**Mission Design and Implementation Considerations for Lunar Night Survival.** R. Vaughan[1], [1]Mission Design Division, NASA Ames Research Center, Moffett Field, CA

**Introduction:** Lunar night survival, while being a technical design challenge, also has an impact on mission planning and execution during the flight system development phases (Phases A-D). Depending on mission objectives, different locations on the lunar surface result in different challenges to technical formulation of a comprehensive mission design and implementation. Equatorial regions have temperature extremes between day and night (<100K to >380K) but are somewhat cyclical and predictable. Polar regions can have milder thermal environments in terms of overall surface temperature swing and opportunities for extended durations for solar power but pose unique challenges in temporal and spatial availability of both sunlight and direct-to-Earth communications. Options for surviving the night will depend heavily on mission objectives, lunar location and program cost and schedule constraints.

**Lunar Night as a Mission Variable:** Whether the primary purpose of the mission is scientific, mapping and prospecting, or demonstrating capabilities and technologies, surface traverse planning and concepts of operation will heavily influence the necessary capabilities of the flight system. Lunar night will be one of the variables to consider but may not be the biggest driver of system complexity. Clear flow-down of mission objectives, combined with surface mission planning and operations will ultimately lead to determining where, and how much lunar night survival will impact system design, as well as programmatic cost and schedule resources necessary to carry out the project.

**Lunar Night Survival Planning; Equatorial:** Equatorial regions of the moon experience a consistent and regular ~14 Earth-day duration of night-time. During the day, overhead sun limits the radiative view to cold space and during the night, temperatures plummet, increasing the demand for energy for survival. Nuclear energy sources are typically considered due to the extended duration of darkness. This approach will have an impact on the system design, having to deal with both hot and cold temperature extremes, but will also require additional cost and schedule resources for analysis, design, test and paperwork/process (Presidential Directive-25). Other technical solutions may be possible as well but they also may require additional resources for achieving technological readiness and incorporation. Understanding these mission drivers will be a crucial step in scoping out the development activity and allocating resources for successful execution.

**Lunar Night Survival Planning; Polar:** The definition of "night" becomes less distinct at near-polar latitudes. Latitude and local topography play a critical role in defining the duration of local shadows. It varies from locations of near-perpetual sunlight all the way to permanently shadowed regions. This presents a more open trade space for missions requiring more than 14 Earth days. Determining an appropriate landing site for both mission objectives and required shadow survival time, combined with an appropriate flight system design requires careful mission planning analysis.

**Operating Through the Night:** Planning to operate through the night could significantly increase the demand for energy depending on the concept of operations. Depending on local topography, polar locations (above ~80 deg) can also lose line of sight communications for 2 weeks or more every month, so either increased levels of autonomy or reliance on communications relays will be required. The flight system design approach and mission/traverse planning will be impacted by these frameworks, as well as additional technology maturation and design and testing activities during development.

**Mission Design/Planning for Lunar Night Survival:** An existing set of lunar mission planning tools, utilized by the Resource Prospector Mission Development team at NASA Ames, provide the capability to understand the trade space and mission drivers to bridge the gap between mission objectives and designing a reference mission that results in understanding the technical system design drivers and ultimately, formulating the project execution plan and resource requirements. As always, tools are just a part of a broader process in concept maturation, planning and execution. Understanding lunar night survival mission requirements, within the context of the mission objectives and planned against an project execution framework will result in a comprehensive approach to ensure successful progress and completion of the mission.

We present some of the design, development, cost and schedule impacts of dealing with problematic night time lunar conditions, whether for near-equatorial or near-polar landed lunar missions.