ACTIVITIES OF A UNIVERSITY BASED AIRCRAFT DESIGN CONSORTIUM IN EUROPE

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Abstract

In 1989, the Department of Aerospace Engineering at Glasgow University began discussions with the Aircraft Engineering department of the Czech Technical University in Prague (CVUT), in what was Czechoslovakia, with a view to establishing a formal collaboration. These discussions led, in late 1990, to the establishment of a university based design consortium within the E.C. TEMPUS framework. This paper describes the activities of this consortium and, in particular, two aircraft design projects, designated TP-11 and TP-41, which provided the focus for design related work. TP-11 was conceived by CVUT Prague as a test platform for student project work such as in-flight experiments courses. The versatility of the aircraft is such, however, that it has potential for the home-build recreational market. TP-41, on the other hand, is a more sophisticated economic multipurpose aircraft which can be configured for either two or four-seat operation. It is aimed at applications such as business, training and recreational flying. This paper describes the current state of progress on these two aircraft projects and discusses options for their future development.

Introduction

In 1989, the Department of Aerospace Engineering at Glasgow University began discussions with the Aircraft Engineering department in the Technical University of Prague (CVUT), in what was Czechoslovakia, with a view to establishing a formal collaboration. These discussions led, in late 1989, to the submission of a proposal within the E.C. TEMPUS framework to create a European Design Consortium in Higher Education. The principle aims of this consortium, which consisted of Glasgow, CVUT and ten other partners, were the introduction of new technology to the teaching of Aerospace Engineering within the Czech Republic and the establishment of a permanent collaborative East-West framework in Aerospace Engineering education. In December 1990 the project was awarded a three-year TEMPUS grant by the European Community. During the three years of the project, the size of the consortium was increased to sixteen partners including the Department of Aircraft Engineering at the Technical University of Brno (VUT) in the Czech Republic. The profile of the consortium is shown in Fig. 1.

Prior to the formation of the Aircraft Design Consortium, the teaching of aerospace engineering in the Czech Republic concentrated very much on the fundamental theory of aircraft design. The limitations imposed by the technology available at University level restricted the practical application of this theory considerably. Additionally, although the Universities provided graduates for the Czech aircraft industry, no framework existed for formal collaboration on design projects. Consequently, the technology transfer from education to industry and vice-versa was poor. One direct effect of this was a very slow evolution of curricula associated with aircraft design.

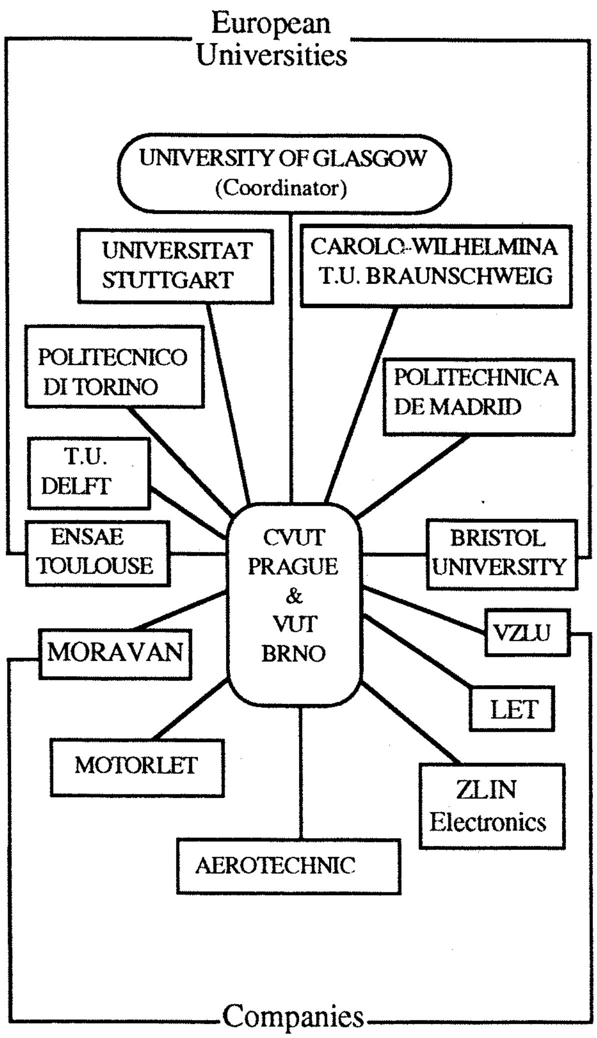


FIGURE 1. Profile of the aircraft design consortium.

The TEMPUS project went a long way to addressing these fundamental problems(1,2,3). In particular, through TEMPUS it was possible to introduce advanced laboratory facilities which provided the basis for enhanced practical design activities within the two Universities. For example, computer assisted design courses in aerodynamics, structures and performance now exist for students in the last two years of undergraduate study. These courses rely heavily on software packages purchased under TEMPUS such as FLUENT and FLOTRAN for fluid dynamic analysis and PATRAN, NASTRAN and ANSYS for structural analysis. Additionally, at CVUT Prague, a new course on aerodynamic design has been established. This course is again aimed at students in the penultimate or final year of undergraduate study and has been developed along the lines of similar courses taught in western institutions. At VUT Brno, through co-operation with partner enterprises, it was possible to establish an In-Flight experiments course. Courses such as this, which involve students in flight testing aspects of aircraft, are normal in the West and are often mandatory for accreditation purposes. The effect of these changes has been such that, at VUT Brno, the aircraft department has now been given the status of an Institute and provides a design and consultancy service for the Czech aircraft industry. This environment is ideal for the development of a new breed of graduate who is fully conversant with modern design practises.

In terms of establishing links between Czech industry and the Universities, the project has been particularly successful. As indicated above, VUT Brno now interacts directly with industry and, to a lesser extent, so does the aircraft department at CVUT Prague. Also, the two aircraft departments are now engaged in collaborative activities and have established very strong inter-university links.

To support the main aims of the Consortium, Czech academic staff participated in training programmes hosted by European universities in key aircraft design disciplines including, aerodynamics, structures and systems. In this training process the emphasis was on new technologies and teaching methods. Staff placements in participating enterprises were also arranged with a view to retraining in current design practices. It was envisaged that the most effective way to co-ordinate and develop these activities would be to focus them on a particular design project. For this reason, it was agreed that all project work would be aimed at the design and construction of a prototype light aircraft designated TP-11. This aircraft was based on a previous design developed at CVUT but was to incorporate and benefit from the technological input from the Western European partners. Originally, it was hoped that the prototype aircraft could be designed and manufactured within the project budget and time scale. Unfortunately, for a number of reasons, this proved to be impossible and, although steady progress was made, the prototype has yet to be built.

When the Department of Aircraft Engineering at the Technical University of Brno joined the project, it seemed appropriate to extend the scope of activities to encompass an additional design project centred in Brno. Initial configurational studies of a four-seater light aircraft had already been initiated by staff and students at VUT prior to joining the TEMPUS consortium and so this provided the logical focus for design activities at Brno. As a result of the TEMPUS programme, the theoretical development of this aircraft, designated TP-41, is now at a very advanced stage although there are no plans, at present, to build the aircraft.

Although the Consortium became involved in several other design projects, including a solar powered aircraft and a world class glider, the majority of effort was directed towards TP-11 and TP-41. The configuration and design specifications of both of these aircraft are discussed in the following sections.

TP 41

The TP-41 is an economic multipurpose aircraft which can be configured for either two or four-seat operation[4]. It is aimed at applications such as business, training and recreational flying. The aircraft was developed at the Institute of Aerospace Engineering, VUT Brno, and at present exists as an advanced conceptual design.

In the initial stages of development, a market survey was undertaken to assess the viability of the aircraft. This study drew heavily on research carried out by the Czech aircraft industry and similar studies conducted in Germany, the U.K., Canada and the U.S. By aiming the aircraft at the N (normal) and U (utility) categories of the FAR23 regulations, the potential for around 2100 units per annum, covering applications such as recreation, business, post and cargo, training and surveillance, was identified. Approximately 8% of this annum requirement is derived from the internal market in the Czech Republic.

The N category variant can be characterised as a low-wing, all-metal, four-seat aeroplane for business and tourist applications. The aircraft, which has a maximum take-off weight of around 950kg and a maximum payload of 350kg, is illustrated in Fig. 2. Its wing is an all-metal, self-supporting, double-spar (35% and 70% chord), structure which is divided into a trapezoidal outboard and a rectangular inboard section. The wing skin is made from duralamin sheets covered by an aluminium protective layer. The wing design includes integral fuel tanks which are located in the front part of the outer wing sections. A slotted flap, which can be deflected to 20^{o} on take-off and 40^{o} on landing is located on outboard sections of the wing while hinged inner flaps are preferred. These inboard flaps are only used during landing when they are deflected to 40^{o} with the main flaps.

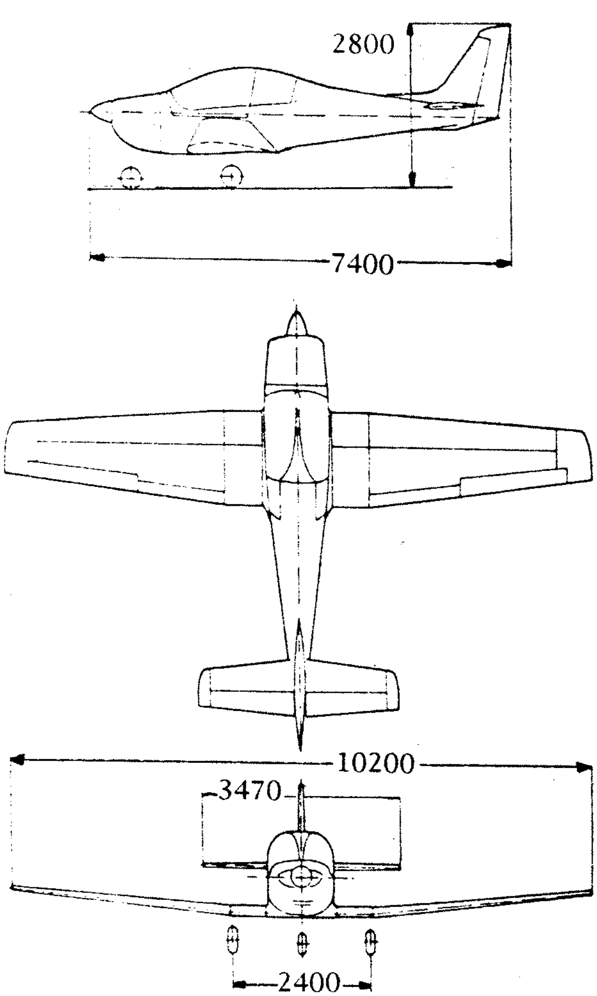


FIGURE 2. Three view drawing of TP-41 aircraft.

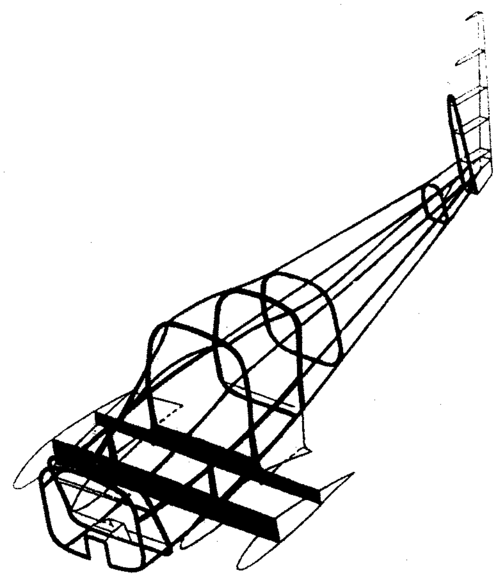
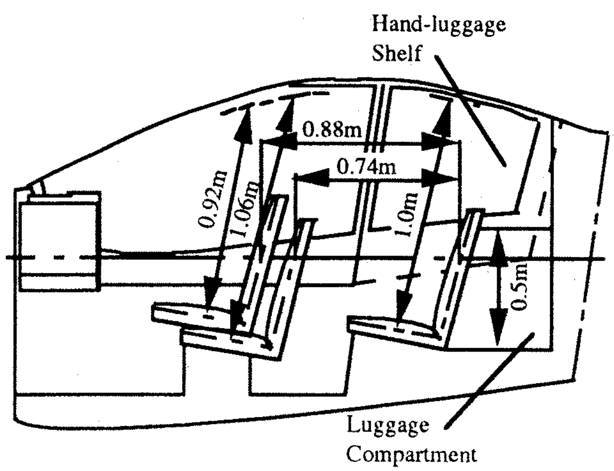


FIGURE 3. Main structural elements of the TP-41 fuselage



'FIGURE 4. Four-seater cockpit arrangement of TP-41.

The fuselage is of similar construction to the wing and is again all-metal. Figure 3 shows the location of the fuselage support structure and the integrated central wing section. Access to the cockpit is via doors hinged on the central column of the canopy frame. The cockpit itself, shown in Fig. 4., is designed for good visibility and, in the four seater configuration, has two adjustable front seats and bench type seats in the rear. Luggage can be stored either on the rear shelf or in a compartment located behind the rear seats. This compartment is accessible from within the cabin or via a side door in the fuselage.

Control systems in the aircraft are of classical design using rigid rod transmission from the stick and pedals in the cockpit. Twin channel aileron, elevator and rudder controls and single channel landing flap, engine, propeller, longitudinal and directional trim controls are provided. The aircraft also incorporates a fixed tricycle nose-wheel type undercarriage which is controlled from the cockpit. The design is also suitable for a retractable undercarriage.

Several powerplants were considered for the aircraft but the preferred option is the four-cylinder, four stroke, air-cooled Textron Lycoming model O-320-E2A which has a maximum sustainable power of 140hp. This unit is combined with a two-bladed constant-speed propeller which was specifically designed for TP-41 at the Institute of Aerospace Engineering at Brno. Preliminary performance figures for the aircraft are shown in Table 1 below.

Maximum level speed	280km/h
Cruising speed (75%)	230km/h
Stalling speed: flaps up flaps down	 96.8km/h 85.0km/h
Max. rate of climb	4.9m/s
Endurance (+45' reserve)	5h 29min
Range (+45' reserve)	1100km
Take-off distance to 15m	500m
Landing distance from 15m	423m

TABLE 1. Preliminary performance estimates for TP-41

At present, the TP-41 design study has encompassed a weight analysis, a detailed aerodynamic study, detailed analysis of loading according to FAR23 regulations, preliminary structural component design and a cost analysis. In the cost analysis, it is assumed that the aircraft will be built in the Czech Republic where labour costs are low. On this basis, the cost of development, including certification, has been estimated at 2.9 million U.S. dollars. This figure, when set against a unit sale price of 100 000 US dollars, leads to a projected break-even point being reached approximately four years from initiation of product development. This is shown in Fig. 5. where the projected cumulative profit is plotted against calendar year and production units.

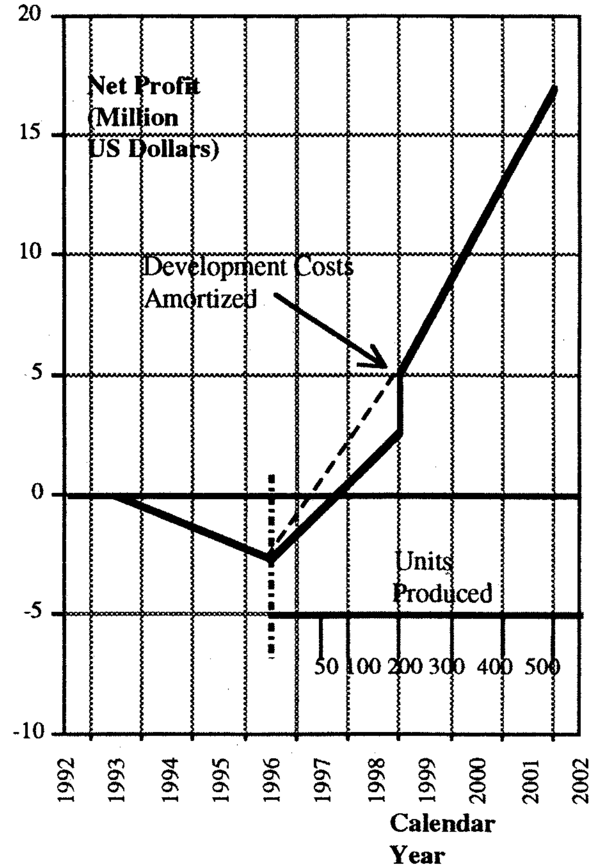


FIGURE 5. Projected cumulative revenue on TP-41 as a production aircraft.

TP-11

The TP-11 aircraft, shown in Fig. 6., is a moderate aspect ratio, high wing, two-seat monoplane with a conventional tail. It has a rugged tricycle undercarriage and a 110-150Hp engine driving a moderate diameter three-bladed pusher propeller. A tubular steel space frame is used to provide a robust front fuselage with extensive cockpit glazing and thus, high levels of pilot visibility. Several options were considered for the wing construction but, due to financial and technological limitations, it was anticipated that the first prototype would have a conventional metal wing. All other stressed parts of the aircraft would be constructed from metal. Ultimately, however, it was hoped that the final design would make extensive use of carbon fibre and that the majority of the aircraft's structure could be vacuum formed. For a production version, this would result in a reduced manufacture time and lower labour costs.

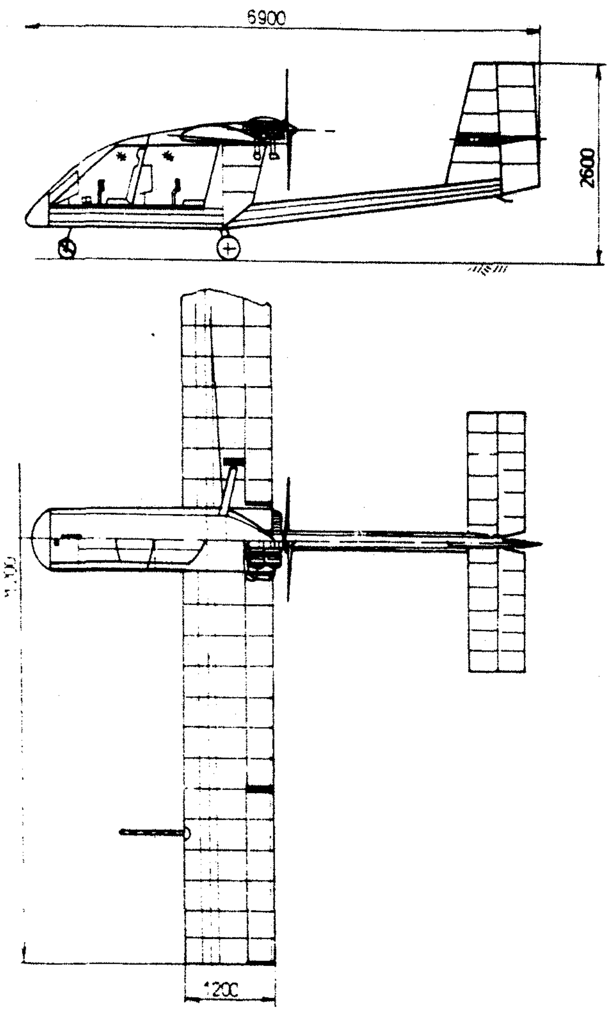


FIGURE 6. TP-11 aircraft

Initially, TP-11 was conceived by the Aircraft Engineering Department at CVUT Prague as a flight test vehicle for student project work. As such, the TP-11 aircraft represented a technologically enhanced version of a previous design which had been manufactured and flown by VZLU prior to the TEMPUS project. As the project developed, however, it became apparent that the TP-11 design could be marketable for a variety of applications including training, agriculture, surveillance and recreation. Of these, recreational flying appeared to be the most likely market area for the aircraft. In particular, the FAA has established certification requirements for very light aircraft (VLA) under 750kg maximum take-off weight. This means that a new category for hand built sport recreation aircraft is being allowed. It is likely that a consequence of this will be improved sales of kit-build composite aircraft. The TP-11 design is an ideal candidate for this market particularly if the aircraft ultimately makes extensive use of composite materials.

At this stage, several beneficial features of the aircraft have been identified including certain performance benefits. The flight envelope of the vehicle is illustrated in Fig. 7. where it may be noted that, although the aircraft has a respectable cruise speed, it has the capability of very slow flying. Additionally, TP-11 is very manoeuvrable at low speeds and can produce a reasonable rate of climb. These performance features, coupled with low operating costs, excellent visibility and a STOL capability, all enhance the aircraft's appeal.

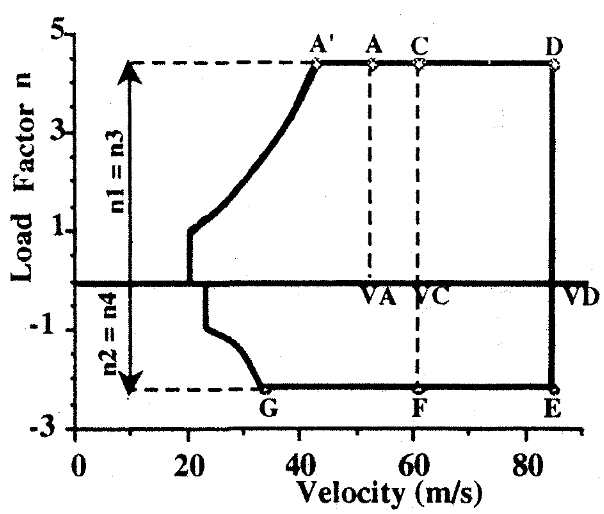


FIGURE 7. TP-11 Flight Envelope

During the TEMPUS project, substantial progress was made on the development of the vehicle. The main activity centred on the aerodynamic design of the airframe and, in particular, the choice of wing section. A series of wind tunnel tests[5] were conducted at the Aeronautical Research and Test Institute (VZLU) in Prague to assess the performance of aerofoil profiles for use on the main wing of TP-11. The tests were conducted in the Institute's 1.8m low speed wind tunnel which is of classical Eiffel design and was built in 1927. As a consequence of these tests the SM701 aerofoil, which is a 16% thick section originally designed for use on world class gliders, was selected for TP-11. Additional tests were also conducted on a three-dimensional model of the full aircraft to assess its likely performance. The results of these tests were used to further advance the design study. Indeed, towards the end of the TEMPUS project, limited progress had been made on the construction of a prototype. Completion of the prototype is largely dependent on the availability of sufficient future funding. Design studies on the aircraft are, however, continuing and new applications are being explored. One such application is the use of TP-11 for amphibious operation. Glasgow University, in collaboration with CVUT, hope to carry out water tank tests in the near future to assess take-off and landing characteristics of the aircraft under these conditions.

Concluding Remarks

The TEMPUS initiative has provided substantial funds to re-generate teaching facilities in the two Czech Universities. It has provided new computer suites at both CVUT Prague and VUT Brno along with laboratory equipment for the teaching of design, aerodynamics, structures and materials. As indicated in the introduction, the consortium has also helped the Aircraft Department at Brno to become the first university based Aerospace Engineering Institute in the Czech Republic. These achievements are tangible signs of the short-term success of the project but long-term success is more difficult to quantify. It is anticipated, however, that the strong collaborative links established between the Czech universities and their Western European partners will continue to develop for many years to come. The aircraft design projects described above represent two of the many activities encompassed by the TEMPUS consortium. These activities helped to produce a cohesive structure for collaboration and contributed substantially to the success of the overall project.

In recognition of the success of the overall project, the E.C. has recently awarded the Consortium limited follow-on funding to maintain and disseminate the results of the original programme. An essential part of these activities will be continued collaboration on the aircraft design projects in the hope that suitable funding can be secured to develop the two aircraft projects further.

Acknowledgements

The authors wish to acknowledge the financial support of the European Community TEMPUS programme (JEP 1179). The authors would also like to acknowledge the contribution of the following consortium partners: Universidad Politechnica de Madrid, T.U. Delft, Universitat Stuttgart, Politecnico di Torino, ENSAE Toulouse, Carolo-Wilhelmina Technical University Braunschweig, University of Bristol, VZLU Prague.

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