Department for Transport

Security-Technology
RESEARCH INNOVATION GRANTS
HMG

Security Technology Research Innovation Grants Programme (S-TRIG) 2020-21

Project Case Studies

This document officially presents the findings from the 18 projects that were funded as part of the Security Transport Research and Innovation Grant Programme 2020. S-TRIG was funded by the Future Aviation Security Solutions (FASS) Programme (jointly run by the Department for Transport and the Home Office). It was designed to bolster innovative research, development and feasibility work developed to tackle future challenges affecting the UK's national security. The S-TRIG programme sought projects within five key industry areas;

- Aviation security
- Border detection and security
- Detection of contraband entering prisons
- Protection of infrastructure and crowded places
- Counter-drones

Delivered by

CATAPULT
Connected Places

TRL 5 www.camor.co.uk

CAMOR – Online Immersive Platform for the Provision of Security Training

Challenge

Aviation is an industry that contributes at least £22 billion to the UK economy, along with over 230,000 jobs. CAMOR is developing an innovative approach to train aviation staff in General Security Awareness Training (GSAT) through the use of 3D immersive learning and the introduction of game-based learning to break the mould of traditional training that learners do not find engaging.

Abstract

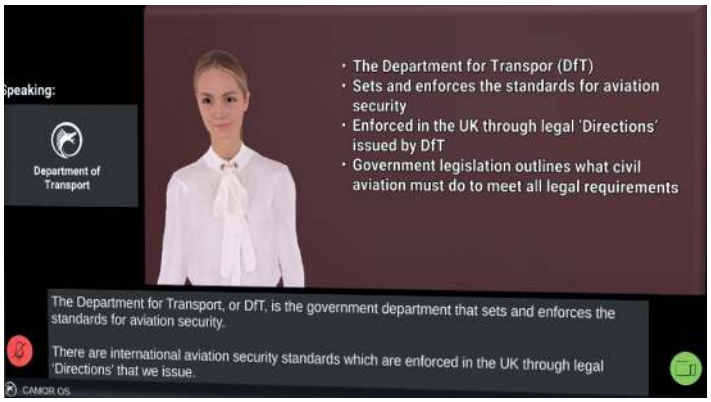
Immersive learning is a technique that utilises technology to produce simulated or artificial environments to provide learning. CAMOR is utilising game-based learning to enhance the quality of GSAT training, especially where human factors remain a critical and persistent issue in security. Regulation demands high levels of security and quality of training. Academic research identifies that gamified training encourages learning, the efficacy of training, motivation and increases employee conformity with procedures, and delivers higher learning gains.

Activity

S-TRIG has supported the research required for the development of the immersive platform from a proof of concept. Research has been conducted with a cohort of aviation staff using a prototype immersive environment to evaluate the relevance of academic theory in relation to game-based learning. Initial findings from the research have allowed the training prototype to be refined and enhanced following feedback. Staff completing the GSAT training are supported with a mobile 'companion' app, its role is to assist staff in their critical decision-making processes after training and guide them when dealing with suspicious behaviours or incidents. The support allows staff to act with confidence and increases vigilance. A Learning Management System (LMS) supports the training and 'companion' App and permits push notifications in the form of alerts and training reminders to staff, boosting the security culture of an organisation. The LMS provides a tool to monitor and audit training, ensuring compliance with regulatory requirements. **79%** of participants in the pilot gave positive responses to ease of use and ability to interact with the gameplay. **66%** stated immersive learning was more enjoyable than traditional methods.

Impact

Integrating Technology, People & Training. Game-based immersive security training will change the way we engage with learners. It has the power to teach, train, educate and motivate. It has the potential to deliver increased vigilance and confidence and ultimately a reduction in vulnerability.



Implementation Pathway

CAMOR will launch the GSAT immersive learning, 'companion' App and Learning Management System in the Summer 2021.

Conclusions

Academia has highlighted the benefits of game-based immersive learning. The ultimate objective is to demonstrate that game-based, with the support of an LMS and 'companion' App, can result in a reduction in vulnerability in aviation security that can be quantified and qualified. Initial findings have shown that learners find the technology more engaging and enjoyable and therefore this, in turn, should lead to enhanced retention of information and confidence when dealing with a real-life security vulnerability. CAMOR will continue to seek innovative ways to train staff to achieve the best possible results in other products.

TRL 5

www.cranfield.ac.uk

Cranfield University – Drone Classification for Airport Protection

Challenge

Counter Drones: Aerial drones present a constant low-cost threat to airports and other critical infrastructures. High resolution cameras and radar systems can classify drones using machine learning, separating them from birds and other clutter. Accurate identification with low false positives is critical for not disrupting normal day-to-day operations and maintaining an efficient economy.

Whilst deep learning has transformed image classification, a key open challenge to achieve extremely high accuracy by sourcing relevant but rare training data sets (e.g. rare drone design). This often means a large amount of resources and time is dedicated to broad data collection and (re)training - without a guaranteed convergence in improving accuracy.

Abstract

Drone data and classification is not well understood and training machine learning algorithms take a significant time to reach high accuracy. We aim to improve the image classification accuracy of aerial drones by identifying the missing data needed for robust deep learning training.

Activity

We have built a drone image database (4-5k data sets) that enables deep learning algorithms to reliably detect drones (98-100% accuracy). We developed a novel explainable AI method to continuously update the database with the most important missing images from a deep learning accuracy perspective.

This update procedure uses generative adversarial networks (GAN) and topological data analysis (TDA). Understanding how machine learning interprets drones can improve counter-drone ecosystems. This addresses the "Counter-Drones" airport protection challenge by directly demonstrating its success at our own airport in a variety of scenario settings.

Impact

Protect air space from drones through explainable deep learning.

Deep learning can understand how to detect drones in novel ways and identify what data is missing.

Implementation Pathway

Integrate into detection systems for real-world environment testing.

Conclusions

We have developed the key technology to enable missing data detection and higher accuracy drone detection. This allows a wide range of stakeholders interested in detection and adversarial machine learning to improve their algorithms and combat against deep fake attacks. We are engaging a number of commercial stakeholders to explore joint test work and continued research to demonstrate impact.

TRL 5

www.hubertshum.com

Durham University – Tracking Drones Across Different Platforms with Machine Vision

Challenge

Drones can pose a major risk for aviation safety, due to both negligent and malicious use. While cameras are now widely used for security monitoring, it is infeasible to manually analyse a large quantity of streaming video footage. How can we make use of machines to automatically, accurately and robustly analyse video streams for drone tracking?

Abstract

We believe the solution to future drone monitoring lies in the advancement in machine vision. Combining our team's expertise in deep learning, a state-of-the-art machine learning framework, with big data of the drone footage we collated, we present a drone tracking solution far more advanced than existing technology.

Activity

We researched and developed a software prototype that detects and tracks drones automatically from video captured by different camera platforms, demonstrating the potential of the state-of-the-art deep learning algorithms we employed in drone analysis.

Impact

Our fully-automatic, low-cost prototype enables the tracking of drones captured by different cameras in different environments and weathers, forming a solid foundation of counter-UAV systems.

Implementation Pathway

We adapt state-of-the-art deep learning algorithms with the use of big data to empower machines in drone tracking, resulted in an accuracy even better than real-human's.

Captured by a smarphone

By a fixed security camera

By a drone-mounted camera

By an infrared camera

A fixed-wing drone

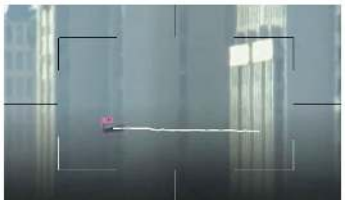
Multiple drones tracking

Cluttered background

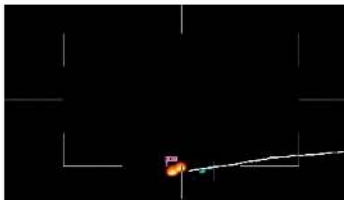
A tiny drone <10 pixels

Telling a drone from birds

Tracked trajectory visualisation



Tracked on a PTZ camera



Tracked at night

Conclusions

The project is hugely successful. Our prototype achieved highly accurate results in challenging scenarios as showcased in the image above. We are now exploring knowledge transfer and further research funding opportunities. To promote the project, we will submit a research paper to the world-class conference IEEE IROS.

TRL 3

www.haloxray.com

SEED – Scatter Enhanced Explosives Detection HALO X-ray Technologies

Challenge

Airport X-ray security screening systems use algorithms to automatically identify explosives but have high false alarm rates that result in disruption to the flow of passengers. A modified algorithm that includes scattered X-rays can significantly reduce these false alarms rates, reduce touch points and play a pivotal role in new passenger self-screening approaches.

Abstract

Airport passenger self-screening portals, in concept, offer numerous advantages over traditional security lanes. However, the current state-of-the-art X-ray absorption based screening technologies suffer too high a false alarm rate to make such portals operationally viable. HALO has developed an alternate screening system based on X-ray scatter that provides orthogonal information to traditional X-ray screening systems deployed at checkpoint. Combining the complementary signals from both screeners results in a much lower false alarm rate. Recent government sponsored upgrades have enabled the HALO scatter system to also measure absorption signals simultaneously in one unit. There now exists an opportunity to develop a single algorithm that can automatically identify explosives with an operationally viable false alarm rate by combining these orthogonal signals and paving the way for passenger self-screening.

Activity

HALO has access to a database of co-registered bag images containing explosives in absorption and scatter spaces. The S-TRIG grant funding was used to create the first automatic scatter enhanced explosive detection (SEED) algorithms. HALO has built image segmentation algorithms that identify explosive candidates using absorption only, scatter only and both signals combined to compare and contrast the merits afforded by each approach. The performance of the SEED algorithm has also been compared to that of a deployed absorption-only system.

Impact

Airport Passenger Self-Screening portals that utilise SEED will revolutionise the way we travel.

HXT264 scatter and absorption scanner

Implementation Pathway

Seek partnerships with other vendor and technology providers to form a complete passenger operated self-screening portal for aviation security.

Conclusions

Explosive detection algorithms that operate in absorption-only and scattering-only domains yield false alarm rates that are not operationally viable to support passenger self-screening portals. However, the false alarming objects differ between the two orthogonal spaces. By combining the segmentation algorithms using AND logic to find consensus between the signals, we find the probability of detection is maintained but the false alarm rate significantly reduced. Our proof-of-principle SEED algorithm yields a 20% increase in the number of explosives detected with half the false alarm rate of a currently deployed absorption-only system.

With further funding we intend to construct a full engineering prototype of a passenger self-screening portal based on our current scatter technology (HXT264). This new prototype design will retain all the significant components of the original system (significantly de-risking this effort) in a new mechanical envelope designed to facilitate rapid screening and focused on operation solely by the passenger.

TRL 4-5

www.iconal.com

Iconal Technology – Multi-sensor approach for rapid non-contact contraband screening

Challenge

This project addresses challenges in border detection and security, specifically the development of techniques for the detection of narcotics or other contraband concealed on the body that do not rely on ionising radiation.

Abstract

In this project we aimed to investigate the possibility of using a combination of sensing technologies to detect concealed contraband items (e.g. narcotics, currency) carried on the body of a person. The physical properties of some of these items might enable them to be detected in a non-contact, quick, covert and safe manner when concealed under clothing.

Activity

Iconal has recently completed a UK Government funded Innovative Research Call technology development project named "AcES". That project focussed on non-contact detection of concealed mass casualty threats (i.e. explosives and weapons); both person-borne and carried in a bag. In this project we developed a TRL5 prototype system consisting of an integrated suite of sensors. The prototype uses machine learning techniques to analyse sensor data and deliver real-time results.

The scope of this project was to collect data using a modified form of the AcES system from a number of different people carrying concealed simulant contraband items in realistic concealments, then analyse this data looking for features that could enable automated discrimination between those carrying and not carrying contraband.

The AcES prototype systems used in this project

Impact

This technology could provide border officials with capability to rapidly screen large numbers of people for concealed contraband.

Implementation Pathway

Data collected in a live operational environment would help confirm performance. A revised prototype tailored to the needs of border officials would be the logical next step beyond this.

Conclusions

Through the work conducted in this project we have shown that the AcES prototype was able to be modified reasonably easily to screen moving people for narcotics and currency smuggled on the body. New algorithms and data processing approaches have been developed targeted for this application.

We have identified reasonably consistent signatures for the presence of contraband. In the future this can let us optimise the sensor hardware and algorithm design to refine and improve detection capability, improving sensitivity to reduce the limit of detection, and improving the specificity to reduce the prevalence of false positives. Even without much refinement of hardware we believe we have demonstrated performance that is still highly promising. More training data to improve the classifier accuracy through improved resilience and ability to generalise could yield operationally useful performance in the near-term future for border officials.

TRL 3

www.iconal.com

Iconal Technology – Gait analysis for identification of anomalous carried bags

Challenge

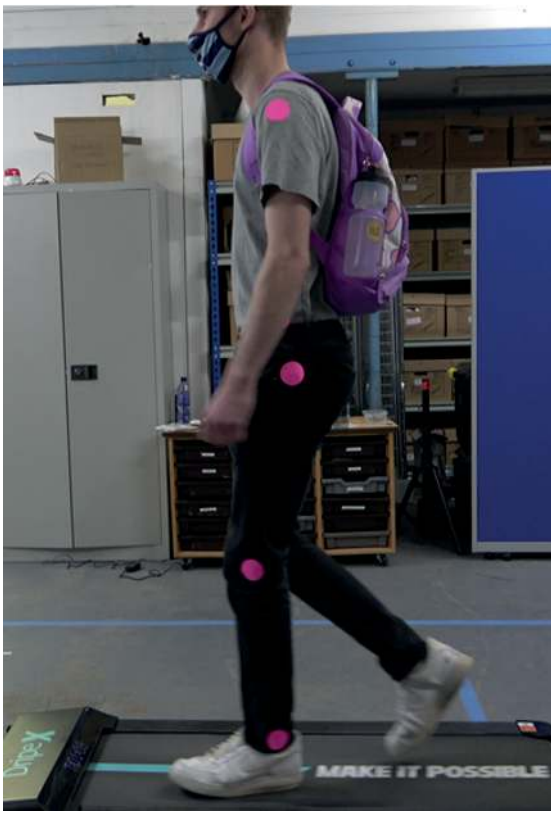
This project addresses the challenge of protecting infrastructure and crowded places. Specifically, it identifies a low-cost, unobtrusive technique that can be used as a first sift to identify individuals carrying bags that require further screening at a high-footfall venue.

Abstract

Recent trends indicate that mass-casualty threats are heavy and often presented in large bags (>20L), as smaller bags cannot contain enough material. These bags are frequently heavier than the average "benign" bag carried in many crowded places, such as museums, concerts and sporting events. We used 2D- and 3D-video analysis to identify "anomalously heavy" bags entering these crowded places.

Activity

We analsyed an individual's gait when carrying a bag using 2D- and 3D-video analysis. These technologies are low-cost, particularly compared to those used in other screening systems, as they utilise off-the-shelf consumer products developed in other application areas. They are also very unobtrusive (equivalent to CCTV) and may be perceived as less subjective than selection by a human security screener.



The AcES prototype systems used in this project

Impact

Gait video analysis could be used as a first sift to identify "anomalously heavy" carried bags in a high-footfall setting.

Implementation Pathway

Further data with a larger population is required to develop an automated classifier.

Conclusions

Gait video analysis could potentially be used to identify anomalous bags being carried into crowded places. We have identified promising features that could be used to identify these bags in some high-footfall settings. We also assessed which technologies would be best-suited for a further phase of work in this area. This further work would involve larger-scale data gathering, which could then be used to develop a preliminary automated classifier.

TRL 2

www.iconal.com

Iconal Technology – Development of home-made explosive detection simulants

Challenge

This project aimed to investigate the possibility of developing a material to simulate powder-based home-made explosives for millimetre-wave explosives detection systems. This enables safer, lower-cost development and testing of new detection capability, in comparison to testing using live materials.

Abstract

This project has been a collaboration between Iconal and the National Physical Laboratory (NPL). The two companies have worked closely together on this project, with NPL contributing their millimetre-wave and terahertz expertise for characterisation and verification of Iconal's simulant designs. Significant progress was made towards development of two simulants of powder-based HMEs.

Activity

The project has researched how techniques developed by Iconal Technology for simulants of commercial and military explosives can be adapted for use with other types of explosives. We investigated tools and materials that could be used to produce and validate home-made explosive simulants.

Throughout this project Iconal has worked in close collaboration with the National Physical Laboratory (NPL) who conducted material characterisation measurements and have provided expertise on material properties at high frequencies. The work was partially supported by NPL's "Measurement for Recovery" initiative, set up to support industrial recovery during the Covid-19 epidemic.

Impact

This technology will provide a low-cost, safe alternative to live home-made explosives for testing explosives detection systems.

Image: US National Archives + GetArchive

Implementation Pathway

Iconal will seek to continue development of HME simulants by seeking funding from HMG or other security R&D programmes.

Conclusions

Significant progress has been made towards the development of home-made explosive simulants. Recommendations for future work have been made to address various repeatability issues that were encountered during the manufacturing stage of these simulants. We are confident that an effective home-made explosive simulant can be manufactured consistently if these recommendations are taken on board. Collaboration with NPL was successful despite limitations brought by the COVID-19 pandemic. Iconal will seek to continue development of HME simulants by seeking funding from HMG or other security R&D programmes. We also aim to continue collaboration with NPL for this and other similar projects in future.

TRL 4-5 www.overview.co.uk

Overview Ltd – Laser Source Lighting for Security & Counter UAS

Challenge

An opportunity exists for the application of laser source lighting to products in the security and counter UAS markets. Long-range high intensity eye-safe spotlighting based on emerging laser source technology could be used to significantly extend the operating range of security cameras, to provide a clear visual deterrent to intruders and to prevent drone surveillance by dazzling visual cameras and disrupting capability for navigation.

Abstract

In this work Overview Ltd. carried out testing to assess the potential benefits of incorporating a collimated laser source illuminator (CLI) within a motion enabled camera platform. Such a product is capable of emitting narrow beam (<2°) white and infra-red light to ranges up to 1km making it a potentially advantageous alternative to conventional LED illumination. Benefits in performance are compounded by low size, weight and power consumption

Activity

In this S-TRIG funded project, Overview carried out a series of tasks to prototype a PTZ platform equipped with camera module and CLI unit to serve as a basis for performance testing work. Activities included the mechanical and electrical design required to mount and power the CLI, development and verification of heat sink arrangement and configuration of software to allow control and video capture. A programme of testing was carried out to compare performance of the CLI to that of conventional LED CCTV lighting. In outdoor night time testing, an assessment of range performance and camera dazzle ability was made, exploring both white light and infra-red modes.

Impact

Provides a foundation to develop security and counter UAS products incorporating laser source lighting.

Implementation Pathway

We are currently working on a project to develop drone detection, identification and tracking systems and we are investigating the application of laser source lighting.

Conclusions

A PTZ camera platform integrated with a laser source spotlight was successfully produced. At a basic level, it demonstrated that CLI technology could be installed, powered and operated within the constraints imposed by a typically sized high performance PTZ camera platform. The performance testing carried out showed that the laser-source light was effective at illuminating a target, in darkness, at ranges up to 1000m compared with a 300m effective range of the LED lighting tested. In dazzle testing, the narrow and high intensity beam of the CLI unit was successfully able to overwhelm the image produced by an observing camera, blocking out all distinguishable detail from the recorded scene.

Overview Ltd. designs, develops and manufactures market leading precision sensor positioning systems and is seeking to combine emerging illumination technology with our highly precise motion platforms to produce innovative products for the security and counter UAS markets. We are currently engaged in a project to develop counter UAS systems for use in critical locations such as airports or prisons and we will investigate the potential for application of laser source lighting within this area. Overview Ltd regularly works collaborativley on projects and welcomes contact from businesses with interests or expertise in these areas.

TRL 3-5

www.rinicom.com

Rinicom Limited – ARTIFACT

Challenge

Ultra-wideband radars are widely used by security forces, however significant time is required to process the received signals. ARTIFACT (Artificial Intelligence-enhanced ultra-wide band see-through Radar for Non-Invasive Screening Bags and Rucksacks) will counteract this drawback by offering rapid real-time observation of bags and rucksacks.

Abstract

ARTIFACT aims to develop a novel Ultra-wideband radar which will be enhanced by a proprietary AI algorithm, allowing rapid and real time inspection from the required operational distance of rucksacks, handbags, and other small packages without the need to open bags. Rinicom aims to develop and test a prototype radar, which will be wall-mounted, weighing less than 1 kg and capable of operating while the object in question is in motion. The radar will process the reflected signal with the assistance of a novel proprietary AI module. All data processing and AI algorithms will be run on a standard tablet, this enables the person monitoring the tablet to stay a safe distance from the people being monitored. The Ultra-wideband radar module will be implemented utilising an SDR development platform, allowing further improvements in modulation formats and cancellation of phantom reflections. The initial use case is at entry/exit points for critical infrastructure premises and associated sensitive sites, to examine hand-held luggage and hand-held deliveries thus addressing both insider and external threat vectors. A wider application is use at large public events where bag searches are required prior to entry.

Activity

We developed and implemented the proposed ARTIFACT system, which consists of two major components, a novel miniature UWB radar and a proprietary AI algorithm. As an integral part of this feasibility study, we tested both the RF and Signal Processing components of the ARTIFACT system using a variety of handheld bags and rucksacks in various possible operational scenarios (different distance range, different hidden objects). The conducted tests proved the feasibility of rapid real-time inspection from the required operational distance (approximately a 50 cm deep window from 0-5 m). In addition to detection of hidden objects, we demonstrated the ability to detect and track a human target within the field of view of the device.

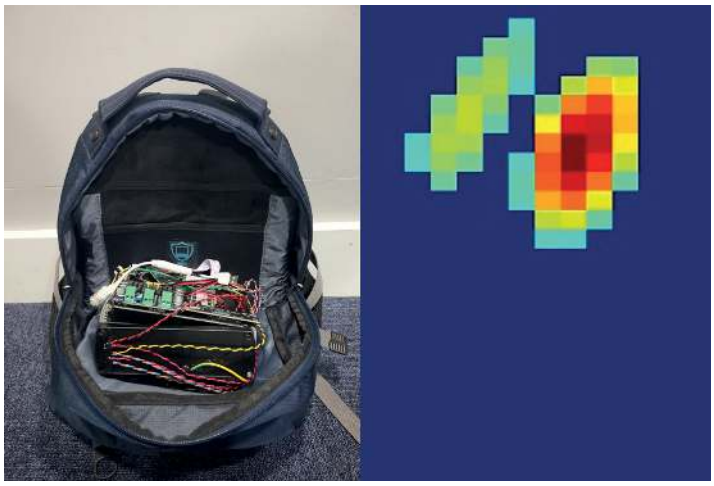


Figure – Example Scenario

Impact

Artifact will detect and classify dangerous and prohibited items in rucksacks from the required operational distance.

Implementation Pathway

We will develop collaborative partnerships and alliances to amplify and accelerate routes to market and maximise exploitation opportunities in the UK, across the EU and wider international markets.

Conclusions

The conclusions from the conducted tests confirmed our rationale for conducting this feasibility study, identified advantages of the proposed solution, highlighted areas for future improvement and added confidence to our strategic decision to add ARTIFACT to our product portfolio. The following outputs were documented: 1) The design and fabrication of a wall mounting enclosure and attendant hardware, 2) The initial Digital Signal Processing (DSP) implementation, 3) The initial version of the Neural Network. The Commercialisation Strategy will include a marketing plan to promote and raise awareness of the ARTIFACT solution. This will combine the publication of several articles in leading police, defence and security magazines and journals with attendance at a suite of identified conferences and exhibitions to demonstrate the ARTIFACT solution. In addition, a bespoke ARTIFACT webinar event will be delivered to attract new end-users to maximise exploitation opportunities in the UK, across the EU and to wider international markets.

TRL 4

www.rinicom.com

Rinicom Intelligent Solutions Limited – Drone-Alarm

Challenge

Existing C-UAV systems are not able to offer quantitative measures for risk assessment. Drone-Alarm will provide a novel AI-enhanced module for classification of payloads and generation of quantitative risk assessment measures for "un-cooperative" UAVs.

Abstract

Currently, there are a number of C-UAV systems on the market which deliver efficient solutions for autonomous detection, tracking and classification of "un-cooperative UAVs", while selection and activation of the most appropriate response measure is often addressed by applying neutralisation methods based on subjective decisions made by the system operator. The selection of the most appropriate response method could be made more efficient and compliant with the existing regulations if a C-UAV system could produce quantitative measures for risk assessment. However, to the best of our knowledge, none of the existing C-UAV systems can offer such a functionality. Therefore, in this project we propose to develop, implement, and verify a novel AI-enhanced module for classification of payloads and generation of quantitative risk assessment measures for "un-cooperative" UAVs. One of the main deliverables from the project will be a new powerful AI enhanced classification tool, able to work alongside most pan/tilt/zoom cameras and CCTV cameras (ONVIF) incorporated in legacy C-UAV systems.

Activity

Initially, we expected that a drones Centre of Rotation (CoR) would be the same as its Centre of Mass (CoM). However, after several flights we discovered that the CoR was not correlated with the CoM, nor is the CoR consistent during a manoeuvre. We changed our focus to better understand how the drone-relative position changes over time in terms of position and acceleration and the correlations between the CoR and the rotational characteristics of the drone itself. To achieve this, we compared the CoR characteristics for a laden and unladen drone.

Impact

Drone-Alarm will improve the selection and activation capabilities of the most appropriate neutralisation methods.

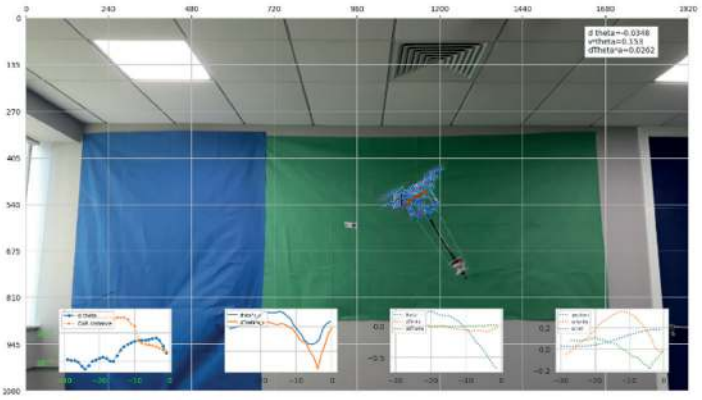


Figure - Silhouetted drone extracted CoRcharacteristics

Implementation Pathway

Further funding is required to develop the prototype into a viable product. In the interim DRONE-ALARM will be tested at selected airports to attain feedback in a real-life environment.

Conclusions

We have developed an approach that is able to extract some meaningful data regarding a drone's translational and rotational kinematics. The approach is applicable in real-time and produces statistically meaningful results in terms of extracting instantaneous CoR and quantifiable behavioural data describing how the CoR changes over time. There are measurable behavioural differences in how a laden and unladen drone behaves and these differences can be extracted and analysed in real time, based solely on a video feed. Ultimately this should allow us to make meaningful distinctions between a laden and unladen drone as well as inferences about the presence of a payload and the relative mass of the payload to that of the drone. With further funding we believe Drone-Alarm can be tested in a real-life environment with key early adopters in a clearly planned roadmap to exploitation and commercialisation.

TRL 5-6

www.dynamical.com

Dynamical Systems Research Ltd – Drone Detect

Challenge

Development of drone detection capability using LiDAR technology.

Abstract

A feasibility study that used fixed-location long-range LiDAR sensors along the perimeter of an airfield to detect drone proximity to the airfield, aerial perimeter breaches and exact real-time drone location. The feasibility study demonstrated the effectiveness of aerial drones being detected and tracked using fixed-location long-range 3D LiDAR sensor arrays.

Activity

Long-range 3D LiDAR sensors can detect objects 400ft away. The proof of concept demonstrator integrates such sensors with edge artificial intelligence (A.I.) platforms for purpose of drone detection and real-time tracking of drones. The proof of concept system communicates drone proximity warnings, perimeter breach alerts and drone location in real-time to the system operator/observer.

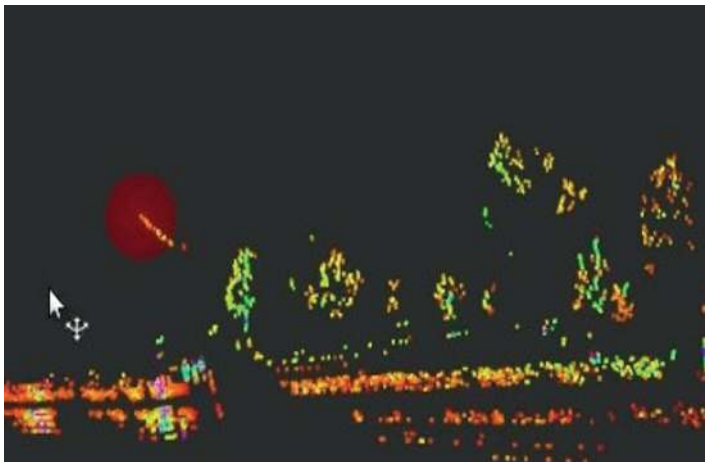
The innovation comes in several parts: sensory data fusion, drone detection algorithms and understanding the overall system effectiveness and best configurations of LiDAR sensors on the area perimeter.

Impact

LiDAR drone detection enable securing and evidenting intrusions into no-fly areas such as airports, prisons.

Implementation Pathway

LiDAR Drone Detect demonstrator ready for pilot deployment project with industrial partner or government agency/department to create commercial solution or integrate as a component of a multi-sensory detection solution.



Conclusions

Dynamical has successfully integrated and tested the suitability and effectiveness of several LiDAR 3D sensor systems in detecting and tracking flying drones.

Real-time detection algorithms have been developed to track multiple aerial objects in a geofenced area or that track multiple aerial objects on and around the perimeter.

The detection algorithms have been implemented in GPU CUDA code to allow for deployment on GPU-capable edge nodes around the perimeter of an area.

A computer simulation environment has also been established that allows for processing of real-time LiDAR information as well as playback of historical sensory data.

TRL 4

www.createc.co.uk

Createc – Improving Aviation Security at Airports by Integrating Multi-modal Crowd Observation Technologies

Challenge

Airports allow billions of travellers to connect across the globe each year. This movement is supported by thousands of support staff and businesses in a complicated symphony with a constant strive for safe, efficient, and frictionless travel. The protection and management of passengers is challenging. Tiredness, delays and excessive queuing can lead to stress and antisocial behaviour.

Abstract

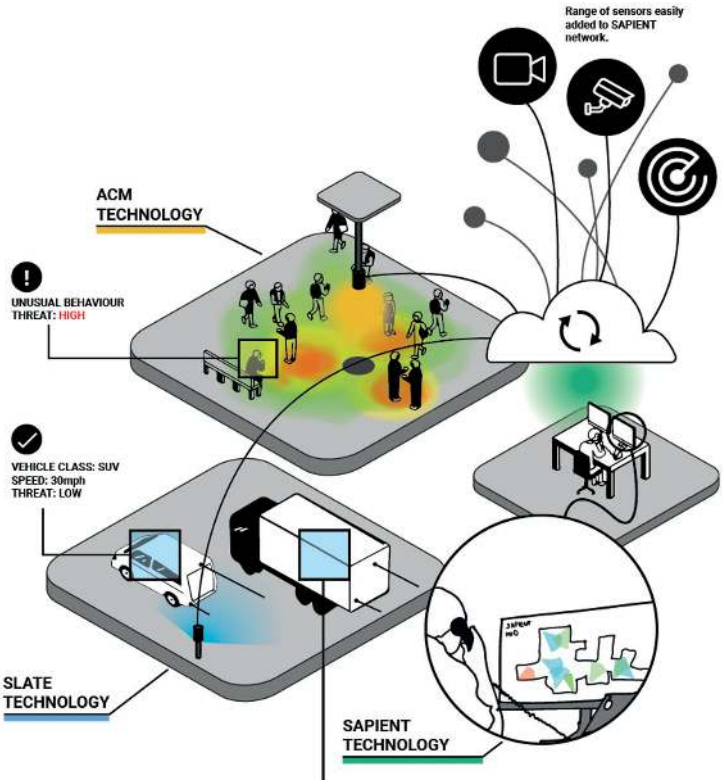
A connected, smart airport, has the potential to improve customer experience, increase revenues and improve safety. This project looks at the feasibility of integrating two different Createc technologies for 'people and vehicle monitoring'in aviation security to improve the flow of passengers throughout the airport footprint. The study investigated what value could be gained using the indentified tracking technologies and how a data analysis function could improve safety, security and customer experience.

Activity

The initial part of the study focused on familiarisation of existing passenger flows through the airport footprint by using a combination of desk research and interviews with key security and operational staff at airports.
The capability of the technologies were unknown to the staff and the objective was to define 'enhanced use cases' based on what is possible. The main part of the study investigated literature review and interviews how the combined capability of the technologies ACM Crowd Monitoring and SAPIENT framework could achieve the enhanced use cases. In addition to monitoring passengers, we investigated how new technologies could be added to the system to enhance the capability.

Impact

Value to multiple airport teams with an Open Platform for monitoring and managing people, vehicles and assets.



Implementation Pathway

We will be looking for site operators who would be interesting in running a small scale trial. The Open Platform model will then allow staged scaling up of the solution.

Conclusions

An analysis of the passenger journey through the airport demonstrated a strong need for technology that can predict and manage flow. However, one of the strongest key findings was the requirement of an Open Platform to manage the technologies. This would allow multi-function access to the data across different teams such as Operations and Planning, thus the ability to share the cost of such a platform between departments. The other key finding came from analysing the journey of an aircraft at an airport.This showed how Foreign Object detection and IoT sensors can be used to increase safety. The integration of new technologies to the open platform was also examined to future-proof the solution and hence further improve safety and security across the entire airport estate and other crowded spaces such as train stations and arenas.

TRL 1-2

www.cranfield.ac.uk

This is not a technology development but experimental infrastructure

Createc – Improving Aviation Security at Airports by Integrating Multi-modal Crowd Observation Technologies

Challenge

A lack of a large-scale UK representative research and development, experimental, environment to study **public safety, security and resilience** at the system-of-systems level, facilitating collaboration between academia, government and industry.

Abstract

The project was a feasibility study providing evidence to answer three questions: (i) Would an ARENA be worthwhile? (ii) Are the characteristics necessary achievable? (iii) What is the path to implementation.

The concept of The Academic Research and Evaluation Networked Area (ARENA) initiative will fill a gap in the UK's public safety, security and resilience sector by providing a large-scale, representative, integrated test environment to explore issues around the development of protective security and data technologies and their networking within an urban environment and system-of-systems paradigm. ARENA is a collaboration operated by academia working with government and industry and will provide innovators and entrepreneur's access to develop and 'showcase' products and ideas.

Activity

The project involved wide consultation, a survey of stakeholders, structured interviews and workshops. A report has been produced and support for implementation sought.

Impact

Enhanced pace and effectiveness of new technology and policy implementation – to aid public safety/ security and resilience. Enhancing UK prosperity.

Implementation Pathway

Follow on study and pilot programmes leading to a submission for government funding in Autumn 2021.

Conclusions

An ARENA would fill a UK capability gap and offer many diverse and valued benefits to stakeholders including government, academia and industry.

These include:

- **Greater public safety**
  - Reducing risk
- **Enhance the pace of developing and deploying new technology**
  - Increased exposure of products and services
  - Cut cost of approvals/reduce time to market
- **Increased integration of technologies and services**
  - Encourage better data handling
  - Encourage gathering more and better data
- **Increased collaboration between Government, Industry, and academia**
  - Inform and test government policy/legislation
  - Cross-fertilise expertise
- Increased standing of the UK internationally.

Creating and operating ARENA poses significant challenges, but none are 'showstoppers'. A practicable operational and technical design to produce the desired benefits has been produced. A road map to implementation has been established.

TRL 3

www.metrasens.com

Metrasens Ltd – Covert screening for mass-casualty weapons

Challenge

Crowded public spaces where conventional security checkpoints are not possible are potential targets for terrorists using weapons of mass-casualty. The challenge is how can such places be protected from this threat in a practical and affordable way?

Abstract

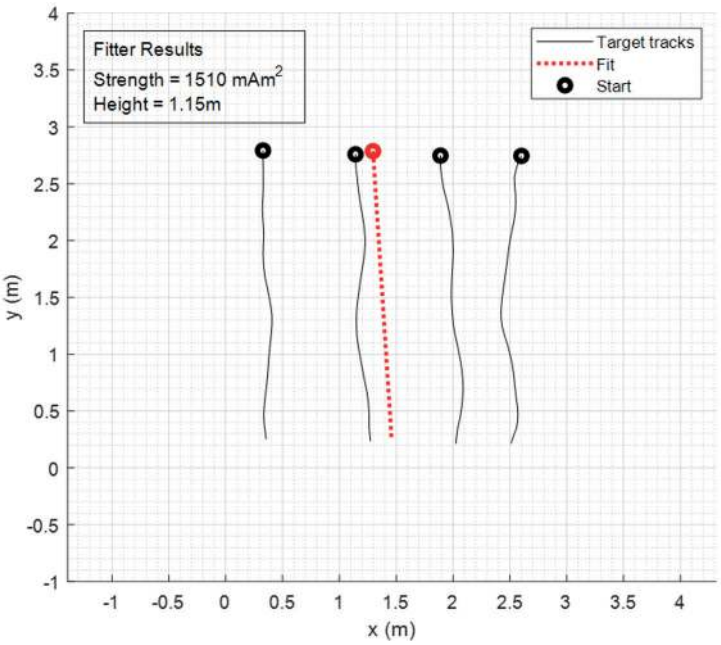
This project researched a system that can detect Weapons of Mass Casualty (WMC, i.e. rifles, bombs) in crowded areas without any physical constraints on the crowd. Public areas of interest are airport terminals, train/bus stations, large office atria, stadiums and venues. It comprises arrays of weapon detecting sensors hidden beneath the floor together with arrays of downward facing people-tracking cameras. The camera data should pre-condition the weapon detection algorithms, without which the problem is much more difficult. The weapon screening applies to the whole individual including any personal bags, backpacks, hold-alls, or suitcases. Because all of the sensors are underfoot or overhead there are no obstacles or restrictions for the public. There is no divestment needed. The sensors are non-radiative so there are no risks to the public.

Activity

We built an artificial floor under which a six-module sensor system array was located. An overhead gantry was built to accomodate the tracking camera. Data was collected with people passing through the arrays, some with WMC surrogates. All sensor data was input to a processor and code was written to fuse the camera information with magnetic data. We opted to try 'fitting algorithms' to determe the trajectory and magnetic strength of the targets. The figure shows one result where an AK47 rifle was detected and tracked correctly. The magnetic strength closely matched the known strength of the rifle and its height above the ground. The three other people were non-divested.

Impact

To secure the public from mass-casualty attacks, where conventional security is not possible.



Plan view of four people simultaneously tracked top to bottom (black lines) by the camera. Red line is the track of an AK47 rifle carried on the left side of the second from left person

Implementation Pathway

This will feed into the technology development process at Metrasens and become a product.

Conclusions

We have successfully shown that an underfloor array of weapon detecting sensors can correctly identify and track some WMCs (rifle under a coat and a PBIED surrogate in a holdall). This in the presence of several other non-divested people in the field of view of the system. The processing stage required the development of fitting algorithms for the magnetic data with starting points conditioned by the tracking camera.

These successful results prove the feasibility of this innovation, but further development and refinement will be required to make it robust in real environments.

TRL 4

www.durham.ac.uk

Durham University – Towards ECAC C3 (Explosives Detection) Using Deep Learning Enabled Multi-view X-ray

Challenge

Increased demand for higher aviation security screening standards means substantial investment for airports to continually meet these higher performance criteria. To reduce these costs we look to exploit advances in classification algorithms, enabled by research in deep machine learning (Artificial Intelligence, AI), to meet higher explosives detection standards on existing hardware.

Abstract

Currently all major airports are required to upgrade to the new ECAC (European Civil Aviation Conference – international aviation security standards body) C3 security standards for airport scanners. This currently involves a significant investment in Computed Tomography X-ray (CTX) scanner technology, as it is the only technology certified to this new standard at present. However, such an investment is both costly and involves the integration of scanners with larger Size, Weight and Power (SWaP) requirements into existing airport environments.

In this project we investigate a lower cost, viable alternative to CTX equipment that would enable smaller airports and overseas countries to enhance their capabilities to meet ECAC C3 standards without additional cost and SWaP requirements.

Activity

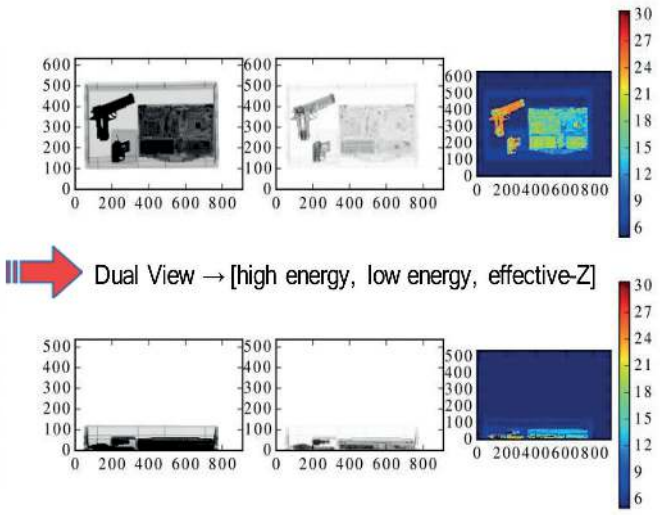
Based on our bespoke access to the raw X-ray data (High/Low/Effective-Z) from our on-site Gilardoni FEP ME640 dual-energy dual-view X-ray scanner (DfT certified to ECAC C1 and Liquid Explosives Detection Systems 2C), we evaluated the use of several leading deep learning algorithms (''deepnets'', convolutional/deep neural networks) for the detection of representative simulant substance in a bespoke dataset also containing several hundred benign **"stream of commerce"** items to assess probability of detection and false alarm rate.

Impact

Deep learning algorithms will enable higher explosives detection standards (ECAC C3) to be achieved on lower cost X-ray hardware.

Implementation Pathway

We will partner with a number of identified partners with an existing presence in the aviation security market to look to bring this capability to market as a software upgrade to existing in-service hardware.



Conclusions

Durham was able to successfully achieve detection/discrimination of representative materials within multiple-view X-ray imagery via a processing pipeline consisting of raw X-ray imagery (High, Low, Effective-Z), a spatial co-occurrence matrix representation of the distribution of this information and a deep learning classification approach to a level that offers promise against the discrimination required for a future ECAC C3 capability on this non-CTX scanner hardware.

With further funding Durham can become a global leader in material detection algorithms that enable ECAC C3 Explosives Detection on lower-cost Multi-view X-ray hardware to complement their existing global impact in prohibited item detection and CTX Threat Image Projection (TIP) algorithm development.

TRL 3

www.strath.ac.uk

University of Strathclyde – Drone Classification Range Extension using AI

Challenge

Detecting drones is still a challenging topic and for radar sensors it is difficult to discriminate them at long distances from other targets such as birds. Enhancing the distance at which a radar based system is able to recognise drones would increase safety and security by allowing for more time for mitigating actions.

Abstract

This project was aimed at assessing the potential of Artificial Intelligence to enhance the range at which drone classification based on radar can be achieved.

The topic is highly relevant given the current range limitations of counter-drone radars to classify small drones versus other detected targets (i.e. birds, cars), which in most cases is much shorter compared to the actual detection range. This can lead to a high number of false alerts before a target confirmation is possible.

In order to unlock the potential of the micro-Doppler based done classification at long ranges, the development of an AI framework is proposed that exploits radar observations of targets in different frequency bands. Generally, higher frequencies result in high fidelity micro-Doppler signatures but are only suitable in short ranges due to propagation losses. On the other hand, low frequencies are more suitable for longer ranges but do not result in as good micro-Doppler signatures. AI offers the opportunity to exploit relationships between higher fidelity training data and signatures of UAVs at obtained with lower frequency surveillance radar by fusing them at the training stage. This will enable to extend the possible classification range when only one of the two radar sensors is used.

Activity

The Sensor Signal Processing & Security Laboratories (SSP&S labs) at the University of Strathclyde, used the S-TRIG grant to demonstrate the feasibility of this concept. After modelling the radar return from Drones and Birds as at two different frequencies and selecting a suitable AI framework, the potential recognition range gain have been identified. The obtained results are encouraging showing a gain of 25% for a mmWave radar.

Impact

The framework will enhance drone classification range thus providing more time to deploy countermeasures.

Implementation Pathway

We will partner with TU Delft to apply for a Defence And Security Accelerator project to validate the technology on real data. We have also started discussions with potential industrial partners.

Conclusions

The SSP&S labs have successfully demonstrated the feasibility of this concept, showing that the latest advances in AI can help in addressing a fundamental issue in using radar for drone detection. The findings showed that by fusing data acquired by two sensors, working at different frequencies, enhances the classification range. Specifically, fusing both L-band and mmWave data on the training stage while operating only with the mmWave sensor resulted in 20% classification range gain. The cost of the solution is limited to the availability of an additional sensor for training data gathering only, while the benefit of having longer classification ranges translates in enhanced time to deploy countermeasures.

In partnership with TU Delft (owning X and S band rooftop radars) a DASA proposal will be prepared to validate the concept, while discussions on potential routes to market will start with Industry.

TRL 3

www.uws.ac.uk

University of the West of Scotland – Novel design of wide – angle Compton camera

Challenge

The detection and identification of illicitly trafficked special nuclear materials and other radiological hazards at the UK borders, transport hubs and entertainment venues.

Abstract

The illicit trafficking and theft of radioactive materials continues to pose a threat to the security of states and their population.

International agencies such as Europol, Interpol and the IAEA continue to record instances of attempted thefts of radioactive materials by organisations and individuals who may seek to use these materials in attacks.

This project aims to develop an inexpensive and portable deviceproviding a wide-angle view of a densely-populated environment allowing for the presence and location of radioactive material to be determined in real-time. It is envisioned that this solution will be an improvement on the technology currently utilised to identify radiological materials.

Activity

Members of the nuclear physics research group at the University of the West of Scotland have used an S-TRIG grant to develop a prototype device to investigate the feasibility of using novel materials and techniques to construct a Compton camera for the location of radioactive sources within an environment. These materials and techniques offer the potential to be significantly less expensive compared with technology currently deployed to monitor for radiological hazards in addition to requiring less maintenance. Being more compact and portable than existing solutions, this device will offer improved detection capabilities while being surreptitiously deployed in locations with high population throughputs.

Impact

This novel design will allow for the development of inexpensive and portable radiation detectors to identify potential threats from radiological hazards.

Implementation Pathway

We will work with key stakeholders to apply for innovation partnerships schemes offered by the STFC in order to bring this technology to market.

Conclusions

Based on techniques routinely employed in fundamental nuclear physics experiments, this novel design offers the potential to be transformational in terms of the detection of radiation within crowded environments. The device can be deployed passively and will offer a 360-degree view of the surrounding environment. The significantly lower cost and lower maintenance requirements, compared with competing technologies, will mean that it can be deployed more widely and enhance the current radiation detection capabilities of the UK.

It is hoped that this device can be brought to market through the exploitation funding schemes offered by the Science and Technology Facilities Council. Combining this technology with trained artificial intelligence systems could also offer exciting opportunities in the security sector.

The techniques exploited to develop this technology can be utilised in other areas such as the surveying of legacy radioactive waste at disposal facilities inaccessible to humans and could be deployed in next-generation space-based gamma-ray telescopes to augment visible and gravitational radiation telescopes.

TRL 5

www.synbiosys.co

Synbiosys – VORO Drone Capture System

Challenge

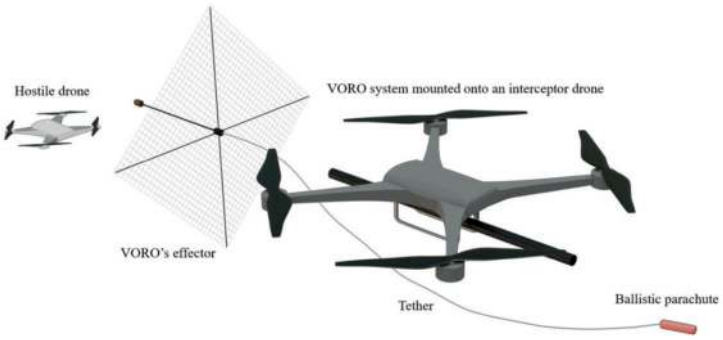
Malicious or irresponsible drone use is an increasing threat to the security and safety of the public. As these drones become more affordable and increasingly autonomous, the problem is expected to become harder to solve. Synbiosys' VORO system provides a safe, effective solution as a payload for interceptor drones. It is designed with high-speed autonomous drone combat in mind, providing a capability one step ahead of any threat.

Abstract

The VORO system launches a small high-speed effector at a target drone from a platform drone. The effector is an aerodynamic projectile with an ensnarement net. This net becomes tangled with the target drone's propellers, disabling, capturing and neutralising the drone. The design is scalable, robust and retrofittable onto any interceptor drone platform. A completely modular design allows the platform drone to be equipped with multiple VORO systems to face a multitude of threats and scenarios.

Activity

We elevated our concept from TRL3 to TRL5 with the work done under the S-TRIG grant. We were able to demonstrate consistent neutralisation of a flying drone in controlled laboratory conditions. A tether and controllable release system were designed, built and tested, along with an electronic trigger circuit suitable for interfacing with any platform drone.



Impact

The VORO drone capture system provides a safe and reliable way of neutralising hostile drones. Its long range and high-speed effector equip interceptor drones with the power to secure airspace from malicious drones, protecting people and infrastructure.

Implementation Pathway

Synbiosys' next steps are to continue to develop and test the VORO system. Through a combination of further funding calls, internal investment and collaborations with drone manufacturers full flight testing against airborne targets is planned for summer 2021.

Conclusions

The milestones reached in this S-TRIG project have brought the VORO system to the point where it can now be incorporated into interceptor drone platforms for in-situ testing.

The next stage of development will involve the incorporation of a recoil suppression system using a ballistic parachute. This will increase the range and accuracy of the device and gives the capability to counter larger targets. Synbiosys will also explore how the VORO system could be deployed on ground mounted platforms, such as defensive positions and on land vehicles.

For more information about the S-TRIG Programme, please visit:
https://cp.catapult.org.uk/opportunities/s-trig-programme/

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