(Cover Story)
Ann Slavin (Boeing) at the Starfire Optical Range at Kirtland Air Force Base - Laser Guide Star Adaptive Optics Systems

AIAA LA-LV Celebrates Month of Women & Women's Equality Day

Space Philosophy Gathering 2021

An Evening with Stratolaunch
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(Cover Story) Ann Slavin (Boeing) at the Starfire Optical Range at Kirtland Air Force Base -Laser Guide Star Adaptive Optics Systems

by Dr. Robert Q. Fugate, Speaker/Lecturer of the AIAA Space 2015 von Karmann Lecture

Ann Slavin is currently a manager for The Boeing Company at Kirtland AFB, NM where she is responsible for a team of 55 employees providing engineering for the US Air Force Research Lab’s R&D efforts at the Starfire Optical Range advancing capabilities for Space Domain Awareness. She began her career in aerospace as the daughter of a USAF officer, attending air shows and watching test aircraft at Edwards AFB and pondering sonic booms. Ann joined the USAF out of college as a weather officer where she was certified as a weather forecaster and supported aviation operations. After earning her MS in atmospheric sciences, and a short deployment with the US Army, she was offered the opportunity to join the team at Starfire developing and demonstrating the first natural and laser guidestar adaptive optics systems. It was here that she found her love of atmospheric research; the discovery of new instrumentation for characterizing the atmosphere; the analysis of data and the story it told in relation to effects on ground based imaging systems; and blending weather forecasting knowledge with attempts to forecast optical turbulence. Ann left the Air Force to pursue her career with Boeing supporting contracts with AFRL at Starfire where she has spent the last 25+ years collecting and analyzing data, providing data to support engineering designs, mentoring the next generation of atmospheric researchers, and working with the most talented group of engineers, scientists, technicians, and support people that anyone could ever hope for.

About the Photographer/Author: 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 Adaptive Optics,” the key technology that has enabled a revolution in extremely large ground-based telescopes to see clearly through the turbulent atmosphere.

Special Edition: Month of Women and Women's Equality Day
(August 21) AIAA LA-LV Celebrates Month of Women & Women's Equality Day

(screenshots only) [https://engage.aiaa.org/losangeles-lasvegas/viewdocument/program-for-2021-august-21-aiaa-la](https://engage.aiaa.org/losangeles-lasvegas/viewdocument/program-for-2021-august-21-aiaa-la) [https://rss.com/podcasts/aiaa-losangeles-lasvegas/260213](https://rss.com/podcasts/aiaa-losangeles-lasvegas/260213) (Podcast) [https://youtu.be/S6Rw_0ZpiY0](https://youtu.be/S6Rw_0ZpiY0) (YouTube)

10:00 AM  Welcome and Introduction (Ms. Marilee Wheaton)
10:05 AM  From Passengers to Pilots" (Ms. Leslie Czechowski, Moderator: Mrs. Marilee Wheaton)
11:15 PM  The 1st Panel Discussion (Moderator: Mrs. Marilee Wheaton)
12:25 PM  Ms. Tanja Schroeder (Exhibitor Briefing: "EnCorps and STEM Teachers Program")
12:40 PM  Miss Isis Ginyard (Special K-12 Student Briefing: "Development of the Stella App")
12:55 PM  The 2nd Panel Discussion (with an Early Career (Professional) focus)
02:05 PM  Adjourn

Ms. Marilee Wheaton (Bottom) opening the event on August 21, and introducing Ms. Leslie Czechowski (Upper Right) for the featured presentation.

Ms. Leslie Czechowski (Right) talking about many exciting and inspiring stories about the pioneering women, who had great passion for aviation, and went from passengers to pilots. Some even lost their lives. (Left) the Pistol Packin' Mama, who flew B-17 sorties and missions during WWII.
Panelists for the first Panel (from Upper Left to Lower Middle): Ms. Leslie Czechowski, Ms. Marileee Wheaton (Moderator), Dr. Claire Leon, Ms. Claudine Phaire, Dr. Swati Saxena, Attn. Jennifer Perdigai, Dr. Anita Sengupta. The panelists taking turns expressing their views on Women’s Professional Career Development, the challenges they encountered and how they overcome them, etc. Each of their stories were very inspiring, lots to learn. So happy to have those wonderful women professionals with us on this meaningful day, which will be remembered for the rest of our lives. Truly a once-in-a-lifetime experience.

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Ms. Tanja Schroeder (Upper Right) briefing on EnCorps’ Teachers Program, with Ms. Marilee Wheaton (Lower Right) commenting.
(August 21) AIAA LA-LV Celebrates Month of Women & Women's Equality Day

Isis Ginyard, a young women student at Windward High School, in Los Angeles, and rising star in research and applications in the psychology space travel, presented an impressive and mind-opening briefing about her STEM project, the "Stella" App, designed to aid research and psychological coping in situations where individuals are isolated for long periods of time, such as in space travel, space colonization and settlement, and the isolation caused by a pandemic. The Chat box of the Zoom meeting was full of kudos from attendees. Members and guests of the AIAA-LV section praise your efforts and are here to support you!

The 2nd Panel, with an emphasis on Young/Early Career Professionals, sharing their stories, with laughter and tears. People really had a great time and enjoyed themselves! Very professional and inspiring! Great sharing and advice! (From Upper Left to Lower Right) Ms. Janet Grondin (Moderator), Ms. Kathleen Fredette, Ms. Janelle Wellons, Ms. Marilyn McPoland, Ms. Laura Duffy, and Ms. Niyati Chokshi.
LMU Systems Engineering Faculty, Dr. Claire Leon, Elected to National Academy of Engineering (NAE) (Dr. Leon has been the speaker / panelist in AIAA LA-LV events)

https://www.nae.edu/19579/19581/20412/248884/Dr-Claire-Leon

https://seavernews.lmu.edu/2021/03/01/systems-engineering-faculty-elected-to-national-academy-of-engineering/

(The following article was originally published by LMU and is reprinted here with permission from LMU)

Claire Leon, Ph.D., senior lecturer in systems engineering and former director of the Systems Engineering Program at Loyola Marymount University, was elected to the National Academy of Engineering early in 2021.

Membership in the academy of some 2,500 US and international members is among the highest professional distinctions accorded to an engineer. Membership honors those who have made outstanding contributions to engineering research, practice or education.

Leon was among a group of 106 US and 23 international new members elected this year. They will be formally inducted at the academy’s annual meeting in fall 2021.

“When you work really hard at something, it’s nice to be recognized and honored,” Leon said.

The National Academy of Sciences was created by Abraham Lincoln, and the National Academy of Engineering branched off from there, explained retired U.S. Air Force, four-star General Ellen Pawlikowski, a member of the NAE and mentor to Leon. “The mission is to support the nation as experts in science and engineering. Members are expected to dedicate their time and expertise on studies, etc. It is an honor, but it comes with responsibility.”

Leon is no stranger to responsibility. She served as graduate program director for LMU’s Systems Engineering Program from 2017 to 2020. Under her leadership, she achieved a number of accomplishments, including updating the curriculum to help address industry’s most pressing issues and providing students greater flexibility with customizing the program to meet their individual needs. She updated the Dual Degree MS in Systems Engineering/MBA program and extended the program to the other engineering disciplines. She also recruited a number of new professors with strong industry background to share their experiences in Software Architecture, Cybersecurity, and Resilient Space System Design.

Leon supported undergraduates interested in aerospace by becoming the faculty advisor to the Loyola Marymount Aerospace Research Society, and helping another group of students establish an AIAA chapter at LMU.

She also created two new courses designed to inspire students interested in aerospace: a graduate course titled “Occupy Mars: Explorations in Space Travel and Colonization,” and an undergraduate first-year writing class titled “Becoming a Multi-Planetary Species.”

Leon came to LMU from the U.S. Air Force, where she served as director of launch enterprise, responsible for a budget exceeding $2 billion and a workforce of more than 200 employees and 500 support contractors. Her responsibilities included procuring launch vehicles for the Department of Defense, as well as developing the strategy to procure the next generation of launch vehicles for the coming decade.

Prior to that, Leon retired from Boeing as vice president of National Programs after serving more than 34 years in the aerospace industry.

Throughout her career, she distinguished herself as a problem solver and was often brought in to fix troubled programs. Much of her work is classified, but Leon tells of one unclassified program she helped get back on track. The wide band gap-filler satellite program was behind schedule and struggling. Under her leadership, the program became so successful that the Air Force customer ordered three new satellites and changed its name from being a gap-filler to the more permanent Wideband Global SATCOM.

Leon also helped women in her company as an Executive Champion for Boeing’s Women In Leadership organization and personally mentored many up and coming women, who she stays in touch with to this day. Earlier in her career, Leon participated in the National Research Committee, sponsored by the National Research Council. That committee recommended technologies the country should invest in to become more competitive. Now, as a member of the National Academy of Engineering, she hopes to serve the nation through similar contributions toward national security, education of engineers, and other issues.

“It’s exciting to be part of a group that will work on tough national issues going forward,” Leon said.

Leon earned her bachelor’s degree in mechanical engineering from George Washington University. She has a master’s degree in management from University of Redlands and an MBA from UCLA. She earned her Ph.D. from the Drucker School of Business at Claremont Graduate University. She sits on the advisory board for CalTech’s Space Solar Power Program and on the board for the Santa Barbara company, Power Bloom.
Ms. Janelle Wellons: A Young Engineer Steps Into the Light

Written by Celeste Hoang (2019 Nov. 01) (Ms. Janelle Wellons was a panelist in the AIAA LA-LV August 29 event)

Janelle Wellons reveals how she fought an uphill battle against the pitfalls and stigmas of the "diverse" label - and found her true calling as a powerful new force at JPL.

In high school, Janelle Wellons excelled in her classes, especially math, and quickly climbed to the top of her class. By the spring of her senior year, she had an acceptance letter in hand from her dream school, the Massachusetts Institute of Technology. But while that should have been a joyous time, an incident with a high school classmate cast a long shadow.

"One of my classmates approached me in front of a group of friends and said, 'We all know the reason you got accepted into MIT is because you're black,'" Wellons recalled. "No one standing there said anything, and the fact that no one stood up for me spoke volumes."

Today, Wellons shows no hint of how close she came to giving up - not because of the sting of one comment that broke the surface, but because of the doubts and questions that worked invisibly during her formative years.

Bright-eyed with an ebullient personality and hearty laugh, she works as an engineer at NASA's Jet Propulsion Laboratory in Pasadena, California, where she operates the Lunar Reconnaissance Orbiter's Diviner instrument - a radiometer that measures the surface temperature of the Moon. Wellons is also developing the system that will command the Multi-Angle Imager for Aerosols instrument, which will launch around 2022 to study how Earth's pollutants affect people's health on a global scale.

Just three years out of college, she is one of the youngest staffers on a Moon mission and an Earth mission. But while her progress has been quick, it was not easy.

A Gray Summit

Wellons grew up in South Jersey, the eldest of two siblings. Her mother was a secretary at an oil and gas corporation, and her father worked in warehouses. When she was about 6 years old, she went with her mother on a bring-your-child-to-work day and spent the morning surrounded by engineers doing demonstrations for the kids.
Ms. Janelle Wellons: A Young Engineer Steps Into the Light

"It opened my eyes to realize: an engineer makes things!" she said. "I got that into my mind."

But as she grew older, Wellons realized that reaching her goals would sometimes come alongside prejudice. The acceptance-letter incident wasn't her only brush with racism. Wellons felt racial tension throughout her high school years, especially since she was often one of the few black students in her advanced placement classes.

"It kind of defined me. It was like they couldn't see anything else," she says. "In high school, people joke about bad things all the time and they always say they were kidding to make it OK, but after a time, it gets to you," she says.

By her senior year, she recalled, "Something was just not right."

It wasn't feeling hurt that alarmed her. It was feeling nothing at all.

The spring of her senior year, Wellons received a call from the MIT Office of Engineering Outreach Programs with the news that she'd been awarded a scholarship.

"It should've been a very happy moment, but I didn't feel anything and just hung up the phone and sat outside by the lockers," she recalled. "When I realized I couldn't feel happy about that, I realized there was something really wrong with me.

"That's when the suicidal thoughts started to creep in, like, 'Why can't I have authentic reactions anymore?' I knew it was a serious problem."

Shedding the Label

Wellons' parents sought out a therapist to help her, and as she entered MIT, things dramatically improved. She joined a black student union, pledged a sorority and interacted with a multicultural community on campus.

"I definitely had a huge transformation in college," she says. "When you take away the 'smart black girl' label, you become your own person and people can have a conversation beyond that."

Still, her course load was demanding, and Wellons quickly realized she was, as she says, "in another realm of smart," finding herself sitting next to a gold medal winner of the International Math Olympiad and doubting why she was admitted to MIT. "But that was a good thing."

Although she thought she might major in mathematics, an aerospace engineering class changed her mind. The professor showed a photo of an astronaut fixing NASA's Hubble Space Telescope and revealed that he was the person in the photo. Wellons was in awe.

"The opportunity to be taught by an astronaut was something I could not pass up," she said. "I realized that's what I wanted to do - I'm going to learn about space from experts! I was blown away by that."

Another professor introduced her to the value of critical self-assessment during a capstone project involving an Antarctic penetrator probe. "He was a really tough professor who would angrily say, 'This would never pass a review in the industry,' and would heavily criticize our presentations," she recalled. "But my standards are much higher now because of him, and I'm just as nitpicky."

Real-time Engineer

Wellons applies that work ethic around the clock at JPL. She's on call 24/7 for the Diviner instrument Reconnaissance Orbiter, sometimes getting calls at 2 a.m. and, on one rare occasion, had to rush to her laptop in the middle of a night out with friends.
Ms. Janelle Wellons: A Young Engineer Steps Into the Light

"The one scary thing is, you are the engineer responsible for the instrument's success," she said. "You are the operator, and you can't afford to be sloppy in this job. Instruments don't sleep."

Wellons' typical day starts with checking on the health and safety of her instrument or, as she puts it, making sure it's alive and well." Then she'll work with the science team and, depending on what they would like to look at, help figure out if their requests can be met without putting the instrument's well-being at risk.

"You're in charge of making sure the scientists don't push the limit," she explained. "If you get too greedy, you might break the instrument."

Then she creates the commands that will be sent to the instrument.

Community Builder

At JPL, Wellons balances gratitude for her career and awareness that being a black female engineer comes with challenges.

"I am so thankful to be here, because growing up, I rarely if ever saw someone who looks like me working at a company so incredibly amazing, making history every day," she said. "At the same time, that doesn't mean [there aren't] comments toward me. JPL is made up of individuals with their own thoughts and experiences and perspectives on life, so of course you're going to have instances. It's definitely not going to slow me down, though."

To help spread the message of inclusion, Wellons is on the board of JPL's African American Resource Team, which she's helping revitalize.

"It's about building a cultural community and encouraging other young people to come work here," she says.

While Wellons often has work on the brain, she also carves out time to give back.

Last summer, she spent two weeks in South Korea, helping third- through sixth-graders at space camp learn about extraterrestrial volcanic bodies, launch bottle rockets and simulate rover driving.

Looking back on what she's been through, Wellons remains focused on positivity and making the most of her time at JPL - seeking out mentors, gaining a wide variety of experiences and setting her sights on making her voice and her vision heard.

"Being here a short time doesn't mean that you can't accomplish great things quickly," she said. But not easily, in her experience, and not without the right people on your side along the way.

"I am immensely thankful for the opportunities and support that have brought me to JPL, because it was never a straight shot," Wellons said. "Don't forget those who have supported you, believed in you, prayed for you, taught you and lifted you up when you felt especially down."

When the World Was Upside Down: A Perspective on Depression
Paperback – May 3, 2018
by Janelle Wellons (Author), Sharnice A. Jones (Foreword)

https://www.amazon.com/When-World-Was-Upside-Down/dp/1980997470
LEADING LADIES OF... AEROSPACE WONDER WOMAN WEDNESDAY!

by Joanna Boatwright

I am excited to introduce to you Roz Lowe 🇺🇸 as this week’s featured Wonder Woman. Please join me in wishing Roz CONGRATULATIONS!

#1 Joined Aero: 1982

#2 Fav. Aero moment: My favorite Aerospace moment was taking my son on a private tour of Space X. He was a huge fan. We made some components on the first rockets in an unheard-of amount of time. At that time Space X was a company reminding us all that big things are possible and I played a small role in making what was thought impossible, possible with an ahead of time delivery The private tour for my son and a few of his mechanically inclined friends made me the coolest mom to my 17 year old for a good 2 weeks so a winning moment in my career.

#3 LLOA role model: My neighbor, Shirley Richmond, who was the 85th employee at Hydraulic research / Textron in Valencia CA, over 50 + years ago. She started when women did not really play a big role in the industry. She began as a machinist eventually managing a team until she retired from Honeywell. She is now in her 90's and I love her stories so much about how things were back in the day I often think she'd be a great documentary to this day she’s one of my favorite people to talk shop with.

#4 Best Leading Lady Moment: My best leading lady moment was developing a love he thread rolling course for a large aerospace company and implementing the course into the organization. 14 inexperienced machinists with little to no experience thread rolling would in 16-weeks be making their own setups and efficiently running their machines at above rate production with a zero% scrap rate at the end of 18 months tracked. The company no longer had to outsource their thread rolling business and 14 inexperienced individuals now had the training they needed to feel secure in their trade making a higher wage with the improved skills and filling a hole in the industry where it’s very difficult to find talent.

To nominate the Wonder Woman in your circles please become of member of the Leading Ladies Of... Aerospace LinkedIn community

(Editor's Note: Ms. Roz Lowe has been volunteering for the AIAA LA-LV Section for related events and newsletter articles. Thank you so much, Roz!)
Beginning of New Era: SMC and SSC
by Prof. Mike Gruntman, Professor of Astronautics at USC; AIAA Distinguished Lecturer / Speaker
(2021 August 14) [https://www.linkedin.com/pulse/beginning-new-era-smc-ssc-mike-gruntman/]

On August 13, 2021, the United States Space Force replaced the storied Space and Missile Systems Center, SMC, with the new Space Systems Command, or SSC. The new Command will remain at the Los Angeles Air Force Base which was also renamed the Los Angeles Garrison. SSC is one of the three field commands of the U.S. Space Force, the sixth branch of the armed forces established by President Trump on December 20, 2019.

This consequential event provides an opportunity to remind us the origins of the U.S. ballistic missile and space programs and SMC. The following is an excerpt from [Blazing the Trail](http://astronauticsnow.com/bttp/btt_pp_231-234.pdf), pages 231-234.

[beginning of excerpt]

The Teapot Committee [established in October 1953 and chaired by John von Neumann] recommended a radical reorganization of the ballistic missile effort. The Atlas, with the projected range of 5500 n miles (10,200 km), would now rank a top priority of the Air Force and the actual development would begin.

Setting up a special development management agency for the entire Atlas program was deemed most urgent. The complexity of the ICBM was thus demanding emergence of a new technical area, system engineering and technical direction, that would become prominent in the future. The Committee stated that “the nature of the task for this new agency requires that over-all technical direction be in the hands of unusually competent group of scientists and engineers capable of making system analyses, supervising the research phase, and completely controlling the experimental and research phases of the program.”
Beginning of New Era: SMC and SSC

Two days before the Teapot Committee issued its report, another independent study confirmed the feasibility of the Atlas ICBM. The assessment by RAND's Bruno W. Augenstein stated that the Atlas could achieve the operational status in the early 1960s providing the stringent performance characteristics were somewhat relaxed and the program priority and funding increased. In an assuring development on 1 March 1954, the Bravo test demonstrated the feasibility of high-yield, compact, and low-weight nuclear warheads: the Atlas program was now possible within the state of the art.

The report of the Teapot Committee triggered a set of events that significantly accelerated the American ICBM program. First, the reorganization of the Air Force development effort followed. To manage the Atlas program, the special Western Development Division (WDD) was activated under command of General Schriever at 409 East Manchester Blvd., Inglewood, California, in July 1954. Second, the role of the system engineering and technical direction was substantially expanded. The Ramo-Wooldridge Corporation (R-W), the predecessor of TRW, Inc., was founded by Simon Ramo and Dean Wooldridge to provide such services for the Air Force. (In contrast, the Army relied on its in-house expertise of the von Braun's group at the Redstone Arsenal for technical direction of the Army ballistic missile programs.) R-W's Space Technology Laboratory (STL) would thus become the main participant in the Atlas and other ICBM, IRBM, and space programs. The STL's role generated controversy, however, and, in several years, many functions in system engineering and technical direction would be taken over by the newly formed nonprofit Aerospace Corporation.

Development and deployment of such complex systems as the ICBM and future spacecraft required new management approaches. Concurrency, broadly understood as the parallel development and simultaneous completion of all of the tasks necessary for system development and deployment, became critically important. Bernard Schriever was among the pioneers of this emerging management concept when he advocated concurrency in a special Air Staff study in 1950.

Schriever's WDD grew, assuming later the responsibility for the Titan, Thor, and Minuteman missile systems as well as for the early military space programs, including the photoreconnaissance Corona satellite system. General Osmond J. Ritland became WDD's vice commander in April 1956. In June 1957, WDD was reorganized into the Air Force Ballistic Missile Division (AFBMD). Schriever built a unique military organization with a high level of education where “more than one third of the hand-picked officers held Ph.D.'s and Master's degrees.”

The Air Force assigned the highest priority to the Atlas program on 14 May 1954 and gave the full go-ahead in January 1955, with Convair's Astronautics Division in San Diego, California, as the prime contractor. Convair that had led the Atlas development was not entirely happy with the new arrangement that significantly downgraded its role in systems engineering and technical direction. Thus, the Teapot Committee led to a fundamental reorganization of the entire American strategic missile program. The Committee, in the words of General Schriever, “really pulled the cork and got the ICBM program underway” (Schriever 1972, 58).

The Western Development Division has been evolving and changing its names throughout the years. It became SMC in 1992.


About the Author: Prof. Mike Gruntman, Professor of Astronautics at USC Viterbi School of Engineering, astronautics; space missions; space exploration; space applications; spacecraft; rocketry; spacecraft propulsion; space physics; space engineering; space plasmas; space sensors; space and science instrumentation; orbital debris; interstellar flight; history of rocketry and spacecraft, missile defense; space education - https://en.wikipedia.org/wiki/Mike_Gruntman. Short courses on space systems (AIAA, ATI) to industry and (friendly) governments; AIAA Distinguished Lecturer

Expertise: astronautics; space missions; space exploration; space applications; spacecraft; rocketry; spacecraft propulsion; space physics; space engineering; space plasmas; space sensors; space and science instrumentation; orbital debris; interstellar flight; history of rocketry, spacecraft, and missile defense; space education; short course to government and industry

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(August 14) AIAA LA-LV Space Philosophy Gathering 2021


10:00 AM: Mr. Dan Dumbacher (AIAA Executive Director) - Welcome
10:10 AM: Prof. Madhu Thangavelu (Moderator) – "Introduction to Space Philosophy"
10:30 AM: Mr. Luke Jerram - "Museum of the Moon"
10:45 AM: Dr. Jacques Arnould - "Space Oddity? A brief philosophical meditation inspired by David Bowie"
11:00 AM: Mark Wagner, Ph.D. - "The Moon Village School: Challenges, Designs, and Expert Feedback"
11:15 AM: Dr. Gennaro Russo, Ph.D. - "The Cislunar City anticipated by the Center for Near Space"
11:30 AM: Prof. Christopher Cokinos - "Engineering the Arts for Space: Concept of "Mission Laureates""
11:45 AM: Atty. Michelle Hanlon - "Why Protect the Bootprints?"
12:00 PM: Mr. John C. Mankins - "The Space Technological Sublime"
12:15 PM: Dr. David H. Levy - "A Nightwatchman’s Journey: The Road Not taken."
12:30 PM: Dr. Niamh Shaw - "Beyond the Space bubble- the importance of engaging the disengaged"
12:45 PM: Ms. Britt Duffy Adkins - "Resisting a Static Space Society: Designing for Adaptability and Transience"
01:00 PM: Ms. Melodie Yashar - "Envisioning A First Peoples"
01:15 PM: Leslie Wickman, Ph.D. - "How the Awe-Response Triggered by Nature Stimulates Exploration"
01:30 PM: Mr. Frank White - "Overview Effect & Cosma Hypothesis"
01:45 PM: Dr. Stan Rosen - "Will Space Settlement Change Humans?"
02:00 PM: Lawrence (Larry) Downing, DMin - "Beyond Earth: The Human Venture to the New Frontier"
02:15 PM: Mr. Henk Rogers - "Why are we here? What is our purpose?"
02:30 PM: Ms. Ayse Oren - "Carving the Moon"
02:45 PM: Maj. Sean McClain - "Space Domain Awareness and In-Space Personnel Recovery"
03:00 PM: Prof. Wes Jones - "The Astronaut’s Memorial"
03:15 PM: Ms. Britt Duffy Adkins - "Resisting a Static Space Society: Designing for Adaptability and Transience"
03:30 PM: Concluding Panel (Added: Mr. Howard Bloom and Dr. Lawrence H Kuznetz)
04:00 PM: Adjourn

Dan Dumbacher, AIAA Executive Director, welcoming the international group and sharing his thoughts about the Space Philosophy.

Prof. Madhu Thangavelu (USC), a passionate introduction and opening the program.
(August 14) AIAA LA-LV Space Philosophy Gathering 2021

Prof. Madhu Thangavelu (USC) presenting "Museum of the Moon", for Mr. Luke Jerram, who could not make it.

Synopsis

- David Bowie - The Space Rocker
- Space Oddity – 1969 song year after Kubrick/Clarke Space 2001:
- Most Popular Space Song
- Curiosity – NewSpace – Space 2.0
- Constellation – Opposition – Consistency
- Space Barons – Branson VG, Bezos BO, Musk SpaceX – Inspiration mission
- Experience – Space Tourism for All
- Huge gap between experiencing Space and Colonies(Settlement)
- Escape Earth or Preserve – Climate Change
- SpaceShip Earth
- Isolality & Emergence of New Human -Oddity
- Cannot predict but Wilo (species) are heading out into IT

Prof. Madhu Thangavelu (USC) presenting for Dr. Jacques Arnould on "Space Oddity philosophy," inspired by David Bowie.

Dr. Mark Wagner, Ph.D. on “The Moon Village School”, explaining the importance and issues.

(Left) Dr. Gennaro Russo discussing "The Cislunar City anticipated by the Center for Near Space” and Space Economics;
(Right) Prof. Christopher Cokinos emphasizing the importance for Art to work together with Engineering and Science.
(August 14) AIAA LA-LV Space Philosophy Gathering 2021

Atty. Michelle Hanlon explaining her concept "Why Protect the Bootprints?" by citing several examples like migrations etc.

Mr. John C. Mankins sharing his idea of the inspiring "The Space Technological Sublime", quite insightful and fun.

Dr. David Levy explaining why the awe for the sky is crucial, sharing the exciting stories working with the Shoemakers for the Shoemaker-Levy 9.

Dr. Niamh Shaw presenting "Beyond the Space bubble- the importance of engaging the disengaged" and explaining her efforts in getting people involved and interested, which is also what AIAA/LA-LV has been doing.
(August 14) AIAA LA-LV Space Philosophy Gathering 2021

Ms. Britt Duffy Adkins on "Resisting a Static Space Society", telling people what her Celestial Citizens have been doing.

Ms. Melodie Yashar on "Envisioning A First Peoples", bringing up the key issues of how the first space pioneers would be thinking.

Dr. Leslie Wickman explaining the awe for skies and how the awe-response triggered by Nature stimulates Exploration.

Mr. Frank White presenting his views "Overview Effect & Cosma Hypothesis", citing Dr. Stan Rosen’s observations on overview effect from the '70s.
(August 14) AIAA LA-LV Space Philosophy Gathering 2021

Dr. Stan Rosen discussing the philosophical argument "Will Space Settlement Change Humans?"

Lawrence (Larry) Downing, DMin presenting his long-time thoughts on “Beyond Earth: The Human Venture to the New Frontier”

Mr. Henk Rogers hitting the core issues of the space-faring people, discussing “Why are we here? What is our purpose?”

Ms. Ayse Oren citing some of the Earth and Space architecture examples and discussing "Carving the Moon" for settling there.
Maj. Sean McClain on "Space Domain Awareness and In-Space Personnel Recovery", explaining how space inspired many activities.

Prof. Wes Jones sharing his thoughts on winning the "The Astronaut’s Memorial" competition and winning the contract to build it.

Prof. Madhu Thangavelu (USC) and Mr. Howard Bloom engaged in exciting conversations on the "Grand Theory", as well as the philosophical views presented by Dr. Bob Krone, who could only attend in the event but could not present in person.

Dr. Lawrence H Kuznetz, sharing his philosophical points on the Legacy of the Space Shuttle & more.
Prof. Madhu Thangavelu (USC) presenting on behalf of Dr. Bob Krone on his views of Space Philosophy.

Prof. Madhu Thangavelu (USC) summarizing and concluding the presentation session with very inspiring remarks, citing several important figures in how men and women have been thinking about space and moving toward it.

Some speakers remained in the event and joined the fun and informative panel discussion.
The Cislunar City anticipated by the Center for Near Space

by Dr. Gennaro Russo, Center for Near Space - Italian Institute for the Future, Napoli, Italy

1. Introduction

The era of the Humankind Expansion into the Space started already. The exploration action implemented for almost sixty years by NASA, Roscosmos, ESA and by an increasing number of national Space Agencies is highlighting the enormous fallbacks of space economy on the well-being on Earth. Though, its further evolution is tied to the development of private/commercial initiative, which will originate a commodity sector which we can name Made in Space.

It is CNS opinion that symbolically 100 years later than “the first step of a person out of the Earth” the cislunar space will be lived by a permanent community distributed in different quarters (or districts): a true Cislunar City [1], which will also be an intermediate or starting spot for scientific missions to Mars and nearby asteroids.

The development of the Cislunar City will require high comfortable habitat with areas for socialisation, physical activities, cultivation and food production, research laboratories and industrial activities which are necessary to make the city sustainable. To tackle this challenge, CNS launched a multicultural/multigenerational Orbitecture Working Group (WG) which involves scientists, technologists, architects, botanists, artists, sociologists, psychologists, etc., but also university and high school students.

2. The Cislunar City

The Cislunar City will consist of several separate units, with different dimensions: an archipelago of districts each one characterised by a prevailing (not exclusive) function. Everything is internally connected by a network of daily transports and also connected towards the outside (Mars, asteroids, etc.)

The concept of the Cislunar City as an “archipelago” of minor differentiated units allows its agile realisation in the time, facilitates successive aggregations, maintenance, management, substitutions units. It will be a simple and complex entity where autonomous administrations will coexist, which implies an effective coordination of the whole under (exempli gratia) the planning and urban management of the United Nations.

One of the main and most important inclusive study which is worth to run is to think of the Cislunar City as a whole to adequately balance the distribution of functions amongst its quarters. The development of a complex transportation system which may guarantee some 100,000 pax-equivalent/year is a key problem to face to minimise times and costs of the Cislunar City development process.

The development of the Cislunar City will require the definition of habitats in orbit and on the surface of our natural satellite which satisfy industrial and scientific research requisites, but also day-by-day needs. The communities of people dedicated to the management of quarters and their systems, their maintenance, engaged to take care of financial-economical aspects of living in space, will start a more general economical-commercial style of living which includes the need to host tourists or travellers.

It’s CNS opinion that these studies, projected in a sufficiently long time, may identify innovative requirements which the on-going space activities don’t perceive. On the contrary, once taken in consideration, they could help and support a better evolutive dynamics to make feasible an ordinary living in space better sustainable than the one of the International Space Station astronauts.

The basic assumptions to define the Cislunar City may be summarised by the following items:

• To limit the costs of transfer from Earth of structures/installations by reducing the mass to transport and implementing their construction in a condition of reduced gravity, both inside the pressurised modules (where also the production of food must be considered) and in the outside vacuum. Wide usage of Additive Manufacturing in the outside vacuum conditions will be applied;
The Cislunar City anticipated by the Center for Near Space

- To associate to the manufacturing in space utilising lunar, asteroid and terrestrial raw materials, a capability to assembly, integrate and accomplish functional tests in space, so to establish a true Made in Space;
- To adequately exploit the multiple advantages given by the reduced gravity condition to optimise the production processes;
- To look after conditions of living and working comfort, including the design and realisation of specific innovative clothing;
- To limit dependency on Mother Earth, maximising the principles of sustainability by taking care of agriculture, production of energy, fuels and in-situ constructions;
- To extend to Space the principles and concepts of Green and Circular Economy, beyond what’s has been already accomplished.

3. Characteristics of the Cislunar Space

The Cislunar City will be distributed between the Low Earth Orbit, the Lagrangian spots of the Earth-Moon system and the Lunar Low Orbit.

It’s worth to recall here some aspects and characteristics of these spots in Space. The Low Lunar Orbit suffers of the effects of gravitational perturbations originated by different sources among which concentrations of masses under the lunar surface (mascons) \[3-4\]. When a satellite transits over, the mascons may pull it forward, backward, to the left, to the right or attract it downward, with a direction and intensity which is dependent on the satellite trajectory. Without periodic orbit corrections, most satellites positioned on low lunar orbits would crash on the Moon.

With respect to the Lagrangian spots, L1, L2 and L3 are spots of unstable equilibrium. It is possible to keep the space system around the equilibrium spot over semi-periodic orbits called Halo. On the contrary L4 and L5 are spots of stable equilibrium.

4. The Quarters/Districts

The configuration of the evaluated Cislunar City is based on 12 quarters. It is natural and logical to think that their number is higher in the space surrounding of the Earth. On the other hand, it must be considered that 50 years are not really too many and the space stations, also private, which are thought of today and will be soon in operation will act as triggering spots or support settlements (a kind of country villas) for the development of the City quarters and not much more. These stations, as they are thought of today will be all of small dimensions and will host a limited number of people (<10).

Next, let’s talk of the Moon. It appears evident that the terrestrial gravity is a tremendous force which implies an unsustainable expenditure for each development far from the low orbit. The exploitation of resources outside the Earth is an indispensable element for the development of the Cislunar City. While the (solar) energy may be collected in whichever position in space, raw materials may be found on the Moon. That’s why it will be necessary to foresee several industrial settlements on the surface of our natural satellite, in LLO and space surrounding. Further engineering and economical efforts may allow to find raw materials also on asteroids which come in proximity of the Earth.
The Cislunar City anticipated by the Center for Near Space

So, it’s possible to consider the configuration sketched in Fig. 1:

- **LEO** 5 quarters with prevailing tourist, logistic, industrial functions
- **L1** 1 quarter, multifunctional interchange hub and starting station towards Mars or nearby asteroids, corresponding to the SpaceHub [6,7]
- **L4 e L5** 2 quarters with prevailing industrial function
- **LLO** 2 quarters with prevailing tourist and logistic function
- **Moon** 2 quarters with prevailing industrial function, one of which corresponding to LunaFab [8,9]
- **Research** The research units will be distributed in almost all quarters, with prevailing scientific activity corresponding to the specific quarter.

The analysis of the functions and the relative sizing make plausible the breakdown general picture reported in Tab. 1.

The quarters in the space will have a configuration similar to SpaceHub [6,7] (Fig. 2), i.e. planet-morph and rotating around their axis to generate conditions of partial gravity. Instead, the quarters on the Moon will be based on the “archaeological” approach to minimise the impact on the surface and dropdown costs/times of realisation [8].
The Cislunar City anticipated by the Center for Near Space

5. Macro-functions and Functional Elementary Units

The four main macro-functions which characterise the Cislunar City may be declined by the following general definitions:

- **Industry**: mining, refining to separate constitutive elements, fabrication of semi-finished products, production of components, sub-systems and systems; energy generation; production of fuels; …
- **Research**: material characterisation, identification of solid and gaseous primary components, potential applications; life science, astronomy; planetology; research in reduced gravity environment; …
- **Management**: management of the quarter, including supplies, maintenance, repairs, transport network towards the other sites of the City; communications; …
- **Resort**: hotel, lodging, common spaces of socialisation, cafeterias/bar, …

Each quarter, with its functional activities, will be organised as an adequate mix of elementary functional units. A tentative subdivision and characterisation of the functional elementary units is in the following:

- **Industrial Unit**
  - Mining equipment
  - Processing systems
  - Warehouses
  - Searching and drilling rovers
  - Systems for the extraction and storage of water

- **Research Unit**
  - Chemical analysis laboratory
  - Physical analysis laboratory

---

**Tab. 1 – Breakdown of main functions and personnel distribution within the districts of the Cislunar City**

<table>
<thead>
<tr>
<th>Zone</th>
<th>District</th>
<th>Main function</th>
<th>Population</th>
<th>Industry</th>
<th>Research</th>
<th>Management</th>
<th>Guests / Tourists</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEO</td>
<td>N. 1</td>
<td>Hotel</td>
<td>100</td>
<td>10</td>
<td>20</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N. 2</td>
<td>Hotel</td>
<td>150</td>
<td>15</td>
<td>30</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N. 3</td>
<td>Industrial Processing</td>
<td>80</td>
<td>40</td>
<td>15</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>N. 4</td>
<td>Industrial Processing</td>
<td>80</td>
<td>40</td>
<td>15</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>N. 5</td>
<td>Stazione di rifornimento e manutenzione</td>
<td>50</td>
<td>20</td>
<td></td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>L1</td>
<td>N. 6</td>
<td>SpaceHub</td>
<td>100</td>
<td>33</td>
<td>34</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>L4/L5</td>
<td>N. 7</td>
<td>Solar Power Station</td>
<td>35</td>
<td>10</td>
<td></td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>N. 8</td>
<td>Industrial Processing</td>
<td>60</td>
<td>30</td>
<td>10</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>LLO</td>
<td>N. 9</td>
<td>Hotel</td>
<td>100</td>
<td>10</td>
<td>20</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N. 10</td>
<td>Assembly and Warehouse</td>
<td>40</td>
<td></td>
<td></td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Moon</td>
<td>N. 11</td>
<td>LunaFab</td>
<td>120</td>
<td>60</td>
<td>24</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>N. 12</td>
<td>Industrial Processing; extraction and material processing (Helium 3, metals, silicon, …)</td>
<td>100</td>
<td>50</td>
<td>30</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

**TOTAL**: 1015, 250, 162, 273, 330
The Cislunar City anticipated by the Center for Near Space

- Characterisation test laboratory
- Biochemistry and Biology laboratory
- “Analog” laboratory for Deep Space travels

○ Management Unit
  - Control Room, i.e. general headquarter (local government)
  - Offices
  - Supplies
  - Warehouse
  - Infirmary / first aid
  - Crops
  - ECLSS (Environmental Control and Life Support System)

○ Resort
  - 1-2 person lodging units
  - Common spaces of socialisation
    - Cafeteria
    - Bar
    - Entertainment (playroom, movie room, meeting room, …)
    - Gymn
    - Rest areas
    - Green
    - Terraforming limited zone

○ General systems
  - Production (solar panels, nuclear fission/fusion) and energy distribution
  - Supply storage (water, fuel, …)
  - Telecommunication system
  - Shop for supply/maintenance of vehicles and transport systems
  - Moon landing platform and transfer vehicles
  - System of “biomass” wastes for the secondary production of methane (fuel, …)

6. The Transportation System

As already mentioned, we estimate that the Cislunar City will be served by a complex transport system capable of guaranteeing a flow between the various districts and to / from the Earth of the order of 100,000 passenger-equivalent per year. The system will be multimodal and modular, based on commercial vehicles. We believe it is plausible and balanced to forecast transport systems of 10 pax in average plus 9 tons of cargo, for a total of about 30 m$^3$ of payload.
The Cislunar City anticipated by the Center for Near Space

Taking into account the average number of people per district (85 units), it is correct to estimate one arrival and one departure per terrestrial-day for tourist districts, traffic that doubles for industrial sites and triples for logistic ones. This corresponds to an annual traffic of about 120,000 passengers and over 100,000 tons of goods.

The 46 daily departures/arrivals can be guaranteed by a fleet of 22 vehicles plus 5 (20%) assumed to be in rotation maintenance. In order to reduce (non-recurring) development costs, the 27 vehicles will all be the same (Fig. 3) with different engines. The average mass of these vehicles was assumed to be 40 Mg. Only in the case of launch from Earth, the “standard” vehicle will be associated with a first booster stage.

With reference to current technologies, the systems will have better performance and the "routes" (i.e. the orbital trajectories) will be faster thanks to greater fuel capacity and therefore greater availability of delta-V. We estimate that this increase can be of the order of 100%, summing up all factors. As a result, travel times on the various routes are reduced by approximately 25%. Taking these factors into account, the aforementioned fleet of 22 operational vehicles will be able to complete a full cycle of all routes in approximately 36 hours (1.5 Earth days), which corresponds to approximately 17 full cycles for each lunar day.

The fuel produced on the Moon will largely be used to satisfy the transportation needs for exploration missions to Mars, nearby asteroids and more starting from LLO/L1; it will also be used for missions within the Cislunar City to the neighborhoods in LEO and to the Earth. For departures from Earth, however, the fuel will obviously be supplied by terrestrial production.

The schematic and simplified map of the transport lines is shown in Fig. 4, where obviously each line is a more or less complex orbit.

![Fig. 4 Transports in the Cislunar City](image-url)
The Cislunar City anticipated by the Center for Near Space

The routes (orbits) will have very different characteristics depending on the various parameters involved and mainly the mass of the vehicle, the characteristics of its propulsion system (specific impulse, Isp) and the amount of fuel available. These last two elements define the thrust budget (or overall speed variation, V) with which the orbit manoeuvres are carried out. Considering the technological evolution that will take place in the next decades, an increase in performance of the order of 20% has been considered, together with a doubled availability of V, with a consequent greater possibility of orbital manoeuvres (accelerations/decelerations) which result in a reduction of travel times.

It is underlined that in the assessments made on the transport systems, special means that will be used for missions to Mars and nearby asteroids have not been taken into account. For these missions, which will remain essentially scientific, four departures per year from the Cislunar City can be estimated with a consumption of about 1200 Mg/year of LOX-LH2 or equivalent for other types of propulsion.

7. The Cislunar City Economy

The economy of the Cislunar City represents the value created by the activities of research and development, extraction of raw materials, processing/transformation and production, manufacture, use, services (maintenance, repair, tourism, health, entertainment, etc.) and current life of the 1000-person permanent population. A highly reliable, low-cost space transport system is paramount for the development of the Cislunar City.

The economy structure of the Cislunar City can be described by the following high-level tree structure:

Cislunar City - Economic Structure

- Transport System
  - Shuttles connecting Earth and LEO
  - Cislunare Metropolitan net (Cyclers):
    - Earth-Moon Circle (Cycler 1)
    - Lagrangian Circle (Cycler 2)
  - Shuttles connecting LLO and Moon surface
  - Refueling and Maintenance Station
    - Multifunctional interchange node. Departure station to Mars or nearby Asteroids
- Industrial System
  - Industrial Processing Sites
  - Industrial lunar Processing Site for water extraction & processing (fuel production)
  - Solar Power Station
  - Assembly and Warehouse
- Tourist System
  - Hotels
  - Resort
- Scientific and Technological Research System
  - Scientific Laboratories distributed in almost all districts
  - Exploration Missions towards Mars and nearby Asteroids
The Cislunar City anticipated by the Center for Near Space

Let's analyse the individual categories to estimate their economic representativeness.

*Infrastructures*

The most important space infrastructure ever built is the International Space Station, which cost around € 150 billion. We refer to it in the following, also considering that the future role of entrepreneurs will introduce cost reduction factors that will add to those linked to the increase of human experience in terms of activities and technologies.

So, by scaling the costs of the ISS as function of the ratio between the volumes of the ISS to those of the SpaceHub [6] and applying an overall cost-effectiveness factor of 40%, we come to an estimation of the cost of the SpaceHub at € 960 billion. The investment cost of the 12 districts can be obtained therefore also taking into account the different complexity of the individual settlements, as well as a small benefit deriving from the use of the same design for groups of neighborhoods. For example, the districts intended mainly for the tourist function (hotels) can all derive from the design of the SpaceHub. Thus, with this approach, we estimate the economic value of the infrastructures to be around € 6.9 trillion.

As for the annual cost, it is estimated a 2% value of the initial investment for maintenance and 1% for management. The investment is considered to be amortized over 50 years.

*Transportation System*

The cost of developing the transport system is estimated from available data. In particular, reference is made to SpaceX's Starship which is the largest commercial project currently under development, a transport system capable of carrying 100 Mg of payload whose development cost is indicated between 5 and 10 billion €. Considering the evolution of the technique and the transition from "one of the type" to a serial approach (albeit small), we estimated the non-recurring cost (NRC) of development at € 7.5 billion. The recurring cost of producing a single vehicle is estimated as 3% of the NRC. The total cost of the fleet of vehicles is thus about € 13.6 billion.

The annual cost is calculated as the sum of maintenance for 2% of the initial investment, management for 1%, as well as amortization considered over 25 years.

*Research System*

This item includes the costs of the researchers (162 units) distributed over almost all the districts, investments in various types of scientific equipment and operating costs. For simplicity, the cost of the sector is calculated parametrically, reaching a value of € 1.2 billion per year.

*Tourism System*

This item is also calculated on a parametric basis. Considering the constant presence of 330 guests and an adequate unit price of the entire package for each (terrestrial) day, a turnover of over € 24 billion is obtained. Correspondingly, an all-inclusive operating cost equal to 1/10 of the turnover has been assessed.

*Industrial System*

For this item, the costs were considered incorporated in the management and maintenance costs of the infrastructures; production costs have been estimated as 1/20 of revenues. For the latter, it was assumed that each of the 7 predominantly industrial districts is able to produce/process 2 Mg/day of raw material or pre-processed products. It is assumed 250 production days per year to take into account periodic maintenance times and various types of machine downtime, and conventionally evaluated everything at the common cost of platinum.

*Annual budget (year 2070) under present economic conditions*

In 2070 we can foresee a turnover of about € 370 billion, considering costs and revenues, as indicated in the following table.
The Cislunar City anticipated by the Center for Near Space

<table>
<thead>
<tr>
<th>Costs:</th>
<th>367,7 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructures</td>
<td>345,9</td>
</tr>
<tr>
<td>Research</td>
<td>1,2</td>
</tr>
<tr>
<td>Transports</td>
<td>1,0</td>
</tr>
<tr>
<td>Resort</td>
<td>2,4</td>
</tr>
<tr>
<td>Industry - production</td>
<td>17,3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Revenues</th>
<th>385,6 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transports</td>
<td>12,0</td>
</tr>
<tr>
<td>Resort (Tourism)</td>
<td>24,1</td>
</tr>
<tr>
<td>Industry</td>
<td>346,5</td>
</tr>
<tr>
<td>Film sets, Advertising and miscellaneous</td>
<td>3,0</td>
</tr>
</tbody>
</table>

**Global Space Economy growth, including the economy of the Cislunar City**

The accumulation over the years of economic flows up to 2070, linked both to the four economic chapters above strictly related to the cislunar economy and to the space economy on Earth, stands at about € 60 trillion according to the following table.

<table>
<thead>
<tr>
<th>CUMULATIVE ECONOMIC FLOWS AT 2070</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport System</td>
</tr>
<tr>
<td>§ Shuttles connecting Earth and LEO</td>
</tr>
<tr>
<td>§ Cislunar Metropolitan (Cyclers)</td>
</tr>
<tr>
<td>§ Shuttles connecting LEO and Moon surface</td>
</tr>
<tr>
<td>§ Refueling and Maintenance Station</td>
</tr>
<tr>
<td>§ Multifunctional interchange node: Departure station to Mars or Asteroids</td>
</tr>
<tr>
<td>Industrial System</td>
</tr>
<tr>
<td>§ Industrial Processing Sites</td>
</tr>
<tr>
<td>§ Industrial Lunar Processing Site for water extraction &amp; processing (fuel production)</td>
</tr>
<tr>
<td>§ Solar Power Station</td>
</tr>
<tr>
<td>§ Assembly and Warehouse</td>
</tr>
<tr>
<td>Tourism System</td>
</tr>
<tr>
<td>§ Hotels and Resort</td>
</tr>
<tr>
<td>Scientific and Technological Research System</td>
</tr>
<tr>
<td>§ Distributed Scientific Laboratories</td>
</tr>
<tr>
<td>§ Exploration Missions towards Mars and nearby Asteroids</td>
</tr>
<tr>
<td>Space Economy on Earth</td>
</tr>
</tbody>
</table>

Sub-Total 44,5

TOTAL 59,5 Trillions €

Taking into account the estimates by the China Aerospace Science and Technology Corporation (CASC) [14] and by US United Launch Alliance [15], projecting economic development up to 2070 according to anticipation profiles, at the CNS we estimate an economy of 2 (2040), 9 (2050), 28 (2060) and € 59 trillion in 2070, as shown in the following figure.
8. Conclusions

The development of the Cislunar City will generate enormous economic benefits not only for its own development, but also to support and perhaps as a new guide for the development of the economy on Earth. The Center for Near Space believes that the economy linked to the Humankind Expansion in Space will most likely represent the new great cycle of development, or the next industrial revolution. The evolution of this cycle will have to be verified both in terms of overall duration and evolution of the degree of diffusion. Assuming a qualitatively similar trend to previous major cycles (see Fig. 5), the Era of Space Industry could reach full maturity within the first half of the next century.

![Fig. 5 – The Great Cycles of World Investment and Development [10]](image)

This would lead to even more substantial economic developments than indicated in this article.
The Cislunar City anticipated by the Center for Near Space

Acknowledgement

The author wishes to tanks of those friends and colleagues who contributed to the thoughts and elaborations given in this paper, namely members of the CNS working group OrbiTecture: Giuseppe De Chiara, Guido De Martino, Stefania De Pascale, Anass Hanafi, Veronica Moronese, Piero Messidoro, Massimo Pica Ciamarra, Claudio Voto, Caterina Arcidiacono. For SpaceHub: Mattia Barbarossa, Roberto Chiaiese, Alessandro Concas, Luca Mastroia, Altea Nemolato, Dario Pisanti, Aurora Martina Russo, Giampiero Martuscielli, Valentino Scalera, Vincenzo Torre. For LunaFab: Salvatore Albachiara, Deborah Buonafine, Anselmo Cecere, Matteo D’Iorio, Raffaele Menichini, Pietro Di Sarno, Michele Nigro, Silvia Molinini, Emanuele Palomba, Fabio Paudice, Lorenzo Pavone, Davide Pederbelli, Marco Penta, Pasquale Scognamiglio, Marco Sorito, Raffaele Sparago.

References

[14] Zhang Yulin, “From the center of the earth to the space of the earth and the moon”, People's Daily, 8 May 2019
Beyond Earth: The Human Venture to the New Frontier
by Lawrence (Larry) Downing, DMin, Retired after more than 40 years as a parish minister serving Seventh-day Adventist churches on both coasts

The lighted candle that propels an alien vehicle and its cargo out toward infinite Space is evidence that human endeavor has created a system that forever changed how we understand Earth, our home for multiple millenniums, and the cosmos of which Earth is a part.

Within us lie forces that nudge us to reach beyond the boundaries that define and confine our activity. Historians, sociologists and others of their kind have sought to tease out what drove those from an earlier time to test their abilities and prompted them to set out sans reliable charts, instruments and base support to experience and explore Lands Beyond.

Today, when a space craft leaps toward the stars the technological gadgets packed within that craft boggle the mind. The humans aboard, surrounded by all the wonderments, may be an interesting attachment, but, in fact, the human is not infrequently termed a passive interloper; not an essential component to the mission.

Settled snug among the engineered parts and systems the human presence, from our perspective, makes all the difference in the world. It is the human factor that excites and thrills the soul and catches firm our attention. The human, unlike fabricated contrivances, has the ability to observe, reflect on what is seen and how that may impacts our understanding of the universe. This process is the seed bed to generate and test as yet unknown concepts.

Questions begin to form. Conclusions are reached, some discarded, others incorporated into one’s world view.

Frank White’s The Overview Effect: Space Exploration and Human Evolution records his interviews with astronauts pre and post-flight. What comes clear is this: the perspective from Space had a profound impact on all who viewed Earth and the cosmos from a vantage point few have witnessed. Questions percolated through consciousness that sought answers. There were times of doubt, feelings of isolation. Struggles to tease out meaning and purpose for life. Thoughts of beginning and thoughts of termination. It is reasonable to assume questions like these will arise from others who inhabit Space. Machines will not provide answer. The human factor has pertinence and purpose as humans soar toward the Beyond.

By tradition, major events call for some form of ritual. Who will fill that role? What training or experience will initiate appropriate action initiated in response to meaningful events, secular or religious.

Those who design and monitor journeys that reach toward Space do well to consider how best to provide meaningful response to the events, beliefs and practices that await passengers and crew. Expect there will emerge concept and theory to shake one’s soul. Who will be present to support and guide through troubled times?

We can expect marriages to occur. A woman may get pregnant—yes, birth control will be prescribed but are not failsafe—ask your local obstetrician. Sterilization may not be a welcome solution. Who will be assigned to provide support?

Disruptions between and among passengers or crew are to be expected. Disagreements may escalate to dangerous levels. Divorce is possible. Who will have the skills to mediate?

Should someone die or an infectious disease surface, the effect on the community may be swift and hurtful. People do not venture into space to die. When death occurs, what is the protocol? A slot on a space vehicle or other form of disposal for those who die in space? Will it be that the deceased will join with other orbiting bodies?
Beyond Earth: The Human Venture to the New Frontier

When humans venture Beyond Earth it is reasonable to expect those who inhabit Space will value the arts, entertainment, literature, music, associating with others, and recreational activities. All of these practices and innumerable others like them are part of our humanness.

The challenge for those who plan, implement and monitor the Space Ventures is to nurture the qualities that enhance our unique qualities. Resist with vigor the Spockian ideals. Societies and countries have attempted to function by enforcement of strict rule, cold logic and lock-step obedience. The results have been catastrophic to those who resisted the mandated thought or behavior.

The authors of Hebrew and Christian Scriptures and other ancient documents describe places and events that take the reader to venues far removed from Earth. The writers describe scenes that occurred in worlds far removed from ours with the same ease as we describe events next door.

The human inhabitants of heavenly places, as reported by both sacred and secular writers, were plagued by the same insecurities, jealousies and frailties that afflict us today. The Gilgamesh Epic, reports how Gilgamesh, the hero of the 2nd millennium BCE Akkadian flood myth, survived a world-wide deluge. Fear, doubt, bravery and eventual triumph over natural events were part of the story. In the end, when the waters subsided, the survivors were accepted by the gods.

The first inhabitants of a space community will encounter challenges far different than humans have ever encountered. Not the least part of the puzzle relates to the question: How can those who journey beyond Earth create a society that will benefit all and how will that society be maintained? These questions and others like them, transport us from the realms of science and verification into the fuzzy venues of philosophy, epistemology, morals, ethics, faith, hermeneutics, religion and anthropology. Will such philosophical quests evolve into a new religion or belief system? These questions and others await answer.

Numerous terms have been created in an attempt to identify the mysterious powers that lie deep within the human mind. In Hebrew that force is ruach. In Greek: pneuma—from which our word pneumatic derives.. In English we speak of soul, spirit, breath. Whatever term is selected, there is brought to fore life’s mystery. It is our task to protect and nurture that powerful force that alone is ours.

It is not possible to predict with accuracy what life will be like for those who first establish a self-perpetuating presence Beyond Earth. What we can predict, with some degree of accuracy, is that challenges that test our abilities will continue; some expected, others not. Likewise, we can expect human nature to evidence itself in the far-off places in a similar manner to that which we now experience on Earth.

There will arise situations where greed dominates, violence breaks forth and other maladies that impact our Earth lives will be evident. Likewise, we can expect to find acts of extreme kindness, unselfishness, care and other positive human responses. The existential questions will continue, perhaps even intensify: Why am I here? What is the meaning of my life? Why evil? Why destructive behavior toward others? Why do I behave as I do? When I die, what awaits? The response to these questions, and others like them, will provide the framework upon which an ethical and moral value system rests and from which viable belief systems arise.

Components of our humanity serve to remind us of why it is essential that those who venture beyond Earth promote and practice ethic and moral systems that value good over evil. There will be respect for those who practice a faith system that meets their spiritual and emotional needs and an assurance that people who inhabit far-Space can live in accordance with their conscience, in so far as that belief promotes the good. These principles will not assure a successful sojourn, but without them, one can expect eventual failure.

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Engineering the Arts for Space: Developing the Concept of "Mission Laureates"

Prof. Christopher Cokinos, Professor of English, Affiliated Faculty, Arizona Institutes for Resilience
Affiliated Faculty, Social, Cultural and Critical Theory; Mentor, Carson Scholars program; University of Arizona

The term “laureate” refers to someone who receives an honor, deriving from the Ancient Greek tradition of placing a laurel wreath on the head of the honoree. The laurel tree was sacred to the god Apollo, patron deity of poets. More recently, countries such as Great Britain and the United States have had offices of poet laureates, a tradition that has spread to states, cities and towns.

Here I want to argue for a new kind of laureate, one attached not to a region but to a mission, specifically missions to space.

The arts have long been engaged with astronomy, the night sky and, more recently, with space programs—consider NASA’s famed fine arts program that placed painters and illustrators such as Norman Rockwell and Robert Rauschenberg in the middle of launch facilities, training and more. There is of course a long tradition of “space art,” first popularized by Chesley Bonestell. Fine arts photographers such as Michael Light have given their craft over to space imagery. As well, many writers have turned their attention to space, from Oriana Fallaci to Margaret Lazarus Dean. As co-editor of Beyond Earth’s Edge: The Poetry of Spaceflight, I know that poets have responded vigorously—if not always enthusiastically—to the Space Age.

If we are to continue to inspire the wider public, the space community needs more organized approaches to positive artistic engagement with missions and science. We need more than science-communication Tik-Toks, though they too have value, and we need to expand artistic participation across multiple disciplines and not rely mostly on the visual artists as has traditionally been the case.

Later this year I hope to discuss these and other ideas in greater detail for a presentation at the Moon Village Association conference. Here I want to concentrate on one specific suggestion for increased systematic arts engagement in space activities: mission laureates.

I’d like to argue for the benefits of including artistic participation—poetry, music, visual arts, dance and more—as part of every mission’s public outreach. My vision is one in which every NASA mission has an arts laureate who writes poetry or composes songs or paints watercolors or performs music as part of the public engagement process. This need not be expensive nor time-consuming—poets, for example, are used to being underpaid; I know, I am one. But for minimal investments mission laureates would create lasting and inspiring art works that are more than value-added: They will speak to the human passion for creation, whether of villanelles or data. Mission laureates should be an integral part of space agency public outreach.

In part I have decided to promote this concept after having been inspired by the upcoming lunar rover VIPER, for which I wrote a sonnet. I gave the poem to the mission team as a gift. It’s theirs to use in any way that might engage the public. But that was a one-off, individual effort. More systematic approaches are needed, now more than ever as we enter a new golden age of space activities. Science-driven, factual, lyrical work about space missions—crewed and robotic—should be integrated into each project’s public outreach. For relatively little effort, NASA and other agencies could see a range of long-lasting, public-facing artwork—from sculpture to essays, from digital art to dance—that will humanize space exploration and valorize something that both art and science share: curiosity and a sense of wonder.
An Evening with Stratolaunch (with Dr. Zachary Krevor, Col. Evan "Ivan" Thomas, and Mr. Mason Hutchison) including an overview of the aircraft and the Flight 02 recap

(Screenshots only) [https://youtu.be/5ve6ysOqkhx](https://youtu.be/5ve6ysOqkhx) (YouTube); [https://rss.com/podcasts/aiaa-losangeles-lasvegas/266244](https://rss.com/podcasts/aiaa-losangeles-lasvegas/266244) (Podcast)


Dr. Zachary Krevor (COO, Stratolaunch LLC) opening the program, also talking about the history from Mr. Paul Allen's time.

Mr. Mason Hutchison (Lead Engineer)(the one on the top level of the scissor lift in the left picture), talking about the challenges.

Col. Evan "Ivan" Thomas (Director, Flight Operations) talking about the 1st and 2nd flights and safe landings.

Many good questions/comments in the Q&A session, lots of fun and delightful networking and Interactions as well. Very inspiring.
James Webb Space Telescope and LA Gauge – A Small Company on a Big Project

by Julian Bailinson

When it launches at the end of October, NASA’s James Webb Space Telescope (JWST or Webb, for short) will be the most advanced piece of optical equipment ever sent into space, far surpassing the capabilities of the Hubble Space Telescope (HST) which came before it. Unlike the HST, which sits at approximately 340 miles[1] from the Earth’s surface, the JWST will be positioned at the Earth-Sun L2 Lagrange Point, almost 4 times as far away as the Moon[2]. Here it will co-orbit the sun at the same speed as Earth. Facing towards our local star will be a massive sunshield, an accordion-file stack of foil sheets that will protect the delicate equipment from the harsh, unfiltered light shining on it. This will be absolutely crucial, as the Telescope needs to be as cold and dark as possible to perform its main function: to see the oldest light still traveling in the universe. To detect this ancient information, it will make use of a segmented primary mirror, an enormous feat of optical engineering. The mirror is a futuristic honeycomb made of 18 gigantic hexagons, precisely machined from pure beryllium and coated in gold, then painstakingly aligned over the course of months to create one gigantic, super-effective spyglass for peering back in time[3].

LA Gauge was one of many aerospace design houses and manufacturers that were involved in Webb’s creation. Working at LA Gauge, a highly specialized beryllium machining shop in Sun Valley, California, I had a unique opportunity to understand what it means to be one of the small companies that contributed to one of the largest projects in Aeronautics history. Not only that, but a select few members of the company were taken to the Northrop Facility in Redondo Beach to see Webb before it was finished with testing. I spoke to company President Jyot Bawa and Lead Engineer Tony Ruiz about this experience and their feelings on being a part of the project as a whole. Additionally, I spent some time learning about Webb from people on the project at NASA: Michael McClare, the lead for all official media on the mission, and Sophia Roberts, a media director and producer whose behind-the-scenes series about the construction of Webb allowed LA Gauge to see it in all its glory before it left the planet.

A LITTLE BACKGROUND

I first asked each of them a simple question: what is it like to see Webb in person?

“Wow, this thing is huge. It is incredibly…sophisticated, and in a way- and this is me as a pedestrian- delicate.” -Jyot Bawa, LA GAUGE

“[I]t’s pretty awesome to be able to see it.” -Tony Ruiz, LA GAUGE

“[T]he mirrors are gold and the sun shield is silver and it’s just that silver and gold that’s beautiful to see.” -Mike McClare, NASA

“[Y]ou open up a door and suddenly it’s just there. Honestly, my heart fluttered a little bit. It’s beautiful.” -Sophia Roberts, NASA

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Indeed, the James Webb Space Telescope is very pleasing to the eye. The shining silver sunshield creates what appears to be a giant life raft to keep Webb afloat in space. Atop that is the golden mirror, a massive array possessing a reflector that makes it look more like a laser cannon than an observatory. The form is impressive enough, but it does not communicate the true grandeur of the device until you get a sense of its scale. “It’s huge,” says Mike McClare, “and it’s in a very big clean room, and once it’s in there, unless you have a person kinda standing next to the telescope, you really don’t get a sense of how large it is. It’s impressive.” The mirror alone, when fully extended, is 21 feet across, and the sunshield comes in at 72 feet by 32 feet[3]. For comparison, the Hubble Telescope’s already-impressive mirror is just under 8 feet in diameter[1].

The construction of Webb, while visually striking, is entirely a matter of function. Its express goal is to see back in time to the very earliest light sources in the universe, including the very first stars and galaxies that formed, hopefully unraveling some of the mysteries about where we came from and how. To do this, it takes full advantage of the infrared light spectrum, the range of wavelengths just too long to be seen by the naked eye. Webb’s infrared capability is one of its huge advancements over Hubble; the HST is primarily geared towards seeing in visible and near-ultraviolet light[1], which have shorter wavelengths, but this limits how old the objects are that it can observe. This limitation is due to the phenomenon of Cosmic Red Shift, wherein light wavelengths get longer the further they travel due to the expansion of the universe. According to Mr. McClare:

[1]It’s very similar to a Doppler Effect with sound, so when an ambulance is moving towards you the pitch is very high, and when it’s moving away it goes down. Same thing happens with light, but we have a little bit different thing happening in the universe, and that’s that the universe is expanding, and light from objects that are very distant, they’re moving away from us faster than objects that are closer. We call that “Redshift,” and so the farther an object is, we give it a different Redshift value, and I believe the farthest value is a Redshift of -12. So that means it’s about 12 or so billion lightyears away.

This is referred to as “Redshift” because it causes shorter wavelength visible light to extend and thus appear more red in hue than it did originally (red being the longest wavelength visible color). When traveling over distances on the order of 12 billion lightyears, the light wavelengths extend so much that they pass below the visible spectrum and into infrared. These are exactly the magnitudes of distance that Webb must account for when searching for the first starts and galaxies to have formed in the young universe. Thus, to view this ancient, heavily-redshifted light, it is imperative that Webb be able to see in infrared.

Many aspects of the JWST are designed entirely around capturing the infrared spectrum better than anything before it. First, its position at the Earth-Sun L2 is notable, as infrared is generally absorbed and emitted by the Earth’s atmosphere, so the further away the telescope is, the better[2]. Second, the gargantuan sunshield is needed to protect its infrared-sensitive instruments from being blown out by our sun. Not only does it need darkness, but it needs cold; “[It’s] going to work down in temperatures very close to absolute zero… 30-50 K,” (Or about -370° Fahrenheit) says Mr. McClare. This temperature will be achieved on the mirror side of the telescope, while the sun-facing side will be at a balmy 342 K (185°F)[2]. Third, the striking array of golden honeycomb mirror plates is tuned especially for seeing infrared light. Instead of one single-piece mirror, Webb uses 18 individual panels, each approximately 4.3 feet (1.32 m) across and arranged in such a way that they can form one 21-foot (6.5 m) mirror, nearly 3 times the size of Hubble’s primary mirror[3]. The main advantage of a mirror constructed in this way is that it can be folded for transport, thus making it possible to have a craft with a much larger capturing surface (which better suits it to seeing older, dimmer light) that can still be launched in a cost-effective manner. The mirror’s immense size allows it to obtain as much light as possible, and the gold coating helps reflect the infrared spectrum in particular.

The construction of the panels is impressive in and of itself. The process for polishing them was an arduous one, according to Mr. McClare:
James Webb Space Telescope and LA Gauge – A Small Company on a Big Project

To get [the mirrors] polished correctly, we had to polish them incorrectly at room temperature and then put them in a special vacuum chamber and freeze them down to that operating temperature and then do what we call “metrology,” testing to make sure it is polished correctly. And if they [aren’t], we have to make note of where those issues are, bring them back up to room temperature, polish them again incorrectly, and then freeze them and do a test to make sure they’re right.

Ms. Roberts adds about the test chamber:

[The telescope] had to be moved on to Johnson Space Center in Houston, because they have that cryo-vacuum chamber. It’s actually in Chamber A, which is where the space capsules were tested, so it’s really cool. Not only does it look really cool ‘cause it has this 40-foot wide, perfectly circular door, but... the historical nature of it is really awesome.

While needing to be made incorrectly according to a calculation of how it would respond at operating temperature, the gold coating also needed to be incredibly smooth to create a proper surface. Mr. McClare states that “[t]hey are so smooth and polished that if you enlarged one of those mirrors to, let’s say, the size of the United States, the highest “mountain” on the mirror would be the height of a dime. They’re super smooth.”

A question I posed to Mr. McClare came from an outsider’s perspective: will the pictures look any good if they’re entirely in infrared? What kind of images will we be getting? He reassured me that not only can Webb see further back in time than Hubble, but its images will be of comparable or better quality:

They’ll be beautiful; the resolution on Webb is greater than that on Hubble, we’re capturing more light with that larger mirror, so our resolution for our images is gonna be fantastic. So if you’re thinking ‘Oh, we’re gonna get these kind of muddy-looking infrared images of these things,’ we’re not. We’re taking the same kind of photography that we would do in regular light, and we’re just shifting it all over to the infrared, so the pictures will look fantastic.

Picture taken by Sophia Roberts underneath JWST’s mirror. Per Ms. Roberts: “Here is that favorite photo of mine when Webb was ‘cup down’. The camera lens is wide, so it’s a little tough to tell, but we are just a few feet away from the mirrors. The black part of the picture is the AOS, that was just maybe 2 ft off the ground. It’s the closest I’ve been to the telescope, close enough I needed to be grounded to prevent any electrical charges from jumping from myself to the telescope. I had to crawl to get to into that area.”
James Webb Space Telescope and LA Gauge – A Small Company on a Big Project

THE BIG AND THE SMALL

The James Webb Space Telescope promises to be an incredible feat, the product of international efforts in engineering, planning, and commitment to studying the universe. Ms. Roberts says:

[I]t’s really awe-inspiring... in my opinion, working on space-related things is one of the most optimistic things that humans do. It takes the best minds and it requires international collaboration and collaboration across scientists and engineers over the world to do something that’s... grand enough to be put into space.... [A] spacecraft I think is really truly the embodiment of the human spirit and... feeling optimistic about the future.

About the sheer scope of the project and his involvement, Mr. Bawa at LA Gauge states:

I’m just grateful that I live in a time where I get to see things like this.... So that was very cool, to be like ‘Wow, humans are quite incredible when they focus on an objective.’ And so to see something that colossal... for exploration purposes... [and] yes, it’s being built to answer certain questions, but... also a big piece of it is ‘Let’s just get out there and see... what we see....’ I just find that very exciting and I’m very grateful that I get to see a version of us doing that.... [W]hat’s interesting to me also... when I saw it is the amount of precautions that are being taken... in how it’s set up, and the idea that this assembly happened in so many different places, and even once it’s assembled, it has to go on a boat, it has to travel over land and over sea to an island... and then it needs to be launched... and all these things need to be taken care of. It just really... brings it to life when people talk about... quality control.

Stepping back from the grandeur, however, provides a look at how such a project is tackled by one of the contractors helping with it. Mr. Bawa says:

It is very, very easy for us, in the day-to-day, to forget... to need a reminder. We focus so much on schedule, or quality, or something very particular... the numbers, just anything.... Especially with the long lead times associated with producing these parts, and then after we produce it, we don’t hear anything for a very long time, in many cases.

Mr. Ruiz, as an engineer at LA Gauge, has a very interesting perspective on his involvement:

[I]t’s almost like anything else, I mean we make a lot of parts for a lot of different companies.... [So] to the extent of just fabricating it... applying your craft at what we’re doing here specifically is always pretty consistent, right across the board.... the way we approach almost everything is like ‘Okay, we’re making parts that are critical,’ and we apply that same skillset across the board... we try and approach every job like it is a part of something that’s going into space.... [W]e try and... not compromise how we do things and the quality.... [W]e try and perform at a certain level always, and that... quality doesn’t change.... We use the same standard. That’s the thing, and it’s a high standard.

On a day-to-day basis, working on such a project is no different from any other. But after the work has been done and the final product built, then there is time to think about the meaning of the work and what feelings it elicits. Per Mr. Bawa:

[T]he idea that LA Gauge is involved with these kind of end applications is very motivating and invigorating. It makes me very proud about what we do... [and] that what we do matters.... [T]o be reminded of the ‘why,’ like why we even exist in the first place, this is... probably the best reminder, is to actually see it in action.... I’m very proud of the fact that we can contribute to that kind of end application.... [I]t brings a lot of meaning to our work.

This pride and meaning came to the forefront when members of the LA Gauge team were allowed to see the James Webb Space Telescope on full display before it left the planet. Mr. McClare says of their visit:

[W]e were very happy to share the fruits of their labors with them.... When they got there, everybody was just floored. It’s a beautiful thing to see, and to know that they had a hand in building some of the components, that was a lot of fun to see. Their reaction was wonderful.... I’ve been on the project since 2009, and I really try hard not to
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get jaded, but after seeing it over and over, you can’t help but [go] ‘Oh ya know, it’s the telescope again.’ But when you see people who haven’t seen it before, especially the folks who have worked on it and haven’t seen what it looks like at the end, that’s impressive. I really enjoyed just seeing that perspective again, fresh eyes on it, reminds you just how special this spacecraft and this mission is.

Indeed, the experience of working on Webb for a small company is one that does not truly set in until long after the machining is done and the components shipped. The process of making the parts is like any other; not to say that the parts are not cared for, but rather that the same extraordinary care given to components destined for Webb is given to parts going to any other project, space-faring or not. Treating it as a normal job can help to minimize distraction, supposition, and favoritism. But once that project is finished and presented, all of the emotions come to the forefront. The sense of awe, the wonder, the pride of being a part of something this immense and talked-about. After the hard work is done is the time to step back and take in the meaning of what has been accomplished.

IT’S ELEMENTARY

The genesis of LA Gauge’s opportunity to see Webb planet-side is the miniseries being produced by Ms. Roberts with assistance from Mr. McClare, called “Elements.” In Ms. Roberts’ own words:

[T]he point of the series is to take sort of a Material Science look at why we chose the materials that are on the telescope. So there are some really key things that have to happen in order for there to be a successful mission: it needs to be lightweight, it needs to be able to hold its position really well, it needs to be able to withstand being very cold and stable in those cold temperatures. So beryllium checks all the boxes for these parameters. Actually, I was really excited to hear about LA Gauge; I had been trying to figure out who I could reach out to that works with beryllium.... And then LA Gauge really just rolled out the red carpet for us. It was so wonderful.

On the specific episode that LA Gauge assisted with:

For this episode, my primary goal was to show that beryllium is... one, very strong, so it’s six times stiffer than steel. The second major point... that it deals with cold very well. So, under a certain temperature it stops shifting.... Very material changes to some degree with temperature change. Molecules sort of spread out and move faster when they’re hot, and they sort of condense and don’t move as quickly when they’re cold. And [beryllium’s] rate of change is very small.... It’s also very lightweight.

On the overall experience of visiting LA Gauge to film:

Honestly, I was so surprised at how much they were willing to do for us. We [came] in with a bunch of gear, and they were so hospitable, it was really lovely. Everyone came out and we’re trying to get these various shots, I’m trying to get my lines.... [but] they just really allowed us to do... within reason what we asked, which was lovely. They pulled out a scale, [and] I was able to... show the weight differences between aluminum and beryllium. We plopped it in dry ice and I did some very poorly done measurements to show that beryllium shrinks less than aluminum. They allowed me to pick up a block... with gloves... staying safe, and... also getting shots walking through the shop, just showing the process and what it is. And you know we’re walking in people’s workspaces... with cameras and things that are oftentimes uncomfortable for people to be around because... suddenly you become so self-conscious, and everybody just rolled with it and [it] was really nice.

And thus LA Gauge was allowed to see Webb before it was packed away. Mr. McClare says: “Mostly I felt... after we went out and did the work at LA Gauge, that they really deserved the opportunity to go see [the telescope].”

ON THE ROAD TO THE AIRPORT

Now, in September 2021, Webb is finally out of the testing stage and has been approved for flight. No longer on full display, it has been folded up and made ready for its journey to space-- an adventure that begins all the way back at Northrop Grumman. Per Mr. McClare:
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[W]e are transporting it by ship. So there’s a special cargo container called the... STTARS, and it stands for Space Telescope Transport Air Road and Sea. It’s a large white container.... [W]e fold Webb up into its launch configuration and we place it into this container, and that is driven across the road. So it goes from the Northrop facility to the Los Angeles harbor and it is loaded onto a ship that the company Arianespace uses, and they’re the one that makes the Ariane 5 rocket [Webb’s launch vehicle]. So it’s going on their ship, and it’s going to take about 21-ish days to go from Los Angeles through the Panama Canal to Kourou [French Guiana], and then it’s taken off the ship in Kourou and driven up to the launch facility for what we call “Spacecraft Processing.” It goes here, it gets checked out to make sure it survived its sea voyage, and then it gets placed into the rocket fairing here and kind of closed up, and then the fairing gets placed on top of the Ariane 5 rocket, and then it gets rolled out to the launchpad, and then they launch it. So once it leaves Northrop, it’s kind of on its journey to space. That’s the beginning of its road trip to get to the airport to take it to space.

Once launched, Webb will travel the 930,000 miles to its post at the Earth-Sun L2, where it will begin the arduous setup and calibration process. According to Mr. McClare:

[A]fter launch, there’s about 14-20 days that [it’s] going to take to actually unfold it on orbit, and then after that, it’s going to take another 3 or 4 months to perfectly align the mirrors and allow all the instruments to cool to the right temperatures before we start doing science. So it’s probably going to be 5-6 months after launch that we’re going to get that first [image].

He makes sure to add that the long wait will be entirely worthwhile:

It’s going to most likely do what Hubble did when it was put in orbit; it completely rewrote our idea of the universe, and I believe that Webb will do the same thing.

The James Webb Space Telescope is the product of over 20 years’ labor on the part of engineers, scientists, manufacturers, and many others to create the most advanced infrared observatory ever. For LA Gauge, as one of those manufacturers, the experience as it happens is solely that of performing a job: meeting design expectations, ensuring quality, and shipping completed and reliable products. After this, however, there is time to reflect on the gravity of the work that has been done. It is then possible to step back and look at the scope of the project that they have contributed to, and the questions that they will help answer: Where did we come from? How did we get here? What’s out there? Furthermore, upon getting to see the physical enormity of the device that they helped create, the work takes on a new meaning, and this meaning comes with an enormous sense of pride, not only in their own work, but in the work of all involved, and the optimism and human ingenuity that it represents. This realization of the impact that one small company’s work can have on such a huge project is put succinctly by Mr. Bawa:

“Wow, what we do matters.”

Biography

Julian Bailinson is Contracts Lead and Technical Writer at LA Gauge Company in Southern California. When not researching massive extragalactic objects that are billions of years old, he keeps things more contemporary by performing with the 1960s Garage band The Lost Mynds.

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COVID-19 U.S. Mortality and Infection Trends

by Daniel R. Adamo (adamod@earthlink.net), 2021 August 30

(Three addenda to the original article in the AIAA LA-LV 2020 October Newsletter)

19 November Addendum

If the COVID-19 pandemic teaches us anything beyond patience and perseverance, it is to assume nothing about the disease without empirical data substantiating a conclusion. For example, consider mask-wearing by the general population as a means to prevent new COVID-19 infections. Early in 2020, this practice was generally discouraged because surgical masks were in short supply and needed by front-line medical workers who were most at risk. By March 2020, however, it was realized COVID-19 spreads primarily through respiration (even by infected individuals who are asymptomatic), sneezing, or coughing. In addition, it was demonstrated this spreading could be dramatically reduced by wearing homemade multi-layer cloth masks over the nose and mouth when social distancing measures were not possible. Until recently, cloth masks were viewed only as a means of preventing infections from the wearer to others. In November 2020, the CDC began informing us that an uninfected mask-wearer is also protected to an appreciable degree from being infected when exposed to COVID-19.15 For those readers old enough to remember, these epiphanies are playing out much like our knowledge of Acquired Immune Deficiency Syndrome (AIDS) in the 1980s.16

Keeping our still-evolving appreciation of wearing a mask in mind, consider recent developments in the quest for a safe and effective COVID-19 vaccine. In November 2020, the first solid effectiveness evidence is becoming available for such a vaccine. Although preliminary effectivity rates exceeding 90% have been reported, supporting data have yet to undergo formal peer review. Furthermore, widely supplying and distributing a safe and effective vaccine to correctly prioritized recipients is a complex and politicized process unlikely to conclude before 2022.17

Assuming a significant portion (think 60% or more) of the U.S. population is willing to undergo COVID-19 vaccination, there is hope our country could thereby achieve the "nirvana" of herd immunity to put the pandemic behind us. Evolved mask-wearing experience should temper our vaccine optimism in this context as well. No COVID-19 vaccine has been demonstrated to provide anything like 90% effectivity for all major demographics over intervals longer than a few weeks after administration. We are only now beginning to understand the duration of a natural immune response in humans who recover from COVID-19 infection.18

The current pandemic continues to exhibit infection "waves" over time in a manner very similar to the so-called Spanish influenza of 1918-19.19 As the winter of 2020-21 approaches, we appear to be entering the third and most severe COVID-19 wave thus far. Figure 12, an update to Figures 9, 10, and 11, illustrates the onset of this third wave in relation to its predecessors. We

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can only hope the current, most daunting surge of infection is also the last of this pandemic, as the third wave was a century ago.

Figure 12. Slopes for progressively later or "sliding" 14-day linear fits to cumulative U.S. COVID-19 infections are plotted as a function of each fit's ending UTC. For example, the last point on 19.0 November UTC is the slope of the fit ending on that date and beginning on 5.0 November UTC. This slope has a value of 148,679.7 new infections per day.

On 19.0 November 2020 UTC, a cumulative total of 11.864 million individuals in the U.S. had been infected with COVID-19. Assuming the Figure 12 infection rate on that date was maintained thereafter (literally, "flattening" the Figure 12 curve at its last point), 60% of the U.S. population would be infected on $T_{60\%} = 23$ April 2024. If, as has been hypothesized previously on p. 15, only one-tenth of actual U.S. infections are being reported and tallied, 19.0 November trends would place $T_{60\%}$ on 11 January 2021. This 10-fold infection rate hypothesis is about to be rendered absurd. If we were going to achieve anything resembling herd immunity two months from now, our infection rate should be tailing off. Instead, U.S. infection rates are soaring and could easily increase to 200,000 per day by December 2020. Ever higher infection rates will certainly be our near-term fate if indoor Thanksgiving dinners with multiple households in attendance are widespread later this month.
Trends 11 March 2021 Addendum

This addendum is written one year after the World Health Organization declared COVID-19 a pandemic. As illustrated by Figure 13, the U.S. has now passed its third wave of infections begun in the Fall of 2020.

Figure 13. Slopes for progressively later or "sliding" 14-day linear fits to cumulative U.S. COVID-19 infections are plotted as a function of each fit's ending UTC. For example, the last point on 11.0 March 2021 UTC is the slope of the fit ending on that date and beginning on 26.0 February 2021 UTC. This slope has a value of 63,216.0 new infections per day.

The correlation between a holiday or other social event and Figure 13 infection rates about three weeks later is remarkable. In the latest example, Superbowl Sunday on 8 February 2021 UTC precedes a pause in decreased infection rates by 27 February.

A hopeful development has been the start of U.S. COVID-19 vaccinations on 14 December 2020.20 Those fully vaccinated in the U.S. currently number more than 32.9 million,21 while

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COVID-19 U.S. Mortality and Infection Trends

those recovered from infection number 29.4 million.\textsuperscript{22} Under the naive assumption only never-infected people are being vaccinated, something like \((32.9 + 29.4)/329.7 = 19\%\) of the U.S. population has some degree of immunity to infection. As of 3 March 2021, the Mayo Clinic estimates herd immunity in the U.S. will be achieved when 70\% of the population is immune to COVID-19.\textsuperscript{23} Given the number of people too young or otherwise disinclined to receive a vaccine, achieving herd immunity through additional COVID-19 infections could appreciably increase the current U.S. death tally of 542,007.

Cause for concern in Figure 13 is the ever-increasing local minimum infection rate following each surge. After the first surge, the local minimum was about 20,000 new infections/day in May-June 2020. After the second surge, the local minimum was about 40,000 new infections/day in September 2020. Currently, a slow decrease towards 60,000 new infections/day is evident after the third surge, despite vaccination dose rates averaging more than two million/day in early March 2021.\textsuperscript{24} Director of the National Institute of Allergy and Infectious Diseases, Dr. Anthony Fauci, estimates new infections in the U.S. must be reduced to well under 10,000 per day before the pandemic can be considered under control and lifestyles can return to something resembling normal.\textsuperscript{25} This infection rate threshold, together with the current rate, are at odds with absence of mask-wearing mandates and other social distancing policies in some states.\textsuperscript{26} These could rapidly lead to a fourth surge during the Spring of 2021.

In addition to imposing social distancing and mask-wearing on responsible human behavior, elevated infection rates provide more opportunities for COVID-19 to mutate. Natural selection tends to favor inherently more transmissible mutations. These variants have been detected globally (including in the U.S.), and they have so far shown a tendency to reduce vaccine efficacy.\textsuperscript{27} Ultimately, proliferation of variants may require new vaccines be developed and administered to vulnerable populations in a manner akin to yearly influenza vaccines.

Given the global nature of pandemics, it would be wise for the U.S. to share with other countries any surplus vaccines or other means to inhibit COVID-19 infections worldwide. Only with global immunization can humanity hope to minimize additional mutations and truly put the pandemic under control, bound for the annals of medical history.

\textsuperscript{22} The tally of those recovered from infection is the current cumulative number of infections (29.9 million) minus the number of deaths (0.5 million) as reported at [https://corona.help/country/united-states#charts-nav](https://corona.help/country/united-states#charts-nav) (accessed 11 March 2021).


\textsuperscript{24} Reference [https://www.huffpost.com/entry/covid-vaccine-us-2-million_n_6041752ec5b660a0f3874542](https://www.huffpost.com/entry/covid-vaccine-us-2-million_n_6041752ec5b660a0f3874542) (accessed 11 March 2021).


\textsuperscript{27} Reference [https://en.wikipedia.org/wiki/Variants_of_SARS-CoV-2](https://en.wikipedia.org/wiki/Variants_of_SARS-CoV-2) (accessed 11 March 2021). Also note that "reduced efficacy" only indicates a greater frequency of symptomatic cases is being detected among those vaccinated. Tests leading to vaccine approval by the CDC for emergency use have yet to document any vaccinated subject developing acute COVID-19 symptoms resulting in hospitalization or death.
11 August 2021 Addendum

As evident in Figure 14, the U.S. is now in its fourth wave of COVID-19 infections being attributed primarily to the "Delta" variant. This mutation places one thousand times more virus in respiratory tracts of infected humans than do previous variants, is two to three times more infectious, and is responsible for more than 80% of current U.S. cases.28

![Figure 14](image.png)

**Figure 14.** Slopes for progressively later or "sliding" 14-day linear fits to cumulative U.S. COVID-19 infections are plotted as a function of each fit's ending UTC. For example, the last point on 11.0 August 2021 UTC is the slope of the fit ending on that date and beginning on 28.0 July 2021 UTC. This slope has a value of 107,960.7 new infections per day.

With respect to controlling the Spanish flu pandemic in 1918-19, our present advantage is high vaccination rates. By 19 April 2021, free safe and effective COVID-19 vaccinations had become available to anyone in the U.S. 18 years or older, but falling demand was reported by April 23. On May 10, the FDA began approving vaccines for those 12 years or older.29 There is now hope vaccinations for children 5 years or older could be approved by the FDA before 2022.30

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COVID-19 U.S. Mortality and Infection Trends

Unfortunately, as annotated in Figure 14, the U.S. population was not 50% fully vaccinated until 30 July 2021.\textsuperscript{31} Perhaps the Delta variant's virulence, plus the threat of still more contagious and harmful COVID-19 mutations if the pandemic persists, will convince more people to seek vaccination. But halting the pandemic is not possible unless world-wide herd immunity is achieved. Vast regions in Africa and the Middle East have populations less than 29% vaccinated, even partially.\textsuperscript{32}

The U.S. currently has tallied 37.0 million cumulative infections\textsuperscript{33} and 194.9 million residents with at least one vaccination dose\textsuperscript{31}. Retaining the naive assumption that no infected U.S. resident also receives a vaccination, the U.S. population of 332.6 million\textsuperscript{34} has at most \((37.0 + 194.9)/332.6 = 69.7\%\) of this population with some level of COVID-19 immunity, albeit much of it not supported by rigorous scientific study.

Because the Delta variant is at least twice as transmissible as previous COVID-19 strains, estimates of the immunized portion of population required to achieve herd immunity have increased from 60-70\% to 80-90\%.\textsuperscript{35} This has led health officials in the U.S. and abroad to opine herd immunity is not possible.\textsuperscript{36}

To be clear, those fully vaccinated still have about a 10\% chance of contracting the Delta variant if exposed. Individuals afflicted with these "breakthrough" infections are also capable of transmitting the disease to others, but the transmission rate is yet to be determined with confidence.\textsuperscript{37} However, only one in 11,828 breakthrough infections results in hospitalization, while one in 708 unvaccinated individuals will be infected to a degree requiring hospitalization.\textsuperscript{38}

The Delta variant has caused social distancing policy to tighten in some locales. For example, the state of Oregon has mandated mask-wearing indoors for all over age five, regardless of vaccination status, beginning 13 August 2021.\textsuperscript{39}

\textsuperscript{33} Reference https://corona.help/country/united-states#charts-nav (accessed 11 August 2021).
\textsuperscript{34} Reference https://www.census.gov/popclock (accessed 11 August 2021).
(August 28) (1) Deep Space Communications, by Dr. Jon Hamkins (2) Aerospace Robotics and Autonomy Research at Caltech (how to combine Machine Learning / Artificial Intelligence (ML/AI) with GNC), by Prof. Soon-Jo Chung

Dr. Jon Hamkins explaining the components/hardware in Deep Space Communication and the sizes of a DSN antenna.

Dr. Viterbi (the gentleman in the middle of the photo on the left) and the algorithms were keys to the (Deep) Space Communications.

Prof. Soon-Jo Chung explaining the concepts of using AI/ML in spacecraft swarm formation to explore the interstellar object Oumuamua.

Prof. Soon-Jo Chung showcasing the drone swarm formation by using AI/ML on GNC. What a beautiful light path of the drones!
(August 7) (1) Countering Objections to Space Settlement, by Mr. Al Globus
(2) Urban-focused satellite CO2 observations from the Orbiting Carbon Observatory-3: A first look at the Los Angeles megacity, by Dr. Matthäus Kiel
(Screenshots Only)

Mr. Al Globus showing the feasibility and importance of going to space for settlement, citing the case of the Biosphere 2.

Mr. Al Globus countering the objections against space settlement by addressing each of different kind of settlement.

Dr. Matthäus Kiel presenting the exciting OCO-2 / OCO-3 and the studies on the CO2 fingerprints, especially for Mega Cities like Los Angeles.

Dr. Matthäus Kiel showing the data from Space and Ground worked very well together to better understand the the CO2 distributions.
(July 31) Design and Development of Lighter-Than-Air Systems: Making Balloons Fly and Float! by Prof. Rajkumar S. Pant


Prof. Rajkumar Pant discussing the history of Lighter-Than-Air (LTA), really fun, inspiring, and informative. People almost forgot about the time!

Prof. Rajkumar Pant reviewing some common airships structures, high altitude balloons, and various LTA systems. Tons of fun!

Prof. Rajkumar Pant revisiting the case of Hindenburg (left), and his educational outreach using biomimicry for a Flying Fish!

Prof. Rajkumar Pant is a great professor and lecturer, showing more educational projects, and also some novel LTA system concepts.
Worldline numerics applied to custom Casimir geometry generates unanticipated intersection with Alcubierre warp metric

Harold White\textsuperscript{1a}, Jerry Vera\textsuperscript{1}, Arum Han\textsuperscript{2,3,4,5}, Alexander R. Bruccoleri\textsuperscript{6}, Jonathan MacArthur\textsuperscript{6} (with Permission)

\textsuperscript{1} Limitless Space Institute, 16441 Space Center Blvd., Bldg. D-200, Houston, TX 77058, USA
\textsuperscript{2} Department of Electrical and Computer Engineering, Texas A&M University, College Station, USA
\textsuperscript{3} Department of Biomedical Engineering, Texas A&M University, College Station, USA
\textsuperscript{4} NanoBio Systems Lab. (nanobio.tamu.edu), College Station, USA
\textsuperscript{5} AggieFab (aggiefab.tamu.edu), College Station, USA
\textsuperscript{6} Izentis LLC, P.O. Box 397002, Cambridge, MA 02139, USA

Received: 17 May 2021 / Accepted: 25 July 2021
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Abstract While conducting analysis related to a DARPA-funded project to evaluate possible structure of the energy density present in a Casimir cavity as predicted by the dynamic vacuum model, a micro/nano-scale structure has been discovered that predicts negative energy density distribution that closely matches requirements for the Alcubierre metric. The simplest notional geometry being analyzed as part of the DARPA-funded work consists of a standard parallel plate Casimir cavity equipped with pillars arrayed along the cavity mid-plane with the purpose of detecting a transient electric field arising from vacuum polarization conjectured to occur along the midplane of the cavity. An analytic technique called worldline numerics was adapted to numerically assess vacuum response to the custom Casimir cavity, and these numerical analysis results were observed to be qualitatively quite similar to a two-dimensional representation of energy density requirements for the Alcubierre warp metric. Subsequently, a toy model consisting of a 1 µm diameter sphere centrally located in a 4 µm diameter cylinder was analyzed to show a three-dimensional Casimir energy density that correlates well with the Alcubierre warp metric requirements. This qualitative correlation would suggest that chip-scale experiments might be explored to attempt to measure tiny signatures illustrative of the presence of the conjectured phenomenon: a real, albeit humble, warp bubble.

1 Background

Work being conducted under a DARPA DSO\textsuperscript{1} grant is investigating the implications of the dynamic vacuum model for the possibility of structure to the Casimir energy distribution manifested in a parallel plate cavity. The dynamic vacuum model predicts that the negative vacuum energy density present in the parallel plate cavity is not isotropic, rather there is a varying energy density field present in the cavity with an average value that corresponds with that predicted by the traditional equation for parallel-plate Casimir energy density. The structure predicted to be manifest in the cavity takes the form of a larger magnitude negative vacuum energy density concentrated along the cavity mid-plane that relaxes non-linearly to the unperturbed state at the cavity boundaries. Based on detailed studies of the atomic orbitals of the hydrogen atom, and deriving the acoustic wave equation from the Schrödinger equation [1,2], it is speculated that the energy density structure in a Casimir cavity is coupled to a small polarization field in the vacuum fluctuations resulting in a small but non-zero electrostatic field originating along the cavity mid-plane and terminating at the grounded cavity walls. It has been further reasoned in the literature that it may be possible to construct a customized Casimir cavity equipped with small pillars placed at the mid-plane as depicted in Fig. 1 such that when the pillar channel is sampled by a high impedance oscilloscope, the scope would detect a transient non-zero voltage signal\textsuperscript{2} that would rapidly go to zero as the stored energy in the polarization field is depleted from the measurement process [4].

\textsuperscript{1} Defense Advanced Research Projects Agency Defense Science Office.
\textsuperscript{a} e-mail: sonny@limitlessspace.org (corresponding author)

\textsuperscript{2} A recently published paper [3] details an experimental campaign using an asymmetric Casimir cavity arrangement where one cavity has a small separation and the other cavity has a much larger effective separation. This experimental campaign observed a current flow from the larger cavity electrode to the smaller cavity electrode. Our cavity is analogous in that the two parallel plates define a large cavity and the plate-pillar system plays the role of the smaller cavity.
If these cavities can be made small enough and arrayed together in large enough numbers to increase the stored energy, the magnitude and duration of this predicted transient voltage signal may be detectable in a laboratory setting. The equation that predicts the magnitude of this small but non-zero electrostatic field was derived in [4] and takes the following form: \( E = \frac{\sqrt{\varepsilon \pi}}{1000 \text{m}} \). A quick calculation for a Casimir cavity with a 4 \( \mu \text{m} \) gap predicts a magnitude of the electrostatic potential arising from the polarization of the vacuum fluctuations along the mid-plane of the cavity to be \( \sim 0.7 \text{ mV} \). Figure 2 shows some examples of the current nanofabrication trials runs that are ongoing as part of the effort. The left panel in the figure depicts a recent result obtained utilizing a Nanoscribe 3D printer to evaluate a range of cavity gaps and pillar sizes. The right panel shows recent etching results using Deep Reactive Ion Etching (DRIE) equipment to etch the high-aspect ratio cavity planes into a silicon wafer substrate.

Fig. 2 Initial results from current nanofabrication trials runs: the left panel in the figure depicts a recent result obtained utilizing a Nanoscribe 3D printer to evaluate a range of cavity gaps and pillar sizes; the right panel shows recent etching results using Deep Reactive Ion Etching (DRIE) equipment to etch the high-aspect ratio cavity planes into a silicon wafer substrate that minimizes the magnitude of the negative vacuum energy density present inside the pillar, and hence the magnitude of the detectable signal? It was during the analysis process seeking to address this screening question that an unanticipated intersection with the Alcubierre metric was found.

2 Introduction

The literature search phase of this DARPA project discovered a numerical methods approach known as worldline numerics [5–9] that can be used to study and quantify the Casimir energy density and force. The curious aspect of this modeling approach that makes it of high interest to the DARPA project is that it predicts that there is structure (spatial variation) to the negative vacuum energy density in a Casimir cavity analogous to the predictions of the dynamic vacuum model. The primary value of considering an implementation of this model technique is that it provides a high fidelity prediction of the perturbed vacuum state inside model geometry (e.g. the evanescent fields in structure) along with predictions for the perturbed vacuum state within the cavity gaps. An additional benefit of the worldline numerics method for studying the Casimir effect is that it can be used to address any type of geometry with effectively no restrictions on curvature or lack of smoothness.

Due to the similarities with the dynamic vacuum model and its computational flexibility coupled with maturity, this worldline numerics technique has been implemented to consider the custom Casimir cavities and determine the predicted negative vacuum energy density distribution in the cavities and within the pillars. Figure 3 depicts the numerical analysis results from our implementation of the worldline approach.

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3 Also referred to as the loop cloud method [10].
Fig. 3 Panel (a) shows a 2 dimensional section cut of a sphere-plate case using the numerical worldline technique. The approach was implemented using Open MPI-enabled c-code and the analysis was run on 100 2.40 GHz Intel Skylake CPUs. The model grid was a 50 × 50 × 50 grid with a 2000 unit-loop ensemble. The bottom plot shows a vector plot of forces normal to model surfaces and was created by importing the worldline numerics results into COMSOL considering a 3 dimensional sphere with a radius of 4 µm separated from an infinite flat plate by a separation of 4 µm. The approach was implemented using Open MPI-enabled c-code and the analysis was run on 100 2.40 GHz Intel Skylake CPUs. The model grid was a 50 × 50 × 50 grid with a 2000 unit-loop ensemble. The top panel shows a 2 dimensional section cut of the predicted distribution to the negative vacuum energy density between the two bodies where it should also be noted that the field gradients extend into both the body of the sphere and the flat plate in the form of evanescent fields. The bottom panel shows the distribution of forces across the surfaces of the model and was generated using COMSOL. The following section provides a brief summary of the details behind the worldline numerics analytic approach.

3 Synopsis of Casimir worldline numerics

The string theory inspired worldline numerics approach to determine the Casimir effect is developed in detail in [5], and the critical aspects of the analysis technique are briefly summarized here for convenience. With the objective of evaluating the Casimir interaction energy $E_{\text{Casimir}}$ (e.g. normalized) arising from the coupling of a real scalar quantum field $\phi$ of finite mass $m$ with a background potential $V(x)$ that represents the Casimir geometry, the key equation from Section 2.1 of [5] is the effective action shown in Eq. (1).

$$\Gamma[V] = -\frac{1}{2(4\pi)^2} \int_{1/\Lambda^2}^{\infty} dT T^3 e^{-m^2 T} \int d^4 x \left( \langle W_V[y(t); x] \rangle_y - 1 \right)$$

(1)

The expectation value in Eq. (1) is the average of the loop ensemble over all closed loops with Gaussian walks:

$$\langle W_V[y(t); x] \rangle_y = \frac{\int_{y(0)=y(1)} \mathcal{D}y W_V[y(t); x] e^{-\int_0^1 dt \dot{y}^2/4}}{\int_{y(0)=y(1)} \mathcal{D}y e^{-\int_0^1 dt \dot{y}^2/4}}.$$  

(2)

where the following “Wilson loop” identity has been introduced with $y$ representing the (unit) loop path, $x$ representing the position shift of the unit loop in model space, and $T$ denoting the proper time and serves to scale the unit loops:

$$W_V[y(t); x] = \exp \left[ -T \int_0^1 dt V(x + \sqrt{T} y(t)) \right].$$  

(3)

Equipped with this information, one can calculate the (unrenormalized) Casimir energy as $\delta = \Gamma'/\int d\lambda$0 where the integral represents the “volume” in the time direction. When considering the Casimir force, the portion of the Casimir energy that has a dependency on the relative positions of the bounding geometries can be obtained by subtracting the energies of the single objects from the total Casimir energy.

$$E_{\text{Casimir}} = \delta V_1 + V_2 + \cdots - \delta V_1 - \delta V_2 - \cdots$$

(4)
The Casimir force can be obtained by taking the negative spatial derivative of this interaction energy, and further, this process has removed any UV divergences. In the Dirichlet limit \( \lambda \to \infty \) and for a massless scalar field with Dirichlet boundaries in \( D = 3+1 \), the worldline representation of the Casimir interaction energy boils down to:\(^5\)

\[
E_{\text{Casimir}} = -\frac{1}{2(4\pi)^2} \int_0^\infty \frac{dT}{T} \int d^3x_{CM} \left( \Theta_\Sigma [x(\tau)] \right)_\tau
\]  

\( (5) \)

The worldline functional \( \Theta_\Sigma [x(\tau)] = 0 \) if the re-scaled unit loop does not intersect any Casimir geometry and \( \Theta_\Sigma [x(\tau)] = 1 - \eta \) if the re-scaled loop intersects \( \eta \geq 1 \) Casimir geometry. The numerical evaluation process requires two discretization steps. The first is the discretization of the path integral into an ensemble of \( n_L \) random paths \( x_i(\tau) \), \( \ell = 1, \ldots, n_L \) with each path forming a closed spacetime loop. The second is the discretization of the proper time interval \( \tau \in [0, T] \) into \( N \) steps such that an individual closed loop consists of \( N \) points per loop: \( x_{\ell k} := x_{\ell}(k \cdot T/N), k = 1, \ldots, N \). Transporting and rescaling the ensemble of unit loops to a point \( x_{CM} \) in the model takes the following form: \( x_{\ell k} = x_{CM} + \sqrt{T}y_{\ell k} \). Applying these two discretizations to the Casimir interaction energy in Eq. (5) yields the following form:

\[
E_{\text{Casimir}} = -\frac{1}{2(4\pi)^2} \int_0^\infty \frac{dT}{T} \int d^3x_{CM} \frac{1}{n_L} \sum_{\ell = 1}^{n_L} \Theta_\Sigma [x_{CM} + \sqrt{T}y_{\ell}].
\]  

\( (6) \)

As the worldline numeric approach for the Casimir phenomenon is based on (massless) scalar fields, the technique can currently only assess idealized behaviour for bounding geometry and cannot assess any frequency dependence of materials. Additionally, the approach developed to date in the literature does not account for the impacts of temperature. However, it is still a very capable and appealing technique in that it can provide quick and fairly accurate assessments for very complicated geometries where analytic techniques are not practical.

3.1 Generating unit loops, computational approach, and implementation validation

The developers of the worldline numerics for the Casimir phenomenon explored numerous ways\(^5\) to generate ensembles of unit loops with Gaussian distribution ranging from a heat bath kernel to random walks, and finally landing on a technique denoted as the “v-loop” algorithm. The curious reader is encouraged to review the referenced manuscript for a thorough discussion of the benefits and shortfalls of the different techniques explored. The “v-loop” technique was selected as it can computationally generate an ensemble of \( n_L \) each having \( N \) points per loop without having to perform multiple iterations on each loop to realize a closed random walk/worldline with the required statistical characteristics. Figure 4 shows several examples of unit-loops generated by the v-loop methodology ranging from a 100 point unit loop to a 5000 point unit loop. A summary of the computational procedure steps are provided here to facilitate the reader’s understanding of the “v-loop” approach:

1. generate \( N - 1 \) numbers \( w_1 (i = 1, \ldots, N - 1) \) with a Gaussian distribution \( e^{-w_1^2} \) (e.g. using Box–Müller method);
2. calculate \( N - 1 \) numbers \( \tilde{v}_i \) by normalizing \( w_1 \):

\[
\tilde{v}_i = \sqrt{\frac{2}{N}} w_1,
\]

\[
\tilde{v}_i = \sqrt{\frac{N + 1 - i}{N + 2 - i}} w_i, \quad i = 2, \ldots, N - 1;
\]  

\( (7) \)

\( ^5 \) A thorough articulation of the renormalization process is detailed in Section 3.2 of [8].
3. calculate \( v_i \) for \( i = 2, \ldots, N-1 \) with the following:

\[
v_i = \bar{v}_i - \frac{1}{N+2-i} v_{i-1,1},
\]

where \( v_{i-1,1} = \sum_{j=2}^{i-1} v_j \); \( i \leq N \).

4. a unit loop \( \mathbf{y} \) can now be created by using:

\[
y_1 = \frac{1}{N} \left( \bar{v}_1 - \sum_{i=2}^{N-1} \left( N - i + \frac{1}{2} \right) v_i \right),
\]

\[
y_i = y_{i-1} + v_i, \quad i = 2, \ldots, N-1,
\]

\[
y_N = -\sum_{i=1}^{N-1} y_i.
\]

5. this procedure is repeated \( n_L \) times to create the unit loop ensemble \( \mathbf{y}_\ell \) with \( \ell = 1, \ldots, n_L \).

The benefit of this numeric worldline approach is that it can be used to address any type of geometry while other approaches such as Proximity-Force Approximation (PFA) are not as flexible. Additionally, the approach has no dependency on the choice of model grid spacing or grid choice. The answer for a single point of interest in space does not have any interdependency on any other model grid points and may be calculated in total isolation if that is all that is needed. Figure 5 provides a pictorial representation of the analysis process for a parallel plate Casimir cavity. As indicated in the figure, once the loop ensemble has been generated the computational process to calculate the Casimir interaction energy follows the below enumerated steps:

1. The loop ensemble is moved to each model grid point of interest and scaled using proper time until \( 2^+ \) bodies in the model are pierced;
2. the scale at which an individual loop pierces \( 2^+ \) bodies defines the integral limits for the Casimir interaction energy integral;
3. the energy at the geometric point of interest in the model is increased based on wavelength (loop scale) and loop weight factor;
4. this scaling process is repeated for each loop in the ensemble at a geometric point of interest in the model;
5. the above steps are repeated for each geometric point of interest in the model.

Validation of our implementation of the numeric worldline approach was done on a plate-plate case and a corresponding plate-sphere case and was compared to documented results in the literature [5]. For the reader’s awareness, the work documented in [5] conducts extensive analysis to compare analytic results to the numeric results produced by the worldline technique for the simple plate-plate scenario and plate-sphere scenario. The referenced study explored the impact of number of points per unit loop, number of unit loops in an ensemble, separation distance of geometries, coupling, and mass. It is not the intention of this paper to duplicate the viability of the overall worldline numerics approach as this has already been done in the literature as noted, rather the intention of this paper is to apply this very powerful and flexible technique to fairly complicated geometries where only numerical methods can effectively be used. In our validation effort, we confirmed that our model predict the correct Casimir force for a given plate-plate or sphere place scenario, and subsequently compared their Casimir interaction energy density results from their numeric worldline algorithm to our interaction energy density results from our numeric worldline algorithm. The subsequent more complicated geometries we consider forthwith as part of this work do not have trivial analytic solutions which is why the numeric worldline technique is employed.

A plot of the results from our implementation is provided in Fig. 6 for the two cases and the plot also includes a plate-blade case. The geometry of all three cases is such that the closest point of separation between all three cases is identical allowing for comparison of the results to evaluate the effects of curvature. The plots reflect the energy density as measured along a line normal to the plate-plate geometry and these geometric points of interest are the same for the plate-sphere and plate-blade cases. The colors of the Casimir energy density plots correspond to the colors of the toy geometry also overlayed on the plot facilitating comparison of the results and to clearly see the impact of curvature. Comparing our results to those in literature indicates that our algorithms are functioning properly.

### 4 Analysis results and unanticipated findings

As discussed in the opening of the manuscript, the critical concern for this project is if the presence of a pillar in the Casimir cavity would serve to screen itself in such a way that it would be unable to see the negative vacuum energy density gradient predicted to be present in the cavity if the pillars were not present. A model was built to assess a grid running \( \pm 4 \mu \text{m} \) in both the \( x \) and \( y \) axis. The \( x \)-axis is the vector normal to the parallel cavity plates, and the \( y \)-axis is orthogonal to the \( x \)-axis and defines the 2D surface for the energy density plot.
Fig. 5  Panel (a) shows the unit loop ensemble being moved to a geometric point of interest in model. Panel (b) shows scaling of one of the unit loops from the ensemble to the point that it intersects 2+ bodies of model. This establishes the support $\mathcal{S}_I$ to be used in integration and determine the weighted contribution of the loop to the Casimir energy density of the vacuum at this point in the model.

The origin of the coordinate system is at the center of the pillar. The analysis results are shown in Fig. 7 with a two dimensional representation of the energy density depicted in the left panel and a log of the energy density levels in the right panel. Inspecting the log-plot on the right shows that while the presence of the pillar in the cavity does perturb the field, it actually serves to slightly increase the effective negative vacuum energy density seen in the pillar by a factor of 3–5 compared to the density level present without the pillar in the cavity. These analysis results would suggest that the pillar does not adversely self-screen itself in a manner that prevents it from seeing the field magnitude in the cavity with no pillar present. Rather, due to the slightly elevated state, it could be reasoned that the pillar seems to focus the gradient in a manner that would at most allow the pillar to drain the stored energy in the cavity at a quicker rate once it is connected to a high impedance oscilloscope. This effect might result in a need for more cavities to provide enough stored energy such that the duration of the transient voltage signal will last long enough for detection.

While the analysis results discussed above are encouraging for the project objective of attempting to measure the presence of structure in the negative vacuum energy density within a customized Casimir cavity, the implications of this particular predicted negative vacuum energy density distribution is quite intriguing for an altogether different reason. As it so happens, the structure of the field around the pillar in the two dimensional plot is qualitatively very similar to a plot of the negative vacuum energy density necessary for the Alcubierre warp metric. 7 Figure 9 shows a zoomed view on the numeric worldline analysis of the plate-pillar case on

7 The Casimir phenomenon was first discussed as an alternative source to exotic matter for the idea of a wormhole in [11,12] and later expanded on in a book[13] on wormholes by Visser. It was also identified by Alcubierre[14] in his seminal paper as an alternative source to exotic matter for the manifestation of a warp bubble. The Casimir phenomenon
Fig. 6 Plot of validation runs for plate-plate and plate-sphere cases. The plot also includes a plate-blade case. The geometry elements are represented by a thick vertical black line for the left Casimir cavity plate, a thick vertical cyan line for the right plate, a thick gray quarter circle to show the location of the sphere, and an orange horizontal line representing the blade. The colors of the plots of energy density distribution match the color of the corresponding geometry overlayed in the plot. The magnitude of the energy density distribution clearly shows a decrease in magnitude as the cases go from plate-plate to plate-blade. Additionally, the plots show that there is a shifting of the peaks to the right due to the curvature effects.

Fig. 7 The white lines represent a 4 µm Casimir cavity, and the circle represents the 1 µm pillar located at the midplane of the cavity. Panel (a) shows the linear 2D plot of the energy density and panel (b) shows the log 2D plot. The bright yellow regions show the impact of the presence of the pillar on the energy density, and the log plot shows that the pillars do not self-screen themselves from the background field gradient resulting from the presence of just the plates (lime-green color).

Fig. 8 [17]. The York Time field is depicted as a grid that has a wave-like appearance with a simple representation of a notional craft overlayed on top of the field to show the connection between the spacetime disturbance and the source of the negative vacuum energy density. The York Time plot indicates that space is expanding behind the spacecraft and contracting in front of the spacecraft. The craft depicted in

\[ ds^2 = -dt^2 + (dx - v_s f(r_s) dt)^2 + dy^2 + dz^2 \]
\[ f(r_s) = \frac{\tanh(\sigma (r_s + R)) - \tanh(\sigma (r_s - R))}{2 \tanh(\sigma R)} \]  

The critical element of the model that enables stellar hyperfast transit is conjectured to be the York Time which is a measure of the expansion and contraction of space associated with the metric. A plot of the York Time is provided in

Footnote 7 continued
has more recently been explored by Garattini in [15,16] as a sourcing material for “benign” wormholes.

Footnote 8 continued
serving as a multiplier of the ship’s initial velocity, akin to watching a movie in fast-forward. With the canonical form of the metric, the expansion and contraction of space is viewed as a response of spacetime as the hyperfast craft transits through space – space piles up in front of the craft and stretches out behind the craft.
the plot has a central part located in the center of the warp bubble in the region where the spacetime is flat, the proper acceleration \( \alpha \) is zero, and local clocks are synchronized with external clocks on earth. The craft is equipped with a ring structure that represents an encapsulation of exotic matter or negative vacuum energy density distributed throughout.

The York Time, \( \theta \), and the energy density distribution \( T^{00} \), are shown in Eqs. (11) and (12) respectively. The \( v_s \) term again represents the velocity of the craft, \( x_s \) represents the position of the center of the craft (and hence the fields), and the \( \gamma^2 \) and \( z^2 \) just define a radial distance \( \rho \) from the central \( x \)-axis. Anecdotally, a sensitivity analysis of the field equations conducted in \([19,20]\) showed that by varying the shell thickness parameter, \( \sigma \), one could reduce the magnitude of the York Time, and as a result the total energy required to make the concept work. The analysis effort created two animations available online that show the response of the York Time field \([21]\) and the energy density field \([22]\) to variation of the shell thickness parameter. The animations show that as the warp bubble wall thickness increases the peak energy density decreases significantly, and as the warp bubble wall thickness decreases the peak energy density increases. The reasoning behind this response is that the York Time can be viewed as a sort of 3-dimensional strain of space, and as the shell thickness increases, the amount of 3-dimensional strain needed to manifest a target speed \( v_s \) decreases which is accompanied by a decrease of energy density, and thus a reduction in total energy. This is not without a cost – as can be seen in the online animation of the York Time field, the region of flat spacetime available for the critical portions of the craft, say for a crew or science instruments, is decreased as the bubble wall thickness is increased. So the energy optimization process has a competing constraint in the form of the required size, \( R \), for the warp bubble to adequately encapsulate sensitive cargo within the flat spacetime region inside the bubble wall.

\[
\theta = \frac{v_s x_s}{\gamma^2} \frac{d f(v_s)}{d r_s}
\]

\[
T^{00} = -\frac{1}{8\pi} \frac{e_t^2 (y^2 + z^2)}{d r_s^2} \left( \frac{d f(v_s)}{d r_s} \right)^2
\]

Now that the Alcubierre metric has been introduced and the critical elements have been identified and discussed, a comparison between the exotic matter requirements of the warp concept and the numeric worldline analysis results for the custom Casimir cavity may now be made. The top panel of Fig. 9 shows a close up view of the predicted response of the quantum vacuum within the custom Casimir cavity, and the bottom panel shows a 2-dimensional representation of the energy density necessary for the Alcubierre model. The concentrations in the negative vacuum energy density due to the presence of the pillar in the Casimir cavity are qualitatively very similar to the 2D representation of the \( T^{00} \) for the Alcubierre model. It should be noted that the 2-dimensional plot for the Casimir cavity is in effect a linear extrusion extending up from the surface of the paper meaning the lenticular shaped concentration is rod-like, while the Alcubierre plot is a revolution which yields a toroidal distribution.

Based on the custom Casimir cavity results for the parallel plate cavity with a cylindrical pillar at the mid-plane, a toy model comprised of a 1 \( \mu \)m diameter sphere suspended in the middle of a 4 \( \mu \)m diameter cylinder was implemented and the numeric worldline analysis technique was used find the predicted Casimir energy density. Figure 10a shows a section cut of the toroidal Casimir energy density for the sphere-cylinder system which correlates well with the toroidal Alcubierre energy density requirements. If one could manufacture a chip with these types of nano structures (nano-spheres suspended in nano-tubes), an experiment might be designed and attempted to conduct a test to measure transit time of say a current (alternately a photon or electron) through a tiny conductor (alternately open bore) routed through the center of the sphere(s). This transit time could be compared to the time it takes for a current ( photon/electron) to run through a mirror system that has no external tube (control test). If need be, many of these nano structures could be arranged in parallel to increase the time resolution of the notional experiment.
Fig. 10 The top panel depicts a section cut of predicted toroidal Casimir energy density distribution for sphere-cylinder system comprised of a 1 μm diameter sphere suspended in the middle of a 4 μm diameter cylinder. The approach was implemented using Open MPI-enabled c-code and the analysis was run on 660 2.40 GHz Intel Skylake CPUs. The model grid was a 100 x 100 grid with a 2000 unit-loop ensemble. The bottom panel depicts a notional experimental setup that comprises an array of sphere-cylinder constructions arranged such that a pulse of electrons or photons may be routed through the test device in an attempt to measure a change in transit time for an equivalent pulse routed through free space would not be some simple analogue or proxy representation of a space warp phenomenon, rather it would be a genuine implementation of the idea in physical fact with observable consequences in the laboratory – just not in the dramatic form of a craft bound for a distant stellar destination.

Footnote 9 continued
pathway between two points and also enabling the formation of the necessary negative vacuum energy density around the sphere to boost the effective velocity.

(see Fig. 10b). If a difference in transit time were observed, this would be an empirical confirmation of the generation of a real nano scale warp bubble on a chip. To be clear, this

It could be speculated that a nano sphere might be made to translate through a nano cylinder as a more direct implementation of the Alcubierre model with the provision that it may be viewed as a space warp/wormhole hybrid with the cylinder serving as the connecting pathway between two points and also enabling the formation of the necessary negative vacuum energy density around the sphere to boost the effective velocity.
5 Conclusions

The impetus for the work discussed in this manuscript was to explore the implications of the dynamic vacuum model as applied to a custom Casimir cavity geometry. The dynamic vacuum model suggests that the state of the negative vacuum energy density in the cavity is not just an isotropic value that is constant throughout the enclosing geometry, rather it has spatial variation and can manifest complicated structure. In the process of the team exploring the literature, a technique called worldline numerics was discovered that also predicts that there is structure to the perturbed vacuum state that is predicted to exist in a notional Casimir cavity. This technique was used to evaluate the predicted state of the vacuum in response to the presence of small pillars placed at the midplane of a Casimir cavity. The analysis showed that the pillar would not adversely screen itself from the predicted background field that exists in response to just the presence of the plates. The analysis also showed a possible intersection with a model developed in the context of general relativity to understand how hyperfast stellar travel might be manifested mathematically. The qualitative correlation would suggest that a chip-scale experiment might be explored to attempt to measure a tiny signature illustrative of the presence of the conjectured phenomenon.

Acknowledgements This work was supported by the DARPA Defense Science Office Quest for Undiscovered Energy Storage and Thrust (QUEST) Program through funded agreement HR0012090082. Special thanks goes to Limitless Space Institute for organizational and institutional support, Prof. Mike Fiddy and Dr. David Lewis for helpful technical discussions, and Mark Rademaker for help with visualization graphics (e.g. Fig. 8). Godspeed.

Data Availability Statement This manuscript has no associated data or the data will not be deposited. [Authors’ comment: This paper is primarily a theoretical work. The algorithms used have been summarized in the text and references to the salient literature have been provided. All necessary data related to the article are presented and discussed in the narrative.].

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Funded by SCOAP³.

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Aero alumni chatted happily in the beginning, and saying hello to Don’s family, while chatting on COVID-19, water resources etc.

The aero alumni chatted on several interesting topics, including the X-59, F-20, Chuck Yeager etc. shared by Roy Martin, the YF-23 test pilot.
Excerpts on Dr. Stephen Bryen's article "If You Live in Taiwan, Time to Worry" and "Evacuate Afghanistan Through Aggressive Action"

by Dr. Ken Lui (AIAA LA-LV Council Member)


The recent news on the retreat from Afghanistan has caused ripples and discussions on the consequences. Allies around world were questioning the commitment and reliability of the US support. Though the situations could vary from regions to regions with different cases and scenarios, great concerns have been raised. Taiwan has been facing the danger of attacks and invasion from China/PLA (People's Liberation Army) and the rapidly modernized and ever-expanding advanced weapon systems in the air, over/under the water, and in space. Escalating military drills by the US allies and China/PLA in the West Pacific, Taiwan Straits, South China Sea, East China Sea, have brought attention. The situation related to Afghanistan is not a single event, but has triggered a series of profound impacts and adjustment in the Indo-Pacific, global defense, geopolitical influences etc. It has also quite some potential impacts on aerospace and defense. Here are some excerpts from the two articles.

"Taiwan needs to worry about American reliability. Unlike Afghanistan where the United States had committed its forces for two decades, Taiwan has no U.S. forces and no assurance that the United States will come to their defense if attacked by China."

"The primary issue is U.S. reliability. South Korea, Japan and Taiwan all depend directly on the United States. Without support, none of them can avoid war—in Korea the threat from Pyongyang, in Japan and Taiwan the threat from Beijing.

Neither Taiwan nor Japan can defend against China by themselves. South Korea is different only in the sense it has a formidable army and a lot of firepower. But in any war South Korea would pay a very high price.

The United States has troops in Japan and on Okinawa, and in South Korea. Will they fight or leave? The United States has mutual defense treaties with both countries, unlike the case of Taiwan where only the Taiwan Relations Act offers some help to Taiwan.

Will the United States stay the course in the Pacific?

Stability in the Pacific depends on strong and visible U.S. resolve and U.S.-led deterrence. That seems to be at risk right now.

The signals coming from Washington are anything but positive."

"The Digital Dunkirk, which was organized at first by U.S. military veterans, has been helping people make it to the Kabul airport by helping them maneuver around fixed and mobile Taliban guards and sentries. They do this with satellite imagery and keep constant watch on an evolving situation. Even with this help, making it through the final gauntlet is challenging, in many cases not possible.

One wonders why the Pentagon did not provide this kind of intelligence to American, allied, and Afghan friends whose lives are in great danger. The lack of Defense Department initiative is only understandable in the context of egregiously poor planning."
Excerpts on Dr. Stephen Bryen's article "If You Live in Taiwan, Time to Worry" and "Evacuate Afghanistan Through Aggressive Action"

"It is not that our troops on the ground are doing badly—they are heroes—but it is clear there is much more we could have done, such as going out and collecting those who need to evacuate and convoying them to the Kabul airport."

"Bagram performed an important surveillance role. This can be restarted. Surveillance aircraft along with C-130 gunships should be brought back in. Bagram would have provided another, more secure alternative to Kabul. It can easily handle the largest transports including the massive C-5 and the Ukrainian Antonov-225 which could take more than 1,000 people at a clip. The An-225 has been used for years to deliver U.S. and allied military supplies to Afghanistan, including heavy equipment."

"To the degree possible, the United States should reconstitute some Afghan forces clustered in and around Bagram. Unfortunately, the Pentagon is now saying it won’t retake Bagram. This is a cardinal mistake that fits into the jigsaw of other mistakes and blunders that are costing far too many lives and ruining the reputation of the United States."

"We are about at the last chance for the survival of many people who we put under our wings and in our service. It is clearly past time to get smart. Hats off to the Digital Dunkirk warriors. But we need more, we need it now, and we need to learn to be tough again."

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

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

Without the airpower the US Air Force mostly hates, the rapid collapse of Afghanistan was inevitable
by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 August 16
https://asiatimes.com/2021/08/the-ironical-end-of-the-war-in-afghanistan

There is a great irony in the collapse of US-backed Afghan forces and the success of the Taliban.

While the US officially focused on pulling US troops out of Afghanistan, what we really pulled out was the air power that supported not only US troops, but more importantly also Afghan soldiers.

The irony is that the US Air Force hated the Afghan campaign because the war lacked the kind of targets the US Air Force was designed to strike.

The United States has the most sophisticated and highest tech air force in the world, bar none. The F-22 and F-35, the two flagship fighter bomber and air superiority aircraft, lead the world in stealth and overall capability.

Yet it was the 1970s vintage A-10 and the 1960s vintage B-52 that proved most valuable in Afghanistan, the first because it is a hurtful, close support machine and the other because, in uncontested airspace, it can drop tons of bombs on the enemy – 70,000 pounds or 32,000 kilograms or 35 tons.

The US also used the B-1 bomber, known as the Bone (vintage 1986), to good effect. But the B-1 is mostly grounded because the plane’s airframes are cracking and some of its systems, including fuel pumps, have become leaky and dangerous.

Back in February the Air Force started to retire the B-1 to make way for the forthcoming B-21, which doesn’t fly yet.

The key advantage of the B-1 is speed – if it is lurking in an area it can reach a target flying at Mach 1.2 (921mph or 1,482kph), while the B-52 lumbers along at a maximum speed of 400 mph (644 kph). When you need help in a hurry, the B-1 is more efficient than both the B-52 and A-10.
The ironical end of the war in Afghanistan
Without the airpower the US Air Force mostly hates, the rapid collapse of Afghanistan was inevitable

A Boeing B-52 Stratofortress carries a heavy payload but is slow in the air. Photo: AFP / Win McNamee / Getty Images

Airpower’s limits

When President [Biden announced the US withdrawal from Afghanistan] last April, the US began ending US airpower support.

Unlike conventional wars, airpower in Afghanistan could only fill a singular role, which was bailing out US, coalition and Afghan forces in firefights with the Taliban – and also when possible, striking Islamic terrorists. Neither the F-22 or F-35 were useful in Afghanistan, and while US F-16s did fly, they were mostly providing ISR (intelligence, surveillance, target acquisition and reconnaissance) support.

As Colonel Jon C Wilkinson and Andrew Hill point out in their exceptional article, [Airpower Against the Taliban] in Air and Space Power Journal, the US Air Force’s main focus is on high-end peer and near-peer adversaries and it specializes in air dominance and destroying ground targets.

In Afghanistan, there is no infrastructure belonging to the Taliban to destroy and the Taliban is not a near-peer adversary in the conventional military sense of the term. The Taliban, instead, is an insurgency with considerable popular support in the country, and what they lack in popular support they earn through fear, intimidation and viciousness.

What US and allied airpower did in Afghanistan was to support coalition troops in firefights.

When the US pulled airpower back, the remaining Afghan forces were left with only the airpower the US left them. Most of that was a motley collection of propeller-driven fixed-wing aircraft and transport helicopters.

The best of the lot were 19 A-29 Super Tucanos, designed as a COIN (counter-insurgency) aircraft. The A-29 is a turboprop aircraft developed in Brazil. The US also supplied Cessna 208B propeller aircraft, based on a commercial design.
The ironical end of the war in Afghanistan

Without the airpower the US Air Force mostly hates, the rapid collapse of Afghanistan was inevitable.

Even with the equipment provided to the Afghan Air Force, essential contractor support all but disappeared starting in July. To add to the Afghan woes, at least one of their top pilots was murdered in front of his home, and all the remaining pilots were directly threatened by the Taliban, who knew who they were and where their families lived.

The US was never willing to provide powerful jet fighters or helicopter gunships to the Afghans.

A deteriorating stalemate

In fact, even with all available US airpower engaged in Afghanistan, the US had no hope whatsoever in rolling back the insurgency. By 2010 it was clear that the best that could be achieved was a deteriorating stalemate, but at a huge cost in lives.

Moreover, the Air Force kept trying to get rid of the A-10 over the last decade, even though it consistently earned praise from US and Afghan soldiers. The A-10 did not fit the profile the Defense Department had in mind for the future.

The Pentagon instead claimed the F-35 could perform the same roles as the A-10 with its formidable GAU-8 Avenger 30-mm hydraulically driven seven-barrel Gatling-type cannon used by the A-10 to chew up the enemy. At best the F-35 can carry 220 rounds of ammunition which it can fire off in four seconds.

The A-10 carries 1,350 rounds of lethal ammunition and has double the range of the F-35’s cannon.

Right smack in the middle of the Afghan war the Air Force tried to get rid of all the A-10s. In the latest Biden administration proposed defense budget, the Air Force proposes getting rid of 42 A-10s. One wonders, furtively, what it would have meant had the Afghan Air Force been equipped with some of the A-10s that the Air Force wants to liquidate?

A lot has been made of the lack of fighting will of Afghan forces. But even when the US was there in full force, the American-led coalition could not defeat the Taliban. Fast forward to today, and without suitable airpower, the Afghan foot soldier knows he can’t win.

The US yanked out the airpower it had, walked away and left the Afghans holding an empty bag. Of course, the Biden administration knew this, but instead pretended that the Afghans could defeat the Taliban even if we never could.

Without the air power the US Air Force mostly hates, the rapid collapse of Afghanistan was inevitable.

Now Afghan President Ashraf Ghani has fled the country, probably with US help. The Taliban has taken over.
Famed A-10 Warthog pioneer passes away: Warthogs for Taiwan?

Pierre Spey was part of the Pentagon's 'Fighter Mafia' and a long-time opponent of the not-so-stealthy F-35 by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 August 24

https://asiatimes.com/2021/08/famed-a-10-warthog-pioneer-passes-away/

The A-10 Warthog has until recently been a mainstay of the US Air Force. Photo: US Air Force

Pierre Spey, one of the most interesting and controversial aircraft designers and a Pentagon nemesis, died this week at the age of 83. Spey was responsible for the design of the A-10 close support fighter and in part for the F-16 design.

And he was a longtime opponent of the super-expensive stealthy F-35.

Spey was born in 1937 in Nice, France. His parents, both Jewish, escaped the coming holocaust and made their way to the United States. Spey was admitted to Yale University at the age of 14 and later studied at Cornell University. He studied aeronautical engineering, mathematical statistics and operations research.

Starting out at Grumman Aircraft (where the A-10 was eventually built), he went to the Pentagon where he was part of what became known as the “Fighter Mafia” – teaming with John Boyd and Thomas P Christie. Robert Coram in his book on John Boyd has a good deal to say about Spey and Christie.

After his Pentagon career, Spey became a record producer focused on jazz. Some of his recordings were highly praised. The equipment for the recording studio was put together by Spey in his home in suburban Maryland, near Washington DC.

His recording with the Addicts Rehabilitation Center Choir singing Walk With Me appears in Kanye West’s 2004 hit Jesus Walks.

Spey was a highly successful Air Force and Pentagon infighter. Through his influence, the A-10 was chosen over the objections of Air Force brass and Pentagon leaders.

The A-10 is a unique close air support and ground attack aircraft that the US Air Force has been trying to get rid of for decades. Unfortunately for the Air Force, the A-10 has performed brilliantly in the two Iraq wars and in Afghanistan.

The A-10 was called the Warthog because from the outside it is an ugly aircraft. But the Warthog designation was also a term of affection from the pilots who flew the aircraft.
Famed A-10 Warthog pioneer passes away: Warthogs for Taiwan?
Pierre Spey was part of the Pentagon's 'Fighter Mafia' and a long-time opponent of the not-so-stealthy F-35

Tom Christie said: “He was one of the most detested people by the United States Air Force because he was challenging a lot of sacred programs and strategies.”

The A-10 was originally designed to support NATO if there was a Soviet invasion of Europe. It was designed to knock out Russian armor, radars and command centers and support allied troops against Warsaw Pact forces.

The A-10 features a very unique design. It has two engines, mounted high on the upper rear which are designed to reduce the heat signature that infrared anti-aircraft missiles seek. It has self-sealing foamed fuel tanks that can take ground fire hits and not explode or burn and a titanium cocoon protecting the pilot.

The aircraft design allows the fighter to operate at low speeds and to be maneuverable. It carries a powerful GAU-8, 30mm hydraulically driven seven-barrel Gatling-style autocannon that can fire 3,900 rounds per minute.

It also carries Maverick (AGM-65) air-to-ground TV-guided missiles and bombs. In Operation Desert Storm in 1991, A-10s destroyed more than 900 Iraqi tanks, 2,000 other military vehicles and 1,200 artillery pieces.

On a single day, A-10s destroyed 65 Iraqi, mainly Russian-built heavy battle tanks (T-62s and T-72s).

In Afghanistan, the A-10 was primarily engaged in providing close air support against the Taliban and protecting US and Afghan troops. Most of the time this involved ferreting out Taliban fighters ensconced in mountainous areas surrounding friendly forces rather than performing an anti-armor role. Again the A-10 was tremendously successful.

Even so, the Air Force continues to try and rid itself of the A-10 and replace it with the F-35, something Spey believed was a mistake. The F-35 in a close support role, if it ever was used that way, would be extremely vulnerable to ground fire and in that scenario its stealth capability would be of no value.

Spey considered stealth as a scam because he said Russian radars (which China has copied) using longer-wave frequencies would be able to detect the F-35 and shoot them down. Spey also criticized the F-35 because it is not maneuverable, can’t fly slow and only carries a small weapons load, mostly because the F-35 to retain its stealthiness must carry weapons internally.
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Pierre Spey was part of the Pentagon's 'Fighter Mafia' and a long-time opponent of the not-so-stealthy F-35

Moreover, the original F-35 did not have a gun system – it was put on the aircraft later after much criticism. Of course, the F-35 carries a smaller ammunition load and smaller caliber than the A-10, has a less effective range and isn’t of any use in ground support if the aircraft has to stay far from the conflicted area for safety reasons.

The F-35 is extremely expensive to operate and hard to maintain. The A-10 is far cheaper to operate and easy to maintain even at remote locations (something that can’t be done with the F-35).

Acquisition costs also are radically different. In current-day dollars, the A-10 would cost US$9.3 million (it is no longer manufactured and the plant where it was made is closed). By contrast, the F-35 costs in excess of $78 million and its sustainment costs could bleed the Air Force budget.

In Spey’s view, the F-35 is not a combat survivable aircraft because it can’t really provide close support and because its lack of maneuverability means it wouldn’t survive in any close encounter with enemy aircraft.

By contrast, the A-10 was built to take hits and keep flying. A number of A-10s were shot up in the Iraqi conflicts, but were able to return to base.

In the latest Biden-backed budget, 43 A-10s will be scrapped if the budget is approved by Congress.

A fitting tribute to Spey would be to give the 43 A-10s the Pentagon wants to scrap to Taiwan.

The A-10 would be a superb aircraft to destroy any attempt by China to launch an invasion of Taiwan, since the aircraft could slice up Chinese landing craft and destroy any armor that the Chinese might be able to get onto the island in an attack.

Supported by upgraded and new F-16s that can challenge China’s top combat aircraft, Taiwan would have a fighting chance to stop even a powerful China from a successful attack.
America’s ‘Great Retreat’ is well underway
The US is rapidly lowering its military profile and backing away from commitments to allies in the Middle East and Asia
by Dr. Stephen Bryen, Former Deputy Under Secretary of Defense, 2021 July 29
https://asiatimes.com/2021/07/americas-great-retreat-is-well-underway

Sailors assigned to the amphibious assault ship USS Makin Island clear out of the way of a Marine Corps F-35B Lightning II in preparation for takeoff from the flight deck of the ship. Photo: US Marine Corps / Patrick Crosley

Why would the US Department of Justice drop five cases against Chinese researchers including Dr Juan Tang, a cancer researcher who allegedly lied on her visa application after photos of her were found wearing a Chinese military uniform?

Part of the answer is that Tang’s case was dropped to facilitate Deputy Secretary of State Wendy Sherman’s high-level visit this week to China, where she was treated hostilely by her Chinese hosts.

The five cases are just part of a bigger picture which can best be termed as “The Great Retreat.” In many areas, the US is lowering its profile and backing away from its commitments.

For example, the US has pulled its only aircraft carrier, the USS Ronald Reagan, from the Pacific ostensibly to cover the retreat from Afghanistan. But whether the Ronald Reagan carrier will return to Japan in the future isn’t altogether clear.

As the need for an aircraft carrier while the US pulls out of landlocked Afghanistan is questionable, the result is that the US is leaving the Pacific devoid of carrier coverage, which appears to contravene the US policy of protecting its regional allies and partners in the region.

In Guam, the US has moved its big bombers including the B-1 and B-52 back to the continental United States (CONUS in Penatgonese) and is using the Guam base mostly as a forward depot where it can try and cycle in bombers on an as-needed basis. The real problem: Guam is increasingly threatened by Chinese missiles.
America’s ‘Great Retreat’ is well underway

The US is rapidly lowering its military profile and backing away from commitments to allies in the Middle East and Asia.

Meanwhile, the B-1 “Bone” strategic bombers, which have played an important tactical role in Afghanistan, are now mostly grounded with problems ranging from fuel delivery issues to failing aerostructures. Less than 10 B-1s are currently flyable.

There are only 21 B-2 stealth bombers in the entire US inventory, but most if not all of these would be on standby for a nuclear mission. This leaves the lumbering B-52 as the main US long-range bomber that can be used on conventional missions.

Unfortunately, the B-52 is an easy target and can only operate with standoff weapons, removing its main advantage which is the ability to deliver heavy bomb loads on targets.

The US has also pulled its air defense systems, including the Patriot and THAAD from Saudi Arabia, Iraq, Jordan and the United Arab Emirates, making clear its displeasure with those countries and underscoring its effort to conciliate Iran.

Of course, the decision to leave Afghanistan was taken without adequate coordination with Afghan authorities. US troops and contractors left Bagram Air Base in the middle of the night unannounced, and never formally turned the base over to the Afghan army. The base was immediately looted.
America’s ‘Great Retreat’ is well underway

The US is rapidly lowering its military profile and backing away from commitments to allies in the Middle East and Asia.

Along with Afghanistan, President Biden is preparing to take US troops out of Iraq. Already the US Embassy in the Green Zone in Baghdad is subject to regular rocket attacks.

The US has the C-RAM gun system in place, but its effectiveness against rockets is poor. It won’t be long before the embassy will be indefensible.

Meanwhile, the US Defense Department has released information about yet another war game apparently focused on the “battle for Taiwan.” But the Pentagon thinks that US forces in support of Taiwan would be “swiftly and thoroughly dominated.”

The latest wargame only reaffirms results in earlier wargames run by Rand Corporation, the US Marines and a number of think tanks. But the difference is that now the Pentagon has come to the realization (if it hadn’t known before) that its warfighting methods no longer can work in peer-to-peer or peer-to near-peer conflicts.

Making matters worse, US air defense systems remain a shambles and probably are ineffective in any war scenario.

The US relies on three main systems: tactically on Patriot PAC 3, strategically on AEGIS (at sea and ground-based) and THAAD. The fourth system, the Ground Based Interceptor (GBI) is at the moment a nearly dead letter, despite huge costs, because it needs a new interceptor missile.

And Northcom assesses that North Korea could overwhelm and knock out the GBI as early as 2025, if not sooner, and potentially attack the United States. GBI is based in Greely, Alaska and Vandenberg Air Force Base near Lompoc, California.

A THAAD interceptor is test-launched in Kodiak, Alaska, on July 11, 2017. Photo: Leah Garton / Missile Defense Agency / Handout
America’s ‘Great Retreat’ is well underway
The US is rapidly lowering its military profile and backing away from commitments to allies in the Middle East and Asia.

In the latest test of AEGIS against two short/intermediate-range ballistic missile targets, only one of the targets was hit. That test, on July 24, 2021, took place off of Hawaii.

The AEGIS system was installed on the USS Ralph Johnson (DDG-114) and used the AEGIS interceptor missile, SM-6 Dual II. The ship fired four missiles against two targets and hit only one.

This was an improvement over a previous test last May where a single target was not intercepted. AEGIS is regarded as perhaps the best US system for short and intermediate-range terminal ballistic missile defense and is the backbone of Japan’s sea-based interceptors.

In missile defense, it is generally understood that firing two missiles at a target should yield a 95% probability of a hit. The latest AEGIS test only achieved 50%.

Concern over missile defenses is matched by the increasing vulnerability of US weapons platforms and bases. While the US has bases in Japan including on Okinawa, and further away in South Korea and Guam, all of them would be exposed to massive Chinese missile attacks.

In addition, US aircraft carriers, even if available, will have to locate hundreds, if not thousands, of miles from a war front such as Taiwan, rendering them less than useful for launching and supporting fighter aircraft. Most US carriers do not support the F-35.

The latest wargame also suggests that the US could not maintain networked communications, meaning that they could be disrupted by the enemy.

An F-35B Lightning II set for take off aboard the amphibious assault ship USS Makin Island (LHD 8) in support of Northern Edge 2021. Photo: US Navy / Ethan Jaymes Morrow
America’s ‘Great Retreat’ is well underway
The US is rapidly lowering its military profile and backing away from commitments to allies in the Middle East and Asia

A key US wartime advantage is the ability to mass firepower on high-value targets using networked systems to find the target, direct the nearest interceptor to the target, and knock it out. Networked communications is an important US force multiplier and key to US battle dominance.

Not included in the wargame released information is the distinct possibility that the Pentagon does not have high confidence in the usefulness or survivability of the semi-stealthy F-35.

The F-35 is mainly a tactical air superiority platform that carries only a limited number of bombs because it must carry them internally. It has somewhat limited range and it will have to potentially compete in a conflict scenario with increasingly better Chinese aircraft (Su-35, J-20) equipped with beyond visual range (BVD) air-to-air missiles and advanced AESA radars.

The Navy’s surface ships are primarily useful for anti-air missions and for challenging China’s surface ships. There is some progress in anti-ship missiles, especially the Long Range Anti-Ship Missile (LRASM) which can be used by aircraft including the F-18, B-1B and F-35 and on surface ships.

It has a range of 300 miles and is regarded as stealthy. Unlike the Russian Tsirkon (Zircon) hypersonic missile, which flies at 5,000 mph or 8,047 kph and fits in existing ship launch tubes, the LRASM (when it is deployed) is subsonic.

The Russians successfully test-launched a Tsirkon missile from the frigate Admiral Gorshkov on July 19. The Tsirkon has a range of 1,000 kilometers (621 miles) and can’t be detected on radar, according to the Russians.

Whether China will acquire the Russian missile or build their own is not known, but the Tsirkon significantly outperforms anything the US now has or will have in the next four or five years.

Meanwhile, the Biden administration’s proposed defense budget (roughly $716 billion) is 4% less than the 2020 Trump defense budget after galloping inflation is taken into account. The Biden administration is maintaining the US Navy at 296 ships, down from the Trump administration goal of 316 ships by 2026.

The Navy will get only one new Arleigh Burke class guided-missile destroyer at a cost of $2 billion, not two as the Navy had planned. The proposed defense budget also cuts older US Air Force jets from the inventory, including some of the A-10 fleet (42 to be retired from a fleet of 367), and retiring 47 F-16 C/Ds, 48 F-15 C/Ds, 14 KC-10 and 19 KC-35s.

The US Marines’ expeditionary capability is also being terminated, leaving the Marines as some sort of adjunct to the US Navy. The Army’s budget is also being cut back compared to the other services, but yet it hopes to be able to overmatch potential opponents, mainly China, by 2035.

In essence, then, the current US posture is best defined as “The Great Retreat.” The US is pulling in its military horns, at least for the time being, leaving partners and allies, especially in the Middle East and East Asia, exposed and uncertain.

Under the circumstances, many current US allies and partners may thus seek accommodation with China or in the Middle East aligned instead with Russia and Iran.
Cryogenics
Vacuum Systems for Space Applications
Take a look into space
into space

Where no man has gone before ...

This famous phrase refers to the enormous extension of space and the fascinating objects that can be found therein. Leybold offers a broad range of vacuum technology to explore them. Vacuum pumps are needed to simulate space conditions to test the equipment for space missions. Deep space on the other hand needs to be investigated with the help of telescopes. Coating large mirrors of optical telescopes is an essential technique in which vacuum pump systems are also mandatory.

The only possibility to evacuate large scale vacuum chambers within a reasonable time under clean conditions is the use of cryopumps. Leybold, with its 165 years of experience in vacuum technology and more than 50 years of experience in cryogenics, has been equipping large volume vacuum chambers for space simulation and mirror coating for several decades. Not only pumps are supplied for this purpose, but also gauges, leak detectors and fittings.
Nowadays, mirrors of high-performance telescopes have diameters of several meters and are usually produced using coating techniques in large vacuum chambers. One example is the 8 m mirror at the Gemini telescope on Mauna Kea (Hawaii). It is not feasible to transport big mirrors to the enhanced altitudes where most of the optical telescopes are situated. Thus, big mirrors must be coated on site. Due to environmental influences, further re-coating – usually with aluminum or silver – is necessary every 1 to 2 years. At the Gemini telescope, this is performed in a 150 m³ vacuum chamber by magnetron sputtering using three large cryopumps COOLVAC 30.000 reaching a base pressure of 10⁻⁶ mbar within 6 hours.

The COOLVAC series is equipped with original Leybold pneumatic and mechanic cold heads. The cold heads are not only used for cryopumping, but for any application that requires cryogenic temperatures such as the cooling of sensor chips in telescopes.

Low temperatures reduce the thermal noise and allow for high resolution pictures. This way, telescopes benefit twice from the use of cold heads: by mirror coating and by sensor cooling.
If space equipment fails during a mission, it is nearly impossible to fix it. Such a failure would trigger astronomical costs and hence producers of space equipment are making a big effort to test their products as long as they are on earth. Space travel, scientific and commercial satellites, as well as extraterrestrial research can only be successful if all materials, components and devices involved are successfully tested under high-vacuum conditions. Extreme temperatures in space often range from -200°C to +150°C. All products for space missions must withstand these conditions.

Space simulation chambers are equipped with vacuum pumps and a shroud to thermally decouple the test equipment from the surroundings. Electrical heaters inside the chamber simulate the temperature conditions in space. The vacuum equipment must resist the resulting heat radiation. A high tolerance against this influence is provided by the COOLVAC series which consists of cryopumps with the highest thermal stability on the market.

Unusual conditions demand unusual solutions

The required pumping speed of a vacuum system is determined by several parameters like chamber size, desorption rates, or utilized materials. In addition, the sealings define the total leak rate which limits the reachable ultimate pressure. When process gases are used, the desired working pressure is crucial. Depending on these requirements, Leybold configures an appropriate vacuum system consisting of cryopumps, turbomolecular pumps and corresponding forevacuum pumps.
Unusual conditions demand unusual solutions

Today, electrical propulsion is the keyword for the movement of space crafts beyond our atmosphere where the high vacuum of space is entered. In comparison to chemical propulsion systems, electrical propulsion has the advantage that the thruster material does not need to resist high temperatures. Electrical propulsion uses ionized particles, usually xenon, which are accelerated by an electric field. Xenon has the highest mass of all stable noble gases. Thus, it produces a large thrust per particle.

State-of-the-art xenon thrusters emit a gas flow of 0.1 to 10 mg/sec. In order to maintain a high vacuum pressure at this flow in thruster test chambers, a large pumping speed is required, often in the range of 10,000 to 100,000 l/s for xenon. The benefit of a large mass for propulsion on the one hand is an enormous challenge for vacuum pumps on the other hand.

Leybold has developed an optimized and simple cryogenic solution for xenon pumping. A COOLPOWER 140 T cools a metal disc down to cryogenic temperatures which freezes solid xenon to this cryopanel. This solution supplies a nominal pumping speed of more than 10,000 l/s for xenon. Prior to the thruster test, a high vacuum is usually supplied by turbomolecular pumps and dry fore-vacuum pumps. During the thruster test, they remove gases, e.g. from external leaks, which cannot be removed by the cryopanel as this is at a temperature that is optimized for the pumping of xenon gas.
Leybold can equip chambers of different sizes with appropriate systems

<table>
<thead>
<tr>
<th>chamber size in m³</th>
<th>COOLVAC 3.000</th>
<th>COOLVAC 10.000</th>
<th>COOLVAC 30.000</th>
<th>COOLVAC 60.000</th>
<th>LEYVAC 80</th>
<th>DRYVAC 250</th>
<th>DRYVAC 650</th>
<th>DRYVAC 5.000</th>
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<td>3 m³</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>30 m³</td>
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<td>100 m³</td>
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<tr>
<td>1.000 m³</td>
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<td>3.000 m³</td>
<td>4</td>
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</tbody>
</table>

Typical configuration for space simulation chambers of different sizes. The actual pump configuration can be adapted if required by the application.

Empirical diagram which describes the required pumping speed for a space simulation chamber depending on its size.

A full-range vacuum supplier

Leybold has a broad portfolio of COOLVAC cryopumps in the range between 1,500 l/s and 60,000 l/s pumping speed for nitrogen. Not only is the vacuum completely oil-free, but a major advantage of this type of pumps is their large pumping speed for water vapor. The largest cryopumps can also be equipped with liquid nitrogen connections to cool the pump’s heat radiation shield. This way, several built-in cold heads and their supplying compressors can be omitted and costs can be saved. Of course, „dry“ solutions with fully automatic control electronics are also available.

As a full liner, Leybold also supplies the appropriate forevacuum pumps – if required with control system – for space simulation chambers. Experienced application engineers configure the full vacuum system and work out the important parameters such as pump down time.

Additionally, Leybold delivers leak detectors and vacuum gauges – if required with calibration in own labs. Upon request, installation and service support is supplied by the worldwide service network as well as customer training by the renowned Leybold Vacuum Academy.
Vacuum Components for Space Applications

**COOLVAC**
Cryopumps
COOLVAC vacuum pumps are refrigerator cryopumps which generate a vacuum when gaseous substances are bound to the cold surfaces within the pump by means of cryocondensation. Thanks to the pumping principle, COOLVAC cryopumps have a high effective pumping speed for all gases.

**RUVAC WH**
Roots Blowers
RUVAC WH Roots pumps attain high pumping speed and best ultimate vacuum with maximum safety in modern industrial applications. The smart design of the pumps combines highest robustness with the most compact roots pump design on the market. Operation with frequency converter optimizes the power consumption and protects the roots pump against thermal overloads.

**TURBOVAC MAG**
Turbomolecular Pumps
Smaller space simulation chambers with volumes of 1 m³ or less are evacuated by large turbomolecular pumps like MAG W 2200 iP. In very large chambers these turbo-molecular pumps are often used to evacuate chambers to the starting pressure of the cryopump in a fast and cost effective way.

**LEYVAC**
Screw Vacuum Pumps
This new pump series shows an outstanding pumping speed, also in the high pressure area similar to oil-sealed vacuum pumps. Their robustness, dust compatibility and thermal monitoring capabilities of the motor and pump casing ensure high process reliability.

**DRYVAC**
Screw Vacuum Pumps
The DRYVAC is a new family of dry compressing vacuum pumps. Depending on the application the pumps are available with various equipment components. All versions of the DRYVAC family are water cooled, very compact and can simply be integrated into various pumping systems.

**COOLVAC**
Cryopumps
A broad range of vacuum gauges measuring from 10⁻¹² to 1500 mbar is available. These are either active gauges with integrated electronics or passive gauges using a 19" rack controller. The gauges can be equipped with different interfaces to communicate with control systems. The latest development is the unique GRAPHIX controller with touch screen operation. All gauges can be delivered with calibration certificates by Leybold calibration labs.

**LEYVAC**
Screw Vacuum Pumps
Leybold USA Inc.
5700 Mellon Road
Export, PA 15632 USA
+1 724-327-5700
info.ex@leybold.com
www.leybold.com
Principle
Currently, the rolling vehicles (car & train) are submitted to at least 2 forces which oppose its progress in the air:

1) The aerodynamic force \( (F_{A1}) \) with the expression: 
\[
F_{A1} = \left[ \frac{1}{2} \cdot \rho \cdot (SC_X) \cdot V^2 \right] \cdot CY
\]

In which:
- \( \rho \): density of the air on the ground \( \rho = 1.2 \text{ kg/m}^3 \)
- \( SC_X \): coefficient of penetration in the air, and is on average \( SC_X = 0.65 \)
- \( V \): Vehicle speed on ROAD
- \( CY \): Chilowsky coefficient such that: \( 0 < CY < 1 \)

Example on highway: \( V = 80 \text{ mh (36,11 m/s)} \) \( \Rightarrow F_{A1} = 508 \text{ N} \)

2) The running force \( (F_R) \) has the expression: 
\[
F_R = 0.1 \cdot M \cdot (1 + V/41)
\]

In which:
- \( M \): Total mass of the vehicle (with 2 passengers), \( M = 1200 \text{ kg} \)
- \( V \): Speed of the vehicle on freeway \( V = 36,11 \text{ m/s (80 mph)} \)

Example on highway with these 2 passengers and \( M = 1200 \text{ kg} \) \( \Rightarrow F_R = 226 \text{ N} \)

Illustration
Here: \( D \) = Drag, and we can see that the aerodynamic force is composed of a force due to the overpressure, and a force due to the depression. These 2 forces added together represent the aerodynamic drag. In the example chosen above: \( F_{A1} = 508 \text{ N} \)

R: The force due to the running of the vehicle on the road: \( F_R = 226 \text{ N} \)

The Chilowsky effect
Introduced (this physical effect) in France because of the immigration at the beginning of the 20th century of the great russian scientist, Constantin Chilowsky. He proposed to the French army to apply this effect to the french shells so that these "instruments of dialogue" have a range superior to the German shells ("our playmates" at that time!!)

Opposite the ground tests carried out in France on shells in... 1917 under control of the CNRS!

http://videotheque.cnrs.fr/doc=4277
Principle

The principle of this effect consists in producing a kind of aerodynamic corolla, an aerodynamic shield constituted in the first place by air ejected at high speed (but lower than the speed of sound because the noise) through a slot of reduced thickness but over a length adapted to the front end of the vehicle. In fact, the air molecules which, at the screen, came to collide with the front face of the vehicle, and thus opposed to its advance (it is the drag of pressure, the most important!), these molecules are then diverted from this solid front face, and thus WITHOUT contact with this material part!

A depression is thus created between this shield and the front of the vehicle:
Important remark: It is ABSOLUTELY necessary that this cavity be "closed" on its lateral parts (blind cavity), keeping only its upper part open as illustrated (marks 14 and 145) on the French patent issued by France in 2019:

Mr. Chilowsky (and his experimental successors) had noted that a PROPULSIVE force could develop on the shell, and thus, very paradoxically, conclude that "the faster we advance, the more we advance!"

But of course, there is a limit to how much the speed of the vehicle will increase, and the air molecules outside the vehicle will "penetrate" the aerodynamic shield and fill the cavity, thus cancelling out the depression that was the source of the propulsive force, or at least of a strong reduction in the famous and no less fatal drag! To restore this same depression, it is necessary...
to increase the blowing speed and the thickness of this aerodynamic sheet, and thus to increase the power of the compressor (which we will develop shortly). We can feel that a limit is approaching, and that we will have to find the right balance...

The compressor

It goes without saying - but it's even better when you say it! - that this blowing air positioned on the front of the vehicle must be produced by an adapted device: the **compressor**. The compressor will provide the air pressure necessary to produce the aerodynamic shield which, by blowing through the slot, will partially "envelop" the front face of the vehicle.

According to the US Department of Energy, "electric vehicles convert at least 77% of the electrical energy supplied by the grid into power at the wheels. Traditional gasoline-powered vehicles convert only 12 to 30 percent of the energy in the fuel to power the wheels." Feb 23, 2021

Here is a possible design of this Chilowsky car that we will explain in the conclusion:

The choice of a Wankel compressor is justified by the fact that blowing speeds < 250 m/s can be produced by a maximum overpressure < 1.5 bar. This is very low. Moreover, a Wankel compressor, due to its simplicity of functioning, its lightness, and its very low vibrations, can be driven by an electric motor, itself powered by batteries as we will explain later. Finally, the main criticism of this type of compressor is the leakage, which is solved by using complex linear segments (developed by Mazda), BUT to ensure a compression ratio > 8. For our application this is not the case at all, as we will need a compression ratio < 1.5. We will therefore accept the slight air leaks that will follow in view of the many advantages that this type of compressor offers! In addition, MEASUREMENTS made by the American Department of Energy show that, given the various efficiencies, the electrical supply is by far the most efficient. The only problem lies in the ecological manufacture of the batteries, and especially in their recycling. But one thing is clear: In this physical world, nothing is perfect!

The 2017 simulations and the Chilowsky Coefficient, \(C_Y\)

In 2017 - date of the simulations conducted for the understanding of this Chilowsky effect - it is fair to say that the physical models used to characterize these simulations are now reliable to approach the physical reality to more than 80%. 
In fact, the simulations carried out by the company CD Adapco on its software Star CCM+ made it possible to obtain some results on the left. It becomes possible to produce a "negative drag (in red) ", and thus thrust!

On this table, it appears that a CONCAVE device positioned on the front point of the vehicle with a blowing speed of 250 m/s allows to create a small thrust of almost 9 N, and thus, by abusing language, a "negative drag " .

But without wanting to search for a thrust thanks to this device, we will be satisfied with a 51% reduction in the drag of the car's passenger compartment which "consumes" almost all of the drag.

Thus, with the following dimensions:
- Length of the slot: \( L = 100 \text{ cm} \)
- Thickness of the extrados slot: \( e = 0.3 \text{ cm} \)
- Blowing speed \( V_S = 220 \text{ m/s} \)
- \( N = 1.3 \) (one - and more - extrados blowing slot)
- Blowing angles \( \alpha_{extrados} = 20^\circ \), \( \alpha_{intrados} = 40^\circ \).
- Flow rate \( D_S = 1.08 \text{ kg/s} \) and \( M = V/a \) (\( a \) = speed of sound)
- Blowing force = \( D_S \cdot V_S \)

The pressure required to produce the flow rate with a blowing speed of 220 m/s can be deducted from the expression:

\[
\pi_s = (1 + \left[\frac{\gamma - 1}{2}\right]\cdot M_S^2) \cdot \gamma / (\gamma - 1)
\]

\( \pi_s \) (\( P_S/P_a \)) = 1.4 (to take into account pressure losses), \( T_a = 288 \text{ K} \), \( C_P = 1005 \text{ J/kg.K} \), and \( \eta = 0.85 \) (compressor efficiency) the compression power becomes:

\[
P_{\text{Compression}} = (D_S \cdot C_P / \eta) \cdot T_a \cdot (\pi_s^{(\gamma - 1)/\gamma} - 1) = (D_S \cdot C_P / \eta) \cdot T_a \cdot (\gamma - 1)/2 \cdot M_S^2 = 31 \text{ kW}
\]

If \( \alpha_{extrados} = 20^\circ \) is the extrados inclination angle of the slot, and \( \alpha_{intrados} = 40^\circ \) is the intrados blowing slot inclination angle, then the total blowing force, \( F_{S+} \), will have the value:

\[
F_{S+} = D_S \cdot V_S \cdot (\sin\alpha_{extrados} + 1/3 \cdot \sin\alpha_{intrados}) = 234 \text{ N}
\]

So, this value of 234 N will be subtracted from the drag WITHOUT device.

Finally, if the Chilowsky coefficient, \( C_Y = 0.49 \), knowing that the drag outside the device is \( F_{A1} = 508 \text{ N} \) to which we must therefore subtract \( F_{S-} \) and thus obtain the power of the electric motor at the wheel. Hence the following expression:

\[
P_{\text{Elec_Roue}} = [(508 - 234) + 226] \cdot 36,11/0,77 = 500 \cdot 36,11/0,77 = 24 \text{ kW}
\]

Hence a total electrical power, \( P_\Sigma \), to be supplied by the batteries: \( P_\Sigma = (24 + 31) = 55 \text{ kW} \)

Power of a thermal car without device: \( P_{\text{Th}} = 734 \cdot 36,11/0,25 = 106 \text{ kW} \)

That is, in electric, a reduction of power of 52%!!

Moreover, the Chilowsky effect has been confirmed by a group of students from the famous Mines ParisTech under the responsibility of eminent teachers-researchers from Sophia Antipolis (Nice) of CEMES. Thus, it is possible to summarize their investigations by the following illustration:

These students recorded their work on YouTube: [https://www.youtube.com/watch?v=lqh0RCla3GY](https://www.youtube.com/watch?v=lqh0RCla3GY)
The batteries/Autonomy/Mass
In this part, we estimate the mass of the battery for an autonomy of 600 km on highway at the authorized speed of 80 mph (36.11 m/s). And to compare the whole to the kerosene for an aeronautical application. Then, after, to return to the "clean" car.

Simple calculations:
The ICP (Inferior Calorific Value) of Kerosene is 43 MJ/kg (43x10^6 J/kg)
At -55°C, it does not freeze (temperature at cruising altitude of most international commercial aircraft). Its density is 0.8 kg/liter, and its price per kg remains very competitive!

Without making an apology for oil, but only with an engineer's point of view, we are going to compare this fuel with the capacities of current batteries and in the near future:
1) To present, lithium-ion batteries have an energy density performance of about 250 Wh/kg or 0.9x10^6 J/kg
2) To remain in the field of wheeled vehicles, if we agree on the following parameters:
   a) Distance travelled: 600 km = 6.10^5 m
   b) "Cruising" speed: 80 mph or 36.11 m/s
   c) Coefficient of drag, Cx = 0.3 (the Mercedes CLA, the best of all in this field, has a Cx = 0.23, and the average car has a Cx > 0.4), that is an average S.Cx = 0.65 m^2
   e) Classical aerodynamic drag force FA = ½.ρ.[S.Cx].V^2

Under these conditions:
1) Aerodynamic drag force, FA1 = ½x1.2x0.65x36.11^2 = 508 N
2) Energy consumed over 600 km = 508x600x10^3 = 304.8x10^6 J
3) Current energy density = 250 Wh/kg = 250x3600 = 0,9x10^6 J/kg
4) So, a mass for the batteries: (304,8/0,9) = 338 kg

And this is without taking into account that the battery should not be discharged, and preferably keep at least 10% of its charge, and also taking into account that the exceptional efficiency of the electric motor is at least 0.9, it would then be necessary to increase the mass of the batteries of at least 20%; that is to say a final mass of approximately: = (338/0.8) 422 kg

We are not yet ready to substitute current commercial aircrafts (> 200 seats) by electric propulsion aircrafts (not hybrid)! Knowing also that the batteries do not like at all the low temperatures (cruising altitude for the planes) which see then their output drop brutally. What can we say about the ecological plan, without counting ALL the production chain of these batteries until their recycling?

Note: The much lighter landing weight of the aircraft will have consumed a large part of the fuel: Landing on shorter distances, lower fuel consumption, and/or higher speed during the cruise, while the battery mass remains almost unchanged during the trip!
Returning to the car, taking into account the resistance, \( FR \), produced by the rolling of the tires on the road, \( FR \) admits for expression:

\[
FR = 0.1 \times M \times (1 + V/41) = 226 \text{ N}
\]

Expression in which:
- \( M \) = Total mass of the vehicle, here also, \( M = 1200 \text{ kg} \)
- \( V \) = "Cruising" speed on the highway, \( V = 36.11 \text{ m/s (80 mph)} \)

The blowing represented at the end of the intrados is intended to compensate in an aerodynamic way the weight of the batteries obtained by the shape of the lower part of the body and the blowing of the intrados limited to 1/3 of that exerted on the extrados. In fact, the total weight of the vehicle is maintained at 1200 kg.

With this intrados + extrados blowing, the aerodynamic thrust \( + \) projected on the axis, and considering with \( \alpha_{\text{int}} = 40^\circ \) and \( \alpha_{\text{ext}} = 20^\circ \), this force therefore becomes:

\[
D_S = \gamma \cdot Pa \cdot \left( \frac{4}{3} \right) \cdot Lx \cdot M/a = 1.08 \text{ kg/s}
\]

\[
F_{S+} = D_S \cdot V_s \cdot (\sin \alpha_{\text{ext}} + 1/3 \cdot \sin \alpha_{\text{int}}) = D_S \cdot V_s \cdot (0.342 + 0.214) = 132 \text{ N}
\]

In these conditions, this positive blowing force \( F_{S+} = 132 \text{ N} \) will be subtracted from the Aerodynamic Resistive Force of the capsule which will have benefited from the Chilowsky device, and this one has been established at \( F_A = 508 \times 0.49 = 250 \text{ N} \).

Thus, with \( M = 1200 \text{ kg} \), and \( V = 36.11 \text{ m/s} \), the total force of this resistance, \( F_\Sigma \), becomes:

\[
F_\Sigma = F_A + F_R = (250 - 132) + 226 = 344 \text{ N}
\]

It is this force at the wheel that the motor of this electric vehicle will have to overcome. The power of this electric motor will therefore be - taking into account the considerations. According to the US Department of Energy, "electric vehicles convert more than 77% of the electrical energy supplied by the grid into power at the wheels", hence:

\[
P_{\text{Electric Motor}} = 344 \times 36.11 / 0.77 = 16.1 \text{ kW}
\]

Let the total power of the batteries be:

\[
P_\Sigma = P_{\text{Compressor}} + P_{\text{Wheels}} = 37 + 16.1 \Rightarrow P_\Sigma = 55 \text{ kW}
\]

Compare to the power at the wheel of a thermal car WITHOUT the Chilowsky device:

\[
F_\Sigma = 734 \text{ N} \& V = 36.11 \text{ m/s} \Rightarrow P_{\text{Power}} = 734 \times 36.11 / 0.25 = 106 \text{ kW}
\]

**Conclusion**

Taking into account these hypotheses on the Chilowsky coefficient, \( C_Y \), limited to \( C_Y = 0.51 \) in order to prevent any omission of non-théorisables resistive forces, it seems reasonable to affirm that under these conditions and by default, on this distance of 600 km at the speed of 80 mph on a freeway, this Chilowsky device increases the autonomy of the Battery of 48% \([(106-55) / 106]\). It is as IF the energy density of the battery increased from 250 Wh/kg to 370 Wh/kg!
Note on the weight of the batteries: Taking into account the reserves and efficiencies, the weight of the batteries with and without Chilowsky device, for:

a) Driving distance = 600 km (6.10^5 m)
b) Highway speed = 80 mph (36.11 m/s)

Under these conditions, for the weight $P_{\text{Bat}}$ of the batteries, we obtain:

Without device:  
$$P_{\text{Bat}} = 6.10^5 \times 7.44 \times 10^2 / (0.8 \times 0.9 \times 10^6) \times g (g = 9.81) = 6082 \text{ N}$$

With device:  
$$P_{\text{Bat}} = 6.10^5 \times 3.44 \times 10^2 / (0.8 \times 0.9 \times 10^6) \times g (g = 9.81) = 2812 \text{ N}$$

Thus, with a lower body area estimated at 1.2 m x 3 m = 3.6 m^2, the intrados overpressure required to compensate for the weight of the battery WITH Chilowsky device must be:  
$$\Delta P = 2812 / 3.6 = 781 \text{ Pascals} < 1\% P_a \text{ (atmospheric pressure on the ground)}$$

This eliminates the need for a differential device, provided that a computer is developed that regulates the speed of each wheel in any curve geometry.
It is possible to neutralize the aerodynamic drag on highway at 80 mph:

\[ F_{\text{aero}} = \left[ \frac{1}{2} \rho \cdot (S \cdot C_x) \cdot V^2 \right] \cdot C_y - \gamma \cdot \rho \cdot L \cdot x \cdot e \cdot M / a \cdot V_s \cdot \sin \alpha = 0 \]

With: \( S \cdot C_x = 1.5 \times 0.3 = 0.45 \) / \( V = 36.11 \text{ m/s} \) / \( V_s = 220 \text{ m/s} \) / \( \alpha = 20^\circ \) / \( L = 100 \text{ cm} \) & \( e = 0.3 \text{ cm} \)

In these conditions: \( C_y = 0.17 \) (it is also possible to create a “negative drag”!)

The only powers to consider are the power due to blowing, and the power due to the tires:

\[ P_{\text{blowing}} = (\gamma \cdot \rho \cdot L \cdot x \cdot e \cdot (M / a) \cdot C_P / \eta) \cdot T_a \cdot (\gamma - 1/2) \cdot M S^2 = 23 \text{ kW} \]

Note that this power, \( P_{\text{blowing}} \), is proportional to \( M_s^3 \)

Thus, with \( V_s = 200 \text{ m/s} \Rightarrow M_s = 0.588 \Rightarrow P_{\text{blowing}} = 17 \text{ kW} \Rightarrow P_{\text{total}} = 30 \text{ kW} \)

\[ P_{\text{rolling}} = 0.1 \times M \times (1 + V/41) \times V/0.77 = 11 \text{ kW} \]

That is to say 3 kW per ??-Electric-Wheel!

Considering that the weight of the battery is compensated by the lift of the fuselage, and that the mass of the car with 2 passengers is \( M = 1200 \text{ kg} \).

Hence a total power with \( V_s = 220 \text{ m/s} \) evaluated at: \( P_{\text{total}} = 35 \text{ kW} \)

A battery < 200 kg, an energy density of 250 Wh/kg and a range of 600 km.
Integrating an electric motor in the wheels would offer more living space but also impeccable motricity.

Integrating an electric motor directly into the wheels of a car is one of those ideas that seem so great because of the benefits it can bring. The technique, far from being new, has never been able to break through. But today, a Slovenian company promises to revolutionize this sector.

From the city car to the super sporty, the company Elaphe offers a range of proposals

We thought the subject was classified as a "good idea that didn't work out" since giants like Michelin had abandoned their projects for wheels with an integrated electric motor. First presented at the Paris Motor Show in 2004, the Active Wheel was even considered for installation in production vehicles by 2016.

But the French tire manufacturer stopped as early as 2014. Reasons cited? The weight of these motors housed in a fully equipped wheel, and the manufacturing costs. A price that would have further increased the already high bill for electric cars at the time.

Today, companies such as Elaphe in Slovenia propose solutions that are a priori very successful and even supported by European funds. But first, let's see what this famous wheel with integrated motor consists of...

Integrated motor = opportunities for designers
The preferred area for these wheels is electric cars. To date, all cars in this category have one or more motors embedded between the wheel axles. Up to 3, for example at Audi for its e-tron S and Tesla for its Model S.

With this type of architecture, the axles that connect the engine(s) to the wheels take up a lot of space and "eat up" part of the passenger compartment. The same goes for the engine(s) which also take up some of the interior volume.

By moving the motors to the wheels, designers can redefine the space dedicated to motorists. They're starting from almost a blank sheet of paper, since the batteries are always housed under the floor, which is flat by definition. This is the main argument of the designers of these integrated engines.

Integrated engine = more interior space
Caltech Announces Breakthrough $100 Million Gift to Fund Space-based Solar Power Project

by Kathy Svitil, 2021 August 03

https://www.caltech.edu/about/news/caltech-announces-breakthrough-100-million-gift-to-fund-space-based-solar-power-project

Today, Caltech is announcing that Donald Bren, chairman of Irvine Company and a lifetime member of the Caltech Board of Trustees, donated over $100 million to form the Space-based Solar Power Project (SSPP), which is developing technology capable of generating solar power in space and beaming it back to Earth.

The donation was made anonymously in 2013, but the gift is now being disclosed as SSPP nears a significant milestone: a test launch of multifunctional technology-demonstrator prototypes that collect sunlight and convert it to electrical energy, transfer energy wirelessly in free-space using radio frequency (RF) electrical power, and deploy ultralight structures that will be used to integrate them.

Donald Bren first learned about the potential for space-based solar energy manufacturing in an article in the magazine Popular Science and in 2011, he approached Caltech's then-president Jean-Lou Chameau to discuss the creation of a space-based solar power research project. In 2013, he and his wife, Brigitte, a Caltech trustee, agreed to make the donation to fund the project. The first of the donations that now exceed $100 million was made that year through the Donald Bren Foundation, and the research began.

From left, Sergio Pellegrino, the Joyce and Kent Kresa Professor of Aeronautics and Professor of Civil Engineering, Jet Propulsion Laboratory Senior Research Scientist and co-director of the Space-Based Solar Power Project; Brigitte Bren; Donald Bren; Ali Hajimiri, the Bren Professor of Electrical Engineering and Medical Engineering and co-director of the Space-Based Solar Power Project; and Richard Madonna, project manager of the Space-Based Solar Power Project.

Credit: Caltech
Caltech Announces Breakthrough $100 Million Gift to Fund Space-based Solar Power Project

"Donald Bren has brought the same drive and discipline that he has demonstrated with master planning communities to the Space Solar Program," says Caltech President Thomas F. Rosenbaum. "He has presented a remarkable technical challenge that promises a remarkable payoff for humanity: a world powered by uninterruptible renewable energy."

Donald Bren is best known for master planning and master building the all-new City of Irvine, regularly named one of America's greenest cities. He has led Irvine Company's effort to permanently preserve more than 60 percent (57,500 acres) of the Irvine Ranch property along the California coast.

"I have been a student researching the possible applications of space-based solar energy for many years," says Donald Bren. "My interest in supporting the world-class scientists at Caltech is driven by my belief in harnessing the natural power of the sun for the benefit of everyone."

SSPP aims to ultimately produce a global supply of affordable, renewable, clean energy. A key benefit of harnessing solar power from space is that it provides access to the sun to create power all day, every day, free from weather constraints or darkness of night.

The project's first test, which will occur in early 2023, will launch technology prototypes for the solar power generators and RF wireless power transfer, and includes a deployable structure measuring roughly 6 feet by 6 feet.

The Brens have no financial stake in the project and will not benefit financially from any technology that is created.

"It shows the magnitude of the generosity," says Ali Hajimiri, Caltech's Bren Professor of Electrical Engineering and Medical Engineering and co-director of SSPP. "They really want to change the world and truly see this as an opportunity to make a lasting difference for the planet, while generating a broad range of novel technologies with impact in many areas such as wireless power, communications, and sensing."

The Bren's gift has allowed researchers to overcome many early hurdles and funded the hiring of doctoral students to work on the project with a five-year commitment, notes Sergio Pellegrino, Caltech's Joyce and Kent Kresa Professor of Aerospace and Professor of Civil Engineering and co-director of SSPP. Pellegrino is also a senior research scientist at JPL, which Caltech manages for NASA.

"It allows us to think ahead," Pellegrino says. "Without that, it couldn't get done."

"Solar energy is the world's most abundant energy resource. However, sunlight is intermittent at the earth's surface. This ambitious project is a transformative approach to large-scale solar energy harvesting for the Earth that overcomes this intermittency and the need for energy storage, since sunlight shines continuously in space," says Harry A. Atwater, who is an SSPP researcher, Otis Booth Leadership Chair of the Division of Engineering and Applied Science and the Howard Hughes Professor of Applied Physics and Materials Science, and director of the Liquid Sunlight Alliance.
Hoverboards are going to be the new upcoming airborne vehicle for the mobilization. It can be used for domestic as well as for entertainment purpose. Currently, few companies are trying to build a hoverboard by using the magnets of similar poles and a bunch of metal sheets. But it can work for a very short period of time because of Earnshaw’s theorem which states that “a charged particle cannot be held [statically] in a stable equilibrium by electrostatic forces alone” and self-evidently it’s not feasible to lay metal sheets everywhere. Therefore, based on the concept of drones, this paper proposes a design of a hoverboard to solve the above stated issue. Drones like bi–copter are compact in design and they resemble more to a skateboard and that is why they are the perfect choice as a primary/base design.

For our preliminary constraints, we finalized 3 inches of lift, along with the assumption to lift the weight of 60kg for which thrust of 120kg (combining both rotors) would be required to maintain a consistent thrust to weight ratio of 2:1. Therefore, required thrust from each motor will be of 60kg approx. From the numerous kinds of motors in the market, like brushed and brushless, along with a few motors which can easily provide the thrust of 60kg-70kg, they all need large propellers measuring up to 25-30 inches. Consequently, these will increase the size, shape and weight of the hoverboard by infinite proportions.

Moreover, it would become difficult to operate, along with a downfall in its efficiency. Usage of heavy motors with small propellers won’t be much useful because it won’t be able to develop enough pressure difference to hover the board and to meet the required thrust. There are miniaturized jet engines also in the market which can be used for generating the thrust. But even with miniaturized jet engines, the required thrust is not possible with the current resources available. Another thing to note here is that the miniaturized jet engines consume a lot of fuel for even running over short period of time due to which cost to weight ratio would increase tremendously.
HOVERBOARDS- A FUTURE FLYING MACHINE

Therefore, we can conclude that it is not possible with present development in motors, propellers and miniaturized jet engines to construct a hoverboard. Heavy motor would be required which can perform even with small propellers or extremely miniaturized jet engines and which can generate large amount of thrust. As per the current trend of the drastic changes in technology today, it is quite safe to say that someday we will meet our specific requirements and we will be able to hover in air.

Vidit Aggarwal  
Dr. Sudhir Kumar Chaturvedi
Small Bodies Near and Far (SBNAF): Measurements database for thermal infrared of small bodies in the Solar System

Mahima Gupta and Sudhir Kumar Chaturvedi
School of Engineering
UPES Dehradun-248007
India

The sequence and the combination of visible and thermal data from the ground and astrophysics space missions is the core to improve the scientific understanding of near-Earth, main-belt, trojans, centaurs, and trans-Neptunian objects (TNOs). The Small Bodies Near and Far (SBNAF) method will determine the size, revolution, and aspect, thermal inertia, surface roughness, and in some cases of mass/bulk densities and even internal structure, for targets out to the most remote regions in the Solar System. In this article, the portrayal of Small Bodies: Near and Far Infrared Database, is an easy-to-use tool assigned to facilitate the modeling of thermal emission of small bodies of the Solar System. The database that gathers the measures of thermal emissions for small Solar System targets is contrarily available in scattered sources and implements a complete description of the data, including all the information necessary to perform direct scientific interpretations without the need to access additional external resources. This federal database includes characteristic data of asteroid detections of large surveys (e.g. AKARI, IRAS, and WISE) and an accumulation of small body observations of infrared space telescopes (e.g. the Herschel Space Observatory) also implements a web interface to access this data. An example for the direct application of the database shows how they estimate the thermal inertia of specific populations, for example, asteroids within a given size range. The thermal inertia scaling differently with heliocentric distance (i.e. temperature) may alter the description of the data and analysis about the widely-used radiative conductivity exponent ($\alpha = -3/4$) that might not be adequate in common, as suggested in past years studies. The interpretation of field and modeling the thermal emission for asteroids ought to experience substantial growth in the last decade and spatially resolved from space instruments in situ thermal emission data. The standard subsolar temperatures of near-Earth asteroids are 300 K, and 200 K in the main belt. The thermal emission of these asteroids' summits is in the mid-infrared (10–20 µm). Although these wavelengths are partially available from the ground, the broad majority of these observations are discharged by space instruments. Despite their mild surface temperatures, the modeling of near-Earth asteroids profited from far-infrared observations too. Past Jupiter and in the transneptunian region, the typical surface temperatures descend from 100 K to 30–50 K, and the corresponding ejection with a peak in the far-infrared (50–100 µm) is almost exclusively observed from the space. Centaurs and TNOs were pleasantly perceptible with the far-infrared indicators of the Spitzer Space Telescope. While some original and primary goal of asteroid thermal infrared measurements is to derive diameters and albedos (solar radiation), the detector sensitivity improvement as well the accessibility of multi-epoch observations not only offer more precise diameters including albedos, but also give the permit for deriving other physical properties, such as thermal inertia and surface roughness.
Space solar power (SSP) usually involves gathering energy in space, converting it into a microwave beam, and directing that beam at Earth to be converted into electricity. The National Space Society has promoted SSP for decades. A year or so ago the Alliance for Space Development made SSP one of its four legislative objectives, and in the last month the Beyond Earth Institute and the Progressive Policy Institute have made major moves promoting SSP, including a draft Presidential Policy Directive by Beyond Earth. Why this much interest now?

Because for many moons studies have found SSP to be technically sound, but too expensive to take off. That may be changing. In particular, two of the largest costs, launch and manufacturing, are dropping like a stone.

**Launch**

In 2011 the space shuttle flew its last flight in the midst of a long era of $20,000 per kg launch costs on mostly expendable boosters. Today (2021), the cheapest launch vehicle is the partially reusable SpaceX Falcon Heavy with an advertised launch price of around $1,400 per kg, a reduction of well over an order of magnitude. But there’s more.

SpaceX has been developing the fully reusable launch vehicle, Starship, with an estimated launch cost of somewhere around a few hundred dollars per kg, another order of magnitude reduction in cost if all goes well. While SpaceX frequently misses deadlines they have consistently achieved their performance goals. They build and operate the most successful launch vehicle of our day, the partially reusable Falcon 9.

This suggests it is reasonable to expect a reduction in launch cost of around two orders of magnitude when compared to the shuttle era. But there is more.

**Manufacturing**

While launch costs are a major fraction of the economic problem faced by SSP, they are not the largest. Satellites are generally significantly more expensive than launch. Typical cost of a payload can range from a few thousand dollars per kg to 200 thousand per kg or more. Such high prices reflect that space payloads traditionally are handcrafted one of a kind systems. To significantly reduce costs requires manufacturing large numbers of identical components to amortize automation and achieve other manufacturing economies of scale. The problem for SSP, a new source of power, is to get economies of scale when building the first operational powersat.
Why Space Solar Power Now?

The communication satellite constellations are leading the way to the first step. They consist of thousands of identical, or nearly identical, spacecraft that conform to certain communication protocols. These spacecraft can be, and are, mass produced. For even a single constellation the number of satellites is large enough that one can get economies of scale. For the SpaceX’s Starlink constellation this difference in cost is about 100 to one. Again, two orders of magnitude cost reduction. As you may have guessed, there is more.

The SPS-ALPHA (Solar Power Satellite by means of Arbitrarily Large Phased Array) design takes the next step, generating economies of scale in the manufacture of a single, albeit extremely large (km scale), satellite. SPS-ALPHA consists of more than a million modules of only 16 types, ~60,000 modules per type. The list of types changes as the design matures, but for illustrative purposes, a few of these types might be:

1. An adjustable mirror module type that reflects sunlight onto an array of beam generation modules that take sunlight from one side, and emit microwaves via phased array from the other
2. A beam generator module type that converts sunlight to microwaves
3. A simple robot arm type that can work in groups to construct and repair the powersat by adding and removing modules
4. A module type with electric propulsion for station keeping and transferring the finished powersat from a construction site in Low Earth Orbit to operations in Geosynchronous.

In addition, there are a number of trusses. Using the trusses for structure, much like bones in our bodies, modules self-assemble in space in an environment designed for robotic construction and repair. The closest analogy is a robotic warehouse where robotic forklifts move pallets around, a much easier task than navigating on the surface of Mars, which is not designed for robotic exploration!

Conclusion

Mass production of modules combined with the cost reduction for launch that Starship promises may at long last close the SSP business case with a two orders of magnitude cost reduction in the most expensive parts of a spacecraft: launch and manufacture. This is why there is so much interest. Even if the business case does not completely close it will certainly take a giant step in the right direction and develop valuable technology in the process.

Acknowledgements

Special thanks to John Mankins for most of the ideas and data in this piece.
Maximus Trest: Ultra Cardboard Pinball & Greeting Card DJ; Interview by TV Tokyo / Japan

https://vancouver.makerfaire.com/maker/entry/176
https://drive.google.com/file/d/1DoXqtDqK6PbFLJCvB8JDUJgcPjHAWr/view

Young Maker Max Trest loves all things tech, engineering, history, and more! He's bringing a couple of his projects to Maker Faire Vancouver, including a couple that he's spent most of his summer working on:

Ultra Cardboard Pinball:

Ultra Cardboard pinball is a custom-made, kid-sized, completely modular pinball machine. The machine is built out of cardboard, plastic cups, and other materials, and features LED lighting. There are two stock games, but by swapping out the title and placing anything you want on the machine, you can make any type of pinball game and then rearrange the parts for an unlimited combination of games. Max even ripped out two audio chips so that the sound and music can be customized for each game!

Fully Automated LEGO Mindstorms EV3 Candy Machine:

The candy machine dispenses two different types of candy and uses sensors to detect and dispense candy when a user puts their hands in front of the machine. There is also a really cool rotating sign on top that syncs to the type of candy that the person picks.

RC Truck:

Max took apart an RC car and turned it into a cardboard RC truck. The truck is like a mini version of a Japanese Dekotora truck, which is a decorated tech art type truck. The RC truck Max made is lit up, has a spinning disco ball at the back, an alien stuffy as the driver, and a cow stuffy in the back.

Max has been featured in Peace Arch News, https://www.peacearchnews.com/community/budding-developer-creates-a-lego-sized-white-rock/, was interviewed by a TV crew for a Japanese TV show on the TV Tokyo network, and has won an Inventor of the Week competition.
FLIGHT TO VENUS – A Special Conjunction
by Dr. Robert Q. Fugate, Speaker/Lecturer of the AIAA Space 2015 von Kármán Lecture

This photo exists only because of a series of remarkable events. I had made plans to photograph the transit of Venus on June 5, 2012. The transit of Venus is an astronomical conjunction event in which the planet passes in front of the Sun over a period of several hours. The next Venus transit won’t be until December 11, 2117. So, I wanted to get this once in a lifetime event right.

I live in Albuquerque, NM and the morning of the event, the sky was not perfectly clear - there were high thin cirrus clouds. I wanted a clear sky, so I looked at the weather and found that the sky just west of Albuquerque was perfect (it turns out it cleared in Albuquerque in time for the transit, but if I had stayed, I would have missed this shot). quickly looked at Google Earth and picked a spot south of Interstate 40 at the Continental Divide exit. I got
FLIGHT TO VENUS – A Special Conjunction

my equipment loaded in my Jeep and headed west. So the first event enabling this photo was my decision to pick the Continental Divide as the place to shoot the transit.

I arrived at my selected site just after noon. The site was an abandoned Forest Service camp about 15 miles south of Interstate 40 at the Continental Divide turnoff. The site was at the peak of a small hill rising a hundred feet or so from the surrounding terrain. I decided to locate just below the top of the hill to get some shade from the trees in the area.

I set up my tripod, 400mm lens and Nikon D800 camera. I had an attenuating filter that reduced the light reaching the camera by a 1000 times to protect my camera’s sensor and to make exposures even possible. I started photographing the sun and just as predicted, Venus appeared at the edge of the solar disk right on time.

I began collecting images on a regular cadence of about 15 minutes, adjusting the pointing of the lens and camera for each set. Venus moved steadily across the disk of the Sun. There were several large sunspots to adding interest to the photos.

I was using an old Nikon 400 mm f/2.8 lens and a 2X teleconverter making the effective focal length of the lens 800 mm. I had to manually focus the lens using the live view display on the camera (the only sensible approach for this kind of shot) but had electronic control of the effective aperture. Most exposures were 1/4000 sec at f/5.6, ISO 100. Even though the lens was old, the optical quality was outstanding.

I saw several high flying aircraft with short contrails and thought “Wouldn’t it be neat if one passed in front of the sun?” But, alas, all afternoon none were even close.

As the sun got lower in the sky, I realized that I would get a better view of the sun as it approached the horizon if I moved my location to the top of the hill. I had moved my vehicle and equipment only about 100 yards but that move enabled the Flight to Venus shot because I would not have seen the plane approaching from the first location and would not have been ready to take the photo.

When the Sun was only 3 degrees elevation, I spotted an aircraft’s contrail on the horizon headed directly toward the Sun. As it got closer I got more excited but I couldn’t keep watching since the Sun was so bright. I started thinking, “How will I get this shot if it does pass in front of the Sun?”

I had a cable release attached to the camera so as to not add any vibration and blur the highly magnified image. I had to press the cable release twice to make a picture: once to raise the mirror and once to fire the shutter. I thought I should change to burst mode to get more pictures. I was using live view so could see the Sun on the rear screen of the camera.

Just as I was thinking about changing my camera’s mode, the plane appeared on the left edge of the Sun!

I nearly panicked but knew with the mirror up mode on the camera I only had one shot. I waited a heart beat (I later computed that it took 3.8 seconds for the plane to cross the disk) until the plane was just to the right of the center of the Sun and as quickly as I could pressed the cable release twice.
FLIGHT TO VENUS – A Special Conjunction

I was dumfounded!! Did I get the shot?
I quickly recalled the image from the memory card.
YES! I GOT IT!

I was thrilled and could hardly concentrate on photographing the rest of the transit. The Sun finally sank into the tree line ending a perfect day.

When I got home late that night and downloaded and backed up my shots, I was able to display the airplane shot on a big screen computer. My immediate thought was “If I were the pilot of that aircraft, I would want this photo.” So a three day quest began to find out what that aircraft was and who was flying it.

I checked all the online sources I could find about scheduled flights within range of Continental Divide, NM at the time of the photo. Nothing. The shape of the plane indicated it was either an MD-10 or MD-11, out of passenger service in the US, but used by UPS and FedEx. These type aircraft were also used by the Air Force as aerial refueling tankers so I thought it may be a military plane. After two days of searching the internet and making inquiries on aircraft forums, I thought “It’s time to call the FAA.”

I found a fellow at the FAA Albuquerque Center, Brett Stewart, who was interested in helping me identify the plane. I told him the time, my location, and the direction I was looking. I had also estimated from the scale of the photo and the length of an MD-10 type aircraft that the plane was about 70 miles from the camera. With that information, Brett quickly found the flight in question. It was a United Parcel Services MD-11 on a flight from Ontario, CA to Louisville, KY. And, it was an unscheduled flight. It turns out UPS needed the MD-11 back in Louisville before its scheduled next morning flight because one of their 747 aircraft was taken out of service. So, the 3rd event materialized making the photo possible - an unscheduled flight in exactly the right place and direction at exactly the right time.

Brett at the FAA said he would contact the Chief Pilot at UPS. He did. The next day I got a call from Chief Pilot John Ransom. He said “I understand you have a photo you’d like to get to one of our crew.” I said, “Yes.” “Well”, he replied, “just send it to me and I’ll see they get it.” I had planned to make large framed prints, so before going to all that expense and trouble, I asked John, “Maybe you should look at the photo and see whether or not you think they would like to have it.” He agreed and I told him where to find it on my website.

In about 15 minutes he called me back. “Holy crap! They are going to want this picture. Let me get in touch with them and I’ll have Captain David Kantor give you a call.”

Later that day I got a call from Captain David Kantor. He told me the story of how he learned about the photo from his Chief Pilot, John Ransom. “Right after we landed in Florida and just as I turned on my cell phone while still in the cockpit, my phone rang. It was the Chief Pilot. In all my years at UPS I had never had a call from the Chief Pilot.”

He told me “We’ve had a call from the FAA!” David said his heart nearly stopped. If you are a pilot you never want to hear those words. John went on, “It looks like you were off course and at the wrong altitude.” David couldn’t muster a reply. Then John said, “In fact it looks like you were headed to Venus!” David said he was confused and relieved at the same time. “OK, what’s going on?” John then proceeded to tell the story of how I had contacted the FAA in Albuquerque and how Brett had identified the UPS flight as being in the photo.
FLIGHT TO VENUS – A Special Conjunction

David was an instant celebrity at UPS. He became known as Captain Planet. Someone made him a brown cape with appropriate decorations. The FAA controllers in Albuquerque started asking “Is this Captain Planet” when he checked in to the Center on cross country flights.

I made the prints, framed them and sent them to John Ransom. He subsequently presented the print to Captain David Kantor and Assistant Chief Pilot Scott Quinlan made a presentation to First Officer Dean Burke. I also provided a print to Brett Stewart at the FAA Albuquerque Center, where it hangs to this day.

The word spread among UPS pilots worldwide that there was a cool photo of a UPS plane in front of the Sun and Venus. I sold over 70 unmounted poster prints to pilots. I donated a large framed print to the UPS United Way auction which sold for many hundreds of dollars. Subsequently it was featured on the cover of UNIQUE magazine (in three languages) - “The world’s bespoke private jet luxury lifestyle magazine,” and featured on Earth Sciences Picture of the Day by invitation (I should have submitted it to NASA’s Astronomy Picture of the Day but never did).

In the photo it is remarkable to realize that the distance to the plane is 67 miles, the distance to Venus is 27 million miles and the distance to the Sun is 92 million miles. The angular distance between the plane and Venus is less than 0.05 degrees.

Epilogue

Sadly and tragically Capt. David Kantor died suddenly (natural causes) in February, 2017. We had stayed in touch since the photo and had developed a lasting friendship. His untimely death hit me, his family, and his pilot community very hard. At the request of UPS, I made a special print of Flight to Venus with the inscription “Blue Skies and Tailwinds” which was displayed at his memorial service. I have also had several communications with David’s father, who is so proud of his son and his love for flying. Who would have thought that the events of June 5, 2012 and the single click of a camera shutter would result in so many memories?

Bob Fugate
Albuquerque, New Mexico
AIAA LA-LV Aerospace News Digests by Dr. Ken Lui, AIAA LA-LV Section

(Aug 16) Ashley Kowalski: What does it take to be selected for a NASA Human Research Program?

(Aug 20) NASA's Hubble successor, the James Webb Space Telescope, finally ready to ship

(Aug 25) Boeing Unveils F-15 Qatar Advanced Jets; Rollout ceremony for Qatar’s F-15 jets held in St. Louis today

(Aug 30) Inside the Final Hours at Kabul Airport; The Last U.S. Military Plane Has Left Kabul. What’s Next for Americans, Afghans Left Behind?

(Aug 24) Aerojet Rocketdyne expands Canoga Park facility for NASA's Moon and Mars rocket

(Aug 27) Space Development Agency transitioning to US Space Force

(Aug 31) NASA’s hopes waning for SLS test flight this year

(Aug 23) Fastest-moving asteroid flies closer to Sun than Mercury

(Aug 31) Satellite Observes Power Outages in New Orleans

(Aug 31) Hurricane Ida As a Category 4 Storm (from ISS)

(Aug 23) Aerospace is Redefining the Future of Small Satellites (DiscSat)

(Jul 19) A Framework for Developing Trust in Artificial Intelligence

(Aug 11) Why Digital Engineering is Essential to the Future of Space

(Aug 25) Space Systems Command is more than a name change, says new commander

(Aug 24) Air Force’s Kendall Creates Space Acquisition Office, Accelerates Absorption of Space Development Agency

(Aug 24) After meeting with ULA and Blue Origin, Air Force secretary cautiously optimistic about Vulcan

(Jul 29) Russia’s Nauka module briefly tilts space station with unplanned thruster fire

(Aug 26) Best time for humans to travel to Mars is when the sun is roaring, scientists say

(Aug 23) Long Beach Reemerges as an Aerospace Hub

(Aug 24) DARPA Requests Information For Wing-In-Ground Effect Aircraft For The U.S. Military
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 Adaptive Optics,” the key technology that has enabled a revolution in extremely large ground-based telescopes to see clearly through the turbulent atmosphere.

Every few years the orbits of Mars and the Moon (as observed from a particular place on Earth) cross in the sky. These events are not of great scientific value these days since we have so many other means to study the Moon and Mars. But they are interesting to watch especially through a telescope or even binoculars.

One of these events occurred just before sunrise on Tuesday February 18, 2020. Mars went behind the Moon at 04:36 AM and reemerged at 05:42 AM. The Moon was about 1/4 illuminated in the 3rd quarter phase so the occultation started with Mars encountering the bright limb and emerging from the dark limb. When Mars emerged from the dark limb, it created an interesting view in real time since Mars just grew in brightness, magically appearing in the dark sky. There will be an interesting occultation on the evening of Dec 7, 2022 for North America. The Moon will occult Mars while in a penumbral eclipse.

I travelled to Magdalena, New Mexico for the event. I used the Takahashi Epsilon 180ED telescope (f/2.8, 500mm focal length and the Nikon D850 camera to photograph the occultation. This is a single exposure at 1/500 second at ISO 400. It is a 100% crop (wish I had a longer focal length telescope for these planetary events).
Photography Gallery: Venus-Jupiter Conjunction 2019
(Dr. Robert Q. Fugate)

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Jupiter and Venus were in conjunction on November 24, 2019, shown here over the city of Albuquerque, New Mexico at 8:41 PM local time. This is a single exposure with a Nikon D850 set to ISO 200 and Sigma Art 105 mm lens at f/2.8. Exposure time was 0.4 seconds on a tripod.
RSVP and Information: [https://conta.cc/361vdvc](https://conta.cc/361vdvc)

AIAA LA-LV e-Town Hall Meeting 9/11 (Online on Zoom)

_**Saturday, 2021 September 11, 10 AM PDT (US and Canada) (GMT -0700)**_

**The SpaceX Starship is a very big deal and**

**Countering Misconceptions in Space Journalism**

_by_

**Dr. Casey Handmer**

Physicist (PhD Caltech) and Software Engineer

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

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

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AIAA LA-LV e-Town Hall Meeting 9/18 (Online on Zoom)
Saturday, 2021 September 18, **10 AM PDT** (US and Canada) (GMT -0700)

(Part I: 9 AM PDT (GMT-0700))

**Space Technology & RADAR Applications**

by  
**Dr. Sudhir Kumar Chaturvedi**  
Associate Professor and Placements Internship Coordinator,  
Department of Aerospace Engineering, UPES Dehradun, India

(Part II: 10:30 AM PDT (GMT-0700))

**MDAO models for Conceptual Designs**

by  
**Mr. Jim Guglielmo**  
AIAA Associate Fellow  
Manager of the Vehicle Design, Analysis and Optimization Group, Boeing Research & Technology

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AIAA LA-LV e-Town Hall Meeting 9/25 (Online on Zoom)
Saturday, 2021 September 25, 10 AM PDT (US and Canada) (GMT -0700)

The Dragonfly Mission to Titan

by

Dr. Ralph Lorenz
Principal Professional Staff
Applied Physics Lab., Johns Hopkins University

Dr. Ralph Lorenz worked as an engineer for the European Space Agency on the design of the Huygens probe to Saturn's moon Titan, and as a planetary scientist at the University of Arizona, and since 2006, at the JHU Applied Physics Lab. His activities have centered on Titan, Cassini-Huygens and future missions there, but his interests include Mars, dust devils, sand dunes, planetary atmospheres and landscapes, and aerospace systems. He is associated with NASA's InSight mission at Mars, the Perseverance rover, the Japanese Venus orbiter Akatsuki, and is the Mission Architect for Dragonfly, NASA's next New Frontiers mission (a rotorcraft lander for Titan). He is author or co-author of nine books including 'Lifting Titan's Veil', 'Spinning Flight', 'Exploring Planetary Climate' and 'Space Systems Failures', as well as over 300 journal publications.

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