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ANALYSIS OF THE POLISH HOME ARMY DROP ZONES DURING WORLD WAR II, USING GEOGRAPHIC INFORMATION SYSTEMS

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Summary

The aim of the research presented in this paper was to determine the precise location of drop zones that were used for parachute jumps of the 'Silent and Unseen' paratroops (Polish: *Cichociemni*) and for delivering military equipment during World War II. The studies were based on historical research containing information about the locations of the jumps and their schematic arrangement, Ordnance Survey Maps of the pre-war period, and a GIS system with contemporary geographic digital maps. Within the work, the available information about the drop zone locations of the period from February 1941 to December 1944 is summarized. Moreover, the calibration of available schematic maps is presented, based on contemporary digital data. The final part of the study contains an estimation of drop zone location errors compared against military tactical maps.

Keywords

digital historical maps • historical GIS • calibration • 'Silent and Unseen' • drop zones • Polish Home Army

1. Introduction

Over the last two decades, the dynamic development of Geographic Information Systems (GIS) can be observed, which has opened new possibilities for solving research problems that exist on the boundary between different disciplines of science. GIS has become an effective tool for conducting detailed analysis, in some cases giving an impulse to the creation of new scientific disciplines or sub-disciplines. One example is Historical GIS, in which studies of the past are based on technology that connects historical information to spatial dimensions. A. Affek [Affek 2012] noted that studies of land development restoration of historical landscapes and administrative boundaries are one of the fundamental research problems in HGIS. On the other hand, I. N. Gregory [Gregory 2008] has identified the practical value of this sub-discipline. First of all, HGIS could help historians obtain answers about geographical aspects of their research, as well as providing them with the ability to use effective tools to carry out quantitative and qualitative analysis of historical data, enriched with location attributes.

This opinion is consistent with that of B. Szady [Szady 2008], who argues that each of the GIS functions could be used in historical and geographical research projects, enabling to accelerate, organize and unify them.

Located midway between geography and information technology, GIS can also be successfully applied to military history. Military maps are invaluable historical sources that make it possible to obtain location information of past military operations, perfectly supplementing geographic descriptions contained in written sources. Formalizing historical information is useful especially in areas in which historical knowledge is not sufficiently explored, for example, due to the secret nature of military operations, or due to difficulties in accessing archival material that is often located abroad. An example of such subject matter is the history of the 'Silent and Unseen' (direct translation of the Polish-language 'Cichociemni') – soldiers of the Polish Armed Forces who were trained from 1940 in the UK and from the end of 1943 also in Italy. The 'Silent and Unseen' soldiers were dropped by air into occupied Poland to serve in the ranks of the Union of Armed Struggle/Home Army in World War II. There are numerous scientific historical papers devoted to the subject of drop zones locations of soldiers of the Polish Armed Forces [e.g. Mroczkowski, https://rzeszow.academia.edu/KrzysztofMroczkowski, accessed on 5 April 2017], however none of them touch upon the aspect of spatial data visualization.

The aim of the study was two-fold: to determine the possibility of the precise location of drop zones where parachute jumps of the 'Silent and Unseen' and drops of military equipment took place, and to attempt and assess the adequacy and relevance of the selection of these zones in terms of the criteria set out in the British Special Operations Executive (SOE) instructions.

It should be noted that air operations were initiated on the night of 15/16 February 1941 and lasted until 28/29 December 1944. The soldiers were dropped in the following operational seasons:

1. The trial season: 15/16 February 1941 – 8/9 April 1942.
2. 'Intonation': 1/2 September 1942 – 2/3 April 1943.
3. 'Retort': 9/10 September 1943 – 30/31 July 1944.
4. 'Retaliation' and the Warsaw Uprising: 1/2 August 1944 – 28/29 December 1944.

Within a period of less than four years, there were 858 aircraft takeoffs, with 483 resulting in a drop or landing in Poland (three operations code-named 'Bridge'). During this time, nearly seven hundred receiving centers were created in Poland. Their location was determined with dispatches based on Ordnance Survey Maps at a scale of 1 : 300,000 using orthogonal coordinates expressed in millimeters. To avoid confusion, the locations of offices using polar coordinates (where the point of reference was the town or railway station near the drop zone) were also determined. 316 'Silent and Unseen' (one of these, twice) were dropped in Poland, as well as twenty-eight political couriers (one of these, twice), one Hungarian, and four Britons. Moreover, circa 670 tons of military equipment (weapons, ammunition, explosives, medicines, radios) were sent, of which more than 443 tons were received. The drops also contained significant financial resources, including ca. 35 million dollars and 19 million deutsche marks [Tucholski 1984].

Our main goal was to demonstrate the possibility of using GIS in the study of the 'Silent and Unseen' history and to present a sample analysis of selected drop zone locations. Due to the large number of drops, the authors limited their analysis to areas in the vicinity of Warsaw. Moreover, they considered not only drops of people, but also of equipment. It should also be noted that the analysis was based mainly on information from compact monographs (that had been written based on source materials), but without querying the direct sources. Thus the article is a first step towards a more detailed research, that will deal simultaneously with original historical documents and comprehensive set of spatial data regarding drop zones in all operational seasons.

The studies were based on historical research containing information about the locations of the jumps with their schematic arrangement, on the Ordnance Survey Maps from the prewar period, and on the GIS system with contemporary geographic digital maps. As part of the study, the available information about the drop zone locations in the period February 1941 – July 1944 was summarized. The first step was to calibrate the available schematic maps (found in subject literature), based on modern contemporary digital maps, and then apply the locations of drop zones to these maps. Uncertainty concerning drop zone locations, based on deformation size generated during the calibration process, was also estimated. Analysis of the compatibility of the final drop zone locations with the criteria given in the SOE manual based on calibrated tactical maps published by Polish Military Geographical Institute in the years 1934–1938 was performed for the purpose of assessing the adequacy of drop zone placements in specific locations. Verification of drop zones described in historical literature was performed based on the description of their location, and approximate geographic coordinates. The result was an adjustment of drop zone positions according to a contemporary geographical map, as well as a sample analysis (for two of the sites) of the accuracy of their location, reconstructed with schematic maps or geographic coordinates.

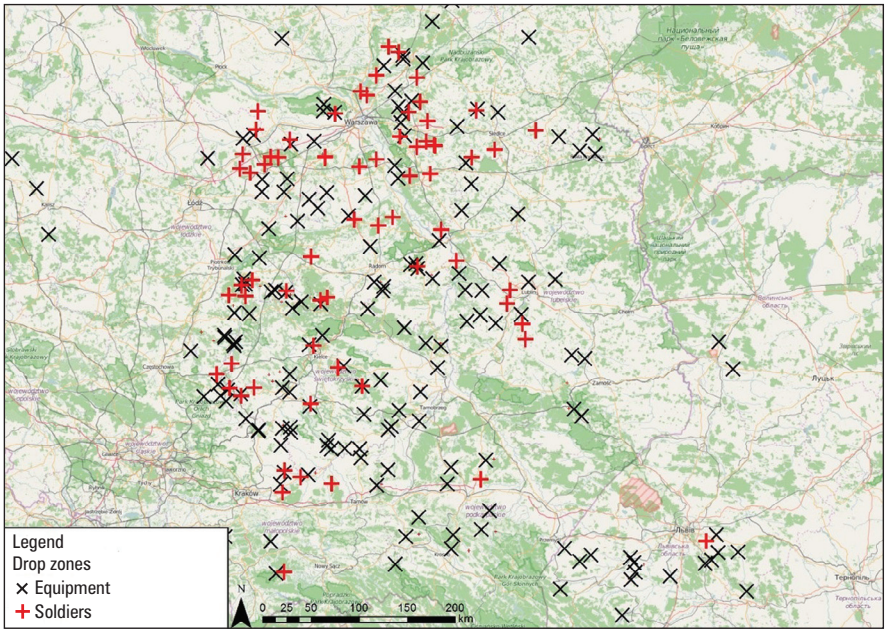
2. Used sources, data and software

Locations of drop zones where people and equipment were dropped are known from dispatches exchanged between the command of the Union of Armed Struggle/Home Army staff and the Commander-in-chief in London. These locations were given in descriptive form, containing the approximate position in millimeters from the edges of a particular map sheet in the meridional and latitudinal direction, for example '...300th Krakow from the right 88 mm, from the top 80 mm...' and the position relative to the surrounding towns, such as '...one and a half kilometers west of Kobyła Village, half a kilometer to the south of Włoszczowa...' [Bieniecki 2005]. In the case of several sites, the position was also determined using geographical coordinates, with accuracy to the minute. These approximate locations are illustrated in the recently made schematic uncalibrated maps of the General Government [Mapy archiwalne 2017]. These maps, due to the purpose and the method of their execution, do not allow any verification of correctness or accuracy assessment of considered locations, which in many cases substantially differ from the geographical coordinates reported in the literature. In addi-

tion, the analyses were also based on Tactical Polish maps at scale 1 : 100,000, published by the Military Geographical Institute in 1934–1938. The studies were conducted in a commercial GIS system using contemporary base maps.

3. Calibration

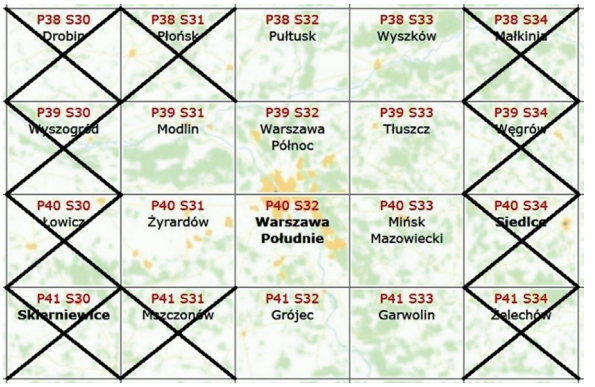
Paper schematic maps [Bieniecki 2005] showing the locations of drops of people and equipment have been scanned and calibrated based on contemporary digital maps. The first stage of calibration was to determine ground control points (GCP), which are related to characteristic objects on the map [Affek 2012]. Due to the limited content presented in the available maps, the authors decided that the only possible control points could be the places of Bzura, Bug, Pilica, Wieprz, San, Wisłoka, and the Nida and Dunajec river confluences. Furthermore, in case of map II (Figure 3), the Warta, Prosna and Narew estuaries to the Bug River were used (they are marked with dots in Figure 3). The confluence points are also characteristic points in the process of cartographic generalization, and therefore they act as immutable points for maps in various scales. In the next step, the positions of drop zones were moved from the schematic to digital maps by distinguishing zones where equipment (black symbols) was dropped and those where people (red symbols) were primarily dropped (Figure 1).



Source: authors' study based on [Bieniecki 2005]

Fig. 1. Location of drops presented on the contemporary base map. Red crosses denote drop locations of equipment and people; black crosses denote equipment-only drops

For each point on the calibrated schematic map, we were able to specify the amount of displacement relative to the original location on the uncalibrated map. In this way, the accuracy of the designation of individual drop zones was estimated, based on the schematic maps. Moreover, the calibration of all the sheets covering the General Government and the Warsaw area was performed for the scanned Tactical Maps (Figure 2). Calibration was performed using available geographical coordinates of the selected points of adjustment.



Source: http://igrek.amzp.pl/

Fig. 2. Tactical Polish Maps used for analysis

4. The analysis of drop zone locations of the Polish Home Army

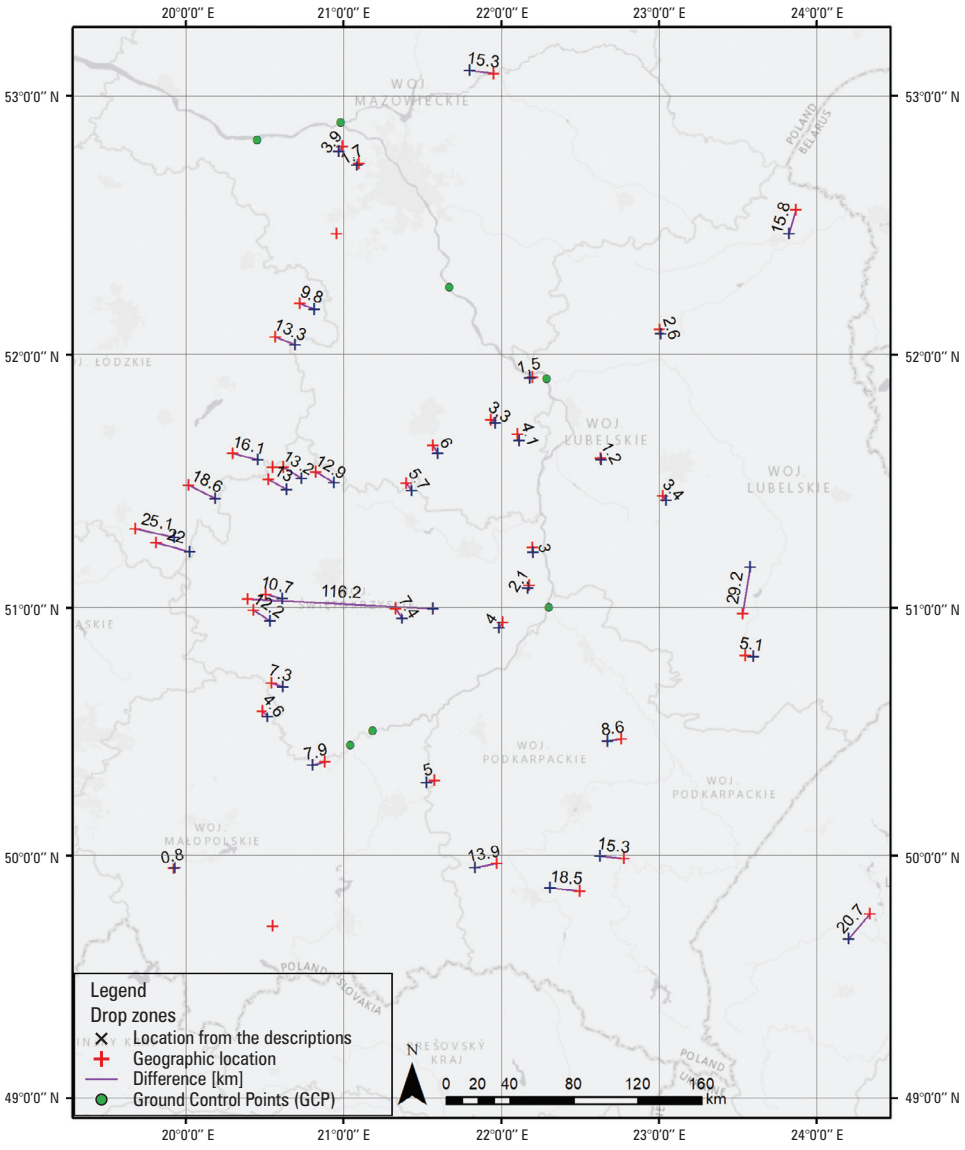
In order to assess the accuracy of the information given in the literature, the authors considered drop zones whose descriptions contained geographical coordinates of their locations. The assessment was based on a comparison between the coordinates and their location on the schematic map. The third factor taken into account was the description of the drop zone locations found in the literature. A list of drop zones and their positions obtained by both methods, and the distance between the two locations of the same drop zone (obtained by the same methods), as well as estimated location errors are shown in Table 1. Differences in locations vary from one to several kilometers, and in one case the difference exceeds one hundred kilometers (the 'Gruszka' zone). The following figure (Figure 3) shows the mutual orientation of the individual drop zones obtained by the two methods. As shown, the directions and the size of the differences between the drop zones are haphazard. It can be concluded that the errors are random rather than being a result of inadequately performed calibration procedures. Errors in drop zone locations for which the military dispatches had geographical coordinates resulted from rounding the numbers that specified these coordinates. When we round the coordinates to arc minutes, the location error for Polish latitude is ± 926 m. If the position was given to a tenth of a minute, the error decreased to ± 154 m.

Table 1. List of drop zones shown in figure 3, for which geographic coordinates are known, along with the calculated errors

Drop zone name	Geographic location [λ, φ]	Geographic location error [m]	Location from the descriptions [λ, φ]	Errors of locations from the descriptions [m]	Difference between geographic locations and locations from the descriptions [m]
Bocian	N49°43’ E22°01’	± 926	N49° 43’ 36” E19° 44’ 12”	± 1388	18.507
Borówka	N50°58’ E19°38’	± 926	N50° 56’ 10” E19° 49’ 29”	± 2145	21.343
Buk	N51°01’ E19°31’	± 926	N50° 59’ 9” E19° 44’ 12”	± 2380	24.559
Byk	N51°08’ E22°29’	± 926	N51° 7’ 8” E 22° 30’ 14”	± 809	3.447
Cekinia	N51°14’ E20°21’	± 926	N51° 11’ 39” E 20° 27’ 5”	± 1085	13.248
Cykoria	N51°13’ E20°32’	± 926	N51° 10’ 48” E 20° 37’ 60”	± 794	12.880
Cynamon	N51°11’30” E20°16’00”	± 154	N51° 9’ 22” E 20° 22’ 8”	± 1227	13.027
Dynia	N51°10’40” E21°02’30”	± 154	N51° 9’ 6” E 21° 4’ 17”	± 111	5.681
Georginia	N50°49’ E21°44’	± 926	N50° 48’ 23” E 21° 43’ 24”	± 608	2.144
Grab	N50°57’ E21°45’	± 926	N50° 55’ 60” E 21° 45’ 18”	± 462	2.999
Gruszka	N50°46’ E20°09’	± 926	N50° 43’ 60” E 21° 11’ 33”	± 1514	116.208
Hamak	N52°17’30” E20°46’30”	± 154	N52° 17’ 12” E 20° 45’ 44”	± 1365	1.684
Hipopotam	N50°34’ E22°57’	± 926	N50° 33’ 44” E 22° 59’ 42”	± 988	5.088
Jarząb	N51°21’ E21°40’	± 926	N51° 19’ 41” E 21° 40’ 35”	± 152	4.091
Jawor	N51°33’ E21°45’	± 926	N51° 32’ 54” E 21° 44’ 14”	± 317	1.468
Jemioła	N51°24’ E21°31’	± 926	N51° 23’ 20” E 21° 32’ 26”	± 320	3.314
Jerzyk	N49°49’ E21°33’	± 926	N49° 48’ 2” E 21° 25’ 40”	± 1895	13.887
Kobuz	N50°22’ E20°14’	± 926	N50° 20’ 48” E 20° 15’ 38”	± 1649	4.616
Kogut	N50°11’ E20°35’	± 926	N50° 10’ 20” E 20° 30’ 51”	± 2921	7.941
Konwalia	N51°18’40” E21°11’30”	± 154	N51° 16’ 57” E 21° 13’ 11”	± 421	5.963
Mirt-1	N50°44’ E20°59’	± 926	N50° 41’ 53” E 21° 1’ 9”	± 1753	7.380

Nagan	N49°38’ E23°39’	± 926	N49° 32’ 31” E 23° 31’ 43”	± 1328	20.702
Newa	N51°14’00” E19°46’30”	± 154	N51° 13’ 57” E 19° 46’ 27”	± 2059	4.147
Nida	N51°10’10” E19°49’00”	± 154	N51° 7’ 24” E 19° 57’ 58”	± 1776	18.571
Owca	N51°16’ E22°08’	± 926	N51° 15’ 38” E 22° 8’ 19”	± 436	1.245
Papuga	N50°07’ E21°12’	± 926	N50° 6’ 30” E 21° 9’ 24”	± 2048	5.028
Perkoz	N50°16’ E22°15’	± 926	N50° 15’ 33” E 22° 10’ 24”	± 604	8.624
Pinia	N50°41’ E21°35’	± 926	N50° 39’ 53” E 21° 33’ 46”	± 962	4.006
Przetak	N52°36’ E21°32’	± 926	N52° 36’ 39” E 21° 23’ 50”	± 940	15.286
Raróg	N49°50’ E22°16’	± 926	N49° 50’ 39” E 22° 7’ 50”	± 1026	15.273
San	N51°48’30” E20°26’30”	± 154	N51° 47’ 18” E 20° 31’ 26”	± 1041	9.799
Skawa	N51°41’30” E20°18’20”	± 154	N51° 39’ 47” E 20° 24’ 55”	± 1149	13.260
Solnica	N52°03’ E20°39’	± 926	N52° 1’ 54” E 20° 40’ 26”	± 1104	4.251
Tchórz	N51°43’ E22°28’	± 926	N51° 42’ 10” E 22° 28’ 24”	± 1332	2.599
Topola	N50°43’40” E20°11’00”	± 154	N50° 41’ 22” E 20° 16’ 27”	± 1593	12.162
Tuja	N50°28’ E20°17’	± 926	N50° 27’ 16” E 20° 20’ 46”	± 2958	7.321
Tulipan	N50°47’ E20°15’	± 926	N50° 46’ 10” E 20° 20’ 36”	± 2679	10.700
Tur	N50°53’ E22°56’	± 926	N50° 52’ 50” E 22° 58’ 30”	± 1212	29.219
Wiersze	N52°21’ E20°41’	± 926	N52° 19’ 60” E 20° 39’ 41”	± 1305	3.933
Wilga	N49°35’20” E20°17’30”	± 154	N49° 35’ 15” E 20° 17’ 25”	± 2201	233
Wisła	N51°17’ E20°04’	± 926	N51° 15’ 40” E 20° 12’ 26”	± 1384	16.142
Wydra	N52°08’ E23°14’	± 926	N52° 2’ 59” E 23° 11’ 35”	± 2708	8.681
Zamek	N49°46’30” E24°14’00”	± 154	N49° 39’ 36” E 24° 16’ 49”	± 2194	12.089
Żywica	N49°48’ E19°44’	± 926	N49° 48’ 3” E 19° 44’ 24”	± 4466	754

Source: authors’ study based on [Bieniecki 2005]

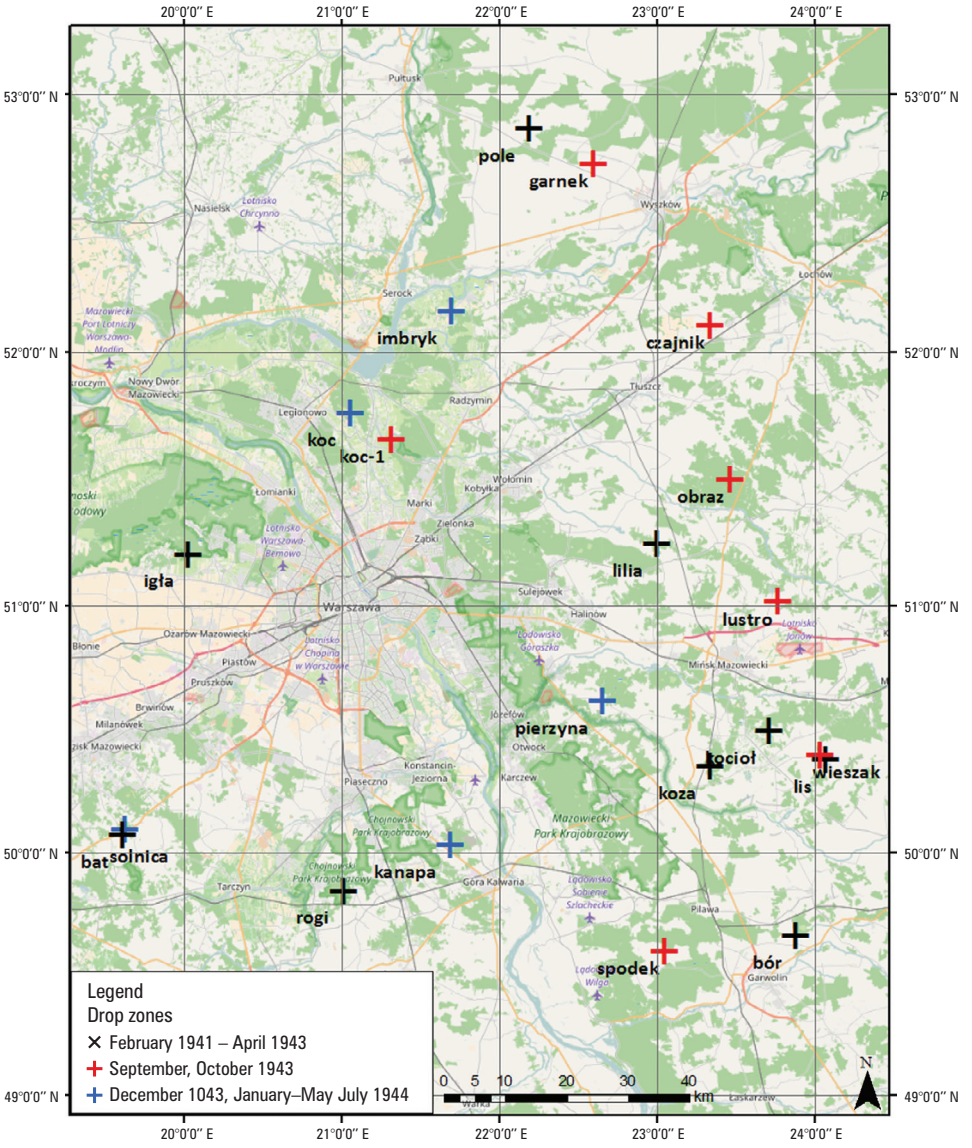


Source: authors' study

Fig. 3. The mutual orientation of drop zone positions obtained based on reading the scans (black crosses) and geographical coordinates (red crosses)

Location accuracy analysis of drop zones, for which there were no geographical coordinates, was carried out based on descriptive information from prewar tactical maps. The analysis in this case turned out to be a difficult task. Correction of drop zone locations depends on the precision of the description given in the literature. Therefore, only points

in the vicinity of Warsaw, with relatively good descriptions and geographic coordinates given in the literature, were chosen for the exemplary analysis (Figure 4). Table 2 contains results of the accuracy assessment of drop zone locations, performed based on descriptions in dispatches from the staff of the Commander-in-chief in London.



Source: authors' study based on [Bieniecki 2005]

Fig. 4. Locations of drop zones in the Warsaw area that were analyzed in the work. The colors of crosses correspond to the operating seasons

Table 2. List of analyzed drop zones located near Warsaw, shown in Figure 4

No.	Drop zone name	Operational season	The information source	Available description of the drop zone
1	Pole	Trial season	Scan/description	Unreliable (area with significant elevation changes, cliffs, proximity to buildings and watercourses, difficult to identify from the air). Non-compliance between the scan and description (distance from Wyszków)
2	Kocioł	Trial season	Scan/description	Reliable
3	Lilia	Intonation	Scan/description	Unreliable (point from the scan was located twenty three kilometers northwest of Mińsk Mazowiecki train station instead of twelve kilometers, no information about the village). It is difficult to determine the exact position – probably around the Cyganka village
4	Koza	Intonation	Scan/description	Quite reliable (point from the scan was shifted five kilometers too far south on the railway line). Possible location – north of the Grzebowilk village
5	Lis	Intonation	Scan/description	Quite reliable (point from the scan was shifted eight kilometers too far to the southeast). Possible location – north of Zglechów
6	Rogi	Intonation	Scan/description	Quite reliable (point from the scan was located in the woods, moved three kilometers too far to the east of the property Łosie). Error in measuring the distance from Grójec: it is twenty four kilometers instead of sixteen kilometers
7	Bat	Intonation	Scan/description	Unreliable (point from the scan was shifted nine kilometers too far to the southeast) No information about the surrounding countryside
8	Bór	Intonation	Scan/description	Reliable
9	Igła	Intonation	Scan/description	Quite reliable (point from the scan was shifted ten kilometers too far to the northwest, but is consistent with description)
10	Czajnik	Retort I	Scan/description	Quite reliable (overstated distance of a point from the scan for ca. six kilometers)
11	Garnek	Retort I	Scan/description	Reliable
12	Koc-1	Retort I	Scan/description	Quite reliable (the point from the scan was shifted five kilometers too far south)
13	Spodek	Retort I	Scan/description	Quite reliable (in the area with significant elevation changes on the watercourse, the point from the scan was moved about two kilometers northwest)

14	Obraz	Retort I	Scan/description	Quite reliable (the point from the scan was shifted eight kilometers too far to the south, but there is a better match to the description)
15	Lustro	Retort I	Scan/description	Quite reliable (point from the scan was located twelve kilometers northeast of Mińsk Mazowiecki train station instead of nine kilometers, lack of information about the surrounding villages). Possible location – south of the Mistów village
16	Wieszak	Retort I	Scan/description	Quite reliable (point from the scan was shifted eight kilometers too far to the southeast, but it is consistent with the description)
17	Przetak	Retort I	Scan/description/ coordinates	Location from the coordinates and from the scan is reliable (detailed description in the text of the article)
18	Solnica	Retort I i II	Scan/description/ coordinates	Location from the coordinates is more reliable than from the scan (detailed description in the text of the article)
19	Kanapa	Retort II	Scan/description	Quite reliable (point from the scan was shifted twenty kilometers too far to the south, but it is consistent with the description)
20	Imbryk	Retort II	Scan/description	Unreliable (point from the scan was located thirty three kilometers northwest of Tłuszcz train station, not Dąbrowa village; a point is located on the border of the old branch of Bug, near the wetland). Possible location near Dąbrówka village
21	Koc	Retort II	Scan/description	Less reliable and low scan accuracy compared to drop zone of Koc-1
22	Pierzyna	Retort II	Scan/description	Quite reliable (point from the scan was shifted eleven kilometers too far to the west in the area with significant elevation changes). Possible location – north of Rząkta village

Source: authors' study based on [Bieniecki 2005]

Table 3. The results of the assessment of drop zone location accuracy, as exemplified by the 'Solnica' and 'Przetak' zones

	Criterion							
Drop zone name	**A. Drop zone selection**		**B. Aircraft safety**		**C. Ease of drop zone identification**			
	Area A1. Terrain with no obstructions with an area of min. 548 m², increased to min. 731 m² in cases when several packages of equipment or several people were dropped	**Topographic terrain elements** A2. Avoidance of agricultural land and wetlands (plowed fields posed a threat to jumpers) A3. No phone lines or high voltage network A4. Lack of tall trees A5. Favorable elements: bushes and thickets nearby	**Safety of drop zone** B1. Area located away from heavily defended buildings (to avoid concentrations of anti-aircraft artillery) B2. Area located away from the enemy's airports	**Landform** B3. Terrain as flat as possible (to avoid mountains, hills and valleys unless they are wide)	**Lakes, rivers, lakes and canals** C1. Shoreline C2. Estuaries (more than 45 m in width) C3. River width min. 27 m; without too many rivers in the area (difficult to identify) C4. Lake width min. 800 m (preferably one lake only) C5. Channels with unnaturally straight lines	**Forests and forest massifs** C6. min. 800 meters wide C7. regular shape	**Roads and railway lines** C8. straight sections of road with a length of min. 1.5 km C9. main road lined with trees C10. railways (in winter they create black lines)	**Cities and built-up areas** C11. Town with more than 20 thousand residents
Solnica: from coordinates 18 pts	A1. 2	A2. – A3. 2 A4. 2 A5. 0	B1. 2 B2. 2	B3. 2	C1. 0 C2. 0 C3. 0 C4. 0 C5. 0	C6. 2 C7. 2	C8. 1 C9. 0 C10. 1	C11. 0

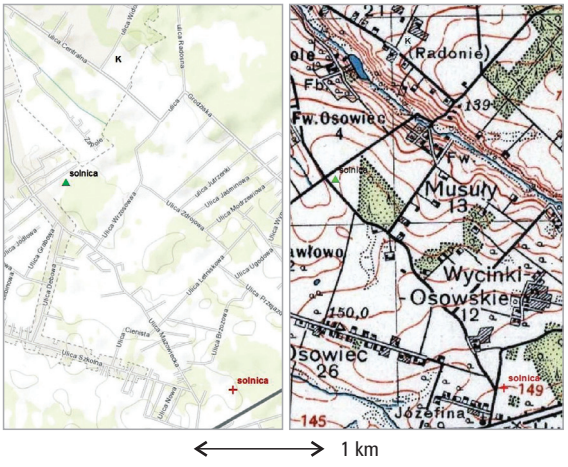
Solnica: from the schematic map 16 pts	A1. 1	A2. – A3. 2 A4. 0 A5. 1	B1. 2 B2. 2	B3. 2	C1. 0 C2. 0 C3. 0 C4. 0 C5. 0	C6. 2 C7. 1	C8. 2 C9. 0 C10. 1	C11. 0
Przetak: from coordinates 17 pts	A1. 0	A2. – A3. 2 A4. 0 A5. 2	B1. 2 B2. 2	B3. 1	C1. 0 C2. 2 C3. 2 C4. 0 C5. 0	C6. 2 C7. 0	C8. 2 C9. 0 C10. 0	C11. 0
Przetak: from the schematic map 12 pts	A1. 0	A2. – A3. 2 A4. 2 A5. 0	B1. 0 B2. 2	B3. 2	C1. 0 C2. 0 C3. 0 C4. 0 C5. 0	C6. 0 C7. 0	C8. 2 C9. 0 C10. 1	C11. 1

Source: authors' study based on [Hart, Mann 2014]

Each of the drop zones were analyzed and rated according to the instructions of the British SOE, which constituted the main guidelines for Division VI and Special Branch Division III of the command [Hart et al. 2012]. These instructions distinguished the following groups of criteria: factors determining the choice of the drop zone (group A), factors affecting the safety of the airplane (group B), and factors determining the ease of the drop zone identification (group C). Individual points were assigned numerical values: 0 in the case of total noncompliance with the criterion and the actual state, 1 in the case of partial compliance, and 2 in the case of total compliance.

Below are examples of the analysis of two drop zones located in the Warsaw area, for which both the literature description and the geographical coordinates are known (Table 3). Each of the drop zones was analyzed separately in two ways: firstly, based on geographical location (coordinates), and secondly, based on the approximate location (from the description given in the literature). This made it possible to assess more precisely the accuracy of drop zone location, especially the approximate locations marked on the schematic map with red crosses, which in both cases differed significantly from the geographical locations (green triangles).

As a first example, we have examined the case of 'Solnica' drop zone (a bastion; bastions were the drop zones that could receive drops from several aircraft at the same time), where drops were made on 9/10 September 1943, 30/31 July 1944, and 18/19 November 1944. For this zone, its geographic location is known (N52°03' E20°39') and marked by a green triangle on the contemporary base map as well as on the Ordnance Survey Map at scale 1 : 100,000, drafted in 1938 (Figure 5). From the description it is also known that the drop zone is "...located seven kilometers south of Grodzisk Mazowiecki railway station, near the village of Osowiec" [Bieniecki 2005].

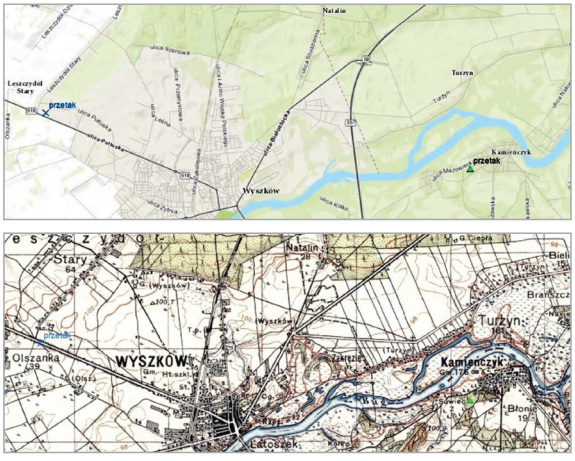


Source: authors' study basen on http://igrek.amzp.pl/

Fig. 5. Location of 'Solnica' drop zone designated using the scan of the schematic map (red cross) and geographical coordinates (green triangle)

The conducted analysis shows that the locations obtained based on the geographical coordinates are slightly more responsive to the requirements specified in the selection of potential drop zones (eighteen points out of thirty-eight possible points in the case of the coordinates, and sixteen points out of thirty-eight possible points in the case of the schematic maps). These differences are not large, and in the case of two criteria, a favorable score was appointed to zones defined using schematic map (points A5 and C8). Most of the criteria are met to a similar degree (both areas are located away from telephone lines, high voltage networks, or heavily defended objects and airports; both areas are flat, difficult to identify in terms of proximity to water bodies, rivers, lakes and canals, but easy to identify with regard to the proximity of forests or roads). In the case of 'Solnica' zone location obtained from the schematic map, criterion A1 and C7 are only partially fulfilled, which distinguishes this point from the place designated using coordinates.

As a second example, the authors considered the case of 'Przetak', where a drop was made on 16/17 April 1944. Also for this zone, its geographic location (N52°36' E21°32') is known and marked, similarly to the previous location, on the contemporary base map and the Ordnance Survey Map with a green triangle (Figure 6). From the description it also appears that the drop zone is "...located six km to the east of Wyszków train station" [Bieniecki 2005].



Source: authors' study basen on http://igrek.amzp.pl/

Fig. 6. Location of 'Przetak' drop zone designated using a scan of a schematic map (blue cross) and geographical coordinates (green triangle)

The results of this study show that in this case, similar to the case of 'Solnica', the location of the drop zone obtained from the geographical coordinates meets the specified requirements more effectively. Moreover, in this case, the differences are much greater (seventeen points out of thirty-eight possible points in the case of the coordi-

nates and twelve points out of thirty-eight possible points in the case of the schematic map). The greatest difference in scores in favor of the location from coordinates was demonstrated for criterion C (ease of drop zone identification); while in four cases, more points were granted to the location determined using the schematic map (points A4, B3, C10 and C11). In both places, surface criterion (A1) had not been met, while the other groups of criteria were met to the same degree (both areas are located away from telephone or high voltage lines and enemy airports; both are not easy to identify in terms of proximity to coastline, lakes, canals, major highways, and forests).

The proposed approach unequivocally makes it possible to evaluate the adequacy of drop zones based on the criteria that existed during World War II. Such assessment could provide a starting point for further research, including attempts to find better locations, according to operative instructions, more suitable for dropping the 'Silent and Unseen' and the equipment, and are located in the vicinity of a particular drop point.

5. Conclusions

The analysis we have conducted leads to the conclusion that the locations of the drop zones designated above – or even the locations designated within the boundaries – cannot be treated as their actual locations. The actual spots where specific parachute jumps took place were determined using illuminated signs in the locations chosen by the people responsible for receiving the drops. These places may be different from those mentioned in the dispatches and known to pilots due to local and time-varying conditions. The drop zones presented in this paper had been assigned locations that were defined based on military dispatches, while their actual locations could be offset by as much as several kilometers. One factor that influenced the decision was the terrain, which made it easier to identify the drop zone or better meet the safety requirements of people and equipment. Determination of places was also based on the SOE instructions that allowed planners to select the most suitable locations within a given area of a municipality or a county. In the authors' opinion, using the same guidelines made it possible to recreate the real locations of drop zones. It should be noted that the only reliable way to identify the actual locations of drop zones would be the memories of eyewitnesses or participants. Similarly, zone location errors are due to GIS procedure errors. Real errors, regarded as the difference between the actual and estimated location of a specific drop zone, cannot be determined due to lack of knowledge of the actual location of the zone.

According to the authors, the article indicates the great potential that Geographic Information Systems pose for the analysis of historical data. A concrete example showcased in the article responds to the important question concerning the reliability of information presented in the literature commemorating the military effort of the 'Silent and Unseen' during World War II. It also illustrates the potential for GIS applications in historical research, which are postulated – as mentioned in the introduction – by many scholars. These studies are also significant for many people and circles, including local

communities taking action to commemorate the events described herein. In 2014, in Radonie village near Grodzisk Mazowiecki, a chapel with a memorial plaque was built, whose location is shown in figure 5 by the letter 'K'.

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