A Computer-Based System to Analyze and Assess Flight Safety of Military Aircraft

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ABSTRACT

The purpose of this paper is to present principles describing the operation of a complex system that assesses flying safety of military aircraft. The computer-based system TURAWA has been developed in the Air Force Institute of Technology and at present is being implemented in air force bases. The system allows for proper management of flying safety.

1.0 INTRODUCTION

Flight safety is a key issue of any aeronautical system. The safety aspect defines the system's capability to prevent undesired (hazardous) air events and effects of such events, if they have already occurred. In other words, one of the most essential requirements to be satisfied by any aeronautical system is to ensure the level of high flight-safety. The flight safety level is usually the result of many various factors, which may often prove decisive. These usually include the skill and health of the flying staff, the whole process of carrying out air missions, the organisation of air training, the reliability of operated aeronautical systems, weather conditions, etc [1].

What should be done to reasonably control flight safety is to follow carefully and in real time all the undesired air events and their results, any actions undertaken at individual air bases and the effectiveness thereof. Measurable effects in this field (including the economical ones) could be provided by a computer-based system, and only. Such a system is intended and expected to provide analyses and assessment of different hazards. Both should be based on actual information, possibly of immediate access. Lack of such a system prevents us practically from any complex analyses and assessment of the safety level, and precludes any forecasts in this field. The effects of different factors on the safety level as well as the effectiveness of implemented preventive treatment also remain beyond any analyses, assessments, and forecasts. In the system assessing flying safety of military aircraft, air bases (i.e. immediate users of aircraft) should be the primary source of any data on causes of undesired air events, errors made during flying missions, symptoms and effects of the events, and relationship between these errors and undesired air events. Lack of an effective and reliable information sub-system practically excludes any sensible actions [2].

The above-mentioned reasons gave grounds for a complex system to analyse and assess flight safety. The system intended for the aviation of the Armed Forces of the Republic of Poland is operative under the name TURAWA (Fig. 1). Efforts to develop this system were started in Air Force Institute of Technology in 2003. Since 2008 the system has been in test operation.

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Figure 1: Homepage of the TURAWA system

2.0 CONFIGURATION OF THE TURAWA SYSTEM

The TURAWA system is fully functional within a computer network. It has been designed using a three-layer architecture (Fig. 2), with the following layers to be distinguished:

- the customer's layer that includes the system users' computers, each of them equipped with the www browser,
- the applications layer, i.e. a server that contains the system's logic,
- the database layer accomplished by means of the database server that stores the recorded data.

The system user can make use of any computer equipped with the Internet browser and connected to WAN (the computer network of the Armed Forces of the Republic of Poland, Internet). The user can connect with the applications server that transmits their request to the database server. The database server prepares a reply to the question/request, and then - by return - sends it back via the applications server to the user of the system. Both the information collecting and processing take place in the Oracle 10g-grounded database. The applications and database servers interconnected with the Local Area Network (LAN) form the so-called system's node, which is located at Air Force Institute of Technology, Warsaw, Poland. The Institute is the administrator of the system.

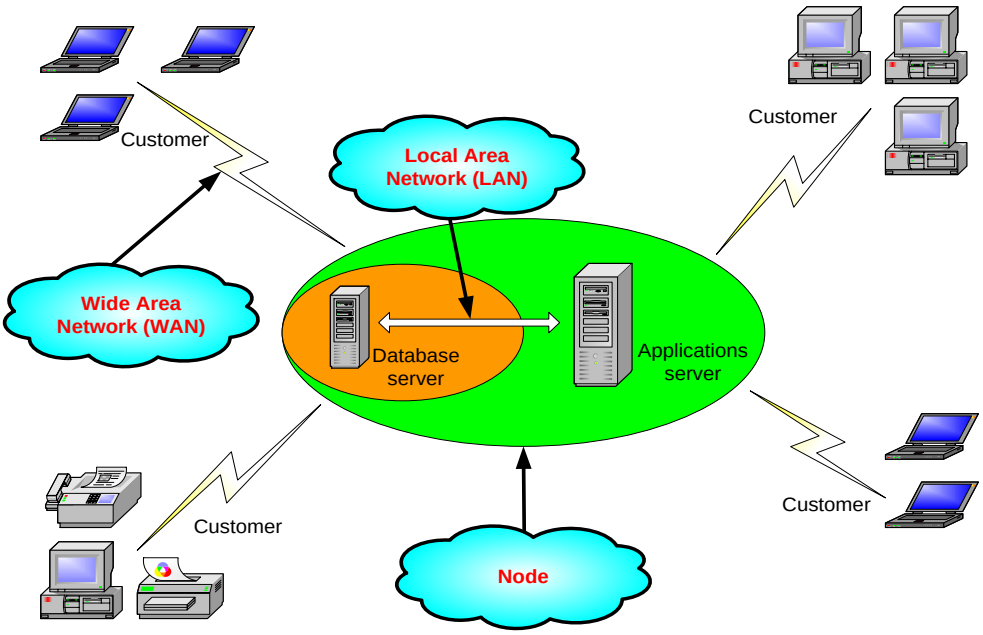


Figure 2: A diagram of the three-layer architecture of the TURAWA system

3.0 APPLICATION OF AND BASIC ASSUMPTIONS ON THE TURAWA SYSTEM

The TURAWA system designed to analyse and assess flight safety of military aircraft is used by:

- the flight safety service and commanding staff at all organisational levels of the Polish Armed Forces,
- flying staff of the Polish Air Force,
- aero-engineering staff of the Polish Air Force,
- research centres that deal with the problems of flight safety.

The TURAWA system has been intended to provide rational flight-safety control, the aim is achieved by means of:

- connecting individual users into one compact system operating within a computer network,
- collecting detailed information on how the air training process proceeds, and on flight safety – for each of the flying-staff members: starting with the day of putting their name in the files up to the day terminating the flying service (Fig. 3),
- providing capability to track back the 'training history' of each member of the flying staff, from the point of view of flight safety,
- generating information from the data bank individually for each user, according to earlier granted authority,

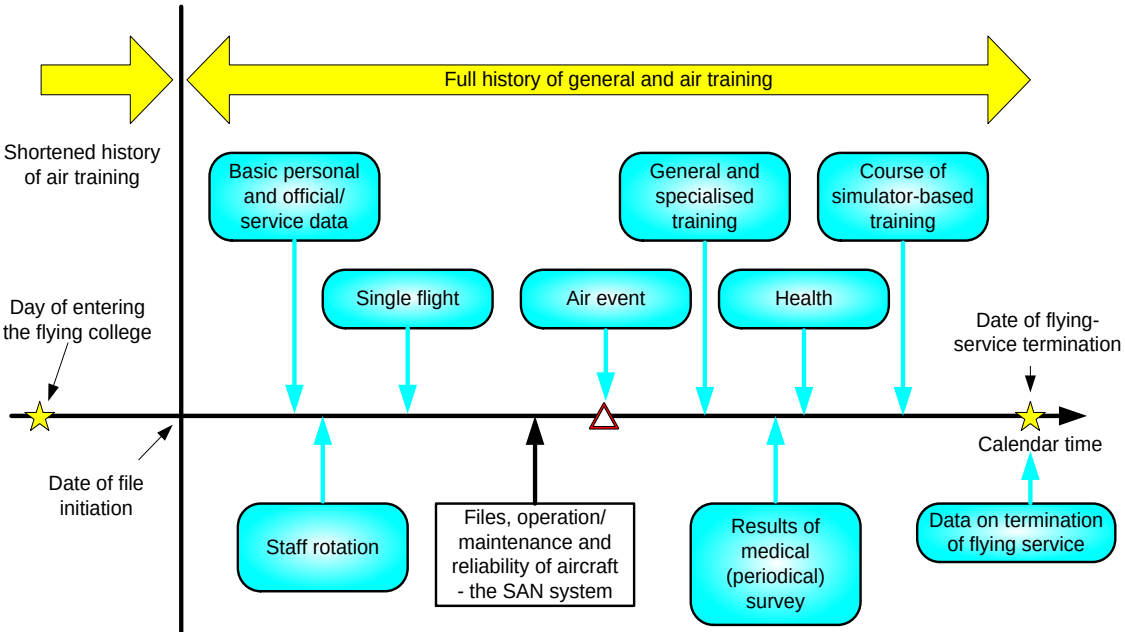


Figure 3: The process of collecting data on air training and flight safety

- continuous data acquisition (in the course of air training and other tasks performed in the air) – directly from air squadrons, wings, groups (Fig. 4),

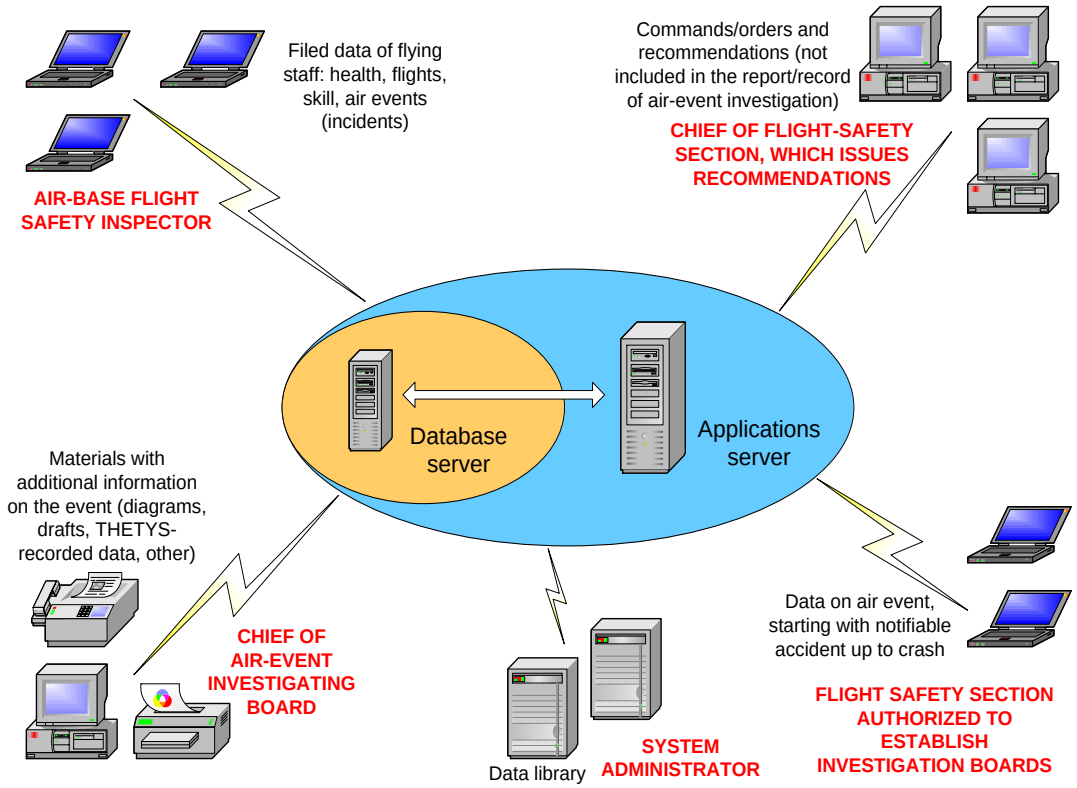


Figure 4: The diagram of how data is acquired for the TURAWA system

- providing capability to introduce - at each level higher than the air base - command documents, and then to trace how they are put into practice;
- providing capability to thoroughly analyse flight safety, in all its aspects, including the whole flying staff on all types of aircraft operated in the military aviation.

4.0 THE SCOPE OF INFORMATION COLLECTED IN THE TURAWA SYSTEM

Information collected/stored in the TURAWA system is the basis for any further analyses. There are five major sets of information included in the system (Fig. 5):

Figure 5: Major sets of information included in the TURAWA system

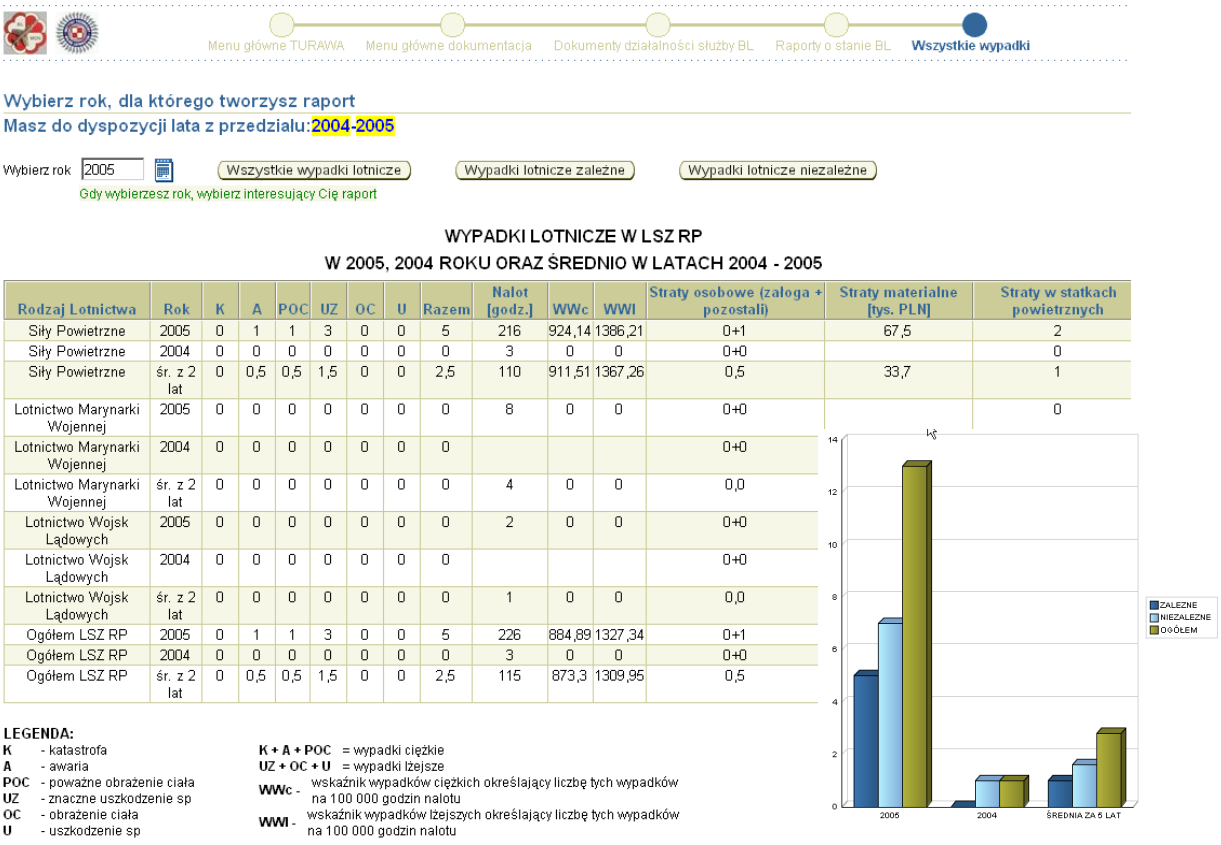
- **flying staff**: data are recorded on each aircrew member, including the most essential personal details, history of military service, civilian and military education, command of foreign languages, specialist training, skill gained, qualifications, unfitness for service, health, stays in hospitals and/or sanatoria, leaves, etc.;
- **air events**: all air events are recorded starting with an incident up to an air crash; the data include: the grade of event, location, circumstances and the course of event, description of weather conditions, data on the aircrew, data on the aircraft, expert opinions issued by the investigation board, causes of the event, shortcomings, etc.;
- **flights**: every flight of an aircraft is recorded, including take-off date and hour, total flight time, time of flying under particular weather conditions, type of flight, information on any exercise performed in the course of flight, checks, and each aircrew member: function and time spent on board, while blind flying;
- **aircraft**: the most essential data and operational or maintenance data of each aircraft taking part in the air event (data/records are gained from the SAMANTA BIS system);
- **preventive measures**: data on both preventive actions taken in effect of any air event and prevention-dedicated recommendations issued by the flight-safety service on the grounds of problem-oriented analyses of the set of air events; recorded are the following data: the reason for

introducing preventive treatment, the kind and number of a document that requires preventive treatment to be introduced, the name of the document issuer, date of issue, the kind and content of the preventive treatment, who receives recommendations, time and date of completion.

5.0 ANALYSIS AND EVALUATION OF FLIGHT SAFETY

A guiding principle and a primary objective to generate the TURAWA system was to allow for thorough analyses of air events, hence to develop effective preventive actions and measures. In particular, the TURAWA system facilitates what follows:

- analysis and quantitative assessment of flight-safety levels for different aircraft types, for any time interval, and at any organisational level of military aviation; also, a forecast on the flight-safety level against some specific, calendar-based time horizon, and determination of trends and nature of changes taking place, causes and expected effects (see, e.g. Fig.6) [3];
- verification of training, organisational, operational and/or maintenance-oriented undertakings aimed at keeping the required high flight-safety level [3];



Rodzaj Lotnictwa	Rok	K	A	POC	UZ	OC	U	Razem	Nalot [godz.]	WWc	WWI	Straty osobowe (załoga + pozostali)	Straty materialne [tys. PLN]	Straty w statkach powietrznych
Siły Powietrzne	2005	0	1	1	3	0	0	5	216	924,14	1386,21	0+1	67,5	2
Siły Powietrzne	2004	0	0	0	0	0	0	0	3	0	0	0+0		0
Siły Powietrzne	śr. z 2 lat	0	0,5	0,5	1,5	0	0	2,5	110	911,51	1367,26	0,5	33,7	1
Lotnictwo Marynarki Wojennej	2005	0	0	0	0	0	0	0	8	0	0	0+0		0
Lotnictwo Marynarki Wojennej	2004	0	0	0	0	0	0	0				0+0		
Lotnictwo Marynarki Wojennej	śr. z 2 lat	0	0	0	0	0	0	0	4	0	0	0,0		
Lotnictwo Wojsk Lądowych	2005	0	0	0	0	0	0	0	2	0	0	0+0		
Lotnictwo Wojsk Lądowych	2004	0	0	0	0	0	0	0				0+0		
Lotnictwo Wojsk Lądowych	śr. z 2 lat	0	0	0	0	0	0	0	1	0	0	0,0		
Ogółem LSZ RP	2005	0	1	1	3	0	0	5	226	884,89	1327,34	0+1		
Ogółem LSZ RP	2004	0	0	0	0	0	0	0	3	0	0	0+0		
Ogółem LSZ RP	śr. z 2 lat	0	0,5	0,5	1,5	0	0	2,5	115	873,3	1309,95	0,5		

LEGENDA:
K - katastrofa
A - awaria
POC - poważne obrażenie ciała
UZ - znaczne uszkodzenie sp
OC - obrażenie ciała
U - uszkodzenie sp

K + A + POC = wypadki ciężkie
UZ + OC + U = wypadki lżejsze
WWc - wskaźnik wypadków ciężkich określający liczbę tych wypadków na 100 000 godzin nalotu
WWI - wskaźnik wypadków lżejszych określający liczbę tych wypadków na 100 000 godzin nalotu

Figure 6: Quantitative assessment of the flight-safety level in the TURAWA system

- detailed identification and assessment of environmental hazards to flight safety (birds, icing, etc.);
- support decision-taking processes concerning flight-safety, and any investigation that finds causes which have produced specific effects; also, identification of relationship between causes and effects of undesirable air events [1];
- design, implementation and tracing of the applied preventive measures and actions; evaluation of effectiveness (Fig. 7);

Figure 7: Preventive measures/undertakings and how they are accomplished – as recorded in the TURAWA system

- establishing/generating data libraries on aviation rules & regulations, air law, the most fundamental specifications (technical and tactical data) of operated aircraft and airborne equipment, and other data suggested by the TURAWA users;
- detection of weak points in the air-training, flight-organisation and aircraft operating/maintenance systems decisive to flight-safety levels of different aircraft types;
- a comparison between flight-safety levels for military aircraft in the NATO member countries,
- current evaluation (e.g. of the skills gained, according to pre-set criteria, health, etc.) of any group of flying staff (a single pilot, aircrew, specific groups of pilots, the whole staff of the military aviation of the Republic of Poland) (Fig. 8);

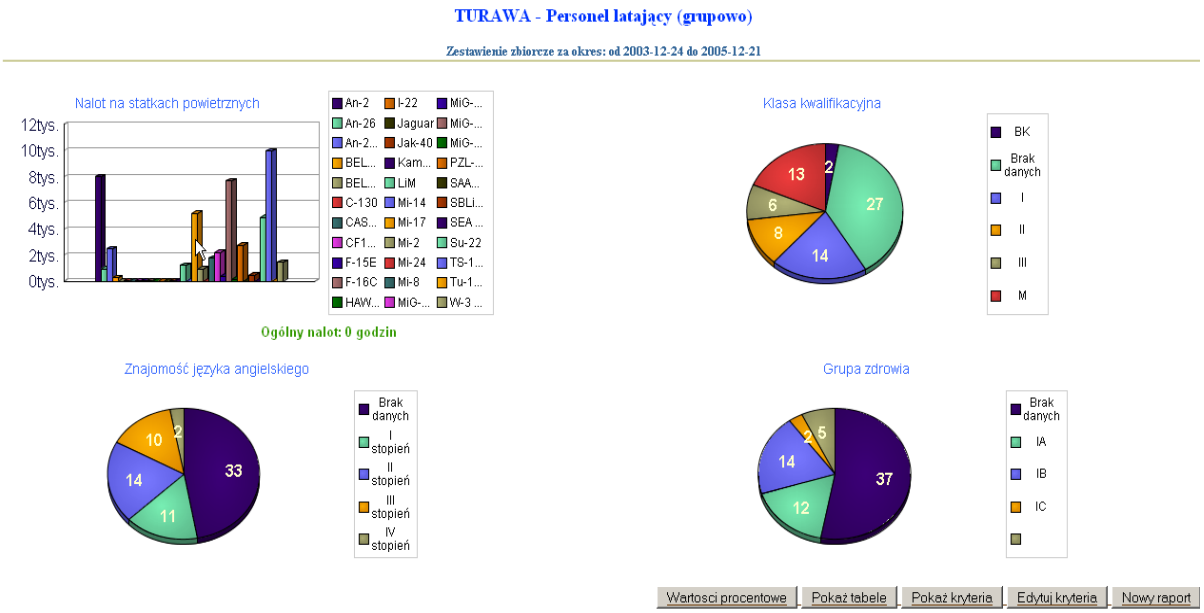


Figure 8: Assessment of skills gained by the flying staff

6.0 THE MOST IMPORTANT PROBLEMS AND INTERESTING SOLUTIONS APPLIED DURING DESIGNING AND IMPLEMENTING TURAWA SYSTEM

- The size and complexity of the system: the system is very complex, there are many connections between elements of the data base and between system applications which poses a huge challenge for the people who design and develop the system

- Technology used: the technology ADF/UIX implemented in Oracle tools (JDeveloper) has been used in the major part of the work. This technology looked promising in the year 2004 when the begging of design of the system took place. Soon it appeared that although it offered great speed and the ease of making applications it proved to be not flexible enough. Therefore, some more complex GIU elements had to be done with the use of other technologies.

- The use of the Internet as a basic network: During working on the main assumptions of the system it appeared that an existing military network is not able to connect all future users of the system. Innovative for the Polish Armed Forces method which uses commercial Internet networking for transmitting RESTRICTED data has been developed. VPN (Virtual Private Network) with the use of proper hardware has been used. It obtained approval of the appropriate services.

- An interesting solution has been introduced. One number is used to code full rights and access to appropriate functions by every system user.

- Information has been placed in the system's logic which allows for automatic addressing messages about accidents and other events concerning flying safety, depending on the user who sends the information.

7.0 CONCLUSION

A complex approach to flight safety presented by the TURAWA system allows for proper management thereof. This is possible owing to the capabilities to track air events as they occur, to determine reasons and effects of the events, to assess skills of the flying staff, and to assess effects of how the recommended preventive actions have been performed and accomplished. Application of the most recent solutions in the field of database design provides capabilities to keep the system open. Implementation of three-layer architecture (applications server, database server and customer) provides capability for further development of the system to include other components of the air-training process). It also enables co-operation with other systems (e.g. with a system to analyse and evaluate reliability of military aircraft - "SAN", with an integrated system of military-aircraft-dedicated logistics management).

Implementation of the TURAWA system is expected to improve effectiveness of preventive actions and, at the same time, to reduce the number of air accidents, which always cause - apart from significant, yet measurable damages and heavy losses in material goods - also the non-measurable effects, i.e. personal injuries and/or loss of life.

8.0 REFERENCES

[1] Żurek, J., Smalko, Z. & Zieja, M. (2009). *Methods applied to identify causes of air events*. European Safety and Reliability Association Annual Conference 2009, Prague, Czech Republic.

[2] Krutkow, A., Pigłas, M., Zaworski, T. & Zieja, M. (2009). *Informatyczne wspomaganie sterowania niezawodnością i bezpieczeństwem lotów wojskowych statków powietrznych.* XXXVII Zimowa Szkoła Niezawodności, Szczyrk, Poland.

[3] Żurek, J., Niezgoda, T. & Zieja, M. (2008) *"Aging processes as a primary aspect of predicting reliability and life of aeronautical hardware"*, Journal of KONBiN No 5(8)/2008, ITWL Warszawa, Poland

[4] Zurek, J., Jazwinski, J., Kaleta, R. (2005) *Some Selected Methods of Studying Reliability of Aeronautical Systems.* The Interenational Symposium on Stochastic Models in Reliability, Safety, Security and Logistics, Beer Sheva, Israel.