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Role of Geographic Information Systems in analysing the selection of cichociemni drop zones based on a case study of the “Mewa 1” drop zone

Abstract. The article discusses the possible use of GIS tools in detailed spatial analysis of materials and old maps showing the activities of Polish soldiers during World War II. The research was based on information regarding the military operations of the “Silent and Unseen” paratroopers (in Polish: cichociemni) in the General Government (GG), available in the archives of the Polish Underground Movement Study Trust (in Polish: Studium Polski Podziemnej) in London, as well as on prewar maps of the Polish Military Geographical Institute (in Polish: Wojskowy Instytut Geograficzny – WIG). The authors present the historical background to, and important details of the cichociemni airdrops. They also describe how these operations were organised and suitable airdrop sites selected. The main part of the article is devoted to an analysis and assessment of the extent to which selected drop sites of the cichociemni complied with the criteria contained in the instructions of the Staff of the Commander-in-Chief in London (in Polish: Sztab Naczelnego Wodza w Londynie). The article presents a case study of the “Mewa 1” drop zone located in the GG. The authors used calibrated WIG maps, which they then converted into vector versions. They also made use of modern DTM and a slope map created on its basis. All the criteria for selecting drop zones included in the historical instructions were analysed. Based on the example of the drop zone in question, as well as on the authors’ own spatial analyses, it was concluded that this particular drop zone met some of the criteria formulated in the guidelines of the Commander-in-Chief’s Staff, but only partially met others or failed to meet them at all. In addition, the authors noted a number of limitations regarding these criteria. For example, they did not take into account the locations of the occupiers’ garrisons or anti-aircraft positions, which are particularly important for the success of airdrop operations. The analyses and the results thereof constitute the first study of the armed operations of the cichociemni in GG areas using digital maps and spatial analyses based on GIS.

Keywords: historical GIS, cichociemni, World War II, drop zones, spatial analysis

1. Introduction

The rapid development of geographic information systems (GIS) in recent years has created new opportunities for solving research problems in almost every field and scientific discipline. Modern geoinformation technologies have been successfully applied not only in the exact

and technical sciences but also in the social sciences and humanities, including, since the 1990s, in history and historical geography (Gregory, 2005; Gregory & Ell, 2007; Knowles, 2008; Szady, 2008). Although “history has always been geohistory” (Kelley, 2010, p. 22), GIS has offered historians innovative tools for collecting, processing, analysing and sharing spatial in-

formation from the past (Szady, 2013), thereby opening up new avenues for expanding historical knowledge.

Reflexions on the role and importance of geographic information systems in historical research have been accompanied by an ongoing debate on the difficulties and limitations encountered in the research process (Gregory & Healey, 2007; Konopska, 2015; Konopska et al., 2023; Konopska & Barwiński, 2021; Kuna, 2014; Nita & Myga-Piątek, 2012; Ostrowski, 2008; Panecki, 2015; Plewe, 2002; Rumsey & Williams, 2002; Szady, 2018; Zawadzki, 2018). The most common problems are semiotic (reading and interpreting meanings in written sources), cartographic (difficulties accessing old cartographic materials, disparities between the degree of generalisation of old topographic maps and the degree of generalisation of modern topographic maps, as well as difficulties in interpreting symbols of old maps), and historical (uncertainty, inaccuracy, and incomplete information) in nature.

The above issues are of importance not only to researchers working with written and cartographic sources dating from Antiquity, the Middle Ages, and modern times, but also to those exploring recent history (Juhász, 2011; da Silveira, 2014). It should be noted, however, that the more recent the sources, the more complete, accurate, and accessible they are, which is important when reconstructing the historical landscape. In this regard, especially worthy of attention are the topographic maps produced by military institutions in Poland, especially in the period after World War I. The most prominent such body was the Polish Military Geographical Institute (in Polish: Wojskowy Instytut Geograficzny – further WIG), founded in 1919. WIG began its work by standardising and updating topographic maps left by the Austro-Hungarian, German, and Russian armies, and then proceeded to create its own original sheets (Kuna, 2018).

WIG's maps are now considered a valuable and reliable source of historical and geographical information (Krassowski, 1973; Kuna, 2018; Słomczyński, 1934). They are of high quality, intricately detailed and cover the entire territory of Poland, and as consequence provide an important platform for analytical and comparative research. These maps have been used not only to reconstruct former administrative borders or to assess changes in land use

but also to provide valuable geographical and spatial information allowing for an in-depth analysis of military operations that have taken place in Poland.

The availability of WIG maps in digital form together with other written sources from the 20th century ensures an extensive spatiotemporal database for geohistorical analyses using modern GIS tools (commonly described as Historical GIS). It will enable researchers to find answers to difficult questions, verify hypotheses, or expand their existing knowledge to include aspects that would have gone unnoticed when using traditional research tools.

Refining geohistorical information is especially important in cases where historical knowledge is insufficient due to the secret nature of military operations. One such example is the activities of the "Silent and Unseen" (in Polish: cichociemni), i.e. the paratroopers of the Home Army (in Polish: Armia Krajowa) recruited from the Polish Armed Forces in the West and the Polish Army of General Anders. The cichociemni began receiving training in Great Britain in 1940 and later also in Italy from the end of 1943. They were dropped by air into occupied Poland to serve in the ranks of the Union of Armed Struggle/Home Army (in Polish: Związek Walki Zbrojnej/Armia Krajowa, further ZWZ/AK).

The literature on the cichociemni includes numerous studies on their airborne missions and airdrops, their training in Great Britain and their activities in occupied Poland, including individual combat operations in which Home Army paratroopers took part after their jumps (Bieniecki, 2005; Golik, 2016; Mroczkowski, 2007; Tarczyński, 2001; Tochman, 2000, 2002, 2007, 2011; Tucholski, 1984, 2009). Of pivotal importance are the memoirs of the cichociemni themselves, in which they describe their often difficult, experiences before, during, and after the war (Bałuk, 2008; Bystrzycki, 1985; Czepczak-Górecki, 2017; Iranek-Osmecki, 2004; Janowski, 1996; Lachowicz, 2011; Majorkiewicz, 1972). However, it should be noted that to date no research has focused on the role played by geographical factors in such events. According to the authors, such analyses may serve as a valuable complement to the substantial existing literature on the history of cichociemni, opening up new research perspectives in this area.

Among those sources that devote a little more space to geographical issues, Bieniecki's

(2005) extensive monograph deserves particular attention. Drawing on British, Polish, American, and South African source materials the author describes in detail the special missions of British airborne units between February 15, 1941 and December 28, 1944, units in which Polish crews also took part. The book provides the locations of the drop zones used by the cichociemni, both in descriptive form, often with the geographic coordinates provided, as well as in the form of schematic paper maps.

An in-depth analysis of this bibliographic source earlier prompted the authors of the present article to conduct a detailed study of the issue of locating cichociemni drop zones (Polończyk et al., 2017). This is the first study to use GIS to determine the precise locations of those places where cichociemni and equipment were dropped during World War II. By means of geoinformatics, it was possible to detect discrepancies between these locations, determined on the basis of scans, and the geographical coordinates provided in the monograph and descriptive information obtained from archival documents. In addition, the authors assessed the adequacy (accuracy) with which these places were selected according to the criteria set by the British Special Operations Executive (further SOE). The results of the research motivated the authors to explore this topic further with a view to conducting more in-depth spatial analyses. This bore fruit in a research project financed as part of the "DIALOGUE" programme of the Ministry of Education and Science in 2018–2023 entitled: "The GIS in history. The popularisation and possible applications of modern geoinformatic tools in the humanities based on the example of the special operations of the cichociemni – the Silent and Unseen' paratroopers".

The present article offers an in-depth analysis and assessment of the extent to which selected cichociemni drop sites in the General Government (GG) complied with the criteria contained in the instructions of the Commander-in-Chief's Staff in London (in Polish: Sztab Naczelnego Wodza w Londynie). The paper focused on one such drop zone, "Mewa 1" (in English: "Seagull 1"), located in the Home Army District in Krakow, 15 km south of the town of Skalbierz (currently in Proszowice County in the Lesser Poland Voivodeship).

The authors relied on source documents from the archives of the Polish Underground Movement Study Trust (in Polish: Studium Polski Podziemnej, further SPP), digital versions of pre-war operational (in Polish: mapa operacyjna) and tactical maps (in Polish: mapa taktyczna) of Poland, prepared according to the WIG and GIS class systems, as well as a modern geographical digital map. Initially, the "Mewa 1" drop zone was located on operational and tactical maps dating from 1938 and printed in paper form. The next step involved calibrating and vectorizing the tactical map using ArcGIS software. These steps paved the way for more detailed analyses, i.e. a series of distance analyses and analyses of the terrain around the facility based on a digital terrain model (DTM). The results of these analysis made it possible to assess the accuracy and suitability of the location of "Mewa 1" according to the Commander-in-Chief's Staff instructions. The article ends with a discussion and conclusions setting out the possibilities and limitations of GIS in research on the cichociemni, taking into account both written and cartographic sources.

2. Historical background

On August 20, 1940, a special military unit was formed in Great Britain – No. 419 (Special Duties) Flight RAF. It was a squadron assigned to conduct special airborne operations planned by the British SOE, an organisation cooperating with resistance movements throughout Europe, including Poland. The aim of these operations was to transfer trained cichociemni soldiers and couriers, as well as money, equipment, weapons, and supplies to ZWZ/AK forces fighting the German occupation forces (Kalinowski, 1969; Olejko & Mroczkowski, 2011; Tucholski, 1984).

The process of establishing locations for individual drop zones was preceded by preliminary preparations for the flights themselves. One important aspect of the entire project was ensuring successful flights over the airdrop site (Figure 1).

Special airborne missions over occupied Poland usually took place on bright nights when there was a full moon and thus in very specific weather and astronomical conditions. For safety reasons and because of the considerable distances between Great Britain and the GG,

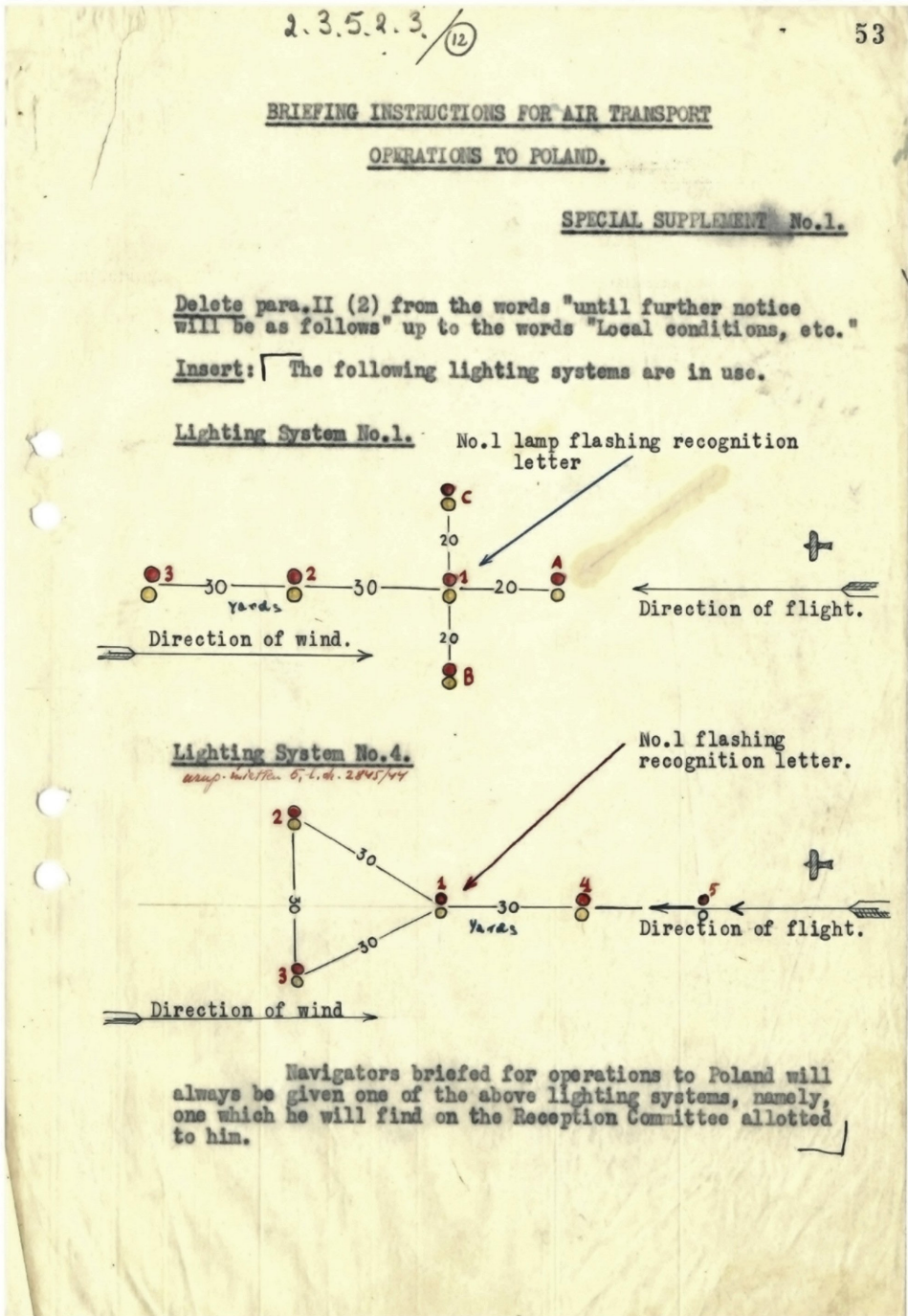


Figure 1. Document supplement "Briefing instructions for air transport operations to Poland" from December 31, 1943 (Polish Underground Movement Study Trust, reference no. A.113)

these missions depended on visual reconnaissance, which required great skill from the navigator as well as excellent knowledge of the terrain. This involved comparing the terrain shown on the maps with passing landmarks, such as rivers, hills, railway tracks, and stations, or distinctive housing settlements (Tucholski, 1984).

Navigators and pilots relied on available military charts (Figure 2). Due to the lack of aerial maps covering the entire territory of occupied Poland at that time, they made use of operational maps of Poland prepared by WIG at the scale of 1:300,000 (Bieniecki, 2005).

The navigators modified these maps with their own additional markings denoting distinctive landmarks. These usually included church towers and town halls, the aforementioned stations and railway stations, railway lines, rivers, and

above all bridges, which due to their construction, often stood out from the terrain during night flights. During these missions, they also observed other standout structures, such as windmills, monasteries, factory chimneys, the towers of mine shafts, oil wells, castles or their ruins. For the navigators, the very topography of the land and its distinctive shape played an important role, e.g. the end of agricultural fields and the beginning of wetlands, hills and cliffs, etc. The pilots operating these aircraft made their flights in accordance with a predetermined course based on information obtained from the navigators, including with regard to the declination and inclination of the Earth's magnetic field. The course was then corrected during the flight with regard to altitude, flight time at a certain speed, and correlated with topographical

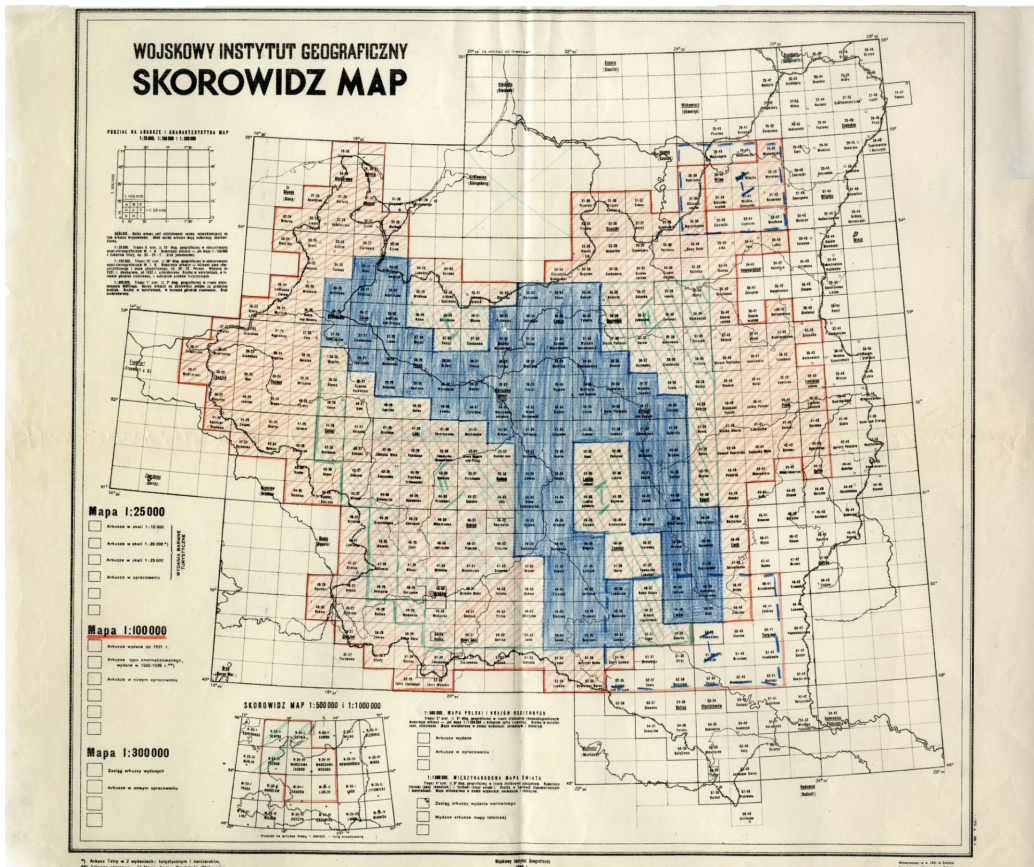


Figure 2. Map index of the WIG from 1939, reissued in 1941 (Polish Underground Movement Study Trust, reference no. A.050)

landmarks. Another key source of information that determined the course of the flight was data that intelligence gathered on the location of Luftwaffe bases and airfields, as well as on night fighter units stationed there and anti-aircraft battery positions (Mroczkowski, 2007).

The first flights transporting the cichociemni took place on the night of February 15/16, 1941 and lasted until December 27/28, 1944. Cichociemni were dropped in the following operational seasons:

- 1) the trial season: February 15/16, 1941 – April 8/9, 1942,
- 2) “Intonation”: September 1/2, 1942 – April 2/3, 1943,
- 3) “Riposta”: September 9/10, 1943 – July 30/31, 1944,
- 4) “Retaliation” and the Warsaw Uprising: August 1/2, 1944 – December 27/28, 1944 (Bieńczycki, 2005).

The choice of locations for cichociemni drop zones (or the equipment itself) in the years



Figure 3. Archival aerial photograph of the area around Nowe Brzesko, probably from 1944, at the approximate scale of 1:46,000; Rb30/20 camera, focal length: 200.56 mm (National Archives and Records Administration, reference no. TU GX 895A SK, photo no.391)

1941–1944 was dictated not only by strategic considerations, but also by geographical, environmental, and landscape conditions. In many cases, the most important factors determining the final location of an airdrop or field landing site were the technical capabilities of the flying aircraft, the intensity of partisan activity in a given area, the deployment of German troops, the location of the front line, which was gradually moving westwards, and finally – but no less important – the mood of the local community towards the Home Army (Mroczkowski, 2007).

According to the records of the VIth Bureau of the Commander-in-Chief's Staff, a total of 642 drop zones were selected throughout the GG, having met the organisational, landscape, and other requirements listed above. The vast majority of them never received a single mission. A total of 73 airborne missions were conducted during which the cichociemni and their equipment were dropped onto 66 sites (Tarczyński, 2001).

The Krakow Home Army District (in Polish: Okręg AK Kraków), in which "Mewa 1" was located, had a mountainous and hilly topography, which was dominated by forests alternating with patches of arable land (Figure 3). The existence of poorly accessible places, including highlands – the Beskid, Gorce and Tatry – was conducive to partisan activity. At the same time, however, it is also important to bear in mind the various difficulties that hampered guerrilla activity, including the vast size of the occupier's forces in the District. There were large numbers of Germans in Krakow alone. The latter was the seat of the central authorities of the GG, powerful intelligence and Gestapo services, and a strong gendarmerie. In 1940 the police and SS forces numbered more than 10,000 people. Up to 50,000 German soldiers were stationed periodically in the city and its vicinity. Despite the fact that Krakow was full of German troops, it was also one of the largest and most important hubs of the resistance movement, both its military and political wings. The location of the drop zones in the vicinity of a large and strategically important urban centre like Krakow ensured that the paratroopers could quickly penetrate the city and distribute materials from local drops (Mroczkowski, 2016).

The location of the drop sites was determined by telegrams based on staff maps at the scale of 1:300,000. Cartesian coordinates were provided in millimetres together with polar coordi-

nates expressed in kilometres, for which the point of reference was a town or a railway station near the outpost. The approximate location of a drop point was determined by measuring the distances given in millimetres from the edges of a specific map sheet in the meridian and latitudinal directions. In addition to telegrams, the locations of outposts were also contained in the record cards of airdrop zones. These cards were descriptive documents prepared by the VIth Bureau of the Commander-in-Chief's Staff that included, besides a drop zone's location, contact addresses, its standby period and the course of the mission. The record cards also include information regarding map sheets drawn at the scale of 1:100,000, on which a given zone can be located.

Before the beginning of each operational season, a member of a special unit of the Vth Bureau (Communication) of the ZWZ/AK Headquarters, most often called a "Syrena", went out into the field as a "delegate of the Headquarters" and, with the help of people from the local field network, marked a specific drop field (Jasiński, 2016; Tucholski, 1984). The location was then noted on maps, reconnaissance was conducted of the local area and local facilities occupied by the Germans identified, including field observation points, gendarmerie outposts, antiaircraft batteries, etc. Contact addresses for paratroopers were also provided in the event of a failed drop outside the zone area. The commander of the zone gathered the crew and assigned soldiers individual tasks: receiving an airdrop, escorting the paratroopers from the landing site, and ensuring their safety. After the crew had been sworn in, received their training and rehearsed their tasks, the zone was ready to receive a drop and went on standby (Mroczkowski, 2007; Tarczyński, 2001).

The first source document containing guidelines on how a drop zone should be organized is Annex 2 to Instruction No. 8 entitled "Drop Zone Operating Instructions" (in Polish: "Instrukcja funkcjonowania placówki odbiorczej zrzutu", SPP, reference no. A.113). This document is undated; it is contained in the file of the VIth Bureau of the Commander-in-Chief's Staff as document number 3330/tj.41. The updated document – under the same name – is dated June 1, 1943 (SPP, reference no. A.421); in the file of the VIth Bureau of the Commander-in-Chief's Staff, it is listed as document number

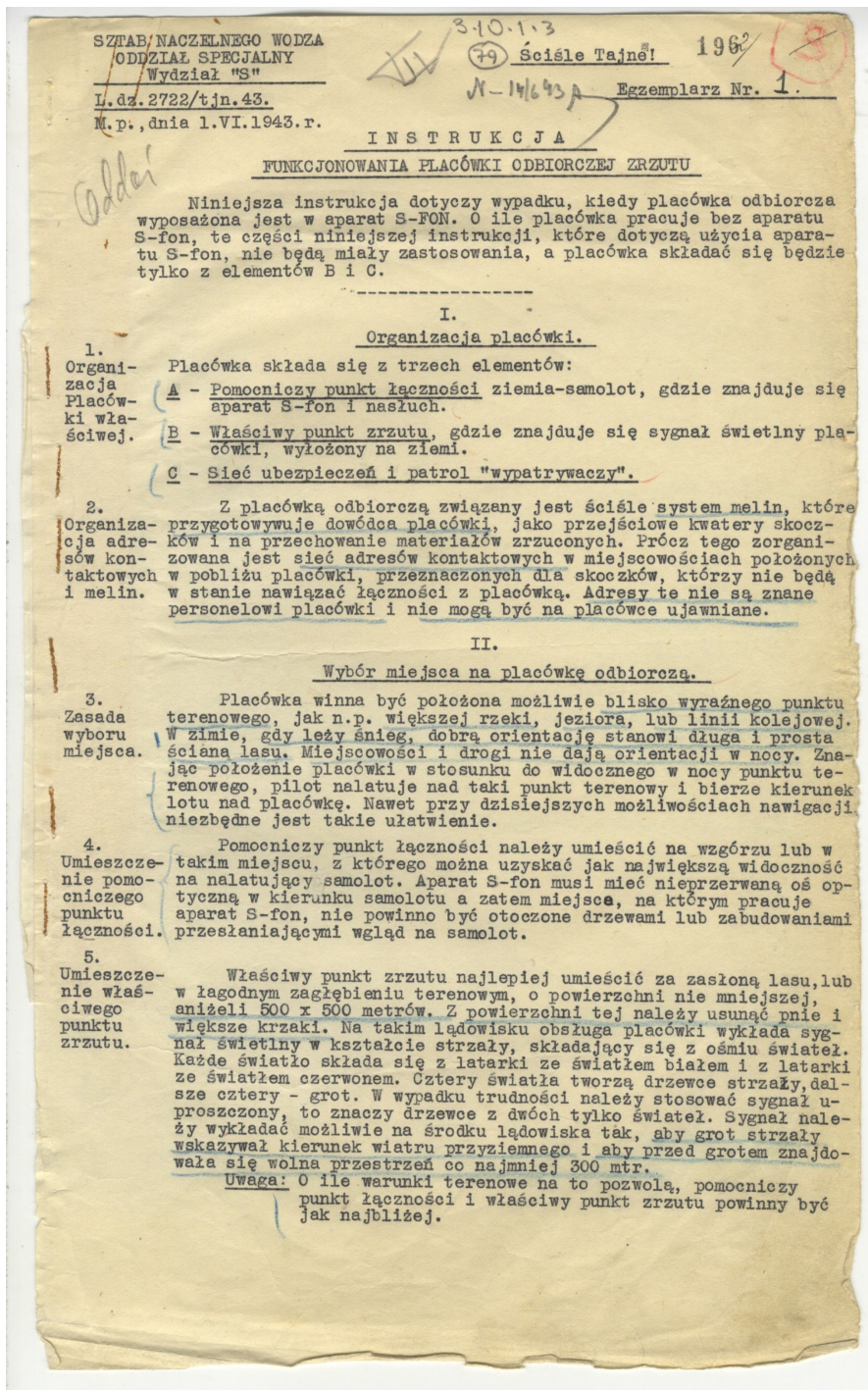


Figure 4. Title page of the document "Drop Zone Operating Instruction" of June 1, 1943 (Polish Underground Movement Study Trust, reference no. A.421)

2722/tjn 4 (Figure 4). An integral part of the "Instruction..." from 1943 is Appendix No. 2 entitled "Data needed to launch the drop zone" (in Polish: "Dane potrzebne dla uruchomienia placówki odbiorczej zrzutu") and Appendix No. 3 entitled "Airdrop Receiving Staff Duties" (in Polish: "Obowiązki personelu placówki odbiorczej zrzutu"). The third document, "Drop Zone Operating Instructions for the Airdrop of People and Materiel" (in Polish: "Instrukcja funkcjonowania placówki odbiorczej zrzutu ludzi i materiału"), is dated March 24, 1944 (SPP, reference no. A.113); the document number is missing from the files of the VIth Bureau of the Commander-in-Chief's Staff. The guidelines provided in all three documents served as the basis for the analyses presented later in the article.

3. Materials and methods

The basic source material that enabled the authors to determine the exact location of the "Mewa 1" drop zone was a record card obtained on the basis of an archival query to the London SPP (SPP, reference no. A.121).

The "Mewa 1" (Figure 5) drop zone, document numbers 5021/43 and 2202/44, was listed in the files of the VIth Bureau of the Commander-in-Chief's Staff under numbers 411 and 223. It was initially designated as a place capable of receiving a drop from a single aircraft. Later, it was changed into a "bulwark" (in Polish: "bastion") selected as a site for receiving drops from two, and later from three aircraft. The "Mewa 1" record card includes information indicating

298 BAST III
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MEWA 1.

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		Spalona — Bula 2 dnia 1. VI. godz. 21.30 Spalona — Bula 2 dn. 2. VI. godz. 15.07	
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Figure 5. Fragment of the record card of the drop zone "Mewa 1", no date (Polish Underground Movement Study Trust, reference no. A.121)

that the zone should be sought on the “Kielce” map sheet (scale 1:300,000), measuring 27 mm from the left side and 68 mm from the bottom. The card does not specify on which 1:100,000 maps the zone might be located. There is only the following information: “48-31”. This indicates that the zone can be found on the “Brzesko Nowe” map (48th parallel, 31st meridian).

The analysis was based on the following items: an operational map of Poland (scale 1:300,000), i.e. the “Kielce” sheet dating from 1938 (Appendix 1), a tactical map of Poland (scale 1:100,000), i.e. the “Brzesko Nowe” sheet from 1938 (Appendix 2), and a modern DTM of the drop zone area, which was downloaded from the resources of the Head Office of Geodesy and Cartography (Geoportal, n.d.). Additionally, a slope map, that is a gradient map, was also prepared. This presents the slope of the terrain in terms of percentages or degrees along with the direction of the slope. The slope map was an auxiliary tool to help assess the degree of topographical differentiation in the drop zone area.

The authors assessed the extent to which the “Mewa 1” drop zone complied with the instructions referred to in part 2 of the article and which are also found in the SPP collections. The criteria contained in these documents are presented as a whole in tabular form (Table 1). The letter “X” denotes the criteria specified in the first set of instructions (undated document), the letter “Y” represents the criteria contained in the instructions from June 1943, while the letter “Z” constitutes the criteria included in the instructions from March 1944. Moreover, to increase the transparency of the analysis, the criteria were divided into three types, i.e. the area of the drop zone, its safety and the ease with which the place could be identified using landmarks (The National Archives Documents, 2004).

The analyses were conducted with the commercial ArcGIS platform, using a modern digital map as a background.

4. Preparation of historical data and maps

4.1. The process of locating a drop zone

In the first stage of their analysis, the authors assessed the geographical coordinates of the

drop zone in question. Their location was based on information kept on the Commander-in-Chief’s Staff record card, which measured the distance in millimetres from the edges of the 1:300,000 scale map. This location was then transferred to the 1:100,000 scale map identified by the parallels and meridians visible in the appropriate entry on the card.

In this way, “Mewa 1” was located on the 1:300,000 “Kielce” map sheet, 27 mm from the left side and 68 mm from the bottom. This point was then transferred to the 1:100,000 “Brzesko Nowe” map sheet, located at 48th parallel and 31st meridian. The landing zone was located approximately 15 km south of Skalbierz, which is consistent with the corresponding entry on the record card.

4.2. Digitisation and calibration of old maps

Digitising an old paper map is a process that involves several steps, from scanning the map to using calibration software. The initial phase of the process involved producing a scan at the highest possible resolution.

Due to the fact that old maps often contain artefacts and flaws, the scan in question was also edited with photo processing software. This technique made it possible to remove unnecessary markings or annotations added to the original map by its users. The project was based on WIG maps, which were scanned with an accuracy of 300 DPI.

The next step involved georeferencing the map, which in the case of old maps is by no means a trivial task. Due to the inaccuracy of the drawing, deformation of the paper, and the lack of any standard scale, it was decided to designate control points on the map in such a way that they could be assigned coordinates in the PL-1992 system (Figure 6). Crossroads, bridges, churches and other long-lasting man-made landmarks, as well as distinctive natural landmarks (river confluences, mountain peaks, etc.) were identified on the selected raster and their coordinates were read from a modern base map contained on the Polish Geoportal website. The selected reference points were set to be as stable as possible in terms of their location in the field.

If the control points could not be determined by means of natural objects, other fixed points,

Table 1. Criteria for determining the drop zones contained in the instructions of the VIth Bureau of the Commander-in-Chiefs' Staff in London. Source: authors' own elaboration based on documents from the Polish Underground Movement Study Trust, reference numbers: A.113, A.421

CRITERIA					
A. DROP ZONE AREA		B. DROP ZONE SAFETY		C. THE EASE WITH WHICH A PLACE CAN BE IDENTIFIED – LANDMARKS	
A1. Area not less than 400x120 m (X).	<i>Drop zone safety</i> B1. It is important that suitable conditions exist for hiding (burying) dropped materials in the vicinity of the proper drop point (X).	<i>Landform</i> B4. The drop point should be located in a forest clearing or in a shallow depression in the terrain (X, Y). B5. The landing zone should be located behind forest cover or in a shallow depression in the ground so that its visibility from the surrounding area is minimized (Z).	<i>Reservoirs, rivers, lakes channels and channels</i> Distances C1. Location 1–16 km from a bend/mouth of a larger river (X). C2. Relative location 1–16 km from a lake or a large pond (X).	<i>Forests and forest massifs</i> C5. A long, straight forest line serving as a landmark (in winter, when there is snow) – (X, Y). C6. Visible point at night – beginning of a forest (X).	<i>Auxiliary communication point</i> C8. The ground-to-aircraft auxiliary communication and orientation point (A) should be located on a hill or some other location so as to ensure the greatest possible visibility of the approaching aircraft at an angle of more than 180 westward (X, Y). C9. Point A cannot be located in a pit or surrounded by trees or buildings (X, Y). C10. Distance between point A and B (proper drop point) – about 1.0 to 2.5 km (X).
A2. Area not less than 500x500 m (Y, Z).	B2. Remove stumps, stones, and larger bushes from the drop zone area (X, Y). B3. There must be no stumps, larger or hard bushes, trees, protruding stones, fences, even the smallest ditches, or other similar obstacles in the drop zone area (Z).		<i>Landmarks</i> C3. A visible landmark at night – a river bend or larger river (X, Y, Z). C4. Visible point at night – lake (X, Y, Z).	<i>Roads and railway lines</i> C7. A clear, distinctive terrain point very visible at night – railway track (Y, Z).	
D. ADDITIONAL INFORMATION	D1. The drop zone is connected to a system of dens prepared by the drop zone commander as temporary quarters for paratroopers and dropped material. In addition, there was a network of contact addresses in towns located near the drop area, intended for paratroopers who did not make contact with the zone after the drop (Y, Z). D2. Lookout Patrol (people/material drop lookout) positioned in the downwind extension of the signal; the distance of the patrol from the signal depends on the strength of the wind – when the wind is strong, the patrol should be placed at a distance of up to 1000 m (Y, Z).				

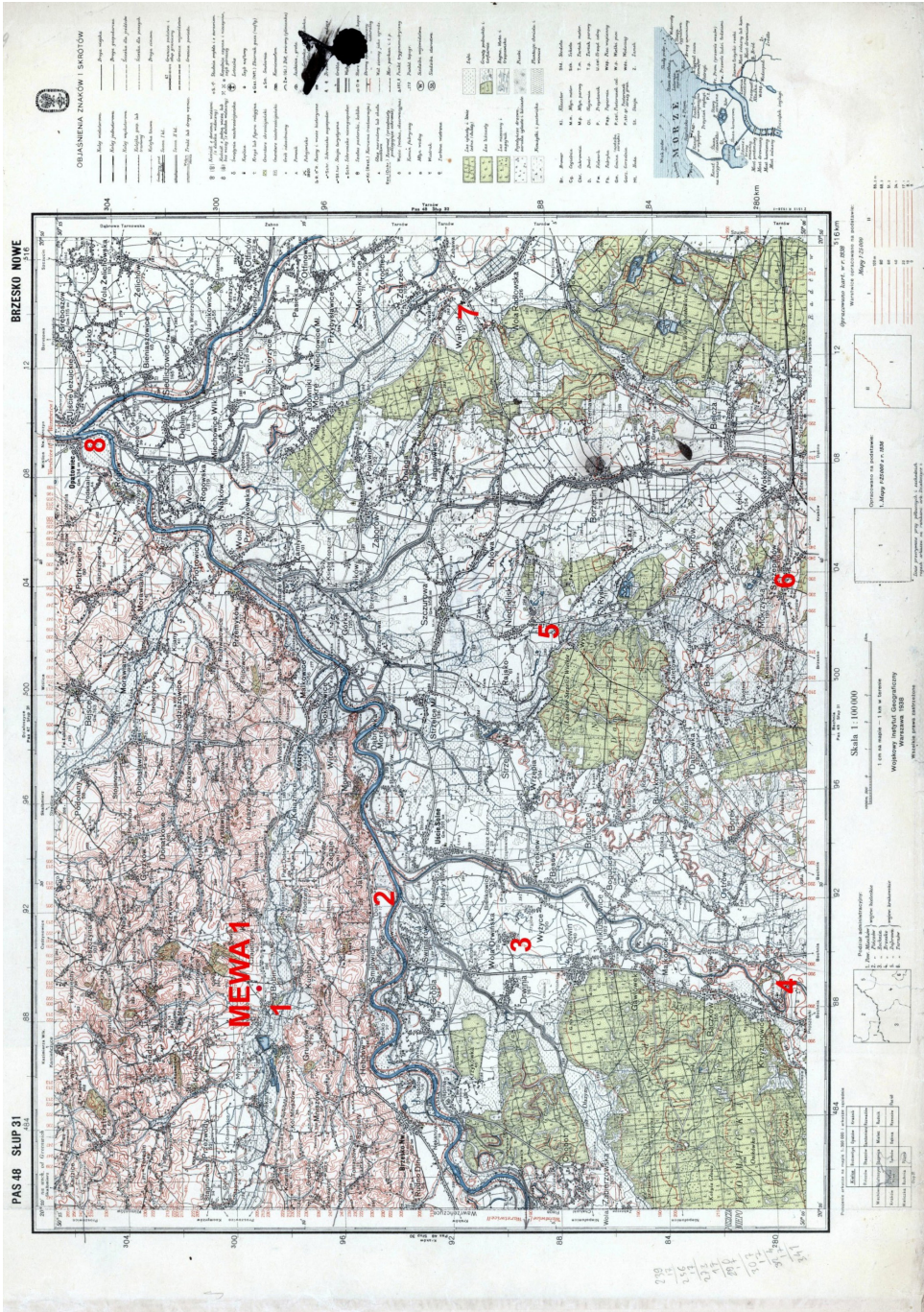


Figure 6. Location of calibration points on the “Brzesko Nowe” tactical map at the scale of 1:100,000 (prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain)

such as churches or castles, were chosen. To check the accuracy of the performed calibration, one of the base maps available in the ArcMap programme was used, on which was superimposed a calibrated raster map displayed with some degree of transparency. This tool helped reduce the margin of error.

Then, applying quantitative evaluation methods for assessing spatial accuracy, the authors examined any possible georeferencing errors. The final step involved fixing points to fit the scan to a modern frame of reference using second-degree surface polynomials (Affek, 2013; Brigante & Radicioni, 2014; Yilmaz & Gullu 2012).

4.3. Vectorisation and preparation of the graphic design of the map

Unlike vector maps, electronic raster maps in scanned and calibrated paper form were unsuitable for performing a number of the spatial analyses relevant from the point of view of the

present research. As a consequence, WIG raster maps had to be vectorised.

The WIG maps intended for vectorisation are divided into thematic layers according to the available legend. Vectorisation was performed manually using ArcGIS software. Each layer was saved in a separate geojson file containing attribute information and vector geometry. It is worth noting that the quality of the spatial analyses is closely related to the quality of the contextual background, referred to as the base map. As a consequence, the authors assumed that the vectorised data would be used to develop the graphic layout of the map, which would include cartographic symbols. This provided the basis for a vector version of the WIG map, a sample of which is presented in Figure 7.

In addition to using a set of cartographic symbols assigned to different classes of terrain, the authors also prepared a number of other symbols, representing successive contact addresses for paratroopers, as well as Wehrmacht garrisons, and cichociemni drop zones. These points were identified on the basis of

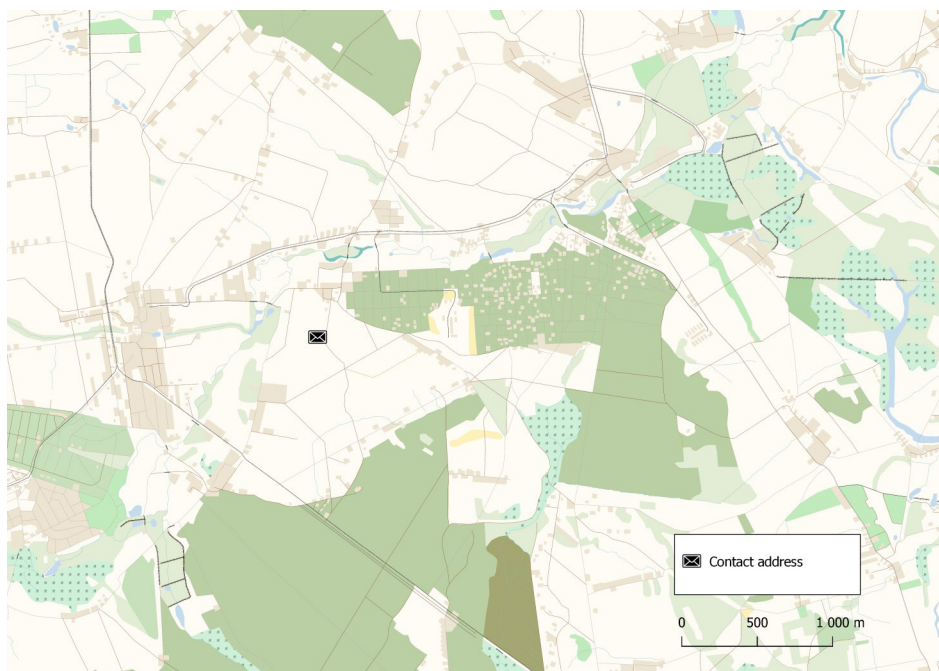


Figure 7. A topographic vector base map developed on the basis of old WIG maps (base map: vectorised "Warszawa Południe" tactical map at the scale of 1:100,000, prewar maps of the WIG, National Library, ZZK S-146 A, public domain)



Figure 8. Cartographic symbols representing (from the left) contact addresses, Wehrmacht garrisons, and cichociemni drop zones

source documents from London and the German-language literature on the subject (*Lexikon der Wehrmacht*, n.d.). The cartographic symbols of these points are presented in Figure 8.

5. Results

5.1. Geospatial analysis

The location of a drop zone, chosen in accordance with the applicable instructions, was key to the success of the mission of every cichociemni soldier. In the case of improperly designated drop zones, the likelihood of para-

troopers or equipment being intercepted by the enemy increased significantly. Whether a drop zone could be considered safe came down to several factors, such as the morphology of the terrain, how developed the area around the drop zone is, and effective access to road and rail infrastructure. These factors have been evaluated in the present article. However, it is worth bearing in mind that besides geographical factors, there may have been other conditions that contributed to the wrong choice of a drop site. These might have included, for example, difficulty in understanding or actually misunderstanding messages exchanged between headquarters in London and the local forces in the GG or inconsistencies in interpreting the criteria contained in the instructions. The analysis of these conditions could be the subject of separate studies.

The authors decided to recreate the decision-making process of the people responsible for selecting the drop zone locations, based on the criteria set by the Commander-in-Chief's Staff. They made use of geospatial data, including the



Figure 9. The "Mewa 1" drop zone marked on the vectorised WIG map (base map: vectorised "Brzesko Nowe" tactical map at the scale of 1:100,000, prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain)

location of the drop zone marked on the WIG vector map, studied the morphology of the area around the facility and conducted a number of distance analyses. Each of the resulting maps was assessed using the criteria defined in Table 1.

5.2. Evaluation of the criteria for the „Mewa 1” drop zone

The location of „Mewa 1” is shown on the map (Figure 9). Lying to the west of the drop zone is the municipality of Proszowice, which is an urban centre with access to a narrow gauge railway.

5.2.1. Analysis of the selected drop zone location in terms of its safety

The first criterion concerned the area of the drop zone (criteria A – see Table 1), which should not be less than 400×120 m (criterion A1) or 500×500 m (criterion A2). Both of these criteria

were formally met; however, the area chosen (according to A2) was located in the immediate (< 100 m) vicinity of several buildings. A much better position would have been to move the drop zone approximately 1 km NNE, as is shown in Figure 10.

The map from Figure 10 can also be used to assess the drop zone in terms of the safety criteria (criteria B – see Table 1).

In the opinion of the authors, the selected location did not meet the assumed B1 safety standards. The conditions for hiding (burying) dropped materials cannot be unequivocally classified as favourable. The dumping zone lay in arable fields and was bounded from the south by the main road and from two sides by rural and farm roads. Located in the immediate vicinity (approx. 300 m) was the settlement of Bobin, which consisted of over 10 residential and farm buildings.

In the case of criteria B2 and B3, it can be assumed that, due to the type of terrain involved (arable fields), the drop zone contained no major



Figure 10. Location of the “Mewa 1” drop zone in close proximity to buildings (marked with the letter A) and its alternative (marked with the letter B). Polygons representing buildings are marked with light-brown symbols (base map: vectorised “Brzesko Nowe” tactical map at the scale of 1:100,000, prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain)

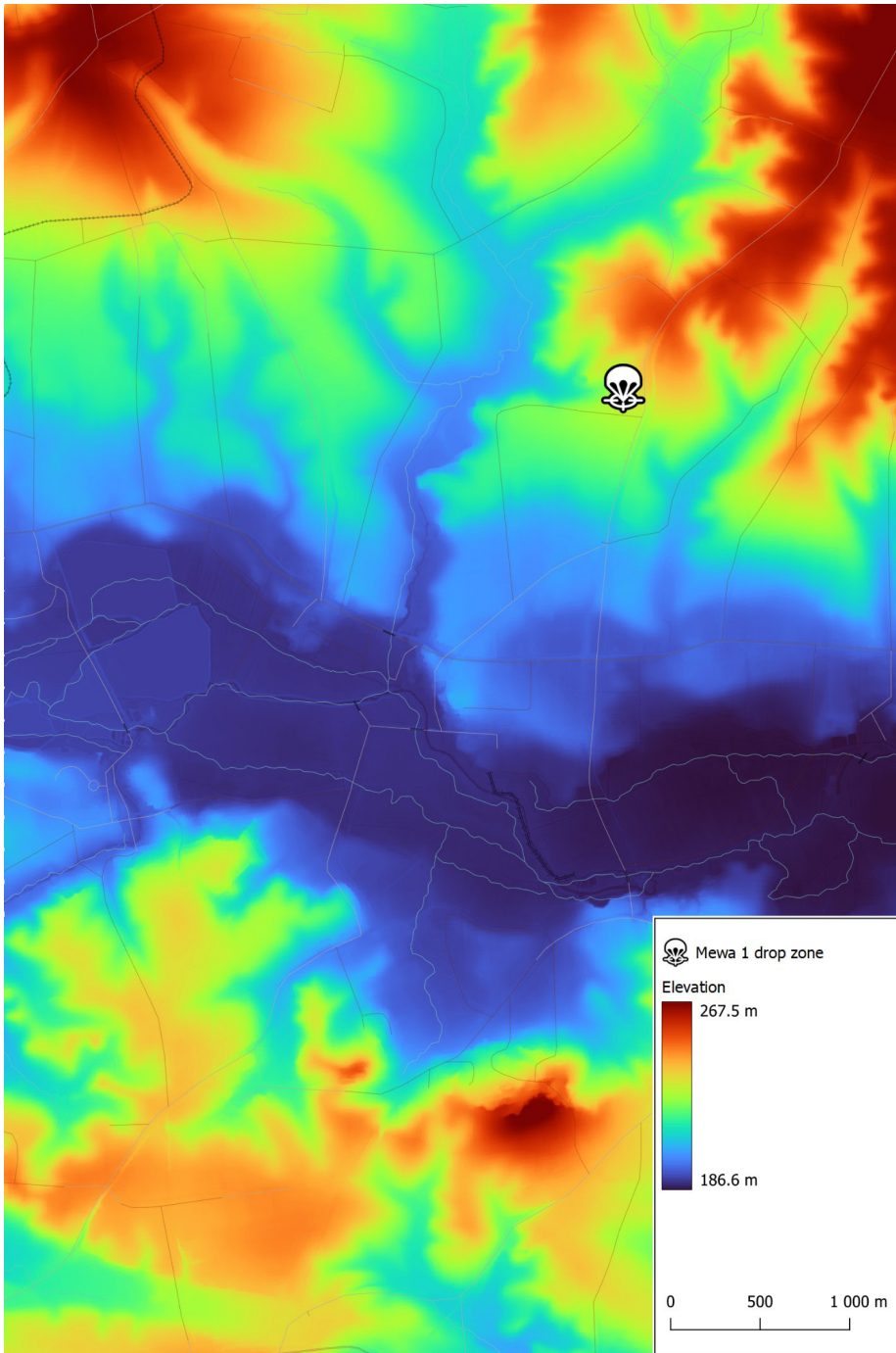


Figure 11. The location of the “Mewa 1” drop zone marked on the DTM (Base map: vectorised “Brzesko Nowe” tactical map on a scale of 1:100,000, prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain; DTM – source: <https://mapy.geoportal.gov.pl>)

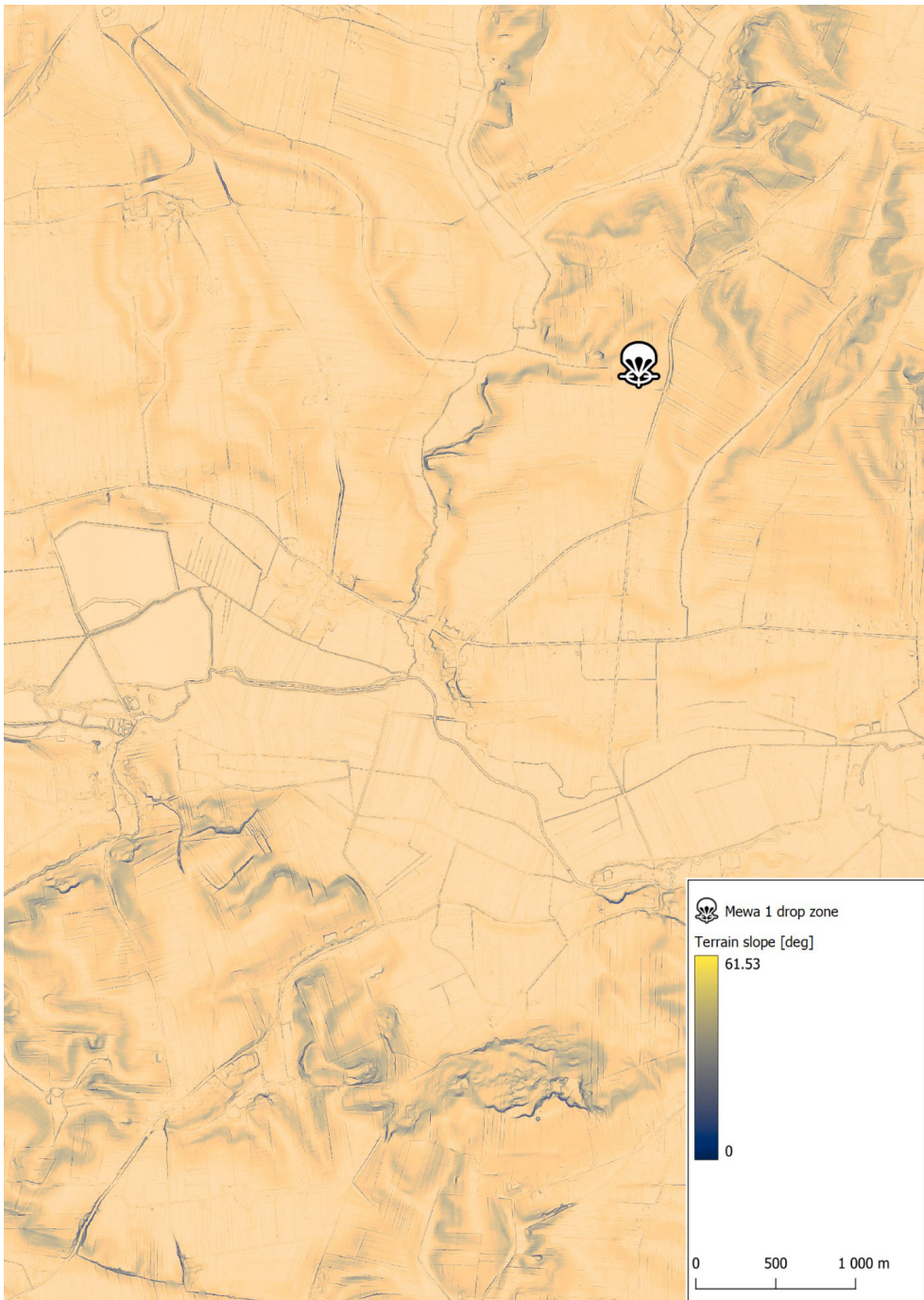


Figure 12. Map of slopes around the “Mewa 1” drop zone (Base map: vectorised “Brzesko Nowe” tactical map at the scale of 1:100,000, prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain; map of slopes based on DTM – source: <https://mapy.geoportal.gov.pl>)

obstacles such as stumps, trees, protruding stones, or any other impediments. However, it should also be pointed out that criterion B3 assumes the absence of even the "smallest ditches". Owing to the fact that only contemporary DTM is available, it is impossible to verify this criterion.

The final safety criterion concerned the terrain. As is shown in the map (Figure 10), the drop zone was located in a cultivated field. The area itself is surrounded by bushes to the south, and there is a forest 1.5 km to the north-east. Based on the contemporary DTM and slope maps (Figures 11 and 12), assuming that the morphology of the terrain has remained unchanged, we can conclude that the designated area was not located in a depression, which means that criteria B4 and B5 were not met. Additionally, the drop zone was not in a forest clearing or behind forest cover, which was also contrary to the requirements of criteria B4 and B5.

Group C criteria (see Table 1) concern the extent to which a drop zone can be identified

using existing landmarks. The proximity of a bend in the Vistula (3.6 km) and a nearby lake (1.6 km) means that criteria C1–C4 had been formally met (Figure 13). It should be noted, however, that several meanders of the Vistula River lie near the drop zone (nine of them are visible in Figure 13). It can therefore be assumed that the navigator had considerable difficulty selecting the right bend lying closest to the drop zone.

The use of existing forest massifs as landmarks was assessed on the basis of criteria C5 and C6 (Figure 14). An analysis of the results shows the presence of a large forest complex with a distinctive shape, which, being a distance of 1.3 km NNE from the drop zone, would have been relatively easy to locate at night. Therefore, these criteria were also formally met.

The drop zone was also 2.8 km from a narrow gauge railway (tracks visible in the northwest part of the map) leading to Proszowice and Kazimierza Wielka. This fact indicates that criterion C, i.e. the existence of a railway line as a landmark, was also satisfied.

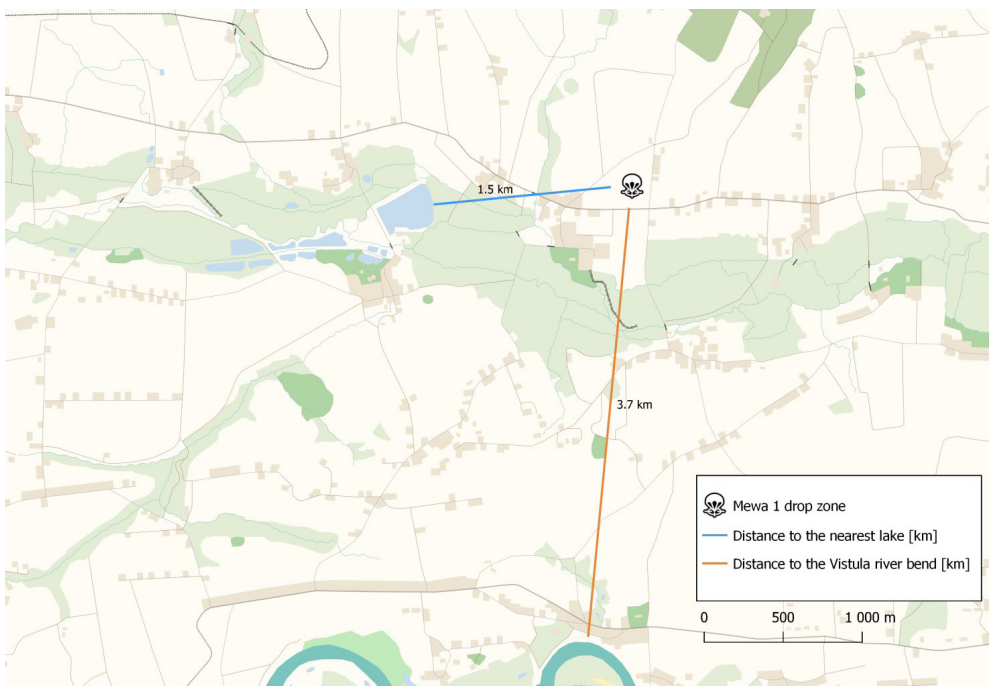


Figure 13. Distance of the "Mewa 1" drop zone from the Vistula bend – orange line and the nearest lake – blue line (Base map: vectorised "Brzesko Nowe" tactical map at the scale of 1:100,000, prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain)

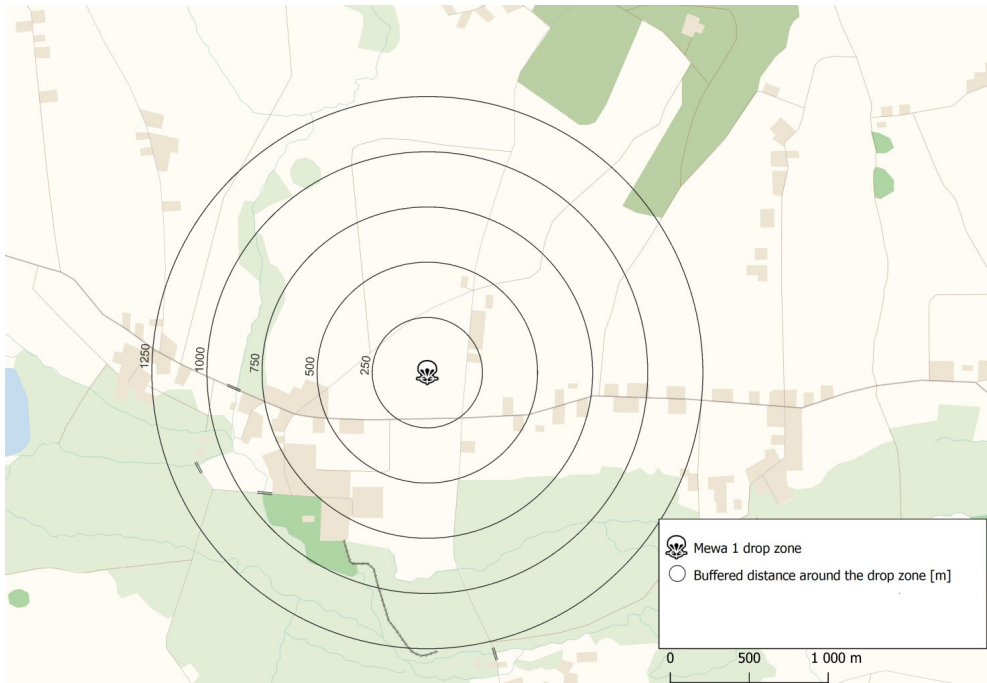


Figure 14. Landmarks in the form of long and straight forest lines together with their distance from the “Mewa 1” drop zone (Base map: vectorised “Brzesko Nowe” tactical map at the scale of 1:100,000, prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain)

The use of a shaded terrain map (Figure 15), on which was superimposed a vectorised WIG map, made it possible to establish two potential auxiliary points for the drop zone. These points are located on small hills, which in turn denotes the fulfilment of criteria C8–C10, namely the guidelines for establishing an “auxiliary communication point” for this drop zone.

The final set of criteria taken into account by Commander-in-Chief’s Staff in London concerned contacts with, and the activities of, personnel in the vicinity of the drop zone (criteria D – see Table 1).

Based on the archival materials alone, it is not possible to show the den system on the map (criterion D1). However, the record card contains information on contact addresses in Bobin (marked in Figure 9 with an envelope icon), which are located near the drop zone (approx. 500 m). This, in turn, means that this part of criterion D1 had been met. On the other hand, when it comes to criterion D2, the archival

documents do not contain information on this subject, and as a consequence, we cannot determine whether this criterion was satisfied.

6. Discussion and conclusions

The analyses presented above made it relatively easy to assess the extent to which the „Mewa 1” airdrop zone adhered to the conditions established by the Commander-in-Chief’s Staff for cichociemni airdrop sites. Thanks to the preparation of a vector version of the military map that included the location of the zone, it was possible to check with a considerable degree of accuracy its compliance with the Commander-in-Chief’s Staff criteria. These criteria specify the requirements that sites had to meet to be considered potential airdrop zones. These included the safety of the drop zone and the ease with which navigators could identify these places. As can be seen from Table 1, the criteria do not include any requirements regarding the location



Figure 15. Potential auxiliary communication points designated for the “Mewa 1” drop zone (base map: vectorised “Brzesko Nowe” tactical map at the scale of 1:100,000, prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain; DTM – source: <https://mapy.geoportal.gov.pl>)

of the occupier, e.g., the distance to the nearest garrisons or outposts, anti-aircraft battery emplacements, or the proximity of a road network that would enable enemy troops to move relatively rapidly to intercept airdrops. It should be presumed that these criteria, as well as the attitude of the local population towards partisan activities, were taken into account during the selection process. However, due to the dynamics of warfare, they had to be checked on an ongoing basis via reconnaissance carried out by people from the local resistance network.

During these airborne operations, the people responsible for identifying suitable drop zones worked exclusively with paper maps, which in many cases were lacking in sufficient detail. As a consequence, the above-mentioned field reconnaissance played a key role, enabling the terrain to be checked one final time to ensure its adherence to the above criteria.

It should be pointed out that the local conditions have changed over the course of nearly

80 years – new buildings have been erected, the forest line modified, the layout of roads and land use altered, new railway lines built and old ones liquidated. Finally, a number smaller lakes have dried up and some of the ponds silted up. In connection with the above, an assessment of the drop zone’s compliance with the instructions of the Staff of the Commander-in-Chief was only possible by means of a vector version of the map from the prewar period.

It is worth emphasising here that the type of historical research presented here requires the use of vector versions of old maps. The quality of the analysis and the accuracy of the conclusions depend on their quality. Therefore, the most important criteria for assessing the results are the precision of both the map calibration and the elements transferred to the vector version. Possible errors at each of these two stages lead to false results and, as a consequence, conclusions. Vectorisation, although time-consuming and labour-intensive, has become an

indispensable feature of the research presented in this article, as it serves as a tool for verifying the criteria and, as a result, partially reconstructing historical events connected with the vital task of determining the drop zones for cichociemni transferred to Poland to fight the occupation forces.

The analyses clearly show that the choice of a specific drop zone was not always fully in line with the previously specified requirements. In the case of „Mewa 1”, a number of criteria were not met or were only partially met. It failed to satisfy criteria B1–B3, regarding the safety of the zone, and likewise it probably also fell short of criteria B4 and B5. On the other hand, criteria C2, C4, and C6–C7, i.e. the existence of landmarks that can assist the navigator in identifying the drop zone, were fulfilled, although criteria C1 and C3 can only be considered partially so. Despite some inaccuracies in how the criteria were applied, it can be concluded that in the case of „Mewa 1” most conditions were fulfilled. It can therefore be argued that such partial compliance was deemed sufficient for two drops to be made successfully – one with paratroopers and equipment, and the other with material – which took place on the night of May 4/5, 1944. When making an overall assessment of the operation, additional attention should be paid to other circumstances, including, for example, the involvement of people receiving the drop and the absence of German patrols during the landing of the paratroopers. It is also noteworthy that Polish pilots and navigators were able to reach the target site, despite the fact that the location of the facility did not meet all the necessary selection criteria.

At this point, the authors would also like to point out that missions did not always take place in formally designated drop sites. In many cases, due to unforeseen circumstances, a drop was made in a slightly different place than the previously planned site, and, as a consequence, depending on the specific operation, the formal criteria may not have been met to the extent previously assumed by the Staff of the Commander-in-Chief. To make the analyses even more precise, at a later stage of the research, it was necessary to refer not only to materials

from the London archives and available literature on the subject but also to possible available sources at the local level. It is worth noting that more and more researchers interested in local history are looking for actual drop zones based not only on archival documents but also on the accounts and recollections of witnesses (Borcz, 2023; Natoński, 2023). Although only in a few cases have reliable accounts of eyewitnesses of events (those of the cichociemni and those of people responsible for looking after them following the jumps) have been preserved, there are other sources and materials that may contain valuable information from the point of view of a given airdrop. Certainly, field research can be a valuable supplement to existing research, which – when reinforced with spatial analyses – brings us closer to achieving an even more accurate reconstruction of the historical facts.

Finally, it is worth emphasising the fact that to date no similar research has been conducted on the history of the cichociemni. According to the authors, the results presented in the article show that the use of old maps and geoinformatics tools for spatial analysis based on historical data on special operations during World War II constitutes an important contribution to the humanities and a starting point for further historical research. Vectorised maps provide the basis for other spatial analyses, such as reconstructing the routes of the cichociemni after airdrops to larger cities such as Warsaw or Krakow. Like many such historical analyses, this involves a considerable degree of uncertainty due to the secret nature of the operations conducted at that time. Nevertheless, it is worth making the effort because – as the authors' own experiences show – this knowledge is important not only for the discipline but also for the communities living near these drop zones that are interested in local history who want to commemorate the achievements of the Home Army paratroopers who jumped there.

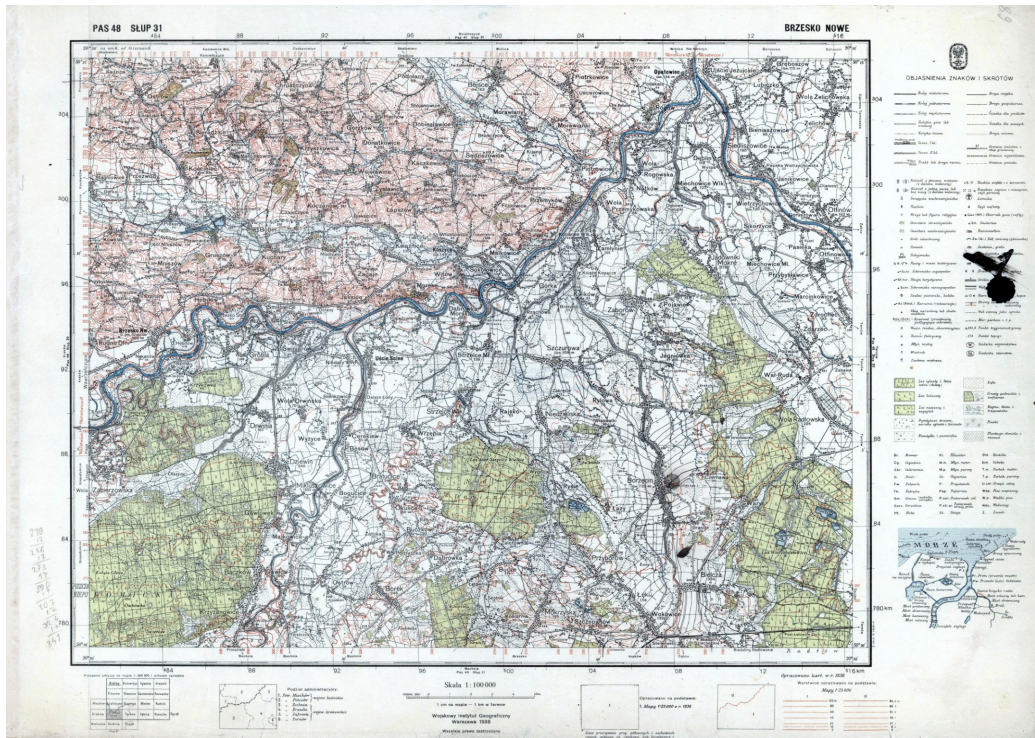
Funding. This research was financed within the framework of the “DIALOGUE” programme of the Ministry of Education and Science in the years 2018– 2023.



Appendix 1. Operational map of Poland at the scale of 1:300,000, “Kielce” map sheet from 1938 (prewar maps of the WIG, National Library, ZZK S-20 841 A, public domain)

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Appendix 2. Tactical map of Poland at the scale of 1:100,000, "Brzesko Nowe" map sheet from 1938 (prewar maps of the WIG, Biblioteka Jagiellońska, M 37/3, public domain)

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