produces elements heavier than iron (the heaviest element produced in lower mass stars) and these heavy elements become part of the ISM. Eventually clumps of material in the ISM coalesce by gravity to form new stars and accretion disks around those stars which form into planets, whose chemical composition comes from the remnants of the supernovae. We wouldn’t have rocky planets without supernovae.

Astronomers using data from the Gaia astrometry satellite now estimate the distance to Cygnus Loop at 2400 light years. This makes the physical diameter of the remnant 140 light years, about 150 times the diameter to the far reaches of our Solar System. This also puts the age of the remnant at 21,000 years. After a supernova explodes, the core that is left becomes either a neutron star or a black hole. Searches for compact stellar remnants in the Cygnus Loop have not been confidently identified. The Cygnus Loop is, not surprisingly, in the constellation Cygnus, east of the bright star Deneb. It has several parts, often seen as individual images, most notably the Eastern and Western Veil Nebulae and Pickering’s Triangle. It was discovered in 1784 by William Herschel with his 18 inch reflector telescope. There are very few supernova remnants that are visually observable with a small telescope but the Cygnus Loop is one of the finest.

I took this image in my backyard in the northeast heights of Albuquerque, NM. I used a cooled, monochrome astro camera and 3 narrowband filters centered on the emission lines of hydrogen-alpha, doubly ionized oxygen, and ionized sulphur. It is presented in a modified Hubble SHO palette in which the three channels from the narrowband filters are rendered as an RGB image, S->R, H->G, and O->B. I modified the colors so that the golds represent Ha, blue represents OIII, and yellows are a mixture of Ha and SII. The stars lose their natural color in this representation.

My four-inch telescope is a Takahashi FSQ 106 EDX4, camera is a ZWO ASI6200MM, filters are 3 nm Chroma in a ZWO EFW filter wheel, autofocuser is a PrimaLuce Labs Sexto Senso 2, all sitting on a Paramount ME mount, unguided. The whole rig is run remotely from my office Linux desktop over ethernet using a Raspberry Pi on the mount running the Stellarmate OS and KStars/Ekos software. The image is a two panel mosaic, with over 20 hours of integration - 243 five minute subframes taken over 5 nights in late August and early September. The subframes were calibrated with flats and darks, registered, normalized, and integrated in PixInsight. The mosaic was constructed in PixInsight using the GradientMergeMosaic process. Final adjustments and cropping were made in Photoshop.

A higher resolution image is available for viewing at https://www.rqfphoto.com/Astrophotography/Nightscapes/i-BxRygsj/A

Bob Fugate
Photography Gallery: Harvest Moon, plus Moon and Venus (Ms. Michelle Evans)

Ms. Michelle Evans

AIAA Distinguished Lecturer | Author, “The X-15 Rocket Plane, Flying the First Wings into Space”

https://www.aiaa-lalv.org/september-28-2020-aiaa-member-spotlight-on-michelle-evan/

Speaker of Several AIAA LA-LV Section Meetings, such as April 10, 2021 STS-1 40th Anniversary

https://www.aiaa-lalv.org/april-10-2021 sts-1 40th-anniversary-celebration-outward-odyssey-authors-present-columbia-and-the-legacy-of-the-space-shuttle-program/

Photos shot on 20 September at 7:39 pm. This was the Harvest Moon rising through atmospheric smoke above the hills of San Luis Obispo. Ms. Michelle Evans shot the image at 300mm and 1/500th.
Photography Gallery: Moon and Venus, a Gorgeous View!
(Ms. Michelle Evans)

Ms. Michelle Evans
AIAA Distinguished Lecturer | Author, “The X-15 Rocket Plane, Flying the First Wings into Space”
https://www.aiaa-lalv.org/september-28-2020-aiaa-member-spotlight-on-michelle-evans/
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Moon and Venus, a gorgeous view!: This photo was taken at 1/4000th of a second exposure at 300mm at 7:11 pm on Saturday, October 9th from Lake Forest, CA.

AIAA LA-LV Section Las Vegas Chapter Meeting (in Las Vegas) 11/1 Monday, 2021 November 1, 4:30-6:00 PM PDT (US and Canada)

**Gary Powers Jr. Spyplane Presentation at the Atomic Testing Museum**

*(at the National Atomic Testing Museum, 755 East Flamingo Road, Las Vegas, NV 89119)*

by

**Mr. Francis Gary Powers, Jr.**

On May 1, 1960, the World Changed...

On Nov 1, 2021, Francis Gary Powers, Jr. will tell his dad's story at the Atomic Testing Museum, 4:30-6pm

Arranged by: AIAA

Hear the inside stories as told to his son. Book availability and Signing will follow. Bring your questions!

NOTE: This is a FREE EVENT, and Seating is limited, so please reserve early.

This is an excellent link for your background prior to attending:

Disclaimer: The views of the speakers do not represent the views of AIAA or the AIAA Los Angeles-Las Vegas Section.

Contact: Mr. Marty Waldman, LA Chapter Chair ([email2mart@gmail.com](mailto:email2mart@gmail.com)) [https://aiaa-lasvegas.org](https://aiaa-lasvegas.org)

Dr. Ken Lui, Events/Program Chair, LA, AIAA LA-LV Section ([events.aiaalalv@gmail.com](mailto:events.aiaalalv@gmail.com))

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RSVP and Information: [https://conta.cc/3C9Fxjf](https://conta.cc/3C9Fxjf)

AIAAL-AV 11/6 Section (Town Hall) e-Meeting (Online on Zoom) Saturday, 2021 November 6, **10 AM PDT** (US and Canada)

**United States Loses First Global Space War to Russians**

*What is Space War? How to Fight and Win the Next Space War?*

by

**Mr. Paul Szymanski**

*Outer Space Warfare Noted Author and Speaker, Space Strategies Center; Space Control Consultant*

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Disclaimer: The views of the speakers do not represent the views of AIAA or the AIAA Los Angeles-Las Vegas Section.

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**November 15-17, 2021, Las Vegas, NV**

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