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

Newsletter

April 2020

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Daniel Raymer Answers Some Questions

by Dr. Daniel P. Raymer, AIAA Fellow, author of "Aircraft Design: A Conceptual Approach"

Dan Raymer piloting a Sling2 (Photo Courtesy of D. Raymer)

Dan Raymer here. You may know me from my crazy aircraft and spacecraft designs, like the tailless airliner or the vertical takeoff jet fighter with the engine installed backwards. In his Flying Magazine article, Peter Garrison once described me as having a "complete lack of preconceptions about how an airplane ought to look." Thanks – I think.

Or maybe you took one of my short courses on how to design aircraft and spacecraft, or you bought my big fat aircraft design textbook or my skinnier "dummies" design book for homebuilders. Or maybe you just saw my ads or my website. I may not be the most famous guy in the small world of aircraft designers, but at least I'm on the list.

Sometimes I get asked questions like "how did you become an aircraft designer?" or "who were your influences?" or "if you are so famous, why aren't you rich?"

I still can't answer the last question, but I had a go at the others, not once but twice. Years ago the AIAA asked me similar questions and published it in their column "Editorial Echoes" (see www.aircraftdesign.com/spotlighton.html). A decade later I wrote an autobiography called "Living in the Future: The Education and Adventures of an Advanced Aircraft Designer." This exercise in egotism actually sells fairly well considering the subject matter and the limited likely audience (www.aircraftdesign.com/livingfuture.html).

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"Dr. Robert Zubrin, The Case for Space, and Moon Direct", Wednesday, September 11, 2019 Northrop Grumman Aerospace Systems, Redondo Beach, CA

by Roger G. Gilbertson

Dr. Robert Zubrin (Right) speaking with Dr. Jeffrey Puschell (Left) moderating the event. (Photo Courtesy of Ken Lui)

Dr. Robert Zubrin pointing to the future of human space exploration. (Photo Courtesy of Ken Lui)

On a warm Wednesday evening the Los Angeles – Las Vegas Section of AIAA welcomed the return of Dr. Robert Zubrin to the Northrop Grumman S-Cafe in Redondo Beach. His previous appearances were notable for his dynamic presentation and lively discussions. This evening proved equally well attended, energetic and inspiring as he shared his views on NASA's current lunar return efforts, and his proposals for an exciting alternate approach to building an affordable permanent presence on the Moon.

A former Staff Engineer at Martin Marietta, in Denver, Colorado, Dr. Zubrin holds master's degrees in aeronautics and astronautics and a doctorate in nuclear engineering from the University of Washington. He has worked in the areas of thermonuclear fusion research, nuclear engineering, and radiation protection, and as a high school science teacher. He is currently president of his own company, Pioneer Astronautics. He has invented unique concepts for space propulsion and exploration, authored more than 200 published technical and non-technical papers, and written many fiction and non-fiction books including his influential "The Case for Mars: The Plan to Settle the Red Planet and Why We Must" (Simon and Schuster 1996).

(More photos on https://bit.ly/3clKb05, https://bit.ly/3eq6W56, https://bit.ly/2Kbisn0*)*

Many space exploration advocates credit that book and his "Mars Direct" proposal with changing NASA's approach to sending humans to Mars from a massive, expensive, and politically unobtainable "Battlestar Galactica" approach to Zubrin's far more affordable "live off the land" approach, which relies on in-situ propellant production using the Martian atmosphere.

In 1998 Zubrin founded the Mars Society, a non-profit, volunteer-driven, international organization dedicated to furthering the exploration and settlement of Mars by both public and private means. He personally led the initial construction and operation of F-MARS, the Flashline Mars Arctic Research Station, a human Mars training facility on Devon Island in the Canadian Arctic, just nine hundred miles from the North Pole.

Attendees lining up after the presentation for the book-signing by Dr. Robert Zubrin. (Photo Courtesy of Ken Lui)

(Continued on Page 17)

Dr. S. Fred Singer -- Pioneer from Great Space Generation

by Mike Gruntman, Professor of Astronautics at USC, astronauticsnow.com

https://www.linkedin.com/pulse/fred-singer-pioneer-from-great-space-generation-mike-gruntman (Authorized by the article author)

Dr. S. Fred Singer, a pioneer from the great space generation, passed away on April 6, 2020. A scientist, government official, and always a citizen. He was 95.

S. Fred Singer (Sept. 27, 1924 – April 6, 2020)

Many know Dr. Singer because of his work and public position on the science of global warming during the last decades. Not that many realize, however, that he played an important role among the early pioneers of the space age, the Great Space Generation. Their work and several concurrent developments in science and government would converge and lead to the first American satellites launched in 1958 during the International Geophysical Year (IGY).

Fred was among those who advanced the concept of IGY.

Jim Van Allen recalled (in 1982) that "The plan for a third International Polar year, later broadened in scope and renamed the International Geophysical Year 1957-1958, originated on April 5, 1950, at a small dinner party of geophysicists at my home [in] ... Silver Spring, Maryland. The basic concept was put forward by Lloyd V. Berkner. He and Sydney Chapman were principally responsible for developing and enlarging the concept to a persuasive level of detail and potential implementation, with the help of suggestions by others present: Ernest H. Vestine, J. Wallace Joyce, S. Fred Singer, my wife Abigail, and myself ..." (Van Allen, 1982).

Blazing the Trail describes (http://astronauticsnow.com/bttp/btt_pp_348-349.pdf) first steps to the scientific satellite: "At its meeting in Rome, Italy, in October 1954, the [international] committee [arranging and coordinating the IGY activities] accepted a proposal by American scientists (Berkner, Kaplan, Fred Singer, Homer E. Newell, Jr., James Van Allen, and several others) to recommend "that the thought be given to the launching of small satellite vehicles, to their scientific instrumentation, and to the new problems associated with the satellite experiments ...". The National Academy of Sciences actively advocated and lobbied through various parts of the Eisenhower administration the idea of preparing and launching American scientific satellites as part of the IGY."

Fred pioneered many highly diverse concepts in those early days. In 1954, he proposed a minimum instrumented orbital satellite MOUSE (in Journal of the British Interplanetary Society). Two years later, he advanced the idea of a satellite experiment to carry clocks to check the effect, predicted by the general theory of relativity, of gravitational potential on clock speed (slowing down). In the same year he explored threat of "meteoric particles" to orbiting satellites (published in ARS' Jet Propulsion in 1956). Then, he worked out a method of calculating impact points of long-range ballistic missiles.

The last time I met Fred in 2012 when he came to Los Angeles. We had a long delightful dinner, long not on food but conversation. He encouraged me to initiate a student project for landing on Phobos and Deimos, his old love concept. After discussion, he agreed that the time was really for serious effort (properly funded and by industry) and not for students playing in a sandbox. Fred was also excited about his work on development of small electricity-producing generators powered by natural gas. Low gas prices and advantage of locating such power sites in the cities made sense economically. Major hurdles were regulatory.

Obviously, we talked about global climate change. Interestingly, Fred did not consider its science exciting but rather straightforward and routine. He saw it in identifying conceivable important processes and focusing on obtaining quantitatively reliable rates, constants, coefficients, etc. that could then be used in complex models.

Fred shared concern about enthusiasm of "learned" (the quotation marks are mine) societies enabling and promoting politicization of global warming science. "AGU is the worst," was his verdict.

Dr. S. Fred Singer, a pioneer from the great space generation. A scientist, government official, and always a citizen.

Stepping Stone to the Moon

by Yvonne Liu (authorized by the Palos Verdes Magazine) https://easyreadernews.com/stepping-stone-to-the-moon/

American Institute of Aeronautics and Astronautics Space Tourism speakers Dave Mackay, Madhu Thangavelu, Thomas Spilker, Bethany Orozco, John Spencer, and John Blincow. (Photos by David Fairchild)

On February 22 of last year, Virgin Galactic Chief Pilot Dave Mackay became the first native Scot in space. The "Scot in Space," along with co-pilot Michael Masucci and Virgin Galactic space tourism director Beth Moses, reached an altitude of 55.9 miles aboard Galactic's SpaceShipTwo. When they landed in the Mojave Desert, a Scottish bagpiper heralded their arrival. Mackay did a little jig. They were the 569th, 570th and 571st individuals to reach outer space.

(The United States military, NASA and foreign agencies define outer space, beyond the earth's atmosphere, as ranging from 50 miles to 62 miles above the mean sea level).

As a lad in northern Scotland, Mackay would gaze out his classroom window to watch low flying Royal Air Force pilots while dreaming of becoming one himself. He subsequently flew for the RAF for 16 years, and then flew Boeing 747s for Virgin Atlantic.

Industry website Spaceflight Now reported that Mackay's "sub-orbital flight moves Richard Branson's company Virgin Galactic one step closer to its goal of launching paying passengers and payloads on brief forays into the weightlessness of space." Last December, Virgin Galactic Holdings became the first publicly traded company to offer commercial space flights.

Mackay and other private spaceflight industry leaders spoke at a forum titled "Space Tourism" on November 23, 2019, at Malaga Cove Library in Palos Verdes Estates. The event was organized by the American Institute of Aeronautics and Astronautics (AIAA). Attendees included executives, engineers and hopeful space tourists.

Moderator and space architect Madhu Thangavelu told the audience, "Space tourism is not just dreaming anymore. It's been done." Thangavelu lives in Rolling Hills and teaches at the University of Southern California Viterbi School of Engineering.

Mackay said space travel has intrigued Branson for years. The entrepreneur copyrighted the words Virgin Galactic and Virgin Intergalactic in the mid-1990s. VG's market research on space tourism has found that what interests potential customers most was experiencing zero gravity and viewing Earth in all its glory from above.

Since 2004, 600 people from 58 countries have paid Virgin Galactic $200,000 to $250,000 to reserve a trip into space. Mackay said space passengers will arrive at VG's Gateway to Space at Spaceport America in southern New Mexico on a Monday. Over the next three days, they will receive training about their space suits and dealing with g-force acceleration and zero gravity. On Friday, six passengers and two pilots will nestle into a reusable VG SpaceShipTwo vehicle. They will be carried aloft by a twin fuselage jet. When the carrier releases the spacecraft, Mackay said, "You'll feel like you're riding right over the top of a roller coaster, which you will enjoy. You've been hearing engine noises for the better part of an hour and now it's silent because you've left the carrier engines behind. That's when the fun begins."

Mackay will orientate the vehicle for optimal views of the earth. Passengers will then unbuckle their seat belts and float in zero gravity while gazing at the big blue marble below: Mother Earth.

"The views from space are truly jaw dropping. Our customers are going to be amazed," Mackay said. Passengers will be told, "Do not take a camera because you don't want to be looking through a viewfinder. You want to take it in with your own eyes because it's something you will never forget," he said.

The trips will last about 2.5 hours.

(More photos on: bit.ly/3054tGa, bit.ly/39Qh2cZ, bit.ly/35Cx72D, bit.ly/35BpLfR, bit.ly/2T4Ua3D) *(Continued on Page 18)*

AIAA Los Angeles-Las Vegas Section Hosts ISS Operations Developer

by David Sunderland, Ph.D.

Col. Mark Pestana (USAF/NASA-Retired) speaking about the operations of the International Space Station (Photo Courtesy of Ken Lui)

On February 13, 2020, AIAA LA-LV was host to Col. Mark Pestana, USAF (retired) at the El Segundo Public Library, for a presentation on "Operations Development of the International Space Station (ISS)". Col. Pestana has an MS in Human Factors Engineering, and has been a research pilot, space operations engineer, instructor (at USC), aerospace artist (designed 15 STS mission patches), and actor (on 12 TV shows). In addition to his work on the ISS, he is known for his work on the Skylab decay study and as a consultant for NASA, FAA and DoD on drone technology.

After a brief introduction to NASA, Col. Pestana treated us to a history of space stations. The Almaz Soviet military station program, proposed in 1964, was later transformed into the civilian Salyut program, with Salyut 1 launched into orbit in 1971. Salyut stations were serviced by Soyuz-manned vehicles (in use since 1967) and the Progress cargo vehicle (similar, but without a return module – effectively a "trash bin"). Due to Soyuz limitations, Salyut crews were limited to 180-day stays. The U.S. space station Skylab had 3 crews of 3 from 1973 to 1974, with stays from 28 to 84 days. The Apollo-Soyuz mission in 1975 demonstrated the ability of Soviet and U.S. vehicles to dock and of crews and operations developers from each country to work together. The Russian Mir station operated from 1986 to 2001, with servicing by U.S. space shuttles from 1995 to 1998. Plans for an U.S. civilian station (he didn't discuss the military Manned Orbiting Laboratory program) began in 1984 with Space Station "Freedom" (later renamed "Alpha") and went through many iterations, and were saved in Congress (by one vote) in 1993, with a cost-sharing MOU with Russia. (Author's note: I have a t-shirt that says "Space Station Freedom: 9 years, $9B, and all I got was this lousy t-shirt". I should have worn it.) Various advanced craft were designed to support the station (ACRV, X-38 CRV, HL-20, Hermes), but all were cancelled.

Next, we heard about the development, with Russia, of the ISS. What had been planned as MIR-2 Base Block became the ISS Russian Core module. Col. Pestana's job was Operations Concept Development, for which he made 4 extensive trips to Russia. International collaboration was the plan from the beginning (there are now 15 nations participating), with astronaut allocation based on national contribution, and 3-6 month "expeditions." Accommodations were planned to cover body sizes from the "5% Japanese female" to the "95% American male," although the Soyuz turned out to be too tight for 50% of American astronauts (he worked to make room for larger seats). There were a number of differences in design philosophy between the teams. Whereas Russian suits were "one size fits some," U.S. suits were modular. Whereas the Russians used thick walls for micro-meteor protection, Americans used multiple layers (ballistic testing was required to convince the Russians this was safe). The ISS had to orbit at the higher latitude of Russian launches, requiring more Shuttle launches for assembly.

Col. Mark Pestana and an attendee engaged in interactive Q & A. (Photo Courtesy of Ken Lui)

(More photos on bit.ly/2yDLFUP)

(Continued on Page 19)

A Documentary That's Truly Out of this World!

The International Space Station (Credit: NASA)

The year 2020 is a major milestone for the International Space Station. This coming November, the station will celebrate 20 years of continuous operation with a human crew aboard. 2020 also marks a very historic moment in the legacy of Chesley Bonestell (1888-1986).

Known as "The Father of Space Art," Chesley used outer space, planets, moons and galaxies as the subject matter for countless numbers of his paintings. He once said, "Space, to me, is the infinite cosmos— the ultimate mystery." Born in the days before automobiles and airplanes, Chesley lived to witness great accomplishments in space exploration, just like his artwork predicted. He never got the chance to explore space himself, but just recently, something remarkable happened. On March 12, 2020, NASA's Johnson Space Center in Houston confirmed that the documentary film of his life, ***Chesley Bonestell: A Brush With The Future***, had been transmitted to the International Space Station (ISS) for the "**Expedition 62**" crew to watch and enjoy.

(Click on this image to see a special video announcement:)

(You can read more on Mark's "Space Hipsters" Facebook post at this link:)
https://www.facebook.com/groups/spacehipsters/permalink/3016787925032737/

Expedition 62 crewmembers onboard the ISS: NASA astronauts Jessica Meir (upper left) and Andrew Morgan (upper right) are perched atop Russian cosmonaut Oleg Skripochka (Credit: NASA)

"I could not be more grateful to NASA for allowing us to share our award-winning documentary about Chesley Bonestell with the crew of the ISS," said the film's producer/writer/director **Douglass M. Stewart, Jr.** "I've had this particular dream for years and thanks to some wonderful assistance from the team at the NASA Johnson Space Center, it's become a reality. Things really began to move forward when I met former NASA Research Pilot and aerospace engineer **Mark Pestana** at a lecture he was giving. He was speaking about his involvement with the development of the ISS at the invitation of **AIAA** (American Institute of Aeronautics and Astronautics). Mark is a huge Chesley Bonestell fan and made the necessary connections with NASA for our film sent up to the ISS."

NASA's Mark Pestana and filmmaker Douglass M. Stewart, Jr.

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AIAA Biomimetics examples in Engineering

by Vahik Khodagolian, Fluid Dynamics consultant

In college, I was using textbooks to solve engineering problems related to drag and noise reduction; heating; cooling; structural efficiency; impact resistance; water repelling, absorbing and collecting; lightweight structures; filtration; adhesives; biofouling; ionized radiation; non-reflecting surfaces; vibration and damping; sensing; navigation; swarm algorithms; energy storage; and many others. Little did I know that all of these problems have solutions that can be found in nature:

Nature is talking, but are we listening?

Biomimetics, or biomimicry, is an emerging field that looks to nature for inspiration to solve engineering challenges at the micro and macro levels. Biomimetics, bionics, biomimicry, biognosis, and biologically inspired designs, just to mention a few names, have similar definitions. I prefer to use the term Biomimetics since it better reflects the science and the way it is applied. Biomimetics is derived from the Greek word "bios," meaning life, and "mimesis," meaning to imitate. It is the study of nature's processes, designs, and models as an inspiration to solve engineering problems. In 1957, the term "Biomimetics" was coined by American biophysicist and inventor Otto Schmitt.

Earth is a 3.8-billion-year-old (estimated arrival of life forms) R&D laboratory, with millions of designed products. Many have failed to survive, but many others have evolved to very advanced organisms, such as us humans. In nature, evolutionary dynamics typically forces natural systems to become highly optimized, resourceful, and efficient. Living organisms make use of solar, chemical, nuclear, wind, and water power; eco-location, magnetic fields, gradients, and gravitational potential energy to feed, hunt, move, sense, migrate, and otherwise accomplish tasks.

I see many design solutions provided by Mother Nature that some traditional engineers and scientists considered when designing and optimizing products or processes. For example, a kingfisher (Fig. 1a) inspired engineers in Japan to model their train, Shinkansen 500, on the beak of that bird to reduce the tunnel boom sound (Fig. 1b), which was especially loud when exiting tunnels. The kingfisher has evolved to dive into the water without making a splash. Before the redesign, the train also had major issues with vortex-induced vibrations.

Figure 1a): Left: An abstract illustration of the kingfisher, whose beak inspired the design of the high-speed Shinkansen 500 train. Right: Eiji Nakatsu, chief engineer of the Shinkansen 500, standing in front of the train. (Photo Courtesy of Vahik Khodagolian)

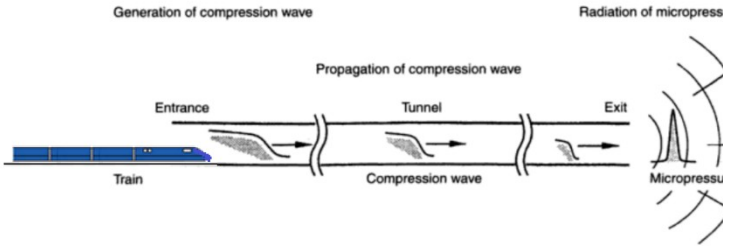

Figure 1b): Illustration of tunnel pressure wave propagation and boom for a high-speed train entering and exiting a tunnel. Image reproduced from Krylov, V.V. (ed.), 2001. "Noise and vibration from high-speed trains." London: Thomas Telford.

The "bullet train" reaches speeds of up to 200 miles per hour, but is almost silent nowadays when exiting tunnels thanks to the kingfisher's beak and Eiji Nakatsu (fig 1a), the chief engineer of the Shinkansen 500 train, who happened to be a bird-watcher.

In addition to the nose design, the designs of the pantograph and pantograph-supporting shaft were inspired by the serrated wings of the owl, which resulted in a vibration-free structure. The pantograph, the structure that connects the train to its power source, had vibrated and made a loud noise before the redesign.

Figure 1c): Left Left: An illustration of the trains redesigned panthograph of the Shinkansen 500 train inspired by the penguins wings, center: an Adelie penguin in action, right: a barn Owl in its silent flight.

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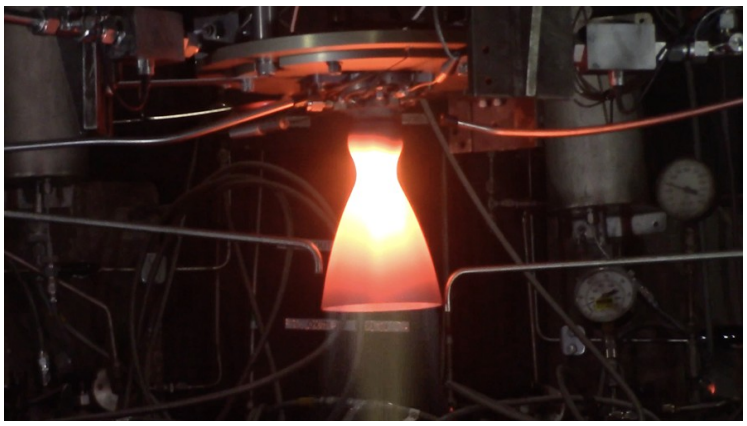
Moon Thrusters Withstand Over 60 Hot-Fire Tests

Authorized by Astrobotic from NASA website (March 25, 2020)



NASA and Frontier Aerospace are developing next-generation thrusters for use on Astrobotic's Peregrine lunar lander. In March 2020, thruster prototypes performed over 60 hot-fire tests in a vacuum chamber. (Credits: Frontier Aerospace)

Huntsville, AL – Future Artemis lunar landers could use next-generation thrusters, the small rocket engines used to make alterations in a spacecraft's flight path or altitude, to enter lunar orbit and descend to the surface. Before the engines make the trip to the Moon, helping deliver new science instruments and technology demonstrations, they're being tested here on Earth.

NASA and Frontier Aerospace of Simi Valley, California, performed roughly 60 hot-fire tests on two thruster prototypes over the course of 10 days. The tests concluded March 16 and took place in a vacuum chamber that simulates the environment of space at Moog-ISP in Niagara Falls, New York. While replicating mission flight operations, engineers collected multiple data streams, including the pressure and stability of the combustion chamber and the pressure and temperature of the feed system, which delivers propellant from tanks to the thruster.

Being developed under NASA's Thruster for the Advancement of Low-temperature Operation in Space (TALOS) project, the thrusters are designed to reduce spacecraft cost, mass and power – three things that constrain every space mission. Astrobotic Technology of Pittsburgh plans to use the new thrusters aboard their Peregrine lunar lander.

"TALOS is about leveraging the benefits of MON-25, which will reduce the amount of power needed for spacecraft when operating in extremely low temperatures," said TALOS Project Manager Greg Barnett at NASA's Marshall Space Flight Center in Huntsville, Alabama.

The thrusters burn mixed oxides of nitrogen and monomethyl hydrazine propellants (MON-25/MMH), which are capable of operating at low temperatures for an extended period of time without freezing. Although MON-25 has been tested since the 1980s, no spacecraft currently uses the propellant. TALOS is capable of operating at a wide propellant temperature range, between -40 and 80 degrees Fahrenheit. That's compared to state-of-the-art thrusters of the same size that generally operate between 45 and 70 degrees Fahrenheit.

Because MON-25 does not need to be conditioned at extreme temperatures like other mixed oxides of nitrogen propellants, it will reduce power requirements for spacecraft operating in low temperatures, resulting in smaller, lighter and less expensive systems. Reducing power requirements for the spacecraft could potentially reduce the number of batteries and the size of solar panels needed to maintain the spacecraft.

"NASA will soon verify this versatile thruster design for space so that the agency and commercial companies can easily implement the technology in future missions," said Barnett. "Astrobotic plans to use this thruster design on their lunar lander that will deliver science and technology payloads to the Moon for NASA in 2021."

The TALOS project is slated to perform engine qualification testing in late summer to ready the thruster design for use on Astrobotic's Peregrine lander. Astrobotic is one of several American companies working with NASA to deliver science and technology to the lunar surface through the Commercial Lunar Payload Services (CLPS) initiative, as part of the Artemis program.

In addition to sending instruments to study the Moon, NASA's Artemis lunar exploration program will land the first woman and next man on the lunar surface by 2024 and establish a sustained presence by 2028. The agency will leverage its Artemis experience and technologies to prepare for the next giant leap – sending astronauts to Mars.

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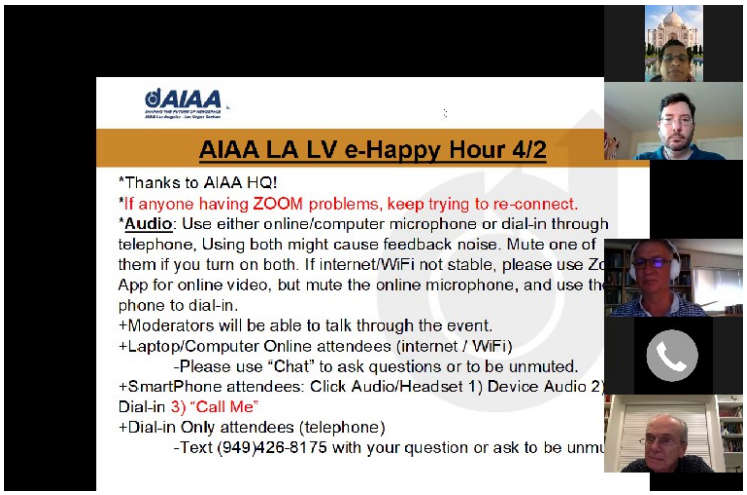
Maintaining Connections with the AIAA Virtual Happy Hour (2 April, 2020)

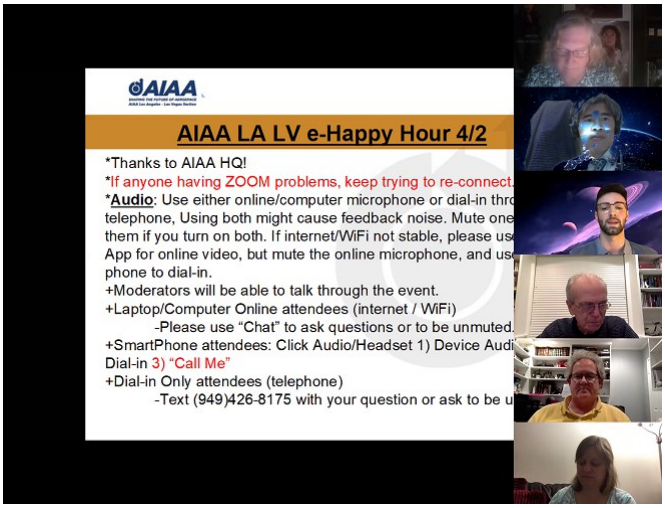
Sponsored by the AIAA LA-LV Young Professional (YP) Committee
by Brett Cornick (M.S. Materials Science, UCLA '18), AIAA LA-LV Council Member

Brett Cornick moderating the e-Happy Hour on 2 April. 2020, with virtual space background. (Screenshot)

On April 2nd, AIAA LA-LV hosted an electronic Happy Hour geared specifically towards young professionals as an opportunity for them to meet and network during this time of social distancing. Nearly 30 active members ranging from college students to seasoned professionals gathered virtually online to share stories, industry insights, job search tips, and words of motivation for any young professionals looking for opportunities and advice in this troubling time. The event lasted 90 minutes and was the first of what is likely to be a series of similar events hosted over the next few months. This event provided a unique opportunity for all members to speak and be heard in a low-stakes, friendly environment.

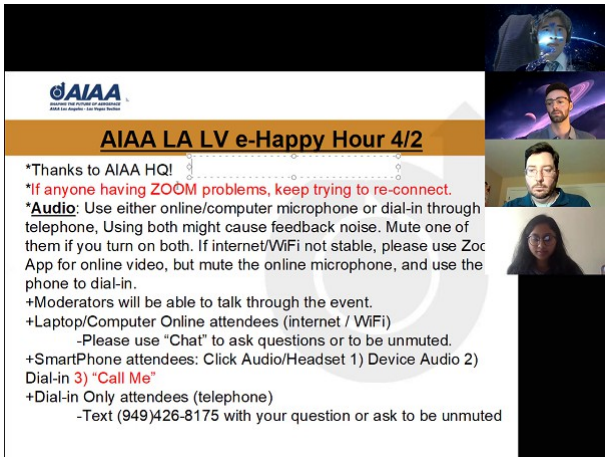


Attendees enjoying the conversations while reviewing the logistics reminder. Images on the right: (Top: Dr. Chandrashekhar Sonwane, AIAA LA LV Section Chair; Middle with white headset: Dr. Daniel P. Raymer, AIAA Fellow; Bottom: Jerry Lockenour) (Screenshot)



Attendees sharing their careers / experiences or expressing concerns / issues. (Screenshot)

I was fortunate enough to be given the task of moderating the Happy Hour, despite relatively minimal involvement in planning and organizing other AIAA events. All it took was a simple email from me offering my time as a volunteer and before I knew it I was put on the job! AIAA is always looking for more young professionals to get involved, so if you find yourself with too much time on your hands during the stay-at-home orders, volunteering for these e-events is a great way to network and stay productive!



Attendees from local and international (from India) joining the conversations and exchanging thoughts. (Screenshot)

**Video and uploads on*

https://aiaa-lalv.org/aiaa-la-lv-e-happy-hour-april-2-2020/, or

https://engage.aiaa.org/losangeles-lasvegas/viewdocument/april-2-2020-aiaa-la-lv-e-happy

Venus sample return mission revisited

by D. Valentian [1], C. Koppel [2], P. Mairet [3], L. Mairet [4].

[1]ITG - Rosny Sur Seine (France), [2]KopooS Consulting Ind - Paris (France), [3]Retired - Toulouse (France), [4]Student - Toulouse (France)

Introduction

The Venus sample return is very interesting from the scientific point of view. The soil composition analysis will offer clues on the mechanisms explaining the differences between Venus and Earth.

However the sample recovery is extremely difficult. The ground conditions are very harsh (460°C, 9.6 MPa). The Delta V requirement is almost as high as on Earth, and the rocket launch shall occur above 55 km I e. suspended under a balloon, thus requiring an UAV to lift the samples from ground to balloon altitude.

Discussion

The mission involves several critical points, each with a significant probability of failure:

- Thermal exposure during sample drilling.
- Fast balloon inflation, at 55 km altitude.
- Thermal exposure of the UAV during ascent to launch altitude.
- Deviation of planned launch trajectory, leading to the impossibility to perform a rendezvous with orbital vehicle, if the propellant capacity of upper stage is not sufficient.

The purpose of this paper is to propose new methods at each critical step, involving a risk reduction for the mission… at the expanse of launch mass. The rocket mass is close to four tons, using proven technologies. This is an order of magnitude higher than previous projects.

The temperature control of the lander involves two innovative methods: advanced thermal insulation and PCM.

The proposed mission aims at reducing the risks associated to each critical step. It involves the launch of two to three Ariane 6, the heaviest payload being the balloon / rocket assembly. Three separate landers/ UAV are provided.

The multiple lander approach offers two advantages:

- It provides more scientific value by returning several types of soils.
- It lowers the risk associated to a single sample loss (e. g. missed UAV / balloon rendezvous).

Conclusion

The technologies studied in the frame of this Venus Sample Return proposal could be used on less ambitious / more affordable missions:

- Venus atmosphere sample recovery (no lander).
- Extended life lander without sample return (advanced thermal insulation concept being combined with a RTG and a pulse tube cooler to provide months of operation on Venus surface).
- Venus low altitude UAV, providing an extended photographic aerial survey, using the advanced thermal control concept, allowing days of operation in the very hot Venus atmosphere.

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Report SCI (98)3, June 1998, Noordwijk, the Netherlands.

[3] Venus Surface Sample Return: A Weighty High-pressure Challenge. Ted Sweetser, Jonathon Cameron, Gun-Shing Chen, Jim Cutts, Bob Gershman, Martha S. Gilmore, Jeffrey L. Hall, Viktor Kerzhanovich, Angus McRonald, Erik Nilsen, Walt Petrick, David Rodgers, Carl Sauer, Brian Wilcox, Andre Yavrouian, Wayne Zimmerman, and the Advanced Projects Design Team (JPL)

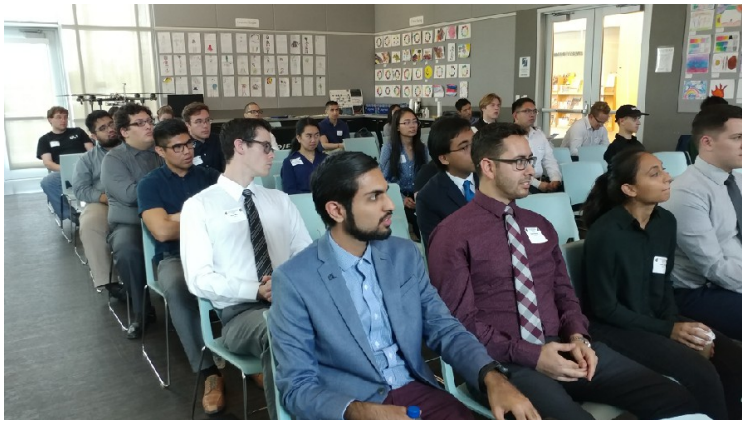
AIAA Student Branches mini-Conference (7 March, 2020)

(Pictures Only)

1st Place Best Presentation: Jessie Flanders (Middle with microphone), Fadwa Naji (Right), Abel Redriguez (Left) (AIAA CSULB BLT) "Beach 1-C Design Report & Analysis." (Photo Courtesy of Ken Lui)

Career Workshop Panel Discussion Session. From Left to Right: Shawn Boike (Insta-grid.com), Prof Mahdi Yoozbashizadeh (CSULB), Karen Grothe (HRL Laboratories), Dr. Nahum Melamed (Aerospace Corp.), Juan J. Velasquez (Aerojet-Rocketdyne). (Photo Courtesy of Ken Lui)

2nd Place Best Presentation: Emma Chao (AIAA UNLV) "Discrete vortex modeling of aerodynamic flutter of a flat plate with damped oscillations."(Photo Courtesy of Ken Lui)



Attendees absorbed in the presentations and discussions. (Photo Courtesy of Ken Lui)

3rd Place Best Presentation: Claudio Duarte (AIAA Cal Poly Pomona) "Thrust Vectoring Senior Project." (Photo Courtesy of Ken Lui)

Shawn Boike (Insta-grid.com) making impressive keynote speech. (Photo Courtesy of Ken Lui)

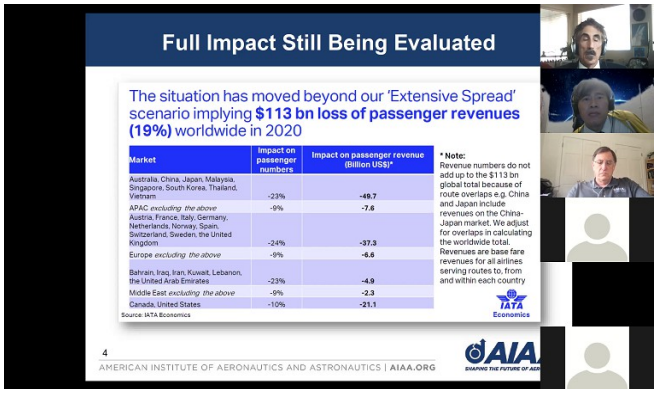
(More photos on bit.ly/2XUYQLH)

(Continued on Page 30)

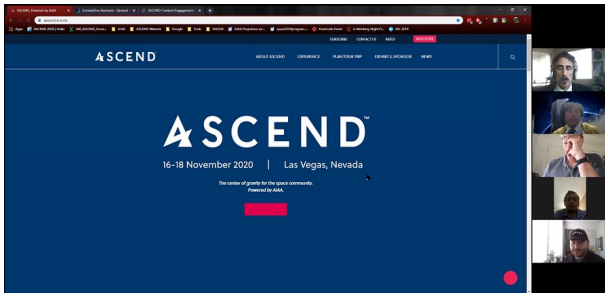
E-Town Hall Meeting on 28 March, 2020:
Present and Future of Aerospace during the time of Coronavirus (COVID-19)

(Pictures only)

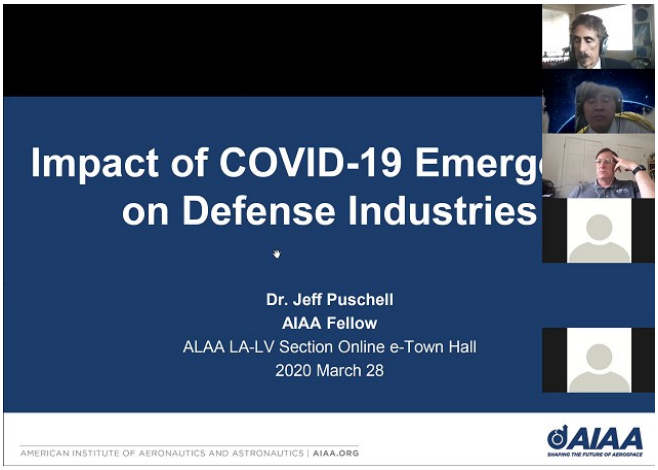
Dan Dumbacher talking about the national impacts of COVID-19. (screenshot)



John Rose discussing the impacts of COVID-19 on civilian and commercial aerospace. (screenshot)

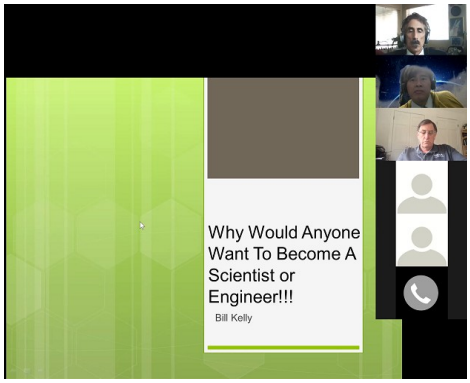


Nathan Boll talking about the preparation for the AIAA ASCEND in November, 2020. (screenshot)

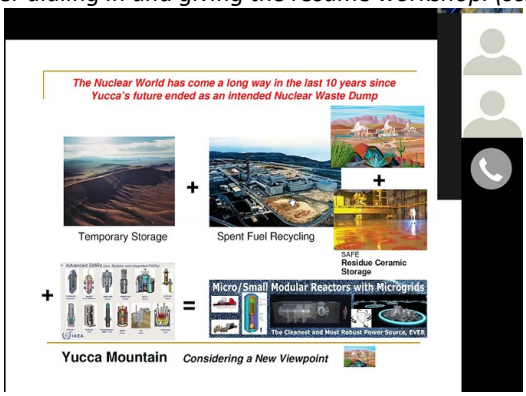


Dr. Jeff Puschell explaining the impacts of COVID-19 on defense industries. (screenshot)

Fred Lawler dialing in and giving the resume workshop. (screenshot)



Bill Kelly dialing in to give the fun and inspiring STEM talk. (screenshot)



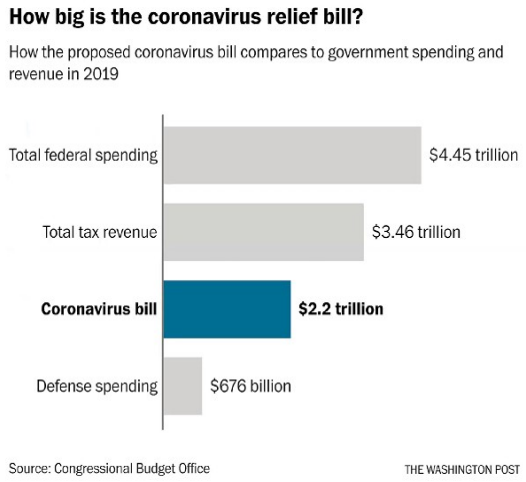
Marty Waldman presenting Part II of his talk on Nevada nuclear power facilities & micro-grids. (screenshot)

**Video and more information on https://aiaa-lalv.org/aiaa-la-lv-e-town-hall-meeting-march-28-2020/ , or https://engage.aiaa.org/losangeles-lasvegas/viewdocument/march-28-2020-e-town-hall-meetin*

E-Town Hall Meeting on 4 April, 2020: (Jennifer S. Perdigao, Fred Lawler, and Erik Jessen)

(Pictures Only)

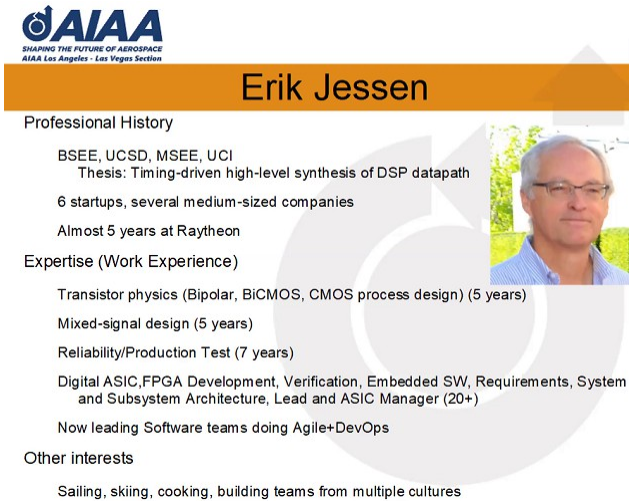
The first speaker, Jennifer S. Perdigao, talking (online) about the government orders on COVID-19 and their impacts on aerospace, defense, supply chains, jobs, etc., and the stimulus packages. (screenshot)



The Coronavirus relief bill, explained by Ms. Jennifer Perdigao (screenshot)

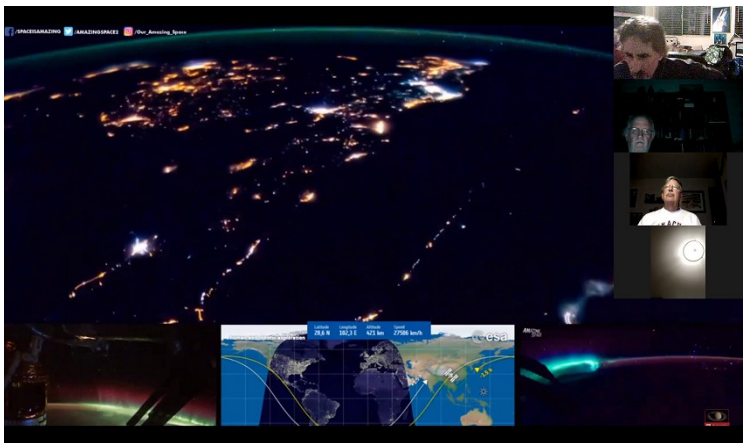
**Video and more information on https://aiaa-lalv.org/e-town-hall-meeting-april-4-2020/ ,or https://engage.aiaa.org/losangeles-lasvegas/viewdocument/april-4-2020-aiaa-la-lv-e-town-h*

Fred Lawler providing great insights into interview techniques. (screenshot)



Erik Jessen is an expert in aerospace systems engineering, Agile, Extreme programming etc. He explained the basics of Agile and its importance. (screenshot)

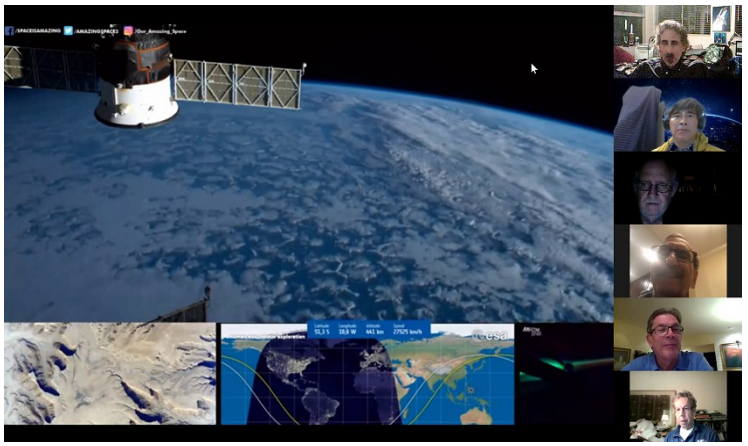
AIAA LA-LV e-Yuri's Night (11 April, 2020) *(Pictures Only)*



Marty Waldman conducting the AIAA LA-LV Yuri's Night, with Live video and path tracking from the International Space Station and inspirational space music in the background. (screenshot)

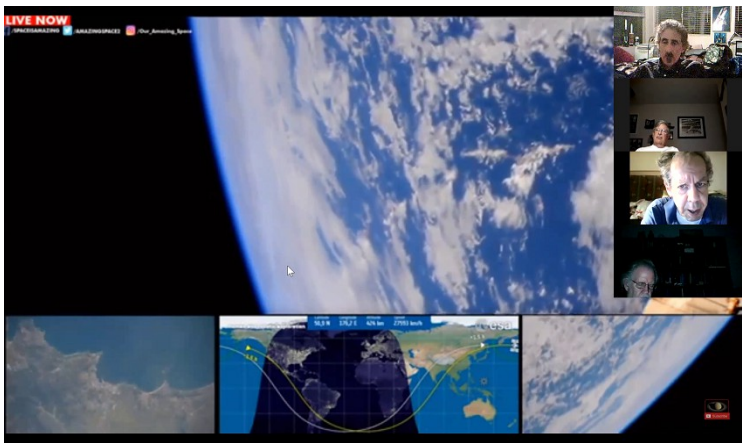
Beautiful upper atmosphere plasma effects taking place while people enjoying the views during the event. (screenshot)

ISS moving along while people enjoying the Yuri's Night with beautiful views from ISS. (screenshot)



Amazing views on the terrains and clouds/ocean, while people talking about life, space exploration, and career etc. (screenshot)

Aerospace professionals analyzing and debunking a recent video clip from Canada about certain unidentified flying objects spotted through a telescope. (screenshot)

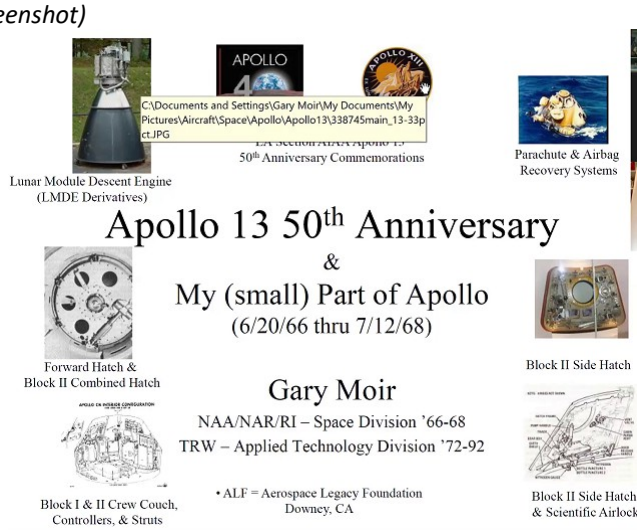


Beautiful Mother Earth and the overview effect / experience in the AIAA LA-LV Yuri's Night led by Marty Waldman. (screenshot)

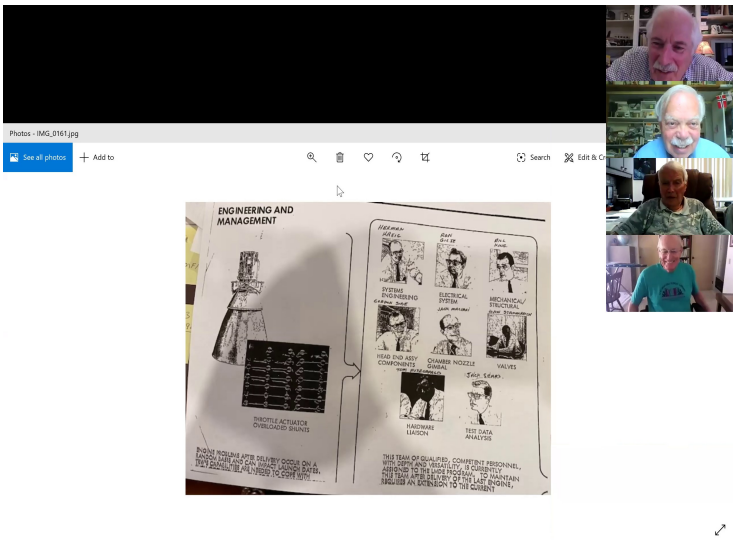
**Video and more information on https://aiaa-lalv.org/aiaa-la-lv-e-yuris-night-2020-on-april-11-2020/ , or https://engage.aiaa.org/losangeles-lasvegas/viewdocument/april-11-2020-e-yuris-night*

Aero Alumni April 15, 2020 Apollo 13 50th Anniversary Online Commemoration *(Pictures Only)*

Gary Moir opening, presenting, and moderating the event. (screenshot)



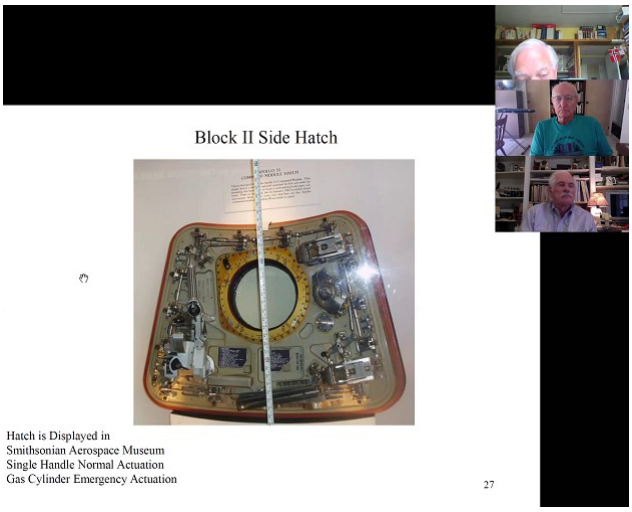
Gary Moir's introduction title slide. (screenshot)



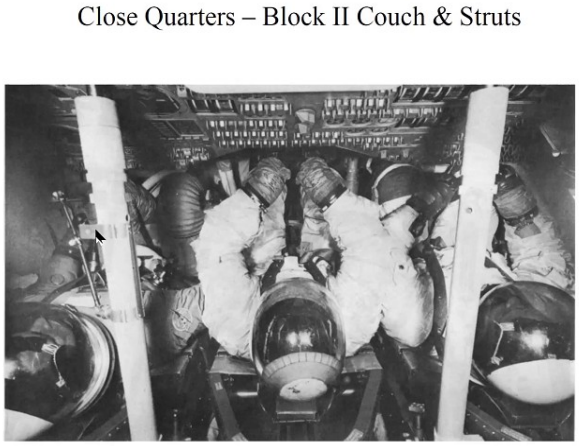
John Stammreich talking about the "Magnificent Seven" with him (then 24 years old) at the rightmost in the second row of the seven Apollo engineers in the picture he shared. He also shared lots of fun and experiences starting his aerospace career at that time. (screenshot)

**Video and more information on*
https://aiaa-lalv.org/aero-alumni-april-15-2020-apollo-13-50th-anniversary-online-commemoration/
, or
https://engage.aiaa.org/losangeles-lasvegas/viewdocument/april-15-2020-aero-alumni-apollo

Don Harvey (upper left), Gary Moir (upper right), Ken (Gary's friend, lower left), and John Stammreich (lower right) recalled the Apollo experiences and discussing about the Apollo 13 . (screenshot)



Gary Moir talking about the hatch he used to work on for the Apollo Missions. (screenshot)



Gary Moir talking about the space inside the capsule for astronauts in Apollo missions. (screenshot)

Daniel Raymer Answers Some Questions *(Continued from Page 1)*

Now I've been asked to put together a few updated pages about my career. I'm told that "people will be inspired and fascinated by you," and "their eyes will be wide-open to see that the AIAA has someone amazing like you."

Really? Get a life, folks! But here goes:

You could almost say that I went into the family business. My father was a Navy test pilot and aeronautical engineer. An uncle, a cousin, and a brother are all airline pilots. I started with model airplanes and Tom Swift books at age eight, and wasted half my childhood designing and flying model aircraft. I started working on my pilot's license at 16, washing a plane for my first lesson.

I went to Purdue University which is known for producing practical, get-it-done engineers. I got pretty good grades (A's, some B's, and let's not talk about that theoretical class on differential equations). In my last year I worked in the Purdue wind tunnel where I learned more than in most of my classes. I joined the AIAA student chapter and was lucky enough to win the AIAA Midwest Region Student Paper Competition, with a paper about my wind tunnel work on a Greyhound bus, of all things. But I lost at the national level, at least partly because I brought the wrong set of slides. Stupid, stupid. Now I'm an AIAA Fellow. Go figure.

After college I got my dream job - a drafting table in the advanced design department of North American Aviation (Rockwell). My first boss designed the X-15. In our small design office were the guys who designed the Space Shuttle, B-1, HiMat, B-70, and others. That's where I really learned how to design airplanes. Later I wrote my big textbook to share what I had learned at the feet of these "masters."

I had several early projects that taught me a lot and gave me a chance to develop some reputation. Shortly after starting at Rockwell I was put in charge of developing computer-aided design capabilities for the advanced design department. I got the job mostly because the rest of the group were older guys who didn't want anything to do with computers. Defining the system specifications forced me to really think about the design process, so I asked a lot of questions and learned a lot. The CAD system we developed worked out pretty well, being used for over 25 years. The X-31 and B-1B were both designed on my system, and it earned me Rockwell Engineer of the Year.

Another project I'll always remember was the Innovative Strategic Aircraft Design Study, looking at new bombers to follow the B-1. I'd long been interested in flying wings and thought that a clean flying wing design, like the Horten flying wings of the 1940s, would offer a good stealth capability. This was long before the B-2 program. I put together a triangular-shaped flying wing design which we studied for four years, including wind tunnel and radar cross section testing. I really thought it would get built, but we were told to stop work on short notice. Later we learned that others had started working on stealth flying wings in the "black" world, while we at Rockwell were supposed to focus on getting the B-1 into production. Darn.

Dan and Ester Raymer at Poppy Fields. (Photo Courtesy of D. Raymer)

(Continued on Page 23)

"Dr. Robert Zubrin, The Case for Space, and Moon Direct", Wednesday, September 11, 2019 Northrop Grumman Aerospace Systems, Redondo Beach, CA *(Continued from Page 2)*

Dr.. Robert Zubrin presenting his visions for Mars human settlement. (Photo Courtesy of Ken Lui)

In 2001, the Mars Society built the Mars Desert Research Station (MDRS) at a Mars-like site in the Utah desert. To date, over 1,000 individuals have participated in more than 200 four- to six-person crews carrying out simulated Mars surface missions. Attendees from around the world conduct one- to two-week long simulations, exploring the Mars-like terrain in full "spacesuits," maintaining the station's systems, growing plants in the facility's greenhouse, conducting Mars-analog biology and geology research, and publishing their results. In fact, NASA's newest class of astronauts, which graduated in January 2020, included Dr. Jessica Watkins, who served as chief geologist for MDRS Crew 86 in 2009. Dr. Watkins now stands eligible for NASA flight assignments, including missions to the Moon and perhaps, one day, to Mars.

So with decades of work focused on sending humans to the Red Planet, some people attending Zubrin's recent presentation may have found it surprising to hear him turning his focus to a closer target – one he has previously opposed as unnecessary for reaching Mars – namely, returning humans to the Moon.

However, as one might expect, Dr. Zubrin does not take changing focus lightly. He gives NASA's renewed lunar efforts a full and rigorous evaluation, and what he finds comes up far short when compared to the efforts of the Apollo Moon landings, which started six decades earlier. In his latest book, "The Case for Space: How the Revolution in Spaceflight Opens Up a Future of Limitless Possibility" (Prometheus Books, 2019), Zubrin again makes his case for both "why" we must go into space, and "how" we can best do that. During the Apollo program, in his words, NASA, "armed with a clear goal, stormed heaven in the 1960s. But for almost a half-century since, it has been adrift, spending vast sums of money with no serious objective beyond keeping various constituencies and vendors satisfied."

To counter the endless "vendor driven" proposals and programs served up by NASA since the Moon landings, Zubrin advocates a return to "purpose driven" missions. Looking at the current administration's push to revisit the Moon by 2024, he decries NASA's continued "wasteful investment in useless projects."

Specifically, Zubrin points to NASA's recently proposed mission architecture centered on a "Lunar Gateway" – a miniature space station placed in a looping one-week orbit in the vicinity of the Moon. He derides the Gateway as "a vestigial form of the Obama administration's defunct and discredited Asteroid Redirect Mission," which at first proposed bringing a small asteroid, and later just a piece of an asteroid, back to lunar orbit for study.

In promoting the Lunar Gateway, NASA lists some of its potential uses as: a place to test equipment further away from the Earth than the ISS, a place from which to remotely operate robotic rovers on the lunar surface, and a lunar observation vantage point. But Zubrin decries all of these as "not reasons for having a gateway, but rationalizations." He sees them as "means in search of an end" and he points out that no earlier Moon proposals, from von Braun onward, had ever invoked a need for an orbiting lunar station of any kind. He succinctly summarized the Gateway diversion by saying "if we're going to go to the Moon, let's go to the Moon!"

Attendees completely absorbed in Dr. Zubrin's speech. (Photo Courtesy of Ken Lui)

(Continued on Page 24)

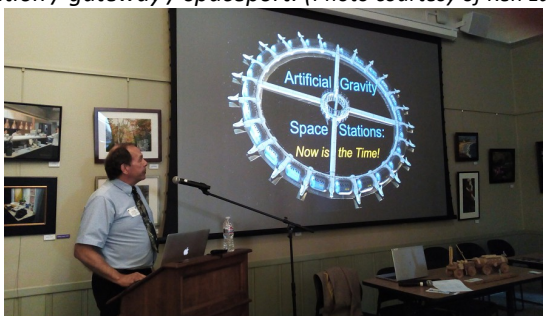
Stepping Stone to the Moon *(continued from Page 3)*

For those who want to spend more time in space, the Gateway Foundation is planning to build a "destination hotel, a low Earth orbit cruise ship, or a city in space with a spaceport," Gateway Chief Architect Dr. Thomas Spilker told the gathering. The prices for a three night, double occupancy stay on its planned von Braun orbiting hotel range from $2 million for a standard room to $5 million for a luxury suite.

Alternatively, you can get paid to work there. "Just as there are many different kinds of jobs on a cruise ship or on a yacht," Spilker said, "those same types of jobs, modified to operate in space, will exist. So, you can be very very rich, you could win a contest to go to space, or you could eventually train and work in space. This industry is growing. We need more and more people for a greater diversity of jobs."

"Everything I do as an outer space architect and a real estate developer for space themed entertainment is focused on the experience. We're creating unique life-changing experiences for people," Spilker said.

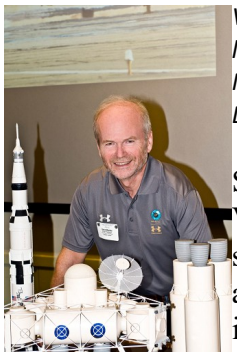
John Blincow, President of the Gateway Foundation, talking about the toilet design that could be used in the proposed von Braun space station / gateway / spaceport. (Photo courtesy of Ken Lui)



Dr. Thomas Spilker, Chief Architect of the Gateway Foundation, discussing the artificial gravity design, and the right timing now to implement it. (Photo courtesy of Ken Lui)

Virgin Galactic's $250,000 ticket is a fraction of the $20 million American entrepreneur Dennis Tito paid in 2001 to spend eight days on the International Space Station. Tito was taken to the space station and returned to earth by Russian spacecraft. But Spilker predicts that it will be 20 to 40 years before the average person (who doesn't work in space) can become a space tourist.

In July, NASA announced that the International Space Station is open for commercial and marketing activities. Regular citizens, not just astronauts, can Airbnb the ISS —for $35,000 a night. Transportation to and from the ISS is not included.



Virgin Galactic Chief Pilot Dave Mackay with lunar base models built by USC professor Madhu Thangavelu 30 years ago. (Photo by David Fairchild)

Space travel is not without risks. A Virgin Galactic pilot died when its first spaceship crashed in 2014. Last April, a SpaceX crew capsule was engulfed in flames during testing.

Nonetheless, moderator Thangavelu said, wealthy people will always want to push boundaries.

In 1987, Branson and fellow adventurer Per Lindstrand were the first to cross the Atlantic in a hot-air balloon.

According to Mackay, Branson is motivated by space travel because he, like millions of others around the world, watched the Apollo 11 moon landing.

"Richard is an adventurer; it's part of his DNA. Space is the ultimate adventure," Mackay said.

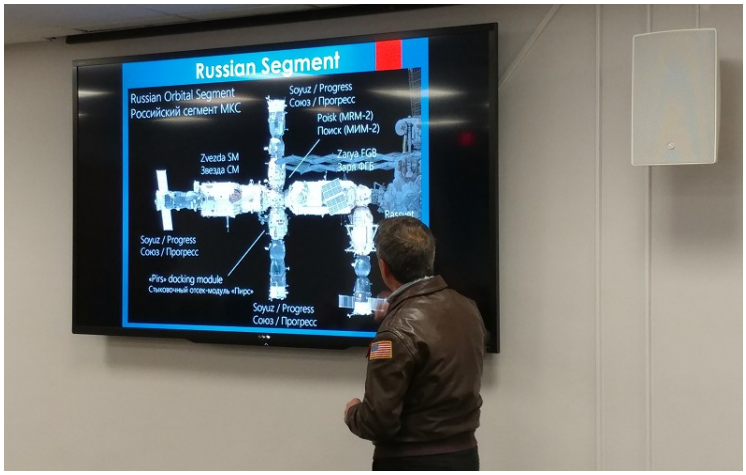
Elon Musk's Space Exploration Technologies (SpaceX), based in Hawthorne, announced plans last year to fly paying passengers to the moon in 2023.

Amazon founder Jeff Bezos's Blue Origin, like Branson's Virgin Galactic, are content for now to fly adventurers to Earth's lower orbit on short trips for recreational purposes.

Thangavelu described short, low orbit trips as stepping stones to the moon. "After some shorter visits to the moon, if we see the data coming back, that we can adjust to partial gravity on the moon, that people can stay for longer periods of time, then we will think about permanent habitation. But that does not mean we should wait until then to think about the future. We should be thinking about it now."

Thangavelu is co-author of The Moon: Resources, Future Development and Settlement.

AIAA Los Angeles-Las Vegas Section Hosts ISS Operations Developer *(Continued from Page 5)*



Col. Mark Pestana explaining the structures of the ISS, including the Russian Segment. (Photo Courtesy of Ken Lui)

We heard several examples of the cultural differences between Russians and Americans. Whereas the Americans would schedule meetings to begin at 8am, the Russians would arrive late and begin with personal interaction (they say "time is infinite"). Ceremonies are important, both on Earth and in space. Upon entering a room (or the station), a period of silent waiting was used to "appease the house spirit." Food and drink were critical elements of all Technical Interchange Meetings, and the Soyuz had a special compartment for "the Commander's cognac." Training sessions at Star City followed a "medieval lecture" model, in Russian, with no handouts. He had to work on the Soyuz seat problem without specifications or photos. Pre-launch ceremonies were elaborate, and held at the Kremlin. There are numerous monuments to Soviet aerospace accomplishments (including the "invention of the airplane"), but there seemed to be a "collective embarrassment" over the term "Soviet."

Col. Pestana went on to describe the environment aboard the ISS. The first "element" was launched in 1998, and the station was "completed" in 2010, although there has been growth since then (e.g. the second airlock on the Russian module). It has been continuously occupied since November 2, 2000, with 120+ crew and 250+ visitors. Features include rotating solar panels, thermal radiators, and water and ammonia cooling inside. Five different types of cargo vehicles are supported. There are 2 toilets: 1 U.S., 1 Russian. There are not enough sleep compartments for all crew to have their own. Exercise equipment includes the recently installed "COLBERT" treadmill. Multiple musical instruments have been brought onboard. Mission stickers are all over. International crews eat together, but have their own food (Americans report "fish aspic stinks").

Lastly, Col. Pestana gave his perspective on the future of manned spacecraft. He reviewed the Commercial Crew program (saves $86M per Soyuz seat, reminiscent of aviation in the 1930's), the Artemis moon program (Orion, SLS, Gateway & Landers), a potential Soyuz replacement, suborbital tourism, and the Bigelow inflatable "hotel." ISS should be maintained at least until 2025. He reminded us that the $20B NASA budget is a relatively small fraction of the $4.5T national budget (US spends $40B on pizza), yet has had a large (10x?) Return on Investment. Col. Pestana feels that the moon offers significant potential for profit (e.g. "truck stop" near poles), while providing a laboratory to study long-duration space flight and the asteroid threat. He reviewed both funded and unfunded Mars projects. Among the reasons to go to Mars was "it will be fun!" Some trips will eventually be one-way ("history did it"), and terraforming might be possible.

The evening concluded with a lively Q&A session. Here is a snapshot. 1) Most challenging logistics? Redundancy, margin to allow for cargo failure. 2) Air? Recycled (O2 generated, CO2 scrubbed), as is urine. 3) Did you meet Neil Armstrong? They shared an office when he was a research pilot, and met 5 times later. 4) How long could the ISS last (say, if Bezos was paying)? Unknown. 5) What about the Soyuz "pinhole"? Low leak rate, origin unknown, was patched. 6) Research accommodations? Examples include antimatter detection magnet, 3D printed heart tissue. 7) Venus? "I wouldn't go." 8) Russian Salyut-7 movie ("Salyut 7: The True Story of the Soviet 'Apollo 13'")? "Hollywood version," but generally correct. 9) Meteor hits? So far like sand grain or paint fleck in shuttle window, no pressure loss, worked on depressurization scenario. 10) Solar weather? Shelter in specific areas. 11) Suits for Commercial Crew? Different colors, noted static cling problem for moon dust. 12) Crew Dragon ergonomics? It will still be full of cargo. 13) Russian radiation standard? Crew wears dosimeter, 1 astronaut told not to fly further, vision problems reported, cancer not significantly increased. 14) Claustrophobic? A personal issue, but probably wouldn't fly if so.

(Continued on Page 22)

A Documentary That's Truly Out of this World! *(Continued from Page 6)*

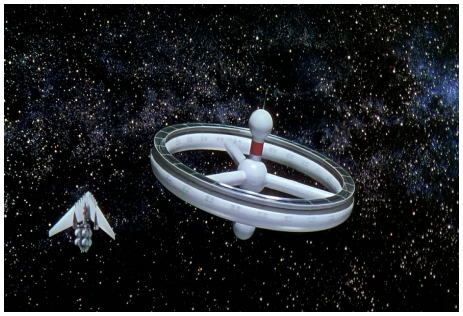
Mark's involvement with NASA goes back a long way. Before his most recent assignment as a Research Pilot at NASA's Armstrong Flight Research Center, he served as an Operations Engineer in the NASA Astronaut Office. He also helped develop the flight crew operations of the International Space Station. That assignment took him to Moscow and to Star City, the cosmonaut training base, to interface with the Russian Space Agency, an important partner in the ISS.

Mark is an award-winning artist member of the International Association of Astronomical Artists (IAAA). He credits Chesley Bonestell for pointing him to the fields of aviation and space. "Chesley's paintings inspired me to pursue a career in aerospace. One nice part is that I also get to use my skills as an artist in my work. I have the unique honor of having designed the astronauts' mission patches for nine Space Shuttle flights, one of which docked at the ISS."

STS-123 Mission Patch created by Mark Pestana.

Chesley was no stranger to space stations. His work with Wernher von Braun included turning von Braun's mathematical formulas and sketches into practical renderings that were featured in magazine articles such as the 1950's Collier's series "Man Will Conquer Space Soon!" and books such as Across The Space Frontier (1952).

*Chesley Bonestell rendering for the 1952 book **Across the Space Frontier**. (Courtesy Bonestell LLC)*



*From the opening scenes of **Conquest of Space** (1955) (Credit: Paramount Pictures)*

A space station appears in a 1955 film that Chesley worked on with producer George Pal called *Conquest of Space*. Since then, Chesley's work has been a part of television shows such as Men Into Space and has influenced iconic films such as Stanley Kubrick's *2001: A Space Odyssey.*

The news that **Chesley Bonestell: A Brush With The Future**" now circles the Earth at 4.76 miles per second brought smiles to its Co-Producers **Ron Miller** and **Melvin Schuetz**. "This is a signature moment that just astounds me. It's incredible!" said Ron, a space artist himself. "Chesley Bonestell has been one of the pillars of my career. I would not be doing what I do today had it not been for his influence...and every painting I do is a tip of my hat to his inspiration." Melvin, a renowned Bonestell historian, agrees. "As a young boy, I became fascinated with Chesley's extraordinary art. It's wonderful that he has now been taken up into space—something that fascinated him so much. That fascination inspired him to create paintings that have encouraged others to accomplish what humanity has dreamed of for centuries—the exploration of the Final Frontier."

The producers extend their sincerest thanks to NASA's Behavioral Health and Performance team, who transmitted the film to the ISS. This team supports the astronauts' leisure time activities like family teleconferences and viewing live sporting events. It should be noted that NASA does not specifically endorse the music or films they provide to the ISS crews. They also can't confirm if the crew has actually watched the film but we're hopeful about hearing some out-of-this-world reviews in the days or weeks ahead! Would that Chesley could be alive today to see how important his life's work has become in a film that now orbits 254 miles above the earth.

The Chesley Bonestell Film Team is deeply indebted to the American Institute of Aeronautics and Astronautics, the National Aeronautics and Space Administration, and to Mark Pestana for their extraordinary efforts on behalf of this film.

AIAA Biomimetics examples in Engineering *(Continued from Page 7)*

Using the wing shape of the Adelie penguin resulted in a significant reduction of wind resistance. The Shinkansen 500 train had 30% less air resistance than its predecessor, and thus used far less energy.

Migrating or foraging animals sometimes move in very large numbers, consisting of hundreds or thousands of animals that move gracefully without bumping into each other. This is an example of nature's brilliant algorithm that with some simple rules for each individual, the efficient maneuvering of thousands of animals is maintained without any advanced software, computers, or algorithms. Examples in nature include bird flocks, fish schools (especially sardines), and some insect species including bees and ants. Many birds migrate or forage in large numbers. With certain species of birds such as the starling, the flock may consist of approximately 100,000 birds. These flocks are known as murmurations (fig 2.).

Figure 2: Left: Murmuration of starling flock in action. Right: A swarm of drones with military or civilian applications for search and rescue, mapping, logistics, and more.

Starlings often fly very close to each other and at relatively high speeds, at approximately 70 km/h (approximately 43 mph), without hitting each other. To escape a hunting falcon, parts of the flock perform incredibly rapid, complex, and collective movements, and later rejoin the rest, like flying choreographed dancers in the sky. They are governed by simple rules that lead to complex movement patterns.

Back in 1987, the pioneering computer scientist Craig Reynolds conducted simulations and research to show that the complex flock behavior is governed by just three simple rules: separation, alignment, and cohesion. Close-together birds would move further apart (separation), birds in general would align their direction and speed (alignment), and the further-apart birds would move closer (cohesion). Researchers in Italy confirmed his hypothesis and created simulations in which starlings were matching the direction and speed of their 6 to 7 nearest neighbors instead of responding to the movements of all of the birds closest to them. This is an example of swarm intelligence, in which seemingly intelligent behavior emerges from the collective behavior of a large number of autonomous animals.

Drones for military uses or civilian drones for search and rescue, logistics and more are being developed by Amazon, FedEx, and others can find their routes using this intelligence. Drone delivery at large scale can save costs, energy and time, but need to be more reliable, efficient and safe.

Other remarkable examples of complex colony behavior include groups of fire ants that link together to form a raft colony. These float on the water surface for hours or days in order to survive, while an individual fire ant would drown after falling into a pool of water after a storm.

Figure 3: Left: fire ant floating raft. Right: close-up view of its structure.

We have a lot to learn from the flocking behavior of the ants, fish, birds, and bees. Applications include swarm robotics, artificial intelligence, algorithms, digital networks, logistics, search optimization, self-healing materials, heating, cooling, energy efficiency, sensing, and navigation. Fish schools can serve as models for the placement of wind turbines; and the V-formations of Canada geese, Northern bald ibises, pelicans, flamingos and other migrating birds serve as models for plane flight (fig 4.)

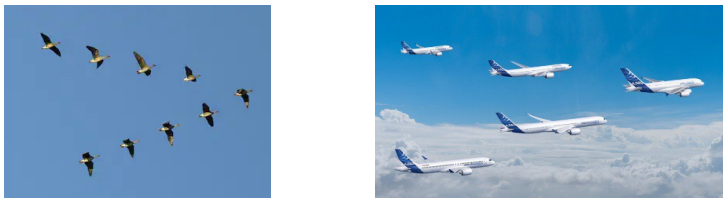


Figure 4: Top: Canada geese in a V-formation. Bottom: Airplanes flying in V-formation

(Continued on Page 25)

Moon Thrusters Withstand Over 60 Hot-Fire Tests *(Continued from Page 8)*

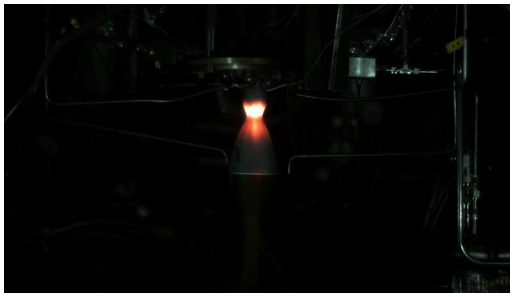
The TALOS thruster is being developed by Frontier Aerospace. The project is led and managed by NASA's Marshall Space Flight Center in Huntsville, Alabama. Once the TALOS design has been qualified for flight, Frontier Aerospace will build the thrusters for Astrobotic's lunar lander under a project called Frontier Aerospace Corporation Engine Testing (FACET). The Game Changing Development program within NASA's Space Technology Mission Directorate funds the technology development project.

Learn more about NASA's investments in space technology:

www.nasa.gov/spacetech

NASA and Frontier Aerospace are developing next-generation thrusters for use on Astrobotic's Peregrine lunar lander. In March 2020, thruster prototypes performed over 60 hot-fire tests in a vacuum chamber Credits: Frontier Aerospace

A new spacecraft thruster prototype developed under NASA's Thruster for the Advancement of Low-temperature Operation in Space (TALOS) project undergoes a hot-fire test in a vacuum chamber. Credits: Frontier Aerospace



A new spacecraft thruster prototype developed under NASA's Thruster for the Advancement of Low-temperature Operation in Space (TALOS) project undergoes a hot-fire test in a vacuum chamber. (Credits: Frontier Aerospace)

About Astrobotic

Astrobotic Technology, Inc. is a space robotics company that seeks to make space accessible to the world. The company's lunar lander, Peregrine, delivers payloads to the Moon for companies, governments, universities, non-profits, and individuals for $1.2 million per kilogram. Astrobotic was selected by NASA in May 2019 for a $79.5 million contract to deliver payloads to the Moon in 2021. The company is also developing advanced space robotics capabilities such as terrain relative navigation, mobile robotics for lunar surface operations, and reliable computing systems for mission-critical applications. The company also has more than 30 prior and ongoing NASA and commercial technology contracts, a commercial partnership with Airbus DS, and a corporate sponsorship with DHL. Astrobotic was founded in 2007 and is headquartered in Pittsburgh, PA.

AIAA Los Angeles-Las Vegas Section Hosts ISS Operations Developer *(Continued from Page 19)*

Excited and enthusiastic attendees talking and networking with the speaker after the Q &A session. (Photo Courtesy of Ken Lui)

About the Author:

David Sunderland received BS and MS degrees from the University of Missouri in 1977 and 1978, and the Ph.D. in 1987 from USC. He joined Hughes Aircraft in 1978, where he designed custom ICs for satellites. He joined IBM in 1989, and was responsible for device design, modeling and groundrules in bipolar, CMOS and BICMOS technologies. He returned to Hughes (later part of Boeing) in 1996, where he was responsible for selection and qualification of high-performance, yet highly reliable and radiation-tolerant, semiconductor technologies for spacecraft applications. He became a Boeing Senior Technical Fellow in 2008, and created a Boeing-wide Community of Excellence, advising programs on the insertion of new electronic technologies. Since retiring in 2016, he remains active in planning for the International Reliability Physics Symposium and JEDEC industry standards activities for space parts, while entertaining his life-long interest in "all things space" through AIAA meetings.

Daniel Raymer Answers Some Questions *(Continued from Page 16)*

A third memorable project was our early work on Advanced Tactical Fighter (ATF), which eventually led to the F-22 program. When I was made Chief Engineer for ATF at Rockwell, it was not considered possible to have stealth and supersonic cruise in the same aircraft. Besides, most people thought that supersonic cruise was a waste of time for a fighter since you "slow down to dogfight." I tried anyway, and came up with a design with really low supersonic drag that also permitted fairly good stealth by the standards of the day. According to analysis and extensive sub- and supersonic wind tunnel testing, the design would indeed supercruise – at Mach 1.80. This design was studied intensively for 3-4 years. After I'd left Rockwell, the top management decided not to put a billion dollars of company money into the program as required by the Air Force to get a contract. So my design didn't get built…. again.

There have been dozens of other projects, ranging from a hybrid-electric hybrid airship to a Mars rover airplane to an otherwise-normal but tailless commercial airliner to an Air Force reusable launch vehicle to an optionally-manned modular UAV for DARPA to a rocket designed to fling a whole squad of marines halfway around the world, land them in a remote site, and get them out when their mission is done. Recently there have been several exciting launch vehicle projects about which I can say nothing – they have grim and powerful lawyers. One or both may fly. Hopefully when that happens, they'll finally let me say "I did that."

Right now, I'm heading a DARPA contract which my company just won called the "Flying Missile Rail." It's described on the DARPA website but the aircraft concept shown there isn't the real one. Mine is much cooler!

Oh right – what about my influences? I should start with my father since he was a Navy Test Pilot (Pax River). He didn't really push me towards aviation but I saw a lot of airplanes as a kid, and I read his old Navy pilot training books and copies of Aviation Week. But as I said in "Living in the Future," he just went to work like other dads. It's not like he took me up in his P-2. I didn't learn until decades later some of the things he did, like teaching the Black Bats how to fly their spy planes over mainland China (he's in that book). RIP, Dad – love you.

Other influences? As a kid I wanted to be the next Kelly Johnson. I read all about Kelly, the Lockheed Skunkworks, and the planes he designed there. I was thrilled years later when they made me Director of Advanced Design at Lockheed, with corresponding title inside the Skunkworks, but most of my work was on the "outside." A big regret of mine is that I didn't somehow arrange to meet Kelly. He was retired and frail, and I didn't want to be a pushy jerk fanboy. I should have, anyway.

I've always admired the simplicity and directness of the design work by Ed Heineman of the Douglas Aircraft Company, especially his A-4 ("Heineman's Hot Rod"). I was lucky enough to meet him at an AIAA meeting early in my career – fanboy again.

Howard Hughes was a hero of mine, as a pioneering race pilot and aviation entrepreneur. He didn't really design airplanes but he paid for their development and pushed his designers to do great and innovative things. I was lucky enough to go inside his H-4 (Spruce Goose) before it was opened to the public. Hughes was dead by this time but I got to meet his Chief Engineer, William Berry, who had been brought out of retirement to prepare the H-4 for public display. Berry gave us an hour-long technical talk on the design including the pioneering work that he and his team had done on molded structures and full-authority hydraulic flight control systems. It was fascinating, and miles ahead of others at that time. For the full story see my autobiography. Later I learned that William Berry was actually the father of singer/songwriter Jan Berry, of 1960's surf band Jan and Dean. I still love their stuff.

Wilbur and Orville Wright were heroes of mine from an early age. I read a child's biography of them when I was about eight, and have been their fan ever since. I still hate it when books or talking heads describe them as "lucky bicycle mechanics." They were true aviation scientists using theory and experiment to, one by one, solve the problems of flight.

I was most influenced by the designers who taught me how "real" aircraft design is done, in my early years at NAA-Rockwell. My main mentor was Lester Hendrix, the designer of the B-1 and HiMat. Harry Scott, one of the main configuration designers of the Space Shuttle, taught me a lot and still does. While long since retired, I occasionally take him to lunch and pepper him with questions. My first boss, Loui Hecq, taught me many things including the importance of getting the landing gear right. George Owl, a Cherokee Native American and the key layout designer of the B-70 and designer of the Formula One Owl Racers, quietly educated me about conics and mechanisms. There were many more – thanks to you all!

Well, that's about it. See you at the airport, or the next AIAA meeting!

"Dr. Robert Zubrin, The Case for Space, and Moon Direct", Wednesday, September 11, 2019 Northrop Grumman Aerospace Systems, Redondo Beach, CA *(Continued from Page 17)*

Zubrin contended that NASA mandating that lunar-bound crews must stop at the Gateway serves no purpose other than justifying the Gateway's existence. He pointed out that the Gateway in fact greatly restricts lunar missions by adding to their propulsion requirements, vastly reducing the windows of opportunity for crews to come and go from the surface, increasing the risks (since, should an emergency return become necessary, Earth always remains in the same position relative to the Moon, but the looping Gateway would be in an optimal location just once a week), and adding billions of dollars in development and operational costs.

NASA's Gateway-focused planning also relies heavily on the overdue and over budget Space Launch System (SLS), which, if completed, will loft 70 metric tons to Low Earth Orbit for around $2 billion per flight (not including its development costs of $23 billion so far). In addition, it will have a launch cadence of no more than one per year.

Compare that to the already operational Falcon Heavy, which is able to deliver 64 metric tons to Low Earth Orbit for an incredible $150 million per flight. That is 91% the payload of the SLS for less than 8% the cost.

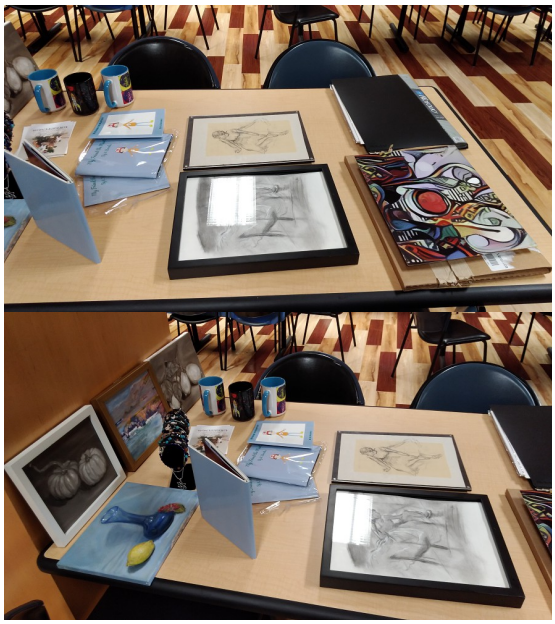
Instead of the Gateway and its vendor-driven agenda, Zubrin proposes a far more direct and cost-efficient approach having the goal of establishing a regular, recurring human presence on the Moon, while remaining well within NASA's current budget. He calls his program "Moon Direct."

Moon Direct uses a vastly different architecture, and would utilize the stores of frozen water ice known to exist at the lunar poles for creating rocket propellant for use by the system. To reach orbit, and to deliver the initial loads of equipment to the Moon, the plan employs the affordable and mostly reusable Falcon 9, Falcon Heavy and Dragon Crew spacecraft as key elements. The primary new hardware NASA would need to develop include a Lunar Excursion Vehicle (LEV) capable of flying from the Moon's surface to Earth orbit (using lunar-derived propellants), or being refueled to return from Earth orbit to the lunar surface with 6 tons of propellant lifted from Earth, as well as the equipment and system necessary for an operational lunar polar base.

In brief, astronauts would lift off from Earth aboard a Dragon spacecraft, dock with the LEV in Earth orbit and transfer to it, and perhaps refuel it for their return flight to the lunar polar base. There, they would conduct their work, refuel the LEV with propellants made from lunar water, and eventually fly back to Earth orbit where they would rendezvous with a Dragon for reentry to Earth's surface. Crew members and Dragon spacecraft could be cycled much like the current Soyuz vehicles that serve the International Space Station, with a new crew going up on a vehicle that then brings the returning crew back down.

Zubrin's plan includes many detailed steps, allowing for the installation and growth of the lunar propellant manufacturing infrastructure as well as for expanding the zone of exploration to eventually include all of the Moon's surface.

As for the cost, his proposal seems astounding. However, by relying on commercially available crew launch vehicles and a reusable LEV using "Moon Made" propellants once the lunar base has been established, recurring missions would cost as little as two percent of NASA's current budget, or about $420 million. Could we really have a regular human presence on the Moon for just a tiny sliver of the money that we are already spending on NASA? With the completion of the ISS in 2011, the end of Space Shuttle operations that same year, and yet no parallel decrease in NASA's funding, where has all our money gone? It seems like a tragedy that we don't have much more to show for it.



Art work exhibition by Veronica Brooks. (Photo Courtesy by Ken Lui)

(Continued on Page 26)

AIAA Biomimetics examples in Engineering *(Continued from Page 21)*

Boeing and NASA engineers have discovered that by mimicking Canada geese through flying planes in a v-shaped formation and cruising in the wake of the aircraft in front, fuel usage is reduced by approximately 10%. Airbus is conducting a new demonstration project this year using two commercial aircraft (A350s) flying in tandem 1.8 miles apart to boost fuel efficiency while reducing emissions.

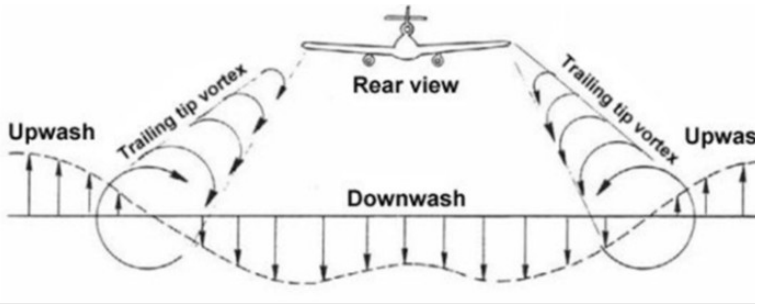


Figure 5: Schematic illustrating the main flow patterns behind an airplane in flight at subsonic speeds, including the downwash, wing tip vortices and associated upwash flow. Image credit Aerospaceweb

Engineers have known about the airflow patterns behind a flying plane for a long time and the possibility of "vortex surfing," in which planes can fly in a V-formation similar to migrating birds to utilize the updraft or upwash created as a result of the trailing tip vortices from each wing (Fig. 5). Modern airplanes could use their navigation and collision-avoidance systems when flying in a V-formation. However, flying in V-formation may be more likely to be employed first on long haul cargo flights. The long-term impact of V-formation flight on the structural stress and fatigue needs to be investigated further.

Formation flight is more challenging for birds than for fixed-wing aircraft. Birds not only adjust their position relative to each other but also must synchronize their wingbeat frequency, thus maximizing upwash capture.

The curiosity that inspired engineers to look to the natural world for answers to the problems they faced is extremely fascinating. Some of the earliest engineers—Leonardo da Vinci, the Wright Brothers, Clément Ader, Mary Golda Ross, and Otto Lilienthal—were pioneers in this field since they encouraged us to look to nature rather than to a textbook for solutions. Similarly, naturalists such as Maria Sibylla Merian, Charles Darwin, and Carl Linnaeus were also instrumental in the development of this field. Although we can never underestimate the power of the human mind to abstract, the forces of nature that govern our world have infinite applications to the field of engineering. There are countless examples of seemingly unrelated nature-inspired designs that engineers could use.

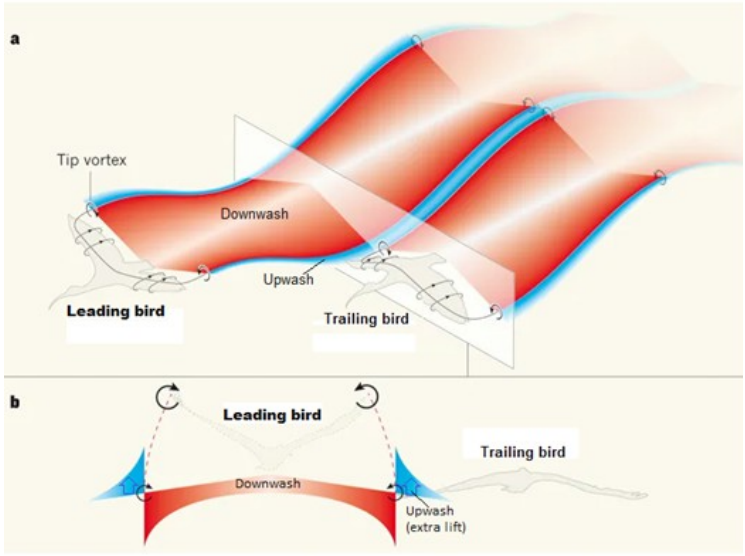


Figure 6. (a, side view; b, rear view). Flow pattern downstream from two Northern bald ibises flying in V-formation. Ref: Steven J. Portugal et al, "Upwash exploitation and downwash avoidance by flap phasing in ibis formation flight", Nature, Volume 505, pages 399–402 (2014)

Shark skin-inspired coatings can reduce drag and fuel consumption on air vehicles, protect the surfaces of marine vehicles from marine growth, and even protect people from harmful bacteria in hospitals. Shark skin surfaces have been known to have drag reduction properties for over 40 years, but new laser surface treatment technologies are making these properties feasible for practical use.

Shark skin-inspired surfaces on airplanes, called "riblets" (fig. 7 and 8), can reduce drag by up to 10%, which results in fuel savings for commercial long-haul airlines of more than 1% according to the aircraft paint supplier Mankiewicz (Germany) and 4JET. They are in the final stages of developing a laser-guided treatment that adds shark skin riblets on top of the aircraft's painted surfaces. The Laser Enhanced Air Flow (LEAF) technology uses the principle of laser interference patterning to create hundreds of riblets within one second.

(Continued on Page 27)

"Dr. Robert Zubrin, The Case for Space, and Moon Direct", Wednesday, September 11, 2019 Northrop Grumman Aerospace Systems, Redondo Beach, CA *(Continued from Page 24)*

Left: Mohana Venkhat, Events/Program Co-Chair; Right: Dennis Wonica, Enterprise Chair. (Photo Courtesy of Ken Lui)

ONWARD AND UPWARD

Recent news stories have brought hints that some at NASA may be coming around to Zubrin's point of view.

In March 2020 NASA's new human spaceflight director, Douglas Loverro, removed the Gateway from the "critical path" for a proposed 2024 return to the lunar surface. Though not cancelling it entirely, Loverro saw the Gateway as an impediment to the mission's urgent goals and budgetary constraints of returning human boots to the Moon. NASA's recent selection of SpaceX as the first commercial provider of cargo and supplies to lunar orbit also bodes well for innovation and cost savings. As Loverro said, "To truly get the new objectives done, things have got to change."

And with change comes hope. Zubrin's decades of advocacy for purpose-driven space missions that expand the human presence for the benefit of all has renewed relevance. With luck, persistence and continued public advocacy, we may see a space renaissance, and at long last, more humans on the Moon, Mars and beyond.

REFERENCES

For information about the Mars Society, visit MarsSociety.com.

For a detailed technical presentation on Moon Direct, see Dr. Zubrin's articles:

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AUTHOR'S BIO

A long-time Mars Society member, as a child Roger found equal inspiration in the Apollo Program and Stanley Kubrick's "2001: A Space Odyssey." These early interests set him on a dual track life and career path. In college he studied aerospace engineering at USC, while managing to spend his free time around the school's film and television department. After two years in Silicon Valley he and friends started what would became the Internet's leading robotics source of the day, RobotStore.com, where he created numerous robotic kits and books about "Muscle Wires" – solid state Shape Memory Alloy actuator materials, and provided some to NASA for the Materials Adherence Experiment which flew aboard the Mars Pathfinder Sojourner rover, now on Mars. In 2005 Roger played the role of Igor Sikorsky for the History Channel's program "Sikorsky and the Rescue Chopper." In 2007 he joined SpaceX as the startup's first full-time "media guy" where he helped document and share the company's early efforts, including producing and directing live Falcon1, Falcon 9 and Dragon mission webcasts, facility tour videos, as well as designing and producing flying model rocket kits of the company's Falcon 9 launch vehicles. His other film credits include "Who Killed the Electric Car?," "Revenge of the Electric Car," "Do You Trust This Computer?," and the Discovery Channel's 2018 release "Above and Beyond: NASA's Journey to Tomorrow" celebrating the space agency's 60 years of incredible accomplishments. Roger currently writes and produces fiction and non-fiction content about diverse science, space, and technology themes relevant to the crew members of Spaceship Earth.

A NOTE ABOUT CAPITALIZATION

Both NASA and the author advocate the capitalization of the word "Moon" when referring to Earth's large natural satellite. Although this runs counter to some influential but slow-to-change style guides, should you agree, please consider adopting the capitalization of Moon and Sun in your usage as well.

AIAA Biomimetics examples in Engineering *(Continued from Page 25)*

Currently, shark skin-inspired riblets are also undergoing tests by the US Air Force. In addition to drag reduction, they can increase airfoil lift, according to a team of evolutionary biologists and engineers at Harvard University. The team in collaboration with colleagues from the University of South Carolina has demonstrated, in the laboratory, lift-to-drag ratio improvements of up to 323% compared to an airfoil without riblets. (Ref. August G. Domel et al. "Shark skin-inspired designs that improve aerodynamic performance", The Royal Society, 07 February, 2018)

Their riblet design mimics the shortfin mako's denticles. The shortfin mako shark is the fastest shark in the world. The mako's denticles have three raised ridges that act as individual vortex generators.

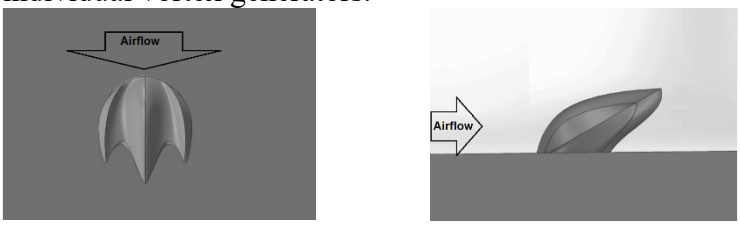


Figure 7: a) Elevated view of shark skin-inspired riblet b) Side view of shark skin-inspired riblet.

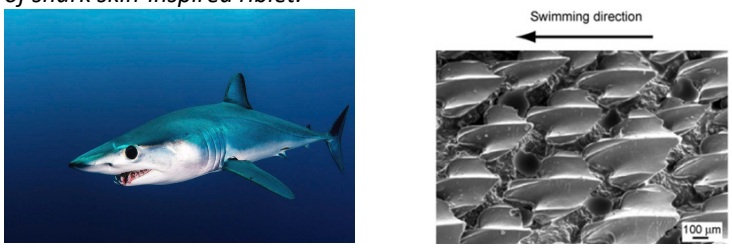


Figure 8: Left: A shortfin mako, the fastest shark in the world. Right: Scanning electron microscope image of the mako shark's denticles (skin protrusions), which have three raised ridges of approximately 0.0079-0.02 inches or 0.2-0.5 mm in height. The denticles are aligned in an irregular array close together, approximately 0.0014-0.0041 inches or 35-105 micrometers apart.

The abalone shell's durable natural composite structure, which can serve as a model for advanced ceramic materials in the future without using toxic chemicals/resins or heat, is currently under investigation by engineering firms. At the nanoscale, an abalone shell is made of thousands of layers of plates. They are locked together by a layer of calcium carbonate, more commonly known as chalk, which is approximately 10 micrometers across and 0.5 micrometers thick. Abalone shells exhibit the highest mechanical strength and fracture toughness of any non-metallic substance known, with many engineering and biomedical applications.

Figure 9: Abalone shell

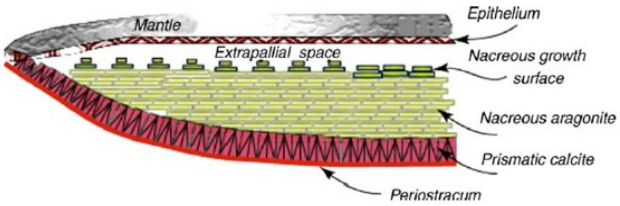


Figure 10: Illustration (side view) of the layers of the abalone shell. Image ref. C.M. Zaremba, A.M. Belcher, M. Fritz, et al.: Chem. Mater., Vol. 8, p. 679 (1996) p. 679

Flying seeds inspired early aviation pioneers and engineers, such as Ignaz "Igo" Etrich in 1904. The design of the glider was derived from the large (15-cm span)-winged seed of *Alsomitra macrocarpa*, a liana that grows on islands in the Pacific. The seed's outgrowths function as flying wings, enabling the seed to glide for significant distances. Several of the early experimenters with tailless aircraft, including Igo Etrich, adapted these principles to the design of powered, sustained flight in heavier-than-air machines (fig. 11). Perhaps some of our future drones could utilize this old technology inspired by a seed.

Figure 11: Left: Illustration of an Alsomitra macrocarpa seed. Right: A replica of a tailless glider plane designed by Ignaz "Igo" Etrich in 1904, whose design was inspired by the seed.

Manta rays are known for gracefully fly through the water. They have inspired some experimental aircrafts. Capable of a top speed of 140 mph (225 km/h) and reaching a maximum altitude of 10,000 ft the, the X-48, Unmanned Air Vehicle (UAV) is a low speed experimental aircraft inspired by the shape of a Manta ray. The remotely piloted airplane, built by Cranfield Aerospace Ltd., tested at Cranfield University (UK), and designed developed by Boeing's Phantom Works working in cooperation with NASA Langley Research Center. *(Continued on Page 28)*

AIAA Biomimetics examples in Engineering *(Continued from Page 27)*


Figure 12): Lef: Image of a Manta Ray, right: The X-48C UAV model plane in flight

Although blended-wing airplane designs are not new, they have been around for many years, with the most famous example from the U.S. government's elegantly designed stealth B-2 bomber. The British Aeronautical pioneer John W. Dunne designed one of the earliest tailless wing-body configurations, which flew in 1912.
Also, Airbus has revealed this year, MAVERIC (Model Aircraft for Validation and Experimentation of Robust Innovative Controls) with its "blended wing body" scale model technological demonstrator. At 2 meters long and 3.2 meters wide, that has the potential to reduce fuel consumption by up to 20% compared to current single-aisle aircraft.

Figure 13): Airbus MAVERIC, the "blended wing body" scale model technological demonstrator, 2020

The main advantages of the blended wing body design include: Less surface area (wetted area) thus less drag, increased fuel efficiency in the order of 5-10% compared to and conventional fuselage, structural benefits due to a thicker wing root and lower aerodynamic noise—all inspired by nature.

The toucan's large, colorful beak is made of a bio-composite material that may inspire the designers of future ultra-light aircraft and cars. It has useful properties such as low weight, high stiffness, strength, good energy absorption capacity, and insulation.
Despite its large size (a third of the length of the bird) and considerable strength, the beak comprises only 5% of the bird's body mass. The beak is built like a sandwich: outside, it is covered with keratin (as in our fingernails) organized in tiny scales that prevent it from cracking. In the middle, there is an air-filled foam structure with many holes, held together by scaffolds of calcium and keratin (fig. 14a).

In addition, engineers have discovered that the toucan uses its oversized beak for heat regulation (fig. 14b). The toucan can heat and cool its bill at an astonishing rate, changing its temperature by up to 10°C (18°F) within a few minutes.

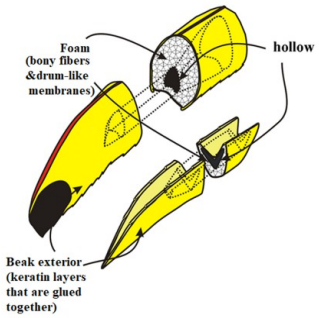



Figure 14a): Left: A toucan with its colorful and prominent beak. Right: Illustration of the interior components of a toucan's beak.

Figure 14b): Infrared thermography image of the radiated heat from the toucan's beak.

The woodpecker's beak pounds into trees at 18-22 times/second and experiences deceleration forces of approximately 1200-1400g, incredibly without the bird's getting a concussion or head injury. The woodpecker's beak has inspired the design of shock-absorbing structures such as those that protect flight recorder electronics and landing gears in airplanes and also protect spacecraft from collisions with micrometeorites and space debris.


Figure 15: Left: A woodpecker hacking its way into a tree. Right: Woodpecker beak-inspired ice ax by the Italian sporting firm CAMP.

(Continued on Page 29)

AIAA Biomimetics examples in Engineering *(Continued from Page 28)*

Lotus flower leaves are hydrophobic, or water repellent, which inspired NASA and other companies to create a nano-textured dust mitigation coating that can be used for space, aeronautical, and other applications on Earth. A technique known as Direct Laser Interference Patterning (DLIP) is being developed via a collaboration of the Fraunhofer Institute for Material and Beam Technology, Airbus, and the Dresden University of Technology, to create a micro lotus leaf pattern on an aircraft wing that would repel water and ice during winter conditions.

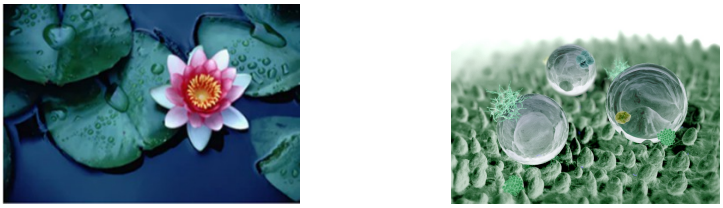


Figure 16: Left: Hydrophobic lotus leaves. Right: an illustration of the microscopic bumps that allow the leaves of the lotus flower to repel water by decreasing the contact area between the water droplets and the leaf surface. (Illustration from William Thielicke)

Tardigrades' or "water bears'" ability to survive in extreme environments may help us to design future spacecraft, probes. and space suits that can withstand ionized radiation far longer and better than we humans can do today. The tardigrades can survive in pressures about six times greater than those at the bottom of the deepest ocean trenches on Earth, go without food or water for 30 years or more, and be frozen to -458°F. That's astonishing for a tiny animal.

Figure 17: An enlarged image of the small, but incredibly resilient, tardigrade.

Moth eyes non-reflective surface has inspired the design of more efficient solar cells and sensitive cameras that can capture the faintest light in our galaxy. The Bolometer detector array, is an instrument as a part of the Stratospheric Observatory for Infrared Astronomy, that uses a custom-made Boeing 747 to fly at high altitudes and make observations of the infrared radiation using a sensitive camera inspired by the night flying moth's eyes.

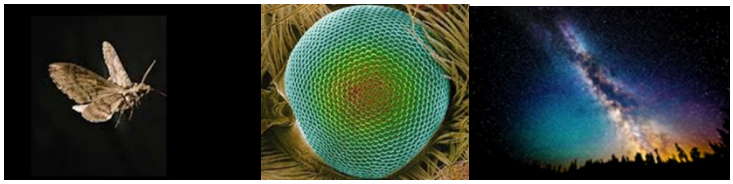


Figure 18: Left: Night flying moth. Center: Moth eye closeup. Right: Night sky image from the Bolometer detector array (image credit: NASA).

Gecko feet inspired the design of a space robot gripper that uses Van der Waals forces to help clean up around 500,000 pieces of manmade space junk that are whizzing about and orbiting our planet at high speeds. Space debris can endanger satellites and space stations, so removing them is the key to preventing future damage.

Robots using similar grippers may soon climb the walls of the International Space Station. Engineers and scientists at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California are developing a gecko gripper robot that could help with inspection and repair of the space station's exterior, and could perhaps conduct a wide range of activities in Earth orbit.

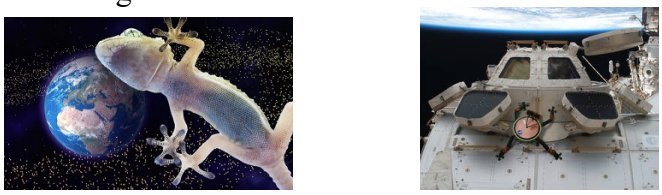


Figure 19: Left: An illustration showing a detailed view of a gecko's feet. Right: Illustration of the Limbed Excursion Mechanical Utility Robot (LEMUR) climbing around the outside of the International Space Station. JPL considered outfitting LEMUR with its gecko-imitating gripper technology. Image credit: NASA

There are countless more examples in nature I could mention, but I hope the examples here serve as an inspiration.

Conclusion

As engineers in the twenty-first century, it is my hope that we keep our eyes and ears open to hear Mother Nature because she is talking to us. *Are we listening?*

Author Biography

Vahik Khodagolian is an innovative award-winning Aeronautical engineer with research experience, who has dedicated over 20 years of his life to work with teams of engineers throughout the world on challenging Aerodynamics, fluid dynamics, Oceanography, and renewable energy projects. His interest in Aeronautical Engineering can be traced back to when he was a child and had the privilege of sitting in the cockpit of the plane with the captain who explained how the "big birds" as I called them fly.

(Continued on Page 30)

AIAA Biomimetics examples in Engineering *(Continued from Page 29)*

Since then, Vahik has pursued advanced degrees in Aeronautical Engineering from: Scandinavian Academy of Aeronautics, University of Gothenburg and Chalmers, Cranfield University, City University of London, and MIT.

Regardless of the important lessons he learned in textbooks, Vahik relied heavily on his inspiration of designs in nature applying biomimetics principles on engineering project in Sweden where he grew up. During his time conducting aerodynamic research at City University of London, Vahik was inspired by the bird's optimum flapping frequency and applied it to controlling the flow over helicopter rotor blades using pulsed jets. While at GVA in Sweden, Vahik was inspired by wavy structures found on marine animals which he discovered reduced vortex induced vibrations, including Seals wavy whiskers and the hammer head sharks wavy shaped head. At Semcon (a consulting firm), he earned the title as "Distinguished Engineer" for his development of novel passive flow control technology on Cars that later lead to his recognition for the "Best Paper Award" at the SAE International Congress in Brazil. In his work at the Swedish National Metrological and Hydrological Institute, he made vital hydrodynamic predications of the flow of an immersed 900-foot long tunnel construction in Stockholm, Sweden.

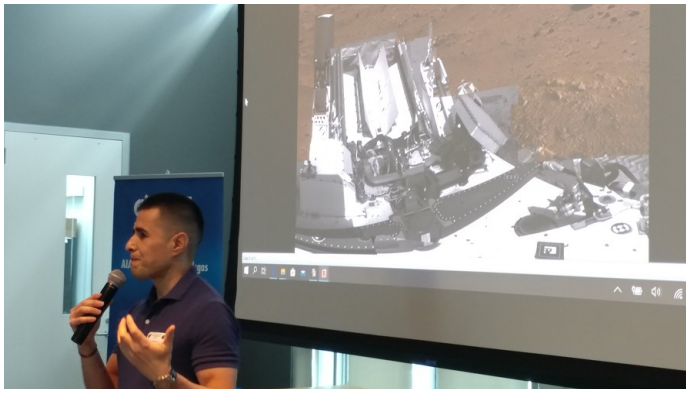
Most recently, he worked with a company named Seatwirl in Sweden where he helped design and simulate one of the world's first 1 MW vertical axis floating wind turbine. In addition, he conducted extensive research and development on biomimetic designs that could be applied to wind turbines, including leading edge serrations inspired by owls' wings and Seguaro Cactus shaped tower to reduce vortex induced vibrations.

Currently here in California, he is a freelancing consultant in Fluid Dynamics and has recently published a book entitled Nature's Magicians which was inspired by his passion for Biomimetics. He is also doing post-graduate online courses through MIT. He is excited to be part of the AIAA's Los Angeles-Las Vegas Division as a Council Member where he can continue to promote the aerospace and engineering industry.

AIAA Student Branches mini-Conference (7 March, 2020)

(Pictures Only) *(Continued from Page 11)*

AIAA UCLA Student Branch making group presentations. (Photo Courtesy of Ken Lui)



Juan J. Velasquez (Aerojet-Rocketdyne) sharing his career experience with the attendees. (Photo Courtesy of Ken Lui)

AIAA UCSD Student Branch. (Photo Courtesy of Ken Lui)

Prof Mahdi Yoozbashizadeh (CSULB) introducing his research and inspiring students. (Photo Courtesy of Ken Lui)

E-Town Hall Meeting on 11 April, 2020: (Michelle Rouch and Erik Jessen)

by Douglass M. Stewart, Jr.

In Case You Missed It:

AIAA e-Town Hall Meeting- April 11, 2020

Featuring Aerospace Artist & System Engineer **Michelle Rouch** and Raytheon Software Designer **Erik Jessen**. Both speakers discussed the impact of Agile and other Project Management programs in the work they do. Not familiar with Agile? From a YouTube video called "What is Agile." Mark Shead explains "Agile is a collection of beliefs that teams can use in making decisions of how to do the work of developing software. The principles [of Agile] are less about telling you what to do than they are about giving you the ability to make a good decision in a articular situation."

Aerospace Art and STEAM Education (Michelle Rouch

Michelle Rouch: "I use Agile as a Program Manager for my work with DoD. I also use Agile with my artistic pursuits. In the creation of the artwork for a book by Astronaut Al Worden that I collaborated on, Agile's workflow integration was incredibly important. Using Agile's principles, I was able to create special paintings made from photographs that could also be seamlessly incorporated into the text of the book and yet allowed the publisher to make sizing changes if necessary to the artwork."

Michelle's Artistic Rendering of Al Worden walking on the gantry in space suit. (Courtesy of Michelle Rouch)

Photo of Al Worden in space suit. (Courtesy of Michelle Rouch)

Extreme Programming Verification: assertions, covergroups and coverpoints. (Erik Jessen)

Erik Jessen: "Agile offers design teams a way to get a project off the ground, keep it out of trouble and make sure it gets done to the highest possible standards. Every project encounters challenges in every phase of its implementation. It's one thing to put together a project in the concept phase and quite another when problems start turning up. Disagreements can be ironed out easily whether its between you and the customer or between members on your team."

For more about Agile, check out this animated explanation:

https://www.youtube.com/watch?v=Z9QbYZh1YXY

For more information about upcoming AIAA events please go to: aiaa-lalv.org

**Video and more information on https://engage.aiaa.org/losangeles-lasvegas/viewdocument/e-town-hall-meeting-on-april-11-20 , or*

https://aiaa-lalv.org/e-town-hall-meeting-april-11-2020-with-michelle-rouch-nd-erik-jessen/

AIAA Member Spotlight Summary (March 3 2020 – April 23, 2020)

April 13, 2020

Daniel P. Raymer, Ph.D.

AIAA Fellow,

author of "Aircraft Design: A Conceptual Approach"

Dan Raymer is President of the design and consulting company, Conceptual Research Corporation. Recipient of the prestigious AIAA Aircraft Design Award, he is a recognized expert in the areas of Aerospace Vehicle Design and Configuration Layout, Computer-aided Design Methodologies and Design Education. During his 10 years in the Advanced Design Department of Rockwell (North American Aviation) he conceived and did the layout design of Rockwell's entries in what became the F-22, B-2, and T-45 programs, and was Head of Air Vehicle Design for X-31 from "blank sheet of paper" (CAD screen) to the configuration that flew (with minor fabrication-driven changes).

His industry career includes positions as Director-Advanced Design with Lockheed, Director-Future Missions at the Aerojet Propulsion Research Institute, and Project Manager-Engineering at Rockwell North American Aviation. He also served as a research engineer and aerospace design consultant at the famous RAND Corporation think tank.

Dr. Raymer is the author of the best-selling textbook "Aircraft Design: A Conceptual Approach" and the well-regarded layman's book, "Dan Raymer's Simplified Aircraft Design for Homebuilders". His newest book, "Living In The Future: The Education and Adventures of an Advanced Aircraft Designer", covers his career and his design projects including most of those described below. Raymer has received both Rockwell Engineer of the Year and the AIAA Summerfield Book awards, and was recently made a Fellow of the American Institute of Aeronautics and Astronautics.

Dr. Raymer teaches a variety of advanced design short courses including the well-known five-day Aircraft Conceptual Design Short Course which has been attended by over 3,000 engineers to date. Dr. Raymer is often a Forum Speaker at the EAA AirVenture (Oshkosh).

Dr. Raymer received B.S. and M.S. engineering degrees in Astronautics and Aeronautics from Purdue, an MBA from the University of Southern California, and a Doctorate of Engineering (Ph.D.) from the Swedish Royal Institute of Technology (KTH). He is a recipient of the Purdue University Outstanding Aerospace Engineer Award which is given "to honor those alumni who have distinguished themselves in the aerospace industry". Dr. Raymer is listed in both Who's Who in America and Who's Who in Science and Engineering.

Click here for a new article on how Raymer became an aircraft designer and who his inspirations were:

Page 1 of this newsletter,

https://engage.aiaa.org/losangeles-lasvegas/viewdocument/april-6-2020article-daniel-ray, or

https://aiaa-lalv.org/daniel-raymer-answers-some-questions/

Friday, April 24th, 2020, 6 PM – 7 PM (Pacific Time)

AIAA LA-LV e-Happy Hour

Volunteers are needed for all AIAA activities, please contact cgsonwane@gmail.com

Click to RSVP !

Come Enjoy with Us!

Friday, April 24, 2020, 6 - 7 PM

Online on Zoom

(Zoom meeting information please see below)

Please join us for a relaxing happy hour online, and share your thoughts!

(1-Click Link for joining the Zoom event online) (RSVP and Information: https://conta.cc/2yqf8lo)

https://aiaa.zoom.us/j/95705908202?pwd=SGk1ak1ZVDZVT0VpMmE1UlRXRjR3Zz09

Meeting ID: 957 0590 8202, Password: 359846

One tap mobile: +16699009128,,95705908202# US (San Jose). Or +13462487799,,95705908202# US (Houston)

Dial by your location

+1 669 900 9128 US (San Jose), +1 346 248 7799 US (Houston), +1 312 626 6799 US (Chicago), +1 646 558 8656 US (New York), +1 253 215 8782 US, +1 301 715 8592 US, 877 853 5257 US Toll-free, 888 475 4499 US Toll-free, Meeting ID: 957 0590 8202

Find your local number: https://aiaa.zoom.us/u/abIuy3L4Tt Questions: **events.aiaalalv@gmail.com**

Saturday, April 25th, 2020, 10:00 AM – 2:45 PM (Pacific Time)

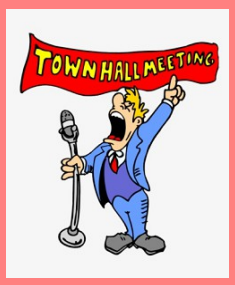
AIAA Los Angeles Las Vegas and SCALACS joint Earth Day e-Town Hall Meeting

Welcome by

Dr. Chandrashekhar Sonwane

Chair of AIAA LALV Section & EPA Scientific Advisory Board member

Dr. Brian Brady, Chair of SCALACS



This event is sponsored by IEEE Coastal Los Angeles Section

**Prof. Madhu Thangavelu, USC (Moderator)*

(Space and City: Lessons from the Future)

**Prof. Sachdev Sidhu, Molecular Genetics and the Donnelly Centre at the University of Toronto (COVID-19 Therapeutic Development in Real Time: Roadblocks and Opportunities)*

**Dr. João Teixeira, Co-Director, Center for Climate Sciences, NASA JPL The Climate of the 21st Century from Space)*

Brett Cornick (Challenges faced by future Generation)

Erik Jessen, Raytheon (Management Theory and Leadership)

Marty Waldman & Prof. Craig Smith (Nuclear Power Grids & Clean Energy)

**Dastan Khalili, Cal-Earth (Panelist)*

**Jane Poynter and Taber MacCallum, Space Perspective (Panelists)*

(- indicate those who will be in the panel session)*

RSVP and Information : https://conta.cc/346bkRO

Join on Zoom! (Price: FREE!!!)

https://aiaa.zoom.us/j/547874525?pwd=SC8ySTZqY1NMeDBBR2hka3MrcUFOQT09

Webinar ID: 547 874 525, Password: 878380

Dial-in by Telephone: 877 853 5257 (Toll Free)

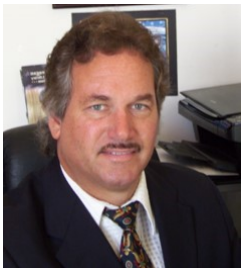
You do not need to be a member of AIAA or ACS to attend the event. Volunteers are needed,contact: cgsonwane@gmail.com, Any questions regarding this event: contact: events.aiaalalv@gmail.com)

Volunteers are needed for all AIAA activities, please contact cgsonwane@gmail.com

e-Town Hall Meeting

Saturday, May 2, 2020, 10 AM

Mars 2020: Perseverance and the Search for Life on Mars, by Michael Staab, Space Force, by Shawn Boike



About the Speakers:

Michael Staab is a Flight System Systems Engineer for the NASA-ISRO Synthetic Aperture Radar Mission at the NASA Jet Propulsion Laboratory. He is the avionics systems-domain lead for the mission, responsible for nominal & off-nominal behaviors and functional design, avionics system verification & validation activities, and the flight system commissioning phase activity. In his previous assignments, he was a Spacecraft Systems Engineer and Flight Director for the Mars Exploration Rover Opportunity, a flight controller, or ACE, for the Cassini spacecraft, and a Mission Systems' Systems Engineer for the Mars 2020 rover. Outside JPL, Michael is a PhD student in the Department of Astronautical Engineering and the University of Southern California and an Aerospace Engineering Duty Officer in the United States Navy Reserves, supporting the NAVAIR and Navy Space Cadre communities. Michael holds a Bachelors of Science in Aerospace Engineering from Wichita State University and a Masters of Science in Aerospace Engineering from the Georgia Institute of Technology.

Shawn Boike has created, lead, directed, managed, consulted on teams & professionally worked in, fortune 100; NASA, NSF, DOD, Boeing, General Dynamics, Lockheed Martin, Northrop Grumman, Honeywell, PPG, Parker, GM, FORD and McDonnell Douglas. Over 35 industrious years' experience in Aerospace & Product Development of; 18 Aircraft, 5 Spacecraft; 5 EV's, Tanks & many Automobiles. Founder of: Insta-Grid, American Industrial Consultants, Solution Vehicles Co. Solutioncell, Author and gained a BSME from MSU and a MBA from SDSU. www.linkedin/in/shawnpaulboike, Website: http://www.insta-grid.com

RSVP and Information: https://conta.cc/2VmzqDV

How to attend the event online?
When: May 2, 2020, 10:00 AM Pacific Time (US and Canada)
Please click the link below to join the webinar: (1-click)
https://aiaa.zoom.us/j/445964298?pwd=Vi9GWDBhMkNlczE2bkZ1dlZ6d050UT09
Password: 780155

Or iPhone one-tap :
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Webinar ID: 445 964 298
International numbers available: https://aiaa.zoom.us/u/abIuy3L4Tt
Events/Program Information: events.aiaalalv@gmail.com

Volunteers are needed for all AIAA activities, please contact cgsonwane@gmail.com

e-Town Hall Meeting

Saturday, May 9, 2020, 10 AM

Pushing Your Envelope:

How Technical Experts and Leaders Defeat Impostor Syndrome and Live with Bold Confidence

Maureen Zappala
Keynote Speaker, Author, Presentation Skills Coach
Founder, High Altitude Strategies
2017-18 President, National Speakers Association, Ohio Chapter

RSVP and Information: https://conta.cc/3b3VF8h

How to join the Zoom event online:

When: May 9, 2020 10:00 AM Pacific Time (US and Canada)
Event: AIAA LA LV May 9 Saturday e-Town Hall Meeting

Please click the link below to join the webinar:
https://aiaa.zoom.us/j/717663129?pwd=YlliaVpycUphMlZlRDYwMkI3WmFRUT09
Password: 613987
Or iPhone one-tap :
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Webinar ID: 717 663 129
International numbers available: *https://aiaa.zoom.us/u/abIuy3L4Tt*

Maureen Zappala, a former NASA propulsion engineer (aka "rocket scientist"), is the founder of High Altitude Strategies. She works with high-performers to overcome "Impostor Syndrome," the secret self-doubt that says "Everyone thinks I'm smarter than I am!"

At NASA Lewis Research Center in Cleveland (Now the NASA Glenn Center) she became the youngest and first female manager of the Propulsion Systems Laboratory, a jet engine test facility. In 1999, she left NASA to become a speaker, author, and trainer. She placed in the top 10 of 30,000 contestants in the 2009 Toastmasters World Championship of Public Speaking. She's authored 4 books, including "Great Speakers are Not Born. They're Built" and "Pushing Your Envelope: How Smart People Defeat Self-Doubt and Live with Bold Enthusiasm." Maureen lives in Las Vegas.

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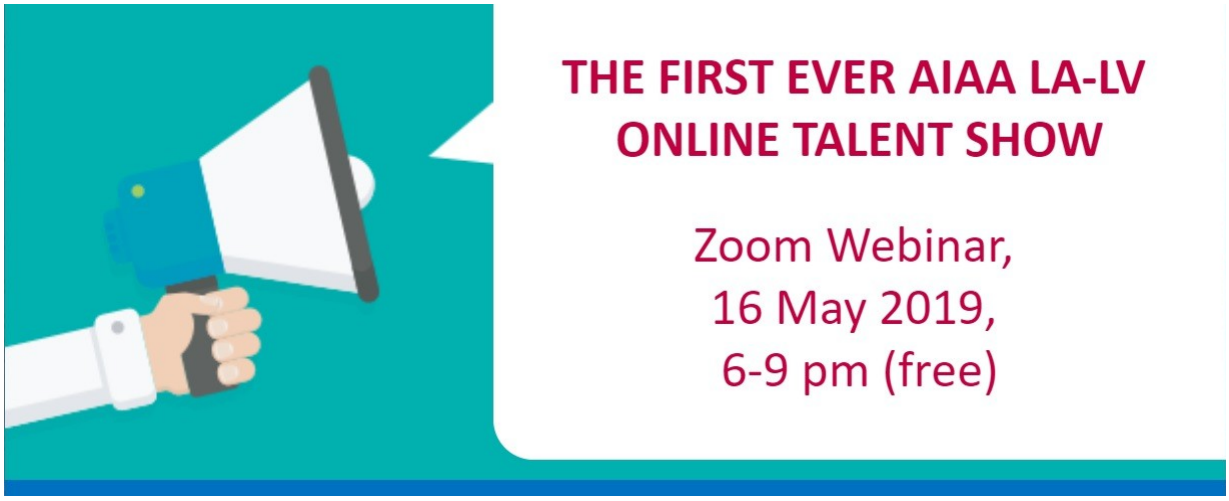

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(we'll need at least 10 acts to make this happen - please be one!)

RSVP and information: https://conta.cc/2yB49Fr

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

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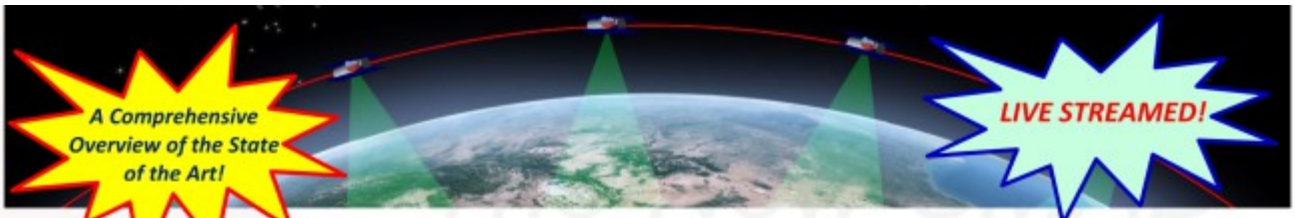
*April 23, 2020, AIAA UCSD Student Branch online event: "The Past and Future of Space Travel". More information on: facebook.com/ucsdaiaa



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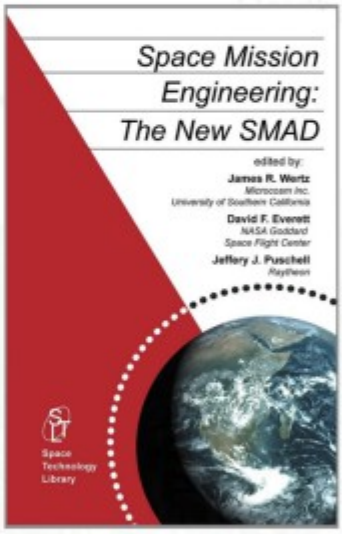

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