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Comparative analysis of various Systems of Aircraft Design Education in Europe

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The level of Aircraft Design Education determines the level of development of Aviation Industry.

Any comparative analysis needs the presence of “Comparison Basis (Reference Point)”.

Russian System of Aircraft Design Education was chosen as the Reference Point for Comparative analysis of various European Systems of Aircraft Design Education.

Short history and description of Russian System of Aircraft Design Education.

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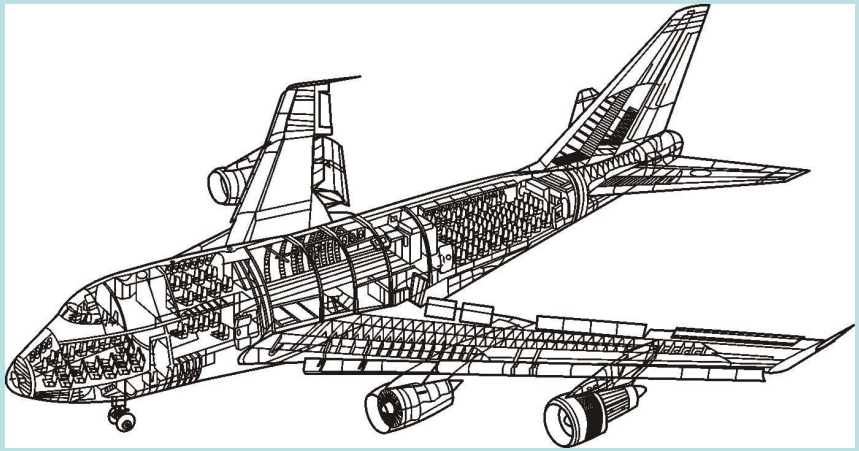
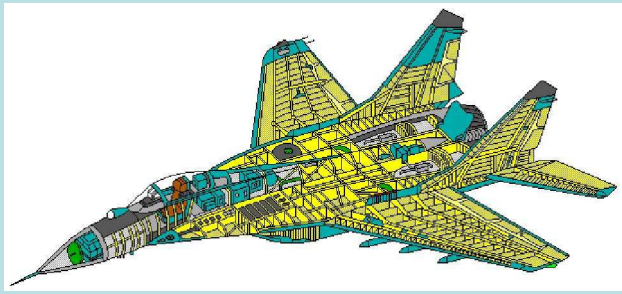
Exceptional position of Aircraft Design Education





Aircraft is a Complex Technical-Organizational System (Man-Machine) System. It includes various types of subsystems (mechanical, power, electrical, electronic, computer subsystems, etc.). Therefore Aircraft Design Education is the independent branch of synthetic engineering education, which has features of both mechanical-engineering and systems-engineering education.

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Exceptional position of Aircraft Design Education

Aircraft is an extremely sophisticated system and the activity in the Aircraft Design Field is very complicated. Therefore in almost all countries the vast majority of aircraft designers has an engineering or master degree. This means that they studied in universities during 5.5 – 6 years. Also due to all these reasons aviation design firms have Centers of Training and Retraining Education. Continuation of education process in this Centers is equal to 1 – 2 years.

History of Development of Russian System of Aircraft Design Education

- The First Stage – Creation of Aviation Specializations for Mechanical Engineers and Specialties of Aviation Mechanical Engineers on mechanical faculties of engineering universities (1911-1920 years).
- The second stage – Creation of special faculties of Aircraft Design (1920-1930 years).
- The third stage – Creation of special Aviation (which were later turned into Aerospace) Universities (starting from 1930).

History of Development of Russian System of Aircraft Design Education

Aviation Specialization
for Mechanical Engineers (1911), which later turned into Aviation Specialty of Aviation Mechanical Engineers at the Mechanical Faculty of Moscow Engineering University

Aeromechanical Faculty of Moscow Engineering University

Moscow Aviation Institute (1930)

Kharkov Aviation Institute (1930)

Kazan Aviation Institute (1932)

Rybinsk Aviation Institute (1932)

Ufa Aviation Institute (1942)

Samara Aviation Institute (1942)

SPb Institute of Aviation instrument engineering (1941)

Moscow Aviation Manufacturing Institute (1940)

Aviation and Aerospace Faculties and Institutes in Komsomolsk-on-Amur, Irkutsk, Novosibirsk, Perm, Voronezh, Tbilisi, Tashkent, and Ulyanovsk

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History of Development of Russian System of Aircraft Design Education

(Education System for Civil Aviation)

Kiev Institute of Civil Aviation Engineers	Riga Institute of Civil Aviation Engineers	Moscow Institute of Civil Aviation Engineers	St. Petersburg Academy of Civil Aviation

Pilot Colleges

Technician Colleges

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Moscow Aviation Institute (Engineering University) (MAI)

- about 17,000 students.
- Several branches in Moscow, Moscow Region, several cities of Russia and abroad.
- 6 main engineering faculties, which educate specialists for design firms and research centers of aviation industry.
- Every faculty has from 4 to 10 departments.
- Every department prepares specialists of appropriate specialty or specialization.
- Graduate degree is “Engineer”. Term of study is equal to 5.5 years.

Main engineering faculties of Moscow Aviation Institute (Engineering University)

- Aviation Engineering
- Flight Vehicle Engines
- Avionics and Electric Systems
- Radioelectronics Systems
- Space-Rocket Systems
- Aviation Weapon Systems

Departments of Aviation Engineering Faculty

- Airplane Design
- Helicopter Design
- Aircraft Subsystem Design
- Aircraft Manufacturing
- Aerodynamics
- Flight Dynamics and Control Systems
- Pre-Design and Effectiveness of Complex Aviation Systems
- Aircraft Certification

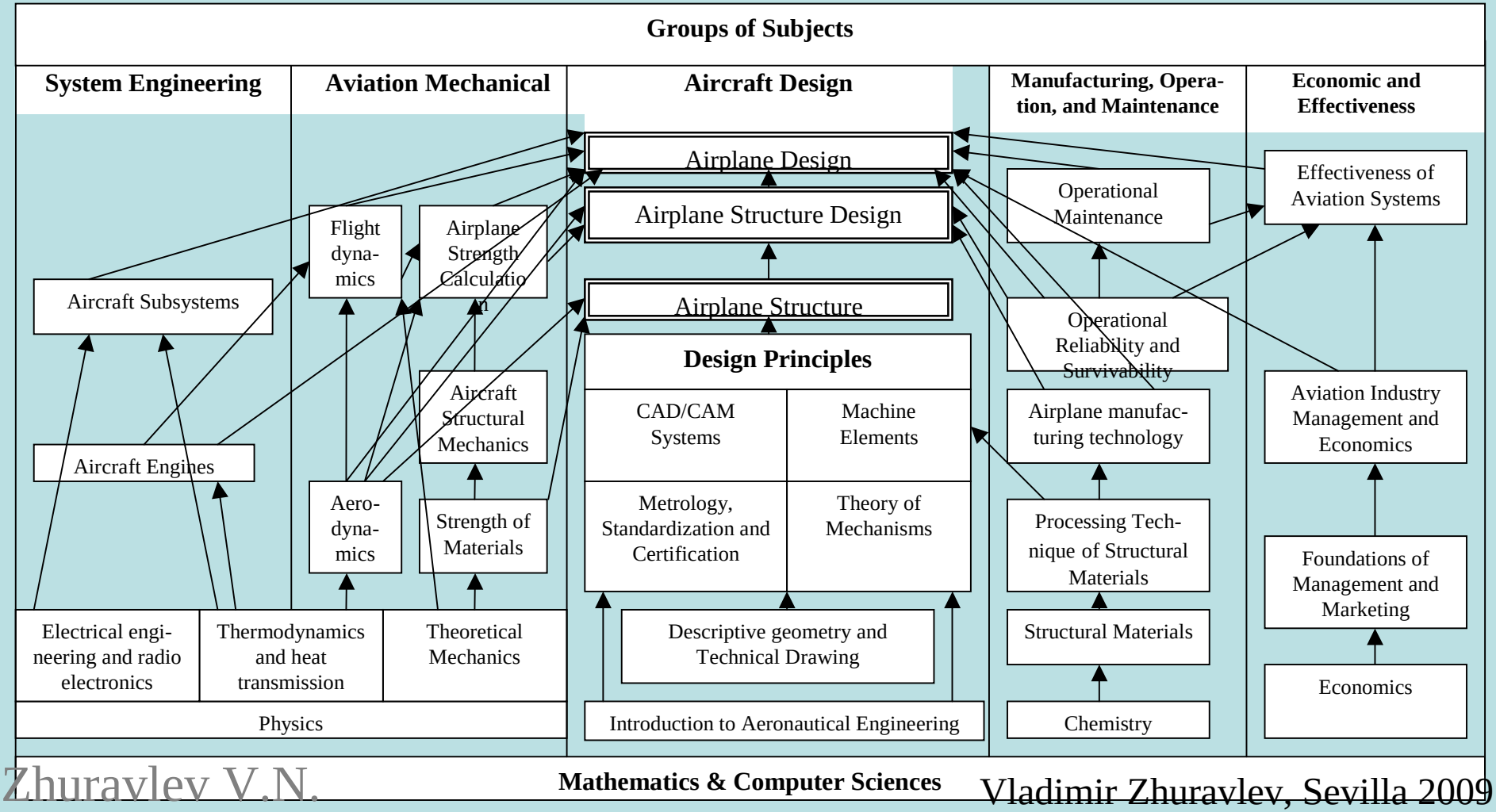
Geographical Distribution of Russian Aviation Industry and Aviation Universities

- Aviation batch production factories are distributed among many Russian regions.
- Aviation research centers and design firms (design bureaus) are concentrated in Moscow and Moscow Region.
- There is a higher concentrations of universities, which train aviation specialists (especially for research centers and design firms), in Moscow.

Specific Set of Academic Subjects in Aviation Universities

- **Physics-Mathematical;**
- **General Engineering;**
- **Aeromechanical (Aerodynamics, Flight Dynamics, Strength of Aircraft Structure);**
- **System Design (Description and Operating of Aircraft Subsystems (Avionics, Power Systems, Control Systems), Operations Research, Effectiveness Theory);**
- **Design (Aircraft Structure Design, Aircraft Subsystem Design, Aircraft Design, Pre-Design of Complex Aviation Systems).**

The curriculum structure for specialty “Airplane Design” (Engineers Degree in MAI) (without liberal arts)



Purpose-Oriented Character of Education of Specialists in Aircraft Design

Starting from 1930s Aircraft Design Education System was differential. The following branches correspond to the main departments of aviation design firms (the appropriate departments are established in Aviation Engineering Faculty of MAI):

- Aircraft Design (Airplanes and Helicopters);
- Aerodynamics;
- Flight Dynamics, Control Systems and Flight Testing;
- Pre-Design and Effectiveness of Complex Aviation Systems;
- Aircraft Certification.

Purpose-Oriented Character of Education of Specialists in Aircraft Design

- Main target of Education of Specialists in the field of Aircraft Design is to ensure the qualification, which is necessary for their activity at the appropriate departments of Aviation design firms and research centers. **The alumni can start their activities without any additional training in the Firm Training Centers (this additional training is widely used in USA and Western Europe).**

Purpose-Oriented Character of Education of Specialists in Aircraft Design

- The curricula and syllabi of subjects are developed by using the results of questionnaires, which are given to key specialists of design firms and research centers.
- Contents of curricula and syllabi of subjects are coordinated with key specialists of design firms and research centers.
- Main part of academic staff are key specialists of design firms and research centers, who work on either regular full-time or part-time basis.

Systematic Character of Education of Specialists in Aircraft Design

- One of the main outcomes of education is the alumnus' comprehensive understanding of all main stages of development and life cycle of aircraft :
  - Pre-Design,
  - Concept Design,
  - Preliminary Design,
  - Detail Design,
  - Testing,
  - Manufacturing,
  - Operating,
  - Maintenance.

Systematic Character of Education of Specialists in Aircraft Design

- Through obtained knowledge about all main stages of development and life cycle of aircraft and by possessing a set of main knowledge and skills, which are used on all stages of development and life cycle of aircraft, an alumnus can:
  - Work basing on system approach, i.e. work within the separate field or stage of aircraft design process to develop a project of a subsystem or element as a part of Complex Aviation System.

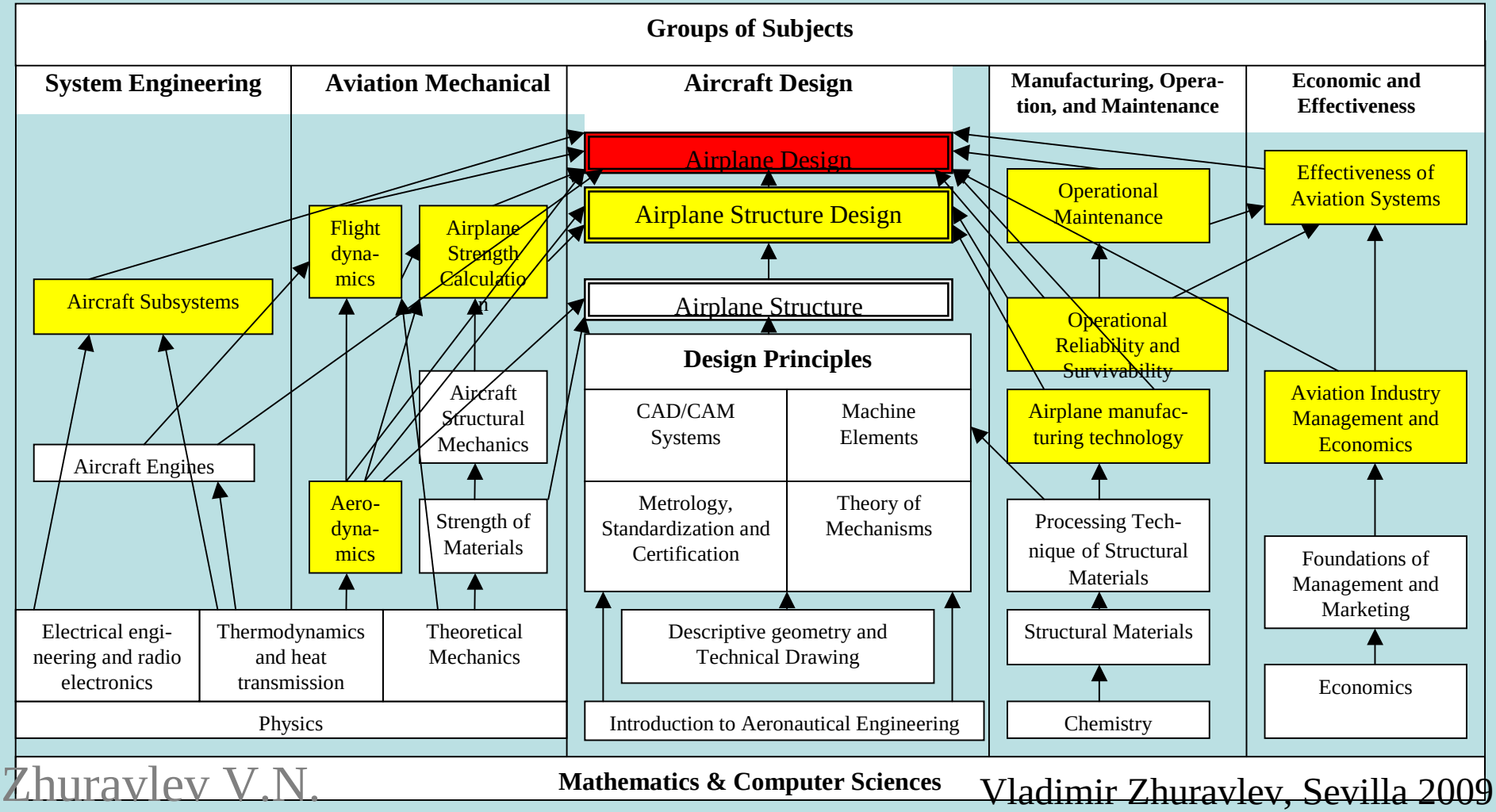
Systematic Character of Education of Specialists in Aircraft Design

- Through obtained knowledge about all main stages of development and life cycle of aircraft and by possessing a set of main knowledge and skills, which are used on all stages of development and life cycle of aircraft, an alumnus can:
  - carry out engineering and/or scientific activity on all stages of aircraft life-cycle,
  - have an opportunity of a high occupational mobility by working successfully in the field of manufacturing, operating and maintenance of aircraft.

Systematic Character of Education of Specialists in Aircraft Design

- **The sequence of learning all subjects is subordinated to strict logic of their interrelation:**
  - Aircraft Design subject is learned on the basis of (and after learning) the following subjects: Aircraft Structure Design, Aircraft Subsystems, Flight Dynamics, Aerodynamics, Aviation Systems Effectiveness, Aviation Systems Economics, Aircraft Manufacturing and so on.

The curriculum structure for specialty “Airplane Design” (Engineers Degree in MAI) (without liberal arts)



Systematic Character of Education of Specialists in Aircraft Design

- The sequence of learning all subjects, their volumes (contents) and durations, which is equal to 5 years and 6 months, are determined by the following factors:
  - Field of specialization of trained specialists,
  - Demands of the potential employers,
  - Long-term experience of teaching the appropriate subjects and training specialists of the appropriate qualification.

Systematic Character of Education of Specialists in Aircraft Design

Example of sequence of learning the appropriate subjects, which determine the necessity for an uninterrupted term of education of Aircraft Design specialists (engineer-designers) in MAI (Structure Design cycle):

1 academic year		2 academic year		3 academic year		4 academic year		5 academic year	
									Aircraft Design
							Design of Airframe Structure	Design of Airframe Structure	
					Understanding Aircraft Structure	Design of Aircraft Elements	Design of Landing Gear and Control System	Design of Landing Gear and Control System	
Engineering Drawing	Engineering Drawing	Engineering Drawing	Introduction on CAD/CAM Systems	Machine Elements	Machine Elements		CAD/CAM Systems in Aircraft Design		
		Solid Mechanics	Solid Mechanics	Aircraft Structural Mechanics		Strength of Aircraft			
Mathematics	Mathematics								
Chemistry	Engineering Materials	Engineering Materials Machining	Engineering Materials Machining	Aircraft Manufacturing	Aircraft Manufacturing	Aircraft Manufacturing			

Essential Basis of Education Process of Specialists in the field of Aircraft Design

- **The Essential Basis of the Education Process of Specialists in the field of Aircraft Design** consists of the available university laboratories with the appropriate equipment:
  - Wind tunnels, simulators, test rigs, and so on;
  - Laboratory-hangars with specially de-skinned aircraft, aircraft units and subsystems on display.

Essential Basis of Education Process of Specialists in the field of Aircraft Design

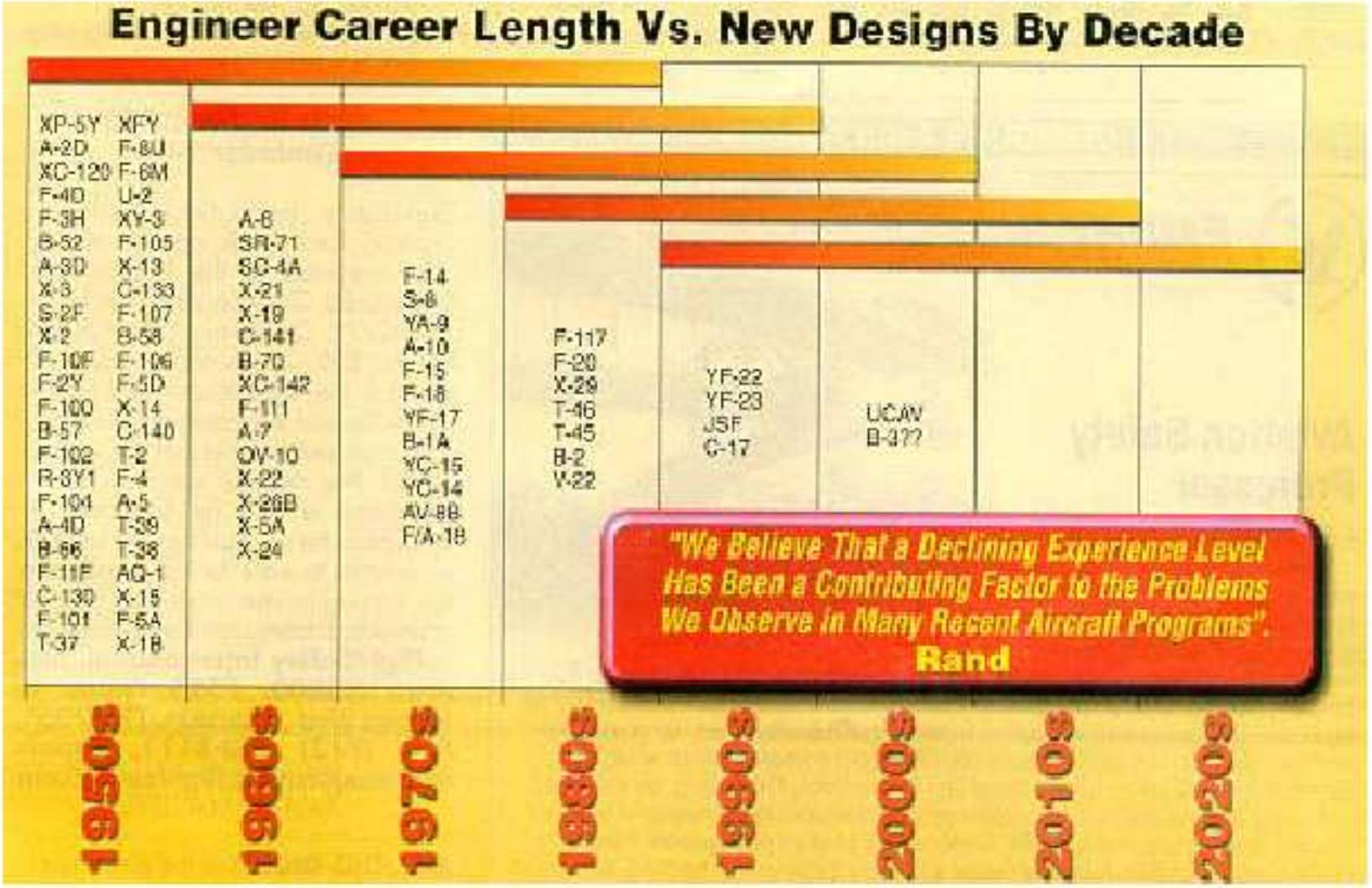
- **The Essential Basis of the Education Process of Specialists in the field of Aircraft Design includes:**
  - **The full set of textbooks for learning all subjects in the field of Aircraft Design was created and published in MAI.**
  - **This set includes the textbooks intended for learning all design stages (from Pre-Design to Detail Design), as well as learning various types of aircraft structures and their Concept Analysis and Synthesis (Sizing).**

Special role of Aviation Universities in Accumulation, Analysis and Development of Aircraft Design Technology

- In all countries and aircraft design firms there is the same tendency of decreasing the number of new aircraft projects. This leads to a reduction of the volume of generated information (rates of replenishment of Knowledge Base at every firm) concerning various layout and structure design solutions, design and manufacturing technologies, and so on.

How Do We Maintain the Knowledge Base?

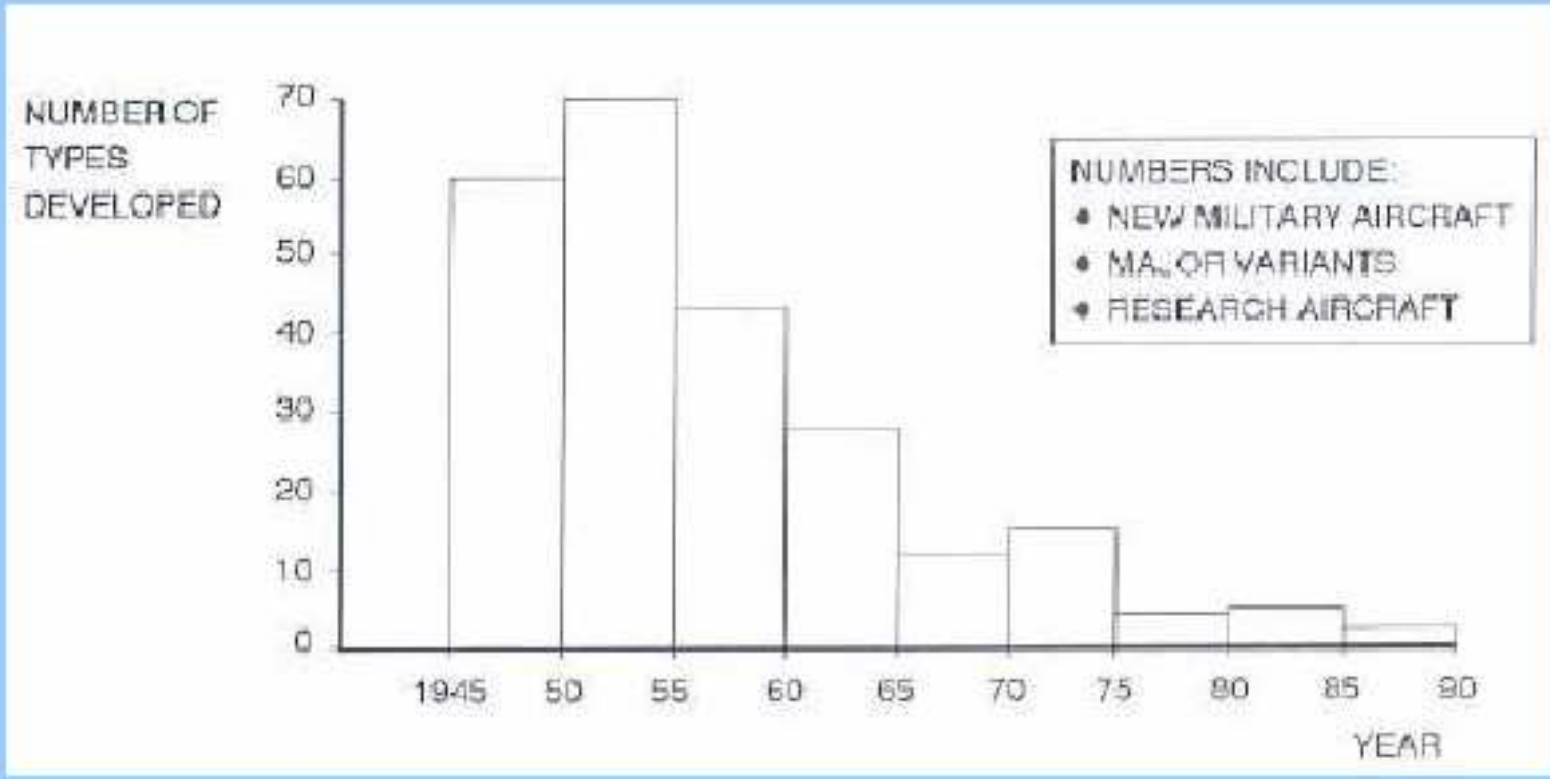
(US Data)



Source: Rand Corporation

Martínez-Val, Pérez and Palacín
Universidad Politécnica de Madrid

EVOLUTION OF MILITARY AIRCRAFT DESIGNED IN UK



Special role of Aviation Universities in Accumulation, Analysis and Development of Aircraft Design Technology

- Reduction of rates of replenishment of Knowledge Bases at Aviation firms leads to the problems in training the appropriate specialists at the Training Centers of these firms.

Special role of Aviation Universities in Accumulation, Analysis and Development of Aircraft Design Technology

- The role of Aviation Universities as training centers for aviation design firms is increasing. Universities start to play the role of centers of accumulation, analysis and generalization of knowledge concerning the developed aircraft (layout and structure design solutions, design and manufacturing technologies, i.e. Aircraft Design Knowledge Base).

Special role of Aviation Universities in Accumulation, Analysis and Development of Aircraft Design Technology

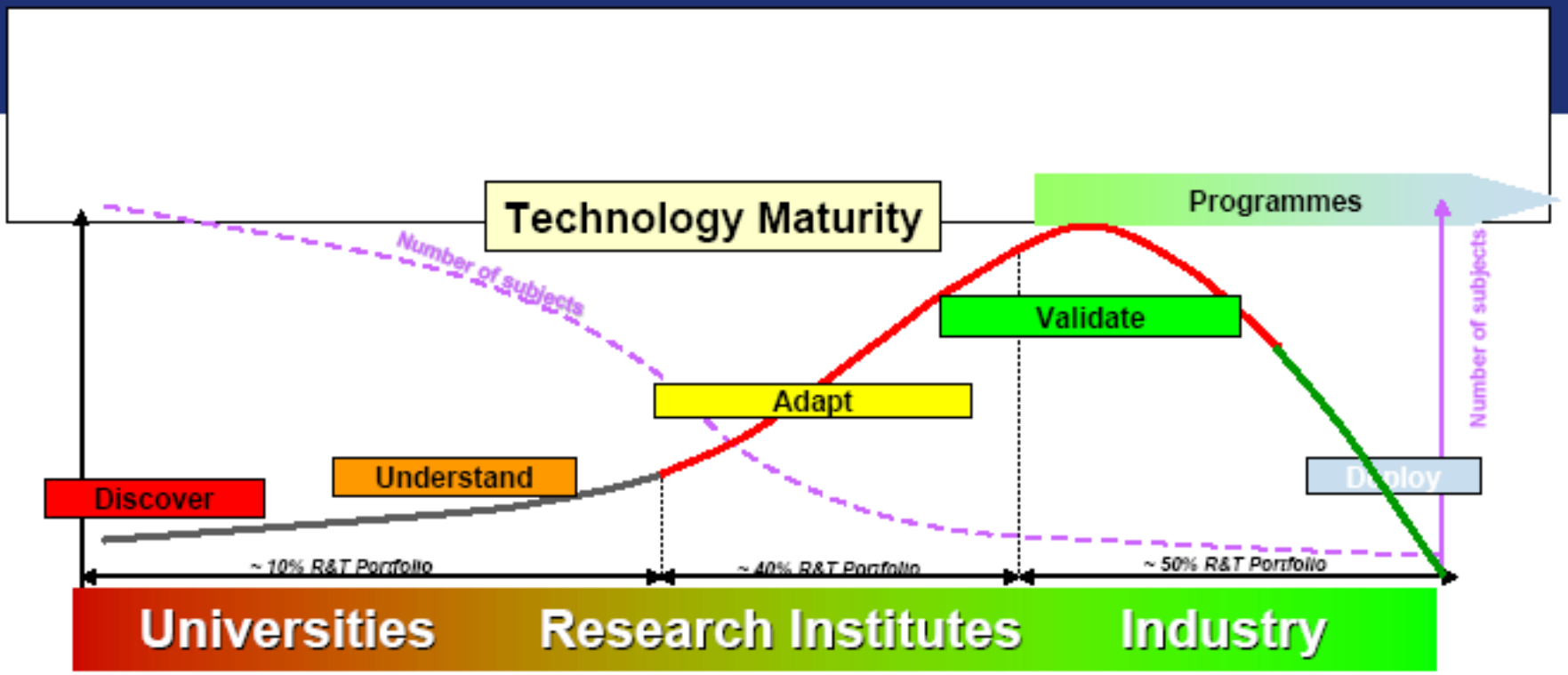
- Main steps of development of Aircraft Design Knowledge Bases in Aviation Universities:
  - Accumulation and classification of samples of aircraft, their subsystems and elements. Russian Aerospace Universities accumulated collections of aircraft, their structure elements (wings, landing gear units, etc.) and subsystems. These collections consist of dozens of samples of various types (starting from 1930s up to modern experimental samples).

Special role of Aviation Universities in Accumulation, Analysis and Development of Aircraft Design Technology

- Main steps of development of Aircraft Design Knowledge Bases in Aviation Universities:
  - Publishing textbooks for subjects, which describe the main Aircraft Design Stages (Pre-Design, Concept Design, Preliminary Design, Detail Design and so on), as well as for such subjects as Understanding Aircraft Structure, Aircraft Structure Design, Aircraft Subsystems Design, Design of Aircraft Elements.
  - During the last 50 years in Russian Airspace Universities there was written and published a number of such textbooks, which generalize the experience of both Russian and foreign aviation design firms.

Scientific Research in Russian Aerospace Universities

- Russian Aerospace Universities carry out a wide range of scientific research: from Basic research up to Applied research.
- Starting from the creation of Russian Aerospace Universities, they design new aircraft of various types:
  - The history of activity of Student Design Firms in Russian Aerospace Universities numbers many decades;
  - Several aircraft design firms of Russian Aviation Industry were established on the basis of Russian Aerospace Universities (for example, the first Russian Helicopter Design Firm under the supervision of I.P. Bratuhin).



- **Universities**
  - Basic research, generally far from application
- **Research Institutes**
  - Applied research, adapting basic research to industrial needs
- **Industrial Companies**
  - Validating technologies for specific component applications

D.Schmitt

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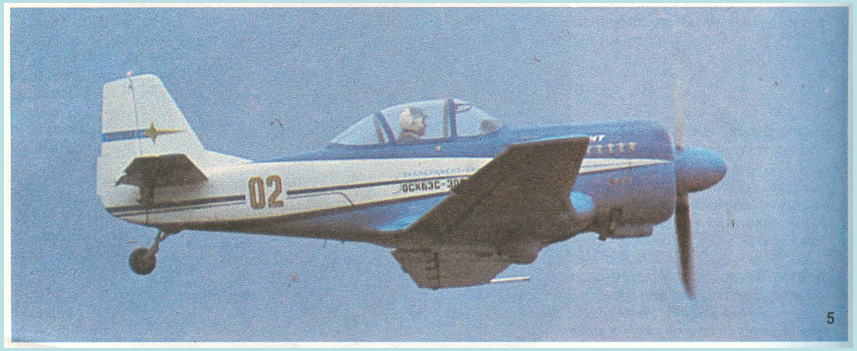
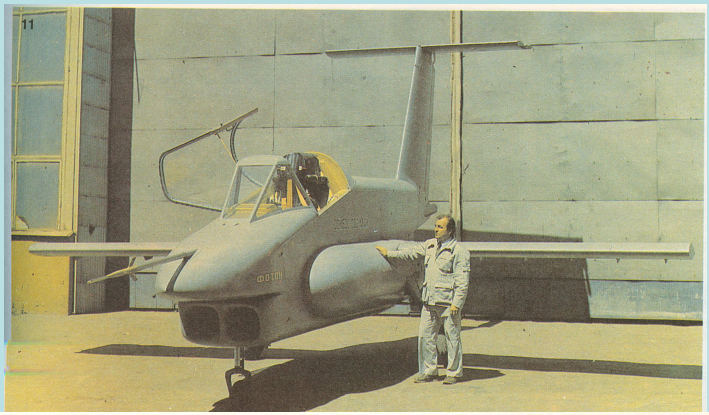
Scientific Research in Russian Aerospace Universities

- Carrying out applied research in Universities gives opportunities to study and develop the advanced approaches and methods, which are used in research centers and design firms of Aviation Industry.
- During execution of applied research Universities carry out analysis and assessment of design layout and structure solutions for aircraft, which are developed by design firms, test their models, elements, full-scale units, manufacturing processes, etc.

Scientific Research in Russian Aerospace Universities

- The execution of applied research in Universities provides the students with opportunities for studying the advanced methods and technologies of research and design.
- The following activities play the main role in teaching the students about the advanced methods and technologies of research and design:
  - Training in research centers and design firms of Aviation Industry;
  - Teaching and training in Core research centers and design firms (the education process is carried out in these research centers and design firms with the key specialists employed as teachers);
  - Work of Students in Design Firms, where they participate in the development of new aircraft of various types.





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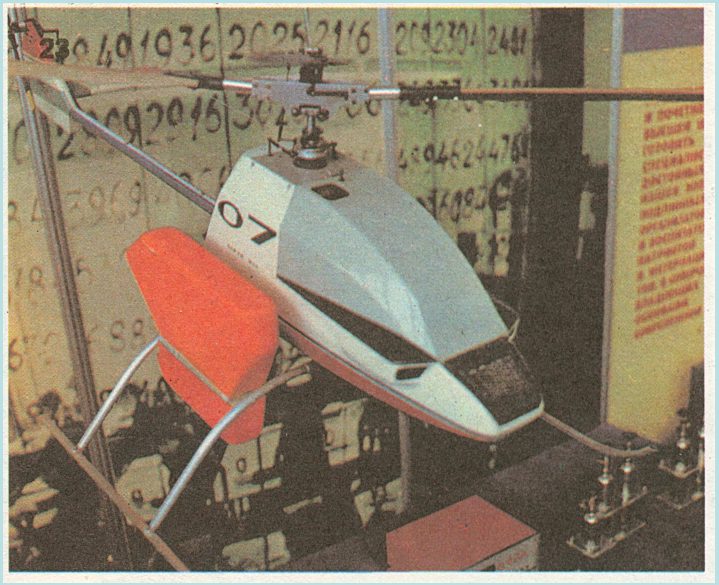

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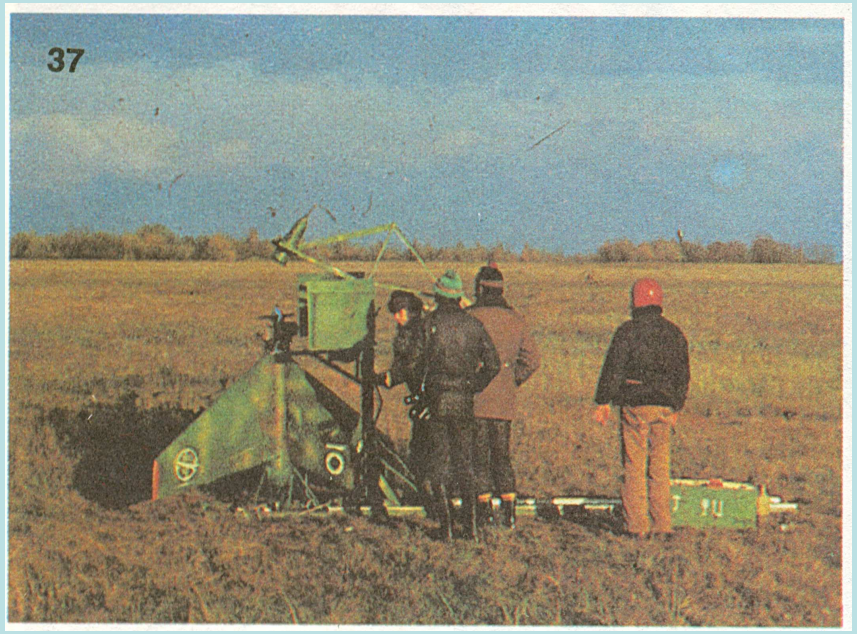

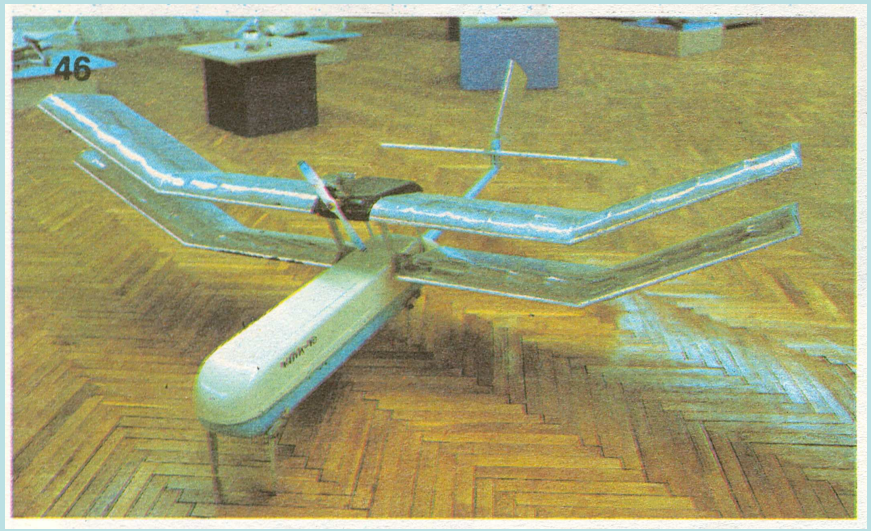

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Comparison of several European aviation universities

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Comparison of European aviation universities was implemented by using the following indicators

- **Main targets and outcomes of Aircraft Design education.**
- **Main places of alumni employment.**
- **Comparison of learned subjects.**

Main targets and outcomes of Aircraft Design education in Various European Universities

- ***Airplane Design Department, Aviation Engineering Faculty, Moscow Aviation Institute (Russia):***
  - To provide the qualification of alumni, which is required for their activity at the appropriate departments of Aircraft design firms (Conceptual Design Department, Preliminary Design Department and Detail Design Department, etc.).

Main targets and outcomes of Aircraft Design education in Various European Universities

- ***Department of Aerospace Engineering, School of Engineering, Cranfield University (UK):***
  - To enable the students to enter a wide range of aerospace and related activities concerned with the design of flying vehicles such as aircraft, missiles, airships, and spacecraft.
  - The students will be able to demonstrate the implementation of the principles of aerospace design related to aircraft performance, structures, and systems, appropriate methods and techniques.

Main places of alumni employment

- ***Aviation Engineering Faculty, Moscow Aviation Institute (Russia):***
  - Aircraft design firms of Russian Aviation Industry (Airplane Design Firms (Sukhoi, Mikoyan, Tupolev, Ilyushin, Yakovlev, Myasishchev, Beriev), Helicopter Design Firms (Mil, Kamov), Aircraft Subsystems Design Firms),
  - Research and testing centers of Russian Aviation Industry (Zhukovsky Central Aerodynamics Institute (TsAGI), Gromov Flight-Research Institute (LII), State Research Institute of Aviation System (GosNIIAS) and so on),
  - Research and testing centers of Civil Aviation;
  - Batch production factories of Russian Aviation Industry,
  - Airline companies,
  - State aviation offices (Air Transport Department, etc.),
  - Air Forces (Research and testing centers, etc.),
  - Doctorate PhD Programs.

Main places of alumni employment

•Department of Aerospace Engineering, School of Engineering, Cranfield University (UK):

- BAE Systems,
- Airbus (UK and Europe),
- Dassault,
- Messier Dowty,
- Royal Air Force,
- Royal Australian Air Force,
- Royal New Zealand Air Force,
- Greek Air Force,
- Doctorate PhD Programs,
- FLS Aerospace,
- Canadian Air Force,
- Rolls Royce,
- STRAND Engineering,
- Magellan Aerospace,
- Marshall Aerospace,
- UK MoD,
- Air France Engineering,
- Air France Pilot,
- MEDYSYS.

Main places of alumni employment

- Hamburg University of Applied Sciences (Germany):
  - AIRBUS Deutschland,
  - Lufthansa Technik,
  - EADS (Eurofighter, Eurocopter, Astrium),
  - MTU,
  - Rolls Royce Aero Engines,
  - DLR, IABG,
  - Bundesamt fur Wehrtechnik und Beschafung,
  - Luftfahrtbundesamt,
  - Suppliers,
  - Engineering offices.

Main places of alumni employment

- **DEPARTMENT OF MECHANICAL AND AERONAUTICAL ENGINEERING, UNIVERSITY OF PATRAS (Greece)**
  - Hellenic Aerospace Industry (big maintenance center, with limited production of aircraft components) requires about 10-12 eng. / year,
  - Greek airliners (about 10 eng / year),
  - Greek Air-force (about 10 eng / year),
  - .. and Europe is an open market.

List of Subject Blocks for Comparison (in credit points)

- Mathematics and Computing,
- Physics and Mechanics,
- Chemistry and Engineering Materials/Machining,
- Engineering Drawing and CAD/CAM Systems,
- Machine Elements,
- Aeromechanics,
- Propulsion Systems,
- Aircraft Manufacturing,
- Solid Mechanics and Aircraft Structure (Aircraft Structural Mechanics),
- Understanding and Design of Aircraft Structure,
- Avionics,
- Aircraft System Engineering,
- Operation of Aircraft,
- Airworthiness,
- Aircraft Design.

Comparison of Subjects
Mathematics and Computing Block

Departments, Universities	Mathematics	Computing
Airplane Design Department, Moscow Aviation Institute, Russia (Engineer)	24 cp	4 cp
	28 cp	
Department of Aircraft and Ships, Budapest University of Technology and Economics, Hungary (BS)	23 cp	7 cp
	30 cp	
Department of Automotive and Aeronautical Engineering, Hamburg University of Applied Sciences, Germany (MS)	16 cp	

Comparison of Subjects
Physics and Mechanics Block

Departments, Universities	Physics	Mechanics
Airplane Design Department, Moscow Aviation Institute, Russia (Engineer)	14 cp	10 cp
Department of Aircraft and Ships, Budapest University of Technology and Economics, Hungary (BS)	14 cp	26 cp
Department of Automotive and Aeronautical Engineering, Hamburg University of Applied Sciences, Germany (MS)	17 cp	22 cp

Comparison of Subjects Chemistry, Engineering Materials/Machining, Engineering Drawing and CAD/CAM Systems, Machine Elements Blocks

Departments, Universities	Che-mistry	Engineering Materials/Machining	Engineering Drawing and CAD/CAM Systems	Machine Elements
Airplane Design Department, Moscow Aviation Institute, Russia (Engineer)	3 cp	12 cp	21 cp	8 cp
	44 cp			
Department of Aircraft and Ships, Budapest University of Technology and Economics, Hungary (BS)	4 cp	11 cp	8 cp	11 cp
	34 cp			
Department of Automotive and Aeronautical Engineering, Hamburg University of Applied Sciences, Germany (MS)	35 cp			

Comparison of Subjects Aeromechanics, Propulsion Systems, Avionics, Aircraft System Engineering Blocks

Departments, Universities	Aerody-namics	Mech. of Flight	Propul. Systems	Avio-nics	A/C System Eng.
Airplane Design Department, Moscow Aviation Institute, Russia	6 cp	6 cp	7 cp	6 cp	8 cp
	33 cp				
Department of Aircraft and Ships, Budapest University of Technology and Economics, Hungary (BS)	3 cp	5 cp	10 cp	2 cp	3 cp
	23 cp				
Department of Automotive and Aeronautical Engineering, Hamburg University of Applied Sciences, Germany (MS)	28 cp				

Comparison of Subjects

Aircraft Manufacturing, Solid Mechanics and Aircraft Structure (Aircraft Structural Mechanics), Understanding and Design of Aircraft Structure, Operation of Aircraft, Airworthiness, and Aircraft Design Blocks

Departments, Universities	A/C Manuf.	Solid Mec. and A/C Struc.	Und. and Des. of A/C Struc.	Ope-ra-tion of A/C	Air-wor-thi-ness	Air-craft Design
Airplane Design Department, Moscow Aviation Institute, Russia (Engineer)	11 cp	19 cp	34 cp	4 cp	3 cp	5 cp
	76 cp					
Department of Aircraft and Ships, Budapest University of Technology and Economics, Hungary (BS)		5 cp		5 cp	3 cp	2 cp
	15 cp					
Department of Automotive and Aeronautical Engineering, Hamburg University of Applied Sciences, Germany (MS)	48 cp					

Conclusions

- Such comparative analysis of various Systems of Aircraft Design Education can be useful for:
  - Aviation universities (for positioning their placement within the community of European aerospace universities, searching for ways of education improvement, searching for contacts and making exchanges, etc.);
  - University entrants and students (for the selection of field of their education);
  - Employers (staffing and searching for partners in universities for collaboration in the fields of personnel training and research);
  - State offices (forming educational strategy, selection of directions and priorities in the field of supporting of regional and national education systems).

- Analysis of educational innovations, which were recently adopted in some European universities, shows that similar innovations were used in other universities and countries. These facts confirm and emphasize the necessity of interexchanging the experience between European universities. Such exchange can help improving the effectiveness of their educational activity thus advancing the European Aviation Industry.

Thank you!

Please, questions?