GRC – NASA Multidisciplinary Aeronautics Research Team Initiative (MARTI)
NASA Hyperloop Design and Optimization – 2016

Mentor Name(s)/Phone #(s): Jeff Chin/216 433-2026 & Dr. Christopher Heath/ 216 433-2757
Office/Division Name: Propulsion Division (LT)
Branch Name: Propulsion Systems Analysis Branch (LTA)

Project Title: Design and Prototype Development of a Hyperloop Vehicle Concept for Next-Generation Transportation

Type of Opportunity: □ X Research Associateship (MARTI)

Project Description:

1. **Brief background & NASA mission/program support:**

Aeronautics research at NASA is driven by a growth in demand, sustainability, and technology convergence for high-speed transport. The Hyperloop is a transformative fully electric vehicle concept that combines commercial air vehicle speeds with train-like efficiency, offering primary benefits of each. These traits align perfectly with NASA ARMD's strategic thrusts (specifically Transformative Aeronautics Concepts Program, TACP) involving ultra-efficient commercial vehicles and transitioning to low-carbon propulsion. The vehicle's unique operation, intended range, efficiency, and passenger throughput set it apart from any other NASA aeronautics pursuits.

The Hyperloop is an aero-derivative concept, where passenger and/or cargo vehicles fly within partially evacuated tubes at ground level. Primary thrust is provided by external linear accelerator motors, while an on-board electric-driven compressor bypasses flow through the vehicle. This forward facing compression system combined with a low-pressure environment produces favorable aerodynamics enabling speeds rivaling aircraft, and also provides secondary thrust by exhausting through an aft nozzle. Lastly, the Hyperloop concept adopts the use of non-contact air bearings or Maglev technology to reduce ground friction effects. In short, the concept is a "high-altitude electric propulsor operating in severe ground effect" and could serve as a high-visibility, near-term test-bed for many aircraft engine technologies and high speed launch systems.

In 2014, NASA system engineers performed initial evaluations of the Hyperloop vehicle, supporting general concept feasibility. In Aug. 2015, SpaceX offered to sponsor an international Hyperloop vehicle grand challenge, inviting participants from academia, industry and government to design Hyperloop concepts and sub-scale prototypes to be evaluated on a test track in Summer 2016. To date, NASA's Convergent Aeronautics Solutions (CAS) project is sponsoring an exploratory effort to build a team, continue feasibility research, and develop a roadmap of overlapping technologies that would mutually benefit Hyperloop and more conventional NASA research goals. The research is a potential candidate for CAS FY '17 funding, with conceivable benefits to numerous other ARMD projects, including particularly the TACP. There is an opportunity to align research objectives with projects ranging from advanced Protruded Rod Stitched Efficient Unitized Structure (PRSEUS) composites under the Environmentally Responsible Aviation (ERA) Project, to electric components, to distortion tolerant inlets and fans under the Advanced Air Transportation Technologies (AATT) Project. The autonomous vehicle operations and university/industry collaborations could also mutually benefit the Safe Autonomous Systems Operations (SASO) and Long-term Engagement in Authentic Research with NASA (LEARN) projects, respectively.

By Spring 2016, GRC hopes to expand the collaboration to other NASA centers, government agencies, and even universities and industry partners. The research would span several disciplines, with students working closely with a diverse set of mentors. The students may travel for Hyperloop Design Weekend, hosted by SpaceX, and other collaborative events.

2. **Objective(s) of project:**
The objective of this project is to identify, further assess, and demonstrate the feasibility of various design components necessary for the viability of the Hyperloop vehicle concept. This will involve analytical modeling of aerodynamic, electrical, and structural properties of the system. Beyond paper studies, the team will develop hardware designs necessary to demonstrate or validate key technology components. An opportunity also exists to present Hyperloop vehicle designs to a panel of experts from industry (SpaceX, Tesla Motors) and academia should NASA funding permit.

3. **Specific Eight-Student Team Assignment:**
a) Students and mentors will meet to establish a plan, identify roles, and responsibilities
b) Research existing openly available vehicle designs, applicable tech and toolsets
c) Develop an analytical model to size and down-select the necessary batteries, compression system, levitation system, and fuselage design.
d) Perform high-fidelity analyses (FEA, CFD) to further substantiate the chosen design.
e) Design a minimum viable prototype for a vehicle subsystem or test-rig hardware to validate a key-enabling component(s) from any of the subsystems mentioned above.
f) Participate in an internal NASA design review, vetting the project design and implementation plans
g) Collaborate with an internal or external partner for manufacturing and integration
h) Generate a report and/or publication summarizing the design and test results.

4. **Expected Outcomes** –
(a) **Research and Engineering**: Students will work in a team with a group of mentors to design a vehicle subsystem and/or testing apparatus
(b) **Poster Presentation**: The group will present results to groups of NASA managers and researchers through oral presentations.
(c) **Final Report**: The team will compile the results and findings in a NASA TM or conference paper or journal article, depending on results.

Desired Attributes:
* Desired skills for team members would include:
Python or Matlab for system level analysis and/or
Computer solid modeling for mechanical design and/or
Rapid prototyping: such as 3D Printing, carbon fiber wrapping and/or
Experience with higher order analysis requiring FEA or CFD
* College/Academic Level at time of Internship or Fellowship:
Rising Senior, Senior, Master's, Doctoral
* Academic Disciplines/Majors:
Aerospace, Mechanical, Electrical, Physics, Controls, Math, Computer Science

Applicable Program:
□X NASA Multidisciplinary Aeronautics Research Team Initiative (MARTI)

Session(s) (select): □ X Summer 2016

Work Environment: Laboratory and office setting, with an opportunity for external travel/collaboration

Alternate Mentor(s) or Co-Mentor(s) Name: Dr. Isaiah Blankson **Phone(s)**: 216.433.5823 **Code(s)**: LT