AEROCAPTURE FEASIBILITY ASSESSMENT FOR MISSIONS TO VENUS. Y. Lu[1†], P. G. Athul[2†], and S. J. Saikia[3†] and J. A. Cutts[4‡], [1]yelu@purdue.edu, [2]apradee@purdue.edu, [3]ssaikia@purdue.edu, [†]School of Aeronautics and Astronautics, Purdue University, 701 W. Stadium Ave., West Lafayette, IN, 47907, [‡]james.a.cutts@jpl.nasa.gov, NASA-Caltech Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA, 91109.

Venus Exploration: Venus has been visited by spacecraft from US, Russia, and Japan over the last few decades; however, the last US mission to Venus—Magellan, was over 20 years ago. As instrument capability increases, another mission to Venus could significantly improve our understandin. Exploring Venus will help in understanding how our planet has formed. three goals were identified in VEXAG Goals, Objectives & Investigations study [1]:

- understanding the atmosphere's origins and its evolution, as well as the climate history,
- determining how the surface and interior evolved,
- understanding the interior-surface- atmosphere interactions over time, as well as if liquid water was ever on Venus.

There have been missions proposed to perform atmospheric and/or surface sample returns, where an Earth return orbiter is required [2]. Recently, Venus Bridge—a SmallSat program is studies at NASA, aiming to link the past and future US exploration by one or more small missions launching in the early-to-mid 2020s [3].

Venus Bridge Study: Venus Bridge study considered low-cost candidate concepts including CubeSats, SmallSats, in-situ/lander, and balloon, all of which have delivered payload less than 200 kg. For a low-cost mission, ride-along options with spacecraft that are using Venus for gravity assist either for exploring the heliosphere or the outer planets, are particularly attractive. However, the ΔV requirements for achieving orbit and particularly a tight orbit using chemical propulsion can be prohibitive. Aerocapture is a promising alternative for mass-efficient Venus Bridge orbital missions but approaches to aerocapture that avoid complex navigation and control capabilities will be essential if aerocapture is to be affordable.

Aerocapure Assessment: Aerocapture has been shown to enhance mission capabilities to Venus by an increase in delivered payload of 79% for circular orbit (and 43% for elliptic orbit) [4]. Aerocapture assessments were completed by NASA in 2006 for missions to Neptune, Titan, and Venus [5]. While the study results on Neptune and Titan are detailed, Venus aerocapture study report lacked in detail and provided a reference point design. Parametric study of Venus aerocapture was also conducted in [6]; they considered an Apollo style entry vehicle with *L/D* of 0.2 and 0.35, and entry velocities from 10-15 km/s. There is a need to perform a feasibility study on Venus aerocapture and conduct more comprehensive parametric studies. Previous study on Aerocapture assessment for ice giants conducted at Purdue University has provided more insights on the applicability of aerocapture—key parameters in aerocapture system design being vehicle *L/D*, required corridor width, peak g-load, peak heat rate, and total heat load [7].

In this study, feasibility of aerocapture at Venus is analyzed with a comprehensive approach considering a range of vehicle *L/D*, ballistic coefficient, and arrival V_∞. Deceleration load limited is considered, and peak heating rate and total heat load are also evaluated using empirical relations. A parametric study of the target apoapsis and post-capture required ΔV will also be conducted. Detailed applicability and feasibility space will be presented. Results and conclusions will be drawn in the perspective of vehicle design consideration and interplanetary arrival conditions.

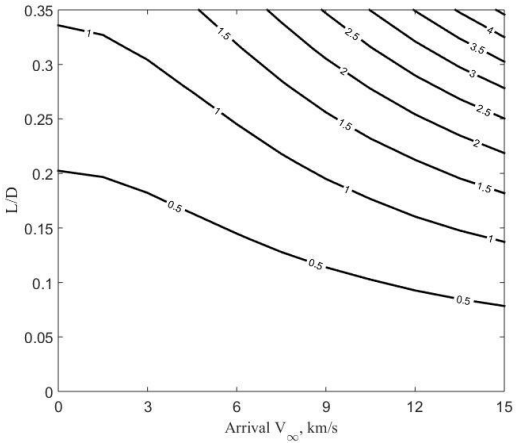

Fig 1: Theoretical corridor width for aerocapture missions to Venus.

Interplanetary Trajectory Consideration. In addition, trajectory search will be performed for a ballistic transfer for Venus orbiting mission, thus obtaining for more details on the arrival declination and time of flight to Venus.

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