Flight laboratories role in aviation related projects and teaching methodology development. Polish and Georgian Case Studies

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Abstract: *Aviation is the most dynamic and fast developing transport mode, strong aviation has a key role in a country's strength and economic development. Aviation system connects with other modes of transportation, where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. The constant growth of the flights intensity in the world faces new challenges for international aviation organizations to increase safety requirements, for this reason implementation of the innovative technologies and the taking following measures are necessary: increasing the flight altitudes between the aircrafts, raise the airspace bandwidth; using satellite navigation; reduction of economic indicators and flight performance of routes in order to optimize flight time; improvement of landing trajectories for less negative effects on populated areas (emissions and noise). Above mentioned technological changes will have an impact at the qualification level of aviation specialists, both in the air and on the ground, and will lead to the formation of their knowledge, and responsibilities, as well as requires development of new skills. Based on statistical data, taking into account the increase in the intensity of flights, it is also important that there should be a sufficient number of qualified and competent people personnel to ensure a safe and efficient aviation system, for these reason it is important to integrate into aviation educational programs new innovative, practical based teaching methodologies in order to meet requirement of new technological environment in aviation field. In the research is analyzed aviation education modern requirements and technological development tendencies, provided gap between new technologies and aviation educational programs teaching methodologies, use of flight laboratories in Poland and Georgia analyzed as a case studies. Paper provides flight laboratories use as a recommended concept in aviation education for students projects and teaching methodology development.*

Keywords: *aviation education, flight laboratories, teaching methodology, innovative technologies.*

Introduction

The efficiency of human role in aviation should be considered as new, at the stages of planning and designing systems and technologies, as well during their implementation and operation. Human errors In order to prevent the risks caused, their extensive and effective management in an operational context, it is impossible to achieve regulatory bodies, service providers and operating personnel without a coordinated effort [7].

Human error is the key factor which is still challenging the aviation, based on different scientific research papers and statistical analysis proves that, human error and mistakes is one major problem, which is the reason of different aviation accidents or incidents, it is connected to the different reasons, some of the are clarified below:

a) Initial training of personnel to adapt to the new technological environment of aviation;

b) Formation of new knowledge, skills and duties, which is defined and necessary to maintain the safe operation of the aviation system;

c) Social factors and the management of changes that related to the increase automation level.

In order to fulfil the criteria's of the new technological environment in aviation, education and teaching methodology improvements is important in order to gain learning outcomes, which increase the competencies of the graduates and develops the practical skills, flying laboratories and in-flight tests in student projects have critical role in this process, as a new methods for teaching. [6]

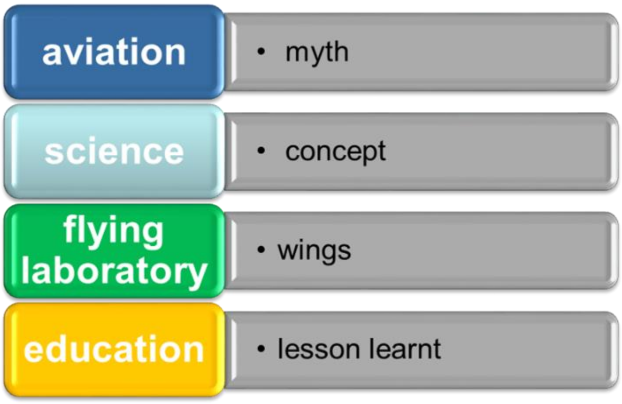

Figure 1 - Aviation, science, education, flying laboratories for in-flight tests existed at mythic Age

Aeronautical science focuses on designing, developing, operating, and applying aircraft within the earth's atmosphere. It's a multidisciplinary field integrating physics, mathematics, and engineering aspects. Since first steps of aviation development science is playing critical role for development of the new concepts and integrated into the aviation systems, before the first official flight in 1903 year aviation was myth for the society but till today many lessons learnt into the development process and flying laboratory's consider as wings for aviation education methodological enhancement and next developments of the practical component of the teaching programs. [5]

There are lots of flying laboratories used in science and education activities in the World at present

Figure 2 - Flying laboratories all over the World

Types of aerial vehicles could be used as prototypes of the flying laboratories and used as practical examples and cases studies for teaching methodology development.

- Aircraft
- Balloons
- Rockets
- Helicopters
- Drones and many others.

There are lots of flying laboratories used in science and education activities in the World at present for example, at Cranfield University, Delft University of Technology, Technical University of Munich, Technical University of Pennsylvania and others. Into the paper be provided case studies of Poland and Georgia in order to fully integrate and implement flying laboratories into the proper educational programs of Rzeszow University of Technology and Georgian Aviation University.

- What are the benefits of using flying laboratories?
- Real experiment condition
- Attractiveness
- Real facilities and devices
- Efficiency
- Practical skills development
- Student oriented teaching and others

What fields and sub-fields can we use it on?

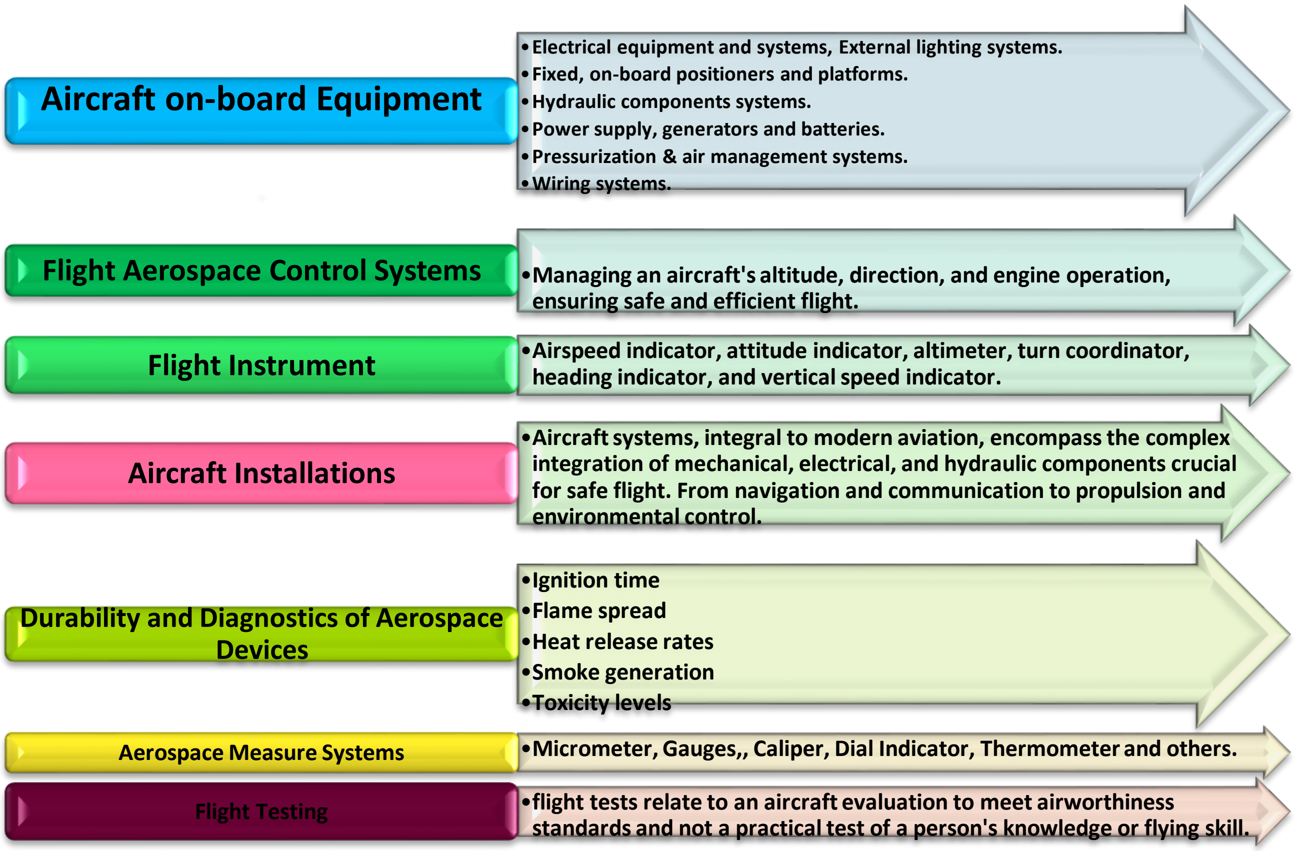

Figure 3 – Taxonomy of flying laboratories categorization and use in aviation field

To conduct in-flight test, is it possible to use for all the level education, for instance:
- Regular student lessons
- Student projects
- Diploma projects
- Doctoral student research
- Other student activity.

Research Methodology

To fulfil the objectives, the research based on the following methodology: Analysis, synthesis, qualitative, and comparison methods. There are following open question for the further development flying laboratories:

- What is the structure of flying laboratories?
- What is the development process procedures?
- How, when, where, who will develop them?

There are the possible actions to be done in order to answer the open questions:

- Give specific samples of usage flying laboratories in flight tests in education;
- Present possibilities their applications;
- Familiarization with flying laboratories.

It is as well critical to be downed the following myths: In-flight tests are always very expensive, flying laboratory is always very sophisticated facility, In-flight tests require staff having extraordinary skill, there is no possibility to involve them into standard student courses and other tasks what need the right sharing of the information's, for this purposes should be done proper consulting, mailing, students groups with competent information, preparation of information booklets, special guidelines, use of flying laboratories in practices and their impact assessment to the quality of education and outcomes of the educational programs.

Early Results

In order to asses flying laboratories role and get results, it is important to analyses their use in real environment to the aerial vehicles, based on the research it is possible to compare two case studies, and overview the general structure of the flying laboratories development in teaching methodology and in aviation projects:

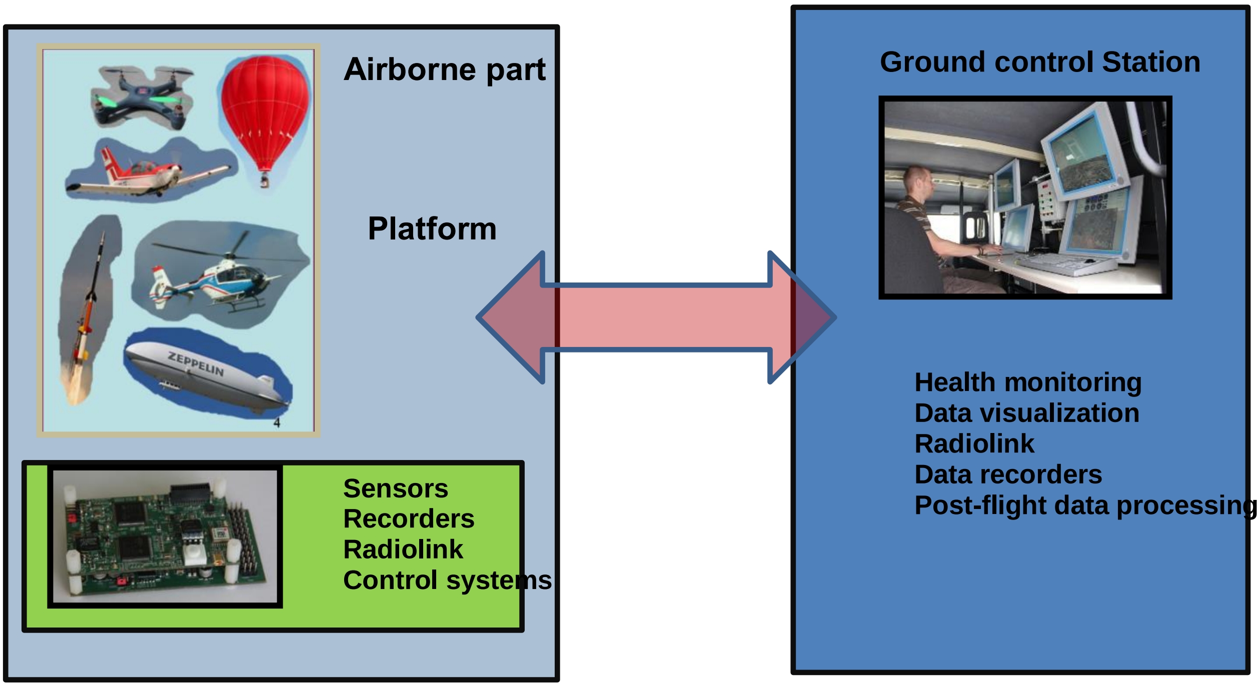

Figure 4 – General structure of flying laboratories operation

Case study of Poland

Figure 5 - Optionally Piloted Vehicle (MTOW 495kg, Max. Airspeed (Vne) 270 km/h

Min. Speed 65 km/h 2 seats)

Research and education

- Flight tests of control laws for ultralight aircraft
- Tests of heavier onboard equipment
- Activities for 4 students at the same time – two person on board the aircraft and two persons in the car (ground station)
- Relatively low operating costs

Objectives of the research

- Aircraft handling qualities assessment in selected flight phases
- In-flight test maneuvers preparation
- In-flight experiments and data analyzes
- Handling characteristic during typical flight phases (horizontal flight, coordinated turn).
- Static and dynamic stability tests.
- Aircraft characteristics during landing at different configurations.

Research results and outcomes of the experiment is provided on the figure 6.

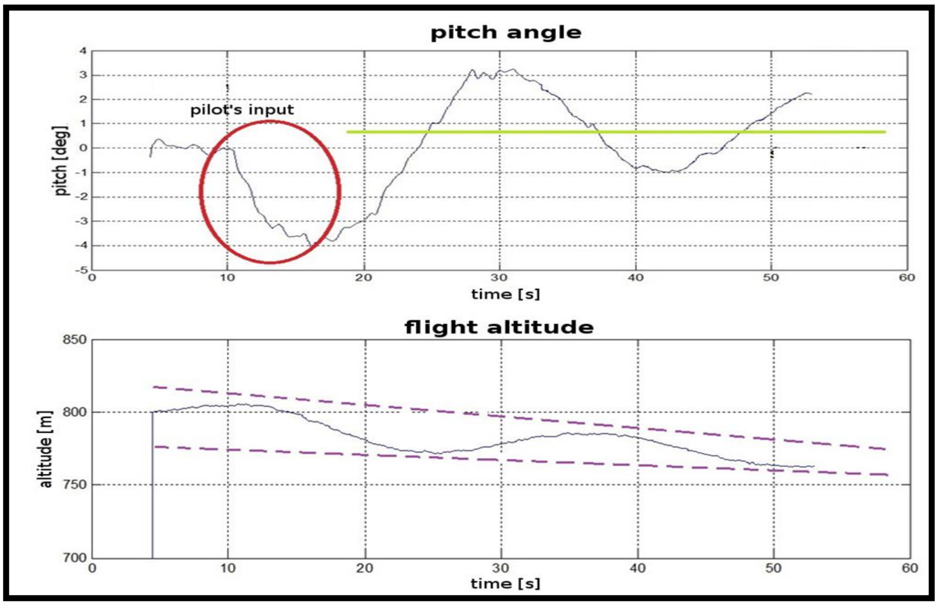

Figure 6 - Longitudinal stability tests

Figure 7 - Piper Seneca V (MTOW: 2155 kg, Never exceed speed: 378 km/h, 6 seats)

Research and education

- Flight tests of control laws for general aviation planes
- Tests of heavier onboard equipment
- Activities for small group of students – six persons on board the aircraft

Objectives of the research

- Investigation of general aviation aircraft performances
- In-flight test maneuvers preparation
- In-flight experiments and data analyzes
- Max speed at horizontal flight investigation
- Climb rate investigation
- Stall speed investigation.

Research results and outcomes of the experiment is provided on the figure 8.

	Pomiar co 30 sek.	Pomiar w odstępach 1-minutowych, lewy i prawy silnik			
Czas	**Wysokość**	**Obroty silnika**	**Ciśnienie ładowania**	**Temperatura na wlocie silnika**	**Temperatura otoczenia**
min.	ft.	RPM	in. Hg	°F	°F
0	3000	2500	32	1311	32
		2500	32	1283	
1/2	3540				
1	4060	2495	32	1301	26.6
		2500	31.5	1280	
1 1/2	4620				
2	5080	2500	31.5	1278	24.8
		2500	31.5	1264	
2 1/2	5520				
3	6000	2495	31.5	1271	24.8
		2505	32	1261	
3 1/2	6520				
4	6980	2500	315	1266	24.8
		2510	32	1258	
4 1/2	7440				
5	7900	2505	31.5	1264	21.2
		2510	32	1254	
5 1/2	8360				
6	8860	2505	31.5	1263	19.4
		2510	32	1251	
6 1/2	9040				

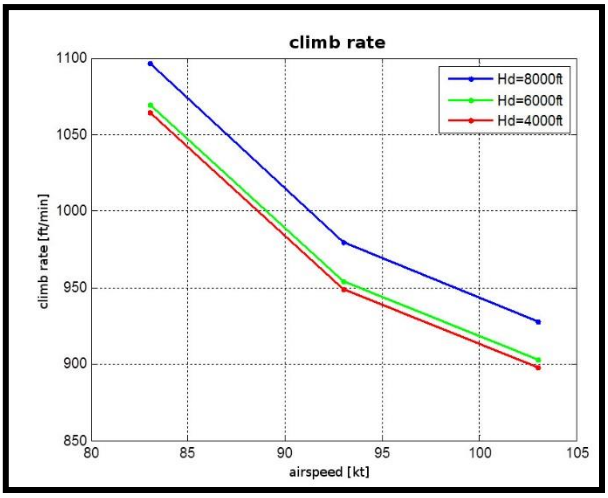

Figure 8 - Climb rate tests results

<u>Case study of Georgia</u>

Figure 9 - Tecnam P2008JC (MTOW 650 kg, Max cruise speed 215 km/h)

Min. Speed 81 km/h, 2 seats)

Research and education

- Tests of Tecnam P2008JC flight parameters
- Take-off performance comparison analysis with weight 630 kg and 530 kg [4]

Objectives of the research

- Investigation of general aviation aircraft flight performances
- In-flight experiments and data analyzes operation performance with different load

Research results and outcomes of the experiment is provided on the figure 10.

Weight = *530 kg*
Flaps: *T/O*
Speed at Lift-Off = *48 KIAS*
Speed Over 50ft Obstacle = *61 KIAS*
Throttle Levers: *Full Forward*
Runway: *Grass*

Corrections
Headwind: - 5m for each kt (*16 ft/kt*)
Tailwind: + 15m for each kt (49 *ft/kt*)
Paved Runway: - *10%* to Ground Roll
Runway slope: + 7% to Ground Roll for each +1%

Pressure Altitude [ft]		Distance [m] Temperature [°C] -25	0	25	50	ISA
S.L.	Ground Roll	88	111	137	167	**127**
	At 50 ft AGL	190	237	290	349	**268**
1000	Ground Roll	96	121	150	182	**136**
	At 50 ft AGL	207	258	315	379	**287**
2000	Ground Roll	105	133	164	198	**146**
	At 50 ft AGL	225	280	342	412	**307**
3000	Ground Roll	115	145	179	217	**157**
	At 50 ft AGL	245	305	373	448	**328**
4000	Ground Roll	126	158	195	237	**168**
	At 50 ft AGL	266	332	406	488	**352**
5000	Ground Roll	137	173	214	259	**181**
	At 50 ft AGL	290	361	442	532	**377**
6000	Ground Roll	150	189	234	284	**195**
	At 50 ft AGL	316	394	482	580	**404**
7000	Ground Roll	165	207	256	311	**210**
	At 50 ft AGL	345	430	526	632	**434**
8000	Ground Roll	181	227	280	340	**226**
	At 50 ft AGL	376	469	574	690	**466**
9000	Ground Roll	198	249	308	373	**243**
	At 50 ft AGL	411	512	626	754	**500**
10000	Ground Roll	217	273	337	409	**262**
	At 50 ft AGL	449	560	685	824	**537**

Weight = *630 kg*
Flaps: *T/O*
Speed at Lift-Off = *48 KIAS*
Speed Over 50ft Obstacle = *61 KIAS*
Throttle Levers: *Full Forward*
Runway: *Grass*

Corrections
Headwind: - 5m for each kt (*16 ft/kt*)
Tailwind: + 15m for each kt (49 *ft/kt*)
Paved Runway: - *10%* to Ground Roll
Runway slope: + 7% to Ground Roll for each +1%

Pressure Altitude [ft]		Distance [m] Temperature [°C] -25	0	25	50	ISA
S.L.	Ground Roll	134	169	208	252	**192**
	At 50 ft AGL	283	352	431	518	**398**
1000	Ground Roll	146	184	227	275	**206**
	At 50 ft AGL	307	383	468	564	**426**
2000	Ground Roll	159	201	248	301	**221**
	At 50 ft AGL	334	417	509	613	**456**
3000	Ground Roll	174	219	271	328	**237**
	At 50 ft AGL	364	453	554	667	**488**
4000	Ground Roll	190	240	296	359	**255**
	At 50 ft AGL	396	493	603	726	**523**
5000	Ground Roll	208	262	323	392	**274**
	At 50 ft AGL	431	538	657	791	**561**
6000	Ground Roll	228	287	354	429	**295**
	At 50 ft AGL	470	586	717	862	**602**
7000	Ground Roll	249	314	388	470	**317**
	At 50 ft AGL	513	639	782	941	**645**
8000	Ground Roll	273	344	425	515	**342**
	At 50 ft AGL	560	698	853	1027	**693**
9000	Ground Roll	300	377	466	565	**368**
	At 50 ft AGL	611	762	932	1122	**744**
10000	Ground Roll	329	414	511	620	**397**
	At 50 ft AGL	668	833	1019	1226	**800**

Figure 10 - Tecnam P2008JC take-off performance comparison analysis results with weight 630 kg and 530 kg

Figure 11 - Tecnam P2006T (MTOW 1230 kg, Max cruise speed 269 km/h)

Min. Speed 115 km/h, 4 seats)

Research and education

- Tests of Tecnam P2006T flight parameters
- Single Engine Instrument Approach Procedure TEST

Objectives of the research

- Investigation of general aviation twin engine aircraft flight performance
- To develop the student's ability to shoot an approach with one engine inoperative, and maintain positive control of the aircraft. [3]

Research results and outcomes of the experiment is provided as errors calculated and analyzed during flight by student:

- Failure to maintain proper heading
- Failure to maintain aircraft control
- Failure to maintain proper glide slope and LOC (localizer)
- Failure to understand the proper procedures of an instrument approach [1] [2]

Conclusions

Based on the research and investigation and cases studies analysis in two different educational facilities in Poland and Georgia, it is possible to conclude, that flight laboratories have very important and positive role in aviation related projects and teaching methodology development. It is very flexible to use this method into different airplane get parameters by the students, make analysis of them and strengthen theoretical knowledge into the practical part of the following educational courses: Aircraft control systems, flight recorders and data analyses, aviation radio systems, In-flight tests, aerodynamics and others.

Flight laboratories use is possible in real experiment conditions, has high attractiveness from students, students has direct connection with real facilities and devices by their hands, non-complex platform are necessary, supplementary devices are used, gives students opportunity to generate new ideas, practical part has becoming more efficient, as a result myths regarding useless of such method into educational process is down.

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სასწავლო ლაბორატორიების როლი საავიაციო პროექტების და სწავლების მეთოდოლოგიის განვითარების პროცესში.

პოლონეთის და საქართველოს შემთხვევების კვლევა

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რეზიუმე: *ავიაცია ყველაზე დინამიკურ და სწრაფად განვითარებად სატრანსპორტო დარგს წარმოადგენს, ძლიერ ავიაციას აქვს გადამწყვეტი როლი ქვეყნის სიძლიერის და ეკონომიკურ განვითარების შენარჩუნების საქმეში. საავიაციო სისტემა პირდაპირ დაკავშირებულია ტრანსპორტის სხვა დარგების განვითარებასთან. საავიაციო სისტემაში სახელმწიფო პასუხისმგებლობა საჰაერო მოძრაობის მართვის და რეგულირების საკითებზე აერთიანებს ცენტრალური და ადგილობრივი ხელისუფლების როლს, რომლებიც ფლობენ და მართავენ აეროპორტების უმეტესობას. მსოფლიოს მასშტაბით ფრენების ინტენსივობის მუდმივი ზრდა უსაფრთხოების უზრუნველყოფის მიზნით, ახალი გამოწვევების წინაშე აყენებს სამოქალაქო ავიაციის საერთაშორისო ორგანიზაციებს, რათა მოხდეს ინოვაციური ტექნოლოგიების დანერგვა და შემდეგი ზომების მიღება: საჰაერო ხომალდების ფრენის სიმაღლეების გაზრდა, საჰაერო სივრცის გამტარუნარიანობის ამაღლება, სატელიტური ნავიგაციის აქტიური*

გამოყენება აფრენა-დაფრენის ეტაპებზე, ეკონომიკური მაჩვენებლების გაუმჯობესება, მარშრუტების ოპტიმიზაცია ფრენის დროის დაზოგვის მიზნით, დაფრენის ტრაექტორიების გაუმჯობესება დასახლებულ პუნქტებზე უარყოფითი ზემოქმედების შემცირების მიზნით (ემისიები, ხმაური) და სხვა.

ზემოაღნიშნული ტექნოლოგიური ცვლილებები გავლენას მოახდენს საავიაციო სპეციალისტების კვალიფიკაციის დონეზე, როგორც ჰაერში, ასევე ხმელეთზე და გამოიწვევს მათი ცოდნისა და პასუხისმგებლობის ფორმირებას, ასევე მოითხოვს ახალი უნარების განვითარებას. სტატისტიკურ მონაცემებზე დაყრდნობით, ფრენების ინტენსივობის ზრდის და ინოვაციური ტექნოლოგიების განვითარების ტემპის გათვალისწინებით, მნიშვნელოვანია, კვალიფიციური და კომპეტენტური საავიაციო დარგის სპეციალისტთა შესაბამისი მომზადების შემდგომი განვითარება უსაფრთხო და ეფექტური საავიაციო სისტემის უზრუნველსაყოფად. სწორედ ამიტომ, მნიშვნელოვანია საავიაციო დარგის საგანმანათლებლო პროგრამებში ინოვაციური, პრაქტიკული და ლაბორატორიული სწავლების მეთოდოლოგიის ეფექტური ინტეგრირება, ახალი ტექნოლოგიური გარემოს მოთხოვნების დასაკმაყოფილებლად.

კვლევაში გაანალიზებულია საავიაციო განათლების თანამედროვე მოთხოვნები და ტექნოლოგიური განვითარების ტენდენციები, წარმოდგენილია სხვაობა ინოვაციური ტექნოლოგიების განვითარების ტემპსა და საგანმანათლებლო პროგრამებში პრაქტიკული კომპონენტის განხორციელების მეთოდოლოგიას შორის, პოლონეთის და საქართველოს მაგალითებზე დაყრდნობით. სტატია ითვალისწინებს სასწავლო ლაბორატორიების გამოყენების რეკომენდირებულ კონცეფციას, როგორც საავიაციო პროექტების განხორციელებისა და სწავლების მეთოდოლოგიის განვითარების ერთ-ერთ საფუძველს.

საკვანძო სიტყვები: *საავიაციო განათლება, სასწავლო ლაბორატორიები, სწავლების მეთოდოლოგია, ინოვაციური ტექნოლოგიები.*