**Design Process for Initial Wing Design**

**Driving requirements which led to the wing design:**

* From Stubblebine, lift approximately 40 lbs
* Span limited due to length+width+height = 175 inches (SAE requirement). Save a few inches for safety-I believe we designed to 170 inches
  + Span increased from last year’s 96 inches to 100 inches to achieve extra lift (last year only lifted 33 lbs total)
* Want an approximate elliptic wing design – best lift characteristics
* Wing root and wing tip CL’s need a difference of at least 0.1 to ensure that when the root begins to stall, the wingtips where the ailerons are located do not stall at the same time.

**Trade Studies**

* Trade studies to investigate:
  1. Span
  2. Wing Area
  3. Taper ratio
  4. Taper break location
  5. Sweep
* Results from into the above five characteristics research are located in AircraftDesign > trunk > Aircraft\_Models > Reg2015Aircraft\_AeroCats > Aerodynamics > Presentations > AClemens\_JKeller\_9\_30\_14.pptx and AClemens\_10\_23\_14.pptx
  1. The first file goes over wing sweep and an initial study of span, wing area, taper ratio, and taper break location.
  2. The second file goes a more refined study-after a previously flawed Python script-of the optimal wing span, wing area, taper ratio, and taper break location.

**Design Simplicity**

* Design simplicity dictates that having a continually curved taper ratio would be a difficult item to design and construct, especially the wingtips without the aid of 3D printed wing caps. The 3D printed wing caps may also be too weighty out on the wing tips and would create an unnecessarily heavy bending moment on the spar.

**Airfoil**

* Andrew Stubblebine and Josh Combs were going to look into a new airfoil. Seemed that they couldn’t improve the S1223 used last year. Josh mentioned he found an airfoil section from a Brazilian plane from 2004 or so-Still waiting to hear back from Josh on whether or not he was able to recreate it or not.

**Results of Trade Studies** (putting words to the presentation named “AClemens\_10\_23\_14.pptx”)

* This was included in the presentation titled “AClemens\_JKeller\_9\_30\_14.pptx”, sweep, using the Aerothon code, has no effect on the overall CL or CD. Thereby it was deemed an unnecessary design feature and our plan will feature no wing sweep (forwards or backwards).
* Due to the lift at the wingtips when in actual flight, the wing bending induces dihedral which will help stabilize the plane (hopefully we will be able to somehow measure this angle change (take a photo during testing directly behind the plane during takeoff?))
* There was a bug in the code from the previous results I had presented. The second and third slides describe that error and how it was fixed (irrelevant for the final report discussion)
* Wrote a script to do a trade study on the maximum lift at the root and the maximum lift from the wing tips. The difference between the root and wing tip CL was placed in a table after running the script for taper ratios from 0.2 to 0.9 by steps of 0.05 and taper break locations following the same steps. Those results are seen in **slide 4**. Seeking a difference of only 0.1, something last year did, it is a safety margin so that when the wing’s root stalls, the wingtips, where the control surfaces are located, will stall later giving the pilot a chance to bring the plane out of stall. We chose a taper ratio of 0.35 and a taper break location of 0.65 (the taper ratio leaves a constant chord section to begin tapering at a location 65% of the way from the root to the wing tip). This location was chosen because it was very close to the 0.1 difference requirement, the larger constant chord section meant an easier build process, the small taper ratio means that the chord will be much smaller at the tip thereby removing excess structural weight from the wing.

**Slide 5** details the maximum CL’s provided by each taper ratio and taper break location. Despite a taper break location at 0.5 with taper ratios of 0.7-0.9 being possible and having a larger maximum CL than the chosen design of TR=0.35, TB = 0.65, the figure plotted illustrates that while the maximum overall CL is increased, when after the root stalls, the wingtips essentially stall together. By using my design, the largest chord section of the aileron will stall last giving the pilot control for as long as possible before losing complete control of the aircraft as shown in **slide 6**.

**Slide 7** discusses how the wing is expected to stall, from maximum CL down to wingtip CL. A second graph demonstrates CL vs. AoA and how I expect the wing to stall (backing up our design).

**Slide 8** shows the expected CD across the wing. In all we expect less total drag overall than last years (especially at the ailerons). Elliptic wing still beats our drag at the root but in general has a higher drag than our wing.

**Slide 9** details span versus total planform area. Ideally we are looking at maximizing lift so I really only looked at the top right figure. Given a 100 inch span, and arbitrarily choosing a planform area of 1750 inches squared, mostly just to be something different from last year’s, we expected a total lift of approximately 43 lbs.

**Slides 10-12** demonstrate the top view differences of last year’s design versus mine versus and elliptical planform.

**Slide 13** summarizes the new wing design and shows an image of the new shape.

**Slide 14** runs Aircraft.py and outputs the weights, C.G.’s, rates of climb, and ground roll among other items using last year’s aircraft design, only changing the wing to be my wing instead of theirs.

**Slide 15** uses Stubblebine’s new wing placement, shorter total length of the wing (tip to tail) and shows a table detailing the differences between last year’s design and this year’s design. With this configuration our empty plane weighs less, increases ground roll by ~10 feet to 194.08 ft. ( I, Andrew Clemens, would prefer it be closer to 175 feet, hopefully with tail S&C refinement we can do this). The new placement decreases rate of climb, takeoff AoA, and overturn angle.

**Final Configuration**

* Taper ratio is 0.35
* Taper break is 0.65
* Wing span (tip to tip) is 100 inches
* Wing area is 1750 inches squared
* Airfoil is the S1223-same as used last year

Aerodynamics – have not investigated wing incidence angle nor have we looked at the tail section of the aircraft. There is an idea for the tail to be essentially cut off and use a much smaller section of spar design or tubing to run the tail out there. I, Andrew Clemens, see it as unnecessary weight, hopefully through CFD we’ll be able to confirm this without creating more drag for the plane.