Rocket Design Final Project

Final Report Due Date: Friday, March 15 at 11:59pm

Final Presentations: Monday, March 11 from 8:30-10:20am

Background:

A group of venture capitalists are interested in funding a network of small satellites to provide satellite internet coverage across the globe. They have asked us to design a low-cost rocket with a reusable first stage that can place a single 1,000 kg satellite into a 500 km altitude low-Earth orbit. They would like us to submit seven different proposals. Accordingly, the class has been divided into seven teams of six students (list to follow). Each team will develop an independent design that should meet the stated goal as effectively as possible.

Guidelines, Constraints, and Assumptions:

1. The choice of propellants is at the discretion of the individual teams.

2. The launch vehicle may have one, two, or three stages, in series or parallel, or both. If you use more than one stage, you may use different sets of propellants in each stage. Only the first stage is reusable.

3. Assume that the cost of each launch can be calculated from the following equation:

$$C = \alpha m_0 \left[\frac{1-\beta_1}{N_1} + \sum_{j=2}^{n_s} (1-\beta_j) \right]$$

   Here, $\alpha = 1{,}000$ \$/kg, m_0 is the initial launch mass (to be determined by your design), $N_1 = 10$ represents the number of times the first stage can be re-used before it is decommissioned, and β_j is the payload mass fraction of the j$^{\text{th}}$ stage. For stages that use liquid bipropellant engines, assume the structural factor of each stage to be $\varepsilon = 0.15$. Assume the structural factor of each stage solid rocket stage to be $\varepsilon = 0.07$.

4. Ideal rocket theory and ideal gas theory may be used.

5. Assume that the total Δv of the mission is 9.0 km/sec, which includes drag and gravitational losses.

6. The materials of construction of the combustion chamber(s), and/or solid rocket casing(s), and nozzle(s), as well as of the propellant tanks (if you use liquid propellants), rocket body, etc., are up to each team to choose (again, “unobtainium” is not permitted!).

7. If you choose a solid propellant for one or more of the stages, the choice of solid propellant, its grain configuration, the geometry of the unit, and the materials of construction are at your discretion. However, the design of the stage must follow the same general guidelines as for liquid rockets, and must be feasible with current technology, i.e., "unobtainium" materials cannot be used.

8. For the selected propellants, you must determine their physical and chemical properties, and compute all the usual performance parameters of a rocket engine, i.e., P_i, P_c, P_e, T_c, T_e, γ_c, A_c, A_t, A_e, L^*, $\mathcal{M}$, u_e, C, C^*, C_F, and F, some of which will depend on the ratio of chamber-to-throat-area that you choose.

9. Use the online CEARUN code for your combustion computations (if you experience any difficulties, let the instructor and TA know immediately, and then switch to the downloadable version).

10. For the combustion chamber(s) and/or the solid rocket casing(s) select the materials of construction based on the expected temperature(s) of combustion. You may choose whatever thermal protection system you feel would best suit the combustion chamber(s) and/or the solid rocket casing, and the nozzle(s), such as regenerative cooling, ablative liners, high-temperature materials, radiative cooling, or some combination thereof.

11. If you choose a liquid propellant system for one or more stages, you must address the following issues: delivering the propellants to the rocket motor(s) (pressure-fed or turbopump-fed); selecting and sizing the components that are required by the delivery system (such as tubing, valves, pressure regulators [if any], etc.); the design of the injector; estimating the pressure drops through the propellant delivery components and the injector.

12. You may not simply copy any existing launch vehicle!

13. Keep in mind that your team is competing against the other design teams. Accordingly, your team must not consult or share results with any of the other teams, nor may you consult any faculty members or anyone else, at or outside the UW. Only the course instructor or TA may be consulted. Note, also, that this project takes the place of the final exam, and is worth 40% of your final grade.

Deliverables:

Each team will be responsible for two deliverables:

Deliverable 1: Written Report (Proposal)

Each group's proposal (i.e. final report) will be due *Friday, March 15 at 11:59pm*. The reports must be submitted to Canvas as PDF files. The main text of the report, including the abstract and conclusions, and figures and tables, is limited to 12 pages with 1-in margins, using Times New Roman 12 pt. font and 1.5 line spacing. The list of references may take up no more than two additional pages. In addition, four pages of appendices are permitted. Any deviations from these format requirements will be penalized. The report writing guidelines and the scoring rubric will be posted to Canvas shortly.

Deliverable 2: Oral Presentation (10-minute Pitch)

Each group will have 10 minutes to present their design to the classroom on *Monday, March 11 from 8:30-10:20am.* The presentation should summarize: (1) your design approach, (2) the main features of your design, (3) the distinguishing aspects of the design (4) the ability of the design to meet the stated objectives and cost per launch, and (5) the next steps you would follow if it was chosen for funding.

Final Note: Creative (but feasible) solutions are encouraged! So have fun!

Teams:

Group 1: Albrecht Cheng Fetters Klem Major Ramirez Vadillo Wilhere	Group 2: Aldaz Chilcott Greenup Lang Manson Singer	Group 3: Alexander Cisler Hines Laplace Minatani Sykes
Group 4: Atwell Cundiff Howard Laslett-Vigil Molidor Truong	Group 5: Bakker Delbow Hsu Lestenkof Parker Unruh	Group 6: Browne Duer Keene Lin Peterson Vucenovic
Group 7: Diep Le Magayanes Nichols Pearson Zhang		