

Newsletter

AIAA Los Angeles-Las Vegas
Section El Segundo, CA

2021 DECEMBER EDITION

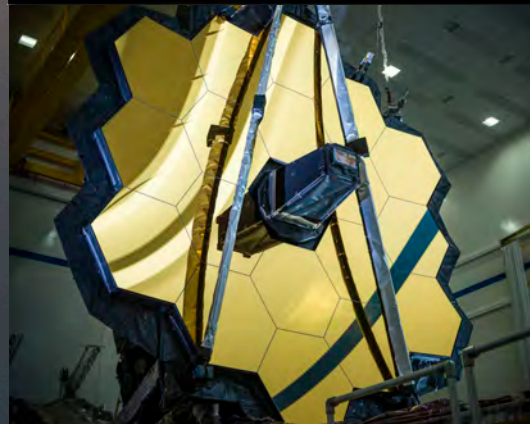
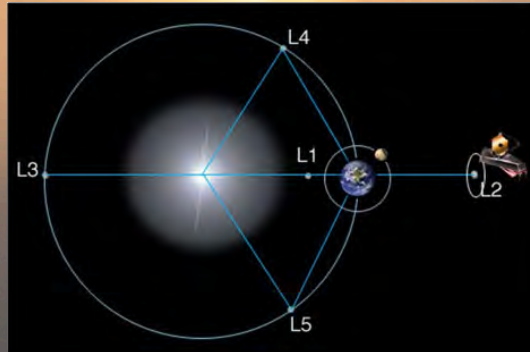
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James Webb
Space Telescope
(JWST) launches
into Space on
Christmas

A New Page of
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(NASA) Delivered
speech to AIAA LA-
LV on Back to the
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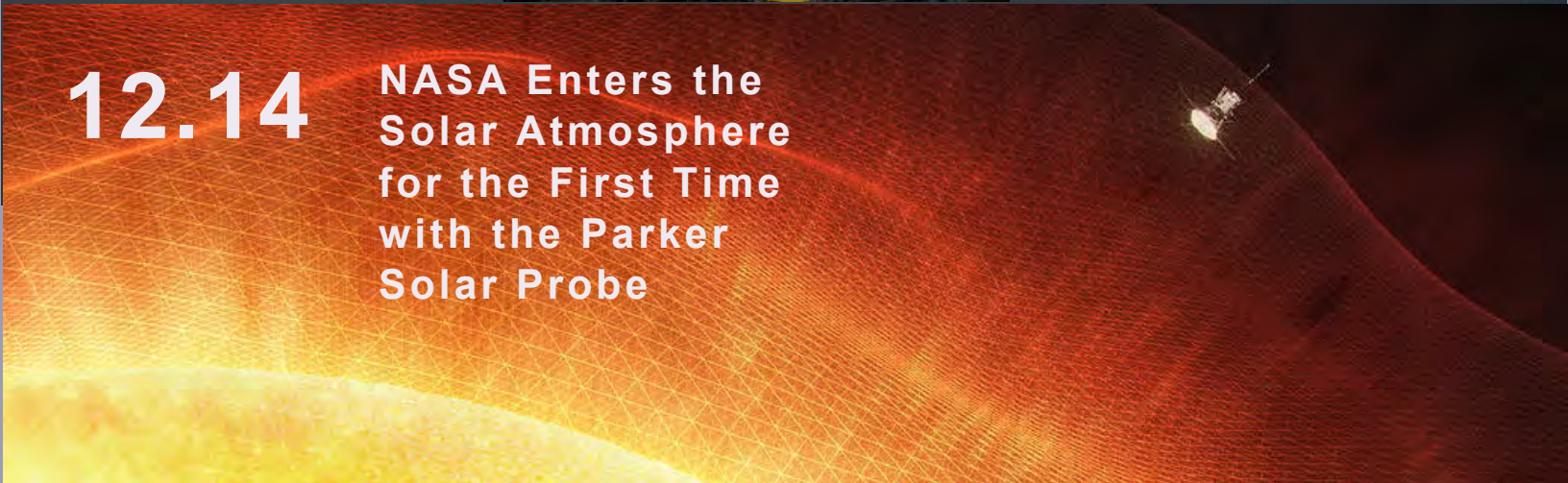
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Mission marked
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rocket booster

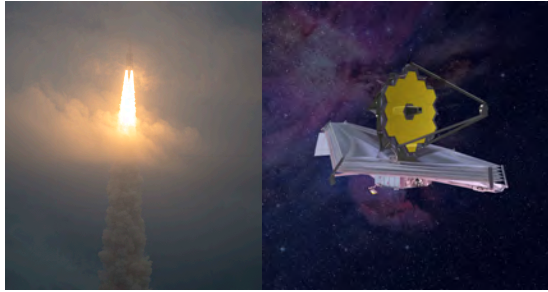
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AIAA LA-LV
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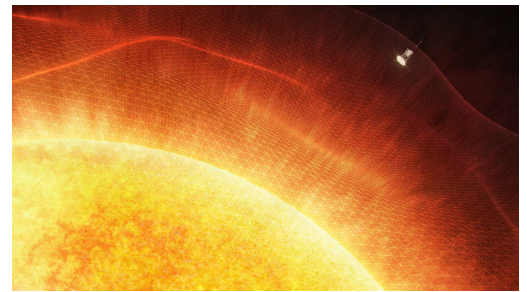
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for the First Time
with the Parker
Solar Probe





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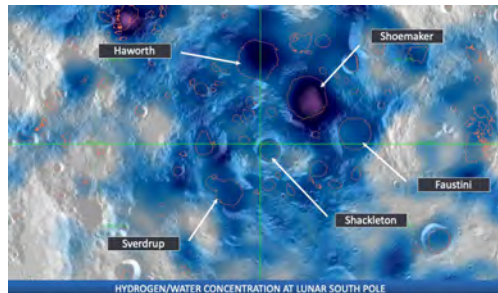
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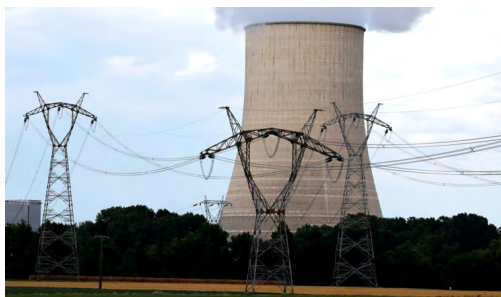
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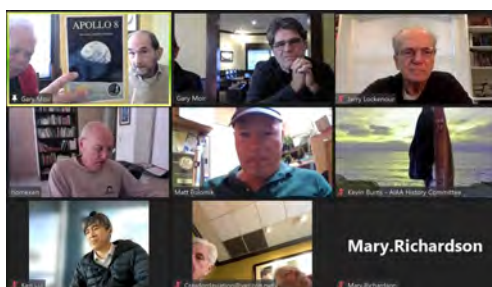
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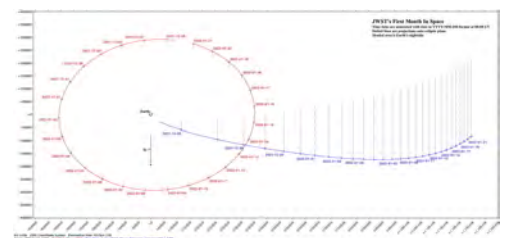
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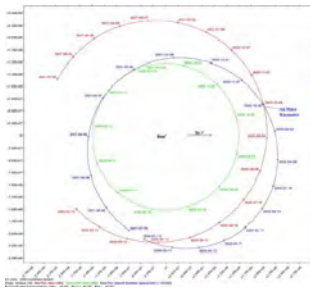
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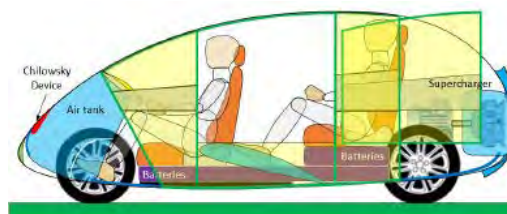
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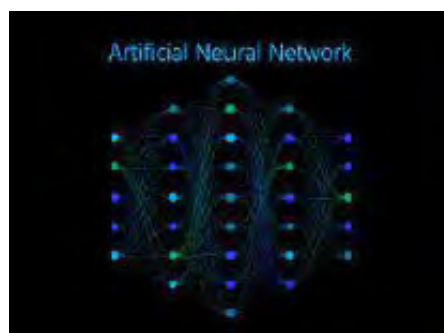
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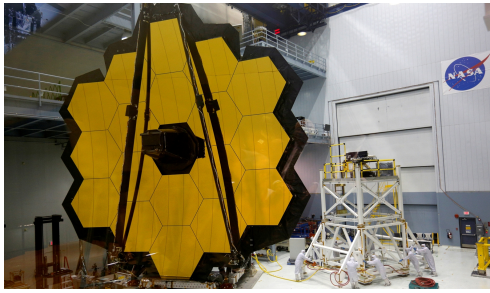
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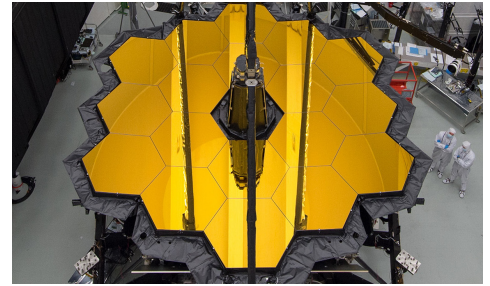
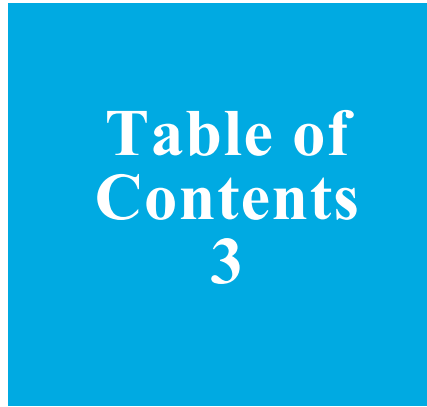
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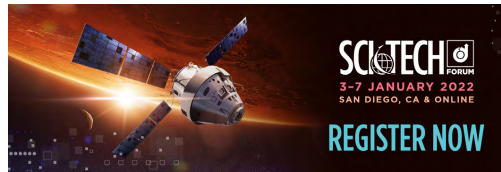
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(Cover Story) NASA's Webb Telescope Launches to See First Galaxies, Distant Worlds

<https://www.nasa.gov/press-release/nasas-webb-telescope-launches-to-see-first-galaxies-distant-worlds>

by NASA, 2021 December 25



Note: This release was updated on Dec. 25 to reflect the observatory's release at approximately 870 miles (1,400 kilometers).

NASA's James Webb Space Telescope launched at 7:20 a.m. EST Saturday on an Ariane 5 rocket from Europe's Spaceport in French Guiana, South America.

A joint effort with ESA (European Space Agency) and the Canadian Space Agency, the Webb observatory is NASA's revolutionary flagship mission to seek the light from the first galaxies in the early universe and to explore our own solar system, as well as planets orbiting other stars, called exoplanets.

"The James Webb Space Telescope represents the ambition that NASA and our partners maintain to propel us forward into the future," said NASA Administrator Bill Nelson. "The promise of Webb is not what we know we will discover; it's what we don't yet understand or can't yet fathom about our universe. I can't wait to see what it uncovers!"

Ground teams began receiving telemetry data from Webb about five minutes after launch. The Arianespace Ariane 5 rocket performed as expected, separating from the observatory 27 minutes into the flight. The observatory was released at an altitude of approximately 870 miles (1,400 kilometers). Approximately 30 minutes after launch, Webb unfolded its solar array, and mission managers confirmed that the solar array was providing power to the observatory. After solar array deployment, mission operators will establish a communications link with the observatory via the Malindi ground station in Kenya, and ground control at the Space Telescope Science Institute in Baltimore will send the first commands to the spacecraft.

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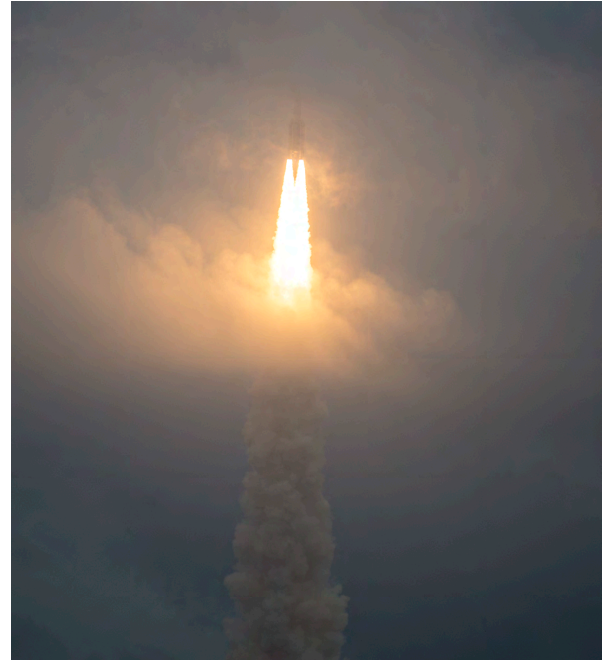
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(Cover Story) NASA's Webb Telescope Launches to See First Galaxies, Distant Worlds

Engineers and ground controllers will conduct the first of three mid-course correction burns about 12 hours and 30 minutes after launch, firing Webb's thrusters to maneuver the spacecraft on an optimal trajectory toward its destination in orbit about 1 million miles from Earth.

"I want to congratulate the team on this incredible achievement – Webb's launch marks a significant moment not only for NASA, but for thousands of people worldwide who dedicated their time and talent to this mission over the years," said Thomas Zurbuchen, associate administrator for the Science Mission Directorate at NASA Headquarters in Washington. "Webb's scientific promise is now closer than it ever has been. We are poised on the edge of a truly exciting time of discovery, of things we've never before seen or imagined."

The world's largest and most complex space science observatory will now begin six months of commissioning in space. At the end of commissioning, Webb will deliver its first images. Webb carries four state-of-the-art science instruments with highly sensitive infrared detectors of unprecedented resolution. Webb will study infrared light from celestial objects with much greater clarity than ever before. The premier mission is the scientific successor to NASA's iconic Hubble and Spitzer space telescopes, built to complement and further the scientific discoveries of these and other missions.



NASA's James Webb Space Telescope launched Dec. 25 at 7:20 a.m. EST on an Ariane 5 rocket from Europe's Spaceport in French Guiana, on the northeastern coast of South America. Webb, a partnership with the European Space Agency and the Canadian Space Agency, will explore every phase of cosmic history – from within our solar system to the most distant observable galaxies in the early universe.

Credits: NASA/Bill Ingalls

"The launch of the Webb Space Telescope is a pivotal moment – this is just the beginning for the Webb mission," said Gregory L. Robinson, Webb's program director at NASA Headquarters. "Now we will watch Webb's highly anticipated and critical 29 days on the edge. When the spacecraft unfurls in space, Webb will undergo the most difficult and complex deployment sequence ever attempted in space. Once commissioning is complete, we will see awe-inspiring images that will capture our imagination."

The telescope's revolutionary technology will explore every phase of cosmic history – from within our solar system to the most distant observable galaxies in the early universe, to everything in between. Webb will reveal new and unexpected discoveries and help humanity understand the origins of the universe and our place in it.

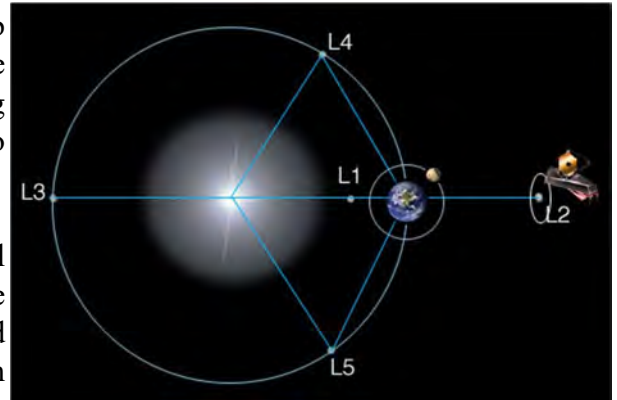
NASA Headquarters oversees the mission for the agency's Science Mission Directorate. NASA's Goddard Space Flight Center in Greenbelt, Maryland, manages Webb for the agency and oversees work on the mission performed by the Space Telescope Science Institute, Northrop Grumman, and other mission partners. In addition to Goddard, several NASA centers contributed to the project, including the agency's Johnson Space Center in Houston, Jet Propulsion Laboratory in Southern California, Marshall Space Flight Center in Huntsville, Alabama, Ames Research Center in California's Silicon Valley, and others. For more information about the Webb mission, visit: <https://webb.nasa.gov>

(Cover Story) L2' Will be the James Webb Space Telescope's Home in Space

<https://www.nasa.gov/topics/universe/features/webb-l2.html>

When you ask an astronomer about the James Webb Space Telescope's orbit, they'll tell you something that sounds like it came from a science-fiction novel. The Webb won't be orbiting the Earth –instead we will send it almost a million miles out into space to a place called "L2."

L2 is short-hand for the second Lagrange Point, a wonderful accident of gravity and orbital mechanics, and the perfect place to park the Webb telescope in space. There are five so-called "Lagrange Points" - areas where gravity from the sun and Earth balance the orbital motion of a satellite. Putting a spacecraft at any of these points allows it to stay in a fixed position relative to the Earth and sun with a minimal amount of energy needed for course correction.



The five Lagrangian points for the Sun-Earth system are shown in the diagram below. An object placed at any one of these 5 points will stay in place relative to the other two. Credit: NASA

The term L2 may sound futuristic and mysterious, but the name actually honors a Mathematician born in 1736. The Lagrange points were named after the Italian-born mathematician and astronomer Joseph-Louis Lagrange, who made important contributions to classical and celestial mechanics. Lagrange studied the "three-body problem" (so-called because three bodies are orbiting each other) for the Earth, sun, and moon in 1764, and by 1772 he had found the solution; there are five stable points at which you could put an object and have it stay fixed in place relative to the other two.

In the case of L2, this happens about 930,000 miles away from the Earth in the exact opposite direction from the sun. The Earth, as we know, orbits the sun once every year. Normally, an object almost a million miles farther out from the sun should move more slowly, taking more than a year to complete its orbit around the sun. However, at L2, exactly lined up with both the sun and Earth, the added gravity of the two large bodies pulling in the same direction gives a spacecraft an extra boost of energy, locking it into perfect unison with the Earth's yearly orbit. The Webb telescope will be placed slightly off the true balance point, in a gentle orbit around L2.



The James Webb Space Telescope relative to the Hubble telescope's orbit around the Earth. Credit: NASA

Why send the Webb telescope all the way out to L2? When astronomers began to think about where the Webb telescope should be placed in space, there were several considerations to keep in mind. To begin with, the Webb telescope will view the universe entirely in infrared light, what we commonly think of as heat radiation. To give the telescope the best chance of detecting distant, dim objects in space, the coldest temperatures possible are needed.

(Cover Story) L2' Will be the James Webb Space Telescope's Home in Space

<https://www.nasa.gov/topics/universe/features/webb-l2.html>

"A huge advantage of deep space (like L2) when compared to Earth orbit is that we can radiate the heat away," said Jonathan P. Gardner, the Deputy Senior Project Scientist on the Webb Telescope mission and Chief of the Observational Cosmology Laboratory at NASA's Goddard Space Flight Center in Greenbelt, Md. "Webb works in the infrared, which is heat radiation. To see the infrared light from distant stars and galaxies, the telescope has to be cold. Webb's large sunshield will protect it from both Sunlight and Earthlight, allowing it to cool to 225 degrees below zero Celsius (minus 370 Fahrenheit)." For the sunshield to be effective, Webb will need to be in an orbit where the sun and Earth are in about the same direction.

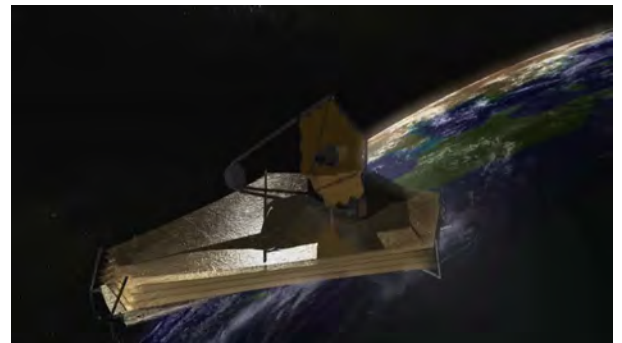
With the sun and the Earth in the same part of the sky, the Webb telescope will enjoy an open, unimpeded view of the universe. In comparison, the Hubble Space Telescope is in low-Earth orbit where it goes in and out of the Earth's shadow every 90 minutes. Hubble's view is blocked by the Earth for part of each orbit, limiting where the telescope can look at any given time.

The Spitzer Space Telescope, another infrared telescope, is in orbit around the sun and drifting away from the Earth. Spitzer is already more than 100 million kilometers (60 million miles) away from the Earth, and eventually its path will take it to the other side of the sun. Once we can no longer communicate with Spitzer that means it is at the end of its mission life.

In contrast, a major perk of parking at L2 is the ease of communications. Essentially, the Webb telescope will always be at the same point in space. "We can have continuous communications with Webb through the Deep Space Network (DSN)," Gardner said. "During routine operations, we will uplink command sequences and downlink data up to twice per day, through the DSN. The observatory can perform a sequence of commands (pointing and observations) autonomously. Typically, we will upload a full week's worth of commands at a time, and make updates daily as needed."

Even before the Webb telescope, L2 has been known to astronomers as a good spot for space-based observatories. There are already several satellites in the L2 orbit, including the Wilkinson Microwave Anisotropy Probe, and the Herschel and Planck space observatories. But there's plenty of room for another neighbor, and the Webb telescope will be heading out to L2 in the near future.

The Webb telescope is a joint project of NASA, the European Space Agency and the Canadian Space Agency.



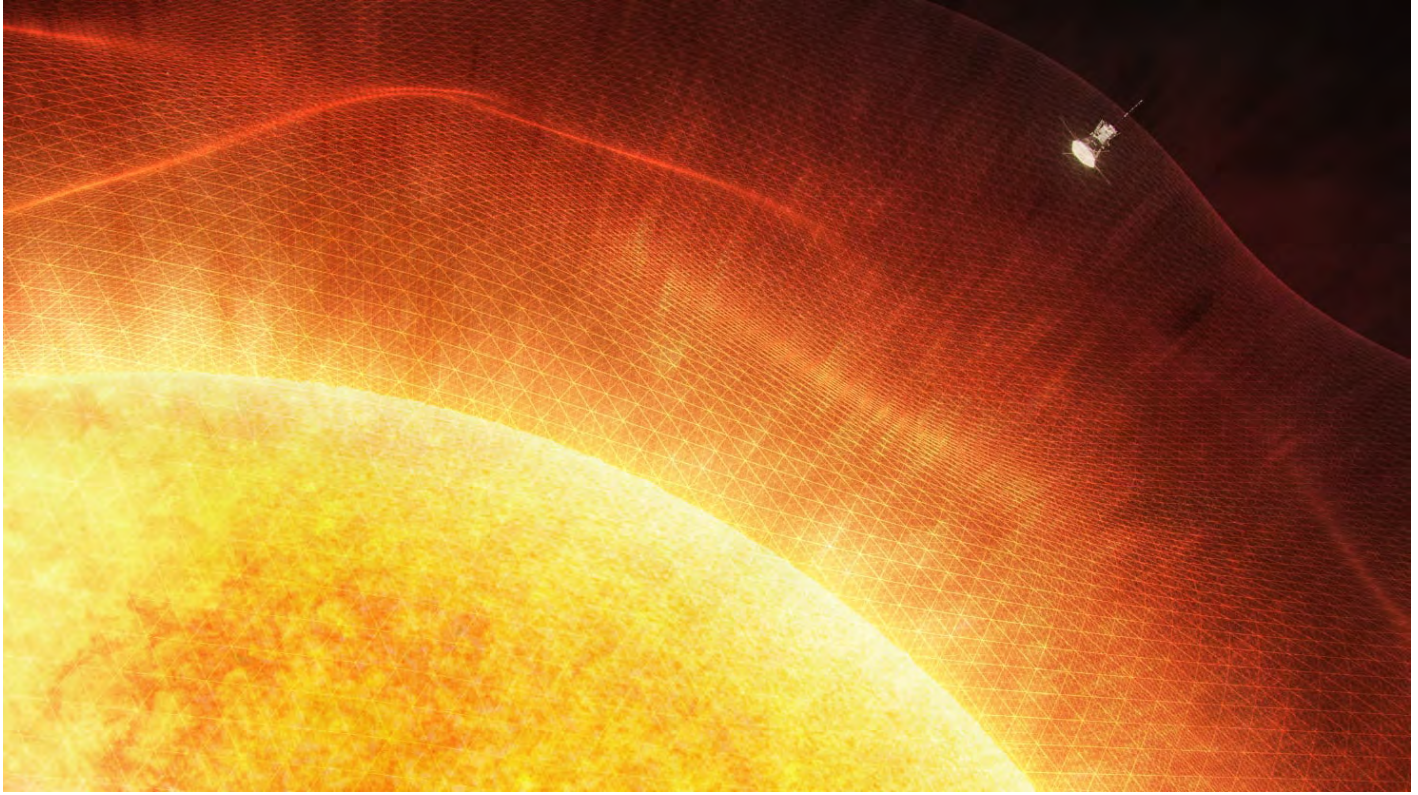
https://www.nasa.gov/mpg/463492main_JWST_HD_LARGE_QT_Video_1.mpg

> Click on image to view animation.

This animation shows the Webb Telescope spacecraft orbiting far from the Earth. Credit: NASA/Chris Meaney (HTSI)

NASA Enters the Solar Atmosphere for the First Time, Bringing New Discoveries (Parker Solar Probe)

(2021 December 14) <https://www.nasa.gov/feature/goddard/2021/nasa-enters-the-solar-atmosphere-for-the-first-time-bringing-new-discoveries>



A major milestone and new results from NASA's Parker Solar Probe were announced on Dec. 14 in a press conference at the 2021 American Geophysical Union Fall Meeting in New Orleans. The results have been published in Physical Review Letters and accepted for publication in the Astrophysical Journal.

For the first time in history, a spacecraft has touched the Sun. NASA's [Parker Solar Probe](#) has now flown through the Sun's upper atmosphere – the corona – and sampled particles and magnetic fields there.

The new milestone marks one major step for Parker Solar Probe and one giant leap for solar science. Just as landing on the Moon allowed scientists to understand how it was formed, touching the very stuff the Sun is made of will help scientists uncover critical information about our closest star and its influence on the solar system.

"Parker Solar Probe "touching the Sun" is a monumental moment for solar science and a truly remarkable feat," said Thomas Zurbuchen, the associate administrator for the Science Mission Directorate at NASA Headquarters in Washington. "Not only does this milestone provide us with deeper insights into our Sun's evolution and its impacts on our solar system, but everything we learn about our own star also teaches us more about stars in the rest of the universe."

As it circles closer to the solar surface, Parker is making new discoveries that other spacecraft were too far away to see, including from within the solar wind – the flow of particles from the Sun that can influence us at Earth. In 2019, Parker discovered that magnetic zig-zag structures in the solar wind, called switchbacks, are plentiful close to the Sun. But how and where they form remained a mystery. Halving the distance to the Sun since then, Parker Solar Probe has now passed close enough to identify one place where they originate: the solar surface.

NASA Enters the Solar Atmosphere for the First Time, Bringing New Discoveries (Parker Solar Probe)

The first passage through the corona – and the promise of more flybys to come – will continue to provide data on phenomena that are impossible to study from afar.

“Flying so close to the Sun, Parker Solar Probe now senses conditions in the magnetically dominated layer of the solar atmosphere – the corona – that we never could before,” said Nour Raouafi, the Parker project scientist at the Johns Hopkins Applied Physics Laboratory in Laurel, Maryland. “We see evidence of being in the corona in magnetic field data, solar wind data, and visually in images. We can actually see the spacecraft flying through coronal structures that can be observed during a total solar eclipse.”

Closer Than Ever Before

Parker Solar Probe launched in 2018 to explore the mysteries of the Sun by traveling closer to it than any spacecraft before. Three years after launch and decades after first conception, Parker has finally arrived.

Unlike Earth, the Sun doesn’t have a solid surface. But it does have a superheated atmosphere, made of solar material bound to the Sun by gravity and magnetic forces. As rising heat and pressure push that material away from the Sun, it reaches a point where gravity and magnetic fields are too weak to contain it.

That point, known as the Alfvén critical surface, marks the end of the solar atmosphere and beginning of the solar wind. Solar material with the energy to make it across that boundary becomes the solar wind, which drags the magnetic field of the Sun with it as it races across the solar system, to Earth and beyond. Importantly, beyond the Alfvén critical surface, the solar wind moves so fast that waves within the wind cannot ever travel fast enough to make it back to the Sun – severing their connection.

Until now, researchers were unsure exactly where the Alfvén critical surface lay. Based on remote images of the corona, estimates had put it somewhere between 10 to 20 solar radii from the surface of the Sun – 4.3 to 8.6 million miles. Parker’s spiral trajectory brings it slowly closer to the Sun and during the last few passes, the spacecraft was consistently below 20 solar radii (91 percent of Earth’s distance from the Sun), putting it in the position to cross the boundary – if the estimates were correct.

On April 28, 2021, during its eighth flyby of the Sun, Parker Solar Probe encountered the specific magnetic and particle conditions at 18.8 solar radii (around 8.1 million miles) above the solar surface that told scientists it had crossed the Alfvén critical surface for the first time and finally entered the solar atmosphere.

“We were fully expecting that, sooner or later, we would encounter the corona for at least a short duration of time,” said Justin Kasper, lead author on a [new paper](#) about the milestone published in Physical Review Letters, and deputy chief technology officer at BWX Technologies, Inc. and University of Michigan professor. “But it is very exciting that we’ve already reached it.”

NASA Enters the Solar Atmosphere for the First Time, Bringing New Discoveries (Parker Solar Probe)



For the first time in history, a spacecraft has touched the Sun. NASA's Parker Solar Probe has now flown through the Sun's upper atmosphere – the corona – and sampled particles and magnetic fields there. Credits: NASA's Goddard Space Flight Center/Joy Ng [Download this video in HD formats from NASA Goddard's Scientific Visualization Studio](#)

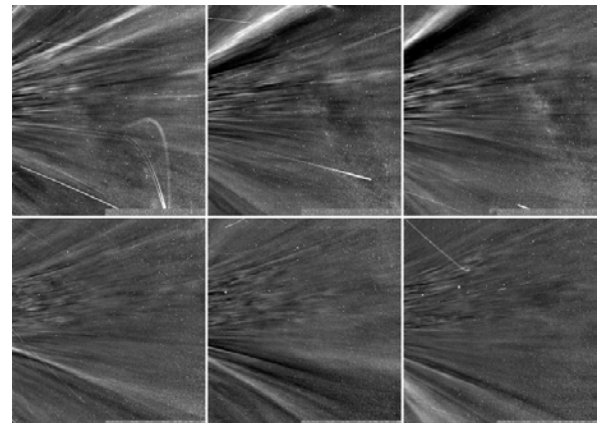
Into the Eye of the Storm

During the flyby, Parker Solar Probe passed into and out of the corona several times. This is proved what some had predicted – that the Alfvén critical surface isn't shaped like a smooth ball. Rather, it has spikes and valleys that wrinkle the surface. Discovering where these protrusions line up with solar activity coming from the surface can help scientists learn how events on the Sun affect the atmosphere and solar wind.

At one point, as Parker Solar Probe dipped to just beneath 15 solar radii (around 6.5 million miles) from the Sun's surface, it transited a feature in the corona called a pseudostreamer. Pseudostreamers are massive structures that rise above the Sun's surface and can be seen from Earth during solar eclipses.

Passing through the pseudostreamer was like flying into the eye of a storm. Inside the pseudostreamer, the conditions quieted, particles slowed, and number of switchbacks dropped – a dramatic change from the busy barrage of particles the spacecraft usually encounters in the solar wind.

For the first time, the spacecraft found itself in a region where the magnetic fields were strong enough to dominate the movement of particles there. These conditions were the definitive proof the spacecraft had passed the Alfvén critical surface and entered the solar atmosphere where magnetic fields shape the movement of everything in the region.



As Parker Solar Probe passed through the corona on encounter nine, the spacecraft flew by structures called coronal streamers. These structures can be seen as bright features moving upward in the upper images and angled downward in the lower row. Such a view is only possible because the spacecraft flew above and below the streamers inside the corona. Until now, streamers have only been seen from afar. They are visible from Earth during total solar eclipses.

Credits: NASA/Johns Hopkins APL/Naval Research Laboratory

NASA Enters the Solar Atmosphere for the First Time, Bringing New Discoveries (Parker Solar Probe)

The first passage through the corona, which lasted only a few hours, is one of many planned for the mission. Parker will continue to spiral closer to the Sun, eventually reaching as close as 8.86 solar radii (3.83 million miles) from the surface. Upcoming flybys, the next of which is happening in January 2022, will likely bring Parker Solar Probe through the corona again.

“I’m excited to see what Parker finds as it repeatedly passes through the corona in the years to come,” said Nicola Fox, division director for the Heliophysics Division at NASA Headquarters. “The opportunity for new discoveries is boundless.”

The size of the corona is also driven by solar activity. As the Sun’s 11-year activity cycle – [the solar cycle](#) – ramps up, the outer edge of the corona will expand, giving Parker Solar Probe a greater chance of being inside the corona for longer periods of time.

“It is a really important region to get into because we think all sorts of physics potentially turn on,” Kasper said. “And now we’re getting into that region and hopefully going to start seeing some of these physics and behaviors.”

Narrowing Down Switchback Origins

Even before the first trips through the corona, some surprising physics was already surfacing. On recent solar encounters, Parker Solar Probe collected data pinpointing the origin of zig-zag-shaped structures in the solar wind, called switchbacks. The data showed one spot that switchbacks originate is at the visible surface of the Sun – the photosphere.

By the time it reaches Earth, 93 million miles away, the solar wind is an unrelenting headwind of particles and magnetic fields. But as it escapes the Sun, the solar wind is structured and patchy. In the mid-1990s, the NASA-European Space Agency mission [Ulysses](#) flew over the Sun’s poles and discovered a handful of bizarre S-shaped kinks in the solar wind’s magnetic field lines, which detoured charged particles on a zig-zag path as they escaped the Sun. For decades, scientists thought these occasional switchbacks were oddities confined to the Sun’s polar regions.

In 2019, at 34 solar radii from the Sun, Parker discovered that switchbacks were not rare, but [common in the solar wind](#). This renewed interest in the features and raised new questions: Where were they coming from? Were they forged at the surface of the Sun, or shaped by some process kinking magnetic fields in the solar atmosphere?

The new findings, in press at the *Astrophysical Journal*, finally confirm one origin point is near the solar surface.

The clues came as Parker orbited closer to the Sun on its sixth flyby, less than 25 solar radii out. Data showed switchbacks occur in patches and have a higher percentage of helium – known to come from the photosphere – than other elements. The switchbacks’ origins were further narrowed when the scientists found the patches aligned with magnetic funnels that emerge from the photosphere between convection cell structures called [supergranules](#).

In addition to being the birthplace of switchbacks, the scientists think the magnetic funnels might be where one component of the solar wind originates. The solar wind comes in two different varieties – fast and slow – and the funnels could be where some particles in the fast solar wind come from.

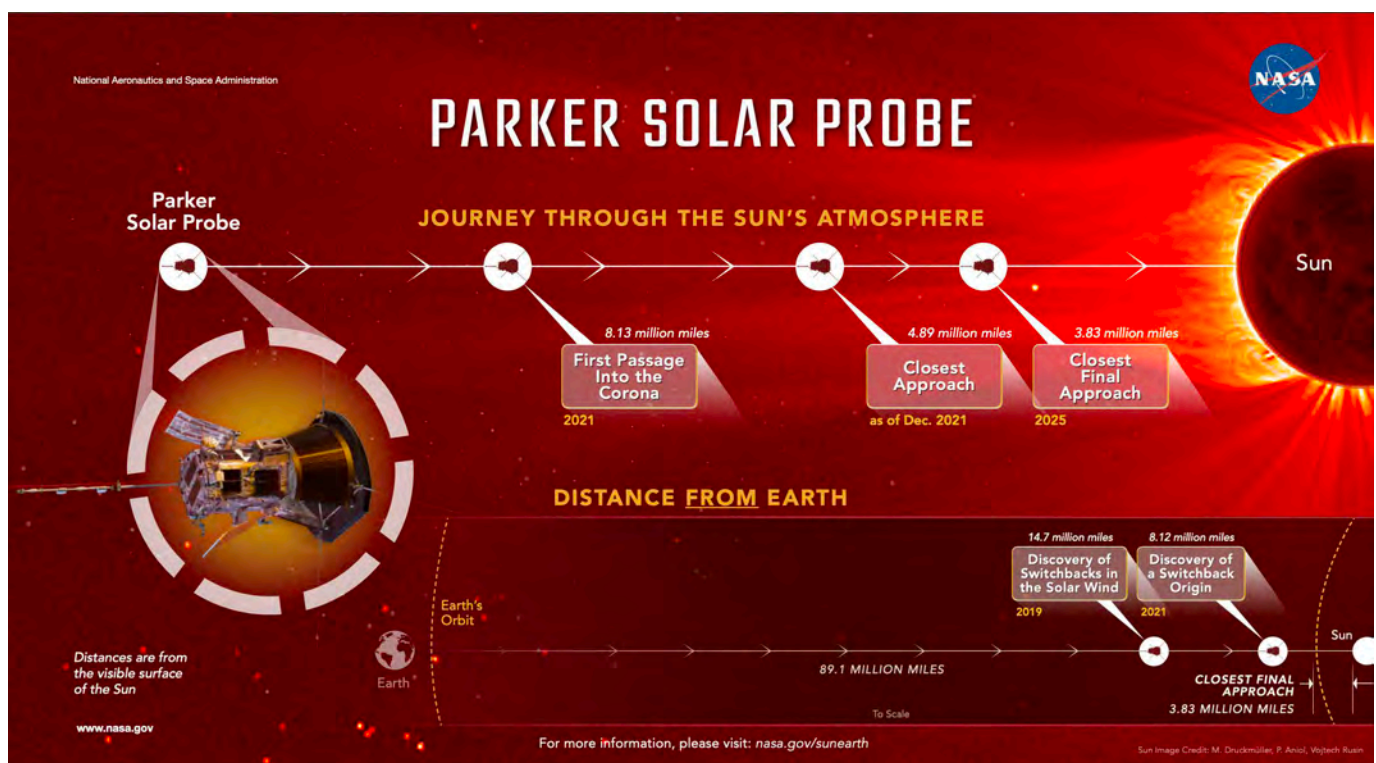
NASA Enters the Solar Atmosphere for the First Time, Bringing New Discoveries (Parker Solar Probe)

“The structure of the regions with switchbacks matches up with a small magnetic funnel structure at the base of the corona,” said Stuart Bale, professor at the University of California, Berkeley, and lead author on the new switchbacks paper. “This is what we expect from some theories, and this pinpoints a source for the solar wind itself.”

Understanding where and how the components of the fast solar wind emerge, and if they’re linked to switchbacks, could help scientists answer a [longstanding solar mystery](#): how the corona is heated to millions of degrees, far hotter than the solar surface below.

While the new findings locate where switchbacks are made, the scientists can’t yet confirm how they’re formed. One theory suggests they might be created by waves of plasma that roll through the region like ocean surf. Another contends they’re made by an explosive process known as magnetic reconnection, which is thought to occur at the boundaries where the magnetic funnels come together.

“My instinct is, as we go deeper into the mission and lower and closer to the Sun, we’re going to learn more about how magnetic funnels are connected to the switchbacks,” Bale said. “And hopefully resolve the question of what process makes them.”



As Parker Solar Probe ventures closer to the Sun, it's crossing into uncharted regimes and making new discoveries. This image represents Parker Solar Probe's distances from the Sun for some of these milestones and discoveries.

Credits: NASA's Goddard Space Flight Center/Mary P. Hrybyk-Keith

NASA Enters the Solar Atmosphere for the First Time, Bringing New Discoveries (Parker Solar Probe)

Now that researchers know what to look for, Parker's closer passes may reveal even more clues about switchbacks and other solar phenomena. The data to come will allow scientists a glimpse into a region that's critical for superheating the corona and pushing the solar wind to supersonic speeds. Such measurements from the corona will be critical for understanding and forecasting extreme space weather events that can disrupt telecommunications and damage satellites around Earth.

"It's really exciting to see our advanced technologies succeed in taking Parker Solar Probe closer to the Sun than we've ever been, and to be able to return such amazing science," said Joseph Smith, Parker program executive at NASA Headquarters. "We look forward to seeing what else the mission discovers as it ventures even closer in the coming years."

Parker Solar Probe is part of NASA's Living with a Star program to explore aspects of the Sun-Earth system that directly affect life and society. The Living with a Star program is managed by the agency's Goddard Space Flight Center in Greenbelt, Maryland, for NASA's Science Mission Directorate in Washington. The Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, manages the Parker Solar Probe mission for NASA and designed, built, and operates the spacecraft.

SpaceX's 100th recovery of an orbital class rocket booster (CRS-24 Mission)

SpaceX, 2021 December 21 (<https://www.spacex.com/launches/index.html>)



On December 21, 2021, SpaceX's Falcon 9 rocket launched Dragon on the 24th Commercial Resupply Services (CRS-24) mission for NASA from historic Launch Complex 39A (LC-39A) at Kennedy Space Center in Florida, completing our 31st and final launch of the year. Dragon separated from Falcon 9's second stage about twelve minutes after liftoff and will autonomously dock to the space station on Wednesday, December 22.

CRS-24 also marked the 100th recovery of an orbital class rocket booster. SpaceX remains the only launch provider in the world capable of propulsive landing and re-flight of orbital class rockets. While most rockets are expended after launch — akin to throwing away an airplane after a cross-country flight — SpaceX is working toward a future in which reusable rockets are the norm. To date, SpaceX has:

- Launched 138 successful missions;
- Landed first stage rocket boosters 100 times; and
- Reflown boosters 78 times, with flight-proven first stages completing 75 percent of SpaceX's missions since the first re-flight of a Falcon 9 in 2017.

2021 was particularly impressive, during which the SpaceX team:

- Launched 94 percent of all missions on flight-proven Falcon 9 boosters;
- Safely carried eight astronauts to the International Space Station for NASA, in addition to transporting ~28,000 pounds of critical cargo and scientific research to and from the orbiting laboratory;
- Completed the world's first all-civilian astronaut mission to orbit, which flew farther from planet Earth than any human spaceflight since the Hubble missions;
- Launched humanity's first planetary defense test to redirect an asteroid, among other important scientific missions; and
- Deployed more than 800 Starlink satellites to low-Earth orbit which are helping to connect over 150,000 customers and counting around the world with high-speed, low-latency internet.

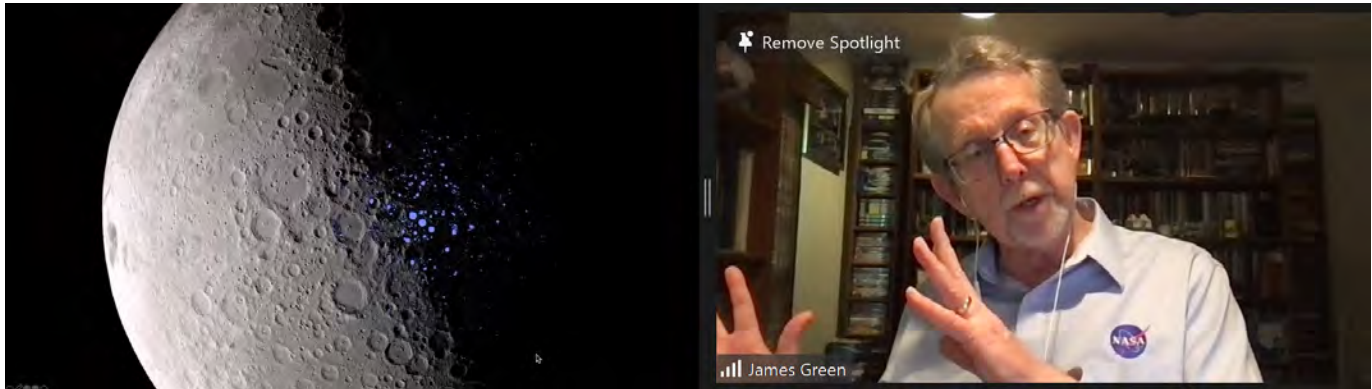
In the year ahead, SpaceX's launch cadence will continue to increase, as will the number of flight-proven missions, human spaceflights, Falcon Heavy missions, and people connected with internet by Starlink. We're also targeting the first orbital flight of Starship, and have resumed development of a lunar lander for NASA that will help return humanity to the Moon, on our way to Mars and beyond.

(December 4) The Exploration of the Moon and then onto Mars, by Dr. Jim Green

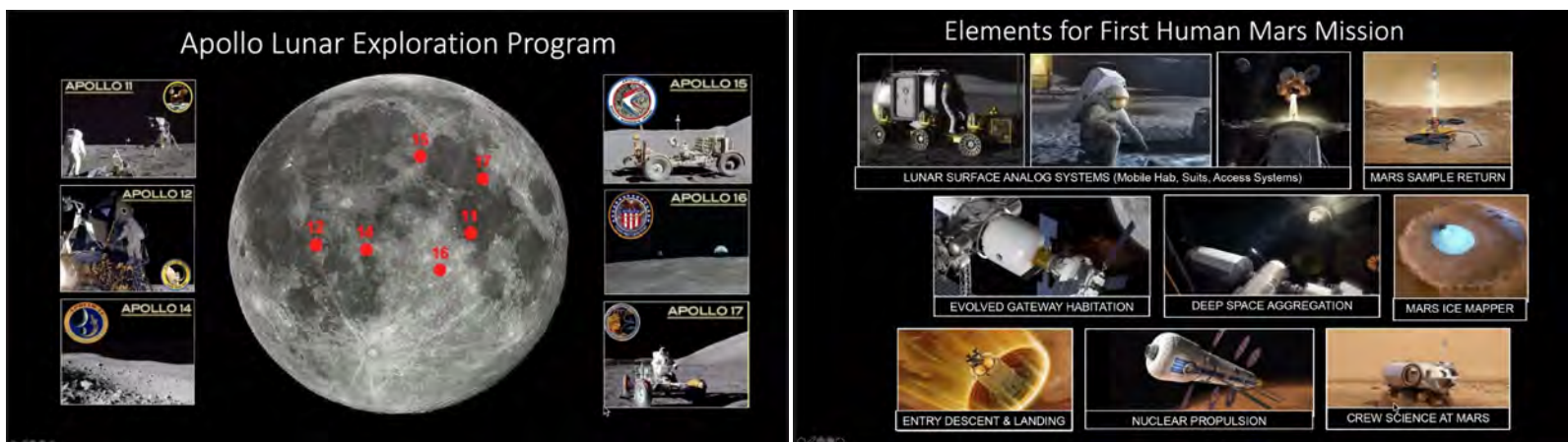
(Dr. James L. Green: NASA Chief Scientist) (Screenshots Only)

<https://www.aiaa-lalv.org/2021-december-4-the-exploration-of-the-moon-and-then-onto-mars-by-dr-jim-green/>

Editor's Note: This the post-event posting of the events/activities, not the advertisement for the upcoming events. For more details of this event, multiple reminders/flyers have been sent out and the details are not repeated here. please see the link above or <https://conta.cc/3rxG8J6>



Dr. Jim Green Opening the event with the explanation of the (water) resources on the Moon and the landing site candidates.



Dr. Jim Green reviewing the Apollo Lunar Exploration efforts and the Elements for First Human Mars Mission.



Dr. Jim Green showing the ongoing efforts in NASA to pave the way to go back to the Moon and onto Mars. The attendees were so enthusiastic with never-ending questions. Dr. Jim Green answered the questions very patiently and in details, granting multiple extensions of the Q&A Session.

(December 18) AIAA LA-LV Space Philosophy Christmas Gathering

(Screenshots Only)

<https://www.aiaa-lalv.org/2021-december-18-aiaa-la-lv-space-philosophy-gathering/>

Editor's Note: This the post-event posting of the events/activities, not the advertisement for the upcoming events. For more details of this event, multiple reminders/flyers have been sent out and the details are not repeated here. please see the link above or <https://conta.cc/33DMSLx>



This event flyer has very exciting elements of Christmas, family, and space, designed by Prof. MadhuThangavelu with Robert McCall's art.



Prof. Madhu Thangavelu (Moderator) together with the speakers who signed in early in the beginning welcoming the audience.

00:00:00 – Madhu Thangavelu (Welcome) and Nicole Stott (Opening Remark)
 00:16:23 – Arthur Gordon – Overcoming Objections to Space Travel
 00:32:00 – Jim Crisafulli – Global Space Enterprise: The Case for Multinational Collaboration
 00:41:30 – Adriano Autino – Expanding Civilization Beyond Earth's Limits: An Evolutionary Process
 01:00:50 – Alice Gorman – Space Archaeology And Why It Matters
 01:16:09 – Kaja Antle – Museums In The Age Of Human Expansion To Space: Extended Reality For Living & Working Off-Earth
 01:30:53 – Steve Durst – Egalitarian Considerations and Cislunar Development
 01:47:30 – Samer El Sayary – Space Exploration, A Utopian or dystopian future?
 02:07:17 – Anita Sengupta – Red Mars, Green Mars, Blue Mars: How the Space Program Creates Sustainable Technology
 02:23:00 – Michael Potter – From Scarcity to Abundance
 02:45:45 – Phnam Bagley – Imperfect Astronauts: Inviting The Whole Of Humanity Into Space
 03:05:30 – Fiorella Terenzi – Life Lessons of the Universe
 03:26:35 – John Rummel – Stewardship of the Earth and the Universe Beyond – You are everything to me!
 03:45:23 – Panel Discussion moderated by M. Thangavelu
 03:42:50 – Concluding Remarks by M. Thangavelu
 04:57:49 – Fin

The actual timings sequence/agenda on December 18 with very exciting talks and speakers!

(December 18) AIAA LA-LV Space Philosophy Christmas Gathering



Astronaut Nicole Stott opening the event sharing her thoughts on Space Philosophy, showing her book "Back to Earth" on what life in space taught her about our home planet and our mission to protect it.

Overcoming Objections to Space Travel

By Gordon Arthur

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Dr. Gordon Arthur



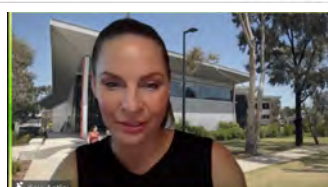
Mr. Jim Crisafulli



Mr. Adriano Autino



Dr. Alice Gorman



Dr. Kaja Antle



Mr. Steve Durst

(December 18) AIAA LA-LV Space Philosophy Christmas Gathering



Prof. Samer El Sayary



Dr. Anita Sengupta



Mr. Michael Potter



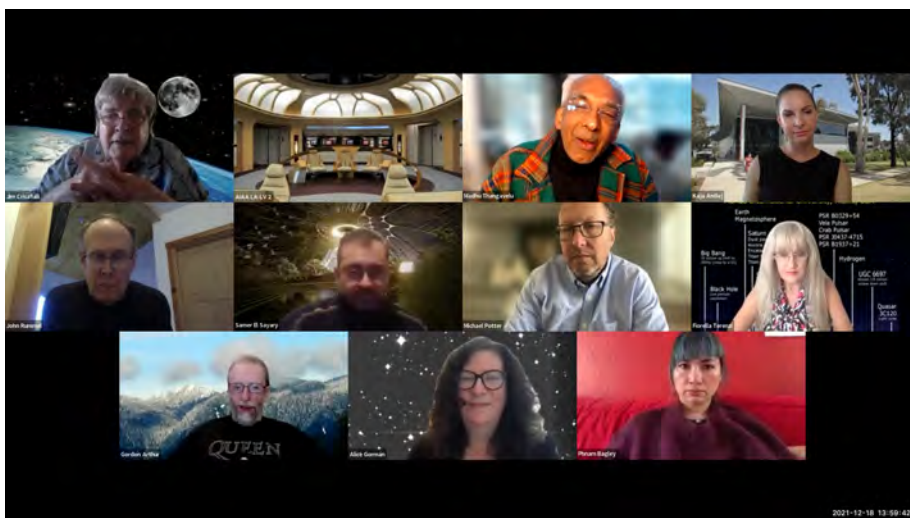
Ms. Phanm Bagley



Dr. Fiorella Terenzi



Dr. John Rummel



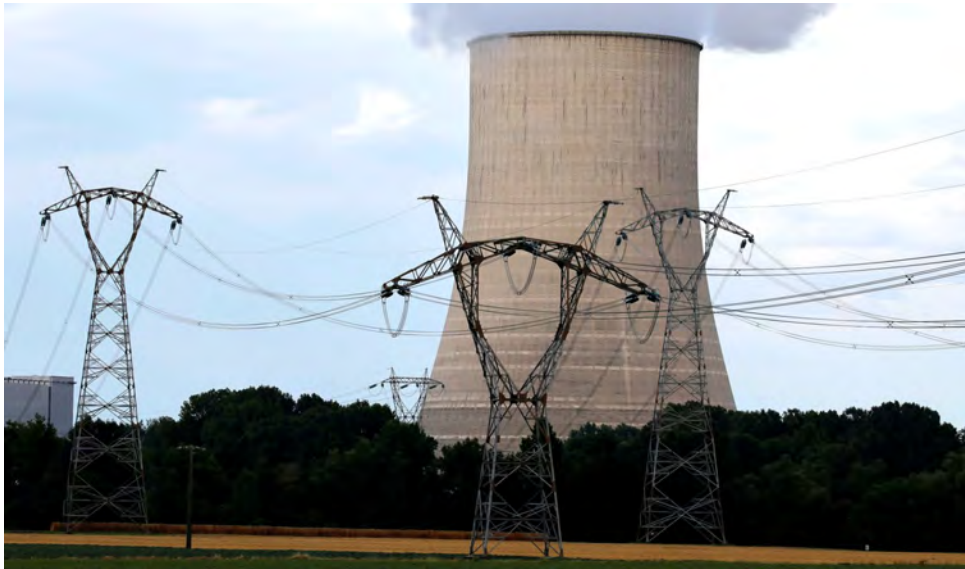
The remaining speakers expressing their further views on space philosophy in the concluding panel discussion and answering questions in the Q&A session.

Prof. Madhu Thangavelu summarized and concluded the event and wished everyone a Happy Holiday Season!

The New Nuclear Moment - *Parts of the Left are shifting to pro-nuclear*

Dr. Robert Zubrin, 2021 December 4 (with permission)

<https://www.nationalreview.com/2021/12/the-new-nuclear-moment/>



Power lines near the Golfech nuclear plant on the border of the Garonne River between Agen and Toulouse, France, in 2018. (Regis Duvignau/Reuters)

The past few weeks have seen a radical change in the outlook for nuclear energy. Coincident with the global COP26 conference, major center-left forces have shifted their position from opposition to support. While a year ago French president Emmanuel Macron was calling for cutting the nuclear fraction of France's electric power from its current 75 percent down to 50 percent (thereby eliminating the world's only actually decarbonized major electric-power grid), on November 9 he **called** for "relaunching construction of nuclear reactors in our country . . . to guarantee France's energy independence, to guarantee our country's electricity supply and achieve our objectives, in particular carbon neutrality in 2050." Whereas a few months ago European Union bureaucrats drawing up the "taxonomy" that defines which energy sources would be considered carbon-free (i.e. valid substitutes for fossil fuels) excluded nuclear power, now nearly all except the fanatical Germanic states have reversed themselves. Indeed, the map of pro- and anti-nuclear Euro-pean countries now closely resembles a map of World War II circa March 1945, shortly before the taking of the Ludendorff Bridge broke the last line of organized resistance in the Reich.



Downfall. European anti-nukes appear to be retreating towards a bunker in Berlin. (Nuclear Society SLO/via Twitter)

The New Nuclear Moment - *Parts of the Left are shifting to pro-nuclear*

And even in Germany, pro-nuclear forces are taking to the streets.



Mothers for a Nuclear Germany demonstrate in Berlin. "Geht mit Kernkraft" means "Go with Nuclear Power." (Mothers for Nuclear Deutschland Schweiz sterreich/via Twitter)

U.S. energy secretary Jennifer Granholm began her tenure ten months ago by announcing the Biden's administration's commitment to strangling the nuclear industry by blocking the establishment of a waste repository. But at the COP26 conference last month, she was **all in for nuclear power**: "We are very bullish on these advanced nuclear reactors," Granholm said. "We have, in fact, invested a lot of money in the research and development of those. We are very supportive of that."

It may be noted that Granholm was voicing support for types of reactors that do not yet exist. Furthermore, she still supports the efforts of the environmentalist movement to increase the costs of nuclear power and make it appear as unsafe as possible by forcing wastes to be stored at power stations near cities, instead of under a mountain in Nevada. Nonetheless, the change in tone is remarkable.

While the pro-nuclear shift on the left seems to have surfaced overnight, the forces behind it have been at work for some time. In the United States they have been led by several groups, including the Breakthrough Institute and a Democratic Party think tank called the Third Way.

Founded in 2003 by Ted Nordhaus and Michael Shellenberger, the Breakthrough Institute has gathered an impressive array of Enlightenment humanist intellectuals, including sociologist **Bruno Latour**, journalist and author **Gwyneth Cravens**, Nobel Prize-winning physicist **Burton Richter**, political and environmental scientist **Roger A. Pielke Jr.**, sociologist **Dalton Conley**, Oxford professor Steve Rayner, plant geneticist Pamela Ronald, sociologist Steve Fuller, environmental thought leader Stewart Brand (founder of the 1960s *Whole Earth Catalog*), philosopher Steven Pinker, and ecologist Emma Marais.

The New Nuclear Moment - *Parts of the Left are shifting to pro-nuclear*

In 2015 this group issued an “Ecomodernist Manifesto” calling for humanistic, non-zero-sum approaches to solving environmental problems, including climate change. Taking a bold stand in defiance of established left-wing Malthusian groupthink, the Ecomodernist Manifesto called for nuclear power. “Human civilization can flourish for centuries and millennia on energy delivered from a closed uranium or thorium fuel cycle, or from hydrogen–deuterium fusion,” it proclaimed. The manifesto then went on to say:

Nuclear fission today represents the only present-day zero-carbon technology with the demonstrated ability to meet most, if not all, of the energy demands of a modern economy. However, a variety of social, economic, and institutional challenges make deployment of present-day nuclear technologies at scales necessary to achieve significant climate mitigation unlikely. A new generation of nuclear technologies that are safer and cheaper will likely be necessary for nuclear energy to meet its full potential as a critical climate mitigation technology. In the long run, next-generation solar, advanced nuclear fission, and nuclear fusion represent the most plausible pathways toward the joint goals of climate stabilization and radical decoupling of humans from nature. . . . The ethical and pragmatic path toward a just and sustainable global energy economy requires that human beings transition as rapidly as possible to energy sources that are cheap, clean, dense, and abundant.

Breakthrough Institute staffer Jessica Lovering followed this up with a series of policy papers identifying specific areas for action to break the nuclear deadlock. Lovering then went on to found two more left-leaning organizations, Energy for Growth and the feminist Good Energy Collective, which published a multitude of additional policy papers calling for advanced nuclear power and making the case for the necessity of using nuclear energy to lift the world’s developing nations out of poverty.

Many of the leaders, experts, and spokespersons of the nuclear lefties have been women. This wasn’t a completely new development, as Marie Curie and Lise Meitner had founded nuclear physics by discovering radioactivity and nuclear fission, respectively. Yet the arrival of a force of fierce female fission freedom fighters on the political battlefield is having a real impact, reshaping the nuclear message into a form congenial to progressives.

Their recommendations have begun to make their way into Democratic Party policy circles, with a key role being the think tank known as the Third Way.

In 2016, the smart money hit the canvas when Donald Trump defeated Hillary Clinton in the November presidential election. Clinton had a great résumé and the full and enthusiastic backing of the nation’s political establishment, along with nearly all news and entertainment media. By any conventional calculation, she should have beaten the erratic Trump by 20 points. Instead, by the time Election Night was over, Trump had won. While many of Clinton’s disappointed supporters sought solace in blaming the defeat on racism, sexism, or Putin, a cold, hard look at the electoral map told a different story. Clinton lost the election in the industrial Midwest. Across the rest of the nation, states were won or lost in accord with the pollsters’ confident predictions. But to the amazement of all, Pennsylvania, Ohio, Michigan, and Wisconsin — the industrial heartland, whose unionized labor had been the base of the Democratic Party since FDR — was swept by Trump.

The party clearly faced a problem, and at least some of its leaders recognized that the core of the issue was reconciling the passions of its environmentalist supporters with the real needs of blue-collar workers. “For what profiteth a candidate if she gains the donations of Tom Steyer but loses the votes of the industrial Midwest,” commented one wag. There had to be a way to please both.

The New Nuclear Moment - *Parts of the Left are shifting to pro-nuclear*

The party was not about to abandon its core belief that carbon emissions present an existential threat to humanity, so changing its position on coal mining or fracking was out. But nuclear power is carbon-free. If the party embraced nuclear power, it could support both economic growth and environmental necessity. Not all Democrats saw things that way, but some did. Thus was born the Third Way.

Similar factions have begun to appear among center-left social democrats in Europe as well. In fact, some hard-left groups, such as the Irish Workers' Party, have shifted their stance.

To be sure, environmentalist leaders themselves have not changed their position. This summer saw the spectacle of the Environmental Defense Fund and the Natural Resources Defense Council cheering the shutdown of New York State's Indian Point nuclear-power plant. In Europe, Greenpeace and the World Wildlife Fund are screaming bloody murder at the shift in the EU's taxonomy to place nuclear in the charmed circle. But these groups have only themselves to blame for their abandonment by part of the political Left. While the greens may have been using global warming as a pretext for their real deindustrialization goal (just as they used **global cooling** in the 1970s), they have actually managed to convince a lot of people that carbon emissions need to be reduced. In fact, they have convinced so many people that the issue has gotten out of their control.

An "existential crisis" is one that threatens human existence. While green fanatics can shout "radiation danger" as hard as they like, the fact of the matter is that not a single person in the world has ever been harmed by a radiation release from any of the thousand or so pressurized-water reactors that have operated on land and sea for the past 67 years. If you believe that human existence is at risk from fossil fuels, you would have to be insane to continue to shun or sabotage the demonstrably practical nuclear alternative.

Personally, I do not agree with the Third Way line that nuclear power is needed to stop the "existential crisis" of climate change. I don't believe there is such a crisis, and I'm not willing to pretend I do. In the 1950s and 1960s, Oak Ridge National Laboratory's visionary director, Alvin Weinberg, attempted to use the "existential crisis" of that time, the "population explosion," to make the case for nuclear power. I think that was a mistake, because the Malthusian ideologues pushing the population crisis were intrinsically hostile to nuclear power. They hated it for the same reason that the current green anti-human movement hates nuclear power: It threatens to solve a problem they need to have.

But peace. In policy, as in religion, there is more than one path to virtue. If concern over global warming (or lost elections) persuades the center-left to switch sides and fight for nuclear power, I'm cool with that. We can march separately but strike together.



ROBERT ZUBRIN is president of Pioneer Astronautics, an aerospace research-and-development company. His latest book is **THE CASE FOR SPACE: How the Revolution in Spaceflight Opens Up a Future of Limitless Possibility**. [@robert_zubrin](https://twitter.com/robert_zubrin)

Imagination and the Astronomical League

by Dr. David H. Levy, Comet and Asteroid Hunter, Co-Discoverer, Shoemaker-Levy 9 (2022 January article)

“A Dragon Lives forever, but not so girls and boys.”

Three quarters of a century ago, during the Second World War, the famous Harvard astronomer Harlow Shapley, along with Charles Federer, founding editor of Sky and Telescope Magazine, launched an association of astronomy clubs across the United States. It is called the Astronomical League, and it thrives to this day with more than 100 astronomy clubs. Unlike the national Royal Astronomical Society of Canada, the League is designed to be a more loosely structured organization. According to Carroll Iorg, its current president, one of its most critical and central goals is to inspire the next generation to enjoy the night sky. If that goal should fail. The possibility exists that there may be no Astronomy for future generations.

As part of this vital goal, the Junior Astronomical League, a new subset of the Astronomical League, is now meeting every second Sunday over zoom. But there is something more. My next book will be devoted to those young stargazers. It actually began as a typewritten saga I wrote in 1958 when I was ten years old, and of all the 40 plus books I have written, this is Wendee's favorite. I am now completing a second edition of this book, in which a small group of children go on a stargazing adventure with Clipper, a magic beagle, and with Eureka, an enchanted reflector telescope. They go past the Moon and planets, the stars, the distant superclusters of galaxies, and even the great voids in distant empty space.

In its final chapter, this book explores the theme articulated in the last verse of Peter, Paul, and Mary's eminent song “Puff.” “A dragon lives forever, but not so girls and boys.” The children, now grown, go to university. When they complete their college education, the young woman, adept at math and physics, becomes an astronomer, but the young man goes on to become a lawyer. He marries, has children who are now grown themselves, and unhappily gets a divorce. To recover he decides to take a vacation trip to Arizona. Driving his rented car one evening, he pulls off the road, gets out of his car, and looks at the stars. As childhood memories flood back, a second car pulls off. The young woman astronomer gets out of her car. The two cannot believe they are reuniting, and they catch up for hours. Then there is a break in their conversation. As the couple looks up silently at the stars, the magic beagle, and the telescope, appear and take shape. In that one ultimate celestial adventure, the magic of the night has returned.



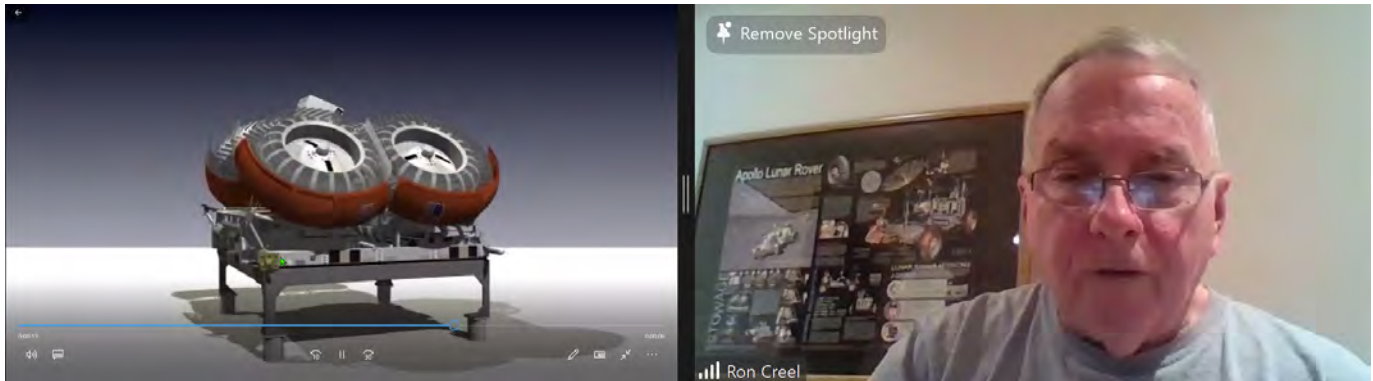
Clipper began his life around 1956 as a Bar Mitzvah present for Richard, my older brother.

(December 15) Lunar Roving Adventures - Dust, Dust, Everywhere - What Are We Going To Do? by Mr. Ron Creel

(Retired Space And Thermal Systems Engineer, Member of the Apollo Lunar Roving Vehicle (LRV) Team)
(Screenshots Only)

<https://www.aiaa-lalv.org/2021-december-15-lunar-roving-adventures-dust-dust-everywhere-what-are-we-going-to-do-by-mr-ron-creel/>

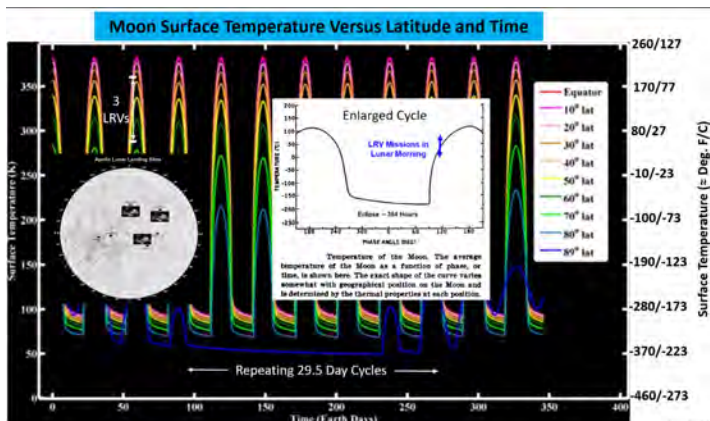
Editor's Note: This is the post-event posting of the event/activity, not the advertisement for the upcoming events. For more details of this event, multiple reminders/flyers were sent out and the details are not repeated here. Please see the link above or <https://conta.cc/3105p6V>



Mr. Ron Creel explaining the design of the Lunar Rover by showing a very nice animation.



(Left) The Lunar dust is a very serious and tough issues. The Apollo astronauts used special brushes to help each other cleaning the lunar dust on their spacesuits. (Right) The control panel of the Apollo Lunar Rover had a very interesting design.



Ron Creel on the Polaris Rover Replica at USSRC



Young Moon Explorers Driving LUROVA™ Simulation Game at VBAS "Astronomy Day" and USSRC "Observe the Moon" Night

Questions?



LUROVA™ in Action Using LRO Terrain Data

LRO = Lunar Reconnaissance Orbiter

LUROVA = Lunar ROVing Adventure

USSRC = United States Space and Rocket Center

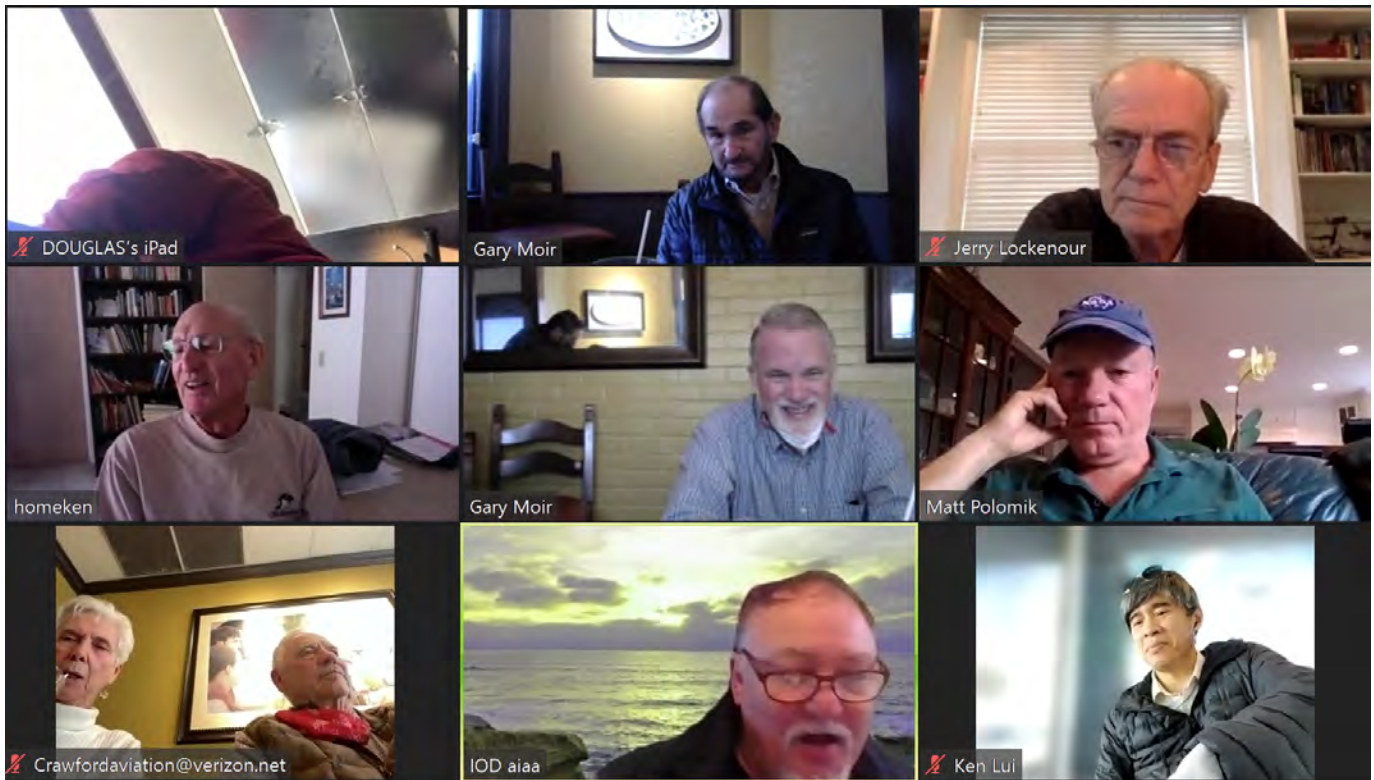
(Left) The temperature variation on the Moon is another important factor in the lunar rover design. (Right) Mr. Ron Creel answering enthusiastic questions and showing his STEM K-12 Outreach with the simulator and 3D-printed gadgets etc.

(December 15) AIAA LA-LV Aero Alumni Meeting *(Screenshots Only)*

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Attendees either joined Mr. Gary Moir in the Olive Garden in Torrance in person, or online on Zoom, for this Aero Alumni Christmas Meeting. (Upper Left) Mr. Gary Moir (Left in the picture) and Mr. Harvey Eidinoff (Right in the picture), showed a book on Apollo 8.



Attendees taking turns expressing their views on Apollo 8, 17 and recent news. (Bottom Middle) Mr. Kevin Burns, Chair of the AIAA History Committee, expressing interests in the rich history of AIAA and aerospace in the Los Angeles area and making some proposals.

Northrop Grumman Platform-Agnostic AN/ASQ-236 Dragon's Eye Pod Achieves First Flight on an Operational F-16

Successful flight demonstrates interoperability of the radar pod with the F-16 fighter

by Northrop Grumman Corporation, 2021 November 18 (with permission)

<https://news.northropgrumman.com/news/releases/northrop-grumman-platform-agnostic-anasq-236-dragons-eye-pod-achieves-first-flight-on-an-operational-f-16>

BALTIMORE – Nov. 18, 2021 – The Air National Guard has flown the Northrop Grumman Corporation (NYSE: NOC) AN/ASQ-236 Dragon's Eye Active Electronically Scanned Array (AESA) radar pod on an operational F-16 for the first time. The Air Force intends to deploy the pod operationally to both its Guard and Reserve F-16 fleets.



An Air National Guard F-16 being prepared for its first operational flight with AN/ASQ-236 Dragon's Eye pod on board.

“The addition of the Dragon's Eye to the F-16 Viper is a force multiplier, enabling warfighters to detect, track, identify and target faster in theater,” said Susan Bruce, vice president, advanced mission capabilities, Northrop Grumman. “This pod is rapidly adaptable to new platforms and it features advanced radar modes that can be shared across our fifth-generation radar portfolio.”

The AN/ASQ-236 Dragon's Eye pod is already operational on the U.S. Air Force F-15E Strike Eagle. It can be integrated on both large and fighter-sized platforms. Northrop Grumman has previously integrated the AN/ASQ-236 pod on an Air Force Special Operations Command AC-130 gunship and Air Force Global Strike Command B-52 bomber during a proof of concept demonstration.

The AN/ASQ-236 Dragon's Eye radar pod is a tactical Ku-band AESA radar surveillance pod that provides aircrew with all-weather, multi-target detection, track and engagement capability. Northrop Grumman's sensors and electronic warfare systems give warfighters superiority across the spectrum and allow for faster, more informed decisions.

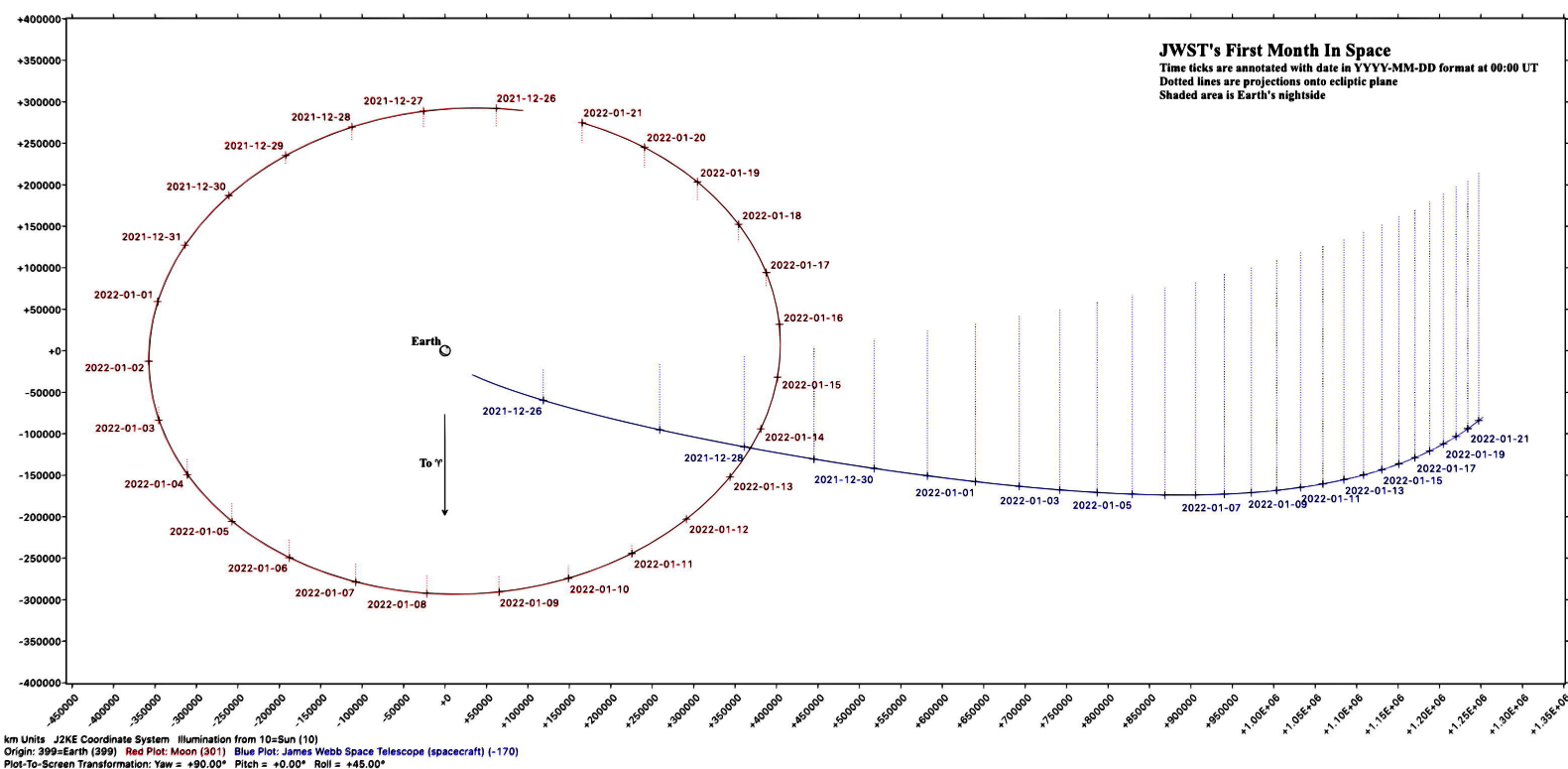
Northrop Grumman is a technology company, focused on global security and human discovery. Our pioneering solutions equip our customers with capabilities they need to connect, advance and protect the U.S. and its allies. Driven by a shared purpose to solve our customers' toughest problems, our 90,000 employees define possible every day.

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by Mr. Daniel R. Adamo, AIAA Associate Fellow, Astrodynamics Consultant
2021 December 25

Credit: JPL's Horizons ephemeris server at <https://ssd.jpl.nasa.gov/horizons/>

Following an on-time launch at 12:20 PM UT on Christmas Day, the James Webb Space Telescope (JWST) is undergoing successful initial deployment activities. Further critical deployment milestones are planned over the coming weeks (ref. <https://www.floridatoday.com/story/tech/science/space/2021/12/25/nasas-james-webb-telescope-launches-kicking-off-nail-biting-mission/9006733002/>). This on-time launch renders reasonably valid a planned trajectory for JWST's first month in space as posted to JPL's Horizons server on 23 December 2021. The graphic plots Earth-centered motion of JWST, together with that of the Moon, during the month following launch.



A Troubling Trend In Mars Forward Planetary Protection Policy

by Mr. Daniel R. Adamo, AIAA Associate Fellow, Astrodynamics Consultant

2021 November 20

Background

Throughout recorded history, and particularly since the Industrial Revolution began (1750-1850)¹, human stewardship of planet Earth has been far from exemplary. Despite ongoing controversy over the degree humans have influenced the global warming phenomenon, there is virtually no dissent regarding existence of collision hazards from human artifacts/debris in low Earth orbit (LEO). On 10.8 November 2021 UTC, ISS performed its 30th collision avoidance maneuver only 6 hours before SpaceX launched its Crew-3 mission for a rendezvous.² Less than five days later, the ISS crew was ordered to don spacesuits and shelter in place due to debris from a Russian antisatellite test.³ In addition to one-on-one collisions, there is a growing threat from the Kessler syndrome,⁴ a scenario in which LEO is rendered unnavigable, as dramatically portrayed in the vintage 2013 fictional movie *Gravity*.⁵ On occasion, uncontrolled atmospheric entry of orbiting human artifacts can also threaten lives and property on Earth.⁶

Moving out into interplanetary space, Mars looms as a future stewardship challenge. Unlike the sterile Moon, Mars may have a present-day biosphere whose accessibility to human study by the nascent field of astrobiology would be unrivaled off-Earth. In-situ Mars surface exploration began for the U.S. with two *Viking* landers in 1976, "NASA's first life detection mission".⁷ Indeed, one of the primary reasons NASA cites for exploring Mars is "to possibly answer origin and evolution of life questions".⁸ Although answers to these questions might be provided by identifying fossils native to Mars, the most conclusive and compelling development in this astrobiology inquiry would be discovery of extant Mars life forms.

Given the importance of living Mars organisms to space exploration, both NASA and the international Committee on Space Research (COSPAR) have adopted the practice of *forward* planetary protection (FPP) whereby Mars is shielded from contamination by Earth life forms.⁹ NASA's Office of Safety and Mission Assurance (OSMA) states, "Planetary Protection policies and requirements ensure safe and verifiable scientific exploration for extraterrestrial life."¹⁰

Although NASA and other space agencies are practicing some degree of FPP in the context of Mars exploration, a disturbing precedent has been set for private sector space activity. On 6 February 2018, the first Falcon Heavy launch placed its second stage and an attached Tesla Roadster on an interplanetary trajectory crossing the heliocentric orbit of Mars. With this

¹ Reference <https://historyofmassachusetts.org/industrial-revolution-america/> (accessed 10 November 2021).

² Reference <https://gizmodo.com/space-station-will-make-an-emergency-maneuver-after-det-1848031344> (accessed 11 November 2021).

³ Reference <https://spacenews.com/russia-destroys-satellite-in-asat-test/> (accessed 18 November 2021).

⁴ Reference https://en.wikipedia.org/wiki/Kessler_syndrome (accessed 10 November 2021).

⁵ Reference the video trailer at https://www.youtube.com/watch?v=_KJHRF6RITQ (accessed 10 November 2021).

⁶ Reference <http://www.thescruffyastronomer.com/2021/05/long-march-5-b-uncontrolled-re-entry.html> (accessed 10 November 2021).

⁷ Reference https://mars.nasa.gov/#red_planet/4 (accessed 11 November 2021).

⁸ Reference https://mars.nasa.gov/#mars_exploration_program/3 (accessed 11 November 2021).

⁹ Likely of even greater importance is *backward* planetary protection, the practice of shielding Earth from contamination by extraterrestrial life forms. However, backward planetary protection is at most peripheral to this paper's focus on unambiguously detecting and studying extant Mars life.

¹⁰ Reference <https://sma.nasa.gov/sma-disciplines/planetary-protection> (accessed 11 November 2021).

A Troubling Trend In Mars Forward Planetary Protection Policy

mission, the private sector entered interplanetary space for the first time. Heliocentric motion before and after the first Mars close approach by the Roadster is illustrated in Figure 1 using the "tesla_s10" trajectory posted on JPL's *Horizons* ephemeris server.¹¹

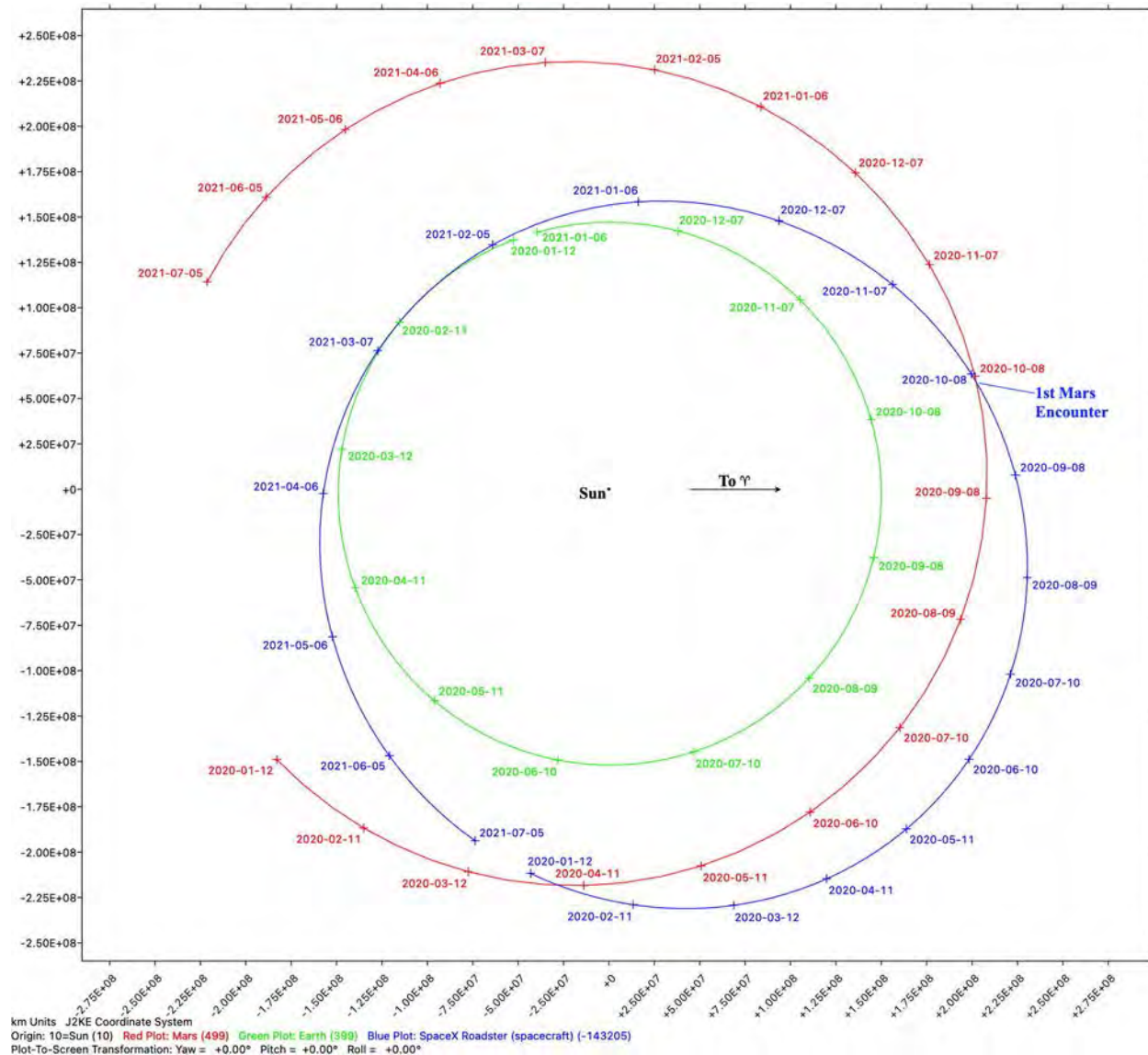


Figure 1. Heliocentric motion of Earth (green), Mars (red), and a Tesla Roadster launched 6 February 2018 (blue) is plotted in the ecliptic plane. Time ticks ("+" markers) appear at 30-day intervals and are annotated with 00:00 UTC dates in YYYY-MM-DD format. The first Mars encounter by the Roadster at right reaches a minimum distance of 7.4 million km on 7.3 October 2020 UTC.

While NASA sends upper stage hardware in the general direction of Mars with every mission it launches to the red planet, that hardware is subject to decontamination standards under FPP policy. No such standards were applicable to the Roadster, whose private sector mission did not

¹¹ Reference <https://ssd.jpl.nasa.gov/horizons/> (accessed 12 November 2021).

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explicitly target Mars and was licensed by the FAA. The FAA only regulates private sector spaceflight to ensure Earthly lives and property are protected. This policy was enacted by Congress as a "learning period" beginning in 2004, and it has no FPP provisions.¹² Nevertheless, all three orbits in Figure 1 are coplanar within about one degree. That geometry, together with Roadster gravity assists from Earth near some perihelion passages, make it impossible to completely discount a Mars hypervelocity impact in the future. Unlike NASA hardware, the Roadster poses an uncontrolled and unquantified threat to astrobiology interests on Mars.

With this background in mind, consider a preliminary report written by the National Academies of Science, Engineering, and Medicine Committee on Planetary Protection (CoPP), titled *Evaluation of Bioburden Requirements for Mars Missions*, and announced via email on 11 October 2021.¹³ The bulk of this paper is devoted to commentary regarding the CoPP report, and specific references to it appear in [] brackets without further attribution. The report's opening Summary section paragraph [p. 1] reaffirms the importance of astrobiology to NASA's Mars exploration mission and is reproduced here.

For ages, scientists and philosophers have pondered the origin, prevalence, and nature of life in the universe. That quest for knowledge is manifest today in NASA's goals for exploration of the solar system and the universe, especially concerning Mars. Evidence for persistent liquid water on ancient Mars, significant amounts of contemporary water ice, the planet's proximity to Earth, and its similarities with Earth as a terrestrial planet, have made Mars important in the search for existing or extinct extraterrestrial life.

The CoPP Report's Statement of Task

A NASA statement of task dated 22 February 2021 [p. 1] appears in the CoPP report as Appendix A [pp. 59-60]. The CoPP itself is first described in the statement of task as a "long-term ad hoc committee" whose scope "includes the study of those aspects of planetary environments, the life sciences, spacecraft engineering and technology, and science policy relevant to the control of biological cross-contamination arising from the robotic spacecraft missions and the human exploration and utilization of solar system bodies."

Although NASA does not license or otherwise govern conduct of private sector missions to Mars, the National Aeronautics and Space Act of 2010 states: "Congress declares that the general welfare of the United States requires that the Administration seek and encourage, to the maximum extent possible, the fullest commercial use of space."¹⁴ This NASA function is presumably why the CoPP is concerned with "utilization of solar system bodies". It should be noted that truly "commercial" enterprises on Mars may first arise decades after private sector

¹² Reference <https://www.washingtonpost.com/technology/2021/06/23/space-tourism-faa-regulation/> (accessed 19 November 2021).

¹³ This publication may be downloaded as a PDF file at <https://www.nap.edu/download/26336> (accessed 13 November 2021).

¹⁴ Reference Public Law 111-314, Section 20102 "Congressional declaration of policy and purpose" (c) "Commercial Use of Space" as downloaded at https://www.nasa.gov/sites/default/files/atoms/files/public_law_111-314-title_51_national_and_commercial_space_programs_dec._18_2010.pdf (accessed 14 November 2021).

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activity there has begun to seriously compromise astrobiology interests.¹⁵ In a Mars mission context, this paper will use "private sector" in its narrative and will consider that terminology to be synonymous with "commercial" when citing other references.

Turning to the CoPP report in the statement of task, NASA provides the following direction.¹⁶

The Committee on Planetary Protection (CoPP) shall write a report that identifies criteria for determining locations or regions on Mars that are potentially suitable for missions of less restrictive bioburden than the current requirements for Category IV. The report shall also illustrate the use of those criteria by identifying some potentially acceptable locations that meet those criteria and are suitable for reduced bioburden criteria. Additionally, the report shall consider the appropriateness of mission activities that occur beneath the Martian surface in these locations and how deep such mission activities should be allowed. [p. 60]

At no point in the statement of task does NASA document *motivation* for developing relaxed bioburden requirements at some Mars surface locations with respect to bioburden requirements of Category IV missions. This paper will draw attention to CoPP report findings and recommendations that could seriously compromise astrobiology interests in specific scenarios. How those compromises are justified by enabling presumably conflicting interests is beyond the ken of nearly all who will read the CoPP report, including many FPP stakeholders. With motivation omitted from the statement of task, meaningful risk-versus-gain tradeoffs to be inferred from the CoPP report cannot be made with confidence.

The statement of task also requires the CoPP report to "briefly comment" on the suitability of relaxed bioburden locations as venues for human exploration missions while primarily focusing on a robotic mission context. In this context, NASA solicits CoPP views on whether or not relaxed bioburden "criteria may be useful (although likely not sufficient) when considering how human missions can be carried out without large-scale biological contamination of Mars." [p. 60] No CoPP report content relating to return planetary protection is solicited by the statement of task.

A Global Mars Contamination Threat Below One Meter Depth

The CoPP's principal conclusions regarding NASA's statement of task report requirements are summarized in Box S.1 [p. 4] as follows.

Due to the sterilizing conditions of the Martian surface, the Committee's considerations of bioburden relaxation focused on avoiding potential access to the subsurface by terrestrial microorganisms. Information on subsurface access points is uncertain, and knowledge of conditions in the Martian subsurface is incomplete

¹⁵ A fictional portrayal of this potential conflict may be found in the Nat Geo docudrama *Mars*. Season 2, Episode 1, "We Are Not Alone" is illustrative. Reference <https://www.nationalgeographic.com/tv/shows/mars/episode-guide/season-02/episode-01-we-are-not-alone/vdka10877028> (accessed 14 November 2021).

¹⁶ For those unfamiliar with FPP terminology, *Category IV* mission requirements in the ensuing excerpt are reproduced in CoPP report Appendix C [pp. 62-63]. These requirements currently apply to all Mars surface missions conducted under NASA auspices.

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and mostly model-based. Bioburden requirements could be relaxed if the following criteria are met:

1a) Mission activities do not include subsurface activities, OR

1b) For mission activities as deep as 1 m, the landing site is in a location where no ice is detected in neutron or thermal data;

AND

2) For both cases above, the landing site is a conservative distance from any subsurface access point, to be determined considering wind conditions for the location and season and best estimates of microorganism survival time in the surface UV environment.

Box S.1 Criterion 1b equates to a global moratorium on operations below 1 m surface depth on Mars for any mission not meeting Category IV bioburden requirements. Now contemplate the Table 1 history of landing attempts on Mars with Criterion 1b in mind.

Table 1. The crash history of spacecraft landing attempts on Mars is summarized.¹⁷

Year	Lander	Crash?
1971	<i>Mars 2</i>	Yes
1971	<i>Mars 3</i>	No
1976	<i>Viking 1</i>	No
1976	<i>Viking 2</i>	No
1996	<i>Pathfinder</i>	No
1999	<i>Polar Lander</i>	Yes
2003	<i>Beagle 2</i>	No
2004	<i>Spirit</i>	No
2004	<i>Opportunity</i>	No
2008	<i>Phoenix</i>	No
2012	<i>Curiosity</i>	No
2016	<i>Schiaparelli</i>	Yes
2021	<i>Perseverance</i>	No
2021	<i>Zhurong</i>	No

From Table 1, a lander crash rate of $3/14 = 21\%$ is evident. Each of the crashes all but certainly penetrated the surface of Mars to a depth greater than 1 m. If the speed of impact alone fails to penetrate below 1 m depth, explosive or volatile substances aboard a lander will further assure this outcome. Figure 2 documents the *Schiaparelli* crash site.

While no mission *plans* to crash on Mars, a substantial crash probability nevertheless applies to *any* Mars lander. Recent U.S. one-ton Mars rovers have arrived on Mars after a process termed

¹⁷ Reference <https://theconversation.com/landing-on-mars-the-historical-missions-that-failed-and-the-ones-that-made-it-161211> (accessed 15 November 2021).

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"Seven Minutes of Terror".¹⁸ A crash will violate Box S.1 Criterion 1b and pose a serious FPP threat if the lander is not decontaminated in accord with Category IV requirements. As noted previously, motivation for relaxing these requirements is not stated in the CoPP report, but cost reduction is probably at the heart of it [Finding 9, p. 3]. Less expensive private sector missions will undoubtedly "foster the fullest commercial use of space" in accord with NASA's charter. But Mars landing missions with tight budgets and minimal decontamination expenditures might also be compromised in their design and fabrication such that they are *more* likely to crash than government-funded missions appearing in Table 1. These disasters could pose highly undesirable consequences to astrobiology interests on Mars. A lost private sector mission can be rebuilt and launched again, but Mars biosphere contamination cannot be undone.

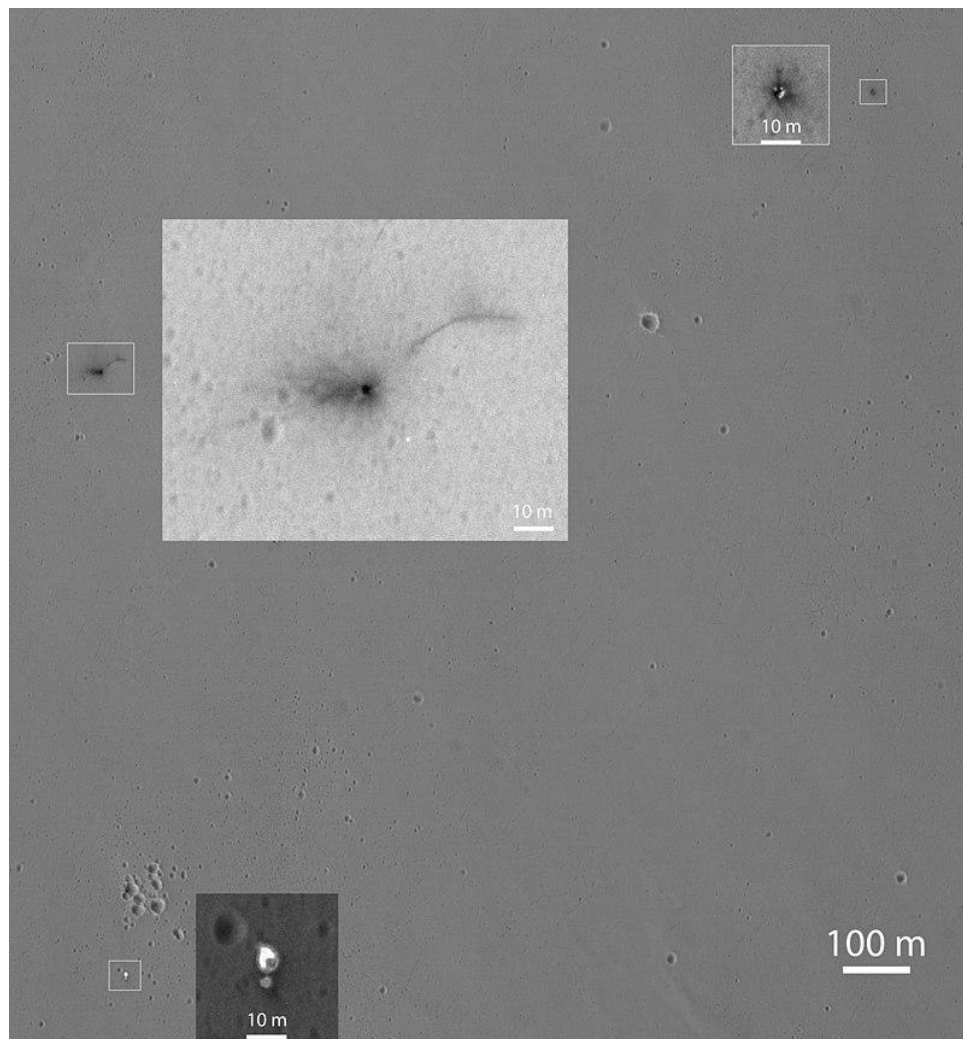


Figure 2. Mars Reconnaissance Orbiter imagery of the *Schiaparelli* crash site was obtained on 25 October 2016. Magnified insets detail the leading heat shield impact (top right), lander impact (middle left), and the parachute/trailing heat shield (bottom left). Estimated lander impact speed (supported by telemetry) is 83 m/s.¹⁹

¹⁸ Reference <https://mars.nasa.gov/mars2020/timeline/landing/entry-descent-landing/> (accessed 15 November 2021).

¹⁹ Reference https://en.wikipedia.org/wiki/Schiaparelli_EDM (accessed 15 November 2021).

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The CoPP report fails to document any Mars lander crash considerations as though such mishaps never occur. In the context of Finding 7 [p. 43], the report mentions "possibilities of off-nominal landings". But this context addressess landing site location uncertainties. Thus, "off-nominal" likely refers to navigation precision with respect to planned touchdown coordinates rather than to a lander crash on Mars. Report narrative [p. 49] recommends Table 4-1 "should be expanded to include conditions involving unintended impacts", but consequences posed by such impacts in the context of Box S.1 Criterion 1b are never developed. The CoPP report *does* document detection of "nearly pure ice" exposed by recent, presumably natural, craters on Mars [pp. 36-37]. Similar cratering from a crash could therefore mix Mars ice with Earth contaminants.

The process of in-situ bioburden reduction, through which a lander is decontaminated by ambient Mars surface conditions after lander touchdown, is documented in Finding 9 [p. 52]. Relying on this technique implicitly *requires* an intact landing that cannot be guaranteed. A lander crash before in-situ bioburden reduction can proceed would again violate Box S.1 Criterion 1b.

Consequences From Boots On The Ground At Mars

Any human presence on Mars brings with it a vastly increased bioburden with respect to Category IV limits [p. 62]. Furthermore, human radiation shielding requirements are likely to entail emplacing habitats well below the 1 m depth limit set by Box S.1 Criterion 1b [p. 4] with local access to large amounts of subsurface water ice as illustrated by Figure 3.

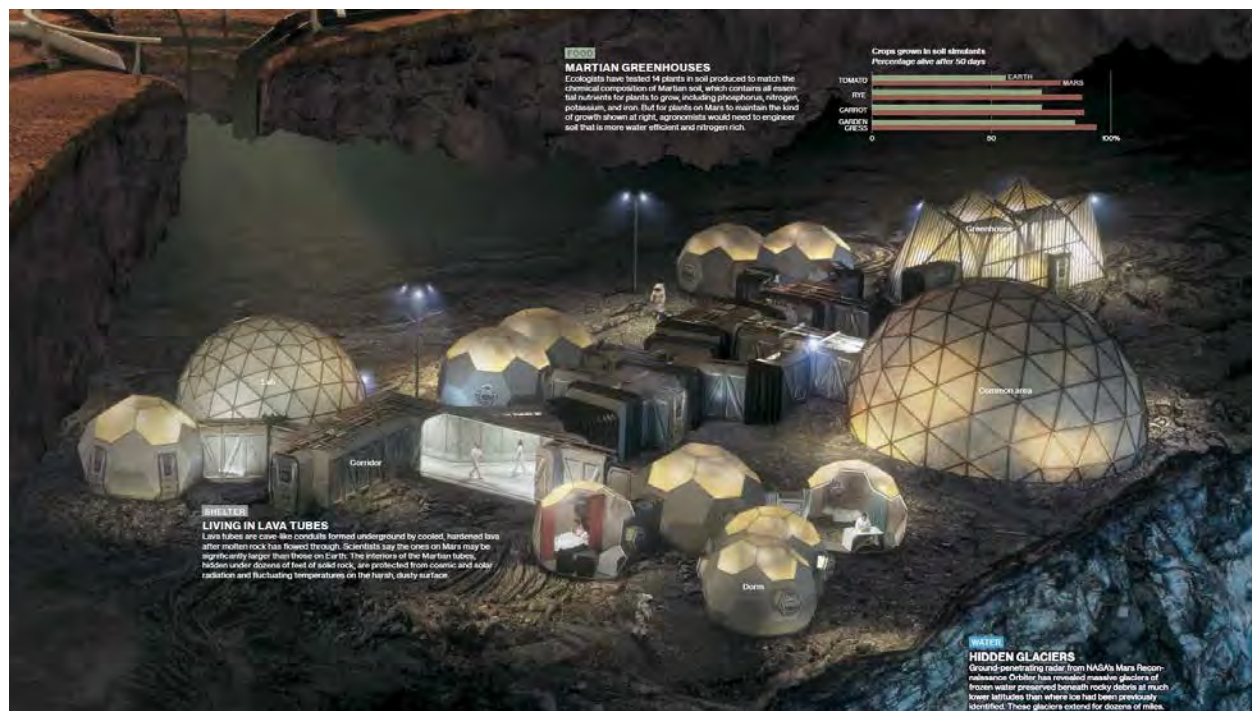


Figure 3. In this cutaway view, a subsurface habitat concept from NatGeo's *Mars* docudrama features pressurized domes and connecting tunnels shielded from potentially lethal solar and cosmic radiation exposure on the surface of Mars.²⁰

²⁰ Reference <https://www.humanmars.net/2016/10/hd-images-from-natgeos-mars-tv-series.html> (accessed 16 November 2021).

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The CoPP appears aware of FPP inadequacies regarding human presence on Mars, as stated in the following excerpt from the report (**boldface** text is as printed in the report) [p. 55].

Given the underdeveloped nature of planetary protection policy for human missions to Mars, caution is necessary in addressing, even briefly, the suitability of applying guidelines for planetary protection for robotic missions to human missions. Robotic missions launch with fixed and limited bioburdens that environmental conditions in flight and on the Martian surface contain, reduce, and destroy over time. By contrast, the presence, movement, and activities of microbially diverse humans have the potential to increase biological contamination on and beneath the Martian surface over time. This difference counsels against relying on less restrictive bioburden standards for robotic missions as criteria for setting planetary protection policy for human missions.

Figure 3's subsurface habitat concept and its impact on Mars FPP is also recognized in the CoPP report: "sustained access to, and in-situ use of, subsurface water ice and possibly caves are considered critical for human missions. Meeting this need may expose such resources and areas to sustained contamination from astronauts and bioburdens of robotic, non-scientific activities (e.g., in-situ resource utilization) that support human missions." [p. 55]

Much like the U.S. Department of the Interior (DOI), NASA has been placed in an institutional conflict of interest between Mars astrobiology (conservation, in the DOI analog) interests and Mars development (logging, in the DOI analog) interests.²¹ This conflict is summarized in the following excerpt [p. 13].

Considerations such as [possibly confounding the search for indigenous Mars life] define and shape the forward contamination hazards on Mars and, at the same time, provide the degrees of freedom that can allow safe exploration and possible development on Mars. The committee developed its report sensitive to both the risks, the opportunities and the goals, and recognizing that planetary protection measures are not intended to inhibit any activity in extraterrestrial environments, but rather to foster such activity while preserving, to the greatest extent reasonable, the prospect that important scientific goals can be realized.

The foregoing excerpt appears to place science/astrobiology as subservient to "any activity" off-Earth because the latter cannot be inhibited (or even deferred). This ranking is difficult to reconcile with CoPP report Finding 1 [p. 2], where astrobiology reigns supreme, as excerpted below.

The discovery of indigenous life on Mars would be a signal event in the development of human knowledge, with widespread impact and implications.

²¹ Beginning in 1926, the FAA and its predecessor organizations were placed in a similar conflict by Congressional mandates to both regulate and promote civil aviation. The FAA's promotional role was largely eliminated with the Federal Aviation Reauthorization Act of 1996. Reference https://www.faa.gov/about/history/chronolog_history/media/b-chron.pdf (accessed 19 November 2021).

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Preserving unambiguous separation or distinguishability of terrestrial organisms from indigenous Martian organisms, by application of planetary protection protocols, or by other scientifically accepted means, is essential to realizing NASA's solar system exploration goals and addressing profound questions that have long preoccupied humans.

If Finding 1 is compromised by lax FPP policy, particularly one tolerating premature human presence on Mars, there is no "going back" to a pristine Mars biosphere. A better path forward to responsible stewardship would defer contaminating a contemplated biosphere until more is known about the Mars environment, particularly its subsurface. Before humans become Mars inhabitants, the Moon, Phobos, Deimos, and some four thousand known asteroids²² invite us to explore or develop sterile, more accessible, and equally hospitable destinations.

When humans reach Deimos, roundtrip light time to the visible surface of Mars is reduced to less than 0.2 s. Based in a subsurface habitat akin to that illustrated in Figure 3, it is then practical for humans to perform the most dexterous and engrossing exploration tasks imaginable through immersive interfaces with thoroughly decontaminated robotic surrogates on Mars. This low-latency telepresence (LLT) Mars exploration concept enables highly productive scientific returns.^{23,24} It also implements a global 20,000 km sterile buffer zone "between areas of human activity and locations of astrobiological significance" [p. 55].

By using LLT to explore Mars *before* humans land there, our species would be on the fastest route possible to discovering life on Mars without threatening to destroy it or confound the discovery. To help ensure all space-faring nations adopt a humans-on-Mars moratorium, this policy should be negotiated through COSPAR. As the CoPP report illustrates, our ignorance of any extant life on Mars (particularly its nature, location, and vulnerabilities) is profound. Only when the possibility of present-day life on Mars is excluded or localized with high confidence should the moratorium be lifted.

Conclusions And Recommendations

Since 1971, landings on Mars have been conducted with robotic spacecraft developed and operated by civil space agencies in accord with COSPAR-adopted FPP standards. These standards have, for good or ill, established a de facto baseline of Earth contamination on Mars.

With the first private sector hardware to enter interplanetary space in 2018, this situation began to evolve. No FPP standards were applied to this hardware even though it crosses the orbit of Mars and could someday impact the planet.

²² Reference the NHATS data table at <https://cneos.jpl.nasa.gov/nhats/> (accessed 18 November 2021, when a tally of 3985 NHATS-compliant asteroids was made). Set all constraints to their most permissible values and note the number of table entries obtained.

²³ Reference R.C. Anderson (et al, ed.), *Space Science Opportunities Augmented by Exploration Telepresence*, Keck Institute for Space Studies, NASA, 2020. This report may be downloaded at https://www.kiss.caltech.edu/final_reports/Telepresence_Final_Report.pdf (accessed 17 November 2021).

²⁴ Reference http://www.aiaahouston.org/Horizons/%5bNumber_Sign%5d115-A_White_Paper_Roadmap_for_Low-Latency_Telepresence_at_Mars_from_Deimos.eml (accessed 20 November 2021).

A Troubling Trend In Mars Forward Planetary Protection Policy

The preliminary CoPP report reviewed by this paper attempts to develop criteria under which more permissive FPP requirements could be applied to future Mars landers. Unfortunately, at least one of these criteria must ignore crash landings on Mars as credible mishaps even though more than 20% of Mars landing attempts through 2021 have suffered this fate. The preliminary CoPP report also proposes an in-situ decontamination strategy relying on ambient Mars surface conditions post-landing, thus discounting the possibility of crashes as well.

Motivation for more permissive FPP requirements is never documented in the preliminary CoPP report, nor in NASA's statement of task creating the CoPP and requesting this report. There is evidence within the preliminary report implying Mars mission cost reduction is the missing motivation. Absent a clear statement of such motivation, however, the "gain" side of the FPP risk-versus-gain equation is missing. In contrast, the "risk" to be traded at Mars is loss of arguably the most profound scientific discovery of the twenty-first century.

In the context of future human landings on Mars, the preliminary CoPP report offers little hope current FPP contamination levels on Mars can be maintained. Furthermore, NASA's Congressional charter to promote "the fullest commercial use of space" places the Administration in an institutional conflict with astrobiology interests it funds. The following recommendations are therefore submitted for consideration.

- 1) At its earliest opportunity, the U.S. should initiate COSPAR negotiations to declare an international moratorium on human Mars landings until robotic-enabled exploration determines Mars is sterile or any extant Mars life can be reliably insulated from contamination by humans on Mars. This action is urgent because these negotiations will be time consuming, and the first footsteps on Mars may otherwise be historic fact well before 2050. Given its current leadership in Mars exploration, both human and robotic, the U.S. will never have better leverage in advocating the moratorium than now.
- 2) The FAA's practice of licensing private sector missions entering interplanetary space should be augmented to include FPP standards adopted by NASA and COSPAR.
- 3) Any relaxed Mars FPP measures advocated by the CoPP preliminary report should be deferred until they are reevaluated in the all-too-likely context of a spacecraft crashing on Mars and thus penetrating more than 1 m below the surface.
- 4) Human space flight beyond the Moon should be conducted with an eye toward establishing a subsurface habitat on Deimos. Numerous highly accessible asteroids are available as steppingstone destinations with which to incrementally develop habitat emplacement and operational techniques for Deimos. If the recommended moratorium on human Mars landings is still in place when a Deimos habitat is established, highly productive LLT-based exploration of Mars using low-bioburden robotic surrogates on the surface becomes practical. This exploration will expedite the moratorium's end, and the Deimos habitat will serve as precursor to similar post-moratorium subsurface facilities on Mars from which ongoing highly productive LLT-enabled Mars exploration will also be conducted.

Milley's Sputnik Moment and China's Nukes

by Dr. Stephen Bryen, Senior Fellow, Center for Security Policy; Former Deputy Under Secretary of Defense
 2021 December 2 https://www.theepochtimes.com/milleys-sputnik-moment-and-chinas-nukes_4135904.html



Military vehicles carrying hypersonic DF-17 missiles travel past Tiananmen Square during a military parade in Beijing, China, on Oct. 1, 2019. (Jason Lee/Reuters)

Joint Chiefs of Staff Chairman General Mark Milley called it a “Sputnik” moment, recalling the time when the Russians were the first to put a satellite in orbit.

Milley was talking about China’s test of a space launched nuclear hypersonic glide vehicle, a fractional orbiting hypersonic bombardment system. But, in fact, it was not a Sputnik moment. Russia’s satellite did not pose any strategic or existential threat. What Milley should have said is that the Chinese test of a space launched hypersonic glider was a “Cuban Missile Crisis” moment.

The Cuban Missile Crisis was an attempt by the Soviet Union to put on Cuba a nuclear strike capability made up of missiles and nuclear bombers. On Sept. 4, 1962, President John F. Kennedy warned the Russians about putting “offensive” weapons on Cuba.

But the deployment continued with additional missiles and warheads en route to Cuba and launching sites on the island were made ready (some of them already operational). That led to the confrontation in October when the United States demanded the withdrawal of the missiles and warheads and put in place a quarantine of the island. Finally the Russians agreed and pulled them back (the United States was secretly obliged to pull 100 Jupiter missiles and warheads from Turkey as part of the deal).

At the time Russia had around 300 to 500 nuclear weapons on missiles (mainly in Russia and on submarines) while the US had 3,500. A key advantage to the Soviets was to balance out their deficiency with a near-the-US Cuban nuclear capability. In September/October 1962 around 20 nuclear warheads had been delivered to Cuba and another 20 were on their way. At the end of the day, looked at only from the perspective of numbers, the Soviets got the better of the final deal given that the US pulled 100 Jupiter missiles from Turkey.

Fast forward to China today. China is in the midst of a major increase in its nuclear strike missile capability. China is aiming to have a stockpile of 1,000 nuclear weapons by 2030 which is still far below the United States (5,550 nuclear weapons) and Russia (6,255 weapons).

Milley's Sputnik Moment and China's Nukes

Even with its rapid nuclear expansion, China remains well enough behind that Chinese strategists no doubt realize that if a major conflict came about, China would be at a severe disadvantage and could suffer from a first strike from the United States or, for that matter, from Russia (which in future may not be so friendly with China).

China cannot depend on Russia, where the two countries are strengthening their defense relationships, in the case of a nuclear attack. That helps explain why China has been looking for fast ways to neutralize the U.S. nuclear threat by acquiring a novel kind of first strike capability.

When Nikita Khrushchev planned to move R-14 intermediate and R-12 short range missiles and Ilyushin Il-28 bombers to Cuba the objective was to create a credible first strike Soviet capability on that island. The R-12's got there (range 1,292 miles capable of hitting New York or Dallas) but the R-14's were en route (range 2,500 miles covering most of the United States).

The United States in 1962 had numerous air defenses mainly based on the Nike, Nike Ajax and Nike Hercules systems. Nike Hercules had a range of around 90 miles and its solid-fueled rocket could reach 150,000 feet. It carried a nuclear warhead (the smallest was the W-31, which was a boosted fission nuclear explosive which could be set with a yield of 2, 20 or 40 kilotons—Hiroshima was around 16 kilotons).

Unfortunately, the Nike system was not capable either of reliably detecting or destroying a ballistic missile warhead. The Nike missile defense series was designed against Russian bombers, not missiles (which is one of the important reasons why in the 1970s most of the Nikes were decommissioned).

Had the United States not responded to the Soviet challenge, the nuclear balance would have changed decisively because the missiles in Cuba would give the United States very little warning time to respond to any attack by the USSR.

It isn't clear whether the Cuban missiles alone would constitute a first strike capability, but it would have certainly enhanced that possibility. In any case it obliged the United States, as part of a Kennedy-Khrushchev agreement, to pull its nuclear missiles out of Turkey, a major victory for the Soviets.

China's Hypersonic Missile

A fractional orbiting hypersonic nuclear weapon offers China similar advantages for a number of cogent reasons. First off it shortens U.S. response times, perhaps dramatically, unless the United States can field new space-based sensors and orbiting satellite killers that can find and remove China's space-based threats.

The likelihood of space-based missile defenses being deployed anytime soon is unlikely, although China's demonstration of a fractional orbiting hypersonic bombardment system (FOHBS) and its demonstration of new killer satellites suggests the United States is going to have to move forward with countermeasures sooner, rather than later.

Existing U.S. missile defenses (which are few and far between) probably cannot intercept hypersonic glide vehicles, possibly not even detect them.

Milley's Sputnik Moment and China's Nukes

A second advantage for China is for them to have credible leverage over the United States, making it easier for China to pursue non-nuclear aggressive operations primarily in the Pacific. This means the First Island Chain and its crown jewel Taiwan, but beyond that with China making an effort to push the United States forward-deployed forces back from Japan, Okinawa, and possibly even Guam.

China is looking to dominate Asia economically, politically, and militarily. A hypersonic weapons capability like FOHBS demonstrates Chinese technological and military superiority, at least in the eyes of those nations bordering China, but also increasingly in U.S. defense circles, including the Defense Department.

The United States has been very slow in responding to the rise of China's military power. U.S. force deployments have remained more or less the same and few improvements have been made in firepower for U.S. ground, air, and naval forces.

At home the United States is seriously behind both Russia and China in developing and fielding hypersonic weapons, and the United States is not known to be working on a space launched hypersonic glider.

While the United States retains a strong nuclear deterrent, it urgently needs to address how to support and help much weaker U.S. allies who do not have strong military capabilities. While the United States has helped Japan by F-35 sales and coproduction, it has not done very much for Taiwan which lacks stealth jets, submarines or even a first rate coastal defense capability. It appears there is no urgent plan of any kind to build up pro-U.S. forces in the Pacific.

The Pentagon covered up China's FOHBS. China conducted two tests, one in July and the other in August. It wasn't until mid-October when the Financial Times told the world about the Chinese tests and only on Oct. 28 when Milley told Bloomberg Television about the "Sputnik" moment.

Certainly the Pentagon knew about the tests because all space events are carefully tracked and analyzed. And even with the confirmation of the revelations, the administration is silent about what to do about the new threat.

Now there is increasing evidence that "experts" are claiming the Chinese FOHBS is nothing to worry about and "don't have to be a Sputnik moment." Washington's response so far is to maybe "talk" to China and even proposing setting up a "nuclear hotline" as if that would be of any use. It appears the administration is not seriously thinking about any challenge from China.

The lack of any U.S. administration policy and the Pentagon cover up are reasons for profound concern, as is the lack of a coherent U.S.-China policy that can deter China.

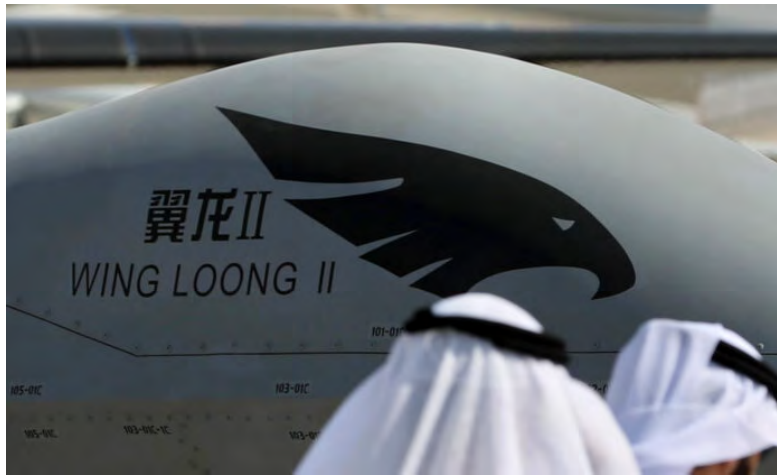


Dr. Stephen Bryen is regarded as a thought leader on technology security policy, twice being awarded the Defense Department's highest civilian honor, the Distinguished Public Service Medal. A senior fellow at the Center for Security Policy, his most recent book is "Technology Security and National Power: Winners and Losers."

Drones Are Winning the War in Ethiopia

by Dr. Stephen Bryen, Senior Fellow, Center for Security Policy; Former Deputy Under Secretary of Defense
2021 December 8 (with permission)

https://www.theepochtimes.com/drones-are-winning-the-war-in-ethiopia_4146525.html



Participants walk past a Chinese made Wing Loong drone displayed during the Dubai Airshow in the United Arab Emirates on Nov. 14, 2017. (Karim Sahib/AFP via Getty Images)

Commentary

The war in [Ethiopia](#) between the left wing [Tigray People's Liberation Front army](#) (TPLF) and the world-recognized democratic government of Ethiopia has entered a new, largely unexpected phase thanks to drones.

Prior to the extensive use of drones, the TPLF (which now wants to be known as the Tigray Defense Force) had advanced far into the most sensitive Ethiopian territory, within around [130 miles from Ethiopia's capital](#), Addis Ababa, triggering a state of emergency.

Then something profound happened: the Ethiopian Air Force began using drones to attack the TPLF's armored personnel carriers, artillery emplacements, and troop transports. At the same time, Ethiopia massively mobilized, calling in militias from around the country to fight the TPLF.

Now the TPLF is [in a major withdrawal](#), as it faced huge casualties and the chance its army could be cut in half by advancing Ethiopian troops. So far at least, the withdrawal has been relatively peaceful (only one known drone strike was carried out, perhaps to hurry along the TPLF pullback). But as the TPLF convoys must operate on roadways and are exposed, one cannot rule out further strikes by the Ethiopian Air Force that could now cause great damage.

The drones are coming from China, Iran and Turkey. At least one top analyst in Pakistan, [Sajit Nadeem](#) suspects the Turkish drones, [TB-2 type](#), the same that were used very effectively in the Nagorno-Karabakh war, are operated by Turkish "experts" flown into Ethiopia.

Today there is a competition among potential suppliers of drones and other military hardware. Initially the UAE provided significant support to Ethiopia, fearing that it would become a base for hostile forces. The UAE bought and sent to Ethiopia Chinese [Wing Loong](#) drones. Based on the U.S. Predator and [Reaper](#), and using the same Austrian-built [Rotax engine](#) (which Austria says is not export controlled), the Wing Loong is both a surveillance and attack drone, carrying both rockets and bombs.

Drones Are Winning the War in Ethiopia

Iran has supplied its own drone, the Quds [Mohajer-6](#). This drone also carries guided rockets and uses a TV and Infrared camera to pick out targets. (The same drone is now being co-produced in Venezuela under license from Iran.)

Turkey is supplying the Bayraktar TB-2. That system, which is also now [co-produced in Ukraine](#), carries two types of guided rockets made in Turkey. The TB-2 has a sophisticated electro-optical target tracking and laser system making it perhaps the most accurate of the drones operating in Ethiopia.

The TPLF is almost powerless against drone strikes as it does not have any counter-drone capabilities.

The biggest change of all is China is now selling drones directly to Ethiopia and could well be financing purchases from other countries, Iran and perhaps Turkey (although that is not proven). Even more significantly, China's Foreign Minister [Wang Yi visited Addis Ababa](#) in early December and made clear China is giving Ethiopia its full support.

China is a major investor in Ethiopia and has much to gain from supporting the Addis government, especially by replacing the United States, which is not supporting Ethiopia (in fact, the Biden administration has secretly been boosting the TPLF, a foolish and completely counterproductive policy).

The war is not over yet, but the TPLF is in a corner. The TPLF says that it is carrying out a tactical withdrawal and will fight on "our convenient ground," suggesting a protracted conflict with guerilla tactics. That certainly can lead to a bloody and long term problem for Ethiopia, but over time Ethiopian forces can, if they want to, push the TPLF back toward its capital Mekelle. Whether TPLF can hold onto public support, given its heavy casualties and its retreat, remains to be seen.

Today the Tigray area, in the north of Ethiopia, is surrounded by hostile forces and can't pursue its leftist, Leninist-style fight without outside support. Perhaps the United States was thinking about military support to Tigray and certainly it was [trying to get relief supplies](#) into the area, although blocked by the fighting.

There is a near famine caused mainly by the war, but there also have been many atrocities, especially those perpetrated by Tigray forces in many of the towns and villages they temporarily dominated.

It is indeed too bad the United States wound up on the wrong side in the Ethiopian war and let China move in and replace U.S. influence. That pattern can now be expected to be perpetuated in all of Africa. But as for Ethiopia, which is the biggest power in the Horn of Africa, it means more trouble keeping the Straits of Hormuz open in the Red Sea, a vital corridor. The United States does have a base in Djibouti, but so do the Chinese, rather neutralizing the U.S. presence.

Overall the Biden administration has pursued a counterproductive and furtive policy in the Persian Gulf and on the African continent, supporting Iran at the expense of our long-time allies Saudi Arabia and the UAE, embracing the Houthis in Yemen (across the way from Eritrea and Ethiopia), and now blundering in Ethiopia.

The arrival of armed drones has turned the tide of the war; but the political tide for the United States ran out even before that because the United States was supporting the wrong side.

(Views expressed in this article are the opinions of the author and do not necessarily reflect the views of The Epoch Times or AIAA.)

Turkish drones could decide who wins a Ukraine war

Russia placing high-stakes bet its Pantsir mobile air defense system can best Ukraine's Turkey-made Bayraktar armed drones

by Dr. Stephen Bryen, Senior Fellow, Center for Security Policy; Former Deputy Under Secretary of Defense 2021 December 22 (with permission)

<https://asiatimes.com/2021/12/turkish-drones-could-decide-who-wins-a-ukraine-war/>



Turkey's military drone, the Bayraktar TB2, has a proven track record in Syria and Nagorno-Karabakh. Photo: AFP / Muhammed Enes Yildirim / Anadolu Agency

Russia says it recently shot down [40 Turkish Bayraktar drones](#) – although they have turned up only one as evidence – in Syria, while [Francis Fukuyama](#), a leading American political scientist at Stanford, says the transfer of Turkish Bayraktar TB2 drones to Ukraine could be a “game-changer.”

Which is it?

The Russians are placing their bets based on the [Pantsir](#) short-range and mobile air defense system that has seen action in Syria and Libya. The Turks and Fukuyama base their arguments on Bayraktar's success in Nagorno-Karabakh, Libya and Syria – and more recently in the Ethiopian Tigray war.

But who is right? A lot depends on whether the Russians can actually deliver positive results thwarting drone attacks in the Donbass region in Ukraine. So far, there has been at least [one successful Bayraktar attack](#).

Ukraine's army [destroyed a howitzer](#) with a Turkish-made Bayraktar drone. Allegedly the drone strike came after a Ukrainian soldier was killed by a separatist [122mm D-30 howitzer](#) and another wounded.

In 2015, [the Pantsir-S was deployed to the Donbass region](#), at least temporarily. Then they were pulled back into Russia. While Russia has put Pantsir units into the Crimea, which it annexed, so far it has not moved any to the eastern Ukraine Donbass region.

However, [some think a Pantsir deployment to Donbass](#) is coming soon.

The Pantsir-S is a short-range air defense system (range less than 20 kilometers) that combines 2-stage interceptor missiles and an autocannon (2A38M, 30mm). The original model, Pantsir-S1, has been improved with better radars and electronics.

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The newer models may have been introduced with Russian forces in Syria. Reportedly the Russians have also added an electro-optical targeting system to Pantsir, providing an alternative in cases where the radar is jammed.

Each Pantsir unit carries 12 missiles (type 57E6 or 57E6-E export). Each missile is composed of a booster rocket and the missile itself, which has a fragmentation warhead. Flight guidance is provided entirely by the ground station.



A Pantsir-S air defense missile system at an exhibition in Vladivostok, Russia. Photo: AFP / Vitaliy Ankov / Sputnik

Russia masses forces

Russia has assembled a large fighting force around Ukraine which may have also been expanded into Belarus. This is a modern strike army that has heavy armor, shock forces, full air and missile support and mobile air defenses that include Pantsir and other air defenses (like the BUK).

[Disclosed CIA estimates](#) are that the Russian force, when fully composed, will consist of about 100 battlefield tactical groups made up of some 175,000 soldiers. Russia has [also mobilized reservists](#), an unusual step.

Yet Russian President Vladimir Putin's concern about the Bayraktar – he has spoken to Turkish President Erdogan about the sale to Ukraine – suggests the Russians are more likely to keep adding to the Donbass separatist forces instead of a full-scale military invasion, or at least Putin wants to keep both options.

Against a heavy Russian strike, the few Bayraktars in Ukrainian hands could not conceivably blunt a Russian advance, even if they sustained no losses. But if the conflict stays as it is, with creeping increments on both sides, the arrival of the Pantsir can be expected to counter the Bayraktar drones.

But are the Russian claims about Pantsir correct? Is it a Bayraktar killer?

The official Russian line is that the Bayraktar is an easy target because it is big, flies slow and can easily be tracked. The Russians also assert that “average” operators using Pantsir can knock out Bayraktars.

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The Bayraktar TB-2 is a large drone with a wingspan more than an F-16. The wingspan of an F-16 is 33 feet, or 10.06 meters. The Bayraktar wingspan is 39 feet, or 11.9 meters. It is also slow flying – roughly 80mph, or 129kph – and not stealthy.

The hard evidence on Pantsir S performances comes from Syria and Libya. In Libya and Syria, as many as 23 Pantsir systems were knocked out, many by Bayraktar drone strikes.



The [Pantsir-S](#) is very mobile, but prone to having its system jammed. Photo: WikiCommons

The game-changer

At least one Pantsir was hit under transit and another destroyed in an aircraft hangar in Libya, but others were operational. In Libya, some Pantsir units were manned by the secretive Russian mercenary group [Wagner](#) – aka PMC Wagner, ChVK Wagner or CHVK Vagner – so the suggestion that the operators lacked experience or were unprepared is not credible.

It did not start out the way it ended in Libya and Syria. In the early phases, Pantsir was able to knock out drones of different types, including Bayraktars. But then something changed. Turkey introduced a system, the [Aselsan Koral electronic warfare system](#), that successfully jammed the Pantsir radar system.

This left the Pantsirs as sitting ducks.

There isn't any doubt the Russians have been trying to recover from the failure of the Pantsir-S system in Libya and in Syria. The heavy losses, particularly to Turkish drones, is a real sore spot for the Russian producers, who are promoting export sales, and for the prestige of Russian military technology.

Coupled to the devastation of air defense systems Russia supplied to Armenia – knocked out by Israeli loitering munitions such as [Harop](#) and by Bayraktar drones – Russian claims on behalf of its air defense superiority suffered after devastating performance failures.

Turkish drones could decide who wins a Ukraine war



A Bayraktar TB2 unmanned combat aerial vehicle at the Victory Parade in Baku. Photo: WikiCommons

Russia supplied Armenia with the S-300, 9K33 Osa, 2K11 Krug, S-125 Neva, Buk M2, Strela 10 and 2K12 Kub, plus ZSU-23-4 anti-aircraft guns, almost all of them destroyed.

Does Russia have an answer to Turkish drones now being deployed by Ukraine's military? That will depend on whether the new version of Pantsir – designated Pantsir SM, introduced in 2019 – can be jammed by Ukraine's forces and whether the Bayraktar can be jammed by the Russians.

It is well known that Russia has [put in place many jammers of its own, capable of knocking out GPS channels](#) and cutting communications between Bayraktar drones and ground stations. Without communications, the Bayraktar system cannot function.

As things now stand it is not possible to know, beyond Russian and Turkish marketing of their respective products, whether Bayraktar will be a game-changer in Ukraine. Given what the Russians have learned and their experience in electronic warfare, the best bet is the Bayraktar will not be very effective, even if the Russians never invade.

The Mystery of the Christmas Star

by Ron Miller, Space Artist, Author and Co-Producer of Chesley Bonestell: *A Brush With The Future* (www.chesleybonestell.com)

There is one subject that has fascinated both astronomers and space artists for a very long time, and it is a subject that—once every year—is hard to ignore: the **Star of Bethlehem** (also known as the **Christmas Star**) and what it might have been.

Over the centuries many astronomers have been fascinated by the story of the Christmas Star. It is first mentioned in Matthew 2:1-2 which, in the King James Version, reads "Now when Jesus was born in Bethlehem of Judæa in the days of Herod the king, behold, there came wise men from the east to Jerusalem, saying, Where is he that is born King of the Jews? for we have seen his star in the east, and are come to worship him."



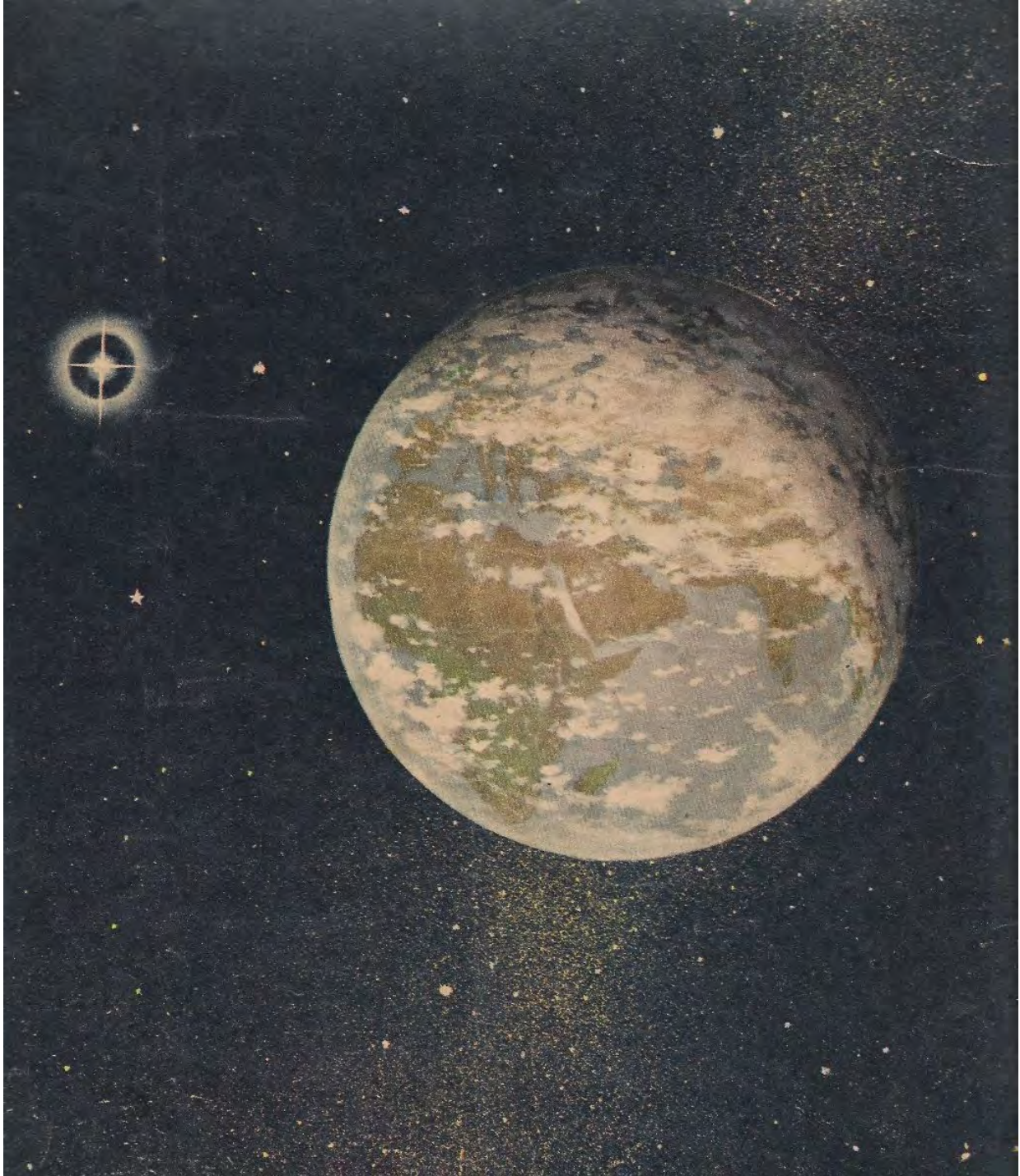
Credit: Google Art Project

A Franco-Flemish painting circa 1400 depicting the arrival of the Magi with the guiding star above.

The passage suggests that it may have been an actual star—or at least some sort of heavenly body—that the Magi saw. Many astronomers have wondered: if there was a Christmas star, what might it have been? Possibilities are complicated by the question: Just when was Jesus born? There are no clear Biblical references. Today, most scholars believe the birth of Jesus occurred sometime between 4 and 7 BC. Consequently, there have been many suggestions regarding the possible nature of the Christmas Star.

Chesley Bonestell (1888-1986) was both artist and astronomer but was not a particularly religious man. In fact, he was a self-proclaimed agnostic. However, he did create one illustration of the Christmas Star. It appeared as an inside illustration in the December 23, 1951 issue of *This Week Magazine*.

The Mystery of the Christmas Star

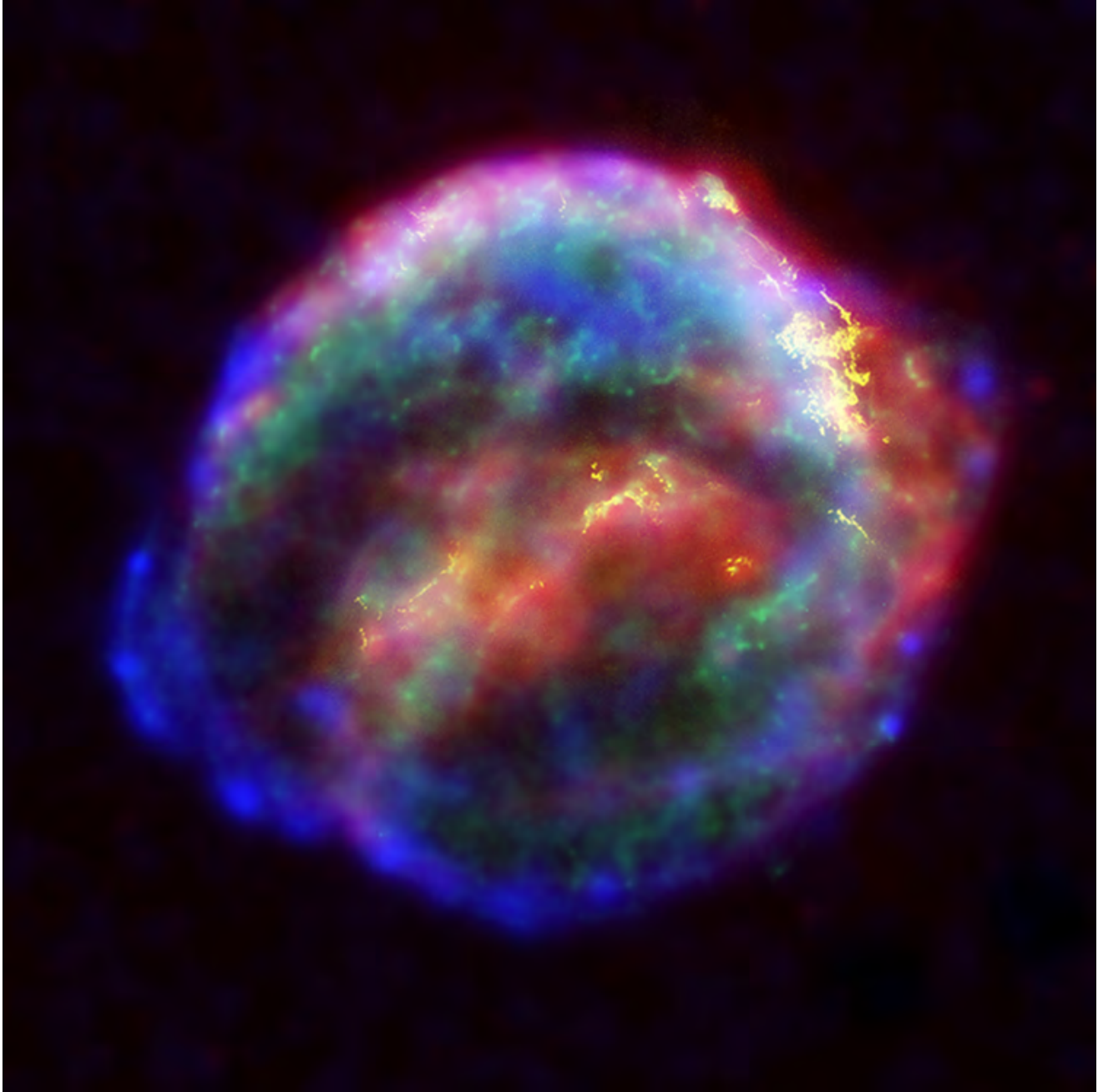


Credit: This Week Magazine

The Christmas Star (1951) by Chesley Bonestell.

One idea was that the Star of Bethlehem was in fact a **supernova**: an exploding star. This would have been a one-time event that would have appeared in the night sky for only a relatively short time. However, astronomers have found no remnants of a supernova from the period nor was the appearance of one recorded by other cultures.

The Mystery of the Christmas Star



Credit: NASA

The remnants of a supernova, as seen in this composite photograph from the Hubble Space Telescope, Spitzer Space Telescope, and Chandra X-ray Observatory. The explosion of this star was witnessed by astronomer Johannes Kepler in 1604.

Among the most famous naked-eye supernovas were those observed by Danish astronomer Tycho Brahe in 1572 and by the German astronomer Johannes Kepler in 1604. Both were visible with the naked eye even in daytime. The sudden appearance of a bright new star in the sky would surely have been noticed by astrologers and taken as a sign of some important event.

The Mystery of the Christmas Star



**In this painting, Bonestell depicts
a nova, seen from a hypothetical nearby planet.
From the book, *Beyond the Solar System* (1964).**

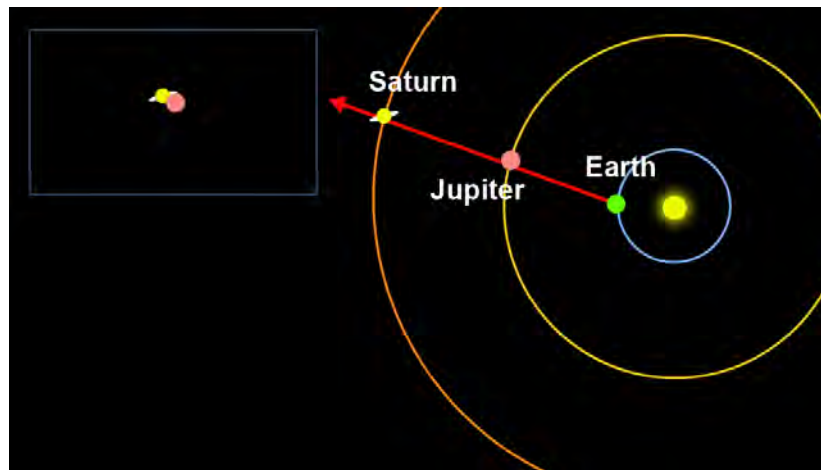
The Christmas Star that the Magi saw may have been a particularly bright comet, something long associated with prophecies and portents.

The Mystery of the Christmas Star



In this small painting, created by Bonestell for himself late in life, Romans are amazed by the sight of a brilliant comet in the evening sky.

Another theory is that the Christmas Star may have been a **conjunction** of **Venus**, **Jupiter** and a real star, **Regulus**. A conjunction is when stars and planets appear very near one another in the sky—sometimes so close as to appear as one.



In a conjunction, two distant objects will appear to the naked eye as one when viewed in the night sky from Earth.

A conjunction of Saturn and Jupiter in December 2020 created a brilliant Christmas star in the winter skies for many nights.

There are other conjunctions that occurred within the decade usually ascribed to the birth of Jesus: A conjunction of just Jupiter and Venus or Jupiter and Regulus are examples. These heavenly bodies would all have had special significance: Jupiter is the king of the planets, Regulus is the Latin word for “prince” and Venus was a symbol of love and fertility.

Here are some illustrative planetary paintings by Chesley Bonestell:

The Mystery of the Christmas Star



Jupiter seen from near its moon, Callisto,
in a 1974 painting by Chesley Bonestell.

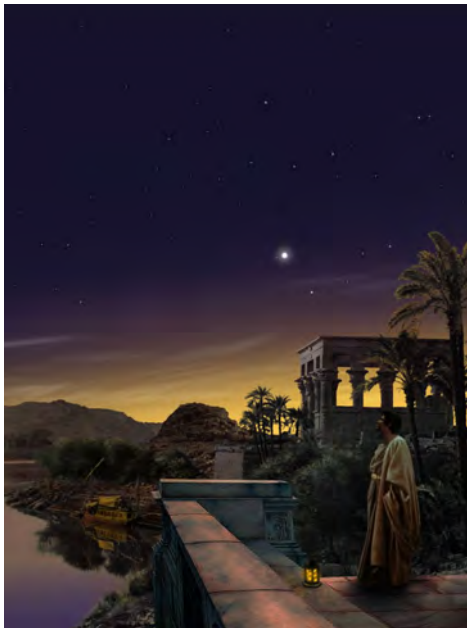


Bonestell published this view of Venus as it might appear to an approaching spaceship in *The Conquest of Space* (1949). The two small stars to the right of Venus are the Earth and the Moon.

The Mystery of the Christmas Star



The Christmas Star as a comet (left) and as a supernova (right) as imagined by author and space artist, Ron Miller.



The Christmas Star as a conjunction of Venus and Jupiter (left) and as a conjunction of Jupiter and Regulus (right) as conceived by Ron Miller.

It's now been over 2000 years since the birth of Jesus and we may never know astronomically what the Star of Bethlehem actually was. Space telescopes like the Hubble and the soon-to-be launched James Webb telescope, will shed more light on the mysteries of the universe. For certain though, the beauty of the cosmos above and the celebration of Christmas are still with us. We should ponder the message that comes so often at this time of year—"Let there be peace on Earth"—and let it find its way further into the hearts and minds of all the peoples on this planet.

For more information about Chesley Bonestell and the award-winning documentary about him, please click here: <https://bit.ly/3etXJtB>

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Review

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The lunar surface as a recorder
of astrophysical processes


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The lunar surface has been exposed to the space environment for billions of years and during this time has accumulated records of a wide range of astrophysical phenomena. These include solar wind particles and the cosmogenic products of solar particle events which preserve a record of the past evolution of the Sun, and cosmogenic nuclides produced by high-energy galactic cosmic rays which potentially record the galactic environment of the Solar System through time. The lunar surface may also have accreted material from the local interstellar medium, including supernova ejecta and material from interstellar clouds encountered by the Solar System in the past. Owing to the Moon's relatively low level of geological activity, absence of an atmosphere, and, for much of its history, lack of a magnetic field, the lunar surface is ideally suited to collect these astronomical records. Moreover, the Moon exhibits geological processes able to bury and thus both preserve and 'time-stamp' these records, although gaining access to them is likely to require a significant scientific infrastructure on the lunar surface.

This article is part of a discussion meeting issue 'Astronomy from the Moon: the next decades'.

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The lunar surface as a recorder of astrophysical processes

1. Introduction

There are multiple scientific reasons for wishing to resume the robotic and human exploration of the lunar surface, ranging from lunar geology to astrobiology (for reviews see [1–4]). Other papers in this volume are mostly concerned with the potential of the lunar surface as a platform for astronomical observations of various kinds, whereas in this contribution we argue that the lunar surface itself will have recorded much of astrophysical interest. In this sense, the Moon itself can be viewed as a giant ‘telescope’ which has been observing and recording astrophysical processes ever since it first developed a solid surface some 4.5 billion years ago.

Several factors combine to make the lunar surface an ideal, and perhaps unique, recorder of a wide range of astrophysical processes throughout Solar System history. Primarily, this is because the lunar surface, unprotected by an atmosphere or, for much of its history, a magnetic field, has been directly exposed to the space environment for most of the last 4.5 Gyr. As a consequence, particles and radiation from space have impacted the lunar surface unimpeded, leaving evidence of their presence in the rocks and soils of the lunar regolith. Examples include solar wind particles and cosmogenic products of solar energetic particle (SEP) events, and thus a record of the past evolution of the Sun, and cosmogenic nuclides produced by galactic cosmic rays (GCRs), and therefore a record of the past galactic environment of the Solar System. The lunar surface may also have accreted material from the local interstellar medium, including supernova (SN) ejecta and material from interstellar clouds encountered by the Solar System in its journey around the Galaxy. Equally as important as the collection of these astrophysical records, however, are lunar geological processes which facilitate their long-term preservation. As a relatively low-mass planetary body, whose own internal geological processes largely ceased billions of years ago, the Moon has preserved an ancient surface with some sampled crustal rocks dating from 4.3 to 4.4 Gyr [4]. Crucially, and unlike the possibly equally ancient surfaces of some asteroids, for most of its history the Moon has been sufficiently geologically active to bury, preserve and ‘time-stamp’ ancient astrophysical records in near-surface rocks and soils. Key processes include the covering of old surfaces by lava flows, pyroclastic deposits and impact crater ejecta blankets, and ancient records preserved by these processes may be recoverable by future space missions [1,5].

2. Lunar records of solar activity

Our knowledge of the past evolution of the Sun comes mainly from theoretical modelling (e.g. [6,7]) and observations of other solar-type stars having a range of ages (e.g. [8,9]). These studies indicate that, whereas the overall solar luminosity was probably only approximately 70% of its present value when the Sun formed, its faster rotation would have resulted in greatly enhanced magnetic activity and associated solar wind and UV and X-ray emission. Thus, we expect the luminosity of the Sun to have increased, and the strength of the solar wind and high-energy photon and particle emission to have decreased, throughout Solar System history. Both of these effects will have had implications for the habitability of the terrestrial planets and, in particular, for the environment within which life originated and evolved on Earth [10]. In addition, the decrease in solar magnetic activity has likely resulted in a corresponding increase in the GCR flux in the inner Solar System owing to the shrinkage of the heliosphere [11], which may also have had consequences for biological evolution on Earth.

Although generally accepted, the low total luminosity of the Sun in its early history is difficult to understand given the evidence for liquid water on the surfaces of early Earth and Mars (i.e. the ‘faint-young-Sun’ paradox [12]). Most proposed explanations invoke enhanced greenhouse gas concentrations in the atmospheres of these planets, although difficulties remain with these models [13]. One suggested alternative explanation is that the Sun may have been more massive, and thus more luminous, in the past, but that it lost several per cent of its initial mass in strong solar winds early in its history [14,15]. Observations of limited mass-loss from young solar-type stars have cast doubt on this proposal [16], but direct measurements of the strength of the solar wind through time could in principle settle the issue. In any case, it is clear that obtaining direct

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observational evidence of solar activity through time would not only provide important insights into the evolution of the Sun as a star, but also improve our understanding of the evolution of the atmospheres, surface environments and habitability of the terrestrial planets. Here, we argue that the near-surface environment of the Moon has the potential to provide this valuable information.

The Sun is an emitter of both low and high-energy particles which may potentially yield information about solar processes and evolution. Solar wind particles (electrons and protons, alpha particles, and trace heavy ions with energies up to approx. 10 MeV) are emitted constantly from the Sun's corona, varying in intensity with solar activity. Higher energy (approx. $10\text{--}10^3$ MeV) particles, often referred to as solar cosmic rays (SCRs) or SEPs, are episodically emitted during solar flares and coronal mass ejection events and are able to produce a range of cosmogenic nuclides when they impact planetary surfaces (e.g. [17–19]).

Analyses of samples returned by the Apollo and Luna missions have revealed that the lunar regolith is an efficient collector of solar wind particles and cosmogenic nuclides produced by SCRs [5,17,20], and that it, therefore, potentially contains a record of past solar activity (e.g. [21–24]). In this context, determining the time dependence of both the flux and composition of the solar wind would be of interest. Whereas the overall solar wind flux is probably the most direct indicator of solar activity, in practice the surfaces of regolith particles can become saturated with solar wind [25], and the solar wind concentration retained in the regolith is influenced by each individual grain's exposure history (e.g. [25–29]). These factors may make regolith particles insensitive to recording bulk temporal flux variations. However, there is evidence that changes in solar activity also affect the relative abundances of ions in the solar wind owing to differential ionization in the solar wind source regions [30], potentially making the *composition* of the solar wind a proxy for solar activity. In addition, early solar activity, and especially the frequency of coronal mass ejection events, may have been responsible for the wholesale depletion of moderately volatile elements such as Na and K in the surficial regolith, which may also be detectable in lunar samples [31].

The implantation depths of solar wind ions into regolith particles depend on the irradiation energy, the mass of the irradiating particles and the composition (chemistry and mineral lattice structure) of the target material (e.g. [32,33]). To access these records, research has focused on the determination of the light element (H, C, O, N) and noble gas isotope (He, Ne, Ar, Kr, Xe) budgets of small rock fragments or individual mineral grains (e.g. [25,34,35]), and analysis of depth-dependent concentrations of these elements within the grains (e.g. [36]) using noble gas acid-step leaching techniques (e.g. [37]) and secondary ion microprobe analyses (e.g. [38]). However, all these efforts are constrained by the nature of the existing lunar sample collection. Of necessity, samples collected by the Apollo and Luna missions (see [39] for a review) were obtained from the present-day surface of the Moon and most have had a very long, but generally indeterminate, exposure to the solar wind. Moreover, unless they have been deeply buried and recently exhumed, surface samples are unlikely to have sampled the most ancient (i.e. several Gyr-old) solar wind that is of greatest interest in investigating early solar evolution, although progress may be made by studying solar wind trapped in ancient regolith breccias dating from that time [40]. Similar considerations apply to inferring past solar activity from cosmogenic nuclides produced by SCRs (e.g. [17,41]).

A key requirement for further progress would be to obtain independent information on the absolute ages of both the start and end times of solar wind and SCR exposure for a range of samples exposed to the space environment at widely different times in the past. Fortunately, just such 'time-stamped' samples likely exist on the Moon in the form of ancient regoliths (hereinafter 'palaeoregoliths') that were exposed to the solar wind and SCRs at discrete times in the past and then covered up, and thus preserved, by later geological processes. Obtaining such samples would greatly help in reconstructing a record of solar activity through time (although the individual grain exposure histories within sampled palaeoregolith deposits will still need to be considered).

Before leaving this discussion of lunar records of past solar activity, we draw attention to the possibility that the vertical temperature profile in the uppermost few metres of the lunar

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regolith may record the history of the solar irradiance over the last several centuries [42]. Such measurements have been applied to reconstructing terrestrial surface temperature changes over similar time scales [43], but implementation on the Moon would yield a measure of solar irradiance variations free of the complexities introduced by Earth's atmosphere and climate. Building on results from the Apollo heat-flow experiments, Miyahara *et al.* [42] calculated that a temperature measurement precision of approximately 0.01°C over a depth range of approximately 10 m would be able to distinguish between different models of the total solar irradiance back to the Maunder Minimum in the mid- to late-seventeenth century. In addition to providing information on very recent solar activity, such measurements may be helpful in understanding the historical evolution of Earth's climate system. Obtaining them will require the drilling of multiple boreholes to approximately 10 m depth (i.e. five times the depths of the Apollo heat-flow measurements of approx. 2 m).

3. Lunar records of galactic processes

As the Solar System has been orbiting the Galaxy for the last 4.6 Gyr it will have experienced a wide range of different galactic environments. The recent review of galactic rotation constants provided by Vallée [44] implies that the Sun traverses the entire spiral pattern of the Galaxy every approximately 720–1760 Myr (where the uncertainty arises from continuing uncertainties in the angular velocity of the spiral arms). As the Galaxy appears to have four major spiral arms [45], this implies spiral arm passages every approximately 180–440 Myr, during which periods the Solar System may have experienced a range of interesting astrophysical phenomena including nearby SN explosions and transits through dense interstellar clouds. Reconstructing this history would provide astronomically valuable information on the structure and evolution of the Galaxy, as well as astrobiologically important information relevant for understanding the past habitability of our own planet [46–49]. Previous attempts to find correlations between spiral arm crossings and Earth's climate and extinction records have been controversial and ambiguous (e.g. [47]), in part be due to a lack of reliable geological records of the Solar System's astrophysical environment.

As reviewed in earlier publications [50,51], the lunar surface is likely to be a much better repository of this information for the same reasons that it will have preserved a record of ancient solar activity—i.e. it has been constantly exposed to the space environment throughout Solar System history, while also manifesting geological processes able to preserve records of this exposure. There are at least three forms that such records might take

- variations in the GCR flux, as recorded in the abundances of cosmogenic nuclides and/or radiation damage preserved in lunar surface rocks and soils
- direct accretion of interstellar matter and/or SN ejecta onto the lunar surface
- variations in the lunar cratering rate driven by gravitational perturbations of the orbits of comets and/or asteroids by changes in the galactic gravitational environment.

(a) Recording variations in galactic cosmic ray flux

Several galactic processes affect the GCR flux in the inner Solar System, operating on a range of time scales [52–54]. On the longest time scales (greater than 1 Gyr), the average GCR flux may reflect the galactic star formation rate, which could provide useful constraints on models of galactic evolution (although it would be necessary to account for an expected secular increase in GCR flux reaching the inner Solar System due to decreasing solar activity [11]). On time scales of the order of a few 100 Myr, the GCR flux is likely to be moderated by an enhanced SN rate, and/or collapses of the heliosphere owing to encounters with dense interstellar clouds, associated with the Sun passing through galactic spiral arms [55–57]. On still shorter time scales (tens of Myr), additional variations in the GCR flux may be expected owing to the oscillation of the Sun about the plane of the Galaxy (with a period of approx. 64 Myr and amplitude approx. 70 parsecs [57]), and possible short-term variations in the size of the heliosphere owing to fluctuations in the

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local interstellar medium density [11]. Stochastic events, such as nearby (say, less than or equal to 50 parsecs) SN explosions, may be superimposed on these secular and quasi-periodic galactic influences. For example, Melott *et al.* [58] have considered the GCR flux at the Earth due to a SN at distance of 50 parsecs and find that the GCR flux could be elevated by between one and three orders of magnitude above its current value for several thousand years (see fig. 1 in ref. [58]).

There are at least two ways in which evidence for GCR variations might be recovered from exposed Solar System samples. Firstly, the high-energy GCR particles leave tracks of radiation damage in exposed materials, the density of which is proportional to the GCR flux and exposure duration [5,22,59]. Secondly, when GCRs interact with atomic nuclei in geological materials a variety of cosmogenic nuclides (e.g. ^3He , ^{10}Be , ^{21}Ne , ^{36}Cl , ^{38}Ar) are produced as a result of spallation and neutron capture reactions (e.g. [60]). Typically, these interactions occur within the uppermost metre or so of the exposed surface (e.g. [5,61]). Results of searches for GCR variations based on meteorite samples have proved to be controversial and inconclusive (e.g. [62,63]), in part because they only record an integrated GCR flux since becoming exposed to the space environment. As Wieler *et al.* [62] note ‘because of the limited sensitivity of the time-integrated GCR signals provided by meteorites, it is wise to consider ... also the differential GCR flux signals provided by terrestrial sediment samples.’ Because terrestrial samples can be dated independently of the cosmic ray flux, this is a potentially powerful approach, but is limited by the relatively recent ages of terrestrial sedimentary samples, the complexity of Earth’s geological and erosional history, and by the fact that the primary GCR flux is attenuated by the Earth’s atmosphere and magnetic field. It is here that the lunar geological record may be able to help.

Several cosmogenic nuclides have been measured in lunar samples (e.g. [22,29,33,64]), and in principle the GCR flux could be inferred by measuring the density of cosmic ray tracks and/or the concentrations of cosmogenic nuclides in exposed lunar materials. In practice, there are a number of complications, especially the generally unknown exposure and shielding histories (i.e. burial depths) of existing lunar samples. These uncertainties would be mitigated if the start and end times of the exposure of a given lunar sample, together with its burial history, could be determined independently. This will likely be key to reconstructing GCR records from which the changing galactic environment of the Solar System might be inferred. As for the solar wind history, the recovery of GCR records from buried palaeoregolith layers would be one possibility, although unlike the solar wind case the development of a surficial regolith may not be required to preserve GCR records because they will also occur at approximately metre depths within crystalline rocks.

We note in passing that a nearby SN explosion would also produce an enhancement in the neutrino flux, which in principle might be detected by damage tracks produced in mineral lattices by nuclei recoiling from a neutrino interaction. It has been proposed to search for such signals in terrestrial rock samples [65], but lunar samples would provide a longer temporal baseline and avoid the neutrino background produced in Earth’s atmosphere.¹

(b) Recording the direct accretion of interstellar matter

In its journey around the Galaxy, the Solar System will have been exposed to a range of different interstellar medium densities. As reviewed elsewhere ([66] and references cited therein), at present the Solar System appears to be located close to the boundary of a low density ($n_{\text{H}} \sim 0.1\text{--}0.2\text{ cm}^{-3}$, where n_{H} is the density of hydrogen nuclei) interstellar cloud (the ‘Local Interstellar Cloud’, LIC), which is itself located in the even lower density ($n_{\text{H}} \sim 0.005\text{ cm}^{-3}$) and approximately 100 parsec radius Local Bubble within the Local (Orion) Arm of the Galaxy. As noted by Cohen *et al.* [11], even small changes in the extent of the heliosphere caused by the Solar System moving in and out of low-density clouds like the LIC may have produced variations in the inner Solar System GCR flux on Myr time scales. On longer time scales, and especially during

¹We thank Joe Silk for this observation.

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spiral arm passages, much denser interstellar environments are likely to be encountered, possibly resulting in the direct accretion of interstellar gas and dust onto the atmospheres and surfaces of the terrestrial planets [67–70].

In their study of the interaction of the Solar System with interstellar clouds, Yeghikyan & Fahr [68] found that for interstellar densities of $n_H \geq 1000 \text{ cm}^{-3}$ the size of the heliosphere would shrink to less than one astronomical unit, leaving the Earth (and the Moon) directly exposed to interstellar material. The frequency with which the Solar System encounters such dense interstellar clouds is uncertain, with estimates varying between approximately 300 Myr and 3 Gyr [68,70–72]. For both astronomical and astrobiological reasons it would be desirable to reduce this uncertainty, and to determine whether or not encounters with dense interstellar clouds have influenced life on Earth. Pavlov *et al.* [67] calculated that if it took 200 000 years to cross a cloud with $n_H \sim 1000 \text{ cm}^{-3}$ then $\sim 1 \text{ kg m}^{-2}$ of interstellar dust would be deposited on exposed planetary surfaces, where it might be identified by distinctive chemical and isotopic signatures. Given the likely ages and relatively short durations of interstellar cloud encounters, the ancient and relatively undisturbed surface of the Moon appears far more likely to retain a record of such events than the dynamic surface of the Earth, especially if they have been preserved within independently dateable palaeoregolith deposits.

In addition to collecting interstellar dust, it is also possible that airless surfaces such as that of the Moon will provide a record of the gaseous component of interstellar clouds through which the Solar System has passed. One possibility would be interstellar pick-up ions, ionized and accelerated within the heliosphere and then implanted into the surfaces of lunar regolith grains [73]. In addition, now that there is abundant evidence for volatiles trapped in permanently shadowed regions (PSRs) at the lunar poles [74], where temperatures are typically of the order of 40 K [75], it may be worth considering whether directly accreted interstellar gas penetrating the inner heliosphere during interstellar cloud traverses could have become cold-trapped onto PSR surfaces; this might be a fruitful topic for future investigation.

As reviewed elsewhere [51], another component of interstellar material that might be identified on the lunar surface would be ejecta from nearby SN explosions. There has been a long-standing recognition that SN occurring within a few tens of parsecs, and perhaps as distant as 100 parsecs, may deposit debris enriched in radioactive elements within the Solar System (e.g. [76–79]), and evidence for two such events, in the age ranges of approximately 2 and approximately 8 Myr, has been reported from ^{60}Fe deposition in ocean sediments [80–82]. Cook *et al.* [83] argued that the lunar surface has some advantages as a collector of SN ejecta as the much slower rate of surface re-working would allow it to accumulate in more concentrated layers than on Earth, and in 2016 this group [84] identified ^{60}Fe enhancements in Apollo 12, 15 and 16 soil samples (collected from depths a few centimetres or less) consistent with the approximately 2 Myr old SN event recognized in Earth ocean sediments. However, where the lunar record is likely to come into its own is in identifying debris from much older SN events than are likely to be preserved by Earth's dynamic surface environment. It is true that this will be complicated by the short half-lives ($T_{1/2} \leq \text{a few Myr}$) of radioisotopes likely to be present in SN ejecta (see table 1 of Fry *et al.* [79] for a summary), but two such isotopes, ^{146}Sm ($T_{1/2} = 100 \text{ Myr}$) and ^{244}Pu ($T_{1/2} = 80 \text{ Myr}$), are sufficiently long-lived to have recorded one or more spiral arm passages. In addition, careful analysis of the decay products of once-live isotopes in SN ejecta (e.g. ^{26}Al , ^{53}Mn , ^{60}Fe , ^{41}Ca) might also reveal the signatures of ancient SN events. We also note that Siraj & Loeb [85] have recently suggested that SN-accelerated dust grains might leave detectable tracks in mineral surfaces exposed at the lunar surface. Any such detections of SN ejecta would be expected to correlate with evidence for enhanced GCR (and neutrino) fluxes, so these different lines of evidence for ancient SN events would be mutually supportive.

Finally, we briefly mention an even more exotic possibility: recently it has been proposed that geological materials may record interactions with some candidates for dark matter particles [86] and, should the Solar System have encountered variations in the density of such particles in its orbit around the Galaxy, the long-lived lunar geological record would appear ideally suited to recording them.

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(c) Recording variations in impact cratering rate

The third category of lunar geological records with the potential to provide insights into galactic processes concerns the changing gravitational environment of the Solar System. It has long been speculated that the changing gravitational potential as the Solar System oscillates above and below the galactic plane, and passes through galactic spiral arms, may perturb the orbits of comets in the Oort Cloud and increase the impact cratering rate in the inner Solar System (e.g. [46,49,55,87–89]). Identifying possible periodicities and/or episodic spikes in the impact cratering rate, which might then be correlated with the Solar System's galactic environment, is problematical primarily because the terrestrial impact record is so sparse [90]. By contrast, the lunar surface holds an essentially complete impact record for most of Solar System history [91]. It follows that, by obtaining and dating samples of impact melt from a sufficiently large number (possibly hundreds) of lunar craters, it ought to be possible to determine unambiguously whether or not temporal variations in the impact flux have occurred and are correlated with galactic structure (although if most of the impactors were from the asteroid belt rather than from comets [92] any galactic signal might be muted). Note that we would expect any galactic periodicity in the cratering rate to be correlated with the GCR flux, which is also recorded on the Moon. Obtaining such a complete impact record for the Moon would also have many other benefits for planetary science, including refining the inner Solar System impact cratering chronology and constraining models of the dynamical evolution of planetary orbits (e.g. [4] and references cited therein).

4. Preserving the record

The Moon will only record a history of past astrophysical processes if evidence for them has reached the surface and then been preserved by lunar geological processes. Before turning to the means of preservation, it is important to consider whether the lunar surface has always been as open to external influences as it is today. There are at least two aspects to consider: the ancient lunar magnetic field, and a possible early atmosphere.

Palaeomagnetic studies of Apollo samples suggest that between approximately 4.2 and approximately 3.6 Gyr ago the Moon had a core-generated magnetic field comparably strong to the Earth's present-day magnetic field (i.e. several tens of μT), which then declined by at least an order of magnitude prior to 3.2 Gyr ago [93]; it may have persisted at this reduced level (approx. $5\mu\text{T}$) until about 2.5 Gyr ago, finally ceasing (less than $0.1\mu\text{T}$) sometime before approximately 1 Gyr ago [94]. As a consequence, at least during the early part of this time period, the Moon's surface would have been partially shielded from the solar wind, so this would need to be taken into account in interpreting the most ancient solar wind records; possibly samples collected close to palaeomagnetic poles, where the magnetic field lines would tend to channel charged particles to the surface, would be preferred for such studies. On the other hand, high-energy GCRs, and uncharged particulate material (e.g. SN ejecta and interstellar dust particles) would not be expected to be significantly affected by an early lunar magnetic field. The presence of an ancient lunar atmosphere would potentially impede a wider range of exogenous material from reaching the surface, including some fraction of the primary GCRs. Given the Moon's low gravity, its only realistic opportunity to accumulate an atmosphere would be during periods of intense volcanic activity when the rate of magmatic degassing might transiently exceed the rate of atmospheric loss. Based on these arguments, Needham & Kring [95] estimated that a transient lunar atmosphere having a surface pressure of up to approximately 9 mbar (i.e. 1.5 times higher than the current atmospheric pressure on Mars) might have persisted for approximately 70 Myr at the peak of mare volcanism. On the other hand, Wilson *et al.* [96] have argued that the intervals between individual mare eruptions (approx. 20 000–60 000 years) would have been too long for such a transient atmosphere to accumulate. In any case, it appears that any ancient lunar atmosphere would only have affected the accumulation of astronomical records on the Moon's surface for geologically brief periods approximately 3.5 Gyr ago.

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Assuming that they reach the lunar surface unimpeded, the various astronomical records discussed in this paper will only have survived in detectable quantities if geological processes have acted to preserve them. This is especially true of material deposited directly onto the surficial regolith (e.g. solar wind particles, interstellar pick-up ions and accreted interstellar material) because otherwise these records will be disturbed and diluted by the continuous comminution and overturning (gardening) of the regolith by the unremitting impact of small meteoroids [20]. Owing to the deeper (order metre) penetration depths of GCRs, the record of cosmogenic nuclide formation, required to reconstruct variations in the GCR flux, is probably less sensitive to surficial regolith processing, but any record dating back hundreds of millions of years will still need to be protected from the disturbing effects of larger meteorite impacts. To illustrate this point, consider the solar wind and cosmogenic nuclei extracted from surface regolith samples collected by the Apollo missions. Solar wind and cosmogenic noble gases have been extracted from regolith samples collected at all six landing sites (see [33] for a recent review). However, these regoliths have mostly been developed on surfaces with ages exceeding 3 Gyr (e.g. [97]) so any evidence for temporal variations within them will have been smeared out by impact-induced gardening during these vast spans of time. Some exceptions are provided by samples collected on the ejecta blankets of young impact craters, such as South Ray crater (Apollo 16; estimated age 2 Myr), Cone crater (Apollo 14; 25 Myr) and North Ray crater (Apollo 16; 53 Myr), but these estimated ages [91] are mostly derived from cosmic ray exposure, so are not independent of the GCR fluxes that we seek to determine.

What we really need is to identify materials (e.g. palaeoregoliths) that were once exposed at the lunar surface for a known duration and which were subsequently covered by overlying material so that they have been isolated from the space environment ever since. Fortunately, there are at least three geological processes that will have acted to cover, and therefore preserve, pre-existing surfaces throughout lunar history:

- eruption of low-viscosity basaltic lava flows
- deposition of pyroclastic deposits around sites of explosive volcanism
- emplacement of impact crater ejecta blankets.

There are pros and cons associated with all three preservation mechanisms, which we now discuss.

(a) Lava flows

Basaltic lava flows cover approximately 17% of the lunar surface, mostly on the nearside, and their generally low viscosity and apparently laminar flow [98,99] suggests that palaeoregolith layers may be preserved beneath or between them. Once sampled, basalts can be dated to high accuracy using standard radiometric techniques (e.g. [97]), so the ages of palaeoregoliths trapped between lava flows could in principle be well constrained [5]. However, most mare basalts appear to have been erupted within the relatively narrow time interval between about 3.8 and 3.3 Gyr [100] (although older lava flows may be buried by younger ones now exposed at the surface), and there is no evidence for large-scale basaltic volcanism more recently than approximately 1 Gyr ago. It follows that palaeoregoliths dating from the last approximately 1 Gyr, which more or less encompasses the Solar System's most recent traverse of the galactic disc, are unlikely to be preserved between lunar lava flows unless younger, smaller scale, eruptions have occurred. In this context, it is worth noting that small patches of basaltic lavas, apparently erupted within the last 100 Myr, may have been identified on orbital imagery [101]. However, although these localities could potentially preserve valuable astronomical records from an important time interval, such young lavas are unexpected on the basis of our current understanding of lunar geology and the original interpretation of some of these features has been questioned [102]. Clearly further work to determine whether or not basaltic lava flows with ages less than 1 Gyr exist on the Moon would be desirable.

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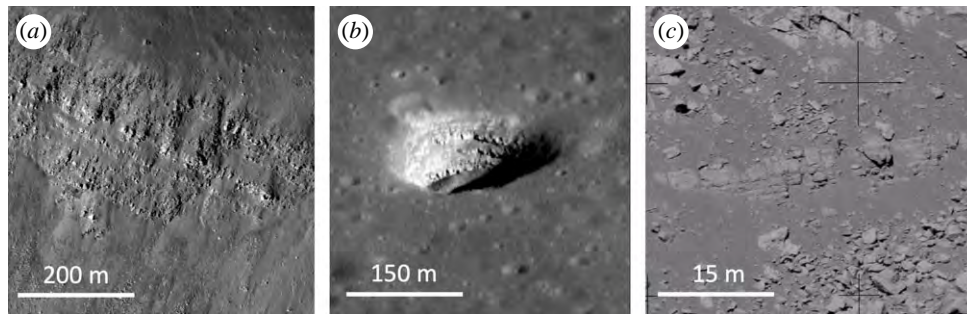


Figure 1. (a) Mare basalt stratigraphy in Mare Serenitatis exposed in the wall of the 16 km diameter impact crater Bessel (21.8° N, 17.9° E; LROC image M135073175R/NASA/GSFC/ASU). (b) Similar layering exposed in walls of a collapse pit in Mare Ingenii on the farside (36.0° S, 166.1° E LROC image M184810930 L/NASA/GSFC/ASU). (c) Metre-scale basalt layers exposed in the wall of Hadley Rille (26.1° N, 3.6° E) photographed by Apollo 15 astronaut David Scott using a 500 mm focal length lens; the outcrop is about 1300 m from the camera (NASA image AS15-89-12104).

Probably the main disadvantage of lunar lava flows as preservers of astronomical records within buried regolith layers is the heating of the regolith substrate by the overlying lava when it is emplaced. Detailed studies of this process [103] indicate that the uppermost approximately 20 cm of regolith covered by a 1 m thick lava flow would likely experience at least partial degassing of implanted volatiles, with thicker lava flows requiring approximately proportional thicker regolith to provide adequate insulation. This sets a lower limit to the thickness of palaeoregoliths able to preserve a good record of solar wind and other implanted volatiles. As regolith production rates are thought to be in the range $1\text{--}5\text{ mm Myr}^{-1}$ (where the lower value is the estimated present-day rate and the higher value relates to fresh basaltic surfaces approximately 3.8 Gyr ago [104,105]), it follows that fresh surfaces would need to be exposed for tens to hundreds of Myr to accumulate regoliths thick enough to shield implanted volatiles from an overlying lava flow. These long regolith accumulation times would lead to a loss of temporal resolution for any astrophysical records they contain. However, it is worth mentioning the recent suggestion [106] that degassing of some mare lavas may result in the formation of metre-thick fragmented layers, ‘auto-regoliths’, on their surfaces. If present, these would assist in the preservation of volatiles should they subsequently be covered by younger lavas. We also reiterate that a thick palaeoregolith is less of a necessity for the preservation of non-volatile records (e.g. heavy nuclei delivered as SN ejecta and some of the less mobile cosmogenic nuclei produced by GCRs) as these may be preserved within layered basalts lacking interbedded regoliths (such as those shown in figure 1).²

We illustrate the concept of palaeoregolith preservation and dating with the aid of a prominent lava flow on the surface of Mare Imbrium (figure 2). Here, a younger lava flow overlies older mare basalts, so we would expect a palaeoregolith layer to be preserved underneath it. This palaeoregolith layer will contain material reaching the surface of the Moon in the time period between the emplacement of the under- and overlying lavas. Ideally, radiometric dating of returned samples would provide these ages, but as none have yet been obtained from this region we have used standard crater size-frequency distribution (CSFD) measurements to model the ages of these flows (for details see electronic supplementary material). Based on our CSFD measurements, the underlying basalts have an absolute model age of $3.30^{+0.04}_{-0.05}$ Gyr, while the overlying lava flow has an absolute model age of $3.03^{+0.12}_{-0.17}$ Gyr. We, therefore, hypothesize that sandwiched between these two lava flows there will be a trapped palaeoregolith layer containing records of the solar wind, SCRs, GCRs and possibly other astronomically valuable records,

²Although insulation provided by even a thin regolith may be helpful in preserving more volatile GCR products (e.g. ^{36}Cl , $^{37,39}\text{Ar}$) and in preventing the annealing of radiation damage tracks (we thank one of our referees, Gregory Herzog, for this observation).

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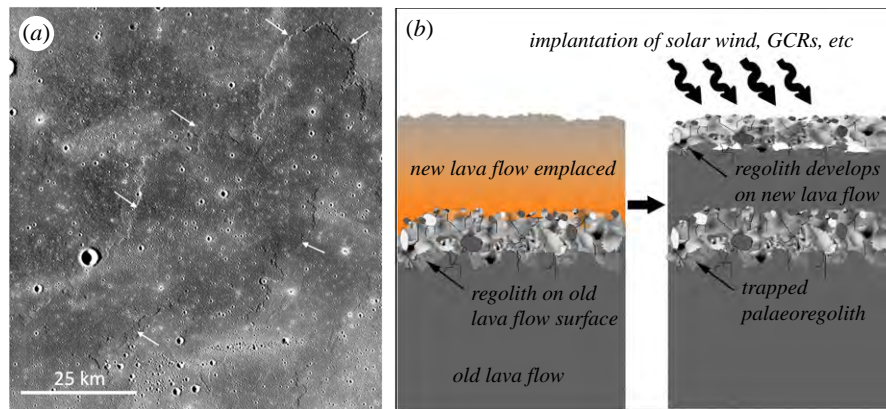


Figure 2. (a) A prominent lava flow (arrows) on the surface of Mare Imbrium (31.5° N, 338.0° E; Kaguya Terrain Camera/JAXA). Based on CSFD measurements (see electronic supplementary material), we obtain an absolute model age of $3.03^{+0.12}_{-0.17}$ Gyr for this lava flow, and an age of $3.30^{+0.04}_{-0.05}$ Gyr for the older lava flows over which it has flowed, so we expect an approximately 3 Gyr old palaeoregolith to be trapped between the two (see text). (b) Schematic illustration of the trapping of a palaeoregolith layer by an overlying lava flow; a palaeoregolith such as this would be expected to contain solar wind, GCR, and other astrophysical records that were implanted during its time on the surface, meanwhile a new regolith develops on the younger lava flow and captures more recent astrophysical records. (Online version in colour.)

that reached the surface of the Moon within the approximately 300 Myr period separating the emplacement of these two lava flows.

Estimating the extent to which any underlying palaeoregoliths will have been heated by overlying lava flows such as this, as well as drawing up plans for sampling them, requires an estimate of the lava flow thickness. In this case, the CSFD of the underlying surface shows that all measured crater sizes have been resurfaced by the upper lava flow, yielding a minimum flow thickness of approximately 20 m (see electronic supplementary material). If emplaced as a single lava flow of this thickness the modelling of Rumpf *et al.* [103] would imply that a palaeoregolith below it would need to be several metres thick in order to prevent thermal degassing of solar wind and other trapped volatiles. Such a thick regolith is unlikely to have been generated in the approximately 300 Myr available given the estimated $1\text{--}5\text{ mm Myr}^{-1}$ regolith formation rates. On the other hand, there is evidence, for example, layers exposed in the wall of Hadley Rille (figure 1c) that some mare basaltic lava flows are built up of multiple thinner (approx. 1 m thick) layers, and if this were the case here it would help reduce the propagation of heat into an underlying regolith [103]; the same would apply if the underlying lava had developed a fragmental ‘auto-regolith’ on eruption [106]. In any case, as stressed above, non-volatile and some GCR-produced cosmogenic nuclides are much less susceptible to thermal disturbance and are likely to be preserved even under such a relatively thick lava flow.

We stress that we have here merely used these Imbrium lava flows as an example. The comprehensive mapping and dating of mare basalts presented by Hiesinger *et al.* [100] indicate that there are hundreds of large (greater than or equal to 50 km in size; fig. 17 of [100]) lava flows on the lunar surface spanning the age range approximately 4.0–1.0 Gyr, and doubtless many thousands of smaller examples such as that discussed here, all with the potential to preserve underlying palaeoregolith layers with a correspondingly wide range of ages. Moreover, as noted above, stacks of layered lava flows (figure 1) have the potential to preserve some astronomically important records (e.g. the GCR flux) in the absence of interleaved palaeoregolith layers. That said, unless evidence for small-scale basaltic volcanism within the last approximately 1 Gyr is confirmed (e.g. [101]), lava flows are unlikely to preserve astronomical records within this timeframe.

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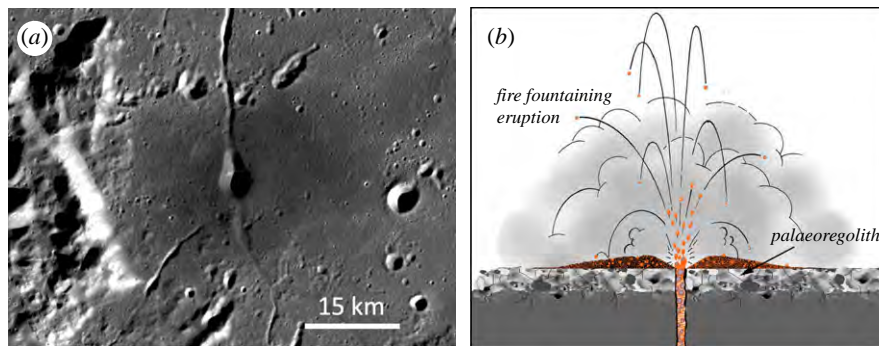


Figure 3. (a) Dark pyroclastic materials surrounding a presumed volcanic vent in the Schrödinger Basin on the lunar farside (75.3° S, 139.2° E; LROC image/NASA/GSFC/ASU). (b) Schematic illustration of a pyroclastic eruption covering a pre-existing regolith to preserve a palaeoregolith underneath (adapted with thanks from LPI CLSE Higher Education Resources). (Online version in colour.)

(b) Pyroclastic deposits

In addition to the effusive eruption of low-viscosity mare basalts, lunar magmatic processes have also resulted in occasional explosive or pyroclastic volcanism [107,108]. The resulting pyroclastic deposits are fine-grained units of basaltic glass fragments mantling surfaces around volcanic vents (figure 3), with sizes ranging from approximately 10 km² to approximately 50 000 km² and thicknesses estimated at several metres [107,109]. McKay [110] has argued that pyroclastic deposits may be the best preservers of palaeoregoliths owing to their relatively gentle mode of emplacement. Moreover, because the small (typically tens of micrometres in diameter) basaltic glass fragments that make up the deposits would have mostly cooled and solidified before impacting the surface, the buried regolith would not be subject to the thermal disturbances associated with burial by active lava flows.

The main disadvantage of pyroclastic deposits in the present context is the ancient, and relatively brief, time periods in which they formed, dating from the main phase of lunar mare volcanism with an estimated age range of 3.8–3.2 Gyr [100,110]. While doubtless preserving valuable records of the early Sun, palaeoregoliths buried by currently identified pyroclastic deposits are, therefore, unlikely to preserve more recent galactic influences on the Solar System. As in the case for basaltic lava flows, a search for more recent pyroclastic deposits would be valuable.

(c) Ejecta blankets and impact melt deposits

Impact cratering has been continuous throughout lunar history [91], so palaeoregoliths covered by crater ejecta blankets and/or impact melt deposits (figure 4) have the potential to preserve records from more recent times than those covered by lava flows or pyroclastic deposits. This will be especially important if we seek well-resolved temporal records for the Solar System's most recent orbit around the Galaxy. Dating the emplacement of crater ejecta blankets could be achieved by sampling and radiometrically dating associated impact melt (e.g. [111–113]). Importantly, such ages would be independent of assumptions regarding the GCR and solar wind fluxes that we wish to reconstruct from the underlying palaeoregoliths. If the pre-existing regolith was developed on a basaltic lava flow, this too could be sampled and dated, thereby locating the palaeoregolith sandwiched between lava flow and ejecta blanket in a well-constrained time window.

Although impact melt deposits have the potential to preserve palaeoregoliths in the same way as lava flows, they suffer from the same potential disadvantage of thermally disturbing volatile

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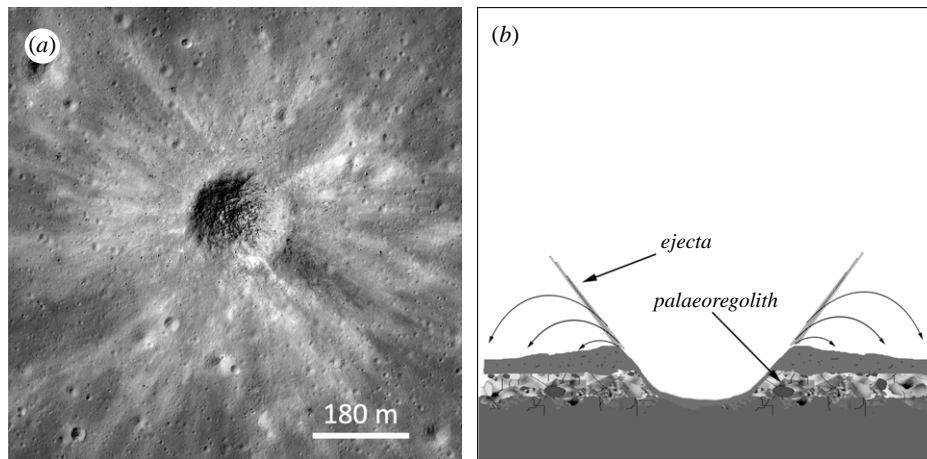


Figure 4. (a) An unnamed fresh 185 m diameter impact crater in Mare Nubium (20.9° S, 350.3° E; LROC image M183588912R; NASA/GSFC/ASU); note the prominent ejecta blanket. (b) Schematic illustration of a crater ejecta blanket covering a pre-existing regolith to preserve an underlying palaeoregolith.

records. The same may be true of palaeoregoliths buried by thick ejecta blankets from large craters which may contain significant volumes of impact-heated materials [114]. On the other hand, the ejecta of small craters is not thought to be at a high temperature when emplaced, so the main uncertainty in their value as preservers of buried palaeoregoliths is the degree to which the pre-existing surface is mechanically disturbed in the process. As the ejecta is mostly emplaced ballistically [115], this is likely to depend on the size of the impact and the distance from it, and may be quite variable. It is also likely to disturb some records more than others, with very surficial records (e.g. solar wind, pick-up ions and SN ejecta) being more disturbed than deeper-lying cosmogenic nuclides produced by GCR interactions. Further work on the mechanical and thermal effects of impact ejecta emplacement would be desirable.

5. Locating and accessing the record

Gaining access to these astronomical records will present considerable technical challenges. There are two main aspects: identifying the most promising locations where such records are likely to be preserved, and accessing and sampling these locations.

(a) Locating the records

We have argued that the astronomical records we seek will be preserved in sub-surface layers, such as buried palaeoregoliths or lava flows, that were once exposed at the lunar surface. Practical considerations suggest that an initial search must be based on surface features accessible to remote-sensing techniques that are indicative of the likely presence of suitable sub-surface deposits. Examples include the geological mapping and dating of surface lava flows (e.g. [100]), pyroclastic deposits (e.g. [107]), and the ejecta blankets of small Copernican-aged craters. In addition, high-resolution images of the lunar surface have revealed multiple locations where sub-surface layers outcrop in the walls of rilles, craters and collapse pits ([99]; figure 1). Studies of areas where small impact craters have penetrated overlying materials to reveal sub-surface boundaries may also help identify suitable locations [116], as would orbital ground-penetrating radar measurements [117]. Ultimately, it will probably be necessary to visit a sub-set of identified localities with robotic or human explorers employing geophysical techniques, such

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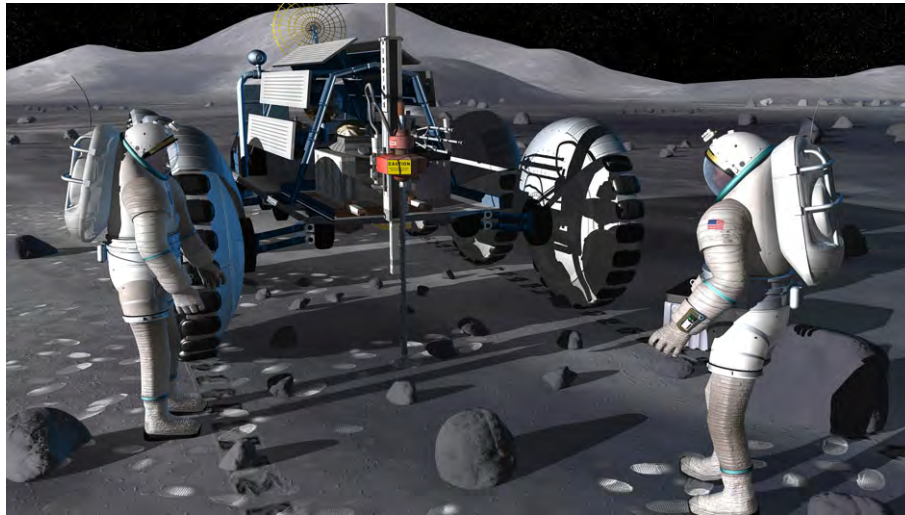


Figure 5. Artist's concept of astronauts supervising a lunar drilling system. Such a capability would permit access to the sub-surface, for example, to extract palaeoregolith samples containing ancient solar wind and GCR records, and is an example of how astrophysics, among other sciences, could benefit from establishing a human-tended research infrastructure on the Moon (image credit: NASA). (Online version in colour.)

as ground-penetrating radar [118,119] or refraction seismology [120], to confirm the existence of suitable sub-surface deposits and to assess the practicalities of sampling them.

(b) Accessing the records

An optimal architecture for accessing and sampling sub-surface deposits would provide for the following capabilities [50,51]:

- ability to deploy equipment at a wide (preferably global) range of locations on the lunar surface
- surface mobility, ideally with a range of several tens of km around a given landing site (for example, this would permit access to the boundaries of lava flows having a wide range of ages; see e.g. the mare basalt maps provided by Hiesinger *et al.* [100])
- detection of sub-surface palaeoregolith deposits (e.g. using ground-penetrating radar or active seismic profiling [119,120])
- access and sampling of outcrops on steep slopes such as crater walls or entrances to collapse pits (e.g. [121])
- drilling from 10s of metres to perhaps approximately 100 m depths (for a review of suitable planetary drilling technology see [122,123])
- return of samples to Earth for analysis; the quantity required will depend on the number and types of sites (e.g. palaeoregolith layers) sampled, but based on the analysis of Shearer *et al.* [124] we estimate this to be approximately 100 kg for each exploration mission or sortie (which would presumably visit multiple individual localities; compare with the 110 kg returned by the Apollo 17 mission).

Although some of these capabilities might be achievable with suitable designed robotic missions (e.g. [121]), as argued elsewhere (e.g. [1,2]) large-scale exploratory activities such as these would be enhanced by renewed human operations on Moon (figure 5). Especially enabling would be the creation of one or more permanently, or semi-permanently, occupied scientific research stations on the lunar surface, as exemplified by the 'Moon village' concept advocated by the

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Director General of the European Space Agency [125]. The creation of such an outpost would offer significant opportunities by providing a scientific infrastructure on the lunar surface, just as human outposts in Antarctica facilitate research activities across multiple scientific disciplines [126–128].

6. Conclusion

The Moon is likely to preserve a rich historical record of astrophysical processes relevant to understanding the evolution of the Sun and its changing galactic environment. In order to access these records, it will be necessary to collect samples from sub-surface strata that were directly exposed to the space environment at known times in the past and for known durations. Such geological records undoubtedly exist on the Moon but accessing them will require a greatly expanded program of lunar exploration. Ideally, this will include the eventual establishment of Antarctic-style research stations to support large-scale exploration activities. Such a research infrastructure would also support a wide range of other scientific activities on the Moon [2,4], including, in the present context, observational astronomy and astrophysics.

Data accessibility. Additional data can be found in the associated electronic supplementary material.

Authors' contributions. I.A.C. conceived the paper and drafted most of the manuscript. K.H.J. provided most of the expertise relating to solar wind in the lunar regolith and produced the diagrams illustrating palaeoregolith preservation. J.H.P. and H.H. performed the CSFD measurements of the Imbrium lava flows. All authors provided intellectual content and critically reviewed the whole manuscript prior to submission.

Competing interests. We declare we have no competing interests.

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New eCar Chilowsky

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ABSTRACT

After claiming that the technologies of the 21st century must be, more or less, renewable, a brief summary of the turbulent adventure of Constantin Chilowsky, russian emigrant (co-inventor with Paul Langevin of the sonar), presented in 1915 his last invention to French Army. His disposal consisted in equipping the front point of a shell with a device in order to at least equals the range of the reputedly unbeatable German shells. By taking this last invention, and adapting it to the exigencies of our century, it becomes possible to reduce the drag of any vehicle moving in the air, and even, paradoxically, to create thrust. All the numerical simulations carried out with world-renowned companies* attest to the validity of this aerodynamic device known as the "drag reducer" whose new coefficient: $0 < C_Y < 1$ measures the efficiency of this device. $C_Y = 0$: drag neutralized.

CONTEXT: At the beginning of the 21st century, the world communication network is totally deployed, to the effect that by road, by air & space or by sea almost no point on the planet remains isolated. But in parallel to this frenetic activity, the activation energy is almost exclusively thermal, and thus essentially oil-based. It goes without saying that this precious non-renewable liquid will eventually dry up, even if we cannot predict when it will end.

Moreover, a "whistle-blower" has been widely diffused over more than half a century of activity through the environmentalists. In fact, our commitment to "cleaner, quieter, lighter, recyclable, etc. etc." has been repeatedly under assault to the point that our consciousness has now fully integrated these data from our first conceptual pencil movements! Thus, forced or partisan, all the actors of the industrial world as well as academic are now claiming this approach. The time has come for electric vehicles (at worst, "hybrids"), and soon for hydrogen. This is how fashions work, and even Techno-Science is not immune to them...

It goes without saying that we adhere to this always "cleaner, less noisy, etc.", and we are going to demonstrate it with this new concept: the "New eCar Chilowsky": pronounced in english "eCar" in reference

to the mythological Greek Icarus, with here the "New" to mean that the "flight plan" will be respected this time without any rerouting...

1 CHILOWSKY EFFECT

Origin: All this information in reference is extracted from this book written by Dominique PESTRE / CNRS



Éditions which takes again the essential genesis of this very turbulent "adventure" Chilowsky, with a "y" as attests the orthography taken again at the time of the deposit of its official patent as it appears below.

"When the new Minister of Public Instruction, Paul Painlevé, on November 13, 1915, decreed the mobilization of scientists and laboratories, his objective was to give an impulse to technical invention in order to improve the equipment and armament of soldiers By attaching the *Direction des inventions intéressant la défense nationale* to his ministry, Painlevé did not mask his intention to remove inventive activity from the military sphere and place it under the control of scientists, "the only ones capable", according to him, "of recognizing or detecting inventiveness in a project and of distinguishing between a chimerical project and an idea that could be realized.

"... The reality is however more complex.... because the physicist is led to work with the artillery engineers during the year 1918 only because of the difficulties experienced by the Chilowski team in the realization of the "ogive flame shell"... But, while in the summer of 1917, the physicist succeeded in developing a reliable method for the expertise of the Chilowski shell (the high-speed wind tunnel), the artillery engineers did not hesitate to use the new device for tests on their projectiles, old or improved.

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"The idea of using a current of air at very high speed was taken up again in 1916, at the suggestion of Mr. Chilowski by Mr. Langevin in order to verify certain combustion phenomena "

"The archives of the artillery allowed later to identify ... the named Sewall, engineer-mechanic of the American army assigned to the "operation Chilowski" in the autumn 1917. As for the Russian inventor, Constantin Chilowski, known to historians of science for his collaboration with Langevin on underwater wave detectors, he remains an enigmatic character..."

"Finally the invention of the Chilowski ogive flame shell and its expertise by Paul Langevin, it seemed useful to us to trace the stages of this little-known operation, which illustrates through its dead ends and failures, but also its achievements and fruitful productions, the random construction of the policy of inventions and scientific mobilization, ... defined by ... Paul Painlevé..."

THE OGIVE FLAMMATE SHOT OF Chilowski: THE "PROJET-PHARE" OF THE DIRECTION OF INVENTIONS (1915-1918)

"However, ... at the Ministry of Armament in September 1917 and the attachment ... of the Directorate of Inventions, Experiments and Technical Studies (DIEET), a more rigorous mode of management ... to meet the instructions of action and efficiency recommended by the government Clemenceau. ... Jules-Louis Breton, who ensured for the years 1915-1917 ... the continuity of the work of the Directorate of Inventions, but also the inventors responsible for projects, such as Chilowski ... the chronology of the work of the team in charge of the realization of the Chilowski shell and to analyze the essentially conflicting relationships that were established between the different actors ... ".

"The project to invent the "ogive flame shell", presented in December 1914 by Constantin Chilowski to the Commission of Inventions, would probably not have received such an enthusiastic welcome without the active support of Painlevé. The Chilowski shell is one of the 780 inventions selected between 1915 and 1918, but its inventor enjoys a privileged status... A character "full of charm and susceptibility [...], bubbling with ideas and showering the Directorate with countless projects"... He would have played the role of fetish inventor for the Management. One element, underlined by Jules-Louis Breton, seems to us more decisive: Chilowski was a student of Nicolaï Joukowski - a reference that makes sense when one analyses Painlevé's interest in aviation and the theoretical research of the Russian mathematician in the field of aerodynamics."

"Let us remember that Paul Painlevé became interested in aviation as soon as the first motorized flights took place in 1906 and became its active and prominent advocate in the political class where he made his entrance in 1910..."

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"In this field, Painlevé refers to the founding work of Gustave Eiffel, who had just set the first milestones of experimental aerodynamics by designing the first operational wind tunnel to carry out tests on models of aeroplanes "at a fixed point".

"The work of this mission consisted in translating Joukowski's aerodynamics course into French and Gustave Eiffel's research published in 1912 into Russian. Thus, ... Painlevé was able to recruit several of Joukowski's students ... first of all Constantin Chilowski, whom he associated as an inventor with the Directorate of Inventions in 1915, then Wladimir Margoulis, whom he appointed in 1917 to the scientific direction of the Eiffel Laboratory, and Dimitri Riabouchinski (Joukowski's pupil and patron forced to emigrate by the Bolshevik revolution), to whom he gave a job as scientific advisor at the Aerotechnical Institute of Saint-Cyr that same year.

The principle of the Constantin Chilowski ogive flame shell thus entered the sphere of the Inventions Directorate According to Jules-Louis Breton, the project of the warhead flame shell that the Russian inventor presented in December 1914 to the experts of the Inventions Commission was adopted in February 1915 with great enthusiasm.

"The invention is based on the idea that by equipping a shell with a device producing a flame at the front of the ogive in the first few seconds of its trajectory, the heat of the flame, by expanding the atmosphere at the front of the shell, should decrease the resistance of the air to the advancement of the projectile and thus increase its range "considerably"... One can also think that by mentioning gains in range of more than 50 % ... the inventor awakened the hope of giving the French artillery a firepower equivalent to that of the German artillery, considered at that time as very superior. ... If the effects of combustion in a stream of air at very high speed remain an unexplored field, the phenomenon of shockwave caused by a projectile when its speed exceeds that of sound (it results in a sudden increase in air resistance to the advancement of the projectile) is on the other hand well known to ballisticists, since the work of German physicist Ernst Mach. "

" ... Chilowski has from the spring of 1916 important financial, material and human resources In 1917... the chemistry laboratories of the École Normale Supérieure and the Sorbonne were made available to the team. The Chilowski project can therefore be considered, because of the exceptional support it received during the mobilization of 1915, as the flagship operation of the Direction des inventions.... The results obtained with large-caliber Marine shells are considered sufficiently encouraging (with a 20% increase in range)" "More than two years passed ... before its inventor, the unassailable Chilowski, was concerned with the work of his collaborators... But, ... the team of the rue d'Ulm, which worked in an autonomous way, has no more

intention of being accountable to Chilowski than to his ministerial supervision..."



"...for the mission to work, Loucheur must also neutralize Chilowski and resolve the delicate issue of the patent (Fig.1). Jules-Louis Breton... is therefore charged with negotiating the purchase of the patent from the inventor "to preserve the interests of the French State".

"... after having been the flagship operation of the Directorate of Inventions, the Chilowski shell

adventure was immediately forgotten with the return to peace, even though the ogive flame shell was still alluded to ... when the first bulletin of the National Office of Scientific Research and Inventions (ONRSII), which succeeded it in 1921, was published."



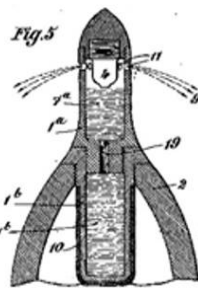
Video realized in 1917 by the Direction des Inventions of the CNRS : <http://videothèque.cnrs.fr/doc=4277>

2 WHY A CENTURY OF ABSENCE?

The reading of this historical reminder on the intricacies of politics, science, technology and the human condition, by its last paragraph, is enough to understand, or at least, to note the reasons for the abandonment of this formidable invention. In fact, without stubbornly sticking to this thermal approach of reducing the drag of a vehicle moving in the air, we have decided to create, this time, an aerodynamic shield on the front end of the vehicle, whose function will be to deflect the air molecules from their impact on the material part of the vehicle, and thus to reduce its drag significantly. Of course, we will have to check that the energy needed to produce the compressed air to generate this shield is much less than the one used to produce thrust directly, or better: at a given energy level, the drag reduction due to this device can even produce ... thrust!

To do this, we first solicited companies very competent in numerical simulations since we knew nothing about the sensitivity

- * SIEMENS/CD Adapco
- * Sophia Antipolis/CEMEF



of the various parameters that regulate this Chilowsky effect.

3 NUMERICAL SIMULATIONS

CD Adapco: This American company was created by a Boeing spinoff, and acquired by Siemens in 2016. CD Adapco was suggested to us during our first association (2009) with EADS Innovation Works/Yann Barbeau (now Airbus Innovation). We developed several specifications concerning first of all a technological breakthrough thruster according to the Humphrey cycle, but also on the Chilowsky and Coanda effect, whose developments we continued at our own expense, and thus after the interruption of our collaboration with EADS...

Centrale Paris: We have also benefited for 3 consecutive years from the support of 1st year students at Centrale Paris as part of their programme (ENJEUX); this has also enabled us to carry out wind tunnel tests, and thus to verify the interest in developing a Chilowsky drag reduction device

Xplorair Aerospace - MSC Software: similarly, with MSC Software (partner of Dassault Systèmes/Lyon). These simulations at our own charge allowed us to confirm the interest of application of such a device of reduction of the drag. If we insisted on obtaining results validated by the very sophisticated models used in numerical simulations, it is because the advantages of such a device are so important that we decided to refer to multiple approaches...

Mines ParisTech-Sophia Antipolis: In association with Laurent Tapie (son of BT) as an investor in this technology, the CEMEF (Centre de Mise en Forme des Matériaux) entity of the famous engineering school of Mines ParisTech, had solicited me to propose technological subjects in its theoretical aspect to submit to these 1st year engineers. Of course, after having exposed the potential advantages of this Chilowsky effect, a group of students focused on the analysis and the simulations of this effect, under the supervision of the eminent teachers-researchers of the CEMEF.

IPSA: After an intensive cooperation with a number of students from grades 4 and 5 year of IPSA (School of Aeronautics and Space Engineering), we are now in close contact with the 4th year engineering students of ESTACA who are working on 3 of our projects, including a Chilowsky device applied to the electric car.

Other companies: We will not detail the cooperation with Altran, Alten, Sogeti High Tech, and other companies such as **Weare Aerospace**, **Comat Aerospace**, for which we express our sincere gratitude!

4 SIMULATIONS BY CD ADAPCO

We must confess that at the beginning there is a huge confusion, because with the only reading of the figures opposite taken again on the patent deposited by Mr. Chilowsky in 1917, we were then persuaded that the "shield" deployed at the time of the launching of the

powder contained in the front point of the shell had for function to deviate the molecules of external air so that they do not impact the body of the shell (Fig.2). By doing so, the drag was then strongly reduced, and thus to increase the range of the shell. But it is not the case, because in the mind of Mr Chilowsky, the combustion of the powder at the exit of this front point had for only function to increase the temperature of the air, and thus to reduce, by its dilation, the resistance to the advance of this shell. In fact, to strongly decrease the density of the air in contact with the projectile due to this dilatation. As what an error of interpretation can generate a whole new innovation!

In fact, the concept that we have been developing for several years in the conviction that we were, in a way, taking over the Chilowsky patent, is quite different. Let us judge:

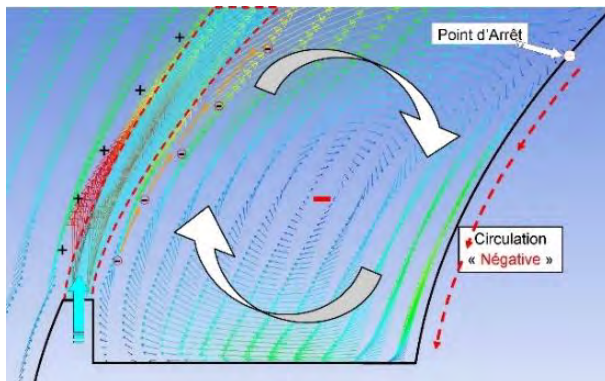


Illustration produced by "Centrale Paris"

Instead of deploying a heat shield, we opted for an aerodynamic shield positioned on the front part of any vehicle (plane, car, train, Ekranoplane) that moves in the air. Thus, this layer of air, by viscosity, drags the molecules that "populate" the cavity, which is only open on its upper part, as shown opposite (Fig.3), so as to create a depression. And it is this depression which produces a thrust which is subtracted from the global drag force to reduce the resistive force. It is even possible to produce - by abuse of language - a "negative drag" as we will see later, and thus paradoxically, to produce thrust!

However, we will keep the name "Chilowsky effect" because undoubtedly our technological aerodynamic device of drag reduction would never have been born without the patent registered by Mr. Constantin Chilowsky in 1917.

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*Sophia Antipolis/CEMEF

5 THE SIMULATIONS ANALYZED



Siemens's Chilowsky Simulations

Simulations performed by CD Adapco in 2017 based on our specifications, which evolved based on interim results.

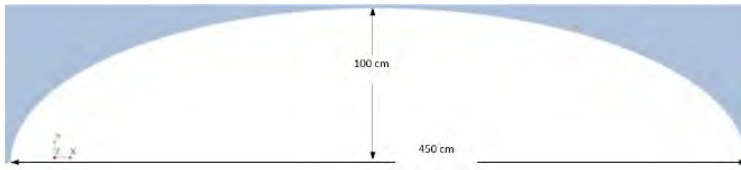
5.1 Some results analyzed:

Simulations de l'effet Chilowsky	
Description du modèle	
Table of Contents	
Description du modèle.....	4
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- Description du modèle	
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Simulations avec déviateur.....	24
Déviateur concave-Vitesse amont 60 m/s-Soufflage 250 m/s-Angle 20° -Distance 10 cm.....	30
Déviateurs concave et convexe- Vitesse amont 60 m/s - Soufflage 250 m/s - Angle 20° - Distance 15 cm.....	44
Déviateur convexe- Vitesse amont 60 m/s - Soufflage 250 m/s - Angle 20° / 30° - Distance 15 cm.....	61
Déviateur convexe- Vitesse amont 60 m/s / 36 m/s - Soufflage 250 m/s - Angle 30° - Distance 15 cm.....	77
Profil elliptique et tronqué- Vitesse amont 60 m/s - Soufflage 250 m/s - Angle 30° - Distance 15 cm.....	89
L'objectif est de simuler l'effet Chilowsky. Pour ce faire, une demi-ellipse sera placée dans une veine numérique. Un flux d'air amont créera une force de traînée sur la demi-ellipse. Il s'agira alors de montrer qu'en présence d'un soufflage situé à proximité du bord d'attaque du profil, il est possible de réduire, neutraliser, voire inverser la force de traînée résultant de l'action du flux d'air amont sur le profil.	

- Dans le cadre de cette étude, les simulations seront en 2D
- Les paramètres investigués seront:
 - La distance entre le bord d'attaque de l'ellipse et le soufflage,
 - La vitesse du flux d'air amont,
 - La vitesse du soufflage,
 - L'inclinaison du soufflage par rapport à la verticale,

But before continuing in the analysis, it is imperative to indicate that we will take into account only the trends in growth or decline because, in addition to freezing the various parameters which seem to us optimized with regard to the minimal drag force, even, negative (thrust), we will have to carry out simulations in 3D, being understood that the present simulations carried out in 2D have a depth of some cells. We will come back to this...

The shape on which all the simulations will be done is a half ellipse of reference, and the blowing tube of 5 mm



of width is at 10 cm of the front point inclined of 20°, and here without concave nor convex deviator:

5.2 Without deviator

This table (Tab. 1) shows the forces exerted on the profile, without blowing, $V_s = 0$ m/s, then with a blowing speed, $V_s = 200$ m/s and $V_s = 250$ m/s. The sign " - " indicates that the total force is opposed to the vehicle's advance. A first observation is that blowing strongly reduces the opposition force, and secondly that the pressure force is decisive in these efforts since going from 200 m/s to 250 m/s multiplies this force by almost 11 while the shear force (friction) is multiplied by only 1.2. At this step, it is not possible to determine the gain compared to a direct thrust because we do not know the depth of the profile (number of cells in order to minimize the calculation time of simulations).

	Force de pression en X (N)	Force de Cisaillement en X (N)	Force Totale (N)
No Blowing	-97.0	-31.2	-128.2
Blowing 200 m/s	-4.1	-50.0	-54.1
Blowing 250 m/s	43.0	-60.3	-17.3

Tableau 1: Blowing without deviator

On the other hand, we can make the following allowable hypotheses:

C_D (half ellipse) = 0.3; $V(\text{front}) = 60$ m/s

$S = h \times L$ ($L = \text{depth}$) = 0.2017 m²; $\rho = 1.177$ kg/m³

In these conditions we will have well:

$$F(\text{ellipse}) = \frac{1}{2} \rho \cdot (S \cdot C_D) \cdot V^2 = 128.2 \text{ N}$$

The direct thrust in continuous flow has the expression:

$$F(\text{direct}) = \gamma \cdot P_{\text{at}} \cdot S_s \cdot M^2$$

P_{at} (atmospheric pressure) = 101 325 Pascal

$$M_1 = V_s/a = 200/340 = 0.588$$

$$M_2 = 250/340 = 0.735; S_s = (0.2017 \times 0.005) = 0.001 \text{ m}^2 \text{ then:}$$

$$F_1 (\text{direct}) = 49 \text{ N} \Rightarrow G_1 = 128.2 - (54.1 + 49) = 25.1 \text{ N } 20\%$$

$$F_2 (\text{direct}) = 77 \text{ N} \Rightarrow G_2 = 128.2 - (17.3 + 77) = 43.9 \text{ N } 34\%$$

In our opinion, these gains are not yet significant enough to impose such a device...

5.3 Contribution of a concave deviator

It became imperative to introduce a deviator (Tab. 2).

Sans déviateur	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
No Blowing	-97.0	-31.2	-128.2
Blowing 200 m/s	-4.1	-50.0	-54.1
Blowing 250 m/s	+43.0	-60.3	-17.3

DEVIA. 10 cm	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
No Blowing	-103.0	-32.6	-135.6
Blowing 200 m/s	+11.7	-50.4	-38.7
Blowing 250 m/s	+64.4	-61.7	+2.7

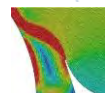
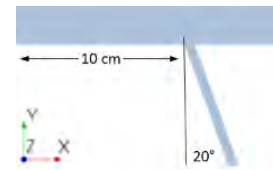


Tableau 2: Blowing with deviator

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With a concave deviator, we immediately see that the gains are much more important, and it is also possible to create thrust (+2.7 N). Using the same calculation procedure, we arrive at:

$$G1 = 135.6 - (38.7 + 49) = 47.9 \text{ N } 35\%$$

$$G2 = 135.6 - (-2.7 + 77) = 61.3 \text{ N } 45\%$$

This concave deviator (Tab. 3) can be redesigned to increase the pressure force, reduce the shear force (friction), and for a much lower non-blowing pressure force.

SANS déviateur	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
No Blowing	-97.0	-31.2	-128.2
Blowing 200 m/s	-4.1	-50.0	-54.1
Blowing 250 m/s	+43.0	-60.3	-17.3

DEVIA. Concave 10 cm	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
No Blowing	-103.0	-32.6	-135.6
Blowing 200 m/s	+11.7	-50.4	-38.7
Blowing 250 m/s	+64.4	-61.7	+2.7

DEVIA. Concave 15 cm	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
No Blowing	-109.2	-32.2	-141.4
Blowing 250 m/s	+69.3	-60.4	+8.9

DEVIA. Concave 15 cm	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
No Blowing	-109.2	-32.2	-141.4
Blowing 250 m/s	+69.3	-60.4	+8.9

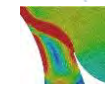
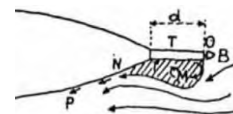


Tableau 3: Blowing with two shapes of deviators

Let's examine this physical phenomenon but with concave & convex deviators and with the same input data. The table above shows all the results, noting that it is possible to create thrust (+), which means (if the rolling resistance of the tires allows it), that the car moves forward by itself.

It also appears that the distance of the blowing tube to the front end (10 cm and 15 cm) of the vehicle is a parameter that must be taken into account. Thus, for the same concave deflector, one observation is evident: the closer the outlet plane of the blowing tube is to the front end of the vehicle, the more the pressure force increases while the shear force decreases! This is what Mr. Chilowsky had observed in his time:



* En diminuant d , l'effet diminue d'intensité, s'annule, puis change de sens, de sorte que pour $d = 5$ mm, on a une action propulsive très nette qui augmente d'intensité jusqu'à $d = 0$.

This table 4 of values confirms the increase in pressure force as the deflector moves closer to the front tip:

DEVIATEUR	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
Concave 10 cm	+69.3	-60.4	+8.9
Concave 15 cm	+64.4	-61.7	+2.7
Convexe 15 cm	+58.6	-60.3	-1.7



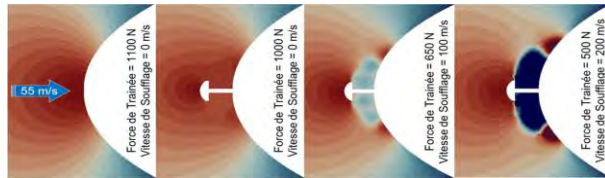
Tableau 4: Two distance of concave deviator

In the same way, the front speed (Tab. 5) also indicates perfectly that the more this speed of displacement is reduced, the more the force of the device would tend to produce positive forces. And this speed of 36 m/s is the one authorized on highway (130 km/h), indicating then that it is possible to neutralize the drag (+0,1).

Vitesse amont	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
60 m/s	+3.8	-62.8	-59.0
36 m/s	+43.5	-43.4	+0.1

Tableau 5: The front speed

This tendency is almost intuitive because the blowing flow will be brought back less abruptly to the aerodynamic breaking point; and the Coanda effect, this time, will be able to operate more easily to the point that this highly energized overlayer will remain in contact with the extrados of the capsule for much longer, thus delaying the eventual turbulence zone. In addition, the air inlet of the compressor naturally tends to aspirate this air, thus helping to keep this blowing layer pressed against the extrados, while avoiding the ingestion of birds



Work done by Mines ParisTech

<https://www.youtube.com/watch?v=lqh0RCIa3GY>

On the other hand, the inclination (Tab. 6) of the supply tube indicates an unequivocal tendency:

Angle	Force de pression (N)	Force de Cisaillement (N)	Force Totale (N)
20°	+58.6	-60.3	-1.7
30°	+3.8	-62.8	-59.0

Tableau 6: Inclination of the tube

The objective is to establish correlations between these different parameters, to define their sensitivities, and to determine the power of the compressor ad minima knowing that from 3 points we will always be able to pass a curve there.

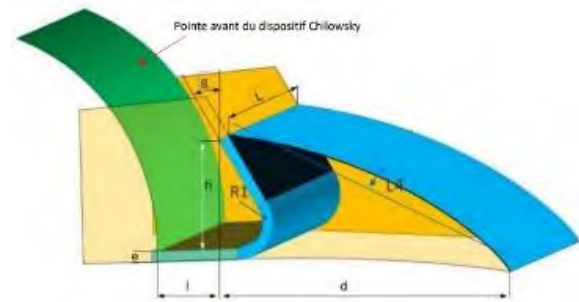
5.4 Preliminary conclusions

We still need to explore some parameters extensions:

- 1) Blowing distance, $l = 0.5$; 5 cm; 10 cm
- 2) Blowing speed, $V_s = 180$ m/s; 200 m/s; 220 m/s
- 3) Inclination of the blowing tube, $\alpha = 0^\circ$; 10° ; 20°
- 4) Front speed: 90 km/h; 130 km/h; 200 km/h
- 5) Shape/dimensions of concave & convex deviators
- 6) Shape of the front tip of the vehicle
- 7) Width of the blowing slot, $e = 2$ mm; 3 mm; 4 mm
- 8) Tests with pulsed blowing

* SIEMENS/CD Adapco

*Sophia Antipolis/CEMEF



Experimental Chilowsky's device

6 NEW COEFFICIENT C_Y

After the coefficient of drag, C_D , after the coefficient of lift, C_L , it becomes possible to introduce the Chilowsky coefficient, C_Y (Y to recall the contribution of Mr. Chilowsky) such as: $-0.1 < C_Y < +1.0$. The sign - to indicate that it is possible to create, paradoxically, thrust instead of drag. C_Y thus measures the efficiency of the device. Such as $C_Y = 1$ means that there is no drag reduction, and $C_Y = 0$ to indicate that the drag is totally neutralized. It will be enough then to multiply the traditional drag force: $F_D = \frac{1}{2} \rho \cdot S \cdot C_D \cdot V^2$ by C_Y .

7 APPLICATIONS - VARIOUS VIDEOS

7.1 s-UAM + Simulator concept (3 minutes):

<https://youtu.be/Ri5ZKH8bnnA>

"s" for "short", i.e. the take-off/landing area will be positioned at the border of the city, and at least 30 km from the center. On landing, the passenger capsule is clipped onto an electric cart to become a piloted or autonomous electric car; the "captain" can take control of it until the rendezvous point. Same process on the way back: The passenger capsule is extracted from the cart and wings are clipped onto the capsule as shown in the educational video. Moreover, throughout the flight, the ground control centers follow the aircraft continuously. Finally, after training on a simulator, the title of "captain" is awarded to the candidate, which authorizes him to remain in permanent radio contact with the head of the ground station.

7.2 New eCar Chilowsky (1 minute):

<https://youtu.be/5yIWYCYzoLA>

Due to the Chilowsky device, it becomes possible to strongly reduce the drag of the electric vehicle, thus increasing the autonomy of the batteries by at least 50% in an aerodynamic way.

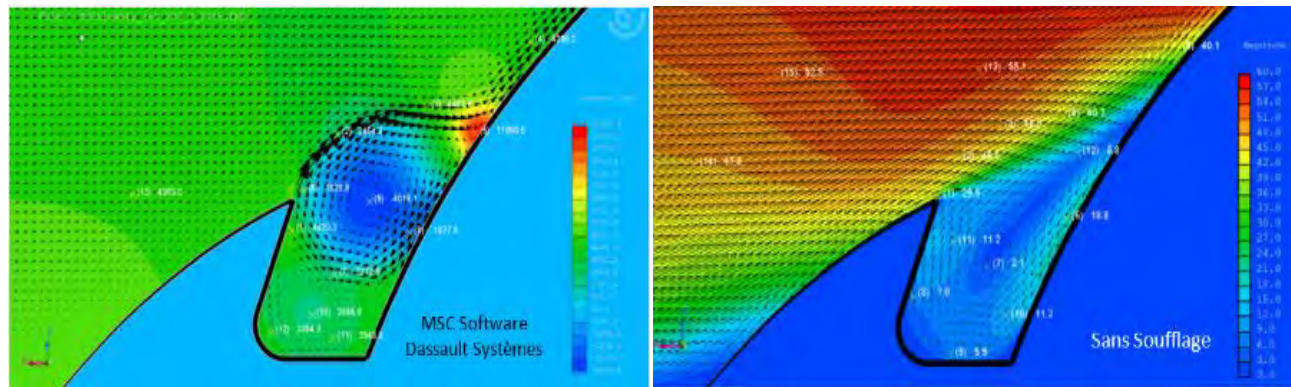
7.3 Take-off aid (1 minute):

https://youtu.be/9vMcdWb_tPQ

This device which, at landing, adapts the flaps of the reverse in order to reduce the distance of rolling and to preserve also the tires, at takeoff, these same flaps, are positioned so as to support the principle of the Ejector (validated experimentally by NASA), and thus to increase the thrust reducing the distance of takeoff **without** overconsumption.

8 SUGGESTIONS AND RECOMMENDATIONS

As soon as the 4th year student-engineers of ESTACA shared in 3 groups, one of which is working on the Chilowsky effect, will be operational, then the complements of simulations such as evoked supra in 5), and even if it is with the Fluent simulation software that the said simulations will be carried out, the essential will be to note the tendencies to the increase or the decrease during the variations of each parameter. If done, we will then be able to determine a set of parameters that we believe will optimize the power of the supercharger in charge of producing the compressed air for the blowing.



- * SIEMENS/CD Adapco
- * Sophia Antipolis/CEMEF

ANNEXE

8.1 Air compressor/supercharger power:

$$P_{\text{Blowing}} \text{ (kW)} = [\frac{1}{2} \gamma \cdot P_{\text{at}} \cdot C_P / \eta \cdot T_{\text{a}} \cdot (\gamma - 1) / a] \cdot (L \times e) \cdot M_S^3$$

$$P_{\text{Blowing}} \text{ (kW)} = 2.83 \cdot L \times e \cdot M_S^3$$

If $L = 73 \text{ cm}$; $e = 0.25 \text{ cm}$ and $M_S (220/340) = 0.647$

$$P_{\text{Blowing}} = 14 \text{ kW}$$

With an overpressure ratio: $\pi = P/P_{\text{at}} = 1.5$

For a centrifugal compressor efficiency: $\eta = 0.85$

$[M_S (180/340) \Rightarrow P_{\text{Blowing}} = 8 \text{ kW and } P/P_{\text{at}} = 1,21]$

The blowing Mach, M_S , as a function of pressure has the expression: $P/P_{\text{at}} = [1 + \frac{1}{2}(\gamma - 1) \cdot M_S^2]^{\gamma/(\gamma - 1)}$

With blowing speed $V_S = 220 \text{ m/s} \Rightarrow$

$$M_S (220/340) = 0,647 \Rightarrow P/P_{\text{at}} = 1,325$$

Taking into account the unavoidable pressure losses:

$$P/P_{\text{at}} = 1,5.$$

Initial data

V : Vehicle speed (m/s)

$S.C_D$ (Frontal area of the vehicle): $1.5 \text{ m}^2 \times 0.2 = 0.3$

F_Z : Weight of the vehicle (N)

F_{RA} : Aerodynamic drag force (N)

F_{RR} : Rolling resistance force (N)

$$F_{RA} = \frac{1}{2} \cdot \rho \cdot (S.C_D) \cdot V^2$$

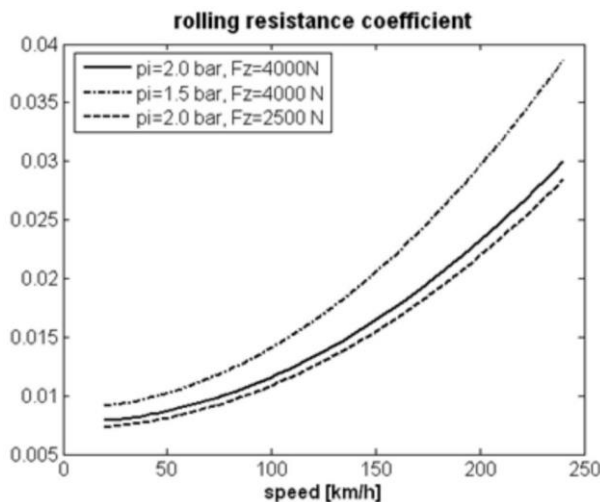
C_Y : Chilowsky coefficient

Expression of the rolling resistance force

$$F_{RR} = 142 \cdot (F_Z/F_{Z0})^{1,273} \cdot (V/V_0)^{0,709}$$

$F_{Z0} = 8000 \text{ N}$ & $V_0 = 33,33 \text{ m/s}$ (120 km/h)

Réf : LTAS - Ingénierie des Véhicules Terrestres/Université de Liège / 2020 – 2021, page 120 figure 3.72 :

**Low Speed Rolling Resistance Force**

For low speeds such as $60 \text{ km/h} < V < 80 \text{ km/h}$, the F_{RR} expression for $6 < F_Z \text{ (kN)} < 8$:

$$F_{RR} \text{ (N)} = [0,00149 \cdot V^2 - 0,15 \cdot V + 15,36] \cdot F_Z$$

$$V = 60 \text{ km/h} \text{ \& } F_Z = 6,83 \text{ kN} \Rightarrow F_{RR} = 80 \text{ N}$$

$$F_{RA} = \frac{1}{2} \cdot \rho \cdot (S.C_D) \cdot V^2 \Rightarrow F_{RA} = 50 \text{ N}$$

$$F_{\text{Total}} = F_{RR} + F_{RA} = 80 + 50 = 130 \text{ N}$$

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High Speed Rolling Resistance Force

For high speeds such as $100 \text{ km/h} < V < 120 \text{ km/h}$, the F_{RR} for $6 < F_Z \text{ (kN)} < 8$:

$$F_{RR} \text{ (N)} = [0,00513 \cdot V^2 - 1,03 \cdot V + 66,44] \cdot F_Z$$

$$V = 120 \text{ km/h} \text{ \& } F_Z = 6,83 \text{ kN} \Rightarrow F_{RR} = 114 \text{ N}$$

$$F_{RA} = \frac{1}{2} \rho \cdot (S.C_D) \cdot V^2 \Rightarrow F_{RA} = 200 \text{ N}$$

With the **Chilowsky** device, $C_Y = 0.3 \Rightarrow F_{RA} = 60 \text{ N}$

But at this speed, the lift force developed by the small lateral wings (whose weight can be negligible) is such that $F_{LWings} = 1170 \text{ N}$; on the other hand, the drag force, at this incidence of 13° , is worth: $F_D = 19 \text{ N}$

Calculation of the battery's mass

D : Distance covered (m)

$E_{\text{Spé}}$: Specific Energy (Wh/kg)

V : Vehicle speed (m/s)

$$S.C_D: 1,5 \text{ m}^2 (\text{Frontal surface}) \times 0,2 = 0,3$$

F_Z : Weight of the vehicle (N)

F_{RA} : Aerodynamic drag force (N)

F_{RR} : Rolling Resistance Force (N)

$F_{RA} = \frac{1}{2} \rho \cdot (S.C_D) \cdot V^2$; Aerodynamic Resistance Force (N)

F_{RR} at low speeds

C_Y : Chilowsky coefficient

About this coefficient C_Y , as there will always remain a residual drag due to the wings, the rear wheels, the underbody and the vortex drags:

$$0,2 < C_Y < 0,5 \Rightarrow C_Y = 0,3$$

New eCar Chilowsky data

$D = 600 \text{ km}$; $E_{\text{Spé}} = 250 \text{ Wh/kg} = 0,9 \text{ MJ/kg}$

V highway = 120 km/h ; $F_Z = 8000 \text{ N}$; $C_Y = 0,3$

$$F_Z = 8000 \text{ N} \Rightarrow F_{RR} = 134 \text{ N} \text{ \& } F_{RA} = 200 \text{ N}$$

$F_{RR} + F_{RA} = (134 + 200) = 334 \text{ N}$ and with the **Chilowsky** device, $C_Y = 0.3 \Rightarrow F_{RA} = (200 \times 0.3) = 60 \text{ N}$, hence:

$$F_{R\text{Total}} = F_{RR} + F_{RA} = 134 + 60 = 194 \text{ N} \Rightarrow E_{\text{Total}} = D \times F_{R\text{Total}}$$

$$\text{Total } E = 6 \cdot 10^5 \times 194 = 11,64 \cdot 10^7 \text{ MJ} \Rightarrow M_{\text{Battery}} = 129 \text{ kg}$$

Note also that at this speed, the wings reduce the total weight of the vehicle, $\Delta F_{Wings} = 1177 \text{ N}$ which is subtracted from the total weight, that is to say:

$$F'_Z = 6830 \text{ N} (8000 - 1170) \text{ and thus } F'_{RR} = 114 \text{ N:}$$

$$F_{R\text{Total}} = 114 + 60 = 174 \text{ N}$$

which imposes a mass of batteries: $M_{\text{Battery}} = 116 \text{ kg}$

Advantages of the side wings

In addition to facilitate the introduction of passengers into the cabin, these wings (NACA 4415) with a $C_L = 1,5$ and $C_D = 0,0237$ for an angle of incidence $\alpha = 13^\circ \Rightarrow$

$F_L = 1170 \text{ N}$ and $F_D = 19 \text{ N}$, for $V = 120 \text{ km/h}$, and

$$S = 2 \times 0,5 \text{ m} \times 1,2 \text{ m} \times \cos \alpha = 1,17 \text{ m}^2$$

So, this lift reduces the additional weight of the batteries (for an electric vehicle on freeway), which will reduce this weight aerodynamically: $(142 - 125) \cdot g = 170 \text{ N}$, for a total weight of the vehicle $F_Z = 6830 \text{ N}$ (2 passengers + batteries + ...) and thus a $F_{RR} = 114 \text{ N}$, which will allow to reduce the incidence of the wings and thus the drag:

$$C_D = 0,00021475.\alpha^2 - 0,00196.\alpha + 0,01288$$

$$C_L = 0,0586.\alpha + 0,7382$$

$$5^\circ < \alpha < 13^\circ$$

$$C_L(13^\circ) = 1,5 \text{ \& } C_D(13^\circ) = 0,0237$$

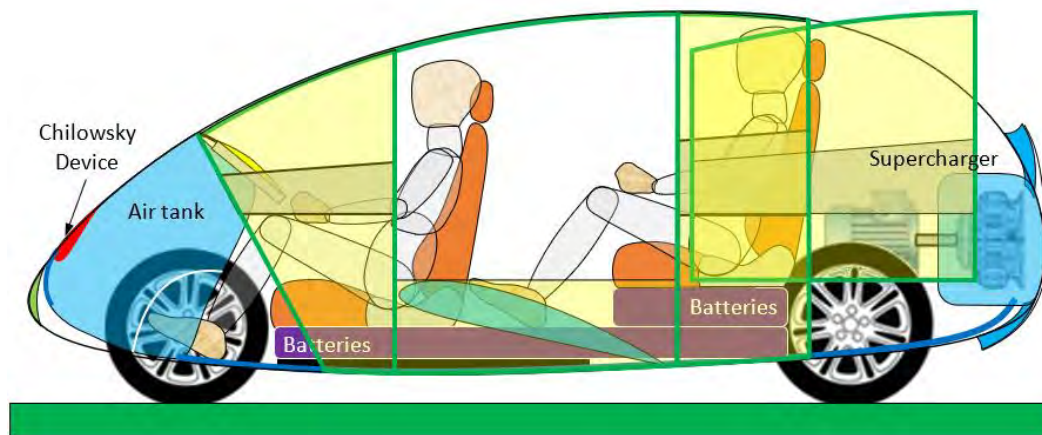
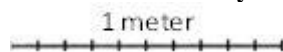
Note: on a distance of 60 km return trip from the takeoff area to the city center with a 30% of reserves, that is to say 80 km, the energy necessary for this trip at a limited speed, $V = 60 \text{ km/h}$ (16,67 m/s), will reduce the weight of the battery, with $F_{RR} = 80 \text{ N}$ and $F_{RA} = 50 \text{ N}$, that is to say the mass of battery: $M_{\text{Battery}} < 12 \text{ kg}$, and especially **without** Chilowsky's device!

Conclusion

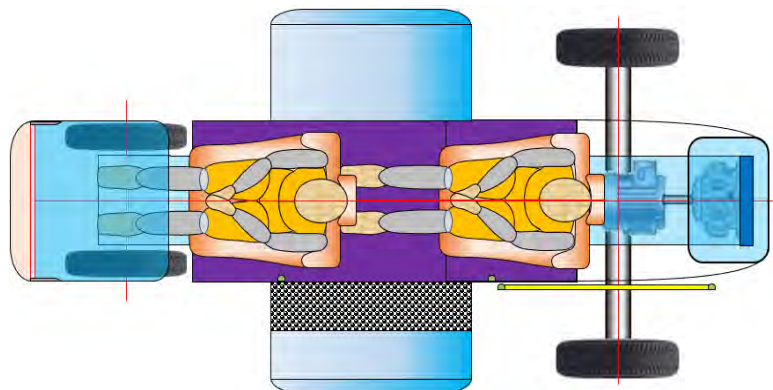
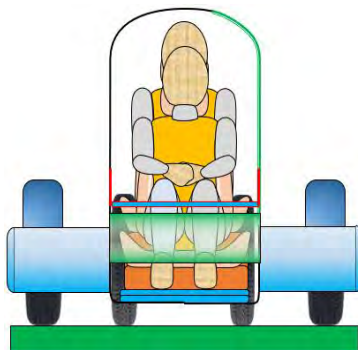
According to the weight of the 2 passengers (150 kg max), the inert mass of the vehicle, the distance (80 km) without recharging the batteries, the specific energy of about 250 Wh/kg (0,9 MJ/kg), at a speed of 60 km/h (or even more?), the on-board computer will constantly adjust the angle of incidence ($5^\circ < \alpha < 15^\circ$) of the side wings in order to reduce the drag for a maximum lift, because they will relieve the total weight of the vehicle.

Note: Contrary to thermal vehicles, electric vehicles have the same weight whatever the distance covered...

New eCar Chilowsky



Aeronautical mannequin: 183 cm



* SIEMENS/CD Adapco

*Sophia Antipolis/CEMEF

Electrostatic Dischargers

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When two electrically charged objects, like the physical body and a device inherit contact with one another, electricity is discharged. This phenomenon is called ESD (Electrostatic Discharge). ESDs generated from the physical body are often of the order of several thousand volts. This high voltage pulse enters the device that's touched, leading to a malfunction or destruction of the IC circuits inside it. In order to stop the destruction of a product or system thanks to the intrusion of ESD into an device that was touched, it's necessary to put in countermeasure components that suppress or remove ESD.

ESD first requires a development of a charge. This happens when two unique materials rub together. One of the materials becomes positively charged; the opposite becomes charged. The positively-charged material now has a charge. When that accusation comes into contact with the legitimate material, it's moved and that we have an ESD. On occasion the heat from the ESD event is extremely hot, although we don't feel it once we are shocked. However, when the charge is released onto a device like an expansion card, the extreme heat from the charge can melt or vaporize the small parts in the card causing the device to fail. Sometimes an ESD event can damage a tool, but it continues to function. This is called a latent defect, which is tough to detect and significantly shortens the lifetime of the device.[1]

Numerous electronic gadgets are defenceless to low voltage ESD occasions. For instance, plate drive parts are delicate to just 10 volts. Hence, makers of electronic gadgets fuse measures to forestall ESD occasions all through the assembling, testing, delivery, and taking care of cycles. For instance, a worker might wear a wrist tie when working with gadgets or may wear ESD control footwear and work on an ESD floor mat

that causes the electrostatic charge to travel into the bottom rather than into the device. Sensitive devices are often packaged with materials that shield the merchandise from a charge.

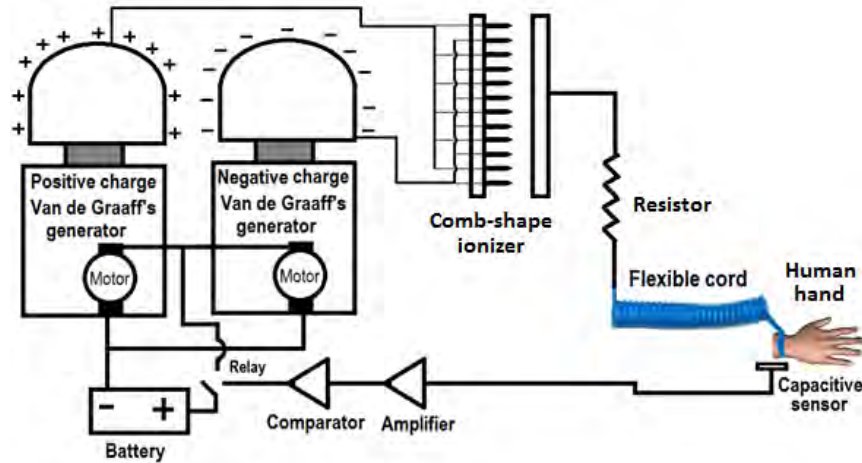


Fig.1 mobile static dissipater[2]

https://www.researchgate.net/figure/Design-concept-of-a-mobile-static-dissipater_fig1_289494371

The electrostatic interaction of an aircraft with the atmosphere could also be a posh phenomenon involving many factors:

- Aircraft factors
- Capacitance
- Shape
- Speed
- Engine characteristics
- Surface materials

In simple terms, the aircraft may be a capacitor that's charged and discharged by various processes. Its electrostatic state is defined by the rates at which this capacitor is charged and discharged, the locations of the charging and discharging, and therefore the amount of charge on the 2 aircraft. The electrostatic state of an in-flight aircraft is summarized by Kirchhoff's law relating all of the charge flow in and out of the aircraft:

The damage of electrostatic discharge (ESD) may be a well-known problem within the semiconductor industry. When the physical body (operator) is in touch with an electrostatic sensitive semiconductor unit during the manufacturing process, damage to the oxide and other active parts of the device is caused by transferring of charge between device and human body. Semiconductor industry adopts preventive and protective approaches by grounding the physical body with a wrist strap connecting to utility ground to neutralize the charge and fixing ESD preventive and protective workstation. Wearing a wrist strap is impractical for the operator and it causes psychological effects because the operator wouldn't wish to be a strap.

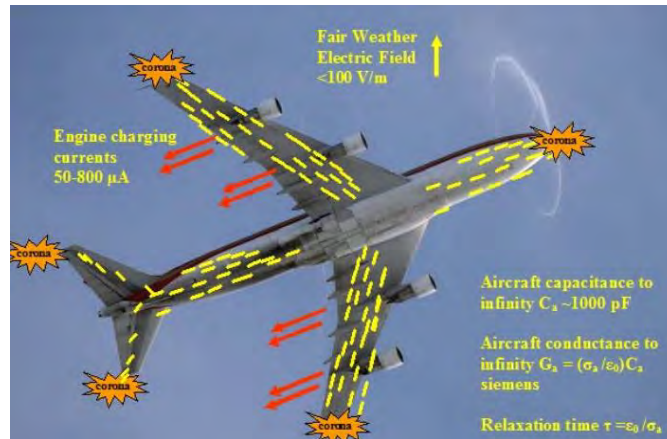


Fig 2 Electrostatic state of aircraft flying in clear air
https://www.ema3d.com/wp-content/uploads/downloads/AEP_3.pdfped.

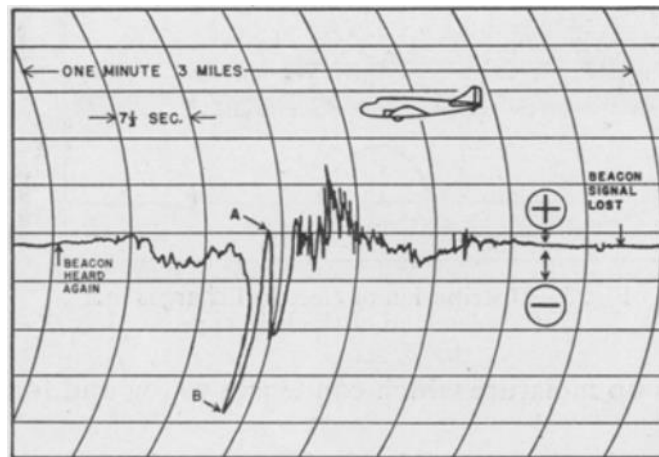


Fig 3 The first known measurement of aircraft charging in flight [3]

Keywords: Electrostatic Discharge, charge flow, vaporize, Semiconductor

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UAV and its operations

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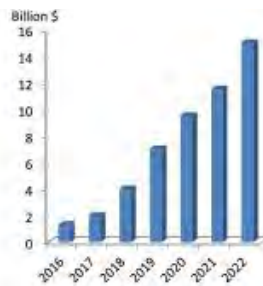
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Unmanned aerial vehicles are utilized in various genuine applications (app) like payload conveyance, traffic checking, moving articles in apparently hazardous climate, and reconnaissance. The utilization of UAVs in any of these app. requires the arranging of achievable and ideal directions for the movement of the vehicles. Way arranging calculations for UAV flights contrast from ground vehicles in that the arranging issues should be tackled in a 3D(three dimensional) arrangement space. Contrasted with two-dimensional spaces, these conditions are dependent upon higher levels of vulnerability and moving deterrents. UAVs will be needed to cooperate progressively with other flying or static items which might show up in their flight ways, along these lines making worldwide way arranging practically unthinkable, as it is practically difficult to completely delineate the arrangement space. In certain applications, UAV and UGV way arranging issues are consolidated for joint assignment execution in complex conditions. UAV way arranging includes planning a flight way coordinated towards an objective with insignificant extensive expenses, i.e., negligible likelihood of being annihilated while meeting the UAV execution imperatives.

UAVs can likewise help make and keep up with correspondence lines between casualties, ground groups, and the control community, and furthermore with other fiasco reaction organizations. Angermann et al. (2011) investigated the chance of quadcopter arrangement trips to make a correspondence network by going about as hand-off chains for view correspondence.

Unmanned aerial vehicles (UAVs), otherwise called drones, are one of the major mechanical advancements of today. A bunch of UAVs is of central premium for its capacities to facilitate alongside the inclusion of enormous regions or coordinate to accomplish objectives, for example, terrain mapping. Coordination and participation in UAV bunches additionally progressively license immense quantities of airplanes to be prepared by a solitary client.

Key Words: UAV, org, 3D, app,



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- ✚ <https://euagenda.eu/upload/publications/untitled-59610-ea.pdf>
- ✚ <https://www.faa.gov/uas/>
- ✚ <https://www.cbinsights.com/research/drone-impact-society-uav/>
- ✚ <https://link.springer.com/article/10.1007/s10064-020-01766-2>

STUDY OF NEURAL SENSING

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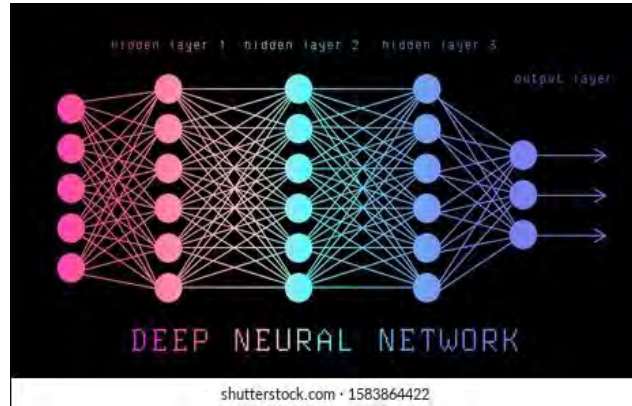
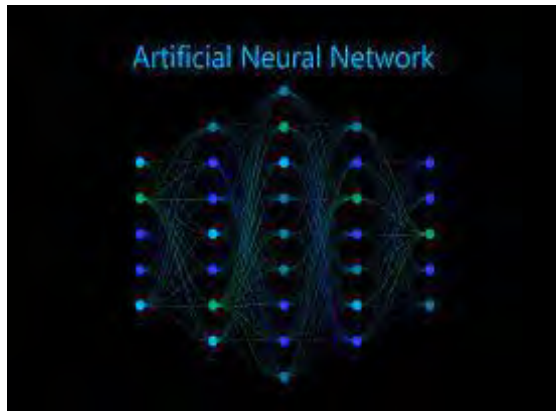
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Artificial Intelligence(AI) refers to the simulation of human intelligence in a machine that is programmed to think and act like humans and is employed for specific purposes. The goal of AI is to create systems that can perform tasks that would otherwise require human intelligence. Building an AI system is a careful process of reverse engineering human traits and capabilities in a machine. AI programming works on three cognitive: learning, reasoning, and self-correction. It gives enterprises insights into operations that may not have been aware of and in some cases can perform tasks better than humans. Particularly when it comes to repetitive, detail-oriented tasks. The application of artificial intelligence is endless. The technology can be applied to different sectors and industries. Technologies like machine learning and natural language processing are all part of the AI landscape. Each one is evolving along its path and can be combined with others to produce results.

The concept of neural networks or artificial neural networks(ANN) has its roots in artificial intelligence. A neural network is a series of algorithms that endeavors to recognize underlying relationships in a set of data by mimicking the human brain's operation. These are computing systems inspired by biological neural networks. An ANN is based on a collection of connected units or nodes called artificial neurons, which loosely model the neurons in a biological brain. Each connection, like the synapses in a biological brain, can transmit a signal to other neurons. An artificial neuron receives a signal then processes it and can signal neurons connected to it. The connections are called edges. Neurons and edges typically have a weight that adjusts as learning proceeds. Neurons have thresholds such that a signal is sent only if the aggregate signal crosses the threshold. Typically neurons are aggregated into layers. Different layers may perform different transformations on their inputs. The signal travels from the first layer(input layer) to the last layer(output layer), possibly after traversing the layers multiple times.

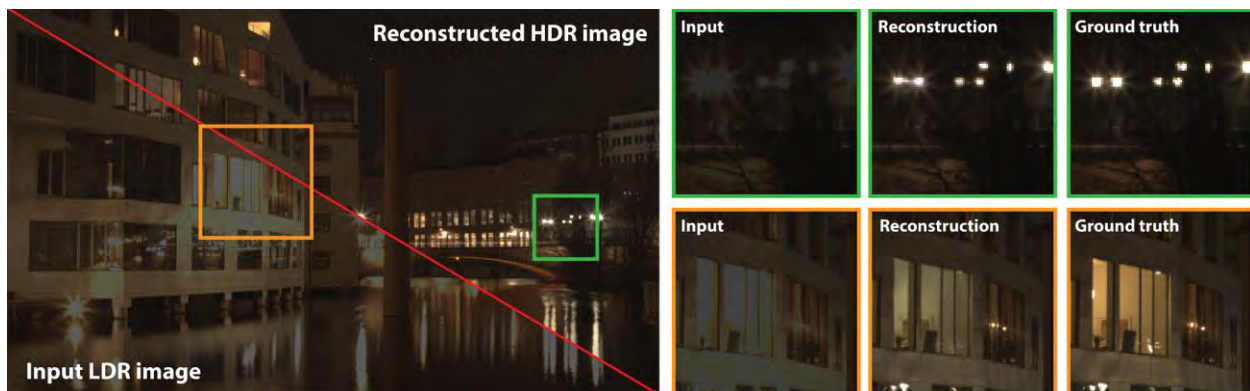


<https://media.istockphoto.com/vectors/neural-network-model-with-thin-synapses-between-neurons-vector-id1156059931?s=612x612>

<https://image.shutterstock.com/image-vector/neural-network-graphic-scheme-artificial-260nw-1583864422.jpg>

Neural Sensing

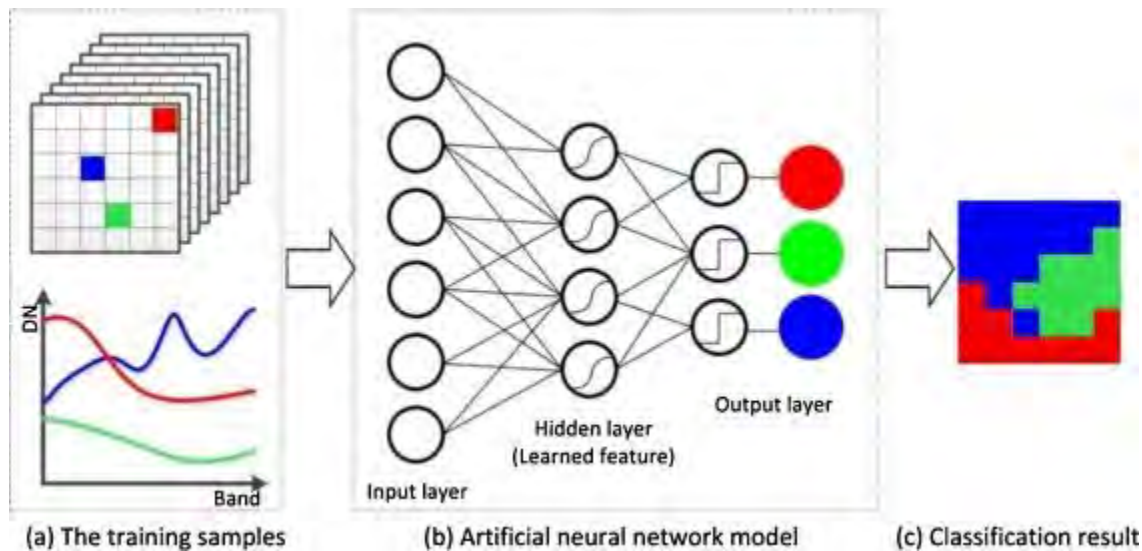
There are real-time (rapid response) and remote sensing applications that require an inexpensive, compact, and automated system for identifying an object. Such a system can be built by combining sensors array with an ANN. Neural sensors can be used in various applications like they can be used as a methodology to optimize per pixel shutter functions jointly with a differentiable image processing method, as a neural network, in an end-to-end fashion. These types of sensors are used in remote sensing using HDR imaging.



<https://camo.githubusercontent.com/3e9faab1200e16c3e376279a62acd130f2d227fd46473d5cccd1b123f57d4235/687474703a2f2f776562737461666662e69746e2e6c69752e73652f7e676162656936322f686472636e6e2f696d672f7465617365722e6a7067>

Neural networks and sensors have gained widespread popularity in satellite-based remote sensing applications. ANN has been used in mapping the lands. Land cover classification is the process in which

pixels are grouped according to the similarities of their spectral properties. If a pixel satisfies certain criteria then it is assigned to the land over the class that corresponds to those criteria. Land cover classification takes data from different sensors such as optical and radar images.



<https://ars.els-cdn.com/content/image/1-s2.0-S1568494617307081-gr9.jpg>

One of the future applications of this system is neural network modeling for aircraft flight guidance dynamics. Using the onboard navigation data, wind speed, and inertial speed of the aircraft, these records can be used as the basis for the neural networks. A network can be trained to understand the data that is continuously fed or input. For, modern aircraft, onboard navigation systems are able to estimate with good accuracy the current aircraft position, inertial speed, and wind speed, their records can be used as a basis for training the neural network. The structure of the neural network comprises several input nodes, neurons in the hidden layer with activation functions, and output nodes with linear transfer functions. The training of these networks must be validated using an independent validation database. When relevant validations are obtained, the output of the neural network is submitted as reference values to autopilot operating in basic modes. This technology is still new and is a field of research and study.

Keywords: Artificial Intelligence, machine learning, neural networks or artificial neural networks(ANN), artificial neuron, Neural Sensing, HDR imaging, remote sensing, autopilot.

Auxiliary Power Unit Maintenance

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Paper presents capacities and upkeep methodology of auxillary power unit. An Auxiliary Power Unit or APU allows an aircraft to operate autonomously without reliance on ground support equipment such as a ground power unit, an external air-conditioning unit or a high pressure air start cart. An electrical framework is fundamental part of the most oversimplified airplane plans. Framework intricacy and limit fluctuates between various sorts of motors. Assistant force unit is likewise intended to give drain air by redirecting some blower release air from the way to the combustor and into the plane channel framework.

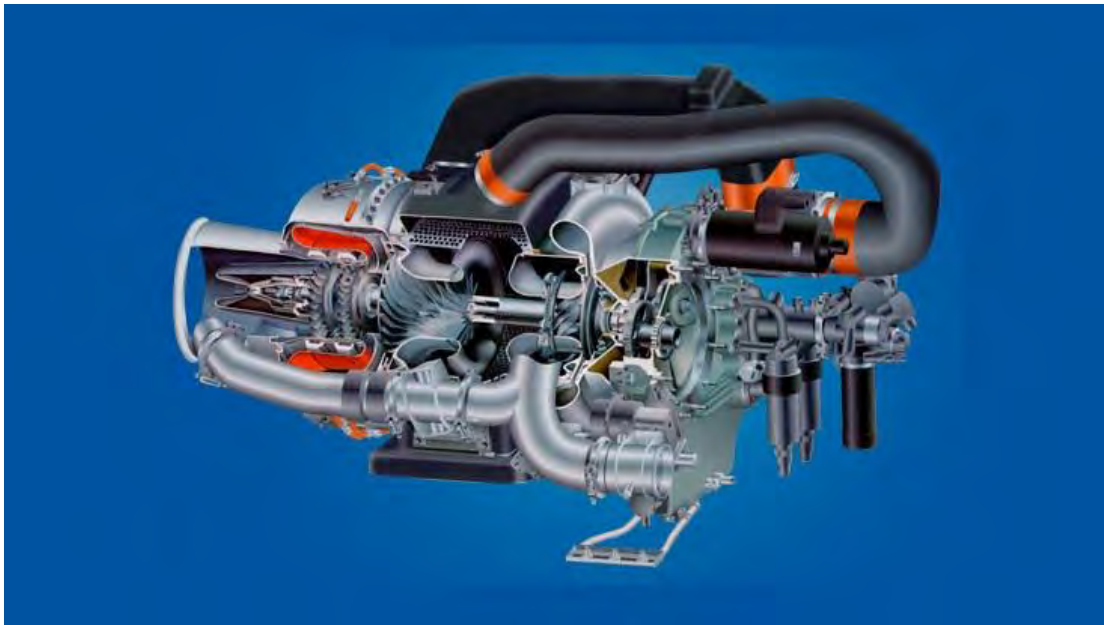


Figure 1: Design of Auxillary Power Unit

The auxillary power unit support help (APU) is intended to fulfill APU upkeep prerequisites for forward region upkeep locally available the airplane, at the flight line, and in the taxi. APU is at first being exhibited on flight line equipment. The support climate incorporates among its parts a man-made

consciousness (AI) based indicative framework, a computerized specialized data framework, and an upkeep the board framework. The symptomatic framework is based on a center of demonstrative information sources that incorporate an occasion based framework work model, a primary model, indication/deficiency data, and a wide scope of coordinations information. This center symptomatic model is intended for conventional application to any electromechanical framework including motors, flight controls, landing pinion wheels, and transmissions. It can likewise be applied to electronic frameworks, including aeronautics.

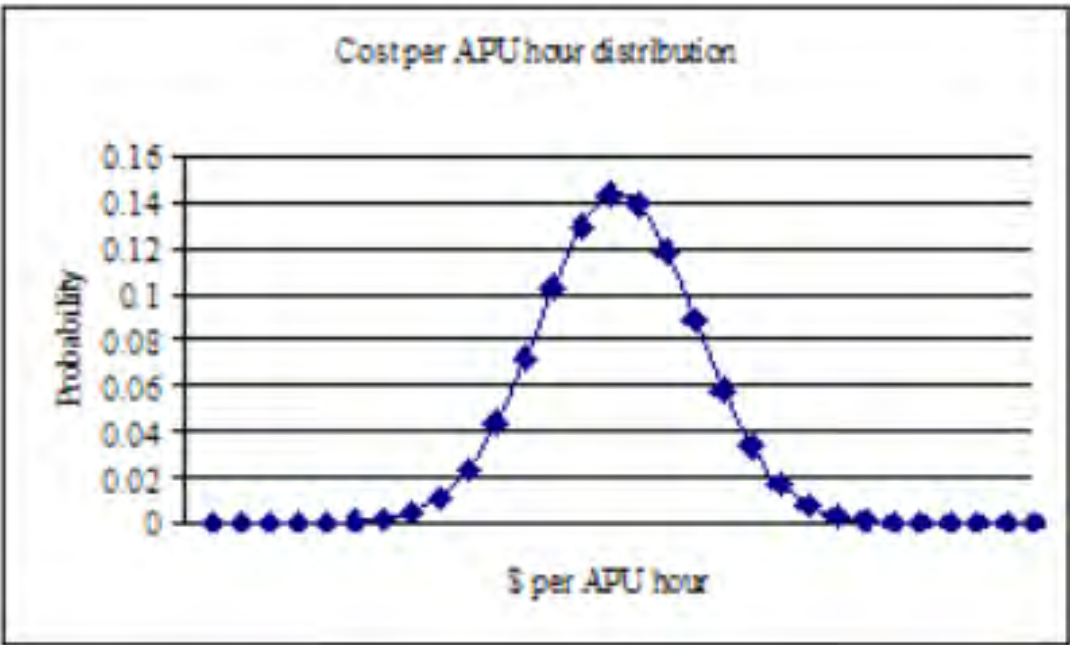


Figure 2: Distribution of the operating cost per APU hour

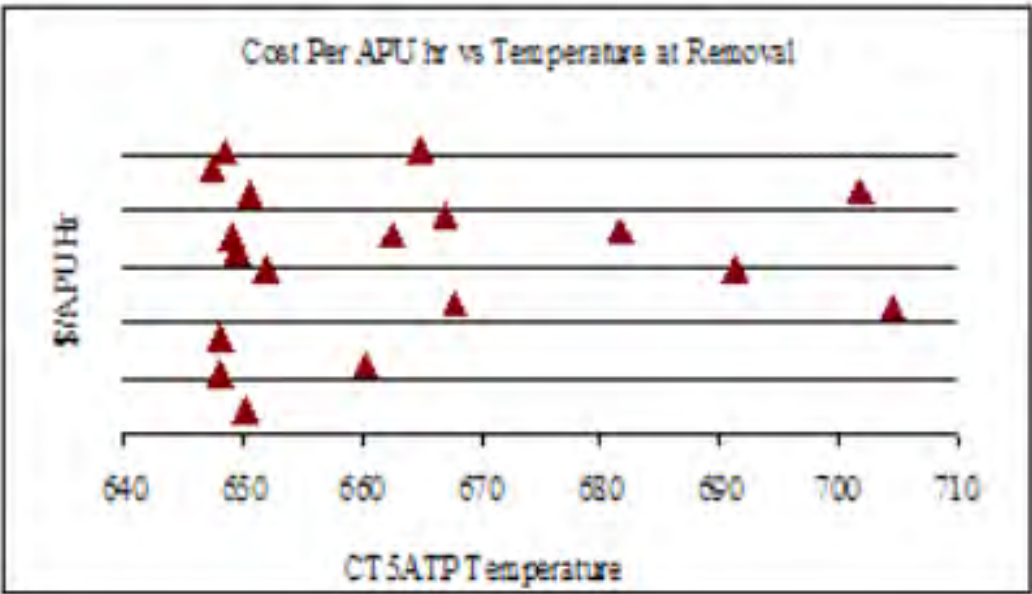


Figure 3: Cost of repair per APU operating hour vs. CT5ATP

This paper deal with the maintainance of APU and maintaince of its parts, as well as the time there is need for the maintainance of APU and estimating the overall cost of the APU maintainance.

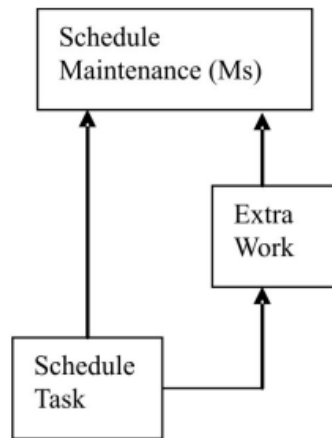


Figure 4: Scheduled Maintenance

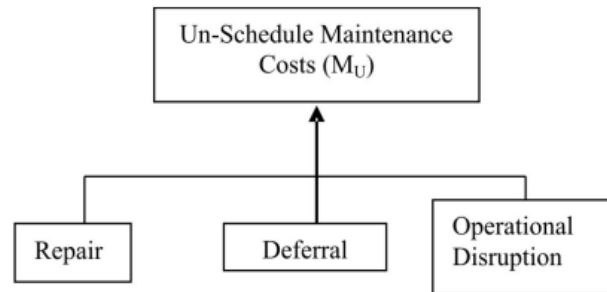


Figure 4: Scheduled Maintenance

Key Words: Engines, Aircraft propulsion, Fuels, Generators, Airplanes, Shafts, Maintenance.

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4- Yabsley, A., & Ibrahim, Y. (2008). Study on maintenance contribution to Life Cycle Costs: Aircraft Auxiliary Power Unit example. 2008 IEEE International Conference on Industrial Technology. doi:10.1109/icit.2008.460833

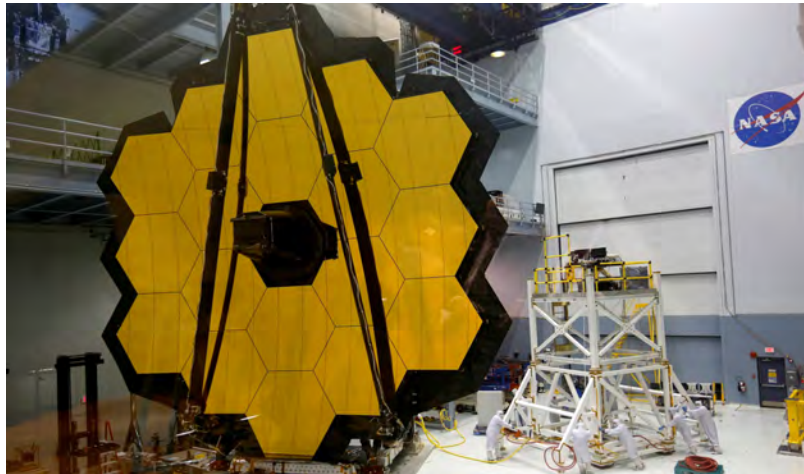
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NASA at Its Best - *The Webb Telescope shows what a purpose-driven space program can accomplish.*

Dr. Robert Zubrin, 2021 December 28 (with permission)

<https://www.nationalreview.com/2021/12/nasa-at-its-best/>



The mirror of the James Webb Space Telescope during a media unveiling at NASA's Goddard Space Flight Center at Greenbelt, Md., in 2016. (Kevin Lamarque/Reuters)

On Christmas Day, **NASA's** long-awaited James Webb Space Telescope (JWST) was finally launched into space.

The JWST is, by far, the greatest astronomical observatory ever built. Its primary mirror is 21 feet across, triple that of **Hubble**, giving it ten times the light-gathering capacity. Add to that the fact that its infrared optics are ten times as sensitive, and the result is a telescope a hundred times as powerful. The discoveries it could make are beyond reckoning.

With the JWST, we will be able not only to find many more extrasolar planets but take **spectra** of their atmospheres. If we detect free oxygen, that will reveal the presence of active biospheres. This is so since oxygen is highly reactive with most of the elements that compose our universe and therefore cannot exist long in substantial amounts in free form unless it is being actively liberated by photosynthetic organisms. The JWST will also reveal vast amounts of new knowledge about the formation and nature of stars, galaxies, black holes, and other astrophysical phenomenon. Perhaps most exciting of all, we will be able to see as never before light emitted from objects more than 13 billion light years away, allowing us to peer back in time to view the infancy, and perhaps even birth, of our universe.

The importance of the latter cannot be underrated. Most of our knowledge of physics, including Newton's laws, much of electromagnetism, relativity, and nuclear fusion, was obtained through astronomy. This is to be expected because the universe is the best lab there is. It's the biggest and disposes of vastly greater energy, matter, space, and time than any other. Its study promises much more.

As impressive as it may be by past standards, our knowledge of physics today is very incomplete. We know how masses and charges interact but have no idea of how they were created in the first place. In fact, our textbooks say they can't be created. Yet, here they are, all around us. Furthermore, while we know a number of physical laws, we don't have a clue as to why they have been tuned to great precision as to make life possible. The "multiverse" answer to this mystery is simply the counsel of despair, equivalent to answering questions like, "Why did the Union win the Civil War, the Titanic sink, the chicken cross the road, etc.?" with, "No reason. In other universes it happened otherwise." Real science requires a causative explanation.

NASA at Its Best - *The Webb Telescope shows what a purpose-driven space program can accomplish.*

Clearly, we have a lot to learn. If we can discover how and why these things came to be, we could potentially acquire new forms of technological virtuosity as remarkable compared to those we wield today as ours are in comparison to those of ancient times.

The JWST program stands as a very useful contrast to other NASA enterprises that are not as well conceived. For example, NASA's directorate in charge of developing plans for human Mars missions recently advanced the idea that NASA embrace the concept of minimum-duration surface-stay missions. This makes no sense. There are two basic flight plans for human Mars exploration. The short-stay plan, known for reasons that derive from ancient astrological terminology as the "Opposition Class" mission, involved spending two years in flight between Earth and Mars on unequal outbound and inbound legs, and 30 days at Mars. The long-stay plan, known as the "Conjunction Class" mission, involves taking six-month voyages each way to Mars and back but spending 18 months on the Martian surface. The NASA Mars planners argue that, by adopting the Opposition plan which minimizes surface-stay time, they are minimizing risk and cost. In fact, if one takes into account that the purpose of the mission is exploration, it should be apparent that exactly the opposite is true. The right figure of merit for Mars mission designs is person-days on Mars divided by unit cost. The Opposition Class mission requires higher energy trajectories, and thus more propellant and higher launch costs, than Conjunction missions. To accomplish the same amount of Mars exploration as a single Conjunction Class mission, 18 Opposition Class missions would be required, each costing more than a Conjunction mission, with vastly greater cost and risk for the total effort.

The early Mars and the early Earth were twins, both being rocky planets sporting bodies of liquid water on their surface and carbon dioxide-dominated atmospheres. That early Earth gave birth to life. If the theory is correct that life emerges naturally from this process of chemical complexification, then it should have appeared on Mars as well. There can't be life on the Martian surface today, because there is no liquid water there. But with enough time for field exploration, astronauts landing on Mars could potentially find fossils that prove its past existence on the surface or set up drilling rigs to bring up live microbes that might still exist in reservoirs of water underground. Finding the latter would reveal the biochemistry and structure of life produced by a separate origin. This would tell us, for example, whether the RNA-DNA information system used by all life on Earth is fundamental to the nature of life or just one sample drawn from an infinite tapestry of possibilities. The implications of such knowledge would be profound for biology and biotechnology. We would learn something not just about Earth life, but life itself.

This is the kind of research worth risking life and treasure for. It is something that only human explorers on Mars can do. It is consequently the true *purpose* of human Mars exploration. But NASA's human Mars-mission designers are not thinking of the purpose of the Mars mission. They are just thinking of it as something to do that would justify continued spending on a variety of technology-development projects that have constituencies within NASA or its contractor communities. Their mission plan, therefore, does not have to actually accomplish anything, or minimize its cost or schedule. Quite the contrary, the longer it takes, the more its costs, and the more complex it is, the more constituencies it can support. That is why there is no urgency in its accomplishment, and, while minimizing science return, it maximizes cost by including all sorts of extraneous, expensive, and risk-adding elements like lunar-orbital space stations and advanced-propulsion interplanetary motherships into its architecture. It is not a *purpose-driven* mission. It is a *constituency-driven* mission.

NASA at Its Best - *The Webb Telescope shows what a purpose-driven space program can accomplish.*

But the JWST, like Hubble, is a purpose-driven mission. We have launched it to do science, not just to say we have put a big telescope into space. So no one would consider cutting its operational life to 30 days in order to reduce the cost or chance of failure of the mission. Nor would anyone choose to make it dependent on a non-existent lunar-orbital space station for its operation or postpone its deployment until gigantic futuristic nuclear-electric spaceships are available for its transportation. It has serious business to do, and it is being approached in a serious way.

Considered as a mission plan, the JWST is not perfect. Its major flaw is that it has not been designed to be serviced. This is a step backwards for NASA, whose Hubble Space Telescope was serviceable, a feature that allowed it to be saved when its initial configuration proved to be flawed — and then greatly improved with more advanced technology as its life was extended over 30 years. It is true that, as it needs to be stationed a million miles away at the Earth-Sun Lagrange Point L2 — four times the distance to the Moon — the JWST is intrinsically more difficult to service than Hubble, which is in low Earth orbit. But still, L2 is only a two-week voyage away. NASA should have designed the JWST to be serviced and, having not done so, should now entertain proposals to develop technologies that would allow it to be serviced regardless.

The JWST effort has also been guilty of cost and schedule overruns. It was begun in 2002, with a target launch date of 2010 and a projected budget of \$3 billion. Instead, it came in at \$10 billion and eleven years overdue. This made the program the target of considerable criticism in recent years, with some going so far as to call for its cancellation. But provided it works as planned, future history will not remember any of that. After all, who today remembers the cost overruns and schedule delays of the Parthenon, Notre Dame, or other monumental works that have been handed down to us by the people of the past?

The comparison of the JWST with medieval gothic cathedrals is apt. Both represent in physical form the highest ideals of the societies that created them. In the case of the cathedrals, faith in a benevolent god who created us in his own image and who died to set us free. In the case of the JWST, our commitment to the search for truth. The JWST will provide us many discoveries, but it will grant us an even greater gift. It will show future generations that we were noble.

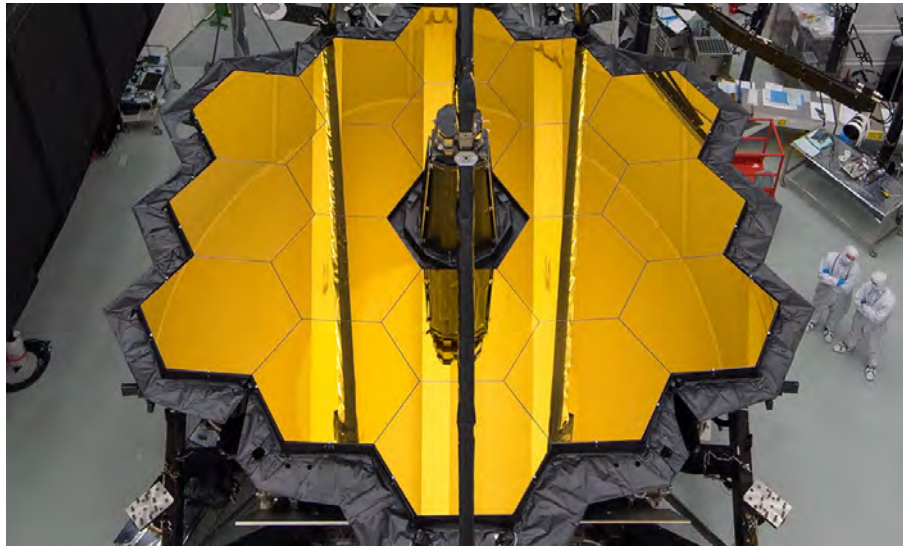


ROBERT ZUBRIN an aerospace engineer, is the founder of the **MARS SOCIETY** and the president of Pioneer Astronautics. His latest book is **THE CASE FOR SPACE: HOW THE REVOLUTION IN SPACEFLIGHT OPENS UP A FUTURE OF LIMITLESS POSSIBILITY**. [@robert_zubrin](https://twitter.com/robert_zubrin)

AIAA Statement on Successful Launch of James Webb Space Telescope

by American Institute of Aeronautics and Astronautics (AIAA), 2021 December 25

<https://www.aiaa.org/news/news/2021/12/25/aiaa-statement-on-successful-launch-of-james-webb-space-telescope>





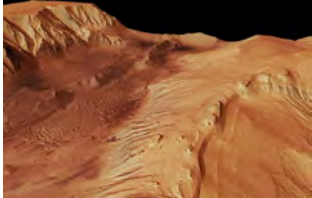

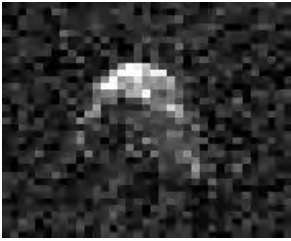
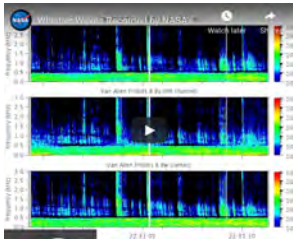







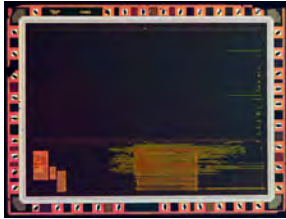






James Webb Space Telescope. | Credit: Desiree Stover; NASA; [Aerospace America](#)

December 25, 2021 – Reston, Va. – The American Institute of Aeronautics and Astronautics (AIAA) Executive Director Dan Dumbacher made the following statement:

“On behalf of the 30,000 professional and student members of AIAA, we congratulate NASA, the European Space Agency (ESA), the Canadian Space Agency (CSA), and the entire James Webb Space Telescope (JWST) team on today’s successful launch. This amazing observatory will allow us to look into the history of our cosmos. We look forward to the new discoveries from JWST that will help us understand the origins of the universe.

Countless AIAA professional members have dedicated years of their careers to the research, engineering, testing, and development of this incredible astronomy mission. In addition, numerous academic and industry partners on the JWST team are AIAA corporate members who contributed mightily to this mission. Applying their technical expertise with determination and perseverance since 1996 has led us to this exciting day. Over the years, they have chronicled their work on JWST by authoring articles for AIAA journals and meeting papers for AIAA forums. These original research results and technological progress on JWST have been published in AIAA’s Aerospace Research Central, at arc.aiaa.org, to fulfill our commitment to ensuring students and professionals can stay current on the most important advances in aerospace science and technology. Through the combined efforts of AIAA members on the JWST mission, they are shaping the future of aerospace.”

AIAA LA-LV Aerospace News Digests by Dr. Ken Lui, AIAA LA-LV Section

 <p>(Dec. 7) Pearl Harbor attack survivors gathered at the site of the bombing to remember more than 2,300 U.S. troops killed 80 years ago</p>	 <p>(Dec. 10) Stratolaunch signs hypersonic research deal with Missile Defense Agency</p>	 <p>(Dec. 16) Large deposits of water found on Mars below the surface at the equator</p>	 <p>(Dec. 24) Axiom Space developing in-house spacesuits to prepare for future stations</p>
 <p>(Dec. 14) \$5 billion asteroid just made its closest pass by Earth for the next 40 years</p>	 <p>(Dec. 11) Eavesdropping in Space: How NASA records eerie sounds around Earth</p>	 <p>(Dec. 23) NASA recorded an absurd sound near Jupiter, here it is</p>	 <p>(Dec. 14) FAA: No more commercial astronaut wings, too many launching</p>
 <p>(Dec. 8) NASA Is on the Cusp of a New Era</p>	 <p>(Dec. 22) Britain and Japan join forces on next-generation fighter engine</p>	 <p>(Dec. 17) Vandenberg SFB Envisioned as a 'National Spaceport'</p>	 <p>(Dec. 17) AFRL jumpstarts early research on cislunar monitoring, satellite servicing</p>
 <p>(Dec. 18) Rep. Young Kim supports public-private partnerships for space innovation</p>	 <p>(Dec. 22) Defense Production Act Title III Presidential Determination for Radiation-Hardened and Strategic Radiation-Hardened Microelectronics</p>	 <p>(Dec. 22) Defense Production Act Title III Presidential Determinations for Submarine Industrial Base Production</p>	 <p>(Dec. 1) China's New Carrier-Capable Stealth Fighter's Canopy Is Its Most Intriguing Feature</p>
 <p>(Dec. 3) A Flock Of U.S. Military Business Jets Has Descended On Southern California</p>	 <p>(Dec. 5) A Message From Secretary of Defense Lloyd J. Austin III on the Passing of Senator Dole</p>	 <p>(Dec. 6) Edward Shames, last surviving 'Band of Brothers' officer, dead at 99</p>	 <p>(Jul. 22) Nokia is one giant step closer to landing the first cellular network on the Moon</p>

RSVP and Information: (<https://www.aiaa.org/SciTech/registration>)

Enabling Sustainability Through Aerospace Technology
AIAA SciTech Forum is the world's largest event for aerospace research and development. The 2022 forum will explore the science, technologies, and policies that are shaping our industry's future and enabling sustainability.



5 Reasons You Should Attend the Forum

AIAA SciTech Forum is the world's largest event for aerospace research, development, and technology. The hybrid format will allow you to participate in person in San Diego or virtually, based on your preference and level of comfort. There are many reasons why you should participate in the forum, but we've narrowed it down to the top five.

1. Innovation Starts Here

AIAA SciTech Forum and its predecessors have been delivering aerospace research and technology findings that have driven innovative developments for more than 50 years.

2. Monumental Technical Program

Your peers will present nearly 3,000 technical presentations on the latest innovations spanning 60 aerospace research topics that will drive advancements in the industry. Topics include aeroacoustics, fluid dynamics, applied aerodynamics, aircraft design, spacecraft structures, electric propulsion, and guidance, navigation and control. Summary videos of all technical presentations will be available online and on demand.

3. Hear from Experts

The high-profile speakers and panelists participating in the plenary sessions, Forum 360s, and special sessions are proven business leaders and innovators. They are thought leaders with their fingers on the pulse of the aerospace industry.

4. Aerospace Sustainability

The forum theme is Enabling Sustainability Through Aerospace Technology. Industry leaders will provide their perspectives on socioeconomic and workforce sustainability; operational futures for air and space; sustainability through diversification; and the environment.

5. Make Connections in Person & Online

The forum aims to bring together over 5,000 participants from across the globe in a hybrid setting representing hundreds of government, academic, and private institutions. 2022 will see the return of the Exposition Hall and in-person recruitment events for students and young professionals.

RSVP and Information: (<https://conta.cc/30yW0zX>)

AIAA LA-LV 1/15 Section (Town Hall) e-Meeting (Online on Zoom)

Saturday, 2022 January 15, 11 AM PST (US and Canada)

Space Suits and Life Support Systems for the Exploration of the Moon and Mars

How designing a spacesuit for Mars can improve one for the moon, prevent forwards and backwards planetary contamination and help stop the next pandemic on Earth

by

Dr. Lawrence Kuznetz

Former NASA Senior Scientist and Aerospace Engineer



Disclaimer: The views of the speakers do not represent the views of AIAA or the AIAA Los Angeles-Las Vegas Section. Contact: Dr. Ken Lui, Events/Program Chair, LA, AIAA LA-LV Section (events.aiaalav@gmail.com)

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