MOONSHOT: A COMBINED RAMAN / LIBS INSTRUMENT FOR LUNAR EXPLORATION. E. C. Laan[1], W. van Westrenen[2], A. Wielders[3], J. Heiligers[1] and MoonShot partners[4], [1]TNO Science & Industry, Space & Science department, Stieltjesweg 1, P.O. Box 155, 2600 AD Delft, The Netherlands (erik.laan@tno.nl), [2]VU University Amsterdam, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands (wim.van.westrenen@falw.vu.nl), [3]Space Horizon, Duindoornlaan 24, 2015 LB Haarlem, The Netherlands (arno@spacehorizon.com), [4]Philips Applied Technologies, Delft University of Technology.

Introduction: Developments such as the rise of commercial so-called 'space travel' companies show that the world is at the threshold of a new age of space exploration ('Space 2.0'). Coinciding with the transition from Space 1.0 to Space 2.0, a new phase of commercial lunar exploration ('Moon 2.0') was initiated by the announcement of the Google Lunar X Prize.

Participation in Moon 2.0 requires a new approach for conducting space projects as schedules are tight, additional and non-traditional risks are involved, and new types of requirements are imposed on scientific payloads. MoonShot is a project led by the Dutch Organisation for Applied Scientific Research TNO, with partners from industry and university planetary science research centers in the Netherlands, that aims to provide a combined Raman/LIBS instrument as scientific payload for Moon 2.0 lunar and other planetary exploration missions.

Instrument and Objectives: The Raman/LIBS instrument is a fundamental, next-generation instrument for mineralogical and elemental (atomic) characterization of lunar soil and rock samples. It uses an Optical Head (OH) to illuminate samples with laser light that generates physical phenomena (Raman shift and plasma for the LIBS) with light emission. Emitted light is collected and relayed to a spectrometer using optical fibres to record a spectrum on a CCD for sample identification. Additional hardware components are a Deployment Mechanism (DPM) to accurately position the OH above the sample and an Electronic Assembly for instrument support and CCD readout. It is the first time that Raman spectroscopy and LIBS are combined into one miniaturized instrument with minimum mass, volume and use of resources, a high spectral performance and rapid analysis.

The main science objective of the instrument onboard a lunar mission would be to determine the mineralogical and elemental composition of the lunar surface, to (a) provide details on the geological and geochemical evolution of the Moon (b) perform detailed in situ mapping of lunar material of interest for lunar exploitation means and the realization of a future lunar base (c) demonstrate technology for future planetary exploration missions and terrestrial spin-offs.

Current status: The Raman/LIBS instrument was previously pre-selected as part of the ExoMars rover's Pasteur payload and its end-to-end functional performance has been demonstrated in an Elegant Bread Board using natural samples under mission representative conditions. Subsequently a Development Model (DM) of the spectrometer was built, which is intended to be adapted (interfaces, temperature, atmospheric pressure, radiation, dust environment) for accommodation on a lunar mission. As a result, parts of the Raman/LIBS instrument have a high Technology Readiness Level (TRL), while other subsystems (e.g. the DPM) have a low TRL, expected to increase rapidly depending on specific mission boundary conditions.