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Paweł DOBRZYŃSKI[a,*], Stanisław LIPSKI[b], Bogdan MACHOWSKI[a,*], Roman MUSIAŁ[c]
[a] Military University of Technology, Warsaw, Poland
[b] Institute of Precision Mechanics, Warsaw, Poland
[c] MindMade Sp. z o.o., Warsaw, Poland
[*] Corresponding authors: pdobrzyn@o2.pl (P. Dobrzyński); machdom@wp.pl (B. Machowski)

EXPANDING THE CURRENT POSSIBILITIES OF DATA RECOGNITION AND RETRANSMISSION USING MODERN AEROSTATS

Key words: aerostat, image recognition, radar recognition, retransmission of data.

Abstract: The article presents the issues of using modern aerostats to increase the capabilities of image recognition and radiolocation systems, as well as data retransmission. A feature that differentiates airships from balloons is their own propulsion and rudders, thanks to which their flight can take place after a pre-planned route and long distances. Airships are divided into three classes; pressure (frameless), half-skeletal, and skeletal. The article recalls the concept of the stratospheric aerostat and also presents the aerostat of low altitudes made in this country, which is a continuator of the interwar reconnaissance system using the LECH airship. The aerostats presented in the article belong to the group of airships. Already in pre-war Poland, it was necessary to eliminate the military superiority of the western and eastern neighbours through the possibility of pre-emptive actions resulting from the possibility of recognizing the situation from the air at that time. Currently, the country is working on innovative solutions for modern aerostats. There is the possibility of implementing a stratospheric aerostat by Polish companies that are adapted to the specificity of geographical latitude, which is in the sphere of our interest in recognition and retransmission.

Poszerzenie obecnych możliwości rozpoznania i retransmisji danych przy wykorzystaniu współczesnych aerostatów

Słowa kluczowe: aerostat, rozpoznanie obrazowe, rozpoznanie radiolokacyjne, retransmisja danych.

Streszczenie: Artykuł przedstawia problematykę wykorzystania współczesnych aerostatów w celu zwiększenia możliwości systemów rozpoznania obrazowego i radiolokacyjnego, a także retransmisji danych. Cechą różniącą sterowce od balonów jest posiadanie przez nie własnego napędu oraz sterów, dzięki czemu lot ich może odbywać się po z góry zaplanowanej trasie i na znaczne odległości. W artykule przypomniano koncepcję aerostatu stratosferycznego, a także przedstawiono wykonany w kraju aerostat małych wysokości będący kontynuatorem międzywojennego systemu rozpoznania wykorzystującego sterowiec ciśnieniowy LECH. Przedstawione w artykule aerostaty należą do grupy sterowców. Już w Polsce przedwojennej widziano konieczność niwelowania przewagi wojskowej zachodniego i wschodniego sąsiada poprzez możliwość działań wyprzedzających wynikających z możliwości ówczesnego rozpoznania sytuacji z powietrza. Współcześnie w Polsce prowadzone są prace nad innowacyjnymi rozwiązaniami współczesnych aerostatów. Warto podkreślić, że przedsiębiorstwa krajowe mają możliwości opracowania i wykonywania aerostatów stratosferycznych dostosowanych do naszej szerokości geograficznej i różnych zadań związanych z rozpoznaniem i retransmisją.

Preliminary

The history of the use of observation aerostats by the Polish Army dates back to the interwar period and is connected with the introduction of the LECH airship (Fig. 1) [1]. The airship “Zodiac VZ-11” was purchased in 1921 by the Polish Shopping Mission in Paris for the needs of the Department for Maritime Affairs.

Its main task was to patrol the Polish coast of the young state. In March 1922, a dozen boxes were brought from Gdansk to the balloon port in Toruń at the Officers' Aerostatic School containing components of the LECH aerostat.

The basic parameters of the LECH airship that operated in Poland in 1922–1928 are as follows [2, 3]:

- Pressure type (frameless, soft) [4];
- Capacity: 3150 m³;
- Length: 50 m;
- Diameter: 12 m;
- Flight speed: 80 km/h;
- Range: 800 km;
- Ceiling: 3000 m;
- Crew: up to 6 people; and,
- Place of stationing: airship hall in Toruń.

Fig. 1. View of the airship "Lech" over Warsaw in 1926 [3]

Many years have passed since the use of the LECH aerostat, and there have been major changes in the structure of airspace-based measures as a result of the increasing use of unmanned aerial systems and the development of anti-aircraft missiles. In the times of drones, HAPs and real satellites, does the use of aerostats have a future? According to the authors, the answer is yes and with a wide range of applications. For example, an aerostatic reconnaissance platform can be used by all types of armed forces, because it is characterized by the following features [5–7]:

Minimal maintenance (as opposed to aircraft);

- The possibility of several months' watchfulness over the designated area at the selected altitude (as opposed to the plane);
- The possibility of self-guidance of on-board systems for a specified ground-based target;
- The ability to prepare for a specific mission;
- The possibility of constant monitoring of any area and infrastructure of the opponent;
- The possibility of simultaneous detection and tracking of many ground, air, underwater and surface targets;
- The ability to conduct operations in all weather conditions day and night at any state of the atmosphere;
- The ability to immediately transition from the sleep state to the combat work condition after receiving the signal, e.g., from one's own alerter;
- The ability to conduct activities without prior specialized preparation;
- The possibility of quick replacement of on-board equipment components, which requires repair, review, or modernization; and,
- The possibility of safe work outside the range of small arms, artillery, or MANPADS.

The above description shows that the scale of application of the aerostatic project is huge and depends only on the inventiveness of the Armed Forces and the needs of specific missions. Special interest in aerostats has been declared by the following: Navy, Special Forces, Air Force, Land Forces, and Territorial Forces that perform combat tasks in a rapidly changing environment [8, 9].

Nowadays, particular importance is attached to the desired state of situational awareness. Regardless of the type of troops, maintaining the required state of situational awareness in relation to resources and one's own actions and other stakeholders is one of the basic elements determining the level of security and quality of the tasks carried out by the Armed Forces.

The systematic increase in the use of stratospheric platforms in the strategy of military (as well as civil) activities results both from the cost-effectiveness of such a solution and from the need to supplement the capabilities resulting from the use of satellite and airborne systems for more effective early warning about threats, imaging and radio-electronic reconnaissance, navigation, intelligence, communication assurance, and continuous border surveillance. The latter aspect is of particular importance in regions with a higher risk of terrorism, illicit trafficking of weapons, drugs, immigrants, emergencies. However, the most important aspect of stratospheric aerostat acquisition and use is the fact that it is impossible to obtain intelligence and reconnaissance data from the areas of the Baltic Sea Region. It is also impossible to obtain intelligence and reconnaissance data from areas such as the Gulf of Gdańsk, the Kaliningrad Oblast, and other border regions.

The global market for stratospheric platforms is estimated at approximately USD 5.42 billion in 2016 and its value, in line with the forecasts included in the CAGR report, will increase in 2021 to the value of approximately USD 11 billion. This report includes the forecast of the aerostat market, its growth dynamics in the next five years, taking into account the possibilities of application, developed technologies, and the large geographical potential of regions and countries. In the report, 2015 was adopted as the base year, and the forecast period covers the years 2016–2021.

The authors of the article see the urgent need to use the offset capabilities created by the modernization programs of the Polish Armed Forces to cooperate with companies such as Thales Alenia Space to develop the Polish version of the reconnaissance platform (HAPS) based on the STRATOBUS project. On the other hand, in the field of lower altitudes, there is a need to support the efforts of domestic companies, as exemplified by the skyRANGER observation system, which are the result of cooperation of companies belonging to the WB Group (WB Electronics S.A., Arex Sp. z o.o., MindMade Sp. z o.o., Flytronic Sp. z o.o., Radmor S.A.).

1. Observation aerostat skyRANGER

SkyRANGER (Fig. 2) is a system for long-term observation from high altitudes. The main elements of the system are the coating, the trailer with the mast, the nacelle with the observation head, and the monitoring and control station. The mobility of the system allows for its start-up in up to 30 minutes. The airship can remain in the air for up to 3 days without having to replenish technical gases. The image is recorded by a camera placed in a stabilized head. The system allows for effective detection of a human being within a radius of 4 km and detection within a radius of 2 km. The image is transmitted to the ground via a ray tube. The head is powered by a battery, which allows for 8 hours of continuous operation. The aerostat can safely carry out the mission at wind speeds up to 8 m/s and gusts up to 12 m/s.

The balloon shell is made of polyurethane with low permeability of low molecular weight gases. Brits are combined with each other in ultrasonic welding technology, which guarantees the tightness and durability of connections. The shape of the airship is aerodynamically optimized in order to obtain minimal frontal resistance while maintaining the maximum volume of the solid. Aerodynamic balance guarantees the stability of the structure. Helium, as a low molecular weight gas, penetrates through the aerostatic coating, which requires systematic supplementation. The gas permeability is about 1 cubic meter per day. The coating can be made of white or colourless material. The white coating can be used as a preventive measure and is easy to detect in the sky during the day. The colourless coating is difficult to detect, allowing for reconnaissance missions.

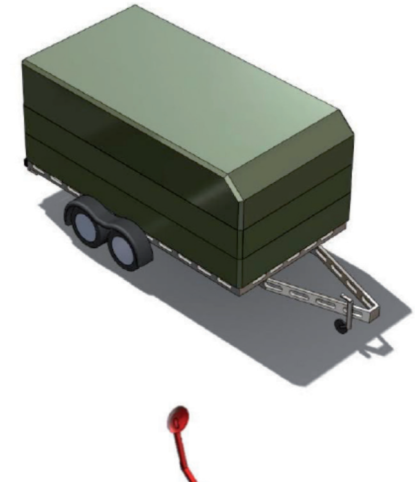
An integral part of the system is a trailer for transporting and mooring / anchoring the balloon (Fig. 3). It has a rack enabling the transport of 12 cylinders with a capacity of 10 m^3 with compressed gas (6 to fill the airship and 6 as spares). The trailer is equipped with a folding mast allowing for safe mounting of the filled airship. The mast can be rotated around the vertical axis of the airship, thanks to which the anchored airship will set itself in the “upwind” position.

An electric rope winch allows controlling the airship's flight altitude with winding speed of the rope at 20 m/min. The winch is equipped with a safety brake, which is automatically activated in the event of a power failure. The aerostat can be equipped with a backlight system, where the user can control the switching on of backlight and the choice of light colour. The illumination of the shell can be useful when performing a mission after sunset in the airspace where other users such as helicopters of the Border Guard are located.

Fig. 2. Airship system skyRANGER docked in a mobile mooring station [22]

The skyRANGER system is equipped with an observation head with a daylight camera of HD quality as standard equipment. The camera is equipped with 30x optical zoom and 2x digital zoom, which allows one to detect a vehicle from a distance of 8 km, a man from a distance of 6 km, and recognition from a distance of 1.5 km. It is possible to install a surveillance head equipped with a thermal imaging camera with VGA resolution. The head is also equipped with a 3-stage stabilization system. Both heads are powered by batteries and their operation time is up to 8 hours.

Before installing the system, it is important to ensure proper location. Within a radius of 50 meters from the place of operation of the airship, there should be no obstacles higher than 5 meters. Start-up of the system requires pumping 6 cylinders with compressed helium. Helion is a mixture of helium-based gases, which is lighter than air and non-flammable, and the refining gases used allow for prolonged operation of the system. The cost of one-row filling of the coating is about 7,000 PLN net. The permeability of gas through the coating is about 1 m^3 per day of the mission.



Length	5,5m
Width	2,4m
Capacity	1000kg
Cylinders with helium	12
Additional equipment	Anchor for anchoring the airship
	Winch
	Aggregate 230 / 400V

Fig. 3. The basic parameters of the skyRANGER and the view of a trailer model equipped with a folding mooring mast for the aerostat [22]

2. Stratospheric aerostat stratobus

In December 2016, the Military University of Technology hosted a meeting of the initiatives group, whose aim was to determine the feasibility of an international project for the construction, equipment, integration, and operational application of a stratospheric reconnaissance platform, as one of the sources of long-range reconnaissance. At the invitation of the Dean of the Faculty of Mechatronics and Aviation of the Military University of Technology, the meeting was attended by representatives of sub-mentees interested in the implementation of an autonomous platform in Poland. The impulse for the meeting was the development and submission by the team of authors (representatives of: WML WAT, PCO S.A. and the Polish Space Agency) of an application entitled "The stratospheric platform as part of the system of reconnaissance and protection of the Armed Forces and infrastructure of the Republic of Poland" for the 3rd competition "Innovations for the Armed Forces of the Republic of Poland" in the "Concepts" category, organized by the Inspectorate of Implementation of Innovative Defense Technologies of the Ministry of Defense (I3TO MON).

According to the authors of the application, such a platform is characterized by an advantage over commonly applied solutions, resulting from a large controlled area, high survival capacity, long maintenance-free operation time, the low costs of carrying out missions and general operations. The aim of the project is to integrate and equip the stratospheric platform as an autonomous system for early detection and warning of threats. Such a platform, in addition to the features mentioned above, is characterized by the ability to monitor a large area, high survivability, long periods of unmanned operation, and the low cost of operation (e.g., in comparison with satellite systems).

Fig. 4. STRATOBUS stratospheric aerostat [23]

STRATOBUS (Fig. 4) is a 100 m long, and it is a stratospheric unmanned airship with a diameter of 33 m, a total mass less than 5 000 kg and a load capacity of 250 kg and 5 kW for the load (Table 1). The operating altitude is 20 km. It is expected that this aerostat will be driven to the ground for only one week during the whole year in order to perform a servo standstill, which includes, among other things, refuelling with RFC

(Reversible Fuel Cell) gas. In the STRATOBUS project, several innovative solutions have been applied, such as the use of a large fixing ring for propeller engines and a nacelle, allowing the aerostat to rotate photovoltaic panels towards sunlight.

The stratospheric platform project supports the following important aspects that increase the chances of its implementation:

– The acquisition of the host platform (i.e. aerostat with supervision and ground handling system) may become a part of the offset program, as such, platforms are offered by Western international arms consortia.
– The availability of the platform for NATO would allow the reimbursement of a significant part of the costs of purchasing the missing technologies in Poland and, probably, also the costs of its operation.
– The stratospheric platform could be integrated and equipped with devices developed and manufactured in Poland, using innovative technologies (e.g., imaging / radar / electromagnetic recognition, positioning, communication, etc.), which currently cannot be used due to the lack of another type of carrier.
– Experience with the exploitation of stratospheric aerostat would enable domestic companies to gain "technological abutments" in the areas which were previously reserved for companies producing or exploiting space technologies (working at low temperature and extremely low pressure, temperature gradient, high-energy radiation, etc.).
– The stratospheric location of the reconnaissance platform in practice prevents any interference from the outside, with the possibility of rapid emergency and safe lowering of the platform to the ground.

Table 1. Basic information about the STRATOBUS project [23]

Diameter	33 m
Length	100 m
The maximum payload is useful	250 kg
Operating height	20 km
Maximum horizontal flight speed	25 m/s
On-board energy generator	85 kW
The power supply method during the day	Photovoltaic cells
Surface of solar cells	1660 m^2
The power supply method at night	Hydrogen fuel cells

One of the variants considered in Poland of using the STRATOBUS aerostat is to equip it with a dedicated version of radar with an electronically scanned matrix system of the 4th generation, e.g., based on the Northrop Grumman AN/APG-80 radiolocator with a range of 300 km and an angular width of 140° tracking area, which would allow simultaneous tracking of up to 50 air targets (including the ability to simultaneously track 6 targets with the accuracy of STT).

The key factors increasing the world market for aerostatic systems are the major competitive advantages of aerostatic systems (compared to aircraft, observation or satellites) [12, 13], as well as the increasing need for continuous recognition, observation and reconnaissance worldwide. The most frequently observed competitive advantages include the following:

- Things not required: airports, pilots, rockets, satellites;
- No costs of aviation fuel and equipment repairs;
- Easily accessible and free solar energy;
- There are no air traffic regulations in force;
- High precision positioning of the platform (gps);
- High precision of image data, 10–15 cm at ground level;
- Short cycle of observation repeatability;
- Continuous monitoring – continuous, irreplaceable and the only method to record and monitor processes and situations quickly-changing (sudden fires, floods, huragans, explosions, etc.);
- A wide range of multispectral registration;
- Many months of continuous photographic flight and one central database;
- The cheapest and fastest process of obtaining processing and sharing crisis data; and,
- Stratospheric aerostats can be used to build an independent communication system (internet, mobile telephone, television, and other communication systems).

An independent communication system (internet, mobile telephone, television, and communication systems) [11] using the possibilities of stratospheric aerostat or high altitudes for Poland, apart from diagnosis, may be a key undertaking allowing for media independence.

The vision of a complex telecommunication system with the use of aerostats for Japan is presented in Fig. 5.

In Europe, works have been carried out for a long time in the field of telecommunications aerostats – examples are shown in Fig. 6.

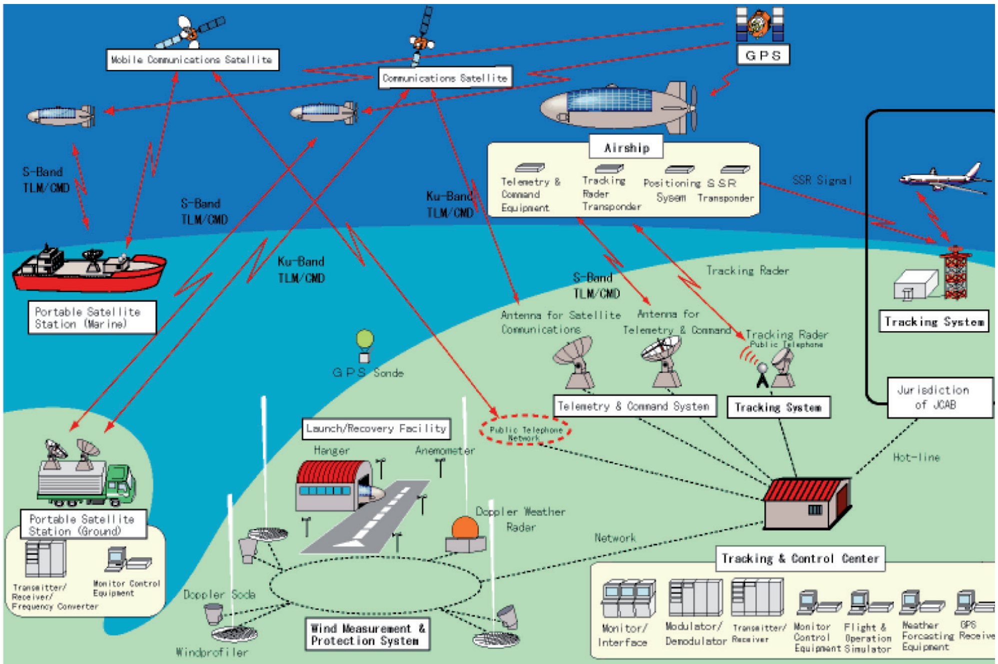
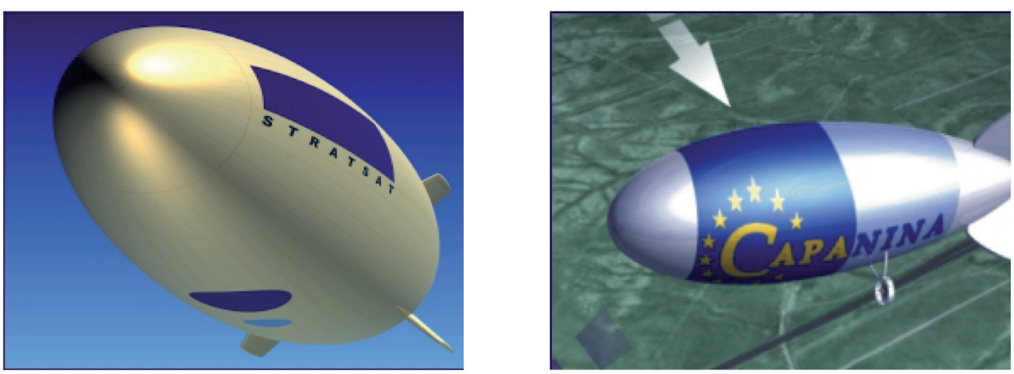


Fig. 5. An exemplary application of telecommunications aerostat – Japan [24]



"STRATSAT" HAA High Altitude Airship. Airships could provide a cheap and quick way of bringing mobile phone networks and fast internet connections to remote parts of the world. Engineers at Britain's Advanced Technologies Group (ATG) are working on developing airships that could provide the telecoms networks of the future

"CAPANINA" HAA High Altitude Airship. The CAPANINA project will develop broadband capability from aerial platforms to deliver cost effective solutions providing a viable alternative to cable and satellite

Fig. 6. Examples of European telecommunication aerostat projects [25]

3. Polonia stratospheric aerostat concept (reconnaissance and retransmission)

The recognition needs within the basic radiolocation recognition zone are defined by the allied "Concept of Air Surveillance" (MC 507), which defines the requirements for the parameters of the radar recognition zone. In the article [15], J. Kwika presented Polish possibilities of radiolocation diagnosis (as of 2015) and the possibility of extending the possibilities of aerostatic recognition.

The required radar recognition capabilities are not achievable only with the use of ground-based radar equipment, especially in the low altitude range. In the case of ground objects of a potential opponent, Polish capabilities are practically insignificant, and the problems related to the diagnosis are presented in the works [16, 17].

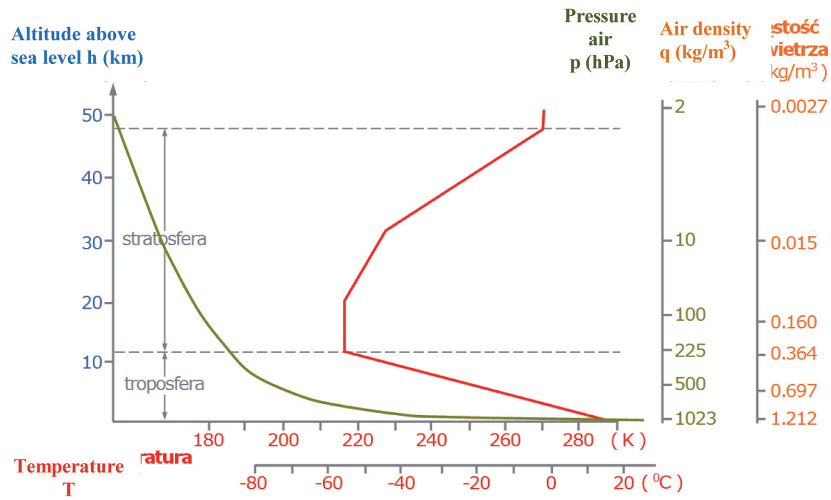


Fig. 7. Dependence of temperature T, atmospheric pressure p and air density q from height h [20]

Taking into account the stratospheric aerostat operating at a height of about 20 km, it should be designed to be adapted to the weather conditions prevailing at these altitudes, Fig. 7.

The necessity of having the ability to retransmit data results from the following political and military reasons:

– Poland may use European satellite systems, e.g., European Space Agency (ESA) or American entities (NASA, Space X), but access to them is limited and very expensive. Moreover, total dependence on external providers of these services, in such important areas of state security, may end, as in the case of the system of terrestrial radio and television transmitters, with the fact that in important moments for the country we will be cut off from them due to "desynchronization of transmitters" [18, 19] or "interference of an unknown nature".
– There is no possibility to ensure broadband connectivity in military operations in areas of conflict where the Polish Armed Forces conduct or have conducted operational activities, e.g., Iraq, Afghanistan. Without the support of allied satellite communications, it was not possible to ensure communication with the command units and the command units with the country. This also applies, at present, to mountainous areas in our country in terms of communication with the use of UKF radio stations.

The aerostatic power supply system is one of the most important on-board systems. By supplying energy to other systems, it influences, in many ways, the geometry of the ship, many features and solutions of the design, mass, the duration of active operation in position, and others. Failure of the power supply system leads to failure of the whole device.

In the composition of the power system, the following can be distinguished:

- Primary power (chemical battery),
- Secondary power (solar cells), and
- Devices for processing, charging, and automatic control.

Figure 8 shows that cells with an efficiency of more than 40% are already known. Mass-produced cells achieve an efficiency of about 20%. Research is also underway into polymer and organic cells that would have a better energy/price ratio, despite their lower impact.

The average solar energy is about 1361 W/m^2. Taking into account a certain stratospheric absorption, the surface of the aerostat can achieve about 130 watts per 1m^2 of solar cells (with an efficiency of 8–13%). The solar panels are located on the outer surface of the aerostat. The designed surface area of the panels is 2000 m^2. Therefore, the maximum available power in favourable conditions will be about 2000 [m^2] x 0.13 [kW/m^2] = 260 kW.

It is worth noting that, due to the ellipsoidal shape of the aerostat, only a certain part of the surface of the panels can be perpendicularly directed towards the Sun. The rest of the panels will partially absorb the sun's radiation, which will result in a decrease in their efficiency. As a result, it must be assumed that the available power will be in the range of 90–110 kW. In order to maximize the energy emitted by the batteries, a change of the orientation of the aerostatic ship can be used. It uses a specialized autonomous system of automatic maximization of the received solar energy. Automation of the power supply system includes devices for controlling the operation of photovoltaic cells, as well as monitoring its parameters. Typical tasks include the following:

- Maintaining system parameters within the following ranges: voltage, temperature, pressure;
- Switching modes of operation, for example, switching to a backup power source;

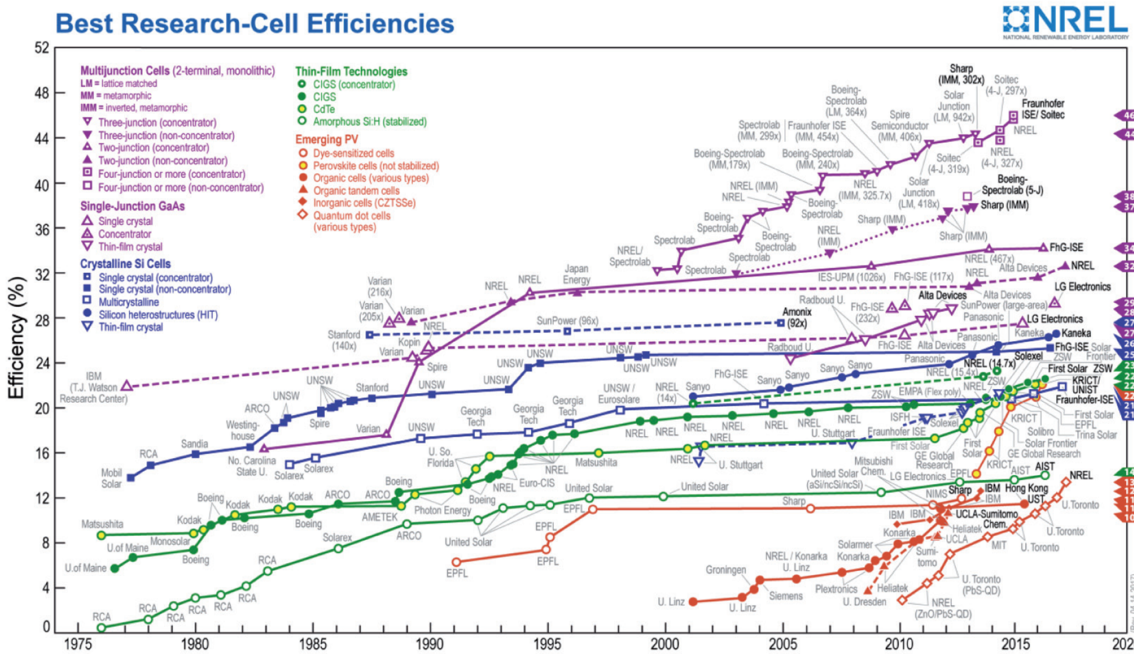


Fig. 8. Comparison of efficiency of solar cells produced in different technologies [26]

- Failure detection, emergency protection of power sources, in particular against short-circuit current; and,
- Generating information about the system status to the telemetry system.

Solar cells eventually degrade under the influence of the following factors:

- Erosion from meteorites reduces the optical properties of the photovoltaic surfaces;
- SEM reduction of cells, especially during coronal mass ejections and solar flares;
- Thermal shocks caused by deep cooling of the structure during the night and on heating in the illuminated and vice versa.

This phenomenon destroys the fastening of individual battery elements and the connections between them. There are a number of measures to protect the batteries against these phenomena. The time of effective operation of solar panels is several years.

During the night, photoelectric converters stop producing energy, so the power supply system is supplemented with chemical batteries (buffer batteries).

Figure 9 show that a single cell can provide energy with a voltage of 0.5 V and a current of several dozen mA. Therefore, in order to achieve the required parameters for many on-board devices, it is necessary to connect serial-parallel cells into battery assemblies.

In addition, on-board equipment requiring AC power supply shall be equipped with appropriate inverters and propeller-driven electric motors shall be capable of generating alternating current with energy recovery (intelligent super capacitor charging system required).

The energy demand of the reconnaissance equipment was determined on the basis of the analysis presented in position [20] for about 1 kW and the weight of the unit for about 200 kg. The transmitters of retransmission systems together with the antenna unit have a demand of 8–10 kW at a weight of about 400 kg.

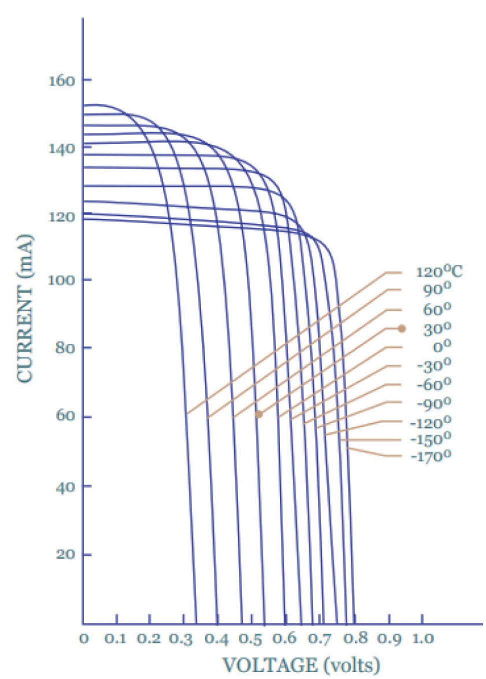


Fig. 9. The voltage and current characteristics as a function of the temperature of a single solar cell [27]

On the basis of preliminary calculations for power and usable mass for the designed aerostat required for our latitude, the basic parameters are presented in Table II. The construction itself envisages the use of national experience in the field of aircraft construction and operation, reaching for the most modern solutions, as presented in item [21].

The range of perimeters for parametric height change is shown in Fig. 10. If the proposed reconnaissance and retransmission systems meet the assumed requirements, the real range of the system will be about 200 km.

Table 2. Basic information about the Polonia project

Diameter	40 m
Length	120 m
The maximum payload is useful	600 kg
Operating height	20 km
Maximum horizontal flight speed	35 m/s
On-board energy generator	100 kW
The power supply method during the day	Photovoltaic cells
Surface of solar cells	2000 m^2
The power supply method at night	Hydrogen fuel cells

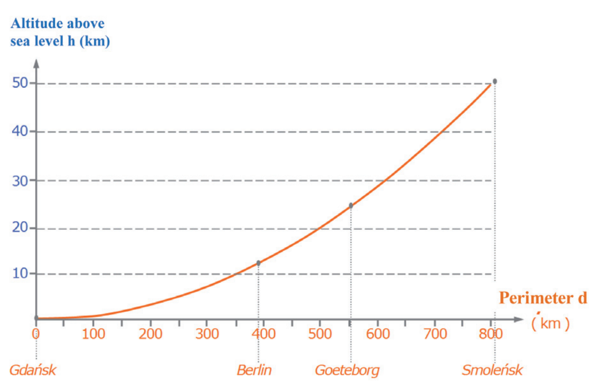


Fig. 10. The influence of the height of observation h on the size of the perimeter d [16]

Conclusions

In the interwar period, Poland quickly assimilated innovative projects. The Balloon and Parachute Factory [14], whose history dates back to 1920 in the inter-war period, produced around 200 N-NN barrier balloons ([4] – additionally 50 ZS-1 and ZS-2 balloons), 50 (according to [3] – 60) observation balloons, 25 free sports balloons with a capacity of 2200, 1600, 1200, 750, and 450 m^3 (according to [3] – 40 balloons of different capacity), 3 jumping balloons, and 1 stratospheric balloon of the Polish Star.

After the outbreak of World War II, the factory was evacuated. The first transport set off from Legionowo on 6.09.1939 in the direction of Zamość, where it was planned to start a new factory. However, on September 9th, the transport was directed to Zaleszczyki, near the border with Romania. On September 17, the factory's property was evacuated to Romania and taken over by the Romanian authorities. The attempts to recover it did not have any effect.

The stratospheric platforms, as early detection and warning systems for emerging threats, have undeniable advantages over common solutions, resulting from a large area of early warning (detection) surveillance, high survival capacity, good early warning capability, and low cost of removal and operation. Another factor that supports Poland's interest in aerostats is the possibility to obtain helium trapped in natural gas deposits, which, contrary to the ending of its sources in Europe and few other sources in the world, will be available for many years, since it occurs in high concentrations in relation to the volume of natural gas.

"In the future, Polish entities could be the manufacturer of their own innovative airship con-structures (including stratospheric ones) and a subcontractor of the main components of such airships, e.g., for Thales Alenia Space", said Paweł Czapski [28], the author of CREOTECH Instruments in 2016, in his publication "Analysis of the possibility of implementing the programme for the construction of stratospheric airships for the needs of national defense and safety". Maybe there will be a chance for the creation of a national project?

Three years have passed since the decision-makers [16] became aware of the problem of recognition and retransmission of data in Poland and abroad with the use of stratospheric aerostats, e.g., through the implementation of the Polonia aerostat project. As a member of the alliance, Poland has much to propose in the scope of the presented problems. If the state authorities, under the influence of foreign lobbyists, are unable to make decisions in the field of advanced technologies, then we have the effect that the aerostats will observe the southern border of Europe, and we will be able to communicate with foreign services about floods, fires and other threats such as "green people" a month after the event (e.g., exercises Zapad 2017), of course, only after paying for the service.

The project, implemented as a government order, would create competences and a product for which there is demand on world markets. Poland would have an independent system of observation and retransmission, which should probably be the highest priority for the Polish government. The implementation of the project by a scientific-industrial consortium comprising Polish universities and several dozen Polish enterprises, apart from competence and technically advanced products, would create several hundred jobs in advanced technologies.

References

1. Jankiewicz Z.: *Aerostaty. Balony i sterowce*. 2 edition. Warszawa: Wydawnictwo Ministerstwa Obrony Narodowej, 1982 [in Polish].
2. Morgała A.: *Samoloty wojskowe w Polsce 1918–1924*. Vol 1. Warszawa: Wydawnictwo Bellona, 1997 [in Polish].
3. Wikipedia: *Lech (sterowiec)*. [Online]. 2019. [Accessed 20 April 2019]. Available from: https://pl.wikipedia.org/wiki/Lech_(sterowiec)
4. Kozak Z., Moszumański Z., Szczepański J.: *Wytwórnia Balonów i Spadochronów*. Seria „Zarys Historii Wojennej Pułków Polskich w Kampanii Wrześniowej". Pruszków: Oficyna Wydawnicza Ajaks, 2008 [in Polish].
5. Dobrzyński P., Lipski S., Machowski B., Malawski M.: Analiza możliwości wykorzystania 40-mm miniaturowych pocisków rakietowych w systemie samoobrony aerostatów obserwacyjnych. In: *XXII Międzynarodowa Szkoła komputerowego wspomagania projektowania, wytwarzania i eksploatacji, Pisz, 14÷18.05.2018*. Conferencence proceedings, reprint, 2018 [in Polish].
6. Dobrzyński P., Lipski S., Machowski B., Malawski M.: Platforma stratosferyczna HAP-s jako środek obserwacyjny bliskiego kosmosu. In: *Konferencja Krajowa „Gwiezdne Wojny" – Technologie Kosmiczne i Satelitarne w Systemach Bezpieczeństwa i Obronności, Gdynia 2018.* Presentation [in Polish].
7. Dobrzyński P., Krawczak M., Lipski S., Machowski B., Malawski M., Rosiak J.: *Platforma stratosferyczna jako element systemu rozpoznania i osłony Sił Zbrojnych i infrastruktury RP*. Competition application for the III competition MON „Innowacje dla Sił Zbrojnych RP", 2017 [in Polish].
8. Bolkcom Ch.: *Potential Military Use of Airships and Aerostats*. CRS Report for Congress, 2004.
9. Khoury G.A.: *Airship Technology*. 2 ed. Cambridge Aerospace Series, 2013.
10. Jamison L., Sommer G.S., Porche I.R.: *High-Altitude Airships for the Future Force Army*. Technical Report, RAND Corporation, 2005.
11. Miura R., Oodo M.: *R&D Program on Telecom and Broadcasting System Using High Altitude Platform Stations*. Telecom, 2012.
12. United States Government Accountability Office: *Future Aerostat and Airship Investment Decisions Drive Oversight and Coordination Needs*. Report to the Subcommittee on Emerging Threats and Capabilities, Committee on Armed Services, U.S. Senate. [Online]. 2012. [Accessed 20 April 2019]. Available from: http://www.gao.gov/assets/650/649661.pdf
13. Dumas A.: *The MAAT Project – Multibody Advanced Airship for Transport*. [Online]. 2013. [Accessed 30 April 2019]. Available from: http://www.airtn.eu/downloads/maat-cranfield_airtn.pdf
14. Samoloty Polskie: *Wytwórnia Balonów i Spadochronów*. [Online]. 2019. [Accessed 20 April 2019]. Available from: http://www.samolotypolskie.pl/samoloty/3131/126/Wytwornia-Balonow-i-Spadochronow-WBS2
15. Kwika J.: Rozpoznanie radiolokacyjne – rzeczywistość i przyszłość Sił Powietrznych. *Obronność – Zeszyty Naukowe Wydziału Zarządzania i Dowodzenia Akademii Obrony Narodowej,* 2015, 4(16), pp. 80–97 [in Polish].
16. Dobrzyński P., Krawczak M., Lipski S., Machowski B., Malawski M.: Platforma stratosferyczna jako element rozpoznania i osłony okrętów MW i infrastruktury nadbrzeżnej. In: *VII Międzynarodowa Konferencja Naukowo-Techniczna NATCON 2016 „Technologie morskie dla obronności i bezpieczeństwa", Gdańsk, 2016.* Monograph, 2016, pp. 152–164 [in Polish].
17. Dobrzyński P., Lipski S., Machowski B., Malawski M.: Nowy sposób wskazywania odległych celów dla pocisków rakietowych dalekiego zasięgu. In: *Wyzwania i rozwój obrony powietrznej Rzeczypospolitej Polskiej – obronność RP XXI wieku*. Akademia Sztuki Wojennej (anticipated release in 2019), presentation: 2017-10-18 [in Polish].
18. Dziennik.pl: *Atak czy zwykła awaria? Problemy z odbiorem TVP przypomniały politykom o istnieniu EmiTela*. [Online]. 2016. [Accessed 30 April 2019]. Available from: http://wiadomosci.dziennik.pl/media/artykuly/538443,emitel-awaria-tvp-info-atak-przerwa-emisja.html
19. Telko.in: *10 proc. Polaków ma problemy z MUX3*. [Online]. 2016. [Accessed 30 April 2019]. Available from: https://www.telko.in/10-proc-polakow-bez-mux3
20. Dobrzyński P., Krawczak M., Lipski S., Machowski B.: Assessment of the Usefulness of Observation and Tracking Heads of the Long-Range for the Stratospheric Aerostat Recognition System. *Problemy mechatroniki. Uzbrojenie, lotnictwo, inżynieria bezpieczeństwa*, 2018, 9(4), pp. 163–176, DOI: 10.5604/01.3001.0012.7340.
21. Dobrzyński P., Lipski S., Machowski B.: *Potencjalne aplikacje nanokompozytów ze strukturami grafenowymi w obiektach latających nowych generacji*. In: Marciniak M., Adamkiewicz J. (eds): *Dylematy współczesnej obronności i bezpieczeństwa państwa. Aspekty logistyczne, techniczne i ekonomiczne*. Wyd. Adam Marszałek, 2018, pp. 153–210 [in Polish].
22. Materials provided by the FLYTRONIC.
23. Materials provided by the THALES ALENIA SPACE.

24. TACSTRAT: *Tactical knowledge for strategic development*. [Online]. 2019. [Accessed 30 April 2019]. Available from: http://www.Tacstrat.com.
25. BLIMP: *le monde des dirigeables de haute altitude*. [Online]. 2005. [Accessed 30 April 2019]. Available from: https://www.blimp-n2a.org/projets_haa.htm
26. *National Renewable Energy Laboratory*. [Online]. 2019. [Accessed 30 April 2019]. Available from: https://www.nrel.gov
27. Miller D.W., Keesee J.: *Spacecraft Power Systems*. [Online]. 2004. [Accessed 30 April 2019]. Available from: http://ocw.ateneo.net/courses/aeronautics-and-astronautics/16-851-satellite-engineering-fall-2003/lecture-notes/l3_scpowersys_dm_done2.pdf
28. Czapski P.: *Analiza możliwości realizacji programu budowy sterowców stratosferycznych na potrzeby obronności i bezpieczeństwa kraju*. [Online]. 2016. [Accessed 30 April 2019]. Available from: https://www.researchgate.net/publication/320962234_Analiza_mozliwosci_realizacji_programu_budowy_sterowcow_stratosferycznych_na_potrzeby_obronnosci_i_bezpieczenstwa_kraju

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