



Socio-economic benefits from ESA Technology Transfers

A report for  esa

CASE STUDY: Drone Catcher

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From space debris to rogue drones: how a net-firing gun could help counter both problems

The market for drones is growing rapidly and this trend is set to continue. By 2026, it is forecasted that the global commercial drone market will be worth \$58.4 billion, growing an estimated 16% a year¹. As the technology improves, more opportunities for drone usage are opening - they are no longer a niche hobby or the reserve of military giants. **Drones are expected to compete with traditional systems in a huge number of applications,** from nature conservation to photography to delivery drone fleets, with companies such as Amazon, DHL and Google already expressing an interest².

Drones, or unmanned aerial vehicles (UAVs), are defined as aircraft who carry no human pilot or passengers³. They vary hugely in size, type and price. **Hobbyists can easily purchase a simple drone weighing a few hundred grams for under €100, without a license and with little or no paperwork, depending on the country.** Most drones aimed at the public weigh less than a few kilos and are essentially a toy. Middle range drones weighing 5-200kg⁴ are already in use commercially, for example, in real estate to give a bird's eye view of a property or in shooting Hollywood movies. While the largest drones are not available for purchase by the public and can weigh several tonnes⁵, typically being used for defence purposes, the majority of drones in use are small toys; of the 850,000 drones registered in the US, over 500,000 are recreational⁶.

Yet, alongside the growing possibilities opened up by drone technology comes new dangers. Firstly, there are safety concerns surrounding drone crashes - the blades could easily lacerate someone's skin if a crash occurs in a crowded area. There are also serious concerns about drones interfering with planes and helicopters, particularly following the 33-hour closure of Gatwick airport in the UK in 2018, following sightings of a drone on the airfield. Additionally, drones increasingly represent a security threat, since they can photograph sensitive areas and smuggle items across national borders or into prisons.

Drones also have the potential to disrupt large events, such as football games or concerts, spoiling the enjoyment of millions of fans, and have interrupted a number of high-profile sporting events in recent years. In January 2021, a drone suspended play for nearly 20 minutes in a Premier League football match (Brentford vs Wolves), as the referee was forced to send players



¹ Statista, 2021. *Estimated size of the global commercial drone market in 2021 with a forecast for 2026*. Available at: <https://www.statista.com/statistics/878018/global-commercial-drone-market-size/>

² European Environment Agency (EEA), 2021. *Delivery drones and the environment*. Available at: <https://www.eea.europa.eu/publications/delivery-drones-and-the-environment>

³ RAND, n.d. *Unmanned Aerial Vehicles*. Available at: [https://www.rand.org/topics/unmanned-aerial-vehicles.html#:~:text=An%20unmanned%20aerial%20vehicle%20\(UAV,remotely%20by%20a%20human%20pilot](https://www.rand.org/topics/unmanned-aerial-vehicles.html#:~:text=An%20unmanned%20aerial%20vehicle%20(UAV,remotely%20by%20a%20human%20pilot)

⁴ Drone Tech Planet, 2022. *How Much Do Drones Weigh?* Available at: <https://www.dronetechplanet.com/how-much-do-drones-weigh/>

⁵ Drone Tech Planet, 2022. *How Much Do Drones Weigh?* Available at: <https://www.dronetechplanet.com/how-much-do-drones-weigh/>

⁶ Federal Aviation Administration (FAA), 2022. *Drones by the Numbers*. Available at: https://www.faa.gov/uas/resources/by_the_numbers/

off the pitch until the drone left⁷. Sometimes there is clearly criminal intent, whilst in other incidents it is possible that members of the public simply do not understand regulation on drone use.

A different problem entirely...

Alongside the growing dangers of drone misuse, a completely different problem is developing several kilometres above our heads. Millions of pieces of space debris, fragments of past satellites and other items, are orbiting the Earth. These pieces of space junk pose a threat to working satellites and space missions in the event of a collision, with even the smallest items capable of damaging spacecraft at extremely high speeds. There have been several high-profile collisions already and satellites routinely undergo operations to avoid potential space debris. In this context, ESA has been investigating potential technologies to actively remove space debris through its Clean Space initiative.

Under ESA contract from 2013-2016 Italian engineering firm, Stam, developed a parametric simulator for active debris removal using nets, ARDiNET (Net parametric characterisation and parabolic test), in partnership with Polish firms, SKA and OptiNav. The system consisted of net simulation software, a net ejector and a capturing net, supported by a testing rig and camera system.



Italian engineering firm Stam was founded in 1997 and since then has worked on over 600 projects across a range of disciplines, including security and transport, energy and sustainable economy, space and defence, and robotics and industry 4.0.

The idea was further developed by Stam using European Commission Horizon 2020 funding under the ADR1EN (First European System for Active Debris Removal with Nets) project, with the involvement of Thales Alenia Space, Italy. The project developed the technology and tested in lab-simulated conditions, a scaled-up demonstrator of the net system.

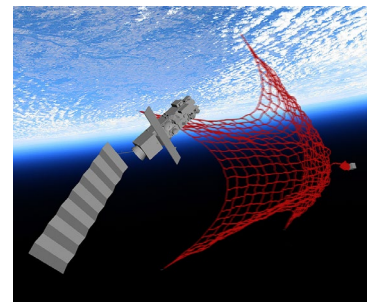


Image: Stam

Space technology brought down to Earth ...

This space debris technology is now being adapted to capture rogue drones on Earth. **Under ESA contract, Stam have leveraged their expertise developed on the ARDiNET and ADR1EN projects to develop a net-firing gun called Drone Catcher.** The system is designed for outdoor spaces where there is a large building or piece of infrastructure to attach the gun to, notably stadiums.

In the event that a drone enters the stadium, one of several Drone Catchers mounted to the stadium itself fires a net at high speed at the drone. The drone quickly becomes entangled in the net, aided by the motion of its blades, then is rapidly retrieved using a powerful motor, before it ever hits the ground. This was the key innovation for the terrestrial application: in space, a piece of debris could be slowly recovered, whilst in a busy stadium, it is crucial to quickly recover the drone to ensure the safety of the crowd, so a large motor had to be added to the system.

⁷ Sky Sports, 2022. Brentford vs Wolves: Drone stops play at Premier League match for 20 minutes in first half. Available at: <https://www.skysports.com/football/news/11748/12522672/brentford-vs-wolves-drone-stops-play-at-premier-league-match>

Potential for significant socio-economic benefits

Stam are still developing this technology, with **the most significant benefits expected in the future**, when the technology is fully commercialised. Still, even at this early stage, some benefits are already being realised through the technology development process.

Developing a drone catcher to solve an urgent problem

Commercial opportunities

Though the technology is still in development, Stam have plans to commercialise their Drone Catcher and are in conversation with potential partners alongside their technology development activities.

The global commercial market for drones is forecast to grow at a 16% CAGR, reaching \$58.4bn by 2026.

These figures⁸ highlight the fast growth of the drones market. As the market increases, alongside limited regulation of who can buy a drone and even more limited understanding of regulation surrounding where drones can be safely flown, there is an **urgent need for solutions** to tackle the rising problem of drones flying illegally, be this over a football stadium, hospital helipad or governmental buildings.

This presents a **clear market opportunity** and Stam, with their expertise developed in tackling space debris, believe that they are in a good position to enter this market with a competitive solution.

New market segments

Stam's engineering activities cover a wide range of markets, but this project is Stam's first to be focused on drones. Given the growth in the market for drones and expectations of continued market growth, this has the potential to be a fruitful area of business, offering **new market opportunities** to this well-established firm.

Furthermore, this project has broadened the business's experience and skillsets in a new market segment.

New networking opportunities

As part of the project, Stam have been involved in discussions with **major global players** in the aerospace, defence and security industries, notably the multi-billion-euro market player Leonardo, as well as experts in electronic defence, Elettronica, and MBDA, a world-leader in missile systems.

Though Stam had some existing relationships with companies such as these, this project has opened up new lines of networking, focussed on aerospace and security, providing new markets and avenues in which to work with these companies.

⁸ Research and Markets, 2021. *Unmanned Aerial Vehicle (UAV) Market by Point of Sale, Systems, Platform (Civil & Commercial, and Defense & Government), Function, End Use, Application, Type, Mode of Operation, MTOW, Range, and Region - Global Forecast to 2026*. Available at: <https://www.businesswire.com/news/home/20210624005687/en/58.4-Billion-Unmanned-Aerial-Vehicle-UAV-Markets-2026-by-Point-of-Sale-Systems-Platform-Function-End-Use-Application-Type-Mode-of-Operation-MTOW-Range---ResearchAndMarkets.com>

Occupying its own niche in the market

A ready-to-go solution suitable for enclosed spaces

Drone Catcher is a modular system which can be attached to the infrastructure of a stadium or other building. Once the net is loaded manually, the system is designed to be **automatic**, not requiring a person to provide ongoing operation of the gun. This means that once a drone is spotted, the system can quickly be made operational, minimising any interruption or disturbance. There is no need for spectators to evacuate and the drone can quickly be removed from sight, with minimal interruption for the crowd at large events.

After use, the net can be reused, and the system can be quickly reloaded ready to be used again. This is in contrast to drone-based net capture solutions whereby the capture drone has a limited battery life (one solution currently available has 30 minutes airtime) and must be recharged before use.

Furthermore, unlike some other solutions, the Drone Catcher is **suitable for use in enclosed spaces**. Some drone removal solutions are mounted on vehicles, so would be unsuitable in many stadiums, for example.

Safety for crowds

The Drone Catcher can be **safely used in a crowded stadium**: the drone is swiftly retrieved in one piece, **never falling a below a 3m height**

Unlike some other potential solutions, the Drone Catcher can be **safely used above crowded areas**, such as stadiums. This is a key advantage of Stam's solution and is derived from two important design features.

Firstly, the solution is **non-destructive**, i.e., does not destroy the drone it captures. A net is shot at the drone and quickly becomes entangled within it. This is unlike many other drone removal solutions which use rubber bullets to take down drones, destroying them in the process - this technique is risky in crowded areas, where bits of shrapnel from the drone could injure those on the ground.

Secondly, the Drone Catcher uses a **powerful motor** to quickly reel in the net and drone after its capture. The net is reeled in fast enough that even at a distance of 30m from the gun, the drone should never get within 3m of the ground, leaving a safe distance between peoples' heads and the captured drone. This is a key advantage of Stam's technology - even other net capture solutions tend to use a parachute to slowly lower the entangled drone to the ground, but this is impractical and potentially dangerous above a crowded space.

Compatible with a wide range of drones

Stam have designed their system to take down drones weighing up to 8kg, although further testing will be required to reach this weight in practice.

This **weight limit goal exceeds that possible by drone-based net capture systems** available on the market, with one competitor solution only capable of taking down drones under 6kg. Other technologies not using nets can take down larger drones, but these technologies have their own disadvantages. Notably, they tend to be destructive solutions and therefore unsafe for a stadium

environment. Though drones may weigh considerably more than 8kg (e.g., military drones), most recreational drones available at an affordable price to the general public weigh less than 5kg⁹.

Furthermore, Drone Catcher is **compatible with self-piloting drones**. Some drone removal technologies use jamming to disrupt the signal between a drone and its pilot. Once this signal is interrupted, the drone will typically 'return home' and cease to be a disturbance. This technology is effective for piloted drones, but not for self-piloting drones, as this class of drone uses artificial intelligence to fly autonomously and carry out routine tasks without a human pilot and is thus immune to jamming technology. Drone Catcher therefore has the potential to take down a wide range of drones.

Keeps evidence intact

A non-destructive solution confers other benefits besides increased safety. Keeping the captured drone intact **allows for forensic analysis** and means the drone itself can be used as **evidence of a crime**.

For example, if the drone has been used to **illegally photograph an area**, these images may be more easily recoverable when a non-destructive solution is used. Additionally, the system can be tested without needing to replace the drone every time a test is conducted.

Providing real economic benefits to end users

Reliable means to eliminate threats from drones

Given its **fixed position, wide ranging drone compatibility** and relative **technical simplicity**, the Drone Catcher offers a reliable drone removal system. This means that management at stadiums, concert halls, airports, prisons, hospitals and other end users can be confident that drones will not interrupt events or important work activities, offering strong peace of mind.

Furthermore, the installation of a drone capture system may **act as a deterrent** to potential disruptors given the drone will likely be taken by the end user and could be used as evidence in legal proceedings.

Cost effective

Drone Catcher aims to be **priced competitively** compared to other solutions on the market, since the ejector system is relatively inexpensive, and the net can be reused.

Unlike other solutions suitable for a stadium environment, the system is **automatic and unmanned**, requiring human involvement only to replace the net into the ejector after use. This is in comparison to, for example, handheld guns to fire nets. Additionally, it does not need to be mounted on a vehicle or drone itself. This further reduces the costs associated with the Drone Catcher system in comparison to competitors.

Cost savings from prevented disruption

A major benefit to customers is the **avoided costs associated with disruptions** to events. Though there is not full evidence on the exact costs incurred to sports and athletics stadiums in past incidents, it can be extrapolated that any incident stopping or significantly disrupting a game/performance has the potential to incur large costs to the venue in ticketing refunds and lost revenue, since the event must be suspended until the drone is removed or leaves the stadium. For example, in 2021, the cheapest ticket to a Premier League Manchester United football game cost

⁹ Drone Tech Planet, 2022. *How Much Do Drones Weigh?* Available at: <https://www.dronetechplanet.com/how-much-do-drones-weigh/>

£31 and the club's stadium (the Old Trafford) has a capacity of 74,140, indicating the type of potential cost impacts, not to mention possible lost television broadcasting revenues.

One incident of serious damages from a drone interrupting a match occurred in 2014. A Euro 2016 qualifying match between Serbia and Albania was abandoned due to a drone flying a politically-motivated flag over the stadium. This sparked a fight including players and fans, causing the game to be abandoned. Not only did fans have to leave the stadium, but both countries were fined €100,000 for the incident¹⁰.

On a much larger scale, one source estimates that the 33-hour closure of the Gatwick runway due to drone disruption in 2018 cost the airport and airlines £50-70m¹¹. By implementing a solution such as Drone Catcher, customers have the ability to safeguard themselves against cost incursions.

It is estimated that the **33-hour closure of Gatwick airport cost £50-70m.**

Spectator enjoyment

The recent disruption caused by drone flying above the Brentford vs Wolves Premier League football game in the UK demonstrated the frustration felt by fans. Home fans chanted their anger against whoever was flying the drone in the match, whilst others took to Twitter to voice their annoyance after the match¹². Whilst there was clearly some novelty in the drone interrupting play, fans were more satisfied when the drone flew off and the match resumed. Such incidents can ruin the enjoyment of paying customers, affecting both those at the stadium and those watching from home. Drone Catcher could therefore help maintain a stadium's **strong brand and reputation** by having a fast solution to deal with interruptions.

With wide-ranging potential applications and benefits...

Potentially life-saving applications

In summer 2021, an air ambulance helicopter came within a few feet of collision with a drone when attempting to land at a London hospital¹³. An official incident ruling found that, "a definite risk of collision had existed" and eyewitnesses saw the drone being deliberately flown into the path of the helicopter and encircling it, all the while there was a critically ill patient on board. In this incident, the drone flew off and the helicopter was able to safely land, yet incidents of drones intercepting planes and helicopters are rising and there is no guarantee that whoever is flying the drone will leave quickly.

Stam's Drone Catcher could be used to **protect hospital helipads**, used in much the same way as in stadiums. Indeed, the fast turnaround associated with the system could be critical in these scenarios, where every second counts in getting patients the urgent care they need. With the system ready-to-go and automatic, drones could be quickly captured and then removed from the airspace extremely fast with Drone Catcher's motor.

¹⁰ The Guardian, 2015. *Albania awarded 3-0 win after Serbia match abandoned over drone stunt*. Available at: <https://www.theguardian.com/football/2015/jul/10/albania-serbia-match-abandoned-drone>

¹¹ Calder, S. (2019). *Gatwick drone disruption over Christmas cost £50m*. The Independent. Available at: <https://www.independent.co.uk/travel/news-and-advice/gatwick-drone-airport-cost-easyjet-runway-security-passenger-cancellation-a8739841.html>

¹² Inews, 2022. *Brentford's game against Wolves temporarily suspended due to a drone above the stadium*. Available at: <https://inews.co.uk/sport/football/brentford-wolves-temporarily-suspended-drone-flying-above-stadium-1417746>

¹³ DroneDJ, 2021. *London helicopter ambulance reports near collision with drone*. Available at: <https://dronedj.com/2021/07/02/london-helicopter-ambulance-reports-near-collision-with-drone/>

National security potential

Drones often carry cameras to photograph or video the ground below. In a football game, illegal use of a drone may compromise licensing laws, but the photographing of governmental buildings or other sensitive locations presents a serious threat to national security.

Early in 2022, drones were spotted flying over a number of **sensitive locations** in Sweden, including a nuclear power plant, parliament and government buildings and the royal palace in Stockholm¹⁴. The country's national security service took the lead in the investigation, demonstrating the severity of the incident. Drone Catcher could potentially **aid national security** in similar future incidents, if installed in governmental buildings, power plants, and other important infrastructure.

Keeping prisons safe

In 2018, a convicted kidnapper broke out of a maximum security American prison using wire cutters which were flown into the prison using a drone¹.

The **smuggling of contraband into prisons using drones is a growing threat**, such as in the example above¹⁵. Items smuggled in include drugs, money, phones and weapons, posing a threat to prisoners and staff, as violence breaks out over contraband¹⁶.

Drone Catcher could potentially be installed around outside spaces in prisons to capture these drones and confiscate contraband. Other jamming solutions are being tested on prisons¹⁷, but these have the disadvantage of sending the drone back to its owner with the contraband still attached, in addition to being highly expensive.

Would these benefits have been realised without ESA?



ESA have played a key role in the development of the Drone Catcher. The original ADRiNET project, which gave rise to the net ejector system, was ESA funded as part of ESA's Clean Space initiative to tackle space debris. The European Commission funded the ADR1EN project, which developed this concept, but Stam then returned to ESA for the **technology transfer** funding. In August 2021 Stam completed an ESA proof of concept study. ESA have therefore been instrumental to this project.

'Stam wouldn't have developed the technology without ESA, or would have been forced to find alternative funding solutions, since the development of the drone catcher required entry into a new market and field tests, which are expensive. Even for conversations with industry actors in the security sector, having ESA as a connection and with their name attached was greatly beneficial.'

Alberto Landini, Stam

¹⁴ BBC, 2022. *Sweden drones: Sightings reported over nuclear plants and palace*. Available at: <https://www.bbc.co.uk/news/world-europe-60035446>

¹⁵ CBS News, 2017. *Prison officials believe two-time escapee used drone in latest jail break*. Available at: <https://www.cbsnews.com/news/prison-officials-believe-two-time-escapee-used-drone-in-latest-jail-break/>

¹⁶ BBC, 2022. *Drugs, weapons 'smuggled to prisoners by drone'*. Available at: <https://www.bbc.co.uk/news/world-us-canada-60262715#:~:text=Contraband%20smuggling%20by%20drone%20has,tackle%20drone%20threat%20to%20prisons%22>.

¹⁷ Guardian, 2018. *Anti-drone technology could be introduced in English prisons*. Available at: <https://www.theguardian.com/society/2018/dec/18/anti-drone-technology-introduced-english-prisons-skyfence>

... with further development and benefits to come

The Drone Catcher is currently at TRL4, following testing as part of the ESA proof of concept study in summer 2021. Stam have a prototype device, which they tested on a real drone in an athletics stadium. Unfortunately, Stam were unable to test on a stadium building due to challenges such as covid restrictions, testing from a large crane instead, which limited the lateral force they could apply to the system, so only lightweight drones were tested. Despite this limitation, **Stam successfully captured a number of drones and retrieved them without the drone falling within 3m of the ground.**

In the future, Stam plan to perform tests at full power and realise the full design of the Drone Catcher. In addition, they hope to partner with another firm who will supply the targeting system, to provide the automatic detection and targeting of the drone. Stam are confident that they occupy a market niche and a **strong commercial opportunity** exists for this product.