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Council of Doctors

ÁGOSTON RESTÁS

*Research and development of the aerial reconnaissance and
extinguishing of forest fires*

Short author introduction of the PhD dissertation

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Budapest
- 2008 -

THE SCIENTIFIC PROBLEM

Most professional literature accepts global climate change as a fact. Some climate models show that with the forecasted greenhouse gas concentration climate can be changed by several degrees. It means that the frequencies of extreme weather phenomena will be higher; some areas will have more frequent heavy rain and floods while in other areas periods of drought will become longer and more severe. During drought the moisture content of vegetation is reduced, meaning that the conditions for burning become much better. The international community uses some special fire weather indexes which predict the frequency and risk of forest fires. The combination of the fire weather indexes with regional climate change scenarios indicate that in Hungary a warming by only 0,5 Celsius degree can increase the frequency of forest fires by up to 50 %. Some scenarios indicate that a warming by 4 degrees Celsius can cause the increase of forest fire frequency by up to 200 – 300 % as well.

The media reports daily that the problem of forest fires is very serious and requires solutions not only in Hungary but at an international level too. The importance of the fighting against vegetation and mainly forest fires prompts the increase of the efficiency of the use of scientific and technological achievements. It involves such new processes as remote sensing based fire detection, explosion extinguisher applications, or geoinformation-based decision support systems. Among these are – nowadays not as everyday practice yet – the applications of aerial reconnaissance and fire fighting that are foci of my work

In almost each report on large forest fires the international media shows pictures and videos made on board helicopters or planes displaying the huge burned areas. Planes or helicopters dropping water are one of the most favourite topics for reporters. The above facts demonstrate the effective applications and the necessity of aerial fire fighting at an international level, proving the spread of the use of this method. Looking at the Hungarian situation, there can be found some similar applications in the recent years. Military and civil pilots provide help using their previous experience. There were no any efforts until now for the description, comprehensive analysis of the previous experience and the establishment of the conditions for the provision for the users.

At the onset of my work I focused only on problems of aerial fire fighting. For this it was inevitable to carry out a basic analysis and review of the traditional forest fire fighting

process. During this analysis it was proved to me that the applications of helicopters and planes can be much wider than dropping water from the air. During my research I discovered the above opportunities and I reevaluated and broadened the topic of my dissertation. In addition to air-based fire fighting I included the topics of aerial reconnaissance, logistical support and the aerial coordination too. Accurate reconnaissance and continuous monitoring of the fire front are indispensable elements for effective aerial fire fighting. Thus aerial reconnaissance is inseparable from fire fighting they coexist. Therefore, defining the topic of my research, I considered aerial fire fighting and reconnaissance as my research areas, but I considered the discussion aerial coordination and logistic support – due to space limitations – only to the extent necessary for the correct understanding of the dissertation.

OBJECTIVES OF THE RESEARCH

I considered as objectives of my research the followings:

1. Study the procedure of the traditional fighting against forest fires, summarize the problems and discover the opportunities for their improvement through the use of aerial support;
2. Systematize the internationally and nationally used equipment for aerial fire fighting, the instruments and materials for extinguishing;
3. Study the experiments of aerial reconnaissance, take conclusions and use them for creating a new special reconnaissance airplane, which is applicable for forest fires on a daily basis;.
4. Examine the effectiveness of aerial reconnaissance aimed at fire detection, and draw conclusions;
5. Examine the international experience regarding of aerial fire fighting, systematise results and draw conclusions;
6. Use the experience of aerial fire fighting, and create a functional system applicable in Hungary;
7. Formulate the general criteria for the effective application at forest fires from an economic point of view.

RESEARCH METHODS

To achieve the given research objectives I applied the following research methods:

1. I prepared a special study plan so that the obligatory and optional subjects, research seminars should support my research objectives as much as possible;
2. I studied the applicable chapters of the available international and national literature, periodicals, studies, manuscripts and the results of the latest research regarding aerial fire fighting;
3. I participated at international and national forums, meetings, study tours and conferences at which I gave presentations. In addition, I gained experience, exchanged ideas with other researchers, scientists and specialists;
4. I collected information on experience in other countries, as well as theoretical and practical results;
5. I made consultations with potential international and national end-users, assessed and summarised their ideas and needs;
6. I made consultations with experts and scientists who were specifically interested in this area;
7. I made a specifically focused research in libraries and in databases accessible through the internet;
8. I systematized my knowledge and experience gained during my carrier, as well as a helicopter pilot and fire fighter;
9. I carried out practical experiments, and depending on the opportunities I adopted and used the results in practice.

BRIEF SUMMARY OF THE RESEARCH BY CHAPTERS

In the first chapter I examined the problems of the fighting against forest fires, as well as their development and the characteristics of the traditional intervention. During this research I adopted and used some concepts that are new for practice in Hungary.

I summarised the results and pointed out the possibility for the solution using helicopters and airplanes.

In the second chapter I examined the requirements for aerial fire fighting support. I reviewed the tasks which can be carried out by aeroplanes and helicopters, the equipment and conditions for dropping water, specifically focusing on formulating the criteria for the economic effectiveness.

In the third chapter I analysed the possibility of aerial reconnaissance by setting up hypotheses and based on it I proved its effectiveness. I created the requirements for the use of unmanned aerial vehicles for forest fire fighting, examined and defined the extreme conditions for their effective use from professional and economic points of view;

In the fourth chapter I dealt with the background and the theoretical principles of aerial fire fighting. I analysed and systematized the factors influencing extinguishing and defined the criteria for effectiveness.

In the fifth chapter I examined the execution of the aerial fire fighting and I took the usable manoeuvres into a uniform system, and based on these I determined the conditions for practical use.

SUMMARIZED CONCLUSIONS

In the **first chapter** I examined the problem of the fighting against forest fires. First from the general form of damage – time function I created and interpreted the new version regarding forest fires. Based on it I proved that the sooner the intervention starts the more effective it is - meaning that the damage is lower and the protected area is larger. I proved that a delay in starting the intervention causes longer fighting time, generates more need for help, unnecessary rise in material loss and rise in the potential risk to civilians. Based on my own experience and on the analysis of the process of fighting against forest fires I determined that, at the present fire services detect forest fires only by passive means, causing unacceptable delay in the start of the intervention.

I determined that the present method for the forest fire reconnaissance consists of walking around the affected area, which causes unacceptable delay in the effective decision making.

I created and introduced the concept of fire line extinguishing speed. I proved that for an effective intervention the fire line extinguishing speed has to be larger than the rate of growth of the fire line, otherwise the fire cannot be stopped by traditional methods. Adopting and examining the concept of fire line intensity which is used at international level, I determined that its increase will reduce the fire line extinguishing speed, and above a certain threshold will make the traditional mission objectively impossible.

Based on my research my conclusion was that the problems can be separated into two well defined groups. One of topics can be characterised by the lack of information and the other one with the limited resources. I manifested the total lack of information and between the ignition and the civil report. I manifested the total or partial lack of, but improvable information, before starting and during intervention necessary for the effective decision making. The limitations of the currently and commonly used resources prompt the introduction of new methods and the increase of the effectiveness of some novel, but only rarely used ones, which opens the question using aerial equipment for fighting against forest fires.

In the **second chapter** I examined the conditions for the aerial support of fire fighting, first giving an overview of the tasks which can be carried out by helicopters and aeroplanes. In addition to the air-based extinguishing I included the topics of aerial reconnaissance, logistical support and aerial coordination also. Logically I extended the notion of aerial reconnaissance to the period before the start of fires, so it includes aerial reconnaissance, which is aimed at the detection of fires; monitoring of fires before starting the intervention; monitoring of fires during intervention and finally monitoring of the affected area for hot spots after stopping the fire front. I applied air traffic for the aerial coordination of aircraft and the aerial control of ground equipment. For assisting the latter one I suggested that a special marking for fire engines should be introduced for their aerial identification. I included in the tasks of aerial support the development of the criteria for the use of specifically trained personnel that would be ready for intervention in special, high risk situations.

I systematized and reviewed airplanes and helicopters that are applicable for aerial fire fighting; the equipment for the dispersion of the extinguishing material, focusing on equipment used in Hungary. I made a suggestion for examining the possibility of using inside tanks on Mi-8T and Mi-17 helicopters. I examined extinguishing material, used for aerial fire fighting and introduced their extinguishing effects. Searching the possibility for raising the

extinguishing effects I pointed out the utility of pressurized air foam systems and explosive extinguisher kits suggesting their additional examination and introduction. For flight safety of I discovered the connection between the flight meteorology and micrometeorology pointing out how they influence aerial fire fighting.

In order to demonstrate of the effectiveness for our national economy I aimed at formulating some general principles to define criteria for economic effectiveness. I determined the economic criteria for fires that can and cannot be extinguished by traditional equipment; in addition, in the frame of a complex comparative analysis the economic criteria for effective joint applications of the traditional and new procedures. I showed that the criteria for economic effectiveness are fulfilled through aerial fire fighting only if the total cost of using airplanes is less than the summarised value of the saved forest and the savings of using traditional equipment due to shorter intervention time.

In the **third chapter** in the context of aerial reconnaissance I examined the aerial reconnaissance for the period before the start of the fire, which is an active monitoring aimed at the detection of fires; the monitoring of fires before starting the intervention; the monitoring of fires during intervention and finally the monitoring of the burned area for hot spots after stopping the fire front to prevent the start of the fire again. .

I examined the effectiveness of the reconnaissance during intervention by setting hypotheses regarding professional considerations, the national economy and limited resources. With the example of regular use I showed the professional effectiveness and I determined the conditions for the realization regarding national economy. Because of the limited resources I searched for the possibility of reducing the costs of aerial reconnaissance and based on it I showed the effectiveness of using unmanned aerial vehicles for forest fires. I worked out some suggestions for the requirements for effectively useable unmanned aerial vehicles and among all fire services in the World taking I put them into service at the Szendro Fire Department and I evidenced the possibility of practical realization. Using unmanned aerial vehicles by fire fighters I proved the possibility of the reconnaissance before starting the intervention

I examined the effectiveness of the reconnaissance for fire detection also by setting hypotheses regarding professional considerations, the national economy and the limited resources. I determined the conditions for professional effectiveness which I made contingent on the time relation between the aerial reconnaissance and the civil report regarding forest fires. I determined the criteria of effectiveness for the national economy and specified that it

can only be guaranteed by introducing objective measure never used in Hungary before - a special fire weather index – suggesting its introduction. Because of the limited sources I searched for the possibility of increasing the effectiveness of aerial reconnaissance by modifying the flight parameters of the aeroplanes and based on the conclusion, over flat areas and with idealistic circumstances, I justified – as a derivate result – the need for a tower based fire detection system. Giving up the idealistic assumption of a flat area, depending on the fragmentation of the relief and in extreme dry weather conditions I stated that the aerial patrol for fire detection can be effective again, suggesting that the criteria should be worked out.

For area monitoring after finishing the fire extinguishing I suggested the use of unmanned aerial vehicles as necessary which I also hold especially appropriate for unmanned aerial vehicle pilot training.

In the **forth chapter** I dealt with the background and theory of aerial fire fighting. I examined the process of dropping extinguishing material, divided the deformation of it into sections and I determined their basic characteristics. I characterized the sections such as the moderate deformation, the disintegration and the fine raining and giving the distance from the outlet hole. For examining the dispersion form I created triangle and parabola shaped models. I showed by practical experience that using the triangle shaped model is reasonable. I examined the characteristics of dispersion at the surface, which can be modified for use for elliptical, ellipsoidal or rectangle shape.

I made some analysis regarding flight parameters. I determined the components of the altitude which, in case of a helicopter flown with and external hanged container, depends on the height of vegetation and the distance between the above two. Depending on the altitude and the flight speed I compared the extent of wet surface to the distribution of extinguishing material and, based on this, I made some conclusions. Giving the different rates of flight speed and outlet time I created a table regarding the size of the wet surface.

I examined the loss of extinguishing material for the various methods. I took into the losses during transport, dispersion during outlet and the ineffective value of wet surface. I defined the factors and rates of the modification of dispersion by wind. I defined the minimum level of effective extinguishing material for various vegetation types based on a special table and formulas.

In the **fifth chapter** I defined and examined the three basic manoeuvres during fire fighting: outlet during straight a head flight, flight to fire and outlet during turning out and outlet staying above the fire. Depending on fire line intensity I suggested the optimal tactic, fighting against fire directly or indirectly, setting up a protective line. I created and by proving its the usefulness I introduced the outlet effectiveness index and I suggested the reduction of loss by overlapping the wet surfaces.

In order to promote the practical use of aerial fire fighting I created a functional systematization based on the differences in geographical features of flat and mountainous areas. In case of plains I considered wind direction, but in case of mountains location of the objects that needed to protection.

NEW SCIENTIFIC RESULTS

1. I improved the methodology for the examination forest fire fighting, adopted the use of fire line intensity to domestic conditions and I created the concept of fire line extinguishing speed.
2. I created a new methodology for examining the economic effectiveness of aerial fire fighting and in this framework I determined the economic conditions at which of fires cannot be extinguished by traditional means, and at which they can be extinguished by the joint use of traditional and new methods.
3. I created a new methodology for examining the effectiveness of aerial reconnaissance regarding forest fires and in this framework I determined the conditions effectiveness from professional point of view and from the perspective of national economy and limited resources.
4. I showed the efficiency of the use of unmanned aerial vehicles for forest fire reconnaissance and I determined the requirements for their use. I showed the feasibility by putting them into service.
5. In order to detect fires as quickly as possible I justified – as a derivative result – the need for a tower based fire detection system.
6. I adopted the international results of fire fighting research to national conditions, I improved them and I systematized their elements taking into account the increase of the effectiveness of intervention. I worked out the effective process regarding fighting against forest fires.

RECOMMENDATIONS

1. I suggest the development and introduction of special marking for fire engines which is identifiable from air.
2. I suggest the development of the conditions for using a special team for aerial rescue regarding forest fires, which team in case of high risk would continuously be ready for intervention.
3. Based on the positive results of using an internal tank I suggest the study of how this methodology could be adapted to type Mi-8T and Mi-17 helicopters.
4. I suggest examination and development of the potential for using high pressurized foam systems and explosive extinguishers by aeroplanes.
5. I suggest the adaptation and introduction of fire risk or fire weather indices generally used internationally.
6. I suggest put into service unmanned aerial vehicles for forest fire reconnaissance at such fire services which have particularly valuable areas or extremely difficult geological features (national parks, nature reserves, mountainous areas).
7. I suggest the improved specification of criteria for the effectiveness of tower and aerial patrol based fire detection systems depending on weather and geographical features.
8. I suggest the improvement and development of the potential for using unmanned aerial vehicles for other special tasks (such as floods, radioactive pollution, air pollution, following tracks).
9. I suggest the development of a special aerial fire fighting and intervention plan for the entire country, with special consideration to the criteria of economic effectiveness, equipment and engines, and water sources.
10. I suggest that some chapters of my dissertation should be used for training, education and courses at fire services and aerial services as necessary