STRATUS 2023 Conference

Systems and Technologies for Remote Sensing Applications Through Unmanned Aerial Systems

May 22-23, 2023

Chester F. Carlson Center for Imaging Science,

Rochester Institute of Technology, Rochester, NY, USA

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Welcome from the General Chair

On behalf of the organizing committee, and the general chair for this year's event, I would like to welcome everyone to the 6th conference (2016, 2017, 2019, 2021, 2022, 2023) on Systems and Technologies for Remote Sensing Applications Through Unmanned Aerial Systems or simply STRATUS 2023. The two-day conference is being held in Rochester, New York, on May 22-23, 2023 at the Chester F. Carlson Center for Imaging Science, RIT.

The idea of this workshop started in 2016 as a result of a conversation between my RIT colleague, Dr. John Kerekes, and me. From this, a proposal was submitted to the IEEE Geoscience and Remote Sensing Society (GRSS) for financial support to host a workshop on UAS's. At that time, we had a one-day workshop with a series of talks by individuals from academia and industry. The total number of abstract submissions was 11 with around 30 participants. The 2016 workshop proved to be very successful and warranted a follow-on meeting which was held in October 2017. The sold-out 2017 workshop included vendor participation and was expanded to two days (one day for tutorials, one day for talks). I am proud to say that seven years later, we have changed from a workshop to a multi-day conference where we are presenting over 30 talks this year with more than 80 registered participants.

The aim of this conference has always been to facilitate interaction between academic researchers, industry researchers, and students working in the field of remote sensing utilizing unmanned aerial systems. I believe our 2023 program will promote the dissemination of research results and technical advances in this still emerging field of unmanned aerial systems. I hope you enjoy the talks, sponsor tables, demos, trivia, and opportunity to network!

Best,
Emmett Ientilucci, Ph.D.
Rochester Institute of Technology
STRATUS 2023 General Chair

Welcome from Co-Chair

Welcome to STRATUS 2023!

Unmanned Aerial System Vehicles (UAS's or UAV's) have gained increasing attention within the remote sensing community in many areas including environment, natural resources, agriculture, and water to name a few. There is an ever-increasing development and advancement in hardware, algorithm/data processing, and applications of UAVs necessitating more frequent scientific gatherings and conferences to exchange the latest advances in UAV remote sensing.

STRATUS 2023 is the 6th STRATUS conference hosted by Rochester Institute of Technology (RIT) on May 22-23, 2023. The first three STRATUSs were organized and hosted by RIT in 2016, 2017, and 2019. In 2021, the conference was virtually held (due to COVID) by University at Buffalo. In 2022, State University of New York College of Environmental Science and Forestry (SUNY-ESF) hosted and organized the 5th STRATUS in Syracuse, NY.

This year's STRATUS has brought together nearly 100 professional attendees from academia, federal and state governments, and industry from across the U.S.A, Canada, and Germany. There is a total of seven technical sessions presenting nearly 30 oral presentations. The topics are broad covering many areas including UAV educational programs, flights and operation, hardware and design, and applications in mapping and surveying, agriculture and forestry, flood and water quality monitoring and special topics. In addition, we have three Keynote speeches, several exhibitors and UAV demo flights on site.

STRATUS 2023 is generously supported financially by UAV industry leaders including HySpex, Labsphere, Headwall, ASPI, Groundpoint Eng., spectral Evolution, and Arcadis. I also should mention that we have a student competition for awards in presentation and UAV Trivia games!

I hope you experience a successful and productive Conference at STRATUS 2023 and extend your network of collaboration and partnerships even further. For those traveling, I wish a safe travel back home and let's keep in touch!

Cheers,
Bahram Salehi, Ph.D., P.Eng
SUNY College of Environmental Science and Forestry (ESF)
STRATUS 2023 Co-Chair

Program Committee

General Chair & Financial Chair

Emmett Ientilucci
Digital Imaging & Remote Sensing Lab
Rochester Institute of Technology

Co-Chair & Technical Program Chair

Bahram Salehi
SUNY College of Environmental Science and Forestry

Conference Committee Members

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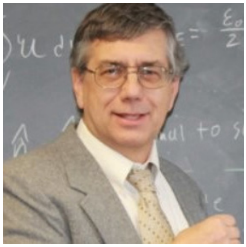
Dept of Computer Science & Engineering
University of Buffalo

Sina Jarahizadeh
SUNY College of Environmental Science and Forestry



Peter Spacher
Rochester Institute of Technology

Karen Braun
Rochester Institute of Technology

Colleen McMahon
Rochester Institute of Technology

Directions to RIT's Center for Imaging Science

From the NYS Thruway: Take exit 46 and proceed north on I-390 to exit 13 (Hylan Drive). Take a left onto Hylan Dr. and continue north to Jefferson Road (Route 252), then take a left at the light. Proceed west a short distance to the main campus.

Once entering campus at the main entrance (indicated with a large sign: "Rochester Institute of Technology, Founded 1829"), follow the signs to the Parking Lot F.

Please print your parking pass and place it on your dashboard.

Scan the QR Code for Driving Directions to Lot F or use this link: https://goo.gl/maps/JFb8S9fxp6ddzgL89.

Reception on Monday Evening

MacGregor’s Grill and Taproom
300 Jefferson Rd.

Monday, May 22
5:30 - 7 PM

Appetizers and two free drinks are included
with your conference registration.
32-min walk or 5-min drive from the venue.

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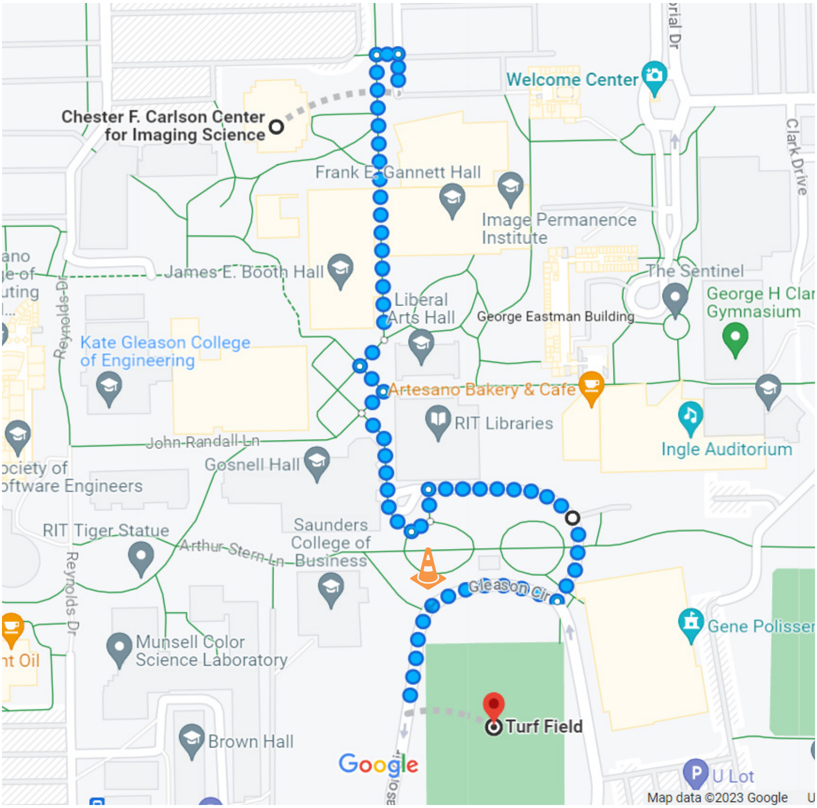

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Thank you for your generous contributions to Stratus 2023!

STRATUS 2023 Program at a Glance

	Day 1: Monday, May 22	Day 2: Tuesday, May 23
8:00-8:30	Registration & Breakfast	Registration & Breakfast
8:30-9:00	**Welcome, Opening Remarks**	**Welcome, Opening**
9:00-9:10	**Overview of IEEE-GRSS Society**	**Overview of RIT Digital Imaging and Remote Sensing (DIRS) Lab**
9:10-9:45	**Keynote-A: Dr. Steven J. Thomson**	**Keynote-C: Dr. Jian Jin**
9:45-10:45	**Technical Session 1:** *Water Quality and Flood Monitoring*	**Technical Session 5:** *Synthetic Aperture Radar (SAR) UAV*
10:45-11:15	Coffee Break/Exhibits	Coffee Break/Exhibits
11:15-12:15	**Technical Session 2:** *Educations and Applications*	**Technical Session 6:** *Agriculture and Forestry Applications*
12:15-1:00	Lunch/Group Photo/ Networking/ Exhibits	Lunch/Group Photo/ Networking/ Exhibits
1:00-1:45	**UAV Workshop-1 by HySpex**	**UAV Workshop-2 by HySpex**
1:45-2:15	**Keynote-B: Robert Lacourse**	**RIT UAV flight Demo**
2:15-3:15	**Technical Session 3:** *Rules, Accuracy and Standards*	**Technical Session 7:** *UAV Systems and Hardware*
3:15-3:45	Coffee Break/Exhibits	Coffee Break/Exhibits
3:45-4:45	**Technical Session 4:** *Hyperspectral UAV*	**UAV Trivia Game-2**
4:45-5:15	**UAV Trivia Game-1**	**Awards and Closing Remarks** Student Presentations and UAV Trivia Winners
5:30-7:00	Reception at McGregor’s	

Monday, May 22

Registration & Breakfast 8:00 – 8:30 AM

WELCOME: 8:30 AM – 9:00 AM
Dr. Emmett Ientilucci, RIT, Dr. Bahram Salehi, ESF, Conference Co-Chairs
Dr. Andre Hudson, Dean of College of Science, RIT

Overview of IEEE-GRSS Society 9:10 – 9:45 AM
Dr. John Kerekes, RIT and IEEE Chief Financial Officer

KEYNOTE-A: 9:10 – 9:45 AM
Dr. Steven Thomson
National Program Leader, USDA-NIFA
Moderator: Dr. Bahram Salehi, ESF

SESSION 1: 9:45 – 10:45
UAV for Water Quality and Flood Monitoring
Session Chair: Dr. Peter Spacher, RIT

9:45 **Using Unmanned Aerial Vehicles to Estimate First Floor Elevations for Flood Risk"**, William Stiteler, Jason Diamond, John Millspaugh and Melissa Hew, ARCADIS

10:00 **Use of UAS Data for GIS-Based Transect Analysis of Localized Ice Jam Flooding Events**, Christopher Badurek, SUNY Cortland

10:15 **Next-Generation UAV-Mounted LWIR Hyperspectral Imaging System**, Joseph Carrock, Mark Norman, Benjamin Saute, Martin Lariviere-Bastien, Martin Chamberland, Telops

10:30 **Applying Drones and Deep Learning models to tackle the algae pollution problem in East coast**, Andrea Balcacer, Amir Zaman, Yulia Kumar, J. Jenny Li, Kuan Huang and Patricia Morreale, Kean University

Coffee Break and Exhibits: 10:45 – 11:15

SESSION 2: 11:15 – 12:15
UAV Educations and Applications
Session Chair: Dr. Farshad Ghanei, University at Buffalo

11:15 **K-12 Education Drones in The Finger Lakes Region**, Bill Campo, Wayne - Finger Lakes BOCES, EduTech

11:30 **A Healthcare 4.0 Infrastructure using Drones and Bio-Chemical Sensors,** Lawrence He, Princeton High School

11:45 **Remote Sensing Course at a Small Liberal Arts College,** Ileana Dumitriu and John Halfman, Hobart and William Smith Colleges

12:00 **Design Consideration of Remote Sensing Applications for Environmental Preservation** Juliet J. Lee, WPAC, Westview High School, San Diego

GROUP PHOTO: 12:15 – 12:30 PM

NETWORKING, Exhibits, and Lunch 12:30 – 1:00 PM

UAV Workshop 1 by HySpex 1:00-1:45 PM
Topic: Hyperspectral UAVs
Moderator: Dr. Peter Spacher, RIT

KEYNOTE-B: 1:45 – 2:15 PM
Robert Lacourse
CEO, TwinSpruce Customs
Moderator: Dr. Emmett Ientilucci, RIT

SESSION 3: 2:15 – 3:15 PM
Rules, Accuracy and Standards
Moderator: Dr. William Stiteler, ARCADIS

2:15 **Assessing thermal imagery integration into object detection methods on air-based collection platforms,** James Gallagher and Edward Oughton, George Mason University

2:30 **Small Unmanned Aerial Systems (sUAS) in Emergency Response**, Kevin Bollino and Christian Lewis

2:45 **UAV Accuracy: Five things you need to know**, Benjamin Houston, Groundpoint Engineering

3:00 **Deep learning and local maximum approaches for tree detection and characterization using UAV imagery over forest areas,** Sina Jarahizadeh and Bahram Salehi, SUNY-ESF

Coffee Break and Exhibits: 3:15 – 3:45

SESSION 4: 3:45 – 4:45 PM
Hyperspectral UAV
Session Chair: Dr. John Kerekes, RIT

3:45 **Drone-based Hyperspectral Imager Characterization at RIT's Optical Calibration Facility**, David Conran and Emmett Ientilucci, RIT

4:00 **Development of Novel Subpixel Targets for a Hyperspectral UAS Data Collection** Chase Cañas, John Kerekes, Colin Maloney and Emmett Ientilucci, RIT

4:15 **Impacts of Shadowing and Adjacent Reflections on UAS Hyperspectral Object Detection** Colin Maloney, John Kerekes, Chase Canas and Emmett Ientilucci, RIT

4:30 A **Predicting Table Beet Root Yield with Hyperspectral UAS Imagery**, Mohammad Saif, Robert Chancia, Sarah Pethybridge, Sean P. Murphy, Amirhossein Hassanzadeh and Jan van Aardt, RIT

UAV Trivia Game-1: 4:45 – 5:15 PM
Moderators: Dr. Farshad Ghanei, UB and Dr Peter Spacher, RIT

Social Gathering at MacGregor's 5:30 – 7:00 PM

Tuesday, May 23

Registration & Breakfast 8:00 – 8:30 AM

WELCOME: 8:30 AM – 9:00 AM
Dr. Emmett Ientilucci, RIT, Dr. Bahram Salehi, ESF, Conference Co-Chairs

Overview of RIT-DIRS Lab 9:00 – 9:10 AM
Dr. Carl Salvaggio, Director of the Digital Imaging and Remote Sensing Laboratory

KEYNOTE-C: 9:10 – 9:45 AM
Dr. Jian Jin
Associate Professor, Purdue University
Moderator: Dr. Karen Braun, RIT

SESSION 5: 9:45 – 10:45 AM
Synthetic Aperture Radar (SAR) UAV
Session Chair: Dr. Bahram Salehi, ESF

9:45 **UAS-based radar systems for snow and soil moisture measurements**, Drew Taylor, Jordan Larson, Feras Abushakra, Shriniwas Kolpuke, Chris Simpson, Omid Reyhanigalangashi, Tuan Luong, Aabhash Bhandari, Adam Hallmark, Zac Herring and Sivaprasad Gogineni, University of Alabama

10:00 **UAV-Based Multistatic Synthetic Aperture Radar System and Applications**, Stefan Valentin Baumgartner, Lucas Leonardo Lamberti, Sumin Kim, Thomas Börner, Victor Mustieles Pérez, Michelangelo Villano and Gerhard Krieger DLR, Germany

10:15 **Active V-Dipole Antenna on UAS for Receiving NOAA Polar Satellite Imagery**, Curtis Manore, Alan Fenn and Hanumant Singh, Northeastern University

10:30 **Simultaneous UAS hyperspectral imaging and water-level Raman measurements of fresh water cyanobacterial blooms (CyanoHABs)**

Carson Roberts, Headwall and Scott Gallager, Coastal Ocean vision

Coffee Break and Exhibits: 10:45 – 11:15

SESSION 6: 11:15 – 12:15
Agriculture and Forestry Applications
Session Chair: Dr. Saeid Homayouni, INRS, Canada

11:15 **UAS Hyperspectral Imagery for Soil Organic Carbon Estimation: The Role of Soil Moisture Content Retrieval Models**, Nayma Binte Nur, Kimberly E. Union, Avery Miller, Charles M. Bachmann, Anna Christina Tyler, Chris H. Lee, and Wendy A. Owens-Rios, RIT

11:30 **High-Resolution Crop Residue Mapping from Multispectral UAV Imagery using Deep Learning Segmentation,** Monsif Baraka, Saeid Homayouni, Jimmy Poulin and Maryam Rahimzad, NIRS, Canada

11:45 **Farmland Contamination Monitoring with Unmanned Aerial Vehicle-Aided Sensor Systems,** Lizbeth He Princeton Day School

12:00 **Comparison of UAV Photogrammetric Software Products in a Forest Area** Sina Jarahizadeh and Bahram Salehi, SUNY-ESF

GROUP PHOTO: 12:15 – 12:30 PM

NETWORKING, Exhibits, and Lunch 12:30 – 1:00 PM

UAV Workshop 2 by HySpex 1:00-1:40 PM
Topic: Hyperspectral UAVs
Moderator: Dr. Peter Spacher, RIT

RIT UAV Flight Demo 1:45 – 2:15 PM
Moderator: Dr. Emmett Ientilucci

SESSION 7: 2:15 – 3:30
UAV Systems and Hardware
Session Chair: Dr. Emmett Ientilucci, RIT

2:15 **Sensorbricks: Medium Volume Heterogeneous Sensor Integration for Unmanned Aerial Systems.**, Adolfo Gutierrez and Steven Aceto, SG2030 LLC

2:30 **Development of a novel Portable Airborne Mapping System (PAMS),** Bernard Akaawase and Leonel Romero, University of Connecticut

3:00 **Technology and Application: Recording of Human Arm Motion Action using EEG Sensory Signal**, Soheli Farhana and Md Masum Billah, Harvard University

3:15 **Revolutionizing Water Quality Monitoring: A Drone-Based Approach for Real-time Monitoring of Bule Algae Growth and Distribution,** Soheyl Faghir Hagh, Adam Zylka, Maddy Zimmerman, Koa Ritz, Jarlath Patrick O'Neil-Dunne, Dryver Huston and Tian Xia, University of Vermont

Coffee Break and Exhibits: 3:30 – 3:45

UAV Trivia Game-2: 3:45 – 4:15 PM
Moderators: Dr. Farshad Ghanei, UB and Dr. Peter Spacher, RIT

AWARDS: 4:15 to 4:45
Student Presentations
Trivia- 1 winner
Trivia- 2 winner

CLOSING REMARKS: 4:45 to 5:00
Dr. Emmet Ientilucci, RIT, and Dr. Bahram Salehi, ESF
Conference Co-Chairs

Keynote Speakers

Dr. Steven J. Thomson
National Program Leader, USDA-NIFA

Dr. Steven J. Thomson is National Program Leader (NPL) with the USDA National Institute Food and Agriculture (NIFA). He engages Universities, other federal agencies, and industry to provide national leadership in Capacity and Competitive Grant programs. The Research, Education, and Outreach programs he leads focus on engineering processes to improve systems relevant to agriculture. These include Engineering for Agricultural Production Systems and NSF-collaborative programs such as the National Robotics Initiative, Cyber-Physical Systems, and AI Institutes. Dr. Thomson received his Ph. D from the University of Florida in the Ag. And Bio. Engineering Dept. and has background in aerial application of crop protection materials, irrigation management, water balance and crop modeling, decision support systems for agricultural management, sensing systems and electronics, precision agriculture, applied statistics, and agricultural safety. Dr. Thomson was incoming Associate Professor at Virginia Tech in the College of Engineering and had received the Alpha Epsilon Award for his Research/Extension program and Outstanding Faculty Award in the Biological Systems Engineering (BSE) Department. He was a Lead Scientist with the USDA ARS before joining USDA-NIFA in early 2016. He has authored or co-authored over 100 publications, two book chapters, and several Extension publications and software.

Robert Lacourse
CEO, TwinSpruce Customs, Canandaigua NY

Robert Lacourse is CEO for TwinSpruce Customs in Canandaigua NY, where uses his vast aviation experience to help UAS operators with FAA Rules and regulations. Robert was one of the first FAA inspectors to validate/ approve the initial UAS Agriculture operators. He recently retired from the FAA as an Aviation Safety Inspector and was the FAA's Drone Focal Point for Western NY. He volunteers his time as a FAA Drone Professional. His UAS experience started in 2016 just as UAS's were making their mark in the national airspace. Robert's aviation experience started over 48 years ago. He received his FAA student pilots license for Gliders before serving 27 years in the United States Airforce where he maintained several types of fighter aircraft. He earned his Aviation safety Management degree, with a minor in aircraft accident investigation in from the Community College of the USAF.

Dr. Jian Jin

Associate Professor, Purdue University

Dr. Jian Jin is an associate professor from the Department of Agricultural and Biological Engineering at Purdue University. Dr. Jin received his Ph.D. in Agricultural Engineering from Iowa State University in 2009. He earned his M.S. degree in Computer Engineering from Denmark Technical University in 2005 and his B.S. degree in Computer Science from Zhejiang University in 2003. Prior to joining Purdue, Dr. Jin conducted research at DuPont Pioneer (now Corteva), where he was most recently a Technology Leader working on crop phenotyping and led a team for the company's new controlled environment phenotyping systems for automated plant screening. Dr. Jin's major research interest at Purdue is to develop the next generation plant sensor technologies, along with machine vision, image processing, and data modeling. He also has interests in other areas of agricultural sensing, broadly defined, and in automation and robotics in agriculture. Dr. Jin is the president and founder of LeafSpec LLC, which aims to deliver the highest quality of plant sensing technologies to plant scientists and crop growers.

ABSTRACTS

SESSION 1: Water Quality and Flood Monitoring

Title	**Using Unmanned Aerial Vehicles to Estimate First Floor Elevations for Flood Risk**
Keywords	Flooding, FFE, Point cloud, photogrammetry
Abstract	Because ground elevation alone does not determine when flood waters will reach the lowest habitable floor, the First Floor Elevation (FFE) is the most important height to determine when setting prices for flood insurance, for doing a cost benefit analysis for flood mitigation, or determining risk in general. Small changes in FFE can have dramatic effects on the estimates of flood damage. In many cities, FFE data is either missing, outdated or inaccurate, and currently, the only way to measure FFE for an elevation certificate (EC) is with a land surveyor, which is costly and intrusive. Arcadis conducted UAV flights in two cities, Miami, Florida, and Portsmouth, Virginia that are prone to flooding, and compared FFE derived from photogrammetric point clouds to flood certificated and/or ground surveyed elevations. Preliminary results show that UAV photogrammetry may be a cost-effective method for quickly and accurately obtaining FFE data.

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Title	**Use of UAS Data for GIS-Based Transect Analysis of Localized Ice Jam Flooding Events**
Keywords	GIS, DEM, Floods, Hazards, Flood analysis
Abstract	This poster reports on GIS-based transect analysis performed on archived UAS data collected in response to the Plymouth, NH ice jam of February 2017. Ice jams are a costly occurrence throughout the northern CONUS as noted by the USACE Ice Jam Database (2020). Media Wing Airshark collected the imagery data under contract with the USGS National UAS Program Office (2017) and rapidly processed it for delivery the day following the flight. Data collected with a DJI Inspire 1 with FC550 sensor for image collection over four miles of the Pemigewasset River resulted in a final 3 cm resolution mosaic image of the ice jam impacted area. We accessed the data set from USGS Earth Explorer and processed it with ArcGIS and Pix4D. First, we examined the aerial mosaic of the ice flow in relation to prior high resolution aerial photos. Next, we compare DEMs derived from the aerial imagery with 1 meter resolution USGS DEMs of the area at six transect locations located along the river. Lastly, we overlay the FEMA National Flood Hazard Layer over the image mosaic to assess spatial extent of the ice jam flooding in relation to expected flood extents. Analysis of the UAS data at transects illustrate the extent of the ice jam and provide useful information on flooding potential within an immediate response time. The results indicate rapid deployment of UAS provides actionable information for local communities on location and extent of flooding threats in response to ice dam breaks.

Authors

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Christopher	Badurek	christopher.badurek@cortland.edu	United States	State University of New York at Cortland

Title	**Next-Generation UAV-Mounted LWIR Hyperspectral Imaging System**
Keywords	UAV Hyperspectral, SwaP, Hyper-Cam
Abstract	Telops has a 20-year history in the design, integration, and deployment of thermal infrared hyperspectral imaging systems through the legacy Hyper-Cam line. Advances in critical subsystem technologies has allowed Telops to develop the next-generation of hyperspectral imaging systems with significant reductions in Size, Weight, and Power (SWaP) requirements while maintaining imaging and data quality performance. This reduction in SWaP requirements yields a significant increase in deployment flexibility, allowing for increased capability for collecting actionable hyperspectral data of remote or difficult-to-access targets. This presentation will serve as an overview of the system architecture and analysis capabilities of the Hyper-Cam Nano, the next-generation thermal infrared hyperspectral imaging system. The Hyper-Cam Nano platform includes a miniaturized (172 x 172 x 181 mm) Fourier Transform Spectrometer (FTS) mounted on a gimbal affixed to an octocopter drone. Taking benefit of state-of-the-art electronics and

	computer systems, the real-time data analysis embedded in the Hyper-Cam Nano enables unprecedented ease of use without compromise to performance. This novel instrument will offer new capabilities in gas detection and identification applications for the defense, industrial, and environmental sectors.

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Title	**Applying Drones and Deep Learning models to tackle the algae pollution problem in East coast**
Keywords	algae detection, algae classification, drones, deep learning, algae pollution
Abstract	As a consequence of global warming, our planet experiences extreme heat waves of unprecedented magnitude. This propagates algae to abnormal amounts allowing siege of our water's ecosystems. When one in every ten people on Earth lacks access to clean water (possibly exceeding 1 billion), many species in the US and worldwide suffer from water pollution; increasing mortality rate. The algae pollution on the East coast has become a rampaging issue, to apply Drone and Deep Learning models would expedite the resolution of this ever-emergent climate predicament. There are many algae image datasets such as those coming from NASA, NIH, NOAA, and non-government databases. However, there are few accurate Computer Vision models' implementations available to the AI community to tune these databases further. For this project we use our own light algae dataset, obtained in North New Jersey (USA) using Mavic model drones, and work with several available algae datasets, then apply the most relevant Transformer Neural Networks for algae detection and classification. These include DETR, Deformable DETR, DAT and Swin. We have extensive expertise in applying drones for parking spot detection as well as several publications on Applying Transformers to Geoscience and Earth Data precisely focusing on the Pollen and Double ITCZ data object detection and classification. We then detect and mitigate biases in the Neural Networks' models and apply various strategies to mitigate them. Once these networks are refined, we use drones to fly over small to medium sized bodies of water recording images to estimate their algae pollution.

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SESSION 2: UAV Educations and Applications

Title	**K-12 Education Drones in The Finger Lakes Region**			
Keywords	Finger Lakes, K-12 Education, sUAS			
Abstract	The state of drone technology at public school districts in the Finger Lakes region; career & technical education, user group formation, drone soccer and drone racing.			
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Title	**A Healthcare 4.0 Infrastructure using Drones and Bio-Chemical Sensors**
Keywords	Healthcare 4.0, Drone, Bio-chemical sensor, Environmental health, Emergency care Case study
Abstract	Healthcare 4.0 synthesizes medical sensors, artificial intelligence (AI), big data, the Internet of Things (IoT), and augmented reality (AR) to transform healthcare. It creates an intelligent health network by connecting patients, medical devices, hospitals, and other healthcare-related components. Recent advances in drones and bio-chemical sensors form a solid foundation to collect the necessary health and medical data from patients to enable Healthcare 4.0. We propose a Healthcare 4.0 infrastructure by employing drones and bio-chemical sensors as edge elements. Sensors are deployed in or on the patients' bodies. They detect bio-medical data on physiological statuses from the patients. Specific biological functions, such as respiration, blood pressure, temperature, heart rate, and electrocardiogram (ECG) are constantly measured by these sensors. These bio-medical data are transmitted via the network to medical professionals for health care purposes. Environmental health is critical to Healthcare 4.0, as it affects individual and population health. Drones are used to monitor environmental health in the proposal. They collect data on air pollution, water contamination, community hygiene, and waste disposal. In

	addition to environmental health monitoring, the mobility feature of drones facilitates new applications in Healthcare 4.0. Drones can provide periodic inspections for safety purposes. Healthcare providers can transport medicine and supplies to remote sites using drones. This is extremely important to provide medical care when an emergency occurs outside of hospital-based settings. We study typical cases in the proposed infrastructure. Challenges and future work are also discussed.

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Title	**Remote Sensing Course at a Small Liberal Arts College**
Keywords	Teaching Remote Sensing, Undergraduate Education, Interdisciplinary Education Physical Concepts, GIS Practicality, Hands-On Activities
Abstract	ENV-281 Remote Sensing: Remote sensing by satellite, aerial photography and more recently UAVs (aka drones) is a rapidly growing tool to solve environmental issues. We initiated an interdisciplinary, co-taught course in 2022 to broaden students' understanding of remote sensing, and the use of Geographic Information Systems (GIS) to perform image analysis. Students are introduced to optics, e.g., reflection/refraction of light, its interaction with mirrors, lenses, prisms, and cameras, the dual nature of light, electromagnetic spectrum, emission and absorption spectra, and energy sources. This fundamental exploration of light and its interaction with our atmosphere and sensors is coupled with the extraction of relevant information from digital imagery using GIS. GIS exercises include an introduction of raster data and their manipulations, georeferencing and digitizing LULC change from sequenced imagery, the display and manipulation of colors, the use of Indices like NDVI and NBR to investigate vegetation health and forest-fire burn scars, and the development of image classification schemas to formulate impervious surface maps. Students also investigate 3D imagery using LiDAR data, thermal imagery, seismic profiling, the process to download satellite imagery, and hands-on activities, such as analyzing imagery collected by their cell phones, a FLIR thermal camera, various spectrophotometers, and small drones. By the end of the course, students demonstrate their knowledge of the fundamental principles, methods of remote sensing, and use of GIS software through the completion and presentation of a final project. It shows their capability to think spatially and answer real world problems.

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Title	**Design Consideration of Remote Sensing Applications for Environmental Preservation**
Keywords	Sustainable development goals, environmental preservation, remote sensing and communication applications, joint communication and sensing
Abstract	The United Nations' Sustainable Development Goals (SDGs) [1] are a set of seventeen interconnected goals aimed at addressing global challenges such as poverty, inequality, climate change, and environmental degradation. The theme of "environmental preservation", which includes SDG 14 "Life Below Water" and SDG 15 "Life On Land" [2], is a hot topic across all age groups, from elementary schools to higher education or research organizations. Apart from mentioning the significant implications of the theme itself, it is also important to strategically consider how to help approach the theme in the societal ecosystem: environment as a given problem, technology as a methodological enabler and people as planners and decision makers. In this study, we propose a set of design considerations for aerial remote communication and sensing applications that can be used for environmental preservation purposes. More specifically, considering a scenario related to SDG 15, we present some interesting use cases and design considerations of remote sensing using a group of unscrewed aerial vehicles (UAVs) where UAVs are capable of so-called Joint Communication and Sensing, which is one of the important topics in the next generation (or also known as 6G) wireless communications [3]. Collaborations among a group of UAVs can enhance the efficiency and accuracy of estimation of certain anomaly (e.g., smog, wildfire) ensuring improvement in both missed detection (MD) and false alarm (FA), eventually leading to performance enhancement of Remote Sensing for environmental monitoring purposes. Type of presentation preferred: This submission is for oral presentation but is also open to a poster presentation.

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SESSION 3: UAV Rules, Accuracy and Standards

Title	**Assessing thermal imagery integration into object detection methods on air-based collection platforms**
Keywords	Thermal object detection, computer vision, FLIR, Uncrewed Aerial Systems, Machine Learning
Abstract	Object detection models commonly focus on utilizing the visible spectrum via Red-Green-Blue (RGB) imagery. Due to various limitations with this approach in low visibility settings, there is growing interest in fusing RGB with thermal long wave infrared (LWIR) (7.5 - 13.5 μm) images to increase object detection performance. However, we still lack baseline performance metrics evaluating RGB, LWIR and RGB-LWIR fused object detection machine learning models, especially from air-based platforms. This study undertakes such an evaluation finding that a blended RGB-LWIR model generally exhibits superior performance compared to traditional RGB or LWIR approaches. For example, an RGB-LWIR blend only performed 1-5% behind the RGB approach in predictive power across various altitudes and periods of clear visibility. Yet, RGB fusion with a thermal signature overlayed provides edge redundancy and edge emphasis, both which are vital in supporting edge detection machine learning algorithms. This approach has the ability to improve object detection performance for a range of use cases in industrial, consumer, government, and military applications. Finally, this research additionally contributes a novel open labeled training dataset of 6,300 images for RGB, LWIR, and RGB-LWIR fused imagery, collected from air-based platforms, enabling further multispectral machine-driven object detection research.

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Title	**Small Unmanned Aerial Systems (sUAS) in Emergency Response**
Keywords	sUAS, Emergency, Response
Abstract	Small Unmanned Aerial Systems (sUAS) integration into emergency response applications has increased over the years for a number of reasons. The ease of procuring these highly capable systems coupled with advancements in autonomous systems has led to local units developing unique training and employment procedures adapted to their manning postures. These procedures do not always align with more established state and federal emergency response procedures thereby preventing sUAS use or impeding broader integration. Working with the Civil Air Patrol (CAP) over the past year, this work has attempted to standardize a CAP methodology for training and deployment of sUAS capabilities at units across the nation. The development of these tactics, techniques, and procedures (TTPs) for integrating sUAS into already established CAP emergency services, albeit still maturing, are yielding promising results. This presentation provides an overview of the CAP sUAS mission and highlights some developments towards integrating

	CAP sUAS into emergency services to include some exploration on Geospatial Data Analysis.

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Title	**UAV Accuracy: Five things you need to know**
Keywords	ASPRS, UAV, Accuracy
Abstract	In this short introductory session, you will become familiar with the newest ASPRS data accuracy standards as they relate to UAV data collections and be provided with a brief checklist intended to help both validate and improve the accuracy of your UAV data. There are many misconceptions about data accuracy, from hardware and software manufacturer statements to understanding and managing error budgets. This brief session will provide the basic building blocks for understanding where your error is coming from and how to manage it. Most importantly, however, will be sorting through the noise of how to test and report it.

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Benjamin	Houston	ben@groundpoint-engineering.com	United States	Groundpoint Engineering

Title	**Deep learning and local maximum approaches for tree detection and characterization using UAV imagery over forest areas**
Keywords	UAV, Photogrammetry, Deep Learning, Tree Detection, Local Maxima
Abstract	Forest management requires accurate, cost-effective, and up-to-date information about forests. Traditional field measurement techniques (i.e., plot measurements and surveying) are expensive, time-consuming, and labor-needy. Unmanned aerial vehicle (UAV) photogrammetry technique, recently has become an alternative solution as a low-cost, fast, and above all, a 3-dimensional (3D) texture model method for traditional field surveying. There are various methods currently employed to detect trees and extract the structural characteristics of trees. In general, tree detection methods can be categorized into 2-dimensional (2D) and 3-dimensional (3D) methods. There are two common ways to detect trees using 3D points; using the 3D point cloud directly and encoding the 3D point cloud into the image. This study aims to compare and assess the result of the tree detection by 1) Local maximum method and watershed segmentation on canopy height model (CHM) and 2) deep learning. For the deep learning approach, the point cloud is encoded into the image that each cell will compute its density, height difference, and height gradient using the point cloud. The results show that deep learning outperformed the Local maximum. Furthermore, the ability of tree detection in both methods is related to window size. As the deep learning performs better than the

	Local maximum and watershed segmentation, calculated tree heights using deep learning are more reliable than the Local maximum. We are planning to conduct field measurements to compare these results against field reference data.

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SESSION 4: Hyperspectral UAV

Title	**Drone-based Hyperspectral Imager Characterization at RIT's Optical Calibration Facility**
Keywords	Hyperspectral, UAV, laboratory measurements
Abstract	The Digital Imaging and Remote Sensing (DIRS) lab in the Chester F. Carlson Center for Imaging Science at the Rochester Institute of Technology (RIT) strives to characterize the performance of our UAV-based hyperspectral imaging (HSI) systems. Our state-of-the-art Optical Calibration Facility (OCF) contains a NIST-traceable, 20 inch integrating sphere and an automated spectroradiometric measurement systems (i.e., monochromator) which allows precise estimates of the radiometric and spectral performance of our VNIR HSI system before and after UAV flights. Utilizing the OCF, our equipment and VNIR drone-based HSI systems have been used as a case study related to the testing procedures outlined in the IEEE P4001 Standard for Characterization and Calibration of Ultraviolet through Shortwave Infrared (250 nm to 2500 nm) Hyperspectral Imaging Devices. This talk will cover the methodology taken to validate the performance of our laboratory equipment in addition to characterization of our HSI drone imager. Estimates of VNIR HSI systems spectral performance will be discussed including the spectral response function and its use in estimating spectral emission lines for accurate wavelength calibration. We will additionally apply photon transfer theory to assess noise properties of our imagery. Finally, we will show how to estimate our drone-based HSI systems etendue, A-star (A*).

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Title	**Development of Novel Subpixel Targets for a Hyperspectral UAS Data Collection**

Keywords	Target Detection, Remote Sensing, System Limits
Abstract	Novel targets have been developed for enabling new research capabilities in subpixel target detection when integrated into a hyperspectral remote sensing data collection. The design ensures samples collected from a sensor are comprised of constant fill fractions of subpixel target material. In addition, when the overall size of the subpixel target is significantly larger than the spatial resolution of the sensor, large numbers of samples with constant fill fractions are retrieved. The development process (design, analysis, fabrication, testing) of the targets will be outlined, with an emphasis on their integration into a recent hyperspectral UAS data collection in Rochester, NY. The UAS technology was advantageous for enabling the design objectives. An overview of the UAS data collection will be discussed, including general research applications for assessing limits of detections. Practical impacts for users of hyperspectral technology will also be presented.

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Title	**Impacts of Shadowing and Adjacent Reflections on UAS Hyperspectral Object Detection**
Keywords	hyperspectral imaging, subpixel object detection, nonlinear mixing, remote sensing linear modeling
Abstract	The presence of shadowing and adjacent reflections in a scene can lead to nonlinear mixing of spectral radiances from materials as measured by an Unmanned Aerial System (UAS) sensor. This nonlinear mixing can be caused by shadowing from tall buildings, scattering within tree canopies, or reflections from adjacent objects. This is especially relevant for hyperspectral sensors, which may be used to detect subpixel-sized objects within a scene. The processing of hyperspectral data often assumes that the mixing of material spectra within a scene is linear; however, this assumption is violated with the presence of these nonlinear effects. To investigate the impact of these effects, a data collect was conducted with novel targets in which multiple experimental configurations were designed to induce shadowing and adjacent reflections onto the target spectra. The impacts of these effects on object detection performance are compared to those from a linear systems performance prediction model. This model tends to underestimate the impact of these effects and overestimate the ability of a UAS-mounted hyperspectral imager to discriminate between a desired target spectrum and the surrounding background.

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Title	**Predicting Table Beet Root Yield with Hyperspectral UAS Imagery**
Keywords	UAS, texture index, vegetation index, crop management, hyperspectral image table beet, yield estimation
Abstract	Precision crop management is becoming increasingly important for table beet production in New York state. It is in this context that unmanned aerial systems (UAS) have been investigated for yield forecasting, which is required for crop management and harvest scheduling. We investigated the feasibility of predicting table beet root weight using spectral and textural features, obtained from hyperspectral imagery collected via UAS. We identified specific wavelengths that were strongly correlated with root yield and used multivariate linear regression to develop models for different growth stages. The models achieved high accuracy and precision, with LOOCV (leave-one-out cross-validation) R2 values ranging between 0.85-0.90 and root mean squared errors (RMSE) between 10.81-12.93% for the best-performing models at each growth stage. The 760-920 nm wavelength region was found to contain the most predictive wavelength indices, which bodes well for development of affordable silicon-based detectors. In summary, our results suggest that the proposed wavelength indices can be used for viable prediction of table beet root yield, although further validation is needed using data from different locations and seasons.

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SESSION 5: Synthetic Aperture Radar (SAR) UAV

Title	UAS-based radar systems for snow and soil moisture measurements
Keywords	remote sensing, radar, soil moisture, snow
Abstract	The agricultural use of water in the United States and worldwide is estimated to be about 70% of the total freshwater resources. Climate change leads to a modification of the hydrological cycle, tremendously affecting the agricultural industry. Conserving freshwater resources is a critical need. We must avoid inefficient irrigation techniques by only watering where it is necessary. UAS-based soil moisture measurement techniques can help to solve this problem. We have developed low-cost, miniaturized ultra-wideband (UWB) radar systems for mounting on unmanned aerial systems (UASs) for the measurement of snow and soil moisture [1, 2, 3, 4]. These radars have been used extensively in Colorado for the measurement of snowpack depth and locally in Alabama for the measurement of surface soil moisture. The systems have been miniaturized to extend the spatial coverage and perform high-resolution measurements using very low transmit power of less than 10 mW. We will present the results of these deployments and highlight some of the capabilities of these systems. We are also developing techniques to use bistatic radar on a UAS pair to measure root zone soil moisture, which has a more significant implication on crop health and the need for targeted irrigation. Using a common-midpoint method, which is an established technique using ground-based and stationary radar [5], we can measure the dielectric constant of the soil to depths in the root zone from 30-60 cm. Preliminary experiments and deployments are being carried out to prove this technique, and the results will be presented at the conference.

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Title	**UAV-Based Multistatic Synthetic Aperture Radar System and Applications**
Keywords	Synthetic Aperture Radar, SAR, Radar, Multicopter, UAV, Remote Sensing, Interferometry, Tomography, Holography
Abstract	At the German Aerospace Center (DLR) we are currently building up a distributed UAV-based synthetic aperture radar (SAR) system for remote sensing applications and preparation of future new space radar missions. The system is scalable and consists in its basic configuration of three multicopters, each carrying a fully digital and polarimetric multi-channel radar sensor covering a frequency span from 500 MHz to 3.5 GHz with an instantaneous bandwidth of 3 GHz. Due to the relatively low carrier frequency even subsurface imaging is possible. The flight time is around 40 min so that per flight an area on ground of at least 1 km² can be imaged. For multistatic imaging the radar sensors need to be operated coherently among each other. This requires special radar synchronization methods and additional onboard hardware. Furthermore, the geographical positions of the radar antenna phase centers need to be known with subcentimeter accuracy, as well as the relative distance between the individual multicopters. Additional to a standard RTK GNSS base station on ground, per multicopter a special developed RTK module with a high accurate inertial measurement unit and a modified data fusion algorithm is needed for reaching the required accuracies. In the talk the system concept, the radar hardware, the technical challenges and solutions will be discussed in detail. Furthermore, some of the envisaged applications like single-pass interferometry, tomography and holography will be addressed. This work was partially funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) GRK 2680 – Project-ID 437847244.

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Title	**Active V-Dipole Antenna on UAS for Receiving NOAA Polar Satellite Imagery**
Keywords	V-Dipole, Software Defined Radio, Weather Satellites, Unmanned Aerial Systems
Abstract	In sub-optimal environments for satellite reception, an unmanned aerial system (UAS) can navigate to a higher vantage point to receive better quality satellite broadcasts. Small UAS platforms are constrained by weight and size, making VHF antenna design difficult for satellite reception onboard a UAS. This research designs, simulates, and implements a small form factor V-dipole antenna to receive high quality National Oceanic and Atmospheric Administration (NOAA) satellite imagery and weather data from a UAS. After a full antenna design using Altair Feko, simulations were run and a matching circuit was modeled. The matching circuit was fabricated and bench tested with the V-dipole and low noise amplifiers before mounted on a custom DJI Matrice 100 UAS platform. A software defined radio filtered and demodulated the VHF satellite signal and an Nvidia TX2 embedded computer processed the satellite images onboard the UAS. Performance was evaluated by the quality of the image reception and practicality of the antenna design in flight. With the upcoming deployment of NOAA's Joint Polar Satellite System, the authors hope this research will inspire others to receive polar orbiting satellite imagery and weather forecast data from a UAS.

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Title	**Monitoring of Cyanobacterial Blooms in Drinking and Recreational Bodies of Water by Air and on the Surface**
Keywords	Hyperspectral Imaging, Raman Flow Cytometry, Cyanobacteria Harmful Algal Bloom, UAV LiDAR and Hyperspectral
Abstract	The increasing occurrence of fresh water cyanobacterial blooms (CyanoHABs), many of which contain toxins harmful or even deadly to humans and animals, demands effective early warning. Direct sampling and measurement of a body of water is accurate at the point of measurement. However, CyanoHAB blooms are heterogenous in nature, meaning that a body of water – even a relatively small one – contains areas of various concentrations of algae. Measurements can also differ depending on the time of day, since colonies of micro-organisms naturally rise and fall in the water column. A direct measurement of a sample taken at the shore may show a concentration that is vastly different than in areas throughout the pond. To increase spatial and temporal sampling resolution, citizens have taken action to monitor and inform water quality managers when they have determined that the CyanoHAB levels have become harmful. Simple scientific tests such as the use of a Secchi disk to measure water clarity, as well as more elaborate measurements using spectrofluorometry and automated cell counters done by citizens themselves can provide important ground-truth data to supplement airborne images from UAVs. We describe an ongoing project by Headwall Photonics (Bolton, MA) and Coastal Ocean Vision (North Falmouth, MA) to measure and image the CyanoHAB blooms in Santuit Pond, Mashpee, MA over the course of several months. The data gathered by a lightweight airborne hyperspectral imaging UAV system imaging in the VNIR (400-1,000nm) is being validated by an automated cell identification and counting system using Raman-imaging flow-cytometry mounted at water level on a small boat. The short-term goal of this project is to correlate measurements taken directly from the flow cytometer and hyperspectral imaging data taken from a lightweight UAV. A long-term goal is to develop an automated measurement system on autonomous watercraft, as well as more automated UAV systems and eventually on small satellites with application-specific software for data acquisition, analysis, and visualization. Related to these goals is a desire to develop a method to detect and provide early warning of impending blooms to communities, as well as provide scientific input as part of remediation efforts.

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SESSION 6: Agriculture and Forestry Applications

Title	UAS Hyperspectral Imagery for Soil Organic Carbon Estimation: The Role of Soil Moisture Content Retrieval Models
Keywords	Soil Organic Carbon (SOC), Soil Moisture Content (SMC), Unmanned Aerial Systems (UAS), Hyperspectral Imaging
Abstract	Wetland ecosystems are an essential component of global carbon sequestration, but accurately measuring and mapping carbon storage at small scales is difficult due to high variability. Remote sensing using hyperspectral imagery is a promising method for determining wetland soil organic carbon (SOC). This study used unmanned aerial systems (UAS) to collect hyperspectral imagery in both the near infrared (NIR) and shortwave infrared (SWIR) spectral ranges to measure SOC in wetland ecosystems. Soil moisture content (SMC) was also considered as an input to the SOC retrieval model, which resulted in improved accuracy. The study also evaluated three models for mapping SMC over large areas and found that the multilayer radiative transfer model of soil reflectance (MARMIT) was more accurate when used with UAS hyperspectral imagery, while a modified version of the soil water parametric (SWAP)- Hapke model outperformed MARMIT when used with laboratory spectral data. The findings suggest that it is important to consider model differences when choosing a model for mapping SMC, especially for describing multiply scattered light. The results demonstrate the potential of remote sensing methods, particularly hyperspectral imaging, for accurately measuring SOC and SMC in wetland ecosystems and improving global scale mapping. This work contributes to ongoing efforts to better understand wetland carbon cycling and its potential contribution to mitigating climate change.

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Title	High-Resolution Crop Residue Mapping from Multispectral UAV Imagery using Deep Learning Segmentation
Keywords	Crop residue cover, Semantic segmentation, Convolutional neural network (CNN) Multispectral remote sensing, Conservation agriculture
Abstract	Accurate estimation of crop residue cover is crucial for enhancing agricultural sustainability, preventing soil erosion, and optimizing tillage practices. It is also a key step for evaluating the effectiveness of soil conservation systems in achieving sustainable agriculture. Remote sensing observations, including multispectral imagery, are a significant data source for cropland mapping and monitoring. Although multispectral UAV imagery does not offer the same level of spectral detail as hyperspectral imagery (HSI), it still provides valuable spatial and spectral information for identifying and quantifying crop residues. This study presents a new analysis framework based on multispectral images to quantify field-level crop residue cover fractions through a deep-learning segmentation. Therefore, we have conducted airborne multispectral surveys using three types of UAV multispectral cameras, i.e., Sequoia, MicaSense RedEdge, and Althum PT, in three agricultural regions of the province of Quebec, Canada. We collected the data from over 60 crop fields. In each field, 5-6 images were taken across the field. Through semi-automatic labeling, aided by NDVI, we obtained 1558 records of the fractional cover of vegetation, crop residue, and bare soil. With these labeled data, multiple semantic segmentation models were trained, including U-Net, Res-U-Net, AttentionUnet, and some pertained models, such as ResNet-50-Unet and VGG 19-Linknet.The experimental results show that: the trained models obtained slightly better performances than the pre-trained ones. The best configuration was ResUnet, with an overall accuracy of 0.92%, IoU of 0.90%, and an F1 score of 0.84).The developed method provides a promising and efficient residue estimation and mapping from diversified agricultural scenes using high-resolution imagery and a deep learning approach.

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Title	**Farmland Contamination Monitoring with Unmanned Aerial Vehicle-Aided Sensor Systems**
Keywords	Sensor Systems, Unmanned Aerial Vehicle, Farmland Contamination, Data Detection Data Collection, Monitoring Readouts
Abstract	Farmland soil contamination is mainly from the excessive usage of Nitrogen-based fertilizers and chemical pesticides. It has negatively impacted the growth of crops and harmed the health of consumers for centuries. A study concluded that pollution was responsible for 268 million disability-adjusted life years (DALYs). The majority of these were caused by farmland pollution. It is critical to accurately monitor farmland contamination before implementing any treatments. This research project applies recent advancements on sensors and drone networks to tackle this issue. It implements drone-aided sensor systems for contamination monitoring. A group of sensors are deployed as a sensing system to cover a farmland. Data detected by sensors are collected via drones for storage, analysis, and further processing. In this proposal, the drone first deploys sensors into farmland in a formation to maximize the coverage. After data detection, the drone will fly out to receive the data from each sensor. Agricultural professionals can use the collected data for analysis. A mathematical model is developed to use the least amount of resources while providing enough monitoring readouts. The model parameters include sensor amount, sensor monitoring range, drone detector power, distance of the drone flying above the ground, monitoring interval, as well as the required readout amount. Typical values are implemented to evaluate application scenarios. Results show this proposal offers feasible guidelines of conducting farmland contamination monitoring.

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Title	**Comparison of UAV Photogrammetric Software Products in a Forest Area**
Keywords	UAV, Photogrammetry, DSM, Forest, AgiSoft, Pix4D, DJI Terra
Abstract	Forest management requires accurate, cost-effective, and up-to-date information of forests. Traditional field measurement techniques (i.e., plot measurements and surveying) are expensive, time-consuming, and labor-needy. Unmanned aerial vehicle (UAV) photogrammetry technique, recently has become an alternative solution as a low-cost, fast, and above them all, a 3-dimensional (3D) texture model method for traditional field surveying. There are various processing and environmental factors that have an effect on final photogrammetric products such as flight altitude, sensors, platform, area of the study, and data processing methods. Currently, there are different commercial and free open-source software packages each using different methods to process UAV data and generate photogrammetric products including point clouds, Digital elevation models (DSM), and orthophotos. This study aims to compare and access the point cloud and DSM generated using three well-known commercial software, AgiSoft Photoscan (Metashape), Pix4D, and DJI Terra. For this purpose, two datasets, captured on the same

day using two UAV platforms in different flight altitudes, were used to compare the generated point cloud and DSM using the three software packages. The first dataset is captured using the DJI Phantom4pro with about 200 ft average flight height and the second dataset is captured using the DJI Matric210 with about 400 ft average flight height. Both flights were conducted over the SUNY ESF Heiberg Forest property located in Tully, New York. The results show that the number of generated points is greater in Pix4D and AgiSoft followed by DJI Terra. Pix4D and AgiSoft in both datasets have generated about 2.5 times denser point clouds than DJI Terra. However, interestingly, DJI Terra outperformed the other two software in generating point clouds of vertical and linear objects such as power lines and poles, AgiSoft and Pix4D. Furthermore, DJI Terra did a better job in detecting trees, and consequently their DSM than AgiSoft and Pix4D. A comparison of the DSM products shows that the spatial resolution of the generated DSM using AgiSoft is 1/4, and DJI Terra is 1/2 of the Pix4D. Furthermore, the elevation profile on DSMs shows that there are elevation differences between these software. For both datasets, the DJI Terra generated higher elevation, then AgiSoft, and finally Pix4D. The elevation differences are about 7ft for the first dataset and about 3ft for the second dataset. We are planning to conduct field measurements to compare these products against field reference data.

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SESSION 7: UAV Systems and Hardware

Title	**Sensorbricks: Medium Volume Heterogeneous Sensor Integration for Unmanned Aerial Systems**
Keywords	Heterogeneous Integration, Modular Miniaturization, Medium Volume, Sensorbricks Microbricks
Abstract	The progression of the evolution of unmanned aerial platforms requires steady progress in our abilities for attaining higher levels of integration of heterogeneous systems. These complex systems are necessary in order to deliver control, navigation, sensing and communications while minimizing weight and facilitating operating within strict energy and power budgets. Although good integration of existing electronic systems is currently possible, solutions involving electronics, inertial navigation, remote sensing, data storage, and various levels of communications are limited, particularly for the case of very small mass-produced aerial platforms. Heterogeneous integration is particularly relevant as Moore´s Law has effectively ended. Future increases in complexity require exploiting 3D stacking of planar devices or exploring multi-domain analog-digital integration. Domains such as optical, magnetics, mechanical, fluids chemical, gaseous and biological would demand immense efforts to assure performance, reliability and cost effectiveness.

	Finding markets capable of benefiting from this kind of integration is technologically challenging and economically important as these new technologies may serve to move us beyond Moore's Law until such a time that Quantum Computing is commercially viable. One possible large market is the one emerging around small unmanned aerial systems. This paper revises possible paths for attaining heterogeneous integration in support of small unmanned aerial systems and proposes a roadmap for enabling unique capabilities for small flying platforms. The main goal of this type of medium scale miniaturization is to enable the development of mass-produced aerial observation platforms serving a wide range of applications in security, defense, emergency services, environmental sensing, construction support, entertainment, arts, and several others yet to be uncovered.

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Title	**Development of Novel Subpixel Targets for a Hyperspectral UAS Data Collection**
Keywords	Target Detection, Remote Sensing, System Limits
Abstract	Novel targets have been developed for enabling new research capabilities in subpixel target detection when integrated into a hyperspectral remote sensing data collection. The design ensures samples collected from a sensor are comprised of constant fill fractions of subpixel target material. In addition, when the overall size of the subpixel target is significantly larger than the spatial resolution of the sensor, large numbers of samples with constant fill fractions are retrieved. The development process (design, analysis, fabrication, testing) of the targets will be outlined, with an emphasis on their integration into a recent hyperspectral UAS data collection in Rochester, NY. The UAS technology was advantageous for enabling the design objectives. An overview of the UAS data collection will be discussed, including general research applications for assessing limits of detections. Practical impacts for users of hyperspectral technology will also be presented.

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Title	**Technology and Application: Recording of Human Arm Motion Action using EEG Sensory Signal**
Keywords	EEG, hemorrhage, Brain activity, feature extraction, sensor signal
Abstract	A technology used to represent the output info from the cerebral nerve location is referred to as an electroencephalograph (EEG). Analyzing EEG signals have been utilized to assess brain abnormalities like hemorrhage. Whenever cerebral tissue undergoes harm leading to a neurological disease, certain bodily segments become immobile or, to use another phrase, immobilized, impairing both physical and mental function. In order to restore a person's muscle movements, neurogenesis is a technique that is frequently employed to educate healthy brain regions to take over the activities of broken sections. The exploratory methodology of such Brain activity for identifying human arm motion using an EEG technique is the main emphasis of this study. Using an Emotive device, the participant performs eight distinct activities encompassing the whole movement spectrum through flexion to bending while their EEG neural impulses are being recorded. Several EEG sensors are employed to gather the unprocessed digital signals in order to find and categorize the correlations. The detector was combined with a strain gauge, which serves as an indication to coordinate human arm motion well with EEG data. MATLAB was employed to import the sensor's unprocessed data and perform extraction of features, pre-processing, and sorting. This study's feature extraction method primarily employed the three-part Hjorth Parameter. Categorization accuracy can be increased depending on how well the extraction of features works. There is the ability to identify arm motion in order to help impaired persons with ADL.

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Title	**Revolutionizing Water Quality Monitoring: A Drone-Based Approach for Real-time Monitoring of Bule Algae Growth and Distribution**
Keywords	Blue Algae, Real time monitoring, Water quality
Abstract	Water quality monitoring is crucial for the health of aquatic ecosystems and the safety of people who use the water for drinking and recreation. In this project, we aim to develop a UAV based mobile platform equipped with various sensors, including turbidity, total dissolved solids (TDS), temperature, PH sensors, etc., to perform water quality measurement in real time. The sensor data as well as GPS coordinated will be transmitted to the cloud through LoRaWAN wireless communication network. In addition, multispectral cameras will be utilized to monitor and track blue algae distribution and movement. This camera is equipped with specialized filters that highlight the unique pigment of blue algae, allowing for accurate detection and mapping. To supplement the drone's measurements, we have also developed a novel fully autonomous custom lightweight 3d-printed water sampling system based on mini

	servo motors. These samplers can collect up to 25 ml of water from Lake Champlain. Currently, the drone can fly automatically to four specific regions, but our goal is to extend this number to eight. To conclude, the goal of this project is to make water quality studies more efficient and accessible in remote bodies of water. By utilizing sensor fusion in conjunction with Geographic Information System (GIS), we can monitor water parameters and the environmental conditions much more accurately and rapidly, facilitating prompt decision makings for water resource management and protection.

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