CUBESATS TO SUPPORT FUTURE IO EXPLORATION. D. A. Williams[1], R. M. C. Lopes[2], J. Castillo-Rogez[2], D.C. Jacobs[1], and P. Scowen[1], [1]School of Earth & Space Exploration, Arizona State University, Box 871404, Tempe, AZ 85287 (David.Williams@asu.edu), [2]NASA Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA, 91109.

Introduction: CubeSats are small satellites built around standardized subunits measuring 10x10x10 cm and weighing 1.33 kg ('1U'), with common configurations including 1U, 2U, 3U, and 6U (with 12U and 24U under development). Last year NASA had a proposal opportunity called Planetary Science Deep Space Small Satellites Study (PSDS3), requesting concepts to apply CubeSats to support planetary exploration, as ride-along payloads for future planetary missions. In this abstract we discuss our proposed mission concepts, an investigation of how CubeSats may be utilized to support future exploration of Jupiter's volcanic moon, Io.

Summary of Study: We would investigate how CubeSats could be utilized to study Io, the most volcanically active object in the Solar System, as part of a future New Frontiers or Flagship mission to the Jovian system. Io represents the harshest environment in which to operate a spacecraft, because it is located deep within Jupiter's radiation belts [e.g., 1] such that spacecraft must endure the complicating effects of radiation on electronics operations, as well as navigation, propulsion, and communication challenges. Our vision is to utilize CubeSats as short-lived, sacrificial probes to gather unique data that cannot be obtained by a Jupiter-orbiting Io Observer spacecraft or other Jovian system mission. We proposed to study the feasibility of three specific mission concepts:

Concept A) A CubeSat released on a descent trajectory towards a specific Ionian volcano. This CubeSat, equipped with visible/near-infrared (VNIR) and/or thermal-infrared (IR) cameras, would obtain grayscale, color, and thermal images of the volcano and its associated features at ever increasing spatial resolutions as the CubeSat descends. This "*Ranger*-style" approach would yield images similar to the descent imager on the Huygens lander. These data would provide detailed information on volcano-tectonic processes of a specific volcano for a range of scales, from the broader context to the high-resolution images obtained prior to impact. The thermal instrument would measure temperatures of small hot areas to determine if these temperatures are consistent with ultramafic lava compositions as suggested from *Galileo* [e.g., 2]. The spatial resolution of these data could not be obtained from a multi-flyby mission such as *Galileo* or the proposed Discovery concept Io Volcano Observer [IVO: 3].

Concept B) A CubeSat released on a descent trajectory directed toward a volcano with an active plume - either a persistent plume (e.g., Prometheus) or a larger, more variable plume (e.g., Pele), in which the spacecraft would contain a mass spectrometer and a dust detector to measure plume gas compositions and dust particle sizes and compositions. This would be similar to the *Cassini* fly-through of the plumes on Enceladus. *In situ* measurement of Io's volcanic gas compositions using a mass spectrometer has not been attempted before, and a CubeSat can risk a flyby at much lower altitude where the gas and dust densities are significantly greater and the compositions are likely more complex.

Concept C) One or multiple magnetometer-equipped CubeSats released on low-altitude, polar or equatorial flybys to measure Io's internal magnetic induction. These data would provide constraints for modeling the depth and melt fraction of Io's magma ocean and variability of its magnetic field. The magnetometer would be similar to INSPIRE, the basis of the ICEMAG instrument on the Europa Clipper mission.

Should a new CubSat proposal opportunity occur, we would propose this study to be conducted by Team-Xc at the Jet Propulsion Laboratory, in conjunction with our CubeSat class in Arizona State University's School of Earth and Space Exploration. Engineering students would investigate various instruments for their viability in Io's radiation environment, supervised by ASU faculty including guest speakers from JPL/Team-Xc. Results from the student's work would feed back to Team-Xc to support the spacecraft design study. Expected outcomes from this study include: 1) mass-power-propulsion-communication-data processing requirements to implement our mission concepts, including required size of the CubeSats, 2) identification of specific instruments to satisfy the CubeSat mission requirements, 3) a recommended parts lists, including Commercial Off-The-Shelf (COTS), available for these instruments, and 4) a final report to be presented to NASA.

References: [1] Paranicas, C., et al., 2004. In *Europa*, Papplardo, R.T., et al., eds., Un. Arizona Press, Tucson, 529-544. [2] McEwen, A.S., et al., 1998. *Icarus, 135*, 181-219. [3] McEwen, A.S., et al., 2014. Acta Astronautica, 93, 539-544.

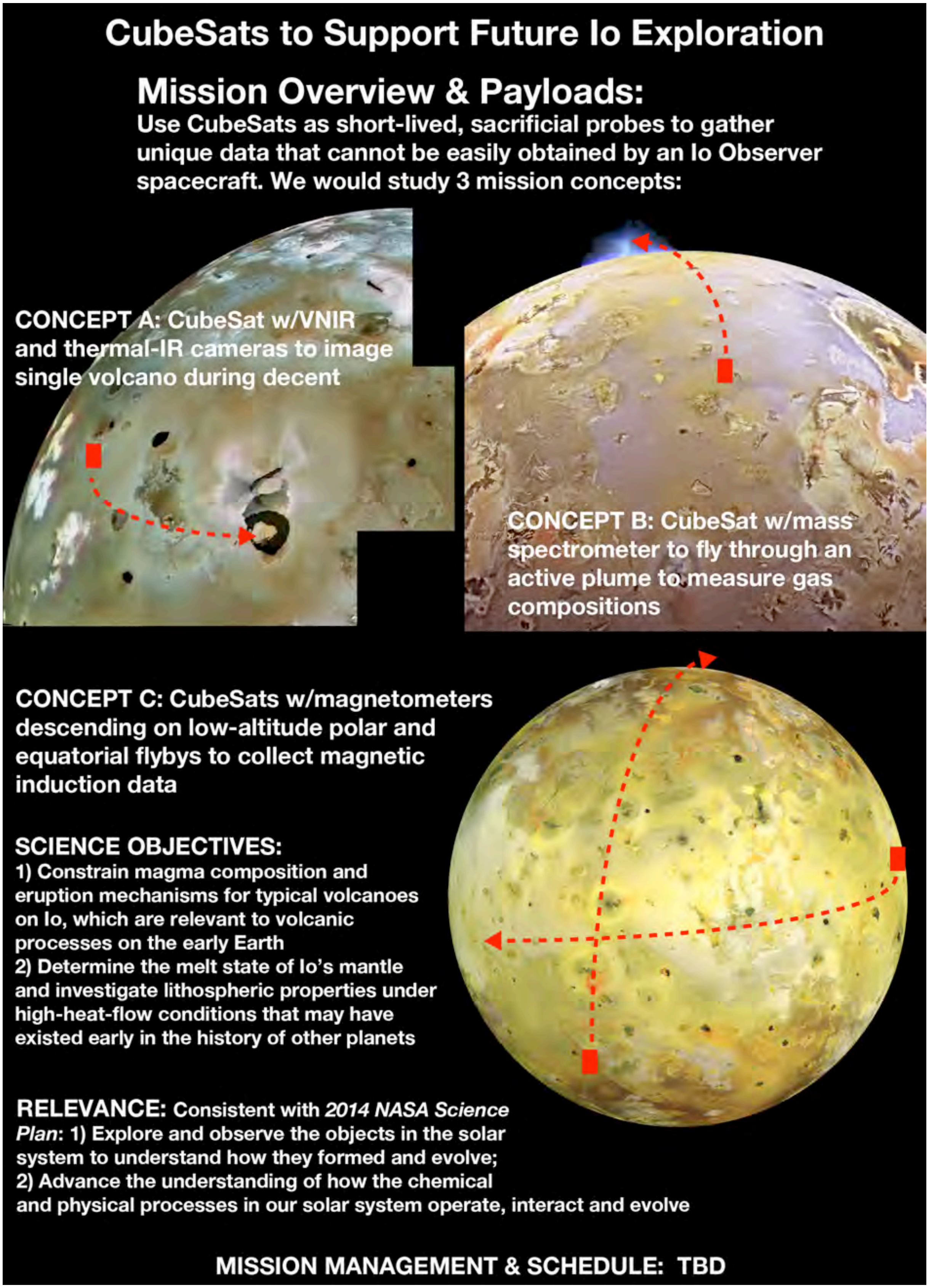

Figure 1. Mission Concept Fact Sheet for our Io CubeSat Study.