Concept Selection

## 1.6 Concept Selection

After analyzing all our generated concepts, we chose a select few to further analyze to ensure that we arrived at the most optimal design for our engineering needs. We began the selection process by generating a binary pairwise comparison, seen in Appendix E. This matrix compares our customer requirements against each other, this allows us to narrow our focus to fewer customer requirements. After the binary pairwise was analyzed, the information gathered was transferred to the House of Quality, seen in Table 1. We used the importance factors from Binary Pairwise and instead compared the customer requirements against our engineering characteristics. We weighed the engineering characteristics in order from highest weight % to lowest. We found them to be: Elevator, Aileron, Static Margin, Resist Effects of Stress, and Weight. Along with the most valued customer requirements and engineering characteristics we then compared them to the designs we’ve established. The comparisons against these are visually represented in the Pugh Charts, table 2 and 3. A more detailed description of the tables and the decisions made will be further discussed.

One noticeable difference in our needs and previous concepts is the decision to not include wingtips in the selection process, this is because it was decided that they don’t have a measurable effect on the aircraft performance which would be influential in the overall design. We began by making a pairwise matrix, which lists the most important needs of the project and gives the important weight factor of each of the customer requirements. After creating our pairwise matrix as shown in Appendix D, we used the customer requirements and compared them against our engineering characteristics using an importance weight factor in our House of Quality (HQT), table 1. This “weight factor” was chosen for each of our needs from the pairwise matrix and resulted in the most important requirements being the controls of the aircraft, the loading/unloading of the aircraft and the maneuverability of the aircraft both on the runway and in the air. Going through each requirement and cross referencing it with our demonstrated characteristics, relative weights were determined, and the characteristics were ranked in order of importance. The two most key design factors were found to be the weight of the aircraft and the control of the ailerons which affect the overall flight stability

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|  |  | **Engineering Characteristics**  |  |
| **Improvement Direction**  | ­­ |  | ­­ |  |  | ­­ | ­­ | ­­ | ­­ |  |  |  |
| **Units**  | ft, sec | ft. | ft, lbs  | Non-Dim | Min. | Deg. | Deg.  | Deg.  | % | ft/s  | lbs.  |  |
| **Customer Requirements**  | **Importance WF Factor**  | Thrust Generation  | Moving Down Runway  | Ability to Provide Lift | Overcoming Drag  | Load/Unload Cargo | Rudder  | Elevator | Aileron | Static Margin | Resist Effects of Stress  | Weight  |  |
| Material  | 5 |   | 1 | 3 | 1 |   | 9 | 9 | 9 | 3 | 9 | 9 |  |
| Stability  | 5 | 3 | 1 |   | 1 | 3 | 9 | 9 | 9 | 9 |   |   |  |
| Takeoff/Landing Requirements  | 6 | 9 | 9 | 9 | 3 |   | 3 | 3 | 3 | 9 |   | 3 |  |
| Wingspan Restrictions  | 4 |   |   | 9 | 9 | 3 |   | 3 | 9 | 3 | 3 |   |  |
| Power  | 5 | 9 | 3 | 3 |   |   | 1 | 1 | 1 |   |   | 9 |  |
| Maneuverability  | 7 | 1 | 9 | 3 | 9 | 9 | 9 | 9 | 9 | 3 |   | 9 |  |
| Lightweight  | 5 |   | 3 | 9 |   |   |   |   |   | 3 | 3 | 9 |  |
| Landing Shocking  | 2 |   | 1 |   |   | 1 |   |   |   |   | 9 | 3 |  |
| Controls  | 11 | 9 | 9 | 9 |   | 3 | 9 | 9 | 9 |   |   |   |  |
| Minimum Cargo Load Required  | 3 | 1 | 1 | 1 |   | 3 |   |   |   | 3 |   | 9 |  |
| Loading/Unloading Payload  | 9 |   |   |   |   | 9 |   |   |   | 9 |   | 3 |  |
| Innovation  | 4 |   |   |   |   | 3 |   |   |   | 3 |   |   | TOTAL:  |
| **Raw Score (2629)** | 223 | 261 | 288 | 127 | 227 | 275 | 287 | 311 | 264 | 90 | 276 | 2629 |
| **Relative Weight %**  | 8.48 | 9.93 | 10.95 | 4.83 | 8.63 | 10.46 | 10.92 | 11.83 | 10.04 | 3.42 | 10.50 |  |
| **Rank Order**  | 9 | 7 | 2 | 7 | 6 | 4 | 2 | 1 | 2 | 2 | 1 |  |

 Table 1: House of Quality

Moving on from the HQT, we created Pugh charts to help finalize our selections and look at the various concepts and compare their certain aspects to a predetermined datum. The datum that we used was the 2019 FAMU-FSU Aero design competition. We decided on using this as a datum because we have access to the physical model as well as the data that the previous group obtained on it. Another reason that the 2019 airplane was chosen was that the 2020 group design was too different for our chosen needs and would be irrelevant when comparing it to our design because of its dual–wing canard shape design. The concepts that we examined were based on 3 fuselage types that the fuselage team decided on with varying wing placements and landing gear configurations. By testing these criteria against the datum we were able to illustrate the pros and cons of each design and discuss their effectiveness in trying to capture our needs. After looking at the results, we chose the SR-22 L and RV-14 L because they had the most pluses, seen in the Pugh chart in table 2, however for deciding our 3rd concept, we decided to go with the SR-22 H over the SR-22 HB because although the latter had 1 more plus, it had an additional minus in the load/unload section that outweighed its weight factor.

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| PUGH Chart: First Iteration |   | Concepts  |
| Selection Criteria  | Datum  | SR-22 H | RV-14 L | SR-22 L | RC-V1 | SR-22 HB |
| Trust Generation | 2019SAEAeroComp | S | S | S | S | S |
| Moving Down Runway | + | + | + | S | + |
| Ability to Provide Lift | + | + | + | + | + |
| Overcome Drag | - | + | + | S | - |
| Load/Unload Cargo | S | + | + | - | - |
| Rudder | S | S | S | S | S |
| Static Margin | + | + | + | + | + |
| Resist Effects of Stress | + | + | + | + | + |
| Weight | S | + | - | - | + |
| # of pluses  |   | 4 | 7 | 6 | 3 | 5 |
| # of Minuses  |   | 1 | 0 | 1 | 2 | 2 |
| # of S |   | 4 | 2 | 2 | 4 | 2 |
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Table 2: Pugh Chart

With the second iteration of our Pugh chart, we took a more scrutinized approach towards the selection criteria and tried to think unbiasedly about the concepts. Comparing them off our datum of the SR-22 HB however, we realized that the SR-22 H concept was practically identical to the datum and only varied by not having a higher resistance to stress effects. This left us with two other concepts, yet it was clear that the SR-22 L was the ideal concept because of the number of pluses it had in critical areas such as load/unload and static margin compared to the RV-14 L. Despite both planes having a low wing configuration, ensuring that they would provide the stability that we need, the SR-22 L also had a greater static margin than the RV-14 L which made it even more stable and more easily able to maneuver.



Table 3: Pugh Chart (Iteration #2)

To better understand what we needed to get out of our design, we developed a normalized comparison matrix to highlight the engineering characteristics that we deemed most important and then judge them against each other to see what the most important ones were, this table was generated by using the criteria comparison matrix in Appendix E and dividing each induvial score of each of the characteristics and diving that by the sum of the column of each characteristic. After comparing, we found that our two most important characteristics were reducing the effects of stress and the weight of the aircraft. We rationalized these findings by acknowledging that reducing weight and stress would help our aircraft maneuverability and increase its overall stability. There are various ways that these could be achieved and so it is now the mission of our team to develop ways to do this without sacrificing the overall production of the aircraft.

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| **Normalize Comparison Matrix** |
| **Engineering Characteristics**  | **Rudder**  | **Stability** | **Resist Stress** | **Weights** | **AVERAGES:** |
| Rudder  | 0.090909091 | 0.090909091 | 0.133333333 | 0.066666667 | 0.095454545 |
| Stability  | 0.090909091 | 0.090909091 | 0.066666667 | 0.133333333 | 0.095454545 |
| Resist Stress  | 0.272727273 | 0.545454545 | 0.4 | 0.4 | 0.404545455 |
| Weight  | 0.545454545 | 0.272727273 | 0.4 | 0.4 | 0.404545455 |
| SUM:  | 1 | 1 | 1 | 1 | 1 |

Table 4: Normalized Comparison Matrix

Shown below is the final rating matrix. This table summates the AHP values for our final two concepts and through the multiplication of the transpose of this final rating matrix to the calculated criteria weights of the engineering characteristics, the alternative value table can be formulated. All of these averages helped give the team a better understanding of what we needed out of our design and helped quantify our final concepts.

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| **Concept** | **Alternative Value**  |
| SR22L | 0.523863636 |
| RV-14L | 0.476136364 |

Table 5: Final Rating Matrix

With the alternative value table providing a scalar representation of the two final concepts, it is observed that the SR22L holds a slight advantage of favorability over the RV-14L when comparing engineering characteristics and their calculated weight. This advantage can be more visually discerned in the following bar graph and thus the concept selection process is complete, with the SR22L being the chosen concept for the plane design.

Although the RV-14L holds an advantage over the SR22L in stress resistance, the SR22L’s advantage over the RV-14L in both stability and weight reduction proves it to be a more efficient and optimal design choice for the completion of the mission profile as well as the execution of the project objective. This is due to the criteria weight that was calculated for both stability and weight being of a higher value and thus a more crucial factor in the selection of an aircraft design.

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| **Final Rating Matrix** |
| Selection Criteria  | SR22L | RV-14L |
| Rudder | 0.5 | 0.5 |
| Stability  | 0.75 | 0.25 |
| Resist Stress  | 0.25 | 0.75 |
| Weight  | 0.75 | 0.25 |

Table 6: Final Rating Matrix

Graph 1: Alternative Value Bar Graph