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Multipurpose River Drone

The potential of multipurpose river drones can open up numerous applications for users. Low production costs, remote control, and autonomous navigation all provide significant advantages while minimising the need for human intervention. Their development, driven by the integration of modern 3D printing and robotics technologies, further expands their range of application, reduces logistical demands, and enhances operational efficiency.

Keywords: *river drone, suicide drone, 3D printing*

Introduction

Today, Hungarian river operations are concentrated on the Danube, Lake Balaton and navigable domestic rivers, as Hungary is a landlocked country, so military activity is mainly conducted on the rivers and Lake Balaton. For the Hungarian Defence Forces (hereinafter: HDF), riverine warships and watercraft play a role in strengthening national defence capabilities. The HDF 1st Engineer and Riverine Guard Regiment's Naval Subdivision primarily ensures the protection of waterway navigation using mine-clearing vessels, EOD patrol boats, and smaller floating technical equipment. This unit is undergoing continuous modernisation and is increasingly adapting to modern military technology developments.

Special attention in naval operations is given to reconnaissance, defensive, and support missions conducted along rivers and lakes, which contribute to national security and regional stability. The HDF regularly participates in international exercises (such as the "Iron Cat" joint navigation exercise with neighbouring Serbia), where the role of waterborne combat vehicles is gaining increasing emphasis. These types of military-technical developments ensure that the Hungarian armed forces are capable of responding effectively to various international conflicts and situations, taking into account the requirements of modern warfare.

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The drones

Innovative ideas and continuous technological development are fundamental in overcoming the challenges of the future. In many cases, concepts that may not seem feasible at first can later form the basis for groundbreaking innovations. Therefore, it is important to think boldly about potential technological advancements, even if they do not seem realistic today. Such in-depth, even daring thinking can not only point to new directions but also provide inspiration that promotes future progress. Technological innovation often emerges from ideas that initially appear impossible, and it is precisely these bold dreams that can lead to the next major breakthrough.

Drones – unmanned aerial and water vehicles – have undergone significant transformation over the past decades and have become indispensable in many areas of life. In the civilian sphere, they have opened up new opportunities across various industries, such as agriculture, logistics, construction, as well as disaster response and life-saving operations (for example, in surveying disaster areas that are difficult or impossible to access for rescue and search services). Their extraordinary importance and wide applicability have also been recognised at the tactical level. With increasingly advanced sensors and cameras, these devices have made aerial surveillance, data collection, and transport not only faster but also safer.

However, drone technology development is not limited to aerial applications: the combination of watercraft and drones has opened new directions in research and development, especially in the field of river drones. The development and deployment of these drones offer numerous new possibilities in water transport, underwater monitoring, and even water-based rescue operations.

In the following, we will examine the key aspects of designing and building river drones, as well as the innovative opportunities these devices can offer. Today, technological advancement is rapidly and profoundly transforming the norms of the battlefield. Our aim is to propose a concept for the application and development of a strategic multipurpose drone, using existing, easily accessible, and quickly replaceable tools and components.

Historical outlook

The use of unmanned floating combat devices deployed against enemy positions is not unfamiliar across various historical eras – in fact, such tactics have sometimes served as decisive moments in battles, campaigns, or even entire wars. In naval battles of the 15th century, the deployment of so-called “fire ships” was prevalent. These were not only set ablaze but were also filled with various explosive materials (tar, sulphur, black powder, oil, overloaded and plugged old or damaged cannon barrels, iron nails, balls, and other debris functioning as shrapnel).[3]

[3] Coggeshall 1997.

These sailing ships were equipped with the necessary munitions and held in reserve until the right moment for deployment. Opposing fleets typically lined up in tight battle formations, which greatly enhanced their effectiveness in combat. Fire ships were primarily intended to disrupt these formations, and secondarily, to destroy individual enemy ships (also sail-powered, and highly flammable due to sails, ropes, wooden hulls, oil, grease, gunpowder, etc.) by setting them on fire.

When the right moment came – namely, when the fleet had manoeuvred into a position to gain the wind's advantage (i.e. receiving a tailwind blowing toward the enemy) – the crew set the sails and rudder of the fire ship to point in the direction of the enemy, secured them in place, ignited the explosives and the ship itself, and escaped in small boats. From that point onward, the ship, now unmanned and uncontrollable, drifted directly toward the enemy's fleet formation.

The enemy could only evade the flaming, exploding, fire-spewing vessel by breaking formation and scattering to avoid the threat. However, in doing so, they lost much of their battlefield efficiency and became significantly more vulnerable to defeat by the still cohesive attacking fleet.

A striking and – retrospectively – decisive example of this tactic occurred on 8 August 1588, in the English Channel during the battle between the Spanish "Invincible Armada" led by Admiral Medina Sidonia, and the English fleet commanded by Admiral Hawkins and his Co-Commander Sir Francis Drake. The smaller, more agile English ships had been unable to break the Spanish crescent shaped formation – curving forward on both flanks toward the enemy – using artillery fire alone. The Spanish, in turn, could not catch or force the English into close combat due to their slower, heavier ships.

This stalemate was broken by a pre-dawn fire ship attack launched by the English fleet. As a result, the Spanish formation was disrupted, and the swift English vessels seized the opportunity to attack the now scattered Spanish ships individually. In the battle that became known as the "Battle of Gravelines" the cohesion of the Spanish Armada was shattered, marking the beginning of its slow but inevitable destruction.[4]

Benefits of water drones

Nowadays, the production and application of aerial drones have reached such a high level that they may call into question the relevance of drones used on water. In the case of an aerial strike, the drone's range of movement is significantly wider, and achieving the desired destructive effect requires a much higher level of operator expertise. It can also move beyond the water surface, is highly manoeuvrable, and provides the operator with a more comprehensive, "bird's eye" view of the given situation.

[4] Erdődy 1979: 210–212.

Aerial drones offer many advantages; however, they do have one major drawback. When used against sea or river vessels, they are not particularly effective, as small-sized drones are incapable of carrying large amounts of explosives. Transporting a larger payload requires a larger body and increased power consumption, which can only be achieved by increasing the battery size – yet this is far from cost-effective.

Currently, the number of drones deployed on rivers remains negligible. However, many companies are now placing strong emphasis on the development of riverbed mapping technologies, with a particular focus on the benefits offered by low draft depth and minimal engine noise. These characteristics not only enable more efficient reconnaissance but also improve measurement accuracy while minimising environmental disruption.

The Black Widow 2 drone – designed for river reconnaissance and, if necessary, explosive transport – was developed in early 2025 in response to the challenges posed by the ongoing Russia–Ukraine war (Figure 1).

Figure 1: Black Widow 2 river drone
Source: Litnarovych 2025

This type of drone has a range of 10 km, can carry a payload of 3 kg, is only 1 m long and has a total cost of $2700. The manufacturer of the product is capable of producing up to 100 devices per month.[5]

Sea drones

The suicide drones born from the Ukrainian–Russian conflict have proven to perform effectively both on water and in the air. "In 2022, Ukrainian President Volodymyr Zelensky launched a fundraising campaign to build a fleet of naval drones to protect Ukrainian cities from Russian

[5] Litnarovych 2025.

missile strikes launched from Black Sea ships."[6] The issue described above resulted in a fast and cost-effective solution. "These drones, powered by water jets, can reach speeds of up to 80 kilometres per hour. During deployment, the operator uses an onboard camera to identify targets and then directs the drone at high speed toward the objective. Two fuses, sourced from Russian aerial bombs, are mounted in the nose of the naval drone, which trigger the warhead upon impact with the enemy vessel's hull"[7] (Figure 2).

Figure 2: Explosive Uncrewd Surface Vessel (USV)
Source: https://x.com/CovertShores/status/1678696313989517313?mx=2

The aforementioned case is a good example that waterborne drones can hold their own alongside their airborne counterparts. Drones developed for use against naval vessels must be capable of overcoming waves and covering long distances due to their maritime operating environment. Achieving long range capabilities (248 miles, approximately 400 km)[8] requires high battery capacity and long distance remote control. Consequently, adapting to maritime conditions necessitates the use of a larger body.

In contrast, river-based applications do not require long distance travel (20–30 km), nor is a large hull necessary to deliver an explosive payload. Additionally, the desired impact can be achieved with a smaller explosive charge.

Application areas

In general, its biggest advantage during application, as with all drones, is the distance from dangerous environmental areas.

6 Hirado.hu 2023.
7 Hirado.hu 2023.
8 Interesting Engineering Official 2023.

In transportation

One of the most cost-effective methods of transportation is shipping by water, which has played a key role in global trade for centuries. The main reason for this is that maritime transport allows for the movement of large quantities of goods over long distances at relatively low operational costs. Ships can carry extremely large volumes of cargo from one point to another at once, dramatically reducing the cost per ton of transport. Waterborne transport is also more fuel-efficient than road or rail transport, as ships encounter less resistance while moving through water, thus requiring less energy for propulsion.

However, this form of transport can also be highly vulnerable: even a single suicide drone can be sufficient to disable a ship's hull. To immobilise a ship, it is enough to render the propellers inoperable by directing a suicide drone into them. As a result, the supply cannot reach its destination on time.

If equipped with proper reconnaissance tools (such as radar), it is possible to detect and neutralise a floating technical device directed at our ship's hull. However, the speed and rapid manoeuvrability of such devices significantly complicates the elimination of a moving target.

Against floating mines and river locks

They can be effectively used against floating mine barriers without endangering personnel or equipment. Their drawback, however, is that they are only effective against floating mines or explosive devices floating on the surface of the water.

In the case of river barriers – such as chains or nets stretched below the waterline, or buoys connected and stretched across the river surface – they can be effective in stopping floating drones. In our opinion, the most suitable solution for stopping drones is a stretched net and buoy system. However, overcoming these is not impossible. To break through, multiple drones are required. We believe that by detonating water drones caught in the barriers, a passage can be opened through the river obstacles, allowing the following drones to pass.

It is also worth mentioning that physical river barriers not only hinder the movement of the enemy but also reduce the mobility of friendly forces and slow down the transportation time necessary for resupplying. On 29 October 2022, Ukraine launched an attack against Russian warships stationed at the port of Sevastopol, prompting the Russian leadership to build a line of defence at the port entrance in order to protect the base of the Russian naval fleet.

Application against coastal targets

It can also be suitable for targeting various coastal objectives, such as destroying port infrastructure, stored equipment, floating structures, dams, or dry docks. In our opinion, significantly more explosive material would be required for demolishing bridge piers, which would necessitate a larger carrier body. This would result in reduced speed and a decrease in camouflage effectiveness due to the increased size.

Against crossing and amphibious troops

Suicide drones can be tactically deployed against amphibious troops crossing rivers, as well as against temporary floating bridges or ferries facilitating the crossing. These devices can effectively neutralise enemy troop movements and disrupt infrastructure essential for river crossings. Against units using small floating craft (e.g. inflatable boats, assault boats), the destructive radius of suicide drones can be increased by filling them with shrapnel. Based on the operating principle of infantry landmines, the primary objective is not necessarily total destruction, but rather rendering technical equipment or human resources combat-ineffective, and producing indirect effects such as disrupting enemy troop movements, breaking the logistical chain, or lowering morale.

"Camouflage"

One of the main disadvantages of aerial drones, in our view, is that their wings, rotors, and lightweight structures are fragile and difficult to camouflage due to their shape. Water-based drone bodies, on the other hand, may be more suitable for long-term deployment in operational areas, hidden among fallen trees or reeds. Thanks to larger battery capacities, we believe these drones can remain in a dormant state for several days, even behind enemy lines. Their power supply can be ensured in an environmentally friendly and sustainable manner – for example through the use of solar panels that harness solar energy to continuously recharge the batteries required for operation thereby enabling extended mission durations.

Reconnaissance tasks

Like most drones, water-based drones should also be equipped with cameras that provide a continuous live feed to the operator while recording footage. As such, they are well-suited for various reconnaissance missions, such as conducting river reconnaissance without endangering human life and collecting necessary data (e.g. riverbank structures, terrain suitable for launching or fording operations, etc.).

Possibilities for developing a river drone

We consider it advisable to develop a multi-purpose riverine drone capable of covering a significant portion of the aforementioned application areas. The core idea is to create a watercraft that can be produced quickly and cheaply – even near combat zones – using 3D-printed hulls and existing, widely manufactured explosive materials or devices containing large amounts of explosives.

Devices manufactured and used in the former Warsaw Pact countries — such as the warhead of the PG-7 anti-tank grenade, the FRT-2.5/5 demolition charge (2.5 kg / 5 kg), and TNT pressed charges – can still be found in large quantities in many Eastern European countries today. The electric detonator required to initiate these explosives can be powered by the same battery pack used to propel the drone. The triggering mechanism can be made safe with a simple arming circuit.

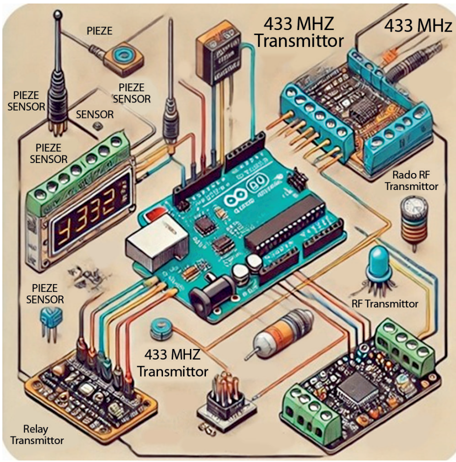

Figure 3: Illustrative figure
Source: compiled by the authors with an AI platform

It may seem necessary to create a body whose hull part consists of modular elements, so that the hull's capacity can be increased or decreased, or possibly replaced modularly, therefore it is advisable to consider a hull design whose properties can offset the possible deterioration in speed and manoeuvrability, such as a catamaran-shaped body. Thus, depending on the task to be performed, the number of explosives and even its shape can be increased. A narrower body allows for lower resistance to water, thus increasing speed and manoeuvrability.

One of the most common methods of 3D printing is the FDM nozzle-pulling process. "The essence of their operation is that a coiled plastic thread, called filament, is placed in a dispensing head unit, which uses a gear to push it into the next component of the print head, the »hotend«. The »hotend« is heated to the appropriate temperature (usually between 200–215 °C) by a heating wire, where the filament melts and, under the influence of the dispensing gear, is extruded through the nozzle at the end of the »hotend« onto a heated tray, where it solidifies again."[9]

3D printing seems like an obvious technology, but it is important to highlight one key factor. 3D printed objects are printed layer by layer, "laid down" by the printer, which results in air-filled "compartments" within the layers of the printed body, which leak through the body under high water pressure, creating a capillary effect.

[9] Ember–Ádám 2022.

There is already a solution to the above mentioned problem: "Diamant Dichtol is an internationally protected brand, suitable for repairing micropores, hairline cracks and finer material distribution irregularities up to 350 bar pressure."[10] This technology works by keeping the printed piece in the liquid following the prescribed parameters. During this time, the liquid fills the capillaries, then, when removed from the special liquid, it "drys" in the capillaries, thereby blocking the path of water and ensuring the waterproof effect.[11]

Considering the above, we believe that 3D printing technology is excellently applicable in the manufacture of hulls, especially for the production of floating bodies for multi-purpose drones. One of the main reasons for this is that in this type of device, the hull is not subjected to such high pressure, since they mainly move on the water surface. 3D printing offers the opportunity for easy and cost-effective production, as well as the ability to customise the hull design, which is especially beneficial for innovative and rapidly changing design requirements. In addition, significant savings can be achieved by optimising material use, while ensuring the necessary functionality and durability.

> "The military application of 3D printing is currently still in its infancy in most countries around the world, but it is now used in many places in the development of military equipment, primarily for prototype production purposes, or less frequently for the production of finished products. At the same time, the application of the technology to the production of various parts, accessories and the reproduction and replacement of worn-out elements can significantly accelerate the production, supply and repair processes, minimising the time between the emergence of a need and the production of a finished product. The implementation of the procedure in stationery and field conditions can also simplify logistics processes and thus the supply chain, since the use of 3D printers provides the opportunity to produce the necessary equipment locally."[12]

> "As 3D prints aren't naturally waterproof, we will need to waterproof them. You can print with more walls of plastic, use higher layers or extrude slightly more plastic, and those do help to reduce the permeability of the print. However, that would use a lot more plastic, especially for a very large print like our boat. Instead, we sealed the outside of the print using some clear coat spray. I did attempt this with lacquer but I prefer the clear coat spray as it contains acetone, so it actually melts the plastic together to create a barrier."[13]

The practical applicability of 3D printed hulls is exemplified by the work of the startup company IMPACD. This innovative company produces ships that are not only efficient and durable, but also environmentally friendly. IMPACD places particular emphasis on the use of recycled materials, many of which can even come from household waste. This approach not

[10] See: https://hujberkft.hu/hu/termekek/diamant/dichtol/
[11] CPSdrone 2024.
[12] Gál–Németh 2019.
[13] Arctic Challenge 2022.

only promotes sustainability, but also reduces production costs, while contributing to the recovery of waste. Such innovative solutions clearly demonstrate how 3D printing can be effectively integrated into modern industrial processes and how it can serve as the basis for environmentally conscious technological development.

If we want to make our hulls more cost-effectively and do not want to rely on any external suppliers, as this may pose potential logistical problems, which is not advantageous when fighting a battle, it is worth building our own multi-purpose river drone. In this case, we can make our device without compromises, and we can also build a drone that is capable of performing all the operations we need on its own and at the same time (reconnaissance, water obstacle removal, destruction). With the development of technology, we have also been able to ignore the battery life. It is not a new thing to be able to continuously charge our drone by installing a solar panel.

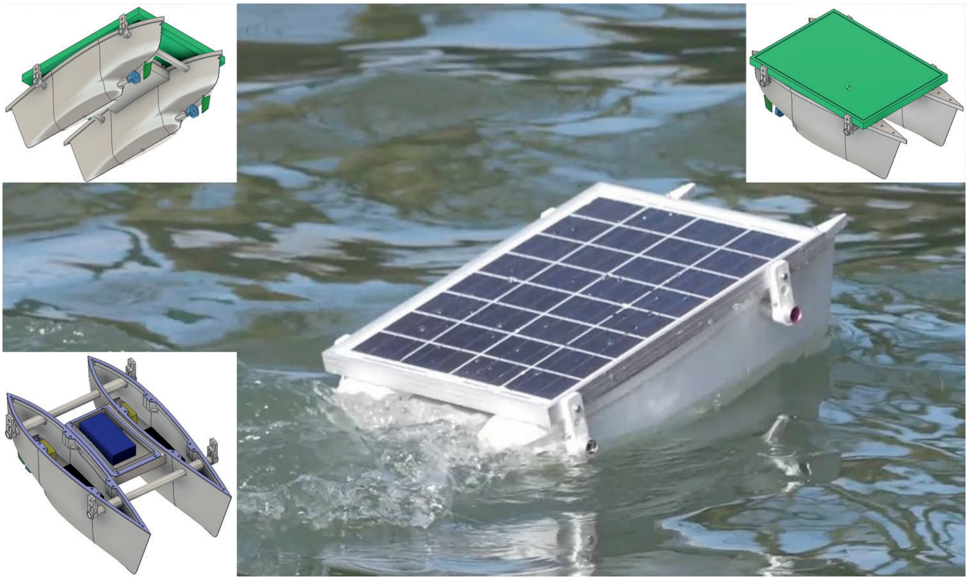

Figure 4: Solar RC Catamaran with 3D Printed Hulls
Source: https://www.thingiverse.com/thing:5421605

After installing the solar panel, another opportunity opens up for us, namely that we can deploy our device well in advance, even camouflaged (the camouflage problem mentioned above is no longer a problem today, as technology already allows the use of glare-saving solar collectors) in areas where we can expect enemy movement. This avoids endangering human life and exposing our troops, since our drone operates like a house with an off-grid stand-alone solar panel system.

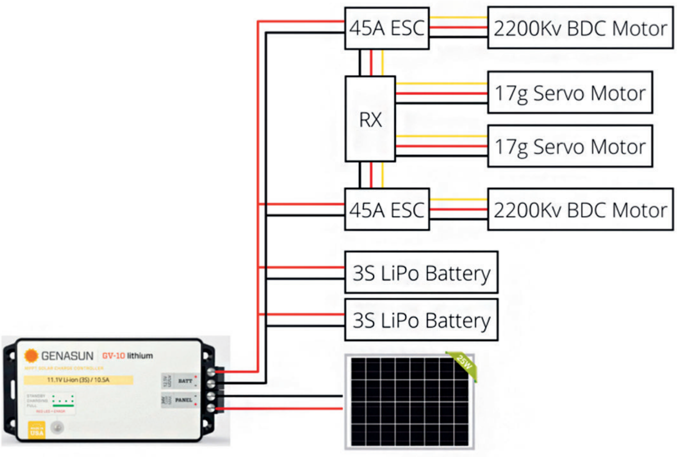

Figure 5: Possible wiring diagram
Source: https://www.thingiverse.com/thing:5421605

Depending on the size of our drone, we can also consider additional options, for example, we can build in a small radar that can map the riverbed to a depth of about 9 m, so we can detect fixed river mines, or even find the most suitable section of the coast for crossing without the use of fossil fuels and with minimal noise. Additional development options, such as a thermal camera, night vision, and a SIM card adapter to increase the control and image transmission distance, offer developers numerous research alternatives.

Conclusion

3D printing and robotics have undergone revolutionary changes in the past decade, not only transforming our daily lives, but also having a significant impact on military and civilian applications. These technologies offer innovative, cost-effective and rapidly adaptable solutions that open up new possibilities in modern warfare. Such advanced systems not only increase the efficiency of operations, but also significantly contribute to maintaining personal safety. Automated tools and 3D printed equipment allow soldiers to perform even more complex and dangerous tasks while minimising human losses and maximising efficiency and precision. These technologies are particularly important for modern armies, as they allow the development of specialised tools and systems that can be quickly adapted to specific operational needs. For example, 3D printing can be used to produce drones, components or even entire platforms required for military operations in a short time, which can be easily adapted to different terrains and target tasks. This flexibility allows one device to be used simultaneously in river, air and land operations, while minimising production and maintenance costs. With further integration of robotics, these drones can become more intelligent, capable of autonomous decision making, real-time data collection and analysis, and more effective communication with other units. This significantly increases the overall effectiveness of operations, while reducing reaction times and improving logistical support. In the future, the development of these technologies will further enhance the effectiveness of military systems. In my opinion, such developments will allow 3D printed drones to be used with minor modifications by other military units. This allows them to be effectively used not only in river operations, but also in air or land operations. It is of paramount importance for modern armies to master these new technologies and integrate them into their daily operations. With this knowledge and technology, the Hungarian Defence Forces can continue to be one of the most decisive and advanced forces in the region, one that not only responds to the challenges of the times, but is also able to actively shape them. Therefore, it is vital that we not only consider the opportunities offered by 3D printing and robotics, but also make them a central part of our strategy and development plans.

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