**Concept Generation**

**Overview**

Concept generation is the process of deciding how to most effectively come up with the required 100 different ideas for the project. Our ideas will be related to four of our rocket’s main subsystems, those being: airframe, avionics, fabrication, and separation/recovery. Given the complexity of our high-powered rocket vehicle, each of our 8 final concepts will be composed of four main ideas for each subsystem. We have decided to conduct our concept generation and selection in this way because developing 100 ideas for 100 entirely different vehicle designs is an undertaking that we believe exceeds the scope of this assignment and project. Different tools were used to assets in generating ideas for each subsystem. The tools used were crap shoot, forced analogy, battle of perspectives, anti-problem, morphological charts, and biomimicry.

**Ideation Tools**

Crap Shoot

Crap shoot is a method that involves the use of random dice throws to generate various solutions. There are items listed one through six for each side of the die and there are 4 dice rolled for each category. Table # below was used to generate ideas with the three main categories being the system, aspect of said system, and innovation pertaining to that system.

Table 1: Rocket Crap Shoot.

|  |  |  |  |
| --- | --- | --- | --- |
| Crap Shoot | | | |
|  | Die 1 - System | Die 2 - Aspect | Die 3 - Innovation |
| 1 | Propulsion | Material selection | Efficiency |
| 2 | Avionics | Size | Aerodynamics |
| 3 | Tail system | Safety | Weight optimization |
| 4 | Fabrication | Stability (CG/CP) | Performance |
| 5 | Recovery | Utility | Cost |
| 6 | Nosecone |  |  |

Anti-problem

The anti-problem approach uses counteractive solutions to a problem to provide insight into the essential characteristics of a viable solution, i.e. how a bad design reveals failure points and areas to improve. To ensure we weren’t overlooking any possible failure points when considering different ideas, our team developed bad ideas aimed at ensuring that the rocket failed to meet safety requirements, recoverability standards and challenge requirements.

Battle of Perspectives

The battle of perspectives method fosters innovative ideas by splitting participants into two groups with distinct biases. Each group generates potential solutions, enabling a multifaceted view of the problem. For this exercise, we chose to involve STEM students and those from non-STEM fields, ensuring a diverse range of insights from varying educational backgrounds.

Biomimicry

Biomimicry involves drawing inspiration from nature to address challenges. The team studied various animals, focusing on how and when they exert the greatest force to engage their muscles, as well as the motivations behind this force. For example, the team looked at flying squirls and how they glide and apply drag for a slow descent. This research yielded valuable insights for our project.

Forced Analogy

Using the forced analogy approach, the team organized a creative workshop where each member brought a unique item from home, such as a tool, toy, or piece of art. After sharing the stories behind their items, the group engaged in a discussion to identify key qualities and functions of each item. They then collaboratively explored how these attributes could inspire innovative solutions to their system’s challenges, fostering a dynamic exchange of ideas and perspectives.

**5 Medium Fidelity**

As explained before, 8 concepts were generated that each contain key design ideas within our rocket system. The team then rated the concepts as high or medium fidelity based on varying parameters. The full list of our 100 ideas, broken down by rocket subsystem, can be found in Appendix E.

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| --- |
| Concept 2: |
| Airframe - |
| Carbon fiber for airframe |
| 6+ ft length |
| Aluminum tail cone |
| carbon fiber fins |
| Avionics - |
| Hardcover |
| Screw-in camera mount |
| GPS locator |
| Airbrake altitude control |
| Fabrication - |
| Metal bracket to attach nose cone to body |
| Machined nosecone tip for more precise aerodynamics |
| Separate pins to align nosecone pieces |
| Custom wrap on body to minimize drag |
| Separation/Recovery - |
| Black powder ejection |
| Deployment bag |
| Bigger pressure vessels with bigger shear pins |
| Higher altitude for main deployment |

Figure 1. Concept 2 ideas.

Concept 2 was created as a best-case scenario, where the team wouldn’t have to worry about budget or time, just to make the most reliable and “advanced” rocket possible. While nothing on this rocket design would be impossible, it was rates as a medium fidelity concept because of its high cost and extreme complexity.

|  |
| --- |
| Concept 3: |
| Airframe - |
| Blue tube for airframe |
| Plastic fin supports |
| Wooden fins |
| Plastic centering rings |
| Avionics - |
| Softcover |
| Central tray |
| Air-tag locator |
| 3D printed electronics retainer |
| Fabrication - |
| Epoxy coated nose cone that is sanded smooth |
| Lock and twist mechanism for securing nosecone |
| Vertically supported fin brackets |
| Central pin to align nosecone |
| Separation/Recovery - |
| CO2 ejection |
| Tape parachute securement |
| Larger drogue and smaller main |
| No extra CO2 ejection ports |

Figure 2. Concept 3 ideas.

Concept 3 was created as a worst-case scenario, where the team would have a very limited budget and little time to complete fabrication of the rocket. This concept was rated as medium fidelity because of its likelihood to not be able to survive the high forces expected by flight. However, the team has done no calculations to determine if it would be sturdy enough for flight or not, so it was kept as a feasible concept.

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| --- |
| Concept 4: |
| Airframe - |
| Blue tube for airframe |
| Plastic fin supports |
| 3D printed fins |
| plastic centering rings |
| Avionics - |
| Softcover |
| 3D printed electronics retainer |
| Egg timer locator |
| Ballast altitude control |
| Fabrication - |
| Shelled tail cone for lightness |
| Inserted threads to attach nosecone to body |
| Central pocket for epoxy |
| Vertically supported fin brackets |
| Separation/Recovery - |
| Black powder ejection |
| Length of shock cord so nosecone hits ground first |
| Later timing of separation |
| Smaller pressure vessels with smaller shear pins |

Figure 3. Concept 4 ideas.

While similar to Concept 3, Concept 4 was made to be as light as possible. This is due to last year’s team’s rocket being one of the biggest and heaviest in the Student Launch Competition, something the team this year would like to change. Concept 4 was rated as a medium fidelity concept for reasons similar to Concept 3 but was ultimately rated as medium fidelity because of its lack of redundant systems, systems that last year’s team found crucial during some flights.

|  |
| --- |
| Concept 5: |
| Airframe - |
| Carbon fiber for airframe |
| 6+ ft length |
| Machined fins - aluminum |
| Titanium tail cone |
| Avionics - |
| Hardcover |
| Compartmentalization tray |
| Airbrake altitude control |
| GPS locator |
| Fabrication - |
| Metal bracket to attach nose cone to body |
| Machined nosecone tip for more precise aerodynamics |
| Separate pins to align nosecone pieces |
| Multiple pockets for epoxy |
| Separation/Recovery - |
| CO2 ejection |
| Deployment bag |
| Bigger pressure vessels with bigger shear pins |
| 1 extra set of CO2 ejection ports |

Figure 4. Concept 5 ideas.

Concept 5 was made to be as heavy as possible. While a heavy rocket is harder to get off the ground, it will also likely be very stable and able to withstand the forces of flight and landing. This concept was rated as medium fidelity because of its high cost and excessive time needed to manufacture it.

|  |
| --- |
| Concept 6: |
| Airframe - |
| Sub 6 ft length |
| Three fins |
| 6- in body-tube diameter |
| Power series nose cone shape |
| Avionics - |
| Softcover |
| Central tray |
| Egg timer locator |
| Wood electronics retainer |
| Fabrication - |
| Epoxy coated nose cone that is sanded smooth |
| Shelled tail cone for lightness |
| Lock and twist mechanism for securing nosecone |
| Central pocket for epoxy |
| Separation/Recovery - |
| CO2 ejection |
| No extra CO2 ejection ports |
| Tape parachute securement |
| Smaller pressure vessels with smaller shear pins |

Figure 5. Concept 6 ideas.

Lastly, Concept 6 was created to be as small as possible. Varying heavily from last year’s design, this rocket would aim to be as small as possible while still being able to complete the challenge requirements. This concept was rated as medium fidelity because of the team’s unfamiliarity with smaller rocket design principles and the reduced size our partner payload team would have to work with in the rocket body.

**3 High Fidelity**

|  |
| --- |
| Concept 1: |
| Airframe - |
| 6+ ft length |
| 6 in body-tube diameter |
| L class motor |
| Four fins |
| Avionics - |
| Hardcover |
| Airbrake altitude control |
| SRS separation detection |
| Wood electronics retainer |
| Fabrication - |
| Machined nosecone tip for more precise aerodynamics |
| Custom wrap on body to minimize drag |
| Metal bracket to attach nose cone to body |
| Multiple pockets for epoxy |
| Separation/Recovery - |
| CO2 ejection |
| 1 extra set of CO2 ejection ports |
| Higher altitude for main deployment |
| Earlier timing of separation |

Figure 6. Concept 1 ideas.

Concept 1 was created to be as big as possible, aligning with last year’s design in size and weight. The goals of this design would not be to copy last year’s rocket, but to stick to its major design principles and innovate where possible. This concept was rated as high fidelity because of the team’s common understanding of how last year’s design was created and manufactured.

|  |
| --- |
| Concept 7: |
| Airframe - |
| Carbon fiber for airframe |
| Four fins |
| 6+ ft length |
| Ogive nose cone shape |
| Avionics - |
| Hardcover |
| Compartmentalization tray |
| GPS locator |
| Ballast altitude control |
| Fabrication - |
| Custom wrap on body to minimize drag |
| Threads to screw nosecone onto body |
| Central pin to align nosecone |
| Central pocket for epoxy |
| Separation/Recovery - |
| CO2 ejection |
| Deployment bag |
| Smaller pressure vessels with smaller shear pins |
| 1 extra set of CO2 ejection ports |

Figure 7. Concept 7 ideas.

Concept 7 was created by allowing each team member to pick ideas that they would like to see in the rocket this year, however the team members were not allowed to talk to one another. These ideas were picked solely on how that team member saw their subsystem perform last year and what they think they could make it better this year. This concept was rated high fidelity because of each team member’s confidence in their knowledge of their subsystem and how it could be improved.

|  |
| --- |
| Concept 8: |
| Airframe - |
| 6- in body-tube diameter |
| Ellipsoid nose cone shape |
| Three fins |
| 3D printed fins |
| Avionics - |
| Hardcover |
| Central tray |
| 3D printed electronics retainer |
| GPS locator |
| Fabrication - |
| Custom wrap on body to minimize drag |
| Vertically supported fin brackets |
| Machined nosecone tip for more precise aerodynamics |
| Shelled tail cone for lightness |
| Separation/Recovery - |
| CO2 ejection |
| Deployment bag |
| Smaller drogue and larger main |
| Later timing of separation |

Figure 8. Concept 8 ideas.

Concept 8 was created by allowing Zenith Program team members to review the available ideas and pick what they think would be a “cool” rocket idea for this year. This concept was ranked as high fidelity because of the program’s members confidence that they could build a rocket using these design ideas. While the program members to not have as much experience in rocket design and building as the senior design team, the team finds their feedback extremely useful as we have idea biases from our past engineering experiences that they do not.

**100 Ideas**

Airframe:

|  |  |
| --- | --- |
| Idea # | Generated Idea |
| 1 | Three fins |
| 2 | Triangular fin set |
| 3 | Rectangular fin set |
| 4 | Additional fin set closer to the avionics bay |
| 5 | Blue tube for airframe |
| 6 | Carbon fiber for airframe |
| 7 | Plastic fin supports |
| 8 | Wooden fin supports |
| 9 | Aluminum tailcone |
| 10 | L class motor |
| 11 | K class motor |
| 12 | titanium tailcone |
| 13 | conical nose cone shape |
| 14 | ogive nose cone shape |
| 15 | ellipsoid nose cone shape |
| 16 | power series nose cone shape |
| 17 | Parabolic nose cone shape |
| 18 | Haack series nose cone shape |
| 19 | 3D printed fins |
| 20 | wooden fins |
| 21 | carbon fiber fins |
| 22 | plastic fins |
| 23 | wooden centering rings |
| 24 | plastic centering rings |
| 25 | nylon shock cords |
| 26 | polyester shock cords |
| 27 | elastic shock cord |
| 28 | carbon fiber tailcone |
| 29 | magnetic fasteners for AV bay |
| 30 | Four fins |
| 31 | Sub 6 ft length |
| 32 | 6+ ft length |
| 33 | 6 in body-tube diameter |
| 34 | 6- in body-tube diameter |

Avionics:

|  |  |
| --- | --- |
| 35 | Hardcover |
| 36 | Softcover |
| 37 | Central tray |
| 38 | Compartmentalization tray |
| 39 | Pushbutton switches (already have) (may reduce drag) |
| 40 | Slider switches (visual indication) Recess? |
| 41 | Magnetic camera mount |
| 42 | Spring-loaded camera mount |
| 43 | Screw-in camera mount |
| 44 | Egg timer locator |
| 45 | Air tag locator |
| 46 | GPS locator |
| 47 | Independent Sensor Recording Subsystem (SRS) |
| 48 | SRS MaTch connector to flight computer |
| 49 | SRS separation detection |
| 50 | SRS ejection excitation detection |
| 51 | SRS inertial measurement unit |
| 52 | SRS forward/bay pressure monitoring (too slow) |
| 53 | Airbrake altitude control |
| 54 | Ballast altitude control |
| 55 | 3D printed electronics retainer |
| 56 | Wood electronics retainer |

Fabrication:

|  |  |
| --- | --- |
| 57 | machined fins - aluminum |
| 58 | epoxy coated nose cone that is sanded smooth |
| 59 | shelled tailcone for lightness |
| 60 | custom wrap on body to minimize drag |
| 61 | vertically supported fin brackets |
| 62 | threads to screw nosecone onto body |
| 63 | lock and twist mechanism for securing nosecone |
| 64 | inserted threads to attach nosecone to body |
| 65 | metal bracket to attach nose cone to body |
| 66 | Separate pins to align nosecone pieces |
| 67 | Central pin to align nosecone |
| 68 | Multiple pockets for epoxy |
| 69 | Central pocket for epoxy |
| 70 | Machined nosecone tip for more precise aerodynamics |
| 71 | PETG nosecone I one piece |
| 72 | 3d printed centering rings |
| 73 | Threaded rods that go through nosecone that can be bolted into body |
| 74 | threaded pins to attach each section of nose cone |
| 75 | magnetic locking screws to attach nose cone parts |
| 76 | modular fin can that allows for interchangeable fin cans |
| 77 | modular nosecone that allows for interchangeable nosecones |
| 78 | drafted fins to reduce drag |
| 79 | hollow nosecone |
| 80 | nosecone with infill pattern |
| 81 | magnetically locked nosecone components |
| 82 | welded nosecone components |

Separation/Recovery:

|  |  |
| --- | --- |
| 83 | Streamer drogue |
| 84 | CO2 ejection |
| 85 | Black powder ejection |
| 86 | Tape parachute securement |
| 87 | Deployment bag |
| 88 | Length of shock cord so nosecone hits ground first |
| 89 | Smaller drogue and larger main |
| 90 | Larger drogue and smaller main |
| 91 | Later timing of separation |
| 92 | Earlier timing of separation |
| 93 | Smaller pressure vessels with smaller shear pins |
| 94 | Bigger pressure vessels with bigger shear pins |
| 95 | Higher altitude for main deployment |
| 96 | Lower altitude for main deployment |
| 97 | No extra CO2 ejection ports |
| 98 | 1 extra set of CO2 ejection ports |
| 99 | Length of shock cord so tailcone hits ground first |
| 100 | Length of shock cord so avionics bay hits ground first |