2015

Radio Controlled Aircraft

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MECHANICAL AND NUCLEAR

Radio Controlled Aircraft

Team: Air Benders

CAPSTONE DESIGN EXPO 2015

Design Process

Problem Statement & Criteria for Success

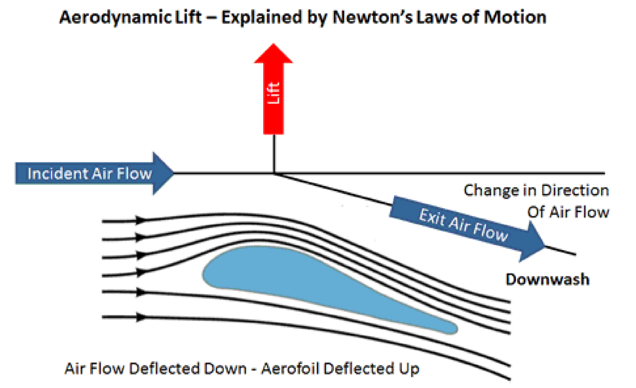
Develop a remote controlled aircraft to take off, fly, and land in a **controlled** and **repeatable** manner. The aircraft design should be easily extended to surveillance or cargo transport applications.

Flight Theory

The Bernoulli Equation is commonly used in preliminary aircraft design calculations, Daniel Bernoulli's equation captures the effect of fluid flowing over a surface. Assuming the fluid is incompressible and frictional forces are negligible the following equation may apply:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

As an aircraft begins to move a relative air speed is generated and air flows over the airfoil. A pressure gradient is developed between the top and bottom of the wing, the lower velocity bellow the airfoil creates a high pressure and the high velocity above the airfoil generates a low pressure. This creates lift and is the basis of heavier than air flight.



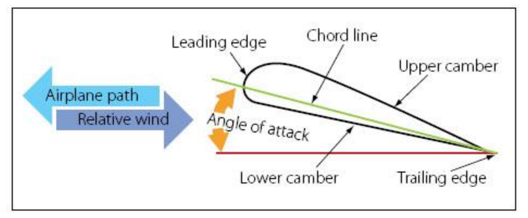


Figure 3-57. Wing terminology.

Estimating R/C Model Aerodynamics & Performance

Dr. Leland M. Nicolai

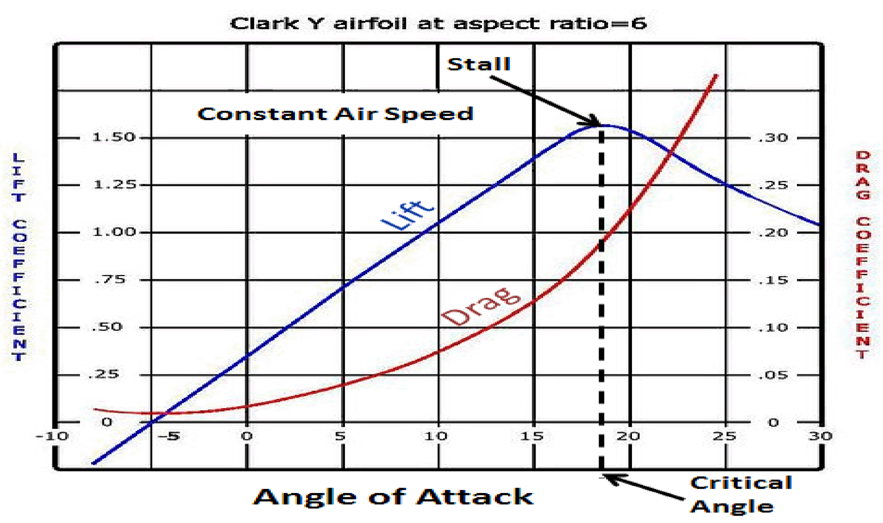
According to Dr. Nicolai's paper, "the only differences between the R/C model and the full scale airplane are the wing loading, Reynolds number and the moments of inertia".

An R/C model wing loading is one to two orders of magnitude less than a full scale airplane due to the square-cube law and will have lower stall speeds and lower take-off distances than full scale aircraft due to the reduced wing loading

R/C aircrafts typically operate with Reynolds Numbers less than 500,000 (Laminar flow) as opposed to a full scale aircraft which operates with a turbulent boundary layer. The turbulent boundary layer is preferred because it delays flow separation over the wing and allows for a higher coefficient of lift.

The moment of inertia on an R/C aircraft is also much smaller than that of a standard sized aircraft and creates inherent instabilities, for this reason *stability and control is one of the main concerns in the design of the aircraft*.

Drag force on plane	Values (lbf)
Fuselage	0.002048
Wings	0.008286
Horizontal tail	0.001643
Vertical tail	0.001452
Landing gear	0.001647
Total drag	0.013489
Take-off drag	3.390



Engineering Process

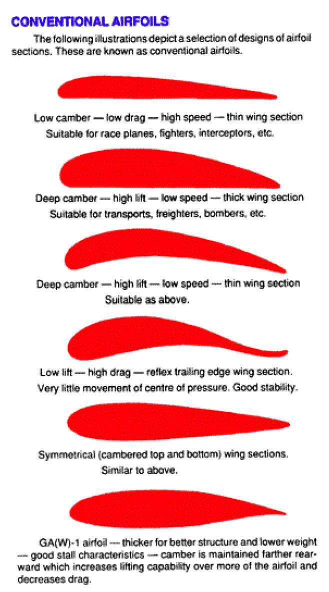
Design Considerations

Safety Issues

An RC aircraft is relatively small compared to modern day vehicles; however, it does have the potential to cause harm to the public if operated incorrectly. The stability and control of the aircraft is a top priority in the design process to prevent any malfunctions during flight.

The team is evaluating a design that allows the aircraft to maneuver by shifting along the pitch and roll axis. The larger wing selection will make it harder for the aircraft to take-off; however, this trade off creates more stability during flight, which is a major concern regarding safety.

User error is also a main concern for safety. Each team member will study the controls throughout the design process and care will be taken in selecting a testing location to ensure minimal safety issues. Most of the time, a crash is due to the lack of skill of the pilot and the inability to correct the position of the plane during flight. Wind is also another major factor causing the crash of an RC plane. To avoid injury to the plane and bystanders, the plane will not be cleared for takeoff in gusty situation or a constant wind speed of over 8 mph. Safety is among the primary concerns of the team and other constraints such as time and money will be sacrificed to ensure safety is optimized.



Manufacturability

Design is inherently an iterative process and the RC aircraft will undoubtedly have some "rocky" landings during the testing phase. Knowing this, the complexity of the parts being fabricated should be kept at a minimum because there is a good possibility of them being damaged during the testing phase and having to be completely rebuilt.

Various materials were considered for the design of the aircraft parts. Different sections of the aircraft need to be considered separately due to the maximum stresses and bending of the plane. Although balsa wood is rigid, it easily succumbs to fracture when put under a moderate amount of stress, thus to increase structural integrity, the fuselage and mounting junctions will use stronger types of wood to brace the balsa wood so that it will not bend when under operation. The fuselage will be constructed of thicker wood and metal bracings to uphold with the engine vibrations protect the motor in the incident of a crash.

The motor determines the maximum power and lift generated and; therefore, the weight of the machine is a primary concern in designing a functional aircraft. A balsa wood frame built around Styrofoam was successfully employed for the fabrication of the wings for last year's design. The same method of combining lightweight plywood, balsa wood and Styrofoam is the team's primary option to minimize weight this year.

Aircraft Properties

Geometric Dimensions	
Overall length	78 in
Fuselage width	66 in
Wing span	84 in
Height	6 in
Cord width	13 in
Wing area	1091.52 in^2

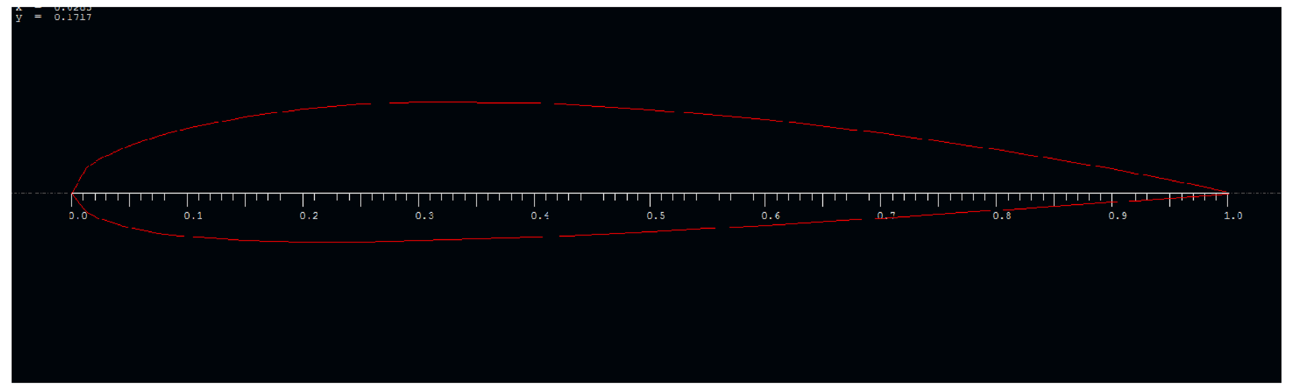
Performance Dimensions	
Airfoil	NACA 2412
Coefficient of Lift	1.02
Coefficient of Drag	0.02
Estimated Weight	25 lb.
Angle of Attack	8.0 degrees
Lift Needed	25.00 lb-f
Estimated Lift	28.65 lb-f
Estimated Drag	
Take off velocity	54.30 ft/s
Take off distance	75.5 ft
Reynolds number	3.40×10^5

Motor Properties	
Motor	OS 120 AX
Weight	22.8 oz.
Horse Power	3.1 at 9000 rpm
Practical rpm	1800 - 9500

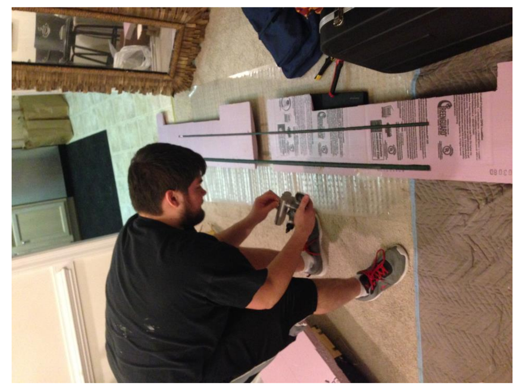
http://www.mpoweruk.com/flight_theory.htm
http://www.airbus.com/aircraftfamilies/passengeraircraft/a320family/a320/specifications/
http://itlims.meil.pw.edu.pl/zsis/pomoce/BIPOL/BIPOL_1_handout_8A.pdf
http://www.allstar.fiu.edu/aero/wing31.htm
http://avstop.com/ac/Aviation_Maintenance_Technician_Handbook_General/3-41.html

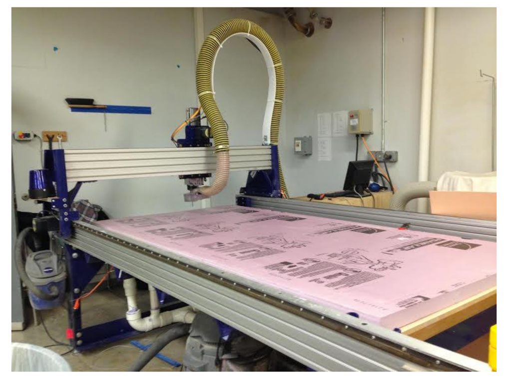
Fabrication Process

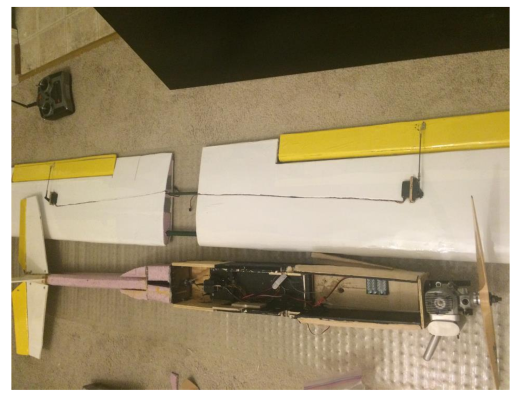
The NACA 2412 airfoil was selected with a deep camber for high lift and low speeds



3D printing was employed using the coordinates from the NACA generator to fabricate the aircrafts wings







A n OS 120 AX gas powered motor with an 18'' propeller was used to power the aircraft

Cost Analysis

Material	Cost	Description	Source
Balsa Wood	$28.42	36''x1/16''x3'' 20 per pack	Amazon.com
Carbon Fiber/Epoxy (61%)	$16.00	Per pound	Rmi.org
Plastic – polypropylene	$0.70	Per kg	Alibaba.com
Aluminum 2045-T4	$7.39	12''x0.375''x0.75''	Onlinemetals.com
Styrofoam – polystyrene	$7.97	18''x12''x2''	Walmart.com
OS 120 AX Motor	$217.98	OS 120 AX Motor	TowerHobbies.com