UAS and CUAS Industry Technology Trends and Developments

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2023 ASSESSMENT

INS International Nuclear Security
Reducing Risk of Nuclear Terrorism

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

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Introduction

Uses of and improvements to unmanned aircraft systems (UAS) are one of the fastest growing technology spaces in the global commercial market. This rapid growth makes it increasingly difficult to keep current with recent advancements in the UAS and counter-UAS (CUAS) industry. Continued rapid growth in UAS and CUAS capabilities and applications is expected over the next several years, thus organizations are seeking ways to evaluate the potential for new operational risks as well as the possibility of integrating UAS or CUAS technologies into their physical security system.

Therefore, there is a need for easily digestible analysis of current capabilities and recent developments.

This is the 2023 review of UAS and CUAS technology trends and developments.

UAS Program Overview

The UAS Program is comprised of a multi-lab team that supports the U.S. National Nuclear Security Administration (NNSA) International Nuclear Security (INS) mission by working with the nuclear security community to better understand the threat and mitigation of UAS incursions. The team conducts evaluations, like this 2023 UAS and CUAS Industry Technology Trends and Developments effort, but also provides targeted studies, testing, and collaborative projects to address the key needs and questions centered around this technology that impact nuclear security. The team shares the results of these studies and testing with partners to assist them in their general awareness of capabilities that may need consideration when conducting facility risk assessments.

The UAS Program gathered current information on significant technology advancements, notable use cases, and potential threat developments to offer a broad, non-sensitive resource that indicates the pace of change within the UAS and CUAS industries. The trends and developments that were included herein fit into six main categories, which are academic. Some items would fit in multiple categories:

1. Platform Development - advancements in airframe, propulsion, and operating capability ***Page 2***
2. Payloads and Sensors - advancements in cameras, radars, unique payload/sensor capabilities, and environmental monitoring ***Page 3***
3. Cyber/UAS Resilience – advancements in hardened critical components, ways to improve supply chain reliability, and use of blockchain for improved security ***Page 3***
4. Autonomy – advancements in fully autonomous flights, structural characterization and inspection capabilities, and recording or filming ***Page 4***
5. CUAS/Blue Force Developments – advancements in communications applications, surveillance and monitoring, and RF protection ***Page 5***
6. State-Sponsored Developments – advancements of heavy-payload UAS flights, drone swarms, etc. ***Page 6***

Platform Development

In the category of Platform Development, we are continuing to see the advancements in the design of smaller UAS, improved battery and hybrid power solutions, and longer flight durations. Two notable advancements in this category were very small, agile UAS and autonomous solar-powered UAS.

OPEN SOURCE ARTICLES OF INTEREST

Cyclotech Flying Car: Unique rotor design enables quick vertical to horizontal movement; 400 kg payload capacity with 40-min flight time.

Soft Robot Morphs from Land to Air Vehicle: New material allows shape changes to transition vehicle operation.

MARSS Kinetic Interdiction Drone: Intercept drone capable of flying >275 kph and taking out up to 3 drones.

Skypersonic Remote Piloting System: Internet controlled first-person-view (FPV) flights.

Autonomous Paintball Shooting UAS: Built in gun barrels and ability to autonomously target individuals.

Detachable Tethered Drone: SAMS-T carries variety of payloads (cameras, sensors, lights, communications, and LIDAR). The tether provides power and communications but can also detach so that the UAS can freely fly.

Fuel-Filled Wings Extend Flight Time: World record flight of more than 39 hours using advanced fuel cell technology and fuel loaded in the wings.

First Hydrogen-Powered VTOL: This drone's endurance is 5 hrs, more than twice that of the lithium battery version. With an average speed of 90 kph, it is good for long distance inspections and large-area surveying & mapping.

Hybrid VTOL: This aircraft has a unique ability to take off and land like a multirotor UAS. Its long wings and gasoline engine allow it to cruise at 97 kph for around 7 hours.

UAS Hoverboard: With 8 rotors, this system can lift 230 kg.

Transforming UAS: Rucksack sized UAS capable of fixed wing or tri-copter form.

Drone-based Loitering Munition: Commercially available racing drones and robotics components accelerate from 0-150+ mph in <1 second.

FAA Certified Delivery Drone: First to be certified, able to carry 2 kg up to 20 km.

Additive Molding Carbon Fiber Airframe: Stronger than titanium.

Ultralight Manned Hexacopter: Minor modification can convert to remotely operated system with 120 kg payload.

Drone Taxis at 2024 Olympics: With a 200 kg payload capacity, these units will travel at speeds up to 200 kph.

Autel Nest: Combination base station, charging station, and protective cover. Dragonfish drone can fly up to 155 min with a 120 km range.

Autel EVO Max 4T: Features optical and millimeter wave radar to avoid obstacles and track up to 32 targets at a time. Supports A-Mesh system that allows drones to communicate with each other and relay coms back to the ground station.

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We expect continued rapid growth in UAS and CUAS capabilities and applications over the next couple of years. It is likely that UAS flight and payload numbers will continue to increase, as improved batteries and hybrid power become more commonplace and less expensive. These advancements will likely make it harder to locate rouge UAS operators. If you would like to schedule a technical exchange to review new UAS/CUAS capabilities that could impact physical security operations, please let your INS contact know.

Payloads and Sensor Development

Payloads and Sensor Development includes advancements in cameras, radars, unique payload/sensor capabilities, and environmental monitoring. Overall, the trend here is of lower-cost advanced cameras and imagers, improvements to commercial package delivery systems, and specialized sensor integration.

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Advancements will continue in this area as well. Higher quality, more robust, and lighter sensors will become commonplace and support the growing efforts to safety-proof autonomous flights. This will not only lead to opportunities to supplement physical security and routine facility operations but will also add sophistication to otherwise unsophisticated adversary capabilities. The UAS Program can assist you in navigating options to improve physical protection of material using UAS as well as strategies that to reduce potential adversary advantages.

OPEN SOURCE ARTICLES OF INTEREST

SkyCam Aviation and Optelos partnership: Data collection service using fixed wing aircraft with 6-sensor platform creates high resolution 3D photogrammetry.

Small, Inexpensive Electro-Optical Sensors: Use of meta optic can considerably lower the size of electro-optical sensors and allow these sensors to be used on small UAS.

Small, low power UAS -mounted radar: Silentium Defense's passive radar to assist CUAS systems with threat identification and tracking.

Autonomous swarm for gas leak detection: Tiny drones follow bio-inspired strategy to detect odors and then communicate with each other to localize the source.

Dart-Shooting Drone: Darts withintegrated sensors can network and collect data in hazardous , remote, or inaccessible locations.

Teledyne FLIR Defense MUVE R430 for Remote Radiation Detection: Algorithm quickly maps and locates radioactive sources real time; small lightweight size improves UAS piloting.

Machine Gun Payload: Ukrainian military has designed a small machine mount on the camera gimbal for DJI M600 drones, allow operator to pan and tilt the gun.

Ultrasonic Monitoring: Drone with ultrasonic sensor finds weak spots in structures and pipelines.

Cyber Resilience

Cyber Resilience includes items on hardened critical components, ways to improve supply chain reliability, and use of blockchain for improved security.

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The obvious trend here is more resiliency against cyber-attacks and radio frequency (RF) spoofing. This is good news for UAS used to supplement physical security and Pro-Force, but potentially limiting to the development of some CUAS options. The UAS Program will be conducting UAS-related cyber scenario testing this year, and the results of our testing will be made available to INS partners upon completion. If you are interested in hearing more about this, please let your INS contact know.

OPEN SOURCE ARTICLES OF INTEREST

UAS Cybersecurity with Aġ: System trains Aġ on DNA of malicious files and could help ensure systems at critical infrastructure do not create cyber vulnerabilities.

More RF bands allowed: U.S. Federal Communications Commission i added RF bands approved for drone operations, which will require upgrades to RF-based CUAS equipment.

Damage resilient small drone: Like bees, this bug-sized drone can fly with up to 20% of its wings damaged or missing.

OPEN SOURCE ARTICLES OF INTEREST

Swarming Attack Kamikaze Drones: Hunter 2 series drones use AI to communicate autonomously with each other, using very low power RF that is undetectable by most RF CUAS.

Flying Dragon: This drone is able to contort into different positions to perform unique tasks, such as turning valves, and fly through small openings.

Autonomous Rolling-Flying Robot: This rolling-flying UAS is used in rough terrain and extreme environments. It extends battery life via ground travel and will fly to quickly get around obstacles.

In the Autonomy category, we not only included fully autonomous flights but also added improved structural characterization and inspection capabilities as well as improvements in recording or filming. Technology in this category is moving quickly, and companies are using artificial intelligence (AI) and machine learning (ML) to improve obstacle avoidance and navigate in GPS denied environments. We have also seen an increase in the drone-in-the-box concepts, in which the UAS is housed in a ready state and able to launch via remote commands or on a programmed schedule to complete situational awareness checks, expanding physical security options. Drone swarm autonomy is also developing – whereby UAS are communicating amongst themselves to be aware of their surroundings and complete integrated missions.

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We expect to see the use of swarms for serious threats, and therefore, facilities will need to prepare for this regardless of whether they have a CUAS in place or not. The military will likely move toward high energy lasers or microwaves to deal with swarms. However, these forms of mitigation are not typically appropriate for nuclear facility operators. The UAS Team can assist you to better understand alternative risk mitigation strategies or step through the complex interactions between physical protection, response, and UAS technologies in a nuclear security event.

CUAS and Blue Force Developments

This category is seeing significant industry output in UAS communications applications, surveillance and monitoring, and RF protection. Use cases in law enforcement and search and rescue using UAS to communicate to suspects, crowds, or people in danger are growing, as is pro-force looking at using tethered UAS to improve physical security detection and surveillance. Industry options for tethered drones can vary widely in price, and customers will likely drive the security and features these will offer. Also trending for law enforcement/security use are handheld RF mitigation devices. These rifle sized devices are fairly low cost considering other CUAS options, and their portability is attractive to users.

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Currently, counter systems face significant implementation obstacles, and many countries are struggling with the regulatory authorities as to who can even interfere with UAS, which are considered aircraft. We expect this problem to take a while to untangle. Therefore, law enforcement and response force will likely have to rely more on handheld jammers to target rouge drones. These require quick detection, assessment, and tracking of the threat prior to their use, which is where the challenge is. The UAS Team is finishing an evaluation of several handheld RF jammers, and the results of this is available to INS partners.

As mentioned, we are seeing more interests by law enforcement in using UAS to improve situational awareness and help protect responders. The UAS Team is conducting a survey of law enforcement who used UAS this year to better understand the benefits and obstacles they have faced when using drones. We are also completing an evaluation of several tethered UAS. If you would like to see the results of the survey or tethered UAS testing, please let your INS contract know.

OPEN SOURCE ARTICLES OF INTEREST

Israel's Laser Wall: This laser wall concept is intended for missile interception but can also protect against UAS.

UAS-Mounted Microwave Energy Mitigation: The Leonidas Pod is a modular high-power microwave (HPM) CUAS that can be mounted on a variety of forms, including a large UAS to deliver directed HPM that can effect swarms while decreasing the collateral damage potential.

Machine Gun Mitigation: This Polish CUAS employs a machine gun on a pan tilt unit. It has radar and a camera to detect and assess UAS before deploying the machine gun, which can shoot 3600 rounds in one minute.

Multi-technology, single operator platform: Integrated CUAS are becoming more common, as multiple technologies offer the best solution for countering an evolving drone threat. The system utilizes machine learning and artificial intelligence to analyze sensor data faster and more precisely than a human operator.

Drone Interceptor & Net Capture Systems: There are several new drone intercept CUAS that deploy nets or physically disable rogue drones. Using AI processing, autonomous flight control, and optical target recognition, these drones will strike a target in flight.
Lamat Interceptor; DroneCatcher; RoboTiCan Goshawk; Kinetic Kill CUAS Racing Drone

Smartshooter Smart Aiming System: Smash 3000 is a target acquisition and tracking smart scope that mounts onto many types of weapons. The manufacturer claims that it doubles the probability of hitting a flying UAS at 100 meters.

LEMUR 2: Law Enforcement drone with glass break and right-side up flipping capability now has thermal camera, microphone and loud speaker, and tracking camera for clutter environments.

Urban Friendly CUAS Ammunition: Designed to air burst into small fragments, this ammo is combined with Slinger's One Shot One Kill accuracy to greatly reduce the number of rounds needed to bring down UAS.

OPEN SOURCE ARTICLES OF INTEREST

US Army Coyote: Tube-launched, this small UAS can be deployed from the ground, air, or a ship and flown individually or in swarms. It operates for up to an hour to conduct surveillance missions or electronic warfare and strikes.

Offensive Swarm: Swarm capability is intended to be low-cost and will have the ability to identify and engage threats with the use of a single controller.

Shaded 136 Kamikaze Drone: This Iranian-made suicide drone has been imported and rebranded as Geran-2 by Russia. It can achieve a speed of 185 kph and claimed range of 2,500 km.

UK DragonFire Laser CUAS: Using up to a 50 kW laser, this CUAS neutralizes drones based on the target size and has a range of 3km.

France Laser CUAS for 2024 Olympics: The High-Energy Laser for Multiple Application – Power (HELMA-P) will be used at the 2024 Olympics. The system can detect drones smaller than a bird, with very high tracking accuracy, and a range of 1km.

While there is little doubt there are other advancements taking place within this category, the UAS Program can only examine what is readily available in the public domain. Development of heavy-payload UAS flights and drone swarms are a hot trend in this category, but what is interesting is the shift in development through industry competition rather than internal government project development. The technology is moving so rapidly that there is more flexibility to be gained watching and working with industry than through the creation of slower moving government efforts.

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It is clear from the number of items in this category that many nations are interested in advancing capabilities using UAS as well as studying improved methods to mitigate UAS used against them. Many of these advancements will find their way into commercial applications at some point. The UAS Team monitors methods and strategies across the globe to assist INS partners as they evaluate UAS threat risks and alternative mitigation techniques. If you would like to know more about the UAS Risk Assessment process, please let your INS contact know.

OPEN SOURCE ARTICLES OF INTEREST

Turkish Loitering Munition Drone: The TB2 is loitering munitions drone with a max flight time of 27 hours. It can fly up to 5400 meters above ground level. The drone carries munitions to precisely drop rather than kamikaze.

Turkish Bayraktar Akinci Fires Supersonic Missile: This high altitude combat UAS can fire a supersonic missile capable of hitting a target up to 140 km away.

RAF and UAS Navy Synthetic Fuel: UK and US Armed Forces completed successful UAS flight using synthetic kerosene fuel.

British Army Nano Bug Drones: These bug-like drones weigh 196 grams and have a flight time of 40 minutes. They can fly in winds up to 90 kph and have a max range of 2km.

Ukraine Punisher Drone: This reusable, fast, precise UAS is capable of delivering explosives to targets up to 45 km away, with max speed of 198 kph. It can cruise at 430 m altitude for up to 3 hours.

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