Mass Analyzer for Real-time Investigation of Neutrals at Europa (MARINE). Murray Darrach[1], Ken Farley[2], Stojan Madzunkov[1], Dragan Nikolic[1], R. Kidd[1] and Evan Neidholdt[1]. [1]Jet Propulsion Laboratory, California Institute of Technology, [2]California Institute of Technology

Presented herein is the progress towards developing a new mass analyzer for analysis the exospheres of planets, moons, and primitive bodies, such as found at Europa or Enceladus. Europa, one of Jupiter's four Galilean moons, may be the most likely place in the solar system to harbor life beyond Earth. Its subsurface ocean plausibly contains the key ingredients for life as well as sources of chemical energy. Clues to the composition and chemical state of Europa's ocean can be found both on Europa's icy surface and in its tenuous atmosphere. Given the high scientific priority of assessing the habitability of Europa's ocean, the Europa Clipper payload includes a Neutral Mass Spectrometer whose purpose is to characterize the composition of ejected surface products during a series of flyby investigations, with a particular focus on quantifying the absolute and isotopic abundances of SO2 and CO2 [1].

The Mass Analyzer for Real-time Investigation of Neutrals at Europa (MARINE), shown in Figure 1, is capable of measuring not only the abundances of neutral particle species in Europa's exosphere including H2O, O2, CO2, and SO2, but also determining their number density profiles at per-second sampling rates as a function of altitude above Europa's surface. The instrument will either detect tracers of potential subsurface biological activity in Europa's exosphere, or place upper limits on their surface abundances. It exceeds all Science Traceability Matrix requirements for the Neutral Mass Spectrometer (NMS) instrument on the Europa Clipper payload while remaining compatible with NMS spacecraft accommodation constraints for mass, power, data volume, and field-of-view. MARINE uses a Quadrupole Ion Trap Mass Spectrometer (QIT-MS) to achieve an unsurpassed combination of low mass (MSHA: 7.5 kg), low power (34 W average), ultra-high sensitivity (1x1014 counts/torr/sec), and ultra-high precision (0.3% for noble gas isotope ratios over 24 hours). This precision is 10 times better than has previously been demonstrated using an ion trap mass spectrometer.

MARINE is a new tool for planetary exploration whose core QIT-MS has been under development at JPL over the last decade, and operated successfully on the International Space Station from June 2010 through September 2012 as the main component of the Vehicle Cabin Atmospheric Monitor (VCAM) instrument. [2] The VCAM QIT-MS met all requirements with margin, performed flawlessly, and exceeded its required 1 year lifetime by over 100%.

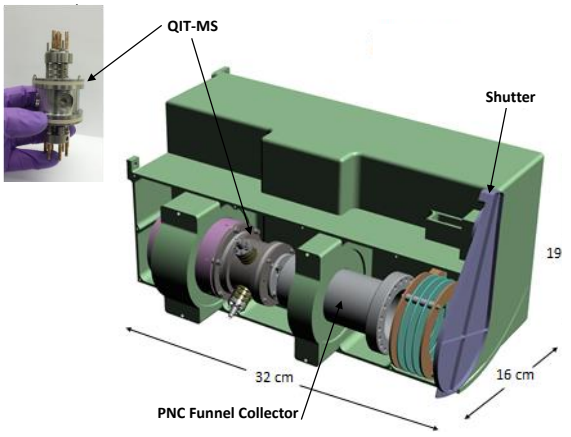

Figure 1. The Boom Mounted MARINE Sensor Head Assembly. The boom mounted MS Sensor Head Assembly (MSHA uses a Passive Neutral Collector (PNC) to funnel neutrals into an ultra-sensitive Quadrupole Ion Trap Mass Spectrometer (QIT-MS). A prototype sensor has been developed and tested under the 2013 Instrument Concepts for Europa Exploration (ICEE) award for the Europa mission concept. Testing with the prototype has verified the design for performance and accommodation specifications. A shutter mechanism has been included in the MSHA assembly to mitigate dust impacts on the PNC over the planned lifetime of the Europa Clipper mission.

References:

[1] B Cassidy, TA, Johnson, RE, Tucker, OJ, 2009. Trace constituents of Europa's atmosphere. *Icarus* 201, 182–190.

[2] Darrach, M R. et al, "Validation Test Results from the Vehicle Cabin Atmosphere Monitor", *40th International Conference on Environmental Systems*, Barcelona, Spain. AIAA-2010-6094, (2010).