SINTEZA 2025
INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE

MANAGEMENT AND TECHNOLOGY SESSION

# IDENTIFICATION OF SAFE HELICOPTER LANDING ZONES AND AN OVERVIEW OF HELIPORTS IN SERBIA

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**Abstract:**

Helicopters are most commonly used in inaccessible areas during various operations, whether civilian or military. This paper aims to provide an overview of existing research on the automatic generation of safe helicopter landing zones and to define the necessary parameters for their application in the territory of the Republic of Serbia. The paper also presents the present-day state of designated helicopter landing areas in Serbia. Notably, with 12 heliports, Serbia is among the leading countries in the region for heliport infrastructure. Additionally, the paper outlines the legal frameworks governing this subject in Serbia, the European Union, and the United States. Finally, the paper proposes parameters that define safe helicopter landing zones. Research of this kind could aid decision-making processes during emergencies in the Republic of Serbia and other countries.

**Keywords:**

Helicopter, Safe Landing Zone, Heliport, Terrain Slope.

## INTRODUCTION

Helicopters are most commonly used in inaccessible areas during various operations, whether civilian or military. With the rapid development of unmanned aerial vehicle (UAV) technology for the same purposes, there is an increasing need for geographic data on these inaccessible regions.

Over the past two decades, the demand for real-time digital surface model generation has grown, particularly for aircraft landings under low visibility conditions [1]. In recent years, with advancements in UAVs and artificial intelligence [2], the need for suitable data for identifying surfaces suitable for vertical take-off and landing (VTOL) aircraft has also increased.

One of the key topics for the armed forces is the assertion by [3] that the ability to rapidly conduct precise terrain assessments and remotely detect associated threats represents a key priority for the United States

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DOI: 10.15308/Sinteza-2025-354-360

Armed Forces. In [4] stated that UAVs were initially used primarily for military purposes, rescue operations, and disaster response, but have since been widely adopted for civilian and commercial applications.

This paper aims to provide an overview of existing research on the automatic generation of safe helicopter landing zones, define the necessary parameters for their application in the Republic of Serbia, and present the regulatory framework for heliports. Additionally, the paper examines the present-day state of designated helicopter landing areas in Serbia.

## 2. LITERARY REVIEW

In [5] state that for helicopter landings in inaccessible areas, such as Yosemite National Park in the United States, a flat terrain free of tree canopies and other hazards is required. Landing a helicopter on the surface and transporting the injured provides an optimal procedure, whereas other techniques, such as hovering to extract an injured person, increase the risk during rescue operations [5].

Currently, for identifying surfaces suitable for vertical take-off and landing (VTOL) aircraft, the most popular method is the processing of 3D LiDAR (Light Detection and Ranging) point clouds collected by LiDAR technology mounted on an aeroplane or helicopter [1]. This claim is supported by numerous articles on the subject. Despite this advanced technology, maps are still necessary for additional analysis. Authors in [1] emphasized the importance of comparing LiDAR collected data with map data to enable pilots to identify the safest landing zones for helicopters [1]. This topic is not only a priority for military applications but also for civilian use, as demonstrated by [6], who similarly used topographic maps to assess obstacles and identify the most suitable helicopter landing zones near high-risk forested areas due to wildfires in Golestan National Park, north-eastern Iran.

According to [6], state that firefighting using helicopters is a common global practice. They further note that helicopters are primarily used in rural areas with underdeveloped road networks. They identified a helicopter landing zone as a flat area devoid of trees, shrubs, logs, and large rocks. In wildfire suppression over unknown forested terrain, it is crucial to assess the safety and efficiency of landing sites [6]. A landing site should be free of obstacles and vegetation within a 50–75 m diameter. Additionally, the terrain slope at the landing site should be less than 5%. In this study, the authors first created a wildfire risk map by collecting data from various sources, including vegetation cover type, physical geographical features, climate, and human factors [6]. To identify safe helicopter landing zones, they defined a minimum area of 50 meters in diameter (greater than 2,000 square meters) alongside other conditions critical for proximity to firefighting areas [6]. The slope analysis was conducted using a Digital Elevation Model (DEM) and a Triangulated Irregular Network (TIN). To identify clear spaces, they used high-resolution satellite images from Google Earth [6].

Authors in [5] compared two GIS-based scientific methods for identifying safe helicopter landing zones using available GIS data in Yosemite National Park, USA. The first method relied on expert judgment, while the second employed machine learning. They concluded that both methods yielded similar results. In both approaches, safe landing zones were identified as areas with a slope of less than 5% and a 90-meter radius free of natural or human-made obstacles [5].

Similarly, [1] stated that real-time identification of safe helicopter landing zones has a significant impact on saving lives, reducing risk, and improving operational efficiency, particularly in search and rescue or medical transport missions, where immediate and accurate determination of a safe landing zone can mean the difference between life and death. In the same study, the authors argued that real-time identification of safe helicopter landing zones in urban environments is highly valuable due to the challenges posed by various obstacles, such as buildings and other structures that frequently change [1]. Additionally, they emphasized that situational awareness and spatial perception are crucial during landings under adverse meteorological conditions, such as fog, smoke, darkness, or sandstorms, which impair helicopter manoeuvrability [1]. A major limitation in real-time safe zone identification is the complexity of computational algorithms, which require extensive processing power and must be significantly simplified for practical real-time use [1]. The approach employed in this study involved first processing LiDAR-generated point clouds, and then creating a slope and roughness map based on the scanned terrain. The predefined slope and roughness values were applied to the resulting map to identify safe landing zones. The threshold values in this study, as defined by the authors, were 24 × 24 meters for the landing area and a terrain slope of 4%, which aligns with established helicopter landing standards [1].

The application of artificial intelligence (AI) in UAV image recognition for rescue missions has been investigated by [2]. AI was utilized for deep learning in target recognition algorithms. The target depends on the UAV's specific purpose. Unlike traditional target recognition algorithms, deep learning-based algorithms can autonomously learn feature representations and detection models necessary for identifying targets from large volumes of raw data, eliminating the need for manually designed features [2]. According to [2], as early as 1997, researchers at Cornell University proposed an automatic target recognition model for UAVs.

Today, UAV usage in military conflicts has become widespread, as evidenced by footage shared on social media platforms from conflicts in Afghanistan, Armenia, Russia, and Ukraine. For navigation, [2] note that UAVs utilize GPS, LiDAR, inertial navigation systems, and visual navigation systems. They highlight both the advantages and disadvantages of GPS, such as the increased risk of signal loss and potential electromagnetic interference in mid-latitude regions with weak signals [2]. The visual navigation system primarily involves measuring various navigation parameters through images captured from the ground using onboard imaging equipment (e.g., lighting systems, infrared imagery, Synthetic Aperture Radar (SAR), etc.) [2]. In [2] state that visual sensors not only facilitate efficient localization and mapping but also detect targets and extract effective spatial semantic information, making them particularly useful for guiding electric UAVs in search and rescue operations.

Geospatial software designed for identifying military helicopter landing zones in extremely challenging environments with minimal terrain preparation is presented in [3]. Their research demonstrated that a DEM with a 30-meter resolution identified numerous favourable landing zones, whereas a 1-meter resolution DEM revealed poor landing areas that the 30-meter resolution DEM failed to detect [3]. Furthermore, the study found that a 1-meter resolution DEM was overly precise, leading to the conclusion that a 5-meter resolution DEM is optimal. This research highlights the efficiency and effectiveness of using DEMs to rapidly identify safe helicopter landing zones [3].

## 3. HELICOPTER LANDING ZONES – HELIPORTS IN SERBIA

Areas designated and intended for helicopter landing are referred to as heliports. In Serbia, they are defined by the Regulation on Conditions and Procedures for Issuing Permits for the Use of Heliports. This subject falls under the jurisdiction of civil aviation, which in Serbia is managed by the Civil Aviation Directorate on behalf of the Government of the Republic of Serbia, operating as a public agency (hereinafter: the Directorate).

According to the Aviation Terminology Glossary of the Directorate, an airport is defined as an area (including all facilities, installations, and equipment) on land, water, or a fixed, coastal, or floating structure, intended wholly or partially for the landing, take-off, and movement of aircraft [7]. The same glossary defines a public-use airport/heliport as an airport or heliport accessible to all users under the same conditions, with its operational hours published in the Integrated Aeronautical Information Package [7].

For comparison, civil aviation in the United States is regulated by the Federal Aviation Administration (FAA), operating under the authority of the U.S. Department of Transportation. In the European Union, civil aviation falls under the jurisdiction of the European Union Aviation Safety Agency (EASA), established in 2002 as an independent and neutral body of the European Union [8].

According to the records of the Directorate [9], there are currently 12 heliports in Serbia, with their locations presented in Figure 1. As clearly depicted in the figure, the distribution of heliports across Serbia is highly uneven.

The southwestern region of Serbia, particularly Zlatibor County, has the highest coverage, with four heliports. In contrast, the entire eastern and north-eastern regions of the country lack any heliport infrastructure. Notably, the Stara Planina mountain region, a well-known tourist destination, is entirely without heliports. This absence of heliport facilities could limit the tourism potential of the area by restricting emergency medical access and reducing the overall accessibility for visitors.

Table 1 presents a comprehensive list of all heliports in Serbia. The data indicate that only seven administrative counties, out of 30 in the Republic of Serbia, are equipped with heliports. Furthermore, analysing the distribution at the municipal level, it is evident that only 12 out of 197 municipalities in Serbia have at least one heliport. This limited coverage highlights significant regional disparities in heliport accessibility, which could implicate emergency response, transportation, and regional development.

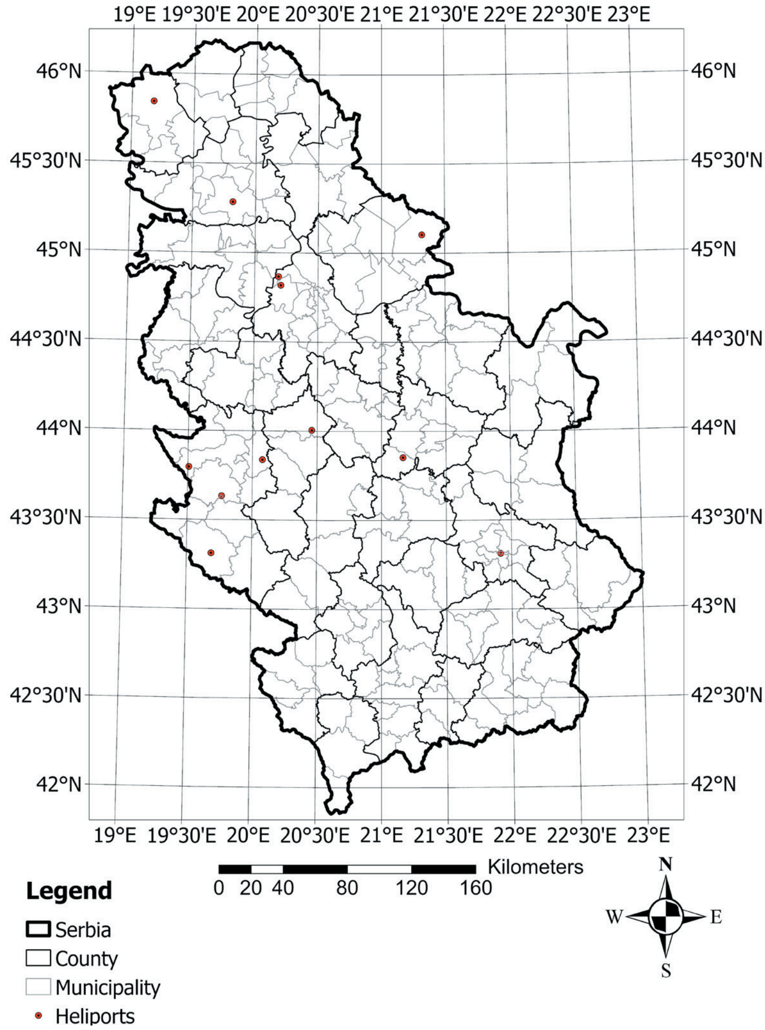



**Figure 1.** Heliports location in the Republic of Serbia. Source: authors, [9]

**Table 1.** List of Heliports in Serbia According to the Records of the Directorate of Civil Aviation of the Republic of Serbia [9]

| Heliport name | Coordinates (WGS84) | | Municipality | County | Permit date |
|---|---|---|---|---|---|
| | N | E | | | |
| Mokra Gora | 434742.92 | 0193027.72 | Užice | Zlatiborski | 20.01.2016. |
| Novi Sad Ciklonizacija | 451703.16 | 0194909.40 | Novi Sad | Južnobački | 24.02.2016. |
| BD Agro | 444907.08 | 0201224.28 | Surčin | Beogradski | 21.07.2017. |
| Gornji Milanovac Takovo | 440021.59 | 0202728.49 | Gornji Milanovac | Moravički | 20.11.2018. |
| Ljubiš Zlatibor | 433802.00 | 0194552.00 | Nova Varoš | Zlatiborski | 07.06.2019. |
| Niš Klinički centar | 431848.04 | 0215457.75 | Medijana/Niš | Nišavski | 08.11.2019. |
| Elgra Vižn | 445201.65 | 0201115.18 | Zemun | Beogradski | 26.02.2021. |
| Loćika | 435112.70 | 0210959.45 | Rekovac | Pomoravski | 19.08.2021. |
| Kalos | 455029.68 | 0191031.64 | Sombor | Zapadnobački | 02.06.2022. |
| Požega | 435021.28 | 0200437.75 | Požega | Zlatiborski | 31.10.2022. |
| Swisslion – Takovo Vršac | 450613.13 | 0211906.74 | Vršac | Južnobanatski | 21.12.2022. |
| Lučice | 431845.50 | 0194122.45 | Prijepolje | Zlatiborski | 19.10.2023. |

Figure 2a presents an example of a heliport in Serbia, located in Mokra Gora, a popular tourist destination in western Serbia, within the Zlatibor County, Užice Municipality. The satellite image showing its exact location is shown in Figure 2b.

According to [11], Serbia had eight heliports in 2024. However, data from the Civil Aviation Directorate of Serbia indicate a total of 12 heliports. Also, according to the Plan for Organizing the Search and Rescue System for Aircraft and Persons in Civil Aviation of the Republic of Serbia [12], the primary participants in search and rescue operations are the Ministry of Internal Affairs, the Ministry of Defence, the Ministry of Health (specifically the Clinical Centres of Serbia and Niš), the Mountain Rescue Service Association, and the Red Cross of Serbia. This ensures that the capacities of all these ministries and organizations can be utilized during such operations, as the Directorate has signed cooperation agreements with them.

Secondary participants in search and rescue operations include all entities listed in the Regulation on the Engagement of Participants in Aircraft Search and Rescue in Civil Aviation [13], with whom the Directorate has not signed cooperation agreements and whose engagement is not specifically defined by law. Secondary participants may include authorities of autonomous provinces and local self-government units, public enterprises, and all-natural and legal persons capable of assisting, as well as aero clubs, aviation organizations, aviation associations, and specialized rescue units [12].

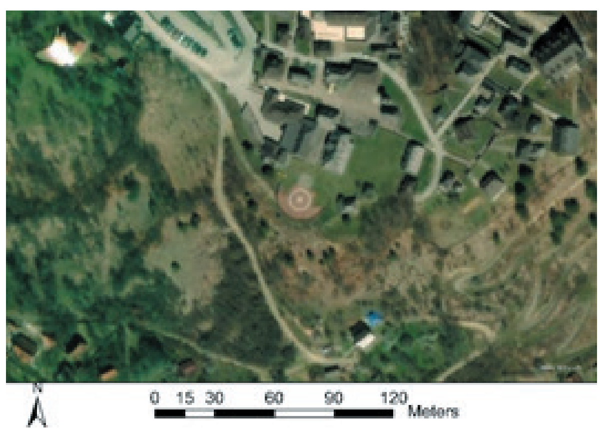
## 4. TERRAIN CONDITIONS DEFINING A FAVOURABLE SURFACE FOR HELICOPTER LANDING

As previously mentioned, in addition to modern technologies used to determine safe landing sites, the most commonly utilized resource is the DEM, which is the basis for calculating terrain slope. Terrain slope is one of the most critical parameters for identifying safe helicopter landing sites. According to the Rule Book on the Conditions and Procedure for Issuing Permits for the Use of Heliports (hereafter referred to as the "Rule Book "), the terrain slope should not exceed 3% to 7%, depending on the helicopter classification [14].

According to Kumar, all single-engine helicopters belong to Class III, while Classes I, II, and III indicate a helicopter's capability to land safely in the event of engine failure [15]. In several cited studies, authors have defined the minimum required terrain slope for a safe helicopter landing zone as ranging from 4% to 5%.

The Rule Book also specifies that the minimum dimensions for helipads must comply with the helicopter manufacturer's manual [3]. Authors in [3]tested their software using the shortest (340 m) and narrowest (45 m) dimensions within their designated test area, covering approximately 15,300 square meters [3]. In [6] defined a safe landing zone as a minimum of 2,000 square meters, with a minimum radius of 50 meters, while [1] specified dimensions of 24 × 24 meters, totalling 576 square meters. The largest helicopter in the world measures 40 × 32 meters, and when compared to the previously mentioned parameters, the required area for a safe landing zone can range from 576 to 15,300 square meters.

a)




b)

**Figure 2.** View of the Mokra Gora Heliport on: a) an Aerial Photograph, b) a Satellite Image
*Source*: a) [10], b) authors.

Beyond these two parameters, soil type is also a crucial factor [3]. In [3] incorporated the National Land Cover Database (NLCD) from the U.S. Geological Survey (USGS), which has a 30-meter resolution, to assess terrain suitability. One of the main limitations in identifying safe landing zones is the availability of digital data required for analysis.

## 5. CONCLUSION

As presented in this study, LiDAR technology is predominantly utilized for assessing safe landing zones for helicopters or UAVs. Through terrain scanning and point cloud generation, LiDAR enables the creation of a digital surface model (DSM), which is subsequently used to produce slope maps. By correlating these maps with predefined parameters for safe landing zones, based on the size of the aircraft it is possible to automatically and proactively determine the most suitable landing areas in emergencies. The only distinction lies in whether this process is conducted in advance by experts or if AI and machine learning algorithms are applied in real time to identify optimal landing locations based on predefined criteria.

Helicopter or UAV landings have proven to be the safest method for rescuing injured individuals during emergencies. Therefore, the identification and definition of safe landing zones are necessary procedures in crisis management. Serbia is not lagging in legal regulations governing the use of helicopters and UAVs in such scenarios. However, it still falls behind more advanced nations in terms of the operational use of helicopters and UAVs for search and rescue and medical evacuation operations.

This research has demonstrated that DEM and slope maps are indispensable tools for defining safe landing zones for helicopters and UAVs. At the same time, large-scale topographic maps remain crucial for such analyses. Future research should explore recognized methodologies for generating slope maps from DEMs and investigate ways to integrate these datasets with digital topographic maps for enhanced accuracy.

Beyond spatial and cartographic data, future studies should also incorporate soil type classification to assess potential hazardous landing conditions despite favourable terrain parameters. This highlights the need for a multidisciplinary approach, requiring collaboration among experts from various fields to ensure comprehensive and reliable results.

## 6. ACKNOWLEDGEMENTS

This study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No 451-03-136/2025-03/200091).

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