The Ganymede Interior Structure, and Magnetosphere Observer (GISMO) Mission Concept K. L. Lynch[1] , I. B. Smith[2], K. N. Singer[3], M. F. Vogt[4], D. G. Blackburn[5], M. Chaffin[6], M. Choukroun[7], N. Ehsan[8], G. A. DiBraccio[8,9], L. J. Gibbons[10,11], D. Gleeson[7], B. A. Jones[6], A. LeGall[7], T. McEnulty[12], E. Rampe[13], C. Schrader[14], L. Seward[15], C. C. C. Tsang[16], P. Williamson[17], J. Castillo[7], C. Budney[7]. [1]Colorado School of Mines, Golden CO 80401 (klynch@mines.edu); [2]University of Texas, Austin TX; [3]Washington University, St. Louis, MO; [4]University of California, Los Angeles, CA; [5]University of Arkansas, Fayetteville, AR; [6]University of Colorado, Boulder, CO; [7]NASA Jet Propulsion Laboratory, Pasadena, CA; [8]NASA Goddard Space Flight Center, Greenbelt, MD; [9]University of Michigan, Ann Arbor, MI; [10]NASA Langley Research Center & National Institute of Aerospace, Hampton, VA; [11]Virginia Tech College of Engineering, Blacksburg, VA; [12]University of California-Berkeley, Berkeley, CA; [13]Arizona Sate University, Tempe, AZ; [14]NASA Marshall Space Flight Center, Huntsville, AL; [15]University of Central Florida, Orlando, FL; [16]Southwest Research Institute, Boulder, CO; [17]NASA Johnson Space Center, Houston, TX.

Introduction: The NASA Planetary Science Summer School (PSSS) at JPL offers graduate students and young professionals a unique opportunity to learn about the mission design process. Program participants select and design a mission based on a recent NASA Science Mission Directorate Announcement of Opportunity (AO). Starting with the AO, in this case the 2009 New Frontiers AO [1], participants generate a set of science goals and develop a early mission concept to accomplish those goals within the constraints provided.

As part of the 2010 NASA PSSS, the Ganymede Interior, Surface, and Magnetosphere Observer (GISMO) team developed a preliminary satellite design for a science mission to Jupiter's moon Ganymede. The science goals for this design focused on studying the icy moon's magnetosphere, internal structure, surface composition, geological processes, and atmosphere. By the completion of the summer school an instrument payload was selected and the necessary mission requirements were developed to deliver a spacecraft to Ganymede that would accomplish the defined science goals. This poster will discuss those science goals, the proposed spacecraft and the proposed mission design of this New Frontiers class Ganymede observer.

Science Objectives: Since its discovery by Galileo in 1610, Ganymede has been visited by three spacecraft which collected data over eight flybys. These missions have led to several remarkable breakthroughs, including the discovery of an intrinsic magnetic field.

The proposed Ganymede Interior, Surface, and Magnetosphere Observer (GISMO) mission would expand on our present understanding of the largest satellite in the solar system. The mission was designed to achieve the following overarching science objectives:

- Characterize the intrinsic and induced magnetic fields of Ganymede; study the interaction of Jupiter's magnetic field with Ganymede's magnetosphere and surface.
- Determine Ganymede's interior structure and composition, with particular focus on the presence, location, and characteristics of a subsurface ocean.
- Understand the mechanisms responsible for the formation of surface features and implications for geological history, evolution, and levels of current activity.
- Determine Ganymede's surface composition and implications for the origin and evolution of surface materials.
- Determine the composition and density of Ganymede's atmosphere.

Instruments: In order to address these science goals, GISMO would carry three primary instruments and a secondary radio science package. Two boom-mounted magnetometers, as well as a body mounted radar sounder and combined visible camera/imaging infrared spectrometer would collect data, figure 1 , throughout the mission as described in the following sections.

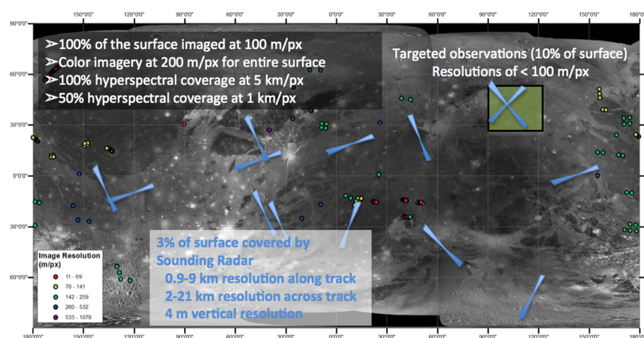

Figure 1. Map indicating the locations and resolutions of images of the surface of Ganymede gathered by the Galileo mission, along with a description of the proposed GISMO data products. Blue lines indicate possible sounding radar swaths for each flyby, while dots indicate the location and resolution of the Galileo images

Magnetometer. The magnetometer package, MaGe, would consist of two triple-axis fluxgate magnetometers mounted at 2.5 m and 5 m on a once deployable five meter boom. These proposed magnetometers are modeled after those employed on the *MESSENGER* and *Juno* missions and would require little new technological development [2, 3].

Radar Sounder. The proposed radar sounder for GISMO was developed based on the two radar instruments currently at Mars: MARSIS (Mars Advanced Radar for Subsurface and Ionosphere Sounding) on *Mars Express* and *SHARAD* (SHAllow RADar) on the *Mars Reconnaissance Orbiter* [4,5]. This radar would allow GISMO to probe below the surface of Ganymede at a vertical resolution of ~5 m during closest approach on each of its 14 flybys.

Camera/Imaging Spectrometer. Simultaneously with radar measurements at closest approach, GISMO would image the surface of Ganymede in the visible and infrared with a high-resolution integrated camera/IR spectrometer, CamVIR. This proposed instrument would consist of a narrow-angle visible camera coupled to an infrared imaging spectrometer by combining the properties of Deep Impacts Medium and High-Resolution Instruments, MRI and HRI [6].

Mission Design Overview: The mission design uses a Venus-Venus-Earth gravity assist (VVEGA) trajectory to Jupiter. The mission would utilize an Atlas V 401 launch vehicle with the 4-m fairing (3.75m static payload envelope), which allows a launch of 2640 kg.

During Jupiter orbital insertion (JOI) the spacecraft would first make a close flyby of Ganymede before perijove at a distance of approximately 6 Jupiter radii. This is near the orbit of Io, possibly providing an additional science opportunity. The Jovian tour phase would involve 14 flybys for the nominal mission of 1 year. The orbit would be in the equatorial plane for the first 5 flybys, and progress to an inclined orbit in order to image Ganymede's poles and mid-latitudes. This combination of orbits would allow for observations of the same areas previously imaged by Galileo but at higher resolution, as well as new areas selected for scientific merit.

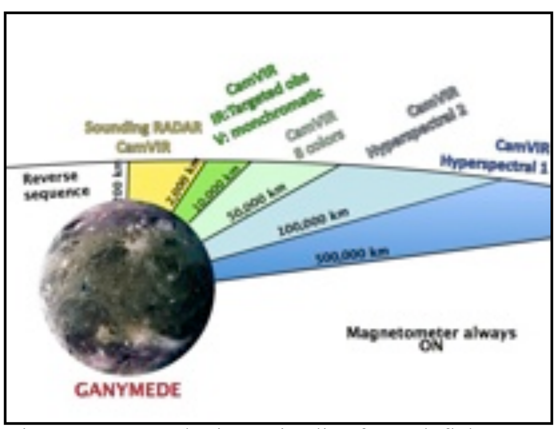

Figure 2. Proposed science timeline for each flyby

Given the science requirements and payload outlined previously, we developed a flyby timeline that determines which instruments will be active as a function of the distance from Ganymede. As shown in figure 2, active science operations are chosen in sequence to begin on approach, at 500,000 km distance from the satellite and then reversed until reaching the same distance on the outgoing trajectory. These staged operations reduce mission complexity so that instruments would not compete for resources, thereby simplify the engineering design [7].

The spacecraft would not carry sufficient fuel for disposal into Jupiter and so a controlled impact of Io would be used. This avoids undesired impacts with Europa, Ganymede, or Callisto after decommission and provides another target of opportunity for studying Io.

As a New Frontiers Class Mission, GISMO would be cost-capped at $650 Million in Fiscal Year 2009. The cost cap and all subsequent costs analyses were converted into Fiscal Year 2010 resulting in an adjusted overall cost cap of $728.5 M in FY10 dollars. The overall mission cost for GISMO would be $709.1 M, which falls short of the cap by $19.4 M and would include all required reserves as defined by the AO [1].

Acknowledgements: The 2010 Planetary Sciences Summer School was held at the Jet Propulsion Laboratory, California Institute of Technology, under government contract to NASA. We would also like to thank the members of the JPL Education office that assisted with the event.

We also wish to thank the members of JPL's Team X for their assistance in developing this design: David Brown, Debarati Chattopadhyay, Bjorn Cole, Joan Ervin, Ron Hall, Robert Haw, Yuyao He, Robert Kinsey, Suzanne Klein, Barbara Lam, Try Lam, Alfred Nash, Laura Newlin, Jamie Piacentine, Steven Pravdo, Natalia Sanchez, Brian Schratz, Parthasarathy Shakkottottai, William Smythe, Matthew Spaulding, Ryan Stern, Keith Warfield, Gregory Welz, Rebecca Wheeler, Paul Woodmansee.

References: [1] *Announcement of Opportunity: New Frontiers (2009)*, NASA. [2] Kivelson M. G. et al. (1998) *JGR,* 103, 963-972. [3] Anderson B. J. et al. (2007) *Space Sci. Reviews,* 131, 417-450. [4] Seu R. et al. (2004) *Planetary & Space Sci*, 52, 157-166. [5] Picardi G. et al. (2004) *ESA Publications,* 51-69. [6] Dalton J. B. et al. (2005) *Icarus, 177, 472-490.* [7] Jones B. A. et al. (2011) *IEEE Aerospace Conference*, Paper #1783.