INFLUENCE OF FLIGHT SAFETY FACTORS ON AVIATION TRAINING IN THE POLISH AIR FORCE

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  Summary. The presented considerations show that the flight safety is directly proportional to interactions between elements forming the aviation safety model. These are: the human factor, the aircraft, environment and organization as well. Relationships occurring between the above factors should be considered in systemic way. This is necessary because disruption in relations between only two elements increase risk of occurrence aviation accident.

  Furthermore, people are responsible for the development of procedures, aviation regulations, construction of aircraft and appropriate preparation of aviation infrastructure. Flight safety during training is dependent to all organizational units. Proper organization and conduct of aviation training is not possible without inculcating discipline in behavior and rules of safe use of aircraft. The training process should be constantly modernized to enable pilots to obtain adequate qualifications for its tasks and therefore allows them to cope with the modern demands of the battlefield. Analyzing of occurred accidents and flight safety in training units from previous years is helpful to adapt the training process to current requirements.

1. INTRODUCTION

Military aviation is constantly modernized, so the training program for military pilots must be updated and adapted to current needs. It allows to educate pilots well so they will be able to fulfill the requirements of flight safety and the modern battlefield. It is important to train pilots as well as it is possible and simultaneously maintain rational management of the budget allocated for this purpose.

Constructing of a proper training program and effective perform of this process could not be possible without historical awareness. Knowledge about the past events allows to analyze accidents which have occurred. On that basis there is possible elaborate optimizing solution for actual and future needs [1]. Society expects a strong and efficient army which will be able to guarantee the safety and independence of the state. The Air Force is one of the components of the armed forces and it plays an important role in hostilities. Achieve dominance in the air enable to execution attacks and destruction of strategic objects for safety and sovereignty of the country. This is not possible without the proper training.

War education already played an important role in ancient times. Civilizations of ancient Greece and Rome were characterized by the rapid development of military actions. Commanders of these nations showed the ability to organize, conduct training and cooperation between militant groups as well [2]. There is another very interesting example of war strategy: *Sztuka wojenna* wrote by the Chinese sage Sun Tzu. This is the oldest book of military actionsin the world called a textbook of praxeology [3].

Learning from past events allows to gain conclusions which help to avoid errors from previous years. Moreover, it permits to modernize rules, procedures and improve aircrafts construction.

2. THEORETICAL ASPECTS OF FLIGHT SAFETY

Safety has paramount importance in every sphere of human life but especially in aviation. This term is constantly connected with needs and requirements of the defining entity. Safety is defined as t*he state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level* [4]. There are carried out operations which are intended to achieve and maintain required level of safety. Nowadays these activities often have a systemic character.

Anybody with a passion of aviation knows that safety is as important to the aviation activity as oxygen is needed to breathing. Therefore, ensuring flight safety is a priority of all organizations and other entities working to improve its level. This term should be treated as property of an aviation system which gives one possibility to conduct any aviation activity without aviation accidents and ability of an aviation system to defy aviation accidents and their negative results as well. Flight safety has interdisciplinary character like generally understood safety. This is due to variety of the areas which create flight safety. We can mention for example:
- aviation personnel,
- aircrafts,
- ground aviation infrastructure,
- control and security systems,
- rules, procedures and standards.

Furthermore, flight safety depends on interactions between elements belonging to the aviation safety model (Fig. 1).

Figure 1 Aviation safety factors

Among others these are:
- human factor understood as aviation personnel,
- the aircraft, it means technical condition, performance and operational restrictions, equipped with devices to warn about dangers, flight control system and efficiency of these equipment as well,
- environment that is the air space with all the physical characteristics like weather conditions, infrastructure and every technical device which is connected to performed operation,
- organization called as regulations, procedures and management of the aviation institution.

Considering issues related to the factors included in the aviation safety model, it is necessary to consider relations between man, machine, environment and organization. To do it properly it should be use the SHELL model (Software, Hardware, Environment, LiveWare, LiveWare). This model is widely use to illustrate interactions between man and the other components of the aviation safety system [5].

The previous version of the SHELL (Fig. 2) model was the SHEL model (Software, Hardware, Environment, LiveWare) which became created by E. Edwards in 1972. It was the basis for *[…] indicate the genesis interpretation of the pilot's errors which is one from factors of interactions between various […] system's components* [6]. Among the essential elements of this theory are:
- Software it means procedures and necessary computer programs and training programs as well,
- Hardware called as machines and equipment,
- Environment: all factors affecting human activity including activities of air traffic services, airports infrastructure, meteorological conditions and flight route,
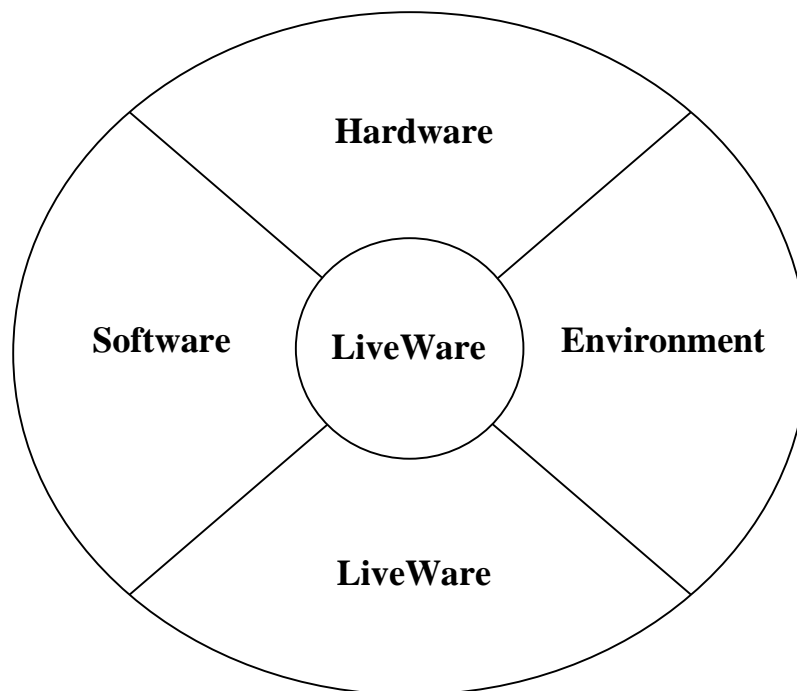- Liveware that is human in the work place.

Figure 2 The SHELL model

That theory was expanded by F. H. Hawkins in 1975. He added the second Liveware element which means human functioning in the organization. This enabled to examine influence of the human factor (not belong to the group of crew members) on the occurred accident. The name of the SHEL model was changed on the SHELL model from that time.

The central element of the theory is the human as the operator. There are examine every relation connected with it. We can mention:
1. LiveWare – Hardware. It means relationship between the operator and the aircraft:

    –   impact of available equipment on human work,
    –   obtain current information and their accuracy, clarity and readability as well,
    –   unambiguous signals which inform and warn about the state of the machine and the traffic situation,
    –   understand rules of operation, correctness checks of devices and systems [6].

2. LiveWare – Software. Safe and effective cooperation of these elements can be achieve if the immaterial elements of the system will be shown in a simple and unambiguous way. These relationships are relating to the uniqueness and easy way of use elements which creates LiveWare and Software. These kind of elements should be characterized by precision, readability and universality [6].

3. LiveWare – Environment. The environment is understood as factors which have influence on human activity. The most important elements of the environment include:
    –   activities of the air traffic services,
    –   meteorological conditions,
    –   airport's infrastructure,
    –   physical and psychological state of human.

4. LiveWare – LiveWare. It means relations between human as the operator and organization. Describe such areas as:
    –   the relationship between superiors and subordinates,
    –   organization of work,
    –   the relationship between collaborators.

Lack of cooperation or inadequate cooperation often has been cause of accidents. According to current experiences it can be said that properly selected training program is conducive to reduce number of mistakes in relations between both of LiveWare factors [6].

The SHELL model is intended to check relations connecting human with rest of elements. The essence of this theory is as follow: discrepancy between man and other elements always leads to human error.

3. ESSENCE OF AVIATION TRAINING OF THE POLISH AIR FORCES

The essence of training in the Polish Armed Forces is to build and development of theoretical knowledge and practical skills of military personnel. It is necessary to maintain a permanent army ability to counter military threats. The training process is carried out in peacetime and it is constantly modifying. This is due to necessity to adapt training for current and future needs. The training process consists of several interrelated elements (Fig. 3).

Persons authorized to perform aviation activities in the Polish Air Force are members of aviation personnel[1]. These people should have appropriate permissions and approvals to perform their duties which are purchased after completing aviation training. Permissions are granted at request of an examiner by the commander of the unit in which training was realized [7]. Approvals are granted by the examiner on the basis of a positive assessment after completing the task related to next one [7].

In general aviation training is nothing more than perform specific actions by trainee under the supervision of trainers on the ground or in the air. These actions are conditioned by the training program. This is a document containing a range of theoretical or practical training process. In the case of theoretical training it includes a list of carried subjects and thematic groups. Concerning practical training that document determines range of training on the ground and in the air [8].

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[1] According to art. 94 of the Polish Aviation Law of 3 July 2002 a member of aviation personnel is every person *[...] who have a valid license or a certificate of competency and is entered into the national register of aviation personnel or other appropriate register kept in accordance with separate regulations.*
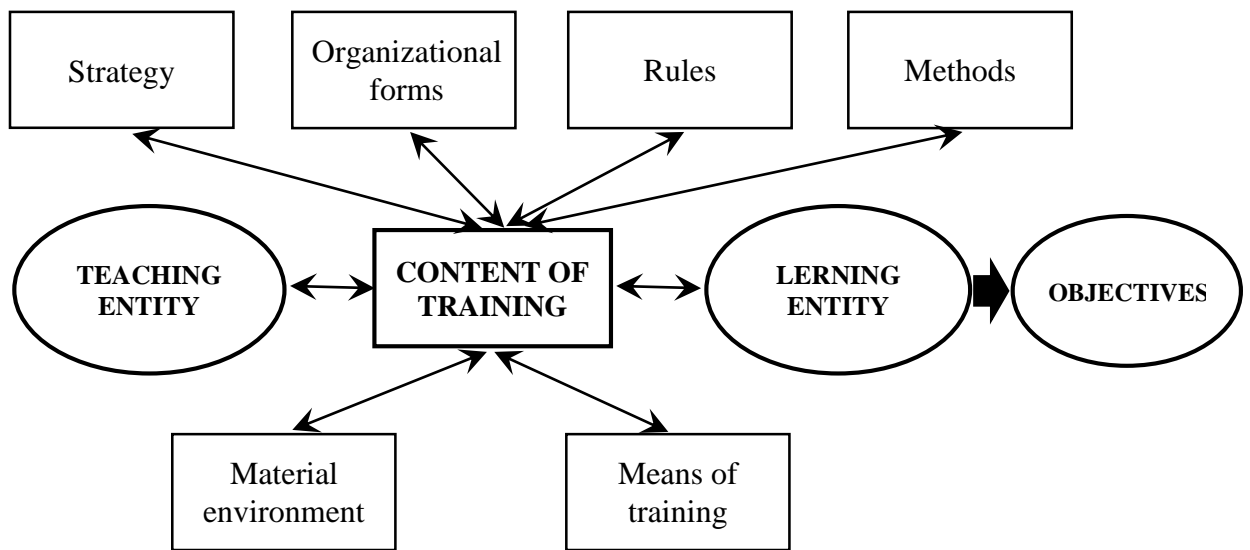
Figure 3 Elements of training process in the army

Full understanding of aviation training essence requires to clarify meaning of terms: trainee and trainer. Trainee is a person who is obliged to perform the task which aim is to provide theoretical knowledge preparing for the duties through the purchase appropriate practical skills. Trainer is a member of the aviation personnel who has instructor permission. This person is responsible for the preparation of trainee to carry out assigned tasks. He submits an application for granting permission for trained person after ended the training.

As it was mentioned, the purpose of aviation training is to obtain the necessary permissions and approvals. Aviation training consists of two phases: training on the ground connected with training on simulator and training in the air as well. These two stages are characterized in the next part of this article.

4. THE TRAINING OF MILITARY PILOTS IN THE POLISH AIR FORCE

Pilot's training is long-lasting and multi-step process (Fig. 4). Realization of the first three stages is associated with education in the Polish Air Force Academy. The fourth stage is carried out in military units. The aviation school is a special place for cadets because the knowledge, skills and habits gain in the university will be used in combat units.
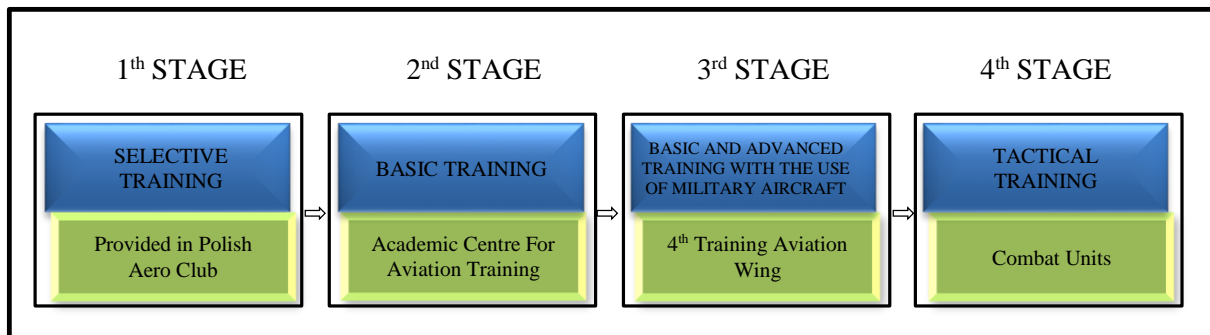

Figure 4 The actual training of military pilots in Poland being in force from 01.10.2012

The first part of training is intended to determine predisposition of candidates to the pilot profession. We can mention for example: divisibility of attention, manual and psychophysical skills and ability

to proper exploitation of the aircraft. This phase is also intended to present the flying possibilities of machines [9].

The second phase of training is realized in the Academic Centre of Aviation Training. This part allows cadets to gain a private pilot license (PPL). This document is necessary for further education. During basic training students are assigned to one specialization:

- jet aircrafts,
- transport aircrafts,
- helicopters [9].

Next part of training is realized in the 4th Training Aviation Wing on military aircrafts. It is divided on basic and advanced training. The aim of basic part is to check mastery of basic pilotage elements. During advanced training are realizing following tasks on military aircrafts:

- combat airborne targets,
- combat ground targets,
- visual – photographic reconnaissance,
- exercise group flights,
- exercise navigational skills during en-route flights [9].

These activities are intended to prepare candidates to next stage of training.

The last part called tactical training realized according to type of aircrafts and nature of combat units.

As it was mentioned before, the Academic Centre of Aviation Training plays an important role in the training of military pilots. This center exists from 2009. Despite this it has already been equipped with the largest database of aviation training in Poland which include simulators and many aircrafts. The training is carried out in accordance with the rules of civil aviation. It is divided into two parts: theoretical training (on the ground) and practical training (in the air).

The theoretical stage prepares candidates for military pilots to pass the theoretical part of exam on private pilot licence (PPL). This training includes nine subjects:

- air law and ATC procedures,
- human performance,
- communications,
- meteorology,
- principles of flight,
- operational procedures,
- flight performance and planning,
- aircraft general knowledge,
- navigation [9].

The practical part of the training in the Academic Centre of Aviation Training is carried out in accordance with the training program which is approved by the Civil Aviation Authority. It is realized on following types of aircrafts:

- Diamond DA-20 C1,
- Zlin 143 LSi,
- Zlin 242 L aeroplanes [9].

The completion of this stage makes it possible to obtain the private pilot license. The practical part is divided into tasks. Candidates for pilots must perform many exercises to fulfill every of task. It allows to learn necessary skills, procedures and flight's elements used during pilotage.

There is achieved a high level of aviation training in the Academic Centre of Aviation Training due to supervision of the Civil Aviation Authority. It is also very important that obtain a civil aviation license permit military pilots to move to the civil aviation and adapt to its requirements after completion of their career.

It should be added that smooth functioning of the process of flight training in the Polish Air Forces would not be possible without the proper relationship between factors which create the aviation safety model: the man, the machine, the organization and the environment. Mentioned factors are characterized

in the further part of this article. These elements have an impact on the level of aviation tasks performance.

5. FACTORS RELATED TO FLIGHT SAFETY WHICH HAVE INFLUENCE ON AVIATION TRAINING

Correct performance of tasks in air forces is possible in one condition. The human has to know tasks environment and equipment which is used. There is necessary speed and accuracy of decisions making in this type of activity. It is not possible without previous preparation in the form of training. The effectiveness of carrying out this kind of process depends on: the human activity, technical condition of aircrafts, organization and environment.

The human factor is nothing more than a group of safety elements associated with the aviation personnel, it means the ground personnel and the flying ones.

The man plays a leading role in the development and shaping process of flight safety. People are responsible for design and construction of aircrafts, development of optimal regulations, procedures, preparation of the aircraft to flight, the state of the aviation ground infrastructure, the training process, the selection of candidates and preparation of the aviation personnel to performance tasks.

The aircraft called machine was one of the main causes of accidents from the beginning of aviation. The elements having the biggest impact on safety in realizing tasks in relation to the aircraft are: ergonomic, security systems, emergency systems, reliability, functional parameters, standardization and automatization.

According to the statistical data the man is a factor which limits technical and tactical aircraft's characteristics. Statistics also show that nine aircraft's crashes in US Air Force in years 1983 – 1984 has been caused by loss of consciousness by pilots [10]. Other difficulties relating to use of military aircraft result from equipping such machines in many variants of armament. It can be hard to remember and then effective use of armament.

Organizational factors include the procedures governing the way in which should operate aviation safety system. These elements also show how will operate this system. Organization include the standard operational rules, suitable normative documents, instructions, training programs and the management of aviation institution as well. In addition, elements considered as part of a group of organization factors are: culture, structure, training, funds, personnel, procedures, norms, principles, relationships, facilities (for example technical) and professional development.

The environment should be considered as the natural environment and the artificial one (made by human). Elements of the natural environment are mainly the weather and landform. However, the artificial environment includes man-made objects necessary for the proper operation of aviation. Among these are airports, airport infrastructure, elements of air traffic control systems and many others.

The most important element which has the biggest influence on aviation safety is human factor. Statistics connected to causes of air accidents confirm this statement. There are many of them but for this study useful are date based on flight safety information brochures publicized in the Polish Air Force Academy from 1975 to 1998 (Table 1).

Table 1 List of aviation accidents occurred in units of the Polish Air Force Academy from 1970 to 1994 and percentage ratio of accidents caused by human [11]

	Accidents dependent on human	Accidents independent on human	Total number of accidents	Percentage ratio of accidents caused by human
1970	0	2	2	0,00 %
1971	5	6	11	45,45 %
1972	10	9	19	52,63 %
1973	4	4	8	50,00 %
1974	10	4	14	71,43 %
1975	5	9	14	35,71 %
1976	11	4	15	73,33 %
1977	11	6	17	64,71 %
1978	8	6	14	57,14 %
1979	10	3	13	76,92 %
1980	11	8	19	57,89 %
1981	10	9	19	52,63 %
1982	12	2	14	85,71 %
1983	4	8	12	33,33 %
1984	3	3	6	50,00 %
1985	3	4	7	42,86 %
1986	7	5	12	58,33 %
1987	3	6	9	33,33 %
1988	2	10	12	16,67 %
1989	6	6	12	50,00 %
1990	8	11	19	42,11 %
1991	5	5	10	50,00 %
1992	1	9	10	10,00 %
1993	0	5	5	0,00 %
1994	5	8	13	38,46 %
Total number	**154**	**152**	**306**	**50,33 %**

According to Table 1 there were 306 overall number of aviation accidents and 154 (50,33 %) caused by human factor. It is necessary to add the majority participation of human oscillated between 40 and 70 %. The largest influence of pilots, technical personnel, air traffic controllers and other people in concerned aviation accidents (over 70 %) took place in 1974, 1976, 1979, 1982 (Fig. 5). The lowest (below 40 %) were in 1970, 1975, 1983, 1987, 1988, 1992, 1993, 1994 (Fig. 6).
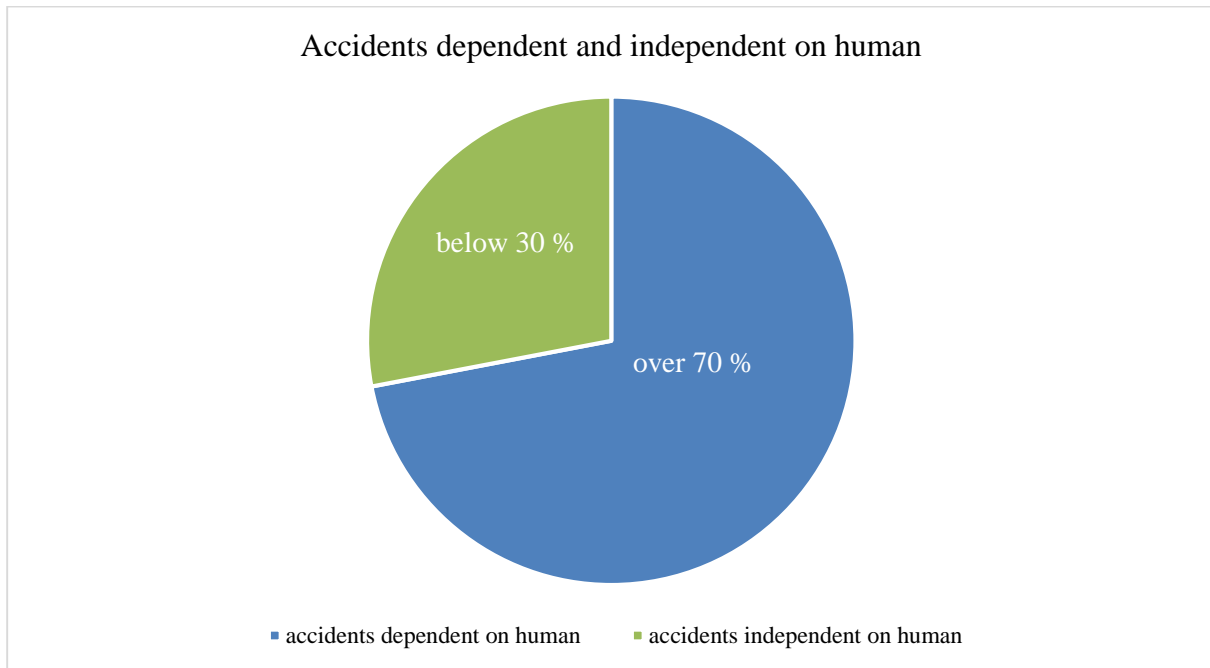
Figure 5 Classification of aviation accidents occurred in units of the Polish Air Force Academy
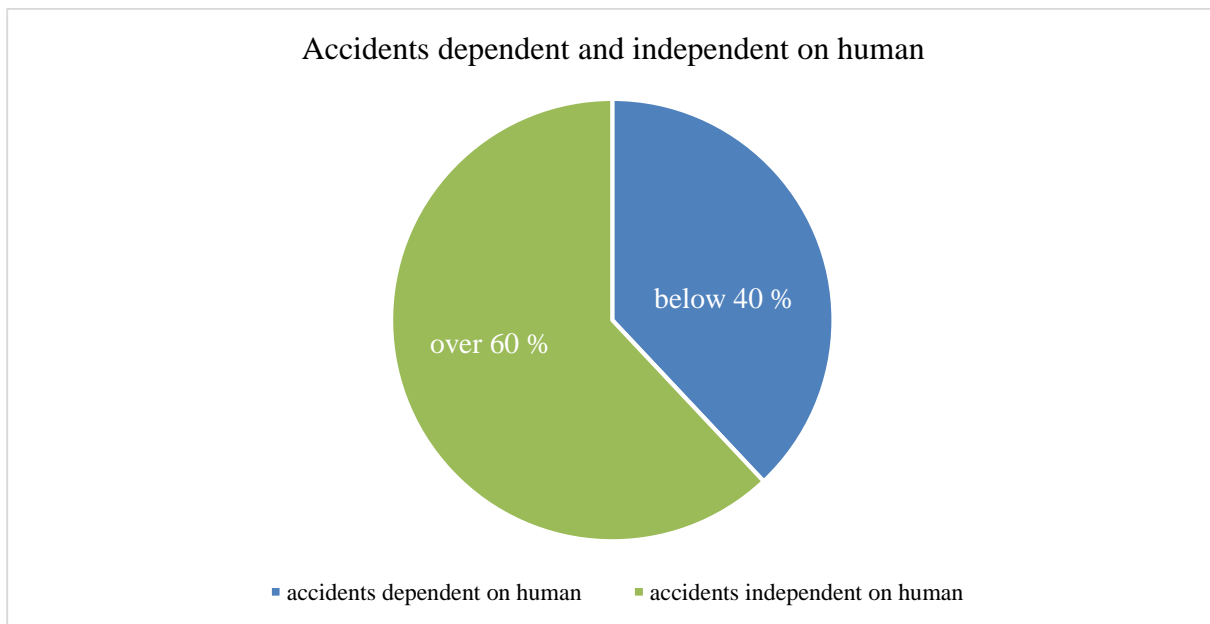in 1974, 1976, 1979, 1982 [11]

Figure 6 Classification of aviation accidents occurred in units of the Polish Air Force Academy
in 1970, 1975, 1983, 1987, 1988, 1992, 1993, 1994 [11].

Besides the above mentioned factors basic elements which have influence on aviation training are planning process and the ability to management own time by trainees. To improve efficiency of time management it is recommended to perform a day plan. This kind of document should contain tasks to perform with indication of the validity and ordered sequence of execution, time intended for own work, rest and ad hoc matters [12].

The organization of the training process is also essential for the safe execution of tasks. It is understood as an integrating and coordinating activities of the entities responsible for the training to achieve desired objectives [1].

In addition to planning and organizing processes, appropriate support of training is also an important part of it. Support process includes logistical support, training facilities, medical facilities and the instrumentation of the training process as well. (Fig. 7).

The logistical support is nothing more than a material and technical resources necessary for the proper conduct of training. The medical facilities are necessary due to possibility of injury during practical training. The training facilities means the technical equipment necessary for training. The instrumentation of the training process is called as documents which regulate the course of the training [1].
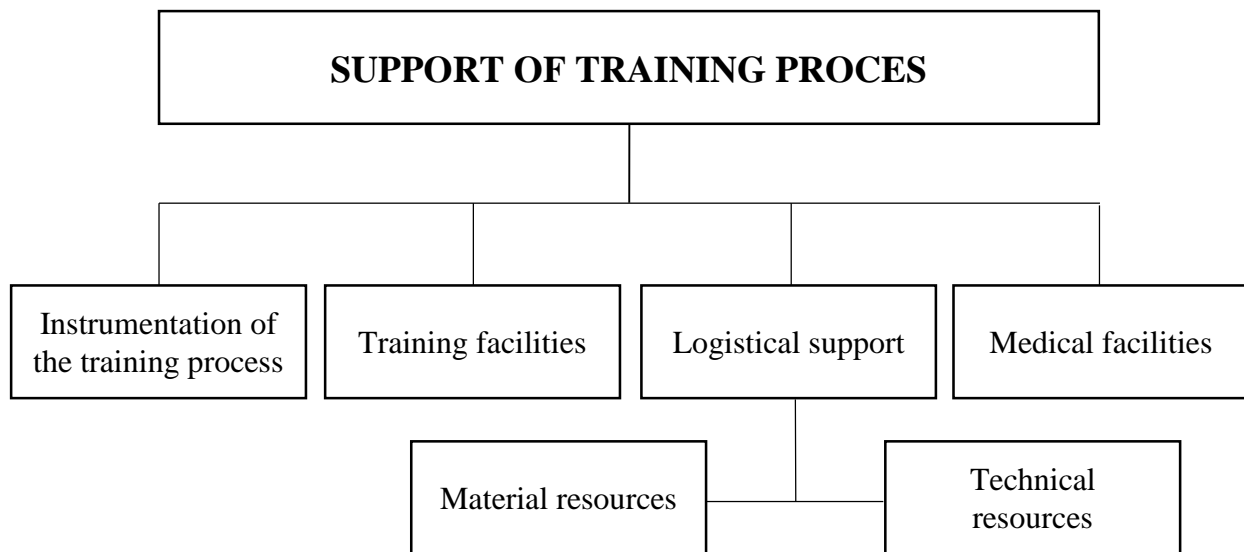

Figure 7 Elements included in support of training process

As it was said before the training process is planned and conscious activity. The successful conduct of that process is possible after defining and achieving training objectives (Fig. 8). These are: general and detailed. It can be mentioned also intermediate objectives related to the realized modules or stages of training.
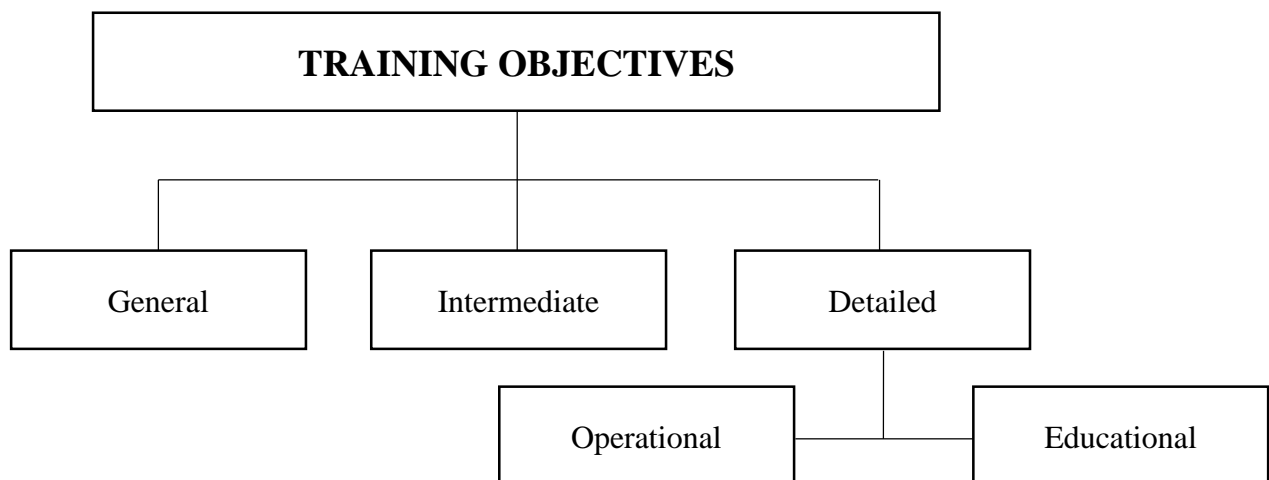
7Figure 8 Training objectives

Human creates training programs which are the basis for realizing aviation tasks. Important for the training process are: planning, support processes, defining training objectives and proper organization. Completion of these steps is very important for the proper training of future pilots and improve the safety of flights.

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