HAUGHTON-MARS PROJECT: Lessons for the Selection of a Landing Site/Exploration Zone for Human Missions to the Surface of Mars. Pascal Lee[1,2,3], Stephen Braham[1], Terry Fong[3], Brian Glass[3], Stephen J. Hoffman[4], Christopher Hoftun[1], Sarah Huffman[1], Brage W. Johansen[1], Kira Lorber[1], Christopher P. McKay[3], Robert Mueller, John W. Schutt[1], Karen Schwartz[1], Jesse T. Weaver[1], Kris Zacny[6]. [1]Mars Institute, NASA Research Park, Moffett Field, CA 94035, USA, pascal.lee@marsinstitute.net. [2]SETI Institute, [3]NASA Ames Research Center, [4]NASAJohnson Space Center, [5]NASA Kennedy Space Center, [6]Honeybee Robotics.

Exploration Zone Name: Haughton-Mars Project, Devon Islamd
Habitat Site Coordinates: 75° 26' N, 89° 52' W

The Haughton-Mars Project (HMP) is an international multidisciplinary field research project focused on Mars analog studies at the Haughton impact crater site on Devon Island, High Arctic. HMP analog studies include both science and exploration investigations. The project began in 1997, and has been hosting NASA-supported research each year since. Haughton Crater is approximately 20 km in diameter and 23 million years old. The crater is remarkably well preserved. Field operations at HMP are based out of a permanent field camp, the HMP Research Station (HMPRS), established in the northwestern rim area of Haughton Crater.

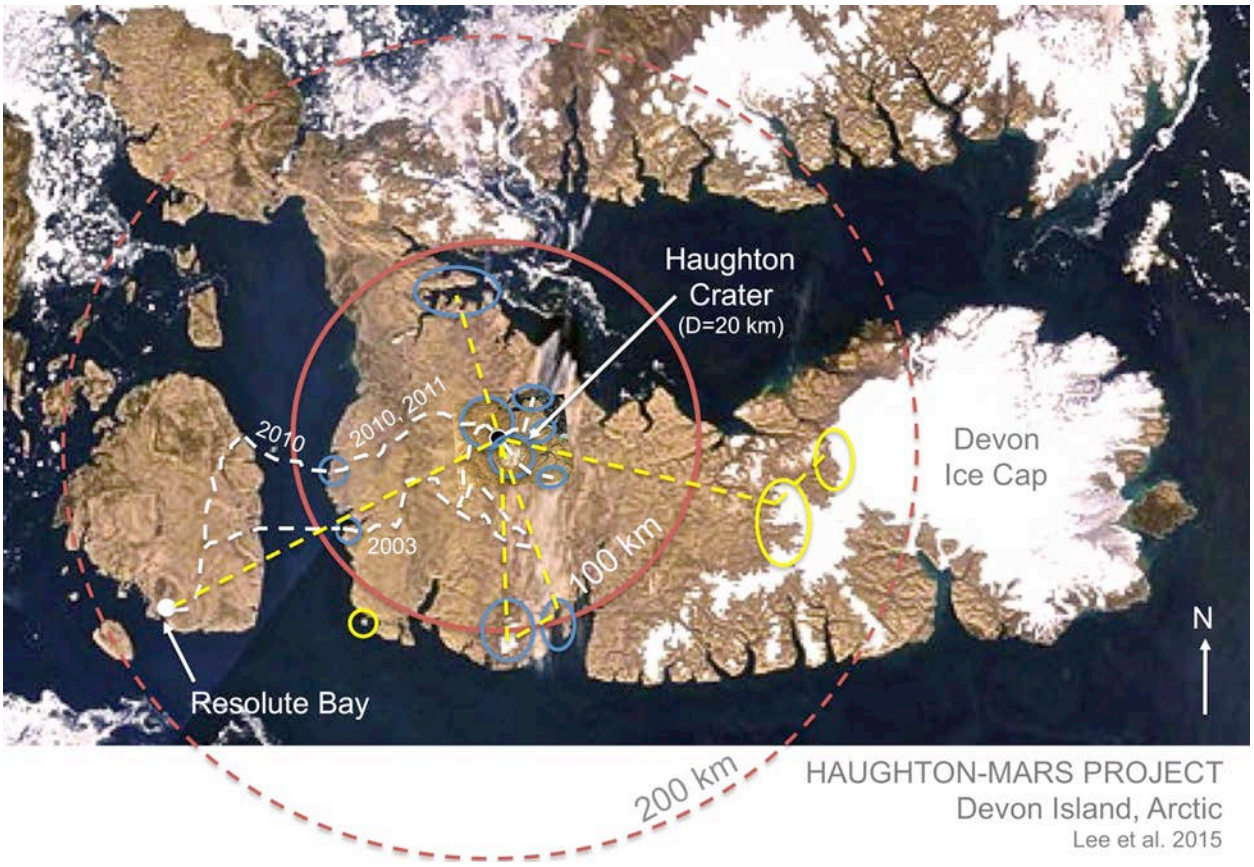

Figure 1: Map of the Haughton-Mars Project (HMP) "Exploration Zone". This map illustrates, in the same smanner as a Landing Site/Exploration Zone (LS/EZ) proposed for Mars, the main regions of interet (ROIs) within an EZ extending out to 100 km. The solid red circle marks the distance of 100 km radial range from the HMP Research Station (HMPRS) or "LS", and defines tthe primary HMP "EZ". The dotted red circle marks 200 km radial range from the "LS". Areas circled (or ellipsed) in blue are high value science targets located within the primary HMP EZ. Areas outlined in yellow are high-value science targets located outside the EZ, but within 200 km radial range from the LS. White dotted lines indicate the paths of crewed rover traverses, with their date (year). Yellow dotted lines indicate airplane or helicopter flights in support of science investigations. The white solid circle marks a site offering resources, in this case, Resolute Bay (a small town on Cornwallis Island, west of Devon Island), which is used for HMP logistics. (Background image: NASA).

Devon Island is the largest uninhabited island on Earth, and offers a wide expanse of vegetation-free terrain that is set in a polar desert. In addition to Haughton, a wide variety of geologic features that are morphologic analogs to geologic features on Mars are present on Devon Island, including canyons, valley networks, gullies, ground ice, patterned ground, debris flows and sprons, cold desert weathering crusts, and paleolake deposits. Astrobiology and planetary protection investigations are also conducted at the site.

Because of the close relevance to Mars of science investigations conducted at HMP, and because science and exploration operations there are conducted in a relatively extreme envionment (by terrestrial standards) and in a real field exploration setting, valuable lessons are learned at HMP that can inform the planning and optimization of future human science and exploration activities on Mars.

Figure 1 shows the range and extent of field science and exploration "regions of interest" (ROIs) at HMP. Since the begiining of the project in 1997, the field site is visited every summer by teams of geoscientists, biologists, and exploration engineers who iterate on advancing the scientific understanding of the site and of its implications for the evolution and future exploration of Mars. HMP-2015 marked the 19th summer field campaign of the project. In this time, approximately 97% of science and exploration investigations at HMP has taken place within a radial range of 20 km from the HMPRS "LS". Excursions for reconnaissance and/or brief sampling to areas beyond 20 km range were generally conducted by helicopter. About a dozen medium-range (5 to 10 km radial range from the "LS") crewed rover traverses have been conducted since 2003 (7th HMP field season onwards) using one of the HMP's two modified Humvees based at the HMPRS, including traverses from the west coast of Devon Island to camp.

Figure 2 shows the range and path of the 2009 field campaign of the HMP's Northwest Passage Drive Expedition (2009-2011), which involved driving a Humvee over a distance of 500 km on sea-ice from Kugluktuk on the North-American mainland, to Cambridge Bay on Victoria Island. The traverse encountered a number of challenges due to difficult weather, electrical problems on the vehicle, and the hummocky and unpredictable terrain (including leads in the sea-ice hidden under snow cover). The 500 km traverse traverse was eventually completed in 8 days. Similar long-range traverses should be possible and planned for Mars ro greatly expand the range amd productivity of future human exploration missions.

Long-range pressurized rover traverses on Mars from a "Landing Site" or a "Habitat Site" to a variety of ROIs will be a key aspect and requirement of human Mars science and exploration operations. In upcoming years, simulations at HMP of dual-pressurized rover traverses (involving two rovers working in tandem and able to lend assistance to one another in a contingency) are recommended. The will be key to informing the design, planning, implementation, and optimization of actual pressurized rover vehicles and traverses on Mars.

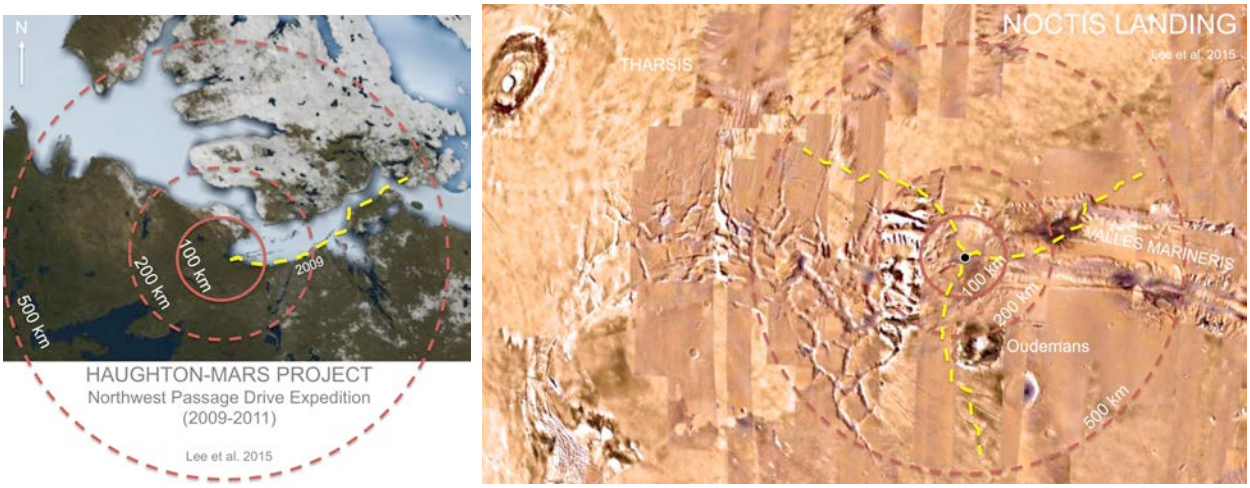

Figure 2: The HMP Northwest Passage Drive Expedition (NWPDX) & Pressurized Rover Traverses on Mars. Left: Map of the HMP NWPDX-2009 campaign of the Northwest Passage Drive Expedition (2009-2011). The NWPDX-2009 travese, which included science stops, represented a driven distance of 496 km over unprepared terrain (rough sea-ice) and was completed in 8 days. **Right:** The path of the HMP NWPDX-2009 traverse projected several times (in various orientations) onto a photomosaic map of Mars, with *Noctis Landing* as the hypothesized Mars Landing Site/Exploratiuon Zone (LS/EZ) (Lee et al. 2015, this conf.). This figure provides some sense of how far traverses equivalent in *radial range* to the NWPDX-2009 traverse would reach if carried out on Mars.