National Aeronautics and Space Administration

THE NRP POST

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Hangar 1 Restoration Begins

IN THIS ISSUE

Photo Credit: NASA Ames/Dominc Hart

On April 4, 2022, Ames Center Director Dr. Tu and UC Berkeley Chancellor Christ's respective leadership teams met to discuss potential research collaborative opportunities.

COVER

On May 6, Ames was honored to host U.S. Congresswomen Anna G. Eshoo and Zoe Lofgren. Reps. Eshoo and Lofgren joined Ames Center Director Dr. Tu as well as our partners at Planetary Ventures to mark the start of a new beginning for Hangar One, the historic Bay Area landmark and reminder of our region's importance to early aviation.

CAL FIRE Operations at NASA Ames

CAL FIRE operates 10 fire/rescue helitack bases across California. The local helicopter stationed in Los Gatos near the Lexington Reservoir is being replaced with a new Sikorsky Blackhawk s70i. This helicopter is much larger and heavier than the current 1970's Bell "Huey" and the current facility isn't large enough for the new ship. CAL FIRE approached NASA Ames about the possibility of relocating the base to their facility. After initial discussions, it was determined that a partnership would be in the interest of both organizations.

CAL FIRE has leased a portion of Hangar N211 to store the CAL FIRE Hawk and the former shop at N248B to house the support vehicles and firefighting tool storage. This will be used to store the Huey in inclement weather until the new CAL FIRE Hawk arrives and the transition training takes place. CAL FIRE also needs a location to sleep, feed, and train the firefighters onsite. It was determined that modular buildings would be purchased by CAL FIRE and placed next to N211 and barracks to be placed at the intersection of McCord and Bushnell Street.

The personnel assigned to the facility will include Fire Pilots, Fire Captains, Fire Apparatus Engineers, Firefighters, and a Mechanic. The new helicopter will include a fixed rescue winch for air rescue operations and carries 1000 gallons of water compared to the 325 gallons for the Huey. The copter will transition to a 24-hour operation in 2023 where there will be a day and night shift. CAL FIRE is excited to be a part of the NASA Ames community. If you see someone in a CAL FIRE uniform, please feel free to come to say hi!

Satellite designed at CMU launches into low-Earth orbit

By Krista Burns

Brandon Lucia's lab developed the Tartan-Artibeus-1 Satellite, the world's first battery-less PocketQube nanosatellite, deployed to low-Earth orbit aboard the SpaceX Transporter-3 Rocket.

SpaceX had a successful Falcon 9 launch of Transporter-3 to orbit from Space Launch Complex 40 (SLC-40) at Cape Canaveral Space Force Station in Florida on January 13, 2022. Aboard was the Tartan-Artibeus-1 Satellite, developed at Carnegie Mellon University, where it was deployed to low-Earth orbit on the SpaceX Transporter-3 Rocket. It was launched as part of the Alba Unicorn constellation under the name Unicorn-2TA1.

"Our lab developed the Tartan-Artibeus-1 Satellite, which is what we believe to be the world's first battery-less PocketQube nanosatellite," said Brandon Lucia, an associate professor of electrical and computer engineering. "This project was led by Ph.D. students Brad Denby and Emily Ruppel from my lab and in collaboration with Alba Orbital, our launch services provider."

The mission's goal was to demonstrate the viability of PocketQube-scale nanosatellites that operate reliably without batteries, eliminating the cost and complexity of battery-based power systems in nanosatellites. The sensor-equipped, 5cm cube (1/8 the size of a CubeSat) can sense its environment and perform orbital edge computing to process sensor data in a way that is robust to intermittent operation.

During the mission, the satellite collected telemetry data about its operation (power state, stored energy, GPS location) and collected and processed sensor data about its environment using applications such as machine learning and inference. The results were sent back to Earth using a low-power radio.

Carnegie Mellon University

"A unique aspect of this mission was that while on orbit, the satellite ran Cote, a physics-based orbital dynamics model and orbital edge computing simulator that we developed, giving the satellite better situational awareness without the need to communicate to earth," said Lucia. "This battery-less satellite is the first of its kind and we are very excited for the new scientific results enabled by this unique deployment to Earth's orbit."

Falcon 9's first stage booster previously launched Crew Demo-2, ANASIS-II, CRS-21, Transporter-1, and five Starlink missions. Following stage separation, SpaceX will land Falcon 9's first stage on Landing Zone 1 (LZ-1) at Cape Canaveral Space Force Station.

Transporter-3 is SpaceX's third dedicated rideshare mission, and on board this launch were 105 spacecraft (including CubeSats, microsats, PocketQubes, and orbital transfer vehicles).

Photo (top): SpaceX Falcon 9 launch of Transporter-3 to orbit from Space Launch Complex 40 (SLC-40) at Cape Canaveral Space Force Station in Florida on January 13, 2022. Photo courtesy of SpaceX.

Source: College of Engineering

Professor Brandon Lucia with his lab students.

BREAKTHROUGH INITIATIVES

The blc1 signal is not alien - but it is a huge leap forward for SETI

By Sofia Z. Sheikh

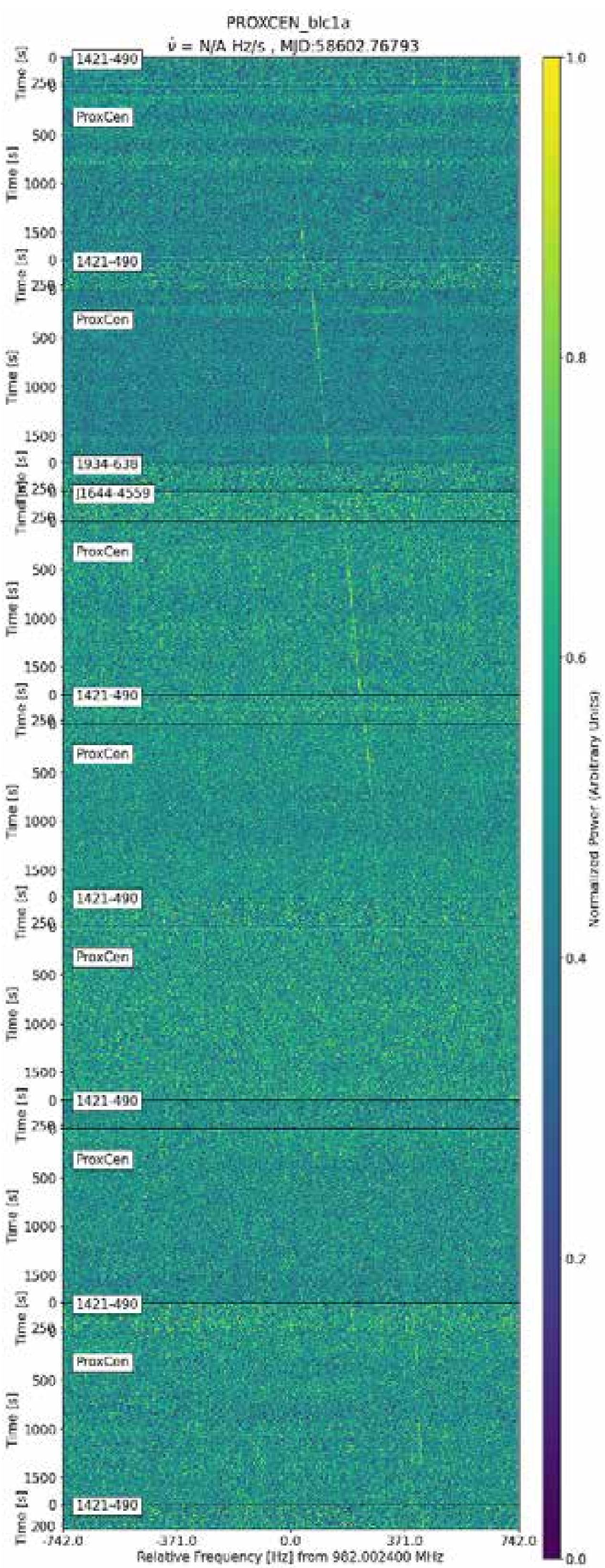
In October 2020, members of the Breakthrough Listen Initiative performed a standard SETI search of radio observations from Proxima Centauri. Our search algorithm flagged a signal that we couldn't immediately explain. This is the story of that signal, blc1, and the journey to understand its origin.

Act I: A Mysterious Signal Is Detected...

In April 2019, the Breakthrough Listen Initiative performed observations of our nearest stellar neighbor, Proxima Centauri (ProxCen), with the Parkes Murriyang telescope in Australia. We were originally searching for stellar flares; learning more about these flares can help us understand the habitability of planets around small, M-dwarf stars like ProxCen. Two years later, the same data were reanalyzed in the context of SETI, the Search for Extraterrestrial Intelligence, looking for technological radio activity from ProxCen. Shane Smith, an REU student working with Breakthrough Listen over the summer in 2020, was the first one to notice that our routine analysis had picked up something unusual. His mentor, Danny Price, posted that plot into our research group's Slack channel. For once, no one in the group had an immediate answer to what could've caused the signal in that plot.

This style of plot is known as a "waterfall plot cadence". The top shows the first observation of the night, continuing downwards in time. From right to left, the radio frequency progresses from low to high. And the color of the plot indicates the strength of radio emission detected, with the green static indicating no emission, and the brighter (yellower) lines indicating strong emission.

With an expert's eye, there are a number of things that stand out about the linear feature in this waterfall plot cadence:



T hat plot - containing what became known as blc1 - looks like this:

1. It was a few-Hz wide narrowband signal. Signals this narrow have no known astrophysical source and must be generated by technology.

2. It had a drift rate (slope) that was non-zero, which is expected for a transmitter untethered to the surface of the Earth.

3. The signal appeared to be absent in the off-source observations (panels not labeled "ProxCen") as would be expected for a signal coming from a single point on the sky.

4. The drift rate appeared approximately linear in each 30 minute panel but seemed to shift over time between panels, as would be expected for a transmitter in a rotational or orbital environment.

5. The signal persisted for a few hours - human-made satellites and aircraft tend to move through the telescope beam and disappear much faster than that.

I had just finished submitting my last postdoctoral application of the cycle an hour before this meeting and was fully intending to take a nice work break for awhile... but as soon as I saw this signal, I was intrigued. I volunteered to lead the analysis.

Act II: Evidence Mounts for a Human Origin
Looking for "fingerprints"

A signal's characteristics - its frequency, drift rate, drift rate evolution, brightness over time, and more can serve as a sort of "fingerprint" that can help us identify its origin. The first thing that we did was try to find a match for blc1's parametric fingerprint. We looked for transmitters that were licensed and known to transmit in this frequency band (reserved for aeronautical purposes in Australia). We compared the drift rate to cars and planes and satellites and asteroid reflections and the telescopes own motion, etc. etc. etc. We checked whether the telescope was pointing in the direction of a nearby building, say, the visitor's center. We checked the temperature logs for signs of heating or cooling in the instrument room, we checked for any events occurring on-site or at nearby facilities, we checked telescope status and chat logs to look for any abnormalities. No match.

Unfortunately, it's impossible to do the same matching exercise for the "fingerprints" of an extraterrestrial signal, as we don't know what characteristics we would expect from them. However, we can search for "green flags" that match reasonable assumptions. For example, let's assume that there's a transmitter on the surface of ProxCen c, the terrestrial planet in the habitable zone of ProxCen. That transmitter should vanish for a while as its planet rotates it away from us, and its drift rate and frequency should change with the planet's orbit. These are features that we already know (or can infer) from radial velocity exoplanet studies of ProxCen. So we checked for these green flags as well. Still no match.

The most consistent explanation, therefore, is single-frequency transmitter that is being electronically-modulated - for example, a relatively high-grade commercial crystal oscillator with a temperature-induced drift. In other words, we found no perfect match for the transmitter on Earth, but it's broadly consistent with Earth-based radio frequency interference. And we found no additional evidence, in this investigation, that implies that the signal was coming from space.

Searching for patterns in time and (frequency) space

To identify whether a signal is radio frequency interference, it can be useful to look for similar signals and see if they are radio frequency interference.

One way to define a "similar signal" is to look for signals with the same "fingerprint" as blc1 that occurred during other observing sessions. Firstly, we checked for similar signals on the days before and after the blc1 observation.

And we do find a match!

Or at least, a close enough match. We find four instances of similar signals to blc1 - with the same frequency and drift rate - from other days of the ProxCen observing campaign. They aren't identical to blc1, but are extremely close in their parameters.

These similar signals appear no matter where the telescope is pointed, including the off-target observations in each cadence: they are all radio frequency interference.

That doesn't conclusively prove that blc1 is radio frequency interference, but it should definitely make us skeptical.

Next, we looked for similar signals at other frequencies during the blc1 observation. Transmitters will often send information over multiple frequencies at the same time, so looking for "lookalike" signals with the same shape, but at other frequencies, may give us more clues to blc1's origin.

This search revealed a set of dozens of blc1 lookalikes across the bandwidth of our receiver. Some of them even looked like blc1 but were mirrored in direction, and some were related to each other by integer multiples of commonly-chosen clock oscillator frequencies in human electronics (ex. 133.333 MHz). This behaviour may seem strange, but it is a characteristic of a particular kind of transmitter inefficiency or malfunction called intermodulation production.

other frequencies, compared to blc1

All of these intermodulation products appeared when the telescope was pointed at ProxCen, but also appeared when it was pointed away from ProxCen: they were radio frequency interference.

Taken all together, we see similar signals to blc1 across many frequencies and on many days. And every time we see them, they are radio frequency interference. This implies that blc1 is an intermodulation product of some Earth-based transmitter.

Act III: We prepare for the next signal-of-interest

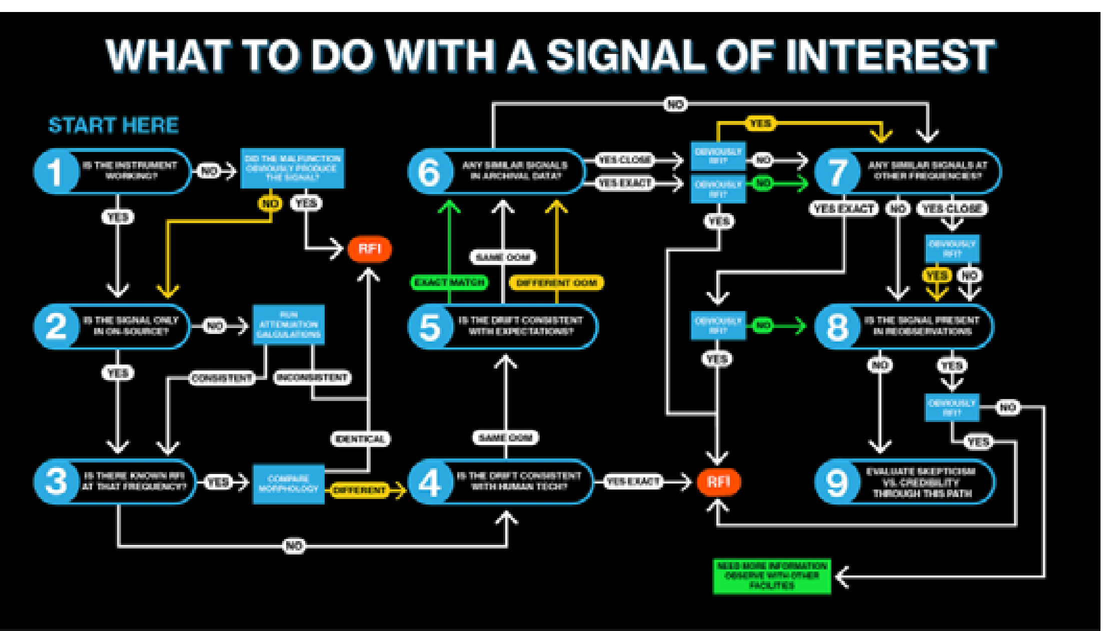
At this point, you might be disappointed - our investigation concluded that blc1 is not an alien signal. So why are we even talking about it any more?

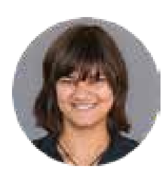
Because it was the closest call that the Breakthrough Listen project has ever investigated, and therefore, the most deeply interrogated signal-of-interest in human history.

And, if that isn't cool enough on its own, we can use that information to prepare for the next signal-of-interest. There had been a lot of discussion about what to do in theory if a signal passed our initial thresholds, but we'd never had to actually put those discussions into practice before. Now we've developed a procedure for the post-detection of a signal-of-interest (see below), we have developed the code to perform these analyses, and we have considered the best way to balance the timely release of data and code with responsible scientific due diligence.

A very complicated flowchart showing the method we developed for verifying a signal-of-interest. For a more thorough explanation of the process, see our blc1 webpage. Figure: Z. Sheikh

In the end, blc1 was the first-ever signal that fooled our search algorithm and required such an in-depth characterization and analysis. But it won't be the last! We look forward to bringing you a 'blc2' someday as we continue the exciting search for extraterrestrial intelligence.





Sofia Z. Sheikh
Post-doctoral Researcher
University of California, Berkeley

Hangar 1 Restoration

By Elena Serna

Hangar 1

Under the Planetary Ventures, LLC, (PV) Moffett Federal Airfield Lease Agreement, PV began restoration efforts on the iconic Hangar 1. Historically, this building was used to store the USS Macon and as a base for aviation programs. After years of being vacant, this giant freestanding structure will undergo massive restoration improvements.

Full-scale abatement started in Spring 2022. The engineering evaluation/cost analysis (EE/CA) report recommended removing impacted paint from the structural elements of the hangar. PV is moving forward with this recommendation, which will take approximately two years to complete.

Abatement will occur in sections and structural upgrades and recoating work will commence thereafter—all of which is planned to occur during the two year abatement time frame. After this initial phase, the re-cladding/re-skinning of the hangar will take place. PV plans to replicate, as closely as possible, the original visual characteristics of Hangar 1. The re-cladding/re-skinning work is expected to be complete in 2025.

When restoration is complete, the historic landmark will be repurposed and used once again. Stay tuned for future updates on how Hangar 1 will be used once its restoration is complete.

NASA Industry Partner Develops ESD Evaluation Protocols for Launch Integrity and CubeSat Startup Success!

By Bob Vermillion, Moffett Field, California

CubeSat programs have been established, not only at NASA centers, but also universities throughout the USA, UK, Europe, and Asia. CubeSats are miniaturized in size compared to traditional satellites. Under the leadership of Professor Alice Smith, Ph.D., Auburn University's SmallSat program thrived in hosting the NASA Academy of Aerospace Quality (AAQ). The author, an AAQ Expert, lectured on ESD preventative safeguards for the build and deployment of CubeSats. Other U.S.A. based universities that have initiated a SmallSat program include Texas-El Paso, Stanford, UC Berkeley, Cal Poly (PolySats), Cornell, Arizona & Arizona State, Michigan, Purdue, Hawaii, Utah & Utah State, UCLA, USC, Brown, U.S. Military Academy, West Point, U.S. Naval Academy, U.S. Air Force Academy, Santa Clara, Alabama, and many others. NASA Ames is amongst the leaders in small satellite innovation. CubeSat functionality after surviving a launch or deployment from space, however, has posed issues.

Facts as of 1 January 1, 2022

- •Nanosats launched: 1802
- •CubeSats launched: 1663
- •Interplanetary CubeSats: 2
- •Nanosats destroyed on launch: 102
- •Most nanosats on a rocket: 120
- •Countries with nanosats: 76
- •Companies in database: 558
- •Forecast: over 2500 nanosats to launch in 6 years

JPL has taken cleanliness and ESD control for their interplanetary CubeSats to a different level. The iNARTE® Certified Aerospace & Defense ESD Engineering training at NASA Ames is a valuable resource for university and CubeSat manufacturers to learn NASA -STD-8739.6B, Secrion 7 protocols in the assembly process of flight hardware.

For qualification testing of the TuPod, RMV verified the survivability of the system from ESD discharges and Triboelectrification before lift-off. The Subject Matter Experts (SMEs) of RMV appear to be the first to qualify additive manufactured materials for static control reliability. Due to the increased usage of additive manufacturing on the ISS, ESD materials are critical for deployment in space.

CubeSat Reliability Testing consisted of the following:

1. Resistance Testing
2. Static Decay Testing
3. High Voltage Discharge Shielding
4. Proprietary RMV Test Method to map Material Reliability in harsh conditions

Resistance testing verifies the TuPod's electrical conductivity properties after the additive manufacturing process. Several attempts by suppliers have failed to achieve uniform dispersion of additive materials to achieve the proper conductivity level. In a 2002 conversation with Ray Gompf. Ph.D., PE (NASA KSC, Retired), ESD events take place during lift-off as the rocket creates its own little lightning bolts.

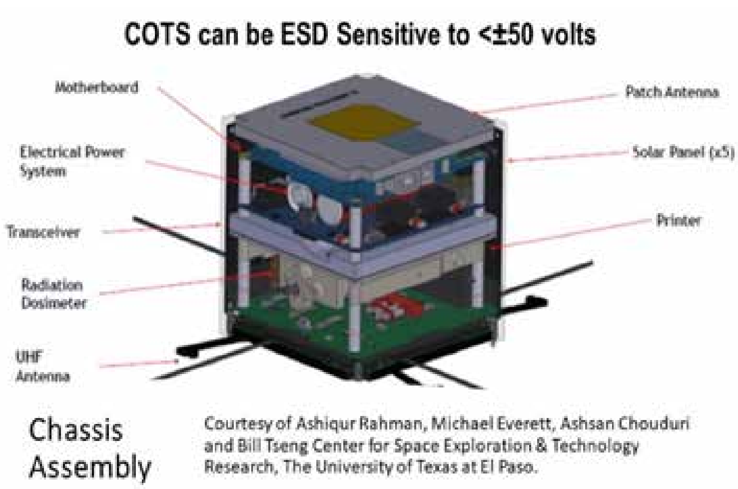


Figure 1

Speed kills and one must factor in microprocessor densification (Figure 1) as ESD Sensitive Devices (ESDS) can be damaged at <50 volts. A researcher can neither discount nor overlook ESD procedures.

The TuPod deployment cylinder outside and inside surface resistance was measured in the static shielding range to insure electrical conductivity. (Figure 4)

The spring-loaded TuPod that deploys 2 TubeSats was mounted on a grounded surface plate (Figure 3) and subjected to electrostatic decay testing. Initially charged to ±1.0kV, the grounded 1-inch cylinder contacted the top TubeSat to initiate electrostatic decay for a cutoff at ±100 volts. An acceptable limit is <2.0 seconds and the TuPod measured 0.06 seconds from 1.0kV to 100 volts and 0.01 seconds from -1.0kV to -100 volts. Successful deployment is more effective when both TuPod and TubeSats are at equal potentials.

For the final ESD test, a component simulator device (CSD) sensitive to <100 volts was placed inside the closed TuPod). The TuPod's outer surface was subjected to 5kV human body model (HBM) discharges at various locations. The CSD passed the HVD shielding test for the TuPod (Figure 2).

Figure 2

ESD Protection from Assembly to Deployment:

Today's ESDS are easily damaged without proper handling for static control integrity, storage and transport. During deployment, separation of TubeSat from the TuPod creates Field Induced Model (FIM) discharges and exposure to change generating hazards and turbulance.

In short, the first article TuPod passed preliminary ESD testing. Moreover, Teton Aerospace assembled the components following NASA-STD-8739.6B ESD protocols to insure successful operational deployment into space.

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Figure 3

Bob Vermillion, CPP, Fellow, is a Certified Product Safety & ESD Engineer-iNARTE® with proven subject matter expertise in the mitigation of Triboelectrification for harsh environments and troubleshooting of robotics, systems and engineered materials

References:

1. ANSI/ESDA/JEDEC JS-001, For Electrostatic Discharge Sensi tivity Testing Human Body Model
2. Model (HBM) Component Level, ESD Association Standard, Aug 28, 2014.
3. ANSI/ESDA/JEDEC JS-002, For Electrostatic Discharge Sensitivity Testing Charged Device
4. NASA-STD-8739.6B, Workmanship Manual for Electrostatic Discharge Control
5. Special thanks to Amin Djamshidpour, Co-Founder Teton Aerospace, amin@tetonsys.com

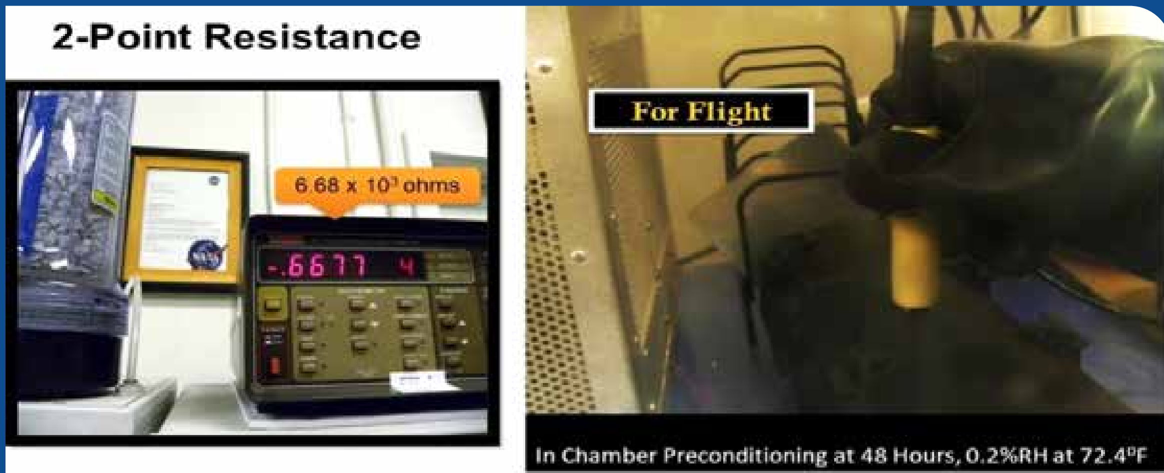

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Figure 4

(displays, flexible electronics, 3D materials) for aerospace & defense, medical device, pharmaceutical, biotechnology, automotive and the electronics sectors. One of Bob's developments was NASA Mars Mission approved. Vermillion received the James A. Russell Lifetime Achievement Award for Packaging Engineering Innovation for Protection of the WarFighter in 2018 and one year later was inducted into the Military Packaging Hall of Fame. Since 2014, Bob is an active participant of the NASA ESD Inter-Agency Working Group (IAWG) as the Agency Technical Authority for ESD, Founder and Co-Chair of the SAE G19 Sub-Committee for Packaging of EEE parts. Vermillion is Founder and CEO of RMV Technology Group, LLC, a NASA Industry Partner and 3rd Party advanced ESD Materials Testing, Training, and Consulting Company.

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