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| N202-107  | TITLE: Radio Communication with Hypersonic Aerial Vehicle |

RT&L FOCUS AREA(S): Hypersonics, Network Command, Control and Communications

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop an effective radio frequency communication system solution for communicating through the plasma sheath surrounding a hypersonic aerial vehicle. ITAR: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

DESCRIPTION: When a vehicle is traveling at hypersonic speed through the atmosphere, a plasma sheath envelops the aerial vehicle because of the ionization and dissociation of the atmosphere surrounding the vehicle [Refs 1-3]. The plasma sheath prevents radio communication, telemetry, and Global Positioning System (GPS) signal reception for navigation [Ref 4]. This radio “blackout” period poses a serious challenge that hinders the use of hypersonic aerial vehicles for future naval applications. Development of an appropriate mitigation method to allow uninterrupted aerial vehicle to control station and control station to vehicle communications through the plasma sheath during the entire hypersonic flight is required. Develop and demonstrate an effective blackout mitigation solution that enables continuous communication between a stationary or mobile platform and a hypersonic vehicle during hypersonic flight. Many mitigation techniques have been proposed, including but not limited to, aerodynamic shaping, magnetic windows, and liquid injection. Any innovative solution capable of eliminating any radio frequency communication disruptions due to the plasma sheath [Ref 4] will be considered.

PHASE I: Develop concepts for communication directly through the plasma sheath of a hypersonic aerial vehicle in the frequency band between 1.1 to 5.6 GHz for error-free GPS and radio communication for a separation distance up to 20,000 km. Perform modeling and simulation of the proposed concepts in the hypersonic environment to validate their feasibility. Complete design tradeoffs to predict the performance, size, weight, and power requirement of the most promising design. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a hardware prototype based on the Phase I design. Demonstrate the prototype’s radio frequency communication capability and characterize its communication performance in a terrestrial plasma chamber to establish proof of concept.

PHASE III: Fully develop and transition the radio frequency communication system based on the final design from Phase II for Naval applications in the areas of reliable and error-free radio communication with hypersonic aerial vehicles. The commercial sector would benefit from this research and development in the area of radio communication with hypersonic re-entry space vehicles.

REFERENCES:

1) 1. Chadwick, K.M., Boyer, D.W. and Andre, S.S. “Plasma and Flowfield Induced Effects on Hypervelocity Reentry Vehicles for L-Band Irradiation at Near Broadside Aspect Angles.” 27th AIAA Plasmadynamics and Lasers Conference, New Orleans, LA, June 1996. https://arc.aiaa.org/doi/10.2514/6.1996-2322 2. Norris, G. “Plasma Puzzle: Radio Frequency-Blocking Sheath Presents a Hurdle to Hypersonic Flight.” Aviation Week & Space Technology, March 2009, p. 58. 3. Blottner, F.G. “Viscous Shock Layer at the Stagnation Point with Nonequilibrium Air Chemistry.” AIAA Journal, vol. 7, no. 12, December 1969, pp. 2281-2288. https://arc.aiaa.org/doi/abs/10.2514/3.5528?journalCode=aiaaj 4. Hartunian, R.A. et al. “Implication and Mitigation of Radio Frequency Blackout during Reentry of Reusable Launch Vehicles.” AIAA Atmospheric Flight Mechanics Conference, Hilton Head, South Carolina, Aug 20-23, 2007

KEYWORDS: Radio Frequency, Communication, Plasma, Hypersonic, Black-Out, GPS