NASA GRC – University Student Design Challenge 2017 Detailed Description

1. INTRODUCTION

NASA Glenn Research Center has been researching and developing innovative technologies in both aeronautics and space flight for 75 years. As an opportunity to further involve undergraduate students, NASA Glenn is hosting the Spring 2017 University Student Design Challenge (USDC). Consistent with its research areas, Glenn is presenting two competitions: one related to aeronautics and the other related to space. The Design Challenge is open to teams of full-time, sophomore-through-senior-year undergraduate students in accredited U.S. academic institutions. The teams are encouraged to be multidisciplinary, with mainly science, technology, engineering and mathematics (STEM) majors but, also, open to students in areas such as economics, marketing, graphic arts, or other disciplines that would aid in the success of the idea. The teams will have faculty advisors at their universities, as well as, regular access to technical mentors at Glenn.

The teams' submissions must focus on NASA Glenn's Core Competencies. Submissions related to the aeronautics Design Challenge must include consideration of energy consumption, noise, emissions, cost, alternative energy, and safety. The Challenge will relate to integrating aeronautics into commuter travel in metropolitan areas. Submissions will answer the quest for how a community would look, if aeronautics vehicles were used as a means to travel within city limits. The full competition description and requirements can be found in Section 3.

A rubric will be distributed to score the submissions. Successful submissions will help to fuel the tradition that NASA Glenn has established to help shape aeronautics and space communities.

2. OVERALL CHALLENGE GOALS

Societal needs include an optimal combination of technical and employable skills to drive and sustain the engine for workplace productivity. This can be done by using widely multidisciplinary teams of students whose majors are Science, Technology, Engineering, Arts, and Mathematics (STEAM). Using the insights of teams of students with highly diverse knowledge will increase both the ability and creativity of the teams and yield team-building and communication skills which can enhance workplace productivity. The Design Challenge calls upon a multidisciplinary view to gain knowledge from the ideas and feasibility assessments that come from it.

3. Aeronautics Design Challenge:

Future Air Vehicles - Concepts and Operations in Metropolitan Areas

The year is 2020. The newly established International Environmental Council, exercising its considerable new powers, has mandated strict new exhaust emission requirements for all forms of civilian transportation. Surface and air transport vehicles of all varieties have been classified and regulated according to levels of carbon dioxide, unburned hydrocarbons, oxides of nitrogen and sulfur, and particulate matter they emit. These new worldwide environmental requirements are effective immediately, with costly fees to penalize owners of existing vehicles and manufacturers of new vehicles out of compliance with the new rules.

Reeling, the Nation mobilizes its engineers, scientists, and transportation planners to design new transportation infrastructure concepts and vehicles for this brave new world. A breakthrough in electronic technology occurs. Soon, engineers are building new classes of batteries and capacitors with twice the energy density of conventional energy storage systems. With this remarkable enabling achievement, experts focus their attention on ground-breaking new transportation concepts and vehicles.

3.1 Description of the "Multimodal Outer Belt" Scenario

For the first time in recorded history, the majority of the world's population lives and works in urban rather than rural areas. The concentration of people compounds several issues, including travel congestion, safety from natural and unnatural disasters, respiratory health, and noise. While commercial air travel still satisfies most long-distance travel needs in the United States, road and commuter rail dominate urban transportation worldwide. In this scenario, it is thought that aviation can alleviate growing urbanization issues within the United States and globally, and create new transportation markets

by better-connecting travelers to and within travel modes. An example of a high-level solution is to implement an aviation-based multimodal outer belt concept in which air vehicles depart from different nodes around the city with short hops between nodes, as shown in Figure 1. These nodes could connect highways, regional airports, rail stations, bus stations, or ferries to yield a more seamless commute around a city.

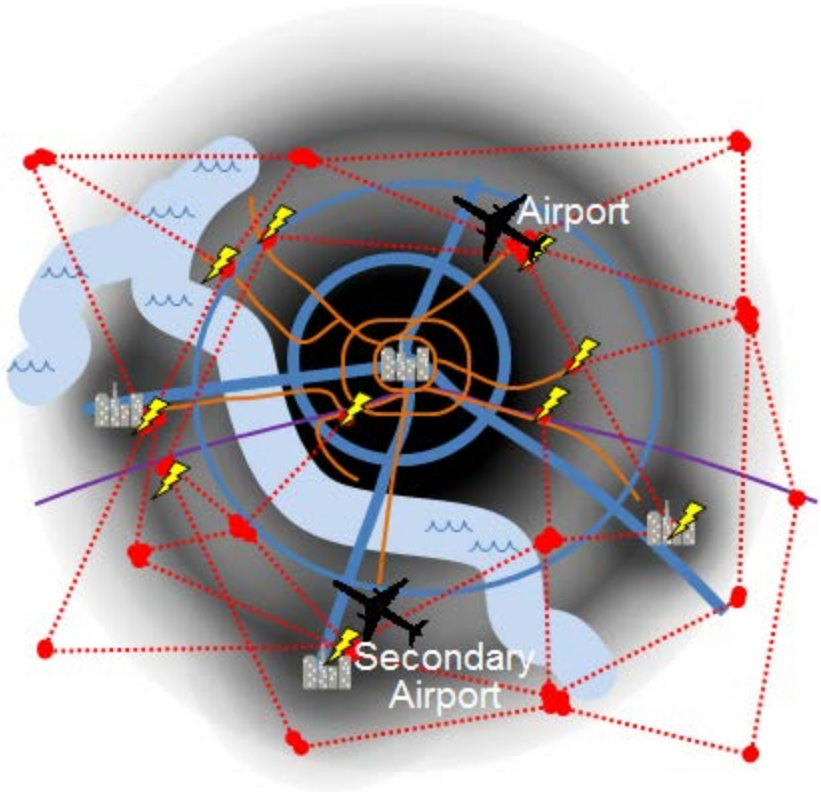

Figure 1.—Example configuration of a metroplex in which aeronautics has been incorporated into intra-city travel.

3.2 Mission Performance Requirements

Conceptual design of an air vehicle is the essential part of the competition. Vehicle characteristics and performance requirements of the transport can be roughly determined from the description of the scenario. Note, however, that the multimodal outer belt scenario is only a guide. Student teams are welcome to deviate somewhat from the scope of the given scenario if characteristics of their air vehicle warrant a change. In any case, each student design team should consider how an air vehicle could satisfy the requirements of the scenario and determine gross vehicle performance requirements such as passenger and payload-carrying capability, range, and airspeed. The mission implies that the transport would mimic a public transportation bus with stops at each node for loading and unloading passengers. The scenario implies that the transport should have zero (or near-zero) emissions and thus will likely be equipped with some form of fully- or hybrid-electric propulsion.

3.3 Air Vehicle Conceptual Design

Once the transport performance requirements have been defined, the student teams need to conceptually design their vehicle. This includes choosing a propulsion system architecture, modeling and sizing the vehicle, and considering the constraints of operating within a populated area. In order to make their design an improvement on the current transportation architecture, an emphasis should be put on fully- or hybrid-electric vehicles. Student teams may exploit the fictitious energy-storage “breakthrough” described above to help close their vehicle in their sizing analysis. Some thought should be given to how the vehicle will operate in and out of the transportation nodes. Other topics to consider include vertical takeoff and landing (VTOL), short takeoff and landing (STOL), advanced power systems, and propulsion-airframe integration. Another key decision is whether the vehicle will be piloted, remotely piloted, or capable of autonomous flight. How (or if) the transports will operate in weather may impact the design. Student teams should propose solutions for dispatch reliability, icing prevention, and safety.

In order to be considered competitive, attention and analysis should be paid to the following required subject areas:

- Definition of the mission (by approximately one-quarter of the semester) and specification on-
  - Sample city and infrastructure
  - Payload, range, and speed
  - Market research on societal impact, public acceptability of air vehicles, and other areas

- Vehicle design (the remainder of the semester) and specification on-
  - Airframe
  - Propulsion
  - Electrical systems and their thermal management
  - Other major systems and subsystems
  - Weight and balance assessment
  - Performance analysis

If gaps or shortfalls in weight or performance are predicted by the analysis, additional technologies may be proposed and used to close the vehicle design. Student teams should be prepared to define what the technologies are and how they will be used.

3.4 Special Considerations for Noise

Community noise will be a key consideration. These transports will be operating in proximity to neighborhoods. Daytime versus nighttime operations and how well the transportation nodes are insulated from populated neighborhoods are important considerations. Special attention should be given at the outset, regarding low-noise vehicle design. Student teams should give attention first to noise metrics. Traditional aviation noise metrics such as those defined by the Federal Aviation Regulations (Refs. 1 and 2) for airport noise and land-use planning may not be appropriate for flight in and between neighborhoods. After appropriate metrics are defined, reasonable noise limits should be set. An estimate of the vehicle's noise signature should be made. The vehicle should then be analytically "flown" between nodes, and noise should be predicted for observers on the ground. If a shortfall between predicted levels and set limits exists, student teams should investigate and propose noise-reduction strategies to close the gap.

References

[1]. Noise Standards: Aircraft Type and Airworthiness Certification. U.S. Code of Federal Regulations, Title 14, Ch. 1, Part 36.

[2]. Airport Noise Compatibility Planning. U.S. Code of Federal Regulations, Title 14, Ch. 1, Part 150.