Dedicated to innovation in aerospace

Enabling safe and seamless drone operations

Royal NLR - Netherlands Aerospace Centre

Unmanned and autonomous aviation at Royal NLR

Drones are a key enabler for innovative solutions to tackle rapidly changing societal, economic and security challenges. NLR is the knowledge partner in this field for industry and government. We offer support in the development, implementation and societal acceptance of unmanned and autonomous aviation, taking into account safety and minimal nuisance. We help with the realisation of safe, sustainable and affordable drone systems and the harnessing of commercial opportunities, and we support the manufacturers in the area of drones and Urban Air Mobility (UAM).

- Development of promising drone applications, for instance for the agricultural sector, medical transport, the inspection of roads, railways and waterways, and traffic control.
- Safe and sustainable integration of the unmanned drone air traffic within the airspace (including U-space and automated drone separation management).
- Development of systems and platforms for unmanned drone air traffic.
- Development of security systems to prevent and combat the use of drones by malicious parties (counter drones).
- Enabling publicly accepted Urban Air Mobility (UAM) applications for transporting passengers and products within cities by air.
- Development of systems for a safe and robust unmanned infrastructure for autonomous drone air traffic (communication, navigation and surveillance (CNS) infrastructure).

We have selected some of the projects, research and capabilities that we have developed ourselves and together with partners.

We hope you enjoy reading and discovering more about Royal NLR in this booklet.

Project partners

Industry: NTT Data (overall project lead), Boeing, Jeppesen, CATEC, Airbus, EHang, AirHub, Space53, Altitude Angel
Research organisations: Royal NLR (demonstrations project lead), ITG, Enaire, Tecnalia, Ineco, ANRA, Cranfield University.

AMU-LED: Urban Air Mobility – Large Experimentation Demonstrations

Urban Air Mobility (UAM) promises to be the next mobility revolution, enabling faster, more efficient and sustainable transport solutions (such as flying taxis and other large drones) throughout urban areas. But there are a number of challenges that need to be overcome for UAM to become a reality. These include the organisation of the lower-level airspace, the scale-up of operations in a safe way, integration with ATM, the development of an architecture that can support operations and public acceptance.

THE CHALLENGE

AMU-LED is looking into the capabilities of U-space to enable UAM by answering questions related to the maturity of concepts and technology, the challenges, and what needs to be done to implement this new form of mobility in cities. AMU-LED will let UAM stakeholders specify various use cases applicable to logistics and the urban transport of passengers, to integrate the UAM environment, to demonstrate the UAS ground and airborne platforms and finally, to assess safety, security, sustainability and public acceptance.

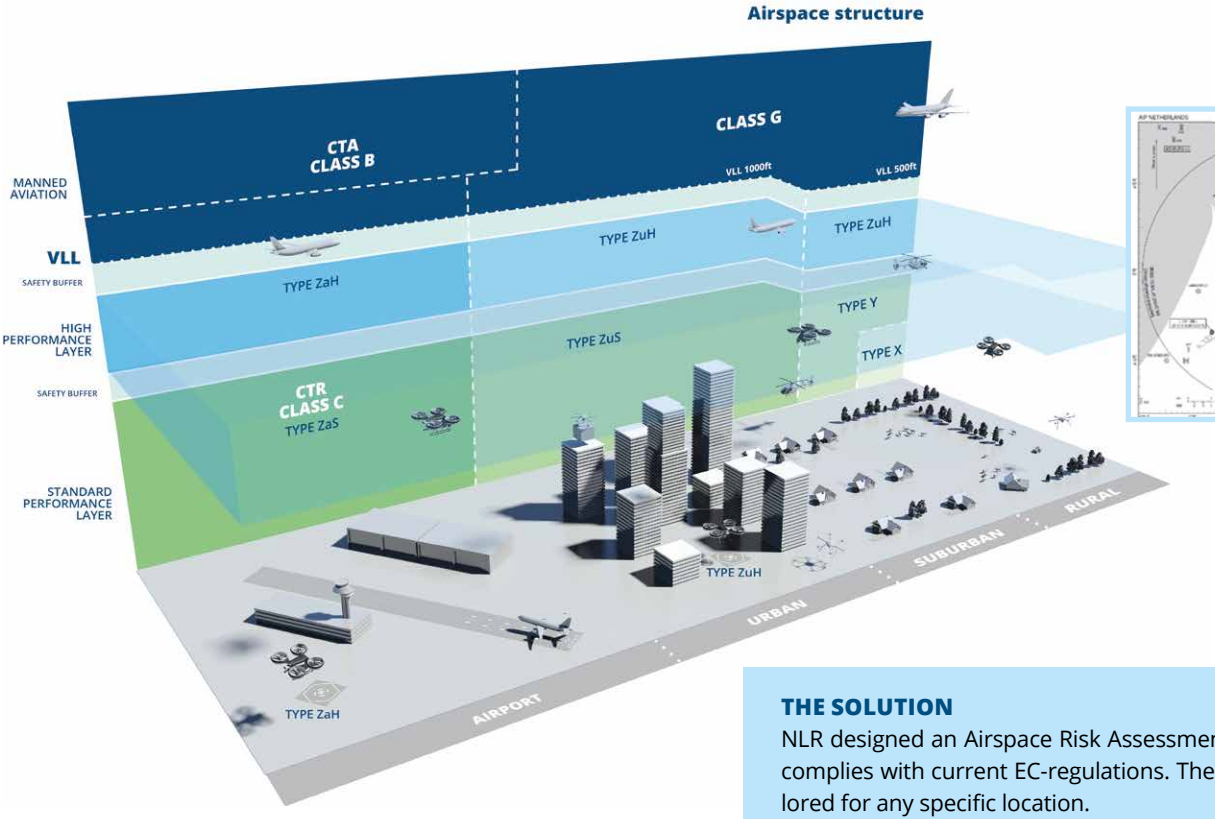
THE SOLUTION

AMU-LED will perform real-life UAM demonstrations and flights using U-space and deploying several types of drones to showcase different scenarios, use cases and applications (e.g. air taxis, emergency services, delivery of goods, surveys etc.) to demonstrate and investigate the research questions. To this end, several major flight demonstrations will take place in the second half of 2022 in the UK, Spain and The Netherlands.

WHAT WE ARE DOING

The project is carried out in a consortium with companies in The Netherlands, Spain and the U.K. Together, an extensive state-of-the-art research has been set up where all relevant aspects were considered. Use cases include taxi flights from the city to an airport and last-mile drone delivery. Special attention is given to emergency flights for police, ambulance and fire fighters.
Within the city of Amsterdam, NLR will investigate the link with air traffic control of Schiphol and the link with other air traffic on arrival routes to the airport. and demonstrate that U-space, the traffic control services for drones, can help to fly in situations where the pilot does not see the drone anymore. Also public acceptance of drones will be investigated.

sesar JOINT UNDERTAKING *This project has received funding from the SESAR Joint Undertaking (JU) under grant agreement No 101017702.*



THE SOLUTION

NLR designed an Airspace Risk Assessment method that fully complies with current EC-regulations. The method can be tailored for any specific location.

- provide the airspace risk assessment
- visualize and simulate airspace operations
- assess how U-space can help to mitigate hazards
- establish requirements for U-space Airspace
- define advanced U-space services
- define a concept of operations for the U-space Airspace to be established

U-space Airspace Risk Assessment

U-space, the air traffic control system for drones, is a set of new services relying on a high level of automation. It offers great potential to fly drones simultaneously in complex environments and is regarded as an enabler for Urban Air Mobility. U-space will provide safe integration with manned traffic. Before the establishment of U-space, EC regulation requires the airspace to be designated as "U-space Airspace" and an airspace risk assessment is required.

THE CHALLENGE

Before assigning part of the airspace as U-space Airspace, a good risk assessment will need to take place for the identification of hazards and mitigation of risks. These risks are air and ground related. In the air, other traffic, manned and unmanned, might intervene with the drone operations. On ground, hazards are related to population or infrastructure, causing risk to the people on the ground. Buildings or existing radio signals might interfere with a the signal to and from the drones.

The airspace assessment considers both air and ground risks by first describing the current operations of manned and unmanned traffic. A forecast of future operations must be given as 'reference scenarios' a number of use cases.

The starting point of a thorough U-space airspace risk assessment is a thorough description that identifies relevant details such as population, public buildings, schools, or high risk industries.

WHAT ARE WE DOING

NLR has set up a method for the performance of an airspace assessment, in line with the EC regulation and accompanying guidance from EASA. The method follows a structured approach towards setting up a full airspace risk assessment for any area that is requesting the use of U-space.

NLR supports organisations, like municipalities, harbors, industry areas and ANSPs, that have plans to operate U-space. NLR performs the airspace risk assessment compliant with EC regulation 2021/664.

Project partners
Government: Dutch Ministry of Infrastructure and Water infrastructure
Research organisation: Royal NLR

DigiCity – a new test facility for launching UAM

Drones have shown that they are technically capable of flying but there is a bottleneck between current innovations and market introduction: as yet, there is no realistic urban testing environment, nor appropriate certification and regulations in The Netherlands. Flying in a dynamic urban environment also engenders issues of safety, cybersecurity, noise and other nuisance, and interaction with other traffic.

NLR is developing DigiCity, an innovation and test centre for drones. DigiCity will be a flexible and realistic operational urban environment where innovative companies can experiment and test their drones. A monitoring network creates an accurate picture of the impact that the drones have on the city environment and vice versa. Assessing how 'city-proof' the drones in the facility are and using the monitoring system makes clear exactly what is still needed for their practical application, which simplifies authorisation procedures and shortens the time to market. That means that DigiCity is the missing link between product development and market approval (including certification). DigiCity is being constructed next to the NLR Drone Centre and on the new Mobility and Infrastructure Test Centre (MITC) in Flevoland (NL).

DIGICITY OUTDOOR

DigiCity is a newly developed urban test environment comprising movable elements, smart traffic flow systems and a digital infrastructure (such as 5G). The urban environment is simulated by 20 to 30 shipping containers. The behaviour of automated drone flights in an urban environment can be tested in these surroundings. To monitor this environment, a measuring system is being developed that tracks all kinds of sensors in the 'city' and on the drone.

DIGICITY INDOOR

This includes the technical measurement and analysis rooms and the 'digital twin', as it is known, of the outdoor test environment. It will also be a place where knowledge is shared, and where space is available for startups. Avy, one of the launching customers of the innovation and test facilities at DigiCity and a project partner, is developing an innovative and sustainable hydrogen-powered drone. The aim is for this device to be able to carry a payload of 15 kg and have a flight time of 2 to 3 hours. Avy will be using the new facilities immediately to speed up the time to market for their own device and will also use the facilities for validation before commissioning.

G4P4 Kansen voor West II

To develop this facility, grants were received from *Kansen voor West* [Opportunities for the Western Region] and from the Covid-19 recovery fund (REACT-EU).

THE SOLUTION

Create a 'metastandard' – providing an overview of the standards by collecting information about ongoing and planned work in terms of technical and operational standards developed for drones worldwide. These are to be assessed/benchmarked to identify best practices, gaps, bottlenecks and applicability. Based on these, a well-reasoned set of standards to support the SORA process and U-Space can be proposed, as well as gaps identified. This can only be done by engaging with key stakeholders and end-users, i.e. representatives of the entire drone value chain.

Harmonising drone standards to support the EU regulatory process

Several studies and surveys have identified a reliable regulatory and standardisation framework as one of the main potential boosters for the drone business. Fostering the growth of safe drone usage requires the implementation of coherent and interoperable global standards for drones in the EU. Many standards are currently under development, either as amendments of existing standards or as new standards being conceived, yet a complete overview and applicability assessment is lacking.

THE CHALLENGE

A lack of harmonised standards is holding back the development of drone-related business, both at a global level and in Europe. This project aims to address this gap by providing a framework for harmonising drone standards, to support the ongoing EU regulatory process through an open repository containing structured information about technical rules, procedures and standards for drones worldwide, including applicability to different Specific Assurance and Integrity Levels and U-Space services.

WHAT DID WE DO

Within the project, NLR developed a methodology to structure and assess the collected technical rules, standards and procedures systematically. The methodology and criteria for their assessment have also been developed to enable the identification of the technical standards (and supporting rules and procedures) with the highest ranking (best practices), as well as the identification of gaps and bottlenecks to ensure safe drone operations. In the subsequent actual assessments, NLR focused on standards for multi-crew coordination and inspection of the UAS (product inspection), to ensure consistency in the ConOps and overall consistency throughout the various assessments. NLR provided the final recommendations to EASA.

Project partners

Industry: Deepblue, EuroUSC, B&C, Flight Safety foundation, CERTH, Ortellio, DJI, Delair, Unifly, IAI

Research organisations: Royal NLR, DLR, TUDelft

SCALAiR: Scaled Test Aircraft Preparation & Qualification

SCALAiR is part of Clean Sky2 Large Passenger Aircraft, and aims to validate scaled flight testing as a viable means for de-risking disruptive aircraft technologies and aircraft configurations to a high technology readiness level. The NLR activities involve 'Test Aircraft Preparation and Qualification'.

THE CHALLENGE

The goal is to develop a highly representative scaled aircraft of an actual aircraft, equipped with very accurate flight test instrumentation to perform measurements during the tests. This will introduce a very cost-effective approach to developing radical new aircraft, as needed for more sustainable aviation.

THE SOLUTION

The project has developed a Scaled Flight Demonstrator (SFD) of a scaled reference aircraft (A320, scale 1:8,5), which is representative for the full-scale aircraft at Mach 0.4. SFD flight test data is measured to show that scaled flight-testing can be used for obtaining flight-mechanics characteristics that are representative of the full-scale aircraft.

WHAT WE ARE DOING

The work included avionics subsystem design & manufacturing & test, SFD airframe (wing & fuselage) design & manufacturing & assembly & integration (with Orange Aircraft), integration of Flight Test Instrumentation (developed by NLR), development of and integration with the Ground Control System (with CIRA), SFD system integration and test, wind tunnel tests at DNW LLF (April 2021), qualification of an operational concept to obtain an authorisation to fly, and training of the flight crew. High-speed taxi tests were performed at Deelen, the Netherlands, in November 2021. A Flight Readiness Review has been conducted successfully, with Airbus as an important reviewer.

The first SFD flight as part of a qualification campaign at Deelen will be performed in the first half of 2022. The mission flight campaign in Italy is planned for mid-2022. All results will be used by ONERA to compile a final report and validate the concept of scaled flight testing as a viable means for future aircraft development.

This project has received funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme.

Project partners
Airbus, ONERA, Royal NLR, CIRA, TU Delft and Orange Aerospace B.V.

Project partners
Research organisations: Royal NLR
Industry: Avy, CryoWorld
Universities: TUDelft/AeroDelft

HYDRA-2: Hydrogen Drone Research Aircraft

Hydrogen as a fuel is considered to be an important alternative for future sustainable aviation. When produced from green energy sources, hydrogen delivers zero CO_2 emissions – only water vapour. Hydrogen is a light-weight fuel with a 3-4 times higher energy density than kerosene. It can be stored in tanks both in gaseous and liquid form. It can be burned in conventional combustion engines, as well as transferred highly efficiently into electric power with fuel cells, as an alternative to batteries.

THE CHALLENGE

Although the use of hydrogen has been employed widely in other industries for many years, the introduction of hydrogen on board aircraft is a major technical challenge, not to mention the tremendous certification effort that's required. It has a significant impact on the aircraft architecture, powertrain components and operations, as well as on the ground infrastructure.

THE SOLUTION

Drones offer an ideal platform for testing hydrogen technologies safely on a smaller scale and at relatively low cost. Hydrogen also offers an extended flight duration and distances beyond what's possible with batteries. This is highly relevant for commercial applications like transporting medicines or cargo, or for first responders or surveying.

WHAT WE ARE DOING

In cooperation with Dutch industry and universities, NLR obtained first-hand experience in designing, selecting, testing and improving hydrogen components (both gaseous and liquid) suitable for drones, as well as extensive safety analysis and test procedures. The HYDRA projects support the standardisation and certification of hydrogen drones for commercial applications, while also preparing for upscaling for large manned aircraft. The first flight of the liquid hydrogen drone is expected to take place in mid 2022.

Beyond Radio Line Of Sight (BRLOS)

Drone operations are often performed with a direct telemetry link enabling the pilot to control the drone. This is not possible if the drone is too far away or it disappears behind obstacles; this is called 'Beyond Radio Line of Sight' (BRLOS), where the telemetry link is not direct but occurs through the 4G mobile phone network, for example. This offers a range of new commercial operations, including in the Netherlands. But the mobile phone network is intended for mobile phones on the ground, not for flying drones.

THE CHALLENGE

If the network is received somewhere on the ground, that's not to say that it can also be received at flying altitude. And if the connection is occasionally interrupted, that's annoying during a telephone call but is unacceptable if it makes a drone uncontrollable. NLR's ambition is to support the Dutch government and industry in conducting BRLOS operations safely through the mobile phone network. This Moonshot is intended to acquire the basic knowledge for this in the short term, and to build up practical experience.

THE SOLUTION

An NLR drone was equipped with a 4G telemetry system, and then flown and piloted from NLR Amsterdam using the 4G network, with a safety pilot at the Drone Centre who could take over the controls.

WHAT ARE WE DOING?

Commercially-available equipment for controlling a drone through 4G was built into a drone. A separate VPN connection had to be set up to meet NLR's security criteria. The drone flew above NLR Marknesse while the pilot was at NLR Amsterdam, controlling the BRLOS drone through the internet and Vodafone's 4G network. The findings have been set out in a report, and follow-up steps are being drawn up.

Project partners
Research organisation: Royal NLR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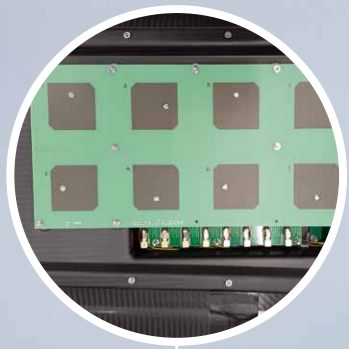


Project partners
Client: European Space Agency (ESA)
Partners: Royal NLR, Orange Aerospace, Bernard Microsystems

ESA Contract N° 4000123386/18/NL/NR
'Embedded antenna arrays in small uav wing structures'

ISABELLE : Integrated Steerable Antenna for Beyond Line-of-sight L-band data Exchange

The market for satellite communications for Unmanned Aerial Vehicles (UAV) is expected to grow significantly over the coming years. The growth of the UAV sector follows from the diversity of potential applications. Among the earliest applications of UAVs for civil use are the so-called dull, dirty or dangerous tasks (e.g. performing oil and gas exploration surveys). To operate a UAV routinely Beyond Visual Line Of Sight (BVLOS), one needs a SATCOM link between the UAV and the Remote Pilot Station (RPS).

THE CHALLENGE

Its dimensions mean accommodating any satellite antenna into small-sized UAVs may be an obstacle. The project has developed an integrated satcom array antenna, taking the electromagnetic, structural and thermal aspects of the antenna integration into account.

THE SOLUTION

Available surfaces such as the wing and tail can be used to integrate antenna arrays. The objective of the ISABELLE project was to demonstrate by design, manufacture and testing, the viability of an embedded antenna array with real-time adaptive beam forming, where the antenna is integrated into the wing structure of the UAV.

WHAT WE ARE DOING

- Provide an overview of the available satellite services and antennas for satellite communication.
- Selection of applications that benefit most of the use of the integration of antennas in the mechanical structure of the UAV.
- Definition of an antenna concept, antenna architecture and antenna requirements.
- Creating a preliminary design of an array antenna integrated in the wing of a UAV.
- Design, manufacturing and testing of a number of the antenna system's critical components.
- Manufacturing of the antenna arrays, the beam formers and the antenna control.
- Measurements to characterise the manufactured components.
- Ground tests, flight tests and a demonstration of the antenna performance during flight

DELMO: multirotor payload drone with separate propellers for lift and control

NLR has developed the DELMO drone (DEdicated Lifting MOtors). An innovative concept for a multirotor drone with two different sets of propellers to optimise the performance, energy consumption and noise impact.

Multirotor drones are controlled by means of variations in revolutions per minute (RPM). Greater RPM means more power, which is used for stability and control. RPM variations of a large propeller cost a lot of extra force and therefore generate higher peak currents. Peak currents are risky for electrical and electronic components, because they often reach the maximum current the systems can handle. This can cause these components to break down sooner, which reduces operational safety and shortens maintenance intervals. The challenge is how to reduce peak currents in a multirotor drone.

Also, unlike traditional helicopters, multirotor drones do not have rotors with a constant rotational speed (RPM). This means that the rotors are more difficult to optimise from an aerodynamic point of view, because the airflow conditions are constantly changing. This results in the performance of these "classic" drones is only optimal in a limited range of RPM conditions.

THE DELMO CONCEPT

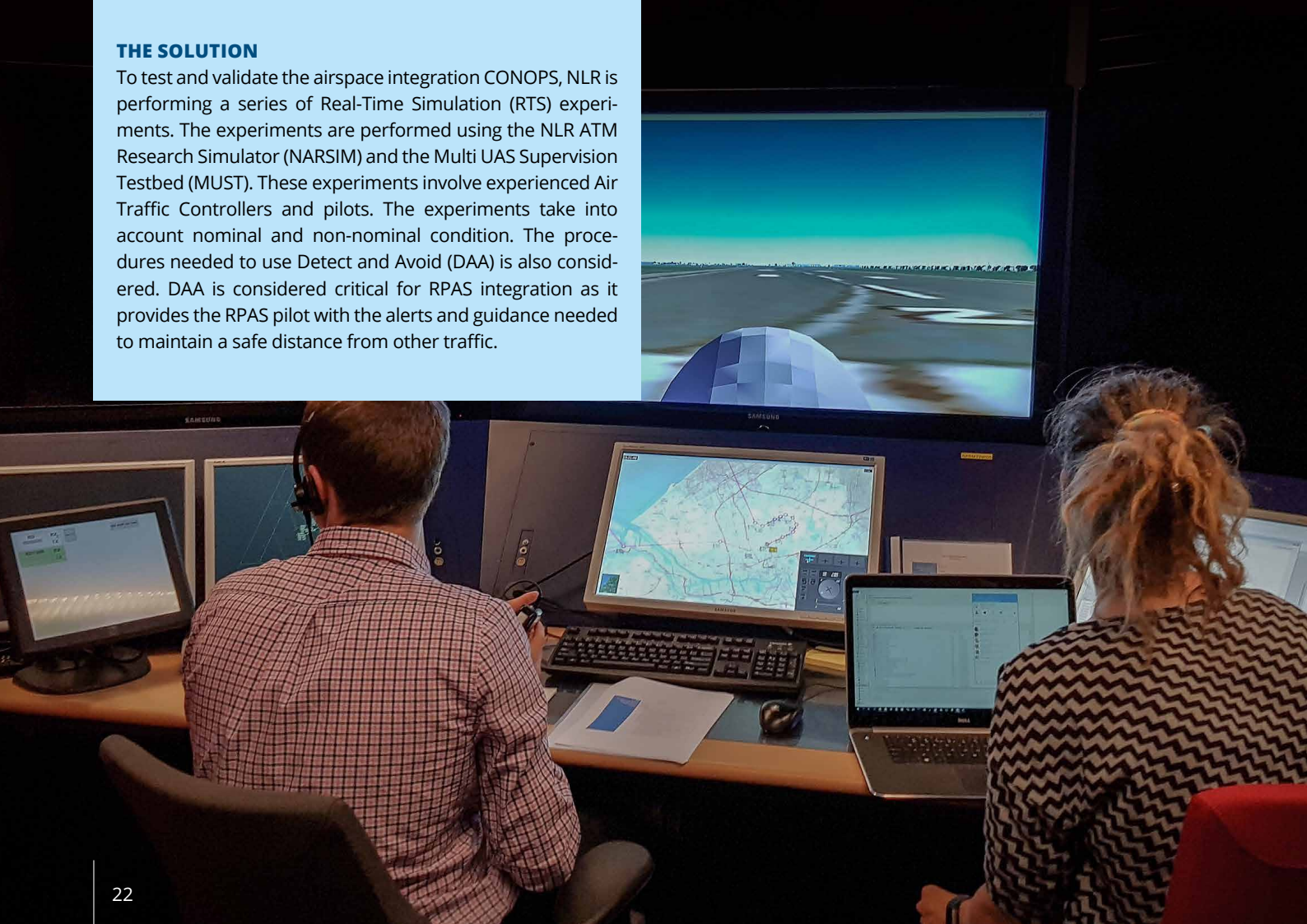
The DELMO prototype has two large rotors which carry about 70% of the total weight. The other four smaller rotors are used to produce the remaining thrust and to control (stabilise and move) the drone. In this concept, the large lifting rotors are constantly active and rotate with a constant RPM, which requires a steady current and thus avoids peaks. The four smaller rotors rotate with a variable RPM for the stability and control, while generating less peak currents due to the small size of the rotors. As the majority of the lift is carried by the large lifting rotors at constant RPM, the performance of the drone can be better optimised than "classic" drones. Finally, a constant RPM is also more suited to reduce noise annoyance since the noise pollution from the lifting rotors is not varying. A specific noise frequency can be targeted and noise mitigations specific to a constant frequency incorporated.

The technological solutions experimented in DELMO can aid the implementation of drones as means to transport payload in a variety of applications, from urban settings to defence applications.

DELMO is a prototype supported by the NLR Living lab, the social and technological disruptive innovation hub within Royal NLR.

THE SOLUTION

To test and validate the airspace integration CONOPS, NLR is performing a series of Real-Time Simulation (RTS) experiments. The experiments are performed using the NLR ATM Research Simulator (NARSIM) and the Multi UAS Supervision Testbed (MUST). These experiments involve experienced Air Traffic Controllers and pilots. The experiments take into account nominal and non-nominal condition. The procedures needed to use Detect and Avoid (DAA) is also considered. DAA is considered critical for RPAS integration as it provides the RPAS pilot with the alerts and guidance needed to maintain a safe distance from other traffic.



Integration of MALE RPAS into European Airspace

In addition to supporting defense operations, Medium Altitude Long Endurance (MALE) Remotely Piloted Aircraft Systems (RPAS) have numerous civilian applications ranging from infrastructure inspection to search and rescue. However, the current regulatory environment in Europe inhibit such applications as they only permit MALE RPAS operations in segregated airspace. Furthermore, each MALE RPAS flight requires numerous permissions from national aviation authorities, and this process can be very time consuming.

THE CHALLENGE

To overcome these issues, and regularise MALE RPAS operations in Europe, it is necessary to develop and validate a comprehensive Concept of Operations (CONOPS) to enable the safe and efficient integration of MALE RPAS into controlled and uncontrolled European airspace.

1. Develop and test CONOPS to integrate MALE RPAS into European airspace, taking into account both nominal and non-nominal conditions
2. Provide empirical evidence to convince all relevant stakeholders that MALE RPAS operations are safe and efficient to fly in European airspace

WHAT DID WE DO

An iterative, step-by-step, approach has been adopted. The first phase of the project focused on setting up the basic simulation infrastructure needed to perform the required experiments. The resulting simulators were used to perform a number of experiments to study the procedures needed to cope with RPAS contingencies, such as Command and Control (C2) link failure, i.e. failure of the digital link between the RPAS pilot on the ground and his/her aircraft in the air. The project is currently in its second phase which is focusing on operations with DAA. To this end, the NLR simulators have been connected to the GA-ASI Conflict Prediction and Display System (CPDS) to provide pilots with DAA alerts and guidance.

Project partners
Industry: General Atomics Aeronautical Systems (GA-ASI) & Information Systems Delft (ISD)
Research organisations: Royal NLR

Small and silent drones for mission landing zone reconnaissance

Selecting a good landing zone in an uninhabited area requires a good and extensive exploration of the terrain by specialists. This is a time-consuming activity that sometimes has to be done in silence. Possible locations are identified using digital maps and satellite data, but that data can be outdated and is usually not very detailed. That is why an initial check of the location is needed with current, up-to-date and more accurate recordings. 'Pathfinders' are sent ahead by parachute to explore the area with small drones that fit in a backpack, in addition to their survival gear and weapons. In the Mission Landing Zones (MILZ) project, the partner CGI developed software that can automatically identify possible landing zones based on operational criteria and data from maps and satellites. A quick on-site reconnaissance of the possible landing zone is preferred for updating and refining the data.

THE CHALLENGE

The reconnaissance must be carried out not only quickly and silently but also with a high degree of accuracy. Good sensors let a drone achieve the required accuracy. The drone has to have a large flight radius. The specialists land by parachute; the drone has to be carried in a backpack and must therefore be small and lightweight. These are challenging requirements. Can ditches and pits in the terrain be detected by a sensor in a small and silent drone?

WHAT DID WE DO

In this feasibility study, NLR analysed the client's operational requirements and the software requirements for achieving the accuracy needed, resulting in a set of requirements for an operational drone and sensor. Using this set of requirements, a selection was made for the drone demonstrator. The assignment was not to design a new operational drone but to investigate its feasibility, focusing on (a) selecting a sensor with the required accuracy, the overlap in photos and (b) investigating if the sensor can be installed in a quiet and lightweight drone that fits in a backpack. A cheap and commercially available fuselage with wings was fitted with a motor, propeller and flight controller. An existing sensor has been selected and fitted; additional preview software allows the overlap to be determined immediately after the drone's reconnaissance flight.

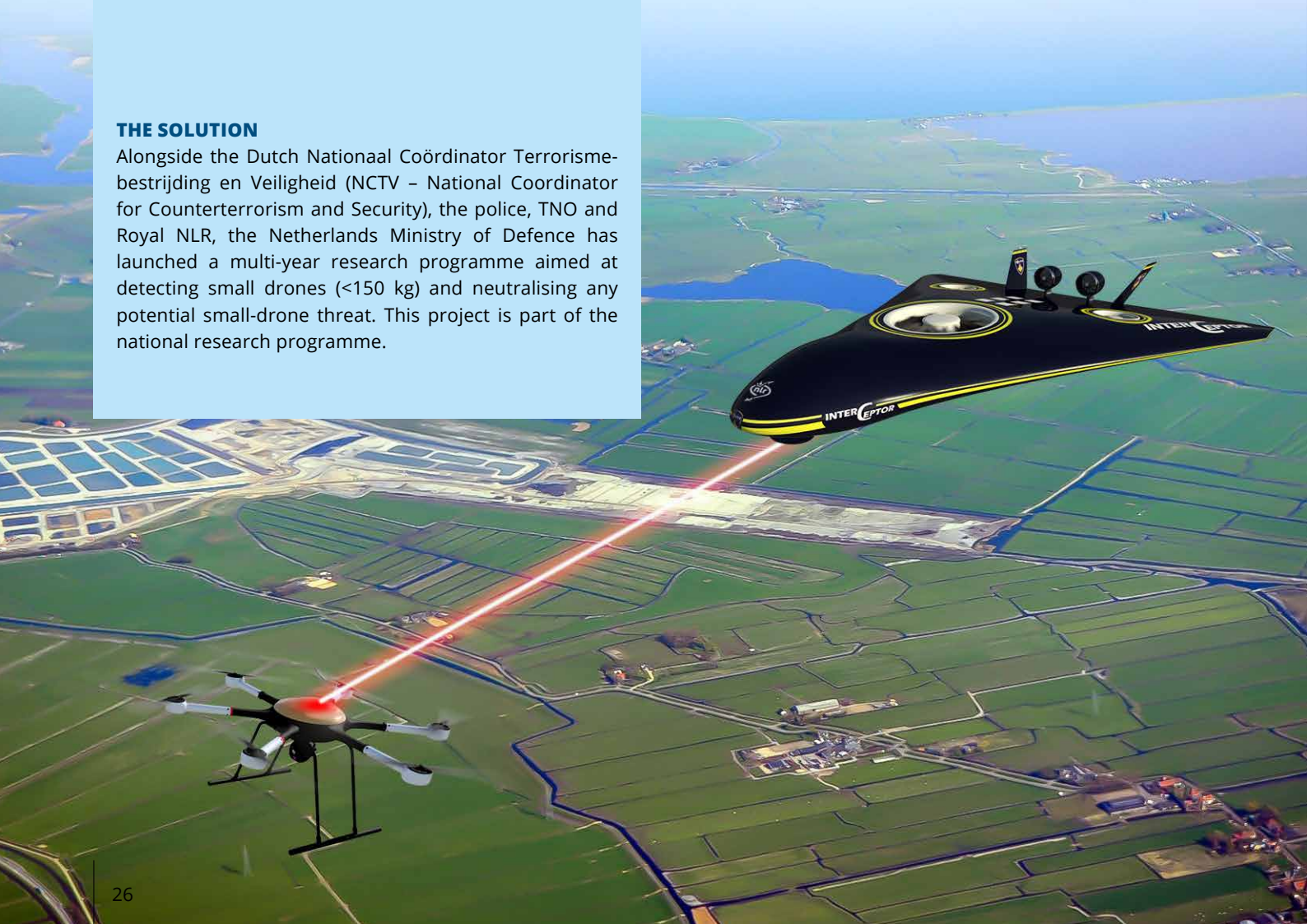
THE SOLUTION

Taking several overlapping sets of pictures from the drone allows height differences in the terrain to be determined. The software that identified the possible landing zones can perform a new analysis based on the height differences derived from the pictures. The pictures also show the current situation on the ground. Overlap is required both along the flight direction and crosswise to it, necessitating numerous overlapping tracks over the area. This requires a small, silent and energy-efficient drone with a suitable and accurate sensor with specific software.

Project partners
Government: Ministry of Defence
Industry: CGI
Research organisations: Royal NLR

THE SOLUTION

Alongside the Dutch Nationaal Coördinator Terrorisme-bestrijding en Veiligheid (NCTV – National Coordinator for Counterterrorism and Security), the police, TNO and Royal NLR, the Netherlands Ministry of Defence has launched a multi-year research programme aimed at detecting small drones (<150 kg) and neutralising any potential small-drone threat. This project is part of the national research programme.



Counter Unmanned Aircraft Systems (C-UAS)

UAS systems are increasingly becoming part of our society and are usually easy to obtain. Continuous and rapid technological developments mean these systems are becoming more advanced and can easily be adapted to the user's wishes. This also gives rise to applications for violent use against both civil and military systems and persons.

THE CHALLENGE

Measures against UAS are often still technologically immature, scarce and expensive. This means research is required on effective and affordable countermeasures for both military and civilian applications. With the Counter-UAS programme, the Netherlands wants to advance the technological ways of stopping a possible drone threat. Countermeasures must consist of layered possibilities for fast (real-time) detection, identification, tracking and neutralisation of hostile UAS, where collateral damage is minimised.

WHAT WE ARE DOING ?

This NLR research programme builds up innovative knowledge, expertise and infrastructure to support the National Police, the Netherlands Armed Forces, NCTV and other (semi-) governmental organisations in the development of effective measures against UAS. This includes both the sub-aspects relating to threat characteristics, the detection of these threats, the techniques and methods to counter the threats, and the technical integration. These aspects require innovative solutions because of their technological complexity.

Project partners
Government: Ministry of Defence, Ministry of Justice & Security, NCTV (all NL) and NATO
Research organisations: Royal NLR, TNO

Detect And Avoid system ADACORSA

To enable safe airspace integration of unmanned aircraft, a Detect And Avoid (DAA) system is required to evade other (manned) aircraft. One solution is to use a Cooperative Traffic Sensor based on transponder signals. Such a sensor is not yet available with a small form factor suitable for unmanned aircraft. Within the Airborne Data Collection on Resilient System Architectures (ADACORSA) project, such a sensor will be developed and tested in cooperation with the partners.

THE CHALLENGE

The main challenges of the project are

- The form factor and power requirements of current DAA systems are not suitable for small and mid-sized unmanned aircraft.
- Due to frequency saturation of the manned aircraft transponder frequencies, drones cannot be equipped with ADS-B transponders.
- Manned aircraft with both Mode-S and ADS-B transponders need to be detected.

Project partners
Industry: Anywi, Celestia Technology Group, Embraer, ESC Aerospace, ISEP, etc.
Research organisations: Royal NLR, TUDelft

WHAT DID WE DO

NLR develops a Direction Finder for the Cooperative Traffic Sensor (CTS) and integrates this with a Mode-S interrogator, developed by project partner Celestia Technology Group. The DAA system uses algorithms developed by NLR for semi-automatic avoidance of other aircraft. These algorithms feature both Remain Well Clear (RWC) and Collision Avoidance (CA) functionalities. The RWC functionality takes into account the rules-of-the-air to calculate a new route for the unmanned aircraft. The calculation is performed onboard to be independent of a data link and allows a fully autonomous system in the future. The DAA system will be integrated and flight tested in the DAA Flying Testbed at the NLR Drone Flight Test Centre. Finally, the developed system will be demonstrated in a logistic support use case.

THE SOLUTION

- Miniaturisation of the DAA system suitable to be integrated onboard of small and mid-sized unmanned aircraft
- Sensor suite advancement to include a direction finder to measure the azimuth such that the relative position to the intruders is known
- Information from ADS-B (manned intruder aircraft) will be used to further increase detection of current airspace users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MUST: Multi-UAS Supervision Testbed

MUST is NLR's testbed for operating unmanned systems. It provides a workplace for an RPAS crew that can be used for controlling multiple RPAS craft at the same time. MUST offers standard functionalities, while also being fully customisable as required. The MUST architecture supports the control of operational and simulated RPAS; this has also been demonstrated in practice. One aspect making this possible is the STANAG 4586 compatibility.

MUST is an integrated component of NLR's Airpower Simulation, where all the NLR simulators can be linked flexibly as required for a variety of missions. For example, MUST has connections to Fighter 4-Ship (F4S), Helicopter Pilot Station (HPS) and Virtual Battlespace (VBS). This makes manned-unmanned teaming (MUM-T) concepts possible, for instance.

MUST can also be coupled to NLR's Video Exploitation System (VES), allowing MUST to be utilised as an element of an actual or simulated data-to-decision chain. Moreover, for carrying out tests for the integration of RPAS craft in controlled airspace, MUST is also linked to NARSIM. NARSIM is NLR's simulation environment for radar and ATC towers. This connection offers options for testing new concepts with RPAS, from the perspectives of both the ATC (e.g. in a tower) and the RPAS crew.

NLR Drone Centre

NLR set up the NLR Drone Centre in 2015. Here, tests and evaluations of (prototype) RPAS and sensor applications are conducted, demonstrations are facilitated, flight inspections are carried out and drone practical training and technical examinations are given.

The NLR Drone Centre has its own restricted airspace with the necessary authorisations and exemptions to facilitate these activities. It offers developers, manufacturers and business users, both civil and military, the opportunity to carry out test flights needed to take advantage of the economic opportunities offered by RPAS developments. The NLR Drone Centre is located at NLR's premises in Flevoland, and complies with all government requirements.

RESTRICTED AIRSPACE

Only aircraft and pilots who fulfil all the statutory requirements may fly in Dutch airspace. The NLR Drone Centre has more extensive dispensation: for example, it is permitted to fly prototypes that do not yet meet all the requirements. The airspace above the NLR Drone Centre is closed to other users, and the territory is also a restricted and closed area. Herewith fulfilling a significant need for drone development and the technology it requires, such as detect-and-avoid sensors that prevent drones from coming too close to other air traffic. In this way the centre supports the development and use of drones and integrating drones safely into civil airspace, and acts as a 'one-stop shop' for the drone sector. With its drone expertise, NLR builds on its integrated knowledge of the entire aerospace chain, using its extensive test and research facilities for this purpose.

RESTRICTED AIRSPACE

HELICOPTER PLATFORM

NLR DRONE CENTRE

RUNWAY 320 M

NLR in brief


One-stop-shop
Global player with Dutch roots
100+
Since 1919
Amsterdam, Noordwijk Marknesse, Rotterdam, Volkel
Innovative, engaged and practical
For industry and government
For fixed and rotary wing
690 employees
€ 91 M turnover
73% Dutch, 23% EU and 4% international
Active in 30 countries
Extremely high client satisfaction

About NLR

Royal Netherlands Aerospace Centre

NLR is a leading international research centre for aerospace. Its mission is to make air transport safer, more efficient, more effective and more sustainable. Bolstered by its multidisciplinary expertise and unrivalled research facilities, NLR provides innovative and comprehensive solutions to the complex challenges of the aerospace sector.

NLR's activities span the full spectrum of Research, Development, Testing & Evaluation (RDT & E). Given NLR's specialist knowledge and state-of-the-art facilities, companies turn to NLR for validation, verification, qualification, simulation and evaluation. They also turn to NLR because of its deep engagement with the challenges facing our clients. In this way, NLR bridges the gap between research and practical applications, while working for both government and industry at home and abroad.

Royal NLR stands for practical and innovative solutions, technical expertise and a long-term design vision, regarding their fixed wing aircraft, helicopter, drones and space exploration projects. This allows NLR's cutting-edge technology to find its way also into successful aerospace programmes of OEMs like Airbus, Boeing and Embraer.

The development of drones is moving fast in every conceivable field. NLR has been leading the way for years. NLR has been providing theoretical training since 2013 and in 2015 it became the first institute to train drone operators in the Netherlands. It was also the first party authorised to certify drones for use in the Netherlands.

NLR operates as a “centre of drone expertise”. It offers expertise and facilities to provide valuable assistance to companies and governmental authorities, for example in designing, testing and certifying quieter drones that can fly further, as well as in integrating drones into the airspace (including in urban areas). NLR supplies the technology, assists with the operation and provides advice about policy and regulations. Furthermore, NLR can offer support in preparing civilian applications such as medical transport and incident response, and in research into defensive applications, e.g. counter-drones for events or interceptor drones.

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