National Aeronautics and Space Administration

EXPLORE AIRBORNE SCIENCE NEWSLETTER

Fall 2020

Director's Corner

Welcome to the ASP Fall 2020 Newsletter. Despite the ongoing challenges presented by COVID-19, the Airborne Science Program, partners, collaborators and scientists have worked to safely execute critical Earth Science flights in support of NASA missions. The University of Alaska completed Alaska glacier mapping in support of Operation IceBridge, the JPL/AVIRIS NG team conducted methane emissions flights, and the UAVSAR/C-20 teams at JPL and Armstrong Flight Research Center (AFRC) were called to action in support of the unprecedented wildfires taking place in the Western U.S. this summer, providing updated information to assist with burned area recovery and forest health assessments. In addition, the Oceans Melting Greenland (OMG) project continued collecting critical ocean temperature and bathymetry data, this year off the northern coast of Greenland and we are grateful for the support of the Kangerlussaq Institute for Science. Also, despite the inability to conduct an in person Student Airborne Research Program (SARP), we did manage to conduct it virtually and engaged in a distributed air sampling project to characterize pandemic related impacts to atmospheric chemistry. Many thanks go out to the mentors, faculty and especially Dr. Emily Schaller who made it a reality.

I'd also like to formally introduce you to my new Deputies, Mr. Derek Rutovic and Dr. Melissa Martin who will be assisting me directly with running the program and with customer interactions. Please enjoy these and other updates from our Program as we look forward to another busy year in 2021. I hope everyone is also staying safe and taking the time they need during these unprecedented times across the world.

Bruce Tagg
Director, Airborne Science Program

What's Inside

Introducing new Airborne Science Program Deputies

Derek Rutovic was recently appointed Deputy Airborne Science Program Director, with a focus in Operations. Derek received his B.S. in Aerospace Engineering from Purdue University in 2004 and graduated as part of Class 143 from the United States Naval Test Pilot School in 2013. Prior to joining the ASP management team, Derek served in both engineering and program management roles for the fleet of aircraft at the Johnson Space Center (JSC). Derek was the lead engineer for multiple aircraft modifications including the installation of the UAVSAR pod on the G-III, the Super Guppy avionics upgrade, and the G-III AXCTD sonobuoy launch system installation. Since 2014 Derek has served as an aircraft program manager, at various times, for the G-III,

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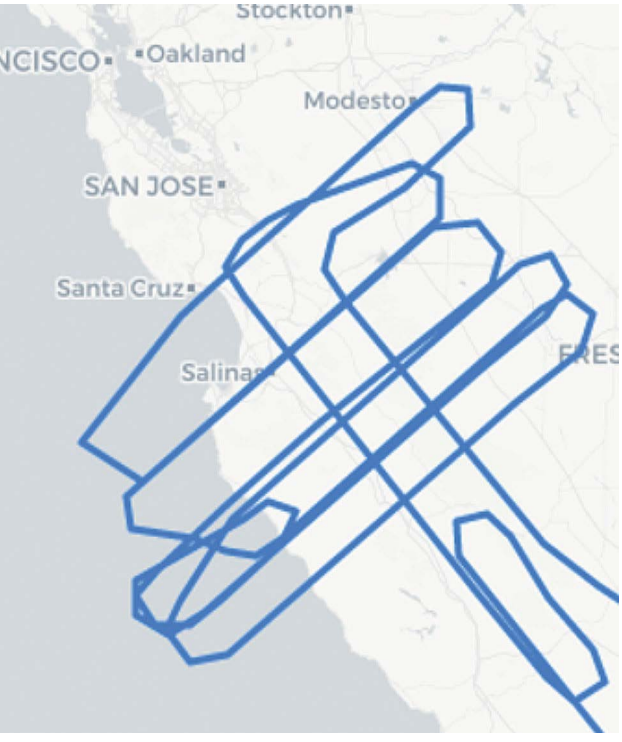
G-V and WB-57F aircraft at JSC, responsible for ensuring success in meeting SMD, HEOMD, and DoD objectives. These program management efforts included the development of the business plan, acquisition, and HEOMD/SMD partnership for the G-V in 2016.

Melissa Yang Martin was recently appointed as Deputy Airborne Science Program Director, with a focus in the Science. She will split her time between supporting ASP and supporting the EVS program in the ESSP Program Office as Mission Manager. Melissa received her Ph.D. in analytical/atmospheric chemistry from the University of California, Irvine in 2009. From 2010 to 2015, Melissa flew on several NASA sponsored field campaigns as a research physical scientist at NASA Langley Research Center (LaRC) measuring CO_2, CH_4, CO and H_2O. Much of her research focused on the study of the carbon cycle, source-sink attribution and use of in situ data for satellite validation. In 2014, Melissa went on detail as deputy project manager for the Radiation Budget Instrument. In Nov 2015, Melissa became Program Director of the National Suborbital Research Center

(NSRC), responsible for science operations support for various NASA airborne research platforms, including the DC-8, P-3, and C-130, as well as management of the Student Airborne Research Program (SARP). She also served as an interface to the scientific community.

UAVSAR views **California fire zones**

Contributed by Yunling Lou, JPL



Flights of the UAVSAR on the AFRC C-20A focused on fires southeast of San Francisco and south of Monterey in Central California.

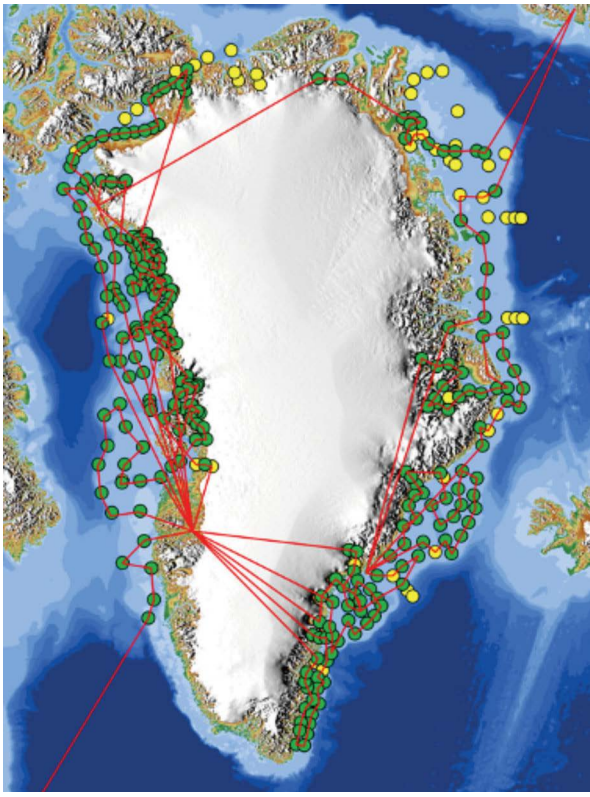
As California experiences one of the worst wildfire seasons on record, NASA's Applied Science and Airborne Science Programs are assisting with the response using NASA's unique airborne sensors. NASA's C-20A aircraft took off from its base at NASA's Armstrong Flight Research Center Building 703 in Palmdale, California, carrying the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) instrument developed and operated by NASA's Jet Propulsion Laboratory. Attached to the bottom of the aircraft, the radar is flown repeatedly over an area to measure tiny changes in surface height with extreme accuracy. But the instrument is also highly effective at mapping burn scars, because radar bounces off vegetation in a different way than they do bare, freshly burned ground. What's more, UAVSAR flights over burn areas produce observations that are ten-times higher resolution than satellites, meaning flights can be quickly tasked to target vulnerable areas of burn scars after being identified in satellite images. After vegetation is burned away, sloping hillsides and valleys can become susceptible to mudslides during winter rains, often months later. The researchers intend to produce data products that can be used to identify areas most at risk.

Oceans Melting Greenland –
Earth Venture Sububorbital-2 mission makes another trip to Greenland

Contributed by Josh Willis, JPL

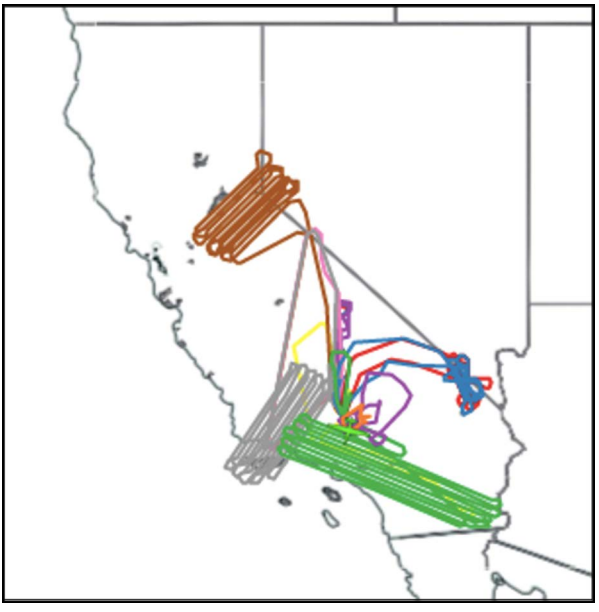
The Ocean's Melting Greenland (OMG) multi-year project seeks to understand how in-water and airborne measurements can improve estimates of glacial discharge from Greenland. This year OMG dropped nearly 350 Airborne Expendable Conductivity Temperature Depth (AXCTD) sensors to measure ocean conditions (ocean salinity and temperature) on the shelf around Greenland. That's more than we've ever dropped before in a single year, and we did it in just under 3 weeks. Every dot is a place where we planned to drop and the ones that turned from green to yellow are the ones where we got good data. The red tracks show where we flew. We spent a lot of time in Kangerlussuaq this year, in Southeast Greenland, as you can see from the map. We were lucky enough to be able to work from that city, while still observing Greenland's strict quarantine rules, because we were supported by the Kangerlussuaq Institute for Science Support, which gave us lodging where we could isolate, but still get to the airplane without contact with any locals. It was an incredibly challenging year, and we were only successful because of the hard work and help of so many folks at JPL, NASA SMD, the US State Department and Canadian, Danish, Norwegian and Greenlandic authorities.

The OMG team worked with Kenn Borek Air LTD, a global leader in Polar Research Scientific Aviation, who provided a Basler DC3-TP for the airborne ocean survey. In total OMG flew 135 hours in 24 days. This is the third year that OMG has utilized a Basler DC3-TP, and first year working with Kenn Borek Air.



AXCTD dropsonde locations for flight series of OMG

The aircraft is well suited for the OMG Greenland survey given the speed, range, ability to operate from short gravel runways, and the ample cabin space.



ER-2 continues flights of California boxes for Western States Diversity Time Series

ER-2 Returns to Flight
for Western Diversity Time Series

Contributed by Rob Green, JPL

The Western Diversity Time Series (WDTS) is the continuation of what was previously called HyspIRI Prepartory mission. The long-running time series has mapped six well-defined regions or "boxes" of California over multiple seasons, landscapes and vegetative conditions, building a database for the earlier proposed satellite mission HyspIRI. The ER-2 flies this mission, carrying various imaging instruments. Past missions have carried MASTER (a multispectral scanner), AVIRIS Classic (a visible to short wavelength infrared imaging spectrometer, and HyTES (a thermal infrared imaging spectrometer).

More than 70 scientific articles have come from these measurements to date.

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NASA's Earth Science Division has funded the continuation of these flights, as both a unique science data set and preparation of the new Decadal Survey mission Surface Biology and Geology (SBG).

In late September, the ER-2 (NASA809NA) was approved for return to flight status and began the new series. These 2020 flights have carried a payload suite consisting of AVIRIS, MASTER, and HyTES, along with PICARD, a new instrument (a visible/SWIR spectrometer) that operates in pushbroom configuration.

SWIFT Engineering HALE UAS completes first flights and lands first customer

Contributed by Matt Fladeland, ARC

With the help of NASA's Ames Research Center, Swift Engineering of San Clemente, California, completed a two-hour flight test of their Swift High-Altitude Long-Endurance (HALE) UAS in July. Swift HALE is an unmanned aircraft system developed by small business Swift Engineering, in partnership with NASA, to demonstrate how successful high-altitude, long-endurance flight can expand science research in a cost-efficient and timely manner. Swift's 72-foot solar-powered HALE weighs less than 180 pounds, flies 10- to 15-pound payloads at a time and is designed to operate at an altitude of 70,000 feet for 30 days or more. Despite its wide wingspan, Swift's HALE is similar in size to a small general aviation (GA) aircraft but at a fraction of a GA's weight. Compared to the NASA ER-2, which also operates at a maximum altitude of 70,000 feet and can carry a 2,600-pound payload for missions over 10 hours, the Swift HALE UAS is capable of flying lightweight payloads for days and weeks on end. This NASA-sponsored SBIR effort will continue with a partnership with the US Forest Service through a NAS SBIR Phase IIE grant, designed to demonstrate the newly developed Swift UAS. The Airborne Science Program is funding a project at Ames to evaluate and demonstrate the use of HALE UAS and how they might contribute to future NASA earth observing architectures. The USFS Phase III contract is in place and the NASA Phase IIE has been approved for funding as well. The USFS plans to deploy a variety of cameras in the visible, shortwave, and longwave infrared coupled with onboard processing and high-speed telemetry to demonstrate real time fire observations. NASA matching funding will explore integration of payloads to support radiation measurements, magnetic fields, and imaging spectroscopy, in coordination with several NASA, DOE, and USGS teams. NASA Earth Science has worked closely with the ARC Safety Office to develop an Interagency Agreement to enable this office to support USFS with Airworthiness and Flight Safety Reviews, as well as Certificate of Authorization (COA) development. The flights are scheduled to take place in June 2021.

The SWIFT Engineering HALE UAS takes off for test flight at the New Mexico Space Port

2020 NASA **Student Airborne Research Program**

Contributed by Emily Schaller, Bay Area Environmental Research Institute

The 12th annual NASA Student Airborne Research Program (SARP) took place from June 15-August 7 as an online program. Every summer since 2009, SARP has competitively selected a group of ~30 undergraduate STEM majors from across the United States for a summer internship experience in NASA Earth Science research that included flights on a NASA research aircraft. This year with COVID-19 travel and social distancing restrictions in place, SARP was grounded, but the internship continued with new at-home data collection and analysis.

Air sample canisters were mailed out to SARP participants in April before the official start of the program in June so that students could sample the air at the peak of stay-at-home orders while emissions were likely lowest in late April. As states begin the gradual process of re-opening in the spring/summer, SARP participants continued to take air samples near their homes, allowing them to track any changes in emissions. Once SARP participants collected all their air samples, they mailed the canisters back to the UC Irvine laboratory where the samples are being analyzed for nearly 100 compounds including greenhouse gases such as methane and carbon dioxide, vehicular exhaust gases, and gases related to industrial activities.

The majority of the time during the internship was spent developing individual research projects using the SARP airborne datasets from the past 11 summers as well as data from other NASA airborne, satellite and ground stations. A team of faculty advisors, NASA scientists, and graduate student research mentors supported students.

At the conclusion of the program, each student delivered a 12-minute AGU conference-style oral presentation on their individual research project. NASA scientists and administrators, SARP alumni and university faculty members attended the online presentations.

SARP class of 2020 in their virtual classroom

Earth Venture Suborbital-3 (EVS-3) Starts, Pauses, Continues

The five EVS-3 projects began planning in 2019 for flights in 2020. ACTIVATE and IMPACTS had flight activities in early 2020. All flight activities were paused during the COVID shutdown. ACTIVATE returned to flight in August, while all other projects have rescheduled, as shown in the table.

Table 1 EVS-3 Project Status

Mission	Aircraft	2020 Progress	Website
ACTIVATE	UC-12B, HU-25A	Spring 2020 mission: UC-12B 67.9 flight hrs; HU-25A 89.2 hrs Return to flight in August: UC-12B 43.5 flight hrs; HU-25A 46.6 hrs	https://activate.larc.nasa.gov/
IMPACTS	P-3, ER-2	Spring 2020 mission: P-3 61.3 flight hrs; ER-2 62.6 flight hrs Return to flight January 2021	https://espo.nasa.gov/impacts
DCOTTS	ER-2	Test flights scheduled for March 2021, science flights for June 2021	https://espo.nasa.gov/dcotss/content/DCOTSS
S-MODE	G-III, B-200, TO	Science flights from Ames begin in spring 2021	https://espo.nasa.gov/s-mode
Delta-X	G-III, B-200 (2)	Upgraded AirSWOT flight tests in October / November 2020. Mission rescheduled for summer 2021	https://deltax.jpl.nasa.gov/

NASA Science Aircraft News

Although both science and work on NASA aircraft slowed during the summer due to COVID-19 precautions, some essential flying continued and work took place in the background. Several science aircraft have returned to flight and others are preparing for upcoming missions. The status of NASA Earth science aircraft is shown in Table 2.

Table 2 Aircraft Status

Aircraft	Status	News	Contact
G-V	Flying	New ports for HyTES, display upgrade	Tyler Thompson
DC-8	Engine repair and heavy maintenance	Return to service 2021, next mission CPEX-AW	Chuck Irving
ER-2	809 flying	Western Diversity Time Series in California	Brian Hobbs
ER-2	806	806 in follow-up from CARE service	Brian Hobbs
P-3	Flying	Next mission: IMPACTS; Pylon study done at LaRC	Mike Cropper
C-20A	Flying	UAVSAR current mission: California fires	John McGrath
JSC G-III	Flying	Next mission: Delta-X	Tyler Thompson
LaRC G-III	Research mods	Preparing for S-MODE, installing PRISM	Bruce Fisher
WB-57 (928)	Flying	Next mission ACCLIP	Pete Layshock

Cooperative Development of NASA LaRC Gulfstream III and NASA JSC Gulfstream V for Earth Science Research

Contributed by Bruce Fisher, LaRC and Tyler Thompson, JSC

The Research Services Directorate (RSD) at LaRC and the Aircraft Operations Division (AOD) at JSC are jointly preparing their Gulfstream III (N520NA) and Gulfstream V (N95NA) aircraft, respectively, for expanded Airborne Science research. Both aircraft already have been modified to have dual nadir portals, as seen in the Figure below. N520NA also incorporates shutter doors for the nadir portals, whereas N95NA incorporates debris fences. Both teams have installed research power distribution systems, intercom communication systems, satellite communications, and NSRC's NASDAT in their aircraft. RSD at LaRC and AOD at JSC are jointly designing and fabricating common installation hardware for several science instruments so that the instruments can be flown in either aircraft.

NADIR ports on the JSC G-V and LaRC G-III

RSD/NASA LaRC has the lead for the following instruments:

- GCAS (GSFC GeoCAPE Airborne Simulator)
- HALO (LaRC High Altitude Lidar Observatory)
- HSRL-2 (LaRC High Spectral Resolution Lidar 2)
- Dropsonde/Sonobuoy launcher (adapted from the existing installation in the JSC G-III (N992NA))
- PRISM (JPL's Portable Remote Imaging Spectrometer)
- CPL (GSFC Cloud Physics Lidar)

AOD/NASA JSC has the lead for the following instruments:

- AVIRIS-NG (JPL's Airborne Visible/Infrared Imaging Spectrometer-Next Generation)
- HyTES (JPL's Hyperspectral Thermal Emission Spectrometer)
- LVIS (GSFC Land, Vegetation and Ice Sensor)
- UV transmissive optical windows to replace the aircraft's passenger windows (replication of the existing design installed on the AFRC C-20A (N808NA))

Both the LaRC G-III and JSC G-III (N992NA) will have three optical windows installed for the SHARC (Hayabusa-2) asteroid sample return mission in Australia in December 2020. PRISM will be installed in the aft nadir portal of N520NA for the S-MODE mission in California currently scheduled for April 2021. GCAS and CPL are tentatively scheduled to fly in N520NA for the MOOSE-LISTOS mission in Detroit and New York in the summer of 2021. GCAS and HSRL-2 will be flown in N95NA for the TRACER-AQ mission in Houston in the fall of 2021. Finally, PRISM, AVIRIS-NG, HyTES and LVIS will be divided between N95NA and N520NA for joint flights from Cape Town, South Africa for the BioSCape campaign in October and November 2022.

Mission Tools Suite – **UPDATE and NEW LOGIN REQUIRED**

Contributed by Aaron Duley, ARC

After nearly two years of effort the next generation Mission Tools Suite is now available. MTSv2 is a complete rework of the initial system, providing new capabilities for telemetry visualization, multi-projection support, including new tools to simplify product search, discovery, and management. The new system has been reworked from the ground-up to take full consideration of lessons learned through nearly a decade of mission operations support. A fully redesigned user interface centralizes common display enhancements (e.g., range rings, wind vectors) and allows greater customization based on ones' mission role and preferences.

MTSv2 has been undergoing operations testing for the past several months with NOAA's Hurricane Research Directorate and the ACTIVATE campaign. Note that the first generation version of MTS has been decommissioned and is no longer available.

You can reach the new system at **https://mts2.nasa.gov.** Your affiliation with an airborne mission or associated platform is required to access the new system. Your previous MTSv1 credentials will not work with the new system. Previous users can revalidate access directly with mission management or with their project's mission liaison office, such as the Earth Science Project Office. Please direct questions and feedback to **aaron.r.duley@nasa.gov.**

SOFRS Corner

Contributed by Vidal Salazar, ARC

Science Operations Flight Request System (SOFRS) Corner
SOFRS Website: https://airbornescience.nasa.gov/sofr NASA Operation IceBridge Project Science Office

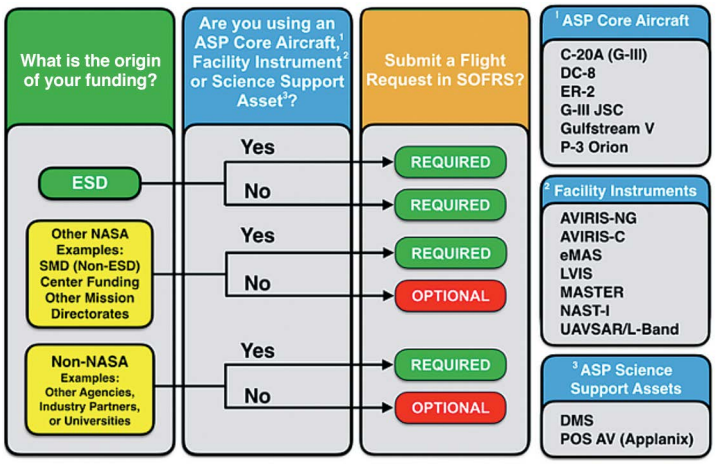
How do I know if I have to submit a SOFRS flight request?

The decision tree on the right will help you find out if you are required to submit a flight request by answering two simple questions:

1.) Will your flight activities be funded by the NASA Earth Science Directorate (ESD), other NASA Directorates, or by a Non-NASA funding source?

2.) Are you using any of the Airborne Science Program's Core Aircraft, Facility Instruments, or Science Support Assets?

The document and additional supporting information can be found in the annual call letter.



Please note, you can still submit a Flight Request even if you are not utilizing NASA ESD funds, ASP Core Aircraft, Facility Instruments, or ASP Science Support Assets. This will allow you the option to take advantage of the robust reporting capabilities of SOFRS!

Remember, send your SOFRS questions to: sofrs_curators@airbornescience.nasa.gov

Transitions - Retirements

Contributed by Diane Gribshaw, USRA

Jeff Myers and **Bruce Coffland** both retired from the Airborne Sensor Facility (ASF) on August 29, when a Zoom retirement party was held in their honor. THEY WILL BE MISSED.

Jeff Myers started working at Ames Research Center in 1976, using his training in aerial photogrammetry from the UC Forestry Dept. to analyze mapping photography from the Apollo Lunar Orbiters. He was soon recruited into what was then known as the U-2 Operational Support Section as a data analyst, and began supporting what would become several subsequent generations of airborne remote sensing systems that would be flown onboard the U-2C, C-130B, and ER-2 aircraft. Beginning with an analog infrared scanner developed in-house, followed by several versions of the Airborne Thematic Mapper Simulator, the JPL TIMS instrument, the AOCI ocean color imager, an AVHRR simulator known a MAMS, and later the MODIS and ASTER simulators MAS and MASTER. Most recently the new eMAS and PICARD imaging systems are beginning to make contributions to NASA earth science research.

He participated in early NASA wildfire mapping projects, including the use of real-time downlinks of TMS IR imagery over the Yellowstone firestorm in 1988. This technology culminated at the Ames ASF with the development of the AMS system, as used on the Altair and Ikhana UAS, and now by the USFS. Much of this architecture was then put to use on the NASA Global Hawk, whose real-time science network was largely developed by ASF engineers; and has since grown into the larger ASP Sensor Network. Jeff took on management of what is now known as the Airborne Sensor Facility in 1989, and would work under five different NASA contractors during his tenure. Besides the sensor engineering

Jeff Myers

projects, Jeff also led the ASF team on numerous international science campaigns and disaster response efforts, including the mapping of multiple earthquake and hurricane events, oil spills, and major wildfires. However, he most values the personal connections with the amazing spectrum of scientists, engineers, and others in the NASA community, that he has had the privilege of working with over all the years, and he intends to remain engaged with this truly incredible airborne science community.

\Bruce Coffland came to Ames ASF in August of 1980 after completing an MA in Geography with minor studies in Photography and Urban Planning. He served the Airborne Science Program (ASP) for forty years under five NASA contractors.

Bruce was originally hired as a photo analyst, and was eventually responsible for the processing of aerial mapping camera film in the Ames photo laboratory. At the time, the ASP engaged in land use and cover mapping camera imagery for the U.S. Forest Service (USFS) to assess both western and eastern state national forests land use and land cover.

Significant photo projects were flown for the state of Alaska and for researching the extensive wetlands of the Gulf Coast states to include interest in fish and wildlife habitats. Coverage included most of the western states, the gulf coast, and eastern Atlantic states and Alaska. The program acquired high-resolution film data until 2005 and the entire film archive is

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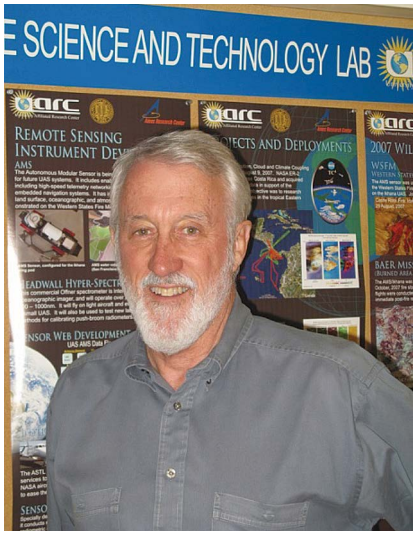

Bruce Coffland

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stored at NASA Ames. The archive is also captured in a searchable geo-referenced database.

In 1995, Bruce became the ASJ Operations Manager. In that capacity, he managed and coordinated flying ASF instruments on non-NASA platforms, including contracting Department of Energy (DOE) aircraft for acquiring low altitude, high resolution, multispectral data over the southwest states and southern California. The data collected supported seismology research, desert hydrology research and wildlife habitat classification.

He was also responsible for contracting with commercial aviation companies for flying Airborne Science instruments provided by the ASF, the Jet Propulsion Laboratory and NASA Goddard, as well as establishing Earth science contracts for use of program imaging resources with universities and other government agencies, including the US Geologic Survey, DOE and USFS.

An outstanding communicator, educator, and bridge-builder, Bruce developed descriptive ASP educational media and exhibits for public and academic distribution at national and international science conferences, and acted as a NASA ambassador to groups of all ages across the country and the world. Bruce feels fortunate to have had an amazingly unique career experience, with remarkable individuals who fostered a collaborative and stimulating work environment in supporting NASA Earth science research for a critical national and international Earth science research facility. The ASF staff and management will be a forever-pleasurable memory. He says thanks to all and "It's been a great ride".

Calendar of events – Fall 2020

Unmanned Systems Canada:
#UC20 Remote (Virtual)
November 3-6, 2020
https://uc20.unmannedsystems.ca/
REGISTRATION is OPEN

Carbon Monitoring System Science Team Meeting and Applications Workshop (Virtual)
November 17-19, 2020
https://carbon.nasa.gov/meeting_2020/index.html
REGISTRATION is OPEN

th Federal UAS Workshop (Virtual),
November 17-19, 2020
Contact Tamara Wilson (tswilson@usgs.gov) or Matt Fladeland (matthew.m.fladeland@nasa.gov)

TFRSAC Fall meeting (Virtual)
November 18-19, 2020
Contact: Everett Hinkley (ehinkley@fs.fed.us) or Vince Ambrosia (Vincent.g.ambrosia@nasa.gov)

AGU Fall 2020 Meeting (Virtual)
December 1-17, 2020
https://www.agu.org/fall-meeting
REGISTRATION is OPEN and closes October 30

AIAA Science and Technology Forum (Virtual)
January 11-15, 2021
https://www.aiaa.org/SciTech

101st American Meteorological Society 2020 Annual Meeting (Virtual)
January 10-14, 2021
https://annual.ametsoc.org/index.cfm/2021/

Virtual 7th North American Carbon Program (NACP) Open Science Meeting -
The future is here: North American carbon cycle science for a changed climate
March 5–26, 2021
https://nacarbon.org/meeting_2021/index.html

2021 IEEE Aerospace Conference (Virtual)
March 6-13, 2021
https://aeroconf.org/

7th ABoVE Science Team Meeting and Research to Operations Workshop
May 10-14, 2021; Fairbanks, AK
ABoVE.nasa.gov

16th International Circumpolar Remote Sensing Symposium
May 17-21, 2020; Fairbanks, AK
https://www.awi.de/en/science/geosciences/permafrost-research/conferences/icrss.html

Airborne Science Program
Platform Capabilities

Available aircraft and specs

Platform Name	Center	Payload Accommodations	Duration (Hours)	Useful Payload (lbs)	Max Altitude (ft)	Airspeed (knots)	Range (Nmi)
ASP Supported Aircraft							
DC-8	NASA-AFRC	4 nadir ports, 1 zenith port, 14 additional view ports	12	30,000	41,000	450	5,400
ER-2 (2)	NASA-AFRC	Q-bay (2 nadir ports), nose (1 nadir port), wing pods (4 nadir, 3 zenith ports), centerline pod (1 nadir port)	12	2,900	70,000	410	>5,000
Gulfstream III (G-III)(C-20A)	NASA-AFRC	UAVSAR pod	7	2,610	45,000	460	3,400
Gulfstream III (G-III)	NASA-JSC	UAVSAR pod, Sonobuoy launch tube	7	2,610	45,000	460	3,400
Gulfstream III (G-III)	NASA-LARC	2 nadir ports; additional research mods in development	7	2,610	45,000	460	3,400
Gulfstream V (G-V)	NASA-JSC	2 nadir ports; additional research mods in development	10	8,000	51,000	500	>5,000
P-3	NASA-WFF	1 large and 3 small zenith ports, 3 fuselage nadir ports, 2 bomb bay nadir ports, 4 P-3 aircraft window ports, 3 DC-8 aircraft window ports, nose radome, aft tailcone, 10 wing mounting points, dropsonde capable	14	14,700	32,000	400	3,800
Other NASA Aircraft							
B-200 (UC-12B)	NASA-LARC	2 nadir ports, aft pressure dome with dropsonde tube, cargo door	6.2	4,100	31,000	260	1,250
B-200	NASA-AFRC	2 nadir ports	6	1,850	30,000	272	1,490
B-200	NASA-LARC	2 nadir ports, wing tip pylons, zenith site for aerosol inlet, lateral ports	6.2	4,100	35,000	275	1,250
C-130	NASA-WFF	3 nadir ports, 1 zenith port, 2 rectangular windows, wing mount for instrument canisters, dropsonde capable, cargo carrying capable	12	36,500	33,000	290	3,000
Cessna 206H	NASA-WFF	Wing pod, belly pod, modified rear window for zenith ports	5.7	1,175	15,700	150	700
Dragon Eye	NASA-ARC	In situ sampling ports	1	1	500+	34	3
HU-25A Guardian	NASA-LARC	1 nadir port, wing hard points, crown probes	5	3,000	42,000	430	1,900
Matrice 600	NASA-ARC	Imager gimbal	1	6	8,000	35	3
SIERRA-B	NASA-ARC	Interchangeable nose pod for remote sensing and sampling and one nadir port	10	100	12,000	60	600
WB-57 (3)	NASA-JSC	Nose cone, 12ft of pallets using either 3ft or 6ft pallets, 2 Spearpods, 2 Superpods, 14 Wing Hatch Panels	6.5	8,800	60,000+	410	2,500

More information available at: **https://airbornescience.nasa.gov/aircraft**