

STRATUS 2022 Conference May 23 – 25, 2022



State University of New York College of
Environmental Science and Forestry

STRATUS 2022 Conference

Systems and Technologies for Remote Sensing Applications Through Unmanned
Aerial Systems

23-25 May 2022, Gateway Center,
State University of New York College of Environmental Science and
Forestry (SUNY-ESF), Syracuse, New York, USA



STRATUS 2022 Conference May 23 – 25, 2022: stratus-conference.com



The 2022 Systems & Technologies for Remote Sensing Applications Through Unmanned Aerial Systems Conference is hosted by SUNY ESF in partnership with IEEE.

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Welcome from the General Chair



Welcome to STRATUS 2022!

Unmanned Aerial Systems or 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.

After three years of successful conferences in 2016, 2017, and 2019 at Rochester Institute of Technology and a virtual conference in 2021 organized by University at Buffalo, SUNY-ESF has organized and is hosting the 5th STRATUS on May 23-25, 2022 on beautiful ESF campus in Syracuse, NY.

This year's STRATUS has brought together more than 100 professional attendees from academia, federal and state governments, and industry from across the U.S.A and Canada. There is a total of nine technical sessions presenting nearly 40 oral and poster 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, two panel sessions, several exhibitors and UAV demo flights on site.

STRATUS 2022 is generously supported financially by UAV industry leaders including, NUAIR, HySpex, LabSphere, Headwall, Arcadis, Applanix, ASPI, and Imagine Aerial. I also should mention that we have a student competition for awards in presentation, poster, and UAV Trivia games!

I hope you experience a successful and productive Conference at STRATUS 2022 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
STRATUS 2022 General Chair

Welcome from Co-Chair



On behalf of the organizing committee, and the general chair for this year's event, I would like to welcome everyone to the 5th conference (2016, 2017, 2019, 2021, 2022) on Systems and Technologies for Remote Sensing Applications Through Unmanned Aerial Systems or simply STRATUS 2022. The three-day conference is being held in Syracuse, New York, on May 23-25, 2022 at the SUNY College of Environmental Science and Forestry (ESF).

The idea of this workshop started in 2016 as a result of a conversation between myself and my RIT colleague, Dr. John Kerekes. 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 of 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, six years later, we have changed from a workshop to a 3-day conference, in addition to having UB host the event in its last iteration (on-line) with SUNY ESF hosting it this year under the leadership of Professor Bahram Salehi. We are expecting over 40 talks this year.

In general, 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 2022 program will promote the dissemination of research results and technical advances in this new emerging field of unmanned aerial systems. I hope you enjoy the talks, sponsor tables, demos, and opportunity to network!

Best,
Emmett Lentilucci, Ph.D.
Rochester Institute of Technology
STRATUS 2022 Conference CoChair

Program Committee

General Chair



Bahram Salehi
SUNY College of Environmental Science
and Forestry

Co-chair/financial chair



Emmett Ientilucci
Digital Image and Remote Sensing Lab,
Rochester Institute of Technology

Local Arrangements Chair



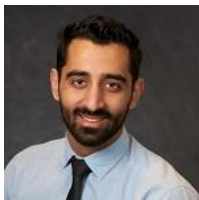
Katherina Searing, Associate Director
Open Academy at SUNY College of
Environmental Sciences and Forestry

Event Coordinator



Lauren LaTray
SUNY College of Environmental Science
and Forestry, Syracuse, NY

Students Involvement Chair and web Administrators



Sina Jarahizadeh
SUNY College of Environmental Science
and Forestry, Syracuse, NY

The University at Buffalo Liaison



Marianne Sullivan
University at Buffalo

Student volunteers

Haifa Tamimina
Valeria Perez
Victor C Igwe
Alexandria Kirkpatrick
Katelyn Scherzi
Yuchen Luo

Scientific Committee



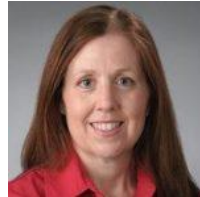
Lindi Quackenbush, SUNY College of Environmental Science and Forestry



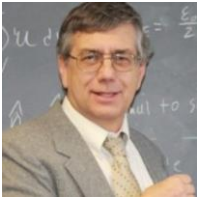
Ken Stewart, President and CEO of NUAIR



Chris Renschler, University of Buffalo



Jamie Winders, Syracuse University



Peter Spacher, Rochester Institute of Technology



Leila Hashemi, NC A&T State University



Chris Badurek, SUNY – Cortland



Mohamad A. Razkenari, SUNY College of Environmental Science and Forestry



Buffy Quinn, Onondaga Com. College

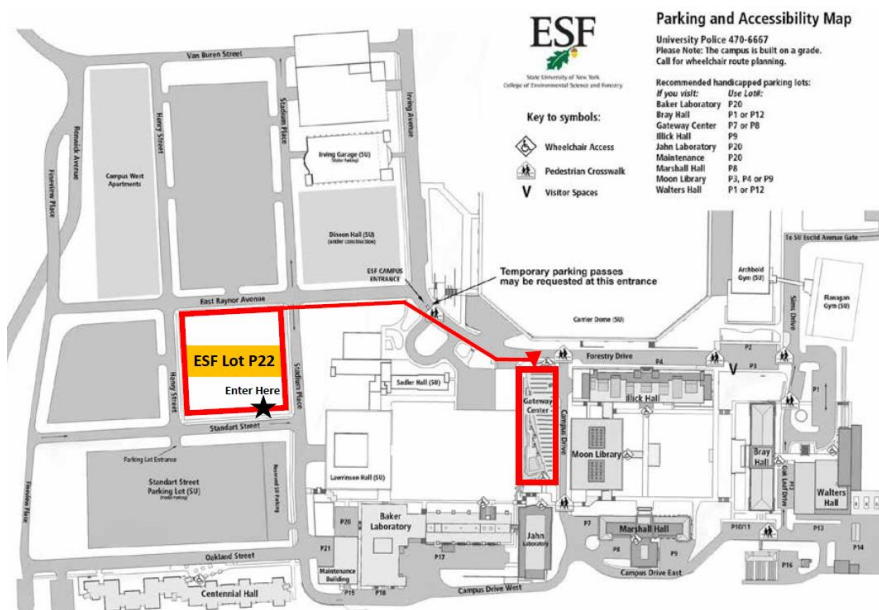
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Driving Direction to SUNY ESF:

On your phone, put Parking 22, SUNY ESF as your destination

Walking from Parking Lot 22 to Gateway center:

<https://goo.gl/maps/oTzHJpC7CSHXkzd26>



ESF Campus Map with Parking Lot.

Parking lot 22 will be available free of charge to the conference attendees



State University of New York College of Environmental Science and Forestry

Parking and Accessibility Map

University Police 470-6667

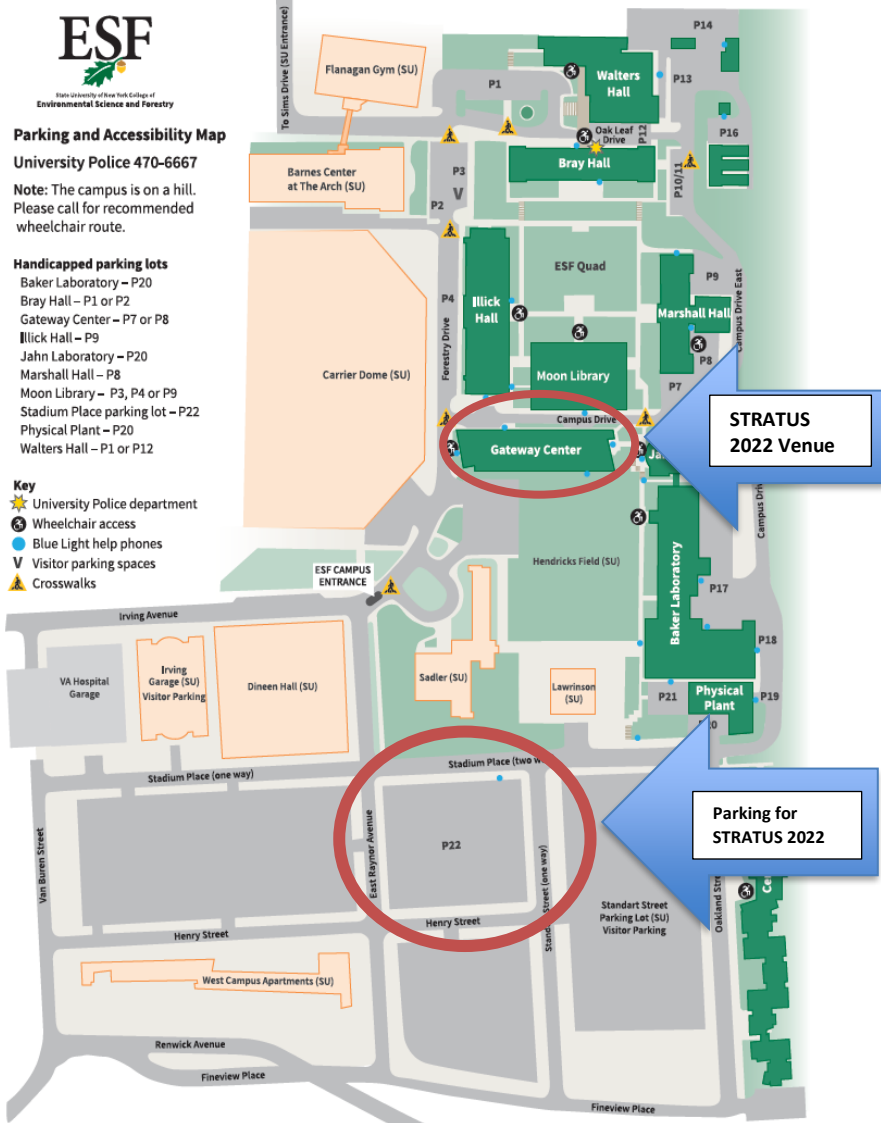
Note: The campus is on a hill. Please call for recommended wheelchair route.

Handicapped parking lots

- Baker Laboratory – P20
- Bray Hall – P1 or P2
- Gateway Center – P7 or P8
- Illick Hall – P9
- Jahn Laboratory – P20
- Marshall Hall – P8
- Moon Library – P3, P4 or P9
- Stadium Place parking lot – P22
- Physical Plant – P20
- Walters Hall – P1 or P12

Key

- University Police department
- Wheelchair access
- Blue Light help phones
- Visitor parking spaces
- Crosswalks



Venue Map

The Venue is in ESF Gateway center (See the ESF map).

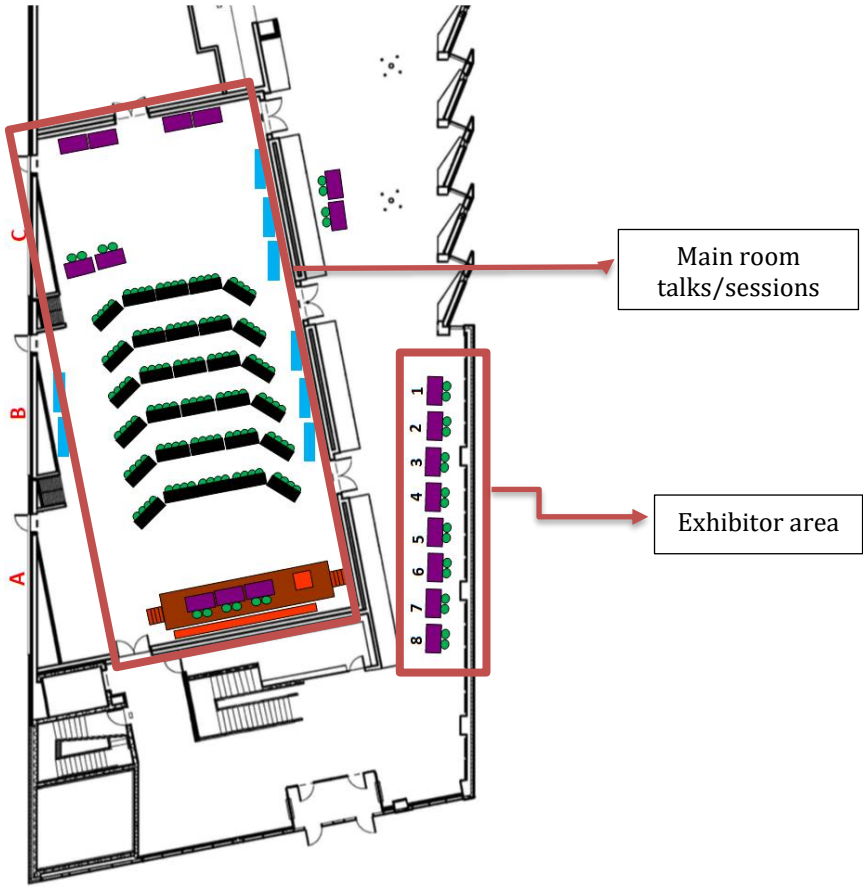
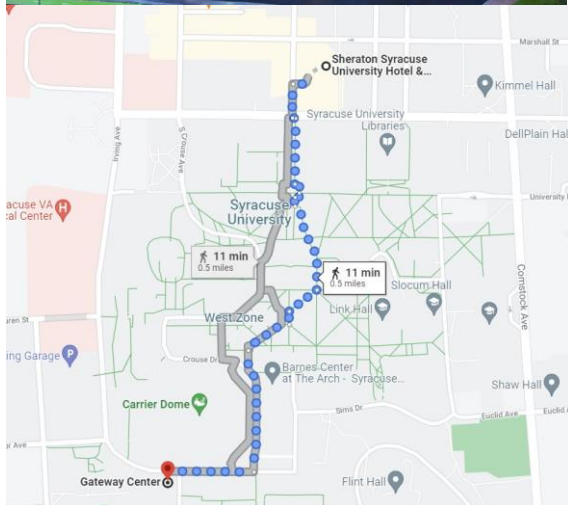


Table #	Company	Table #	Company
1	Headwall	5	Applanix
2	HySpex	6	Arcadis
3	Labsphere	7	ASPI
4	NuAIR	8	Imagine Aerial

Map to Social Gathering on Tuesday Evening

- Tuesday May 24
- 5 PM to 7 PM
- Sheraton at Syracuse University (Sitrus on the Hill) Finger foods and one free drink
- 10 min walk from the venue

**Sheraton at Syracuse University,
801 University Avenue Syracuse, New York 13210**



WiFi Instructions

Visitors to campus can connect to the ESF-Guest wireless network in all campus buildings. Please note that in order to register on the ESF-Guest, visitors must be able to provide a 10-digit cell phone number that is capable of receiving text messages.

How to connect to ESF Guest Network

1. Connect your device to: ESF-Guest
2. Open your web browser on your device.
3. Enter your 10 digit mobile phone number.*
4. Click on "I agree to ESF Terms."
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6. Click Validate Pin.
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8. After 24 hours of use, you will have to re-agree to ESF's Terms & Conditions.

***Standard messaging & data rates apply. ESF is not responsible for any mobile carrier charges**

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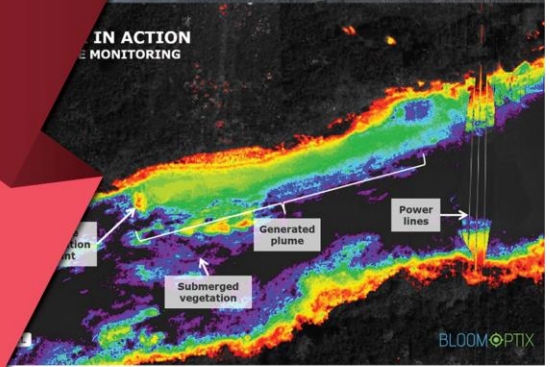
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STRATUS 2022, Session F, 3:00 pm, Tuesday, May 24, 2022



Hyperspectral imaging and analysis of hydrothermal alteration mineralogy in Cuprite, Nevada, Carson Roberts, Isabel Barton, and Jingping He; Headwall Photonics & Univ Arizona

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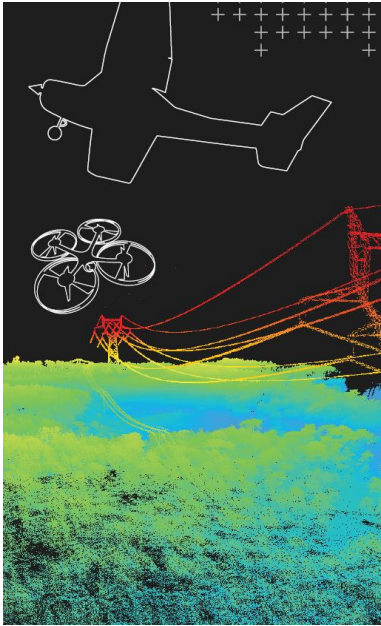
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Program Agenda in one view

	Day 1: Monday May 23	Day 2: Tuesday May 24	Day 3: Wednesday May 25
8:00-8:30	Registration & Breakfast	Registration & Breakfast	Registration & Breakfast
8:30-9:00	Welcome, Opening Remarks SUNY-ESF President: Joanie Mahoney Conference General Chairs: Dr. Bahram Salehi, SUNY-ESF; Dr. Emmett Ientilucci, RIT;	Welcome, Opening SUNY-ESF Provost: Dr. Sam Mukasa Conference General Chairs: Dr. Bahram Salehi, SUNY-ESF; Dr. Emmett Ientilucci, RIT;	Welcome, Opening Conference General Chairs: Dr. Bahram Salehi, SUNY-ESF; Dr. Emmett Ientilucci, RIT
9:00-9:45	Keynote-1: Ken Stewart, President and CEO, NUAIR: Enabling Commercial Drone Operations: Progress in Drone Technology in New York	Keynote-2: Dr. Steven J. Thomson, National Program Leader, USDA-NIFA: UAS-Based Remote Sensing for Agriculture – New Directions at USDA-NIFA and Historical Perspective	Keynote-3: TBA
9:45-10:45	Technical Session A: <i>UAV for Mapping and Surveying</i> Session Chair: Dr. Lindi Quackenbush, SUNY-ESF	Technical Session E: <i>UAV for Educational Programs</i> Session Chair: Buffy Quinn, Onondaga Community College	Technical Session H: <i>Poster Presentations</i> Session Chair: Dr. Peter Spacher, RIT
10:45-11:15	Coffee Break/Exhibit Hall	Coffee Break/Exhibit Hall	Coffee Break/Exhibit Hall
11:15-12:15	Technical Session B: <i>UAV for Agricultural Applications</i> ; Session Chair: Dr. Leila Hashemi-Beni, North Carolina A&T University	UAV Flight Demos2 by ARCADIS Topic: <i>Demonstration of UAV Water Sampling Apparatus at ESF QUAD, Moderated by Dr. Peter Spacher, RIT</i>	UAV Flight Demo 3 by Imagine Aerial Topic: <i>UAV and Artificial Intelligence for Condition Analytics at ESF QUAD</i>
12:15-1:30	Lunch/Group Photo/Networking/ Exhibit Hall UAV Flight Demo 1 by Headwall Topic: Hyperspectral UAVs Moderator: Dr. Peter Spacher, RIT	Lunch/Group Photo/Networking/ Exhibit Hall	Lunch/Group Photo/Networking/ Exhibit Hall

1:30-2:15	Panel 1: <i>UAV Policy, Public Perception, and Privacy Issues,</i> Moderated by Dr. Jamie Winders, Associate Provost, Syracuse University	Panel 2: <i>Research, Teaching, and Applications of UAV in Environmental and Forestry Monitoring: ESF Perspective</i> Moderator: Dr. Lindi Quackenbush	UAV Trivia Game-2
2:15-3:15	Technical Session C: <i>Design of Autonomous UAVs</i> Session Chair: TBA	Technical Session F: <i>UAV for Flood and Water Quality Monitoring;</i> Session Chair: Dr. Eddie Bevilacqua, SUNY-ESF	Technical Session I: <i>UAV Flight and Operation</i> Session Chair: Dr Mohamad Razkenari, SUNY-ESF
3:15-3:45	Coffee Break/Exhibit Hall	Coffee Break/Exhibit Hall	Coffee Break/Exhibit Hall
3:45-4:45	Technical Session D: <i>UAV for Wildlife, Air Quality, and Post Earthquake Damage Monitoring</i> Session Chair: Dr. Chris Renschler, SUNY Buffalo	Technical Session G: <i>UAV Data Radiometric and Geometric Calibration</i> Session Chair: Dr. Chris Badurek, SUNY Cortland	Awards and Closing Remarks Conference General Chairs: Dr. Bahram Salehi, SUNY-ESF; Dr. Emmett Ientilucci, RIT Student Poster and Presentations and UAV Trivia Winners
4:45-5:15	Wrap Up of the Day	UAV Trivia Game-1	
5:15-7:00		Happy Hours/Social At Sheraton Syracuse University	

Monday 23 May

REGISTRATION & BREAKFAST: 8:00 AM to 8:30 AM

WELCOME: 8:30 AM TO 9:00 AM

Dr. Bahram Salehi, ESF, Conference General Chair
Joanne Mahoney, ESF President

KEYNOTE: 9:00 AM TO 9:45 AM

Moderator: Dr. Bahram Salehi, ESF
Ken Stewart, President and CEO of NUAIR,
Enabling Commercial Drone Operations: Progress in Drone Technology in New York

SESSION A: 9:45 to 10:45

UAV for Mapping and Surveying

Session Chair: Dr. Lindi Quackenbush, SUNY-ESF

9:45 Autonomous Exploration and Mapping with UAS, Eric Thorn, Southwest Research Ins.

10:00 The Value of Direct Georeferencing to UAS Remote Sensing, Brad Schmidt, Applanix Corporation (CANADA).

10:15 Artificial Intelligence combined with remote sensing increases drafting efficiency for surveying and mapping, Nadine Natividad, AirWorks Solutions.

10:30 Ground control points geometry distribution assessment on combined horizontal and vertical accuracies of UAV photogrammetric products, Sina Jarahizadeh and Bahram Salehi, ESF.

Coffee Break and Exhibit Hall: 10:45-11:15

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SESSION B: 11:15 to 12:15

UAV for Agricultural Applications

Session Chair: Dr. Leila Hashemi-Beni, North Carolina A&T University

11:15 A Framework for Relating UAS Data to Soil Moisture and Health, Cary McCraine, Raju Bheemanahalli, Volkan Senyurek and Jing Hu, Mississippi State University.

11:30 Deep Learning Approaches to Corn Grain and Silage Yield Estimation from High-Resolution UAS Imagery S. Sunoj, Benjamin Yeh and Quirine Ketterings, Cornell University.

11:45 Snap bean plant count using UAS-based LiDAR point clouds, Fei Zhang, Amirhossein Hassanzadeh, Jan van Aardt, Sean Murphy and Sarah Pethybridge, Rochester Ins. of Technology and Cornell University.

12:00 UAV Data Labeling using Deep Learning, Leila Hashemi-Beni and Meghan Puthenparampil, North Carolina A&T University.

GROUP PHOTO: 12:15 PM to 12:20 PM

NETWORKING and Exhibit

LUNCH: 12:20 PM to 1:30 PM

Moderator: Emmett Ientilucci, RIT

UAV Flight Demo 1 by Headwall 12:20-1:30

Topic: Hyperspectral UAVs

Moderator: Dr. Peter Spacher, RIT

Panel 1: 1:30 to 2:15

UAV Policy, Public Perception, and Privacy Issues

Moderator: Dr. Jamie Winders, Syracuse University

SESSION C: 2:15 to 3:15

UAV System Design

Session Chair: TBD

2:15 **Using Convex Mirrors to Understand Spatial Image Quality in Hyperspectral Imaging (HSI) Data**, David Conran, Emmet Lentilucci, RIT

2:30 **Turning raw hyperspectral imagery into high-accuracy and interpretation-ready mapping products: Direct Georeferencing with HySpex UAV Systems**, Dennis Adamek, Loke Trond, Norsk Electro Optikk/ HySpecx, Norway.

3:00 **Circle Optics (Part-1): Compound Eyes in the Skies**, Andrew Kurtz, Zakariya Niazi and Ian Gauger, Circle Optics.

3:15 **Circle Optics (Part-2): Compound Eyes in the Skies**, Andrew Kurtz, Zakariya Niazi and Ian Gauger, Circle Optics.

Coffee Break and Exhibit Hall: 3:15 to 3:45

SESSION D: 3:45-4:45

UAV for Wildlife, Air Quality, and Earthquake (OUTSTEPS Special Session)

Session Chair: Dr. Chris Renschler, University at Buffalo

3:45 **UAV-Based Monitoring to Track Deer Overpopulation in Upstate New York**, Peter Vailakis, Joseph Won, Melissa Torchio, Connor Townes and Caitlin Tucker, SUNY- Binghamton.

4:00 **UAV photogrammetry and remote sensing applications for whale biology**, "Valeria Perez, Julia Zeh, Elizabeth Josephson, Lisa Conger and Susan Parks, Syracuse University.

4:15 **Thinking Inside the Box and Beyond: Validating UAV-Based Air Quality Measurements**, Chandula Fernando and Matthew Adams, University of Toronto.

4:30 **A semi-supervised deep learning approach for detecting post-earthquake building damages using UAV data**, Narges Takhtkeshha, Ali Mohammadzadeh and Bahram Salehi, SUNY-ESF.

Wrap Up of the Day: 4:45 PM

Tuesday 24 May

REGISTRATION & BREAKFAST: 8:00 AM to 8:30 AM

WELCOME: 8:30 AM TO 9:00 AM

Dr. Bahram Salehi, ESF, Conference General Chair; Dr. Emmett Lentilucci, RIT, Conference Co-Chair
Dr. Sam Mukasa, SUNY-ESF, Provost

KEYNOTE: 9:00 AM TO 9:45 AM

Moderator: Dr. Emmet Lentilucci, RIT
Dr. Steven Thomson, National Program Leader, USDA-NIFA,
UAS-Based Remote Sensing for Agriculture – New Directions at USDA-NIFA and Historical Perspective

SESSION E: 9:45-10:45

UAV Education Program

Session Chair: Buffy Quinn, Onondaga Community College

9:45 **Using UAV Imagery to Foster Civic Engagement in High School Students**, William Flood, Nathan Dubinin and Erika Ruhl, U Buffalo.

10:00 **What I wish I knew when starting a UAV mapping program**, Buffy Quinn, Onondaga Community College.

10:15 **Oswego City Launches Robust Drone program through theory, testing and trials**, Gavin Snyder, Imagine Aerial.

10:30 **How to Conduct UAS Remote Sensing Missions and Be FAA Part 107 Compliant**, Mike Harris and Ashley Cheek, Agrowdrone/FAA.

Coffee Break and Exhibit Hall: 10:45 to 11:15

Workshop/UAV Flight Demo 2 by ARCADIS at ESF Quad Area 11:15-12:15

Topic: *Demonstration of UAV Water Sampling Apparatus*

Moderator: Dr. Peter Spacher, RIT

GROUP PHOTO: 12:15 PM TO 12:20 PM

NETWORKING and Exhibit

LUNCH: 12:20 PM TO 1:30 PM

Moderator: Katherina Searing, ESF

Panel 2: 1:30-2:15

Research, Teaching, and Applications of UAV in Environmental and Forestry Monitoring, ESF Perspective

Moderator: Dr. Lindi Quackenbush, ESF

SESSION F: 2:15-3:15

UAV for Flood and water quality monitoring

Session Chair: Dr. Eddie Bevilacqua, SUNY-ESF

2:15 **Image Analysis for Detecting Harmful Algae Blooms in the Finger Lakes**, Julia Bellamy, Lea Mateo Medina, John Halfman and Ileana Dumitriu, Hobart and William Smith Colleges.

2:30 **Spectral Imaging for the Detection of HABs in the Finger Lakes**, Lea Mateo Medina, Julia Bellamy, John Halfman and Ileana Dumitriu, Hobart and William Smith Colleges.

3:00 **Hyperspectral imaging and analysis of hydrothermal alteration mineralogy in Cuprite, Nevada**, Carson B. Roberts, Isabel Barton and Jingping He, Headwall/ U of Arizona.

3:15 Mapping of Floodwater Extent under Vegetation Using SAR Imagery, Abdella Salem and Leila Hashemi, North Carolina A&T U.

Sheraton at Syracuse University, Citrus on the Hill
Finger foods and one free drink
10 min walk from the venue

Coffee Break and Exhibit Hall: 3:15 to 3:45

SESSION G: 3:45-4:45

UAV Data Radiometric and Geometric Calibration

Session Chair: Dr. Chris Badurek, SUNY Cortland

3:45 Assessment of geometric and radiometric artifacts in UAS hyperspectral imagery, Chase Canas, John Kerekes, Emmett Lentilucci and Scott Brown, RIT.

4:00 TeleSculptor: Free and Open Source Software for Aerial Photogrammetry, Matt Leotta, Kitware Inc.

4:15 Underflight Validation of Landsat 9 Thermal Infrared Sensor, Lucy Falcon and Ethan Poole, RIT.

4:30 Infrared thermometers (radiometers), transfer standards and blackbodies. Use an IRT on a UAV to measure land temperature, urban landscapes, agriculture, water surface, ice or snow and/or to enhance radiometric accuracy of a thermal imaging camera, Bud Foran, Heitronics Infrared.

UAV Trivia Game-1 4:45- 5:15 PM
Moderated by Dr. Marianne Sullivan,
University at Buffalo

Social Gathering and Happy Hours: 5:30 to 7:00

Wednesday 25 May

REGISTRATION & BREAKFAST: 8:00 AM to 8:30 AM

Opening: 8:30 AM TO 9:00 AM

Dr. Bahram Salehi, ESF, Conference General Chair

Dr. Emmett Ientilucci, RIT, Conference Co-Chair

KEYNOTE: 9:00 AM TO 9:45 AM

Moderator: Dr. Bahram Salehi, ESF, TBD

SESSION H: 9:45 to 10:45

Poster Presentations

Session Chair: Dr. Peter Spacher, RIT

Detecting and tracking an underground coal fire using thermal imagery, Kate Sinsabaugh and William Stiteler, ARCADIS.

Reflectance Spectroscopy in the Finger Lakes, Ileana Dumitriu, Julia Bellamy, Lea Mateo Medina, Peter Spacher, John Halfman and Lisa Cleckner.

Detection and Mapping of Forest Regeneration using Unmanned Aerial Vehicles, Abhishek Poudel and Eddie Bevilacqua, ESF.

Automated Building Inspection for Thermal Anomaly Detection and 3D Reconstruction Using a Drone-based Approach, Shayan Mirzabeigi and Mohamad Razkenari, ESF.

GIS Analysis using Archived UAS Data of Ice Jam Flooding in Plymouth, NH, Christopher Badurek and Liam Brush, SUNY- Cortland.

Integrating UAS and Geotech Courses with STEM Entrepreneurship Training, Christopher Badurek, SUNY- Cortland.

Coffee Break and Exhibit Hall: 10:45 to 11:15

Workshop/UAV Flight Demo 3 by Imagine Aerial at ESF Quad Area 11:15-12:15

Topic: *UAV and Artificial Intelligence (AI) for Condition & Predictive Analytics*
Moderator: Dr. Peter Spacher, RIT

GROUP PHOTO: 12:15 PM TO 12:20 PM

NETWORKING and Exhibit LUNCH: 12:20 PM to 1:30 PM

UAV Trivia Game-2 1:30- 2:15 PM

Moderated by Dr. Marianne Sullivan, University at Buffalo

SESSION F: 2:15 to 3:15

UAV Flight and Operation

Session Chair: Dr. Mohamad Razkenari, ESF

2:15 UAS Imaging of sensitive projects on Airport Grounds and in Restricted, Military and Government Airspace, Gavin Snyder, Imaging Aerial.

2:30 A Multi-layer Anomaly Detection Framework for Networked Unmanned Aerial Vehicles, Mohammad Bahrami and Hamidreza Jafarnejadsani, Stevens Institute of Technology.

3:00 Micro-Weather Sensing and Analytics to Close Low Altitude Weather Gaps for Drone Operations, Don Berchoff, James Eanes and Randolph Ware, TruWeather Solutins/ Daniel Wagner Associates/ Radiometrics Inc.

Coffee Break and Exhibit Hall: 3:15 to 3:45

Awards: 3:45 to 4:15

- **Student Oral Presentation**
- **Student Poster Presentation**
- **Trivia- 1winner**
- **Trivia-2 winner**

Closing Remarks: 4:15 to 4:45

Dr. Bahram Salehi, ESF, Conference General Chair

Dr. Emmett Ientilucci, RIT, Conference Co-Chair

Monday Keynote Speaker



Ken Stewart
President and CEO of NUAIR

Ken Stewart serves as President and CEO of NUAIR, responsible for setting the overall vision and strategy for the uncrewed aircraft systems (UAS) organization. Stewart is an experienced industry expert in wireless telecommunications and cloud-based software, with a specialization in building Enterprise SaaS, Federated digital marketplaces, and platforms. Prior to joining NUAIR, Stewart served as the CEO of AiRXOS, a GE aviation company, where he led the innovation, development, and commercialization of Unmanned Traffic Management services. After beginning his career in engineering and management positions at IBM and GTE, Stewart served as an executive with several venture capital and private equity-backed companies commercializing and scaling pre-revenue start-ups and transforming organizations for growth. Stewart also serves as the President of the Commercial Drone Alliance, a non-profit organization that works with federal policymakers and industry stakeholders to help create relevant rules to scale commercial UAS operations.

Tuesday Keynote Speaker



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.

Abstracts

SESSION A: UAV for Mapping and Surveying

Title	Autonomous Exploration and Mapping with UAS				
Author keywords	unmanned aerial system, autonomous exploration, simultaneous localization and mapping				
Abstract	<p>Southwest Research Institute (SwRI) has developed technologies to enable an unmanned aerial system (UAS) to autonomously explore and map unknown environments. This paper will summarize the development and demonstration of simultaneous localization and mapping (SLAM), world modeling, and exploration-based planning algorithms. SLAM is implemented by leveraging the Google Cartographer software suite and lidar point cloud data to provide an odometry estimate and generate a high-fidelity 3-dimensional map. The world model framework includes an obstacle layer to support near-field navigation and obstacle avoidance and a frontier layer that identifies and models regions of the environment that are ripe for further exploration. The planning framework includes a global exploration planner that prioritizes frontiers and a local planner that generates collision-free trajectories to the frontiers. The paper also includes a summary of experimentation conducted at the European Robotics Hackathon (EnRich) 2021 event held at the AKW Zwentendorf nuclear power plant in Zwentendorf Austria. During these experiments, SwRI's UAS autonomously explored and mapped the interior of the power plant and detected live radiation sources, all without any a priori knowledge.</p>				
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Title	The Value of Direct Georeferencing to UAS Remote Sensing
Author keywords	UAS Georeferencing, Direct Georeferencing, GNSS/Inertial Systems

Abstract	<p>The deployment of Unmanned Aerial Systems (UAS) has continued to expand into many application domains, especially given the availability of a wide range of sensor payloads that easily mount to UAS platforms, including RGB camera systems, hyperspectral scanners, LiDAR sensors and much more. Often, one of the key requirements for collecting this data is the need to achieve a high degree of accuracy and precision. This is particularly important for mapping requirements where survey grade data accuracy and precision is required, and/or for GIS analysis, where data layers may need to be tightly overlaid for topological analysis and information extraction. Direct Georeferencing, which uses integrated GNSS /inertial technology is emerging as the preferred way to capture UAS data for georeferencing, given the cost benefits it offers via; 1) the elimination of the need for ground control, 2) the larger offset of trajectory flight lines, and 3) the accuracy and precision that can be achieved. This presentation will provide an overview of exactly what Direct Georeferencing is, what's required to implement a Direct Georeferencing (DG) solution for UAS, the associated benefits, as well as an examination of several DG use cases.</p>				
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Brad	Schmidt	bschmidt@applanix.com	Canada	Applanix Corporation		

Title	<p>Artificial Intelligence combined with remote sensing increases drafting efficiency for surveying and mapping.</p>				
Author keywords	<p>artificial intelligence AI, reality capture, remote sensing, machine learning, image processing, data processing big data, surveying, UAV, UAS, drones, accuracy, aerial data, photogrammetry, existing conditions, topography, modeling, lidar, laser scanning, mobile mapping</p>				
Abstract	<p>Artificial Intelligence is promised to increase efficiencies in many industries, and enable new business models like self-driving cars. Many of the tasks that engineers work on today won't be the same tasks they'll work on tomorrow, and artificial intelligence is expected to drive this apparent change in the profession. Companies are starting to work on various applications that automate the inspection of infrastructure through artificial intelligence, calculation of construction cost based on a few key parameters and statistical models, or propose finalized design solutions. Similar to self-driving cars, however, who some thought would already be deployed at scale today, the application of artificial intelligence doesn't automatically solve all challenges, and the technology has to be implemented in a thoughtful way. This session will cover the potential, the shortfalls, and the challenges of artificial intelligence based on the example of a feature extraction algorithm that vectorizes aerial data from UAVs or aircraft, in order to automate the CAD drafting process. While there are certain limitations, artificial intelligence has significant potential to advance the industry in making sense of massive amounts of data.</p> <p>The key findings we'll present in the session are the following:</p> <ul style="list-style-type: none"> ▪ Use case and demonstration for software that creates CAD drawings autonomously by 				

extracting features of aerial images and point clouds <ul style="list-style-type: none"> ▪ How AI has proven useful in automating certain workflows, such as vectorization and analysis of buildings, pavement markings, roads, utilities, and topography ▪ AI challenges such as in identifying and drawing accurate building footprints; requiring manual analysis, and often traditional extraction tools ▪ How the adoption of AI will require more complex metrics of success, such as intersection over union and number of nodes as a measure for accuracy, and drafting time comparisons as a measure for efficiency, and how these metrics could look like. ▪ Current results that demonstrate the potential of AI to reduce survey linework drafting times by at least 50% 					
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Title	<p>Ground control points geometry distribution assessment on combined horizontal and vertical accuracies of UAV photogrammetric products</p>
Author keywords	<p>UAV, Photogrammetry, ground control points, distribution, geometric pattern</p>
Abstract	<p>Ground Control Points (GCPs) play a vital role in the photogrammetric processing of Unmanned Aerial Vehicles (UAVs) imagery for various applications including elevation and topographic products. Collection of GCPs demands fieldwork with precise GPS/surveying instruments and is arguably one of the most costly parts of a UAV Photogrammetry project. The low-cost onboard Global Navigation Satellite System (GNSS) including GPS together with inertial measurement units (IMU) offers reduction of the number of ground control points (GCPs) required for connecting image coordinate to ground (object) coordinate systems and resolving collinearity equations or fundamental matrix. Not only does the number of GCPs have an effect on topographic data accuracy but also the distribution pattern of the GCPs has a direct effect on the accuracy of the final products (e.g. 3D models and digital surface model -DSM). This study aims to investigate the impact of the geometric distributions of GCPs, in the project area, on the combined vertical and horizontal accuracies of UAV products. For this purpose, four distribution scenarios in two different flight altitudes have been designed to investigate the accuracy of the Check (test) Points (CPs). In the first scenario, GCPs were selected close to the edge of the study area. In the second scenario, GCPs were selected in a zigzag pattern. In the third scenario, GCPs are distributed in the north part of the study area where it has higher elevations than the south part. Finally, in the fourth scenario, GCPs were distributed across the south part of the area where it has lower elevation than the north side. We tested all four scenarios using flight altitudes of 70 m and 100 m and calculated the root mean square error (RMSE) of CPs in combined vertical and horizontal directions for each scenario and the two flight altitudes. Results show that the second scenario (zigzag pattern) provides the lowest RMSE of 0.218 and 0.145 pixels in linear (combined) direction for altitudes of 70 m and 100 m, respectively. The first scenario provided the second-best results with the RMSE of 0.25 and 0.156 pixels for altitudes of 70 m and 100 m. The RMSEs of the fourth</p>

scenario were 0.322 and 0.259 for 70 and 100 m flight heights. Finally, the worst results were achieved by the third scenario with RMSE of 0.369 and 0.412 pixels. This study suggests when the number of GCPs is limited in a UAV project it is better to distribute them evenly throughout the area and not on the edges or sides of the area.

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SESSION B: UAV for Agricultural Applications

Title	A Framework for Relating UAS Data to Soil Moisture and Health			
Author keywords	UAS, Multispectral Imagery, Hyperspectral Imagery, LIDAR			
Abstract	<p>The Geosystems Research Institute of Mississippi State University along with the Agricultural Research Service of the USDA is working to strengthen current UAS remote sensing techniques to integrate Genetics, Environment, and Management data into precision agricultural crop management. This research focuses on relating these techniques to plant stress and/or soil health. The objectives are to develop best practices to collect UAV remotely sensed data from numerous payloads at optimal flight profiles, to develop algorithms to automate data processing from the payloads to indicate plant stress and/or soil health, and to enhance decision support tools with the results of the first two goals to optimize sustainable practices in agricultural production systems. To achieve these objectives GRI has been collecting 5-band multispectral imagery, hyperspectral imagery, and high-density lidar point clouds at various altitudes as well as ground truth for multiple studies related to plant stress and/or soil health. This presentation will cover our current workflows, how the data is being used to meet the objectives to date, and future objectives.</p>			
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Title	Deep Learning Approaches to Corn Grain and Silage Yield Estimation from High-Resolution UAS Imagery				
Author keywords	crop yield, unmanned aerial system, Vegetation indices, deep learning, LSTMs, CNNs				
Abstract	<p>Within-field yield measurements from yield monitor systems on combines or forage choppers can offer useful insights for improving the allocation of crop inputs and other farm resources. However, existing yield monitor systems are expensive, data collection is tedious, and harvest data cleaning is laborious. The objective of our research is to evaluate if corn (Zea mays L.) grain and silage yield can be estimated from high-resolution unmanned aerial system (UAS) imagery in combination with various deep learning approaches. During the growing season of 2019, the Quantix™ Mapper and AeroVironment Decision Support System™ (AeroVironment Inc.) were used to collect weekly imagery. This UAS had a color (RGB) and multispectral (NIR) camera that was used to capture images over 14 weeks across eight fields (three fields for grain; 170 ha total). The UAS images were combined with weather and elevation data to create a dataset. This dataset was used to train a model that maps temporal relationships between weekly images, weather, and landform features (derived from elevation), and predicts end-of-season yield. Long-Short Term Memory (LSTM) neural networks were used to ingest time-series data and model the temporal dependencies between the inputs. Preliminary results show that corn silage fields show potential in predicting yield with an error of up to 6.5 Mg/ha (6.5% average yield). This error is expected to reduce as we fine-tune the parameters. Further research remains to explore convolutional neural network (CNN) models and develop a CNN and hybrid model that would leverage the temporal relationships for improved yield estimation using remote sensing.</p>				
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Title	Snap bean plant count using UAS-based LiDAR point clouds
Author keywords	LiDAR, 3D point clouds, plant count, yield prediction
Abstract	<p>Unmanned aerial systems (UAS)-based remote sensing methods increasingly have been used for yield prediction and other crop management inputs. Most of the approaches rely on spectral features extracted from images, while the structural characteristics of crops, which could become important crop biophysical predictors, largely have been neglected. This project aims to develop plant count algorithms for snap bean using 3D point clouds, generated via a light detection and ranging (LiDAR) system on a low-cost UAS platform. First, we preprocessed the data to obtain a digital terrain model (DTM) and point clouds with z-coordinates normalized by the DTM. We then derived multiple intermediate structural features, including row segment centers, the canopy area as a function of height, filtered via adaptive height thresholds, and the volume of 3D meshes, reconstructed using a Poisson surface reconstruction algorithm. Finally, we used the above metrics to fit regression models to estimate plant count. Results will be presented at the conference.</p>

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Title	UAV Data Labeling using Deep Learning				
Author keywords	UAV, high resolution, data analytic, classification				
Abstract	<p>Rapid development and deployment in the remote sensing platforms and sensors have resulted in the mass collection of high-resolution data. The similarities between the types of data addressed with conventional deep learning applications and RS high-resolution data, as well as the need for fast processing of large RS datasets for real-time monitoring of rapidly changing events such as floods or forest, make a compelling argument for integrating deep learning methods into sensing approaches. However, the accurate labeling of dense data are very critical for the efficient study and understanding of the phenomenon being studied. This research investigates accurate labeling of high-resolution UAV data for the flood mapping tasks. We have implemented U-Net and SegNet to perform pixel-wise labeling of aerial images for inundation areas extraction in Google Earth Engine. With UNet we were able to achieve an accuracy of 96%, compared to SegNet which provided an accuracy of 69% and 70% without and with the data augmentation. The results demonstrate that UAV image labeling and segmentation with UNet provides better results compared to SegNet for flood mapping tasks.</p>				
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SESSION C: UAV System Design

Title	Using Convex Mirrors to Understand Spatial Image Quality in Hyperspectral Imaging (HSI) Data
Author keywords	HIS, Spatial quality, Mirrors
Abstract	The impact of an HSI systems Point Spread Function (PSF) is an important characteristic of spatial performance and becomes unnoticeable when observing large area targets from above (i.e., a drone platform). However, when observing small spectral targets

(i.e., a few pixels), the PSF can have a dramatic impact on separating the target from background signature. This talk will focus on using convex mirrors as ideal point sources to first, diagnosis the system PSF and second, to highlight PSF impacts on small targets through a spectral unmixing experiment.

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Title

Turning raw hyperspectral imagery into high-accuracy and interpretation-ready mapping products: Direct Georeferencing with HySpex UAV Systems

Author keywords: hyperspectral imaging, direct georeferencing, data processing, workflow, batch processing

Abstract

UAV-borne hyperspectral imaging enables high-resolution spatial and spectral data acquisition for medium scale surveying areas, which makes it a preferred remote sensing technique for applications such as geological exploration, precision agriculture, or environmental monitoring. Transforming the recorded raw hyperspectral data into high-accuracy orthorectified images that can be used as interpretation-ready mapping products for those applications usually requires several time-consuming processing steps. This includes radiometric calibration, navigation data post-processing, georeferencing and orthorectification, as well as atmospheric and terrain corrections for reflectance retrieval. Traditional approaches are often reliant on field installations like ground control points for georeferencing, reference panels for reflectance calibration, and preinstalled base stations to improve the position accuracy of the GNSS system. Here, an improved and streamlined hyperspectral data processing workflow for HySpex UAV systems is presented. It is completely independent of any of the above-mentioned ground referencing and offers partly automated data handling through batch processing functions. The workflow includes high-accuracy direct georeferencing of the hyperspectral image data, complementary LiDAR point cloud data processing for the generation of accurate surface models, and an automatic reflectance retrieval procedure that is based on physical atmospheric and terrain correction models. The processing will be demonstrated on a recent demo campaign data set from a copper skarn mine in Tucson, Arizona.

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Title	Circle Optics- Part- 1: Compound Eyes in the Skies
Author keywords	camera system, parallax, navigation, photogrammetry, situational awareness
Abstract	Circle Optics is developing the world's first parallax-free, stitch-free panoramic multi-camera capture system technology. Concurrent with an ongoing effort to complete a second-generation system targeting the Cinematic and VR markets or applications, Circle Optics has pursued other market opportunities and design paths. Circle Optics, which is based in both Rochester and Syracuse NY, has identified significant opportunities in the drone, UAV, and eVTOL markets, where our technology can support a broad range of applications, including those for industrial inspections, security, site mapping and surveying, photogrammetry, and enhanced navigation (e.g., detect and avoid). In this, presentation, Circle Optics will review parallax and its impact on imaging, our design approach for optically and opto-mechanically reducing parallax, the base architectural configurations that the technology can support, and the technical advantages that it can provide.

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Title	Circle Optics- Part- 2: Compound Eyes in the Skies
Author keywords	camera system, parallax, navigation, photogrammetry, situational awareness
Abstract	Circle Optics, as a relative newcomer to the UAV market, recognizes that there are many unexplored opportunities for partnerships or collaboration, and for adapting our technology into this space. Even as we would welcome more discussion with interested parties, Circle Optics is already actively developing its low parallax panoramic imaging technology for potential use in the emerging UAV and eVTOL markets. In this presentation, Circle Optics will describe how the technology is being adapted for use in these markets, to provide appropriate functional capabilities for airborne image sensing at reduced SWaP-C levels. In particular, a series of imaging and system specifications

for different UAV supported applications, and some optical and mechanical design adaptations of the technology to support these applications, will be reviewed.

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SESSION D: UAV for Wildlife, Air Quality, and Earthquake

Title	A semi-supervised deep learning approach for detecting post-earthquake building damages using UAV data				
Author keywords	building damage evaluation, earthquake management, deep learning, drone imagery				
Abstract	<p>With the ever-increasing availability of high and very high-resolution imagery, the assessment of post-earthquake building damage is becoming an important application of remote sensing. However, detection of damage levels according to well-known standards such as EMS-98 is still a challenge. The recent development of low-cost drones along with flexible resolution and suitable coverage has led to an increase in their potential for disaster management. Furthermore, deep learning (DL) methods have recently yielded promising results and some studies have been conducted for damage detection. However, maintaining a balance between time efficiency and accuracy is crucial in crisis management that has received little attention. This study presents a rapid deep learning-based approach that can detect building damage in four levels, including “no visible,” “minor,” “major” and “collapsed”. Our proposed method consists of three steps. Firstly, a “one-epoch convolutional autoencoder” was used to extract deep features from manual features. Then, to eliminate the need for training data, the most challenging part of supervised methods, training samples were selected automatically with a few simple rules and overall accuracy and kappa coefficient of 93.07% and 88.61%, respectively. Finally, eight famous machine learning (ML) methods including SVM, MLP, DT1, AB2, GB3, XGB4, RF5, and KNN were used to generate damage maps. We investigated three scenarios for features (manual, deep, and manual+deep) and the experimental results indicate that fusion of manual and deep features outperforms two other scenarios by far. Additionally, among the ML algorithms, SVM provided the best results, with an overall accuracy and kappa coefficient of 82% and 74%, respectively. This study suggests that drone technology combined with ML algorithms can effectively speed up the process of rescue.</p>				
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Title **Thinking Inside the Box and Beyond: Validating UAV-Based Air Quality Measurements**

Author keywords environmental monitoring, air quality, gaseous plumes, turbulence validation

Abstract A popular strategy when tracking gaseous plumes using an Unoccupied Aerial Vehicle (UAV) is to discretize the volume of interest into a searchable grid of voxels. The UAV moves through the grid, hovering at each point while an observation is collected by onboard sensors. Once the grid-like search is complete, a raster map of concentrations can be created using the observations collected. A discretized search strategy expects an uncontaminated observation at each grid point. This requires the UAV to cause minimal disturbance to the overall field when moving. However, as the UAV enters and exits each voxel of the grid, downwash and turbulence caused by the maneuvers of the UAV can distort the field. It is therefore useful to quantify the magnitude of disturbance caused by the mobility of the UAV, as well as the time taken for the turbulence to stabilize before a reliable observation can be made. With the ability to account for turbulence, observations collected by the UAV may be equivalent to those collected by a network of stationary samplers mounted at each point of the grid. The purpose of this study is to validate observations of air quality taken onboard an UAV. By demonstrating the ability for a UAV-based system to reliably monitor outdoor air quality at a level comparable to stationary samplers, this study demonstrates how UAVs may be used as robust tools for mobile monitoring.

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Title **UAV photogrammetry and remote sensing applications for whale biology**

Author keywords Wildlife Conservation, Whales, Photogrammetry, Body measurements

Abstract UAV technology has experienced huge advancements in recent years across fields as diverse as architecture, engineering, medicine, and wildlife monitoring. For ecological and behavioral field studies of wildlife, UAVs allow scientists to gain access to distant and difficult to access areas, from dense forests to the open ocean. Studies of marine mammals, in particular, can be aided by the use of UAVs to identify individuals, measure body size, count and monitor populations, and track species. The high spatial resolution and coverage provided by UAVs allow for data collection that would be otherwise impossible using traditional boat-based methods. Here we review the applications of UAV photogrammetry and remote sensing for studies of whale biology, with a particular emphasis on using UAV technology for measuring body size and condition in baleen whales. We discuss the variety of hardware and software that has been used for whale photogrammetry with UAVs and include a case study of body measurement using images of the highly endangered North Atlantic right whale.

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Title	UAV-Based Monitoring to Track Deer Overpopulation in Upstate New York
Author keywords	White-Tailed Deer, Public Health, Overpopulation, Forested Biomes, UAV-based Thermal Imaging
Abstract	Over the past 100 years, the overpopulation of White-Tailed Deer (<i>Odocoileus virginianus</i>) has become a crisis that is affecting multiple facets of our environment. Current literature has acknowledged White-Tailed Deer (WTD) populations as a public health and economic concern in urban and peri-urban environments due to frequent and increasing incidences of vehicular accidents. Lack of primary predation from coyote (<i>Canis latrans</i>), bobcat (<i>Lynx rufus</i>), gray wolf (<i>Canis lupus</i>), and black bear (<i>Ursus americanus</i>) populations have enabled WTD populations to expand far past sustainable levels. In forested biomes, overpopulated deer decimate understory which prevents forest regeneration and inhibits roles of wetland populations, threatening overall environmental stability. The application of UAV-based thermal imaging methods has become a viable technique for determining

the extent of the WTD overpopulation crisis. In March 14th 2020, FLIR LWIR thermal imaging cameras were mounted on DJI Matrice 600 Hexacopter UAV-based drones to collect data on WTD population densities in the Binghamton University Nature Preserve. Four separate flights were conducted over a survey of 1.15km² in the Binghamton University Nature Preserve (BUNP). Preliminary analysis indicates the prevalence of 64 deer / km² and estimates an approximate 105 - 205 WTD total throughout the 2.43km² of undeveloped land. Since the carrying capacity of WTD is 3-10 deer/km² in the northeast United States, this analysis is indicative of extreme overpopulation. Using the collected thermal data, we intend to develop methods in constructing an orthomosaic. This orthomosaic will be used to come to conclusions about the density of deer in relation to the developed areas of campus and deer densities relation to biodiversity in the local environment. These methods also are intended to be used to generate yearly census data of WTD encompassing BUNP and the greater Binghamton area in order to build a comprehensive time-set of WTD populations going forward.

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SESSION E: UAV Education Programs

Title	Using UAV Imagery to Foster Civic Engagement in High School Students
Author keywords	High School, Civic Engagement, Geographic Information Systems, Unmanned Aerial Systems
Abstract	This project is designed to support under-resourced high school students as they explore global historical questions using geo-spatial data to analyze and address civic issues. The Data Citizens Western New York (DCWNY) Grant is a Department of Education American History and Civics Education-National Activities Grant Program dedicated to integrating Geographic Information Systems (GIS) into Social Studies pedagogy, encouraging geospatial thinking, and fostering civic engagement in students using geotechnologies. This is achieved by engaging with the students using current geotechnology in real world situations. Part of this process is introducing the students to data collection with Unmanned Aerial Systems (UAS). Field trips to parks with our local civic partners give students the opportunity to have hands-on experience with data collection using UAS. This allows the students to be an active participant in data collection while also being civically engaged. Activities like this allow the DCWNY Grant to strive towards its goal of developing geospatial citizens. During interviews with the students at the end of the program, students' self-reported feeling more civically engaged. Further work with other groups of students is still required, but preliminary results suggest that exposing students to tools, such as UASs, encourages civic engagement when applied to a real-world problem.

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Title	Oswego City Launches Robust Drone program through theory, testing and trials
Author keywords	Municipal, Drone, UAS, testing, trials, multi-sensor, DHS, homeland, security, life-saving, rescue
Abstract	Imagine Aerial was formed in 2017 and quickly became a national solutions provider, utilizing UAS-mounted multi-sensor technology, research, big-data and Ai solutions. Imagine's success propelled us to consult for several urban clients including the City of

Oswego. With a technology-supporting mayor and new fire chief, Randy Griffin, Oswego was poised to become a test center for a new UAS program. Oswego reached out to us and we learned that Chief Griffin was a savvy professor at both SU and Georgetown and helped author their Emergency Management curriculums. He was a liaison to the Technology Directorate at the Department of Homeland Security. Our initial meetings realized a vision for success. Imagine was a research company looking to help clients explore solutions and develop technology. In a time of daily solicitors selling UAS products and services for which municipalities have limited staff and resources to fund or operate, we had nothing to sell them. On the other hand, the chief and I with mayor's approval, initiated a series of REAL-LIFE operations based upon a desired result, to test, provide services and then document results of several UAS operations. We will describe and illustrate our aerial operations over Harbor Fest, describe a unique first-of-its-kind 15-mile UAS operation at Paddle Fest where we live-streamed into a regional multi-jurisdictional local/state/federal emergency command center along with two other operations that helped Oswego develop and launch one of NY State's most respected UAS programs which would go on to gain National Press for a life-saving UAS Rescue.

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Title **What I wish I knew when starting a UAV mapping program**

Author keywords K-12, Education, Best practices

Abstract Onondaga Community College received an NSF Advanced Technological Education grant to integrate UAV data analysis credentials into the geospatial science and technology AAS program. The goal of that grant project is to have students prepared to not just fly drones, but to collect, process, and analyze remotely sensed data with them. Before writing the proposal, I attended several training workshops covering building a UAV curriculum, selecting the right drone, the Part 107 requirements and exam, using Esri products with drone data, and UAV flight planning. Although this preparation was necessary for project planning and taught me a great deal, there were still things I didn't realize I needed to know to get this started on my own campus. In this presentation I will discuss the initial challenges I encountered as I started the program, how I figured out what I needed, and then provide specific information about the hardware, software, and peripherals I needed to get this program off the ground.

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Title	How to Conduct UAS Remote Sensing Missions and Be FAA Part 107 Compliant
Author keywords	FAA, hazards, FAASteam
Abstract	This session will define the difference between hobby and commercial missions, provided details on how to properly register and mark UAS aircraft, present airspace classifications and the B4UFLY app, discuss how to obtain a part 107 license and how to stay current, discuss mission planning techniques to identify hazards and minimize risks, and cover incident reporting requirements.

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SESSION F: UAV for Flood and water quality monitoring

Title	Image Analysis for Detecting Harmful Algae Blooms in the Finger Lakes
Author keywords	Harmful Algae Blooms, Remote Sensing, Image Analysis, Sensors
Abstract	Harmful Algae Blooms (HABs) form when algae grow out of control, creating cyanotoxins that are harmful to the local human and marine ecosystems. HABs are prevalent in every US coastal to Great Lakes region, including the Finger Lakes regions. There is limited knowledge on what causes algae growth to turn harmful, but theories range between nutrient pollution, warm water, still water, and climate change. It is important to research and monitor HABs due to health risks to both humans and animals, creation of dead zones, reduced sources of drinking water, increased water turbidity, and the economic costs associated with them. Standard, in-situ water quality testing to determine the presence of HABs is often time consuming and expensive. With the recent commercialization of drones in the United States, many affordable remote sensing research applications can be explored. Remote sensing of water offers many challenges, from cloud coverage and calibration techniques to water turbidity and surface glare from the sun. Given the many competing factors in remote imaging of water, it is essential to understand the connection between the images and the physical properties of the water. This study aims to evaluate differing water conditions ex-situ utilizing optical imaging techniques in an attempt to correlate trends in the optical images with standard water quality measurements taken from the Finger Lakes.

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Title **Spectral Imaging for the Detection of HABs in the Finger Lakes**

Author keywords Remote Sensing, Reflectance Spectra, HABs

Abstract Harmful algae blooms (HABs) arise in coasts and lakes around the world, including the Finger Lakes. These blooms produce cyanotoxins that damage the flora and fauna of the environment. As of now, scientists are unable to predict when and where these algae blooms will appear. However, nutrients, warm water, and wind are the main contributing factors to trigger HABs. Therefore, it would be of vital importance to find a way to predict these blooms. Remote sensing could be the perfect avenue offering both spatial and time resolution required to monitor the blooms. Since the HABs are changing the composition of the water, visible light spectroscopy offers an effective way for qualitative and quantitative analysis of the blooms. Algae have their own specific optical signature; therefore, the reflectance spectra of water could be correlated with algae concentration in an effort to monitor HABs in Finger Lakes. The success of this research depends heavily on the calibration method. This poster presents our effort in searching for the best method to calibrate the reflectance spectra.

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Title	Hyperspectral imaging and analysis of hydrothermal alteration mineralogy in Cuprite, Nevada
Author keywords	Hyperspectral, Mineralogy Imaging, Drone Imaging, UAV Imaging, Drone-based Hyperspectral Scan, LiDAR, Point Clouds
Abstract	<p>Low altitude (40-80m AGL) UAV Flights were conducted over the Cuprite Hills region of Nevada, USA, with a sensor payload including LiDAR, Short Wave Infrared (900-2500nm) and Visible Near Infrared (400-1000nm) Hyperspectral sensors. The LiDAR data were used to build 3D and Digital Elevation Models of the surveyed terrain, which were in turn used to orthorectify the data from the line scan imagers. Samples were collected from the survey areas and analyzed in the laboratory to generate spectral libraries for classification of the spectral images. Classification of drone-based hyperspectral scans shows the distribution of spectrally active minerals in the exposed upper zone of the Cuprite epithermal system in southern Nevada. The exposures of different types of clays, micas, sulfates, and other alteration products can help to map the nature, intensity, and geochemical conditions of the epithermal processes active at Cuprite, indicating a low-pH fluid system with variable sulfidation. The classified mineral maps were then fused with the LiDAR point clouds to generate 3-dimensional images of the mineralogy of the areas surveyed. Abstract Text:</p> <p>Low altitude (40-80m AGL) UAV Flights were conducted over the Cuprite Hills region of Nevada, USA, with a sensor payload including LiDAR, Short Wave Infrared (900-2500nm) and Visible Near Infrared (400-1000nm) Hyperspectral sensors. The LiDAR data were used to build 3D and Digital Elevation Models of the surveyed terrain, which were in turn used to orthorectify the data from the line scan imagers. Samples were collected from the survey areas and analyzed in the laboratory to generate spectral libraries for classification of the spectral images. Classification of drone-based hyperspectral scans shows the distribution of spectrally active minerals in the exposed upper zone of the Cuprite epithermal system in southern Nevada. The exposures of different types of clays, micas, sulfates, and other alteration products can help to map the nature, intensity, and geochemical conditions of the epithermal processes active at Cuprite, indicating a low-pH fluid system with variable sulfidation. The classified mineral maps were then fused with the LiDAR point clouds to generate 3-dimensional images of the mineralogy of the areas surveyed.</p>

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Title	Mapping of Floodwater Extent under Vegetation Using SAR Imagery				
Author keywords	UAVSAR, Sentinel-1b SAR, L-band, C-band, Random Forest				
Abstract	<p>Synthetic Aperture Radar (SAR) is an active remote sensing method that is capable of collecting data during night and day. SAR sensors emit signals with long wavelengths that can penetrate clouds and vegetation canopies. In this study, flooded vegetation was mapped using Sentinel-1b, C-band SAR data and UAV L-band SAR data. Accuracy assessments were conducted for floodwater maps derived from Sentinel-1b, C-band SAR data and floodwater extent maps derived from full-polarized L-band UAVSAR data. Satellite SAR data and UAVSAR data during flooding in North Carolina's coastal plain areas resulting from Hurricane Florence were analyzed. UAVSAR collected daily data over several flight lines with repeat paths, beginning on September 18 through September 23 in the year of 2018. Sentinel-1b sensed the areas on September 19, 2018. For this research, UAVSAR data and Sentinel-1b SAR data acquired on the same date for the same area, were collected and analyzed. UAVSAR data were processed using polarization decompositions method to identify land cover classes based on their scattering mechanisms. Both data sets were classified using Random forest classification algorithm. Land cover samples were digitized and labeled using high resolution optical data. 70% of the samples were randomly selected to train random forest classifiers and the 30% was used to validate classification results obtained from the two datasets. UAVSAR L-band showed overall higher accuracy than Sentinel-1b C-band SAR data.</p>				
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SESSION G: UAV Data Radiometric and Geometric Calibration

Title	Assessment of geometric and radiometric artifacts in UAS hyperspectral imagery				
Author keywords	Hyperspectral, Remote sensing, Image artifacts, Atmospheric compensation Geometric correction, Image quality, UAV				
Abstract	<p>Image artifacts, derived from geometric and radiometric errors, are observable in many unmanned aerial systems (UAS) based hyperspectral datasets. The effects degrade the image fidelity of a UAS, due to distortion of information transferred through the imaging process. To empirically characterize image artifacts and assess their root causes and effects, a dataset from a small hyperspectral imager fixed-mounted onto a UAS was analyzed. The dataset was collected and processed at the</p>				

Rochester Institute of Technology (RIT), and involved the deployment of a variety of well characterized ground targets onto a field of grass material. Sources of error were investigated from a qualitative perspective, answering questions about the ‘what’, ‘how’, and ‘why’ a particular phenomenon exists in the imagery. These sources of error include instability of the UAS during flight, limitations of sampling rates of the navigation sensors (GPS & IMU), and processing errors during geo-registration and atmospheric compensation of the hyperspectral data. In addition to geometric distortions, radiometric artifacts associated to in-scene atmospheric compensation errors were characterized. This includes a quantitative assessment of error associated to objects exhibiting specular properties, while the compensation method assumes they are Lambertian. Discrepancies between reflectance distributions after transforming data in units of digital counts or units of at-sensor radiance are also shown. Suggestions to improve the image quality of UAS hyperspectral data are presented.

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Title	TeleSculptor: Free and Open Source Software for Aerial Photogrammetry
Author keywords	Photogrammetry, Open Source Software, Computer Vision, TeleSculptor Research
Abstract	Kitware is a collaborative open source software company headquartered in Clifton Park, NY with a focus on innovative research. Over the last decade, Kitware computer vision team has developed TeleSculptor (https://www.telesculptor.org/), an open source software application and toolkit with a focus on photogrammetry using UAV video footage in either visible or infrared. The goals of TeleSculptor are to provide a highly configurable toolkit for researchers to swap in different algorithms into any stage of the photogrammetry pipeline while also providing a graphical application that is easy to use for more general users. TeleSculptor development has been supported primarily by various government agencies including Air Force Research Labs (AFRL), Defense Advanced Research Projects Agency (DARPA), National Geospatial-Intelligence Agency (NGA), United States Special Operations Command (SOCOM), and others. While initial development was primarily for DoD applications, we are now looking for collaborators and contributors to work with us to bring TeleSculptor to more commercial and civilian applications. In this talk, we will provide an overview of what TeleSculptor is and how it works with information about how to get involved in the community as either a user or a developer. We will also summarize some of the active research at Kitware that is using TeleSculptor to explore new directions in aerial photogrammetry including fusion of aerial photogrammetry with

satellite imagery and synthetic aperture radar (SAR), and using multiview observations in 3D to improve detection and classification of small objects using deep neural networks.					
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Title	Infrared thermometers (radiometers), transfer standards and blackbodies. Use an IRT on a UAV to measure land temperature, urban landscapes, agriculture, water surface, ice or snow and/or to enhance radiometric accuracy of a thermal imaging camera.				
Author keywords	Infrared radiation thermometer, Infrared radiometer, Transfer radiation thermometer, Transfer standard thermometer, Blackbody calibrator, Blackbody calibration source, Enhance measurement accuracy of thermal image camera, In-situ calibration, enhancement of thermal cameras				
Abstract	<p>The world's atmospheric sciences community has long recognized HEITRONICS as the leader in commercially available non-contact infrared temperature measurement instrumentation. Ocean scientists utilize HEITRONICS for sea surface temperature for climate change studies, weather forecasting and marine biology health studies. The US-DOE Atmospheric Radiation Measurement (ARM) Program administered by Pacific Northwest National Labs has utilized HEITRONICS for close to 30 years with deployments/studies throughout the USA and the world for land, ocean surface, polar ice and sky radiation temperature measurements. The list goes on and on.</p> <p>Thermal imaging cameras, particularly those utilizing uncooled detectors that respond to longwave broadband infrared radiation, are far less accurate than the measurement performance produced by a HEITRONICS KT15 Series IRT (KT15 is an example of several available series and the presentation will introduce the details to support this statement.) Aligning the measured area of an IRT with a Region of Interest (ROI) within the scene measured by a thermal imaging camera, provides an opportunity to allow the IRT's more accurate measurement by used to provide an in-situ calibration enhancement of the thermal imaging camera.</p> <p>HEITRONICS is also recognized around the world for producing the highest quality/performance longwave infrared transfer standards (within the TRT Series) for use to calibrate other IRT's, thermal imaging cameras, cavity blackbodies and plate radiation sources. HEITRONICS also designed cavity blackbodies, such as Model ME30, that produces superb levels of emissivity as well as temperature uniformity and stability.</p>				
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SESSION H: Poster Presentations

Title	Detecting and tracking an underground coal fire using thermal imagery				
Author keywords	Thermal, underground, fire, coal				
Abstract	In as early as September 2017 an underground coal fire was burning at a glass manufacturing plant. With the building's foundation & supports losing integrity, the plant owner needed to determine the direction of fire movement as neighboring residents were concerned about air quality and damage to their property. In September 2018, Arcadis was contracted to fly thermal imagery multiple times to determine the fire progression and extent.				
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Title	Reflectance Spectroscopy in the Finger Lakes				
Author keywords	Harmful Algal Blooms, Reflectance Spectroscopy, Remote Sensing, Water Quality				
Abstract	Harmful Algal Blooms (HABs) have added toxins to a growing list of New York's waterways. These toxins degrade the water quality and can harm humans and ecosystems. The transient nature of HABs in both space and time result in monitoring challenges, and therefore adds to the difficulty in scientifically understanding the ecological criteria that trigger HABs. This research aims to investigate reflectance spectroscopy as an alternate method of detecting HABs and apply this method for remote sensing using drones. During this summer a small, lightweight spectrometer was used to record reflectance spectra in the wavelength range of 350-800 nm for seven of the Finger Lakes. The poster will present the results and the search for a correlation between these reflectance spectra and the concentration of algae in the lake water.				
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Title	Detection and Mapping of Forest Regeneration using Unmanned Aerial Vehicles				
Author keywords	Unmanned Aerial Vehicles, Image Analysis, PIX4D, Forest Regeneration				
Abstract	<p>Forest monitoring activities are critical to sustainable forest management. One important element of this type of monitoring program is assessing regeneration. Timely and accurate regeneration assessment is essential for landowners to determine if current stocking levels are adequate to meet desired future management objectives and make appropriate decisions related to future management activities. Evaluating new methodologies to improve monitoring efficiency is essential. Unmanned aerial vehicles (UAV) are one of the latest cutting-edge geospatial technologies used to collect forest attributes at high spatial and temporal resolution. Most environmental UAV research focuses on mapping, monitoring, and managing ecosystem processes, and results suggest these systems are feasible, cost and time-effective forest monitoring approaches. This study aims to compare the accuracy and cost efficiency of assessing forest regeneration abundance in recently cut areas in Adirondacks, New York, between (1) traditional field-based regeneration assessment methods and (2) UAV-derived image products. The study utilizes field data from 82 fixed-area sample plots in young conifer stands and multispectral imagery acquired with DJI Matrice 100- UAV fitted with Micasense RedEdge-M camera. PIX4D software was used to process UAV multispectral imagery and create orthorectified imagery, and orthomosaic. Preliminary results show UAVs can detect and delineate individual trees and provide detailed structural information on forest regeneration.</p>				
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Title	Automated Building Inspection for Thermal Anomaly Detection and 3D Reconstruction Using a Drone-based Approach				
Author keywords	Building inspection, UAS, Thermal anomaly, building energy assessment, Building retrofit				
Abstract	<p>Buildings account for 40% of annual greenhouse gas emissions in the United States. There is a significant need for affordable low-emission building retrofit solutions to meet clean energy and climate goals. Building inspections, such as structural assessment and energy audits are essential steps to characterize the existing condition and enable designing retrofit solutions. However, these inspections are often time-consuming, labor-intensive, and expensive. Therefore, making this process scalable, efficient, and affordable is highly beneficial. To this aim, we created a workflow using visual and thermal infrared sensors installed on an Unmanned Aerial System (UAS) that enables fast and scalable data collection from buildings. The workflow comprises a step of designing a drone flight path. Then, the data will be analyzed using computer vision techniques to automate the 3D reconstruction of building digital models. It is demonstrated in building envelope inspection cases in the city of Syracuse, NY. The drone-based approach is used for identifying envelope thermal anomalies and creating a BIM-to-BEM connection. First, by implementing thresholding, Canny edge detection, and morphological operations, various cases of material degradation, air leakage, and beam to wall thermal bridge are analyzed. Next, after creating the 3D point cloud from collected images, the points in the building segment are used to reconstruct the 3D building model. Additionally, the feasibility of the workflow is verified by running a successful energy simulation. This study contributes to improving commercial inspection efficiency, and providing a quick, inexpensive, and reliable approach to inspect, assess, and report buildings for retrofit projects.</p>				
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Title	GIS Analysis using Archived UAS Data of Ice Jam Flooding in Plymouth, NH
Author keywords	GIS, UAS, flooding
Abstract	This poster reports on GIS analysis performed on archived UAS data of 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). 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. First, we examined the aerial mosaic of the ice flow in relation to prior high resolution aerial photos. We compare DEMs derived from the aerial imagery with 1 meter resolution USGS DEMs of the area at ten transect locations located along the river. GIS analysis of the UAS data at transects demonstrate utility of rapid data collection with UAS for flood response.

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Title	Integrating UAS and Geotech Courses with STEM Entrepreneurship Training
Author keywords	UAS, Entrepreneurship, GIS Education
Abstract	We report on a project linking students from GIS and GPS courses with two Computers & Society classes to develop drone startup business ideas. Students worked in teams to develop drone startup business ideas to present to alumni judges with related expertise. Firstly, students received training and coaching on lean startup methods to develop viable proposals from a professor with NSF I-Corps training and a professor with extensive computing business experience. Secondly, teams received instructor feedback and refined their ideas. Next, students delivered their concepts in a 'pitch contest' event held at the end of the semester featuring guest judges, university alumni working in geotechnical or STEM business careers. Based on results from student surveys, we provide conclusions on the effectiveness of this interdisciplinary teaching method in terms of accomplishing learning outcomes, engaging students via teleconferencing, collaborative team project work, and developing students' general skills related to STEM careers.
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SESSION I: UAV Flight and Operation

Title	UAS Imaging of sensitive projects on Airport Grounds and in Restricted, Military and Government Airspace
Author keywords	UAS, Imaging, Airports, Military, Government, Airspace, Imagine, Aerial, building, condition Analysis, LAANC, UTM, waiver, COA
Abstract	<p>Imagine Aerial was formed in 2017 and quickly became a national data provider for building condition analyses, utilizing UAS-mounted multi-sensor technology, research, big-data and Ai solutions. Imagine’s building-specific success propelled us to several large national urban markets within one year. These markets typically fall within Class-Bravo, Highly-Restricted or Military airspace. Our earliest projects required us to write extensive UAS safety cases and devise solutions within these areas. With success under new FAA regulations, Imagine Aerial gained a national reputation in this space and has now worked with every military branch. This presentation showcases a project performed for Syracuse’s NYSANG 174th A.W. where we flew along with MQ-9 Reaper Drones and over Syracuse Airport for UAS work at and above the active airport and base.</p> <p>We share striking global-panoramics of a several-mile environmental stream habitat restoration of Quantico Creek within the highly restricted Marine Base Quantico. We will share a project in Newark Class-B along with work across several states. We provided environmental mapping, modeling, multi-view imaging, global and linear panoramas, photogrammetry, foliage analyses, in sensitive and difficult-to-permit airspace. This presentation shares our process, work, data and results across a three-year progression of highly-engaging UAS and Ai photographs, graphics and data. We touch upon what we did, why, how, the findings and outcomes. We discuss restrictions and their loosening to accommodate the undeniable benefits of UAS and Imaging along with the future of technology with respect to LAANC, UTM and our vision for where we expect UAS/imaging to progress.</p>

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Title	A Multi-layer Anomaly Detection Framework for Networked Unmanned Aerial Vehicles
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Author keywords	unmanned aerial vehicles (UAVs), mobile wireless sensor networks, communication link failures, anomaly detection
Abstract	Teams of unmanned aerial vehicles (UAVs) deployed as mobile wireless sensor networks provide efficiency and maneuverability for many applications, including environmental monitoring, surveillance, and wildfire management, to name a few. Autonomous operations in uncertain and dynamic environments render such systems prone to sensor (node) and communication link failures, posing reconfigurability and resilience challenges. We propose a two-layer monitoring framework that allows for local decision-making and reconfiguration onboard UAVs to address these challenges. In particular, we model the UAVs' network by dynamic graphs with switching topology representing unreliable communication links. We partition the networked UAVs into clusters where each cluster consists of a UAV as the leader and the rest as followers. In the first layer of monitoring, leader UAVs serving as their respective cluster's local center run monitoring algorithms and update the followers' flight plans locally and independently from other clusters. In the second layer of monitoring, a ground control station communicating with the leader UAVs performs data fusion and, accordingly, high-level mission refinements in various circumstances. Our framework is built on unknown-input observer techniques and formation control approaches. We conduct high-fidelity simulations and experiments using quadrotor UAVs in an indoor flight area to validate the effectiveness of the proposed framework.

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Title	Micro-Weather Sensing and Analytics to Close Low Altitude Weather Gaps for Drone Operations
Author keywords	IOT, Remote Drone Weather Sensors, Remote Sensors, Drones Radiometer, NY Mesonet
Abstract	TruWeather is focused on crowd-sourcing micro-weather data from validated and calibrated IoT sensors. TruWeather is leading the ASTM F38 UAS Weather Specification Group, which seeks to modify the requirement to certify a weather instrument to quantifying data performance standards to support drone flight control decisions. Quantifying IoT sensor data accuracy and quality will require the collection of in-situ and remotely sensed weather data from a multitude of sources including the NY State Mesonet Profiler Network, data collected from drones, weather radar observations, video camera feeds, etc. This talk will discuss how drones themselves can sense the

atmosphere through remote sensing applications such as on-board radiometers, infrasound devices, cameras and visibility sensors.

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