



# FLIGHT CORRIDOR FOR HEMS AND NATIONAL CRISIS MANAGEMENT COMMITTEE WITH USAGE HTAWS DURING MINIMUM VISIBILITY CONDITIONS

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## Abstract

*This paper presents a new possibilities and methods of Helicopter emergency medical service operation in marginal adverse weather conditions with using the helicopter terrain awareness and warning system and impact on safety of crew and operation. It explains current operations in Slovakia, the principle of helicopter terrain awareness and warning system. Subsequently, analyzed accidents with most common cause – controlled flight into terrain. Furthermore it analyze, design and verify the possibilities of increasing safety operations for helicopter emergency medical service also summaries designed so-called corridor with verify flights for proposes additions for next higher level of safe helicopter operations.*

## Keywords

*Safety, helicopter emergency medical service, HTAWS, controlled flight into terrain, visibility*

## 1. INTRODUCTION

The helicopter rescue medical rescue service has been used worldwide for several decades. More than 50 years have passed since the first rescue operation in Slovakia. From this time, aviation as such, as well as parts of aviation and individual types of operations using helicopters, developed at a rapid pace.

The technique was gradually developed in an effort to create a safe environment for the performance of this special operation. Several types of helicopters alternated and their equipment varied greatly. The environment and use of these systems also had to adapt to this trend

Despite the great effort to maintain the highest possible safety in aviation, precisely in Helicopter emergency medical service operation, dozens of incidents and accidents occurred which let to the implementation of safety measures and an increase in the level of safety

In the interest of high level of civil aviation safety in the Union, it is necessary to adjust all-weather operations in all relevant areas of helicopter operations, specifically in Anex 6, Part I,II and III.

And does it make sense to operate HEMS helicopters in all weather conditions? After all, so many accidents happened, and precisely in connection with bad weather situations. A pragmatic answer may be that it will be safer to operate helicopters at the current values defined by the regulations and another accident event will not happen. And they keep happening.

The topic of flying helicopters in the rescue system in low to borderline meteorological conditions under constant VFR flight using the Helicopter terrain awareness and warning system, hereinafter referred to as (HATWS), is revealed.

## 2. HEMS OPERATIONS

Despite the use of modern helicopters such as the Bell 429, the operations is carried out exclusively under VFR condition during day and at night. This means that the operation does not include any special low visibility procedures or IFR operation.

The annual report of company that provide HEMS operation in Slovakia itself confirms the need for implementation of new systems, which significantly contribute to the preservation and improvement of safety in connection with the increase in number of rescue missions.

In year 2022, a total of 2 186 patients were transported on board helicopters and airplanes in the territory of the Slovak Republic, which a 10% increase in the number of patients compared to the previous year 2021. Last year the rescue teams from the operation base in Banská Bystrica had the most rescue missions, which with their 418 flights they achieved a record number in one year in the history of company in Slovakia. They were followed by operation base in north part of Slovakia- Žilina with 373 rescue flights. On the third place was the base in Trenčín with 345 rescue flights [2]

Currently, three types of helicopters are used in HEMS operation in Slovakia. Agusta A109K2, Bell 429 and Eurocopter EC135T2/T2+/P2+ [3]

Bell is at the forefront in providing multiple ways of satisfying evolving requirements in helicopter traffic management, flight following and terrain awareness safety.

The Bell 429 (figure 1) is the first helicopter in the light twin category to provide fully-coupled steep (9-degree) LPV WAAS (Localizer Precision with Vertical guidance Wide Area Augmentation System) approaches.



Figure 1 - Helicopter Bell 429

The Bell BasiX-Pro Integrated Avionics System concentrates on providing true operational capabilities and flexibility to our customers to address rapidly changing regulatory requirements and technologies, with an open architecture and flexible avionics systems solutions. The enhancements available for the Bell 429 through optional accessory kits and customizing include the Traffic Advisory System and Helicopter Terrain Awareness and Warning Systems / Enhanced Ground Proximity Warning System. [4]

### 3. HTAWS

ICAO introduced Ground Proximity Warning System (GPWS) carriage requirements in 1978 to alleviate the Controlled Flight Into Terrain (CFIT) problem. A significant decline in the number of incidents was observed after installation of GPWS. The CFIT, however, continued to be a critical flight safety problem. ICAO has, therefore, amended the GPWS provisions in Annex 6. System is designed to warn of dangerous terrain in the vicinity of the helicopter and avoid a collision with the terrain or obstacles on the ground in calculated current flight trajectory and other input data that the system evaluates. [5]

The success after the introduction and implementation of TAWS systems for aircraft pointed to the need to introduce these systems also for helicopters in the form of the HTAWS system. However, the implementation of the system alone does not guarantee the elimination of CFIT- type collisions. An understanding of the system and training to work with. Be able to recognize system displays independently and in a timely manner. [6] [7]

Helicopter Terrain Awareness and Warning System. HTAWS is a computer-based system that provides the flight crew with alerts, (both aural and visual) of pending collision of the rotorcraft with the terrain, considering such items as crew recognition and reaction times. Enhanced awareness is achieved by employing a look-ahead function that provides cautions, warnings, and terrain and obstacle display(s).

The individual displays of the systems are divided into basic colors for easy expression and understanding of the danger in the event of conflict. So that the warning display is clear and legible during the flight at lower altitudes and that the color markings do not interfere during the entire flight.

This display system work only below 2 000 ft above ground level. Individual colors represent a potential danger due to the position and height of the helicopter. In general the color

according to picture No. 1 are red and yellow, the colors of heightened attention represent immediate danger.

The picture represent the view around the helicopter if we take into account the example that the helicopter hover with zero speed. The colors black and green do not represent an immediate risk, but the risk is potential. Both cases require the crew to react to given alert situation, which they mus evaluate as a potential risk or imminent danger.

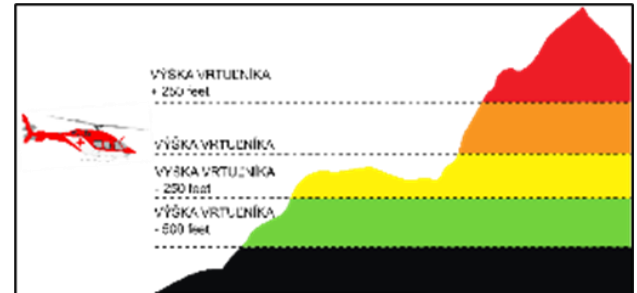


Figure 2 - HTAWS colour annunciation

The HTAWS should provide automatically, as a minimum, warnings under the following circumstances: [5]

- Excessive descent rate;
- Excessive terrain closure rate;
- Excessive altitude loss after take-off or go-around;
- Unsafe terrain clearance while not in landing configuration;
- Excessive downward deviation below the instrument glide path;
- Excessive banking angle;
- Excessive pitch angle; and
- Vortex ring danger [5]

The individual displays of the systems are divided into basic colors for easy expression and understanding of the danger in the event of a conflict. So that the warning display is clear and legible during the flight at lower altitudes and that the color markings do not interfere during the entire flight. This display system only works below 2000 ft AGL.

Individual colors in figure 2 represent a potential danger due to the position and height of the helicopter. In general, the colors according to figue number 1 are red and yellow, the colors of heightened attention represent immediate danger. The image represents the view around the helicopter if we take into account the example that the helicopter hangs in place with a speed of  $V=0$  km/h. The colors black and green do not represent an immediate risk, but the risk is potential. Both cases require the crew to react to the given situation, which they must evaluate as a potential risk or imminent danger.

### 4. CFIT

CFIT (controlled flight into terrain) occurs when an aircraft or helicopter is fully capable of flight under control and the pilot

flies unintentionally and without prior awareness of the terrain, water or obstacle. It is the second most common consequence of commercial helicopter air transport accidents. [8]

It is very important for pilots to understand what conditions lead to CFIT in order to be able to recognize these dangers, avoid them in time and prevent an accident. More than 80% of accidents due to CFIT in the operation of HEMS happened at night. 60% of accidents are fatal. [9]

A pilot should and must:

- expect that the conditions may be worse than predicted by the weather forecast, recognize the signs and dynamics of deteriorating weather,
- check and evaluate the current actual conditions compared to the forecast,
- identify route alternatives and suitable backup airports or safety areas,
- have a sufficient reserve of fuel for unexpected situations,
- listen to ATIS reports during the flight to verify the airport's current weather conditions (if the airport has such reports),
- be ready to divert, turn or land within the framework of maintaining the safety of the flight even at the cost of not reaching the planned landing place,
- and last but not least on the basis of the implementing regulation EU 923/2012 in the SERA.2015 section "Authority of the aircraft commander: The aircraft commander has the right to make a final decision on the execution of the flight". 10 [30]

New technologies help to raise situational awareness to a much higher level than without the introduction of these technologies. Systems that are introduced into modern aviation technology, which is also used in the operation of HEMS in Slovakia, have systems such as EGPWS or HTAWS.

These systems present displays and warnings to pilots within the terrain that creates a dangerous collision situation. These advances in avionics can help to increase safety, but the pilot-in-command is the element that prevents him from getting into situations that would be dangerous if he evaluates them in time. 8 [19]

## 5. DESIGN OF CORRIDOR

From the annual report of the Air Transport Europe company, it follows that of all the hospitals in Slovakia, in 2022, the rescue helicopter was most often seen at the Kysucka hospital and polyclinic in Čadca, where the pilots landed exactly 70 times, and this is the reason why the design and its experimental measurement are carried out for the flight from Žilina – Čadca or backward. [1]

flight corridor is the name behind which the flown route is taken into account, which is tested in advance under satisfactory conditions. Corridor because the track and its control points are led in a corridor that ensures a sufficient distance from the nearest and most critical obstacles from the point of view of the

terrain and other obstacles such as e.g. BTS antennas, Chimneys, Power lines, etc.

The selected corridor was designed to meet the minimum requirement of a minimum height above the ground of 500 ft AGL within a radius of 150 m from the helicopter. In this way, a sufficient safe distance from obstacles, especially off-road ones, will be achieved in individual critical points of the track.

In figure 2 is the line shown in blue, which is mainly used by the crews of HEMS Krištof 06 for the direct flight to the hospital in Čadca and also back to Žilina. The red color shows the route that would ensure a safe flight even under the minimum limit values for VFR or SVFR flight, namely 600 ft AGL with a minimum flight visibility of 800 meters. Individual control critical points are shown in yellow.



Figure 3 - Designed route for corridor compared with direct flight route

## VI. RESEARCH

A part of the paper is also research which aims to enhance helicopter emergency medical service safety during marginal adverse weather through experimental flights with helicopter Bell 429 from one of operational bases in Žilina. A total of 7 flights were made, of which 4 were designed corridors and 3 were direct flights.

For experimental purposes was used calibrated recording device Nano 4 was used for recording the flight, which was subsequently evaluated in the Seeyou Cloud program, additional devices for photo documentation of the dashboard with a Garmin 750 display in Terrain and Map mode and Garmin D2 Bravo watches.

The main criteria include following:

- a) Compliance with the minimum set parameters according to regulation Annex 2 – Rules of the air. Minimum visibility 800 m.
- b) Observing the availability of the helicopter with regard to road traffic or selected safety areas.
- c) Adherence to the flight at a flight height of at least 500 to 1,000 ft above the terrain specified by regulation Annex 2 Rules of the air.

d) Adherence to the time benefit and thus the time deviation of the measured route must not be higher than 25% compared to the flight as the crow flies.

e) Recognition of terrain and other significant obstacles by the onboard HTAWS system and comparison with visual contact, (figure 4) or evaluation of deviations or changes in the underlying maps of the system.



Figure 4 - Detailed HTAWS screen on Garmin G750 during test flight.

a) The flights for the purpose of measurement ranged from 530 to 1,046 ft AGL, which fulfilled the requirement for a min height of 500 ft and also verified the signaling of the system at heights higher than 500 ft AGL.

b) The speed during flight measurement was set to a range of 100-120 kt, for which a minimum visibility of 1,500 m and maintaining visual contact with the ground is established. The required parameters were partially met with the exception of the first control point in two flights when the speed exceeded 130 kt. Speeds ranged from 75 to 135 kt. The times required to fly through the corridor were calculated for the limiting speeds at a visibility of 800 m 50 kt.

c) Maintaining the availability of the helicopter with regard to road traffic or selected safety areas. The intended track replicates the 1st class road E75 in the off-road valley. This road is suitable for coverage by a ground ambulance in case of worsening weather conditions or due to technical reasons of the equipment used. The required parameters were met, the flights were always conducted along the road.

d) Compliance with the time benefit. The time deviation of the measured track ranges from 13.4-28%. It represents potentially good time benefits, but on the contrary, when flying at a speed of 50 kt, the benefit disappears. For individual flights, it was found that the differences in the time needed to fly this route are minimal compared to the time needed to move an ambulance on the road.

e) During the measurement flights, terrain obstacles were recognized on a large scale during the flight at 500-600 ft AGL, where colored warnings and also the voice warning "TERRAIN" were marked. Only one chimney was recognized in Kysucké Nové Mesto, it is the only obstacle that can be found in the database of obstacles in this area. The compliance of the map background with the real terrain in the area of the intended line was fulfilled by a sufficient map background, which included the

representation of a part of the railway line and the power line. Identification of obstacles along the flight path. These were not observed in the system. However, not every obstacle is within tight horizontal and vertical boundaries.

## 6. CONCLUSION

The results of the work show that the use of the HTAWS system during such low flights notifies the pilot and the crew sufficiently in advance of obstacles near the flight trajectory and also of the warning near the terrain. It presents the pilot with a graphic display of the position relative to the terrain to the required extent, which helps to recognize known terrain in the case of reduced visibility.

The route can be used in real operation with minimal time deviations from the flown route by direct flight only under the conditions that there will be no flight with the minimum limiting meteorological visibility at 800 m.

Then the flight speed is very limited to 50 kt. flight is highly marginal and the time benefit compared to ground transportation is slowly but surely being lost, which is not the goal of flights. Flights at such a low speed with minimal visibility are time disadvantageous even with the use of the HTAWS system.

Individual flights confirmed the completeness of the map base of the system. It displayed the terrain relief, the railway line and in some places even the power lines correctly every time it was flown. However, what turned out to be insufficient is the number of obstacles on the flight path from the point of view of low flight. It is only an obstacle that is also marked on the ICAO map, namely the factory chimney in Kysucké Nové Mesto. No other obstacles are sufficiently shown in the map base. This can represent a potential risk for a pilot who does not know the terrain and obstacles well enough, but also for a pilot who performs flights in the space regularly.

After evaluating all the results, we also get to evaluate the status and availability of meteorological data from meteorological stations and web cameras, which are insufficient for this area. It would be necessary to ensure the addition of web cameras and stations, with basic data for pilots, which would greatly help in the decision-making process on the execution of the flight.

The obtained results can help in the future process of developing innovative procedures for VZSS to analyze the options for creating a network of flight procedures for VZSS crews.

## REFERENCES

- [1] AIR-TRANSPORT EUROPE. O nás. [online] Dostupné na: <https://www.ate.sk/sk/o-nas/ate/>
- [2] AIR-TRANSPORT EUROPE. 2023. Tlačové správy [online] Dostupné na: <https://www.ate.sk/sk/aktuality/posadky-leteckych-zachranarov-uskutocnili-3471-zachrannych-akcii-stupli-letecke-prevozy-novorodencov/>
- [3] AIR-TRANSPORT EUROPE. VZSS. Flotila [online] Available: <https://www.ate.sk/sk/vzss/flotila/>

- [4] Bell 429. SPECIFICATION, Publication. 2019. Bell Helicopter textron Inc. [online] Available: [https://www.jubilantenpro.com/Uploads/prospectus/3p sf\\_Bell429ProductSpecifications.pdf](https://www.jubilantenpro.com/Uploads/prospectus/3p sf_Bell429ProductSpecifications.pdf)
- [5] HTAWS Specification [online] Available: [https://www.un.org/Depts/ptd/ptd/sites/www.un.org.Depts.ptd/files/files/attachment/bulletin/2014/April%2014/HTAWS%20Specifications\\_UN\\_Rev3.pdf](https://www.un.org/Depts/ptd/ptd/sites/www.un.org.Depts.ptd/files/files/attachment/bulletin/2014/April%2014/HTAWS%20Specifications_UN_Rev3.pdf)
- [6] SKY BRARY. Helicopter Terrain Awareness and Warning System (HTAWS). [online] Available: <https://www.skybrary.aero/articles/helicopter-terrain-awareness-and-warning-system-htaws>
- [7] EUROCONTROL. Terrain and Obstacle Data Manual. 2021. [online] 3<sup>rd</sup> publication pg. 21-22. ISBN 978-2-87497-079-5. Available: <https://www.eurocontrol.int/sites/default/files/2021-07/eurocontrol-tod-manual-ed-3-0.pdf>
- [8] **Mayhew N.** International Helicopter Safety Team. Training Fact Sheet – Controlled Flight into Terrain. [online] Available: [https://vast.aero/archives/Safety\\_Bulletins/BULLETIN%20CFIT.pdf](https://vast.aero/archives/Safety_Bulletins/BULLETIN%20CFIT.pdf)
- [9] **Kipp L.** Controlled Flight into Terrain Prevention With HTAWS. [online] Available: [https://vast.aero/archives/Safety\\_Bulletins/Training\\_QR\\_4\\_HTAWS.pdf](https://vast.aero/archives/Safety_Bulletins/Training_QR_4_HTAWS.pdf)
- [10] Nariadenie komisie (EÚ) č. 923/2012 z 26. septembra 2012, ktorým stanovujú spoločné pravidlá lietaní a prevádzkové ustanovenia týkajúce sa služieb a postupov v letovej prevádzke a ktorým sa mení a dopĺňa vykonávacie nariadenie (EÚ) č. 1035/2011 a nariadenie (ES) č. 1265/2007, (ES) č. 1794/2006, (ES) č. 730/2006, (ES) č. 1033/2006 a (EÚ) č. 255/2010. published 2012. [online] Available: <https://eur-lex.europa.eu/legal-content/SK/TXT/PDF/?uri=CELEX:02012R0923-20160818&from=DE>