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MILITARY BALLOONING IN POINT OF HUNGARIAN DEFENSE FORCE'S COMMUNICATION SUPPORT

Using balloons in the military is being reborn. They were found as ISR platform holders and communication relays in the battlefields of Iraq and Afghanistan. There is a rising demand to connect the far and blocked areas-in order to provide an alternative solution opposite the expensive satellite communication. In my research, I will study the tethered and autonomous high or low altitude platforms, how we can deploy as a military communication relay. I will show some international examples and highlight the possible way of the Hungarian deploying.

Keywords: balloons, communication relay, helikite, aerostat, ABSOLUTE

INTRODUCTION

Nowadays managing our redundant CIS[1] is crucial in the military operations in order to increase the survivability of the IT[2] systems. We have to use the variable platforms simultaneously and separate, for example microwave and optical backbone, or satellite and hired lines, furthermore internet based VPN[3]s. The microwave and optical backbones provide wide bandwidth for low price, but they are delicate for the environmental disaster and the enemy can easily destroy them. The internet based VPNs use mobile phone network or microwave and optical networks, so they have an INFOSEC[4] threat and they are more vulnerable. The satellite based lines well compensate these hazards, however the operating cost is significantly higher.

An optimized choice would be the usage of balloons. In some cases the aerostats based communication relays can replace the damaged telecommunication towers and satellites. The aim of my essay is to determine the possible architectures of balloons and aerostats that could be used as communication relays, especially which platform is the best fit to support the Force Tracking Systems. Moreover, I would like to find the limits of usage, furthermore I would like to close some technology direction. The analysis of the balloon based Intelligence, Surveillance, Reconnaissance platforms is not part of my paper.

DESCRIPTION OF THE ANALIZED UNMANNED AERIAL VEHICLE

I believe I must exactly define the platforms, which I write in my essay and they will be the base of comparison. It is acceptable that the UAV[5] fits the best for the communication

[1] Communication and Information System
[2] Information Technologies
[3] Virtual Private Networks
[4] Information Security
[5] Unmanned Aerial Vehicles

retransmission tasks [1] because the UAVs can be longer in the air than the manned version with relatively lower cost.

The unmanned rotary wing aircraft is a special type of the UAV. Their rotary wings make the buoyancy that provides the aviation skill. They are able to vertical take-off and down, moreover they are easy to control. Nowadays the pervading unmanned rotary wing vehicles have little weight and minimal payload capacity, so they are not engaged as a telecommunication relay because the weight of the retransmission stations would be over ten kgs [1; p. 14.].

Picture 1. Fixed and rotary wing unmanned aerial vehicles [2][3]

By unmanned fixed wing aircraft I mean the followings; they have fix wing (sometimes fix wing with variable positions), and the thrust of their drive provides speed for the plane. This speed causes the buoyancy on the wing, so they can fly. They have good maneuver skill, they are controlled by remote control system or robotic system. Their military deployment has a wide range from monitoring-data acquisition to hard kill. The well-known types are Global Hawk, Predator, Euro Hawk, etc [1; p. 16.]. You can see unmanned rotary and fix wing aircraft in the Picture 1.

Picture 2. HAV3 airship and meteorological balloon [4][5]

The science encyclopedia determined the concept of balloon and airship. *'The balloon is filled with gas lighter than air (e.g. hydrogen, helium or oil gas), so it is able to lift in the air due to the buoyancy, and it can be afloat, swim in the air'* [6].

'The airship is an aerial vehicle, which can lift to the air like the balloon. It moves via the engine with propellers, which locates under or on the blimp. It is controllable as a plane with the elevator and rudder' [6]. You can find balloon and airship in the Picture 2.

There is a capital difference between the blimps, balloons and the flying vehicles. The aerostats float while the fix and rotary wing aircrafts fly. The tethered and free floating aerostats are differentiated, the tethered balloons are usually employed in low altitude (30 m-5 km), while the free floating aerostats can lift until tens of kilometers. The helikite is a special hybrid form of the tethered unmanned aerial vehicles. This platform was created from the combination of a helium balloon and a kite to form a single, aerodynamically sound tethered aircraft that exploits both wind and helium for its lift. The balloon is generally oblate-spheroid shaped. The aerodynamic lift resists to the wind and allows even small helikites to fly at low and medium altitudes in strong winds that push simple balloons to the ground. The helikite was designed and patented by Sandy Allsopp in England in 1993 [1; pp. 22-23.]. You can see a helikite on the Picture 3.

Picture 3. The combination of the balloon and the kite is the helikite [7]

IMPORTANT MILESTONES OF THE MILITARY BALLOONING

The first hot air balloon was launched in Portugal in 1709 and then the first airship lifted in the air in 1852. The first military deployment was on 24th September 1870 in Strasburg, France, and it was Prussian blimp. No much later (1885) serious research and development began in the United States America (USA) in the field of military ballooning. The early deploy focused on reconnaissance, signaling and fire control. The British Air Force was born in 1878 via applying balloons [8].

Automatic solutions were applied on the meteorological observation balloons in the WWI[6]. They were supported with radiotelegraph, so they were managed via the opening of balloon's valve remotely, so they were able to land [8].

[6] 1st World War

WWI experiences of aerostats showed they are not the best choice for striking, because they were not able to bring big bombs and their maneuver skills were minimal. So the planes reduced the role of aerostats in the air fight. After the WWI that was thought antiquated technology, so the key of surviving was the deployment of barrage balloons. They served well in the protection of British Island in 1940, where 1466 balloons were installed at 1000 m altitude. A net was put between the blimps, so the hostage aircraft flew in the net and they crashed [8].

The 213.9 t German Graf Zeppelin was the biggest fix body airship ever, and it operated in WWII[7]. It was 245 m long and over 200 thousand m^3, it spied via radar at the British airspace in May of 1939 [8]. The biggest airship without fix body started on 21th July 1958, it had 43 thousand m^3 cubic capacities and it was 123 m long, 26 m wide. It served at the US NAVY for two years, until it crashed in the sea and destroyed. The highest altitude is 51815 m that unmanned aerostat could ever reach. It absolved a 1350 thousand m^3 Winzen-type balloon in California in October of 1972 [8].

The next significant milestone from USA point of view in the history of military ballooning was the Vietnam War. 150-170 m^3 aerostats with tail plane was levitated in altitude 300 m, so they operated as a radio relay, and they were able to cover 35-40 km [8].

Radio locator holder tether blimps were prioritized in the '80s, for example the 700 m^3 airships from TCOM LP with 125 kg payload. It worked in altitude 700 m with maximum 90 km/h operational wind speed, and it could survive 130 km/h wind gust. The cables were designed for 5000 kg ultimate tensile strength to the little balloons, and for 30000 kg to the bigger ones. The power capability was between 3.5-31.5 kW, depending on the type. In the'80s one of the biggest aerostats worked on the Bahama Islands, it served for customs of USA. The 365B/H (Mk7-S) was 59.2 m long and 11640 m^3, the maximal weight was 5200 kg with 1800 kg payload. The operational altitudes were between 3000-4500 m, with maximum 160 km/h wind speed. It was fixed to a 30 m radius ring road [8].

We can make a conclusion following the 300 years history of balloons, that the features of aerostats again and again piqued the attention of armaments industry's developers. The balloons funded the air forces of the great powers, they expanded the battle space to the air from the dimension of ground and naval. The planes were their continuous concurrence and planes overcame aerostats. The reason for this is that the planes have better maneuver skill and reliability, furthermore they can better resist to the weather hardships than the balloons.

THE SYNOPSIS OF LATEST MAIN AEROSTATS PROJECTS

Nowadays balloons of NATO[8] armies are being primarily used in the area of carrying ISR[9] platforms. The blimp based camera and monitoring systems were part of camp protection system of many military bases in the battlefields of Iraq and Afghanistan. The deployment of balloon based communication relay is not so significant than the ISR platforms.

[7] 2nd World War

[8] North Atlantic Treaty Organization

[9] Intelligence, Surveillance, Reconnaissance

I mainly focus on the stratospheric (17-22 km, HAP[10]) furthermore Low Altitude (LAP[11]; 30 m – 5 km) aerostats. The stratospheric platforms are similar to satellite in terms of coverage in a bigger territory such as Hungary. LAP can cover smaller area, they primarily can be used to support or replace the telecommunication towers.

The HAV-304[12] was developed by the US Army, it is 38 thousands m^3 big. It has the capability to operate at 6 km altitude, a 3000 km radius of action, and a 21 day on station availability with pilot or unmanned. It was primarily designed for ISR tasks, but it is also able to operate as a communication relay and it has BFT[13] capability. There was only one prototype built until now, and the first test flight was completed in 2012 in the colors of US Army. The project was cancelled in 2013 due to its high costs. It was financed by DARPA[14] within the LEMV[15] program. After the US Army cancelled the project, the device was transferred under the suzerainty of the United Kingdom in 2014. The cost of the project was between 154 and 517 million dollar (included the planning, search and research and development, moreover a part of the test phase), because the full project never came true. This amount multiple times exceeds the expense of the Hungarian Gripen project [9]. The costs of flying hours in the testing phase in 2010 were 10-20 thousand dollar/hour, to which a 10 thousand dollar/flying additional charge was added [10]. It has been found that this airship and the attached equipment meet the requirements, but the full expense without going into service and the systematic using exceeds the capability even of the US Army, so it absolutely exceeds the capability of the HDF[16].

The question: does it worth so many functions to put on one platform? The answer is that not necessarily the many functions cause more cost, but the search and research and development of stratospheric ballooning. The application of stratospheric military ballooning has not yet been taken place as it is shown in the above historical overview. Further researches are required to design the technology. Nowadays there are projects for stratospheric ballooning such as the Thales Stratobus or the Google Loon project.

Stratobus will be a communication relay in the stratosphere, and it will be able to provide continuous unmanned service for long time. It would be based on the wideband 4G LTE[17] standard that is well known from mobile communication. This project has not yet passed into the test phase, but there is an important thing that is worth to be observed. The stratosphere researcher companies analyzed a moment that the platform has to resist maximum 90 km/h operational wind speed [11]. The Google Loon project from the world-famous Google and Raven Aerostar is solicitous following this data. The name of the project is a word-play: The 'loon' is coming from the 'balloon', but the 'loon' is synonym to 'crazy', 'wacky'. The essence of the concept is that there would be installed telecommunication platforms on undirected balloons, so they can cover with LTE network the faraway places of the Earth. They would change the altitude of platforms

[10] High Altitude Platforms
[11] Low Altitude Platforms
[12] Hybrid Air Vehicle
[13] Blue Force Tracking
[14] Defense Advanced Research Agency
[15] Long Endurance Multi-Intelligence Vehicle
[16] Hungarian Defense Forces
[17] Long Term Evolution

to take on position them. If the wind blow it, the system float the balloon higher or lower, in order to arrive in an opposite wind direction, so it can be again on a good position. This project made a serious skepticism in professional circles, and also in the company Google-because of the name 'Loon'. Besides this opinion there is a serious stock invest behind the project [12]. You can find a prototype on the Picture 4.

Picture 4. Stratospheric balloon of Raeven Aerostars with communication relay [13]

In 2005 the MARTS[18] system was installed for Iraqi operation of USA, it was built up from tethered airships, which operated as a communication relay. The system was delivered by the TCOM LP, which is the biggest blimp supplier of USA. The system was able to retransmit transmission of SINCGARS[19], EPLRS[20] and Falcon I series radios, in 125 km radius circle LOS[21] continuous 15 days without pause [14]. The airship resisted 85 km/h wind speed and small weapons. Important to note that these blimps can be easily destroyed by air defense missle or airplane based machine guns. They were 1800 m^3 big, their payload capacity was 225 kg, and the maximum 'flying' altitude was 900 m. The full cost of the system was approximately 14 million dollar, from which they operated 16 balloons [15]. Following the contemporary argument it was more cost-effective to operate balloons then to build towers on the occupied areas and build the security system of them [16]. The company currently delivers aerostats to the war zones of US, moreover to the Mexican – US border, primarily for surveillance tasks.

[18] Marine Airborne Re-Transmission System
[19] Single Channel Ground and Airborne Radio System
[20] Enhanced Position Location Reporting System
[21] Line of sight

On the below table I highlight three platforms from the actual offer, which can be well employed as a military communication relay in different levels.

Name	71M	28M	17M
Type	Tethered airship	Tethered airship	Tethered airship
Level	Strategic	Operational	Tactical
Operational altitude	4600 m	1500 m or 900 m	300 m
Payload weight	1600 kg	385 kg or 570 kg	90 kg
Flight duration	30 days	14 days	7 days
Max. operational wind speed	130 km/h	92 km/h	74 km/h
Max. survival wind speed	167 km/h	130 km/h	101 km/h
Payload power	23,5 kVA	3 kVA or 5 kVA	1 kVA

Table 1. Comparing of the American tethered airships from different levels [17] (Edited by the author)

We can see in the table, that the airships meet the requirements of the operation level. From cost perspective three pieces of 28M tethered blimp were 12.2 million dollar in 2012, while 38 million dollar was paid for fifteen pieces tactical level tethered aerostats [18]. USA installed seven 17M blimp and fourteen telecommunication tower for 90 million dollar in Iraq in 2014 [19]. The costs contained full charge, such as the ISR platforms (locators, cameras), technical support, training of operator, installing, repair kits, and support items, etc. It should be mentioned, that the expenses not only reached but they even exceeded the costs of Hungarian Gripen project. On the Picture 5 you can see a 71M strategic level tethered airship.

Picture 5. TCOM LP 71M strategic level tethered airship [20]

It is appropriate to mention the ABSOLUTE[22] [21] and CAPANINA[23] [22] project of EU[24]. The main target of ABSOLUTE project was to search the available aerostats, which can be

[22] Aerial Base Stations with Opportunistic Links for Unexpected & Temporary Events

[23] Communication from Aerial Platform Networks Delivering Broadband Information for All

[24] European Union

operated as communication relays in emergency situations or any related tremendous unexpected events and during temporary mass events. The project focused on the LAP, especially to the helikites [23]. It was made such a tethered aerostat form traversing of balloon and kite, that it is able to operate in 300 m altitude, and it resists 75 km/h wind speed. It is 34 m^3 big and has 10 kg payload capacity. The platform can load antennas of LTE base station and the necessary electronics with ground power feed. The set-up time is approximately one hour. A pick-up is enough for the transportation, but it requires the road infrastructure to be present. It was employed by soldiers of USA, Norway, Great-Britain and Australia during the Afghan deployment [1]. Important measures were made during coverage tests in the frame of helikite trials. It was studied from 300 m reference altitude, there are stabile LTE signal in different distance. Frequency band 700 MHz and 2.6 GHz were used with modulation QPSK, 16 QAM and 64 QAM. It is concluded according to expectations, that the lower modulation produce better results, but there were problems in distance 15 km in frequency 2.6 GHz, so the technology is well employed up to 10 km. The bandwidth 700 MHz performed well in distance 10 and 15 km. Tests were made in real environment and in medium rugged areas. Its cost is dramatically lower than the previous mentioned balloons. US Army bought helikites for 50 thousand per pieces for Afghan mission [24], however the basic platform – to which more ISR items can be installed - can be bought from the importer for 6 thousand dollar [25].

The research has other important results, for example that the low altitude helikites are relatively cheap, and their deployment is much easier than the HAP's, the researchers claimed the medium altitude helikites will be the future. It is planned to improve up to 2000 m its operational altitude. The improvement of the technology has a good effect on aerostats, also on rotary and fixed wing aircraft as well. So planes gained advantage in the race mentioned previously in the historical overview. Furthermore, perhaps the balloons will never satisfy all demands. On the positive side they are cheap, versatile, they have good payload capacity and realistically they could be the first reaction part on disaster area. The ABSOLUTE project created a new head goal in the field of ballooning: It is not recommended to employ only balloon based communication relays, it is better to create a ground, air and satellite based hybrid solution, where the balloons are part of the quickly reaction forces as a temporary solution. Towards dynamic deployment they would be used with cognitive radio systems, so they can help the optimal operation of the communication network [1].

CAPANINA searched for HAP, which can provide wideband bandwidth (up to 120 Mbit/sec) on wide area (normally in 60 km radius circle). The research between 2003 and 2006 showed many good useable solutions in practice, but it claimed the biggest problem of the technology's employment is its cost. Until now there isn't real business demand on the technology. You can see from the financial statement, that the charge (S&R[25] and deployment) of aerostats is four times higher than the charge for planes [1; p 26].

Moreover there is meteorological balloon based solution, which can be used as communication relay [26]. These aerostats are small (few m^3) and have minimal payload capacity, so they can lift in high altitudes (up to 30 km). Of course these are not tethered balloons, and are exposed

[25] Search and Research

to gusts. They perish in stratosphere because of the pressure difference, and the communication part can return back to the ground with a parachute. Flight time is 30-45 minutes. This technology cannot be used for data link and voice communication very well, because it is not subservient to launch balloons every half an hour. Maximum one or two launch per day they can collect data form the sensors in time windows. The other problem with this technology is that the return unit could hit the ground in wide area. These units can return across the whole Carpathian Basin according to the database of Hungarian Meteorology Society (they launch one balloon per day). It is not unusual that a returning units land out of border [27]. These generate serious INFOSEC problems, because the communication relays and crypto keys can be easily compromised.

We should mention the Hungarian engineers Imre Nehéz and Mihály Sós in this field. Nehéz designed the hardballoon, which is the theory of null diffusion balloon system. It would be dramatically reduced helium emission of aerostats, so they can float in the air longer [28]. The possibility of deploying balloons in Hungary was scholarly studied by companies and workshops led by Mihály Sós [29].

OPPORTUNITIES OF NATIONAL DEPLOYMENT

The R&D[26], operation and running of autonomous robot stratospherically aerostats are not realistic for Hungary in present because of technical and economic situation-and grandiose cost. However a few research claimed that the HAP based communication relays are the future but its price/value ratio does not return for Hungary in national defense level, neither in higher, government level. Based on my research it is generally claimed that the charge of R&D, operation and running of aerostats is higher than other UAV. It is seen through international examples (e.g. tethered of TCOM LP), we can find professional medium and low altitude platforms on the market, which can be used well in practical for military task as communication relay. Of course it is not profitable for great powers to use them only for relay, therefore the balloons are primarily used for holding of ISR platforms and the secondary task is the relay mode. The expense of medium and low altitude platforms is lower than cost of HAP, however I think it would be still unreasonably high for Hungary. Under the present circumstances it won't be acceptable to deploy same balloons, because modern fighter aircrafts would be employed for similar charge, and they would have more significant benefits than aerostats. Moreover the Gripen fleet is huge a financial burden. Furthermore a little amount of aerostats cannot live up to expectations. But the blimps are able to stay longer in the air than rotary and fix air wings, and operate with minimal intervention. Contrary of expectations cost of balloons are dramatically higher than planes.

It is not recommended using meteorological balloons as communication relays, because they have low availability, stochastic conduct of return units, INFOSEC challenges and weather conclusion.

I think military employment of the LAP helikites (30–300 m) carries potential to support the asymmetric and low intense operation in tactical level. The primary task would be to hold ISR

[26] Research and Development

platforms, and only the secondary would be the communication relay. In point of Hungary it would be a good solution to hold the antennas of national TETRA[27] system [30] as a support element. You can find possible version of low altitude tethered aerostats in Hungary on the Figure 1.

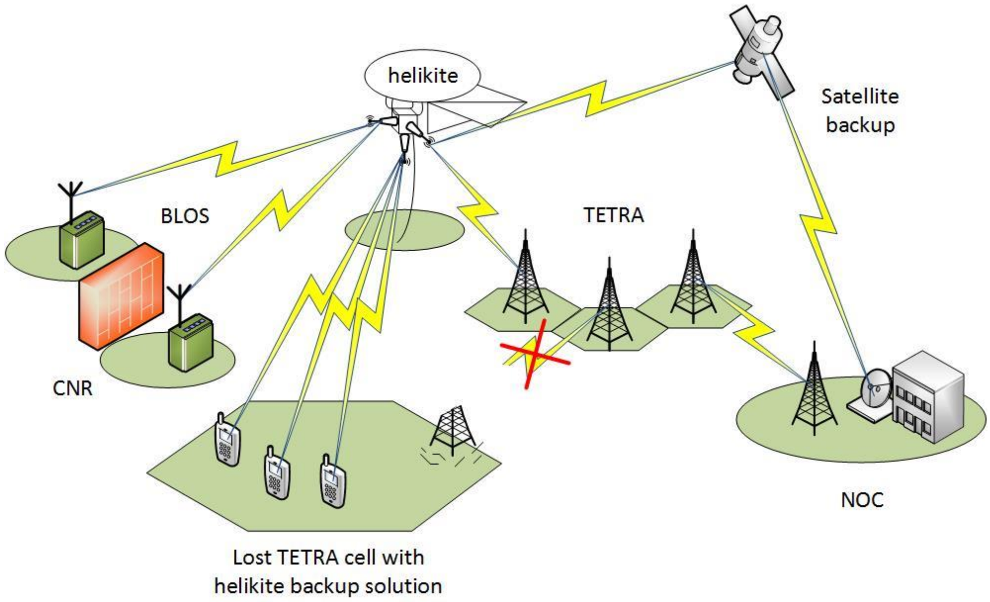

Figure 1. Deployment of low altitude tethered balloons as a communication relay, version (Edited by the author)

You can see on the Figure 1 the helikite has only a complementary role in order to manage the errors in the stationer network and to support the tactical network. Beside of relay mode it would be practical to set up it with ISR platforms (especially camera) in order to support the ISTAR[28] system. Moreover it would support the BFT system, and it can connect the BLOS[29] with CNR[30]'s. The 300 m operational altitude can provide better RLOS[31] for the terminals, furthermore the low bandwidth demand of this system is no problem.

In my opinion it would be worth considering the possibility of deploying helikites in Hungary. As we can see in the upper example, this multifunctional platform is feasible at low cost and its employment would be serious headway in the field IMINT[32] and dubbing communication.

Currently Hungary does not have its own integrated military BFT system, the international operational experiences suggests, that it will be necessary to employ at HDF in the future. The imperfect AI[33] is dilemma of the BFT systems, mainly because its physical problems. Communication network of terrestrial cellular trunked BFT systems (e.g. KFTS[34]) can be easily blocked and destroyed. The satellite links using systems (e.g. FBCB2 BFT[35], IFTS[36]) have

[27] Terrestrial Trunked Radio
[28] Intelligence, Surveillance, Target Acquisition, Reconnaissance
[29] Behind Line of Sight
[30] Combat Net Radio
[31] Radio Line of Sight
[32] Imagery Intelligence
[33] Air Interface
[34] KFOR Force Tracking System – in Kosovo
[35] Force XXI Battle Command Brigade and Bellow Blue Force Tracking -
[36] ISAF Force Tracking System – in Afghanistan

expensive data link costs, and based of practice it would not disregard the time of communication lost because of cover problems (e.g. mobile terminals try to connect GEO[37] satellite in hard rugged or rural areas, where connection is usually lost). In this case the medium and low altitude (300 m – 5 km) aerostat based relays can play important role. In one area operating terminals can see the balloons in similar degree like the satellites. It would improve the coverage, if the low altitude relays (in a few hundred meters instead of thousands meters) were able to provide better receiving values [31]. It can provide longer range and better receiving gradient in covered areas.

In summary, the primary employing mode of balloons is the holding of ISR platforms, secondary is holding of communication relays, but this does not rule out to use both in same time. Its main reason is the high cost. Nowadays one of the main deployed platforms would be the low altitude tethered airships. Low altitude tethered blimps can support well the BFT systems. It is important, that for support and not for replace, because the hired satellite lines are more cost-effective than operate a full balloon based system. It is a possible way to use helikite (only a few pieces) for Hungary in this economical case. It is worth to build it with ISR platforms (primary camera) and communication relay. It can improve the spectrum of useable platforms, providing the option for commanders to choose the best platform.

CONCLUSIONS

I studied the features of unmanned aerostats, it can be concluded that there are such technologies, which are able to support telecommunication claim of military deployment. It should be mentioned it has higher expense than rotary and fix wing aircrafts. The planes won in the competition between the aerostats and planes, and following some international papers [1], it won't change in the future. I suggest examing well employment of balloons because the arguments of balloons are not significant enough. I think, the deployment of balloons would be reasonable, if the special features of balloons (e.g. long time floating in same altitude) were weighted in our decision matrix.

Studying The Hungarian economic situation the charge of a supplementary tethered balloon fleet won't multiple the charges compared to the actual full budget of Hungarian Air Force. In the point of this factor the only reasonable option possibly is to employ the low-cost helikites.

In my paper I achieved the targeted results. Searched and organized the recently available aerostats, which can be used as communication relay. I showed the possible deployment, analyzed their weakness, and moreover suggested employment of a realistic platform, which is also useable in national level. Furthermore I closed a research direction (meteorological balloon as communication relay), because its features are hard to pay off.

[37] Geosyncron Earth Orbital

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BALLONOK KATONAI ALKALMAZÁSÁNAK LEHETŐSÉGE KÜLÖNÖS TEKINTETTEL A MAGYAR HONVÉDSÉG TÁVKÖZLÉSI IGÉNYEINEK TÁMOGATÁSÁRA

Napjainkban a ballonok katonai alkalmazásuk reneszánszát élik. Az 0iraki és afganisztáni hadszíntereken egyaránt megtalálhatóak voltak a megfigyelési és átjátszó pontként telepített léghajók. A nagy illetve elzárt területek összekapcsolására egyre nagyobb igény jelentkezik,így a magas költségekkel járó műholdas kommunikáció mellett célszerű minden más alternatív platformot megvizsgálni. Kutatásomban megvizsgálom a különböző magasságú, kötött és szabadon lebegő ballonok kommunikációs átjátszó állomásként történő alkalmazási lehetőségét. A nemzetközi kitekintés mellett kiemelem a honi alkalmazás perspektíváit is.

Kulcsszavak: ballonok, kommunikációs átjátszó pont, helikite, ABSOLUTE

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