THE WHY AND HOW OF HUMAN OFF EARTH RESOURCE DEVELOPMENT. D. C. Barker[1], [1]MAXD, Inc. P.O. Box 58915, Houston, TX 77258 (donald.c.barker@att.net).

Introduction: Ongoing competition between classical planetary science and the environmental characterization needed to begin sustainable and growing human habitation off Earth creates gaps in the pursuit of knowledge needed to select the optimum location for developing sustainable human infrastructure and architectures. These gaps generally occur due to the goals of science vs resource development, funding source competition, and general miscommunication across these communities. Another part of the reason such gaps exists is because the question of why we are going there in the first place has yet to be efficiently answered regarding sustainable human habitation.

The classical sales pitch for science is to explore and to do "science" based on traditional research solicitations and award funding processes. Whereas the dedicated process of resource identification only uses the scientific process and tools to gain the greatest amount of information regarding the availability of easily extracted resources across regions[1], otherwise called Proven Reserves akin to terrestrial resource mining processes. If said resource information is not available in sufficient granularity and in a timely manner, then spaceflight hardware engineering development processes are either delayed or proceed with unverifiable requirements and risks to fill those gaps. Another kind of risk regarding mission design and sustainability also exists. For example, prematurely choosing and proceeding to a landing location where no or insufficient resources are ultimately found (i.e., akin to drilling a dry hole). This could occur due to pressures to initiate surface activities before sufficient prospecting has taken place. Additionally, sustainability requires sufficient probability of self-sufficiency and economic viability, especially considering potential future access limitations, changes to terrestrial political and commercial support, including budgetary changes over time. Also, for example, what happens when the 3rd mission fails catastrophically, and the focus was not initially on resource availability and sustainability? What happens when congress gets board or distracted and cuts the budget by 20, 50 or 100%? Rarely are these or other distractions sufficiently incorporated into long-term planning.

Lastly, in regard to the question why, often little or no forethought and preparation occurs regarding continued, long-term expansion and growth of infrastructure and populations and the associated resource needs resulting in decisions and metrics being based on a one-off mission architectures.

In order to address the above concerns a dedicated program with infrastructure development in the forefront must be the primary reason in answering the question why and driving the ISRU needs. Then a dedicated resource prospecting campaign, ignoring most classical planetary science scenarios, must be carried out as far in advance of human landing site selection as possible. Finally, studies of how human settlements and analogs have been established and grow, e.g., McMurdo Station, should be revisited.

Filling the Gaps: The vast majority of planetary data acquired to date is from remote sensing spacecraft, which is a problem for prospecting given the observational footprint and time to collect data. For example, the Lunar Reconnaissance Orbiter (LRO)[2] Lunar Exploration Neutron Detector (LEND) has a spatial resolution of 10 km (for the polar regions), and the Lyman Alpha Mapping Project (LAMP) between 100s of meters to a few kilometers. Prospecting ground truth will need cross wide regions with sub-meter resolution aerially and similarly 10s of meters below the surface. Highly accurate resource quantities need to be established.

Finding resources to a high accuracy is only the first part of the battle. Next is the environment in which those resources would need to be extracted. Is it in full lunar sunlight or deeply cold polar shadowed regions (PSR) which range between 250 K to nearly 40K depending on location and season? Open questions remain as to whether mining, infrastructure and habitat hardware would be able to survive and operate in such conditions. These environmental data also fail from the same low-resolution understanding, for example LRO's Diviner polar observations are binned at about 240 m/pixel resolution.

Conclusions: For almost all human history, there has been a preexisting demand for almost any resource being produced. In human spaceflight there is no such demand. This is further compounded by the lack of developed destinations, propulsion systems limitations, and the complexity of human spaceflight. If a highly focused resource prospecting and identification path is not undertaken before humans are sent, then the risk of failure or cancelation, either by technical or sociological effects, remains a high likelihood. We now have to create that destination and assure it has the needed resources available for easy and efficient access and usage so as to create a sustainable human enterprise off Earth.

References: [1] Barker (2020) *Adv. Space Resh.*, 66, 359-377. [2] LRO, https://lunar.gsfc.nasa.gov/instruments.html.