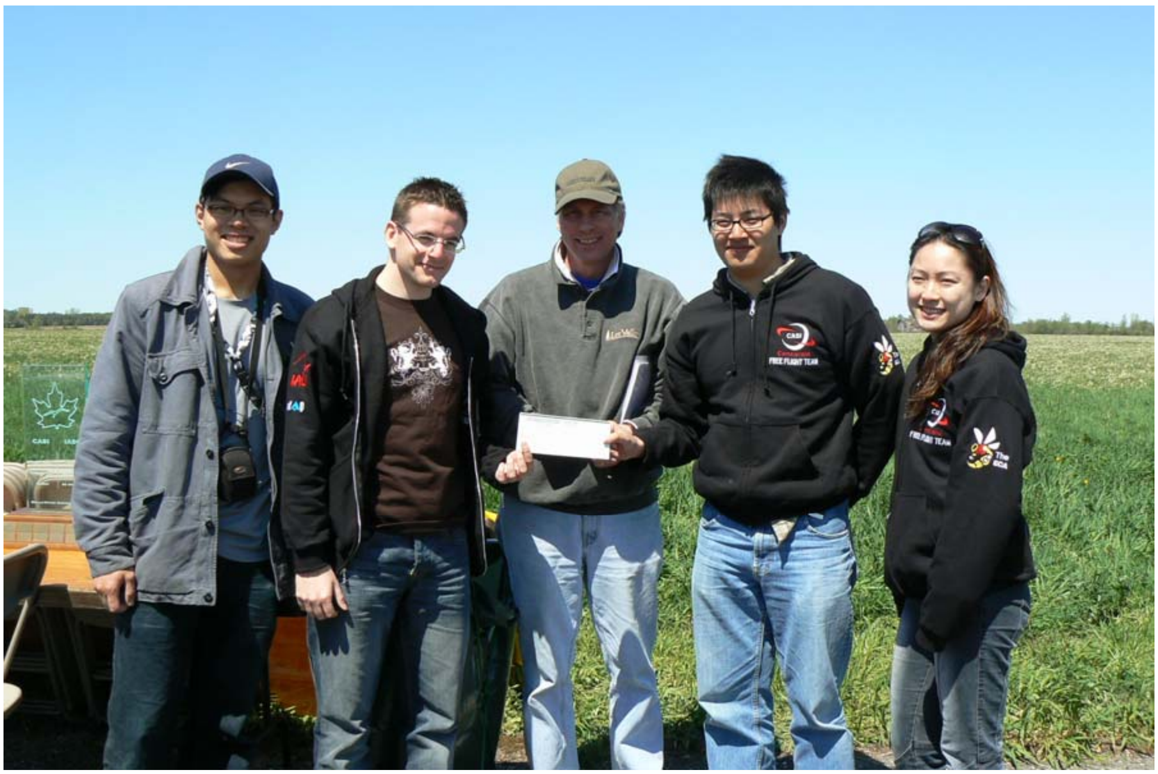
May 2007

CASI Free Flight Team wins 3rd place at Competition 2007



(Identification of team members to come)

Conclusive Report

On September 2006, CASI Concordia has formed a team of 7 students and CASI members for the 2007 CASI Free Flight Competition in May 13-15, 2007 at Gananoque Airport. The team composed of the president of the branch, Gergo Szeles, the competition officer of the branch, Ching Kit Li, ,and five CASI members, Harriet Laryea, Chantelle Lewis, Duc Hop Tran and Jonathan. The project was accepted as one of Concordia University's Capstone projects in August. This later proved to be a good motivation for a successful project. This was the first time Concordia University participated at this competition, therefore the team members had to face a lot of challenges besides the usual difficulty of managing and timing seven people's work. This report summarizes the challenges, failures and successes of the project.

Lack of experience, academic work, personal priorities and sometimes the loss of motivation were key drawbacks, which translated into two months delay. Fourth year is difficult for all students with lot of project deadlines falling on almost the same day. Overall about 20 meetings were organized of the one year period of the project, but only about 50% were attended by all members. The team established a Google account and a Google group website, which proved to be very successful for each member to stay up to date. Furthermore, it archived communication between team members; therefore it is strongly suggested for future teams. Due to the delays the team has lost essential time that could have been spent on test flights and further enhancement of the aircraft. The tail is a good example of delays and its effects on the whole project. Its design was late and hence was not as thought through. Later it became the Achilles point of the glider. Brainstorming proved to be an efficient tool in the preliminary design phase and problem solving/troubleshooting.

Due to the lack of experience the team struggled to find the center of gravity that would provide large stability during flight. Following the test flights the main difficulty was to move the center of gravity forward or near 25% of the chord length of the wing, given the design of the aircraft. The lack of stability led to stalling or quick diving following launch. The tail also proved to be too small to have any effect. Stalling meant that moment over the head (taken at Cg) was much smaller than over the tail. For the final design the team enlarged the tail and moved the fuselage more upfront relative to the wing. Though stability significantly increased, it was still not stable enough at the competition.

The team members commitment and thrive to succeed was proven at the competition, where they worked tirelessly to fix and to come up with new designs for the glider. Once the final designed did not prove to be successful at the competition, the team decided to redesign the whole aircraft over a night to be able to compete the next day. This essentially meant condensing about 3 months work into 12 hours. The wing needed to be cut as it generated too much lift. The fuselage needed to be shortened width and height wise and the head needed to be extended. The team came up with the following design:

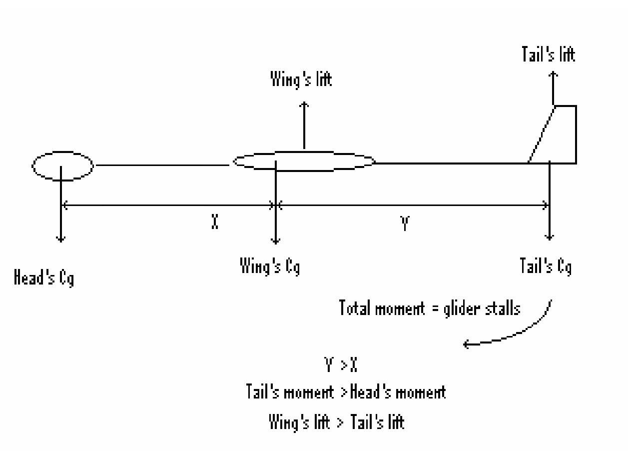


Figure 1: The “on the fly” design

By extending the nose so upfront a large moment is created that can counter-balance the moment created by the tail. The moment mostly consists of the weight of the carbon rod. Due to lack of time and lack of material resources (balsa wood) the team could not do a precise job. On the last day of the competition the new designed proved to be the right path and the glider showed clear signs of stability. However due to rushed assembly and lack of material resources and the need to recycle already used parts, the structural strength of the glider was weak and broke apart on the second flight.

At the end, the team of the University of Toronto placed first, followed by University of Manitoba and third being the CASI Concordia team. Many of the teams struggled with stability. In addition the weather was not ideal for gliding as the wind speed was high with strong gust winds. All the participating University, except Concordia, had been veterans at this competition, meaning they had participated the years before, which is a good source of experience.

With the lack of control at the center of gravity and payload, the first prototype has major stability issue which prevents the glider from launching. The problem with the stability of the glider is that the tail was too heavy compared to the head's weight. This mass from the back creates a moment that stalls the glider and looses speed, dragging and overshooting the angle of attack. The figure below represents the schematic of the forces in action. The Concordia Team's success laid in strong research, the use of software for modeling, the positive attitude of not giving up and for last but not least its strong sponsors. Due to detailed research, wind tunnel tests, test flights and use of CATIA and ANSYS for modeling the team was able to make an excellent report, followed by a very good presentation.

Summary of successes:

- The project was accepted as one of Concordia University's Capstone projects in August.
- The team established effective means of communications, by which all members stayed up to date.
- Group brainstorming proved to be an efficient tool in the preliminary design phase and in problem solving/troubleshooting.
- Strong and extended research, the use of software for modeling, the positive attitude of not giving up and for last but not least the strong sponsors were the main points to put our team in a competitive position.
- The team was able to make an excellent report, followed by a very good presentation.

Summary of failures:

- Lack of experience.
- The academic work, personal priorities and sometimes the loss of motivation for seven members were key drawbacks, which translated into two months delay.
- Due to the delays the team has lost essential time that could have been spent on test flights and further enhancement of the aircraft.

- The team struggled to find the center of gravity that would maintain the stability of the glider during flight.
- Due to the lack of time and resources the team was handicapped in enhancements and repairs during the competition
- The wing span generated too excessive lift due to the strong wind which made the glider hard to control and assemble.

The team suggests the following for the team of 2008:

- Do not design for lightest aircraft and largest wingspan
  - Most teams are closer to the upper weight limit and their wing span is smaller
  - The team's "on the fly" design followed this approach and seemed to be the right path
  - Smaller wingspan allows for further extended nose section and larger tail
- The dihedral wing section should be significantly larger, could even be 40-50% of the wing
  - This provides stability against rolling motion
- The fuselage should be made of thicker wood
- The weakest points of the glider were:
  - fuselage and tail
  - The wing and fuselage attachment points must be reinforced
- The tail's movement should be more restricted
- The tail's connection to the fuselage should be stronger to keep the tail straight
- The vertical stabilizer should be larger
- A separate part should be used as the dethermalizer, instead of using the tail for this purpose
  - E.g.: a flat plate that flips up or down
  - This avoids unwanted movement of the tail
- The tail should only be used as trim
- The design should not be fixed and should be flexible to play around
- The payload should range in between 30 to 50% of the gliders weight; going over that range will only drastically increase the damage to the glider during landing
  - It turned out that most teams only use a couple of hundred grams as payload
- The center of gravity of the glider has to be within 20 to 30% of the wing's chord length
- In order to have a better understanding of each parts' functions, small scale models should be built and tested first
  - The small model can even be test flown for stability
- Use the facilities of the university and societies early on the process
  - Excellent source for prototypes and wind tunnel tests
- The team captain should push the team early in the project when motivation is still high and members have more free time

In conclusion, the team achieved good results at the competition even with the lack of experience. Failures in the design (e.g.: tail, balancing) and approach to the project (lightest aircraft and largest wingspan) were identified and "on the fly" changes proved to be a good path for further advancements. By building on the experience gained this year, future Concordia teams should be able to achieve even better results. On behalf of the team, CASI Concordia would like to thank to all of the team's sponsors and hope that they will continue to support future free flight teams.

The report was created by:

Ching Kit Li
Competition Officer *2006-2007*
Canadian Aeronautics and Space Institute
Concordia University Branch
competition@ecaconcordia.ca

Gergo Szeles
President *2005-2007*
Canadian Aeronautics and Space Institute
Concordia University Branch
president@ecaconcordia.ca

in agreement with the rest of the team members.