Aircraft Design 1

Assignment 4: Stability, Control, Weight & Balance

Grading scale:

|  |  |  |
| --- | --- | --- |
| **Grade** | **Evaluation** | **Equivalent grade/10** |
| 1 | Excellent | 10 |
| 2 | Good | 9 |
| 3 | Satisfactory | 8 |
| 4 | Insufficient | No grade |

Your overall grade was calculated by averaging the components in each numbered item. If your overall report was insufficient, a resubmission is necessary to correct the shortcomings and obtain a grade. If individual items are a 4, it is highly recommended to update them or review them as needed with the provided feedback in your assignment file. Penalties (0.5pts each) are applied for late submissions, or submissions with an incorrect filename or filetype.

|  |  |  |
| --- | --- | --- |
|  | Group |  |
|  | Overall assignment grade |  |
|  | Submission # |  |
| 1 | Weight & Loading Design |  |
|  | Empennage concept with V-bar method and statistical data |  |
|  | V-N Diagram and Class 2 weight estimation |  |
|  | OEW CG position calculation |  |
|  | Aircraft loading diagram for wing position 1 |  |
|  | Aircraft loading diagram for wing position 2 |  |
|  | Aircraft loading diagram for wing position 3 |  |
|  | Wing position vs. CG position graph |  |
| 2 | Stability & Controllability |  |
|  | Stability curve |  |
|  | Stick-fixed neutral curve |  |
|  | Controllability curve |  |
|  | Scissor-plot |  |
|  | Empennage sizing based on Scissor plot and cg travel plot overlay |  |
| 3 | Technical Drawings |  |
|  | Updated Front View drawing with new tail design (include V-stab and H-stab b’s) |  |
|  | Updated Left View drawing with new tail design (include V-stab b, ΛLE, Cr, Ct) |  |
|  | Updated Top View drawing with new tail design (include H-stab b, ΛLE, Cr, Ct) |  |
|  | Annotate Wing MAC**,** Λ**LE**, XLEMAC, neutral point, and CG travel range |  |
|  | Annotate Horizontal and Vertical Stabilizer MACs, Spanwise MAC locs. and LH, LV |  |
| **4** | **General Report Quality** |  |
|  | Specificity of the report to the design |  |
|  | Template/layout |  |
|  | Appropriate level of detail |  |
|  | Indication and use of units |  |
| **5** | **Submission Penalty (-0.5pts each)** |  |
|  | Submitted late (number of days late) |  |
|  | Incorrect filename |  |
|  | Incorrect file format |  |

# Empennage Design

Please follow and document the following 7 steps to guide your tail sizing process:

1. Propose a tail layout with adequate relative positioning of the horizontal and vertical empennages. Use the V-bar method and available reference data to propose a preliminary sizing of the horizontal and vertical tail planes (surface, aspect ratio, sweep angle, chords, and taper ratio).
2. Show the compound gust and load factor V-n diagram, but you do not need to show the computations to build that diagram. Indicate the maximum loading factor selected for the weight estimation.
3. Estimate the aircraft OEW and c.g. position using a Class II handbook (account for the proper maximum loading factors from the V-n diagrams). Organize the various weight contributions into a fuselage and a wing group, as discussed in the lecture notes. Take care to indicate the c.g. position of the wing group elements in the reference system positioned at the leading edge of the mean aerodynamic chord (XCG/CMAC).
4. Compare and document the results from the class II method with the OEW value you calculated in assignment 2. In case of a discrepancy larger than 10%, it is advised to iterate. Also, compare your component weigh fractions with those from reference aircraft (see data posted on BB).
5. Propose a reasonable wing position with respect to the fuselage (XLEMAC) and build the aircraft loading diagram (the potato diagram). Include passengers, fuel, cargo, crew, etc... Check your c.g. range with those of reference aircraft (data provided in lecture notes) and against the limits allowed by the position of the landing gears (check for tip back risk and under/overloading of the nose gear)
6. Modify the wing position (e.g., moving it forward and backward with respect to the initial position) and generate the graph showing the effect of the **wing position on the aircraft c.g. travel**. Show the loading diagrams for the 3 wing positions (you can assume the tail weight constant when shifting the wing). Be sure to compute the c.g. positions relative to the wing group reference system and expressed as percentage of the wing mean aerodynamic chord. Indicate the wing position as ratios between XLEMAC and the fuselage length Lfus.
7. Define your aircraft’s stability and controllability by graphings the **scissor plot** (X plot). Indicate:
   1. The stick-fixed neutral point curve
   2. The stability curve (indicate the stability margin used)
   3. The controllability curve

Note: you can build the stability curve for cruise condition and the controllability curve for landing condition (i.e., at CLmax and fully deployed flaps).

1. Compute the **minimum horizontal tail** surface and the **wing longitudinal position** that allow matching the stability and controllability limits with the operational c.g. travel. Use the method of overlaying the scissor plot with the wing-position vs. c.g. travel graph generated at point 5. Compare the obtained values of tail surface and wing position with your initial estimations. **Iterate** in case of larger differences than 10%.

# Drawings

Update the 3 views (top, front, side) of the aircraft configuration produced in Assignments 1-4 with the new designed empennage (do not show just the isolated tail, but the whole system of fuselage + wing + engines). Additional detailed drawings are allowed.

Annotate the drawings with at least the following information: root chord, tip chord, span, sweep angle(s), MAC, size and position of HL devices, control surfaces and any information relevant to the tail design. Indicate in the drawings also the **MAC, the c.g. range and the neutral point** position, and the stabilizer moment arms.

**Maximum size: 20 pages in total (font 12 pt, single spaced), excluding references and appendices.**

# General Notes

* **ABS (Always Be Specific)**: Focus the discussion on your specific aircraft and design, do not discuss aircraft/spacecraft projects in general, but it is ok to refer to typical designs for comparison.
* **ABC (Always Be Concise)**: Be concise. Always justify & discuss your statements in a clear but concise way. Describe figures, tables, graphs and trendlines and refer to them in the text (no floating figures). Introduction, abstract, acknowledgement sections, etc., are not required. When using graphs (i.e., from the DATCOM method), always **indicate the selected design point** by means of a clear dot or two intersecting lines.
* **Properly reference** your sources; use IEEE or AIAA engineering reference styles. Ensure all figures/tables/graphs/diagrams have descriptive captions and labels/numbers that are referred to in the body of the text. Make appropriate use of literature data. When using work from others, always include detailed references. Plagiarism and straight copying of work is a USC honour code violation and will be reported!
* Treat this as a full engineering report: there must be a minimal narrative explaining the design decisions and report graphs, not simply a compilation of images and graphs there is no need to re-derive equations; but show your values used/calculated (ABS/ABC).
* **RTFM** (**Read the assignment twice**): Make use of the document template provided on blackboard. You are allowed to use your own template as long as it contains the same elements as the provided template. Add relevant oversized additional information (technical drawings, flow charts) in appendices. Do not forget the required Appendixes! References and appendices do not count towards the page limit.
* When using drawings, schematics and images, make sure they are **clearly readable**. Produce good quality drawings **(annotated and to scale**). Hand drawings are acceptable for concept sketches, but only **CAD drawings** are acceptable for the final concept!
* Remember: the required level of detail is that of conceptual design (check the number of decimals in your drawings annotations and calculations!)
* Remove any unneeded white space in all images.
* For military or UAV aircraft refer, when possible, to the civil airworthiness regulations that matches your type of aircraft the best (unless you can find appropriate information in literature).
* Make smart use of tables, equations and graphs to present your work, and use appropriate captions. You can use tables to indicate the input values (with units) of used formulas and graphs.
* Make proper use of version control and submit using the requested filename convention.
* Use a spelling/grammar checker to verify your work!
* For military or UAV aircraft refer, when possible, to the civil airworthiness regulations that matches your type of aircraft the best (unless you can find appropriate information in literature).
* **Pay attention to units**! DON’T mix different units and/or different unit systems (or include both).
* Assignment examples provided (if any) are examples of work that was graded “good” or “excellent”, and may contain errors. Use/reference at your own risk.
* **Remember to indicate the approximate time you spent working on the assignment (do not include the time spent learning Word, Excel, LaTeX, CAD systems, etc.)**