Operating sUAS In GNSS-Denied Environments

PNT Advisory Board Meeting
December 9th, 2021

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AI/Autonomous Aerial Robotics

Made in USA/Dual Use

www.airgility.co

Made in USA/Dual Use

Customers

ASPEN AVIONICS

structural TECHNOLOGIES

AFWERX

AIRO Drone

U.S. Department of Homeland Security

CIT
CENTER FOR INNOVATIVE TECHNOLOGY

NSF

Pipeline Customers

SMARTSecurityPros
Professional Armed Security and Video Surveillance

InertialLabs
Attitude is Everything

PRECISIONHAWK

DroneSense

MRIGlobal

GROUP

hop flyt

National Oceanic and Atmospheric Administration
NOAA
U.S. Department of Commerce

U.S. Justice Department
Drug Enforcement Administration

United States Army

United States Marine Corps

United States Navy

Department of Justice
Federal Bureau of Investigation

Central Intelligence Agency
United States of America

Defense Intelligence Agency
United States of America

Partnerships

University of Maryland
MARYLAND ROBOTICS CENTER

TECH PORT
UAS BUSINESS INCUBATOR

University of Maryland
Department of Aerospace Engineering
Glenn L. Martin Wind Tunnel

DEF TECH MARYLAND

Accelerate 3D

ATA

VRCO

SKY-WATCH

Centeye

RoboticSkies

REMÜV

University of Maryland 1856

Integrity Compassion Professionalism Fairness
Sheriff Stafford County

Recognition

Homeland Security
Science and Technology

MOSAIC

Smart City Works .ORG
a 501(c)(3) non-profit corporation

RMI
REGIONAL MANUFACTURING INSTITUTE OF MARYLAND

magic
MID-ATLANTIC GIGABIT INNOVATION COLLABORATORY

MC
MASSCHALLENGE

Big Idea
CONNECTpreneur

VIRGINIA ECONOMIC REVIEW

Redundancy/Multiple Points of Failure

- GPS
- Inertial Navigation Systems
- VHF Omni-directional Range

Single Point of Failure

“Accurate aircraft position information is essential for safe UAS operations within the Unmanned Aircraft Systems Traffic Management (UTM) system. Unfortunately, the primary system that provides position information, GPS, is a single point of failure in the system, subject to jamming and spoofing, along with on-board failure or poor signal quality in locations such as urban canyons, at high latitudes or high altitudes.”

NOAA

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Single Point of Failure

www.youtube.com › watch

Jamming The GPS Signals On Drones To Crash Them

Vlog Topics: -**Drone** light show in Hong Kong had to be cancelled due to **drones** falling as a result of the GPS ...

YouTube · Alan Yu · Oct 29, 2018

www.youtube.com › watch

Dronebuster Jams Drone Control, Video and GPS - YouTube

The **Dronebuster** is capable of detecting what frequencies a **drone** is ... and **jamming** those **signals**, with ...

YouTube · Roswell Flight Test Crew · May 15, 2018

trackimo.com › different-methods-of-jamming-gps

4 Widely Known Different Methods of Jamming GPS - Trackimo

Any attempt to **jam GPS signals** can affect the performance of the monitoring ... **GPS spoofing** devices ...

Trackimo · LightInTheBox · Jul 18, 2016

www.nbcnews.com › news › vladimir-putin › russia-spoo...

Russia 'spoofing' GPS on vast scale to stop drones from ...

Although Russia's mimicking or "**spoofing**" of **GPS signals** has been ... NBC Exclusive: Russian military ...

NBC News · Mar 26, 2019

www.youtube.com › watch

How to fool a GPS - Todd Humphreys - YouTube

Todd Humphreys forecasts the near-future of geolocation when millimeter-accurate **GPS** "dots" will enable ...

YouTube · TED-Ed · Jun 26, 2013

gizmodo.com › jamming-gps-signals-is-illegal-dangerous-...

Jamming GPS Signals Is Illegal, Dangerous, Cheap, and Easy

If I were to plug the gadget into my car, it would **jam** up the Global Positioning System **signals** within a 16-foot ...

Gizmodo · Jul 24, 2017

www.diyphotography.net › cheap-20-gps-jamming-devic...

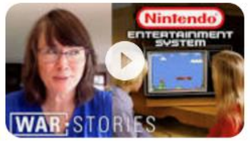
Cheap $20 GPS jamming devices can make your drone fall ...

But as was proven during a choreographed **drone** light show in Hong Kong in 2017, when **drones** lose this ...

DIY Photography · InfiniDome Ltd · Dec 22, 2020

arstechnica.com › information-technology › 2012/02 › u...

GPS jammers and spoofers threaten infrastructure, say ...



Since cell phone towers and some electrical grid systems use **GPS signals** for time-keeping, **GPS jamming** ...

Ars Technica · Feb 23, 2012

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We Augment & Toughen:

- ✓ Sensor fusion provides both redundancy & confidence
- ✓ Algorithm fusion allows navigation/situational awareness prioritization
- ✓ Trustworthy obstacle & collision avoidance
- ✓ Autonomy turns anyone into an expert pilot/operator

The Best Attributes of fixed wing, helicopter and quad-copter UAS

Exoskeleton (Bio Inspired)
Shell body design compatible with molded composites, 3D printing, and injection molding.

Flight Efficiency
Articulated propulsion allows for vertical flight operation and efficient forward flight with body-generated lift (better range and endurance).

Modularity & Field Serviceability
Propulsion and sensor options with easy access for maintenance and switchover to different missions.

Mission Flexibility & Vehicle Scalability
Different missions call for different sensor payloads and even different sizes and form factors.

Revolutionary New Platforms

Delivery &
Communication

HS-1

Dimensions: 5ft X 6ft, 55lbs.

- Payload
- Range
- Low Cost
- Maneuverability

Recon &
Air-to-Air Counter Drone

MS-1

Dimensions: 17in X 14in, 2.75 lbs.

- Payload
- Range
- Low Cost
- Maneuverability

Inspection &
First Response

DS-1

Dimensions: 19in X 14in, 4 lbs.

- Payload
- Range
- Low Cost
- Maneuverability

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Airgility Inc. DS-1 Minotaur

TRL: # 8

Technology Description

Problem? GPS-denied environment autonomy is hard in computationally limited systems such as in small Unmanned Aerial Systems (sUAS).

How is it done today? +90% of sUAS operated in GPS-denied environments (indoors or outdoors) require high level of pilot training and persistent/uninterrupted operator comm link.

Our approach? We employ on-board real-time autonomous edge-processing that use sensor and algorithm fusion for navigation, situational awareness, and prioritization.

Why it will be successful? Autonomy is the key to making sUAS scalable as on-board decision-making allows the machine comm denied persistence in its mission subtasks while the user performs information collection and tactical data sharing.

OV-1

DS-1
MINOTAUR™

Technology Use Cases for US Government

Who cares? Stakeholders with need for attritable aircraft platforms, robotic data sharing, and capability centric approach to battlespace awareness in:

- Contestant Integrated Environments
- Permissive Environments
- Counter-Insurgency Environments
- Major Combat Operations

Use-case description? Expandable Missions having low-cost requirements; assured loss or low-life cycle, storage maintenance, and primarily self-controlled by on-board autonomy while having anomaly detection via artificial intelligence.

Risks? Complexity of on-board decisions in response to dynamic environments; generalized and robust algorithms needed to create the portable robotic building blocks.

Price/Business Model

Proposed Schedule	Time	ROM
Phase 1: DoD CONOPS & Algorithm Dev	6m	$750K
Phase 2: Adapt Attritable Intelligent UAS	6m	$750K
Phase 3: T&E & Algorithm Adj.	6m	$1.5M
Target Unit Price Point		$25k - $35K

Mid-Term and Final Checks for Success

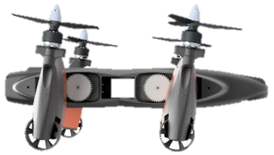
Mid: Attritable Intelligent UAS is adapted to DoD CONOPS via implementation of needed sensors/hardware.

Final: T&E results are consistent with desired system autonomy, scalability demonstration suitable for flexible airborne combat mass operation.

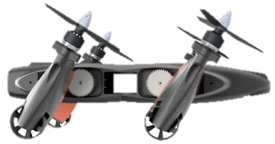
First Response in confined spaces

DS-1 A & B Platform

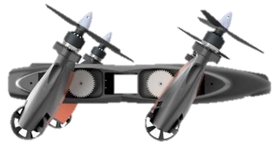
Tilting Thrust
Individual propulsion pod actuation provides unprecedented maneuverability.

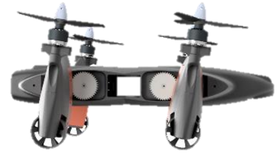


Dash Flight and Speed
Lifting body generates lift; low-drag fuselage optimizes for forward flight speed and power efficiency.



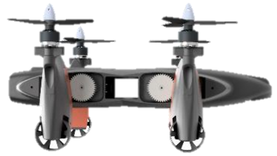
Hover at any body angle
Fixed onboard sensors “look around” by vehicle nosing up or down and rotating side to side.



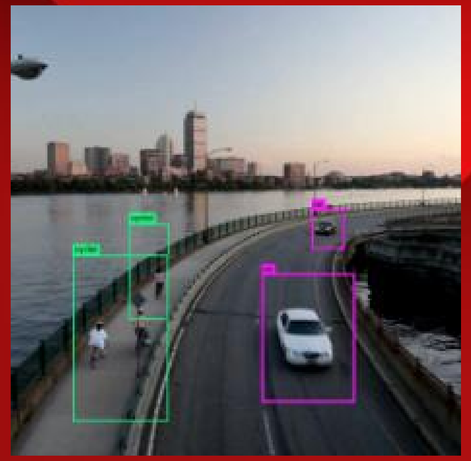


Vertical Take-off and Hover
Runway-less operations, with rollout run from under obstacles.

Vertical Landing
Hover to touch down.



What Makes Us Better
AI Powered Autonomy



Easy to Operate

Camera-based 360 degrees sense & avoid
object/collision avoidance
Train a new pilot in 30 seconds to fly

Object Detection & Facial Recognition

Humanoid and object detection
Neural Network facial recognition and pose detection
Camera tracking to keep subject in view

Event Detection

Understand relationship between objects
Alert on patterns – threat identification

GPS denied Confined Space Navigation

Traverse along boundary or detected path
Identify entry /exit points

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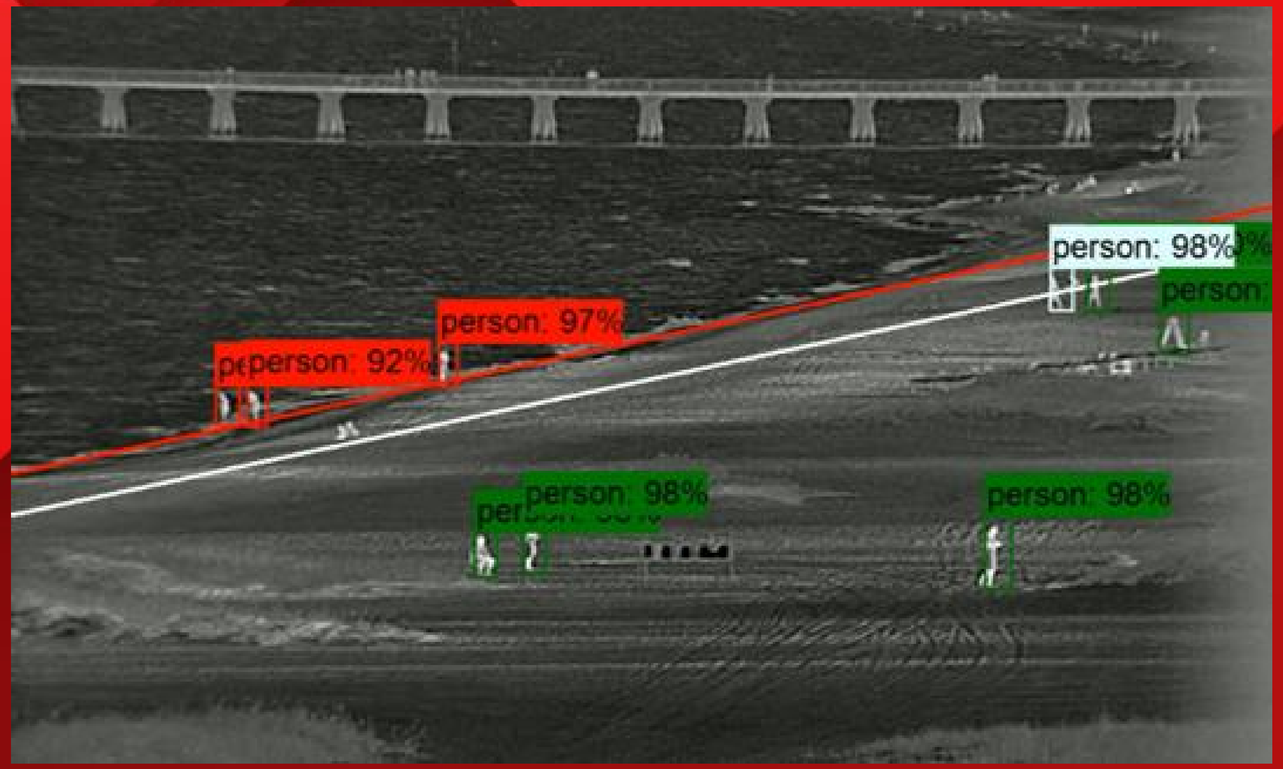
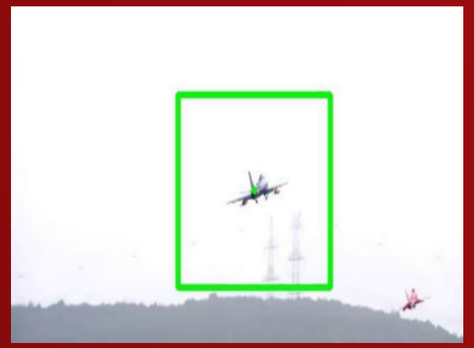
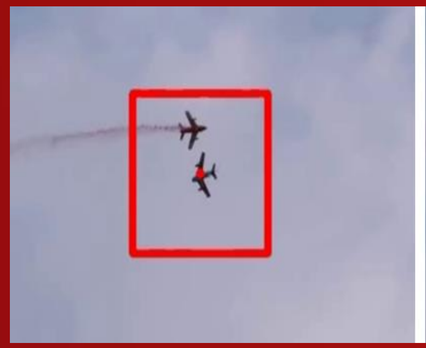
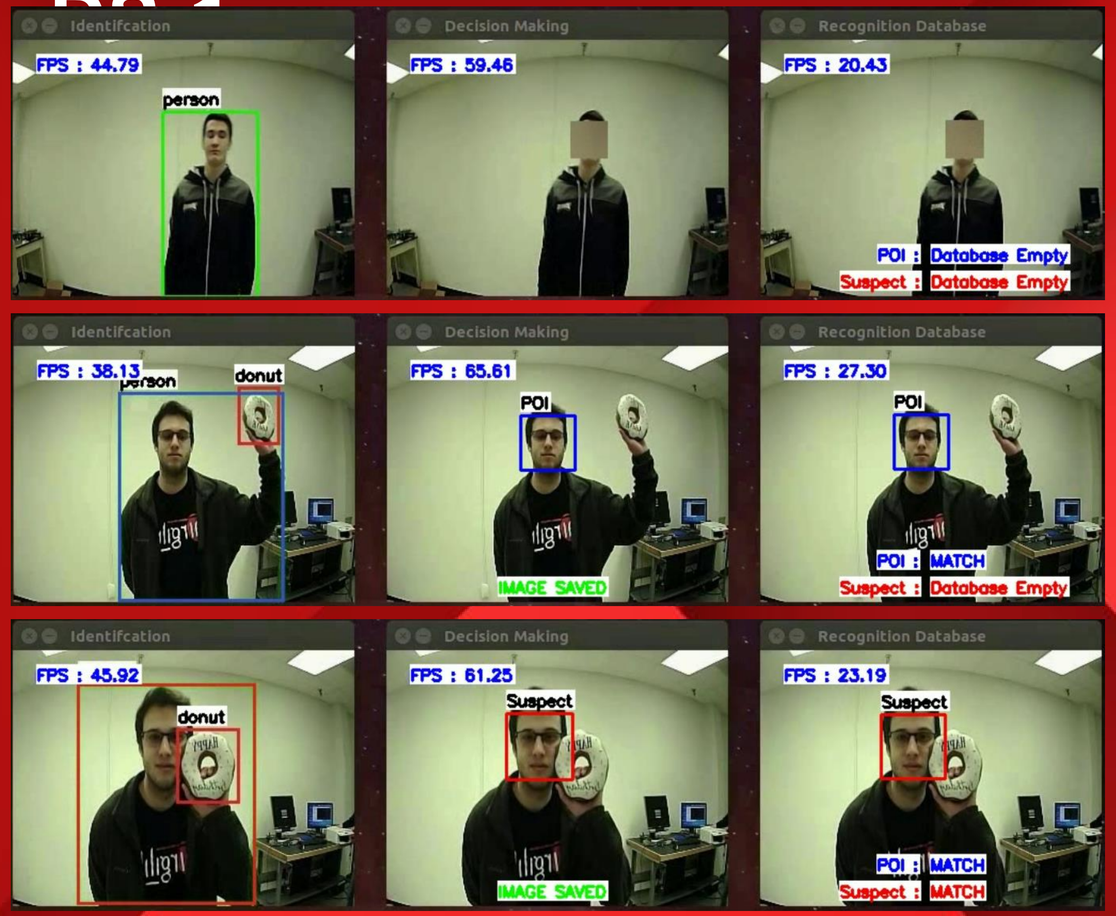
AI Development & ML/non-ML Fusion on









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Our Start with GNSS-denied flight

News Release: S&T Partners with New Innovators to Bring Smart Cities Technologies to First Responders

Release Date: June 25, 2018

For Immediate Release
DHS S&T Press Office, (202) 254-2385

WASHINGTON—The U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) and its research and development partners today selected 13 U.S. and international companies to develop smart cities technologies to assist public safety. The research and development work will focus on in-building sensors, unmanned aerial systems and on/off-body mobile SmartHubs, each of which will combine communications and sensors to increase responder situational awareness, building security and enhance mission-critical operations.

Unmanned Aerial Systems: indoor search and discovery
- Airgility, Inc.

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Autonomy Demonstrations in Complex/Contested Environments

DHS– FEMA Shaken Fury Demo, 3-5 June 2019

Bringing Autonomy to Professional Applications

Enhanced functionality, seamless workflows, and professional-grade training and support

Enterprise

Industrial Asset Inspection
Construction Site Mapping
Residential Roof Inspection

Public Safety

Situational Awareness
Search & Rescue
Accident Scene Reconstruction

Defense

Intelligence & Reconnaissance
Security and Patrol
Incident Response

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What’s Next?

- Early Innings
- Thrust Vectoring
- Industrial wireless mesh networks
- Holistic hardware agnostic AI/Autonomy solutions
- True UAS Navigation reliability in GNSS denied environments (including BVLOS)
- Inertial Navigation System/Radar based velocity system

Wrap Up

What do we do?

- **Conditional & Full Autonomy**
- **Aerial Robotics for HARD missions**
- **Attritable & Scalable Systems**

How we do it?

- **GPS Independent Localization**
- **Navigation & Mission Specific On-board Decision-making**
- **Edge-processing in Computational Starved Robotics**
- **Sensor & Algorithm Fusion**
- **Additive Manuf. & Design**

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