SAT Meeting October 17th 2022

Overview of NOAA BAA Studies

In support of NESDIS Next-Generation Space and Ground Architecture Planning

D. Spencer and S. Boukabara

Why This briefing

- Goal of this meeting is to describe the BAA studies that NOAA has just initiated recently.

- The link to the public announcement of the BAA studies award could be found under: https://www.nesdis.noaa.gov/news/noaa-awards-joint-venture-program-broad-agency-announcements

- We plan to present what the studies are about, who is leading them, who are the support team members on the NOAA side, etc.

- The goal is to introduce the funded studies to the research community and to the NOAA users and programs for their awareness mainly.

- The goal is also to create potential interest and for creating potential collaboration and added value to the studies and to potential partners, if folks are interested.

Joint Venture program

- Purpose of JV is to leverage existing technology and external partnerships (Industry, other Federal agencies, academia, etc.) to meet NOAA mission needs
- The BAAs are funded by the JV program (lead: Lynn Mayo)
- Key Program officials: Beau Backus and Harshesh Patel
- Other Projects beyond BAAs are funded by JV
  - emerging data Exploitation
  - technology maturation
  - SAT and ASPEN
- Strong NASA/NOAA coordination through regular interaction between NESDIS and ESTO

Scope of the NOAA/NESDIS BAA Studies

1)- **3D Winds profiling**: how to best achieve this capability in the future NOAA space architecture using:
- Actual demonstration of technologies
- Holistic assessments of a space constellation using active and passive techniques

2)- **HyperSpectral Microwave Sensing (HyMS):** How best achieve a higher-performing microwave sensing capability in our next-gen space architecture taking into account the new technology developments.

3)- **EODT (Earth Observations Digital Twin):** How could we leverage Artificial Intelligence (AI) to potentially transform how we do ground processing of Earth Observations.

These Broad Agency Announcement (BAA) studies are about the major focus areas on the left. Each focus area is covered by several studies performed by the private sector and/or sister agencies. NOAA is hoping these will inform us in our planning and implementation of the next-gen architecture (both space and ground).

3D Winds Projects - Quad Charts

3-D Winds BAA Synopsis

- 3-D Winds measurement is considered a major gap in our space-based observing system and is deemed to have a great potential to improve the performances of several NOAA environmental prediction systems including global NWP
- Explore technologies that allow for the measurement of atmospheric wind profiles (3D winds) from space
- Identify technologies with the capability to:
  - achieve the goal of measuring 3Dwinds
  - determine the status of these technologies today and how they are projected to evolve in the near future
  - perform a value/feasibility assessment of them

A Comparative Assessment Study of Doppler Wind Lidar Technologies

BAA-NOAA-3DWinds-2022, Objective B

Technical Point of Contact: Sara Tucker, sara.tucker@ballaerospace.com, 303-939-6393
Administrative POC: Courtney Coe, courtney.coe@ballaerospace.com, 303-939-6390

Ball Aerospace
1600 Commerce Street
Boulder, CO 80301

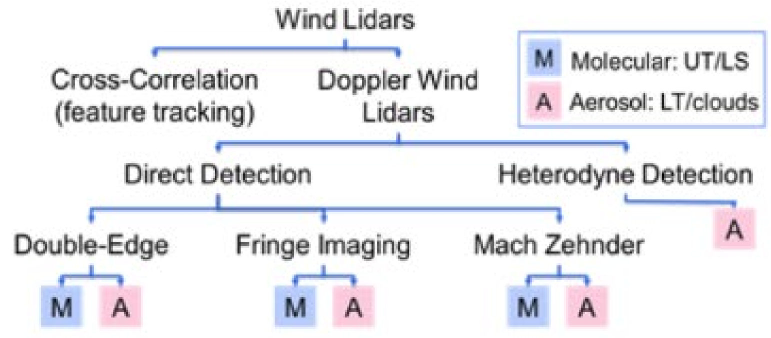
Objectives

Explore the trade space for spaceborne active optical (lidar) measurements of 3D winds from LEO orbits

Quantify the uncertainty for various Doppler wind lidar (DWL) technologies in measuring 3D winds from orbit, given community and GEOSV-NR aerosol and cloud profiles

Assess the potential sampling/coverage limitations for different DWL technology configurations

Assess technology readiness and cost drivers for the different DWL transmitter and receiver technologies



This study will review the different Doppler wind lidar technologies that have been proposed for space-based 3D winds measurements and assess performance, challenges, and opportunities for each

Benefits, Challenges, and Technological Maturity

- Will provide Doppler wind lidar simulations (to include cloud and aerosol inputs) with quantitative measurement uncertainty as a function of technology type, system design parameters, atmospheric state, etc.
- Team includes experts who have worked on modeling and building both heterodyne and direct detection wind lidar receivers.
- Challenges associated with the wide array of system design parameters, will be addressed through normalization: "per photon" and "per watt" analyses.
- Technological Maturity to be assessed for each of the lidar systems' major components.

Team: R. Michael Hardesty, U. of Colorado

Milestones, Period of Performance, and Budget

Period of Performance: Sept 2022 – August 2024

Build atmospheric backscatter/extinction profile tools	Dec 2022
Build orbit modeling tools	Jan 2023
Generate atmospheric profiles for 3 wavelengths	Feb 2023
Build/adapt modeling tools for 4 lidar systems	May 2023
Mid-study status review	Jun 2023
Demonstrate performance modeling for 4 systems	Aug 2023
Complete comparative performance analysis	Dec 2023
Complete technology readiness assessment	Feb 2024
Complete cost-drivers assessment	Mar 2024
Final Review, prepare report and deliver to NOAA	Apr 2024

Trade Space Exploration for Active and Passive 3D Winds Concepts

BAA-NOAA-3DWinds-2022, Objective B

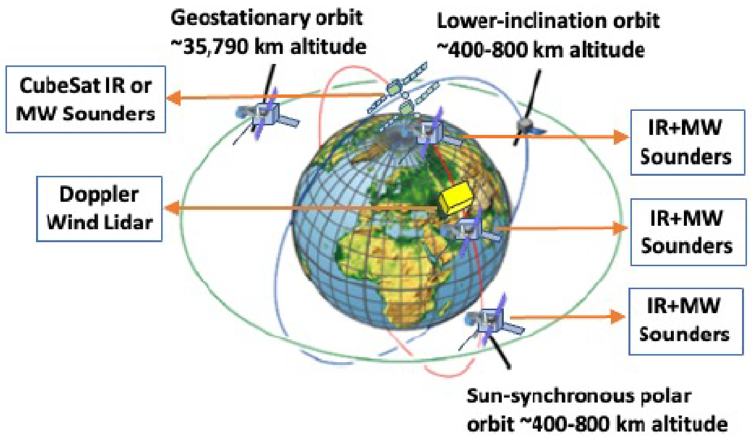
Technical Point of Contact: Derek Posselt, Derek.Posselt@jpl.nasa.gov, (818) 354-8107

Objectives

Explore the trade space consisting of active and passive spaceborne measurements of 3D winds from LEO and GEO orbits, as well as instrument and orbit combinations

Quantify the uncertainty in active and passive spaceborne 3D wind measurements, and assess the sampling effectiveness of various constellation configurations

Examine trades among swath width, resolution, point source and distributed constellation architectures.



This project will explore the synergy among several complementary 3D winds measurement concepts, and return quantitative estimates on their performance.

Benefits, Challenges, and Technological Maturity

- Optical flow feature-tracking algorithm is mature and well tested, and provides superior performance when compared with traditional feature tracking algorithms
- Doppler wind lidar simulator accounts for clouds and aerosol type and concentration, providing quantitative uncertainties as a function of the atmospheric state
- Team includes experts in retrievals from IR, MW, DWL, and their combinations, as well as demonstrated experience with forecast OSSEs
- The challenges are primarily associated with spanning the very large trade space of potential architectures.

Team: Sara Tucker, Ball Aerospace; Xubin Zeng and Amir Ouyed Hernandez, Univ AZ; Svetla Hristova-Veleva, Hai Nguyen, Igor Yanovsky, and Longtao Wu, JPL

Milestones, Period of Performance, and Budget

- Nature run data processed, initial architectures identified 11/22
- Performance (uncertainty, sampling, resolution) of first set of architectures finished, second set of architectures identified 2/23
- Performance of second set of architectures finished, third set of architectures identified. Preparation of forecast OSSEs begins. 12/23
- Architecture study complete, Forecast OSSEs finished. 7/24
- Study report finished and delivered to NOAA 9/24
- Period of Performance: Sept 2022 – Sept 2024

Quad Chart ***3D Winds Study Based on the MISTiC Winds Hyperspectral AMV Constellation Concept***

in response to BAA-NOAA-3D WINDS-2022 Objective B

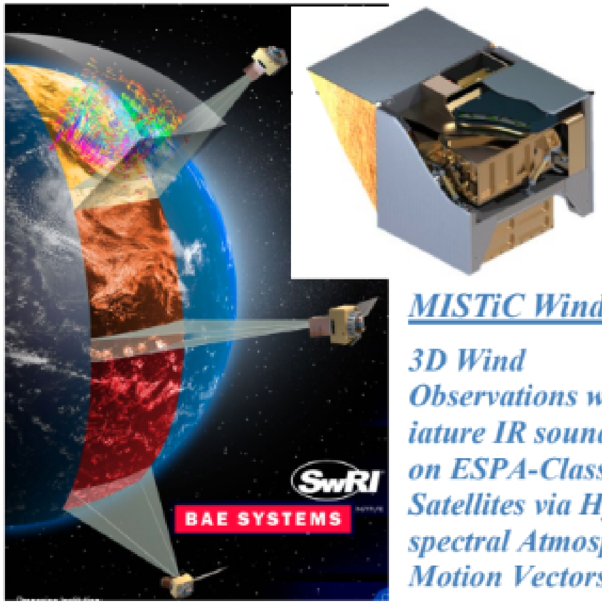
Technical/Administrative POCs: Kevin Maschhoff /Sue Camirand

M/S MER24-116A, P.O. Box 868, Nashua, NH 03061-0868, kevin.maschhoff@baesystems.com

Study Objective

Evaluate the Technical Capabilities of an on-orbit constellation of miniature infrared sounding instruments that work together to meet NOAA's Future 3D-Wind Observation requirements and Compare with Alternate Approaches:

- Compare IR Hyperspectral AMVs, Microwave hyperspectral AMVs, DWL, and Multi-Angle Stereo observation capabilities, in accuracy, spatial coverage, and atmospheric feature capture,
- Assess Potential Observation Synergies, Especially Synergies between Hyperspectral IR-AMVs and Stereo,
- Evaluate Options and Describe Recommended Optimum Observation Architecture.
- Provide sufficient observing system definition for each observation type compared (requirements and key design features) to support a balanced, informed comparison



MISTiC Winds

3D Wind Observations with Miniature IR sounders on ESPA-Class Micro-Satellites via Hyperspectral Atmospheric Motion Vectors

Benefits to NESDIS

- LEO constellation approach for 3D Winds provides a significant observing capability, meeting or exceeding Mid-point requirements with superior geographic coverage, at a much lower mission life-cycle cost than DWL. Observing system components are currently at TRL6 or higher, an assessment the NASA TMCo concurred with for EVM-3
- LEO IR Spectral Radiance and thermodynamic vertical profiling constellation would provide high spatial resolution, global coverage- including high-latitudes coverage, and observations at different times within the diurnal cycle than 1:30 AM/PM.
- Maximally leverages NASA Investment in AIRS & MISTiC Winds IIP to reduce technology and cost risk for NOAA's future distributed observing architecture.

Key Study Milestones-------------------------------Month

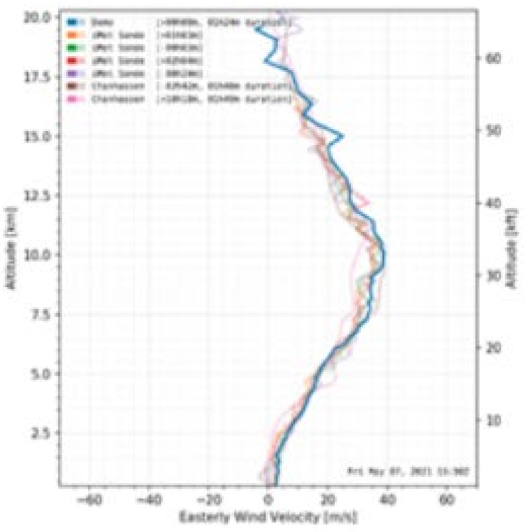
- Observation Method Comparison Study Kickoff-------0+
- Baseline Requirements and Key Design Parameter Definition for Observation Modalities Under Comparison Complete---------------------------------------3
- Mid Term Review--6
  (Compare/Contrast Observation Methods Complete)
- Observation Synergy Evaluation Complete----------- -9
- Review & Report on Optimized System Complete--- -11
- Study Follow-up Questions and Responses Complete-12

HAWCS: HONEYWELL ATMOSPHERIC WIND CAMPAIGN FOR SPACE

541715, Object A, Measuring the Atmospheric Wind Profile, Tom Dobbins, Ph.D., Honeywell International Inc., Aerospace – Advanced Technology, 12001 State Hwy. 55, Plymouth, MN 55441,Tel: 763-954-2477,E-Mail:thomas.dobbins@honeywell.com

Goal: This program will demonstrate the capability of the High-Altitude LiDAR for Atmospheric Sensing (HALAS) system for future deployment on space-based assets. This will be completed through:

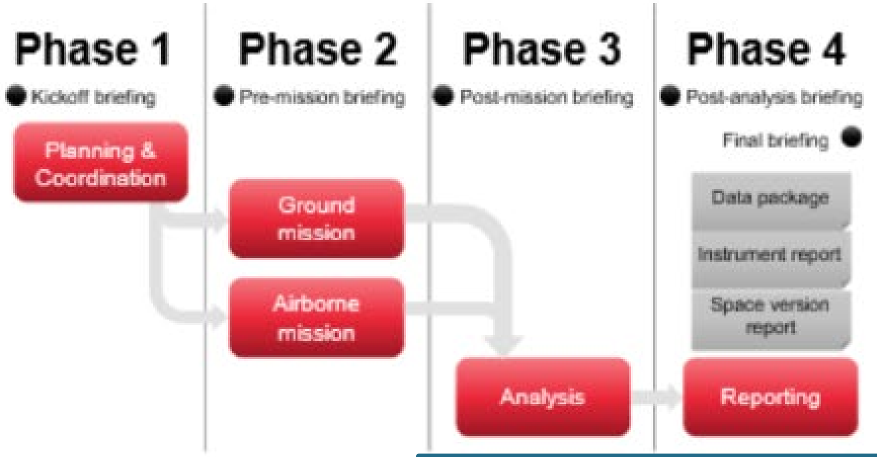
- A month-long wind measurement field campaign with:
  - A Honeywell-owned ground-based HALAS system
  - A HALAS system mounted on an aircraft owned by High-Speed System Test.
- These systems will be validated against each other, as well as with other sensors and atmospheric models



Atmospheric LiDAR Technology from Honeywell

Sensor Capability: Long-range atmospheric UV LIDAR technology provides the capability to simultaneously measure 3D winds, temperature, density, pressure, aerosols, and humidity in order to more accurately measure the state of the atmosphere.

Technological Readiness: The ground-based and airborne based HALAS systems are both fielded assets at TRL8 with extensive operation history



Schedule: 12 Months

3-D Lidar Wind Airborne Profiling Using A Coherent-Detection Doppler Wind Lidar Designed For Space-Based Operation

BAA-NOAA-3DWinds-2022, Objective A

Kristopher Bedka, NASA Langley Research Center
21 Langley Blvd, Mail Stop 420, Hampton, VA 23681
kristopher.m.bedka@nasa.gov. (757) 375-9234

Objective

We seek to work in collaboration with NOAA to:

1) 3D-wind measurements collected by the NASA Aerosol Wind Profiler (AWP) Doppler wind lidar (DWL) instrument,
2) the strengths and weaknesses of the AWP and, in general, coherent-detection DWL,
3) how DWL measurements compare with dropsondes and satellite-based wind observations, and operational numerical weather prediction (NWP) model output,
4) how DWL measurements could improve weather prediction model forecasts via collaborative assimilation experiments with NOAA, and
5) what wind spatial/vertical resolution and vertical coverage would look like from a space-based DWL mission conceived by NASA Langley Research Center (LaRC) and industry partners,

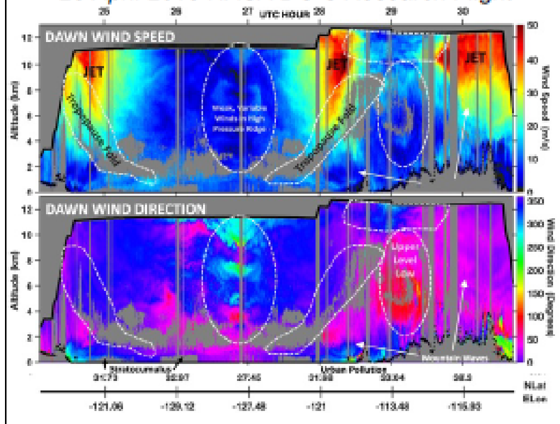
Description of Effort: In close collaboration with NOAA, we propose to fly the new Aerosol Wind Profiler (AWP) Doppler wind lidar instrument aboard the NASA Langley Gulfstream-3 aircraft for 60 hours in late May 2023 and Feb-April 2024 along with AVAPS dropsondes to accomplish the objectives above

Benefits of Proposed Technology

- Coherent DWL instruments provide an inherently precise (< 2 m/s RMS) and high-resolution wind measurements, that have previously found to be useful by NOAA for tropical cyclone and severe storms research and by DLR, ONR, and NASA for process studies.
- Building upon heritage established with the DAWN instrument, AWP will demonstrate a unique, NASA and small business collaboratively-built lidar system, developed with NASA ESTO funding, with laser performance characteristics (56 mJ at 200 Hz) and technologies needed for space
- AWP will collect near-simultaneous data from alternating nadir and off-nadir beam paths, providing u-, v, and w-component observations. Given these characteristics, AWP will be the most advanced/capable airborne DWL instrument in the world.

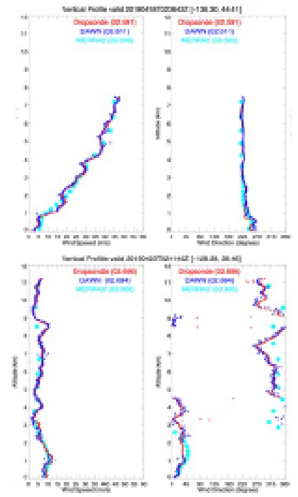
Airborne Coherent-Detection Wind Lidar: Examples and Validation

23 April 2019 NASA DC-8 Research Flight



Graphics From Bedka et al. (AMT, 2021)

Dropsonde Comparisons With High and Low Wind Speeds



The Doppler Aerosol WiNd (DAWN) coherent-detection lidar, a predecessor to AWP, has observed highly detailed and precise winds in its last 3 field campaigns, with < 2 m/s RMS and 0.25 m/s bias across > 400 dropsonde comparisons (N=~42,000 vertical level data points). We expect similar performance with even greater aerosol sensitivity and profile vertical coverage from AWP. AWP has been demonstrated on the ground and will be demonstrated on the NASA LaRC Gulfstream-3 in November 2022.

AWP will serve as a standard for Cal/Val of space-based wind retrievals, while demonstrating lidar system technologies that have a clear path to space

• Project kickoff	Feb 23
• Gulfstream-3 Flight Window 1	late May 23
• AWP Wind Retrieval Data Delivery	August 23
• Gulfstream-3 Flight Window 2	Feb-April 24
• Collaborative Data Analysis and Assimilation Experiments	Aug 23 – Sept 24
• Project Reporting and Closeout	Jan 25

HyMS Projects - Quad Charts

HyMS BAA Synopsis

- Recent advances in component technology have allowed the high spectral sampling of the microwave region to be a realistic and cost-effective possibility, allowing even smallsat compatible sensors to have this feature
- Determine the effectiveness of Hyperspectral Microwave sounding to operational performance by:
  - deploying these new technologies in an airborne or balloon-based platform
  - assessing the value of the data to the NOAA mission.

Developing the NOAA Next Generation Hyperspectral Microwave Sensor (HyMS)

BAA-NOAA-HyMS-2022, NAICS Code, 541715 – Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology), Demonstrating the Hyperspectral Microwave Sensor (HyMS) and Assessing the Benefits for the NOAA mission

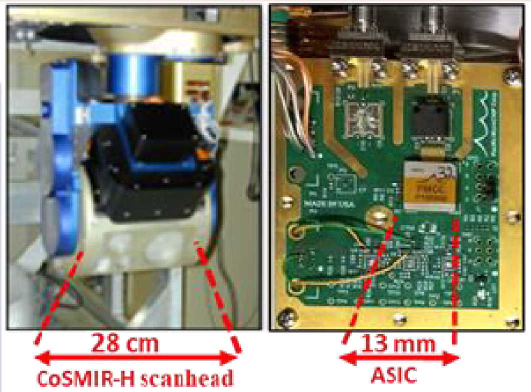
PI: Antonia Gambacorta, Antonia.gambacorta@nasa.gov, 301.614.6202, NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD 20771

Objectives:

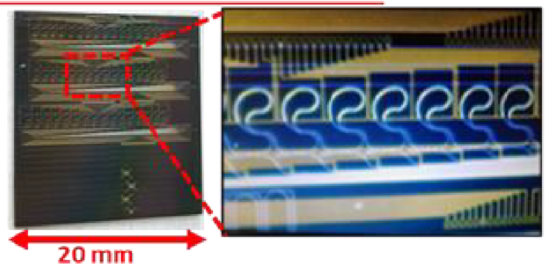
- To deploy the **CoSMIR-H (Conical Scanning Millimeter-wave Imaging Radiometer-Hyperspectral)** and acquire hyperspectral microwave (MW) data, quantitatively demonstrate its benefits for the NOAA mission, and make recommendations on future NOAA HyMS space instruments.

Description of effort:

- We will deploy an 8-week airborne field campaign to observe multiple weather conditions and surface types (land/ocean/coastal, all-sky).
- We will study the impact of multiple factors (spectral coverage, resolution, viewing geometry, noise, etc.) on product performance, determine the optimal HyMS configuration and identified unfilled observational gaps.
- We will perform trade studies using our space borne HyMS concept, **the Hyperspectral Microwave Photonic Instrument (HyMPI)** to draw recommendations on future space borne HyMS sensors.



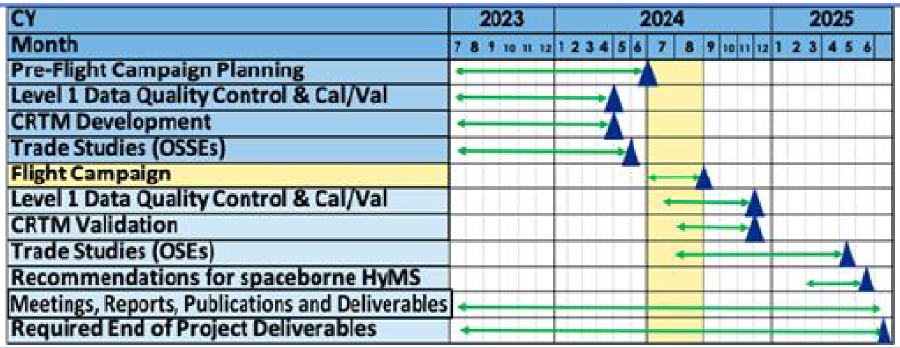
ASIC is the enabling technology of CoSMIR-H low SWAP-C hyperspectral, programmable spectral resolution



Photonic Integrated Circuits (PICs) combined with ASICs (PICASICs) are the enabling technology of HyMPI's low SWaP-C, 10 - 250 GHz contiguous, hyperspectral, programmable spectral resolution.

Benefits of proposed technology, challenges, and TRL

- **The ASIC (Application Specific Integrated Circuits)** is CoSMIR-H hyperspectral enabling technology. With a size of **~13x13mm**, it enables software **programmable** hyperspectral resolution up to **500KHz** in a **4GHz** bandwidth, maintaining low size, weight, power and cost (SWAP-C).
- CoSMIR-H hyperspectral coverage in the **50 and 183 GHz provides up to 50% BIAS and RMS improvement** in atmospheric temperature, water vapor and hydrometeors information content when compared against baseline sensors.
- **The PICASIC (Photonic Integrated Circuit combined with ASIC)** is HyMPI's **10-250 GHz** contiguous hyperspectral enabling technology and will increase Signal/Noise by adding the full **window** regions and the **118GHz** band, maintaining a small sat efficient SWaP (*e.g.*, **2U**).
- We will adapt legacy algorithms to mitigate Radio Frequency Interference, Calibration issues and Noise Instability challenges.
- **CoSMIR-H will be at TRL 6** by the time of the proposed field campaign (July 2024). **HyMPI will be at TRL 5** by December 2024.

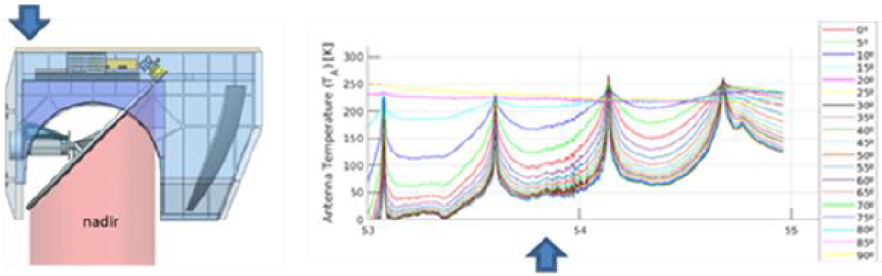


BAA-NOAA-HyMS-2022
Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109
Technical POC: Shannon Brown, shannon.t.brown@jpl.nasa.gov, 818-393-0773
Administrative POC: Edward Chow, Edward.chow@jpl.nasa.gov (818) 393-3854

Description and Objectives

- Upgrade HAMMR airborne sounder to a hyperspectral sounder using existing RF/spectrometer designs
- Integrate instrument with high-altitude balloon to obtain long duration data over a variety of weather conditions over land/ocean
- Calibrate and assess performance of instrument
- Provide recommendations for spaceborne sounders for 2030

JPL SmallSat Software Defined SounderSat Concept



Hyper-spectral, hyper-angle data from our spectrometer protype integrated with the MTHP radiometer (calibration is preliminary). These spectra were obtained at multiple angles looking straight ahead of the plane (90°) and upward toward cold sky (0°) from 45,000ft enabling the O_2 line complex to be resolved in the 53-55 GHz region.

Benefits, Challenges and Maturity

- Software defined spectrometer provides re-configurability, reduces development cost/schedule, adds resiliency to changing user needs
- Increased spectral sampling significant improves information content and increases signal to noise for higher-spatial resolution sampling than ATMS
- JPL spectrometer has flown in an airborne campaign in April 2022 and is ready to support HyMS

Milestone Schedule

- Define key system internal and external interfaces **(ATP+4 mo)**
- Preliminary design review for system integration with Stratocraft **(ATP+12 mo)**
- Fabricate antenna feed, RF, IF spectrometer and data sub-systems **(ATP+14 mo)**
- Complete required modifications to HAMMR instrument **(ATP+14 mo)**
- Integrate and test radiometer sub-system with HAMMR **(ATP+18 mo)**
- Integration and test of HAMMR-HD into World View Gondola **(ATP+20 mo)**
- Launch and operate Stratollite for a 30-day flight campaign **(ATP+21 mo)**
- Complete campaign, Stratollite recovery and de-integration **(ATP+22 mo)**
- Final Report **(ATP+24mo)**

JPL HyMS Team: Shannon Brown, Richard Cofield, Joelle Cooperrider, Evan Fishbein, Omkar Pradhan, Pekka Kangaslahti, Bjorn Lambrigtsen, Alan Tanner **Colorado State University:** Steve Reising

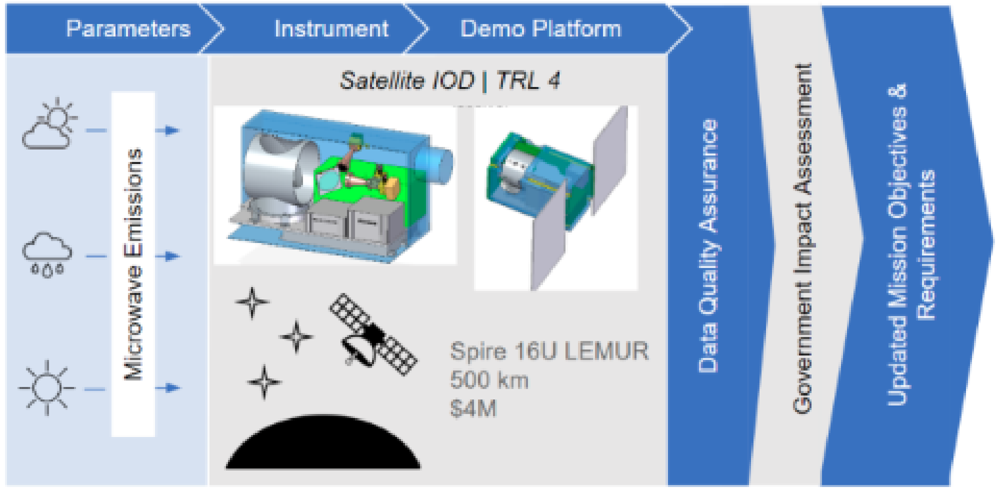
In-Orbit Demonstration of a Flight Tested Hyperspectral Microwave Sounder (HyMS) | BAA-NOAA-HyMS-2022 |

Objectives: Addressing all 5 BAA Objectives | Development Area of Interest: Microwave hyperspectral remote sensing technology

Gary Scoffield | gary.scoffield@spire.com | 210-332-7166 | Spire Global, Inc. | 8000 Towers Crescent, Suite 1100, Vienna, VA 22182

Objective: Expand the development of a mature Hyperspectral Microwave Sounder that has already deployed on the Facility for Atmospheric Airborne Measurements (FAAM) aircraft with the UK Met Office. Evolve payload to enhance spectral bandwidth and performance. Payload and 16U platform development for launch of free-flying In-Orbit Demonstration (IOD).

Description of effort: i) Enhance instrument performance, incorporating recent demonstrations (spectrometer enhancements and thermal management). ii) Evolve instrument towards operational mission equivalent, integrating the payload with Spire 16U LEMUR. iii) Demonstrate HyMS in orbit.



Program Overview

Benefits of proposed technology, challenges, and maturity of technology: Benefits include: i) The high TRL instrument has already flown on aircraft overcoming multiple integration and performance challenges. Key subsystems qualified. Low risk modifications to complete overall systems. IOD sensor already at TRL 4 w/CAD and breadboard produced. ii) Sounding channels for temperature 50-58 GHz and water vapor (175-192 GHz). iii) Wide-band (9.6 GHz instantaneous BW), high-resolution (1 MHz), and state-of-the-art instrument performance (Tsys <200K at 60GHz and <670 K at 183 GHz).

Milestones, PoP, total cost for the project: 2-year program with kickoff in October 2022. Develop HyMS in-orbit demonstration sensor, integrate it with Spire 16U LEMUR, launch, commission satellite, and collect science grade data. 3 month data delivery provided to NOAA.

EO DT AI Projects - Quad Charts

EODT BAA Synopsis

- Explore digital twin technologies to enhance our ability to process, monitor, quality-control, consolidate, fuse, and assimilate environment observations, and streamline the satellite data ground processing and dissemination to users and applications
- The approach developed should allow the following aspects:
  - Satellite Data Anomaly detection
  - Calibration monitoring and correction
  - Next-Gen geophysical inversion algorithms (may include QC and forward operators)
  - Data Fusion (ground and space)
  - Data assimilation interfacing
  - Environmental trends monitoring

Title: AI-Based 3D Earth and Space Observing Digital Twin

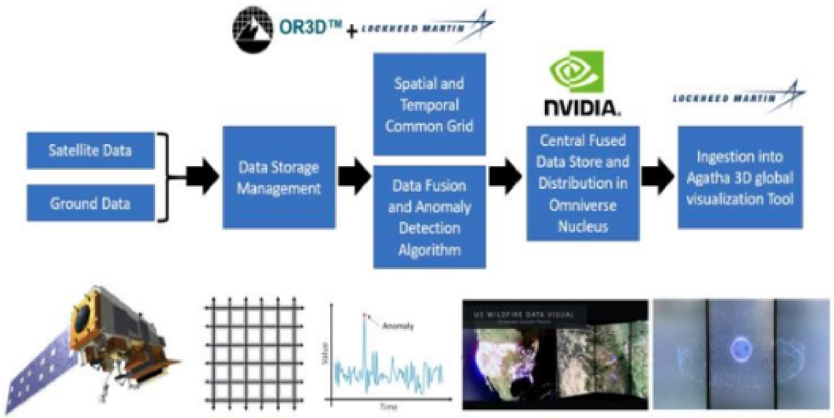
BAA#: BAA-NOAA-EODT-2022, Digital Twin for Earth Observations Using Artificial Intelligence Broad Agency Announcement, Dr. Lynn Montgomery, lynn.montgomery@lmco.com, 303-581-6278, Catherine Turco, (408) 756-6161, catherine.f.turco@lmco.com, Lockheed Martin, 6304 Spine Road, Boulder, CO 80301

Objective: Lockheed Martin, in partnership with NVIDIA, propose an AI-Based 3D Earth and Space Observing Digital Twin which integrates software from both companies to compile, process, and display NOAA data in an immersive visualization. Our agile, scalable EO-DT framework will handle measurements from ingest to fusion to dissemination to end users or operational applications.

Description of effort:

- Use operational OR3D to Create a scalable back-end architecture to ingest and disseminate live data from NOAA ground, sub-orbital, and space-based assets.
- Fuse data and detect anomalies using AI/ML tools from different spatial and temporal resolutions into a physically meaningful data product.
- Combine mature software to provide an immersive 3D global visualization tool with a rapid refresh rate.

Graphic illustrating research and concept:



Benefit of proposed Tech./Maturity of Tech. Research Area:

- OR3D formats, stores, and applies pre-existing AI/ML fusion and anomaly detection algorithms to data.
- NVIDIA Omniverse Nucleus allows different applications to import/export assets to/from the central data store.
- Agatha can visualize data from multiple sensors on an collaborative, interactive 3D Earth and Space platform.
- All SW above is in current use; EO-DT will integrate and adapt to new data sources and challenges.

Challenges:

- Fusing data and preforming scientifical valid interpolation.
- Determining how best to visualize 3D data for both public and operational use.

Milestones		
Virtual Kick-off meeting	ATP	Base
Mid-Project Status Meeting	ATP +12 months	Base
End-Project Status Meeting (Silver Spring, MD)	ATP +23 months	Option
Schedule Cadence		
Agile bi-weekly development meetings with tactical team	Every 2 weeks, or as needed.	Base and Option
Monthly Briefings/Demos	Every 4 weeks	Base and Option
Demonstration of capabilities + NOAA Feedback	Every 12 months formally, and informally at Monthly Briefings	Base and Option
Description of the EO-DT optimal concept as used in this project.	ATP + 12m	Base
Description and recommendations on a standardization of DT interoperability	ATP + 18m	Option
EO-DT system as developed for this project; code readers to exploit it; tools to visualize, grid, & tailor.	Initial: ATP + 12m, Final ATP + 23m	Base and Option
Results of validation. Briefing(s) to the NOAA Systems Performance Assessment Team (SAT).	ATP + 23m	Option
Follow up Questions and Clarification Period	ATP + 23m to ATP + 24m	Option

Period of Performance: October 2022- September 2024

One-stop Digital Space for Earth Observation Processing

BAA-NOAA-EODT-2022
Technical POC- Wanli Wu, wanli.wu@orionspace.com, 303-993-8039
Administrative POC- Rachel Hauser, rachel.hauser@orionspace.com, 303-669-5600
Orion Space Solutions, 237 Century Pl Suite 1000, Louisville, CO 80027

orion SPACE SOLUTIONS

Objective

Advanced digital solutions and physics-informed machine learning technologies will be used to build a seamless and automated Earth observational data processing, analysis & visualization system as a next-generation ground processing enterprise interfacing with NOAA's Unified Earth System Modeling Framework for scientists, engineers, forecasters, and the public to better visualize, understand, and predict the past, present, and future of the Earth environment.

Description

- Develop and optimize machine learning algorithms for multiplatform and multiscale Earth observations quality control, data fusion, grid mapping, uncertainty quantification, calibration, and anomaly detection and correction.
- Digital solutions and APIs seamlessly integrate the data processing enterprise for computing efficiency, robustness, flexibility, and expandability.
- Build with open-source Python libraries to ensure portability and adaptability.
- Comprehensive testing and validation of radiometric and geophysical variables across all Earth domains.
- Data products in NOAA standard level 1 through 4 with adaptable formats and grids.
- Modern visualization toolkits, dashboards, and embedded Jupyter Notebook.

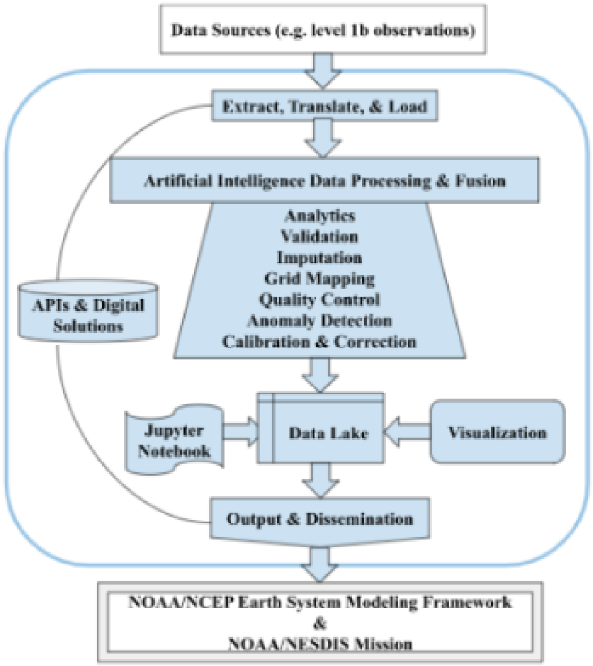


Figure 1 A Sketch of the Digital Twin for Earth Observational Data Processing, Analysis, and Visualization

BENEFITS

- Extend and automate multiplatform, and multiscale Earth Observations Processing with significantly enhanced efficiency and accuracy.
- Serve as the front-end infrastructure to NCEP's Unified Earth System Modeling Framework and enhance NESDIS' mission in data processing
- Allow scientists, engineers, foresters, and the public to disseminate the observational data and reconstruct the Earth environment at this one-stop digital engineering platform.

COST and SCHEDULE

Period of Performance:
24 months.

Table 7. Timeline and Milestones

Year (Quarter)	Major Tasks	Milestone
1 (1)	• Work with NOAA program office on sample data, decoding, and retrieval codes if available • EODT system design • Develop ETL utility/Pipeline	Data pipeline is established, automated, and tested.
1 (2)	• Develop AI models for data retrieval • Develop data lake	Level 1 data in production
1 (3)	• Develop AI models for data fusion • Develop APIs and UI • Data lake development continues	Level 2 data in production
1 (4)	• Continue data fusion AI model development • Data lake development continues • Develop AI models for anomaly detection • APIs and UI development continues	Level 3 data in production
Opt. 2 (5)	• Continue the development of anomaly detection AI models • Data lake development continues • APIs and UI development continues	Level 4 data in production
Opt. 2 (6)	• Develop visualization toolkit and dashboards • APIs and UI development continue • Validation and Testing	All individual components in great shapes and function well
Opt. 2 (7)	• Digital integration of the system • Validation and testing continue	Whole EODT functions smoothly
Opt. 2 (8)	• Full system testing, refinement, demonstration • Technical report & delivery	EODT ready for demonstration and delivery

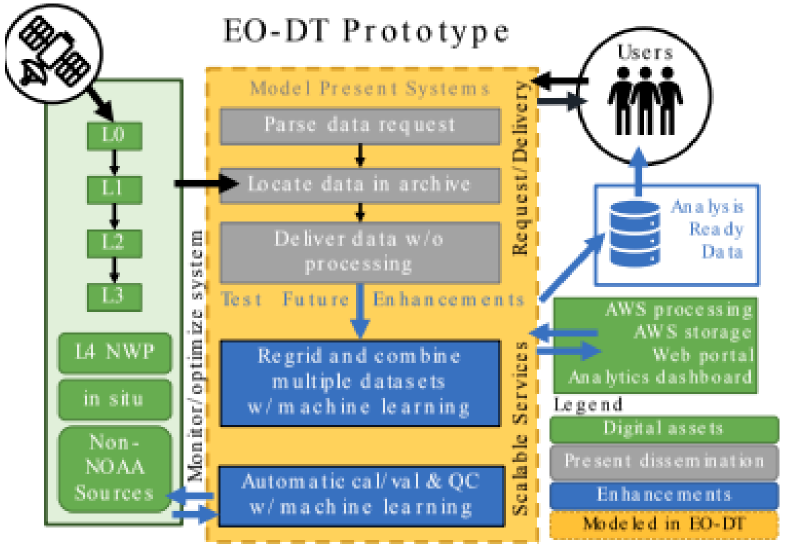
Rapid Prototype of NESDIS Ground System Digital Twin

Digital Twin for Earth Observations Using Artificial Intelligence: BAA-NOAA-EODT-2022

Objective: Rapidly design a prototype of an EO-DT to simulate the ground system. Prototype will be used to (1) demonstrate core functionalities of the present dissemination system for the purposes of study; (2) evaluate enhancements, such as leveraging AI to quickly perform data fusion and anomaly detection. Goal: provide a realistic benefit-cost and requirements assessment of a full EO-DT through a final report and project reviews.

Description of Presented Effort:

- Study the design of a fully functional EO-DT system and demonstrate core functionalities with AWS and a subset of NESDIS data.
- Utilize AI to improve speed over traditional gridding and anomaly monitoring methods. Compare w/NWP.
- Perform case studies with the EO-DT using all five Earth science domains and L1-L3 datasets.



Study Goal: Produce realistic assessment of costs, beneêts, and recommendations using commercial services.

Benefits of Presented Approach

- Rapid development of EO-DT using on-demand cloud services scalable to address future needs.
- Implementation of Agile techniques, government feedback solicited via multiple demonstrations.
- A data agnostic, interoperable, and flexible system.

Technology Maturity: Mature using existing commercial and open-source components.

Challenges: Optimizing system speed and cost.

Period of performance: 13 months

	Months												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Set-up static EO-DT model w/AWS	■	■	■	■	■								
Build communication between EO-DT and ground system			■	■	■	■							
Analytics and ML augmentation of the EO-DT for anomalies/fusion				■	■	■	■	■					
Dashboards, web access to EO-DT									■	■	■		
Validation, DevOps, testing		■	■	■	■	■	■	■	■	■	■		
Agile meeting w/management		■	■	■	■	■		■	■	■	■		
Kickoff, midterm, final review	■						■					■	
Final report												■	■

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BAA Management Team

Study	PM	Deputy PM	Technical lead	Technical Team	COTR
start October 2022					
3D Winds Honeywell (Demonstration)	Harshesh	Dave	Jaime Daniels	Ed Kim	Harshesh
3D Winds Ball (study)	Harshesh	Dave	Jaime Daniels	Dave as constellation expert	Harshesh
3D Winds BAE Systems (Study)	Lynn	Aydin	Jaime Daniels	Dave as constellation expert	Harshesh
HyMS - Spire	Lynn	Dave	Flavio	Ed Kim	Harshesh
EODT Lockheed Martin:	Ramesh	Beau	Sid	TBD (from Working Group)	Kesha
EODT Orion	Stacy	Sherida	Sid	TBD (from Working Group)	Kesha
EODT Science & Technology	Ramesh	Beau	Sid	TBD (from Working Group)	Kesha
start in CY2023					
3D Winds LaRC (demonstration)	TBD (initial coordination: Harshesh)	TBD (such as Kesha, Sherida, etc.)	Jaime Daniels	Ed Kim	NA
3D Winds JPL (study)	TBD	TBD (such as Kesha, Sherida, etc.)	Jaime Daniels	Dave as constellation expert	NA
HyMS JPL	TBD	TBD (such as Kesha, Sherida, etc.)	Flavio	Ed Kim	NA
HyMS GSFC	TBD (initial coordination: Harshesh)	TBD (such as Kesha, Sherida, etc.)	Steve Swadley (need IAA)	Ed Kim, Flavio	NA