SCALED RADIO CONTROLLED PLATFORM

Mihai-Victor PRICOP
INCAS, Numerical Simulation Laboratory, vpricop@incas.ro
Mihai FLORIEAN
INCAS, Numerical Simulation Laboratory, floriean@incas.ro
Georges CRAIOVEANU
INCAS, Aerodynamics Laboratory, gcraioveanu@incas.ro

DOI: 10.13111/2066-8201.2009.1.1.14

Abstract

The paper presents building, preparing and testing of a scaled RC aerial platform, as a basis for future flight measurements. The platform is a 1:6 scaled radio controlled model of AEROTAXI design in development. A number of nine test flights were performed in order to validate the platform as reliable and suitable for dedicate instrumentation. Conclusions regarding the qualitative flight characteristics, shortcomings and future improvements are included.

Introduction

The national funded research program AEROTAXI started in 2004, with an ambitious target: to design a 10 passenger commuter. In 2006 we had the idea to build and fly a 1:6 scale model, to support, encourage and get a feeling of the flying qualities of the full scale development aircraft. The model has been built in the winter 2007-2008. The first configuration was tested in April 2008 and then in May the first flyable one. In 2009 we made some improvements in terms of reliability and safety and gained most of the flying experience, which we find very interesting.

Characteristics

Geometry of the aircraft and further developments were presented in [1], [2]. In order to have a very fast and inexpensive manufacturing, we skipped some model design steps and used elementary rapid prototyping techniques: hot wire cut technique for wing and tail, plastic foam manual shaping, using the talent and skills of our third colleague. The foam cores of the wing and surfaces are balsa covered (1.5 mm) then an adhesive film was applied and ironing was used to enhance the bond with the porous surfaces (balsa and plastic foam).

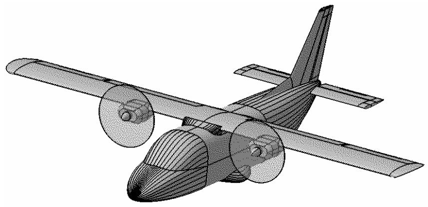

Fig. 1 General view of the configuration

The fuselage has self sustained 20 mm thick plastic foam walls, reinforced with frames and spares in order to attach the landing gear, battery packs, etc. The landing gear is obviously non retractable, having in mind the idea of fast prototyping. The main landing gear fairing is missing. The wing has a spar inserted in the root section, together with a glassing, using two layers of satin fabric at 193 g/mp, with normal alignment. However, the wing is supported by two struts, which are not provided in the full-scale concept. The vertical stabilizer also has a spar inserted, to better connect it to the corresponding bulkhead. The control surfaces are not conforming to the full scale concept with respect to the airfoil, but they have almost the same planar contour and relative size. The most important loss is the missing of the flap slot and corresponding hinge line. Also the ailerons and elevator have the hinge lines on the upper surface.

Fig. 2 Fuselage in the early stage

Fig. 3 The 3rd author is the main builder

The motor nacelles are made using general usage plywood. For shaping the same plastic foam was used, as for the fuselage. Accessories, like control horns, lading gear wheels, cables, connectors, are standard in RC aero-modeling practice.

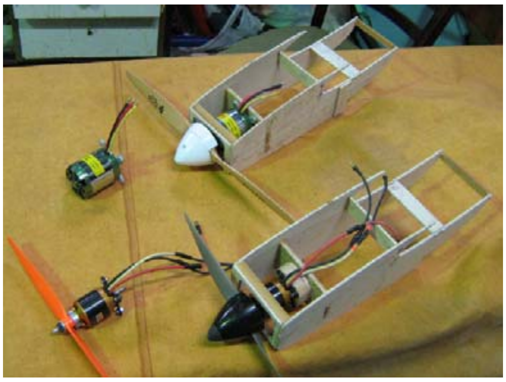

Fig. 4 The nacelles and the two types of considered brushless motors

Propulsion and RC equipment

For the first configuration we used two small Jeti 28-26-10 motors (about 400W maximum power), as a result of a debate and that proved not to be the right decision. In principle, the thrust of two motors with the right propellers should be enough to fly such a model (MTOW about 8 Kg), but the power reserve is too small for our purpose. A really good runway is required to take off. With a similar motor, students managed to fly RC models with a payload of about 7 Kg, in Air Cargo Challenge 2007 – they only need to make a runway tour. So, our first attempt to take off this model, using a not so good field (Chitila RC flying field, near Bucharest) was a failure, but the model escaped undamaged. The next configuration is using different motors, and will be detailed in Table 1Table 1 Propulsion and RC components.

Motors	2 Roxxy 5065-09, 800W continuous power, max. voltage 25V, max. consumption 50A, max. propeller 17x10 in.
ESC – electronic speed controller	2 HiModel 100A Opto, max. voltage corresponding to 6 LiPo cells; it needs 5-6V supply for the signal
Servo	8 Futaba S3003, 3.2-4.1 Kgcm 2 – ailerons, 2 – flap, 2 elevators, 1 – rudder, 1 – nose landing gear
Propulsion packs	2 LiPo 6 cells 4400 mAh
Propellers	APC Elektro 15x10 in
Receiver	Graupner SMC16SCAN, 8 channel – SPCM 1024 bit modulation
Receiver & servo power supply	Powerbox Proffesional 4024; 7 channel; 24 output ports; 5-6V power supply; 2 power input lines
Battery packs for receiver/servo	2 packages of 5 cells NiMH, 4000mAh

Table 1 Propulsion and RC components

Length [mm]	1954
Span [mm]	2560

Table 2 Overall significant dimensions

Wing	3574
Fuselage	6283
Total	9857

Table 3 Mass of the global components [g].

The wing loading is 13.7 Kg/mp, quite large for a normal RC model, but we have found in the literature models in the same class with up to 30 Kg/mp.

The control setup is not the best, but we plan to immediately upgrade it to a reasonable level. The main shortcomings are: single channel ailerons, single channel flaps, single channel elevators and rudder/nose landing gear. While the last is not critical, we must control independently all the control surfaces, in order to fine adjust their end points, neutral positions, etc. Also we don't find useful separate control of the motors. It doesn't add any significant improvement, but complications and risk of operation errors.

Test flying

We have done the first test campaign in the spring of 2008. We learned that the small motors were not practical and changed them. Two good flights were performed at Clinceni airfield. At the second landing, we damaged the nose landing gear, due to a suddenly, cross runway landing. That was due to the bad energy management – the power packs were quite small (half of what we use in 2009) and consumed. At that time we used as a remote control a Futaba FF7, 35MHz and a 9 channel receiver with FM modulation. This configuration it's not safe enough, in the harsh radio environment, so we should use a PCM receiver then not available. From those flights we learned that the model requires a little bit longer runway to take off and a little much longer runway than a normal model. Typically, we need a run of about 30m for takeoff (1.5m obstacle) and an approach and run of more than 150m for landing (10m obstacle). The first flights were setup without any kind of exponential law or mixing in the controls. The flap benefits were not tested. We had only a pair of batteries for two relatively short flights. It was quite obvious that in turns, we need a lot of rudder, because of the strong roll-yaw coupling.

In the summer of 2009, we changed the emitter and receiver to a Graupner MC-22S and SMC16SCAN. Having partially solved the RC safety issue, we used the PowerBox system to have a reliable on board power supply. We kept the same connection setup and performed seven successful flights. We now had the time to play with the exponential weight in the control law, pushed to about 40% for all the aerodynamic channels. We tried to alleviate the roll-yaw effect by using an aileron-rudder mixing from 20 to 35% with little effect. We conclude that we have to fully separate every control surface. The main reason for this strong coupling is the curvature and general behavior of the GA(W)-2 wing airfoil.

The flap was tested both at landing and takeoff. It significantly increases the lift, making the approach somehow more delicate due to an important change in pitching moment.

We used the flap for 3 flights out of 7 and analyzing the onboard movies, we discovered a malfunction for the left servo flap see Fig. 5 That was the explanation for a quite difficult landing.

Aileron efficiency is too high, but this is normal taking in consideration their width of 40% of the wing chord. Elevator and rudder control seem to be sufficiently good. Ground control works also reasonably well and the nose servo is taking a lot of wearing, being not protected with some damping devices in the control rods.

Fig. 5 Difficult landing due to the malfunction of the left flap servo

It is important to mention the quality of the runways we used, in both terms of traffic or ground/obstacles. The first two flights (2008, Clinceni airfield) were performed on an average quality runway, under heavy aerial traffic conditions. The model was getting airborne and landing simultaneously with all kind of ULMs. We were positioned on a grass road near the west end of the airfield.

The first 5 flights in 2009 were performed in the front of Sirna airfield, around a grass road. We found difficult to maintain the model on the road and we experienced heavy deviations both on takeoff and landing.

The 6th flight happened on the beautiful, brand-new asphalt runway of the Romanian Aviation Academy. Our concern was to avoid damaging the new lights along the runway, as well as the model. Some smaller RC models experienced a lot of trouble trying to get airborne from the runway in cross wind conditions. We were quite close to have impact with one light, but eventually took off in good conditions. Landing wasn't an issue.

The 7th and last flight was on the excellent grass runway parallel with the asphalt one and was the smoothest. All the airfields or runways have not permanent obstacles close enough. Here the traffic was nearly stopped, but airfield access is normally forbidden.

We learned in this 7 flights test campaign a series of lessons and we must improve the model:

- More powerful rudder servo and control rod, since we found it broken at the last flight;
- to replace the left flap servo or both with a more powerful, possibly metal gear digital servos;

- to completely separate the control signal for all aerodynamic control servos/channels;
- to find a better solution for receiver plugging as well for the power connectors;
- to make access ports to easily replace the power packs and the measurement equipments;
- to replace the current propeller with larger ones: from 15x10 to 17x10 in;
- to use a damper for the nose landing gear servo – this is almost generalized;

The relevant movie for the asymmetric flap deployment in the landing configuration is here: http://www.youtube.com/watch?v=SfgE8G2Uk2I

The test campaign was possible because of my two RC aero-modeling counterparts: Eng. Florin Duta and Eng. Stefan Mihailescu, my helper.

Fig. 6 Authors before the flight

Fig. 7 Model during a photo pass

Conclusions and future work

Having flown the RC scaled model in a quite successful test campaign, we identified some weak points and we have the chance to fix them. Even we have experienced a strong roll-yaw coupling, we can cope with it, but this is not satisfactorily. Separation of the controls and aileron->differential, flap->elevator and aileron->rudder mixings linear of nonlinear will improve handling qualities and reliability of the model. After this improvement stage we will instrument it with some commercial off the shelf devices, like a Weatronic dual receiver, provided with attitude sensors and GPS, or a more complex EagleTree system including imagery, both as inexpensive onboard packages.

Using a proper airfield/runway is an important issue, so a good quality grass runway we think is the best solution.

Another usage for the model will be to test a new configuration with radically different wing and tail surfaces, see Fig. 8, preserving the fuselage. This time we should not use a "so rapid prototyping" as we need a quite expensive mould, but this is the kind of challenge we like.

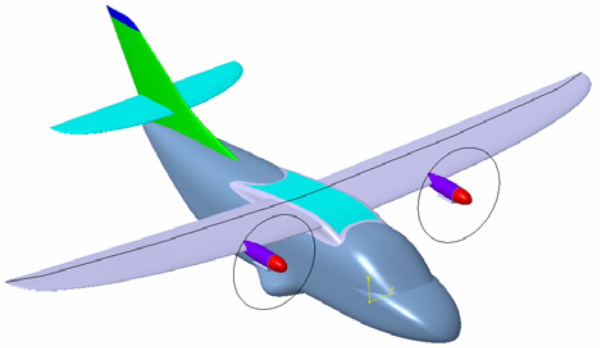

Fig. 8 A new configuration with more advanced aerodynamics

REFERENCES

[1] ***EXEMPLE DE UTILIZARE AVANSATA A SISTEMELOR CAD CU APLICATIE IN PROIECTUL AEROTAXI***, *Dr. Catalin Nae, Ing. Mihai-Victor Pricop, Ing. Iulian Stancu*, CONFERINTA AEROSPATIAL 2005, ISBN 973-0-03993-3

[2] ***AUTOMATIC INITIAL GEOMETRIC MODELING FOR TWO CLASSES OF AIRPLANES***, *Mihai-Victor Pricop, Catalin Nae, Cristian Stanica*, THE 32ND INTERNATIONAL SCIENTIFIC CONFERENCE "MODERN TECHNOLOGIES IN THE XXI CENTURY", BUCHAREST, 1-2 NOVEMBER 2007, ISBN 978-973-640-127-5