

# A Methodological Framework for Geospatial Data Preparation in Missing Persons Search Operations

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## Abstract

Geospatial data should always be prepared according to the specific purpose of their use. Emergency response organizations, such as police and fire brigades, typically maintain geodata tailored to their professional responsibilities. However, missing persons search operations conducted outside urbanized areas represent a distinct and time-critical activity for which geospatial data are often not preconfigured. These operations frequently involve not only official rescue units but also external participants, including volunteers and other non-governmental actors, who may lack access to standardized and purpose-specific spatial data. This paper addresses this gap by proposing a methodological framework for the preparation and sharing of geospatial data specifically designed for missing persons search operations in non-urban environments. The framework defines relevant data layers, harmonizes data formats and spatial reference systems, and establishes data-sharing mechanisms that enable rapid deployment under time-critical conditions. The main contribution of this work lies in the systematic structuring of geospatial data preparation for an operational domain that is currently underserved by conventional emergency mapping practices.

**Keywords:** Geodata management and processing, Search and Rescue, Missing person

## Introduction

Missing persons search operations require rapid and efficient solutions, supported by well-organized field activities. Such organization can only function on the basis of well-prepared geospatial data and their effective sharing among all participating actors. Search operations are primarily led and coordinated by police forces (Powel, 2016; Caloupková et al., 2019; Doherty et al. 2012). Fire brigades, military units, mountain rescue services, and volunteers often assist in field searches (Hanssen, 2018). All these participants should have access to high-quality and standardized geospatial data to ensure that all parts of the potential search area are systematically covered (Drexel et al., 2018).

The core background data consist of basic topographic information used for terrain orientation and the delineation of search sectors. A valuable complement to these geodata includes identified locations offering potential shelter for a missing person (e.g., from adverse weather conditions or for rest) as well as locations that may pose hazards to search teams (e.g., steep slopes or ravines) (Rutová, 2025). Basic topographic data are commonly available, for example through OpenStreetMap. However, police, fire brigades, and military units maintain their own datasets tailored to their specific needs and do not routinely share them. Additional domain-specific layers, particularly the delineation of search sectors, are generally not available.

Although volunteer search groups are always led by a trained professional, at minimum the sharing of these data must be ensured among the individual rescue units. This sharing must be operational and conducted within the shortest possible time.

The delineation of search sectors must be addressed as rapidly as possible, ideally by having them prepared in advance and, when necessary, selecting only those sectors that are relevant

for the specific locality. Search sectors should be defined with an appropriate size, such that search teams are able to cover them within a given time interval before fatigue and loss of attention occur. Sector size varies depending on whether the search is conducted by foot patrols, off-road vehicles, or divers searching water bodies.

Furthermore, search sectors should be designed so that their boundaries can be easily identified in the field. Sector boundaries should therefore follow recognizable linear features such as roads or streams, rather than crossing open fields or forest interiors, where search teams cannot reliably determine when a boundary has been reached (Růžicková et al., 2025). This is critical from an operational perspective, as poorly defined boundaries may result in peripheral parts of search sectors remaining unsearched. Consequently, areas in which the missing person might be located may be inadvertently omitted.

This paper addresses the methodology of geospatial data preparation and sharing by generalizing procedures that were practically implemented and validated in the Czech Republic. A unique situation has emerged in this context, as pre-defined search sectors have been systematically developed in advance - an approach that is not commonly applied in other countries, where search sectors are typically not delineated in such a sophisticated and preconfigured manner.

In addition, a dedicated application has been developed that is freely available and tailored specifically to missing persons search operations (Růžicka, 2021). The application enables the incident commander to assign search sectors and distribute them to individual search teams. It provides a clear overview of which sectors have already been searched, which are currently being searched, and which have not yet been covered. Other users can employ the application to visualize their assigned search sectors and to select background topographic data according to their operational preferences and established practices.

## **Data and Method**

A systematic methodology for geospatial data preparation and sharing was developed and validated through long-term applied development, field testing during training exercises, and operational deployment in a real crisis situation within the Czech Republic.

### **Area of Interest**

The methodology for geospatial data preparation and sharing was derived from the long-term development and practical implementation of solutions to missing persons search operations in the Czech Republic. The study covered the entire territory of the Czech Republic, with a primary focus on non-urban and rural areas, where missing persons searches are most frequently conducted and where geospatial data are typically less standardized.

### **Data Sets**

The delineation of search sectors was based on topographic data at a scale of 1:10,000 obtained from ZABAGED (ČÚZK, 2026). In addition, OpenStreetMap (OSM Contributors, 2026) data were used as an alternative background dataset to ensure interoperability and accessibility for non-state rescue units, such as mountain rescue services and volunteer organizations. This choice was motivated by the fact that the police use proprietary background maps that cannot be legally shared with external or non-governmental actors. In mountainous areas, OpenStreetMap data coverage is often limited. However, these data gaps can be supplemented by volunteers (Fast and Rinner, 2023).

## Instrumentation

A dedicated application, Pátrač, developed specifically for missing persons search operations, was used to support the assignment, visualization, and sharing of search sectors. The application was tested during training search exercises conducted throughout its development and during direct deployment in a real crisis situation.

## Research Method

The proposed methodology was developed by generalizing procedures derived from long-term practical experience and operational requirements. The functionality, usability, and practical benefits of the Pátrač application and the associated geospatial data preparation workflow were evaluated through field testing during training search exercises and real-world operational deployments.

The testing involved search operations coordinated by police officers acting as incident commanders and included participants from mountain rescue services as well as certified and non-certified volunteer dog handlers. Identified weaknesses and limitations related to data storage, data sharing, and operational use were systematically documented and subsequently used to refine the proposed methodology.

The methodology was evaluated through multiple training exercises conducted during the development phase of the application, as well as during direct deployment in a real crisis situation.

## Results

Based on a review of relevant studies (Ewers et al., 2023; Niedzielski et al 2021; Drexel et al., 2018, Powel, 2016; Phillips et al., 2014; Doherty et al. 2012.) and observations from real-world training search operations, several categories of geospatial data were identified as essential for missing persons search operations.

The required geospatial data include:

- the location of the last known position of the missing person;
- topographic information of the surrounding area where the missing person was last observed, serving two primary purposes:
  - identification of potential locations to which the missing person may have moved;
  - terrain orientation for members of search teams during field operations;
- the location of available human resources and technical equipment deployed for field search activities.

These geospatial data are complemented by additional non-spatial information, such as parameters used in models for estimating the potential location of the missing person (e.g., age, physical condition, and mental state), as well as contact information for potential members of search teams and supporting personnel.

The following table provides an overview of the required data according to the operational phase in which they are needed and the actors responsible for their use.

Volunteers are usually organized into groups; however, access to basic information on search sector boundaries is beneficial to ensure consistent spatial awareness among all participants.

It is always possible to return to earlier operational phases if new information becomes available regarding an updated location of the missing person, for example when a witness reports a new sighting.

**Table 1.** Required geospatial data and supporting information for missing persons search operations according to operational phase and user groups.

| Required data / information                                                            | Search operation phase |          |           |             | Users              |                    |                        |            |
|----------------------------------------------------------------------------------------|------------------------|----------|-----------|-------------|--------------------|--------------------|------------------------|------------|
|                                                                                        | Preparation            | Planning | Execution | Termination | Incident commander | State rescue units | Non-state rescue units | Volunteers |
| Location of the last known position of the missing person and accompanying information | x                      | x        | x         | x           | x                  |                    |                        |            |
| Topography of the area surrounding the disappearance location                          | x                      | x        | x         | x           | x                  | x                  | x                      | x          |
| Location of potential search personnel                                                 | x                      | x        |           |             | x                  |                    |                        |            |
| Search sectors                                                                         |                        |          |           |             |                    |                    |                        |            |
| - Initial sector delineation                                                           |                        | x        | x         |             | x                  | x                  | x                      |            |
| - Search status records (searched / in progress / not searched)                        |                        |          | x         | x           | x                  | x                  | x                      |            |
| Current position of search teams                                                       |                        |          | x         |             | x                  | x                  | x                      | x          |

All relevant data are centrally managed by the incident commander, including contact information required for mobilizing search teams. Topographic data are made available to all participants, even though individual searchers (e.g., local residents) are typically guided by a team leader. Search sector data are shared according to the operational role of each participant.

Tools designed for the incident commander support the identification of areas with a potential occurrence of the missing person, the advanced delineation of search sectors, the mobilization of search personnel, the assignment of search sectors to search team leaders through online data transfer, and the recording of search status and progress.

Tools provided to other participants focus on the visualization of assigned search sectors and on access to information regarding the search status of these sectors.

The presented results are based on three years of practical testing, as well as on an extensive prior review of methodologies used in missing persons search operations. These methodologies also identify various types of data applicable to search operations. In comparison with these sources, it can be concluded that the results presented in this paper are consistent with other studies, although these studies often focus only on specific aspects of missing persons search operations. According to the individual phases of the search process, the need for geospatial data is confirmed by the following studies:

- Location of the last known position of the missing person and accompanying information – the need for these data already during the preparation phase of search operations is emphasized by all studies referenced in this paper (Dacey et al., 2023;

O'Brien et al., 2021; Růžicka, 2021; Drexel et al., 2018; Bunch et al., 2016; Fyfe et al., 2015; Doherty et al., 2014).

- Topography of the area surrounding the disappearance location for:
  - Identifying the potential location of the missing person – both for the preparation of automated UAV-based search operations (Ewers et al., 2023; Niedzielski et al., 2021) and for the physical deployment of search teams in the field (Růžicka, 2021; Drexel et al., 2018; Bunch et al., 2016; Doherty et al., 2014);
  - The delineation of search sectors, whether in the form of circular models (Bunch et al., 2016; Dacey et al., 2023; Drexel et al., 2018), other geometries (Barone et al., 2021; Růžicková et al., 2025), travel-time-based models (Růžicka, 2021; Drexel et al., 2018; Doherty et al., 2014), or UAV flight plans for automated search operations (Niedzielski et al., 2021; Drexel et al., 2018);
  - Orientation of searchers in the field during search operations (Fyfe et al., 2015; Battistuzzi et al., 2021; Viljoen et al., 2025).
- Current position of search teams or individual searchers – this primarily concerns search teams operating in the field, while it is less relevant for automated UAV-based searches. Hanssen (2018) states that “We have observed that tracking and visualisation on maps reduces stress in the command centre or command post. It reduces the need for verbal communication with teams in the field.” The need for effective situational management is also emphasized by Drury et al. (n.d.). The need for a shared overview of the positions of various units, including UAVs, should also be included (Urakawa et al., 2020). In automated search operations, such information is directly available from technical systems (Niedzielski et al., 2021); however, if only part of the search operation is conducted using automated methods, these data still need to be transferred to the incident commander (Hanssen, 2018).
- Records of already searched areas – this data is necessary for analysis and improvement of the search methodologies used (Sen and Jindal, 2024).

## Conclusion

The results confirm that the advance preparation of search sectors significantly reduces the time required for operational deployment in missing persons search operations. At the same time, the overall quality of preparation is improved, as search sectors can be designed more appropriately with respect to their size as well as the available human and technical resources under the specific conditions of individual localities. This contributes to a more systematic coverage of the search area and reduces the risk of unsearched or insufficiently searched zones.

All tools required for search operations, as described in the previous section, are supported by the Pátrač application for both the role of the incident commander and other participants who install the application and are assigned a search sector. The application enables efficient sector assignment, real-time sharing of operational data, and continuous monitoring of search progress, which are critical factors under time-critical conditions.

Users can flexibly load topographic data according to their individual preferences and technical possibilities. In the Czech Republic, state emergency response units automatically access to their topographic map; however, this dataset cannot be shared with non-state participants such as mountain rescue services or volunteers. These users can instead load OpenStreetMap or other freely available topographic datasets of their choice, ensuring interoperability across heterogeneous search teams.

Although the presented methodology was developed and validated within the Czech Republic, it is not dependent on country-specific datasets or institutional structures. The conceptual

framework for geospatial data preparation, sector delineation, and data sharing is transferable to other national contexts and can be adapted to different legal, organizational, and technical environments where missing persons search operations are conducted in non-urban areas.

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