Design of a Model of an Additional Meteorological Network for the Needs of the Aviation Component of the Integrated Rescue System

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***Abstract*— This article deals with the design of a model of an additional meteorological network, which would be a source of objective meteorological information through the innovative automatic meteorological station IMS4 Remote Observer. The current state of weather monitoring in Slovakia is insufficient for the IRS aviation component and a large part of the territory remains without meteorological monitoring. Rescue helicopter pilots do not have the opportunity to perform optimal planning of the rescue mission in the event of inappropriate or dangerous weather for the flight. The authors of the article analyze the current state, identify its shortcomings and propose a suitable type of meteorological network following the recommendations of the World Meteorological Organization based on the purpose for which the supplementary network is proposed. Subsequently, the article presents the sequence of modeling of the supplementary network, the method, and the principles of selecting suitable locations for the establishment of measuring points of the information network. The modeling procedure is logically justifiable based on the needs and procedures of flying in General Aviation conditions to which the IRS air component belongs. The article also lists the benefits that the expansion of areas with weather monitoring brings in modern times**

Keywords—meteorological network, Integrated Rescue System, General Aviation

I. Introduction

The geomorphology of the territory of the Slovak Republic is characterized by its complexity and significant differences between the mountainous north and the center of the territory in comparison with the flat south of the country. In case of accidents or incidents, air rescue is used in case of difficult accessibility in complex mountainous areas or in case of time advantage when transporting the patient to hospitals. This activity has been carried out by ATE transport Slovakia for thirty years [1]. Sufficient objective meteorological information about the weather in the critical area and on the route to it is a prerequisite for the correct decision of the helicopter crew, however, there are areas without aeronautical meteorological stations, where helicopter crews are forced to proceed with improvisation or direct aerial survey of the weather during the flight in Slovakia. This may increase the risk of collision with dangerous weather events during flight [2]. This article aims to describe how to model the structure of the supplementary network of aeronautical meteorological stations that would help eliminate this danger. The design of the supplementary meteorological network is compatible with the application of aeronautical ground equipment number LPZ-S-003/2020, IMS4 AeroVis, and AeroCloud Camera-based Remote Observer, from the manufacturer MicroStep - MIS in Bratislava [3]. The device was approved by a decision of the Transport Authority of the Slovak Republic on 21.04.2020, with restrictions for use in night conditions and outside the reporting of SPECI reports [4]. This autonomous system provides full METAR automatic reports, with sky coding certification being the subject of an applied research project under the call of the Agency for Research and Development Support entitled "AeroCloud - Comprehensive Meteorological Cloud Detection System", project number APVV-20-0407, applicant organization MicroStep - MIS, spol. s r.o. Bratislava and the co-research organization of the Technical University in Košice - Faculty of Aviation, which means strengthening cooperation between the private and public sectors in the field of science, research, and innovation. The proposal also respects the recommendations of the World Meteorological Organization on the representativeness of the locations of the installation of measuring points and the structure of the meteorological network [5].

II. Problem Identification

Five aeronautical meteorological stations operated by the Slovak Hydrometeorological Institute and three stations under the administration of the Armed Forces of the Slovak Republic are available to decide on the method of conducting a rescue flight in terms of weather conditions [6]. Civil stations are at the airports in Bratislava, Košice, Piešťany, Poprad and Žilina. Military stations are located at air bases in Malacky, Sliač, and Prešov. Their spatial distribution is expressed in Figure 1.

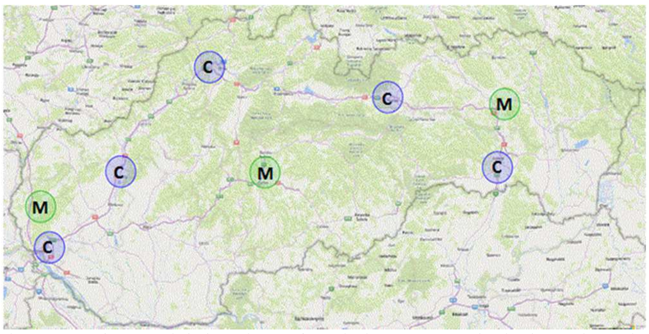

Figure 1 The spatial location of Aviation Meteorological Stations in Slovakia. M - Military, C- civilian [map source: Bing]

In areas without meteorological coverage with bad weather, rescue helicopter crews rely on improvisation, which may lead to inappropriate route selection or, upon arrival at the scene, may determine the unsuitability of meteorological conditions for the safe conduct of the rescue mission [7]. Once the one in an emergency is picked up on board the helicopter, he or she should be transferred to a suitable hospital facility as soon as possible, which in the absence of objective meteorological data may lead to time delays in locating suitable weather conditions and landing suitable and safe routes. In case of the need for the fastest possible transport to the hospital due to the critical health condition of the patient, the success of the rescue operation may be reduced. In such a case, the helicopter crew may be exposed to enormous psychological pressure, with the possibility of taking the risk of flying in inappropriate weather and difficult terrain to save the patient's life. Appropriate monitoring of hazardous weather events, such as low clouds [8,9] or wind shear [10], provides an opportunity to assess the feasibility of the intended flight. Better information on the weather situation can thus help air rescue crews to make the right and quick decision on the appropriate flight path and landing location [11]. Automatic meteorological observation systems are currently well equipped to measure basic weather parameters, while efforts are being made to supplement them with data on the amount and type of clouds, which has a major limiting factor in-flight safety [12-14]. Complementing the current meteorological information network with meteorological stations of a suitable type and their systematic distribution in the territory without weather monitoring seems to be a possible solution to problems with missing meteorological data.

III. Methodology of Problem solving

Before designing the model of the supplementary meteorological network, it is necessary to determine based on the valid recommendations of the World Meteorological Organization [5] which type of information network will be in terms of its purpose. Based on this, the degree of representativeness of individual measuring points and their area range is determined, on which the density and the number of additional stations depend. By determining the area range of representativeness of currently existing measurements (Figure 1), it is possible to determine the size of the area without meteorological coverage. In the synthesis of this knowledge, it is possible to approach the design of the location of additional measurement points in several logical steps that will form the individual layers of the model. By partially overlapping the layers, the model can be continuously optimized. The final design of the supplementary meteorological network model is the result of overlapping optimized layers.

IV. SOLUTION DESIGN

The purpose of the proposed supplementary meteorological network is to provide General Aviation, which includes the IRS air component, with objective information that would be the basis for the correct decision of the crews before take-off and during the flight. This network should reliably monitor the occurrence of dangerous weather phenomena, their variability in time and space. According to the recommendations given in the manual of the World Meteorological Organization for Observation Instruments and Methods, an interscale type of meteorological station with the representativeness of measured data from 3 to 100 km is suitable for this purpose [5]. Reports of measured data and identified phenomena by the IMS4 Remote Observer system are in the form of a METAR message. This type of aeronautical meteorological report has certain limitations and is limited by reporting a maximum possible visibility of 10 km [15]. At the same time, it is desirable to express as accurately as possible the weather in specific places, such as general aviation airports or hospital heliports. For these reasons, the representativeness of the measuring devices was determined for an area of 10 km from the station installation site. In the case of complex mountain areas with the assumption of considerable variability of meteorological elements even less than 10 km, however, still within the limits of the mesoscale, i.e. not less than 3 km in diameter. The exact location of individual network observation stations is not the subject of this article, but during installation, the representativeness of 10 km must be taken into account to exclude places with significant obstacles in the vicinity, infrastructure, terrain depressions, heat sources such as buildings or hot water pipes and other influences that would change the informative value of measured data to a smaller level of representativeness for the environment. Figure 1 shows the areas of the selected representativeness of the stations as circles with a radius of 10 km, which forms the basic layer of the model. The addition of other measuring points is based on the already existing aviation infrastructure of the general aviation airport, which is used for take-off and landing, and it is, therefore, a logical step to place points of the additional meteorological network in these locations (figure 2). Some general airport airports are relatively close to each other, thus overlapping areas of representativeness with which nothing can be done because airports have their specific conditions and the task of these stations is to describe the weather on them as accurately as possible. It is therefore not possible to combine different aerodromes under one measurement or to shift the center of the areas, as they are linked to the aerodrome position. The limit of representativeness of not less than 3 km in diameter for the mesoscale type of observation is nevertheless complied with. Figure 2, therefore, represents the airport layer.

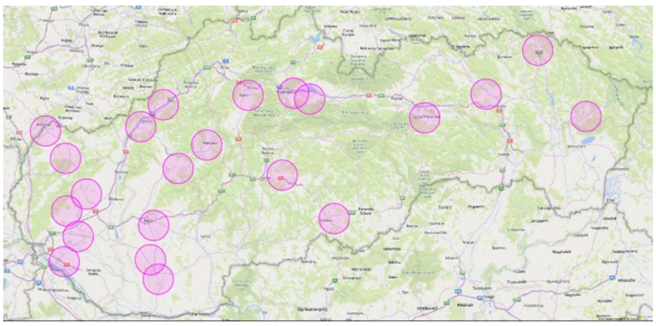

Figure 2 Observation points of supplementary meteorological network on General Aviation airports in Slovakia [map source: Bing]

The task of the IRS air force is to transport the patient from the scene to the hospital facility as quickly as possible. Cities with a hospital on will therefore form another layer of the model. Figure 3 shows the model layer, which is created by a network of hospital sites with ongoing optimization. It is obvious that hospitals are located in several cities, but they are already covered by previous layers. There is no duplication of measuring points of the supplementary network in this way.

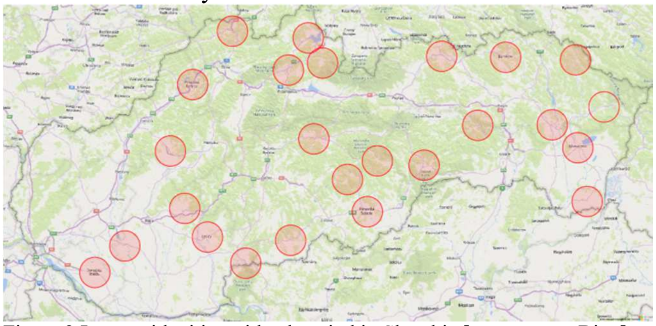

Figure 3 Layer with cities with a hospital in Slovakia [map source: Bing]

By merging the created layers, it is possible to identify places that remain uncovered by meteorological measurements (Figure 4.)

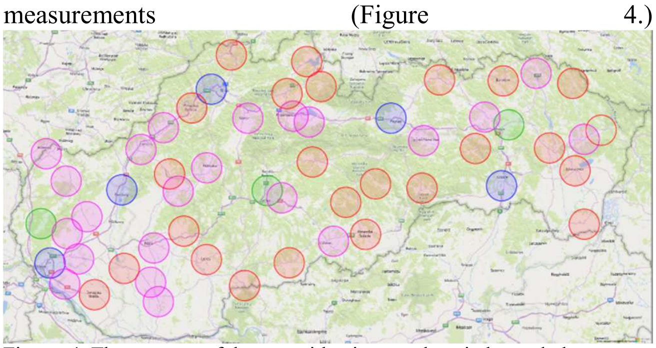

Figure 4 The merger of layers with airports, hospitals, and the current professional meteorological service in Slovakia [map source: Bing]

Areas outside the representativeness of the stations contained in the three layers of the model represent overflight corridors, which, due to the complexity of the geography of Slovakia, is important to monitor for the correct decision to select the safest and fastest route. At the same time, the stations cannot be located on mountain tops, where they would lose their representativeness in the event of cloud cover. The measuring points should be in places overlooking important terrain obstacles, passes, and valleys which, in the event of a low lower cloud base or impaired visibility, would make it impossible to fly over the area. The stations monitoring the flight corridors thus form the last layer of the supplementary meteorological network model and are visually expressed in Figure 5.

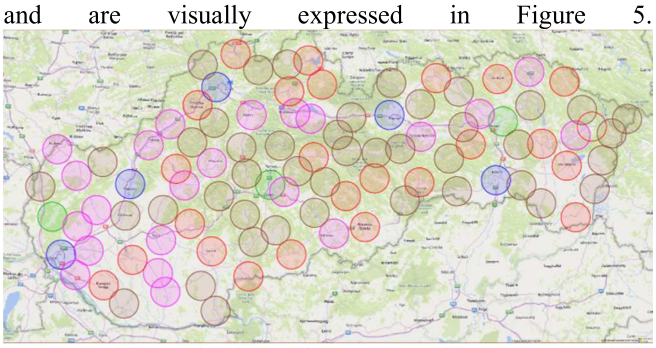

Figure 5 Addition of a layer of meteorological stations in overflight corridors used by the IRS air component to the model [map source: Bing]

Figure 5 represents almost complete coverage of the territory of Slovakia by the monitoring meteorological network. The last step in the design of an additional meteorological network is the reading of the basic layer, which is formed by the currently functioning professional network. The result of this last step is shown in Figure 6.

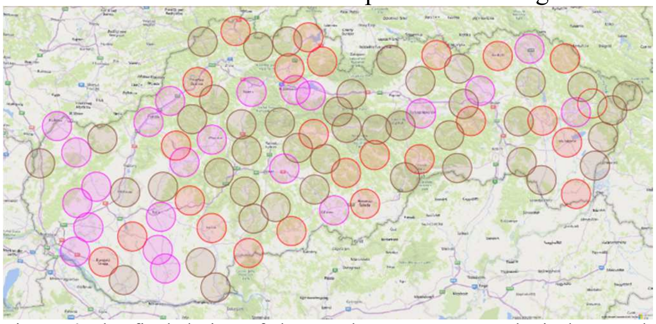

Figure 6 The final design of the supplementary meteorological network model for the needs of the IRS air component [map source: Bing]

Areas not covered by the reach of meteorological stations are either already monitored by the existing network, or they are so homogeneous that the additional stations represent an area larger than 10 km with their data. These are mainly flat areas in the southwest and southeast of Slovakia. On the contrary, in mountain areas, the possibility of significant differences in weather in mountain areas with a presumed strong influence of local specifics such as the Föhn effect, valley inversion, mountain and valley breezes, etc. is needed in more detail.

V. CONCLUSION

The IRS air component has its undeniable advantages over conventional ambulances using land vehicles. The patient can be transported even from difficult to access terrain, it is fast and gentle, the patient is transported directly to the hospital facility. Time plays a crucial role in these cases. In the event of complicated weather in overflight corridors or at the intended handover point to hospital staff, the rescue operation may be extended in the absence of meteorological data from these points. In bad weather, pilots must look for another place to fly over or land, or consider another destination hospital, and without access to objective data, they rely on improvisation such as telephone calls to recreational facilities or petrol stations who are not experts in aviation weather observation. The creation of an additional meteorological network can bring benefits in the form of a reduction in the time required for a rescue operation, which is a prerequisite for increasing the success of the procedure. At the same time, shortening the duration of the flight streamlines the cost of its execution. Knowledge of unsuitable weather in some areas allows crews as an aviation component of the IRS as well as other general aviation pilots to prevent flights in these areas as a prerequisite for increasing the level of flight safety. The design of the network is based on the possibilities of the innovative automatic meteorological solution IMS4 Remote Observer, which can continuously provide all the necessary meteorological data needed for general aviation without the need for the presence of trained personnel [16]. Additional meteorological measurements in as yet unmonitored localities can contribute objective data to understand and generalize the processes involved in the creation of deviations from the prevailing or expected weather conditions. Knowledge of these local peculiarities can also lead to increased accuracy of weather forecasts and further increase of flight safety in general aviation conditions.

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