Brief history of UAV development

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BRIEF HISTORY OF UAV DEVELOPMENT

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In this article, the authors present the technical development of the drones from the beginning to the present. The reader will get to know the most important periods and events of the drone's military application. At the end of the article, the authors summarize the four main purposes of military use of drones.

Keywords: *Flying Bomb, Pilotless Target Aircraft, Unmanned Aerial Vehicle, UAV, drone*

INTRODUCTION

The human's desire to fly high in the sky emerged as early as its common sense. However, it took a long time to make this dream real. A large number of scientists had worked on this topic and it had demanded so many brave people's life, until finally men could ascend from the ground. By that, people's enthusiasm towards the aviation led to success. At first they conquered the air by balloons, later by airships, and finally with airplanes.

Meanwhile, the idea to use a machine that can fly without a person on board has always been in the researchers mind. This idea is not surprising at all, because such a system's advantages are obvious. We don't have to count with the death of the on-board personnel, if the aircraft is destroyed for some reason. In addition, we can use them for such boring tasks, like aerial reconnaissance. Finally, their financial advantage is unquestionable, due to the fact, that in general a UAV's[1] price is lower than the price of a conventional aircraft.

Similar to a lot of objects that are used even in the civilian life, UAVs are the results of the developments carried out during military conflicts. Even though there were some unmanned balloons used as early as the middle of the 18th century to destroy the enemy, in my papers I examine only the heavier-than-air UAVs. These type of aircraft appeared in the First World War that's why I started to study the history of unmanned aerial vehicles from this date. I divided the history into four eras, which are separated by the milestones of the development, subsequently by the military conflicts. As nowadays every nation has their own UAV research program, I found it important to present some of the Hungarian developments too, in the chapter where I describe today's drones[2].

Nowadays unmanned aerial vehicles are invaluable assets for each modern military. We seldom can find a country, whose military does not possess any type of UAV. So we can say that the history of their development is part of the history of military technology.

[1] UAV – Unmanned Aerial Vehicle
[2] Drone – Expression used for the Unmanned Aerial Vehicle

FROM THE BEGINNING OF AVIATION TO THE END OF WORLD WAR II

In 1903 with the first flight taken by the Wright brothers, developments in aviation accelerated and soon the first Unmanned Aerial Vehicle was created. It was the time of flying bombs, which is a manned or unmanned aerial vehicle or aircraft carrying a large explosive warhead, a precursor to contemporary cruise missiles. In contrast to a bomber aircraft, which is intended to release bombs and then return to its base for re-use, a flying bomb crashes into its target and is therefore itself destroyed in its attack. During the First World War it was very difficult to replace the lost airplanes and pilots, which happened quite frequently due to the mass introduction of warplanes. To solve this problem, military leaders started to think about using Unmanned Aircraft, in certain missions. According to the theory of Douhet, a nation's resistance could be broken and a country could be defeated by terror bombings. The use of flying bombs seemed to be a good asset for this task.

The first prototype of such a machine was linked to the American Elmer Sperry, who created an aircraft that was controlled by autopilot. Military professionals saw big potential in the UAV and they gave seven Curtis N-9s to be mounted with this autopilot system. First test flights were carried out in 1917 with a pilot in the cockpit. This pilot was responsible for the take-offs and landings. However, the other phases of flight were guided by the autopilot. After flying 48 km the bombs were ejected, but it couldn't hit closer to the target than 3 km.

Another flying bomb, the Kettering Bug [Figure 1.] was completed in the November of 1917. It was ordered by the US Military and constructed by Charles Kettering. The fuselage was created by Orville Wright, the control and navigation system was developed by the topic's expert, Elmer Sperry who created the automatic airplane that was mentioned above. After take-off the small sized, biplane was guided by the automatism in the direction of the target, where when the preset time passed, the engine stopped, the wings fell down. The torpedo shaped body- filled with 80 kg explosive- hit the target and exploded. [13] The 40 HP 4 piston Ford engine could accelerate the aircraft to 100 km/h. Although the construction was successful, it didn't participate in the war, because by the time the U.S. Military put it into service, the war had ended.

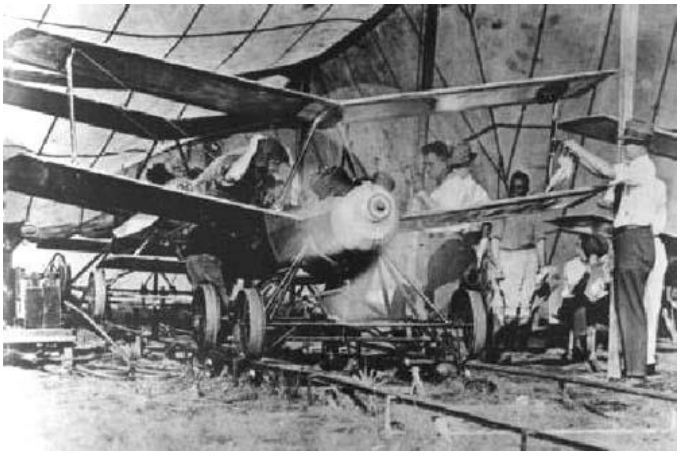

Figure 1. Kettering Bug being prepared for take-off

After the First World War, fighter aircraft became faster, stronger and more maneuverable. This change affected the method of training of the pilots and the air defense personnel. In order to simulate how to act against these air targets, Pilotless Target Aircraft or PTA[3]s where developed. A program with the aim of developing such an aircraft ended up in the creation of the Queen Bee in the United Kingdom. This new type of UAV meant a breakthrough and was a real innovation. It was the first system with the capability of returning after completing its mission, unless it was hit. The remote control system was mounted into a De Havilland DH 82 Tiger Mouth, with a ceiling of 5200 m and a top speed of 180 km/h. Furthermore the Queen Bee was the first aircraft which was nicknamed Drone, meaning that it deserves its place in the history books [13].

After the outbreak of the Second World War, the militaries' demand for Pilotless Target Vehicles started to grow rapidly. That's why the Radio Plane, [Figure 2] codenamed OQ-2 was created in the US by Reginald Denny. It was a monoplane made of wood and propelled by an aircrew. The UAV could land with the help of a parachute if the datalink was lost for some reason, a function that proves it to be a relatively developed model. Furthermore it was able to take off from its landing gears on an ordinary runway. In contrast with the earlier UAVs, damaging could be avoided because of these features.

Figure 2. A Radio Plane on the ramp ready for departure

Following this, several OQ- models were made by Reginald Denny's company, the most developed one of this series was the OQ-14, which remained in service even after the Second World War.

During the war, more and more bomber aircraft were lost in the air defense fire during the terror bombing sorties. The fighting parts started to seek for alternative solutions to replace the conventional bombers. They returned to the idea of using flying bombs for this purpose. Germans started to develop the V-1 aerial torpedo in the end of 1930s with the aim of bombing the city of London. Its technical background was provided by the invention of pulsejet engine in 1941. The system hadn't become combat ready for a long time despite several years of research and experiments. During the test flights is turned out that there were serious problems with its stability. The V-1 was first used in the combat theatre in 1944 against London, as a revenge for the D-day. The engine provided enough power to take the warhead, filled with 850 kg explosive, to a distance of 320 km. To control the flight, the German engineers used a conventional autopilot system consisting of a gyroscope, a barometric altimeter, and distance measure equipment. After reaching the pre-set distance the engine stopped, the V-1 became nose heavy, and

[3] Pilotless target aircraft

started to dive, it acted like a bomb launched from a bomber. At the time of impact, the warhead activated and exploded. During the Second World War, about 3200 V-1s were launched, which demanded about 1000 life. This number shows that even though the Germans called it a ‘magic weapon’ it had little impact on the outcome of the war [15].

EVOLUTION OF AVIATION IN THE FIRST DECADES OF COLD WAR

After the Second World War, researches related to the UAVs continued, which was supported by the big development of automatic systems. In the 1950s with the appearance of aircraft and missiles flying over the speed of sound, the air defense units needed new assets to simulate targets like these. Military leaders wanted to develop pilotless target aircraft with supersonic speed. In 1953 the Radioplane branch of Northrop started working on the AQM-35 supersonic PTA, [Figure 3.] which carried out its first take-off in 1956. It was able to fly as fast as Mach 1.55. Its main task was to help with the training of air defense missile units against supersonic airplanes. Even though it was possible to launch it from the ground, most of the cases it was launched from an airplane, from where it was controlled. All together 25 models was build, but the program was stopped, because the UAV was so fast that the air defense systems couldn’t track it, so they were unable to lock on this UAV [13].

Figure 3. The AQM-35 supersonic target PTA

During the cold war, thanks to the global nuclear threat, strategic reconnaissance became essential. The U-2 spy plane, which was developed by the commission of US government in the early 1950s, became the symbol of this era. However on 1st May 1960 the Soviet air defense shot down a U-2 over the Soviet Union. This incident made it obvious, that high altitude does not provide enough protection, in addition the program’s high costs, and the media scandal following the shooting down, had shown the disadvantages of such airplanes. If we take into consideration these factors, it is not surprising that leaders started to think about unmanned reconnaissance systems that would take high quality photos deep above the enemy controlled area [6] This is how a new application of UAVs, the reconnaissance drones were born.

In 1960 the USAF gave a commission to the Ryan Aeronautical about converting the Ryan Model 147 PTAs into reconnaissance drones. This new UAV was given the name „Lightning Bug” codenamed BQM-34 Firebee. [Figure 4] This RPV could be launched with the help of a catapult either from the ground or from a ship. However, most often it was started from DC-130

airplanes, which could carry 4 drones at the same time. Initially, after having finished its mission, the Firebee landed with its parachute, later specially modified CH-3 helicopter 'caught' it, then put it on the ground on a described location. For the first time, this new unmanned aerial vehicle proved to be a useful asset in the Vietnam War [13].

During the Vietnam War, these models carried out more than 3400 sorties in the 100th Strategic Reconnaissance Wing. As fighter aircraft were often shot down by air defense missiles, it became a priority to locate and destroy them. For this purpose the US used mainly the Firebees. The Vietnamese SA-2 air defense missiles were radio controlled, so it was easy to detect their omitted signals. The drone sent its reconnaissance data on a RB-47 airplane, where the location of the missiles was determined on the basis of this information. In addition the UAV was so developed that it had an active radar warning receiver, which increased its survival capability.

All together the Ryan Aeronautical made 28 modifications of the Model-147 UAV. The new drones' tasks included day-and-night photographing, electronic detection, jamming, deception and spreading leaflets. The fast reaction was delayed by the fact, that information gathered with this could be analysed after the UAV's return. By 1972 it was even possible to broadcast the data live to the ground station. The Ryan Model 147-SC was equipped with TV camera and datalink system. The Ryan Model 147N could amplify its radar signals, so it was detected as it was a much larger target [13]. From 1972 the UAVs joined the propaganda warfare by spreading leaflets, because the conventional airplanes had suffered serious damage during these missions.

Figure 4. Ryan Model-147 UAV

FROM THE END OF VIETNAM WAR TO THE END OF 1990S

After the end of Vietnam War in 1975, from the late 1970s and early 1980s the rapid electronic development gave a huge push for the airplane research. From these years digital technology was used intensively, thanks to the cheap CPUs and software developments [2]. One of the biggest military conflict of this time was the Arab-Israeli War. According to the doctrine of the small country, it invested a lot in its air force. To prepare for the war, intelligence and information gathering turned out to be a crucial point, in which Israel seemed to be the best [11]. It was carried out largely by UAVs, on the basis of the US experiences in the Vietnam War.

In the 1970s Israel was the leading UAV manufacturer country. This era's rapid technologic development, that I have already mentioned, helped this process. Two of the most successful

drones of these decades are the Mastiff and Scout UAVs. They gathered information of the ground and air forces of the enemy, and the location of radio locators and its parameters. During the Israeli air strikes they conducted reconnaissance, estimated the result of the strikes, and monitored the movement of enemy units. Certain UAVs were able to locate and jam the enemy's radio equipment, which capability proves their electronic development. The Israeli Air Force monitored the Syrian air bases by drones, which provided live data about the taking off of MiG fighters. Therefore, Israeli fighters could attack the Syrian airplanes just after take-off.

Having seen the initial success of UAV developments, engineers started to develop even more advanced unmanned aerial vehicles. This new asset was given the name Pioneer. The biggest purchase of Pioneer UAVs, was executed by the United States. At that time the US Marines had a dire need of small, hard to locate, and cheap drones. The Pioneer is capable of flying on a pre-programmed route, but if necessary, an operator also can drive it. During its operation the US Marines faced several technical issues, and spent a fortune to deal with these problems [13]. Its features include a data transmission range of 185 km. It can be air born for 5 hours and it can carry 35 kg of payload.

After Israeli developments in the 1970s and 1980s the USA became the leading UAV producer country. Military conflicts of that time largely contributed to this fact. In 1991 the US and its allies started the Operation Desert Shield in Iraq. The coalition forces came to a rapid win, because they used state of the art technology. The next big conflict was the Yugoslav War. The NATO air force and the UN joined it in 1995 with the operation Deliberation Force. Reconnaissance played a big role in military planning, and leaders used the experience gained from Gulf War [7]. Since the 1990s the UAVs have been the assets, which have collected extreme amount of data flying deep above the enemy controlled area.

During the operation of Desert Shield 15% of reconnaissance aircraft used by the US military were drones. Their extended range of use is well represented by the fact that all branches of the military started using them. From 1995 Pioneers also joined the war in the Balkan, which had proven to be an effective system in the Gulf War. In the same year the USAF's Predator UAV [Figure 5.] was introduced in the European combat theatre. These two models had SAR equipment and were mounted with systems that provided satellite data link. It made possible to operate and carry out its mission in any meteorological condition. During the operations the Predators estimated the success of the air strikes. During the 120 day long operation they flew 750 hours in 80 sorties. Despite of the large number of missions, only 2 Predators were lost. Here we have to mention that some of the UAVs were temporarily stationed in Taszár Air Base, Hungary. From here they carried out patrolling missions over Bosnia. They seemed to be useful in this task, because they are able to send their data in real time to the CAOC or other higher level leading positions.

From the operation of Desert Storm, even the land forces started to use drones. For this, they needed unmanned aircraft that were cheap, could be launched from hand and were easy to use. These UAVs were powered from batteries and mounted with daytime, black and white cameras. Such an asset is the AeroVironment Pointer, which has a wingspan of 2.74 meters, its length is 1.84 meter, and its weight is 3.6 kg. It can be made ready to launch in 5 minutes by 2 people. One system consists of 4 aircraft and a ground control station whose weight is 22kg. The Pointer can operate in 50–150 m high, in a distance of 8 km for one hour. With these inventions, it

turned out that drones can be used in many ways in almost every combat theatre, and they are extremely effective [13].

Figure 5. A Predator UAV in Taszár, Hungary, during the Yugoslav War

UAVS OF THE 21ST CENTURY

In our century stealth capability of fighter aircraft is a basic requirement as well as integrating the on board system into one complex unit. This idea leads us closer to topic of the information warfare, whose aim is to achieve information superiority against the enemy. In the information warfare, both the soldier and the commanding post have a huge need of constant information. To meet this demand, UAVs are used in mass, and they are indispensable in the flow of information. Due to their effectiveness their number is still growing. Although their main purpose was gathering information, today they can execute air interdiction or air suppression missions [4]. Air strike capability is best represented by the MQ-9 Reaper UAV [Figure 6.] of the United States.

The Reaper is the big brother of the Predator, which flew in 2001 for the first time. It is the first hunter-killer UAV designed for long-endurance, high-altitude surveillance. However, its main task is to strike ground targets. For this purpose it can be mounted with several suspension equipment, like the AGM-114 Hellfire air-to-ground missile, GBU-12 laser or GBU-38 JDAM satellite guided bomb. Besides airstrikes, it can carry out strategic air surveillance too, due to its 14-42 hours of endurance. Its first sortie was in Afghanistan in 2007, but since that it was also used in the conflicts of Libya and Mali. The Predator and Reaper aircraft have the highest operational readiness rate of any aircraft in the US DoD inventory, often exceeding 99% mission availability rate.

In today's asymmetric warfare the small, cheap, hand-launched UAVs became extremely important, especially at the army and the marines. They can be used in the urban warfare too, because they are powered by electricity, which makes them silent, portable, and can be controlled with the help of a laptop or tablet. These drones are usually mounted with EO or IR cameras, and its pictures are transmitted in real time to the operator. However we have to take into consideration that in their operational altitude the possibility of visual coordination goes sour due the circumstances of the combat theatre, like smoke, dust or fire. The Black Hornet Nano [Figure 7.] is the best example for this type of drones. This is a military micro unmanned aerial vehicle developed by Prox Dynamics AS of Norway, and in use by the Norwegian and British Army and US Marine Corps. The unit measures around 10×2.5 cm and provides troops

on the ground with local situational awareness. They are small enough to fit in one hand and weigh just over 16 g, including batteries. An operator can be trained to operate the Black Hornet in as little as 20 minutes. The UAV is equipped with a camera, which gives the operator full-motion video and still images.

Figure 6-7. A British Reaper operating over Afghanistan in 2009 and a Black Hornet Nano

This article would not be complete without briefly mentioning the Hungarian UAV developments and researches. The Meteor PTA family has been produced for Hungarian Defense Forces since 1999 by the Aero-Target Bt. These UAVs are used mainly to train the air defense units' personnel, on the practice missile shootings. The first product was the Meteor-1 in the series. In 2005 the company won the competition to modernize the existing PTAs. The Meteor-3 [figure 8.] made it possible to provide cheap and fully Hungarian target material for the users. This UAV is able to follow a rout automatically. Even though its top speed is only 140 km/h, its duration is 40 minutes and range is 60 km. The Meteor-3 has a payload of 4 kg including fuel, and ceiling of 3000 m. It can carry up to 4 pyrotechnic cartridges, but can be mounted with radio telemetry too. In addition it can transport a 180 mm Luneberg lens to increase its radar cross section. The 2.7 m wingspan, 1.8 m long and 11kg body is powered by a 30 cm^3 piston engine. It is launched with the help of catapult and it lands on its skids. Unfortunately, its slow speed decreases its credibility, so the producer began developing a faster PTA.

Figure 8-9. the Meteor-3 ready for departure and an airborne Skylark

Probably, the most important reconnaissance UAV of the Hungarian Defense Forces is the Skylark I LE [Figure 9.], which was bought from Israel in 2009. In this year the training of the per-

sonnel could be started too, both in Hungary and Israel. After the training the system was deployed to the PRT[4] shift in Afghanistan. During the time it spent on mission, it gradually fitted into the system of the team. As the number of flights and the flying hours grew, the demand for the real time air surveillance was growing too. The live pictures were broadcasted to the operational center, giving a huge help for the decision makers. It was used in FOB[5] missions and to secure CIMIC[6] projects. The UAV was also useful in detecting a possible IED[7] attack. Besides these route surveillance in front of own forces, and convoy escort became its principal tasks too.

In our century, we can see that UAVs are used in more and more fields. As they are getting more developed, they can replace conventional aviation in larger and larger numbers. By this, I mean that we have seen that conventionally drones are used for four main purposes:

- a weapon system where the aircraft itself is the weapon (flying bomb);
- or it is mounted with some kind of weapons (Reaper);
- information gathering unit including all UAVs with cameras and reconnaissance equipment (Predator);
- as a simulated target for the air defense units (PTA).

However, today there are researches to create cargo unmanned aerial vehicles too for example the Eurocopter EC-145. This fact suggests that the potential using of UAVs is seemingly unlimited, because of the constant growing of applications and it has become obvious for all militaries in the world. Therefore every nation has its researches in this topic, including countries with such a small military, like Hungary. As time passes they will get so advanced, that we can start thinking about, when will they replace conventional aviation, or will they ever replace it completely? [16][17][18]

SUMMARY

In the First World War drones were just in experimental phase, their mass use was impossible. As the airplanes main task was terror bombing, UAVs were used for this purpose. They had poor automatization, so they were inaccurate. The lack of technical-technological development didn't permit making more complicated, more reliable, and more accurate drones.

Between the two wars it turned out that one possible direction of developments is the PTA. Although we have seen some usable prototypes, they were not ready to be widespread. .However in the Second World War using drones as target aircraft became general, because of the necessity of training pilots and air defense units. Other big area where UAVs were used was the aerial torpedo. These assets tried to replace the lost aircraft during the air attacks, and reduce their high cost. In addition, the leaders didn't have to count with losing a pilot's life or with captivity.

After the Second World War in the arms race of the cold war UAVs were still useful. Most often they were used as supersonic PTA, to train the air defense units' personnel. Air defense missile units went through a rapid development due to the latest jet fighters and nuclear threat. This is

[4] Provincial reconstruction team
[5] Forward Operation Base
[6] Civil-Military Cooperation
[7] Improvised Explosive Device

why strategic air reconnaissance was extremely important at the time of cold war, but after shooting down U-2 over the Soviet Union, US leaders found out, that it is not desired for a pilot flown airplane to spend as much as 12 hours over enemy territory. That's how the first reconnaissance UAV was born, after long series experiments, and it was given the name Lightning Bug.

In the Vietnam War the next big step was when drones were provided by live data network, so the pictures taken by them could be analyzed instantly. It was possible because of the development of electronics and some of the UAVs carried out electronic warfare tasks. More and more systems that had been present only on conventional aircraft were mounted on UAVs, but their main purpose was to take aerial pictures.

In the late 1970 and early 1980 the digital technology made it possible to create cheaper and lighter-than-ever UAVs. The leading developing country was Israel and its drones had multiple roles. They formed the basis of UAVs that we use today.

In the conflicts of 1990s the US forces could execute more accurate strikes than ever. It was largely because of the information that was gathered in large quantities and was processed in a rapid pace. It led to the information warfare, where drones have a key role. In this decade it was proven that all branches can use UAVs and they are very effective in every theatre.

Nowadays each military possesses some kind of UAVs including the Hungarian Defense Forces. We can see that with the extension of their role their number will increase in the future. In my papers I have shown that the military conflicts where the motivating factors to develop drones.

One of main reasons of their development is the limitations of human being. The lack of person on board has several advantages, like extended maneuverability, improved stealth capability and almost unlimited duration in time. In addition most of the cases they are cheaper than conventional airplanes [19]. So we can say that is has always been some new need, the lack of capability or change of application in the conventional aviation that motivated people creating UAVs.

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AZ UAV-K FEJLŐDÉSÉNEK RÖVID TÖRTÉNETE

Ebben a cikkben a szerzők bemutatják a drónok műszaki fejlődését a kezdetektől napjainkig. Az olvasó megismerheti a drón katonai alkalmazásának legfontosabb időszakait és eseményeit. A cikk végén a szerzők összefoglalják a drónok katonai felhasználásának négy fő célját.

Kulcsszavak: *Repülő bomba, pilóta nélküli célrepülőgép, pilóta nélküli légi jármű, UAV, drón*

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