THE ON-BOARD NAVIGATION EQUIPMENT AND POSSIBILITIES OF MODERNISATION OF THE AEROPLANES AND HELICOPTERS OF THE HUNGARIAN REPUBLIC.

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PhD Dissertation
Author's Introduction

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1. FORMULATION OF THE RESEARCH PROBLEM

The accession of the Hungarian Republic into Nato five years ago necessitates changes in the Hungarian Defence Forces (HDF).
The North Atlantic Treaty Organisation sets before the arms of the HDF high standards and modernisation requirements in the area of technical development.
An important aspect of the modernisation of the Hungarian Air Force is the withdrawal from service and replacement of on-board navigation equipment, devices and instruments, and, just as importantly, meeting the modern challenges presented by the changed set of requirements related to navigation capabilities.

Eastern and Central European Nato members used to purchase their military aeroplanes and aircraft from the former Soviet Union, and their design (including, but not limited to, navigation equipment) was aimed at serving the needs of mass armies, a principle which, by now, has completely lost its appeal.
For the above reason, the precision of spatial positioning, the accessibility of positioning data, and the integrity of navigaton instruments do not come up to the standards of modern air navigation.

The majority of navigation devices and instruments found on the aircraft of the HDF are obsolete, their replacement, especially on aircraft flying operational sorties, verges on historical necessity.
In addition, I believe that it is unacceptable that our aeroplanes and helicopters with military markings cannot fully meet the navigation capability standards required by the International Civilian Aviation Organisation (ICAO).
These shortcomings are a serious threat to flight safety.
In the process of analysis, I arrived at the conclusion that the modernisation process has already begun, perhaps the best examples being equipping a few helicopters and aeroplanes with the GPS, and developing UHF/VHF communication.
In the dissertation, I tried to prove that these are but the initial steps, taking which was essential, but far from sufficient.
All the more so, because none of our aircraft has full navigation- and communication-related inteoperability with Nato.

The dissertation was written with the intention of proposing fitting the aircraft with supplementary air navigation instruments and navigation early warning devices which provide aircrews with indispensable information needed for the most appropriate decisions and reactions.

2. RESEARCH OBJECTIVES

When selecting the subject, I had the following research objectives in mind:

Making a proposal for an on-board navigation system and equipment to be installed that will improve the navigation capabilities of the Hungarian Republic's military aeroplanes and helicopters in proportion with the funds available for development purposes.

- To name *devices and equipment to be installed* with the objective of significantly *increasing the precision of route navigation* of the given aircraft.

- *To make a proposal for* installing an approach navigation system which will *increase* the existing *landing minima* of our country's military aeroplanes and helicopters from the current values.

- *To formulate a recommendation* for a navigation device to be integrated, which will ensure for independent tool, *can be used even if ground-based navigation beacons fail*, but fully complies with the requirements of combat air navigation.

- *To name* the sub-area which is currently the most *underdeveloped as regards the combat navigation and communication* of helicopter and aeroplane types designed for *actual combat deployment*.

- *To highlight* the flight safety risks which, during flying live sorties, *endanger* primarily the *physical integrity and lives of the aircrews*, and the successful completion of the mission of the given aeroplane or helicopter.

The objective of my research was to indicate directions for progress in navigation and communication, which will make it both possible and worthwhile to keep 10-30-year-old aviation technique in operation and service.

3. A BRIEF ACCOUNT OF THE INVESTIGATIONS DONE

My dissertation, which consists of two main parts, was constructed as follows.

The first main part is divided into four separate units.

In the first one, I *define* navigation and *introduce* its internationally accepted *classification*.

I *went into detail* on the classification of the principles of air navigation, during which I relied heavily on my experience, related to both the theory and practice, which I gained during 24 years of service as a pilot.

I *compared* this experience with the terminology, aviation procedures and navigation methods of both Soviet (Russian) and Anglo-Saxon origin.

I paid great attention to studying the great amount of Hungarian, English and Russian specialised literature, both printed and electronic, which is available in the university library.

Using the data obtained during the analysing process, carrying out the research as well as practical air navigation tasks, I accomplished the following:

By comparing various terminologies, I *identified* the directions of aeroplanes and helicopters, touching upon possible areas of use during actual sorties.

I *pointed out* the terminological differences between visual and instrument meteorological conditions (VMC and IMC, respectively) on the one hand, and visual and instrument flight rules (VFR and IFR, respectively) on the other. In addition, I called attention to the necessity of using correct terminology closely related to flight safety.

In the last section of this unit, I briefly described the aviation instruments ensuring for the basic navigation of the aircraft of the HDF.

The second main part of my dissertation can be found in Chapter 3, in which I carried out the following tasks and analyses:

I *presented comprehensive oveview* of the system of flying tasks of the Hungarian Republic's military aeroplanes and helicopters.

I *did a detailed discussion* and *analysis* of the questions identified in the research objective of the dissertation, breaking it down *by the type, and, where required, the identification number of the aircraft*.

I *analysed* the operational-navigation capabilities of these helicopters and aeroplanes, and the experience of the HDF as user, and that of other countries operating them.

I *studied* the process of developing the basic navigation elements related to the given aircraft, and explored the methods of display and indication by instruments.

I *found* that the majority of the on-board navigation systems, devices, equipment and instruments of our country's aeroplanes and helicopters represent the technological state of the art of the 1960s and 1970s.

I *did a detailed analysis* of the date of a given aeroplane or helicopter first entering service, the day of its last overhaul, the amount of flying time left in the aircraft, and the influence of the above factors on the modernisation process of navigation.

I *identified* the areas of air navigation I considered most important in determining the direction for development related to the given aircraft, in the interest of making it possible to keep it operational and in service.

I *presented* the on-board navigation equipment of the Hungarian Republic's military aeroplanes and helicopters through a detailed survey of the present state of affairs.

I *identified* the strong points and weaknesses of the military aeroplanes and helicopters of the HDF, as related to on-board navigation systems, as well as the possibilities for improvement, and flight safety risks.

I *stated* that, as a result of the overhauls completed before December 2004, modernisation objectives (identified by aircrews as well) were not entirely met.

I *found* that further postponement of the modernisaion of navigation may, for seveal types of aircraft, result in a significant and unreasonable increase in flight safety risk.

I *called attention to* the fact that the improvement of aircraft landing minima to a reasonable level is of top priority in the navigation development projects.

I *outlined at least two directions for development* related to each aircraft. These aim at eliminating the flight safety risks of the given aeroplane or helicopter, and at making the air navigation positioning data more precise.

I *enumerated* those aircraft-specific on-board navigation devices, equipment and instruments which I suggest should be constructed, the indicated units of measurement of

which should be restructured, and which should be modernised, replaced, or substituted for by another instrument.

I *called attention to* the importance of the field of air navigation communication, as related to all aircraft I examined.

I *re-emphasized* the great importance of the above mentioned field not only for aircrews, but also for personnel specialised in carrying out air traffic control service tasks.

I *mentioned* the fact that it is not only the navigation system of the given aeroplane or helicopter that is worth improving. It is necessary to enhance the capabilities of on-board radio communication facilities by incorporating new capabilities currently not available in the HDF. In addition, it is necessary to install devices that can carry out identification friend or foe with absolute certainty.

While drawing conclusions keeping in mind the sets of tasks available, I *made indirect reference to the modernisation procedure, related to each type of aircraft*, which is indispensable for further use of the given aeroplane or helicopter in the interest of carrying out everyday training and operational sorties safely.

In the Conclusion I summarised the outcome of my research, I identified my new scientific findings, and make recommendations for the further use of my research work.

4. SUMMARY OF CONCLUSIONS

The elaboration of my conclusions was facilitated by my research. In the process I *studied* the progress of air navigation, the definition of various navigation devices and equipment, and basic navigation elements, and their influence on the precision of air navigation.

1./ As regards their application for military purposes in warfare in the present and future, aircraft and air navigation will preserve their high priority. This means that having any military application, including non-combat application, in mind, the first step in carrying out tasks will be to plan, organise, and fly sorties by areoplanes and/or helicopters.
Air navigation planning will continue to be among the initial components of planning, just as it has been in all areas throughout the history of civilian and military aviation.

2./ It is necessary to examine the life left in the given aircraft before any sort of air navigation modernisation commences.
I found that no modernisation on aircraft with less than 24 months in service remaining is cost effective, whereas with 36-60 months, a minimum modernisation concept may significantly improve the possibilities of flying actual everyday sorties with the given aeroplane or helicopter.
If the type has more than 6 years of life left in it, then, with a view to the system of its tasks, it may pay to embark on modernisation even with costs pusing to tens of thousands of dollars.

3./ Electronic interrogation-response devices, supplemented by visual identification procedures, are expected to continue serving as the basis of fully reliable aircraft identification for operational navigation purposes.

4./ In the future, the challenges of air aigation will be determined by the same factors as today.
These factors greatly depend on the quality of the specialised aircrew, the aircraft and its on-board navigation system.
The training standards of specialised aircrew could be maintained by providing for a 'sufficient' number of hours for individual flying, as required by the type of aircraft, and training on flight simulators.
With the exception of transport pilots, the number of flying hours is below that required, in spite of the measures taken and the reallocation of financial resources.
Currently, the HDF has only one flight simulator in working condition, which can only be used for the training of the specialised aircrews of Mi-8 helicopters, soon to be withdrawn from service.

5./ The terrain and line features recognised and identified by aircrews, and the values and signals provided by instruments will remain the primary sources of navigation data. Airborne and ground-based radio locator stations, navigation instruments, satellites and on-board receivers and sensors will play an increasing role.

6./ As regards the human as the most important element in air navigation, visual navigation procedures will remain fundamental, as permitted by the actual meteorological conditions.
The main applications of navigation based on VFR will also remain the same: offensive air support, dogfight, and airspace patrollong activity. Operational sorties will be flown in the lower regions of low nap of the earth flying, in order to enhance, among others, survival capabilities.

7./ The importance and application of navigation systems based on hyperbole-ellipsis radials will diminish. This conclusion is supported by information related to the withdrawal from service of ground-based transmitters of navigation devices (OMEGA, LORANA) based on the above principle.
In the applied procedures of radio navigation, the role of positioning using using orthodrome–azimuth/distance radials simultaneously will increase. However, none of the helicopters or prop trainers of the HDF is capable of applying these procedures using highly sophisticated navigation methods. Tactical fighters, and tactical fighter trainers are capable of displaying azimuth / distance data simultaneously, but only with great limitatons. This undesirable state of affairs has emerged, because the basic data source these aircraft use is based on a navigation sytem the ground-based transmitters of which are practically unusable.
It can be concluded that the weather minima of the military planes and helicopters of the Hungarian Republic have decreased significantly, sometimes to one third of previous values.

8./ For over a decade now, a new group of radio navigation instruments has been represented by satellite navigation systems.
However, the so called multi-channel GPS receivers, which can significantly increase flight safety of the given plane or helicopter, can be found only on a few of our military aircraft. If we use a device capable of receiving data simultaneously from only 3-5 satellites, there is a danger that, in a position unfavourable for reception, the instrument wil not provide any data.
I would also like to call attention to the fact that there is no point in installing a navigation system that can be considered modern if its location may interfere with continuous operation, if it gets overheated and becomes unserviceable in the middle of flying sorties.
There are no GPSs on prop trainers, although it would be possible to install them. At times, aircrews have to fly using their own devices not even mounted on the instrument panel, which is out of the question during flying actual sorties.

9./ On-board equipment, devices and instruments of radio navigation based on INS/GPS principles will probably gain even more importance than at present, because, thanks to rapidly spreading new technologies, their error of measurement, as related to positioning differences, will be decreasing to possibly as little as a few hundred metres.
This is important, because, when using modern equipment, the basic data of on-board navigation systems are generally provided by navigation based on orthodrome – small circle, since, when ground-based equipment with air navigation tasks are working unreliably, the gyroscope, which satisfies precision requirements, can take over from unserviceable ground-based transmitters in a given time interval.

5. NEW SCIENTIFIC FINDINGS

I consider the folowing the scientific findings of my research in the chosen field:

- It is necessary to equip all military planes and helicopters owned by and in service of the Hungarian Republic with on-board receivers of the VOR/DME system, with its full configuration.

- The ILS has to be integarated into the on-board navigation systems of all aircraft of the HDF, with the exception of the AN-26.

- In order to make the navigation systems of all military planes and helicopters owned by the Hungarian Republic complete, they have to be fitted with autonomous GPS/INS navigation systems.

- All our MIG-29, MI-17, and MI-24 aircraft designated for combat have to be fitted with the version of IFF systems providing MODE IV. capabilities.

- On L-39 and YAK-52 trainers operated by the HDF, it is necessary to eliminate the flight safety risk stemming from the restrictions on full engine control imposed on the instructor seated in the rear cockpit.

6. APPLICABILITY OF RESEARCH FINDINGS, RECOMMENDATIONS

The questions analysed and elaborated on in different chapters of the dissertation, and the conclusions drawn from them may, in my opinion, generate ample interest among experts and researchers concerned with issues of modernising air navigation.

I am of the opinion that the content of my dissertation can

- be used in the training of specialised aircrew;

- serve as the basis for the planning of training and operational sorties of the aircraft of the HDF Air Force;

- provide military leaders at the middle- and upper-level with assistance in making decisions related to the modernisation of aircraft;

- provide an incentive for further research.

I consider the dissertation worthy of being used as a source of information in the basic and course system training areas of the education conducted at the Zrínyi Miklós National Defence University.
It may also serve as an information basis for individuals interested in, or engaged in the research of, issues dealt with in various chapters, which might be aided by its publication, complete with illustrations.

7. LIST OF PUBLICATIONS

1. Satellite Navigation: The Way Forward
Presenation at scientific conference 14 th.April
Published „Repüléstudományi Közlemények" (X./4. p. 251-258.) ISSN 1417-0604

2. The GPS and Examples of Application in Aviation
ASC (Academic Student Circle) paper
1st Place in Air Force Section of Institutional ASC in 1998

3. Navigation with Satellites
Edited article
Published: „Haditechnika" (1999/2. p.61-62.) ISSN 0230-6891

4. Examples of the Application of the GPS
Edited article
Published: „Haditechnika" (1999/3. p.55-57.) ISSN 0230-6891

5. The GPS: Past, Present, Future?
Published: „ZMNE Hallgatói Közlemények" (1999/3. p. 147-152.) ISSN 1417-7307

6. Non-conventional Navigation Systems
Presentation in English, given in Balatonfüred: 14-16 th of June 2000.
2nd International Conference on Non-conventional Aircraft, Section V.

7. The VOR-DME System: An Opportunity for the Long Overdue Enhancement of the Navigation Capabilities of the Aircraft of the HDF
Presentation given:02nd of November 2000
Conference of Young Scientists, Bolyai János Faculty of Military Engineering, Budapest
Published: „Bolyai Szemle" (p.89-99.)

8. The Development of Navigation up to the 18th Century
Edited article
Published: „Repüléstudományi Közlemények" (XIII./32. p. 145-157) ISSN 1417-0604

9. Determining Aircraft Directions on the Surface of the Earth.
Edited article
Published:„Repüléstudományi Közlemények” (XIV/34. p. 147-161) ISSN 1417-0604

10. Application of the GPS in Practice
Script supplement
Expected date of publication late 2005

11. The Movement of Celestial Bodies, Navigation Interrelations of Celestial Systems of Coordinates
Edited article
Expected date of publication :„Repüléstudományi Közlemények” in 1st half of 2005

12. The Shapes and Dimensions of the Earth, the Bases of Distance Measuring
Published:„Haditechnika” (2004/4. p.34-36, 45.) ISSN 0230-6891

13. Terrestrial – Navigational Measurement of Time and Its Practical Applications
Edited article
Expected date of publication:„Repüléstudományi Közlemények” in 1st half of 2005

8. PROFESSIONAL - ACADEMIC CAREER

Upon graduation from college, I became an officer on 20th August 1988.

I served in my first assignment as a pilot with the 89th 'Szolnok' Air Transport Brigade of All Arms for six years. During this time, striving to acquire the theoretical knowledge of and practical experience in the profession of air force officers, I became a First Class Pilot, passing all the required classification exams with excellent results.

After this period of field service, I successfully applied for reassignment to college instructor at the Pilot - Observer Department of Szolnok Aviation Officer Training College. In that position, I was also responsible for departmental Academic Student Circle (ASC) activities, and I supervised the work of two of my students, who gained 2nd and 3rd place at national ASC level.

Besides doing my duties, I passed the intermediate level specialised military English language exam in 1996, and also became a qualified instructor pilot.

Following the successful entrance procedure, I started my studies at the Military Science Faculty of Zrínyi Miklós National Defence University in 1997. In 1998 I finished first in the Air Force Section at the institutional ASC conference.

In the same year, I passed the advanced level specialised military English language exam. I have an intermediate language certificate in Russian.

I finished my studies in military leadership at Zrínyi Miklós National Defence University with distinction in 1999.

On the basis of the result of my entrance exam, and the ZMNDF rector's order 199/1999 I was admitted to be a PhD student starting in the academic year 1999/2000, and investigated, among others, the possibilities of modernising the avionics of the aircraft of the HDF.

In the semesters I have finished so far, I passed all my exams with excellent grades.

During my military career, I have been decorated and received formal recognition at different levels more than ten times, among which stands out the one received from the Ministry of Defence Deputy State Secretary in 2002.

Szolnok, 23 rd Januar 2005

Major István Urbán