ZRÍNYI MIKLÓS NATIONAL DEFENCE UNIVERSITY
Doctoral Committee

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MAINTENANCE OF THE AIRCRAFT AND PROBLEMS CONCERNING THE MODERNISATION OF SERVICE

Author's synopsis and official report on the Ph.D. thesis

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FORMULATION OF THE SCIENTIFIC PROBLEM

The air forces of most NATO countries face constant and major tasks in modernizing weapon systems in order to maintain superior airpower. It's not only small countries that have difficulties in the purchase of fighter aircraft and weapons and the additional overhead expenses; today for even developed nations reasonable prices have become more and more important.

Taking the experiences of the last three decades into consideration – especially the air operations carried out in the Gulf War and in the Balkans – the downward tendency in the number of air battles, and especially the short-range manoeuvre character can be definitely demonstrated. These air combat operations mainly meant that one party using up-to-date aircraft and weapons, supported by high-standard multi-sided security measures destroyed the aircraft of their enemy who used less up-to-date technology or less effective air combat support, or did not have sufficient information about the danger situations. In the two conflicts mentioned above – especially in the Balkans – the opposing air forces could not be considered as of equal strength. In my opinion, there were noteworthy differences in the training of fighter aircraft staff, the amount of aircraft used and in their tactical efficiency.

"If we take the political and military situation of the biggest nations into account, it is highly unlikely that the number of air battles and manoeuvrability of the air forces of the USA, NATO, or any coalition created to carry out a single task will grow in the future (which would involve a nearly well-balanced status between the strengths of the opposing forces)."

Yet what makes aircraft designers pay special attention to the increase of operation and modernizing air combat support when designing new airplanes or up-dating existing ones?

One of the most important tasks is to achieve an optimal expense-efficient maintenance of the combat effectiveness and working order of complicated military systems and equipment. The constant working order of complicated combat instruments requires significant expenses (mending, providing spare parts etc), which has to originate from the national budget. So research has to be directed in order to provide the minimum costs of maintenance. It is greatly promoted by the improvement of operating theories, the implementation of reliability, decision-making and system theories, the unified data-collection and analysis systems, the quick advance of information technology, and the expansion of diagnostic and condition-identification methods, the improvement of which has gained momentum these days. Operating is a complex process of using technology, the service support on different levels and mending. While operating, the operators use, store, support (maintain), and mend technology. Next to the reliable, successful tactical usability, economical operation, long durability and the ability to be modernized is just as important.

At present there are MIG-29B and UB type planes in the Hungarian Air Force (obtained in 1993), and the Gripen type fighter planes have also arrived, the training the personnel of which is in progress.

These two types of planes will determine the methods of operations in the next 5-10 years. So, in order to fulfil the objectives outlined above, I am attempting to analyse the structures, the characteristic features of operating these planes in order to make general suggestions to achieve the modernization of operating and service both in the air and on the ground.
I started my research prior to the time of the purchase of the fighter planes, so my results could be used in a future purchase process.
As reader at Miklós Zrínyi National Defence University János Bolyai Military Technical Faculty the Department of Aircraft Onboard Systems, I have been dealing with the questions of operation and maintenance of aircraft and modernizing air support since 1996 teaching various military engineering subjects. During the preparation for my thesis, I spent a long time studying the experiences gained during the operation of fighter planes, analysed the causes of breakdowns, and the impact of operating systems on levels of preservable operability. These days the technological development has brought significant changes in the relations of man and machines. The previous traditional one-way simplified relations have been replaced by an audiovisual, sight-orientated and, at the same time, real interactivity.

RESEARCH OBJECTIVES

In this paper, I have set the following objectives of research:

1. In my thesis, I aim to analyse the structure and functioning of systems of exploitation of military aircraft both in the air and on the ground in order to achieve the maximum standard of the prescribed alert status and economic and operating reliability parameters.
2. During my research, taking the national air fleet into consideration, I am mainly focusing on fighter airplanes, but my conclusions about systems and requirements could be applied to helicopters, carrier aircraft and could be used at the professional training of aviation engineering and mending staff.
3. I am intending to develop an evaluation and grading system that will facilitate to form an exploitation and activity system that is conform with the national security policy with respect to the reliability characteristic parameters and the maximum possible running order level.

RESEARCH METHODS

In order to achieve my objectives and write my thesis, I have used the following methods:

- I have studied the literature relevant to the topic of my thesis, I have carried out expedient research in libraries, at air force units and on the internet;
- I have organised the obtained knowledge;
- I have taken part in nationwide and international conferences, held lectures there, published articles and gained experience;
- I have consulted experts in aviation who are experienced in the field;
- I requested and received feedback, remarks and help about my work from my colleagues, and I incorporated those in my dissertation;

- I have carried out reliability tests of aircraft and analyses their results;
- I have completed the reliability analyses and evaluated their results.

To study the field I have chosen elements of inductive and deductive methods. While collecting data and analysing, I used observations, conversations and interrogation in the inductive exploration phase of my research.

SUMMARY OF THE TESTS CONDUCTED

As far as the structure of this paper is concerned, it is divided into an Introduction, 5 chapters, and the summary of the results of the research completed with 4 annexes. The volume of the document is 126 pages.

In the Introduction, I describe my motivation and considerations that inspired me to write my thesis. Here I state the topicality of my studies, the methods of research, and outline my objectives.

In Chapter I, review the employability of the air force, and its basic capabilities. I demonstrate the general principles of choosing airplanes, and the most widespread way of changing and supplementing military aircraft – that is to say, purchase, and I make suggestions for the Hungarian situation.

In Chapter II, within the framework of the system of the upkeep of military aircraft, I describe the structure of engineering maintenance and mending, the methods of operation. I define a suitable operation strategy based on the main parameters defined by the reliability theory.

In Chapter III, I carry out the analysis of the reliability and operability of running aircraft.

In Chapter IV, I elaborate the implementation of the changeover to the modernization of operation system of aircraft “used by running time, and calendar time” and operation according to state.

I Chapter V, I analyse the breakdowns of MIG-29 type fighter airplanes placing the conclusions of Chapter IV into a practical context.

In the summary of the research part of my paper, in accordance with my objectives, I summarise the scientific work that I have carried out, and phrase my theses. I make suggestions about the practical adaptability of my paper.

SUMMARY OF CONCLUSIONS

Only those tactical fighter airplanes should be deployed in the air force that are able to carry out all three major air missions: air combat, air strike, and tactical air reconnaissance. Other than that, those that can meet the requirements of the boundary values of speed and altitude as much as possible, and have an onboard self-supervisory system to record and display the overcharging, flying and functional parameters, and those that are capable of running the most up-to-date weapons to exterminate air and ground-based targets. In case of airplanes, operability, reliability and applicability should be checked and secured. An expediential operation strategy should be set up for each chosen plane based upon the parameters defined

by the main parameters of reliability theory in order to continuously monitor, collect and analyse data about the working conditions of the aircraft. Next to the upkeep of the maximum possible running order, the minimum financial expenditure, the optimal planning of spare parts and the high standards of MTBF should be secured.
In case of aircraft to be deployed, and creating the conditions of operation, we should pay special attention to the number of aircraft and the creation of "O" and "I" level mending systems. The mending of breakdowns should be made possible with block replacement, with the use of the minimum amount of tools and checking devices on the ground, and with easy accessibility to the onboard instruments. The onboard self-supervisory system automatically localises and displays the block that has to be mended or replaced. The quick download of the data from the onboard acquisition and control system should be ensured after landing.
In an up-to-date airplane, the onboard acquisition and control system perpetually measures and records the overcharging of the structure, their magnitude and duration so that the endurance reserve could be defined any time during operation.
In order to maintain the enduring operational order of fighter airplanes, and to preserve the in-built endurance reserve in real combat operations, the air "acrobatics" carried out with great overcharge displayed at air shows should be minimised. They are very spectacular, but unnecessarily use the in-built endurance reserve.
Those airplanes that were originally not designed to operation by state can be reorganised to a new system. However, their technical conditions must be checked, and the incidental exposed breakdown must be mended first, the endurance reserve must be defined at the time of changeover, and based on these data the real running time must be established. The additional running time can follow from the running time calculated from the endurance reserve.
All through the paper, I analyse the process of operation and the factors that may have an impact on it. Basically, I analyse the technical, economic and maintenance questions of aviation. I do not descend to particulars about the problems imposed by the special and basic training levels of the operating staff, although they are also very significant from the point of view of professional operation, but it would have greatly increased the volume of my paper.
The main requirements of the operation system elaborated in the paper form an evaluation and qualification system that might enhance the strategic defence conception of the country.

NEW SCIENTIFIC RESULTS

I summed up the scientific results of my research presented in the dissertation in the following theses:

1. By the analysis of the tactical structural, actuating and operational data and characteristics of fighter airplanes, I elaborated, and in my conclusions I defined the technical and economic requirements that these planes should meet based upon the ground of reliability. The observation of these requirements ensures the maximal combat effectiveness and minimal financial expenses. [S.6, S.7, S.8, S.10, S.11, S.12, S.14, S.15, S.17, S.18, S.20].

- I elaborated the interconnection between running order and combat effectiveness, and the determination of the optimal amount of spare parts.
- I defined a method for calculating the demand of spare parts.

2. By analysing the overcharge that influences an airplane, I proved that, even in peacetime training, the maximum solidity reserve should preserved so that combat task could be executable. [S.2, S.5].
    - I proved that it is totally unnecessary to use up the endurance reserve of airplanes in air shows.
    - I proved that, in order to preserve the maximum endurance of fighter planes, the use of airplanes for purposes that their original ones should be avoided.
3. I outlined a system of requirements based on reliability theory in order to monitor and analyse the technical and economic parameters, and to create a new operation strategy [S.1, S.3, S.4, S.9, S.13, S.16, S.19].
    - I defined the main elements of the operation system, and the main human-policy criteria in the implementation of the running (complement and training).
    - I demonstrated the interrelation between the reliability parameters of aviation and the necessary expenses.

PRACTICAL APPLICABILITY OF THE RESEARCH FINDINGS, RECOMMENDATIONS

The whole of the paper, and some parts one by one could be applied by engineers operating aircraft and in the training and continuative education of the staff who take part in operation of aircraft at the air force units of the Hungarian Defence Forces.
Based upon the results, the exploration could be extended over airplanes whose operational system is not based on their state.
Based upon the elaborated reliability system, the optimal spare parts supply system could be shaped.
The evaluation and qualification requirements of the exploitation system outlined in this paper could be used – taking tactical and mechanic characteristics into account, and applying multi-aspect decision theory – in the choice of aircraft.

LIST OF PUBLICATIONS AND OTHER SCIENTIFIC PUBLIC ACTIVITIES RELATED TO THE DISSERTATION

S.1 **Békési, B.** Main quantitative indexes reliability. National Defence University Publications, Budapest, 2006/3 (in print).

S.2 **Békési, B.** Analysis of the vertical acceleration coefficient based on the data of the flight recording system Special Electronic Edition of DAB Technical Committee Technical Works, 2006. (in print)

S.3 **Békési, B.** Levels and organizational elements of the maintenance and factors affecting activity. Aviation Science Publications, Szolnok, 2006/1. (in print)

S.4 **Békési, B.** Principal questions of the establishment of maintaining organization. Special Electronic Edition of Aviation Science Publications, Szolnok, 21. April 2006 (on CD supplement).

S.5 **Békési, B.** Analysis of loads affecting on aircraft based on data of the flight recording system. Special Electronic Edition of Aviation Science Publications, Szolnok, 21. April 2006 (on CD supplement).

S.6 **Békési, B.** Criteria for the selection of the new tactical aircraft. Szolnok Science Publications IX. Day of Sciences, Szolnok, 10. November 2005. (on CD supplement).

S.7 **Békési, B. – Szilvássy, L. – Szegedi, P.** Some criteria for the selection of new aircraft. PhD students I. "Jász-Nagykun-Szolnok Megyei" Scientific conference, Szolnok, 08. November 2002. (on CD supplement).

S.8 **Békési, B. – Szilvássy, L. – Szegedi, P.** Criteria for modernization of tactical aircraft. Bolyai Revue special issue, Budapest, 04. November 2002.

S.9 **Peták, Gy. – Békési, B.** Gripen for Hungary. Why the Gripen is the Best Solution. 1ST International Symposium on „Future Aviation Technologies", special issue No.2, Budapest-Szolnok, Hungary, 04. 12-14. 2002. pp. 203-208.

S.10 **Békési, B.** Possible requirements to fighters and their economical relationship. Bolyai Revue special issue, Budapest, 07. November 2001. pp. 139-149.

S.11 **Békési, B.** The determinative fields of economical problems of fighters. Szolnok Science Publications V. Day of Sciences, Szolnok, 06. November 2001. pp. 162-168.

S.12 **Békési, B.** Investigation of the personal, ergonomical and work-psychological connections of the maintenance activity. Aviation Science Publications, Szolnok, 2001/2. pp. 145-154.

S.13 **Békési, B.** Theory of reliability and its use in practice in connection with the likelihood of failures. Aviation Science Publications, Szolnok, 2001/1. pp. 133-144.

S.14 **Szilvássy, L. – Békési, B.** Operationability. „The Influence of the 20th Century Military Technical Revolution on Military Aviation in the 21st Century", Aviation Science Publications, Szolnok, 2001. Special Issue No.1, pp. 115-122.

S.15 **Békési, B.** Main areas of the application activity and thrift problems of fighters. Bolyai Revue,Budapest, 2001/2. pp. 5-18.

S.16 **Békési, B.** Criterias of the system-safety program. Aviation Science Publications, Szolnok, 2000/3. pp. 83-90.

S.17 **Békési, B. – Szegedi, P.** Technical service of aircraft. Bolyai Revue, Budapest, 2000/4. pp. 41-56.

S.18 **Békési, B. – Szegedi, P.** Dependence of the tactical-technical parameters of fighters on the thrift of their maintenance. Szolnok Science Publications IV. Day of Sciences, Szolnok, 03. November 2000. pp. 172-176.

S.19 **Békési, B.** System Safety Program Requirements. Aviation Science Publications, Szolnok, 2000/1, pp. 41-50.

S.20 **Békési, B.** Technical service of planes. Aviation Science Publications, Szolnok, 1999/3, pp. 93-105.

Scientific public activities

1. Member of the Air Force Section of the Hungarian Military Science Society, 1998-;
2. Member of organising committee of conference „Challenges in aviation at the threshold of the 3. millennium", 1999;
3. Co-Chairman of section of „Engineering Sciences III." at the conference „Challenges in aviation at the threshold of the 3. millennium", 1999;
4. Member of organising committee of conference „Renewing Hungarian Aviation Expert Training", 2000;
5. Co-Chairman of section of „Doctorand I." at the conference „Renewing Hungarian Aviation Expert Training", 2000;
6. Member of the companionship of the Hungarian Wings, 2000-2001;
7. Member of organising committee of conference „The Influence of the 20th Century Military Technical Revolution on Military Aviation in the 21st Century", 2001;
8. Co-Chairman of section of „Helicopters" at the conference „The Influence of the 20th Century Military Technical Revolution on Military Aviation in the 21st Century", 2001;
9. Chairman of section of „Pilot Training" at the conference „The Influence of the 20th Century Military Technical Revolution on Military Aviation in the 21st Century", 2001;
10. Substitute Secretary of the Aviation Specialized Groups of the Air Force Section of the Hungarian Military Science Society, 2001;
11. Delegate of the Hungarian Military Science Society Meeting, 2001;
12. Member of Doctrine Logistics and training work-group, 2001;
13. Member of organising committee of the „1st International Symposium on Future Aviation Technologies", held in Szolnok, 2002;
14. Co-Chairman of section of „Operation Support" at the „1st International Symposium on Future Aviation Technologies", held in Szolnok, 2002;
15. Co-Chairman of section of „Multidisciplinary Sciences II." at the „1st International Symposium on Future Aviation Technologies", held in Szolnok, 2002;
16. Member of organising committee of conference „100 Years of Flying Machines. The Aircraft of Military Systems, The Systems of Military Aircraft", 2003;
17. Co-Chairman of the section of „Multimedia supported Education" at conference „100 Years of Flying Machines. The Aircraft of Military Systems, The Systems of Military Aircraft", 2003;
18. Co-Chairman of the section of „Air force's operation support" at conference „100 Years of Flying Machines. The Aircraft of Military Systems, The Systems of Military Aircraft", 2003;
19. Member of the Faculty council of Miklós Zrínyi National Defence University János Bolyai Military Technical Faculty, 2003-2004;
20. Member of the organising committee of scientific conference „Half a Century on Rotary Wings in Hungarian Military Aviation", 2005;
21. Co-Chairman of the section of „Multidisciplinary Sciences" at scientific conference „Half a Century on Rotary Wings in Hungarian Military Aviation", 2005;

22. Member of the Aviation Technical Work Committee of the MTA DAB Technical Committee, 2005.
23. Member of the organization committee of the conference „New Century, New Technology – Gripen in the Hungarian Air Force", 2006.
24. Co-chairman of the „Simulators" section at the conference „New Century, New Technology – Gripen in the Hungarian Air Force", 2006.

PROFESSIONAL ACADEMIC BACKGROUND

My name is Bertold Békési, and I was born in Szolnok in 1969. I went to secondary school there, and took the school-leaving examinations at the 2nd Industrial Secondary Technical School. In 1987 I applied for admission to University of Aircraft Engineering Officer in Kiev. In 1991 I was commissioned 2nd lieutenant and after that I continued my studies in Szolnok Military College. Upon graduation in 1992 became a maintenance engineer.
In 1992 I passed type „C" fluent state exams in Russian with military specialisation.
In 1992 I applied to the certified special engineering course, organised for military officers at the Faculty of Electrical Engineering and Information Technology of Budapest Technical University. I have been an electrical engineer since 1995. I have a Master of Science degree.
On 1st January I became an instructor at Szolnok Aviation Officer Training College. I did four months of field service at the 59th Szentgyörgyi Dezső Tactical Fighter Wing in Kecskemét. At the end, I passed an exam in carrying out the engineering duties related to the MiG-29 aircraft.
On 1st September 1996 I became a college assistant lecturer, and later a university assistant lecturer at the On-Board Systems Department of the Faculty of Management and Organisation of Zrínyi Miklós National Defence University. At present I am an associate professor at the On-Board Systems Department at the Aviation Technical Institute of the Bolyai János Faculty of Military Engineering of Zrínyi Miklós National Defence University.
In 1996 I was selected for further education. I applied for admission to University of Technology in the Faculty of Science and Arts, in Budapest, where I attended a correspondence section and I became an electrical engineer teacher in 1998.

During my ten-year career as an instructor, I have taken part in the training of cadets studying electrical and mechanical engineering, in the re-training of pilots and operators, in professional and life-long learning courses.
In 1999 I successfully participated in the distance learning programme organised by the Institute of Informatics Systems of Gábor Dénes College. My diploma work consisted of developing students guide to the subject "Aircraft Control System" in compliance with the special requirements of distance learning. I defended my diploma work in front of a Qualifications Board.
In 2000 I became 2nd class flight engineer officer.
In 2000 I attended an ECDL basic computer operator course. At the end of the course I passed my exams and received the European Computer Driving Licence.

In 2001 I took a CADKEY design program operator course organised by the Weapons Technical Department of the Bolyai János College Faculty of Military Engineering of Zrínyi Miklós National Defence University.
In June 2001 I attended a three-week NATO orientated course and finished it with excellent result.
In January 2002 I passed type „C" basic level exams in English.
In 2002 I passed qualification exam at MH 87. "Bakony" Combat Helicopter Regiment and with excellent results became a first-class flight engineering officer.
Since July 2003, I have been carrying out the duties of deputy head of the Department of Aircraft Onboard Systems of the Aviation Technical Institute of the Bolyai János Faculty of Military Engineering of Zrínyi Miklós National Defence University.
Since September 2004, I have been carrying out the duties of head of the Department of Aircraft Onboard Systems of the Aviation Technical Institute of the Bolyai János Faculty of Military Engineering of Zrínyi Miklós National Defence University.
On 14th September 2004 I was sent by the MoD Department of Education and Science Management to a distance learning tutor training course organised by the Centre for Distance Learning and Adult Education of BME, which I completed successfully.
In 2004 I competed for the post of the associated professor at the Department of Onboard Systems of "Miklos Zrinyi" National Defence University of Hungary and was constituted at the 1st of February 2005.
In March 2005. I passed qualification exam for the "master" level at the MH 86. "Szolnok" Helicopter Regiment and with excellent results got the title of "Master" at the 1 of April.
In 2005 I competed for the post of the Head of Department at the Department of Onboard Systems of "Miklos Zrinyi" National Defence University of Hungary and was constituted at the 1st of September 2005.
Since October 2005 I have been a member of the Aviation Technical Workgroup of the „MTA DAB" Special Technical Committee.
Since 1st September 2006, I have been carrying out the duties of deputy head of the Aviation Technical Institute of the Bolyai János Faculty of Military Engineering of Zrínyi Miklós National Defence University.
I have type „C" fluent state exams in Russian with military specialisation, and a type „C" state exam in English.

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I hereby would like to thank all the people who have provided invaluable assistance, in the form of constructive criticism, advice and informed opinion, in achieving my scientific objectives.
Special thanks to Dr. György Peták, my scientific consultant, for his efforts and counselling through all these years.

Szolnok, 28st September 2006

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