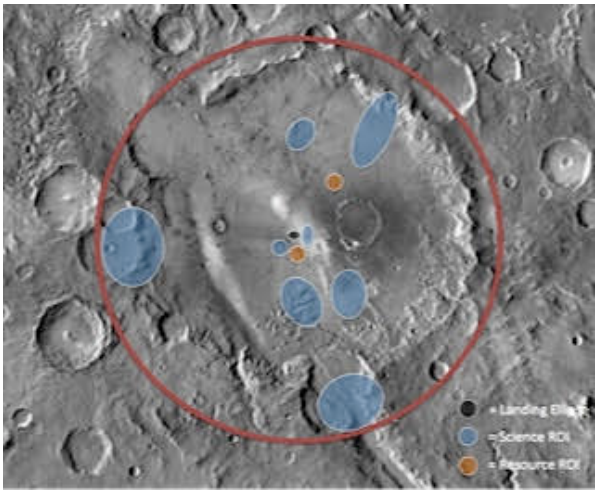
A Landing Site for Human Missions to Mars in Gusev Crater. A. Z. Longo[1], [1]Cardinal Gibbons High School (417 Tharps Lane, Raleigh, NC 27614; azlmsr701@gmail.com).

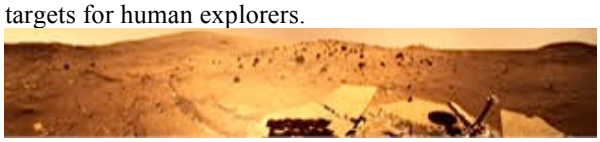
Introduction: I propose Gusev Crater, the landing site for the Mars Exploration Rover (MER) Spirit, as the location for one of the first crewed missions to Mars in the 2030s. Gusev Crater is a 166-kilometer wide impact basin, named after Russian astronomer Matvey Gusev (1826-1866). The crater is located in the southern highlands of Mars, at 14.5° S, 175.4° E. Current analyses suggest that it formed approximately 4.0-3.8 billion years ago during the Noachian era of the planet's history. Many different mineral phases and landforms detected in orbital imagery suggest multiple episodes of past fluvial activity. Our current knowledge of the crater consists of data collected from orbital missions [1] since the 1970s and "ground truth" from the Spirit rover. Spirit landed on January 3, 2004 on the floor of the crater. After initial analysis discovered basaltic rocks, the rover drove to the Columbia Hills, a complex of ~200-foot-tall, heavily eroded kipukas where it spent the rest of the mission [2]. After discoveries of water-altered rocks dating from the Noachian through to the geologically recent past, Spirit succumbed to the cold of the Martian winter in 2011. Spirit's findings in the Columbia Hills region were intriguing, but its mobility restrictions left much to be explored.

Landing Site and Exploration Zone: The 3 by 2-kilometer wide landing ellipse was determined using current Mars landing technologies and a very rough estimate of how far they will have been developed by the mid-2030s. The size of the landing ellipse will be dramatically reduced by the improvement of technologies and the presence of a human pilot capable of reacting to discrepancies in the landing system's performance. The ellipse, which will contain all of the outpost's major hardware, is located at the edge of the Columbia Hills and an unexplored region of etched terrain. The landing site is dominated by very flat topography with only small rocks and craters. No significant landing hazards exist. In the event of an off nominal landing, the vast majority of EZ (exploration zone) terrains are similar, allowing for a safe landing and a quick drive to the base camp. The EZ proposed is 200 kilometers in diameter and covers all parts of the impact basin. The surrounding terrain will provide information related to multiple epochs in its history. There are a total of 8 science ROIs as well as many interesting areas not included as part of an ROI that could be explored. The EZ contains 2 resource ROIs, one located adjacent to the landing ellipse and one about 30 kilometers away.

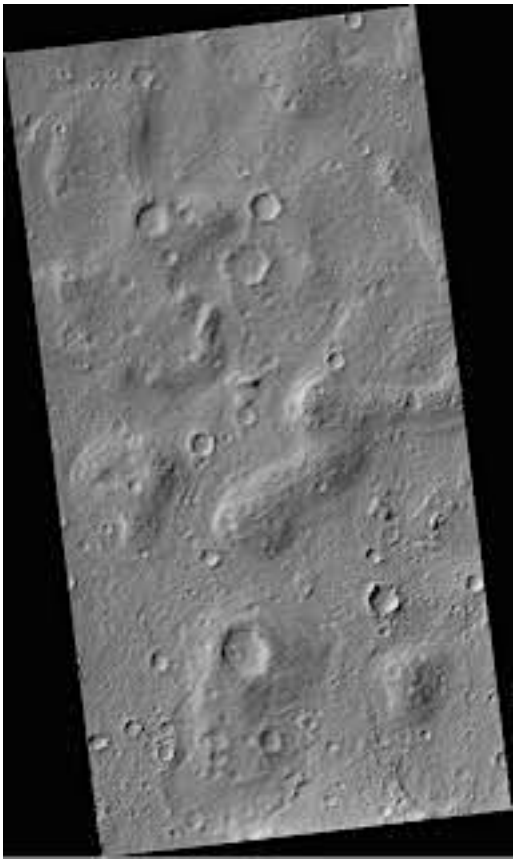


Science Targets: The ellipse contains a land-on, datable volcanic surface, which is a Hesperian ridged plain [3]. The Columbia Hills are located only 2.5 kilometers from the center of the landing ellipse. The Columbia Hills science targets are located in a remarkably compact, 3 by 5 kilometer region of interest and contain a dramatic geologic diversity [4]. Just a few examples of these are at least two igneous units, rare carbonate outcrops formed in a Noachian ephemeral lake, orbitally-detected phyllosilicates (Fe-rich clays, kaolinite, and possibly others) in polygonal terrain, sulfates, and opaline silica outcrops bearing a resemblance to biogenic structures found on Earth [5]. The Columbia Hills also contain the final resting place of Spirit, permitting an Apollo 12/Surveyor 3-type investigation to take place on how mechanical components age in Mars' environment over a long period of time. If repaired by the astronaut crew, Spirit could also be used for additional exploration of the site after they depart. To the south of the landing site is a large exposure of etched terrain. The etched terrain has a similar thermal inertia to the Algonquin-class tephra deposits [6], and has been postulated to have an origin related to fluvial or glacial processes. Similar exposures of etched terrain are present farther to the south, west, and east. Wrinkle ridges on the floor of the crater are similar to those found on the surface of the moon, and could be formed by the contraction of the planet's crust. Other kipukas in the EZ, such as the Apollo 1 Hills, could be compared to the Columbia Hills, providing a window into the planet's distant past. Large groupings of pingos, or permafrost mounds, are 30 kilometers southeast of the landing site [7]. Besides being a potential resource, permafrost has extraordi-

nary potential for preserving biosignatures. On earth, organisms ranging in size from microbial life to juvenile ice age mammoths have been found preserved in permafrost [8]. If microbes once lived on Mars, their remains could be preserved in the Gusev permafrost. The southern portion of the crater is rich in science targets. Mesas at the mouth of the Ma'adim Vallis channel bear resemblance to eroded river deltas, and may be associated with an ancient ocean in the crater. To the east of the mesas are widespread deposits of Fe and Al-rich phyllosilicates. Both the mesas and the walls of Ma'adim Vallis could expose layers of water-altered material. Valleys and craters intersecting the rim of Gusev could also provide geologic context to the area. The Gusev Crater region is rich in science targets for human explorers.



ISRU: In-situ resource utilization (ISRU) is a critical technology, used to create water and fuel from available resources. As indicated by the etched terrain and pingos, Gusev possibly played host to glacial processes in the past. One resource ROI is located at each type of terrain. While the etched terrain will generate some water, the pingos contain much larger quantities. However, they are relatively far away, so the etched terrain will provide a preliminary feedstock until a larger amount of infrastructure can be put in place. Other sites I considered were locales containing recurring slope lineae (RSL), flows of briny water on the surface of Mars. However, exploring these features raises significant concerns about planetary protection guidelines, as the human body contains thousands of microorganisms, which could invade and contaminate this habitable environment. In addition, RSL could contain pathogenic bacteria, which makes pingos and other permafrost locations a favorable water source. In the long term, explorers may intend to build their own habitation units. Structures could be constructed between some of the larger kipukas or mesas located close to each other, utilizing them as the habitat's walls.



Conclusion: Gusev Crater is the ideal location for a manned mission to Mars because of MER Spirit ground truth, a rich diversity of science targets for exploration, and sufficient resources to sustain a human presence on the surface of Mars without jeopardizing planetary protection concerns.

References: [1] Parker M. et al. (2010) *Earth and Planetary Science Letters,* 294.3, 411-423. [2] Arvidson R. E. et al. (2008) *JGR, 113.* [3] Greeley R. et al. (2005) *JGR, 110.* [4] Rice J. W. (2011) *AGU 2010* P33D-1789. [5] Ruff S. W. (2015) *LPSC XLVI* 1613. [6] Ruff S. W. (2014) *Geology,* 42.4, 359-362. [7] Cabrol N. A. et al. (2000) *Icarus,* 145, 91-107. [8] Gilichinsky D. A. (1992) *Advances in Space Research,* 12.4, 255-263.