National Aeronautics and Space Administration

tech bytes

AMES' EMERGING TECHNOLOGIES

VIPER Mission

Moving Toward Success

WINTER 2022

In this issue:

Chief Technologist's Corner

We're pleased to release the fall 2021 edition of Techbytes featuring the VIPER (Volatiles Investigating Polar Exploration Rover) Program as our cover story. We're also pleased to announce our Center Innovation Fund (CIF) FY22 awardees. In addition to featuring the CIFs in our summer edition of Techbytes, I'm planning to hold tag-ups with each CIF team to receive an update on the concepts and progress. We're also reporting on the FY22 STMD Early Career Initiative (ECI) finalists.

The FY23 STMD Early Career Initiative (ECI) call is expected to be released spring of 2022 and we encourage all early career researchers to consider applying. This highly competitive process featured a plethora of compelling concepts important to STMD and NASA including a telemetry system for in-space prognostics and a high-throughput platform for enhancement of TPS materials. In collaboration with the Technology Partnerships office, we are featuring two articles about the NASA Government Invention of the Year and the Software of the Year. Our annual Ames Research and Technology Showcase (ARTS) has been on hiatus during the pandemic however we are planning to hold the event next year to highlight the FY20-22 research and technology awardees.

- Harry Partridge

ABOUT THE COVER

NASA's VIPER mobile robot will roam around the Moon's south pole giving us surface-level detail of where the water is and how much is available for use. This will bring us closer towards NASA's ultimate goal of a sustainable, long-term presence on the Moon – making it possible to eventually explore Mars and beyond. Credits: NASA Ames/Daniel Rutter. Project Manager of the NASA VIPER mission, Daniel Andrews, is pictured lower left.

VIPER Mission **Completes Critical Design Review**

NASA's first lunar mobile robot, the Volatiles Investigating Polar Exploration Rover (VIPER) passed its Critical Design Review (CDR), a critical milestone indicating that the rover has a completed design and has been approved by an independent NASA review board.

There are several "gate reviews" in which a NASA mission must pass to demonstrate it is ready to move to the next phase of development. The CDR is the point in a project's development where the design of a system is complete. This is the "pencils down" moment, where we are done designing a system to meet the specified requirements. Now we turn our attention to manufacturing and procuring the parts needed to turn that design into a working, functioning robot.

Artist depiction of VIPER on the surface of the Moon. Credit: NASA Ames/Daniel Rutter

VIPER Mission **Completes Critical Design Review (cont.)**

As part of the Artemis program, the VIPER mission is managed out of NASA's Ames Research Center, and its primary objective is to get a close-up view of the location and concentration of ice as well as other resources at the Moon's South Pole. By using an onboard suite of instruments developed across the agency and with commercial partners, the mission will be able to identify and eventually map where ice and other resources exist across and below the lunar surface. This resource mapping mission will bring NASA a significant step closer to its goal of the first long-term presence on the Moon and add to our understanding of the origin of lunar water.

The VIPER team has been focused on completing the design of this mission, leading up to this culminating review. With an approved design, the team now looks toward turning that design into real hardware, bringing VIPER to life in 2022.

VIPER has worked against a challenging schedule, made more challenging during a global pandemic when the majority of the team has been working virtually from home. Further, the team has been pathfinding a new interface to a commercial provider who will deliver VIPER to the surface of the Moon via Astrobotic and the Commercial Lunar Payload Services initiative, or CLPS.

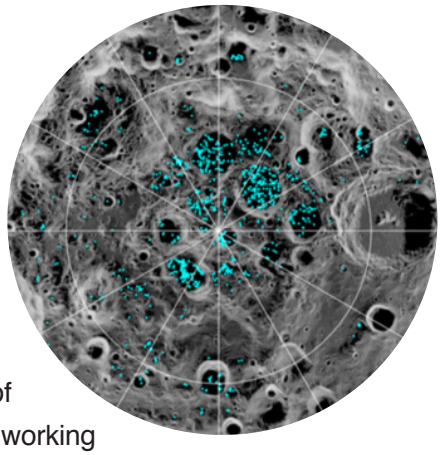

Image of the distribution of surface ice at the Moon's south pole. Credit: NASA

Construction of the rover will begin in late 2022 at NASA's Johnson Space Center in Houston, while the rover flight software and navigation system design will take place at Ames. Astrobotic will receive the complete rover with its scientific instruments in mid-2023 in preparation for launch later that year.

VIPER's Design Passed its Final Test

The CDR is the final review that focuses on the system's design. Ensuring that the rover's

The remarkable VIPER Team continues to impress, evolving an early exploratory mission concept into a complete science flight mission. Credit: NASA

VIPER Mission **Completes Critical Design Review (cont.)**

systems and the instruments are able to work together is no easy task. Passing the mission's CDR builds upon a series of previous Critical Design Assessments (CDA), where independent reviewers evaluated VIPER's systems individually.

The earlier CDA's focused on functions such as flight navigation systems and software, thermal and mechanical systems, and more. The CDR ensured these components are all capable of working together in a fully functional robotic system ready to explore the lunar surface.

Engineers working on base at NASA Ames during the pandemic test robotics software on an engineering prototype of VIPER. Credit: NASA/Dominic Hart

Since VIPER passed its earlier milestone called the Preliminary Design Review, or PDR, the system design has evolved considerably, focusing on how to safely conduct maximum science on the lunar surface. The selection of the region west of Nobile Crater as the rover's landing site was specifically chosen to be a good match for the capabilities of the overall VIPER system while also meeting all science goals.

A Design Ready to Reveal the Moon's Secrets

This final, approved rover design weighs 992 pounds in total and can travel at a speed of 0.45 miles per hour. It uses a solar-charged battery with a peak power of 450 watts and features mounted headlights – the first NASA rover to do so. Using its cameras and headlights, VIPER will navigate around hazards and traverse into craters while staying connected to Earth using the Deep Space Network.

The onboard computer is the brain of the rover that will help VIPER do its job and includes software for running commands sent from Earth, processing data from VIPER's sensors, operating its instruments and driving. Since the Moon is much closer to Earth than Mars, there will be little delay when communicating with VIPER, allowing some of the rover's functions to be performed here on Earth, such as creating maps of the rover's environment to track its position and mapping the resources it finds.

The rover and its components have been tested to endure the extreme lunar environment and answer key questions about the composition of the Moon. Using a hammer drill and three science instruments, VIPER will analyze drill cuttings for ice and other resources. VIPER will also study the soil and gasses in the lunar environment.

This remarkable VIPER team continues to impress, evolving from an early exploratory mission concept into a complete science flight mission. In the end, VIPER will write the books on the nature and location of water and other resources on the Moon.

Go VIPER! ■

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FY22 Center Innovation Fund (CIF) Winners

The Office of the Center Chief Technologist (OCCT) received nearly fifty well qualified and highly competitive CIF proposals, which led to an exceptionally difficult decision for our selection officials, the Ames Research and Technology Council. The OCCT appreciates the time and effort that all the proposal teams clearly invested in their proposals. Congratulations to the following twelve FY22 CIF winners!

- Lauren Abbott
Reusable Feedstock Materials Using Polymer-Coated Microparticles for In-Space Manufacturing

- Edward Balaban
Fluidic Telescope Experiment (FLUTE): to the ISS and beyond

- Anthony Colaprete
DMD Pointing Spectrometer

- Diana Gentry
Integrated Sonde & Analyzer for In Situ Aerosol Measurements at Venus

- Justin Haskins
Rapid assessment of AM metal performance through dislocation physics and machine learning

- Jennifer Heldmann
THEIA – Thermal History Exploration Instrument for Artemis

- Upender Kaul
Transonic Flutter Aerodynamics

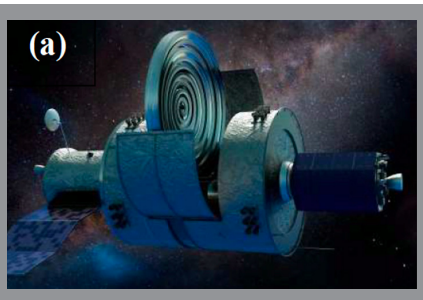
- John Lawson
High-Fidelity Process Model to Enable Additive Manufacturing of Complex Shape Structures

- Brandon Maryatt
Novel Instrument Suite for Martian Environment

- Antonio Ricco
Fluidic Integration of Inkjet Printed Sensors (FLIIPS)

- Thomas Templin & Eleanor Rieffel
High-Performance Quantum-Classical Hybrid Deep Generative Modeling Parameterized by Energy-based Models for Flight-Operations Anomaly Detection

- Christopher Teubert
Thomas Templin and Eleanor Rieffel Physics-Informed Neural Network for Next-Gen Electric Aircraft



Notional depiction of a large-scale telescope with the primary mirror formed using a shape-memory alloy frame and liquified gallium: (a) an early deployment stage and (b) the final configuration.

FY22 CIF Project: Fluidic Telescope Experiment (FLUTE): to the ISS and Beyond, PI: Edward Balaban.

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STMD Early Career Initiative (ECI) FY 2022 ARC Proposal Finalists

The Space Technology Mission Directorate (STMD) released the Early Career Initiative (ECI) call for proposals on March 1, 2021. This annual call from STMD focuses on professional development for early career NASA scientists, engineers and technologists. Centers submitted 2 proposals through their Center Chief Technologists (CCT) to the STMD Program Executive in response to the call.

The 2 ARC finalists, down selected from a final 4, are:

Smart STAMPS: Smart System for Telemetry Amalgamation of Multimodal PrognosticS

- PI Christopher Teubert

Project Vulcan: A Novel Method to Enhance Thermal Protection System Materials with Coatings

- PI Brody Bessire

In total, 11 proposals were submitted to the ARC CCT office in response to the call. While no ARC proposals were selected by STMD this year, we encourage all early career technologists to resubmit their proposal concepts and invite new innovators for next year's call. More information about the ECI program and previous ARC awardees is available at the Center Chief Technologist (CCT) website: **https://www.nasa.gov/centers/ames/cct**

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Ames Selected as a Co-Winner for 2021 NASA Government Invention of the Year Award

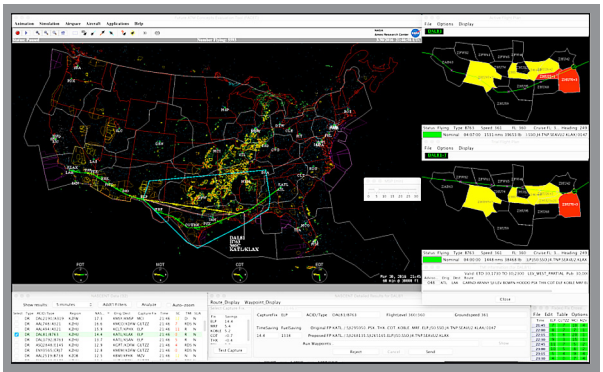
- Kelly Garcia

NASA's Ames Research Center was selected by the NASA general counsel as a co-winner of the 2021 NASA Government Invention of the Year award for our National Airspace System Constraint Evaluation and Notification Tool, or NASCENT, technology. The agencywide award was made at the recommendation of the NASA Inventions and Contributions Board. Every year, NASA issues two prestigious Invention of the Year awards: Government Invention of the Year and Commercial Invention of the Year.

Paul Borchers assessing NASCENT system functionality at American Airlines. Credit: NASA?

The co-winning invention provides evaluation of weather avoidance routes that save more than a user-specied number of minutes of wind-corrected flying time savings, for all the 20 air route traffic control centers in the national airspace system. The system is designed to safely remove inefficiencies in the air traffic

Ames Co-winner for 2021 **NASA Government Invention of the Year Award (cont.)**



The Graphical User Interface (GUI) for NASCENT system demonstrating rerouting of flights to save time while flying around weather. Credit: NASA?

NASCENT Team demonstrating the software to the Alaska Airlines dispatchers. Credit: NASA?

operations, to reduce delays, and save fuel to benefit the traveling public and the environment.

Air traffic managers and flight operators desire a continuous search engine that provides them with safe opportunities to save time and fuel. This invention provides that functionality for suggesting weather and constrained airspace avoidance routes. The proposed advisory routes are free of conflicts with weather, horizontally and vertically, help reduce overall sector congestion, and avoid any Federal Aviation Administration-designated special use/activity areas.

All of this is done while providing suggestions that account for safety and historically used routes to facilitate controller approval. The functionality is implemented according to the current FAA operating procedures, so there is no added cost to the national air transportation system infrastructure. ■

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Airspace Technology Demonstration

2 Selected as NASA Software of the Year Runner-up

- Kelly Garcia

NASA's Ames Research Center was selected as a runner-up for the 2021 NASA Software of the Year award for Airspace Technology Demonstration 2 (ATD-2).The agencywide annual competition rewards high-quality, innovative,and robust software using efficient software engineering processes that meet NASA's stringent safety and reliability standards. Sponsors of the competition include the NASA Chief

A ramp manager at CLT uses the ATD-2 IADS System to implement departure metering in collaboration with Traffic Management Coordinators in the air traffic control tower. Credit: NASA-X

Airspace Technology Demonstration NASA Software of the Year Runner-up **(cont.)**

Engineer, the NASA Chief Information Officer, and the NASA Office of Safety and Mission Assurance.

The ATD-2 project is comprised of technology development and demonstration activities geared toward delivery of near-term benefits to air transportation systems. Arrival, departure and surface activity including terminal sequencing and spacing, and air traffic flow management are several of the projects NASA is working on to make air travel safer and more reliable.

The ATD-2 effort provides solutions to several problems in the complicated, multi-airport environment. At most airports, departures are managed in the order they push back from the gate, which can overload runways and cause excessive taxi and hold times. ATD-2's software algorithms assist ground and local air traffic controllers with managing flights and suggest the sequence the flights should depart and cross the runways and when the flights should be cleared to leave the spots, (which are special flight holding locations on the airport surface where responsibility for the flight is transferred from the airline to air traffic control). ■

A TRACON traffic manager views airport surface and airborne traffic data from the ATD-2 IADS System during the Phase 2 field demonstration at CLT. Credit: Easter Wang

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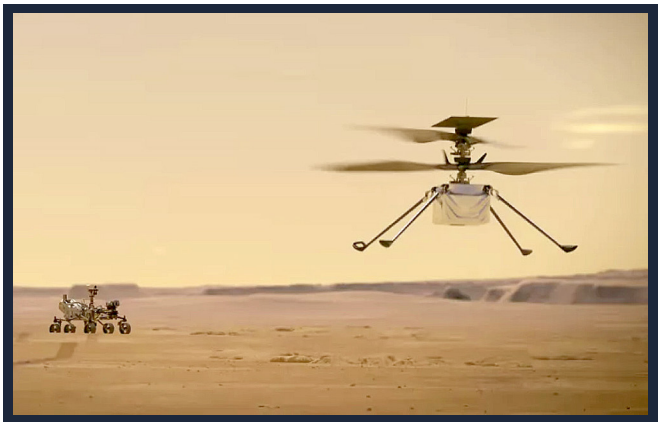
The ATD-2 team from across the country gathered at Ames for the Vision Workshop in Oct. 2019 which focused on the Phase 3 field evaluation and the data-driven finale for ATD-2. Credit: Dominic Hart/NASA Ames.

NASAs Ingenuity Mars Helicopter Team **Receives the American Helicopter Museum and Education Center 2021 Achievement Award**

NASA's Ingenuity Mars Helicopter team was recently honored by a group that really knows their helicopters. The team was recognized with the 2021 Achievement Award of the American Helicopter Museum and Education Center, in West Chester, Pennsylvania. Carlos Malpica represented the NASA Aeronautics arm of the team at the museum's award gala. Dr. Malpica was a key member of the Ingenuity development team for flight control system engineering development, modeling, and testing. One of the key challenges of building Ingenuity was that it was expected to be highly unstable, and the Team was concerned about being able to stabilize it with enough margins that we could account for any unknown dynamics… After all this was the first time a helicopter was being modeled and designed to y on Mars and there were many unknowns! Dr. Malpica was also responsible for the concerted helicopter dynamics system identification (the science of building a mathematical model of a dynamic system based on measurements of the input and output) testing and data analysis. The purpose of the system identification testing was to verify and validate modeling assumptions, and in doing so increase understanding of the physics involved in the flight dynamics of the helicopter.

Ingenuity is a technology experiment and the first aircraft to attempt controlled flight on another planet. It arrived on Mars on February 18, 2021, attached to the belly of NASA's Mars 2020 Perseverance rover. On April 19, it succeeded in its historic first flight. "History is made every day, and the...Ingenuity team certainly made and continues to make history as Ingenuity explores the Red Planet," wrote Bob Beggs, co-founder and trustee of the museum. Congratulations to the whole team and to Ames' team members who contributed their aeronautical expertise!

Ames' Carlos Malpica with the ARMD Seminar Award. Credit: NASA



An artist's impression of NASA's Mars helicopter Ingenuity flying on the Red Planet. Credit: NASA

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The 2021 NASA Ames Technology Transfer Awards Ceremony was held virtually on September 28, 2021. The awards include those from 2019 and 2020. Congratulations to the recipients!

NASA Patent Awards

2019 ISSUED PATENTS

Patent: *10,169,847*
Air-to-Air Background Oriented Schlieren Technique
Innovators: *James Thomas Heineck, Daniel Banks, Edward Treanor Schairer, Paul Stewart Bean, Edward Andrew Haering Jr., Brett Arnold Pauer, Brittany Joan Martin, and David Nils Larson.*

Patent: *10,229,604*
Flight Awareness Collaboration Tool (FACT)
Innovators: *Richard Hugh Mogford, Cody Alan Evans, and Daniel Nicholas Peknik.*

Patent: *10,268,453*
Intelliface Autonomous System Simulation Testbed
Innovators: *James C. Ong, Emilio Remolina, and Peter I. Robinson.*

Patent: *10,275,548*
Interactive Diagnostic Modeling Evaluator
Innovators: *Anuradha Kodali and Peter I. Robinson.*

Patent: *10,332,405*
Unmanned Aircraft Systems Trac Management
Innovator: *Parimal Kopardekar*

Patent: *10,427,807*
Method of fabricating a exible, low-density thermal protection material
Innovators: *Margaret M. Stackpoole, Ehson M. Ghandehari, Jeremy J. Thornton, and Melmoth Allan Covington.*

Patents:
10,463,249 – Comprehensive Oculomotor Behavioral Response Assessment system
10,420,465 – Oculometric assessment of sensorimotor impairment
Innovators: *Leland S. Stone and Dorion Bryce Liston*

2020 ISSUED PATENTS

Patent: *10,229,604*
Nanosensor Array for Medical Diagnoses
Innovator: *Jing Li*

Patent: *10,604,872*
Woven Thermal Protection System
Innovators: *Margaret Stackpoole, Jay Feldman, Donald Ellerby, Ethiraj Venkatapathy, Curt Wilkinson*

Patent: *10,669,045*
Aordable Vehicle Avionics system
Innovators: *James Cockrell, David J Mayer, Aaron James Cohen, Mike Briggs*

Patent: *10,696,423*
Method for transferring a spacecraft from geosynchronous transfer orbit to lunar orbit
Innovator: *Anthony Genova*

Patents:
10,698,024 – Self-healing microchip
10,727,325 – Nanostructure-based vacuum channel transistor
10,816,411 – Temperature sensing within integrated microheater
Innovators: *Jin-Woo Han, Meyya Meyyappan*

Patent: *10,717,836*
Alternative resin systems for thermal protection materials
Innovators: *Tane Boghozian and Margaret Stackpoole*

Patent: *10,752,386*
Flexible ablator for thermal protection
Innovators: *James Arnold, Robin Beck, Wenhong Fan, Jeremy Thornton, Susan White and .*

Patent: *10,787,242*
Variable camber continuous aerodynamic control surfaces and methods for active wing shaping control
Innovator: *Nhan Nguyen*

Patent: *10,815,474*
System for the 3D construction of biologically derived materials, structures, and parts
Innovators: *Diana Gentry, Lynn Rothschild and Christopher Venter.*

Patent: *10,861,256*
System for failure response advice based on diagnosed failures and their eect on planned activities
Innovators: *Silvano Colombano, Paul Morris and Liljana Spirkovska.*

NASA Invention of the Year Awards

Runner-up, 2019 Invention of the Year
MIDAR: Multispectral imaging, detection and active reectance instrument
Innovator: *Ved Chirayath*

Winner, 2020 Invention of the Year
UTM: Unmanned Aircraft Systems Trac Management
Innovator: *Parimal Kopardekar*

NASA Software of the Year Awards

Winner, 2019 Software of the Year
UAS Trac Management Services (UTM)

Team includes: *Arwa Aweiss, Vijay Baskaran, Lauren Claudatos, Marcus Johnson, Ron Johnson, Jaewoo Jung, Sherry Jurcak, Je Homola, Parimal Kopardekar, Joey Mercer, Daniel Mulnger, Natalie Paremski, Tom Prevot, Joseph Rios, Irene Skupniewicz Smith, David Smith, Priya Venkatesen, Punam Verma, and Leo Wang.*

Runner-up, 2020 Software of the Year
Astrobee Robot and Ground Software

Team includes: *Oleg Alexandrov, Jonathan Barlow, Jose Benavides, Maria Bualat, Roberto Carlino, Brian Coltin, Michael Dille, Lorenzo Fluckiger, Terrence Fong, Jesse Fusco, Ruben Garcia, Ryan Goetz, Kathryn Hamilton, Zachary Moratto, Marina Moreira, Theodore Morse, Robert Nakamura, In Won Park, Christopher Provencher, Khaled Sharif, Trey Smith, Andrew Symington, Vinh To, Recaredo Torres, Andres Mora Vargas, DW Wheeler, and Jongwoon Yoo.*

Federal Labs Consortium (FLC) Awards

2019 FLC Far West Region Outstanding Technology Development Award
MiDAR - Multispectral Imaging, Detection and Active Reectance
Ved Chirayath

2020 FLC Far West Region Outstanding Partnership Award
Delta Region Areawide Aquatic Weed Project (DRAAWP)
David Bubenheim