AIRCRAFT DESIGN AT LITH, LINKÖPING UNIVERSITY

Patrick ***BERRY***

Department of Mechanical Engineering,Linköping University,58183 Linköping, Sweden
www.liu.se, patbe@ikp.liu.se

Summary:
Aircraft design at LiTH is a comparatively young education; it started in full scale in 1997. The initiative came from Saab and LiTH with Saab personnel from the very start giving a helping hand in building up education as well as creating a positive research environment in aircraft design.
Aircraft Design is a part in Mechanical Design and runs over the 3rd and 4th year. In the 4th year education is centered on an aircraft project. The main goal of the project is to provide means for practical application of theoretical aeronautical knowledge being gathered over the years. The aircraft projects center on designing, building and flying aircraft models of different sizes and for different applications. The students work together covering the whole process of “real” aircraft design, i.e. conceptual design, detail design, analyses, manufacturing and flight testing.
This work has built up lots of knowledge over the years on how to best design, build and fly test model aircraft of different shapes and sizes.
Saab has also showed great interest in the work we’ve been doing. This may in the future result in further Saab sponsored work in UAV/ Micro UAV design, manufacturing and flight testing.
This paper tells more about some of the more recent projects we have produced at the University.

1. Background

Linköping University began teaching aircraft design in 1997. Currently the education covers the two last years in Mechanical Design. In the last half year the students work on a project. The aim of the project is to design and produce a flying object of some sort, thereby combining theory with hands-on practical work. The project finishes up with evaluation by means of test flying.

Since time (and student skill) is limited, only model sized aircraft are considered. This constraint is in reality no set back, since model aircraft design involves many steps in real aircraft design.

2. Student projects

Over the years a number of student designs have evolved. It all started in 1999 with the R/C controlled “Sunrazor”, which was built in the sole purpose to test off if it would possible to design, build and fly a sun powered aircraft of our own design.

The model had an electrically powered motor which ran solely on sun power. The model was able to fly on 15W of sun power only, which means flying was possible on partly cloudy days as well.

Fig. 1 Sunrazor. Sun powered aircraft model flown in 1999

Local Hawk was built in 2000. It was dedicated to flight testing and therefore needed to be quite conventional and straightforward in its layout. The difference between an ordinary model plane and the Local Hawk was essentially the number of control surfaces (the same as on an ordinary aircraft) and the ability to be able to carry flight test equipment and a number of built in sensors. Flight test data was fed into a data logger during flight. After landing the information was unloaded into a lap top for further analyses.

The Local Hawk was battery powered; R/C controlled and had a motor producing 300W.

Fig. 2 Local Hawk. Model built in 2000 for examining flight tests in small scale

The Lucas project of 2001 was built with the same purpose as for the previous Local Hawk, i.e. flight testing. The difference was its more advanced layout due to the built in STEALTH appearance. The aircraft could carry flight test equipment and sensors on board. To enhance the STEALTH and jet-like appearance the motor was an electric driven fan, hidden in the fuselage. Lucas was R/C controlled and had a motor producing 1200W.

Fig. 3 Lucas. Model built in 2001 with STEALTH-like appearance for flight test purposes

In 2002 we tried something very different and went on designing an ornithopter. The ornithopter was electrically powered with a motor rated at 7W, which worked through a gear box to give the 4 Hz flapping frequency required for flight. The model was R/C controlled, weighed 95 g and could carry a small video camera onboard.

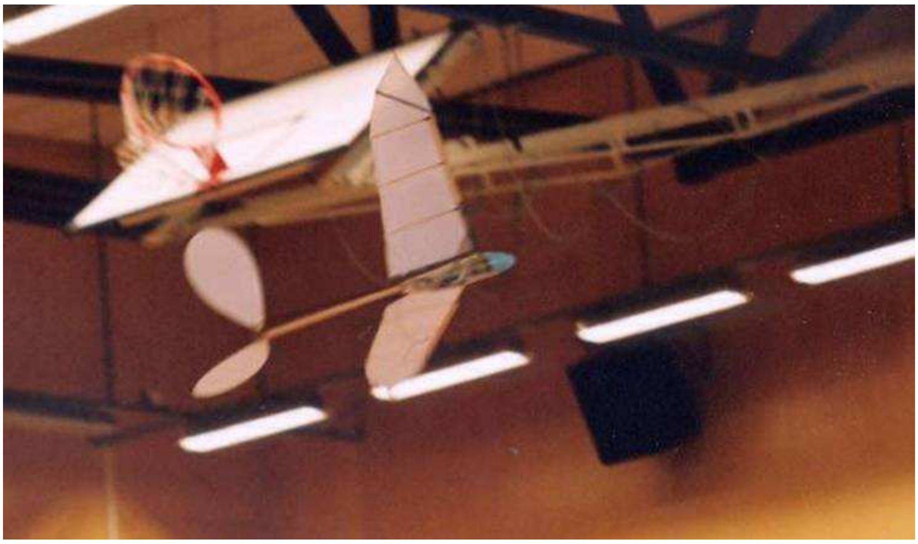

Fig. 4 The Crow. Ornithopter project 2002

Inspired by the previous ornithopter project, the project of 2003 also became an ornithopter which built on the previous experience and the possibility to make the machine even lighter and smaller by using lighter and more effective batteries.

The Woodpecker thus was born and was in fact a scaled down Crow. The motor delivered 3W which made the machine flyable at an all up weight of 46g. The Woodpecker was R/C controlled and was able to carry a video camera onboard.

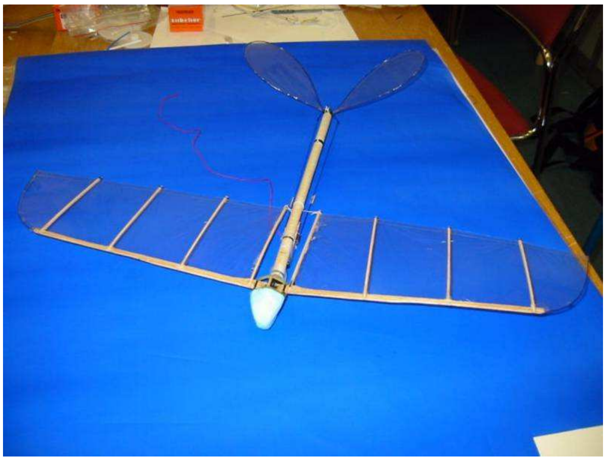

Fig. 5 Woodpecker. Ornithopter project 2003

In 2004 the students worked on a so-called “Backpacker” design. This actually means a R/C controlled electrically powered aircraft used for over the hill reconnaissance. Since it was supposed to be used in a difficult and harsh environment it had to be easy to control, easy to pack, easy to handle, more or less unbreakable and not too sensitive to gust. The payload was a video camera for lap top flight plus a GPS for position control. The aircraft had to be easy to pack by design and was also required to be housed within the measurement of an ordinary lap top case. Two teams worked on the same specification and came out with slightly different solutions. Both were flying wing concepts, due to the package and handling requirements. The Backpacker (2) concept shown in Figure 7 below had a simple and smart solution to the package problem and proved almost unbreakable due to the material chosen. The wing although slightly dense was made in the same material used for child seats in cars. This material is very shock absorbing and forgiving which is proved in Figure 8 below, where a person is able to jumps on it without breaking.

Fig. 6 Backpacker project (1) 2004

Fig. 7 Backpacker project (2) placed on its casing

Fig. 8 Jump test on Backpacker (2) casing

3. Research

Research within the Aircraft Design Group at Linköping University mainly focuses on improving aircraft conceptual design methodology, but with slightly different approaches:

- One approach is to investigate how the use of the water tunnel models in different ways can improve credibility in aircraft conceptual design.
- Due to software developments in CATIA, new possibilities open up to automatically connect design programs with a visualizing tool. This is a new thing which previously was more or less impossible to achieve but thus now is becoming possible. The Aircraft Design Group is investigating how this can be developed further in terms of conceptual design methodology work on aircraft, structures and systems.
- A third approach is to make use of the ability and knowledge we have built up over the years in doing student projects. Nowadays it has become increasingly popular within industry to build and test off "demonstrators". A demonstrator can have different

purposes, such as: testing off new technology or to test off the abilities or to identify possible difficulties with new designs. Demonstrators are usually made in smaller scale to save money on engine development and are thus sized around existing model engines. This means we are coming down to sizes resembling ordinary model airplanes. This might seem a cheap approach for industry and is probably so material wise, but is not so in terms of labor cost. The industry is not used to design aircraft in that scale and therefore tends to mirror its way of working with ordinary sized aircraft into the smaller scaled demonstrator, which only brings up costs even more. This is where the University can give a helping hand, since experience and knowledge is already there. Few people are involved and costs can be kept to a minimum. The Aircraft Design Group is building up methodology on how to design; manufacture and flight test such small scale demonstrators. The purpose is to evaluate basic vehicle behavior in order to complement simulations and expensive wind tunnel research, by reducing the over all development risk. The Aircraft Design Group at Linköping University have already tested this ability in a real project, by designing, building and flying a half-scale version of a future Saab demonstrator aircraft. This aircraft was built to a low price and proved its worth during flight demonstrations.

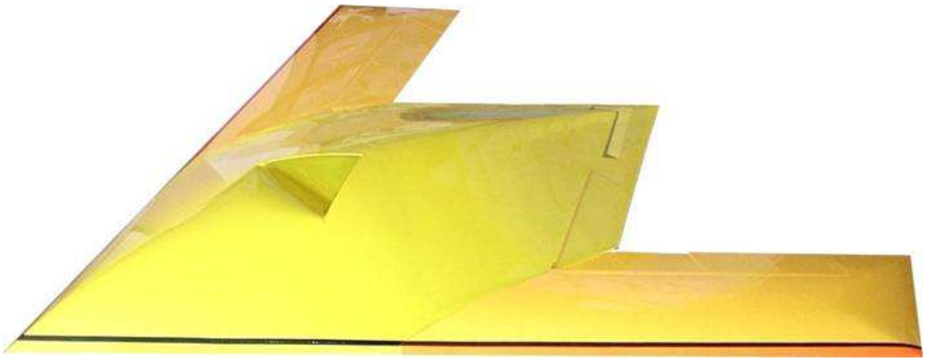

Fig. 9 Half-scale model of future Saab demonstrator

- The Aircraft Design Group also develops the ability to design better ornithopters. Especially wing design, flapping mechanism and flight control are of interest.
- Generally the development of micro UAVs are also interesting, since this is an area of increasing challenge which fits into University research very nicely.