AIAA American Institute of Aeronautics and Astronautics Los Angeles - Las Vegas Section **Newsletter**

Raymer's Rules for Would-Be Aircraft Designers

by Dr. Daniel P. Raymer, President, Conceptual Research Corporation
AIAA Fellow, author of "Aircraft Design: A Conceptual Approach",
"RDS Design Software", "Simplified Aircraft Design for Homebuilders", and "Living In The Future".
http://www.aircraftdesign.com/ray-rule-wouldbe.html (with permission)

Often I am asked by high school and college students, or by recent graduates, what they should do to become an aircraft designer like me. I remember the feeling - when I was a teenager I was already crazy about airplanes, and was eager to be the next Kelly Johnson or Tom Swift.

It's a good job. Airplanes are fun, and airplane people are among the nicest people I know. You get to satisfy both your creative and your analytical urges – like an artist using geometric equations to give perfect perspective to a painting. As a designer, you get to be in the middle of everything, and there is something really ego-satisfying about an entire team of people – sometimes hundreds – working on your design. Even when they find things wrong with it, it makes you feel special!

The pay is fine. Sports and music stars make a lot more money, but most "wanna-be's" never make it in those fields. Anybody who works hard in aerospace will have a good career with very decent pay, eventually owning a nice house and car, and living an upper middle-class lifestyle. If you work for a big company or the government, the job security is pretty good, and even when there is an aerospace downturn the "advanced design" people are usually protected because they are needed to start the next big project. If you work for a small company or start your own, you'll probably get paid less initially but will have greater opportunity for striking it rich – or going broke. Even so, you'll have a great time, learn a lot, and improve your resume for the next job.

By the way, I know some designers and engineers who actually have gotten rich. Some were lucky enough to invent something and make it pay, others started their own companies, but most used the steady income of their engineering careers to finance other investments, especially real estate. One guy quietly worked as an engineer for 30 years, while buying little houses and renting them out, getting up in the middle of the night to fix broken toilets and such. Those little houses were in a place called Manhattan Beach, California. He doesn't have to fix toilets these days…..

 (Continued on Page 42)

June 2021

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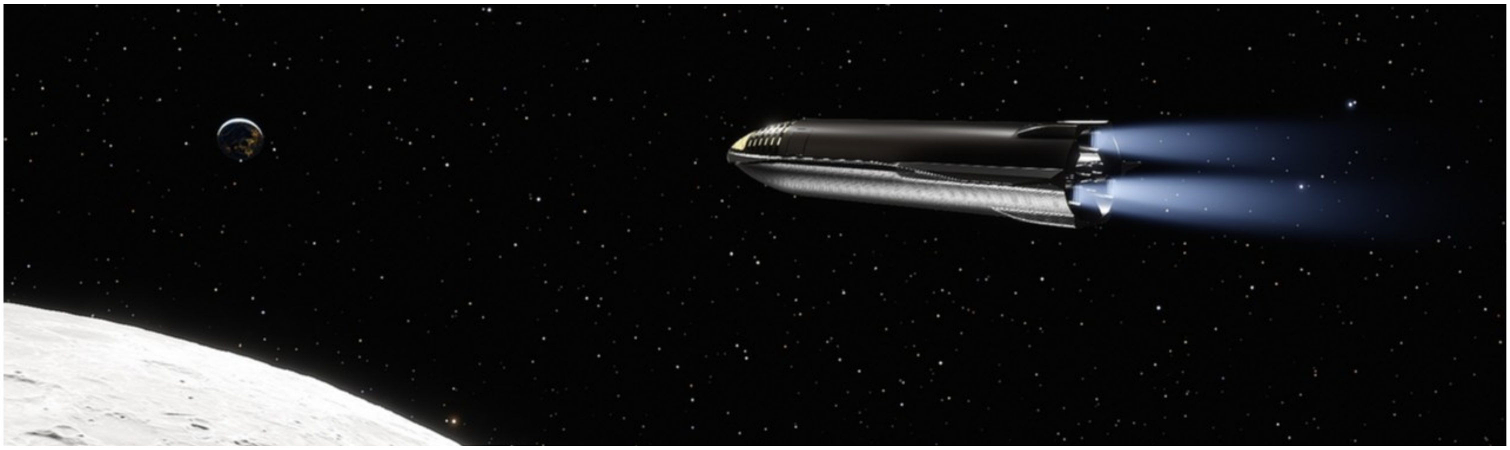
The Profound Potential of Elon Musk's New Rocket

An aerospace engineer explains why SpaceX's Starship will change everything.

by Dr. Robert Zubrin, Mars Society President, 2021 May 12 (with permission)

https://nautil.us/issue/100/outsiders/the-profound-potential-of-elon-musks-new-rocket



In the late afternoon of May 5, SpaceX's Elon Musk tweeted, "Starship landing nominal!" Musk is not known for understatement. But seeing that stainless steel behemoth soar was, for many, something more like phenomenal. Over 5 million people watched the spectacle on YouTube, perhaps many with bated breath, as every prior attempt at landing Starship had gone up in flames. Not SN15. This Starship, after having climbed 12 kilometers and then coasted down in a "belly flop" configuration—using its wide silver body as a brake—descended slowly, the force of its Raptor engines offering a soft, safe landing.

AND THE WINNER IS ...: *Last year, NASA awarded preliminary design contracts for its Artemis program to three contenders (above)—the Blue Origin-led National Team, the Dynetics team, and SpaceX. With Starship, SpaceX offered something radical. NASA, defying expectations, bought it. (Credit: NASA)*

Some folks at NASA probably felt a sense of relief. To the astonishment of the space industry, in April, NASA had awarded SpaceX a $2.9 billion contract to modify Starship to serve as the system that'll take astronauts to the moon. The favorite to win the job wasn't SpaceX, but the heavyweight "National Team," consisting of Jeff Bezos' Blue Origin, veteran aerospace contractors Lockheed Martin, Northrop Grumman, and Draper Labs. The selection was so unexpected that, when word of it was first leaked by the Washington Post, some well-informed observers refused to believe it. Politics suggested the National Team was the safe and sure bet.

Perhaps unsurprisingly, the losing teams (which also included an alliance of small businesses led by Dynetics) promptly protested NASA's choice, temporarily freezing the program. But, since SpaceX offers the most capability, at less than half the price bid by the others, it will likely prevail. NASA will no doubt take heavy fire from Congress for not playing ball. Politicians believe that NASA exists to serve their need to provide economic benefits to their constituents.[1] But the government agency also carries the banner of America's pioneer spirit. It is a human organization, subject to all the flaws of the system that supports it. But it has its moments. And boy, was this one of them. *(Continued on Page 46)*

Newt's World – Episode 259: Why SpaceX's Starship Will Change Everything, *an Interview by Rep. Newt Gingrich with Dr. Robert Zubrin*

2021 June 2 (with permission)

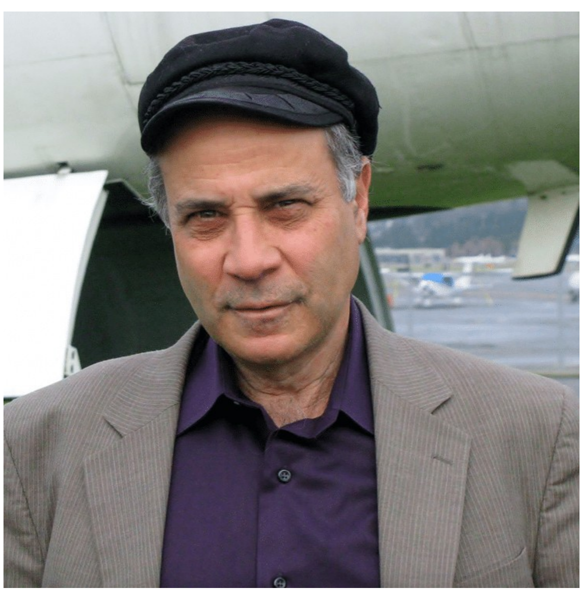
Rep. Newt Gingrich, 50th Speaker of the United States House of Representatives from 1995 to 1999

Dr. Robert Zubrin, President of Pioneer Astronautics, and the Founder and President of the Mars Society

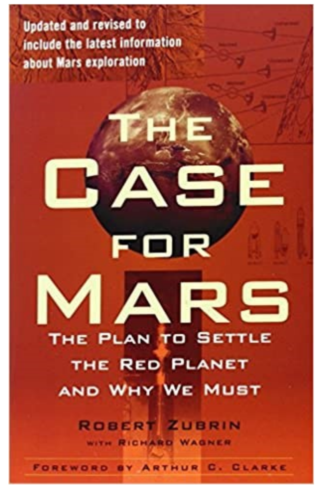
https://www.gingrich360.com/2021/06/02/newts-world-episode-259-why-spacexs-starship-will-change-everything/

Dr. Robert Zubrin is a former staff engineer at Lockheed Martin Astronautics and President of Pioneer Astronautics. He is also the Founder and President of the Mars Society and the author of over 200 publications and several books including ***The Case for Mars: The Plan to Settle the Red Planet and Why We Must***. Dr. Zubrin is here to talk about his recent article, ***The Profound Potential of Elon Musk's New Rocket*** and what SpaceX's Starship could do for the future of space travel.

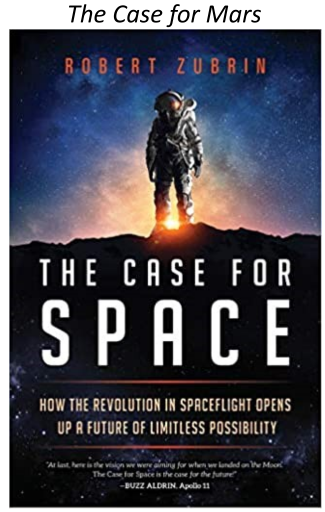
https://megaphone.link/HSW1426791634 (Interview Audio)



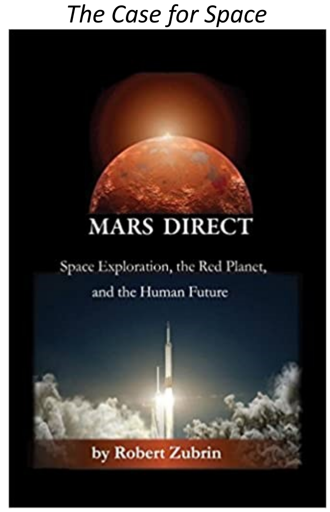
Robert Zubrin



The Case for Mars



The Case for Space



Mars Direct

SpaceX Could Land The First Starship On Mars As Soon As 2024

by Evelyn Arevalo, SpaceX Boca Chica Correspondent, 2021 May 31 (with permission)
https://www.tesmanian.com/blogs/tesmanian-blog/spacex-2024

Featured Image Source: SpaceX

Colonizing Mars will be one of the most important projects in human history. Enabling life on another planet will ensure our species does not go extinct if an event were to threaten all life on Earth. It is important for the human species to learn to adapt on other planets to preserve the beauty of what it means to be conscious. –"Starship is the key to making life multi-planetary and protecting the light of consciousness," SpaceX founder Elon Musk says. His aerospace company works around-the-clock to develop the technology and spacecraft that could change the course of humanity's future. "[…] I think it is important to have a self-sustaining city on Mars as soon as possible. I mean, I am optimistic about the future on Earth but its important to have insurance for life as a whole," he said during the *Axel Springer Award* ceremony in December last year.

Musk's ultimate goal is to develop a Starship spacecraft that will enable hundreds of adventurous astronauts to build the first settlement on the Red Planet. "…Building ~1000 Starships to create a self-sustaining city on Mars is our mission," he says. Musk estimates that manufacturing a fleet of 1,000 Starships over the course of 20 years would help make colonizing Mars possible before the year 2050. –"Building 100 Starships per year gets to 1,000 in 10 years or 100 megatons per year or maybe around 100,000 people per Earth-Mars orbital sync," Musk said in January last year. The orbits of Earth and Mars align (sync) closer to one another approximately every 2 years, enabling a shorter voyage to Mars. Starship would take approximately six months to arrive.

SpaceX could land the first Starship on Mars as soon as 2024. Musk said earlier this month that "2024 is not out of the question for an uncrewed flight" to Mars. The first crewed mission could take place in 2026 depending on the company's progress. SpaceX is rapidly developing the Starship launch system at its Starbase facility in South Texas where the company is preparing to launch the first stainless-steel launch vehicle prototype to orbit this Summer. Over the past year, engineers test launched five Starship vehicles during high-altitude flights powered by a trio of methane-fueled Raptor engines. The flight tests demonstrated how the spacecraft is capable of using its fins for aerodynamic flight and control upon landing. The same landing maneuver performed during test flights, shown in the video below, will be required on Mars upon descent. Musk is 'highly-confident' that Starship will be ready to conduct flights to space in less than three years. "I'm highly confident that we will have reached orbit many times with Starship before 2023. And that it will be safe enough for human transport by 2023. It's looking very promising," he said. However, humans will not be transported to Mars until several uncrewed Starships successfully land on the Red Planet's surface. SpaceX's first crewed mission aboard Starship will be a voyage around the Moon booked by Japanese entrepreneur Yusaku Maezawa, scheduled for 2023.

> SpaceX's fifth high-altitude flight test of Starship from Starbase in Texas pic.twitter.com/FnrXuHpsVj
>
> — SpaceX (@SpaceX) May 13, 2021

About the Author: Evelyn Arevalo

SpaceX Boca Chica correspondent. Writer specialized in spaceflight and space exploration. Rocket connoisseur.

Aerodynamic and Artistic Study of the German Jets

AIAA Distinguished Lecture at the University of Dayton, 2011

by J. Philip Barnes Senior Technical Fellow, Pelican Aero Group (with Permission)

For more information, visit www.HowFliesTheAlbatross.com

INTRODUCTION

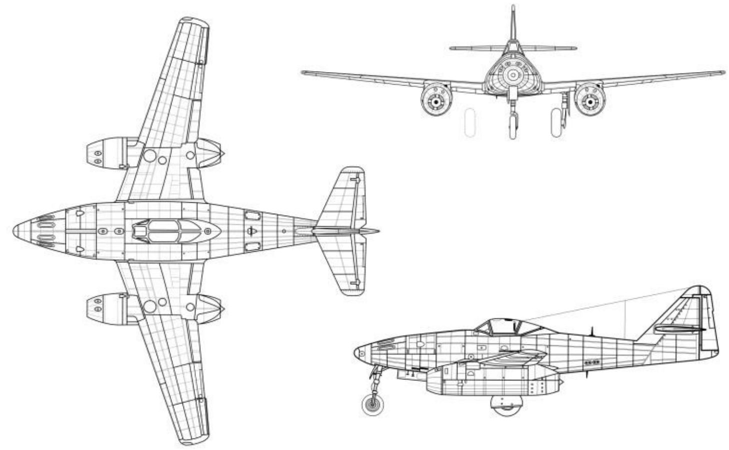
In April 1937, the world's first turbojets independently made their first runs in Britain and Germany (1). Just four days before the outbreak of WWII, the world's first jet aircraft took flight (2). By the last year of the war, the Germans were perhaps five years ahead of the allies in aerodynamic technology. At the time of this article, some 75-years on, the conceptual and real designs of the early "German Jets" continue capturing our imagination, as evidenced by widespread literature and artwork thereof.

Our presentation, after reviewing some fundamental aerodynamic principles, introduces a computationally-efficient method to study aerodynamic forces. We then apply the method to study the top-level aerodynamics of seven German jets, each noted for its unique configuration. Also, renowned computer-graphic artists Mario Merino and Gery Gueville share some of their work herein copyright-free. Thus our title: "Aerodynamic and Artistic Study of the German Jets."

Blohm und Voss P.209

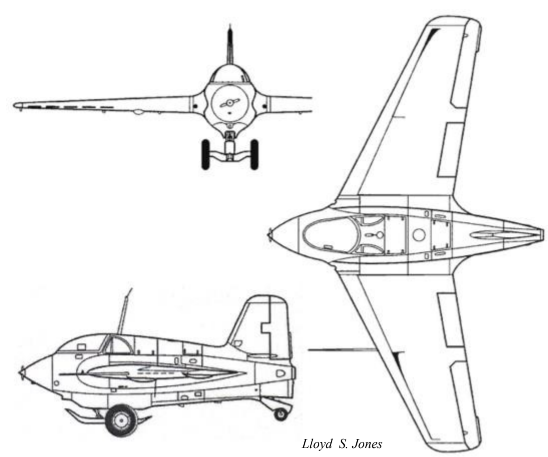
THE FIRST JETS

Although the Allied aircraft Gloster Meteor entered operational service just days before the Me 262, the Me 262 was the world's first jet aircraft to be used in aerial combat (3). Fortunately for the Allies, the contribution of the Me 262 to the German war effort was delayed by Hitler's insistence on its conversion into a fighter-bomber to hold off the coming Allied invasion. Nevertheless, the Me 262 took its toll on Allied bombers in the last months of the war. Its wing was swept to manage the center of gravity (c.g.). Not taking advantage of available German high-speed aerodynamic research, the Me 262 owed its maximum speed of 870 km/hr to the Jumo 004 engine.



Messerschmitt 262 and Jumo 004 (courtesy of Voytek S, Wikimedia)

The rocket-powered Me 163 was test flown beyond its critical speed by pilot Heini Dittmar, to Mach 0.84 where it exhibited instability about all three axes, in part because the forebody, in effect a low-aspect-ratio wing, develops lift and side forces which are unaffected by Mach number, whereas a fin with a relatively "thick" airfoil suffers a reduction of lift (side force) above its critical transonic Mach number. In addition, just as the wing is immersed in downwash due to forebody lift, the fin is immersed in sidewash due to forebody side forces. For both surfaces, such "wash" degrades aerodynamic effectiveness. Although the fin has higher aspect ratio than the forebody and enjoys a certain "end-plate" benefit in its attachment to the afterbody, the forebody and fin of the Me 163 are in close competition with nearly equal and opposite effects on yaw stability. Although an isolated wing is marginally stable in yaw, Albert Betz showed that such depends on tip-local lift. At high speed, both lift coefficient and isolated-wing yaw stability vanish. Thus misbehaved the Me 163.



Messerschmitt 163B

(*Continued on Page 50*)

Virgin Galactic Announces New Contract for Human-tended Research Spaceflight

IIAS Researcher Kellie Gerardi to Fly as Payload Specialist on Research Mission

by Business Wire and Virgin Galactic, 2021 June 03 (with Permission)

https://www.businesswire.com/news/home/20210603005203/en/Virgin-Galactic-Announces-New-Contract-for-Human-tended-Research-Spaceflight

LAS CRUCES, N.M.--(BUSINESS WIRE)--Virgin Galactic Holdings, Inc. (NYSE: SPCE) ("Virgin Galactic"), a vertically integrated aerospace and space travel company, has announced a new contract to fly Kellie Gerardi, a researcher for the International Institute for Astronautical Sciences (IIAS), on a dedicated research flight, during which Kellie will conduct experiments and test new healthcare technologies while she is in space.

The IIAS and Virgin Galactic teams will collaborate with academic and government partners to carefully plan Kellie's flight activities to maximize the science and technology advancements gained from the research experiments.

Kellie will utilize the novel scientific research benefits and applications that Virgin Galactic's Spaceflight System provides for human-tended research experiments to demonstrate and advance the research and knowledge gained from a number of her previous reduced gravity flight campaigns performed here on Earth, including with the National Research Council of Canada (NRC) and the Canadian Space Agency (CSA). Virgin Galactic expects to provide new benefits to the space science research community by offering repeatability, affordability and quality of the weightless environment, which have historically been barriers for many wanting to conduct spaceflight research.

During the spaceflight, Kellie will unbuckle from her seat and undertake the actions necessary to complete each experiment during several minutes of weightlessness. Virgin Galactic will provide bespoke training and preparation so that Kellie is fully equipped to carry out her job as a researcher on this flight and provide on-site pre-flight support for each of the payload experiments. Kellie has previously operated each experiment in reduced gravity flights with the NRC and will be bringing that unique payload specialist experience to the research mission.

The research experiments will include bio-monitoring instrumentation, including the Astroskin Bio-Monitor wearable sensors system. It was developed by Canadian company Carré Technologies Inc. (Hexoskin) with the support of the Canadian Space Agency and is designed to measure the biological effects of launch, weightlessness, re-entry, and landing on spaceflight participants. A second piece of research includes a free-floating fluid configuration experiment, whose data can be used to help inform novel technologies ranging from fluid-based accelerometer systems to humidifiers for spacecraft life support systems, and new syringe designs for administering medication in space.

"We're thrilled to work with Kellie Gerardi and the International Institute of Astronautical Sciences to help further their research in the bio-medical field,'' said Michael Colglazier, CEO, Virgin Galactic. "One of the unique aspects of our Spaceflight System is that it is pilot-flown, which means we're able to fly different flight profiles that meet the needs of our passengers in the cabin – whether that's scientific experiments or people – or in this case both. A big part of our mission is to provide scientists and researchers with reliable and frequent access to space for space-based research. We are very proud to fly Kellie so she can fulfill a lifelong dream, conduct important research, and inspire the next generation of researchers and astronauts."

Kellie Gerardi said: "To call this my life's dream would be an understatement. I've been a champion of Virgin Galactic's mission to democratize access to space from the earliest days, both during my time working a few test stands away at the Mojave Air & Space Port and through my years helping advance the regulatory framework for commercial human spaceflight with the Commercial Spaceflight Federation. The opportunity to fly as a payload specialist on a Virgin Galactic spaceflight brings everything full circle for me, and it's nothing short of an honor to have a front-row seat to the final frontier. I'm grateful to IIAS for the support and confidence they continue to place in me, and I look forward to helping pave the path for many talented researchers who are sure to follow."

IIAS Founder Dr. Jason Reimuller said: "Kellie has consistently demonstrated capability and professionalism in dynamic, operational, and multi-national research environments while enabling novel research. Additionally, her natural ability for science communication will help expand our nonprofit educational and outreach missions, inspiring others to see space as both inclusive of all and as a laboratory to benefit all of humanity. We look forward to working with Virgin Galactic as we expand our research from parabolic flight and analog environments towards longer-duration microgravity exposures in space."

About Kellie Gerardi

Kellie Gerardi is a bioastronautics researcher with the International Institute for Astronautical Sciences (IIAS) who has flown multiple parabolic research campaigns to evaluate commercial spacesuits and conduct research in microgravity. Kellie's work as a science communicator has attracted hundreds of thousands of fans on social media. She serves on the Defense Council for the Truman National Security Project and on the Board of Directors for The Explorers Club, whose esteemed flag she carried during a crew rotation at the Mars Desert Research Station. Kellie also holds a leadership role in global Mission Operations at Palantir Technologies. She is the author of Not Necessarily Rocket Science and the upcoming children's picture book series LUNA MUNA. Kellie lives in Jupiter, Florida with her husband Steven and their daughter Delta V.

Virgin Galactic Completes First Human Spaceflight from Spaceport American, New Mexico - *Welcome Astronauts and Payloads Home After Third Spaceflight*

by Virgin Galactic, 2021 May 22 (with Permission)

https://www.virgingalactic.com/articles/virgin-galactic-completes-first-human-spaceflight-from-spaceport-america-new-mexico/

Virgin Galactic today completed its third spaceflight and the first ever spaceflight from Spaceport America, New Mexico. Today's flight sees New Mexico become the third US state to launch humans into space.

VSS Unity achieved a speed of Mach 3 after being released from the mothership, VMS Eve, and reached space, at an altitude of 55.45 miles before gliding smoothly to a runway landing at Spaceport America.

On VSS Unity's flight deck were CJ Sturckow and Dave Mackay, while Kelly Latimer and Michael Masucci piloted VMS Eve. CJ, who flew as pilot-in-command, becomes the first person ever to have flown to space from three different states. The crew experienced extraordinary views of the bright, blue-rimmed curvature of the earth against the blackness of space. New Mexico's White Sands National Park sparkled brilliantly below. Their experience today gives Virgin Galactic's Future Astronaut customers a glimpse of what lies ahead.

Michael Colglazier, Chief Executive Officer of Virgin Galactic, said: "Today's flight showcased the inherent elegance and safety of our spaceflight system, while marking a major step forward for both Virgin Galactic and human spaceflight in New Mexico. Space travel is a bold and adventurous endeavor, and I am incredibly proud of our talented team for making the dream of private space travel a reality. We will immediately begin processing the data gained from this successful test flight, and we look forward to sharing news on our next planned milestone."

Virgin Galactic fulfilled a number of test objectives during the flight, including:

•Carried revenue-generating scientific research experiments as part of NASA's Flight Opportunities Program.

•Collected data to be used for the final two verification reports that are required as part of the current FAA commercial reusable spacecraft operator's license.

•Tested the spaceship's upgraded horizontal stabilizers and flight controls and validated EMI reductions.

Following the flight, and in line with normal procedures, Virgin Galactic will conduct a review of all test data gathered and thoroughly inspect the spaceship and mothership. Once the team confirms the results, the Company plans to proceed to the next flight test milestone.

To celebrate the first human spaceflight from New Mexico, the Zia Sun Symbol of New Mexico's state flag was placed prominently on the exterior of the Spaceship. In addition, we flew green chile seeds, which are synonymous with the state's rich agricultural and culinary history.

"Fifteen years ago, New Mexico embarked on a journey to create the world's first commercial spaceport," said Sir Richard Branson. ''Today, we launched the first human spaceflight from that very same place, marking an important milestone for both Virgin Galactic and New Mexico. I am proud of the team for their hard work and grateful to the people of New Mexico who have been unwavering in their commitment for commercial spaceflight from day one. Their belief and support have made today's historic achievement possible."

Governor Lujan Grisham said: "After so many years and so much hard work, New Mexico has finally reached the stars. Our state's scientific legacy has been honored by this important achievement, one that took guts and faith and an unwavering belief in what New Mexico can achieve — and indeed is destined to achieve. I can't wait to see what comes next. We are on the cutting edge, the forefront of innovation, and I plan to do everything in my power to keep us there, taking full advantage of our robust economic and scientific potential. On behalf of proud New Mexicans everywhere, I'm incredibly grateful to so many dedicated and visionary collaborators in this effort, not least Sir Richard Branson and former Governor Bill Richardson, the entire Virgin Galactic team and Spaceport team who made possible this long-awaited day."

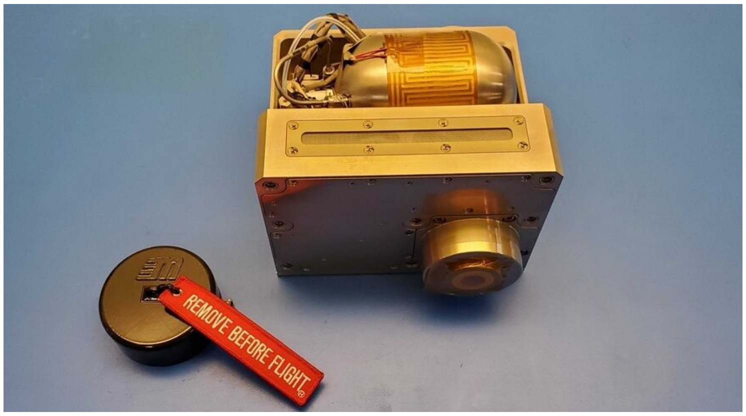
"The Spaceport has always been about the future of New Mexico," said former Governor Bill Richardson. "Our state and our people have a long track record of inspiring innovation and being catalysts for national advances in science and technology. So many of New Mexico's children will benefit from both the educational opportunities and the career opportunities that the space industry offers. I want to congratulate the team at Virgin Galactic for this historic achievement today. This dream began with a handshake between Sir Richard Branson and me, and I'll always be grateful to him for recognizing that New Mexico can and should be the base for the space industry. I want to recognize Rick Homans, who was critical in the creation of the Spaceport. And thank you to Governor Michelle Lujan Grisham for your dedication to the future of New Mexico and to the Spaceport."

"The Zia Sun Symbol is one of our most sacred symbols, central to the Pueblo of Zia," said Governor Frederick Medina. "We are pleased that Virgin Galactic reached out to our Pueblo for permission to utilize this iconic symbol of the state of New Mexico. It is an honor to work with Virgin Galactic and to know that a part of Zia Pueblo will be traveling to space."

This spaceflight was conducted under strict COVID-19 protocols.

Phase Four raises $26 million

by Jeff Foust , 2021 June 11 (with Permission) https://spacenews.com/phase-four-raises-26-million/



A Maxwell plasma thruster, which developer Phase Four says is the most compact system in its class. Credit: Phase Four

WASHINGTON — Phase Four has raised $26 million in a Series B round that will allow it to accelerate production of its satellite electric propulsion systems.

The company announced June 11 it raised the round led by venture capital firm New Science Ventures LLC. The company had raised about $20 million in earlier funding rounds.

The El Segundo, California-based company has developed a plasma propulsion system called Maxwell for use on small satellites. Strong demand for Maxwell after the launch of the first spacecraft with those thrusters earlier this year prompted the funding round in order to fuel the company's expansion.

"A lot of customers get more interested once they realize that this product is real and it's working in space," Beau Jarvis, chief executive of Phase Four, said in an interview. "We got a lot more inbound demand and our team has been pretty small up to this point. In order to make more Maxwell systems we needed to raise more capital."

Phase Four was introduced to New Science Ventures through another investor, he said. That VC firm has previously invested in ABL Space Systems, a small launch vehicle company, and PlanetIQ, which is developing a constellation of satellites to collect commercial weather data.

"Phase Four has the management team, core technology set and product strategy to build a leadership position in the in-space propulsion sector," Somu Subramaniam, managing partner of New Science Ventures, in a statement.

With the new funding, Jarvis said Phase Four plans to scale up production of thruster systems. "We're going to triple the production of Maxwell from now to the first half of next year," he said.

The first satellites with Maxwell thrusters launched in January, and the company now has three systems in orbit. Jarvis said the customers have asked not to be named for now, although Phase Four announced in 2019 orders from Capella Space and Tyvak Nano-Satellite Systems. The company expects to have up to eight thrusters in orbit by the end of the year.

The systems that are in orbit are working well. "Our engineering team says the data on orbit is as boring as the data in the environmental test facility, which is always good," Jarvis said. "That's given us the confidence to build more of them."

Those thrusters in orbit use xenon as propellant, but the company is studying the use of alternatives that can provide cost and mass savings. The company won a Small Business Innovation Research award from the U.S. Air Force in April to work on a version of Maxwell that uses iodine as propellant. Iodine doesn't require high-pressure vessels for storage and is less expensive than xenon.

Jarvis said the funding round will support work on the iodine-fueled version of Maxwell, including a new vacuum chamber dedicated to testing that thruster. "Our team right now is doing some initial testing with the new version of the thruster that will handle iodine. Later this summer, we'll be doing our first in chamber tests with iodine," he said. If all goes as planned, that thruster would be commercially available in early 2023.

About the Author:

Jeff Foust writes about space policy, commercial space, and related topics for SpaceNews.

He earned a Ph.D. in planetary sciences from the Massachusetts Institute of Technology and a bachelor's degree with honors in geophysics and planetary science from the California Institute of Technology.

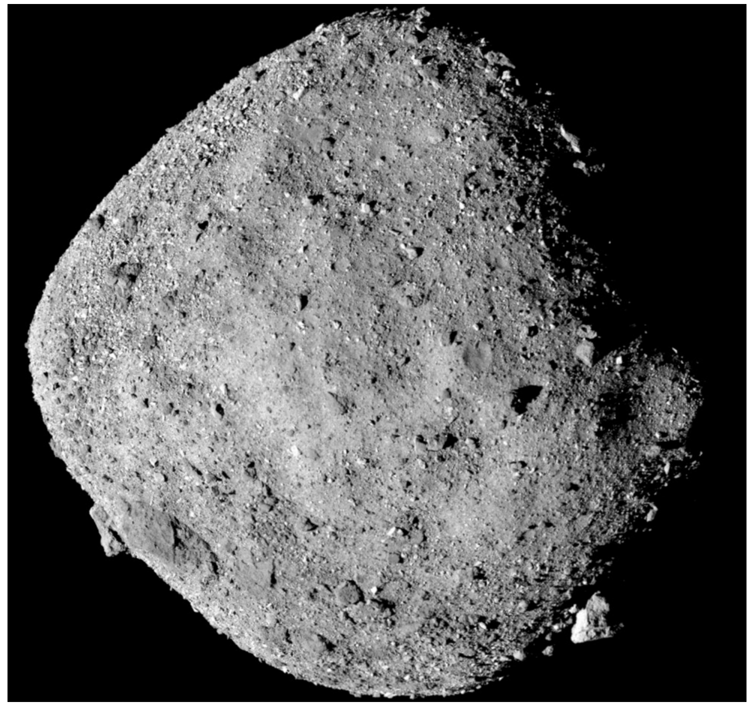
Returning From a Rock in a Hard Place!

OSIRIS-REx Bennu Departure, Aerospace Art, and Chesley Bonestell

by Douglass M. Stewart, Jr. Producer/Writer/Director, Chesley Bonestell: A Brush With The Future (with Permission)

[*https://mailchi.mp/4db0386806c5/what-secrets-will-osiris-rex-revea*](https://mailchi.mp/4db0386806c5/what-secrets-will-osiris-rex-revea)

NASA



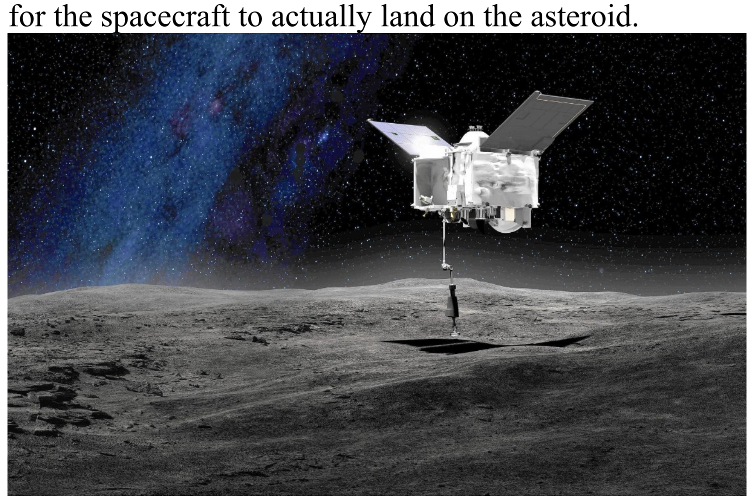
NASA

The asteroid Bennu

About 185 million miles from you right now, one of NASA's spacecraft is starting its journey back to Earth carrying a special cargo of dust and rocks. That material could change our understanding of how the Solar System was formed and how life on our planet came about. With all the news about the *Perseverance Mars Rover,* and the little-helicopter-that-could, *Ingenuity,* you might think that material is coming from Mars. Alas, no. It was collected on an asteroid named **Bennu.**

Barely one-third of a mile wide at its equator, Bennu is considered a perfect time capsule for events that took place 4.6 billion years ago. Asteroids are the rocky remains of the creation of our Solar System. Material scooped up from Bennu's surface and returned to Earth could reveal how planets were formed and possibly, the origins of organic compounds that led to life, as we know it. The spacecraft NASA built for such a mission has the somewhat Ancient Egyptian-sounding name of **OSIRIS-REx,** which is an acronym for **Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer**. It was launched back in 2016 and it took two years to reach Bennu.

In December 2018, OSIRIS-REx arrived and began orbiting around Bennu. After photographing and analyzing suitable sampling sites, the spacecraft dropped down briefly in October 2020. Mission plans did not call for the spacecraft to actually land on the asteroid.



NASA

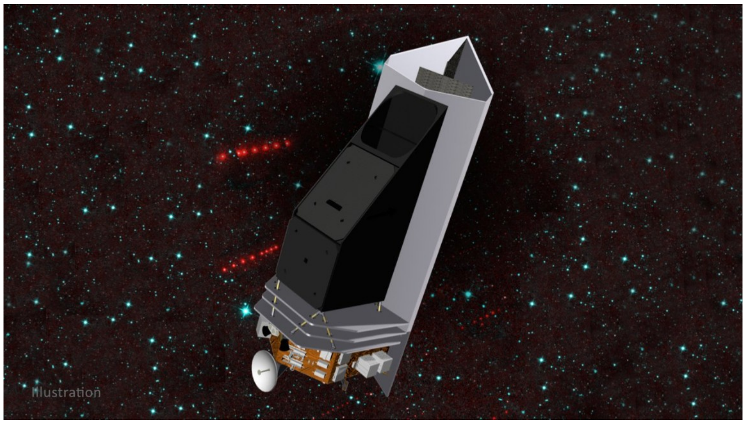
Artist depiction of OSIRIS-REx above the surface of Bennu

(Editor's Note: The AIAA LA-LV Planetary Defense Workshop and Asteroid Explorations Updates event will be on 2021 June 26: https://conta.cc/3hvTlNs)

(*Continued on Page 57*)

NASA Approves Asteroid Hunting Space Telescope to Continue Development

2021 June 11, https://www.jpl.nasa.gov/news/nasa-approves-asteroid-hunting-space-telescope-to-continue-development



NEO Surveyor is a new mission proposal designed to discover and characterize most of the potentially hazardous asteroids that are near the Earth. Credit: NASA/JPL-Caltech

The infrared space telescope is designed to help advance NASA's planetary defense efforts.

NASA has approved the Near-Earth Object Surveyor space telescope (NEO Surveyor) to move to the next phase of mission development after a successful mission review, authorizing the mission to move forward into Preliminary Design (known as Key Decision Point-B). The infrared space telescope is designed to help advance NASA's planetary defense efforts by expediting our ability to discover and characterize most of the potentially hazardous asteroids and comets that come within 30 million miles of Earth's orbit, collectively known as near-earth objects, or NEOs.

"NEO Surveyor will have the capability to rapidly accelerate the rate at which NASA is able to discover asteroids and comets that could pose a hazard to the Earth, and it is being designed to discover 90 percent of asteroids 140 meters in size or larger within a decade of being launched," said Mike Kelley, NEO Surveyor program scientist at NASA Headquarters.

Following completion of the goal to discover 90 percent of all NEOs larger than 1,000 meters (3,280 feet) in size in 2010, the National Aeronautics and Space Administration Act of 2005 (Public Law 109-155) directed NASA to discover 90% of NEOs larger than 140 meters (459 feet) in size. The agency is diligently working to achieve this directive and has currently found approximately 40% of near-Earth asteroids within this size range.

"Each night, astronomers across the globe diligently use ground-based optical telescopes to discover new NEOs, characterize their shape and size, and confirm they do not pose a threat to us," said Kelly Fast, program manager for NASA's NEO Observations Program. "Those telescopes are only able to look for NEOs in the night sky. NEO Surveyor would allow observations to continue day and night, specifically targeting regions where NEOs that could pose a hazard might be found and accelerating the progress toward the Congressional goal."

Discovering, characterizing, and tracking potentially hazardous NEOs as early as possible is crucial in ensuring that deflection or other preparations for impact mitigation can be carried out in time. NASA will test one deflection technology – the kinetic impactor – with its Double Asteroid Redirection Test (DART) mission, to be launched later this year. While there are no known impact threats to Earth for the next century, unpredicted impacts by unknown NEOs – such as the 2013 Chelyabinsk event in Russia – still pose a hazard to Earth. Using sensors that operate in the infrared, NEO Surveyor would help planetary scientists discover NEOs more quickly, including ones that could approach Earth during the day from closer to the direction of the Sun – something that is not currently possible using ground-based optical observatories.

"By searching for NEOs closer to the direction of the Sun, NEO Surveyor would help astronomers discover impact hazards that could approach Earth from the daytime sky," said Amy Mainzer, principal investigator for NEO Surveyor at the University of Arizona. "NEO Surveyor would also significantly enhance NASA's ability to determine the specific sizes and characteristics of newly discovered NEOs by using infrared light, complementing ongoing observations being conducted by ground-based observatories and radar."

NEO Surveyor's approval to move to this next mission milestone brings the telescope one step closer to launch, which is currently scheduled for the first half of 2026. The mission is being developed by NASA's Jet Propulsion Laboratory in Southern California and managed by NASA's Planetary Missions Program Office at Marshall Space Flight Center, with program oversight by the Planetary Defense Coordination Office (PDCO). NASA established the PDCO in 2016 to manage the agency's ongoing efforts in Planetary Defense.

For more information, visit:

https://www.nasa.gov/planetarydefense

(Editor's Note: The AIAA LA-LV Planetary Defense Workshop and Asteroid Explorations Updates event will be on 2021 June 26: https://conta.cc/3hvTlNs)

Engineering Fun During 70 years as a Member of AIAA !

AIAA LA-LV Member Anniversary Spotlight on Mr. Gerard W. Elverum Jr. , AIAA Fellow (70 Years of AIAA Membership!)

by Mr. Gerard W. Elverum Jr. Fellow, AIAA (NASA JPL and STL - Retired)

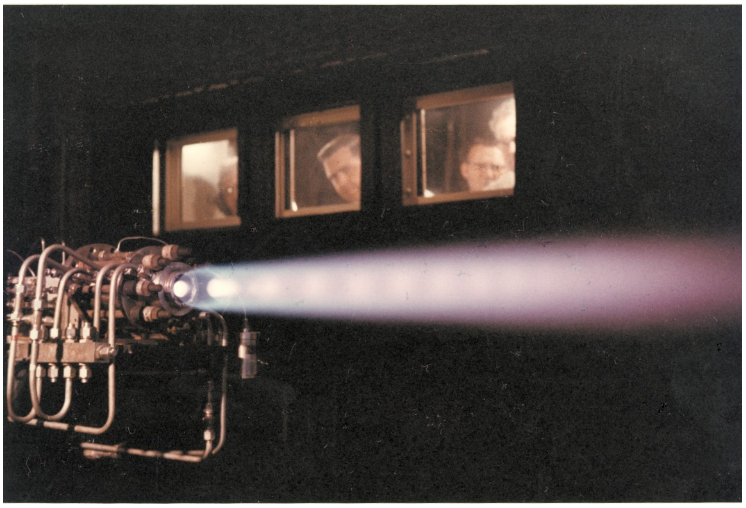
Mr. Gerard W. Elverum Jr.

Jerry Elverum is a native of Minnesota where he attended primary and secondary schools. In 1946 following two years in the Army Air Corps, he returned to Minneapolis to attend the University of Minnesota where he received a Bachelor of Physics degree from the University's Institute of Technology in 1949. With no jobs for a Physicist in Minneapolis, he took a chance on a $25 ride to California. There he talked his way into a what became a "destiny" job at the ***Jet Propulsion Laboratory of the California Institute of Technology.*** From the mid-40s to about 1960 when it became part of NASA, JPL was, as the name says, an Army funded jet propulsion facility.

At **JPL**, Jerry calculated rocket performance of many new "wild" propellants such as Fluorene with Hydrogen and with Ammonia, Hydrazine, UDMH etc. Back in those days there were no integrated solid-state computers. We had to do these thermodynamic and fluid dynamic computations using slide rules and Frieden mechanical calculators. Also, many of the key physical properties of these propellants were also unknown. For example, Jerry measured the density, surface tension and viscosity of **liquid Fluorine**, and the melting point of **Hydrazine nitrate!** He carried out many research programs on combustion and combustion instability, rocket engine design and technology programs on tactical missile-size advanced rocket engines. Jerry joined the **American Rocket Society (ARS)** in 1951. The **ARS** combined with the **Institute of Aerospace Sciences (IAS)** in 1963 to form the **AIAA.**

In March 1959, Jerry joined a new company called ***Space Technology Laboratories*** **(STL*)*** as head of the Advanced Propulsion Section. At the time, **STL** had engineering and technical direction responsibility for the Air force's ballistic missile programs, and Elverum worked on the combustion instability problems of the Atlas, Titan I and Titan II engines. But as its name implied, **STL** had ambitions to become a leader in **NASA** and military spacecraft. They envisioned needs for variable thrust rocket engines to carry out maneuvers in space.

By 1961, based on his experience at JPL, Jerry had invented and was testing a unique design concept for deep-throttling liquid bi-propellant rocket engines.



In those days we tested rocket engines right up close looking at them through a window!

Amazingly, in 1962 appeared the Apollo program! In 1963, **NASA** selected his throttling rocket engine design for a backup development program for the **Apollo Lunar Module Descent Engine (LMDE).** By December 1964, after a year and a half of intense competition with the selected engine contractor, Rocketdyne, NASA committed to the **STL** design for Apollo. Jerry was Program Director and Chief Engineer for **LMDE** throughout its flight design and development. He retained responsibility at **TRW Space and Defense** (formerly **STL**) for providing technical support to **NASA** throughout the entire Apollo flight program.

(Continued on Page 60)

Delightful 40 years of AIAA Membership! -Dr. Che-Hang Charles Ih's Story

AIAA LA-LV Member Anniversary Spotlight on Dr. Che-Hang Charles Ih, AIAA Associate Fellow (40 Years of AIAA Membership!)

by Dr. Che-Hang Charles Ih, Associate Fellow, AIAA (NASA JPL / Boeing - Retired)

Che-Hang Charles Ih has had a lifelong fascination with space and aviation that led him to an award-winning career as an innovator at JPL and Boeing.

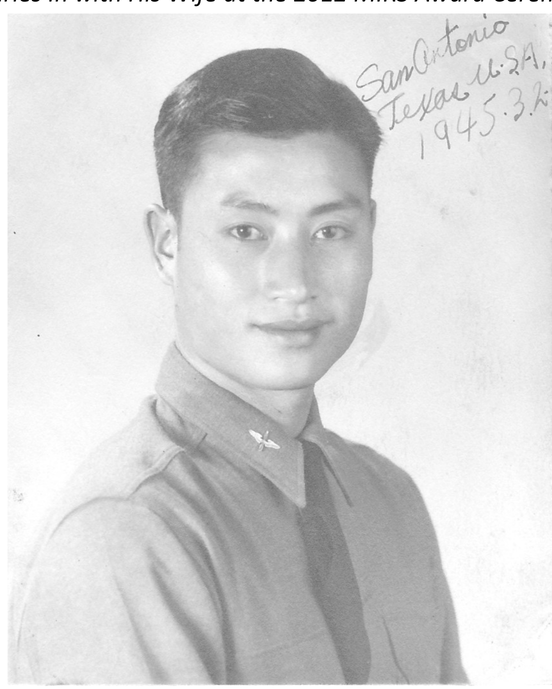
Charles was strongly inspired and influenced by his heroic father, who went into the Chinese Air Force at the age of 18 and, following the bombing of Pearl Harbor, flew B-24s and B-25s in training in the United States aiming at joining a Chinese and American mixed bomber wing against Japanese. However, the war ended before his father finished his training. After World War II, his father returned to China and flew more than 100 high-risk missions as a bomber pilot in the civil war between 1946 and 1949. Many of his father's classmates died in their 20s in the battle. His father survived and was a true hero with many medals.

As a matter of fact, his father narrowly escaped death three times, once when his plane was hit and he sputtered back to his base leaking fuel, only to find his landing gear stuck. He glided to the ground for a rough landing, suffered injuries from the impact, and found himself in the care of a "special nurse" as he recovered. That "special nurse" in the Air Force Hospital later on became Charles's mom. In time, Charles's father and mother, who achieved the ranks of Air Force lieutenant colonel and captain, retreated separately to Taiwan, where they immediately reunited. Naturally, Charles has been fascinated by aviation ever since childhood. He liked to watch planes take off and land. It fascinated him.

As Charles grew older, he was intrigued by further reaches of space. He recalls watching the light spots of satellites fly over the night sky when he was in elementary school, and Apollo 11 and NASA astronauts land on the moon when he was in high school. He was determined since high school to come to the U.S. for advanced degrees and get into the aerospace field.

Influenced by his father's courage and enthusiasm, Charles worked hard, earning a bachelor's degree in mechanical engineering from National Cheng Kung University in Taiwan in 1974. He came to the U.S. with a full scholarship, earned a master's degree in mechanical engineering from Northwestern University in 1979, and a doctorate in control engineering from UCLA with straight A's in 1985.

Charles Ih with His Wife at the 2012 MIRS Award Ceremony



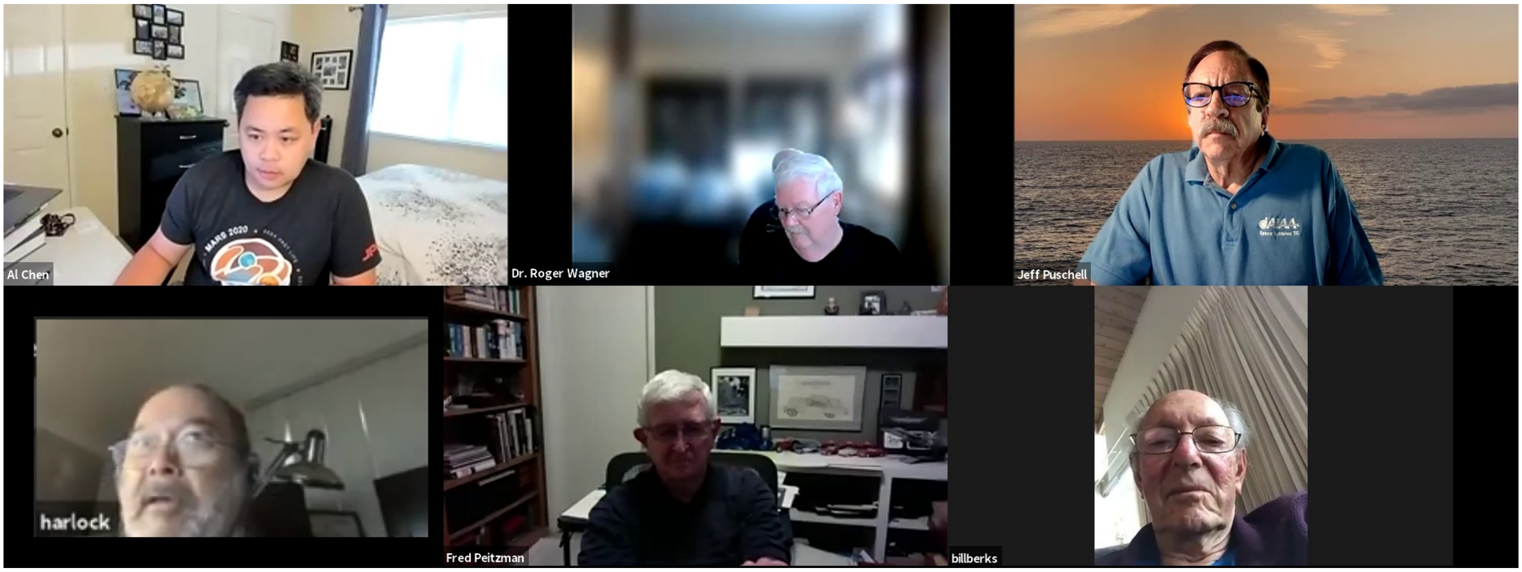
Charles Ih's Father During B-25 Training in San Antonio in 1945

(Continued on Page 61)

AIAA LA-LV Recognized Members with Membership Anniversaries on 5/27

(Screenshots and Names of LA-LV Section Members with AIAA Membership Anniversaries)

https://www.aiaa-lalv.org/the-challenges-of-landing-perseverance-on-mars-by-mr-allen-chen/



AIAA LA-LV Members with AIAA Membership Anniversaries taking turns sharing their fun stories and experiences with AIAA membership and how they first joined AIAA. Upper Left: The Mars 2020 Perseverance Speaker in the event on May 27, Mr. Allen Chen, listening enthusiastically to the interesting stories from those members with membership anniversaries; Upper Middle: Dr. Roger Wagner (50th Anniversary); Upper Right: Dr. Jeff Puschell, AIAA LA-LV Section Chair, AIAA Fellow, listening while leading the session, along with Mr. Aldo Martinez Martinez (not showing the camera/face), AIAA Membership Chair) moderating the Membership Anniversaries Recognition Session; Lower Left: Mr. Doug Ikemi (40th Anniversary); Lower Middle: Mr. Fred Peitzman (60th Anniversary); Lower Right: Mr. Bill Berks (70th Anniversary). Mr. Gerard W. Elverum Jr. joined briefly but got disconnected due to technical issues, but later rejoined as an attendee for Mr. Allen Chen's presentation on Mars 2020 Perseverance landing.

(70th AIAA Membership Anniversary)

William Berks *(attended)*

Gerald Elverum Jr. *(attended, also with an article, p. 11)*

Kenneth Goldman

Herbert Graham

(60th AIAA Membership Anniversary)

Dale Hoffman

Dr. William King

Dr. Munson Kwok

Fred Peitzman *(attended)*

Donald Reeves

Ernest Wade

(50th AIAA Membership Anniversary)

Dr. William Griffin

Mr. David Poland

Dr. Roger Wagner *(attended)*

(40th AIAA Membership Anniversary)

Dr. Che-Hang Charles Ih *(with an article, p. 12)*

Mr. Doug Ikemi

Robert Potts

Ms. Marilee Wheaton

(25th AIAA Membership Anniversary)

Mr. Aykut Altug

Mr. Hovhannes Armenian

Mr. Jason Pugsley

Dr. Judith Rochat

Gary Rolle

Dr. Paul Staszak

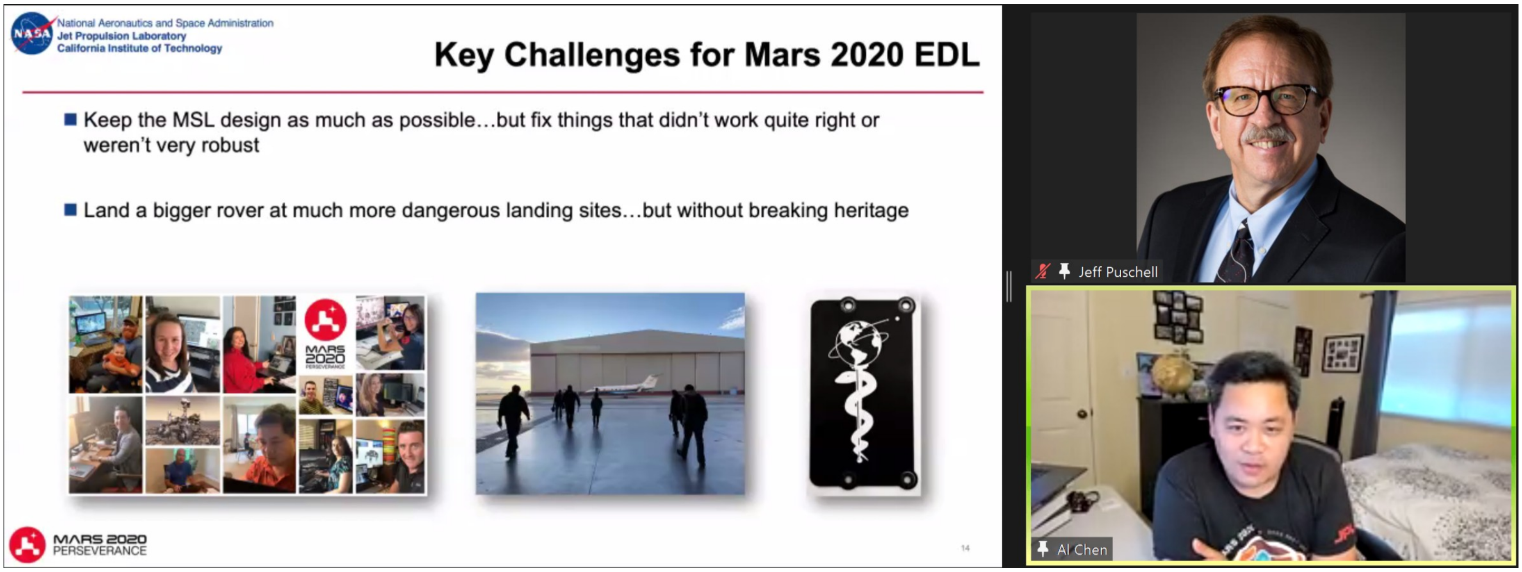
John Walsh

Congratulations !!!

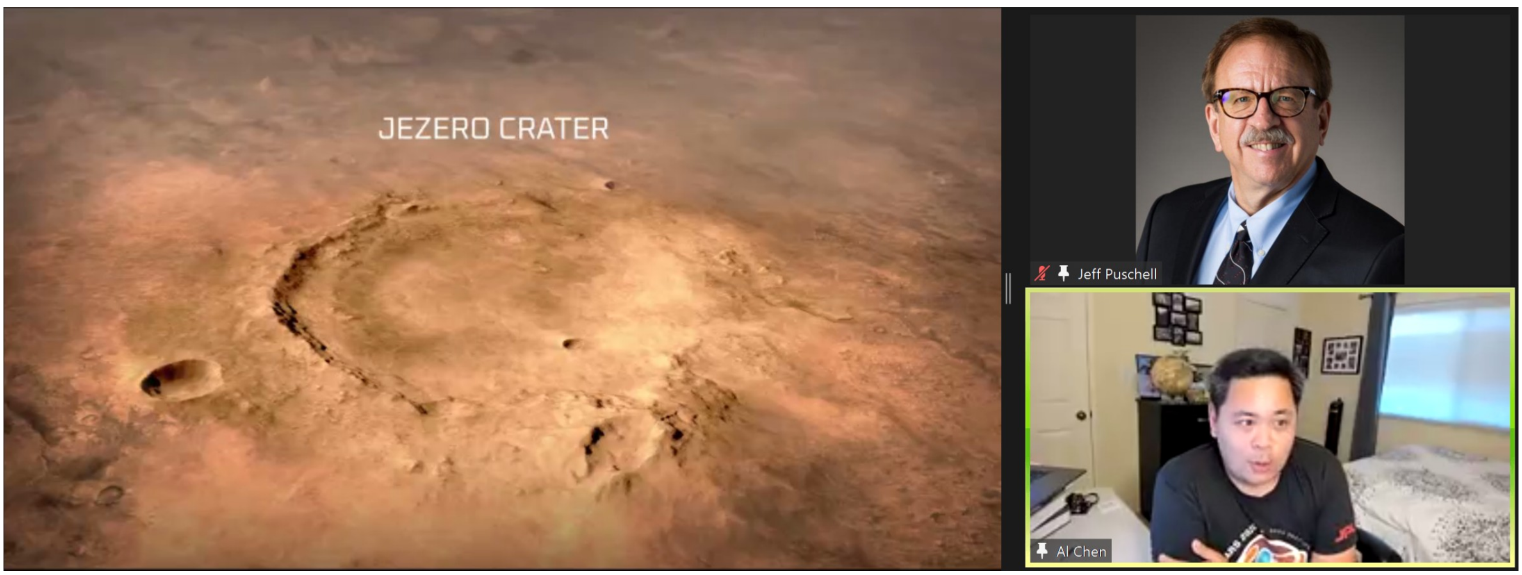
The Challenges of Landing Perseverance on Mars by Mr. Allen Chen (5/27)

(Screenshots Only)

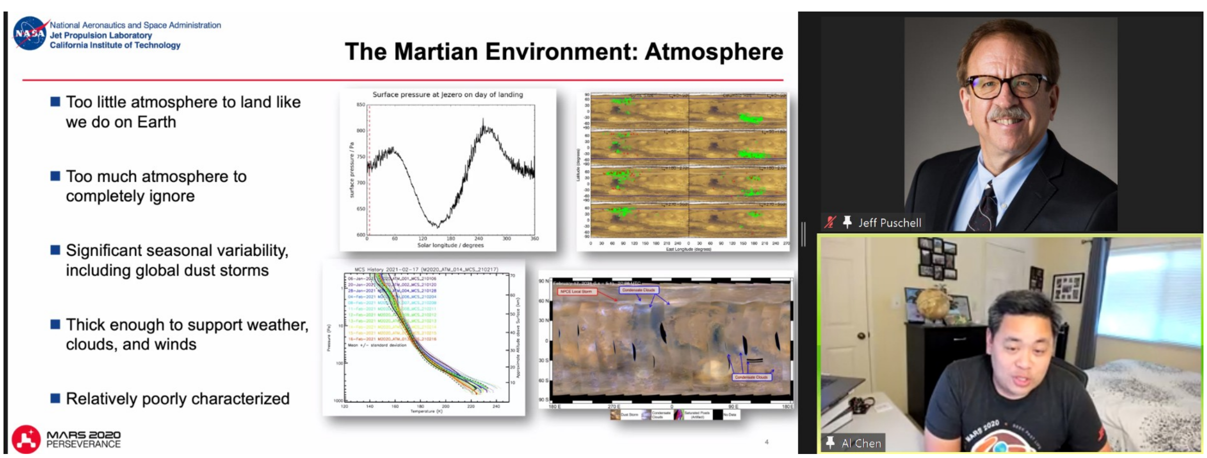
https://www.aiaa-lalv.org/the-challenges-of-landing-perseverance-on-mars-by-mr-allen-chen/



Mr. Allen Chen discussing several key challenges for landing the Perseverance Rover safety and accurately on Mars.



Jezero Crater presented several unique attractions as the landing site, but also several associated challenges.



The Martian Atmosphere played a very important role in the Landing process for the Perseverance.

Beryllium's Backstage Pass

by Julian Bailinson, Writer, the LA Gauge Company

Beryllium is not an unknown name; at number 4 on the periodic table, it was inevitably mentioned in most peoples' grade-school science class. However, it is generally overshadowed by the other, more commonplace elements, and not much is said about it other than "it's rare." In reality, Beryllium is an extremely important metal that has been at the forefront of technology since the early 20th century. It's as if Beryllium has had a backstage pass to many of the most important innovations of the last 100 years: always allowed behind the scenes, previewing what's to come and influencing the course of progress.

Background

Briefly put, Beryllium is a highly desirable metal for many modern applications, from aerospace components to cars, smartphones, and computers. It is sought out for its high tensile strength and extremely light weight, as well as being non-magnetic, lending it many beneficial properties both in pure form and when alloyed with more common materials such as copper and aluminum. However, its relative scarcity and difficulty in being processed safely make it one of the more expensive metals on the market; as of 2020, the cost of one kilogram of Beryllium is about 478 times that of Aluminum[1][2].

In nature, Beryllium is found as an oxide in the mineral Beryl. Even in this form, Beryllium can fetch top dollar, as Beryl is present in the gemstones Aquamarine, Peridot, and Emerald. The earliest chemist to identify Beryllium oxide, Louis-Nicholas Vauquelin, originally named it "Glucinium" because it tasted like glucose (a.k.a. sugar)[1][3]. Yes, really. This was standard practice in 1798, and led to the premature deaths of many chemists.

Role in History

Beryllium has been key to many of the technological advances of the last 100 years. As early as the 1920s, it was used in telephone switchboard manufacturing. By the 1930s, Beryllium was being incorporated into the windows of X-Ray tubes due to it being nearly invisible in X-Ray images, a manufacturing technique that continues to this day[4]. It was also used as an electronic insulator for vacuum tubes; its insulating properties would become more relevant as electronics advanced through the decades.

Beryllium was an extremely important defense and aerospace material during World War II. Its light weight and high strength made it ideal for applications where excess weight was a concern, such as parachute buckles. Many aircraft took advantage of Beryllium for navigational and gyroscopic instruments, as it is non-magnetic (and thus more resistant to interference) and extremely stable across a wide range of temperatures, a highly valuable quality in aircraft that fly at high speeds and high altitudes. It was also identified as an ideal material for nuclear weapons from their inception, becoming a key part of the internal reflectors that create a nuclear blast[1][5][6].

Beryllium continued to be critical to aerospace throughout the latter half of the 20th century, being used for navigation in key 1950s aircraft such as the B-52 Stratofortress, and becoming an integral part of space travel technology; Beryllium heat shields on the Freedom 7 capsule allowed for the first American manned space flight in 1961[6] [7]. By the end of the 60s, NASA was sending people to the moon on the most advanced rockets of the time, many of them using pure Beryllium fuel nozzles[6].

During the 1970s, Beryllium was involved in the iteration and miniaturization of electronics, being key to the components used in microcomputers, which would go on to start the digital age[1]. In the 1980s, intercontinental telecommunications were revolutionized with the advent of undersea fiber-optic cables, which used Beryllium-copper alloy in their pressurizing mechanisms to prevent them from being crushed at the bottom of the ocean[8]. During the 1990s, Beryllium was used in inertial crash sensors for airbag systems, ushering in a new era of automotive safety and standardization[1]. Bicycle racing also began to embrace Beryllium as a material for bike frames, although the cost of a pure Beryllium frame was about $25,000 at the time[9].

In the new millennium, Beryllium was chosen early on as the primary material for NASA's James Webb telescope's mirrors, allowing them to be far bigger than any mirror launched into space before[10]. In 2001, Beryllium was banned from Formula 1 racing after Mercedes-produced engines with Beryllium pistons dominated the sport, causing protests from rival manufacturer Ferrari[6]. Beryllium also found use in renewable energy, being used in solar panels and nuclear reactors[1].

(Continued on Page 64)

AIAA Announces Design/Build/Fly (DBF) Winners (May 18)

(Screenshots Only) https://www.aiaa.org/news/news/2021/05/18/aiaa-announces-design-build-fly-(dbf)-winners

Competition Champions 25 Years of Aircraft Innovation and Design

May 18, 2021 – Reston, Va. – The American Institute of Aeronautics and Astronautics (AIAA) today announced the winners of the 25th annual AIAA/Textron Aviation/Raytheon Missiles & Defense Design/ Build/Fly (DBF) Competition.

The 2020–2021 Design/Build/Fly winners are:

- First Place ($3,000): Dayananda Sagar College of Engineering, Bengaluru, India
- Second Place ($2,000): University of Central Florida
- Third Place ($1,500): Embry-Riddle Aeronautical University, Daytona Beach
- Best Report Score ($100): University of Michigan, Ann Arbor

The contest provides a real-world aircraft design experience for undergraduate and graduate engineering students by giving them the opportunity to validate their analytic studies. The competition is divided into two sections—a proposal and a formal design report. This year teams were also encouraged to submit a video presentation showcasing their aircraft in flight.

This university program invites teams of students to design, fabricate, and demonstrate the flight capabilities of an unmanned, electric-powered, radio-controlled aircraft that can best meet the specified mission profile. The goal is a balanced design that demonstrates flight handling qualities and practical and affordable manufacturing requirements while providing a high vehicle performance.

“Design/Build/Fly is a highlight of the year,” said Dan Dumbacher, AIAA executive director. “Aerospace trains us to adapt to the unexpected. It’s a good lesson for students as they enter this vibrant and meaningful field. Congratulations to the winning teams!”

This year’s teams were treated to a message from Pittsburgh Steelers quarterback and DBF alumnus, Joshua Dobbs. Dobbs is a 2017 graduate of Tickle College of Engineering at the University of Tennessee, Knoxville, where he majored in aerospace engineering with a minor in business administration.

During the awards ceremony, Dobbs shared, “Engineering can be hard, especially in this discipline. We are working to change human transportation on Earth and in space. Seems pretty simple, right? In those moments when the problems seem insolvable and overwhelming, remember why you became passionate about the field. Along any journey to reach your goals you will face adversity. Your attitude will define how you overcome it.”

This year’s DBF objective was to design, build, and test an unmanned aerial vehicle (UAV) with a towed sensor. Missions included delivery of the UAV, transportation of sensors in shipping containers, and surveillance by deploying, operating, and recovering a towed sensor. More details about the mission requirements can be found on the DBF website at aiaa.org/dbf. Follow DBF on Facebook at @Aiaadbf.

“We are impressed with the resilience these teams have demonstrated by continuing their participation during the pandemic. I have enjoyed the video submissions by the teams flying their aircraft – we are inspired by their enthusiasm, talent, and creativity, which are hallmark to this event,” Dumbacher concluded.

The DBF organizing committee accepted 115 proposals for the 2020–2021 competition. Of those, 92 teams submitted design reports and 68 teams submitted a video presentation. The formal reports are scored for design, as well as manufacturing and testing plans.

Russ Althof, director of the DBF organizing committee, said, “We owe our thanks for the success of the DBF competition to the efforts of many volunteers from Textron Aviation, Raytheon Missiles & Defense, and the AIAA sponsoring technical committees: Applied Aerodynamics, Aircraft Design, Flight Test, and Design Engineering. These volunteers collectively set the rules for the contest, publicize the event, gather entries, judge the written reports, and this year, judge the videos instead of the fly-off.”

About AIAA

The American Institute of Aeronautics and Astronautics (AIAA) is the world’s largest aerospace technical society. With nearly 30,000 individual members from 91 countries, and 100 corporate members, AIAA brings together industry, academia, and government to advance engineering and science in aviation, space, and defense. For more information, visit **www.aiaa.org**, or follow AIAA on **Twitter**, **Facebook**, or **LinkedIn**.

NTPS 40th Anniversary!

2021 May 03 (with Permission) https://www.ntps.edu/latest/ntps-40th-anniversary.html

(Mojave, CA)

The National Test Pilot School (NTPS) is proud to announce our 40th Anniversary!! 29 April 2021 marked 40 years of NTPS providing flight test training to Test Pilots & FTEs from over 40 countries around the world. We recently unveiled our 40th Anniversary Painting called "Changing of the Guard" which depicts the EC-145 taking the lead in helicopter flight test training from the UH-1 as they fly over NTPS and other school aircraft (Prints are available). There has been tremendous change in these past 40 years and NTPS has continued to adapt, innovate, and lead in the modernization of flight test training. NTPS was first with Master's degrees, Pre-TPS, significant Systems Curriculum, UAV curriculum integration, Graduate Assistant program, EASA certification, and University accreditation. All great examples of our commitment to our mission to advance flight test competency, improve flight test and aviation safety, and enhance the aerospace profession world-wide. NTPS would like to thank all of our loyal customers from across the globe. Here's to another 40 great years!

Artist: Mark Pestana, Colonel, USAF (ret) (with permission) (See Art Gallery for further Information)

(August 31, 2020) AIAA LA-LV Member Spotlight on Col. Mark Pestana - AIAA Los Angeles - Las Vegas Section)

Consulting research pilot and aerospace systems engineer, supporting NASA, FAA, and DOD

Adjunct Faculty in the Aviation Safety & Security Program, USC Viterbi School of Engineering

Museum of Tomorrow Rising at Edwards AFB Gate

by Larry Grooms special to Aerotech News & Review

PALMDALE, Calif.—Just outside the Main Gate at Edwards Air Force Base, Southern California's Flight Test Museum Foundation is on final approach to landing a new aerospace museum big and bold enough to accommodate not just rare experimental air and spacecraft, but a science and technology gathering place for educators, students, and leaders in industry and government.

Art Thompson, chairman of the private non-profit Flight Test Historical Foundation, and CEO of Sage Cheshire Aerospace in Lancaster told *Aerotech News and Review* in a May 5 interview that the 501(c)(3) foundation is qualified to receive an estimated $1.2 million in assets expected to be salvaged from the dissolved Palmdale-based AERO Institute.

Thompson said the volunteer-led nonprofit foundation is fully qualified and positioned to meet and exceed educational roles previously tasked to AERO Institute, and already engaged as an appropriate charity, defined by a Los Angeles Superior Court Judge as being involved in aerospace education with emphasis on science, technology, engineering, and mathematics (STEM.)

In bold print on the Home Page of the FTHF website is the following Mission Statement:

"The mission of the Flight Test Museum Foundation is to raise funds to support the development of the Air Force Flight Test (AFFT) Museum at Edwards AFB, California and the museum's Blackbird Airpark Annex at USAF Plant 42 in nearby Palmdale.

"The Foundation's fund-raising efforts focus primarily on museum improvements, new construction, exhibits, aircraft acquisition and restoration, and educational programs."

Thompson said the foundation, created more than three decades ago for the purpose of creating a museum for Edwards AFB, Dryden and other aerospace entities in the Aerospace Valley of Northern Los Angeles and Southeastern Kern County, is "the appropriate place for the most significant aerospace educational location in the United States."

In its earlier years, the foundation raised funds through contributions from individual donors and private sector organizations, along with fundraising events, including the annual "Gathering of Eagles" gala dinner. The Gathering of Eagles celebration acknowledged significant achievements in flight testing of aerospace vehicles.

Together with raising money for scholarships and a variety of Science, Technology, Engineering and Math (STEM) education programs, the Gathering of Eagles provided private sector funds to support the Flight Test Museum at Edwards.

Since its inception, the Flight Test Museum Foundation funded construction of a 12,000-square-foot museum building on Edwards AFB, including 8,500-square-feet for exhibits, a 40-seat theater, research library, gift shop, and administrative offices. In addition to aircraft tested at the base, exhibits inside the museum cover formation of the ancient dry lake beds, first military use of Edwards and flight test milestones from the birth of the jet age to the conquest of spaceflight.

Four changes converged over time to render that first museum obsolete. First came the 9/11 terrorist attacks that denied most public access to the base. Secondly, more space was needed to shelter and display a growing fleet of rare and exotic air and space treasures. Just about a year ago, the museum was shut down to all visitors by COVID-19. And finally, community leaders throughout the region recognized that the economy would be best energized by creating an easily accessible and unique visitor attraction with services and amenities available on-site.

"Thinking Outside the Gate," the foundation announced plans to move the museum's inventory and archives from the 8,500-square-foot location on base to a 75,000-square-foot location just outside the West Gate where there is more land for future growth and development.

With Phase 1 site preparation and the foundation laid and paid, Thompson said Phase 2 work of raising the walls and roof can be financed and finished by the end of the year. And he contends the source of that money should be the estimated $1.2 million expected to be put in play by a judicial order.

According to Thompson, the foundation needs about $350,000 to quickly complete the building's shell.

Thompson said he envisions the Flight Test Museum Foundation "doing for education what *Barnes & Noble* bookstores did for public libraries." Browse the bookshelves, have a cup of coffee and good conversations. Beyond that, he said, this aerospace

(Continued on Page 66)

Moonshot Space Museum Coming to Pittsburgh

Astrobotic announces the Moonshot Museum, where visitors will experience real spacecraft being built and be immersed in hands-on lunar exploration activities.

by Astrobotic, 2021 May 5 (with permission)

Astrobotic, a space robotics company located in Pittsburgh's Northside, announced its plans to launch the Moonshot Museum, Pennsylvania's first museum dedicated exclusively to space. The new museum, currently under construction and set to open in the summer of 2022, will be a 501(c)(3) nonprofit organization co-located in a gifted facility inside Astrobotic's headquarters.

The Museum's feature attraction will be a large clean room window through which visitors can watch real lunar landers and rovers being built and readied to fly to the Moon. Museum visitors will experience the thrill of spaceflight up close and learn about possible career paths in the $425 billion thriving space industry through interactive exhibits, educational programs, and curated experiences.

"Space is more than just rocket science. We want to provide the 'spark' – that moment when an individual is inspired to pursue a space or tech career who may not have otherwise done so. For Astrobotic, success is as much about execution of its other-worldly missions and business as it is about engaging with and serving the communities it is a part of," said John Thornton, Astrobotic CEO and Chair of the Moonshot Museum's Board of Directors.

"When you mention space, people think of different things. Whether it's stars, planets, astronauts, or engineers, a common theme is the persistence of curiosity. Curiosity is a spark that can either catch fire or fizzle out – and we want it to catch!" said Sam Moore, Executive Director of the Moonshot Museum. "Fostering confidence for those traditionally under-represented in STEAM is of vital importance," added Moore.

The Moonshot Museum's mission is to make space more accessible by inspiring a diverse audience to write the future of space commerce, science, exploration, and settlement. Both digital and on-site educational workshops will simulate real space missions and foster tech career awareness and readiness in the Pittsburgh region and around the world. The programs will aim to propel individuals of all backgrounds to pursue space careers across a variety of disciplines ranging from science and engineering to medicine, business, law, policy, and the humanities and arts.

"It's about creating STEAM opportunities that will change a child's life," said Bill Peduto, Mayor of the City of Pittsburgh. "Looking in through that clean room window, they'll be able to see something that will leave this planet, and they'll be changed forever. It's about bringing the Moon to Pittsburgh."

The Moonshot Museum is supported by numerous partners, and the Museum's facilities and utilities have been gifted by Astrobotic. Seed funding and startup operations for the Moonshot Museum are made possible with the support of the Richard King Mellon Foundation.

"The Foundation made this lead gift to enable people to see first-hand Pittsburgh's leadership role in the future of lunar travel, and to inspire young people to imagine their own futures in this exciting and growing industry," said Sam Reiman, Director of the Richard King Mellon Foundation.

The museum is currently seeking donations through its website, and welcomes space, science, and education enthusiasts to volunteer to help run future museum programs. For more information, please visit moonshotmuseum.org.

About Astrobotic

Astrobotic is the Moon company and more. We develop advanced navigation, operation, and computing systems for spacecraft, and our fleet of lunar landers and rovers deliver payloads to the Moon for companies, governments, universities, non-profits, and individuals. To date, we have two fully funded lunar lander missions on the books, more than 50 prior and ongoing NASA and commercial technology contracts and a corporate sponsorship with DHL. Astrobotic was founded in 2007 and is headquartered in Pittsburgh, PA.

About the Moonshot Museum

The Moonshot Museum is a 501(c)(3) nonprofit organization whose mission is to inspire a diverse audience to write the future of human space exploration and settlement. The Moonshot Museum will offer an unprecedented opportunity for the public to see real lunar spacecraft being built and to engage with a real space company through interactive exhibits, educational programs, and curated experiences. Slated to open in Summer 2022 in Pittsburgh's Northside, the Moonshot Museum is currently under development and seeking donors and partnerships to launch its STEAM-focused exhibits and programming.

Mars Atmosphere and Climate: Past, Present, and Future by Prof. Bruce M. Jakosky (May 15)

by Mr. Bill Kelly, Aerojet-Rocketdyne Retired, AIAA Senior Member

https://www.aiaa-lalv.org/may-15-2021-mars-atmosphere-and-climate-past-present-and-future-by-prof-bruce-m-jakosky/

Mars Exploration has been making headline news for years but more intensely in the last several months. The Perseverance rover has successfully landed and launched the Ingenuity helicopter, much to the delight of drone enthusiasts everywhere. The Chinese have also just landed a rover named Tianwen-1 which translates to Heavenly Questions. The Opportunity and Curiosity rovers continue to execute mission objectives after many years on the planet. In orbit around the planet are a collection of probes supported by the US, India, the United Arab Emirates, Russia and the ESA.

On May 15, Professor Bruce Jakosky from the University of Colorado presented a marvelous paper touching on the common mission of all those rovers and probes currently on or orbiting the red planet: the search for life on Mars. The title is "Mars Atmosphere and Climate: Past, Present and Future". The content includes data and speculation about what the Martian atmosphere once was, how it got to be what it is today and how we might change it in the future. That's right. Terraforming Mars !!!

The Past: There is evidence that the Martian atmosphere was once much thicker and wetter than it is today. Water existed on the surface in the form of rivers, lakes and possibly oceans. Large surface features which resemble river deltas, branching tributaries and flood plains support the hypothesis.

The Present: The current Martian atmosphere is less than 1% the density of Earth's. It's mostly CO_2 and too cold and dry for liquid water to be stable on the surface. The polar caps are primarily water ice. However, carbon dioxide (i.e. dry) ice exists in the form of clouds in the atmosphere and a thin layer on the ground during winter at the North Pole and year round at the South Pole. Dust devils that can be a kilometer in length and global dust storms are a major part of the Martian weather system.

The Future: The Martian atmosphere continues to get thinner. The lack of a global magnetic field on Mars is a major contributor to the thin atmosphere. This deficit allows the constant solar wind and periodic solar storms to continuously strip away the gases in the upper layers of the Martian atmosphere. Mars may once have had a magnetic field allowing the atmosphere to be dense and warm and wet and thick in the past. There is much speculation as to how this loss occurred.

Q&A: There was a very robust Q&A section which focused on the idea of terraforming Mars. The basic effect desired is to raise the atmospheric pressure to 1 bar (14.5 psia) and temperature on the Martian surface to allow liquid surface water. The usual ideas included injecting H_2O, CO_2 and or other greenhouse gases (CFC, etc.) into the Martian atmosphere by melting the ice caps or freeing gases trapped in minerals. The unusual ideas included putting an EM shield in space to stop the solar wind interaction, redirecting large masses from orbit to impact Mars which would throw dust into the atmosphere or maybe (somehow) stealing CO_2 from Venus and get it to Mars, thus terraforming Venus at the same time. Lots of interesting ideas but all judged impractical at our current technological level.

Professor Jakosky concluded the Q&A session and the presentation by relating an interesting anecdote about the popularity of the subject of Mars. He had flown to Washington DC for a meeting at NASA Headquarters. When he told the cab driver where he wanted to go, the conversation for the rest of the ride was consumed with questions about Mars (and, of course, including UFOs, ET and all his friends). Mars and all things extraterrestrial continue to possess the imagination of DC cabdrivers and the general public – whether you have 3 engineering degrees or not.

Short Bio for Bill Kelly

Bill Kelly is a Senior Member of AIAA recently retired from the Aerojet Rocketdyne Corporation after 19 years of service plus 26 more years at other aerospace (Marquardt, Vacco Industries, etc.) and power industry (Babcock and Wilcox) companies. His experience at Babcock and Wilcox includes system design and start-up testing of large steam boilers and nuclear reactors (Three Mile Island, etc.). His experience at Marquardt includes small rocket engine and ramjet testing (NASP, etc.) and naval weapons systems development. His experience at Aerojet Rocketdyne includes large rocket engine system engineering, assembly and testing (RS-84, J-2X, RS-25, etc.) and system engineering for the MMRTG (Multi Mission Radioisotope Thermoelectric Generator). He holds a BSME from New York University, a MSNE from the University of Virginia and a post-graduate certificate in Aeronautical and Astronautical Engineering from UCLA.

(Continued on Page 67)

Space Nuclear Power & Propulsion, by Joseph A. Sholtis, Jr. LtCol,USAF(Ret) (May 22)

by Mr. Bill Kelly, Aerojet-Rocketdyne Retired, AIAA Senior Member

https://www.aiaa-lalv.org/2021-may-22-space-nuclear-power-propulsion-by-joseph-a-sholtis-jr-ltcol-usaf-ret/

The speaker, Lt. Col. Joseph A. Sholtis Jr., speaking and explaining the issues involved in Space Nuclear Power and Propulsion.

The use of nuclear energy for propulsion and power in space has been controversial since the earliest days of space flight. On May 22, Dr. Joseph Sholtis, Lt Col USAF (Retired) provided summary technical details and an exceptional history of US and Russian nuclear powered space missions (successful and unsuccessful) in his paper entitled "Space Nuclear Power & Propulsion".

Three types of nuclear devices have been used on actual spacecraft to produce heat and electric power. The Radioisotope Heater Unit **(RHU)** is a small capsule utilizing the heat from radioactive decay to keep electronics and instrumentation warm in the cold environment of space and on cold planets. Thermal power levels from these devices are typically of the order of watts. Numerous RHUs are typically placed at various locations on larger spacecraft. The Radioisotope Thermoelectric Generator **(RTG)** uses that same decay heat to derive electric power from thermocouple devices. Thermal power levels range in the thousands of thermal watts. Electric power levels are limited to several hundred watts due to low thermoelectric power conversion efficiency. The heat rejected by these RTGs can also be used for equipment heating like the RHUs. Launched in April, 1965, the US SNAP 10A mission utilized a **nuclear fission reactor** and thermocouples to produce electric power.

Nuclear Thermal Propulsion refers to the technology that uses hydrogen as the core cooling medium which is then heated and accelerated through a rocket nozzle to obtain high thrust. The heat source is an operating nuclear fission reactor. The USAF conducted open air tests of this concept in the Rover / NERVA (**N**uclear **E**ngine for **R**ocket **V**ehicle **A**pplication) program between 1963 and 1972. Environmental concerns stopped NERVA development by 1972 but high propulsion efficiency and reduced space flight duration keep this concept on the list of desirable technologies for manned missions to Mars.

Dr. Sholtis stressed the need for detailed and extensive nuclear safety and risk analysis for each mission and testing, when possible, to maximize public safety after any accident. The US assesses mission risk under the protocols of the US National Environmental Policy Act and the US Safety Review and Launch Approval Process. The nuclear fuel in US RTGs is encased in a fibrous material block which has been designed for fuel containment after a launch abort. Missions utilizing nuclear fission reactors have long term parking orbits or deflection of impact points to remote locations designed into them as contingencies to ensure public safety. Of the 48 US missions that utilized nuclear energy, 4 were unsuccessful. One of these was the Apollo 13 LEM (Lunar Excursion Module) which had RHUs and an RTG. The LEM with its nuclear devices followed the crew capsule to earth and now reside in a deep part of the Pacific Ocean. Of the 33 Russian missions, 8 were unsuccessful. One (Kosmos 954) resulted in radioactive debris scattered across western Canada.

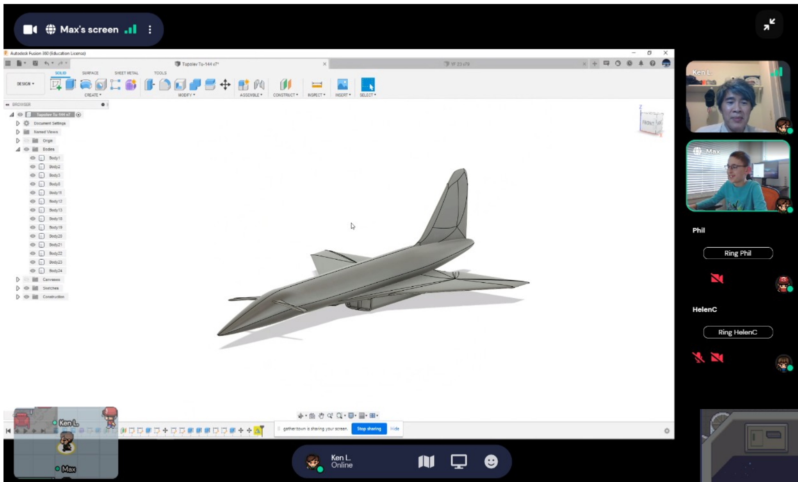
Future RTGs will utilize higher efficiency thermocouples or Stirling cycle power conversion. These devices are projected for use on a future mission to Titan (Dragonfly including a surface rover). Future nuclear fission reactors will provide higher thermal and electric power and also utilize the Stirling cycle for higher power conversion efficiency. The KRUSTY (**K**ilowatt **R**eactor **U**sing **S**tirling **T**echnolog**Y**) concept has already been tested and is projected to be used for electric power at a future lunar base. Future manned missions to Mars are planned to include nuclear fission reactor power plants in the 10,000 kilowatt electric range. Dr. Sholtis' technical expertise was on full display as he fielded technical questions from a number of participants in the closing Q&A session.

Short Bio for Bill Kelly

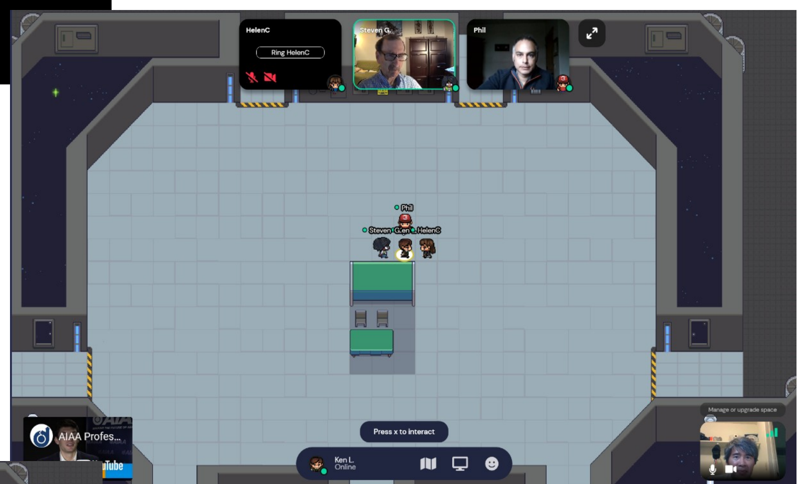
Bill Kelly is a Senior Member of AIAA recently retired from the Aerojet Rocketdyne Corporation after 19 years of service plus 26 more years at other aerospace (Marquardt, Vacco Industries, etc.) and power industry (Babcock and Wilcox) companies. His experience at Babcock and Wilcox includes system design and start-up testing of large steam boilers and nuclear reactors (Three Mile Island, etc.). His experience at Marquardt includes small rocket engine and ramjet testing (NASP, etc.) and naval weapons systems development. His experience at Aerojet Rocketdyne includes large rocket engine system engineering, assembly and testing (RS-84, J-2X, RS-25, etc.) and system engineering for the MMRTG (Multi Mission Radioisotope Thermoelectric Generator). He holds a BSME from New York University, a MSNE from the University of Virginia and a post-graduate certificate in Aeronautical and Astronautical Engineering from UCLA.

AIAA LA-LV e-Happy on AIAA LA-LV Virtual Space Station (May 20)

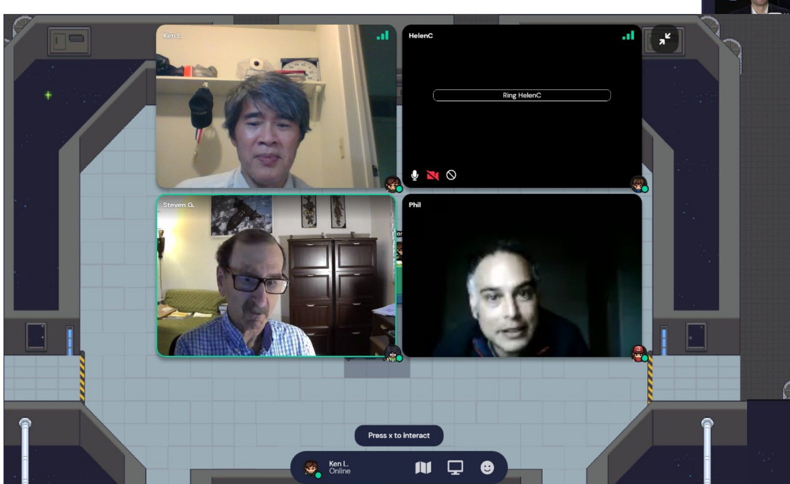
(Screenshots Only)



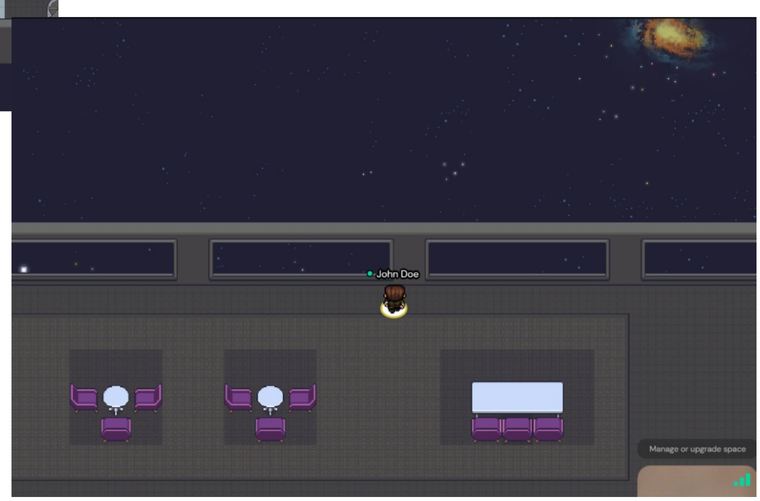
(Left) Max, a gifted middle school student, joined the e-Happy Hour, and showed his advanced aircraft CAD designs and the 3D printed models of them.



(Right) The semi-in-person networking made it more fun and realistic for the interactions for group chats, like in the in-person Happy Hour for networking.



(Left) Attendees getting together and sharing various thoughts on commercial space, space stations, Mars/Moon explorations, and the issues about China's Mars/Lunar/Space Station efforts etc.

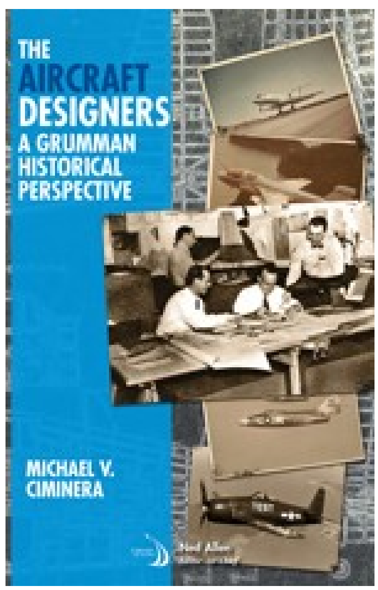


(Right) Attendees could move around their avatars and moved around, getting together, enjoying the sites/views, video games, AIAA posters, membership information / video / brochures etc, and chat with AIAA representative(s) for further information and inquiries for joining the AIAA membership or other subjects / topics.

AIAA LA-LV Aero Alumni Meeting (May 19)

(Screenshots Only)

Retirees (except for Dr. Ken Lui as the Events/Program Chair for supporting the meeting) discussing about the new book and the previous one, both published by AIAA, written by one of the attendees, Michael V. Ciminera, Northrop Grumman VP (Ret). Other topics like the Mars Perseverance Rover and Ingenuity Mars Helicopter, COVID-19 vaccination, variants from India/Brazil, and the possible reopening etc. were also among the topics.



The Aircraft Designers: A Grumman Historical Perspective

by Michael V. Ciminera, Northrop Grumman VP (Ret)

https://arc.aiaa.org/doi/book/10.2514/4.101786

Mike Ciminera has played an integral role at Grumman and Northrop Grumman for over 50 years. Beginning as a college apprentice for Grumman at the age of 17, he became a Vice President managing such areas as Advanced Programs, Systems Group, Electronic Systems, IPATS, F-18 and Joint STARS (Lake Charles, La.). In 2000, he became a Sector Consultant providing technical and program management oversight of programs including Fire Scout, UCAS, and the X- 47B. He continues to consult in aerospace, lecture, write, and serves on other boards namely: Legacy Engineering Advisory Council; Chair of the Leadership Board of the School of Engineering at Rensselaer Polytechnic Institute; President – Western Museum of Flight in Torrance, CA; and the COA (Christian Outreach in Action), a non-denominational center in Long Beach, CA that cares for those in need. (Source: http://gpsana.org/?p=291)

AIAA LA-LV Aero Alumni Meeting (June 16)

(Screenshots Only)

Aero Alumni (retirees) gathered on June 16 and chatting about some interesting topics such as self defense / gun usage and regulation policies, asteroids (and the 1908 explosion in Tunguska, Siberia, as well as the 2013 glancing explosion etc), planetary defense, craters, water sources in CA, AZ, CO, Colorado River Reservoir, nuclear power, green/renewable energy myth and missing links, etc.

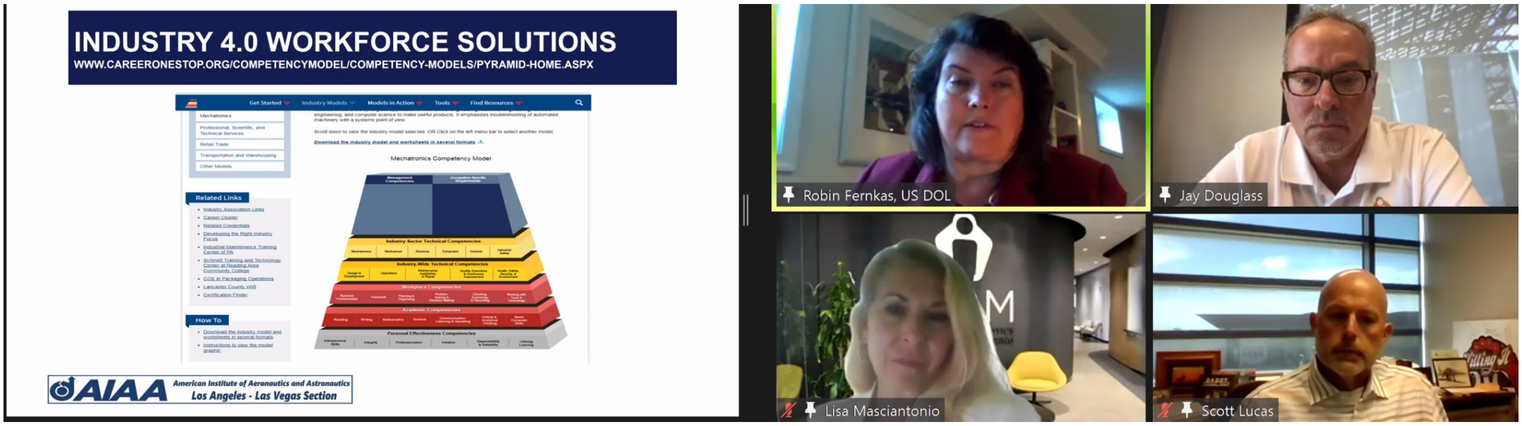
Dr. Ken Saunders (lower left) showing the book he was citing, "The West without Water", during a very informative and insightful discussion about the water resources and distribution in the area including CA, NV, AZ, CO etc.

(1) The Industry 4.0 Workforce (2) Airplane Accident Investigation (June 5)

(Part I) The Industry 4.0 Workforce: – Needs, Issues and Solutions, with Ms. Robin Fernkas, Dr. Scott Lucas, Ms. Lisa Masciantonio, and Mr. Jay Douglass (Moderator)
(Part II) Accidents Happen – Inside the Process of an Airplane Accident Investigation by Mr. John Purvis

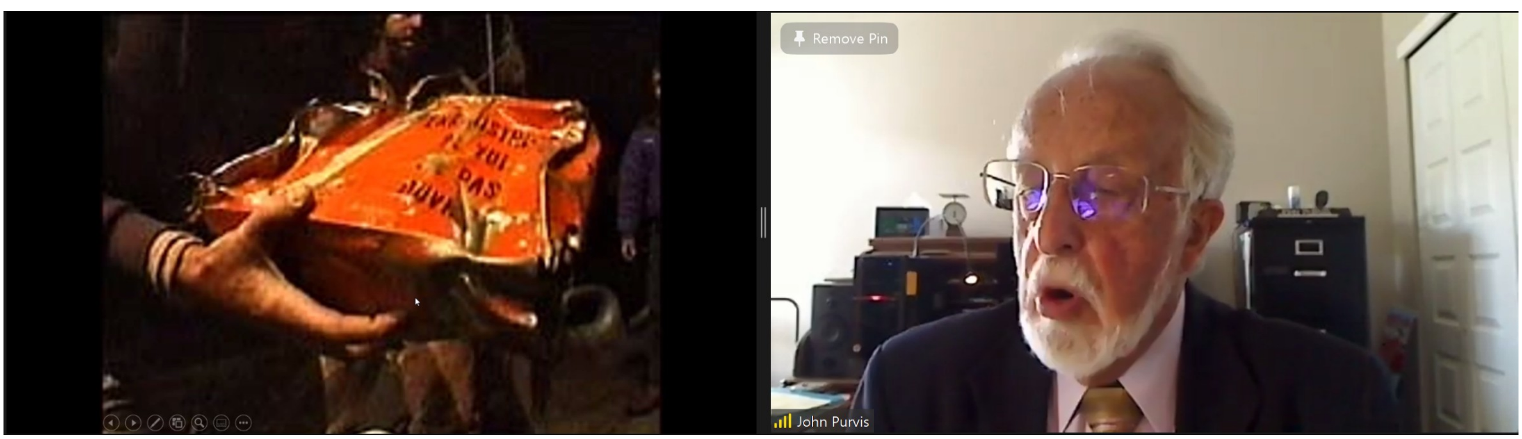
(Screenshots Only)

https://www.aiaa-lalv.org/2021-june-5-1-the-industry-4-0-workforce-2-airplane-accident-investigation/



The speakers/panelists taking about how to get people and the industry ready for the Industry 4.0 trend, the workforce, training, challenges, solutions, etc., especially with the skilled workers related to the robotic manufacturing and management.

Mr. John Purvis talking about the difficulties in the aircraft incident investigation in some of the field trips.

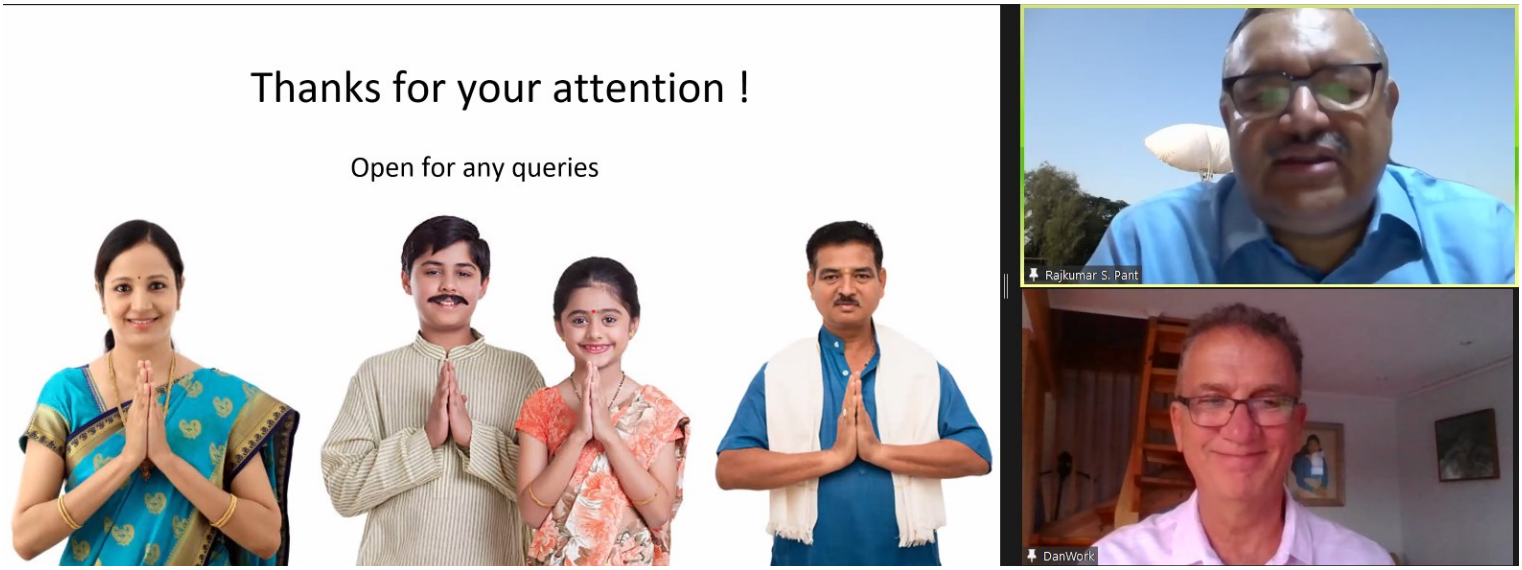


The speaker explaining the importance of the Black Box and the challenges of recovering them.

Aerospace Projects in India: Recent Developments and Future Plans by Prof. Rajkumar S. Pant (June 12)

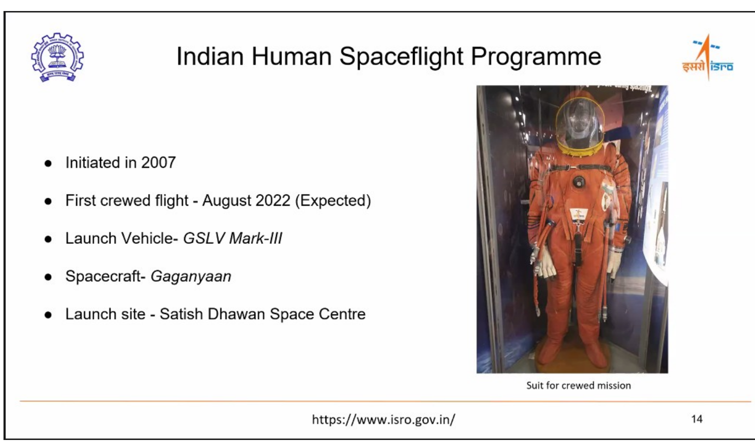
(Screenshots Only)

https://www.aiaa-lalv.org/2021-june-12-aerospace-projects-in-india-recent-developments-and-future-plans-by-prof-rajkumar-s-pant/



Prof. Pant expressing his greetings from India while answering questions, with Dr. Daniel Raymer (AIAA Fellow, whose great help made this event possible) commenting.

Prof. Pant talking the vibrant aerospace education and commercial / start-ups, some of which were inspired by SpaceX and Elon Musk.



India has been developing own human spaceflight program, as well as ingenious aerospace industries and international collaborations.

Starlink Satellite & Debris Sightings

by Daniel R. Adamo, Independent Aerodynamics Consultant, NASA JSC - Retired 2021 May 30 (with permission)
AIAA Distinguished Speaker, AIAA Distinguished Mentor, AIAA Associate Fellow

Introduction

Starlink is a global broadband low-latency Internet service being deployed in Earth orbit by SpaceX.[1] A typical Starlink launch uses a Falcon 9 to place 60 satellites into an orbit inclined 53° to Earth's equator at an altitude near +275 km. Each desk-sized satellite has a launch mass of 260 kg and krypton-propelled Hall-effect thrusters used to reach and maintain a +550 km operational orbit altitude. With satellites planned to number in the *tens of thousands*, the Starlink constellation's launch cadence has briefly exceeded one per week in early 2021.[2]

A bewildering nomenclature has evolved to identify Starlink's prolific launches. The news media typically use a strictly chronologic "Flight No." count starting with 1 for the test launch on 24 May 2019. SpaceX dubbed this "Mission v0.9". It was followed by Flight No. 2, Mission v1.0 L1. To further complicate Mission nomenclature, the numeric suffix for "L" is not strictly chronologic. For example, Flight No. 19, Mission v1.0 L19 was followed by Flight No. 20, Mission v1.0 L17 and Flight No. 21, Mission v1.0 L20.[2] For the sake of brevity, launch nomenclature adopted for this paper appends the Flight No. with the Mission while omitting spaces. Thus, the latest Starlink launch as of this writing is 29v1.0L28 on 26 May 2021 UTC.

Before orbit-raising operations disperse a swarm of 60 Starlink satellites in the days following launch, they appear to Earth-based observers as a remarkable linear convoy of irregularly spaced lights serenely gliding across the twilight sky. Unfortunately, each surge of recently launched satellites tends to temporarily overwhelm U.S. Space Force space situation awareness resources, and two-line orbit elements (TLEs) to facilitate Starlink sighting predictions are unavailable through public channels such as Space-Track[3] until about a week after launch.

This paper initially focuses on analysis to associate a local "strange lights in the sky" report with a specific Starlink launch. A technique is then documented to predict Starlink sightings in the days after a nominal launch once actual launch time is known. An atmospheric entry trajectory reconstruction associated with the 20v1.0L17 launch is also detailed, thus confirming the source of sightings reported 26 March UTC in Washington and Oregon. The paper concludes with insights from an ephemeris-based Starlink trajectory reporting capability being implemented by SpaceX for public access on the Internet.

Correlating A Sighting Report With Starlink Launch 19v1.0L19

The author resides in a rural setting with skies reasonably free from light pollution 79 km southwest of central Portland, Oregon at a location abbreviated as CHNK in this paper. On 17 February 2021, a neighbor reported seeing "a string of 25-50 white lights flying in a trail formation" at 5:30 AM PST (13:30 UTC) that day. The 19v1.0L19 launch on 16 February 2021 at 03:59:37 UTC immediately became the prime candidate in an effort to identify the lights' nature.

(Continued on Page 68)

[1] Reference https://www.businessinsider.com/spacex-starlink-internet-service-elon-musk-all-you-need-know-2021-2 (accessed 22 March 2021).

[2] Reference https://en.wikipedia.org/wiki/Starlink (accessed 22 March 2021).
[3] Reference https://www.space-track.org/auth/login (accessed 25 March 2021) using a no-fee account.

UBC researchers publish paper on risks of mega-constellations

by Marc Boucher, 2021 May 20 (with permission)

https://spaceq.ca/ubc-researchers-publish-paper-on-risks-of-mega-constellations/

Space debris. Credit: Astroscale/Shutterstock.

UBC researchers published a paper today in Nature's Scientific Reports which outlines the risks of mega-constellations in low Earth orbit (LEO).

The paper is written by Aaron C. Boley, Department of Physics and Astronomy, and Michael Byers, Department of Political Science.

The abstract reads:

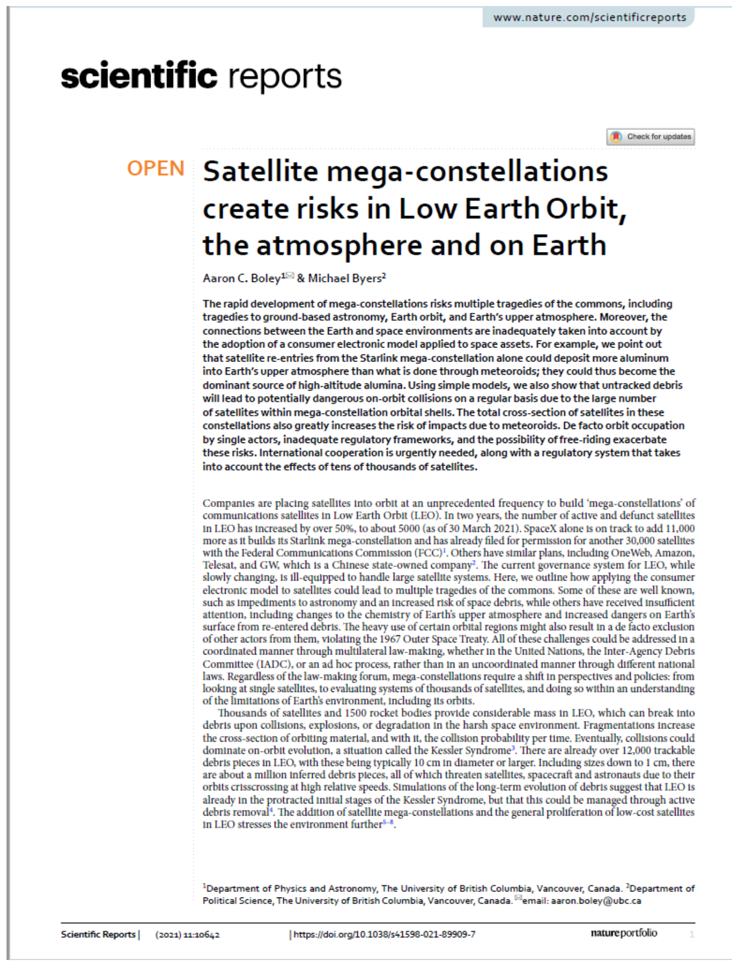
"The rapid development of mega-constellations risks multiple tragedies of the commons, including tragedies to ground-based astronomy, Earth orbit, and Earth's upper atmosphere. Moreover, the connections between the Earth and space environments are inadequately taken into account by the adoption of a consumer electronic model applied to space assets. For example, we point out that satellite re-entries from the Starlink mega-constellation alone could deposit more aluminum into Earth's upper atmosphere than what is done through meteoroids; they could thus become the dominant source of high-altitude alumina. Using simple models, we also show that untracked debris will lead to potentially dangerous on-orbit collisions on a regular basis due to the large number of satellites within mega-constellation orbital shells. The total cross-section of satellites in these constellations also greatly increases the risks of impacts due to meteoroids. De facto orbit occupation by single actors, inadequate regulatory frameworks, and the possibility of free-riding exacerbate these risks. International cooperation is urgently needed, along with a regulatory system that takes into account the effects of tens of thousands of satellites."

The issue of LEO becoming congested has been a discussion for many years now and those that left their space debris behind have been negligent in dealing with it. In 2018 the US issued Space Policy Directive 3 on space traffic management thus positioning itself to be a leader in this area. However, there is no international plan on how to deal with the issue of a congested LEO or the removal of debris that's accumulated over the decades.

The environmental impact of more debris reentering and affecting the atmosphere is a newer discussion which needs more research.

Read the paper on the risks of mega-constellations

https://www.nature.com/articles/s41598-021-89909-7



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Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth

Aaron C. Boley[1] & Michael Byers[2]

The rapid development of mega-constellations risks multiple tragedies of the commons, including tragedies to ground-based astronomy, Earth orbit, and Earth's upper atmosphere. Moreover, the connections between the Earth and space environments are inadequately taken into account by the adoption of a consumer electronic model applied to space assets. For example, we point out that satellite re-entries from the Starlink mega-constellation alone could deposit more aluminum into Earth's upper atmosphere than what is done through meteoroids; they could thus become the dominant source of high-altitude alumina. Using simple models, we also show that untracked debris will lead to potentially dangerous on-orbit collisions on a regular basis due to the large number of satellites within mega-constellation orbital shells. The total cross-section of satellites in these constellations also greatly increases the risk of impacts due to meteoroids. De facto orbit occupation by single actors, inadequate regulatory frameworks, and the possibility of free-riding exacerbate these risks. International cooperation is urgently needed, along with a regulatory system that takes into account the effects of tens of thousands of satellites.

Companies are placing satellites into orbit at an unprecedented frequency to build 'mega-constellations' of communications satellites in Low Earth Orbit (LEO). In two years, the number of active and defunct satellites in LEO has increased by over 50%, to about 5000 (as of 30 March 2021). SpaceX alone is on track to add 11,000 more as it builds its Starlink mega-constellation and has already filed for permission for another 30,000 satellites with the Federal Communications Commission (FCC)[1]. Others have similar plans, including OneWeb, Amazon, Telesat, and GW, which is a Chinese state-owned company[2]. The current governance system for LEO, while slowly changing, is ill-equipped to handle large satellite systems. Here, we outline how applying the consumer electronic model to satellites could lead to multiple tragedies of the commons. Some of these are well known, such as impediments to astronomy and an increased risk of space debris, while others have received insufficient attention, including changes to the chemistry of Earth's upper atmosphere and increased dangers on Earth's surface from re-entered debris. The heavy use of certain orbital regions might also result in a de facto exclusion of other actors from them, violating the 1967 Outer Space Treaty. All of these challenges could be addressed in a coordinated manner through multilateral law-making, whether in the United Nations, the Inter-Agency Debris Committee (IADC), or an ad hoc process, rather than in an uncoordinated manner through different national laws. Regardless of the law-making forum, mega-constellations require a shift in perspectives and policies: from looking at single satellites, to evaluating systems of thousands of satellites, and doing so within an understanding of the limitations of Earth's environment, including its orbits.

Thousands of satellites and 1500 rocket bodies provide considerable mass in LEO, which can break into debris upon collisions, explosions, or degradation in the harsh space environment. Fragmentations increase the cross-section of orbiting material, and with it, the collision probability per time. Eventually, collisions could dominate on-orbit evolution, a situation called the Kessler Syndrome[3]. There are already over 12,000 trackable debris pieces in LEO, with these being typically 10 cm in diameter or larger. Including sizes down to 1 cm, there are about a million inferred debris pieces, all of which threaten satellites, spacecraft and astronauts due to their orbits crisscrossing at high relative speeds. Simulations of the long-term evolution of debris suggest that LEO is already in the protracted initial stages of the Kessler Syndrome, but that this could be managed through active debris removal[4]. The addition of satellite mega-constellations and the general proliferation of low-cost satellites in LEO stresses the environment further[5–8].

[1]Department of Physics and Astronomy, The University of British Columbia, Vancouver, Canada. [2]Department of Political Science, The University of British Columbia, Vancouver, Canada. email: aaron.boley@ubc.ca

Scientific Reports | (2021) 11:10642 | https://doi.org/10.1038/s41598-021-89909-7 natureportfolio 1

About Marc Boucher

Boucher is an entrepreneur, writer, editor & publisher. He is the founder of SpaceQ Media Inc. and CEO and co-founder of SpaceRef Interactive Inc. Boucher has 20 years working in various roles in the space industry and a total of 28 years as a technology entrepreneur including creating Maple Square, Canada's first internet directory and search engine.

Hamas' underwater drones a wake-up call for Israel

Seagoing stealth weapon represents a major new security challenge in Israel's fight with Hamas and by association Iran

by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 May 21 (with Permission)

https://asiatimes.com/2021/05/hamas-underwater-drones-a-wake-up-call-for-israel/

The armed branch of Hamas, Al Qassam, has been taking to the sea as well as firing rockets into the skies. Photo: AFP/Virginie Nguyen Hoang

The Gaza war has seen thousands of missiles fired at Israel, the bulk of which have been shot down by Israel's Iron Dome air defense system. But Hamas "terrorists" – which is how the US government defines them – have also deployed some new sea-going weapons that have the attention of Israeli intelligence.

These weapons are of three types – commando underwater swimmers using swimmer vehicles that are used to smuggle weapons into Gaza and for commando operations; semi-autonomous small boats stuffed with explosives and; the latest, a large unmanned underwater vehicle, or UUV.

A Hamas unmanned submarine was destroyed just after launch by the Israeli Air force and Navy. In a video supplied by the Israel Defense Forces (IDF), one segment shows the blast that destroyed the UUV.

Another shows a small white car escaping after the UUV is destroyed. The car was also hit by a blast and the operators in the car were killed. There is at least one photo of the destroyed car.

The UUV was sent out to attack Israeli targets, most likely the offshore Tamar Natural Gas rig, which is fed by five subsea wells. Because of the Gaza war, all of Israel's offshore platforms have been shut down.

Hamas had been trying to hit the Tamar rig with rockets, but the projectiles lack the accuracy required to hit such a target. Hamas has also launched more accurate drones to do the job. So far the Israel Air force has shot down at least two of the drones using Python 5 air-to-air missiles. A third was destroyed by the Iron Dome air defense system.

The main mystery is where did the UUV come from? According to the Israeli press, which has been tipped by the IDF, the UUV was a fairly large commercial vehicle that had been converted for military use.

Members of the Naval Oceanography Mine Warfare Center at Stennis Space Center, Mississippi, standing by as an unmanned underwater vehicle leaves the surface to search for mines. Photo: AFP/Gary M Keen/US Navy

The IDF pointed out that the UUV was large and was towed to the launch site. It carried 30 to 50 kilograms of explosives – probably not enough to topple an oil platform, but enough to cause major anxiety and secure a psychological victory.

The Tamar platform may not have been the only target and, as of now, it isn't known if Hamas has any more UUVs in its arsenal.

Commercial UUVs are produced in many countries. Commercial applications include seabed mapping, pipeline and subsea structure inspection, oceanographic surveys, environmental monitoring, marine geological surveys and search operations.

(Continued on Page 83)

Some lessons from Tiananmen

Seagoing stealth weapon represents a major new security challenge in Israel's fight with Hamas and by association Iran

by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 June 3 (with Permission)

https://centerforsecuritypolicy.org/some-lessons-from-tiananmen/

In late Fall of 1987 the Defense Department sent me to China. I went there to preside at the inauguration of a Landsat station about 30 miles north of Beijing, and a research station in Beijing itself.

Landsat was and remains a multispectral satellite based imaging system, the only multispectral system then flying. The U.S. and China had been in urgent discussions about the Russian nuclear missile threat aimed at China. The Chinese could not assess how many missiles were aimed at China by the

Soviets or know where they were. Landsat was supposed to fill that gap.

The first Landsat satellites were launched in 1975 and the most recent Landsat was launched in 2013.

I was selected to go to China mostly because I was strongly opposed to giving Landsat capabilities to China. So I suspect that Secretary of Defense Caspar Weinberger, my boss, known for his very British sense of humor, sent me on the mission.

I was hosted by the Chinese Academy of Sciences (中国科学院) which ostensibly would be the operators of the Landsat ground station and research laboratory, which was really a military photo interpretation center. Indeed, the Academy was not a benign scientific organization. It worked for the military on projects ranging from tactical to nuclear systems. When there I was taken to see the new Chinese particle accelerator that could be used for nuclear research.

I was picked up by a big Mercedes limo with two of the main scientists on board plus a driver. The scientists talked to the driver only in Chinese. On that same morning I heard on the Voice of America shortwave broadcast that there had been protests and riots in a number of Chinese cities, the worst apparently in Shanghai. In those days without cell phones or the Internet, I always carried a small but very good shortwave receiver with me. I started doing that in 1973 on a trip to the USSR where the radio was all important to keep me plugged into the Yom Kippur War then raging in the Middle East.

In the car I asked my Chinese colleagues if they heard about the protests and riots. They said they had heard nothing. A little later I asked again and got the same response but, at that point the driver, who was not supposed to be able to speak English, replied with perfect English pronunciation that yes, he heard it on the VOA that morning.

The protests were quickly snuffed out, but that did not mean that the ferment in the Chinese underbelly had gone away. Even ten years before Tiananmen, protests were breaking out around China. And the year before, in 1986 until January 1987 there were widespread student riots in many Chinese cities. They all shared one common characteristic: they wanted the Chinese Communist dictatorship replaced by a freely elected government. In short, they wanted democracy.

I was caught by surprise by the riots. No one briefed me on what was going on in China before I left on my DOD mission.

The same impulse for freedom swept across many places in 1987, including Taiwan. Taiwan was under martial law from May 20, 1949 until July 14, 1987. By November 1987 when I was sent to China, Taiwan was finally moving towards freedom. It would take a few more years and a number of clashes, and the emergence of heroic fighters for freedom, but Taiwan finally became a truly democratic nation, a shining light that was visible in China and may have inspired the student-led Tiananmen protests which unfortunately ended badly when Chinese troops and secret police crushed them on June 4 and 5, 1989.

There are some lessons about Tiananmen we should all learn.

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Was the US complicit in China's COVID research? | Real America's Voice Interview

It's time to put US collaboration with Chinese scientists on 'gain of function' coronavirus research under a microscope

by Dr. Stephen Bryen and Shoshana Bryen, 2021 May 27 | June 10 (TV interview with Dr. Bryen) (with Permission)

https://asiatimes.com/2021/05/was-the-us-complicit-in-chinas-covid-research/

https://americasvoice.news/video/ApzpHGtCgmmr3JB

Hazard suits at the high-security National Biosafety Laboratory in Wuhan. Photo: Wuhan Virology Institute

The Joe Biden administration closed the US State Department's investigation into the origins of the Covid-19 pandemic

But as the pandemic recedes in the United States, there is renewed interest by the scientific and journalistic communities about the origins of the virus and whether it could have escaped from China's Wuhan Institute of Virology (WIV). So, a day later, the president opened a new investigation.

The flip-flop came amid Senator Rand Paul's claim at a Senate committee hearing on the Covid-19 pandemic that the US collaborated with the Wuhan Institute of Virology in China to make a more deadly, transmittable coronavirus. That's putting the Chinese lab leak theory, which Beijing vigorously denies, back at the forefront of the Covid-19 origin debate.

Based on papers published by WIV on the scientific work of Dr Shi Zhengli, the US government investigators have some catching up to do. In 2015, Dr Shi – popularly known as the "bat lady" – published a paper entitled "A SARS-like cluster of circulating bat coronaviruses show potential for human emergence."

Her colleagues on the study included American researchers associated with the University of North Carolina's Department of Cell Biology and may be related to work funded by the US government.

It is possible, although we don't know, that Dr Shi and her team successfully converted a coronavirus, specifically SARS-like virus SHCO14-CoV, from bats to other animals and not only mice. It is also possible, but not proven, that the new virus quickly spread to other animals and then to lab workers, three of whom became sick in November 2019, according to a recent Wall Street Journal report.

This is known as "gain of function" research, which is considered by the US to very dangerous. Between 2014 and 2017, gain of function research, which had been actively subsidized by The National Institutes of Health (NIH) and other agencies, was suspended in the US.

Slightly later, in 2019, the US temporarily closed some laboratories, including the US Army Medical Research Institute of Infectious Diseases (USAMRIID) at Fort Detrick, Maryland, over safety issues.

Personnel working inside the bio-level 4 lab at the US Army Medical Research Institute of Infectious Diseases at Fort Detrick. Photo: AFP/Olivier Douliery

Mistakes and errors in labs

According to the CDC: "The two breaches [at Fort Detrick] reported by USAMRIID to the CDC demonstrated a failure of the Army laboratory to 'implement and maintain containment procedures sufficient to contain select agents or toxins' that were made by operations in biosafety Level 3 and 4 laboratories …" *(Continued on Page 86)*

US government has no answer for pipeline cyberattack

The cyber-attack on the vital oil pipeline has left US military and intelligence service scratching their heads

by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 May 13 (with Permission)

https://asiatimes.com/2021/05/us-government-has-no-answer-to-attack-on-pipeline/

Tanker trucks in an adjacent lot next to the entrance of the Colonial Pipeline tank farm in Charlotte, North Carolina, on May 12, 2021. Fears the cyber-attack would cause a gasoline shortage led to some panic buying. Photo: AFP/Logan Cyrus

On May 7 the Colonial Pipeline, which stretches from Texas to New York and is the largest pipeline system for refined oil products in the United States, was hit by a ransomware attack that resulted in the shutdown of most of the 5,500-mile pipeline.

The company is operating some parts of the pipeline manually and has sought the help of private cyber investigators and the US government. Meanwhile, a huge segment of the US' critical infrastructure is disabled and Washington does not seem to have any answers.

We do not know what the hackers demanded from Colonial Pipeline or even who the hackers are.

Ransomware in its most basic form attacks a cyber network by encrypting everything and demanding ransom before the encryption can be removed. In the case of the Colonial Pipeline, we know that along with encrypting all the computers in the Colonial Pipeline network, the perpetrators also stole a vast amount of company data.

What the thieves plan to do with the data is not known at this time. In prior ransomware cases involving information theft, those who don't pay find that selective information is released to the public or handed over to competitors or to hostile governments.

Computers can be infected in many different ways, even if they are not actually connected to the internet. In the famous Stuxnet case where Siemens industrial controllers were hacked and caused damage to Iranian uranium gas centrifuges – Stuxnet was invented by the US and Israel – the malware was embedded in certain versions of an update of the Siemen's controller's software.

There are many ways to move malware to computers – for example, through email, by hacking passwords and pretending to be a legitimate user, by the use of false credentials or even by an insider working for the company or organization.

Mandiant, a subsidiary of Fire Eye, has produced a useful report that provides information on the main types of malware threats and some background on a few of the bigger perpetrators. Mandiant is now working with Colonial.

Gas stations began to run out of gasoline after motorists rushed to fill up on May 11, 2021, in Atlanta, Georgia. Photo: AFP/Megan Varner/Getty Images

Security challenges

In the United States, aside from government and the military, the bulk of the critical infrastructure is privately owned and operated. While this may suggest that industry security standards are below US government standards, the truth is that both the government – including the military departments – and the private sector are facing similar security challenges.

Almost all computer networks have grown topsy-turvy over the years, and networks often operate network components that have not been updated for security. But

(*Continued on Page 88*)

How to Prevent Another Colonial Pipeline

by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 May 16 (with Permission)

https://www.theepochtimes.com/how-to-prevent-another-colonial-pipeline_3817546.html

In an aerial view, a fuel holding tank is seen at Colonial Pipeline's Dorsey Junction Station in Washington, D.C., on May 13, 2021. (Drew Angerer/Getty Images)

Some small-minded sages are chortling in America that people with electric cars don't have to worry about the Colonial Pipeline, shut down by a cyber attack, because they can get their "gas" from the electric company. They go on to argue for more electric cars.

Of course if it was the power company that was knocked out, the electric cars would not run. And power companies have been knocked out. The Russians killed one in Ukraine, putting it offline for some time.

There is, unfortunately, a related argument in Washington, in the CIA and Pentagon. The CIA has already taken the plunge; the Pentagon tried in a $10 billion project, but it is tied up in litigation. The idea? To put everything in the cloud. In other words, create a single point of failure, ripe for attack by state and non-state actors.

The DOD and CIA cloud ventures illustrate, better than anything else, just how dumb government officials are when it comes to security. And the Pentagon are specialists in creating monstrosities and single points of failure, such as the F-35 that is supposed to replace just about everything "tactical" in the Air Force, even though the plane was never in combat. Crazy.

When it comes to cyber security and dealing with cyber attacks, the U.S. government, even though it has spent hundreds of billions of dollars since 1988, is worse off today than ever. So is the critical infrastructure which includes energy, transportation, water supplies, food supply, communications, chemicals, critical manufacturing (most of which today is offshore), financial services (including the U.S. Treasury, Banks, Stock Markets), health care and more.

In the United States most of the critical infrastructure, other than government and the military, is in private hands, and the U.S. Congress decided in 1988, when the first Computer Security Act was passed, not to require that the private sector meet certain network and computer standards. The private sector was left free to decide on its own what the right amount of protection might be.

In fact and to be fair, today no one knows what the right amount of protection is, because no one actually knows how to protect any computer system with any degree of certainty.

Virtually all the computers used in the United States are made abroad, other than highly specialized supercomputers and certain processors made for defense applications. This includes not only machines that do information processing, but specialized controllers used in manufacturing and for operating power grids and pipelines.

These are known as SCADA-based systems (SCADA stands for Supervisory control and data acquisition systems). The same SCADA boxes that help run power plants and pipelines, control water supplies, and manage transportation and critical manufacturing are commercial devices produced mostly abroad.

One of the most famous SCADA systems is made by Siemens in Germany. It is the same one that runs Iran's uranium centrifuges and will help assure Iran can have nuclear weapons.

While it is possible to build some security "walls" around computer networks and SCADA systems, most of them have been penetrated one way or another. For example, most computer networks are open and store data without any protection. Operating systems, likewise are commercial (off the shelf) and are not encrypted. Network protocols and the internet all rest on standards shared globally and are easily hacked.

Even much of the Defense Department's intellectual property is stored without encryption protection because of obsolete rules the Pentagon follows. These rules say that if an item is not classified, in the Pentagon it isn't supposed to be stored in encrypted format. The National Security Agency (NSA) controls encryption in the US government, and the strict separation of classified from non-classified information is their mantra.

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The F-35 as the future of air to air warfare

by Nick Jost (Lt.Col. ret.) 2021 April 10 (with permission)

https://www.thedefencehorizon.org/post/the-f-35-as-the-future-of-air-to-air-warfare

Abstract: Let´s take a closer look at the future of air-to-air warfare and the F-35 Joint Strike Fighter, the fifth-generation replacement for the aging fleet of western, mostly US-built fourth-generation (4, 4+, 4++) fighter aircraft. A direct comparison between the two generations would not be sensible due to the different concepts and philosophies of each. Fifth-generation means stealth capable. That capability changes the way of warfare entirely.

Bottom-line-up-front: The F-35 will yet have to prove if it really is (or will be) capable of replacing 4th generation fighters like the F-15C & E, F-16, F/A-18 (legacy and Super Hornet) and F-117.

Problem statement: How to fairly assess the potential impact of the F-35 on air-to-air warfare in the context of the heavy criticism the program has faced? How to understand this negative criticism the F-35 program gets publicly confronted with?

So what?: The (potential) operators of this new airframe should rethink their strategy and refrain from phasing out their generation 4, 4+ and 4++ airframes too soon, before the F-35 and its inherent logistics and supply chain will be completely operational.

Source: shutterstock.com/BlueBarronPhoto

The Air Force as a cost-driver

Ever since the beginning of aviation, the value of deploying aircraft in combat to fulfill many different roles has been apparent. Rapid advances in technology were always seen in the military, especially with regards to the advancement of combat aircraft. Today this pattern continues. As a result of the longstanding emphasis on aviation, many countries around the globe devote a remarkable amount of national funds to the maintenance of their armed forces. For some it is enough to simply keep their forces up to date; for others, it is a priority to keep their technology at the highest possible state of the art. The price of this continuous renewal is high, and other branches of the military are often held on a short leash as a result.

The F-35 project is a prime example of this phenomenon. Its development history dates back to the year 1996, when the actual development contract was signed. The first flight of the prototype already occurred four years later, in 2000. The first F-35s (USMC F-35B variant) became operational in mid-2015. That is quite a time span, but not uncommon in the development of new military equipment. After all, the incredible financial investment is supposed to "fit the bill" for decades to come. And here lies the problem. This single platform offered in three different variants (conventional take-off and landing F-35A (CTOL), short take-off and vertical-landing F-35B (STOVL), carrier-based F-35C (CV/CATOBAR)) is supposed to be an "all-in-one solution" that will fit three different branches within the US armed forces and numerous NATO and allied forces around the globe. This single airframe in its three different variants is intended to take over the roles of a multitude of fourth-generation fighters (including 4+ and 4++)[1] in use today. That usually means the aircraft cannot specialize at specific tasks, but will rather be able to perform a wide array of duties adequately.

It has been argued by some that the F-35 may be the last manned fighter aircraft designed.[2] Unmanned aircraft are already in the pipeline. The "loyal wingman" project from Boeing, for example, is a multirole, unmanned aerial vehicle with stealth capabilities that will be used as a "force multiplier" flying alongside manned aircraft to perform missions autonomously, controlled by artificial intelligence.[3] The next logical step in the view of the developer will be getting rid of the "weak link" also known as the human being for all combat airframes. The question is whether society is ready for unmanned aerial vehicles fighting against each other in conflicts or being used to fight against a human enemy. That ethical question remains to be analyzed yet.

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Earth Day Event (April 24) speaker saying hello from France to the AIAA LA-LV Section

by Mr. Jean-Philippe Régnault, 2021 June 10 (with permission)

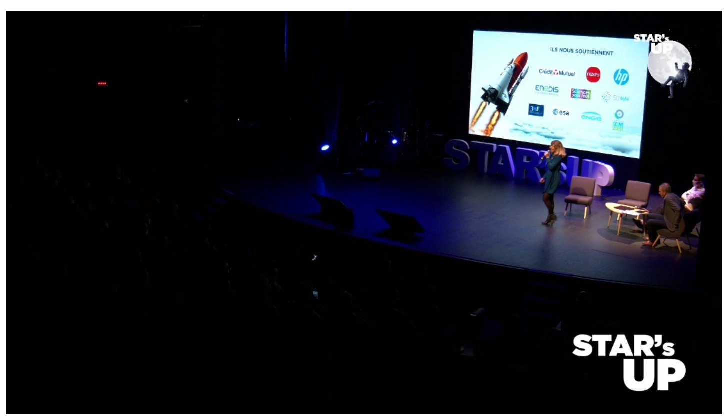
https://www.aiaa-lalv.org/april-24-2021-aiaa-la-lv-earth-day-celebration-2021/

Left: Mr. Jean-Philippe Régnault, the speaker in the AIAA LA-LV Earth Day event on 2021 April 24, made a special video to say hello to folks in the AIAA Los Angeles – Las Vegas Section. (click the picture for video). He is attending an aerospace festival in France.

Right: Mr. Jean-Philippe Régnault has been very passionate about aerospace, astronautics, and aeronautics, and is enjoying the festival with air balloons and other aerospace exhibition.

Left: This aerospace festival is taking place in the beautiful city of Meudon, France, near Paris.

Right: He and the co-speaker in the AIAA LA-LV Earth Day event on April 24, Mr. Michel Aguilar, will also speak in this festival. https://starsupfestival.fr/



Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion

(An AIAA LA-LV New Space mini-conference 2021 article)

by Mr. Michel Aguilar, Science Journalist at the Dépêche du Midi, French Air Force Retired

Background
20th century technology

For more than 100 years, the essential brick of aeronautics, the ENGINE, whether piston or jet, has continuously benefited from technological improvements, innovations and breakthroughs. These permanent improvements have made it possible to constantly increase its lifespan, to continuously reduce consumption, and with the simplest maintenance. At the same time, aerostructure and avionics benefited, in turn, from advances directly related to those in materials, electronics and informatics.

The efficiency of jet engines that power civil and military aircraft, even if undeniable progress has been made, the fact remains that the said thermodynamic efficiency remains very modest to reach at best 30%. That is to say that 70% of the fuel consumed by these engines warms the planet while polluting it! Certainly, the design offices of all the major aeronautical companies throughout the world are bypassing this real "impassable" limitation by developing the Fan or "big fan", and increasingly so large, moreover, that what could more accurately be called "streamlined propellers" have dimensions that dangerously bring them closer to the ground. The undeniable advantage of this solution is that this dilution ratio (ratio between the flow rate of the direct combustion that produces the hot gases and runs the entire engine, and the flow rate of the "large fan") tends towards ratios of 1/20 ! We will then notice the increased drag due to these increasingly strong dimensions, and also the mass which increases but with the advantage of reducing the acoustic power. The engines become "silent"!
Keywords of 20th century aeronautical engines: low efficiency - high fuel consumption - increasingly large dimensions - high drag (resistance to advance) - low sound power - high reliability - increased complexity.

21st Century Technology
In fact, all engine manufacturers on the planet, and not the least of them [GE (USA), Pratt&Whitney (USA), Rolls Royce (G-B), Safran (France), MTU (Germany), AVIC Engine (China), MIG (Russia)], are perfectly aware that in order to achieve double-digit fuel consumption gains, it is essential to go through a technological breakdown in terms of propulsion. Some leads are being studied, and it seems that a promising thermodynamic cycle is the Humphrey cycle instead of the one that has been at the forefront for nearly a century, the Brayton cycle. Obviously, and in any theory, it has been demonstrated that the Humphrey cycle is significantly more efficient than the Brayton cycle, as all engine manufacturers agree. But the real issue is: Which efficient technology can retain all the benefits of this cycle?

And first of all, what is the difference between these 2 cycles?
The current **Brayton cycle** of all turbojet engines on the planet consists of:
a) compress air to a certain pressure b) mix it with fuel, and usually kerosene c) ignite this mixture so that it expands at almost the same pressure; we then speak of **Constant Pressure Combustion** (CPC) d) by expanding through a turbine that it drives in rotation, and that itself directly drives the compressor e) the remaining energy contained in these flue gases will be used to expand through a suitable nozzle, and thus produce the thrust that will propel the aircraft.

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Applications for Artificial Intelligence in Space Systems & Systems of Systems

(An AIAA LA-LV New Space mini-conference 2021 article)

by Brendan L. Rosseau[1] and Parker Saussy[2]
Booz Allen Hamilton Inc., MacLean, Virginia, 22192, USA

I. Abstract*

The rapid advancement in recent years of technologies pertinent to space systems has fueled dreams of a "New Space Age." This paper examines one particular technology that, perhaps to a greater degree than any other technology, has the potential to enhance the capabilities of space systems and systems of systems, and, in so doing, catalyze the development of the space domain. Artificial intelligence (AI), defined generally as the ability of computers to perform "human-like" behaviors, such as learning, reasoning, and identifying patterns, is a powerful tool which, if properly applied, can help address some of the most challenging space problems. Following some background on AI, this paper outlines several of the most promising potential uses for AI and concludes with a brief discussion on some of the challenges to fully leveraging AI in the space domain.

II. Introduction

Humanity's relationship with outer space, traceable to our earliest days as a species, stands as an indelible element of the human story. Across the ages, our conception and understanding of the cosmos has continually evolved; with each progression came new perspectives on the universe we inhabit and insights into the nature of our existence. In prehistoric times, the heavens were both tools for survival and a canvas for human imagination; cave paintings, dating back tens of thousands of years, reveal our ancestors' careful observation of stars to mark the seasons and passage of time, vital information for anticipating the movements of the migratory herds that sustained them, as well as their reverence for the heavens above, anthropomorphizing those distant points of light into familiar creatures. Contributions by the great minds of antiquity, notably Plato, Ptolemy, and Aristotle, but also Hipparchus, Chang Heng, Abd al-Rahman al-Sufi, and many others, refined our understanding of the cosmos, weaving the study of space into a protoscientific blend of astronomy, astrology, geometry, philosophy, and theology, as well as other disciplines. The enlightenment, instigated in no small measure by Copernicus' radical heliocentric arrangement of the solar system, sparked a revolution of thought and reason, of observation and inquiry, of discernment and induction, of which we in the modern age are all heirs. Finally, in the most recent entry in this space saga, humanity succeeded in escaping the atmosphere, thereby opening a new chapter in human history, a period fittingly referred to as the "Space Age." This relationship between humanity and outer space, considering its unabated influence throughout history despite space's remote, intangible nature, has played an outsized role in shaping society and our individual and collective senses of identity.

Today, in the year 2021, we find ourselves at the outset of another potential watershed in human relationship with outer space. Propelled by rapid advances in space technologies, including computing, power generation and storage, launch, and communications, as well as the incipience of new technologies like 3D printing and cloud digital infrastructures, the present moment is characterized by new opportunities for the space domain and a surge of activity directed at realizing its potential value. By any metric, the evidence of unprecedented growth in space activity is striking. The number of space systems in orbit, a figure that has grown slowly since the launch of the first satellites,

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[1] Senior Consultant, Booz Allen Hamilton Inc.

[2] Lead Engineer, Booz Allen Hamilton Inc.

* This article was prepared by the authors in their personal capacities. The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy, opinion, or position of their employer.

An Examination of Wearables and Their Materials: How Can Wearables be Made to Better Protect Astronauts in Space

(An AIAA LA-LV New Space mini-conference 2021 abstrcact)

by Ms. Nicole Chase SEDS-USA (nicolechase13@gmail.com)

Wearables are a quite common thing here on Earth. They monitor biometric activity, and they remind us to do certain tasks. But, what if wearables could be applied to being off Earth in order to monitor astronauts' vital signs and be able to "predict" when a medical emergency was going to happen? This study is a fusion of a literature review and a proposal. The literature review aspect will be done looking at published research about wearables, in general and potential wearables that have been proposed for use in space. The literature review will also examine how certain materials behave in zero gravity, and how they behave over time in zero gravity. The proposal aspect will be based upon the findings from the literature review, and it will propose new and hypothetical wearables made up from different materials that could measure a variety of biometric data such as vital signs and potentially be used as a life saving device in the event of an emergency. These proposed new and hypothetical wearables will be displayed using mock-ups done in CAD. The goal of this study is to not only showcase what information about wearables is already out there, but to engage and educate the public about the importance for new technologies especially as, after all, the human body is a machine and it will take a very sophisticated human-engineered machine to properly observe and forecast when the human body machine's check engine light is illuminated, or flashing.

View From the Cupola: Kathleen Fredette *(iLEAD Schools, Dream Up, and ISSNL)*

by Ms. Kathleen Fredette (AIAA Educator Member), iLEAD Schools, 2018 June 26, with updates on 2021 June 14
https://www.issnationallab.org/iss360/view-from-the-cupola-kathleen-fredette-ileadschools/

If you're reading this, you're the kind of person who enjoys the wonder of things that sparkle in the night. If you've tried teaching, you also know that seeing the shining eyes of wonder is infinitely more meaningful than an educator shining before mesmerized kids. Conductor and author Ben Zander once said, "Look at their eyes. If they are shining, you know you are doing it."

Kathleen Fredette, Director of STEAM Initiatives at iLEAD Schools, discusses how a partnership between iLEAD Schools, which has locations in several U.S. states, and DreamUp is helping to inspire students and engage them in science, technology, engineering, and mathematics topics. DreamUp, an educational spinoff company from commercial services provider NanoRacks, works with student groups to bring student-designed experiments to the International Space Station (ISS). DreamUp is also highlighted in a feature in this issue.

In the age of one-to-one learning, smartphones, and social media, teaching has become a bit more like conducting—amidst the distractions, we strive to draw students to that place of wonder that is harmonious with real learning. Last summer a partnership with DreamUp began an amazing journey for me, a few courageous teachers, and hundreds of students.

Not many teachers have the opportunity to develop an educational project that results in launching a student-designed experiment to the ISS. At iLEAD Schools (K–12 public charter schools), we use project-based learning and social emotional learning as educational delivery systems to develop not just good students but also lifelong learners. Although sending a student experiment to the ISS is exciting, it's tricky to develop and run a project that engages and inspires young people, who are often more interested in their smart devices than in school.

Science-related projects often appeal to a small group of students, leaving the rest stranded in boredom. Our task: How do we create a project that is engaging, rigorous, and accessible to all students and that invites each young person into the arena of authentic learning? How can we use the topic of space as an entry point to the imagination of students, whether they are interested in sports, music, gaming, or dance, or whether they seem altogether uninterested in learning?

It turns out that space is the perfect environment for a reentry into that place of wonder, awe, and infinite questioning—one that opens our minds and hearts to the engagement that real learning requires. Author Elizabeth Gilbert wrote, "Curiosity only does one thing, and that is to give. And what it gives you is clues to the incredible scavenger hunt that is your life." Real learning begins to take place when curiosity and wonder are sparked.

Effective educators start with the end result and work backwards. So, we asked the question, "What content knowledge and skills are needed for young people to design, run, and analyze a space-based experiment?" Because iLEAD Schools are public schools, the project also had to connect to Common Core and Next Generation Science Standards.

We knew kids needed to understand large concepts like gravity versus microgravity and the basics of astronomy, engineering, and the scientific method, but we also wanted each student involved in the project to be able to answer the question, "Why do astronauts float in space?" Developing a space-based experiment also provides forother educational entry points, such as history, space travel, nutrition, rocketry, mathematics applications, technology, art, and geography.

Through DreamUp, our students were able to come up with their own experiment ideas and collaborate with subject matter experts. One of our teachers remarked, "The freedom to choose something that the kids were passionate about was a game changer. Because they could come up with an idea of their own, even some of the lowest-achieving kids were empowered to succeed." These are truly shining-eye moments!

Our partnership with DreamUp involved five iLEAD School campuses spanning grades 5 through 10. Students presented their ideas at a culmination of learning, our Space and Innovation Expo held at a local college (think a science fair on steroids). Jacob Cohen, Chief Scientist at NASA's Ames Research Center, shared the vision of space exploration with our families, inspiring all present to find and use their unique gifts.

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China's Advanced 'Artificial Sun' Fusion Reactor Just Broke a New World Record

by Tessa Koumoundouros, 2021 JUNE 3 (with permission)
https://www.sciencealert.com/china-s-artificial-sun-fusion-reactor-reached-another-milestone#

China has achieved a new milestone in humanity's experiments to harness the power of the stars.

On Friday, the Chinese Academy of Sciences' fusion machine reached 120 million degrees Celsius (216 million degrees Fahrenheit) and clung onto this for 101 seconds.

The last time EAST (Experimental Advanced Superconducting Tokamak or HT-7U) held onto a writhing loop of plasma for so long was in 2017, but the temperature only reached a mere 50 million °C.

In 2018, the reactor held gas heated beyond the 100 million degree benchmark regarded as crucial for generating power, but could only sustain the plasma for around 10 seconds.

Now that it's held plasma at eight times the temperature of the Sun's core of 15 million °C for such a long period, the new record has nudged the world ever slightly closer to this elusive, yet highly sought-after clean power source.

"The breakthrough is significant progress, and the ultimate goal should be keeping the temperature at a stable level for a long time," Southern University of Science and Technology physicist Li Miao told the *Global Times*.

Fusion power makes use of the reactions that take place deep inside the Sun, squeezing hydrogen atoms together into larger elements like helium. Where the Sun relies on gravity to force atoms together, here on Earth we have to resort to less subtle means, ramping up temperatures in specially built generators to generate the atom-melding forces.

Researchers estimate that the amount of deuterium - a stable form of hydrogen containing one proton and one neutron - in one liter of seawater could produce the energy equivalent of 300 liters of gasoline through nuclear fusion.

It takes around 300 scientists and engineers to support and operate the experimental facility that contains EAST. This large, donut-shaped metal tube has a series of magnetic coils used to hold superheated streams of hydrogen plasma zooming around the core.

The challenge is to hold the plasma in place for long enough, in a hot-enough inferno, for fusion to occur. It needs to be even hotter than the Sun because our star's much stronger gravity helps squeeze the nuclei together - something we can't replicate here on Earth.

With the theoretical potential to safely produce such vast amounts of energy without greenhouse gases and barely any radioactive waste, fusion power is considered by some as the holy grail of clean energy.

However, at the moment nuclear fusion is not yet a certainty, with a fully functioning 'artificial sun' still likely decades away. We have yet to even reach the point where a fusion reactor can spit out more energy than it consumes, but some experts think we're getting close.

Korea held the previous record of 100 million °C for 20 seconds. Now, China's artificial sun also managed to reach 160 million degrees °C (288 million °F) for 20 seconds, but there's still a long way to go to get the plasma stable at the required high temperatures.

Nuclear fusion is a great pursuit for a future post-carbon society, but meanwhile, we must do all we can to shift to proven clean power technologies to ensure we can even reach such a future.

We can't afford to sit back and wait for such an alluring, technological quick-fix, but every step forward for nuclear fusion certainly is cause for excitement.

About the Author:

Tessa Koumoundouros is an Editorial Assistant and Journalist at ScienceAlert. She adores all living things, so it's no surprise she mainly writes about biology, health, and the environment.

Tessa has contributed behind the scenes at The Conversation and the Climate Council, and her science reporting has been published by *Lateral Magazine*. She holds a Bachelor of Science with honors, majoring in zoology and genetics, and a Masters in Science Communication. She has also worked as an exotics veterinary nurse, before joining the ScienceAlert editorial team in 2018.

She is an accomplished illustrator and designer, and puts her skills to work when curating incredible images for ScienceAlert's social media, and designing infographics such as our This Week in Science series.

In her spare time, Tessa loves exploring wild places, stalking wildlife with a camera, reading, and drawing.

Honeybee Robotics and mPower Technology Chosen to Design Lunar Charging Station for NASA *(2021 May 25)*

Companies collaborate to provide game-changing solution for vertically deployable solar array

https://www.honeybeerobotics.com/news-events/honeybee-robotics-and-mpower-technology-chosen-to-design-lunar-charging-station-for-nasa/

ALTADENA, Calif. and ALBUQUERQUE, N.M. – May 25, 2021 – Honeybee Robotics, Inc., a passionate leader in technology and product development for advanced robotic and spacecraft systems, and innovative solar company, mPower Technology, Inc., announced today that the companies have been selected to provide an innovative lunar charging solution for NASA.

As electric vehicle charging stations are popping up across the globe, the Moon may soon join in the trend. NASA has selected five commercial teams to develop designs for vertically deployable solar array systems for the lunar surface as part of the Vertical Solar Array Technology (VSAT) project within NASA's Game Changing Development program. These systems may one day be used as charging stations to recharge rovers, battery packs, and other electrical equipment used by spacecraft and astronauts. These solar charging stations would be dropped off by lunar rovers and would deploy large solar arrays to supply sustainable power. The stations would be easily maneuverable, folding up into a volume of less than half a cubic meter for ease of transportation between charging sites.

Two uniquely innovative companies, Honeybee Robotics of Altadena, California, and mPower Technology of Albuquerque, New Mexico, have teamed and will be awarded one of these NASA development contracts. mPower is an industry leader in the design and fabrication of lightweight, flexible, resilient space-qualified photovoltaics, called DragonSCALES™. Honeybee is a world leader in robotics for extreme planetary environments. These two organizations form a powerhouse team that will provide a unique groundbreaking solution to the challenges of providing portable power on the lunar surface.

The concept, called the Lunar Array, Mast, and Power System (LAMPS), will use some of the lightest solar panels ever made. LAMPS extends these solar panels to a height of two stories and unfolds another two-and-a-half stories of panel material using a patented, new deployable boom.

"Honeybee has spent decades designing, testing, and flying mechanisms for planetary surfaces," said Kris Zacny, VP of Honeybee's Exploration Systems division in Altadena, Calif. "Our expertise in subsurface drilling is now going to be flipped on its head to 'dig' up, rather than down. We are thankful to NASA for being selected and very excited by the possibility of combining our expertise, with that of mPower, to make LAMPS a reality."

One of the key technologies incorporated in the LAMPS system is DragonSCALES, a solar module solution, developed by mPower Technology. This lightweight, flexible and resilient power source may be a key enabler for NASA's design goals.

"We are pleased to be partnering with Honeybee to bring innovative space solar power to NASA's VSAT project," said Kevin Hell, chief executive officer of mPower Technology. "DragonSCALES is ideally suited for harsh space environments such as those on the Moon and we look forward to potentially leveraging this technology across a wide range of space and lunar deployments."

About Honeybee Robotics

Honeybee Robotics creates advanced robotic systems for the world's most demanding environments and applications. We are an R&D engineering company that creates unique solutions for our customers' challenges, on Earth and in space. Our robotic solutions are designed to enhance the user experience and extend capabilities beyond what's currently possible. Industries we serve include spacecraft, planetary exploration, defense robotics, medical devices, mining, oil & gas, and utility infrastructure. We make next-generation applications a reality through creative, collaborative engineering that combines the best minds with the best technology. As an R&D service provider, we are deeply committed to delivering results for our customers and partners, from early-stage feasibility studies, to prototyping, to production and product validation. Since 1983, we have completed more than 300 advanced projects for NASA, the US Department of Defense, academia, industry and others. For more information visit www.honeybeerobotics.com.

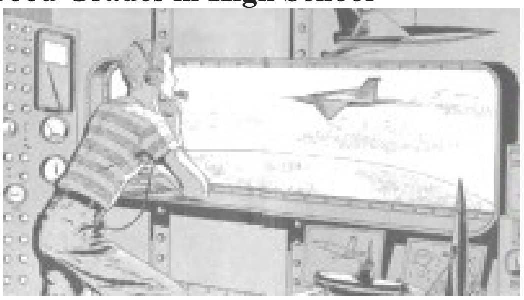
About mPower Technology

mPower Technology is shaping the future of solar power with a revolutionary new technology called DragonSCALES™, a completely flexible, interconnected mesh of miniature solar cells. Leveraging well-established and affordable materials, processes, and tools from the silicon photovoltaic (PV) and microelectronics industries, DragonSCALES enable completely new design options for solar power, removing the constraints of existing silicon and gallium arsenide solar solutions, and enabling highly flexible, resilient, light-weight designs that can be rapidly deployed at extremely low cost. For further information, please contact info@mpowertech.com, or visit www.mpowertech.com.

Raymer's Rules for Would-Be Aircraft Designers *(Continued from Page 1)*

If you really want to design airplanes, follow **Raymer's Rules for Would-Be Aircraft Designers** (presented below in approximately chronological order):

1. Get Good Grades in High School



That means B's or better. Sorry, but if you can't do better than C's you should consider other career options. Take all the math and science your school has, then beg to take more at a local junior college. The most important subjects are geometry, trigonometry, calculus, and physics. If you don't get all of those in high school you can take them in college, but you'll jump out ahead of the pack if you've already taken them. If offered, take Computer-Aided Design (maybe at the local adult education program). Take some English classes that focus on writing skills, including composition and grammar. You could also take a class in public speaking, to learn how to communicate your great ideas to other people.

2. Hang Out Around Airplanes

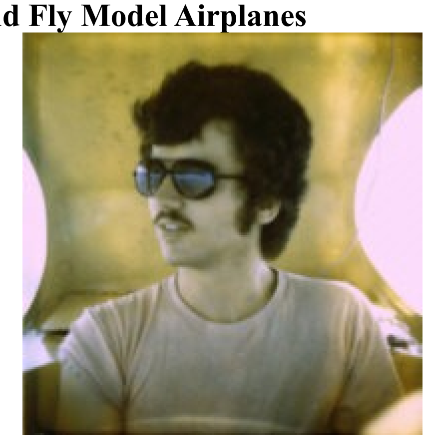
Go to airports and talk to people. You might find pilots working on their own airplane – offer to lend a hand. Go to museums and airshows. Perhaps join Civil Air Patrol, or Junior ROTC. Join the Experimental Aircraft Association (EAA) – you get their great magazine, and it looks good both to get into a university and to get a job afterwards. Many EAA local sections have a building project that always needs helpers - why not you?

Forgive the crass commercial plug, but high school students interested in aircraft design might want to get a copy of my book, Simplified Aircraft Design for Homebuilders. It presents real design methods but at a less-than-college level, and warms you up for my big textbook which you'll probably use when you are in college.

You may also be interested in my newest book, "Living In The Future: The Education and Adventures of an Advanced Aircraft Designer". This non-technical book covers my education, career, and design projects, and gives you an idea of what it is like to become and be an advanced aircraft designer.

My next book is being aimed directly at you. The working title is *Aeronautics and Astronautics for High School* and I hope to have it out early next year. No promises, though...

3. Build and Fly Model Airplanes



Make radio controlled models if you have the money, but even free-flight gliders are fun and teach a lot about design. Don't just build kits or stick together "ARFs" – do your own designs. Try different things. Figure out how to make a strange design stable, explore the problems of flying wings, make a canard design work, etc… BTW, if you are new to radio controlled airplanes, get a PC-based flight simulator program and fly it in "from the ground" view. This teaches you the strange backwards controls needed when the plane is flying towards you.

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Raymer's Rules for Would-Be Aircraft Designers

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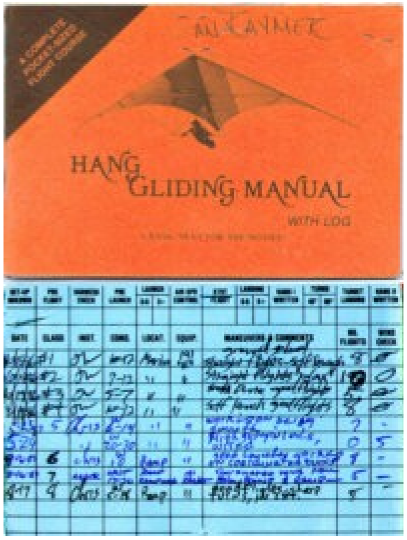
4. Get your Pilot's License



…or at least take a private pilot's ground school class. Many towns have it in adult education night school, which is where I took it when I was 15. If possible, take flying lessons (I worked as a cook to pay for it). You could learn how to hang glide.

5. Take a Shop Class

I had to fight with my high school to get permission since they thought that shop class was only for "dumb" kids, but it really helped me to understand what it takes to actually build something. I had a good time, too. I especially liked working the metal lathe. It is also a good idea to work on cars or motorcycles – buy an old junker and fix it up. Another possibility - take aircraft mechanic classes at the local adult education program.

6. Go to the Best Possible Aeronautical Engineering University

Major in Aeronautical Engineering or in Mechanical Engineering with an Aeronautics track. If you want to be a "real" designer, actually doing the initial layout design of new airplanes, there are several great schools to consider. Certainly University of Kansas is a strong contender (Jan Roskam headed their design program), also Purdue (my school), Cal Poly San Luis Obispo (where Burt Rutan went), University of Michigan (where Kelly Johnson went), Parks - St. Louis, University of Washington, and the University of Southern California. Click here for a fairly complete listing of universities with design programs.

One thing to look for – does the professor who teaches aircraft design have actual industry design experience? It usually helps, although I do know some excellent design professors who never worked in industry but have learned the industry methods anyway. Another thing to ask about – does the university participate in the AIAA student design competitions? Do they win?

If you want to go the more theoretical route, consider Cal Tech, MIT, or Stanford - assuming your grades are tops. With those degrees, you'll be "blue chip" for the rest of your life. Georgia Tech has a good program for would-be designers that is strong on advanced optimization methodologies – the wave of the future for designers. University of Maryland has long been known for hypersonics work.

And yes, get good grades. It really matters.

While at college, try to get involved in wind tunnel testing if your school has one. If not, build your own – be creative! In addition to all the usual courses, take CAD classes. It would also be wise to take writing and speech classes. Communication is very important in engineering, and many engineers seem to have perpetual writers' block.

7. Deliberately Build Your Resume Even While in School

All college graduates have a college degree. Duh! Some graduates have a lot more on their resume. Join AIAA, and maybe SAE, IEEE, and SAWE just for luck. Become a student chapter officer. Here's a good idea – grab the position of organizing the outside speakers. You'll have an excuse to contact important engineers all over the country to see if they will come speak – and even if they don't, you can send them a resume when you graduate!

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Raymer's Rules for Would-Be Aircraft Designers

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Give student papers, and enter the various student paper competitions. Write something for the AIAA Student Journal if you can.

You should also try to get as much “real world” experience as possible. Even if you don’t need the money, you should get a part-time job in something related to engineering, such as being a lab or research assistant. Or, try to find a job that sounds managerial. (But please, don’t put “transportation coordinator” on your resume when you were really delivering Pizza. We aren’t that stupid, and nobody likes being lied to.)

A summer internship at the right place can set you up for a great job later. Try to get one at a major aerospace company, or a government agency like NASA, or a small engineering company that contracts with them. You'll learn a lot and have networking opportunities, meeting people who may help you find a permanent job later. Work-study programs are excellent (especially if you do need the money). It is common for promising interns to be offered real jobs when they graduate, and common to offer them slightly higher pay as well since their true work abilities are know.

8. Get an Advanced Degree

In the old days, many great designers had little formal education. My first boss in the Advanced Design Group of North American Aviation (Rockwell) didn't have one. He may not even have graduated from High School, but that didn't stop him from doing the configuration design of the X-15.

Those days are over - the technologies are too sophisticated, the design tools are too complicated, and the competition is too intense. You still need to love airplanes, and you still need the mythical "designer's eye", but you also need an excellent education to succeed as a designer.

Get a Masters degree in aeronautical engineering, either immediately after your BS or after about 5 years of work experience. Go to the best university you can, but any MS is better than no MS.

A PhD is desirable for the theoretical or methods development areas, and is mandatory for a career in academia. The schools mentioned above are all great for a Ph.D. program, as are many others, and any Ph.D. is better than no Ph.D. (obviously, must be in engineering).

If you want to be a "real" designer, actually laying out the new airplane, then the PhD is nice but not essential. Actually, some think that a Ph.D. may hurt you by making you "overqualified" to be “just a designer” in some people's minds. I think that is foolish – the whole purpose of aeronautical engineering is to create a good design, so the people actually doing the design layout should be the best of the best, not glorified draftsmen. This argument has been going on for a long time.

In my own case, I “dropped out” of Purdue’s Ph.D. program with “just” a Masters Degree when North American offered me my dream job – a drafting table in Advanced Design. My major professor is still mad at me – he had to find another grad student to work his contract. I finally got my Ph.D. fairly recently, after 20 years in design.

Another option - some business courses or even a business degree might help out should you some day start your own aircraft company. I earned an MBA going to night classes at USC early in my career, and I think it helped a lot getting promotions to management.

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Raymer's Rules for Would-Be Aircraft Designers

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9. Work the Back-Door Hiring Game

When you are near graduation, try to find contacts who are actually in the design departments of aircraft companies or government agencies. While you will have to work through the personnel department eventually, a direct contact with the design department manager is far more likely to get you the job you want than just sending resumes in the "front door." How do you find them? Hint - those people give technical papers at AIAA meetings on related topics, and they are often on the AIAA Technical Committees.

When you interview or talk on the phone, be committed to becoming an aircraft designer and exude enthusiasm. Talk about something airplane-related that you have done. I'd rather hire someone who really loves airplanes and airplane design, than hire someone who has better grades but doesn't share my enthusiasm.

10. Then, follow Raymer's Rules for New Grads

Really. They are important. They'll help you get ahead, and may keep you out of trouble. One recent reader from abroad describes them as "admittedly spot-on." I think this means that they are useful. So, click here.

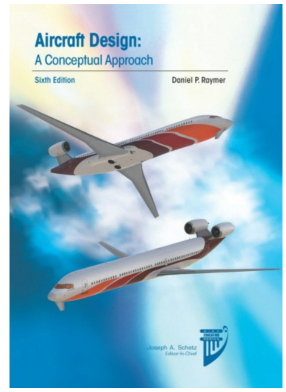
So, those are Raymer's Rules for Would-Be Aircraft Designers. I hope they help. You'll find more design-related information and thoughts at my Aircraft Design Website, including a list of Aerospace Acronyms & Abbreviations and a useful Generic Report Format. You'll also find some sample design layouts, links to aerospace websites, and a listing of books that I recommend for designers.

I wish you the best of luck. It's a fun career. I wouldn't do anything else!

About the Author:

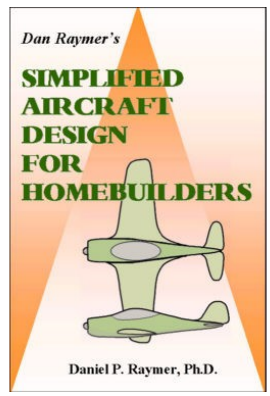
Daniel P. Raymer, Ph.D.

Dan Raymer is President of the design and consulting company, Conceptual Research Corporation, and serves as Program Manager, Configuration Designer, and Chief Engineer for its varied projects. Currently these include the DARPA Flying Missile Rail, the Raymer Manned Mars Plane, and a proprietary high-altitude UAV. (more on: http://www.aircraftdesign.com/raymer.html)

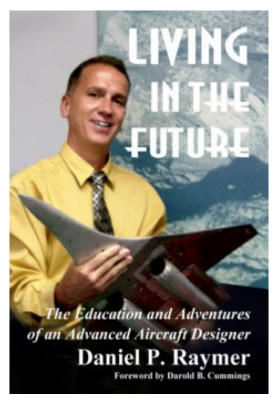


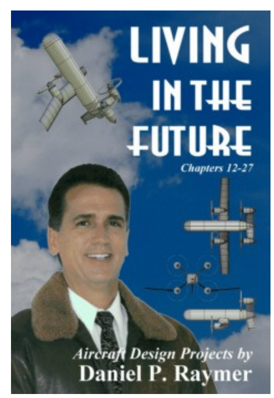
RAYMER AIRCRAFT DESIGN: A CONCEPTUAL APPROACH

(Prestigious AIAA Summerfield Book Award Awardee)



RAYMER SIMPLIFIED AIRCRAFT DESIGN FOR HOMEBUILDERS





http://www.aircraftdesign.com/livingfuture.html

The Profound Potential of Elon Musk's New Rocket (Continued from Page 2)

It was a milestone moment for Musk, too, of course, who founded SpaceX in 2002, fresh off the sale of his digital payments company PayPal, for no less of a purpose than getting humans to Mars. I know, I know. Entrepreneurs—they're usually in it for the money, right? But the cynics are wrong about Musk. I was among those who helped convince him to make Mars his calling. If he wanted more money, he knew plenty of easier ways to get it than to start, of all things, a rocket company, a notoriously difficult venture with little chance of success. He was looking to do things of immortal importance. Colonizing Mars (along with electric cars and solar energy) made the cut.

Let me underscore just how transformative, and how profound, Starship could prove to be to our future in space, and to our understanding of life. I've been in this business for a decent chunk of time. In the late 1980s, I was on the team at Martin Marietta, now Lockheed Martin, that did the preliminary design for what is now called the Space Launch System, NASA's flagship vehicle. It was originally devised as a quick and dirty way to create a heavy-lift booster out of the then-operational Space Shuttle system components. Starship is nothing like the Space Launch System. It's unlike anything NASA has made before. It represents an entirely new concept of space operations, and the impact it very well may have on science is extraordinary.

NASA is still claiming that its Artemis program will use the Space Launch System and the Orion crew capsule to deliver astronauts to the "Gateway," a yet-to-be-built space station orbiting the moon. From there, the idea is to rendezvous with a Starship in orbit that will ferry astronauts to the surface. NASA may fly a few missions that way. But frankly, this is to avoid the embarrassment of having spent so much time and cash on systems that were never used. Once Starship is operational, logic will drive matters in an entirely new direction.

Essentially, the Space Launch System is just the Space Shuttle, but with the airplane-like orbiter deleted, allowing its mass to be replaced by an upper stage and/or a greatly increased payload. Such a simple variant on the Shuttle should have been flying by the mid-90s, and had it been, we could have seen it serve as an enabling technology for a much more capable space program for the past quarter century.

Musk was looking to do things of immortal importance. Colonizing Mars made the cut.

Unfortunately, this did not happen. Despite the fact that a blue-ribbon committee, headed by Jack Kerrebrock, an eminent professor at the Massachusetts Institute of Technology, recommended in 1993 that such a Shuttle-derived heavy-lift booster be quickly developed—as a way of cutting the number of launches required to create the International Space Station by an order of magnitude—he was overruled by then-Vice President Al Gore. Gore wanted to extend the space-station construction program by decades, involving dozens of Shuttle and Russian Proton launches to use as a vehicle for encouraging friendly relations with (i.e. transferring funds to) the new rulers of post-Soviet Russia.[2] So the Space Launch System was delayed two decades, until it was already obsolete.

This sadly left NASA with a generation gap of lost expertise. Responsibility for development shifted to people who had never done anything like it before, so the program limped along well into a new century, with a performance-degraded final design and not even a test flight to show for some 30 years of effort, and more than $20 billion worth of expenditures. In 2005, NASA began developing the Orion capsule to give Americans a way to reach orbit after the retirement of the Shuttle, which was expected to occur (and did) around 2010. This should have been a walk in the park, but somehow, again, NASA, its contractors, and Congress managed to turn this into a multi-decade, $20 billion-plus effort, with just one unmanned test flight, in 2014, to show for the effort. Furthermore, not only the cost, but the mass of Orion had ballooned. Coming in at 26 tons, triple that of the Apollo capsule, it was too heavy for the Space Launch System to deliver into low lunar orbit with the propellant needed to return.

So, the Obama administration came up with the idea of building a space station in high lunar orbit. Instead of going to the moon, astronauts riding Orion could drop by the Lunar Orbit Platform, and enjoy the view. Or maybe they could investigate asteroids which could someday be moved into high lunar orbit using advanced propulsion. Wouldn't that be cool?

Now, I was no fan of the Trump administration. But they must be given credit for recognizing that this plan, which they inherited, was ridiculous. They cancelled the infeasible Asteroid Redirect Mission, and declared that the lunar orbit platform needed to be a "Gateway" to actually go somewhere. So was born the Artemis

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The Profound Potential of Elon Musk's New Rocket

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program, promising to take America back to the moon (and an American woman forward to the moon), by 2024 no less. To avoid embarrassment, the folks at NASA needed the Space Launch System, Orion, and the Gateway to be used as part of Artemis.

But that plan wasn't looking so good. The Space Launch System program was only willing to vouch for a launch rate of one per year. This is despite the fact that, over the course of its 30-year program, the more-complex Shuttle had achieved an average launch rate of four per year (and peak launch rates of eight per year). So, if a lunar mission was to launch within a reasonable time-frame, it would need to consist not only of a Space Launch System to send an Orion into orbit, but also several more medium-lift expendable booster launches to deliver a vehicle to the Gateway, so that a crew could take it from there, down to the lunar surface, and back. NASA scraped together around $1 billion for engineering-design studies, and put out a request for mission-architecture proposals to industry to develop lunar-excursion vehicle concepts to meet the needs of such a plan.

Starship would not be limited to operating as a ferry from lunar orbit to the surface: It can open the way to Mars.

In April 2020, NASA awarded preliminary design contracts to three contenders—the Blue Origin-led National Team, the Dynetics team, and SpaceX. The National Team, taking the $579 million lion's share, proposed an awkward, three-stage expendable lander. It corresponded precisely to the unworkable concept NASA had in mind for its mission plan. The Dynetics team of 25 small businesses, taking $253 million, offered a small single-stage with a drop-tanks lander that though (wisely) diverging somewhat, generally fit the NASA paradigm.[3]

SpaceX, taking the last $135 million, put forward a radically different concept—Starship. It would be an entirely reusable, two-stage-to-orbit, heavy-lift launch system powered by methane-oxygen engines with a capacity about midway between the Space Launch System and the more powerful Saturn V Apollo moon rocket. Because of Starship's reusability, it would incur less than 1 percent the cost of either. Those features, by themselves, would be world-changing, but there is more: Starship would be designed to be refueled in low-Earth orbit by tanker Starships, allowing it to proceed further, for example to Mars, where its propulsion system could be refueled by propellant readily made from the Red Planet's abundant water ice and carbon-dioxide atmosphere.

For the simplest Artemis mission—flying cargo one-way from low-Earth orbit to the lunar surface—Starship comes off well, delivering itself, with its large habitable space and propellant-storage volumes, plus an unmatched 100 tons of cargo, provided it can be refueled with eight tanker flights. One drawback is that, for Starship to land, it would have to have its landing engines moved up, to the top of the vehicle, so its powerful rocket exhaust avoids cratering the surface. The bigger problem is providing all the propellant needed to support Starship operations beyond low-Earth orbit.

It would take at least 10 tanker flights to refuel a Starship operating as a ferry between low lunar orbit and the lunar surface, or 14 if it is forced to make use of the Gateway. These requirements, however, could be reduced by developing technologies to extract oxygen from lunar regolith. Moon rocks are composed of a variety of metal oxides averaging about 50 percent oxygen by weight, and Starship's propellant combination is 78 percent oxygen. By extracting lunar oxygen (and producing metal in the process) the number of Starship flights needed per mission can be cut threefold, greatly accelerating lunar development as a result.

Unlike the competing concepts, Starship would not be limited to operating as a ferry from lunar orbit to the surface: It can open the way to Mars.[4] It was designed from the start to make the human settlement of Mars affordable, which is why Starship meets a much more demanding cost-target than anything a mere exploration program might need. Even for a hefty price, like $300 million per astronaut, NASA would jump at the chance to send its people to Mars to explore. But that flight price wouldn't work for anyone who might want to volunteer to be a Mars colonist. For Mars settlement to be feasible, Starship's ticket-price has to be cheap enough for a middle-class person to afford.

Such a person might be able to raise $300,000 by selling his (or her) house, and a working stiff a similar sum by mortgaging labor (as was done in Colonial America). Enabling such a ticket price would require cutting launch- and space-transportation costs by at least three orders of magnitude compared to those prevailing today,

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possible only by making space systems reusable: A Boeing 737 costs about $100 million and typically carries about 100 passengers—if it were expended after one flight, tickets would cost over $1 million. Only by making Starship reusable can space travel, like air travel, be made affordable.

SPACEPORT: *SpaceX is rapidly expanding its Boca Chica operations (above) to produce Starships faster and turn the small Texas village into a spaceport Musk wants to call Starbase. (credit: Wikimedia Commons)*

In February 2020, I travelled with my wife, Hope, to Boca Chica, a small city in Texas with a lot of low-lying land, near the Mexican border, where SpaceX is developing Starship and rapidly expanding. Musk wants to incorporate a town there and call it "Starbase." A mariachi band was playing outside, entertaining long lines of people waiting to apply for jobs. Hundreds were already at work in the complex. Soon there would be thousands. It was apparent that Musk was not building a ship, he was building a shipyard. In the course of its 30-year Shuttle program, NASA built five Space Shuttles, one every six years on average. On our visit, Musk was gearing up to build Starship prototypes at a rate of one per month, which he's actually done.

Rather than opting to analyze everything for years or decades before any flight tests, as NASA has done, Musk's approach is to build, launch, crash, fix problems, then try again. He's pushed his way through almost the entire flight envelope of Starship's upper stage system. With the success of the SN15 flight, he is now in position to fly it again and again. Musk is aiming for higher altitudes and increased operational perfection until his team can do it blindfolded. SN16 and SN17, incorporating yet more advances on SN15, are nearly complete.

For a space program to be supported, not by three or four flight vehicles, but by scores of them—and eventually hundreds—is revolutionary. Starship ascents will be counted in rates of flights per week, or even *per day*. The Shuttle's average flight rate of four per year, meant that, with a program annual cost of $4 billion per year, the actual cost of a Shuttle flight was a whopping $1 billion. A Starship transorbital railroad, employing 5,000 people, would cost about that much per year. Musk is aiming to manage 200 flights, which is possible with 20 operational Starships each turned around to fly again every 36 days. That would work out to $5 million per flight, 1/200th the cost of the Shuttle with five times its payload, for a thousandfold improvement overall.

The benefits of Starship for both robotic and human exploration are hard to overstate. Mars' recent arrival, Perseverance, can deliver one ton to the Red Planet's surface. Starship, with its 100-ton capacity, can land a battalion of robots. These could include many Perseverance-like explorers, and much bigger versions of the Ingenuity helicopter. Smaller rovers armed with high-resolution cameras could map the area, transmit to Earth, and allow millions of citizen scientists to walk the landscape in virtual reality and point the machines toward anything interesting. Construction robots, too, possibly humanoid in form, could build a Mars base capable of converting Martian carbon dioxide and water ice into methane-and-oxygen rocket propellant to store in tanks. With such a set-up, fully supplied in advance, Starships could start sending humans.

Rovers are wonderful, but they cannot resolve the fundamental scientific questions that Mars—once very much like the early Earth—poses to humanity: Is life unique to Earth, or did it appear on Mars, too? If so, did it use the same DNA-RNA information system, or something else? Is life as we know it on Earth what life *is*, or is it just a particular example drawn from a vast tapestry of possibilities? Finding evidence of past life requires fossil hunting. Perseverance will make a stab at that, but human rockhounds—capable of traveling far over difficult terrain, climbing, digging, working delicately, and intuitively following up on clues—can do the job much better. Finding extant life to determine its nature will require drilling down hundreds of meters to reach underground water where life might still thrive,

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bringing up samples, culturing them, and subjecting them to analysis. That is light-years beyond the ability of robotic rovers.

But there is more. Starship won't just give us the ability to send human explorers to Mars, the moon, and other destinations in the inner solar system, it offers us a two-order-of-magnitude increase in overall operational capability to do pretty much anything we want to do in space. That includes not only supporting a muscular program of probes to the outer solar system, and making all sorts of experimental investigations in Earth orbit economical, but enabling the construction of giant space telescopes. Much of our knowledge of physics has come from astronomy. This is so because the universe is the biggest and best lab there is. There is no better place to do astronomy than space. The 2.4-meter Hubble Space Telescope has made extraordinary discoveries. What might we learn once we are able to build 2.4-*kilometer* telescopes in deep space? The possibilities are literally inconceivable.

Robert Zubrin, an aerospace engineer, is the founder of the Mars Society and the president of Pioneer Astronautics. The 25th Anniversary edition of his book The Case for Mars: The Plan to Settle the Red Planet and Why We Must *was recently published by Simon and Schuster. Follow him on Twitter @robert_zubrin.*

Footnotes

1. Machay, M. & Steinberg, A. NASA funding in Congress: Money matters. *European Journal of Business Science and Technology* **6**, 5-20 (2020).

2. Logsdon, J.M. & Miller, J.R. US-Russian cooperation in human space flight: Assessing the impacts. NASA.gov (2001).

3. While clearly better on a conceptual level than the National Team offering, the Dynetics design never really had a chance, because the team behind it was not credible enough to be given responsibility for something of such central importance to the space program. Rather, they were given a nice chunk of change in order to assure a wide base of support for Artemis.

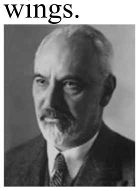
4. It would only take two tanker flights to fly an unloaded Starship one-way to Mars, or five to send it there carrying 100 tons of cargo.

Lead image: AleksandrMorrisovich / Shutterstock

Aerodynamic and Artistic Study of the German Jets *(Continued from Page 5)*

SOME OF THE FOUNDING FATHERS

Our aerodynamic study takes strong advantage of the pioneering work of many of the "Founding Fathers" of aerodynamics. With the horseshoe vortex as modeling clay, we'll apply Ludwig Prandtl's lifting line and induced drag concepts and shift the companion downwash line with the compressibility rule independently developed by Ludwig Prandtl and Hermann Glauert, including the effects of wing sweep. Although supersonic sweep was first theorized by Adolf Busemann, and later independently by Robert T. Jones, Albert Betz was first to suggest and test the benefits of subsonic sweep to delay transonic effects (4,5). Finally, to include forebody effects, we integrate Max Munk's theory of airships with Robert T. Jones' theory of low-aspect-ratio wings.


Ludwig Prandtl


Max Munk


Albert Betz


Adolf Busemann

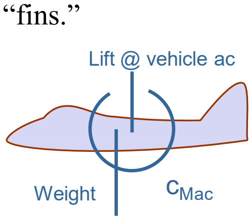

Hermann Glauert

MaryEvans.com


Robert T. Jones

CONFIGURATION AERODYNAMICS

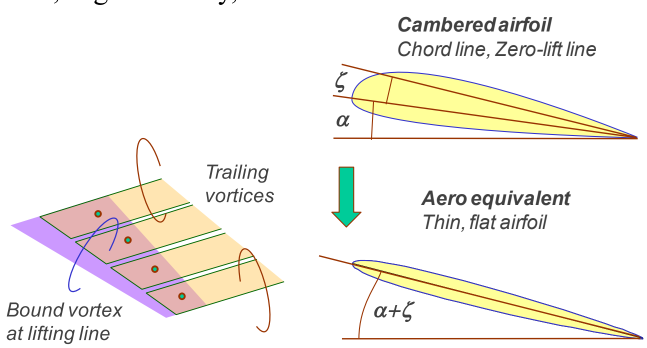
With the advent of the jet engine, the aircraft forebody stretched forward as the wings swept aft. These geometric changes decreased both the pitch and yaw stability of the aircraft. Accordingly, our method of aerodynamic analysis includes the forebody as a significant longitudinal and lateral "lifting surface." In keeping with the basic method, it will be modeled as a "cruciform" consisting of two low-aspect-ratio wings. The forebody planform, wing and empennage together set the "aerodynamic center" (a.c.) of the aircraft, where the total lift is concentrated for the purposes of analysis. The German Jets would have been statically stable, with the center of gravity (c.g.) residing forward of the a.c. and with a nose-up pitching moment balancing the offset of the lift and weight vectors. Such pitch-up moment can be provided by any combination of airfoil reflex, wing sweep with twist, and "decalage" of a canard or horizontal stabilizer, the latter designated herein as a "tail," with vertical stabilizing surfaces designated herein as "fins."



Vehicle Aerodynamic Center

THE VERSATILE HORSESHOE VORTEX

Our "Wing-body Linear Longitudinal-Lateral Lifting Line" (WBL5) method gives the lift (normal force) distribution, as well as profile drag and induced drag over all significant aerodynamic surfaces including the forebody planform, forebody profile, wing, and empennage. The analysis, limited to subsonic, linear aerodynamics below critical Mach, aligns "horseshoe vortices" along lifting lines, nominally at ¼-chord, with empirical modifications. A corresponding downwash line, nominally at ¾-chord, but shifted aft via the Prandtl-Glauert compressibility "rule," connects the points where the equivalent flat-plate (EFP) airfoil flow-tangency boundary condition is applied. The local EFP incidence is determined from the cross products of three vectors representing the chord, flight velocity, and local dihedral.



Rather than adjust aircraft and vortex geometry for angle of attack and sideslip, instead the flight velocity vector is tilted by these angles, with only selected adjustments of wing coordinates applied to account for differential sweep and downwash-node position in sideslip. Simultaneous equations, typically less than 100 per aircraft, are then solved to yield the distribution of horsehoe-vortex strength, from which local normal forces can be computed. The "apparent downwash" method then determines the local induced drag by comparing the observed local lift to that expected based on local incidence and local sweep, together with Mach number.

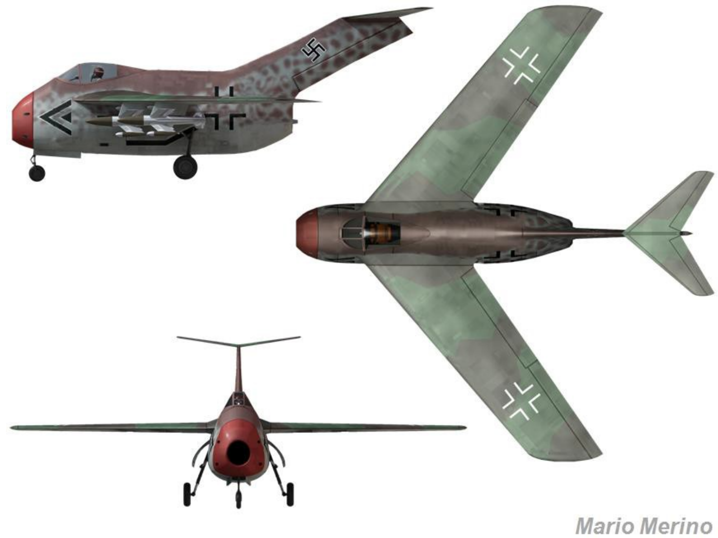
Previously, "lifting-line" methods could not accurately evaluate aerodynamic loads in sideslip. But here, we'll introduce and apply herein an empirical characterization of "isolated-wing" (no twist, fuselage, or empennage) yawing and rolling moments, based on NACA wind-tunnel test data, with a math-modeled "bump" added to the lift of one wingtip and subtracted from the other to yield the observed yaw and roll moments. This characterization, found in the appendix herein, includes the fundamental observation that both yawing and rolling moments of an isolated wing arise from differences in local induced drag, whereby such moments vanish as planar (untwisted) wing lift coefficient (c_L) becomes small (as at high speed), or as "tip-local" lift becomes very small for a twisted wing. Thus, an all-wing aircraft typically goes unstable, or marginally stable, in yaw at the "high" speeds approached by the German jets.

(Continued on the next page)

Aerodynamic and Artistic Study of the German Jets *(Continued from the previous page)*

GERMAN JET One ~ Focke-Wulf Ta183

The FW Ta183, although radical for its day, is the closest we will come herein to a "conventional" configuration. Conceived by Hans Multhopp with development well underway by Kurt Tank at F-W, the Ta183 was noted by its swept, constant-chord wing. The figures below describe the aerodynamics of the Ta183 at a representative "cruise" condition of 0.6 flight Mach number. Along the left and in the center, we show the aircraft with the lifting and downwash lines on each aerodynamic surface The influence of the afterbody can be ignored, as it is immersed in both downwash and low-quality flow. Notice the cruciform models of the forebody planform and profile as thin, low-aspect-ratio wings. At top center, we show the chord-weighted distribution of lift as a function of non-dimensional position "p/h," where "h" designates the halfspan and "p" the "screen-projected" distance along the spar. The central dip is caused by downwash imposed on the wing by the forebody wake and lift which, per the theory of Robert T. Jones, is distributed elliptically over the forebody. We assume use of a zero-pitching-moment airfoil (but cambered forward). It is interesting to see that the tail load is slightly positive With the chosen c.g. position, the aircraft has 8% static margin (normalized c.g-to-a.c. distance). At the right, we show the distributions of lift. (normal force) coefficient, local upwash (negative), profile drag, and induced drag. The overall distribution of chord-weighted drag is shown at the bottom center. Although we admit that it is often difficult to distinguish the various curves with the chosen format, we note that the forebody *planform* drag is greater than the forebody *profile* drag because without sideslip only the forebody planform is lifting.



Focke-Wulf Ta183

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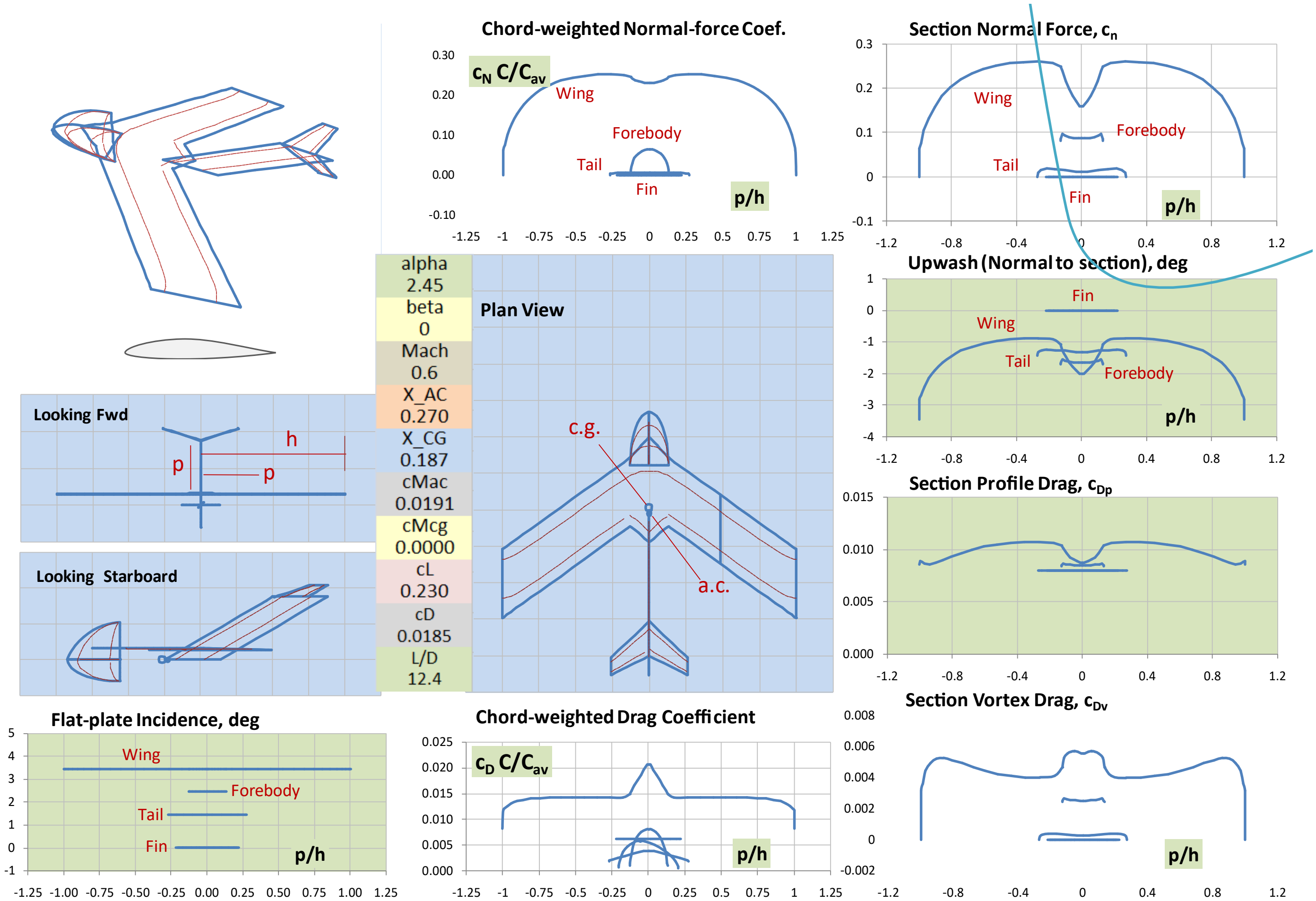


Focke-Wulf Ta183, Cruise ~ Distribution of Lift and Drag Over the Forebody, Wing, and Empennage

Aerodynamic and Artistic Study of the German Jets *(Continued from the previous page)*

GERMAN JET Two ~ Horten iX / Gotha 229

Next we visit an even more radical configuration, that of the Horten-iX /Go-229. In the end, this configuration proved too radical. Offered by the Hortens as a contender for the last-ditch Volksjäger (People's Fighter) competition, the Ho-iX was a favorite of Air Marshal Hermann Goering. He directed Gothaer Wagonfabrik (Gotha) to carry out detailed design and construction. Originally, the Hortens were in charge of the effort, but this soon changed (6). Perhaps due to the frictional Horten-Gotha relationship, the Hortens did not attend the first flight. An example of a key addition by Gotha is the cooling-air blanket to protect the aft skin from hot engine exhaust. Given the perseverance and skill of the Gotha engineers facing major setbacks and a near-impossible deadline, the Ho-iX is appropriately given the alternate designation "Go-229."

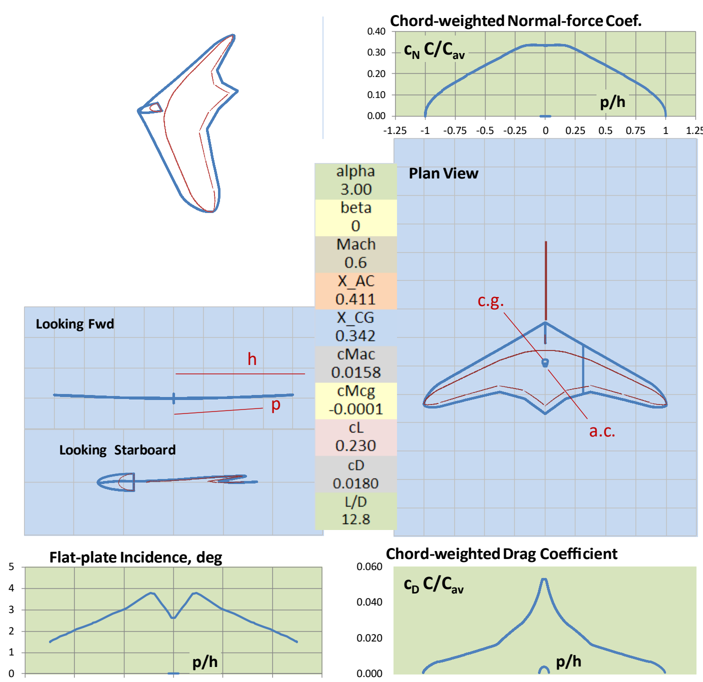
Ho-iX / Go-229

Ho-iX / Go-229 in Action

To stabilize the aircraft in yaw, the Hortens specified drag rudders, in lieu of a swept vertical fin, which we suggest would have offered superior handling and safety with a net reduction of drag. The drag rudders, which opened both top and bottom, alternately left and right, could not balance the yaw moment of single-engine flameout. This shortcoming proved fatal for the first test pilot (Lt. Irwin Ziller) to encounter this condition.

"Wing-only" statically-stable configurations, such as the Ho-iX, typically suffer the need for ballast (550-lb, Ho-iX) to shift the c.g. well forward from its inherent location, set by structure and equipment, to the required location for pitch stability. But of course in aerial combat every pound counts and every *round* counts. Contrary to widespread popular literature, the Ho-iX was built with only 1.5° of chord-line twist, as indicated by the Arthur Bentley drawings. With a reflexed airfoil at the wing root, the local zero-lift-line incidence was 0.5° below the chord line, whereby the wing had just 1° of effective twist, far short of that needed to obtain a "bell-shaped" lift load distribution. As built, the Ho-iX/Go-229 exhibited a "pseudo-elliptical" lift distribution. If instead the aircraft had incorporated bell-shaped lift, twist approaching 10° would be needed, as shown at lower right. Such would develop a strong pitchup moment, balanced by a forward c.g. shift via increased ballast. But, as noted earlier, isolated-planar-wing lateral stability requires non-zero lift near the tips, where the yaw-stabilizing forces originate as left-right differences in induced drag. Since bell-shaped lift would by definition "unload" the wingtips, the Ho-iX would have been neutral or unstable in yaw at the overall lift coefficient corresponding to bell-shaped lift.

With or without bell-shaped lift loading for the Ho-iX, the consistent deployment of drag rudders, having wake thickness and drag forces likely exceeding those of a fin, defeated "reduction of drag by empennage removal."



Aerodynamic Loads in Cruise ~ Ho-iX / Go-229

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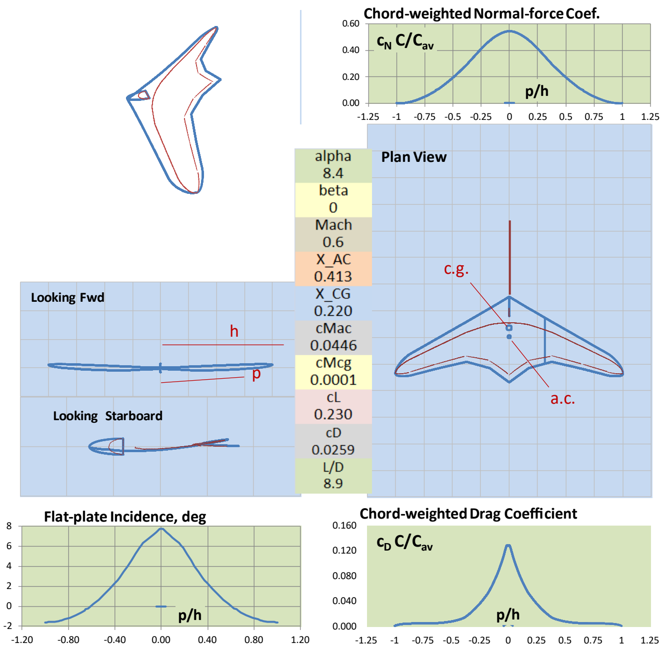
Aerodynamic and Artistic Study of the German Jets *(Continued from the previous page)*



Aerodynamic Loads in Cruise ~ Ho-iX / Go-229 ~ Bell-Lift Option

GERMAN JET Three ~ Focke-Wulf Schwanzloser

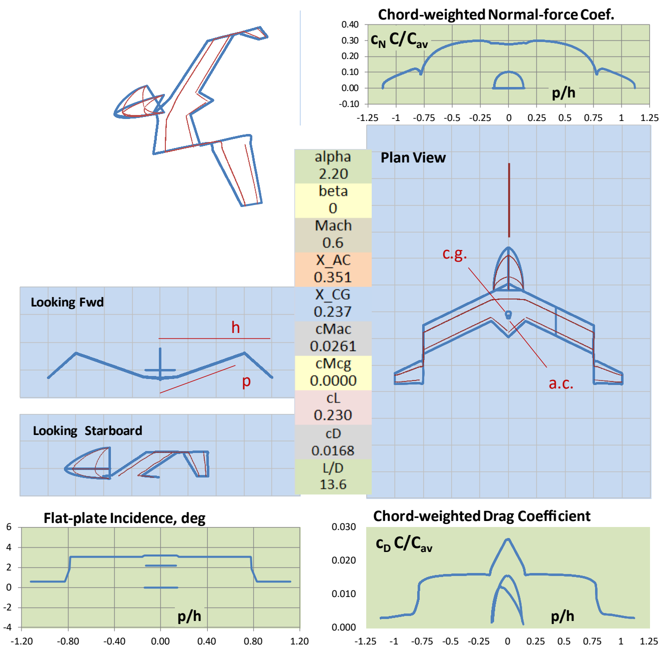
The *Schwanzloser* represented a far-more practical implementation of the "essentially-all-wing" concept by (1) incorporating a forebody to reduce or eliminate nose ballast, while providing superior visibility, and by (2) incorporating inverted winglets to stabilize the aircraft in yaw. Whereas a modern winglet, whether above or below the wing, would have a high aspect ratio to generate local aerodynamic thrust with local induced drag (negative) exceeding in magnitude the local parasitic drag, the winglets of the *Schwanzloser* were too "stubby" for that role. Nevertheless, they provided the necessary yaw stability. Readers familiar with the British *Avro Vulcan,* the design of which followed in time the *Schwanzloser* by only two years, will immediately note strong similarities in the configuration overall.

Focke-Wulf Schwanzloser in Action

GERMAN JET Four ~ Blohm und Voss P.209

Characteristic of design by Dr. Richard Vogt of B&V were the outboard stabilizers or "taillets" of the P.209. Most fascinating is the upwash and positive lift on the taillets, in spite of their 2.5° net decalage needed for the nose-up trim pitching moment.

With neither 3D-aero analysis tools available only after the war, nor wind-tunnel data for the P.209, Dr. Vogt would have been unaware that the "gull-wing" dihedral as originally drawn for the P.209 was insufficient to overcome the yaw-destabilizing effect of the forebody. For study purposes, such dihedral has been increased in the figure below, with thus our designation "P.209A."



Aerodynamic Loads in Cruise ~ Blohm & Voss P.209A

Blohm & Voss P.209 in Action

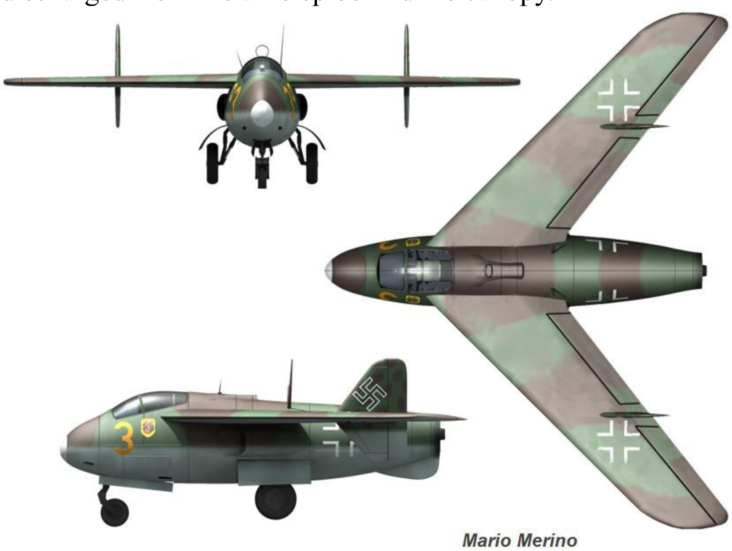
(Continued on the next page)

Aerodynamic and Artistic Study of the German Jets *(Continued from the previous page)*

Blohm & Voss P209 in Action

GERMAN JET Five ~ Junkers EF.128

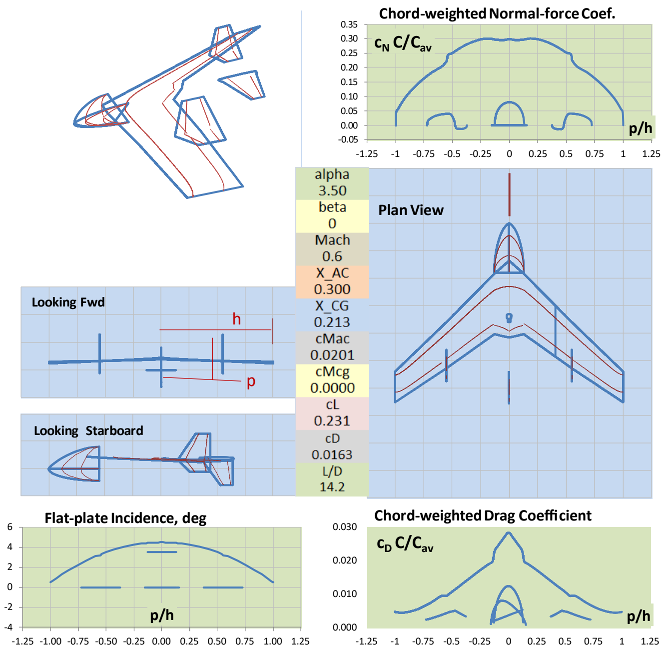
The Junkers EF128 was characterized by a prominent pair of "finlets" and ventral fin, together ensuring a stable gun platform. Also of interest is the inlet boundary layer bleed, discharged from the aft step behind the canopy.



Junkers EF.128

Junkers EF.128 in Action

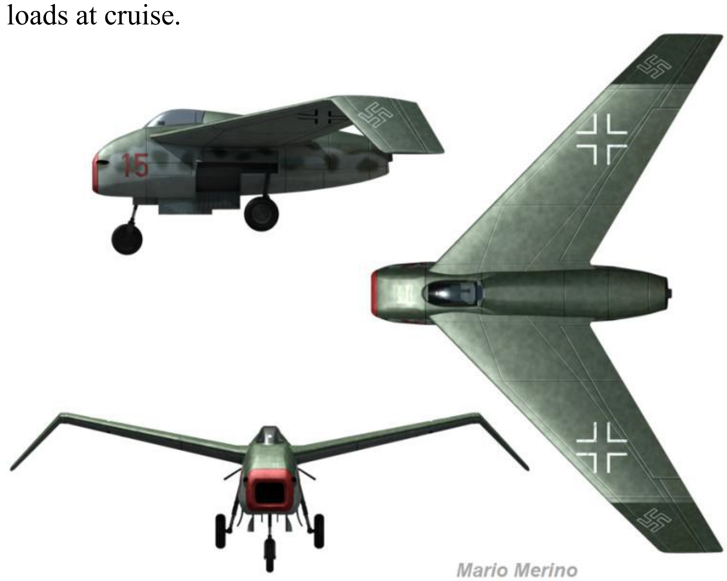
Another interesting feature is the inboard-directed lift of the finlets (assuming they were not "toed out"). These forces arise from the inboard component of flow above the wing, yielding step changes in lift distribution.



Aerodynamic loads in cruise ~ Junkers EF.128

GERMAN JET Six ~ Heinkel P.1078

The pronounced gull-wing dihedral of the P.1078 seems to emphasize the overall simplicity of the configuration. The sharp and sudden reversal of dihedral at the "wrist" of each wing yields, working outboard, a sudden reduction of incidence, favoring handling qualities. However, the distribution of lift normal to the spar remains continuous, as seen in the corresponding figure showing the aerodynamic loads at cruise.



Heinkel P.1078

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Aerodynamic and Artistic Study of the German Jets

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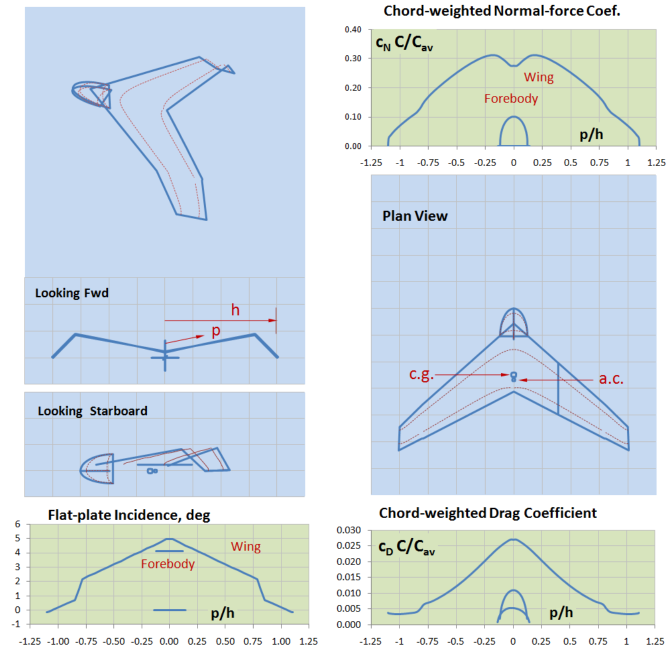
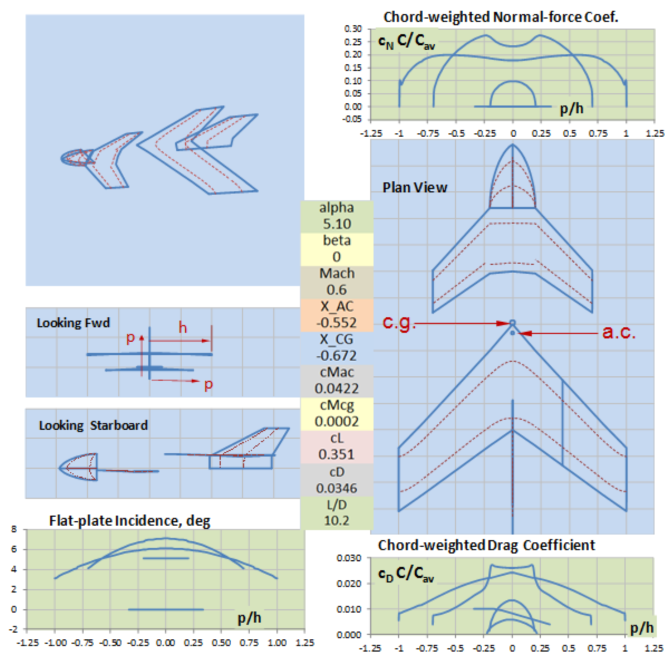


Aerodynamic Loads at Cruise ~ Heinkel P.1078

Messerschmitt Ente in Action

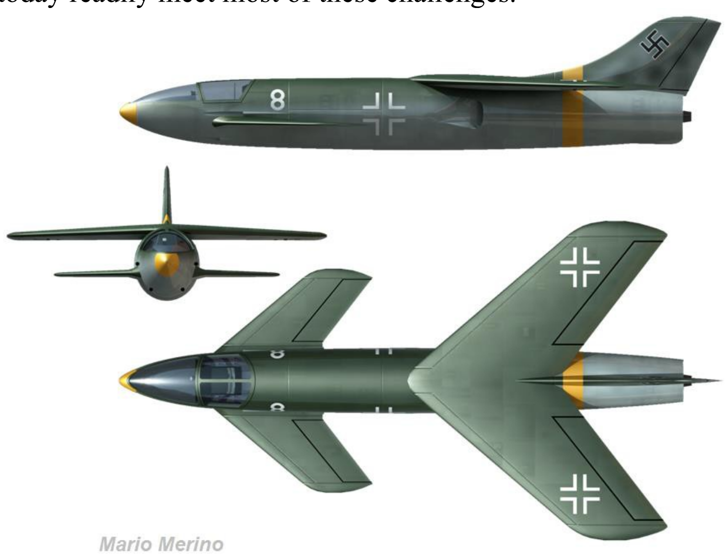


Aerodynamic Loads at Cruise ~ Messerschmitt Ente

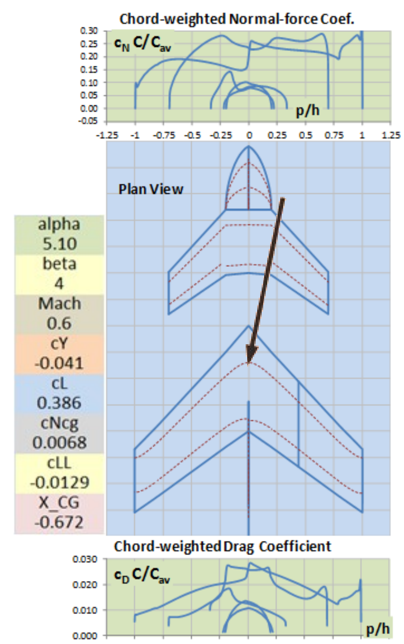
GERMAN JET Seven ~ Messerschmitt Ente

Our last German jet, the *Ente*, is certainly among the most interesting. Its many design challenges would have included (1) locating an appropriate position for the c.g., (2) calculating the lift distributions for the wing and canard, (3) validating yaw stability, and (4) mitigating the effects of canard wake ingestion at the engine inlets.

With the aid of computational methods and hardware unavailable to the Messerschmitt engineers at the time, we can today readily meet most of these challenges.



Messerschmitt Ente



Aero Loads in Sideslip ~ Me Ente

At the right we show the distributions of lift and drag for the Ente at cruise. The small "dome" at upper right represents the distribution of forebody lift. The forebody wake then induces a depression in lift at the canard, and the canard wake induces a depression of lift at the wing.

With 12% "static margin," the c.g. resides well forward of the

SUMMARY and CONCLUSIONS

(Continued on the next page)

Aerodynamic and Artistic Study of the German Jets *(Continued from the previous page)*

We have studied the real and conceptual "German Jets" of WWII from both aerodynamic and artistic viewpoints. We introduced the "wing-body longitudinal, lateral lifting-line" method for computationally-efficient analysis of linear aero loads on simple or complex configurations. We showed that the forebody is in effect a low-aspect-ratio wing, with its planform wake inducing downwash on the wing, and in sideslip, with its profile wake imposing "sidewash" on the fin. An empirical correlation was introduced to characterize NACA test data for the yawing and rolling moments of isolated wings. The German jets were the first to encounter the full force of "transonic treachery." But below their critical Mach numbers, most would probably have flown well in spite of their radical configurations. Today, some 75-years on, we continue to learn from the German Jets.

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2. A.C. Piccirillo, *Heinkel and the Turbojet Engine: Origin of the First Jet Fighter*
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4. Theodore von Kármán, "*Aerodynamics*," Dover, '57, p. 133
5. Meier, *"German Development of the Swept Wing*," p. 42
6. Web site: www.wapedia.mobi/en/ho-229

RECOMMENDED READING

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- *Luftwaffe Secret Projects,* Schick & Meyer
- *Secret Messerschmitt Projects,* Radinger & Schick
- *Ho 229 Spirit of Thuringia,* Shepelev & Ottens
- *A Handbook of Fighter Aircraft*, F. Crosby
- *Jet and Turbine Aero Engines*, B. Gunston
- *High-speed Wing Theory, R.T.* Jones & D. Cohen
- *German Aircraft of WWII*, D. Donald
- *Fluid Dynamic Lift, Fluid Dynamic Drag,* S. Hoerner
- *www.SAE.org, search with quotes: "*J.Philip Barnes*"*

APPENDIX

Figure A-1, based on test data from NACA reports (TN703, TN1468, TN1581, TN1671, TN 2445, RM A6K15), correlates the yawing moment coefficient with lift, sweep, and aspect ratio for isolated, planar wings (untwisted with no dihedral). Interestingly, even a planar rectangular wing is "somewhat" stable in yaw, but for any wing without dihedral, yaw stability requires lift in the vicinity of the wingtips. This was shown by Albert Betz, among the first to investigate the yaw stability of isolated wings. Here, yaw stability vanishes at zero lift because the differential forces which provide yaw stabilization originate from induced drag. Thus, if a planar wing develops no lift, or if the tip regions of a twisted wing develop no lift, then the wing will be "neutral" in yaw. Indeed, the restoring yawing moment is proportional to the square of wing (or tip-local) lift coefficient. Sweep, particularly when combined with low aspect ratio, provides a significant increase in the yaw stability of an isolated wing. Based on limited data, it appears that forward sweep yields near-neutral or slightly-negative yaw stability, whereby dihedral becomes essential unless active yaw stability is to be provided.

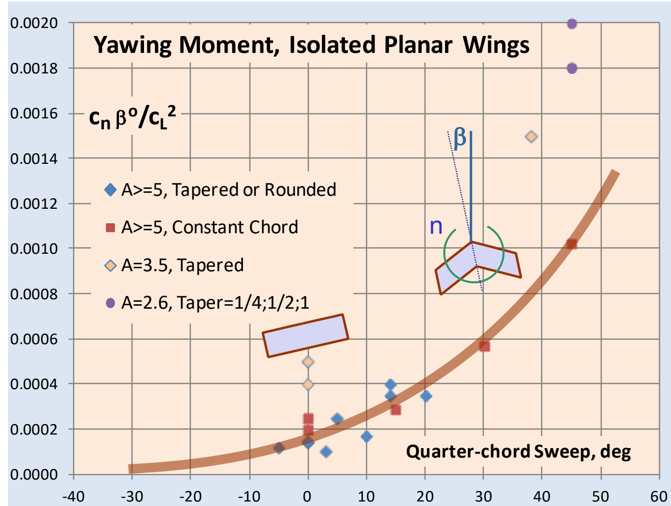


Figure A-1 Empirical Correlation, Isolated Wing Yawing Moment

An aircraft which yaws nose-left (positive sideslip) should naturally roll to the left if unfavorable handling qualities are to be avoided. Whereas the yawing moment is proportional to the *square* of planar wing (or twisted wingtip-local) lift coefficient, the rolling moment coefficient is proportional to the *first power* of lift coefficient (Figure A-2). Again, sweep combined with low aspect ratio affords the greatest "roll due to yaw." As with the yawing moment, a rectangular wing exhibits marginally favorable characteristics, but for roll-due-to-yaw, taper or rounded wingtips tend to degrade the handling qualities.

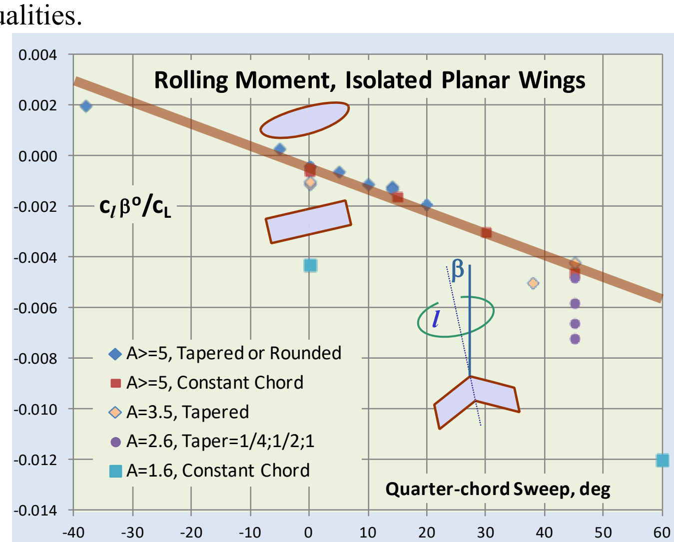


Figure A-2 Empirical Correlation, Isolated Wing Rolling Moment

ABOUT THE AUTHOR

Phil Barnes has a Master of Engineering degree from Cal Poly Pomona and has recently celebrated 40-years with a major aircraft manufacturer where he has been responsible for air vehicle and subsystem performance analysis. He is the author of landmark studies of *dynamic soaring* and *regenerative soaring*, both found at www.HowFliesTheAlbatross.com

Returning From a Rock in a Hard Place! *(Continued from Page 9)*

NASA/Goddard

OSIRIS-REx collecting samples from the surface of Bennu

Instead, it used a probe-like **Touch and Go Sampling Mechanism (TAGSAM)** to successfully obtain rock and dust samples from the surface of Bennu. Once back up in orbit around the asteroid, more photographs confirmed that the mission was complete. With its precious cargo stored on board in the **Sample Return Capsule**, NASA controllers have now told OSIRIS REx to come on back home.

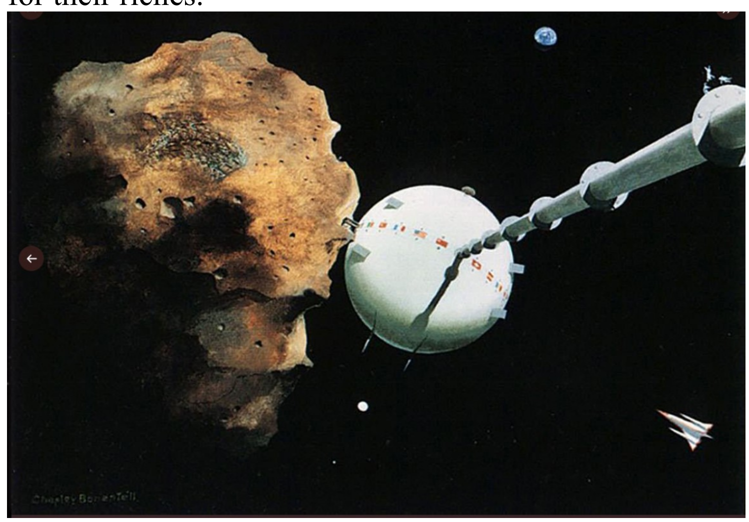
NASA/Goddard

The spot on Bennu where OSIRIS-REx took a surface sample

The return trip to Earth will take another two years. As it approaches our planet in September 2023, OSIRIS-REx will jettison the Sample Return Capsule. The capsule will descend for a landing on the Air Force's Test and Training Range in Utah, using a parachute like the one pictured below:

NASA

When it came to asteroids, **Chesley Bonestell** saw the good and the terrifying in them. They've long been considered a potential resource for precious minerals like **platinum** and **gold**. Any findings of this nature on Bennu will inevitably take us closer to mining asteroids for their riches.



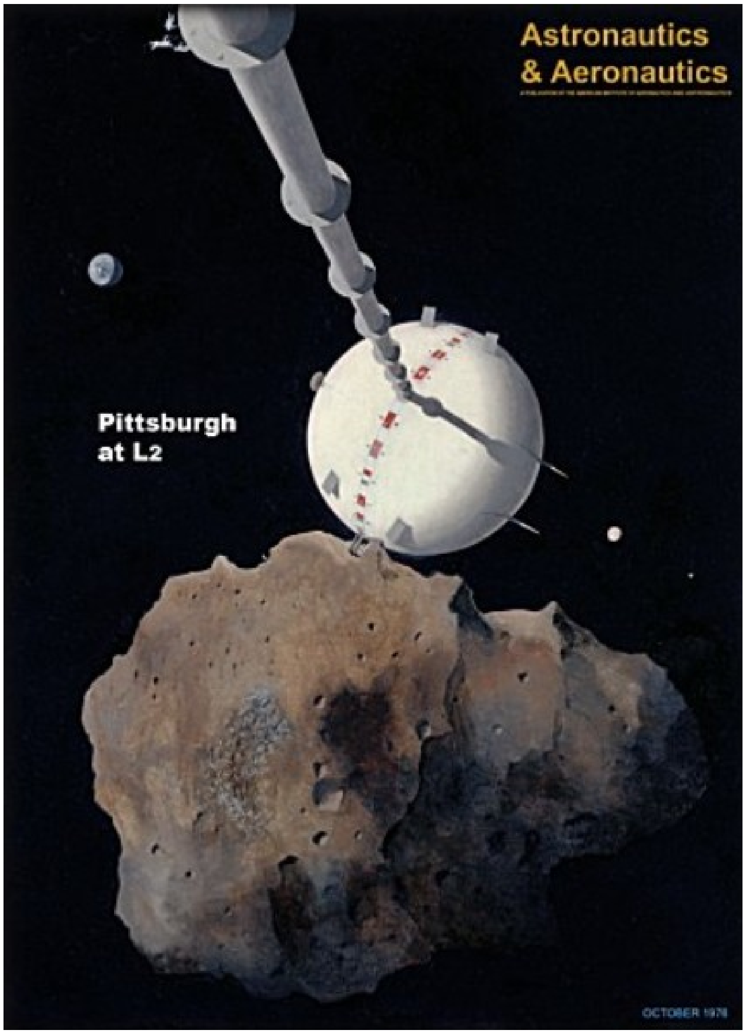
NASA

The original painting of Pittsburgh at L2 by Chesley Bonestell

Chesley showed the future of mining asteroids when he painted **Pittsburgh at L2**, which appeared on the cover of the October 1976 issue of *Astronautics and Aeronautics* magazine 45 years ago.

(Continued on the next page)

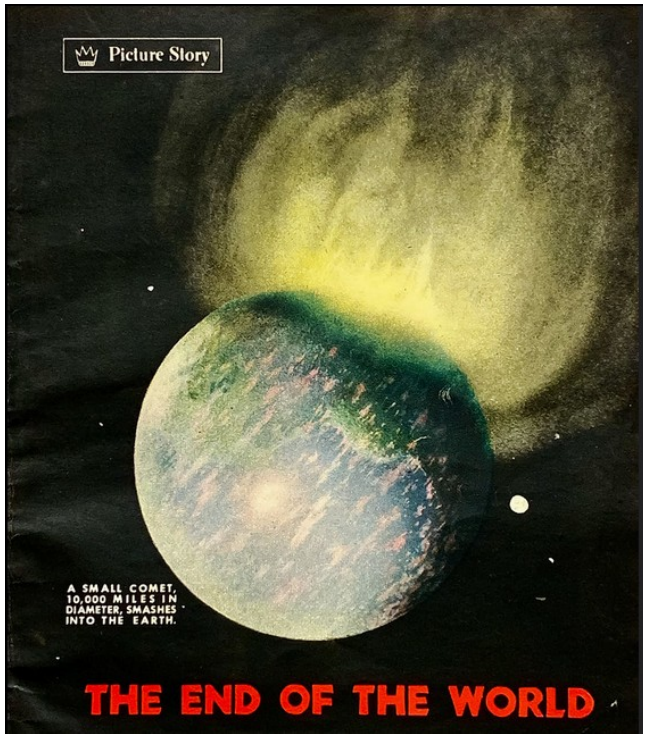
Returning From a Rock in a Hard Place! *(Continued from the previous page)*



AIAA

The cover version of Pittsburgh at L2 by Chesley Bonestell

In his book *Brief Answers to the Big Questions*, physicist and cosmologist **Stephen Hawking** wrote that asteroids pose the biggest threat to our planet. Another collision with one of them, on the scale of the one that wiped out the dinosaurs 66 million years ago, could potentially bring about destruction of all life on Earth. Between the years 2175 and 2199 there is a 1-in-2700 chance that Bennu might collide with Earth. As a defense measure against such a calamity, one part of the OSIRIS-REx mission is to determine what effect its encounter had on Bennu's orbit. Could spacecraft be used to alter the path of a **Near Earth Object** (**NEO**), like Bennu? Scientists will incorporate data from the OSIRIS-REx mission into an **Asteroid Impact Avoidance** study currently being put together by NASA.



Bonestell LLC

For an article called "The End of the World," that appeared in the July 1947 issue of *Coronet* magazine, Chesley Bonestell painted his vision of what an impact with a NEO might look like; in this case a meteor crashing into Manhattan.

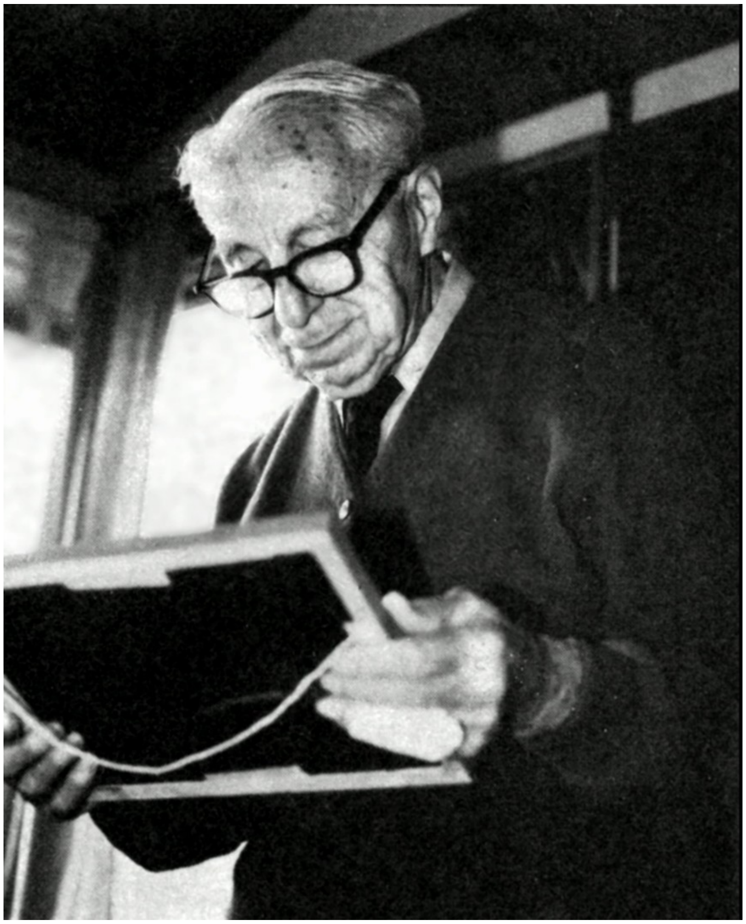
Bonestell LLC

Manhattan Meteor Crater (1947) by Chesley Bonestell

(Continued on the next page)

Returning From a Rock in a Hard Place! *(Continued from the previous page)*

In 1979, Chesley had an asteroid named after him by the International Astronomical Union: **3129 Bonestell**. Please click on the image below to see an excerpt from the award-winning documentary, **Chesley Bonestell: A Brush With The Future,** that covers Bennu's historic mission:



Credit: Kerry O'Quinn

Space Artist Chesley Bonestell

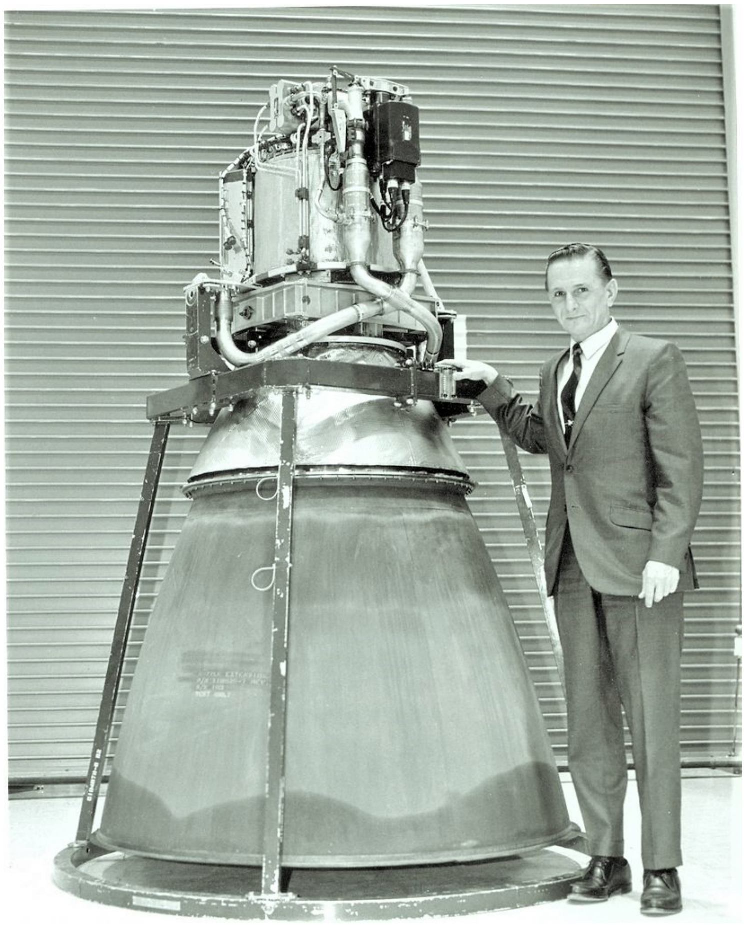
To find out where you can purchase or watch the entire documentary, please click on this image:

Please visit our website: www.chesleybonestell.com

Engineering Fun During 70 years as a Member of AIAA !

AIAA LA-LV Member Anniversary Spotlight on Mr. Gerard W. Elverum Jr. , AIAA Fellow (70 Years of AIAA Membership!)

(Continued from Page 11)



Jerry with the first deliverable LMDE,1967

Six times, starting July 19, 1969 (Apollo 11) through December 11, 1972 (Apollo 17) the engine safely lowered the Apollo Astronauts the last ten miles of their journey to the Moon. The engine was also called upon to bring home the astronauts of the damaged **Apollo 13** in April 1970. A fixed-thrust version of the engine was used in the upper stage (Delta) of the Thor-Delta launch vehicle. Over a period of 12 years the engine powered 65 national and international payloads into orbit.

Beginning in 1972, and until his retirement in 1990, Jerry directed the development of three of the Nation's most powerful high-energy chemical lasers NACL, MIRACL and ALPHA having potential application for both ground-based and space-based weapons. During the Last ten of those years, he was Vice President and General Manager of the **Applied Technology Division** of **TRW's Space and Defense Sector.**

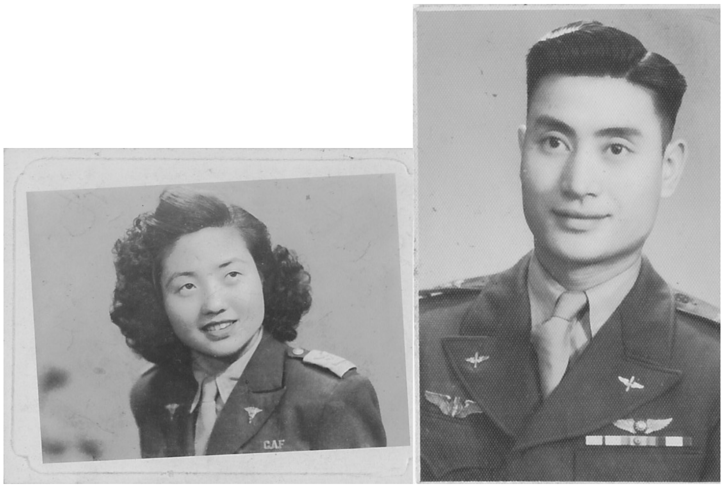
During the past 50 years Jerry has been a member of numerous national Committees, Boards and Commissions; many of which were of particular importance to the interests of the **AIAA.** In 1982 he was selected as a member of the Congressionally mandated **Aerospace Safety Advisory Panel (ASAP)** reporting to the **NASA** Administrator, and served on that important Panel until 1990. In 1986, following the Shuttle 51-L tragedy, he was appointed as a member of the National Research Council's **"Shuttle Criticality Review and Hazard Analysis Audit Commission**". Mr. Elverum was a member of the **NRC's "Commission on Engineering & Technical Systems"** during 1991 to 1995.

Jerry received a **"Special Achievement Award"** from the **ASME** in 1971, and the **"Outstanding Engineering Merit Award"** from the Institute for the Advancement of Engineering in 1972. In 1973 he won the **"James H. Wyld Propulsion Award"** from the **AIAA**, and he was made a **Fellow of the AIAA** in 1983. He was elected to the **National Academy of Engineering** in 1987.

Delightful 40 years of AIAA Membership! -Dr. Che-Hang Charles Ih's Story

AIAA LA-LV Member Anniversary Spotlight on Dr. Che-Hang Charles Ih, AIAA Associate Fellow (40 Years of AIAA Membership!)

(Continued from Page 12)



Charles Ih's Parents

When Charles entered Jet Propulsion Laboratory (JPL) in 1982, his dreams started coming true. For the first eight years, he worked on R & D programs as a lead analyst/task manager in Control Analysis Group, playing a significant role in advancing the art of dynamic modeling, control technology development, analysis, experiment, and validation for a wide range of space systems including the space shuttle, space station, space manipulator, space reflector telescope, anti-friction levitation system, to any large space structures. His work on shuttle experiments and space station modeling, control, and analysis – including station assembly, shuttle docking, astronaut motion, and the management of payloads – laid a significant foundation for the work that continues at NASA, as evidenced by the numerous references to his publications.

The next six years, he was a dynamics and analysis lead in JPL's Galileo Attitude and Articulation Control Systems Group. Galileo spacecraft was launched via space shuttle, and then orbited and studied Jupiter, its moons and its magnetosphere for eight years. Galileo scientists got a direct view of the impact of Comet Shoemaker-Levy 9 fragments on Jupiter, and the mission's discoveries including evidence of water in liquid form under the surface of the icy moon Europa, and a helium concentration in Jupiter similar to that of the sun, according to NASA. Charles's contributions include design and analysis of Galileo control and dynamic systems, anomaly investigation, flight software update, testbed validation, to mission operation. He solved many tough issues and was sent by JPL to Germany to present the Galileo story in an international space conference to aerospace experts from all over the world. His scan platform controller redesign tremendously improved the quality of the images taken and resulted in "all those beautiful pictures" of that corner of space, which were transmitted back to Earth, for the benefit of the scientists as well as an inspired public.

On Dec. 7, 1995, the day of Galileo's successful Probe Relay and Jupiter Orbit Insertion, Charles was interviewed by six local Chinese TV stations and news agencies to introduce the Galileo mission. The interview reached Chinese communities worldwide through TV, newspapers, and the internet.

He has won 10 prestigious NASA awards for technical innovation along with many other NASA and JPL awards, and was recognized as an expert in space systems modeling, control, dynamics, simulation, and experiments across the aerospace community.

Charles Ih's Father (left) During B-24 Training in Florida

(Continued on the next page)

Delightful 40 years of AIAA Membership! -Dr. Che-Hang Charles Ih's Story

AIAA LA-LV Member Anniversary Spotlight on Dr. Che-Hang Charles Ih, AIAA Associate Fellow (40 Years of AIAA Membership!)

(Continued from the previous page)

Charles Ih's Father with the B-25 He Flew in Battle

He then joined Hughes Aircraft in 1996, which later became Boeing, and started contributing to the earth-orbiting satellites that impacted the general public's lives more directly. He was a lead analyst/team lead and a consultation resource & mentor for design, analysis, test, and mission operation of attitude control systems. He has developed several pioneering designs used throughout the space fleet. A lot of the technologies he developed were breakthroughs which led to successful missions. Although the details of his proprietary work are not publicized, people can gaze to space and give him a nod of thanks when they use their cell phones & computers and watch their TVs, and their signals are clear and strong.

His inventions for Boeing have received ten U.S. patents. He also has received three highly prestigious and rare Boeing Special Invention Awards in honor of "inventions of significant value to the company". Boeing officials said Charles's work has had far-reaching impacts on winning and executing satellite contracts as well as enhancing Boeing's leadership in the competitive satellite industry. Besides the three Special Invention Awards, he also received many other awards from Boeing.

He became a prestigious associate technical fellow of Boeing in 2004, an innovator figure in Boeing Frontiers Magazine in 2009, and a spotlight figure in Boeing Technical Fellowship Program in 2012.

Charles also represented Boeing to win the 2012 Science Spectrum Magazines Minorities in Research Science (MIRS) Professional Achievement Award. This highly competitive and prestigious national award recognizes significant achievements in engineering, science or technology, in industry or government. The selection committee looks at the body of work of the nominee, the broad social and economic impact of the career, and the nominee's performance as a role model and mentor for minorities in technology. When Charles was nominated by Boeing in August 2011, company officials said his outstanding skills, expertise and knowledge play an important role in the advancement of Boeing.

He joined the American Institute of Aeronautics and Astronautics (AIAA) in 1981, and became a member of the AIAA Modeling and Simulation Technical Committee since 2008, a competitively selected position. He and his committee have advanced the capabilities of aerospace modeling and simulation by organizing international conferences, issuing newsletters, reporting on modeling and simulation capabilities and tools, and advising industries and academic and research institutes during technical exchange tours. He had served in the committee for nine years until his retirement in 2017.

He became a prestigious associate fellow of AIAA in 2010. He has been a session chairman and presented papers at numerous AIAA conferences, and became the technical chairman for the entire 2012 AIAA Modeling and Simulation Technologies Conference.

By this time Charles has become extensively published in the scientific community. He has more than 40 publication credits in conference literature and scientific journals, including AIAA Journal of Guidance, Control, and Dynamics, AIAA Journal of Spacecraft and Rockets, IEEE Control Systems Magazine, IEEE Transactions on Aerospace and Electronic Systems, ASME Journal of Dynamic Systems, Measurement, and Control, NASA Tech Briefs, etc.

(Continued on the next page)

Delightful 40 years of AIAA Membership! -Dr. Che-Hang Charles Ih's Story

AIAA LA-LV Member Anniversary Spotlight on Dr. Che-Hang Charles Ih, AIAA Associate Fellow (40 Years of AIAA Membership!)

(Continued from the previous page)

Charles Ih's Father with the Canadian Mosquito He Flew in Battle

He has taught advanced spacecraft topics at the UCLA extension to aerospace engineers from all over the world, and gave expert guidance to UC Davis students and professors in their "Mission to Mars" project in 2004. He was invited by AIAA Orange County Section as a keynote speaker to introduce JPL's large structure experiment facility and his superb experiments in 1989. In 1996, he was invited to introduce the Galileo mission at the Chinese-American Engineers and Scientists Association of Southern California, and received the outstanding speaker award.

When he is not hard at work, Charles likes to hike with his family. They especially enjoyed their hiking trips to Swiss and French Alps. He also has been teaching Bible and doctrine class for more than 30 years across the Chinese Catholic community in Southern California, and spreading the Gospel with his singing group "The Flying Seeds," in which he is the music director, arranges songs, plays guitar and sings.

The group's name comes from the image of seeds as they begin to sprout, which look like music notes. Thus, through singing, they plant the seeds of Christ's love, peace, and joy into people's hearts. Over the past 18 years, the group has had 107 voluntary performances all over California in all kinds of occasions – evangelical services, community gatherings, nursing homes, weddings, funerals, Christmas caroling, etc. – to all ages and all races. Eight out of the 107 performances were concerts (with 400~660 audiences) mixing devotional songs with folk songs, many of which were imbedded in the American folk lexicon, and touched the hearts of many.

Between Heaven, mountain hikes and the far reaches of space, Charles's attention continues to be drawn upward. "I have been truly blessed," said Charles. "With God's grace and my father's heroism as my guide, I try to make every moment count."

Beryllium's Backstage Pass

(Continued from Page 15)

An Influential Force

Throughout all these developments, Beryllium has had a kind of backstage pass. If technology were a band, and each major revelation a ground-breaking album, then Beryllium would be the exclusive guest brough in to preview the new material. Beryllium would be the fan brought backstage, asked for feedback, and then invited to the recording studio to hear the newest songs before they are even completed. Its opinions and suggestions on the songs would reshape their composition and in turn have huge effects on the albums released to the public, and thus change public discourse and popular culture. While Beryllium itself is not a superstar, it has had a hand in many of the last century's most famous events and creations: World War II, the Moon Landing, the Computer Revolution, and soon, the NASA James Webb telescope.

About the Author:

Julian Bailinson is a writer working with LA Gauge company out of Los Angeles, California. He earned a BA in English from UC Santa Barbara, graduating with honors. When not writing about aerospace, he spends his time studying 1960s music and fashion, as well as admiring vintage race cars.

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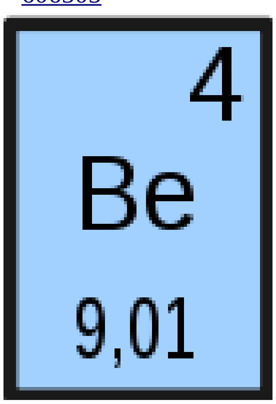
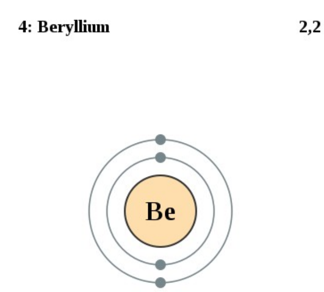
LA Gauge Shop Tour (Beryllium Manufacturing)

https://www.youtube.com/watch?v=cIyQdnk-8P0&t=6s

(Courtesy of Ms. Rosalyn Lowe and LA Gaugue Company)





From Left to Right: Beryllium's perodic table symble, Beryllium nuggets, Electron shell diagram for beryllium, the 4th element in the periodic table of elements. (From Wikipedia Commons)

(Continued on the next page)

Beryllium's Backstage Pass

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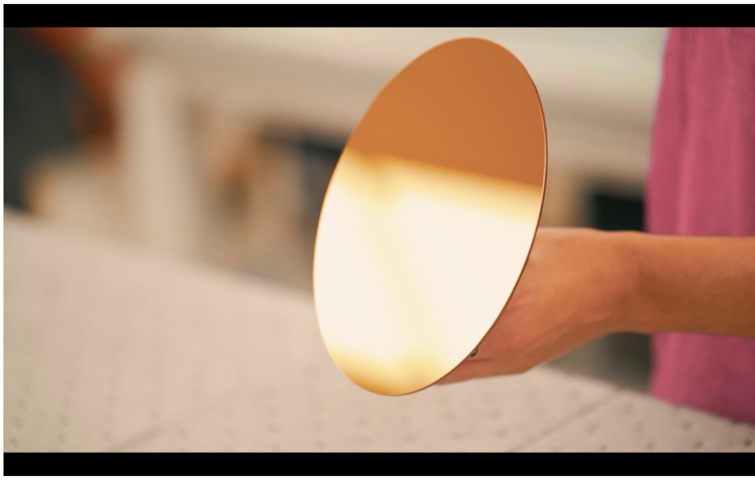


(Left) Gold Mirror : Gold plated beryllium mirror used in telescopes for deep space

(Right) Cold Shield close with dimes: is a component used for the SM-3 Targeting system

(Left) Critical Part Features photo

(Right) Component Head Shot: is a beryllium gyroscopic instruments used for navigation

Museum of Tomorrow Rising at Edwards AFB Gate (Continued from Page 18)

this aerospace museum would become far more than a collection of air and space hardware, by offering "a cultural center for aerospace with classrooms, lecture halls, archival offices, meeting rooms and event centers.

Thompson calls the off-base center provides neutral ground for bringing together groups which might not otherwise be able to meet face-to-face easily and affordably. He specifically mentioned the opportunity for aerospace industry leaders to meet with prospective employees from colleges and universities.

Thompson said it seems ironic that people from all over the world travel to Kitty Hawk, N.C., to visit the place where one airplane flew for the first time yet can't get in to visit the one place in America where the vast majority of first flights took place.

For all of its value to youth education and inspiration, advancement in technological achievement for defense, commercial air transportation, sustainable propulsion systems and space exploration, the stars of the show are and will be the shiny objects flown to and beyond the limits by test pilot exploring cutting-edge technology.

More than 80 aircraft are already in the Air Force Flight Test Museum collection, with 36 on display at Edwards, five at Blackbird Airpark in Palmdale, and the rest in storage or under restoration. Many of the planes wore U.S. Air Force colors, and many more in the X for experimental category were flown separately or jointly by NACA (later named NASA) and even other military branches, including the Navy. Other artifacts in the collection include propulsion systems, missiles, hardware, life support equipment, technical drawings, test reports, personal memorabilia, photographs, and wind tunnel models.

Also coming to the Flight Test Museum is the headquarters office of The Society of Experimental Test Pilots (SETP). The organization provided funds and materials to create the 2,500-square-foot archival space, making the Flight Test Museum become one of the leading sources for in-depth flight test history. The SETP commitment to the STEM mission and program will also be the conduit to connect with a new generation. Students of all ages will have unique access to mentors, instructors and flight test archives provided by SETP.

Edwards AFB and Air Force Plant 42 in Palmdale are hallowed grounds for American aeronautics and astronautics. Pioneers, inventors, and record breakers have continued to make their way to the high desert and the unique weather and topography of the Antelope Valley since almost the dawn of flight.

They came for the cloudless days, privacy from prying eyes and the miraculously hard and flat expanse of Rogers Dry Lake. Edwards AFB and the Antelope Valley were the hub of the golden age of manned flight test popularized by Tom Wolfe's "The Right Stuff."

The area saw America's first jet flight, breaking of the sound barrier, manned rocket plane flights to the edge of space, flight of the wingless Lunar Lander Research Vehicle and the era of the space shuttle

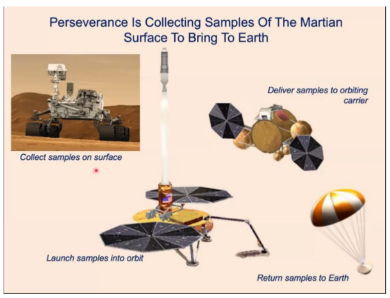
In the new location, the Flight Test Museum seeks to not only preserve and protect the history of flight test but also be the conduit to connect a new generation. With its Latin motto of "Ad Inexplorata," (Towards the Unknown) Edwards has always served as inspiration to each new generation. And with the new STEM center outside Edwards and summer reopening of two portable classrooms on Blackbird Airpark in Palmdale the future looks bright for America's Aerospace Valley.

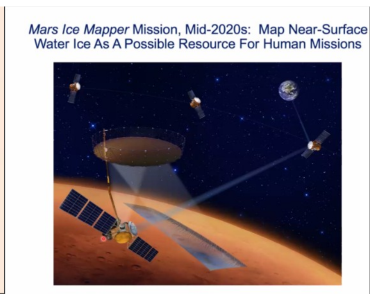
Photos taken in 2011 at Blackbird Park (run by the Flight Test Historical Foundation). Photo on the left: Lockheed F-117 stealth fighter; Photo on the right: Lockheed SR-71 (left) and the Lockheed A-12 (right). (Credit: Michelle Evans)

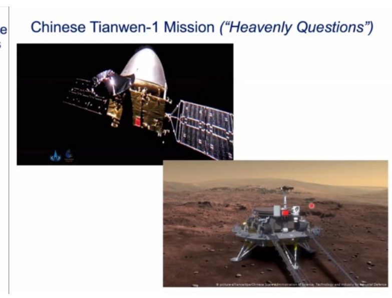
Mars Atmosphere and Climate: Past, Present, and Future by Prof. Bruce M. Jakosky (May 15)

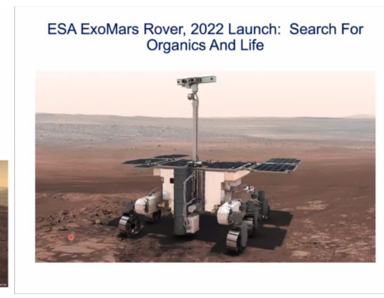
(Continued from Page 20) *(Screenshots only here)*

The speaker starting the presentation by citing the public attention to and the media coverage on / about Mars.

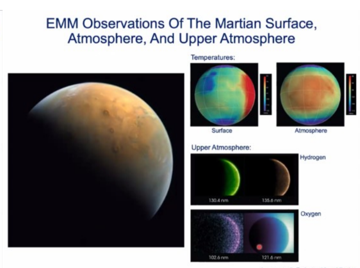


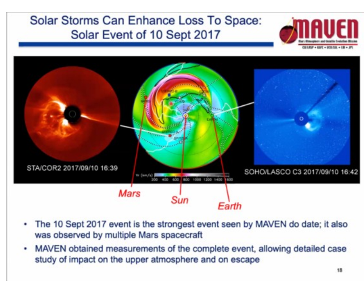


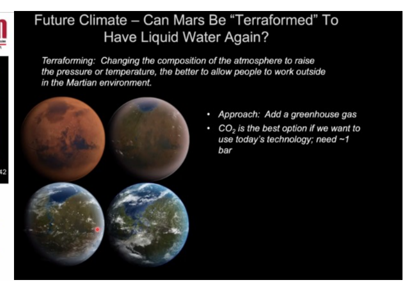




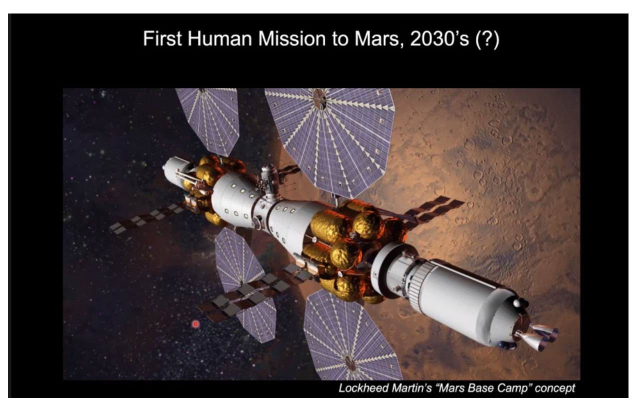
Professor Jakosky talking about the 3 current missions on or over Mars, and some of the future missions to Mars.







The speaking explaining the the issue of the loss of water and atmosphere on Mars, and the possible Mars terraforming scenarios.



Left: Prof. Bruce Jakosky answering questions in the Q&A session; Right: the future human spaceflight to Mars is doable in about 15 years, if we could set our minds to do it, with the existing technology, according to the speaker.

Starlink Satellite & Debris Sightings *(Continued from Page 27)*

When TLEs for all 60 satellites deployed by 19v1.0L19 became available on Space-Track, each satellite's earliest TLE shared the same epoch, equivalent to 22 February 2021 at 20:00 UTC. This time homogeneity permits the satellites to be sequenced in leading-to-trailing order at that epoch with minimal effort. The sequencing parameter is argument of latitude u, the geocentric angle in a satellite's orbit plane from ascending node on Earth's equator to position at the TLE epoch. Furthermore, sufficiently small orbit eccentricities less than 0.0004 among all 19v1.0L19 satellites allow each u to be readily computed. Under this nearly circular orbit condition, mean anomaly M is equivalent to true anomaly, and u is approximated with sufficient accuracy as argument of perigee ω summed with M directly from their TLE values. As an example of this technique, consider bold-faced values for ω followed by M in the Table 1 TLE.[4]

Table 1. An example Space-Track TLE dataset is reproduced for object 47673, one of the 19v1.0L19 satellites. The first line's epoch 21053.83334491 is equivalent to 22 February 2021 at 20:00 UTC. Argument of perigee ω and mean anomaly M values, both in decimal degrees, have been bold-faced in the second line for illustrative purposes relevant to adjacent narrative text. These values are followed by a mean motion of 15.92310806 orbits per day.

```
1 47673U 21012BF  21053.83334491 -.01168176  40691-3 -33822-2 0  9994
2 47673  53.0505  68.9853 0003995 300.4413 316.6259 15.92310806  1825
```

Since the required sum in Table 1's example exceeds 360°, u = 300.4413 + 316.6259 - 360 = 257.0672° for this satellite.

When the sequencing technique is applied to all 60 satellites from launch 19v1.0L19, they fall into two distinct swarms. The "high" swarm, with mean motion near 15.867 orbits/day, numbers 21 satellites falling in the envelope 146.0508° ≤ u ≤ 153.7909°, while the "low" swarm, with mean motion near 15.927 orbits/day, numbers 39 satellites falling in the envelope 256.6813° ≤ u

≤ 277.1053° (including Table 1's object 47673). The Table 1 mean motion value is typical of low Earth orbits, where geocentric angular rate at low eccentricity is never far from 4°/minute. Using this rate, the low swarm's trailing satellite is about (256.7 - 153.8)/4 = 26 minutes ahead of the high swarm's leading satellite on 22.8 February 2021 UTC.

With the passage of time, orbit-raising renders 19v1.0L19 sequencing at the 22.8 February UTC epoch very perishable. To model orbit-raising, Starlink TLEs use negative values for atmospheric drag parameters in the first line, and examples of these values appear in Table 1. As an illustration of sequencing volatility, consider the low swarm and TLEs for its leading/trailing satellites (object 47635 with u = 277.1053° and object 47674 with u = 256.6813°, respectively) on 22.8 February. When JPL's *Horizons* ephemeris server[5] is used to estimate positions and velocities for these two satellites at 17.5 February UTC (about an orbit before the reported CHNK sighting)

(Continued on the next page)

[4] For a full explanation of TLE format and content, reference https://www.space-track.org/documentation#/tle (accessed 28 March 2021).
[5] Reference https://ssd.jpl.nasa.gov/?horizons for user documentation and processing services (accessed 27 March 2021).

Starlink Satellite & Debris Sightings *(Continued from the previous page)*

from their TLEs 5.3 days later, object 47635 (the former leader) ends up trailing object 47674 by about 3.7 minutes of orbit motion (reference Figure 1 and note the difference in orbit sunrise countdowns in their -h:mm:ss format).[6]

Assuming objects 47635 and 47674 still define the low swarm's limits to a reasonable degree during the CHNK sighting time frame, Figure 1 approximates its extent. From this graphic, it is evident the low swarm arrives in CHNK's vicinity near the reported time. Its leading satellites exit eclipse in Earth's shadow to become illuminated by the Sun and visible to casual observers at 13:37 UTC.

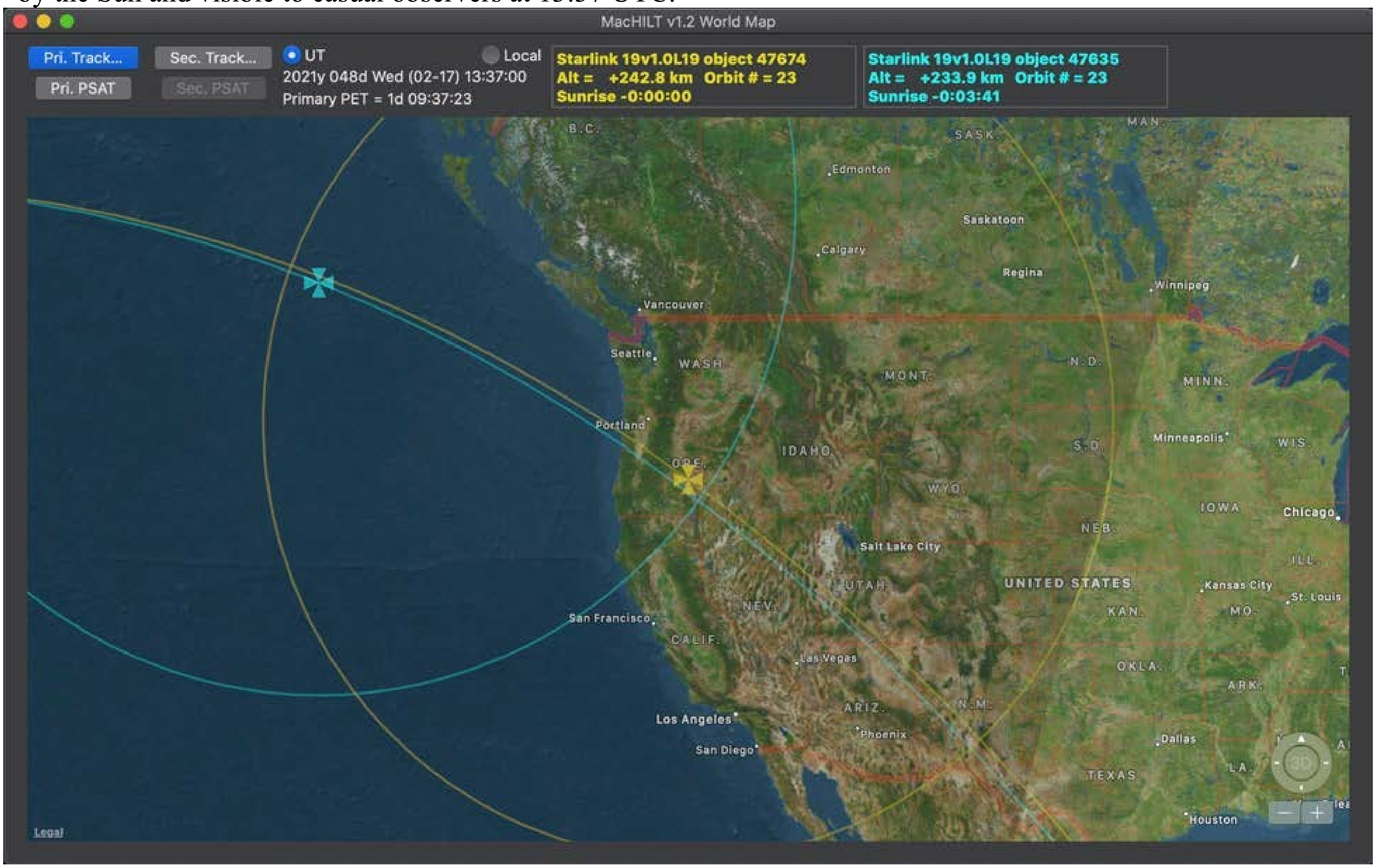


Figure 1. The yellow iron cross position marker, its circumscribing horizon locus, and digital values in the map's top border pertain to object 47674 in the low altitude swarm from 19v1.0L19's Starlink launch as it exits Earth's shadow on 17 February 2021 at 13:37:00 UTC, 33.6 hours after 19v1.0L19 launch. Analogous data for the low swarm's object 47635 are shaded cyan. Earth's sunrise terminator extends from Minnesota southwestward to Texas and is nearly tangent to object 47674's horizon locus as sunlight begins illuminating the satellite on its 23rd orbit.

When low swarm satellites become illuminated by the Sun on orbit 23, they are already starting to set over a CHNK observer's southeast horizon. Object 47365's Sky Track graphic illustrates this geometry in Figure 2.

(Continued on the next page)

[6] One hypothesis for this switched sequencing between objects 47635 and 47674 is the latter started raising its orbit *before* the former did at some point between 17.5 and 22.8 February UTC.

Starlink Satellite & Debris Sightings *(Continued from the previous page)*

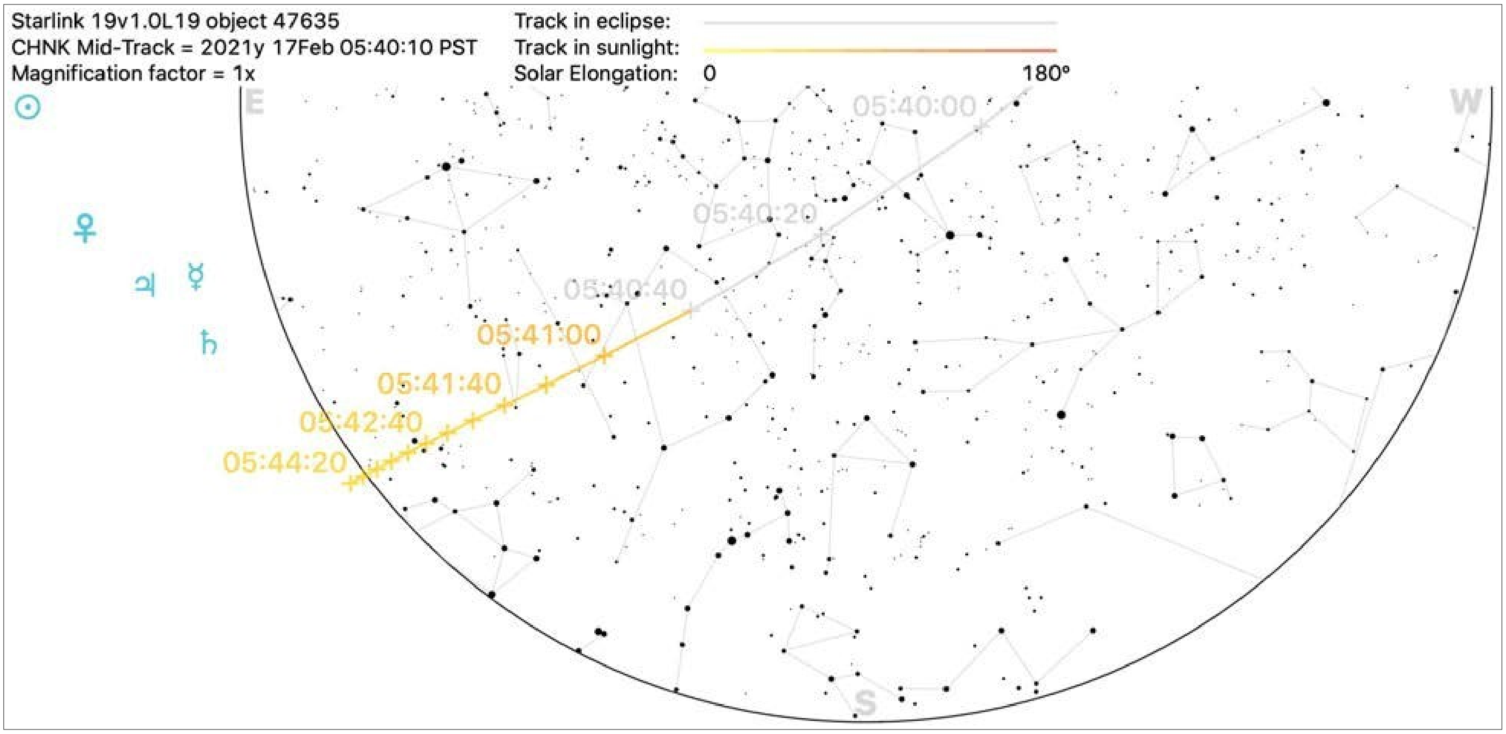


Figure 2. Visible stars south of a CHNK observer's zenith are mapped on 17 February near 13:40 UTC, together with low altitude swarm object 47635's apparent motion as it becomes illuminated by the Sun and sets over CHNK's southeast horizon less than three minutes later (colored track). Astronomical symbols representing objects about to appear over the eastern horizon are (in cyan, right to left) Saturn, Mercury, Jupiter, Venus, and the Sun.

Shifting attention to the high altitude 19v1.0L19 swarm, its leader on 22.8 February UTC (object 47628 with u = 153.7909°) precedes its trailer (object 47667 with u = 146.0508°), equivalent to a spacing of (153.8 - 146.1)/4 = 2 minutes. This is a much more tightly clustered swarm than its low altitude 19v1.0L19 counterpart on 22.8 February UTC. Relatively tight high swarm clustering is also evident from *Horizons* estimates of the two objects' positions and velocities at 17.5 February UTC. Ground tracks for these satellites when they overfly CHNK about an orbit later are plotted in Figure 3. Assuming objects 47628 and 47667 still define high swarm limits to a reasonable extent in Figure 3, all 21 satellites in the swarm would be observed within *seven seconds* of each other during their CHNK overflight.

Comparing digital "Alt" values in Figures 1 and 3, it is evident the high swarm is about 20 km above the low swarm as 19v1.0L19 satellites overfly CHNK on orbit 23. At its greater altitude, the high swarm appears to exit Earth's shadow about 1.5 minutes before the low swarm begins to do so. Although the two swarms will tend to separate thereafter, a casual CHNK observer could easily conglomerate them into one association during their February 17 appearance. Compare Figure 2 with Figure 4's object 47667 Sky Track to compare and contrast appearances of representative low and high swarm satellites in CHNK's sky during their orbit 23 overflight. To reiterate, these reconstructions depend on reasonably accurate *Horizons* position estimates from TLEs 5.2 days in the future.

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Starlink Satellite & Debris Sightings *(Continued from the previous page)*

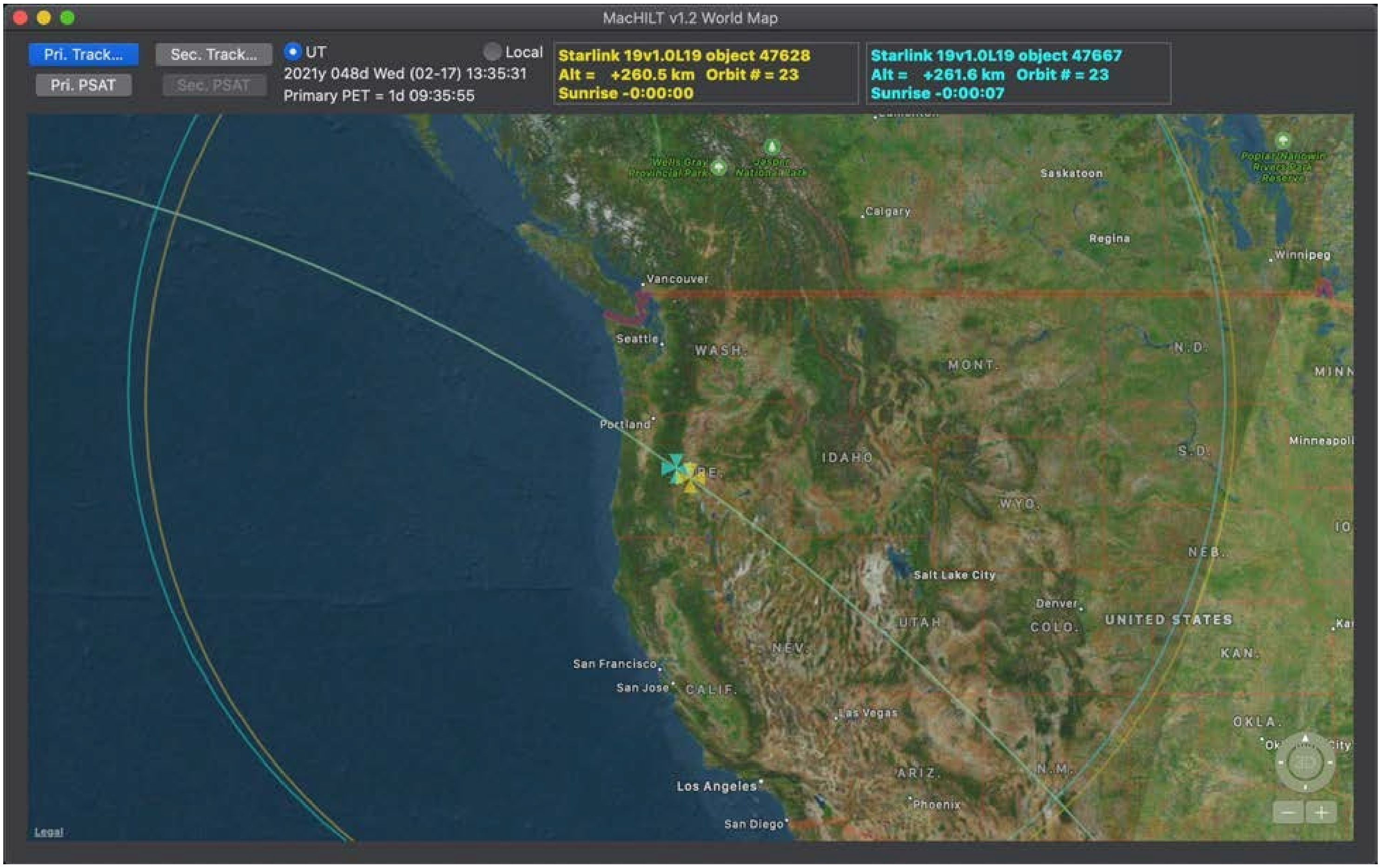

Figure 3. The yellow iron cross position marker, its circumscribing horizon locus, and digital values in the map's top border pertain to object 47628 in the high altitude swarm from 19v1.0L19's Starlink launch as it exits Earth's shadow on 17 February 2021 at 13:35:32 UTC, 33.6 hours after 19v1.0L19 launch. Analogous data for the high swarm's object 47667 are shaded cyan. Earth's sunrise terminator extends from Minnesota southwestward to Texas and is nearly tangent to object 47628's horizon locus as sunlight begins illuminating the satellite on its 23rd orbit.

For a more digital perspective on 19v1.0L19 satellites during their orbit 23 CHNK overflight, consider Table 2 data reckoned with respect to lagging object 47635 from the low swarm.

Table 2. These data pertain to 19v1.0L19 satellites on 17 February 2021 at 13:30 UTC, and values in the rightmost three columns are with respect to low swarm Space-Track object 47635. Curvilinear in-plane distance (positive is down-track from object 47635) is given by ΔX, deviation in semi-major axis (positive is higher in mean altitude than object 47635) is given by Δa, and the angle between each orbit plane and object 47635's is given by Wedge.

Space-Track Object	Swarm	ΔX (km)	Δa (km)	Wedge (deg)
47674	Low	+1681.290	+9.671	0.018
47667	High	+2243.635	+28.634	0.023
47628	High	+2299.914	+27.524	0.025

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Starlink Satellite & Debris Sightings *(Continued from the previous page)*

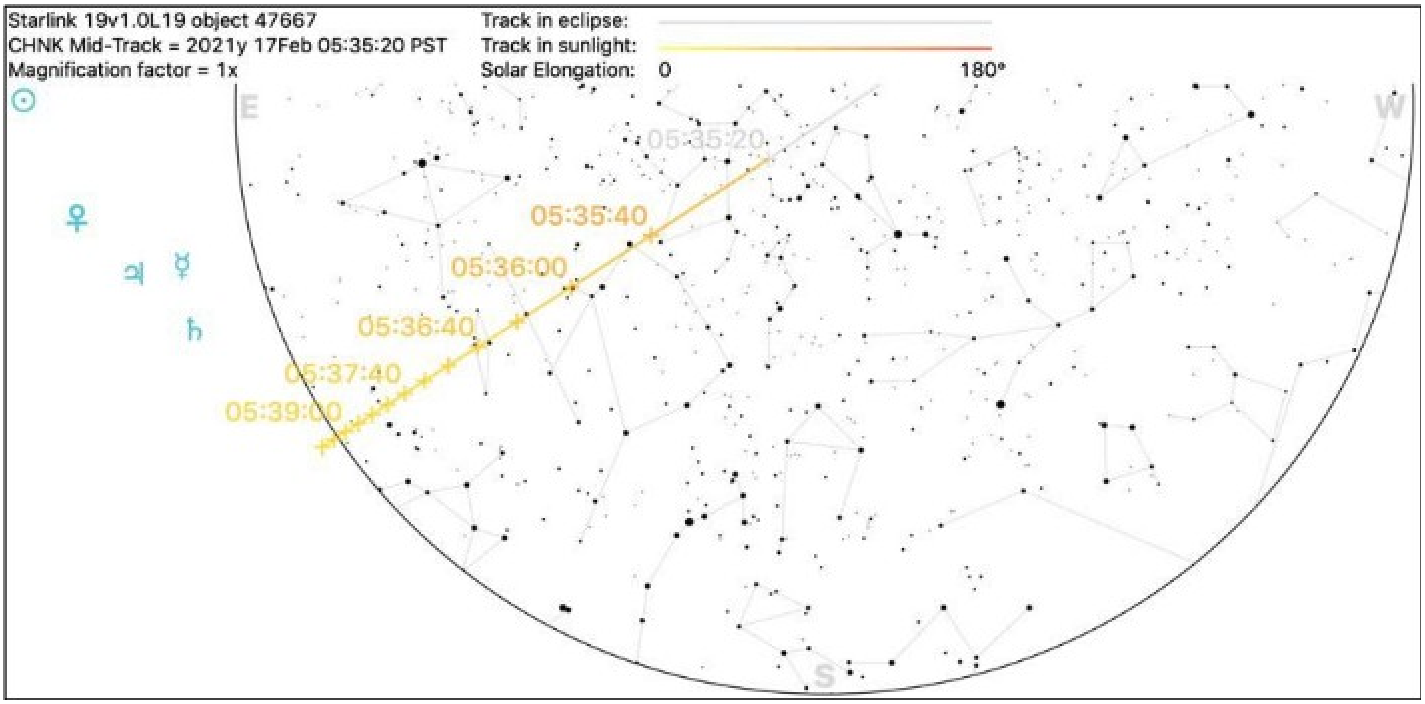

Figure 4. Visible stars south of a CHNK observer's zenith are mapped on 17 February near 13:35 UTC, together with high altitude swarm object 47667's apparent motion as it becomes illuminated by the Sun and sets over the CHNK southeast horizon about four minutes later (colored track). Astronomical symbols representing objects about to appear over the eastern horizon are (in cyan, right to left) Saturn, Mercury, Jupiter, Venus, and the Sun.

From analysis in this section, there is every indication virtually all 60 satellites launched by 19v1.0L19 were visible to casual CHNK observers during a five-minute interval beginning at approximately 13:35 UTC on 17 February 2021.

Sighting Predictions During The Week Following Launch

As previously noted, TLEs supporting Starlink sighting predictions are typically unavailable during the week after the 60 satellites are launched. This is precisely the interval in which satellite swarms are most likely to persist before orbit-raising operations disperse them.

Fortunately, the vast majority of launches fly the same Earth-relative path before these operations begin.[2] Thus, if the Earth-fixed trajectory of a satellite were known before orbit- raising, it could approximate that trajectory for any similarly launched Starlink satellite, regardless of launch time.

In addition to the 60 TLEs associated with satellites from a typical Starlink launch are several pieces of debris in the same initial orbit. These objects have no propulsion, and their TLEs serve as proxies for the post-launch satellite trajectories being sought. The debris object currently in use for this purpose is 47680, a result of Starlink launch 19v1.0L19. Because it has no propulsion, this object's orbit rapidly decayed. Object 47680 was presumably incinerated by atmospheric heating on 14 March 2021.[7] Its initial TLE appear in Table 3.

(Continued on the next page)

[7] Reference https://www.space-track.org/#catalog (accessed 5 April 2021) using a no-fee account.

Starlink Satellite & Debris Sightings *(Continued from the previous page)*

Table 3. The initial TLE for 19v1.0L19 debris object 47680 has epoch 22 February 2021 at 14:06:55.128 UTC. Note the absence of negative atmospheric drag parameters in the first line, indicating no orbit-raising operations are applicable to this object.

```
1 47680U 21012BN  21053.58813805  .00321907  57472-4  46927-3 0  9992
2 47680  53.0516  70.0766 0023659 245.9295 113.9261 16.04072739  1344
```

The Horizons ephemeris server is used to estimate position and velocity for Table 3's TLE on 16.0 February 2021 UTC. Using this state as initial conditions, a WeavEncke coast is performed with zero atmospheric drag acceleration to 19v1.0L19 launch on 16 February at 3:59:37 UTC.[8] The inertial Cartesian state from this 4-hour coast, as referenced to Earth's Equator and Prime Meridian (EPM) coordinate system at the terminal epoch[9], appears in Table 4. This state applies to any Starlink launched from Florida into an orbit with 53° inclination. When launch UTC is specified, these EPM components can be transformed to a standard inertial coordinate system such as the Earth mean equator and equinox of epoch J2000.0 (J2K).[10]

Table 4. The following Earth EPM state vector approximates typical Starlink satellite orbit motion following orbit insertion (about 9 minutes after launch) and prior to orbit- raising when associated with any particular Starlink launch time from Florida into an orbit with 53° inclination.

$$\begin{bmatrix} -798.103949445100 \\ -6557.59410858893 \\ +901.024634774511 \end{bmatrix} \text{km} \qquad \begin{matrix} +4.7517' \\ +0.254(\\ +6.0877(\end{matrix} \begin{bmatrix} 90794138 \\ 7605465948 \\ 43586520 \end{bmatrix} \text{km/s}$$

Prior to Starlink orbit insertion, about 9 minutes after launch, the Table 4 state will coast to a position biased behind the actual powered flight Falcon 9 trajectory, but the coasted speed will be greater than that of the actual trajectory at that time. These deviations lead to a "rendezvous" between the coasted Table 4 state and the actual Falcon 9 trajectory at orbit insertion. Thereafter, the coasted Table 4 state will, in theory, closely approximate the actual post-insertion Starlink trajectory until significant orbit-raising occurs.

Figure 5 illustrates the Table 4 coasted position bias during 19v1.0L19 powered flight at a time 6 minutes 23 seconds after actual launch from Space Launch Complex 40 (SLC-40) at Cape Canaveral Space Force Station (CCSFS), Florida (reference "Primary PET = 0d 00:06:23" in the map's upper border). At this point in time, the coasted Figure 5 position is still about 145 km southwest of SLC-40 as the actual launch trajectory heads northeast. At the Table 4 state's speed of 7.727 km/s, another 19 s will be required before SLC-40 is overflown by the coasted trajectory.

(Continued on the next page)

[8] For details on WeavEncke's pedigree, reference D. R. Adamo, "An Orbit Predictor Optimized For Complex Trajectory Operations", *Astrodynamics 2003, Advances in the Astronautical Sciences*, Vol. 116, Univelt, San Diego, CA, 2003, pp. 2567–2586. Starlink coasts by WeavEncke model perturbations from Earth gravity to seventh degree and order, together with Sun and Moon gravity. Atmospheric drag is generally omitted from WeavEncke coasts of Table 4's state in order to at least partially offset opposing trends from Starlink propulsive orbit-raising over time.

[9] The planet-centered, right-handed, quasi-inertial EPM coordinate system is defined by the unit vector product ***I*** □ ***J*** = ***K***, where ***I*** is directed at zero latitude and zero longitude, ***J*** is directed at zero latitude and 90° E longitude, and ***K*** is directed at 90° N latitude.

[10] Multiple means of performing transformations between Earth EPM and J2K are documented in P. K. Seidelmann, *Explanatory Supplement to the Astronomical Almanac*, University Science Books, Sausalito, CA, 1992, Chapters 2 and 3.

Starlink Satellite & Debris Sightings *(Continued from the previous page)*

The precision with which Figure 5's ground track overflies SLC-40 is noteworthy. This correlation results from a *Horizons* "blind" estimate of a state vector at 16.0 February UTC from Table 3's TLE at an epoch 6.6 days later. The *Horizons* estimate is then coasted forward in time 4.1 hours to take the Figure 5 snapshot. It should be noted that nearly half of Starlink launches through March 2021 have been conducted from Kennedy Space Center Launch Complex 39-A (KSC LC-39A), about 5.7 km northwest of SLC-40. This deviation in launch site location is not considered a significant impediment to using the Table 4 state to predict sightings in the days following a KSC LC-39A Starlink launch.

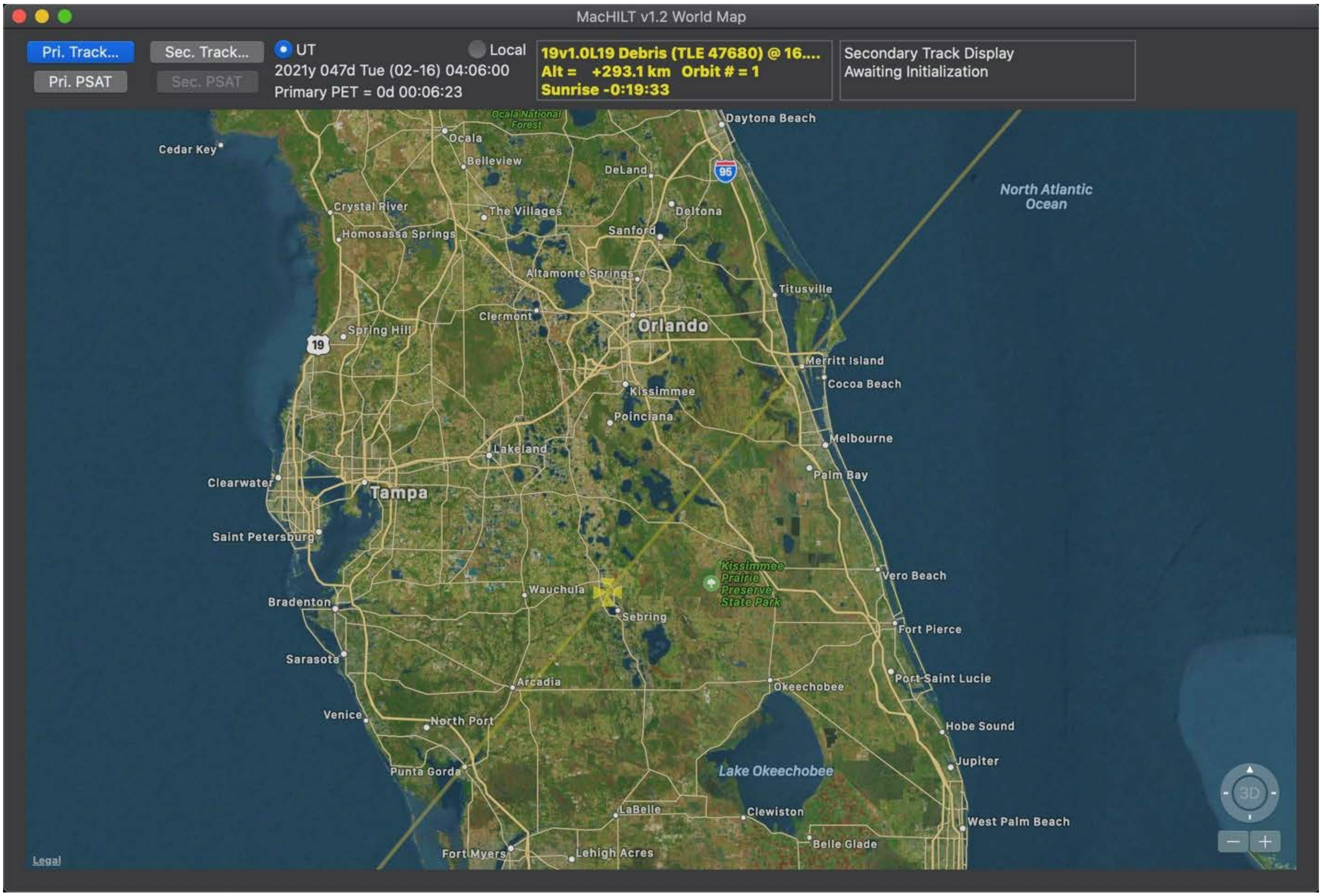

Figure 5. The position of passive orbit debris approximating trajectories of actual Starlink satellites is over central Florida (as indicated by the yellow iron cross icon) and well behind the actual launch trajectory 6 minutes 23 seconds after 19v1.0L19 liftoff. Orbit speed of the debris cancels out its lagging southwestward position bias with respect to the actual launch trajectory at orbit insertion, less than 3 minutes after this snapshot is taken. Thereafter, the debris object closely approximates all Starlink satellites until significant effects from satellite orbit-raising operations accumulate.

Table 4's state is then coasted 33 hours in a 19v1.0L19 context to the time frame at which the CHNK sighting was reported on 17 February. Figure 6 illustrates the resulting CHNK Sky Track. Comparison of Figure 6 with Figures 2 and 4 indicates reasonable conformity with the reported sighting. The illuminated portions of these three Sky Tracks begin immediately after 13:25:40 UTC, 13:40:40 UTC, and 13:35:20 UTC, respectively. With respect to

(Continued on the next page)

Starlink Satellite & Debris Sightings *(Continued from the previous page)*

the 13:30 UTC reported CHNK sighting time, coasting the Table 4 state appears to produce a Star Track reconstruction whose validity is on par with reconstructions from subsequent TLEs.

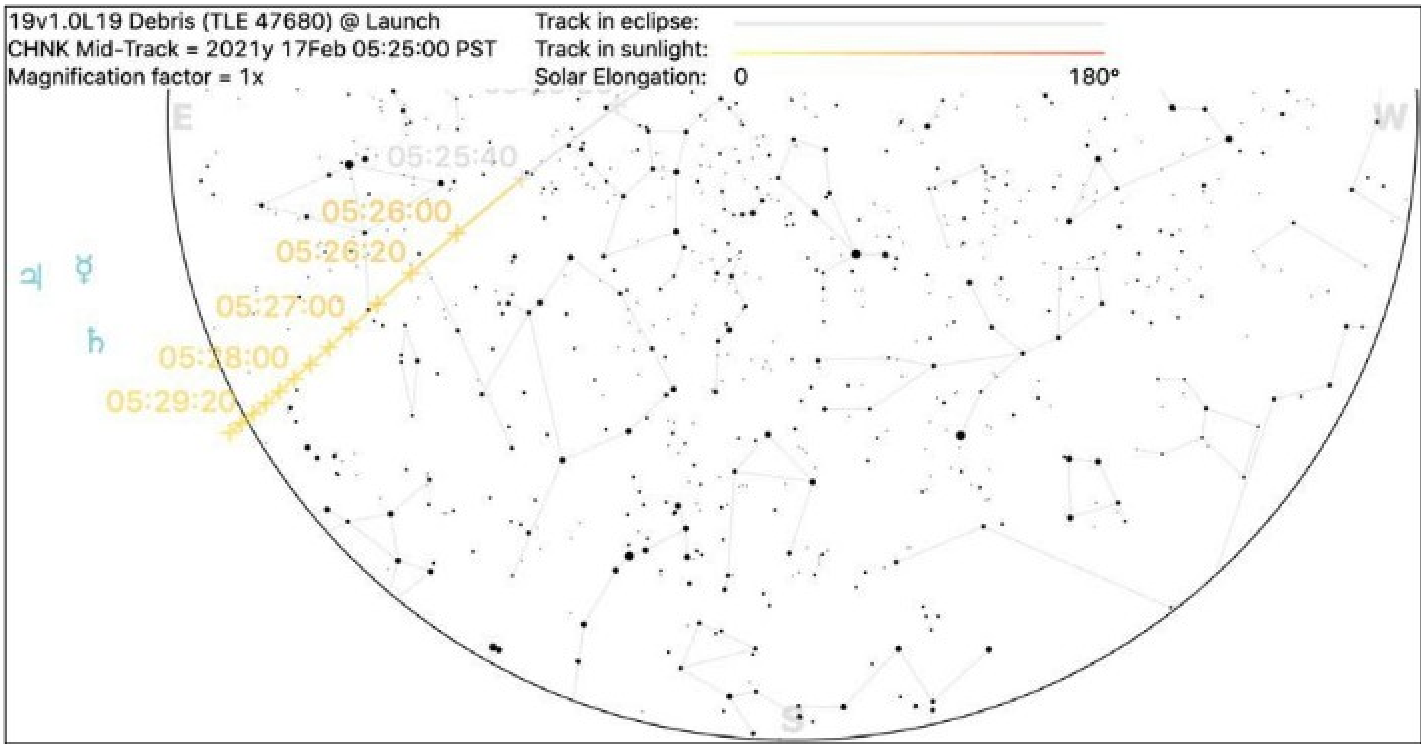

Figure 6. Visible stars south of a CHNK observer's zenith are mapped on 17 February near 13:25 UTC, together with the Table 4 state vector's coasted apparent motion as it becomes illuminated by the Sun and sets over CHNK's southeast horizon about four minutes later (colored track). Astronomical symbols representing objects about to appear over the eastern horizon are (in cyan, right to left) Saturn, Mercury, and Jupiter.

An opportunity for the author to visually verify application of the Table 4 EPM state to Starlink satellites from the 14 March 2021 launch 22v1.0L21 arose on 17 March. Immediately before that opportunity, the following prediction for CHNK had been issued at https://findstarlink.com (accessed 11 April 2021). Note this website uses Mission nomenclature in referencing "Starlink- 21" launch and has a realistic Starlink sighting video on its homepage.

6:03 am [PDT or 13:03 UTC], 17 Mar 2021
Starlink-21, BRIGHT (2.1 [visual magnitude]) for 3 mins
Look from SOUTHWEST (206°) to NORTHEAST (62°)
Elevation (from horizon): start: 41°, max: 62°, end: 10°

Two or three dozen satellites were indeed observed for two minutes starting about 13:03:20 UTC. They were of comparable brightness to stars in the Big Dipper, placing them near magnitude +2.

After applying the 22v1.0L21 launch time of 14 March 10:01:26 UTC to the Table 4 state, it is coasted to the CHNK sighting's time frame with zero atmospheric drag. This CHNK sighting reconstruction emerges from Earth's shadow at 13:09:50 UTC. Assuming atmospheric drag is responsible for this "6.5-minute late" reconstruction, drag frontal area iterations are performed with a drag coefficient of 2.0, a mass of 260 kg, and a NASA-MSFC 50%

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Starlink Satellite & Debris Sightings *(Continued from the previous page)*

atmosphere for March 2021.[11] These iterations achieve shadow emergence at the desired 13:03:20 UTC with an area of 5.3 m². The Sky Track for this iterated reconstruction appears in Figure 7.

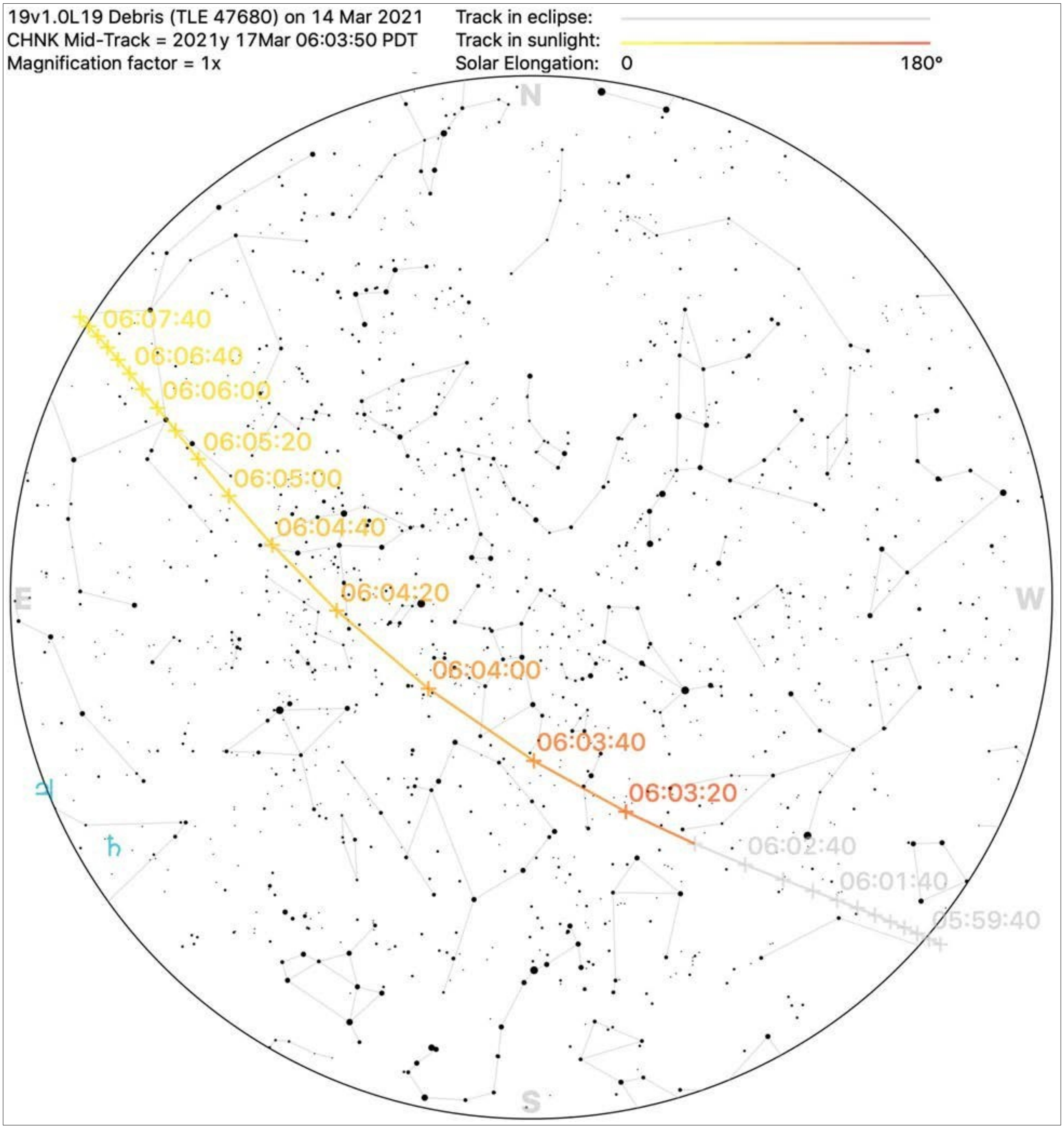

Figure 7. Objects visible above a CHNK observer's horizon are mapped on 17 March near 13:04 UTC. Consistent with 22v1.0L21 launch on 14 March, the colored track is apparent motion of a Table 4 state vector coast as it becomes illuminated by the Sun and sets over the CHNK northeast horizon about five minutes later. Astronomical symbols representing objects near the eastern horizon are (in cyan, right to left) Saturn and Jupiter.

(Continued on the next page)

[11] Reference https://www.nasa.gov/sites/default/files/atoms/files/mar2021f10_prd.txt (accessed 24 April 2021).

Starlink Satellite & Debris Sightings *(Continued from the previous page)*

Figure 7's successful reconstruction of the author's 17 March CHNK observation indicates Table 4's state vector requires a modest degree of drag acceleration during coasting arcs spanning days. The empirically derived 5.3 m^2 frontal area associated with this reconstruction very likely applies to intervals during which no orbit-raising operations are being conducted, or the value would be negative.

Other than a technical supplement to the SpaceX application for an FCC license authorizing Starlink operations, there appears to be no authoritative data on satellite dimensions. In its orbit lifetime calculation documentation, the supplement indicates a Starlink "Vehicle" is associated with areas ranging from 2.6 to 28.3 m^2.[12] Although the supplement is dated 15 November 2016 and was filed with the FCC on 22 November 2016, it has not been amended as of this writing in the FCC File Number SATLOA20161115000118 applicable to Starlink.[13] The iterated 5.3 m^2 frontal area giving rise to Figure 7's sighting reconstruction therefore appears consistent with Starlink satellite fabrication.

Atmospheric Entry Of 20v1.0L17's Second Stage

About 04:00 UTC on 26 March 2021, public reports of bright objects in the sky were widespread in the U.S. Pacific Northwest.[14] Subsequent news media accounts disclose debris from this visual display impacted the southwest portion of Grant County in central Washington. The Grant County Sheriff's office identified one recovered artifact as a Falcon 9 second stage helium tank.[15]

As a responsible orbit debris disposal measure, SpaceX typically reserves sufficient Falcon 9 second stage propellant to conduct a controlled deorbit shortly after launch. Deorbit targets a remote ocean impact to any second stage debris surviving incineration during atmospheric entry. A poll of Space-Track's Decay/Reentry page for 26 March incidents confirms object 47782, a Falcon 9 rocket body, did indeed enter Earth's atmosphere at 03:56 UTC on that date. The SATCAT page at Space-Track reveals object 47782's launch date is 4 March 2021, associating it with 20v1.0L17 Starlink satellites.

The final TLE for object 47782 appear in Table 5 and serve as input to create *Horizons* ephemeris data on 26 March until 04:14 UTC. A northeasterly ground track corresponding to the terminal portion of this ephemeris is plotted in Figure 8.

Table 5. Final TLE for the Falcon 9 second stage are at epoch 26 March 2021 02:17:40 UTC, about 1.7 hours before atmospheric entry and 22 days after 20v1.0L17 launch.

```
1 47782U 21017BN  21085.09560195  .13653889  12658-4  15159-3 0  9993
2 47782  53.0330  71.1789 0007182 279.8435  80.1805 16.49887487  8768
```

[12] Reference https://licensing.fcc.gov/myibfs/download.do?attachment_key=1159449 (accessed 11April 2021), Table A.11-1, p.54.
[13] Reference http://licensing.fcc.gov/cgi-bin/ws.exe/prod/ib/forms/reports/related_filing.hts?f_key=-289550&f_number=SATLOA2016111500118 (accessed 11 April 2021).

[14] Reference https://www.forbes.com/sites/ericmack/2021/03/26/spent-spacex-rocket-burns-up-over-seattle-stunning-skywatchers/?sh=1ea16bf316ca (accessed 10 April 2021).

[15] Reference https://www.nbcnews.com/news/us-news/spacex-rocket-debris-found-washington-state-after-streaks-night-sky-n1262954 (accessed 9 April 2021).

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Starlink Satellite & Debris Sightings *(Continued from the previous page)*

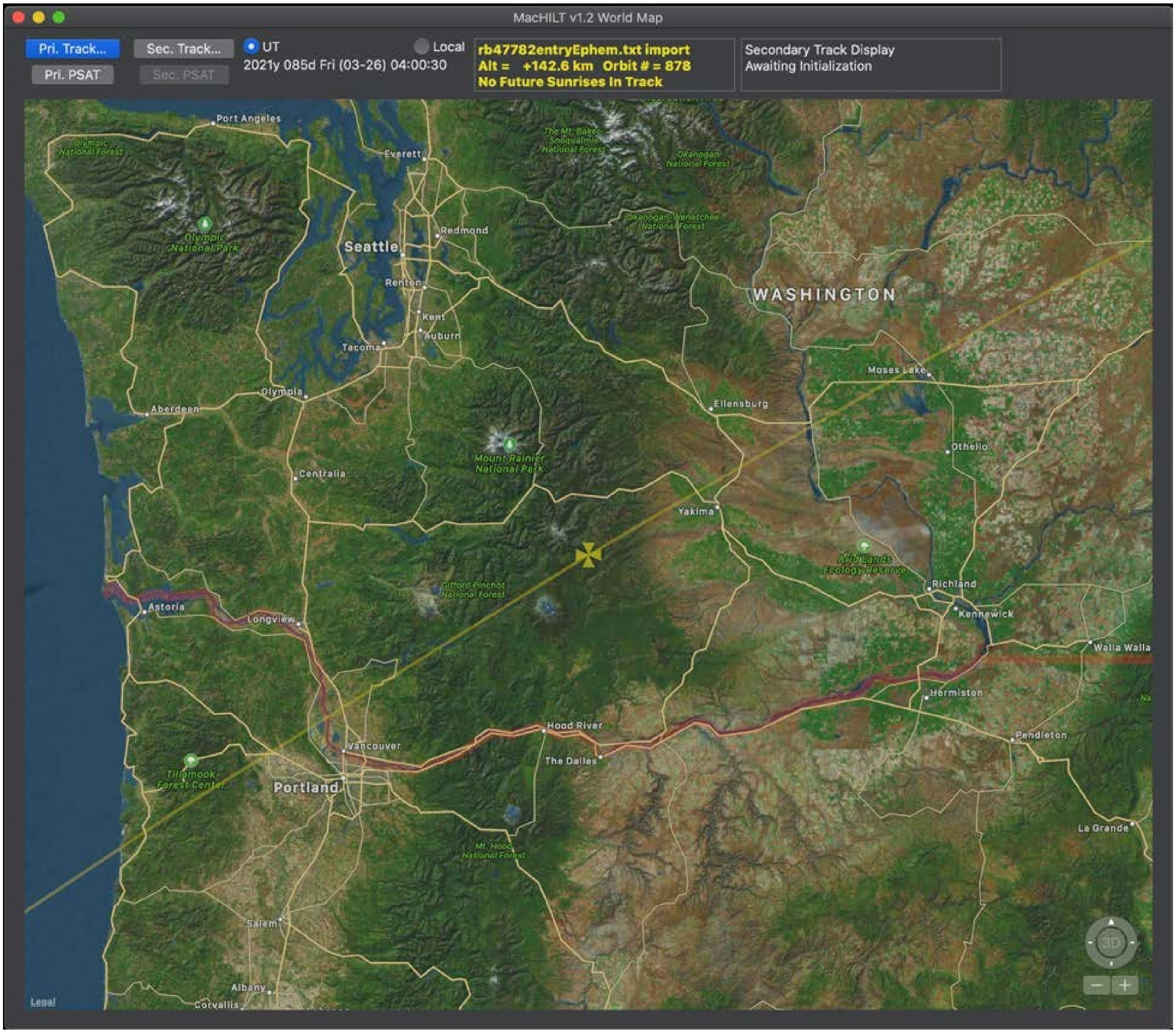

Figure 8. A yellow iron cross icon marks estimated position of 20v1.0L17's Falcon 9 second stage over central Washington during its atmospheric entry on 26 March 2021 at 04:00:30 UTC. The associated northeastward yellow ground track modeled from the Table 5 TLE continues to a point roughly midway between Yakima and Moses Lake (the two cities are about 110 km apart), where debris from the stage impacted and was recovered.

Starlink Ephemeris Postings By SpaceX

On 28 March 2018, the FCC adopted a Memorandum Opinion, Order and Authorization (MOOA) governing Starlink's deployment and operation.[16] To promote collision avoidance in orbit and minimize communications interference associated with orbit operations, the MOOA orders SpaceX to coordinate Starlink trajectories with affected parties. In accord with this requirement, SpaceX has implemented regular updates to satellite-specific Starlink ephemerides conforming with the 18th Space Control Squadron's *Spaceflight Safety Handbook for Satellite*

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[16] Reference https://licensing.fcc.gov/myibfs/download.do?attachment_key=1364689 (accessed 24 May 2021).

Starlink Satellite & Debris Sightings *(Continued from the previous page)*

Operators.[17] Although the MOOA specifically orders coordination with radio astronomy interests, SpaceX is also using Starlink ephemerides on its own initiative to address the constellation's interference with visible light astronomical observations soon after sunset and before sunrise.

Each Starlink satellite is equipped with a GPS receiver providing position navigation to a few centimeters' precision.[18] These data serve as initial conditions for a 3-day SpaceX ephemeris also incorporating any orbit-raising plans for the satellite. Geocentric J2K state vectors in these ephemerides are at intervals of 60 s. These states. together with UTC epochs and covariance data, bring each text-based Starlink ephemeris file to about 2 MB in size.

Commencing circa 30 April 2021, Starlink ephemeris postings were accessible on Space-Track's "Public Files" tab at URL https://www.space-track.org/#publicFiles using a no-fee account. The following noteworthy remarks regarding these SpaceX ephemerides are appropriate.

1) Unlike the launch-to-entry TLE history available for each object in Space-Track's catalog, Starlink ephemerides posted by SpaceX are available to download for only about a day.

2) Uploads are made in .zip packages containing up to slightly more than 1300 ephemerides each. A single package therefore does not cover the entire Starlink constellation and will typically be up to one GB in size before decompressing into .txt ephemeris files.

As an initial evaluation of SpaceX ephemerides, a no-drag reference trajectory is coasted by WeavEncke from Table 4 initial conditions at the 25v1.0L24 launch time (3:44:00 UTC on 29 April 2021). At a specified time, down-track and radial deviations from the reference trajectory are computed and plotted for each available 25v1.0L24 Starlink ephemeris to illustrate this swarm's evolution during orbit-raising operations. Figure 9 is a swarm snapshot at 29.5 April UTC, and Figure 10 is the more evolved swarm at 4.5 May UTC.

Per Figure 9, the 25v1.0L24 swarm is below and ahead of the no-drag reference trajectory 0.3 days after launch. Packed within a down-track envelope less than 60 km, the entire Figure 9 swarm would appear to pass a celestial object in 7.4 s from an Earthbound observer's perspective (see Figure 11 for an equivalent image of a swarm shortly after launch as observed from CHNK).

The 25v1.0L24 swarm's configuration changes dramatically 5 days after Figure 9, as Figure 10 illustrates. By 5.3 days after launch, the swarm's orbit-raising operations have placed it above and behind the reference trajectory. Spanning a down-track arc nearly 1200 km long, an Earthbound observer would see it pass a celestial object in 136.3 s. Indeed, this swarm was observed from CHNK on 8.2 May UTC (9.0 days after launch), with individual satellites passing through the "tail" of the constellation Leo over a period of several minutes.

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[17] Reference https://www.space-track.org/documents/Spaceflight_Safety_Handbook_for_Operators.pdf (accessed 24 May 2021).
[18] Reference https://www.technologyreview.com/2020/09/28/1008972/us-army-spacex-musk-starlink-satellites-gps-unjammable-navigation/ (accessed 23 May 2021).

Starlink Satellite & Debris Sightings *(Continued from the previous page)*

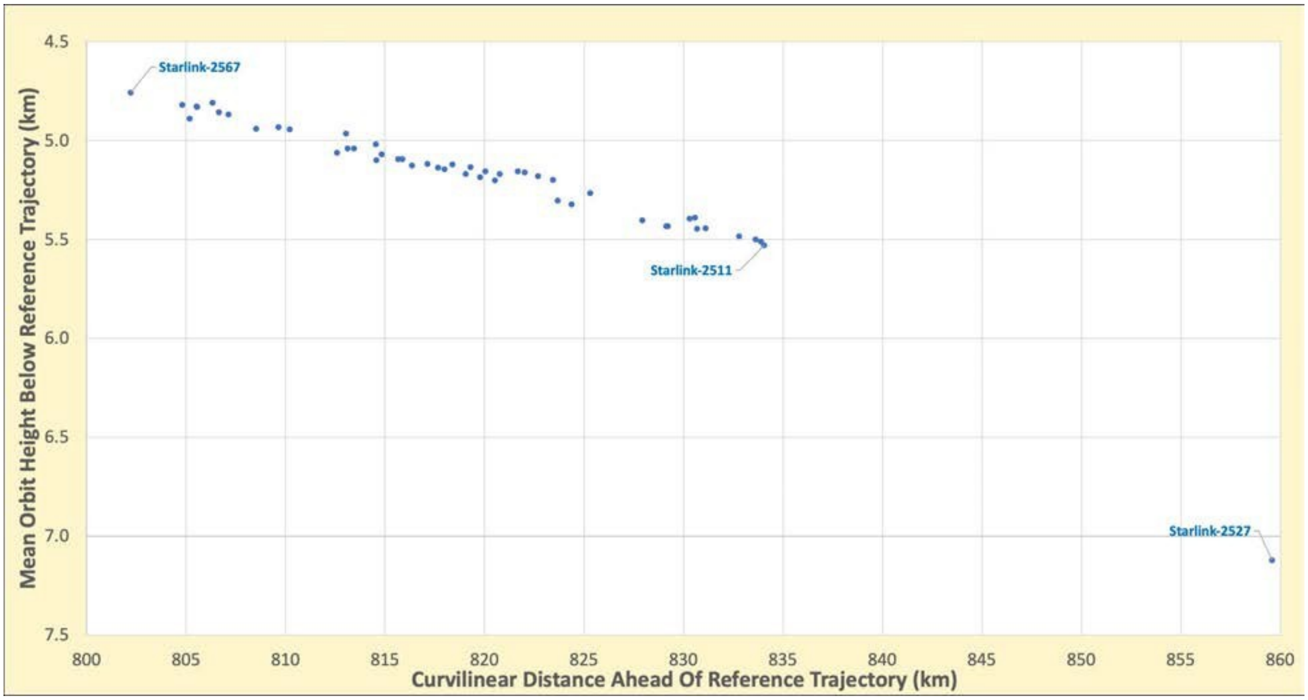

Figure 9. The 25v1.0L24 swarm's configuration is plotted for 50 of its 60 satellites with respect to a no-drag Table 4 reference trajectory on 29.5 April 2021 UTC, 0.3 days after launch. Four-digit annotations reference leading/trailing satellite serial numbers.

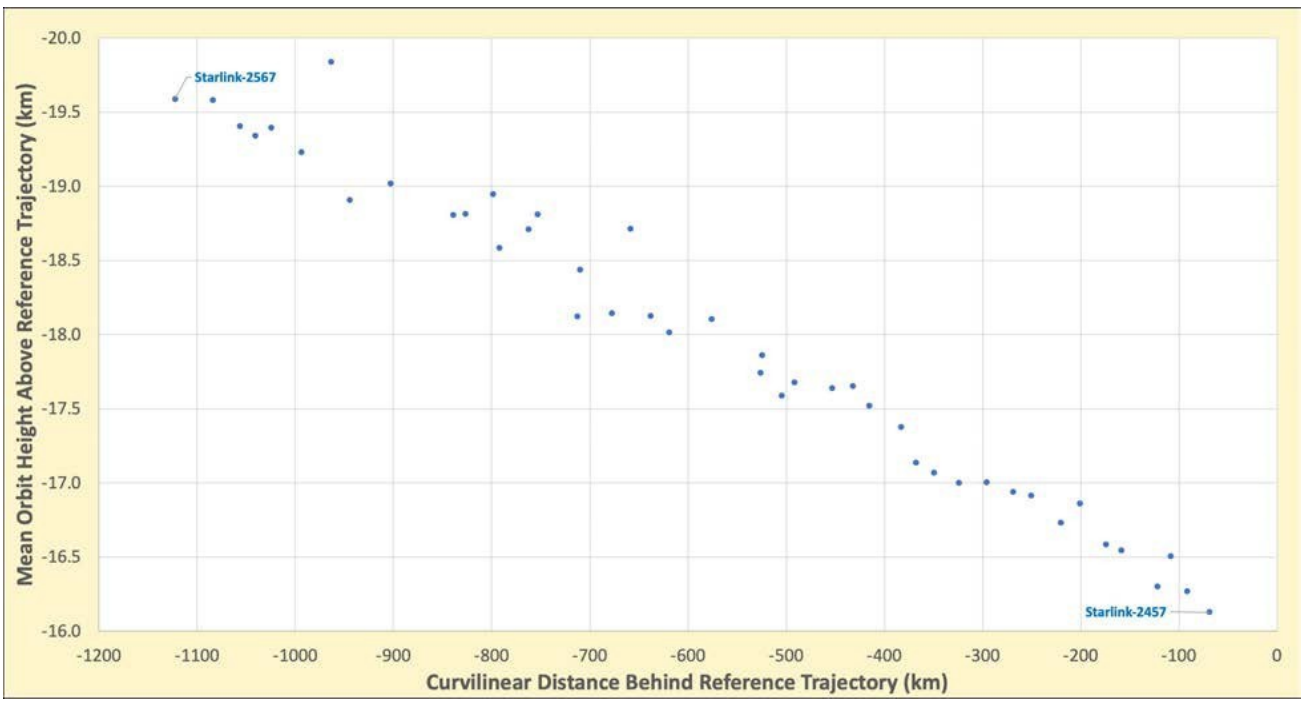

Figure 10. The 25v1.0L24 swarm's configuration is plotted for 44 of its 60 satellites with respect to a no-drag Table 4 reference trajectory on 4.5 April 2021 UTC, 5.3 days after launch. Four-digit annotations reference leading/trailing satellite serial numbers.

In contrast to Starlink TLEs posted at Space-Track based on recent radar observations, those available at https://celestrak.com/NORAD/elements/supplemental/starlink.txt (accessed 28 May

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Starlink Satellite & Debris Sightings *(Continued from the previous page)*

2021) are based on SpaceX ephemerides. Whereas Space-Track only posts TLEs for a specific satellite after it has been catalogued, CelesTrak TLEs become available about a day after launch. CelesTrak also posts post-deploy TLEs reflecting SpaceX's nominal pre-launch planning about a day before a launch attempt. Such a prediction appears in Table 6.

Table 6. The predicted TLE posted at CelesTrak for a Starlink satellite after 29v1.0L28 launch on 26 May 2021 at 18:59:00 UTC has epoch that day at 20:03:22.720 UTC.

```
1 72001C 21044B  21146.83567963  .00766138  00000-0  13098-2 0    09
2 72001  53.0568  66.2809 0017231 169.5560 103.2247 16.01217870   19
```

The JPL *Horizons* ephemeris server is utilized to estimate position and velocity from Table 6's TLE at the 29v1.0L28 launch epoch. Table 4's EPM state vector associated with this epoch has deviations given in Table 7. These deviations are not considered significant in the context of sightings predicted a few days after launch. However, the pedigree of launch-specific SpaceX predictions is preferable to the Table 4 state's generic heritage and will be used in the future whenever timely CelesTrak data are available.

Table 7. These data pertain to Table 4's EPM state vector as associated with the 29v1.0L28 launch time on 26 May 2021 at 18:59:00 UTC. Values are with respect to Table 6's TLE at this launch time. Curvilinear in-plane distance (positive is down-track from the Table 6 TLE) is given by ΔX, deviation in semi-major axis (positive is higher in mean altitude than the Table 6 TLE) is given by Δa, and the angle between the Table 4 and Table 6 orbit planes is given by Wedge.

ΔX (km)	Δa (km)	Wedge (deg)
-588.037	+2.995	0.09

Figure 11 illustrates the advisability of using data with a similar pedigree to the TLE in Table 6 for Starlink sighting predictions shortly after launch. Although the Figure 11 image was obtained looking in the expected part of the sky indicated by a Table 4 coast from the 26v1.0L25 launch time, the predicted appearance was several minutes later than that observed.

Figure 11. The convoluted trails of all 60 Starlink 26v1.0L25 satellites span about 10° in this 4-second, f3.2, ISO 800 exposure from CHNK beginning at 4:24:43 UT on 5 May 2021, 0.4 days after launch.

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Starlink Satellite & Debris Sightings *(Continued from the previous page)*

Conclusions

Active thrusting by Starlink satellites poses a challenge to accurate sighting predictions. Nevertheless, preliminary experience demonstrates useful predictions and reconstructions can be produced in the days following launch, when spectacular linear swarms of satellites can be observed from Earth before they disperse to higher operational orbits.

Because Starlink requires frequent Falcon 9 launches to deploy and maintain a prolific number of satellites in low Earth orbit, unintended circumstances will produce sizable orbiting debris populations in greater profusion than ever before. As illustrated by the 26 March 2021 UTC Washington impact, these debris could become a liability hazard to SpaceX and thus motivate redesign of Falcon 9's second stage.

In addition, other mega-constellations of satellites in low Earth orbit are giving rise to growing space traffic control concerns. In early April 2021, a OneWeb satellite maneuvered in advance of a Starlink satellite's close approach. The associated probability of collision was predicted to be 1.3% at one point. Neither satellite operator was obligated to mitigate this collision under current international regulations.[19] Failure to avoid such collisions could result in a surge of debris, rendering some orbits unusable to all operations for protracted periods. Even global, affordable, broadband, low-latency Internet service may not be worth that cost (if it is even *possible* from low earth orbit post-collision).

[19] Reference https://www.theverge.com/2021/4/9/22374262/oneweb-spacex-satellites-dodged-potential-collision-orbit-space-force (accessed 24 April 2021).

Hamas' underwater drones a wake-up call for Israel (Continued from Page 29)

But commercial UUVs and military UUVs are very much alike. Military UUVs can be weaponized in various ways, including to plant deep water mines, launch torpedoes and missiles and for suicide operations. The Gaza UUV was intended as a suicide one-time weapon.

While the press has reported that the Hamas UUV was autonomous, this does not appear to be correct. The Hamas operators were likely controlling the UUV from onshore.

Hamas had been pursuing unmanned vehicles, air and sea, for some time. The Ababeel1 drone, first used in Gaza in 2014, was designed by Mohamed Zouari, a Tunisian aerospace engineer who worked for Hamas' Izz ad-Din al-Qassam Brigades military wing.

Zouari did his design work in Sfax, Tunisia, where the drone was manufactured and later shared with Iran. Zouari was also known to be working on UUVs. He was assassinated in Sfax on December 15, 2016.

Members of the military wing of Hamas attend a memorial in Rafah on January 31, 2017, for Mohamed Zouari, a 49-year-old Tunisian engineer and drone expert who was killed at the wheel of his car outside his house in Tunisia in December 2016. Photo: AFP/Said Khatib

Hamas UAVs and UUVs are essentially first-generation systems that require a man in the loop. But that may soon change. Iran already has a large fully autonomous UUV.

When Iran struck Saudi Arabia's oil installations at Khurais and Abqaiq in September 2019, it used home-built cruise missiles and drones. The drones were Iranian delta-wing unmanned aerial vehicles – so far unnamed.

What marks them as different is that they appear to operate in a truly autonomous manner and probably have scene-matching technology, enabling them to hit targets with great accuracy. Because Hamas is primarily fed weapons from Iran, it won't be long before Hamas acquires far more accurate UAVs and, perhaps, autonomous UUVs as well.

For the record, Iran has not acknowledged it attacked Saudi Arabia in 2019. However, the trajectory of the weapons indicates they were either fired from Iranian territory or from Iraq in the northern border area. Officially, the rebel Houthis in Yemen took credit for the attacks.

The evolving threat from Gaza no doubt concerns Israel's military to the extent that there is considerable pressure to totally defang Hamas. Whether that can be achieved without a full occupation of Gaza is far from certain.

A new challenge

The use of UUVs will no doubt proliferate in the future. This means that coastal areas, offshore platforms and naval vessels – military and civilian – will be increasingly subject to attack.

No state can afford to have surveillance and attack aircraft and anti-submarine warfare (ASW) ships operating around sensitive targets on a full-time basis.

Oil terminals, refineries, military ports, power plants, offshore platforms and other sensitive installations will be increasingly vulnerable if early-warning sensors and physical barriers are not put in place.

Significantly, UUVs can be carried on fishing boats and commercial sea transporters and dropped into the water near their targets. In late April 2021, a remotely piloted boat packed with explosives targeted the Saudi port of Yanbu in the Red Sea. This was quite far from Houthi territory and the unmanned boat may have been dropped off by a larger vessel in the Red Sea.

Yanbu is 300 kilometers northwest of Jeddah and is an important Saudi oil port. The Houthis have used unmanned boats for many attacks in the past five years. In February 2017, the Houthis used an unmanned suicide boat against the Saudi frigate *Al Madinah*.

Iran also has carried out attacks apparently using UUVs. On May 12, 2019, four oil tankers – two Saudi, one Norwegian and one UAE – were attacked while anchored off the Port of Fujairah in the UAE.

(Continued on the next page)

Hamas' underwater drones a wake-up call for Israel *(Continued from the previous page)*

According to one report, the attacks were done with a UUV called the Azhdar ("Dragon"). The Azhdar looks like an elongated torpedo – it is 8 meters long – but is much slower than a conventional torpedo. It is regarded as extremely stealthy and quiet and can loiter for up to 24 hours and can carry 200 kilograms of explosives. It is battery-powered.

These threats and developments mean that Israel will see the need for new homeland security protection, particularly high-resolution sensors that can pick up UUVs.

An Israeli company, DSIT Solutions, has developed a product called AquaShield, a high-performance Diver Detection Sonar (DDS) system.

The platform of the Leviathan natural gas field in the Mediterranean Sea off the Israeli northern coastal city of Caesarea, a high-value coastal asset. Photo: AFP/Jack Guez

High-value coastal assets

It is designed to provide permanent underwater security for high-value coastal and offshore assets such as naval bases, ports, oil and gas terminals, offshore platforms, underwater pipelines and cables, nuclear power facilities and canals.

For surface security, there are a number of radar solutions optimized to pick up small seagoing vessels and semi-submersibles such as those used by cartel drug dealers in the Caribbean and Pacific for smuggling purposes.

For platform and harbor protection, even the classic underwater security net has been upgraded with fiber optics and can be integrated with sonar detectors.

As UUV and unmanned surface vehicles proliferate, the protection of facilities will increase in importance, particularly in vulnerable areas in East and South Asia.

What is clear is that the rise of unmanned air, land and naval vehicles is creating complex threats that will need to be countered. Not only will such threats proliferate, but they will increase in both capability and sophistication.

Some lessons from Tiananmen *(Continued from Page 30)*

The first is that democracy is vital to the future of Asia. While democracy does not guarantee the absence of war, consider what could have been accomplished if China was democratic. Instead of threatening war against Taiwan or suppressing Hong Kong, or putting Uighurs in concentration camps, or crushing Christian worship places (even homes), instead there would be acceptable solutions in the region and a democratic China could be playing a constructive and positive role.

The second lesson is that the Chinese Communist leaders cannot be trusted. Absolute dictators are always ruthless.

The third lesson is that the most powerful asset the United States has is that it is still the world's beacon of hope for liberal democracy. That is why Taiwan is so vital to the United States and to its allies and friends in Asia and elsewhere.

In a recent table top exercise that brought together leading strategists and senior military officials from Korea, Japan, Taiwan and the United States talking about the threats to Taiwan, it was our Asian friends that reminded us just how important preserving liberal democracy was and why it was the key reason for supporting Taiwan.

If we fail Taiwan, we fail all our friends and we set the stage for a very dark and ugly time for all of Asia and, perhaps, for us as well.

The fourth lesson is that we should not fall into the trap of thinking that China has a separate culture and no interest in liberal democracy. That sort of relativist nonsense is unrelated to reality. Given the chance, China can become a liberal democracy and her students, many of whom study in the United States, carry the flame for a free nation. And why don't we organize to provide democracy education to our Chinese guests studying at our universities, working in our tech factories, or doing R&D at research institutes and organizations? This would give our own educators and students a truly meaningful mission.

The final lesson is we owe it to those who fought and perished in the fight for democracy in China that we keep up the struggle for them.

Was the US complicit in China's COVID research? | Real America's Voice Interview *(Continued from Page 31)*

Level 4 is, in theory, the most secure type of laboratory known today; China's WIV is also a Level 4 lab. But not all the Wuhan laboratory followed Level 4 standards and there are, as Fort Detrick shows, lapses that need to be accounted for.

In fact, the same kind of lapses that happened at Fort Detrick, which centered on waste treatment, also happened at the Wuhan lab.

Furthermore, Fort Detrick was working with other American and foreign labs, which may have included Chinese facilities. For example, Fort Detrick was connected to Canada's National Microbiology Lab in Winnipeg, which was thoroughly penetrated by the Chinese, including at least one known member of China's biowarfare community.

According to Canada's Globe and Mail newspaper: "One of the Chinese researchers, Feihu Yan, from the People's Liberation Army's (PLA) Academy of Military Medical Sciences, worked for a period of time at the Winnipeg lab, a Level 4 facility equipped to handle some of the world's deadliest diseases."

There were at least seven Chinese scientists at the lab. Two of them, "Xiangguo Qiu and her biologist husband, Keding Cheng, were fired in January (2021) after the Canadian Security Intelligence Service … recommended that their security clearances be removed on national security grounds," (allegedly for sending samples of deadly viruses to the Wuhan lab).

On at least one occasion, Qiu, and probably others, visited the Fort Detrick Laboratory. The details are not known, but it can be reasonably surmised that the Winnipeg Lab and Fort Detrick were cooperating, and this cooperation might have included Wuhan.

Was Canada a weak link?

Given Fort Detrick's security level, further investigation is essential.

It also begs the question of Canada giving Chinese scientists, including at least one from the PLA's Academy of Military Sciences, top secret clearances.

The US and Canada, as part of the North American Defense Sharing Agreement, share classified information, which means there is a strong possibility that some classified American information made its way to Winnipeg and then to Wuhan or elsewhere in China.

The National Microbiology Laboratory in Winnipeg, Manitoba, Canada's only level four lab. Photo: AFP / Michel Compte

Not only does WIV need further investigation, but so do American institutions including the National Institutes of Health (NIH), the CDC and Fort Detrick.

In 2017 and 2018, the US did at least two inspections of the Wuhan Laboratory. That raises the question of why did a US inspection team gain entry multiple times to a sensitive Chinese laboratory?

The answer seems to be that the Americans had special status because of high-level, top-secret cooperation between the US, China and other partners (eg, Canada).

Top US infectious disease expert Dr Anthony Fauci has said it would have been "almost a dereliction of our duty" if the NIH had not worked with China to study coronaviruses and "collaborate" with "very respectable Chinese scientists."

"Respectable scientists" working for the Chinese government. That's another avenue for investigation.

International collaboration suggests the US may have halted gain of function research because it was easier and less politically risky to let China do it. China has lower legal standards – try litigating in China if you have any doubt – and, as Fauci said, the US government funded Chinese labs and happily published papers by Chinese scientists.

Those papers today give us a partial record of what the Chinese with the CDC and NIH – and perhaps even the US Army – were up to.

(Continued on the next page)

Was the US complicit in China's COVID research? | Real America's Voice Interview *(Continued from the previous page)*

Former Director of National Intelligence James Clapper insisted Covid-19 was transmitted by animals. Photo: AFP / Brendan Smialowski

The CIA changes course

The US intelligence community had to know all of this, and a lot more.

But the CIA and other senior American officials, including James Clapper, the former Director of National Intelligence, insisted that Covid-19 did not come from the Wuhan Laboratory but was zoonotic, namely that it was transmitted in nature by animals.

Today the CIA appears to have tentatively reversed course as American scientists press for more information.

A proper investigation would have to ask why the US would trust China, knowing how sloppy the Chinese are about food and safety standards. The faulty ventilators, Covid-19 test kits and N-95 masks for physicians and health workers that were sent abroad by China after the outbreak of the epidemic illustrated this clearly for the world to see.

But beyond sloppiness, it seems the US decided to fund and shift dangerous research to Chinese labs run by the Chinese state. The Biden administration erred in closing the investigation and is right to have opened a new one.

Stephen Bryen - Is it possible the US is culpable in the origins of Covid-19? Its time we find out

https://americasvoice.news/video/ApzpHGtCgmmr3JB

Just the News AM with Sophie Mann 06-10-21

US government has no answer for pipeline cyberattack *(Continued from Page 32)*

even if all of them employed the best security practices and followed a disciplined approach in consistently updating hardware and software and trained all employees in best practices, they still remain vulnerable, especially to sophisticated cyber attacks.

The ransomware group that attacked Colonial is known as DarkSide. DarkSide says: "We are apolitical, we do not participate in geopolitics, do not need to tie us with a defined government and look for other our motives. Our goal is to make money, and not creating problems for society. From today we introduce moderation and check each company that our partners want to encrypt to avoid social consequences in the future."

Brian Krebs, a security expert writes that "first surfacing on Russian language hacking forums in August 2020, DarkSide is a ransomware-as-a-service platform that vetted cybercriminals can use to infect companies with ransomware and carry out negotiations and payments with victims.

"DarkSide says it targets only big companies and forbids affiliates from dropping ransomware on organizations in several industries, including healthcare, funeral services, education, public sector and non-profits."

The Biden administration has let it be known that they believe that the Colonial Pipeline attack had, at the least, the backing of the Russian government, but so far they have no proof. In fact, the US government seems at a loss to know how to deal with ransomware attacks.

There is no doubt US-Russia relations are at an all-time low, maybe even worse than during the Cold War where, as Sergey Lavrov, Russia's Foreign Minister explains, that at least the US respected Russia. It is also true that the Russians are trying many ways to put pressure on the United States – and vice versa.

Cyber-spying operations

In the bigger picture, US intelligence says that foreign governments – eg, China, Russia, Iran and others – are either directly running cyber operations against outside targets or getting hackers to do it for them.

Even going back to the earliest computer hacks, Clifford Stoll reported in his book *The Cuckoo's Egg: Tracking a Spy Through the Maze of Computer Espionage* (1989), that a hacker in Bremen, Germany, had penetrated the computer system of the Lawrence Livermore National Laboratory and was seeking classified US Defense Department information. The Bremen hacker was working for the KGB.

Cyber-spying has become not only big business, but a political tool. Photo: AFP/FrankHoermann/dpa

Today hostile governments can afford to set up large and sophisticated cyber-spying operations or use those operations to cripple an adversary. This is something that the Chinese have tried to do against Taiwan, the Russians against the United States, the Ukraine and select European countries such as Estonia and Iran, have used cyber methods to attack Israel.

Many cyberattacks are designed to steal intellectual property. China ripped off Lockheed and Lockheed's suppliers to steal information on the design of the F-35 fighter. Iran has used cyber espionage to steal intellectual property from hundreds of universities and private companies.

Despite government and industry spending hundreds of billions of dollars on computer security, most computer systems and networks remain dangerously exposed to cyber-attacks, including ransomware.

Worst still, as the Colonial Pipeline case underlines, the government including law enforcement doesn't know what to do when a major disruptive intrusion happens. This is especially worrisome because the entire critical infrastructure could be collapsed by a determined adversary and Washington would just be scratching its head, as it is now.

How to Prevent Another Colonial Pipeline (Continued from Page 33)

While the Pentagon has begun characterizing some information as "sensitive but unclassified", it is not entitled to NSA sponsored encryption. Whether sensitive but unclassified information can be protected by law from disclosure appears highly questionable, because DOD says it is not national security information.

Unfortunately this is complete nonsense. Probably 80 to 90 percent of DOD information is unclassified and much of it relates to technology and weapons systems information. It is ridiculous to say it isn't national security information.

A key example: China stole almost all the plans and data for the stealthy F-35 fighter plane, most if not all of it unclassified and unencrypted, thereby seriously compromising a front-line defense program that will cost taxpayers in excess of $1.5 trillion over its life cycle. If this information is not national security related, what is?

When it comes to cyber attacks DOD and the FBI are on a little firmer ground in the sense that they understand the magnitude of the threat. But does the U.S. response reflect the danger to U.S. national security?

DOD, the military departments and other government agencies continue to buy computer and network equipment from China while attempting to put in place security measures. Virtually all the equipment is commercial.

Despite buying billions in computers, laptops, modems, tablets, cell phones, routers, hard drives and tons of other equipment such as GPS and Internet enabled security cameras (with a free backdoor to connect Beijing to U.S. military bases!), DOD has no hardware or software vetting system. In other words, they buy equipment without knowing if it is compromised or full of malware.

If DOD is sloppy, you can imagine what the rest of the government is like, or just how "protected" the critical infrastructure is.

The Colonial Pipeline Case raises another big red flag, since "ransomware" is a major threat in three ways. The first is that ransomware disables computer networks including SCADA systems, from working by encrypting everything with an unbreakable code that you have to pay to get lifted.

The second is that ransomware often includes the theft of information before the ransom encryption kills the network. The stolen information is used partly as a threat to force the network operators to pay the bribe.

And the third matter is that even if you pay, and Colonial has paid $5 million in crypto currency that can't be traced, there is no assurance that the unlock key will work or work effectively. Colonial apparently paid the bribe early on (without telling anybody), but the decryption key they got was working very slowly, if at all. In other words, Colonial got the shaft from the perpetrators.

Suppose that next time the U.S. Strategic Air Command is shut down?

It is clear that commercial networks including hardware and software, much of it from foreign sources, isn't the right way to protect the critical infrastructure to safeguard national security.

Adversary nations have set up elaborate and well trained teams who focus on specific targets and work full time to take them down. And disciplined semi-independent teams of hackers, like the ones who have hit Colonial, are criminal operations. Yet we tolerate both.

Here are a few suggestions before the next disaster happens:

1. Put in place a national program to create secure networks that use hardware built by secure vendors
2. Require all critical infrastructure networks to be vetted by in a Third Party Audit for Security under the aegis of NSA or any other security agency capable of doing it
3. Vet all hardware before it is used by the U.S. Government or critical infrastructure components
4. Go after malefactors, domestic or foreign, and impose stiff penalties on perpetrators
5. Make it clear to foreign governments that if they sponsor or shelter criminal operations they will find their networks destroyed

So far at least our government always promises to make things better (but that never seems to happen) and does not act as if our national security was at stake. It isn't clear if this will continue, but if it does it will have a devastating impact on the United States.

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."

The F-35 as the future of air to air warfare *(Continued from Page 34)*

> The next logical step in the view of the developer will be getting rid of the “weak link” also known as the human being for all combat airframes. The question is whether society is ready for unmanned aerial vehicles fighting against each other in conflicts or being used to fight against a human enemy.

But why is the F-35 project so controversial? Dissenters claim that the F-35 actually lacks in speed and maneuverability compared to generation 4, 4+ and 4++ aircraft, which would not bode well for the cost justification of the new project if true.[4] This negative press may have damaged the reputation of the F-35 before it could prove itself through extensive use in conventional combat.

Shortcomings in replacement parts due to the not yet fully established logistics and supply chain for the F-35 pose a further potential risk and could lead the airframe to be deemed as not combat-ready. In response to this challenge, several operators, most notably the US, are pushing hard to stay within the planned operational timeframe.

Concept-spoiling as a pattern?

This negative campaigning has happened before with different airframes. One of the more recent cases was the Eurofighter Typhoon, which has received a lot of bad press but has proven to be a quite capable, albeit pricey, airframe. Many will remember the lawsuits and teething problems of the early stages of the F-16, which turned out to be a very capable best-seller that has undergone numerous modernizations to stay at the very cutting edge of technological advancement. It is relevant to mention that every aircraft that has been built in the history of aviation has received criticism. Everybody is aware of “teething problems“ or “growing pains" which means that no matter how advanced technology is, you won't get it right the first time. Everything can be designed on computers nowadays, where every item and part of the hardware can be simulated and tested, before it is built. Nevertheless, there will still be design flaws and errors that can only be found once the airframe is being put together and tested in flight.

> One of the more recent cases was the Eurofighter Typhoon, which has received a lot of bad press but has proven to be a quite capable, albeit pricey, airframe.

For all of its advancements, the F-16, as all fourth-generation fighters, must eventually come to an end due to a significant shortcoming: the lack of stealth capabilities. However, stealth technology is expensive, very much so. Not every country is capable or willing of paying the prize for stealth technology. Not every combat situation actually requires stealth either. It is a possibility to gain an advantage by “sneak in unseen, do your thing and get out unseen”.

However, once the advantage of stealth is gone, when the opponent has made visual contact, the story becomes different. In beyond visual range (BVR) fights where “fire and forget” missiles have been fired and have not reached its designated targets, for whatever reason (spoofed, jammed, ran out of fuel, etc.), it still comes down to who has got the “better” aircraft in the sense of maneuverability, speed, acceleration, weapon carrying capability, survivability, etc. since the fight will end up in a “dogfight”. I have never flown any of the F-35 variants in real life or simulations, so I can only examine what I have heard from fellow F-35 and non-F-35 pilots. The F-35 community is very persuasive in explaining where the F-35s strengths lie – stealth, durability, endurance and its multi-role capability. On the other hand, fellow 4, 4+ and 4++ generation fighter pilots comment that the F-35 isn´t worth the money in any respect. It is reportedly not as fast or maneuverable as an F-15 or F-16, and hasn't quite got the firepower and weapon carrying capability of the A-10 or the F/A-18.

> The F-35 community is very persuasive in explaining where the F-35s strengths lie – stealth, durability, endurance and its multi-role capability.

The plane of the future

So, is the F-35 a good “dogfighter”[5]? Among other updates, the F-35 no longer uses a Heads-Up Display (HUD). Instead it uses a technology far more advanced than the Joint Helmet Mounted Cueing System (JHMCS), which already is a technological marvel. The F-35 pilot helmet uses a Helmet Mounted Display System (HMDS), which projects all relevant and desired information right into the pilots´ field of view, no matter where the pilot is looking, be it right down through the cabin floor or anywhere through the aircraft's fuselage. The HMDS is a combination of many high-tech display features: a virtual HUD, digital night vision, distributed

(Continued on the next page)

The F-35 as the future of air to air warfare *(Continued from the previous page)*

aperture system, cueing of sensors and weapons (boresight), target designation, defensive system, encrypted datalink, plus the capability for later HMD advancements. All that encompassed in one “light weight” (dropped from 5.1 to 4.6 pounds) helmet system greatly enhances the pilot´s situational awareness (SA). SA is the most crucial skill for crews in military aircraft. It is a matter of survival. The more systems you have that help you maintain your SA or even help increase your SA, the better. And that is also the main argument from everybody involved in the F-35 program - even though it might not be the fastest fighter jet around or the most maneuverable, it is certainly one of the most or even the most pilot-friendly fighter, SA wise currently flying.

The benefits of the F-35 don’t stop there. While fourth-generation aircraft are very capable and “affordable” compared to their successors, they have to carry a lot of their sensors and equipment externally, thus preventing them from being stealthy. The corresponding aerodynamic drag increases with every item that is “hanging” outside the aircraft, reducing its tactical radius by increasing fuel burn. Stealth aircraft on the contrary carry all of their fuel, ordnance, and sensors internally, which keeps their radar signature (radar cross section) as small as possible. That is especially beneficial when the mission calls to operate undetected, e.g. during reconnaissance or precision strike missions in highly defended areas. Whenever stealth is not required, fuel tanks or extra ordnance can be mounted externally to enhance the combat radius or weapon load. The F-35 relies on stealth. F-35s, employed correctly in battle, would score most of their kills with long-range missiles fired from beyond visual range.[6]

> F-35s, employed correctly in battle, would score most of their kills with long-range missiles fired from beyond visual range.

Why does the F-35 then lose dogfights with fourth generation fighters? Well, there are some explanations. For one, it is a new system: the new airframe, new power plant, new electrical systems, sensors and pretty much everything in the aircraft is new. As with any new system there are “teething problems” in the beginning. Everybody who works with computers is aware of the constant upgrades and software updates programs require. There is no difference to modern aircraft; in fact the biggest part of the development is not the hardware, but rather the software. That is a quick and simple explanation to why things are not going as planned yet and why all the legacy fighters seem to have no problem in air to air combat with the F-35. That of course will change as the software is gradually being updated and integrated within all systems and all bugs will be fixed over time.

Dominance with an uncertain future

But should that be of concern? Not according to some defense strategists and senior officials. The days of the “dogfight” are long gone and since the F-35 uses stealth technology it has a clear advantage. In a perfect world that might be true, but in the unlikely situation where the F-35´s weapons have been spoofed or not found their targets, the opposition will suddenly be very close, where everything ends up in a “furball” - a classic dogfight, where the F-35 won't really excel compared to some modern Russian MiG (29, 35) and Sukhoi (27, 30, 33, 35) fighters. History has proven the days of the dogfight are by far not gone at all. It has happened many times before where long-distance "fire and forget" missiles have not reached their targets for whatever reason. In the time span of a few dozen seconds (supersonic aircraft closure speeds) the adversaries will find themselves once more confronted in a classic dogfight (aka knife fight in a phone booth) situation, where maneuverability still counts. Contrary to mainly US and NATO, Russian philosophy never dropped the dogfight scenario. Look at Russian hardware. Everything is extremely rugged and well-engineered in case the infrastructure (runways, airports) has been destroyed and the need to operate from unimproved landing strips (grass, gravel) arises, whereas in the west we tend to operate from “sterile” FOD (Foreign Object Damage) checked flight decks and runways.

Still, most NATO countries are replacing their fourth-generation airframes with fifth-generation F-35 variants. The biggest threat to this day, besides the asymmetric warfare of terrorism, comes, according to the US National Security Strategy, from countries like China and Russia. Their inventory still poses one of the greatest threats. A large-scale aerial engagement against enemies like that will be less than favorable for the F-35. Russian philosophy never distanced itself from air superiority and the dogfighting capability of their front-line fighters. US (NATO) philosophy got rid of guns on airplanes after Korea, since the thought was future engagements would

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The F-35 as the future of air to air warfare *(Continued from the previous page)*

happen at great distances utilizing radar and (fire and forget) missiles. Vietnam proved that decision to be wrong and guns were quickly put back onto airplanes (e.g. F-4 Phantom) and new advanced fighting courses, most notably the US Navy Fighter Weapons School (TOPGUN) and the USAF Weapons School were established.

> A large-scale aerial engagement against enemies like that will be less than favorable for the F-35. Russian philosophy never distanced itself from air superiority and the dogfighting capability of their front-line fighters.

However, the critical turning point has already been reached; the latest results show a different picture about the capabilities of a very versatile platform that will greatly improve over time. The largest military contract in history involved the development of the F-35 Joint Strike Fighter. There is a lot of economic and political interest behind that program that will ensure it will become a success. More than 620 units have been built up to this day.

About the Author:

Nick Jost (Lt.Col. ret.) has 20+ years of international work experience in the armed forces (Navy and Air Force) as a fighter pilot and special forces operator, running his own aerospace, maritime and defense consultancy as well as working in numerous international projects. Mr. Jost has an academic background in aeronautical science and international relations. The views contained in this article are the author's alone.

[1] An explanation to jet fighter generations:

- Generation 4: Pulse-doppler radar; high maneuverability; look-down, shoot-down missiles (F-14, F-15, F-16, F/A-18, Mirage 2000, MiG-29, Su-27).

- Generation 4+: High agility; sensor fusion; reduced signatures (Eurofighter Typhoon, Su-30, advanced versions of F-16 and F/A-18, Rafale).

- Generation 4++: Active electronically scanned arrays; continued reduced signatures or some "active" (waveform canceling) stealth; some supercruise (Su-35, F-15SE).

- Generation 5: Advanced integrated avionics, low observable stealth (F-22, F-35, Su-57, Chengdu J-20, Shenyang FC-31).

[2] Todd Harrison, "Will The F-35 Be The Last Manned Fighter Jet? Physics, Physiology, and Fiscal Facts Suggest Yes," *CSBA* (April 29, 2015), https://csbaonline.org/about/news/will-the-f-35-be-the-last-manned-fighter-jet-physics-physiology-and-fiscal-.

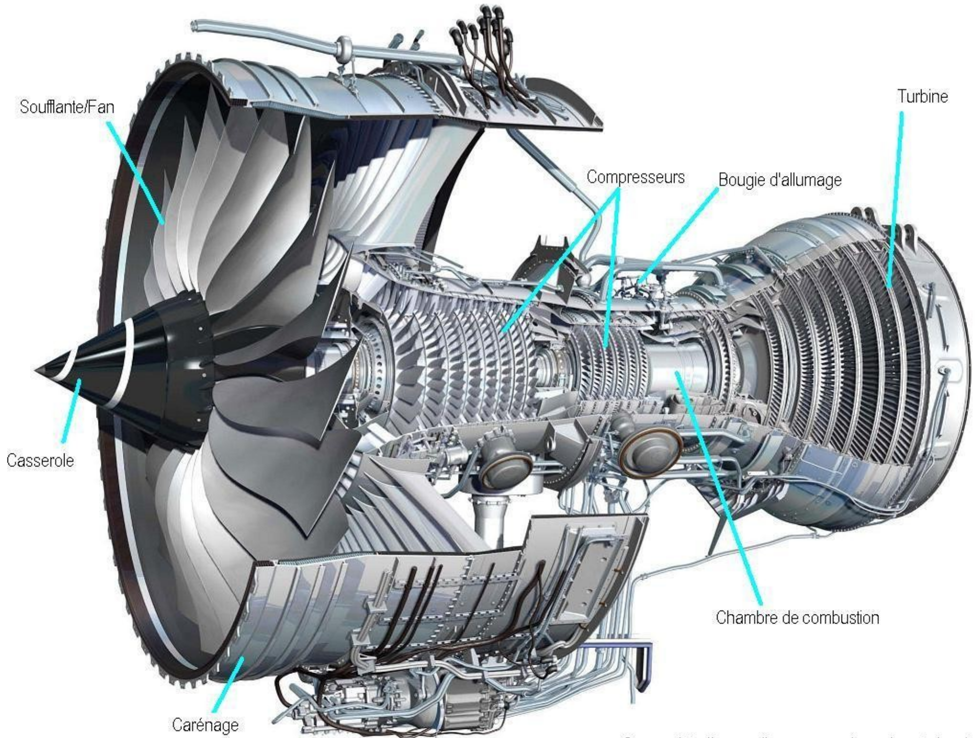
[3] Boeing, "Boeing Airpower Teaming System," *Boeing* (2020), https://www.boeing.com/defense/airpower-teaming-system/.

[4] Matthias Wasinger, "Airpower in the Twenty-First Century: Swing- and Multi-Role versus Single-Role Specialists," *Wild Blue Yonder* (August 17, 2020), https://www.airuniversity.af.edu/Wild-Blue-Yonder/Article-Display/Article/2313184/airpower-in-the-twenty-first-century-swing-and-multi-role-versus-single-role-sp/.

[5] A dogfight is an aerial battle between fighter aircraft conducted at close range. The term dates back to WWI and the "Red Baron" Manfred von Richthofen. Modern terminology for air-to-air combat is air combat maneuvering (ACM), which refers to tactical situations requiring the use of individual basic fighter maneuvers (BFM) to attack or evade one or more opponents.

[6] Alex Lockie, "Dogfighting in an F-35 is 'like having a knife fight in a telephone booth," *Insider* (October 20, 2016), https://www.businessinsider.com/f35-dogfighting-knife-fight-telephone-booth-2016-10?r=US&IR=T.

Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion *(Continued from Page 36)*



Source: http://www.rolls-royce.com/news/assets/prg.jsp

Advantage: completely autonomous engine after a starter located in the nose of the engine (pot) has driven the compressor at a speed sufficient for the cycle described above to maintain itself. Motor said in "one piece".

Disadvantage: the most constraining aspect is that the turbine rotates at very high speeds, which implies that the blades undergo enormous forces due to the centrifugal force, and are, moreover, continuously under the more than hot breath of the gases produced by combustion. This results in a real limitation of the mechanical resistance of the materials composing the blades.

The **Humphrey cycle** of the future propellers of the 21st century consists of:

a) compress the air at the same rate as for the Brayton cycle b) mix it with fuel in the same proportion c) ignite this mixture but this time in a **closed** chamber (combustion chamber); we then speak of **Constant Volume Combustion** (CVC) d) the expansion valve opens while the intake valve remains closed so as to produce the desired thrust (the balloon that is inflated...), and then the intake valve opens so as to allow a new quantity of mixture f) the 2 valves then closing at the same time so that the combustion of this new fresh charge takes place as a CVC.

Advantages: the thermodynamic efficiency is significantly improved, with consumption gains of up to 20%! There is no more Turbine, because the air compression is carried out in a distributed way : Operation in rocket mode! Another decisive advantage: if the compression ratio remains close to 1 (no compression), with the CPC, the efficiency of the turbojet is zero, whereas with a CVC, the efficiency of the Thermoreactor still has a very significant value (30%) as illustrated by the following curves of the efficiency versus the compression ratio:

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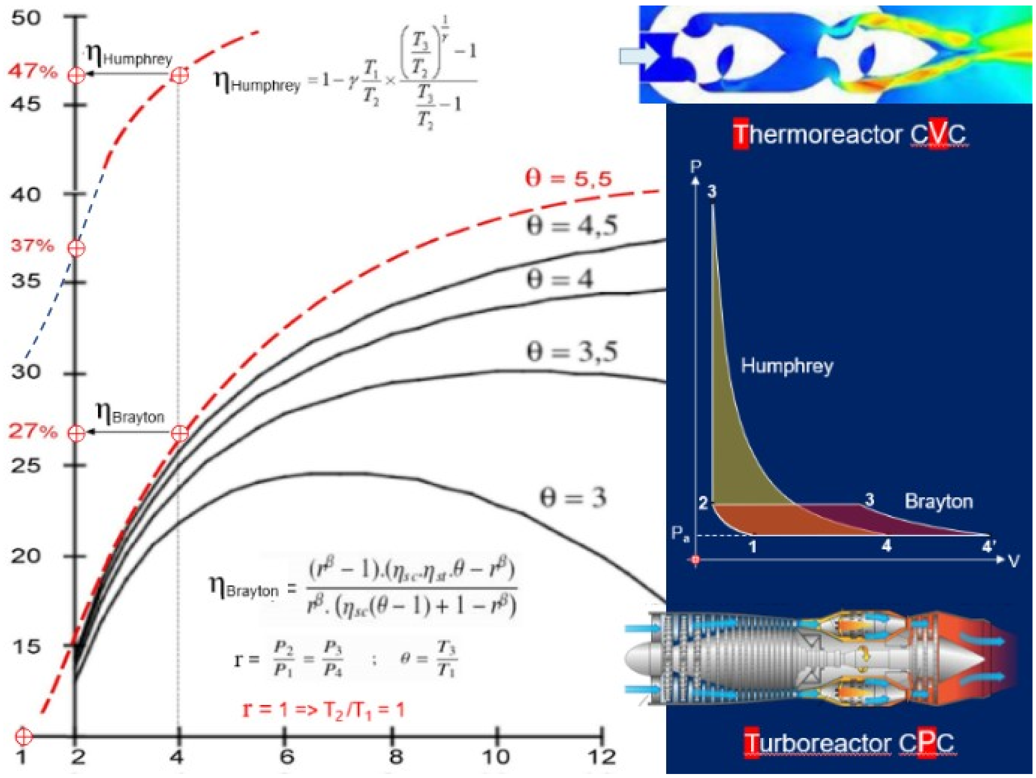
Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion *(Continued from the previous page)*



Disadvantage: Determine the most efficient technology!

Technological competition

US engine manufacturers are the most advanced in this field of CVC research, starting with their "R&D office": NASA! Indeed, as early as the 1970s, NASA demonstrated the undeniable advantage of developing constant volume combustion (CVC) compared to constant pressure combustion (CPC).

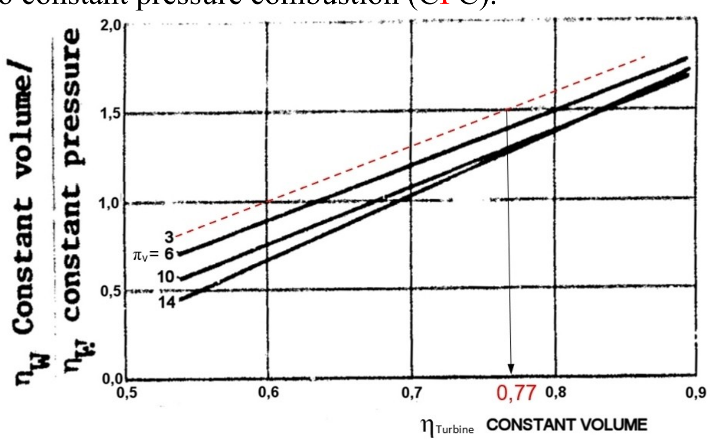


Figure 11. Ratio of economical efficiencies of the constant volume and constant pressure processes as a function of turbine efficiency of the constant volume installation.

1. Report No. NASA TT F-16,618	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle THERMODYNAMIC INVESTIGATION OF GAS TURBINES WITH CONTROLLED CONSTANT VOLUME COMBUSTION		5. Report Date October, 1975 6. Performing Organization Code

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Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion *(Continued from the previous page)*

This figure summarizes the interest well, because as soon as the efficiency of a CVC turbine approaches 0.8 (which is largely achievable nowadays), then the gain is 50%, and for compression ratios of 6, as we will see later, we have stopped this rate between 3 and 4, which will certainly increase the CPC gain!

But of course, everything depends on the technology used to benefit from such advantages. At that time, NASA proposed the concept of opening / closing the combustion chamber via discs in which openings are made:

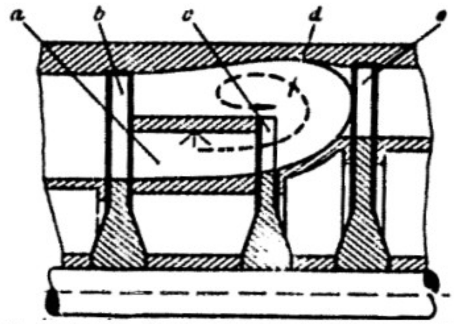
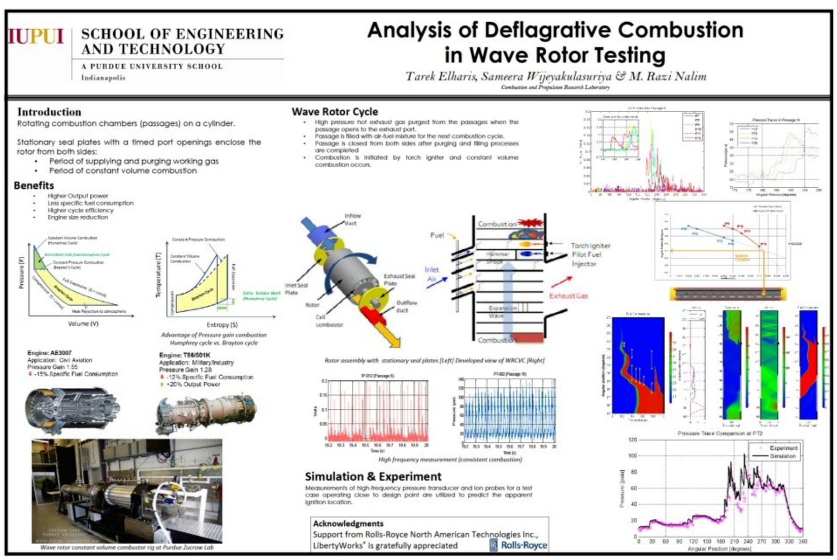


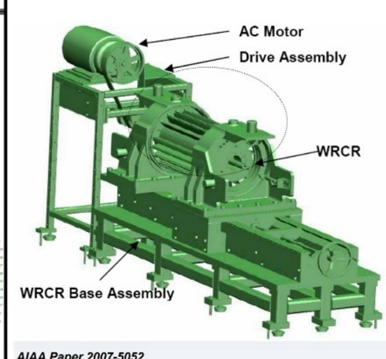
Figure 1. Schematic diagram of a gas turbine operating according to the constant volume combustion method and controlled by disks. a- primary combustion chamber; b, c- rotating disks; d- secondary combustion chamber; e- rotating disk.

Of course, it is entirely legitimate to ask why such a device with such considerable advantages has not been installed on turbojet engines? The answer lies in these 2 observations: 1) the tightness, and 2) the great difference in speed between the disc opening / closing of the combustion chamber, and the driving speed of the compressor which then imposed a reducer whose mass and complexity became prohibitive.

However, another solution has been extensively tested by engine manufacturer Rolls Royce in cooperation with an American university (Indiana University): The Wave Rotor.

The concept of CVC has therefore been experimentally validated and the associated benefits highlighted. In fact, the same question remains: Why did this promising system only remain at the university stadium when the famous engine manufacturer, Rolls Royce, had invested heavily in it? It should also be noted that the patent on this principle of the Wave Rotor was filed in December...... 1940! The answer is the same: sealing between the rotating "cylinder" (5000 rpm) containing the numerous combustion chambers and the fixed fresh gas injection/flange ejection plates.





In addition, the drive of the cylinder required the use of an electric motor, which irremediably condemned any aeronautical application!

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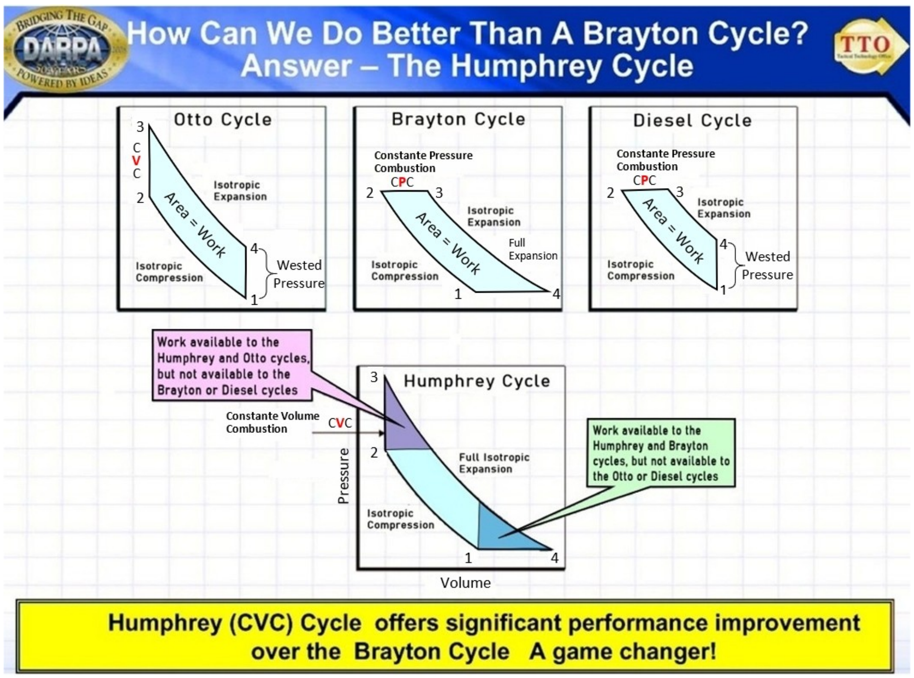
Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion *(Continued from the previous page)*

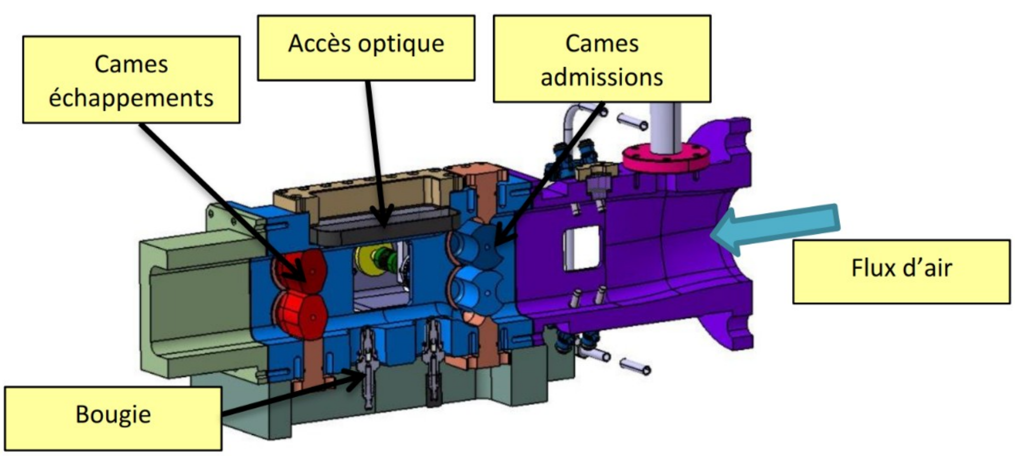
All our research relating to the opening and closing devices of the combustion chamber, and with the contribution of the European Patent Office (EPO) during our patent application for the thermoreactor, which will be explained later, led to a mechanism with reciprocating movements, and that it is linear (valve type) as well as rotary (butterfly type). In fact, in an environment that is very stressful in terms of temperature and pressure, the life span of such mechanisms could only be very short.

The conclusion of DARPA (Defense Advanced Research Projects Agency) was categorical:



It became imperative to imagine a mechanism of a non-alternative type, and therefore continuous!

And it is this strong constraint that led us to design the so-called "Rotary Valve" mechanism, which has been the subject of numerous patent applications. The combustion chamber equipped with its rotary valve for injecting fresh gases at one end and a rotary ejection valve at the other end: The technological breakthrough was born!



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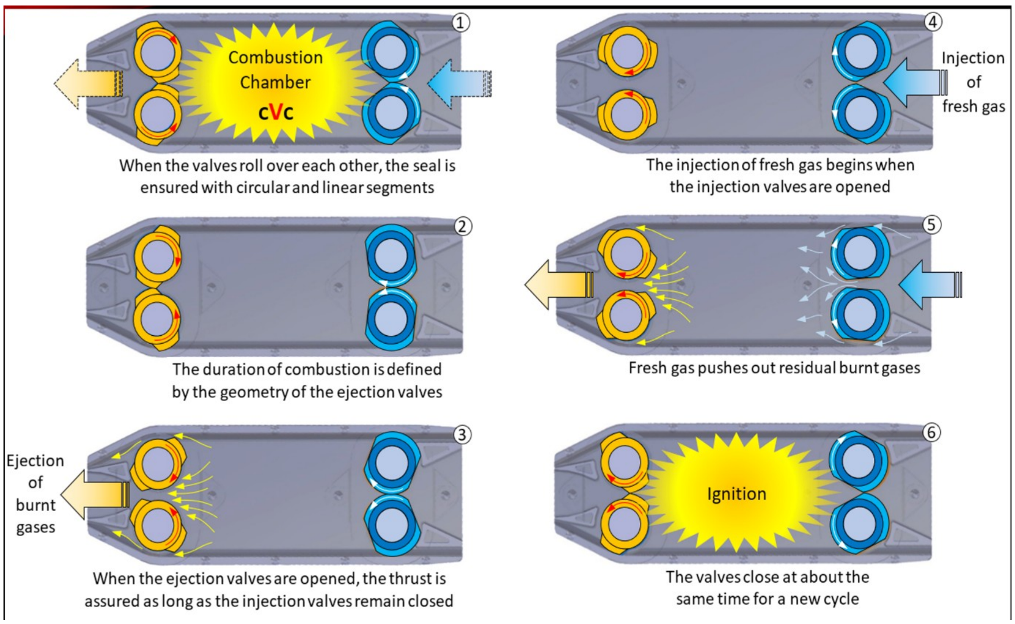
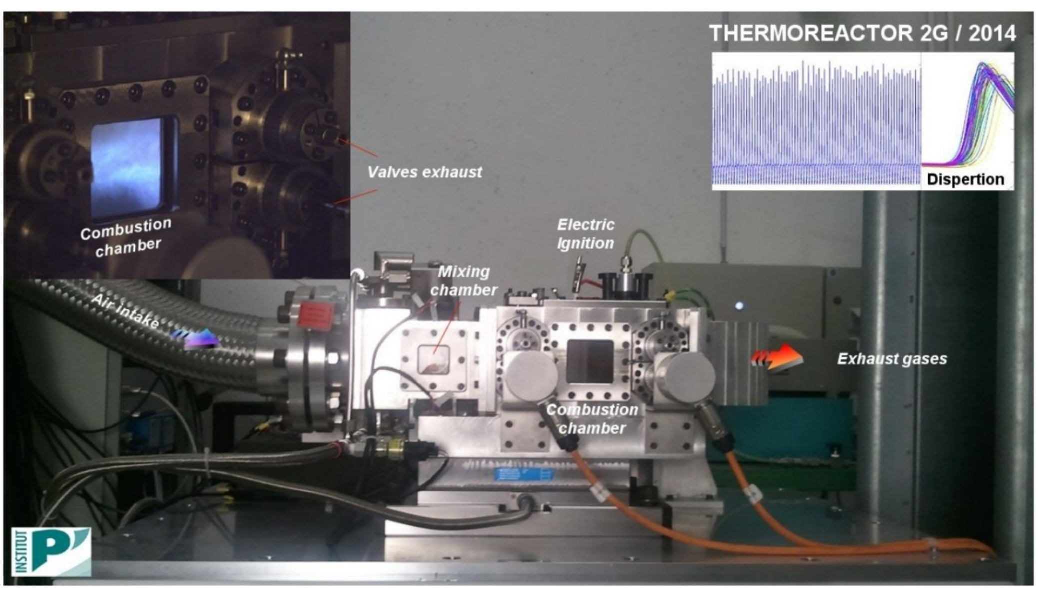
Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion *(Continued from the previous page)*

One imperative: the valves (or cams) of the 2nd generation Thermoreactor (TR2G) had to close at almost the same time, and for mechanical simplicity, they had to turn at the same speed.

III The Thermoreactor
Concept
Thus, the concept of rotary valves, and therefore animated by a continuous movement, will have a definite advantage over competing concepts. Humphrey's thermodynamic cycle is then materialized by the Thermoreactor and its rotary valves to follow the evolution of a single cycle illustrated as follows:



The prototype as it was tested in the P Prime/CNRS/Poitiers laboratory was as shown in the following photo where medallions were used to indicate 1) a visualization of combustion in the chamber, and 2) pressure pulse readings for each combustion:



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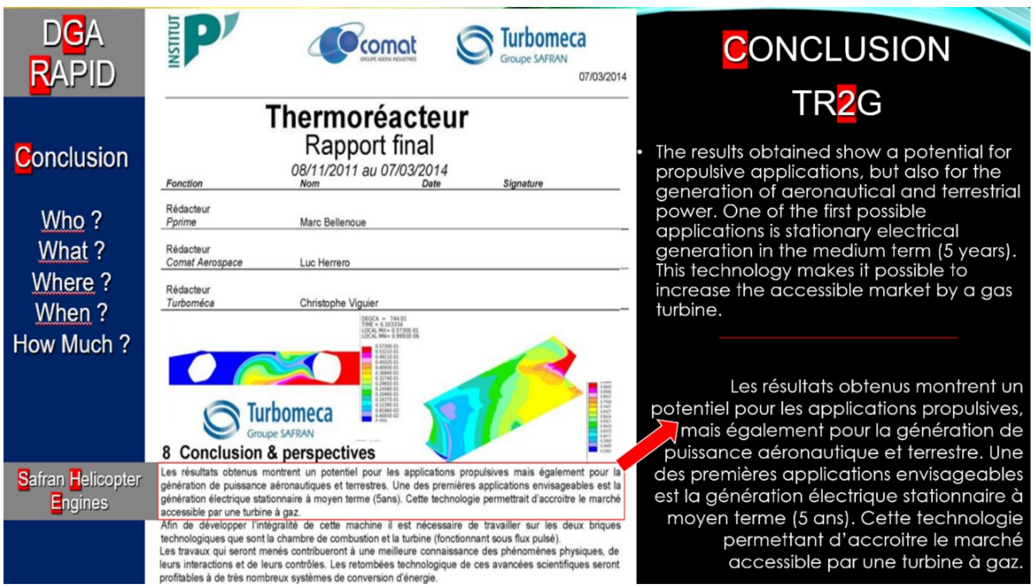
Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion *(Continued from the previous page)*

All that remained was to experimentally validate this concept (POC = Proof Of Concept) in order to position itself at TRL4, this scale of measurement with a technological maturity ranging from 1 to 9 (Technology Readiness Level, see appendix), and created by NASA during the Apollo program (landing in 1969).

2014: Year of the POC

Thus, once the design of this Thermoreactor had been decided, and the patent on which to work had been registered, all that remained was to "experimentally" demonstrate its validity

A consortium was created that brought together Safran Helicopter Engines (formerly Turbomeca, the world leader in helicopter gas turbines) whose function was to confirm, digitally perfect the combustion chamber, analyze the experimental results, design and produce the prototype that was executed in less than 18 months by COMAT Aerospace, and then carry out the tests, and it was the large laboratory, the PPrime Institute of the CNRS de Poitiers, which brilliantly carried out the mission. The DGA (ministry of Defense) had no difficulty in accepting such a consortium, to the point that it selected this team under its RAPID programme by awarding a grant of €1.125 million for a project worth almost €1.5 million. Work actively continued from November 2010 to March 2014.



3.3 "Latest" generation Thermoreactor: TR7G

Based on the lessons learned from these experiments, innovations followed as follows:

Sealing: the bi-valve with its mechanical clearances had 3 potential leakage zones. Required a double mechanism for valve drive, a larger mass (and for aeronautics mass is the enemy number one!), a more delicate adjustment. In fact, we were moving to a single valve.

Ignition: Even if a first ignition is essential, the other ignitions should be as elegant as possible, especially since this ignition via conventional spark plugs has proved difficult to implement, and has a large mass (spark plug + coil + connections + control card). The solution was undoubtedly the principle of thermal ignition as it had been preferred in the famous Wave Rotor. But here again, it was all about technology!

The noise: Pulsed combustion is known to generate a lot of noise. It was then urgent to find a solution that would significantly reduce this sound power. This was done on the basis of a concept that we proposed, and which was validated thanks to the very sophisticated numerical models developed precisely by Sogeti High Tech of Toulouse/Blagnac (Cap Gemini group). A company that is a tier 1 subcontractor of Airbus, particularly for acoustics. The noise reduction in some

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Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion *(Continued from the previous page)*

ranges was in the range of 1 to 30! Funding was provided by Airbus Innovation (formerly EADS Innovation Works).

Increased thrust: In the 2000s, NASA experimentally validated the "Thrust Augmentor", which consists of positioning an ejector as an extension of a turbojet engine nozzle in order to significantly increase the total thrust by nearly 2 ! The only disadvantage for which we still do not see this device on current thrusters is that, given the circular cross-section of current engines, this device can only be applied at very low speeds due to counterproductive drag. The Thermoreactor, with its rectangular cross-section, is very elegantly free from this constraint. A patent was filed on November 12, 2017 under the number FR1771196 !

Aerodynamic Propulsion: The Chilowsky effect discovered at the beginning of the 20th century was applied by Constantin Chilowsky to French shells during the First World War. This physical effect greatly reduces the aerodynamic drag, and can even, through language abuse, produce a "negative" drag and therefore thrust! All the digital simulations we have carried out via a highly competent company (CD Adapco, now under the Siemens banner), clearly show the effectiveness of this effect. And according to an optimized architecture applied to an aircraft, fuel consumption will be significantly reduced.

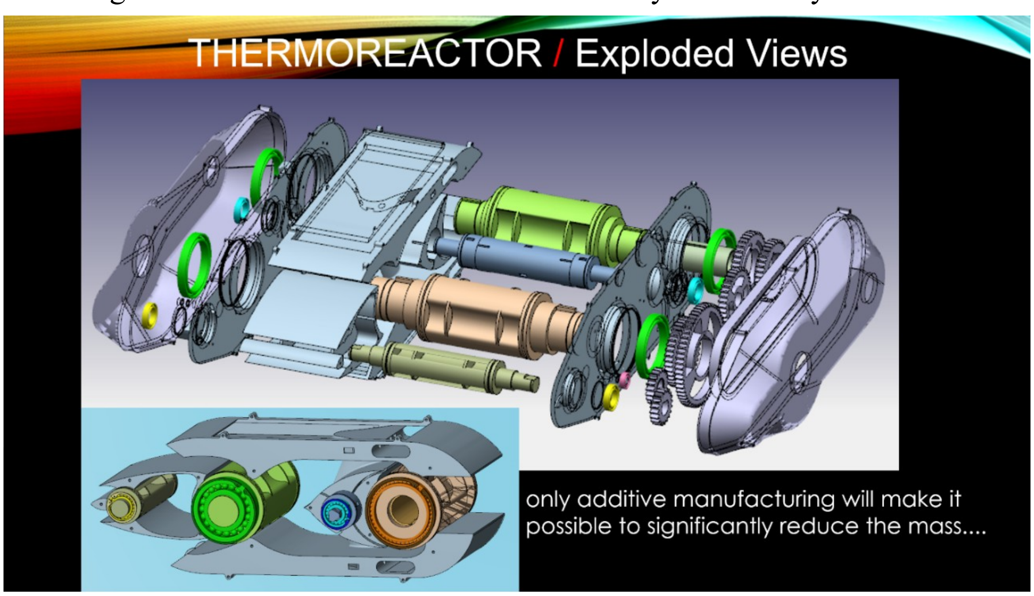
Even if this Chilowsky effect applies essentially to the aircraft, and not to the Thermoreactor, we wanted to point it out now, because it is a very important element for the propulsion of the Xplorair PX200 as we will have to come back to it.

Hydrogen: to reduce the production of NOx during combustion, in accordance with NASA experiments, a small proportion of gaseous hydrogen will be introduced into the fresh charge, which will also help facilitate thermal ignition.

Jamming: for a military application, where the jamming of electronic and computer systems remains a problem, a mechanical solution was preferred which, without presenting the same flexibility of instantaneous adaptation, nevertheless allows, after optimization of the required performance, to gain in robustness and especially to remain insensitive to electromagnetic jamming.

Thus, the 7th generation Thermoreactor, the TR7G, is presented in the following form. We prefer to explain the thrust multiplier device "directly" in view of the recent patent filing date. In addition, whenever possible, a mechanical solution was preferred to any other (electronic / computer / hydraulic) in order to avoid possible interference, particularly in the military version....

Thermoreactor 6G: Drawings made on the CAD software: Catia V5 by Dassault Systèmes:



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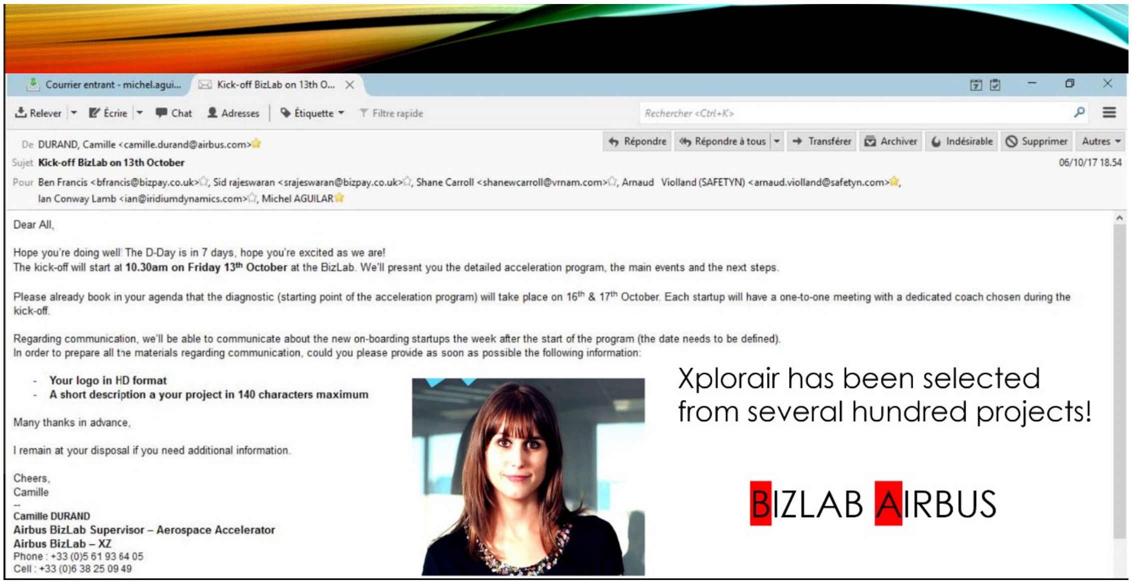
Airbus BizLab selects the Xplorair project AND its Thermoreactor

In 2017, Airbus, through its BizLab, qualified as a project accelerator, for its season III launched a worldwide call for projects. More than 1000 projects were received, and only 7 were selected, including...... Xplorair & Thermoreactor! Of course, it was the thermoreactor that Airbus did not own that made the difference... A few disagreements among the partners of "Xplorair Technologies" caused our participation to be put on hold until the resolution. It is now done... Here is the list of the lucky "elected":



R&D TR7G / Experimentation / Optimization / Certification

The "latest" version of the Thermoreactor, the TR7G, will enter the experimental phase until it is optimized. The sensitivity of control parameters such as injection pressure, valve rotation speed, and air-fuel dosing will be validated. Knowing also that for an aeronautical application, the TR7G will be optimized so as to propel the aircraft up to a sufficient altitude known as "acoustic safety" but less than 1000 meters. The few minutes corresponding to this phase will be considered, by analogy, as the first stage of the rocket where all TR7G will act as boosters.

It remained to identify the company worthy of carrying out the R&D of the TR7G, to carry out all the simulations on combustion, internal and external aerodynamics, prototype design, corresponding plans, and its realization. But above all, to master the entire test chain, starting with the availability of a dedicated test bench.

TR7G Certification

Whatever the application of the TR7G, the certification of this new thruster remains an essential requirement, especially since aeronautical certification will guarantee any other application whose requirements will obviously be less stringent. Except for a drone application which, by nature, will not carry passengers. The company identified for such an operation is APSYS, a 100% subsidiary of Airbus.

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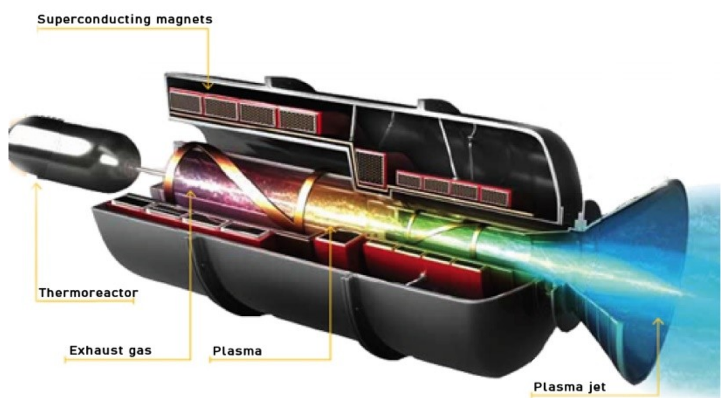
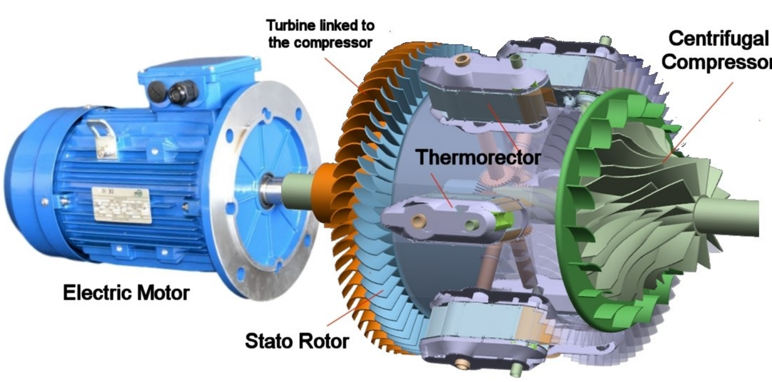
Thermoreactor: its applications

One thing is certain: While the Thermoreactor is an essential "brick" as a propulsion system, there are still many applications for other purposes. However, as an extension of its "Propulsive DNA", a group of 5th and final year students from the IPSA (Institut Polytechnique des Sciences Avancées) is working on an adaptation of the 6th generation Thermoreactor to the space propulsion of a manned capsule. Propulsion based on pulsed plasma from which the combustion products of the TRXG will be expelled at a speed close to 100 km/s !



After its primary function relating to land propulsion by road or rail, sea and air, a transformation of its kinetic energy into mechanical energy will have the function of producing mechanical energy, or more simply said: Creating power.

An example of how the TRXG can be adapted to cogeneration :



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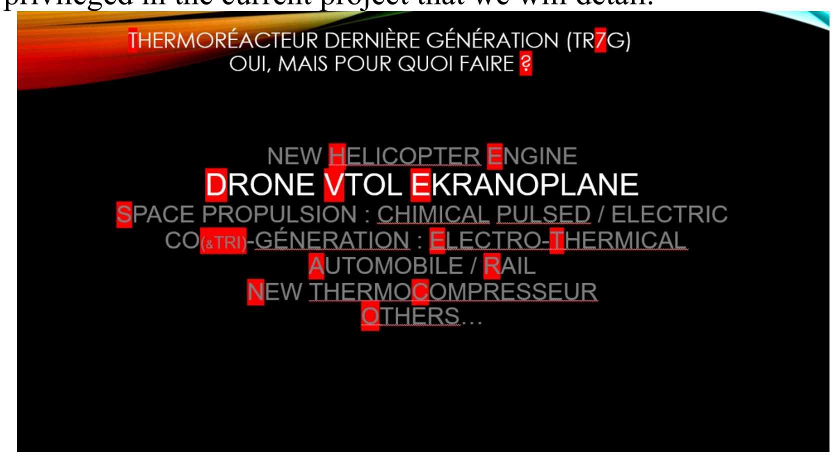
The generator (electricity) is therefore driven by the Stato- Rotor shaft, and a heat exchanger (not shown) heats water intended for heating public, private or industrial buildings.

The electrical powers produced will be spread over a scale of 20 kW to 200 kW per unit. Obviously, for higher powers, for example 1 MW, 5 units will be associated for this maximum production, and according to the needs, units will be activated or not. This will provide unprecedented flexibility and efficiency.

The Xplorair Drone Ekranoplane Autonomous Drone

The flagship application of the TRXG this time is a totally new aircraft since it combines the breakthrough technology represented by the Thermoreactor and its many advantages as developed above, supplemented by the thrust multiplier device, the DMP, of the Chilowsky effect for a strong reduction in the drag of the fuselage coupled to the direct propulsion of the Xplorair. Finally, an Ekranoplane or WIG version, i.e. an aircraft that benefits from the surface effect (land or sea) whenever the mission allows it, and thus will reduce fuel consumption accordingly. And it is this version that will be privileged in the current project that we will detail.



Project objective

One observation: For nearly 20 years, personal aircraft, habitable drones, VTOL (Vertical Take Off and Landing) or not, and therefore requiring a runway for take-off, have multiplied all over the world. And all countries have their own offers. The first to enter the UAV market was Israel, followed by the United States, and then all the industrialized countries. Aero taxis are taking up more and more "space", and seem to be emerging as a solution to the increasingly congested "2D" traffic of large cities. Electric propulsion would be the main argument in view of the "silence" of this type of propulsion. Admittedly, the autonomy remains relatively modest in terms of the energy capacities of the batteries, but this constraint may very well suit the intramural "taxi" version. For information, it is useful to know the ratio between the following energy capacities:

1 kg of kerosene = 16 kg of battery (taking into account the different efficiency)

Of course, batteries will inevitably make progress, but 3rd generation biofuels (microalgae) will also make progress...

Another observation: ALL civil and military aircraft, electric or thermal, VTOL or not, all use propellers or rotors for their movements. And for good reason: They don't own the Thermoreactor!

Why insist on this point? Simply that in a "rescue" version, not having propellers or rotors allows to "bridge" the walls (mountain), the buildings, and thus allows aerostructures totally adapted to this type of mission.

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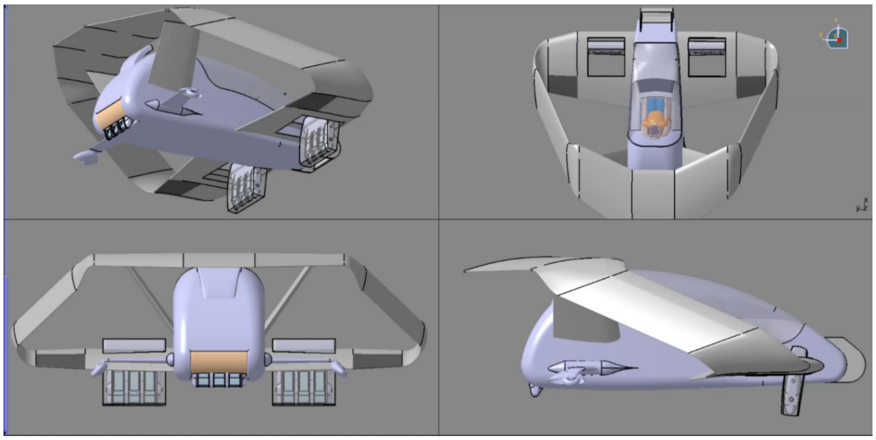
Business Plan Thermoreactor & Xplorair, A Revolution in the World of Propulsion *(Continued from the previous page)*

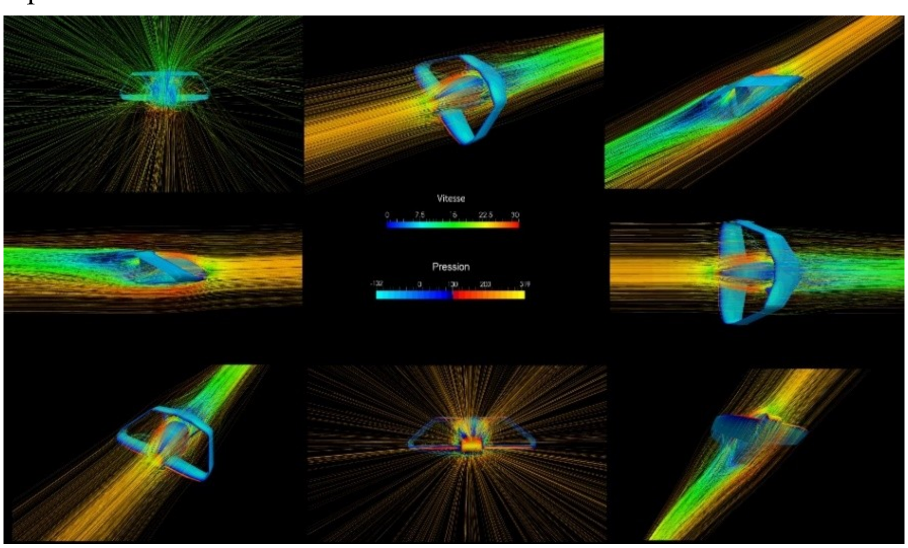
Xplorair: A solution for the 21st century?
The project, the subject of this business plan, will focus on R&D and the production of a prototype aircraft based on 7th generation Thermoreactor (TR7G and more…), up to its certification, and in the pre-industrialization phase. The duration fixed for this realization must not exceed 36 months, and with the objective of presenting this prototype at the 202X Paris Air Show. A precision all the same, the aerostructure will answer the character Ekranoplane or WIG (Wing In Ground effect) whereas the certification will be very lightened in terms of costs and delays...

Here is a first version of this Xplorair PX200 prototype in takeoff mode:



In its **military version**, in addition to the fact that this aircraft will be able to accommodate from 0 to 4 seats, and therefore "0" in the autonomous drone version and a payload of 30 to 300 kg, and up to 4 passengers including a "Captain on board" and therefore controllable. The range will be 800 km, a cruising speed of 200 km/h, a ceiling altitude of 3800 m (without air conditioning), a maximum speed for 2 minutes of more than 700 km/h. In an emergency, a parachute will slow the entire aircraft down, and at 300 meters, after identifying the ground impact point, the capsule alone under the same parachute will detach from the aircraft, and at less than 100 m above ground, an airbag will deploy to strongly cushion the impact.

A "last" aerodynamic operation conducted by the CEMES (Center for Materials Development and Structural Studies, Sophia Antipolis/Nice/France), has used the numerical wind tunnel to validate the aerodynamic properties of this aerostructure type Ekranoplane



(The author and Mr. Mr. Jean-Philippe Régnault will speak in the Star's Up Festival: https://starsupfestival.fr/)

Applications for Artificial Intelligence in Space Systems & Systems of Systems (Continued from Page 35)

has begun increasing exponentially. The number of new systems placed in orbit per year, which for many years held relatively constant around 100, surpassed 1,000 in FY2020 alone. Fueling this rise has been a flood of funding in space technologies and enterprises: in 2020, an estimated $5.7 billion was invested across 135 distinct space startups. Equally remarkable is the manner in which interest and activity in the use of the space domain has proliferated across the globe, with traditional space powers like the United States, China, Russia, and India deepening and expanding their efforts, and newer entrants like Israel, the United Arab Emirates, and even Luxembourg taking bold first steps in myriad unique ways. As these trends continue to unfold, there is reason to believe that we may be in the early days of a new, exciting chapter in humanity's relationship with outer space: a "New Space Age."

This paper examines one particular technology that, perhaps to a greater degree than any other technology, has the potential to enhance the capabilities of space systems and systems of systems, and, in so doing, catalyze the development of the space domain. Artificial intelligence (AI), defined generally as the ability of computers to perform "human-like" behaviors, such as learning, reasoning, and identifying patterns, is a powerful tool which, if properly applied, can help address some of the most challenging space problems. Following some background on AI, this paper outlines several of the most promising potential uses for AI and concludes with a brief discussion on some of the challenges to fully leveraging AI in the space domain.

III. Background on Artificial Intelligence

Artificial intelligence is a concept which, like most cutting-edge technological concepts, has engendered a broad range of definitions and preconceptions that can, in turn, make breaking down the core ideas of AI a daunting and tedious task. The many pop culture references of sentient AI eventually supplanting human decision making, with often disastrous results, can make it difficult to approach this subject with an objective frame of mind. With this in mind, we begin by discussing the principles of artificial intelligence at their most fundamental level.

At its core, AI is a computer's capacity to perform one thing in particular very well: to absorb enough external information and stimuli such that it is capable of mimicking human judgement. As a technology, AI is often applied to achieving a specific end goal. Just as every human's decision-making process, heuristic set, and analytical judgement are molded entirely by individual experience, any mature AI and machine learning (ML), a subset of AI, model must be shaped by an enormous amount of contextual "training data", that – to continue the human-machine metaphor – effectively serves as its own basis for "life experience." Computers are man-made and will only ever do what they are programmed – or "told" – to do. They are enormously powerful and can do what they are told to do at increasingly quicker speeds year after year, but they are still only capable of doing what they are told; no computer today possesses free will. The same rule applies to AI & ML: Artificial Intelligence can only ever make decisions based on the rules which it has derived from its training data – what it has "learned," essentially. The AI/ML world is full of stories of models "overfitting" with bad or incomplete datasets, and in turn reaching bad conclusions. But these errors are usually the fault of stimuli data, not necessarily of the models themselves; moreover, they emphasize that the inherent danger in AI is not that it will become "too smart", but rather that it will get smart enough to essentially fool us into believing it is much smarter than it actually is. With this in mind, it is important to conceptualize AI/ML in terms of how we, as humans, think about problem-solving. The history of computerized automation, up until very recently, has centered around automating mostly basic or manual tasks; things which do not require a great deal of analytical thinking. However, with AI/ML, we now have the potential to automate beyond just repetition and scale: we can potentially automate objective human decision-making, with even more potential to do so at complexity and scale. As such, AI/ML offers humans the opportunity to not only act, but also to think in places where humans simply cannot go, and at rates that humans simply cannot beat.

How might all of this be relevant in a space context? To begin with, unlike things which we can test here on Earth, there is little margin for error or do-overs in space. In other words, once a satellite is launched into orbit, it cannot be pulled back to the ground after running a round of quality assurance. This makes the general principles of agile development – rapid prototyping, upfront risk, real-world testing, regular delivery, etc. – almost impossible to employ in the development of space technology and can add untold amounts of operational and budgetary risk to space-oriented program development. AI offers a potential solution here. While it is difficult to regularly deploy to a "production" environment with space-oriented technologies in order to test them live, one could theoretically train a machine learning model to accurately predict the circumstances & environmental conditions which might face a given satellite while in orbit, so as to potential simulate these conditions and vastly facilitate rapid testing and prototyping. *(Continued on the next page)*

[3] BryceTech (2020). Bryce Global Orbital Space Launches 2020 (Q1-Q4).

[4] BryceTech (2020). Start-Up Space Report 2020.

Applications for Artificial Intelligence in Space Systems & Systems of Systems *(Continued from the previous page)*

Another solution comes in the realm of resilient satellite communications (SATCOM), and satellites being able to intelligently fill emergent gaps based on predefined conditions or stimuli. In an environment such as space, where predicting the paths of debris or solar radiation can make the difference between sending a signal and going offline, AI/ML models could be predictively trained to anticipate potential catastrophic events, and could in turn respond by rearranging or reconfiguring themselves to minimize risk to operations. In short, AI/ML has the capacity to dramatically enhance system capabilities, while significantly offload the potential risk and cost that will come with space-oriented operations in the near future.

IV. Potential of Artificial Intelligence in Space Systems

Since its first use in space systems two decades ago, AI has demonstrated a remarkable capacity of enhancing space systems' performance of certain tasks and, in so doing, greatly augment systems' capabilities. Alongside a maturation in AI in recent years has been a pronounced acceleration in evolution of space-related technologies, opening many new possibilities for the development of outer space for human benefit. Better, more available, more affordable launches in the heavy, medium, and light launch segments means all orbits, and particularly low Earth orbit (LEO), are more accessible than ever before. Hardware and software onboard satellites performing communications, remote sensing, position, navigation, and timing (PNT), and other functions are becoming increasingly refined. Additionally, the ground-based terminals that communicate with satellites, which are a critical, though often underappreciated link in a space system's functionality, have also improved, and many are now capable of transmitting vast quantities of data. The net impact of this exponential improvement of space technologies has been a strong surge in space; so much so, that both industry insiders and casual observers have begun prophesying the incipience of a potential "New Space Age," a not-too-distant future in which the giant leaps in space technologies brought about by a host of commercial space companies drastically improve aspects of human life.

The excitement and anticipation surrounding this "New Space Age" often obscure the harsh reality that bringing about this space-fueled future remains far from a guarantee. Achieving such a future would require overcoming numerous, systematic, long-standing obstacles to the development of the space domain. One such challenge is the cost of accessing outer space, which, though the cost per kilogram has been falling due to innovative developments in rocketry, remains a prohibitive barrier for many would-be entrants to the space sector. An additional structural challenge is the success of any individual space company's success depending in part upon the success of their peers whose business model compliments their own. With space companies dependent on other space companies to fulfill their roles as customers or service providers, the failure of any one company can, in turn, beget the failure of others, creating a potential house of cards. On top of these exist a great many other challenges, including those common to nascent industries, as well as regulatory, environmental, national security, and other idiosyncratic challenges unique to an industry operating in the space domain. Further complicating the issue are the challenges which are only now beginning to emerge, but will only grow over time. Chief among these is the prospect of an increasingly saturated orbital environment filled with thousands of active systems, defect systems that continue to orbit, and millions of debris fragments of various shapes, sizes and orbital velocities, resulting in an unpredictable space environment growing more dangerous with each launch. Taken together, the challenges facing the development of the space domain are significant.

In light of this, the central argument of this paper is that the robust implementation of artificial intelligence has the potential to dramatically enhance the capabilities of space systems and systems of systems, and in so doing, serve as a key tool in addressing systematic space domain challenges and catalyze the development of outer space for human benefit. In this section, we highlight a few applications for AI that are both important to the development of the space ecosystem and in which the application of AI may have a significant impact: data processing, constellation architecture, and facilitating exploration.

The use of AI in gathering and processing data from satellites is perhaps the most important discussed in this paper, due to its capacity to dramatically enhance a system's capabilities as well as its immediate applicability today. The potential value of AI for data processing has long been realized, and indeed many space-focused organizations and companies have leveraged AI for data collection and processing in the past and present. At its core, this application centers around the ability of AI to recognize patterns and discriminate between data that is and is not "of interest" based on training data. Based on the specific function of the satellite, for instance monitoring weather conditions, the training data can be tailored and refined to mature the system's ability to tease out the data of interest from the large set of data it gathers. Through applying AI in this fashion, a single "smart" has the ability to outperform the data gathering capabilities of comparable "dumb" systems, even those consisting of several space vehicles. Thus, a "smart" system is capable of producing a greater, more cost-effective rate of return, and is therefore more likely to justify the *(Continued on the next page)*

Applications for Artificial Intelligence in Space Systems & Systems of Systems

costs associated with launching the system into orbit. However, the application of AI for this purpose can be pushed further. In addition to facilitating "passive" observation, in which simply processes the data recorded from the systems pre-determined observation targets, AI can be leveraged to allow systems to take an "active" observation approach. In an "active" approach, AI would identify when data that is "of interest" is being observed, and then manipulate the satellite's targeting system to continue observing the target "of interest." Once alerted that data "of interest" is being observed and tracked, system can then open up its toolbox, so to speak, observing the target area with the full range of instrumentation it has available. The "active" tracking system can also alert other systems to the presence of data "of interest," which in turn observe the target with the full range of capabilities at their disposal as well. This approach dramatically enhances the capability of a system to gather relevant, useful data, such that it can outperform systems that are orders of magnitude larger, but fail to apply such an approach. The superior ability to gather data "of interest," when applied in tandem with increasingly robust and sensitive observation hardware, has produced not only systems significantly more adept at traditional remote sensing applications, but opened up entirely new applications for space systems, many of which are only beginning to be explored. For instance, HawkEye360, a Virginia-based firm pioneering space-based radio frequency data, has leveraged a relatively small number of satellites to provide clients with a wide array of information, most of which would have been unthinkable just decades ago.

The discussion of leveraging AI across several space systems to enhance capability leads us to the second application to be discussed in this paper: using AI in support of the architecture and health of satellite constellations and so-called "megaconstellations,"consisting of tens of thousands of satellites. Discussion of this topic has gained momentum in recent years due largely to the planning and now executions of satellite constellations of unprecedented scale, such as the 42,000 Starlink satellite that Space Exploration Technologies Corp. (SpaceX) have begun launching or the tens of thousands planned as part of Amazon's Project Kuiper. Planning, creating, managing, and maintaining such vast networks of space systems requires handling vast quantities of data and poses many opportunities for the implementation of AI. Particularly promising is the potential for AI to allow a system to adapt to the unpredictable space environment and maintain the health and efficacy of the overall system. For instance, imagine a constellation of a dozen communications satellites, which work in concert in their respective orbits to provide coverage around the globe. Of these dozen satellites in orbit, one ceases to function correctly, perhaps the victim of a conjunction or a space weather event, or even a simple technical glitch. With the satellite inoperable, a large gap now exists in the system's overall coverage, a gap which will endure in perpetuity unless a change is made. Here, AI offers a potential solution. By incorporating an AI element into monitoring a constellation's health, the system can detect when a change has occurred and, most importantly, self-correct in real time by repositioning the functioning satellites to account for and mitigate the performance gap resulting from the satellite's failure. However, with sufficiently mature AI and the ability to connect to relevant data streams, AI can go beyond the reactive approach to constellation health described above, and instead act proactively to avoid potential threats to the constellation's health in advance. With information on the telemetry of its own constellation's satellites as well as real-time data on all known objects in orbit, a "smart" system could constantly assess potential conjunctions, determine their risk, and, should the level rise above the "acceptable risk" threshold, reposition the satellites in such a way to avoid the threat while maintaining optimal systems performance. This same concept can be applied across several distinct "smart" constellations, connecting them in a neural network and allowing them to act in a synchronized fashion to mitigate risks and maximize performance. In such an arrangement, in which systems of systems communicate and coordinate with one another to optimize outcomes, the risk of conjunctions could be driven ever closer to an impossibility. As the number of systems in orbit, and especially in LEO, continues to rapidly expand, the ability of a system to anticipate threats and act in real time to maintain constellation health will be critical.

The third and final application for AI in space systems to be discussed in this paper is the planning and execution of space exploration missions. Sending robotic spacecraft to explore distant and often poorly understood alien worlds presents a unique set of challenges, including long latency in communications, constraints to spacecraft size and power, a necessity for efficiency, and a dependency on a single spacecraft to gather data of sufficient quality and quantity to achieve often complex scientific goals. Here, AI stands as an attractive solution to many of these problems. By incorporating AI in the spacecraft's guidance system, and "training" it to prioritize examining targets of scientific interest, the robotic spacecraft can respond in real-time in response to the data it is gathering; in ignoring observation targets of little interest in favor of those deemed to have scientific merit, the "behavior" of the robotic spacecraft resembles what might be expected if it were being continuously guided by mission control back on Earth. Given the often-great distances involved in exploring solar system objects, controlling the spacecraft from Earth involves often minutes-long latency times, making real-time decision making by humans impossible. Empowering the spacecraft to determine what to observe and then to maneuver itself to gather the desired data is the only solution for gathering high-quality data in considerable quantities. In this fashion, robotic spacecraft that are wholly or partially controlled by "intelligent" guidance systems are capable of more dynamic, robust exploratory missions, and are therefore better

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Applications for Artificial Intelligence in Space Systems & Systems of Systems *(Continued from the previous page)*

able to justify the considerable resource investment inherent to such missions. This autonomy is also especially important for exploratory missions given the inherent unpredictability of exploring an unexplored, unfamiliar environment. Gathering high quality data often requires being in close proximity with the object in question; for instance, though planetary scientists have garnered a great deal of useful information about the possibility of life on Mars from remotely studying the atmospheric and surface conditions of the red planet, the rovers that prowl the planet's surface remain indispensable tools to making definitive conclusions about the planet's past and present. Though this proximity opens up exciting possibilities for new scientific discovery, it also greatly increases the robotic spacecraft to significantly greater risk, from both known and unknown potential threats. Implementing AI in the navigation system can allow the spacecraft to autonomously determine the optimal path, allowing it to achieve its scientific goals while minimizing risk according to the data at its disposal.

The role for AI in space exploration is significant not only due to its ability to enhance exploratory robotic spacecraft, but also because of the importance of space exploration to the development of the space domain beyond Earth orbit. To date, the vast majority of resources and attention generated during the fledgling space Renaissance have been directed at terrestrially-focused endeavors, projects typically involving spacecraft in orbit around the Earth. Such a focus, given the lower cost thresholds and more immediate, tangible applications, is logical given that the development of the space domain is being driven by commercial entities. Currently, the business case for many of the ambitious extraterrestrial projects, for instance the creation of permanent installations on the Moon or even Mars, simply does not close. However, inherent to the idea of a robust space economy, and thus a developed space ecosystem, is the expansion of human activities beyond the confines of Earth orbit, so much so that the notion of bold, unprecedented space activities is inextricably linked with the contemporary ethos of spaceflight. Should the development of the space domain cease beyond Earth's various orbital regimes, this would represent a failure to achieve the full measure of a generation's space ambitions. Robust space exploration activities represent the key link between the development of terrestrial and extraterrestrial space. Robotic exploration missions provide us with new, often surprising information about solar system objects. The data they gather provide space-interested parties like scientists, space agencies, and commercial companies with actionable information, and often pave the way for future missions or potential commercial applications. Perhaps there is no better example of this than the efforts to better understand our nearest cosmic neighbor, the Moon. The relative accessibility of the Moon with respect to all of solar system objects has made it the focus of a great deal of scientific, commercial, and even strategic interest, producing a self-reinforcing cycle that yields ever more information about the Moon, and particularly about the presence of water ice on and below the lunar surface. The Artemis program, an ambitious effort spearheaded by NASA in partnership with commercial space companies and space agencies around the globe, promises to return humans to the moon for the first time in decades, this time with the intention to establish a permanent presence. Should it succeed, Artemis would represent a remarkable precedent for how gathering detailed information about a solar system object can lead to significant development efforts. Gathering the high-quality data necessary to make the development of solar system objects, nearly all of which can only be feasibly explored via robotic spacecraft, possible will require the implementation of AI.

V. Conclusion

Though there exist nearly unlimited potential applications for the clever implementation of AI to enhance space systems, applying AI for intelligently gathering and processing satellite data, planning and maintaining constellation architectures, and engaging in space exploration are especially consequential to the development of the space domain. In these three applications, AI has the potential to dramatically impact the trajectory of an area upon which the establishment of a robust space ecosystem depends, and, in so doing, has the potential to directly counteract the significant frictional forces operating to the detriment of space domain development. Certain steps can and should be taken to encourage the development and deployment of AI technologies in space systems. The most notable of these

(Continued on the next page)

Applications for Artificial Intelligence in Space Systems & Systems of Systems *(Continued from the previous page)*

potential steps is a general increase in the availability of space data through a deliberate, methodical process of disseminating data from the silos in which they're currently housed. AI capabilities are limited by the data at the system's disposal. Limiting a system's access to relevant space data limits its situational awareness, thus hindering its ability to make "optimal" decisions. The result is a reduction in the overall efficacy of the system and, in the case of systems designed to maintain the health and safety of a constellation, a deterioration in the safety of the orbital environment for all users. It goes without saying that not all data can be made universally available; some information regarding the function and telemetry of certain space systems must remain confidential for national security reasons. That being said, the data that can be shared across all members of the space community should be. Examining potential methods of responsible data sharing, including the establishment of best practices for actors in the space domain, is a subject worthy of further examination.

AI is not a panacea for the many complex challenges facing the expansion of human activity in outer space. However, it remains perhaps the most promising item in our technological toolbox to significantly enhance the capability of space systems and systems of systems. The capacity of AI to improve space systems' ability to perform conventional applications, as well as its ability to open up entirely new potential uses for space systems, instills it with the unique potential to disrupt the space sector, and help usher in the latest, most exciting chapter in humanity's space story.

References

[1] BryceTech (2020). Bryce Global Orbital Space Launches 2020 Q1. https://brycetech.com/reports/report-documents/Bryce_Briefing_2020_Q1.pdf
[2] BryceTech (2020). Bryce Global Orbital Space Launches 2020 Q2. https://brycetech.com/reports/report-documents/Bryce_Briefing_2020_Q2.pdf
[3] BryceTech (2020). Bryce Global Orbital Space Launches 2020 Q3. https://brycetech.com/reports/report-documents/Bryce_Briefing_2020_Q3.pdf
[4] BryceTech (2020). Bryce Global Orbital Space Launches 2020 Q4. https://brycetech.com/reports/report-documents/Bryce_Briefing_2020_Q4.pdf
[5] BryceTech (2020). Start-Up Space Report 2020. https://brycetech.com/reports/report-documents/SIA_SSIR_2020.pdf

View From the Cupola: Kathleen Fredette *(iLEAD Schools, Dream Up, and ISSNL)*

(Continued from Page 39)

We're now in the final phases of experimental design selection, with a launch to the ISS scheduled for next fall. Six finalist teams must create a short video pitching their team's vision, including how they will use this honor to reach more students and the iLEAD community if their experiment is selected to run on the ISS.

The future of education and the culture of science is not measured by the efficacy of repeating back memorized answers; it's in the potential of our children's ambitions and their desire not just to learn but also to explore, inspire, and create! That recipe begins with something tricky, yet brilliant, and it's our goal: wonder, awe, and the literal ability to reach for the stars and dare to dream.

Updates:

On June 3, 2021, two teams of students from iLEAD Schools and Maker Learning Network, along with a delegation of educators and family members, witnessed their microgravity experiments blasting to the International Space Station (ISS) from Kennedy Space Center (KSC) on SpaceX CRS-22. Prior to watching the launch, both teams presented their ideas, including experiment optimization, that the students completed in preparation for this momentous occasion.

AIAA member Kathleen Fredette, iLEAD's Director of STEAM Initiatives, was the point person for the DreamUp to Space Design Challenge, which was offered virtually in 2020 to all students in iLEAD Schools and Maker Learning Network schools and programs, which include seat-based, online and homeschool educational programs in CA, CO, HI and OH. Along with Amber Soto, iLEAD's Director of Mathematics, Fredette ran the entire project via virtual meetings due to challenges associated with the pandemic.

"An unintended and beneficial consequence of the way we ran this year's mission was that students across multiple sites and programs, along with parents and facilitators, were able to join together to successfully develop and launch these experiments," Fredette said.

Prior to presenting at KSC, the teams virtually presented at Space4Youth, an international space event offered by the United Nations Office for Outer Space Affairs, on May 22, 2021. In addition, the teams presented to family members, friends and guests as a final culmination of their work on May 28, 2021. The team members were presented with certificates of achievement from the County of Los Angeles, the Assembly and Congressional offices of CA. Special guests from NASA Ames, Nanoracks, DreamUp, CASIS and the original aerospace assessor panel that selected the teams' experiments were on hand to celebrate their accomplishments.

Next up? Once the experiments return from ISS, the teams will compare their ground truth experiments to those that were activated in microgravity as part of the Postflight Analysis teams.

At last year's ASCEND conference, Fredette delivered a presentation on the efficacy and impact of this type of project on young people and this year will follow up with another presentation. To learn more about this project and iLEAD and Maker Learning Network's student teams, visit iLEADaerospace.org

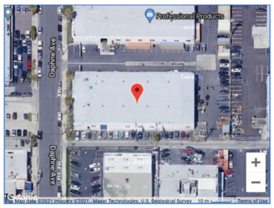
AIAA LA-LV Aerospace News Digests *by Dr. Ken Lui, AIAA LA-LV Section*

(Jun 8) See the First Images NASA's Juno Took As It Sailed by Ganymede

(June 13) G7 nations commit to the safe and sustainable use of space

(June 2) Mach 30 'tunnel' will put China decades ahead

(June 1) California prepares for more West Coast space launches



(June 2) Launcher raises $11 million, ramps up hiring for 2024 flight (Hawthorne, CA)

(June 7) Jeff Bezos and his brother, Mark, will travel to space on Blue Origin's first human flight on July 20

(June 7) Virgin Galactic's Richard Branson Aims to Fly to Space Before Jeff Bezos

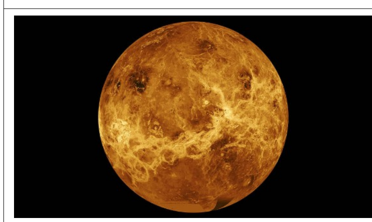
(June 3) Vandenberg Plans Commercial Space Zone to Increase Launch Capability on Base

(June 11) NASA Seeks Proposals for Next 2 Private Astronaut Missions to Space Station

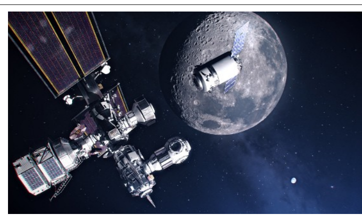
(June 8) Senate Passes NASA Authorization, SSA Legislation as Part of Sweeping China Competition Bill

(June 2) NASA Administrator Bill Nelson Delivers State of NASA Address

(May 7) German scientist predicted man named 'Elon' would lead humanity to Mars in 1953 book



(June 2) NASA Selects 2 Missions to Study 'Lost Habitable' World of Venus



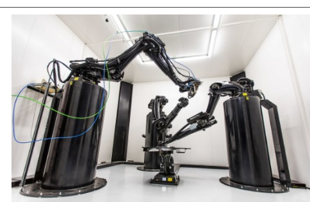
(June 10) NASA Selects University Teams to Develop Moon, Mars Mission Design Ideas

(June 7) NASA Map Gives Most Accurate Space-Based View of LA's Carbon Dioxide

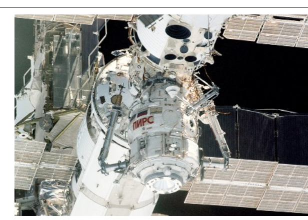
(May 24) Space Force warned to avoid past mistakes as it pursues new satellite acquisitions

(June 15) Launcher Unveils Orbiter, Its Universal Orbital Transfer Vehicle, and Satellite Platform (Hawthorne, CA)

(May 31) New Zealand Signs Artemis Accords



(June 8) Relativity Space Raises $650 Million To Make Its 3D-Printed Rocket Competitive With SpaceX (Long Beach, CA)



(June 2) Russian duo complete decommissioning of Pirs ahead of removal from Station

Photography Gallery: Total Lunar Eclipse (Ms. Michelle Evans)

Ms. Michelle Evans

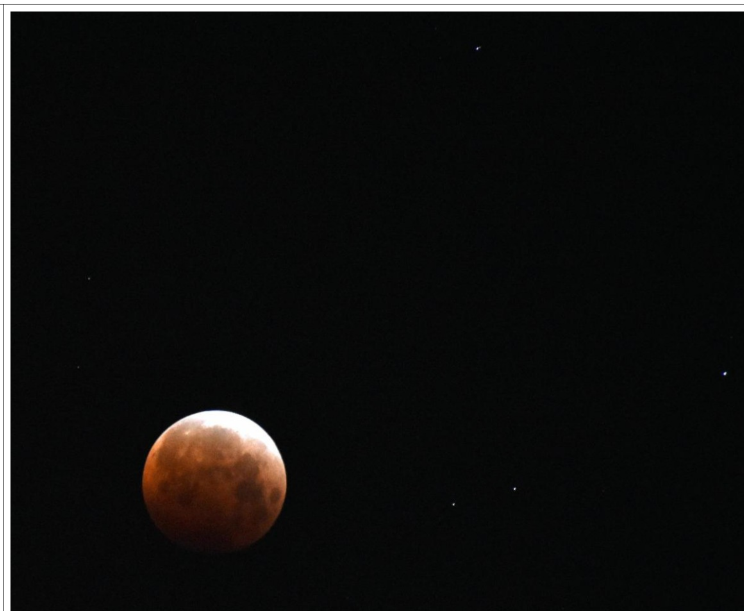
AIAA Distinguished Lecturer | Author, "The X-15 Rocket Plane, Flying the First Wings into Space"

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/

04:22 am at 1 sec at 300mm



04:24 am at 1/8 of a sec at 300mm

04:34 am at 1/10 of a sec at 300mm

04:35 am at 1/10 of a sec at 70mm

(Continued on the next page)

Photography Gallery: Total Lunar Eclipse (Dr. Robert Q. Fugate)

Dr. Robert Q. Fugate was the Speaker/Lecturer of the **AIAA Space 2015 von Kármán Lecture**

Dr. Robert Q. Fugate has a 49-year career in electro-optics research, 35 years as a civilian scientist at the Air Force Research Laboratory and now consultant for DoD, academia, and industry. He is recognized as the "Father of Laser Guide Star AdaptiveOptics," the key technology that has enabled a revolution in extremely large ground-based telescopes to see clearly through the turbulent atmosphere.

The lunar eclipse as seen from Sandia Crest at 10,600 ft above sea level overlooking Albuquerque, New Mexico. Albuquerque was not well situated for the eclipse since it was close to sunrise during the short totality phase and the sky was really too bright to see deep space objects. The Moon was in the constellation Scorpius during totality and a few of those stars are visible. This is a single 1.3 second exposure, Nikon D850 at ISO 400, Nikon 85 mm lens at f/4. The clouds were a bit annoying but do add some perspective and interest.

(Continued on the next page)

Photography Gallery: Total Lunar Eclipse (Dr. Henry B. Garrett)

Dr. Henry B. Garrett

AIAA Fellow

https://www.aiaa-lalv.org/september-21-2020-aiaa-member-spotlight-on-dr-henry-b-garrett/

Speaker, AIAA LA-LV November 21, 2021 Section Meeting

Interstellar Flight Environments and Effects

https://www.aiaa-lalv.org/november-21-2020-e-town-hall-meeting-with-dr-henry-b-garrett-and-mr-lynn-jenson/

Photos taken using a Canon EOS Rebel with a 300mm telephoto lens. La Crescenta, CA.

(Continued on the next page)

Art Gallery: NTPS 40th Anniversary! (Col. Mark Pestana)

Mark Pestana, Colonel, USAF (ret)

(August 31, 2020) AIAA LA-LV Member Spotlight on Col. Mark Pestana - AIAA Los Angeles - Las Vegas Section)

Consulting research pilot and aerospace systems engineer, supporting NASA, FAA, and DOD

Adjunct Faculty in the Aviation Safety & Security Program, USC Viterbi School of Engineering

Speaker, AIAA LA-LV Aerospace Art Virtual Gallery Reception on May 22, 2020

Speaker, AIAA LA-LV Section Meeting on February 13, 2020

Operations Development of the International Space Station

Speaker, AIAA LA-LV Section Meeting on May 23, 2019

Remotely Piloted / Unmanned Aircraft: A Pilot's Perspective on Flying Drones

Speaker, AIAA LA-LV Section Meeting on January 17, 2018

Aerospace Art

NTPS 40th Anniversary!

(See the article for more information)

(Continued on the next page)

Photography Gallery: Comet Neowise (2020) (Tim McDonald)

Tim McDonald

USAF Test Pilot School

Speaker, AIAA LA-LV December 5, 2017 Section Meeting

And The World Turned: Spin Testing The DG-1000S (Glider)

https://www.eventbrite.com/e/and-the-world-turned-spin-testing-the-dg-1000s-aiaa-la-lv-2017-december-dinner-meeting-tickets-37160278393#

&

Speaker, AIAA LA-LV June 20, 2018 Section Meeting

Astrophotography Techniques

http://events.r20.constantcontact.com/register/event?llr=p9tbt6cab&oeidk=a07efeaf7p098eff727

(Continued on the next page)

Photography Gallery: Glider Aviation (Ms. Kathleen Fredette)

Ms. Kathleen Fredette

AIAA Educator Member, iLEAD Schools

*Article Author, See **Page 37** and **Page 104***

Pilot and engineer Troy Wollman

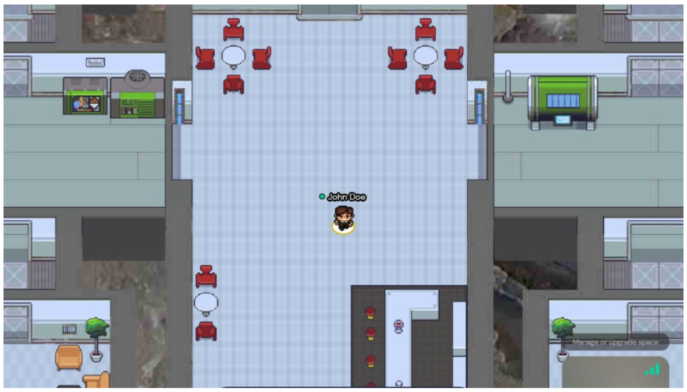
Taking off

RSVP and Information: https://conta.cc/3whFheq

AIAA LA-LV e-Happy Hour 6/17

AIAA LA-LV e-Happy Hour in a virtual AIAA LA-LV Mars Base, Jezero Crater, Mars !

Thursday, June 17, 2021, 6:30 PM PDT (US and Canada) (GMT -0700)



AIAA LA-LV Virtual Mars Base @ Jezero Crater, Mars

Please RSVP / register and join us online on June 17, 2021. The first 20 registrants will be free admission. Additional attendees will need to purchase the ticket at low cost. If you sign up free but can't make it, please inform us so another person can attend with the free admission. The web link, password, and simple instructions will be emailed to the registrants after Monday, June 14, 2021, a few days before the event. Please check the email Spam or Junk folder at that time if you don't see it in your email Inbox.

You will be able to meet, chat, networking, and socialize with a computer web browser, camera, microphone / speaker, and a high-speed internet, similar to join a Zoom meeting with a link/URL and password to be provided a few days before the event. A keyboard (a real keyboard of a virtual keyboard) is needed to move around in the virtual meeting facility, to have the mixed-reality simulated in-person presence and experiences. If your computer is ok for a Zoom video / audio meeting (or similar), it will be ok for this as well.

Please join us and give it a try. And help us to try out for a different new way of networking, socializing, and meeting. It will be fun. Thank you very much ! Look forward to meeting you there in this e-Happy Hour! Enjoy!

Tentative Agenda (All Time PDT (Pacific Daylight-Saving Time, US and Canada))

6:30 PM PDT: Open Door / Floor / Networking / Socializing
8:30 PM PDT: Adjourn

Contact: Dr. Ken Lui, Events/Program Chair, LA, AIAA LA-LV Section (events.aiaalalv@gmail.com)
https://aiaa-lalv.org/events, https://engage.aiaa.org/losangeles-lasvegas, https://aiaa-lalv.org/download

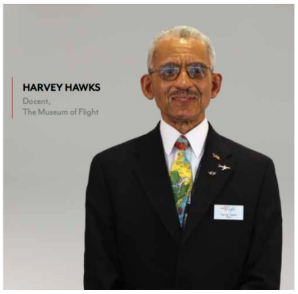
RSVP and Information: (https://conta.cc/3flsa5h)

AIAA LA-LV Juneteenth Event 6/19 (Online on Zoom)

with

Special Message from Congressman Levin

Saturday, June 12, 2021, 10 AM PDT (US and Canada) (GMT -0700)



(Part I)

The Tuskegee Airmen

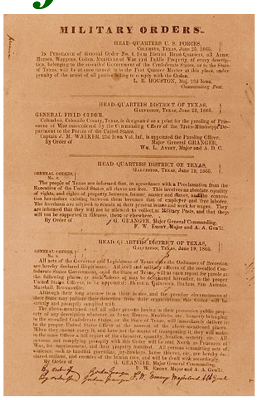
by

Mr. Harvey Hawks

Historian for the Sam Bruce Chapter of the Tuskegee Airmen, Inc.
Docent (tour guide and educator) at The Museum of Flight, Seattle
Boeing commercial airplane weight & balance analysis on SST, B747 and B767 programs – Retired
formerly:
U. S. Army Missile Project Office
General Dynamics, Pomona
Aircraft Structural Design on DC-8 and DC-10 at Douglas Aircraft in Long Beach

(Part II)

Juneteenth Celebration and African American Aerospace Professionals Panel Discussion


MILITARY ORDERS.

General Order No. 3,
June 19, 1865

Panelists:

Mr. Harvey Hawks
Mr. Shelby Jacobs
Mr. Mike Wallace
Dr. Christianna Taylor
Mr. Gary Moir
and
More TBA

Tentative Agenda (All Time PDT (Pacific Daylight-Saving Time, US and Canada))
10:05 AM PDT AIAA LA-LV Welcome and Introduction
10:10 AM PDT Special Message from Representative Levin by Mr. Shelby Jacobs
10:15 AM PDT Mr. Harvey Hawks (The Tuskegee Airmen presentation and Q&A)
11:40 AM PDT Panel Discussion (Tuskegee Airmen, Juneteenth, and African American Aerospace Professionals Career etc.)
01:10 PM PDT Adjourn

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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engage.aiaa.org/losangeles-lasvegas

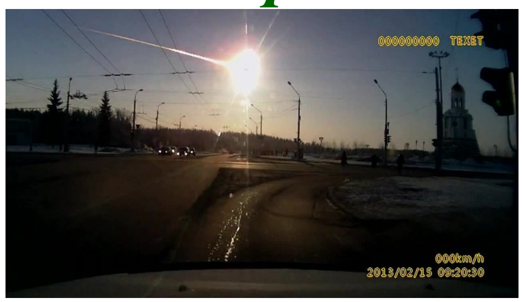
RSVP and Information: (https://conta.cc/3hvTlNs)

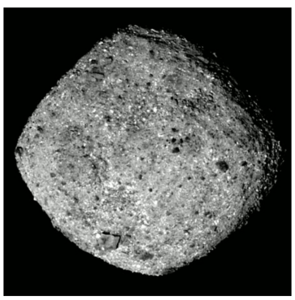
AIAA LA-LV Asteroid Day event (Online on Zoom)

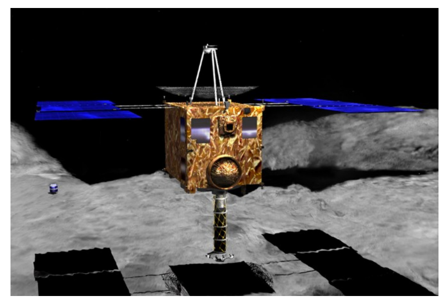
Saturday, June 26, 2021, 10 AM PDT (US and Canada) (GMT -0700)

Planetary Defense Workshop

with Asteroid Exploration Updates







Dr. Nahum Melamed
Project Leader, The Aerospace Corporation

Dr. Andy Rivkin
Investigation Team Lead for the Double Asteroid Redirection Test (DART)
Johns Hopkins Applied Physics Laboratory

Dr. William H. Ailor
Aerospace Fellow, The Aerospace Corporation

Dr. Paul W. Chodas
Director, Center for Near Earth Object Studies
NASA JPL

Prof. Madhu Thangavelu
Faculty Member and Director, USC / ISU

Mr. W. Randy Bell
Senior Project Leader, The Aerospace Corporation

Ms. Monica Maynard
LA School District STEM Director
STEM Office, The Aerospace Corporation

Ms. Lianne P. Mcginley
Corp. Comm. & Public Affairs
Center of Excellence Associate Director
The Aerospace Corporation

Mr. Philip Groves
Asteroid Hunters" IMAX Producer & Writer,
Apophis Pictures, LLC

(More (TBD))

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engage.aiaa.org/losangeles-lasvegas

RSVP and Information: (https://conta.cc/33Uo8eN)

AIAA LA-LV e-Town Hall Meeting 7/10 (Online on Zoom)

Saturday, July 10, 2021, 10 AM PDT (US and Canada) (GMT -0700)

(Part I)

The Psychology for Success in Leadership

by

Dr. Bill Goodman

President & CEO, Goodman Technologies LLC & GTNANO LLC, in the Defense, Aerospace and New Space marketplaces.

Ph.D. in Materials Science and Engineering from UCLA

(Part II)

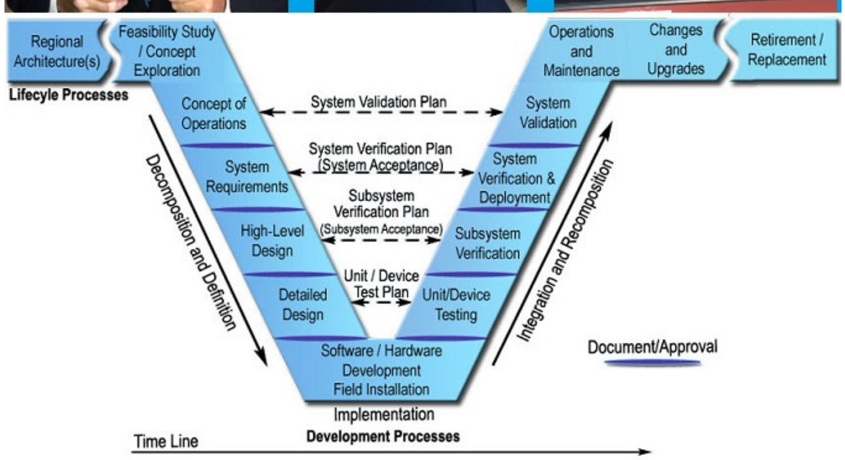
Digital Transformation through MBSE

- ANSYS technology stack, workflows and use cases

by

Dr. Swati Saxena

Technical and Project Manager, ANSYS Inc.



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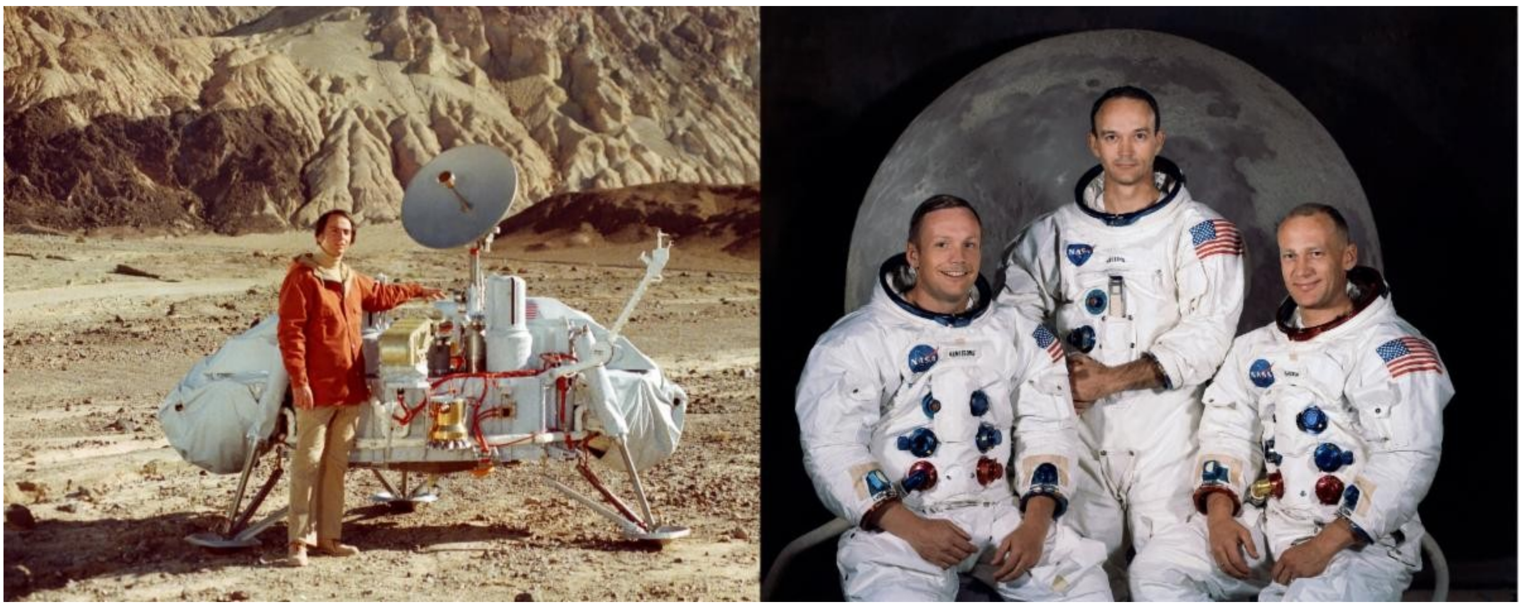
RSVP and Information: (TBA)

AIAA LA-LV e-Town Hall Meeting 7/10 (Online on Zoom)

Saturday, July 17, 2021, 10 AM PDT (US and Canada) (GMT -0700)

Apollo 11 Moon Landing (52nd) and Vikings Mars Landing (45th) Anniversaries



Speakers / Panelists:

(To be Announced)

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RSVP and Information: (https://conta.cc/3tRGgAv)

AIAA LA-LV e-Town Hall Meeting 8/7 (Online on Zoom)

Saturday, August 7, 2021, 10 AM PDT (US and Canada) (GMT -0700)

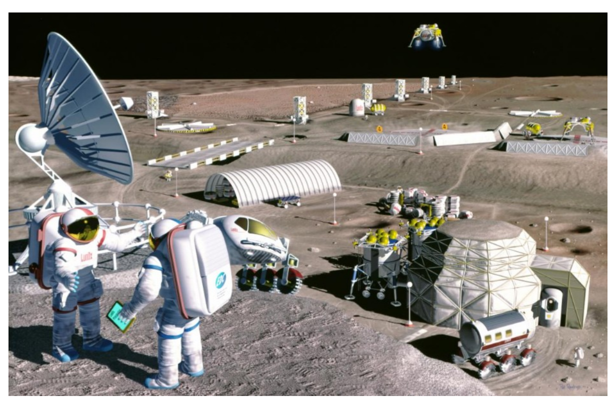
Countering Objections to Space Settlement

by

Mr. Al Globus

Contract software engineer, NASA Ames Research Center - Retired
AIAA Space Colonization Technical Committee
NSS Board of Directors

Space settlement is moving from the fringe of space conversations towards the center. As this happens some will object to one or more aspects of space settlement. Most of these objections have been heard before. Indeed, since space settlement became part of the discussion with Gerard O'Neill's work on free space settlements in the 1970s, many of the same objections have surfaced again and again. The space settlement movement, including this author, has some experience responding to these attacks. This presentation is intended to be a place to find rebuttals to objections to space settlement. For each objection there are talking points and a brief discussion



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