The VUT 100/200 general aviation aircraft family: project and realization

A Pistek and **R Popela***
Institute of Aerospace Engineering, Brno University of Technology, Brno, Czech Republic

The manuscript was received on 15 June 2006 and was accepted after revision for publication on 22 November 2006.

DOI: 10.1243/09544100JAERO126

Abstract: The VUT 100 'Cobra' general aviation aircraft project, as a unique example of functional technology transfer from university research to industrial application and vice versa, is described. New design challenges and their educational impact on the skill level of students and teaching staff at the Institute of Aerospace Engineering are also discussed. Finally, the current state of the project and its future milestones have been mentioned.

Keywords: general aviation, training aircraft, aerospace engineering, education, VUT100, aircraft design

1 INTRODUCTION

New requirements on pilot training according to JAR-FCL regulations require a new conception of aircraft for pilot training, especially for the early stage, till the level of business pilot. Decisive in this respect is the achievement of regulation principles required, as well as low operation costs. After 1980's deep drops of sales in general aviation (GA) aircraft category, the market became again viable and opened to new approaches to fulfil increasing demands on technical level of aircraft for pilot training and duty flying. All these aspects lead to the new project – VUT 100.

2 PROJECT HISTORY

The roots of the project begin from the early 1990s, when a new concept of training aircraft Z-90 was designed by the team led by the chief designer Pistek. The project was not realized, but mock-up of the aircraft was exhibited at Paris Air Show in 1991. Owing to the financial situation and changes in Czech aerospace industry structure during 1990s, new ultra-light version, based on experience from the Z-90 project, was designed. From the early beginning, this project was led by the Institute of Aerospace Engineering (Brno University of Technology) and realized in cooperation with KAPPA 77 Inc. Company. Till these days, about 150 pieces of KP-2U planes were produced and their flying qualities were proved, for example, by stage flight from Brno (Czech Republic) to Luxor (Egypt). Lots of new concepts for GA aircraft design were verified on KP-2U in smaller scales (aerodynamic conception and structural solutions for VUT 100 aircraft) (Fig. 1) and also a wide cooperation between academic and industry institutions was established.

3 VUT 100 PROJECT

VUT 100 was a new project coming from the Institute of Aerospace Engineering. The team established and led by the chief designer Pistek, Director of Institute, started to work on the project in the late months of 2001. The project was supported and widely funded by the Ministry of Industry and Trade of Czech Republic. From the early beginning of the project, there was planned wide cooperation with Czech aircraft industry. The project brought real aircraft design challenge to academic institution and the great opportunity for teaching staff, PhD students, and even for master degree students to increase their design skills above the casual level.

**Corresponding author: Institute of Aerospace Engineering, Brno University of Technology, Technicka 2896/2, Brno 616 69, Czech Republic. email: popela.r@fme.vutbr.cz*

Fig. 1 KP-2U ultra-light aircraft

Fig. 2 VUT 100 'Cobra' in flight

4 VUT 100 TECHNICAL DESCRIPTION

The VUT 100 (Fig. 2) was designed as a new generation of four-to-five seat aircraft, designed under JAR-23/FAR-23 regulations. It is light, multi-purpose, single engine, all-metal low-wing aircraft with retractable tricycle landing gear. The aircraft was designed primarily for basic and advanced training of private and military pilots, night and instrument flight training, with extended possible usage to commercial, tourism and sport flying, aerotowing, and other special purposes. The design involved the complete family of aircraft (single engine/double engine versions, training, aerobatic, and other versions), with large technological heredity of main structural parts. The initial single engine training model with Lycoming IO-360A engine is now entering certification process.

The following table shows the basic VUT 100 COBRA specification data.

Model	VUT100-120i	VUT100-131i
General dimensions		
Length	26.3 ft (8 m)	
Wing span	33.5 ft (10.2 m)	
Internal dimension		
Cabin length	122 in (3.1 m)	
Cabin width	51.5 in (1.31 m)	
Cabin height	48 in (1.22 m)	
Seats	4	
Powerplant		
Engine	Lycoming IO-360-A1B6	Lycoming IO-580-B1A
Power	200 hp	315 hp
Propeller	mt-propeller MTV-12	mt-propeller MTV-9
Diameter	72 in (183 cm)	77 in (195 cm)
Type	Three blade, constant speed	
Weights		
Maximum take-off	2930 lb (1330 kg)	3200 lb (1450 kg)
Useful load	1105 lb (500 kg)	1260 lb (570 kg)
Fuel – usable	90 US galls (340 l)	
Load factors	+3.8 − 1.52 g (normal category airplane)/ +4.4 − 1.76 g (utility category airplane)	
Performance		
Maximum level of speed	155 kts (287 km/h)	175 kts (324 km/h)
Maximum rate of climb	1000 fpm (5 m/s)	
Stall speed	50 kts (93 km)	55 kts (103 km)
Range	1080 nm (2000 km)	1000 nm (1830 km)
Endurance	8 h	6 h

5 ORGANIZATION OF PROJECT

During the project solution, functional organizational structure was established (Fig. 3). The Institute of Aerospace Design as a project leader tightly cooperated with Evektor Inc., a future producer of aircraft, the design organization approval (DOA) holder, and with Technometra Radotin Inc., subcontractor for landing gear production, the DOA and production organization approval (POA) holder, given by Civil Aviation Authority (CAA). The overall project was continually monitored and audited by the Ministry of Industry and Trade.

The overall asset of the VUT 100 project at educational sphere involves students and also institute's staff design skill level growth at many different areas of aircraft design.

Many master's degree students gained real experience in many fields of aircraft design during their work on diploma theses based on the VUT 100 project. Under the leadership of institute staff aspects of aerodynamic, structural and also system integration design were solved in the frame of theses [**1–4**]. At the more detailed level, in the frame of PhD theses preparation, solution to crucial aerodynamic design problems, structural design and landing gear design problems, and fatigue and reliability were solved by doctoral programme students. The aerofoil selection, aerodynamic layout, control surfaces sizing, aerodynamic characteristics and aerostatic loads calculations, manoeuvring and stability analyses, stall behaviour prediction based on computational fluid dynamics (CFD) calculations, and complete design and optimization of new single slotted flap using CFD tools are the main contributions to project coming from the aerodynamics branch at the Institute of Aerospace Engineering [**5**]. The complete finite element method (FEM) non-linear static analyses of main and nose landing gear [**6**, **7**] and the dynamic FEM analysis of pilot and passenger seats [**8**] were done by structural branch. The aeroelasticity certification issues will be solved in the near future. Detailed dependability analyses for aircraft systems were also prepared [**9**, **10**]. The main results should be seen in high level of real-life design problems, which were solved. And also the quality level of analyses for the GA aircraft design was increased by modern design tools incorporated, such as CFD and advanced FEM methods.

Also, the teaching staff of the Institute of Aerospace Engineering gained great experience during work on the real, industry focused project. Mainly, the experience with certification issues solved during the project till now is really valuable. All the new professional experience gained through the VUT 100 project highly increased the staff teaching potential and lectures quality.

6 CURRENT STATE OF PROJECT

At the early stages of the project, during the conceptual and the preliminary design, the main workload was focused on aerodynamic and loads calculations. At this stage, a lot of new approaches and research tasks were solved. The modern methods, such as CFD tools for aerodynamic analyses, were used (Fig. 4).

The great milestone in the project was maiden flight of VUT 100 aircraft during November 2004. The role of the Institute of Aerospace Engineering is now shifting from design to testing. All structural tests of VUT 100 will be carried by the institute testbed. Till mid-2006, the basic tests of the wing and its parts were finished. As seen from the development schedule in Fig. 5, during the year 2006, huge in-flight testing has been conducted and first prototypes are prepared for certification process.

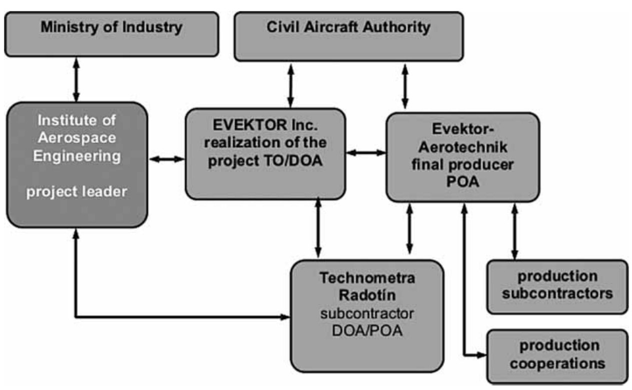

Fig. 3 Organizational structure of project. Educational impact of project

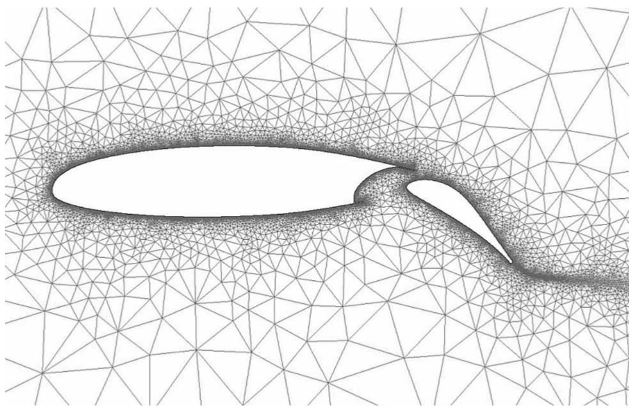

Fig. 4 CFD mesh for slotted flap position and shape optimization

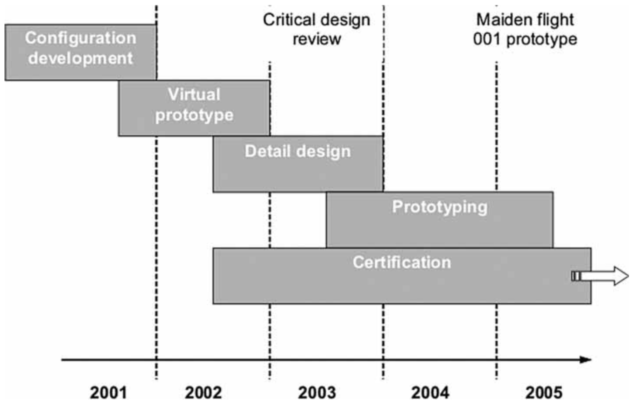

Fig. 5 Development schedule

7 CONCLUSIONS

The VUT100 project is a unique example of technology transfer from university to industry and vice versa. The VUT 100 airplane, now under the commercial name 'Cobra', was designed by the team led by the chief-designer Pistek [**5**, **11**] and then, with a large support of the Ministry of Industry, realized in Evektor Inc. Company. During the time of the project duration, at its different stages, many students (both masters and PhD) gained experience in real-life design problems. In addition, additional experience, such as technical communication, project organization, financial issues, certification requirements, and marketing, had increased the skill level of the institute staff.

Fig. 6 Finally in smooth flight

REFERENCES

1 **Zikmund, P.** *Aerodynamic optimization of VUT100 Cobra aircraft for maximum speed*. Master's Thesis, Institute of Aerospace Engineering, Brno University of Technology, 2006.

2 **Hlinka, J.** *Two engine aircraft family VUT200 study*. Master's Thesis, Institute of Aerospace Engineering, Brno University of Technology, 2004.

3 **Kudela, P.** *VUT100 aircraft wing structure durability analysis*. Master's Thesis, Institute of Aerospace Engineering, Brno University of Technology, 2003.

4 **Teichl, J.** *VUT100 aircraft stability and control analysis – AAA system application*. Master's Thesis, Institute of Aerospace Engineering, Brno University of Technology, 2002.

5 **Pistek, A.** ***et al.*** *Support of new generation aircraft design – VUT100 conceptual and preliminary design stage*. Final report, project funded by Ministry of Industry of Czech Republic, Brno University of Technology, 2000.

6 **Pistek, A.** and **Plhal, M.** The influence of material and geometric non-linearities to accuracy of FEM stress analysis of landing gear. ICAS 2004 Proceedings, Yokohama, Japan, 2004.

7 **Plhal, M.** *Calculating a landing facility considering the materials and geometric non-linearity*. PhD Thesis, Brno University of Technology, 2004.

8 **Splichal, J.** Dynamic analysis of aircraft seat according to FAR/JAR 23 regulation. 4th Youth Symposium on Experimental Solid Mechanics, Castrocaro Terme, Italy, 2005.

9 **Hlinka, J.** *Evaluation of dependability and safety of VUT100 aircraft electrical system*. EVUT 004.03-SY report, Brno University of Technology, 2004.

10 **Hlinka, J.** *Methods for evaluation of aircraft dependability*. PhD Thesis, Brno University of Technology, 2004.

11 **Pistek, A.** Development of new generation general aviation aircraft. Congress proceedings, 11th Australian International Aerospace Congress, Melbourne, 2005. Paper reference number WC0174.

BIBLIOGRAPHY

Aerokurier 2/2006 Magazine – Flugzeug-Report: VUT100 Cobra, 2006 (ISSN 0341-1281).

Eveckor – Aerotechnik plc. Available from http://www.evektor.cz/vut100/index.asp, the final producer, internet page describing technical data of airplane.

Jackson, P., Peacock, L., and **Munson, K.** (Eds) Technical description of aircraft VUT 100 Cobra. In *Jane's all the world's aircraft 2006/2007*, 2006 (Jane's Information Group).

Pistek, A. and **Popela, R.** The VUT 100/200 GA aircraft family: project and realisation. 7th European Workshop on Aircraft Design Education (EWADE 2005), Toulouse, France, 2005, presentation available from http://www.aircraftdesign.org.