Beyond Survival: Compact Combined Power and Packaging Solution for Operating during Night. P.E. Clark[1] and E. Jenson[1,2]; [1]Space Science Center, Morehead State University, Morehead, KY 40351, [2]Blackbox Energy Systems. (p.clark@moreheadstate.edu).

Problem: Opportunities for delivery of compact payloads to the lunar surface via commercial landers are emerging in the coming decade. Characterization of the highly interactive environment of the lunar surface and subsurface, requires night time operation in that extreme environment which, up until now, has required radioisotopes.

Solution: Of all the constraints on packages being delivered via future commercial landers, the limited means of dealing with the extreme cold of lunar night is the most problematic. State of the art packaging with high efficiency thermal components combined [1] combined with a high efficiency energy storage system currently under development by Blackbox Energy systems (described here) could sustain compact in situ measurement packages for stand-alone day/night lunar operation and thus enable science investigations that heretofore required unaffordable dedicated landers with radioisotopes.

Successfully demonstrating the feasibility of such a concept would represent a major breakthrough.

Advances in Thermal Protection: Parabolic Radiator/Reflectors capable of protecting payloads from the extreme high temperatures of lunar day have already been successfully demonstrated for the ALSEP packages. What about protecting a package from extreme cold? High performance thermal components now being developed, demonstrated, and integrated by Bugby [1] include very high-performance thermal switches (a reverse thermal switch with a 2500:1 switching ratio) and Multi-Layer Insulation deployed from a cable system without spacers. When these are combined with the radiators described above, operation during the extreme cold of lunar night, possibly at full duty cycles for low power systems, will be achievable.

Advances in Power Systems: Blackbox Energy Systems is in the process of developing a new energy storage technology that utilizes carbon fiber-based flywheels with high-speed magnetic bearings. A solar power system would provide power to the package during the day. The energy storage system would be charged via a solar power system at the same time and then provide efficient, long duration, high energy density operation during lunar night.

The Blackbox flywheel energy storage system takes advantage of technology breakthroughs over the last decade in materials, including carbon fiber composites and magnetic bearings. It operates at far lower temperatures (down to at least 125 K), over a far greater number of cycles, and with far higher efficiency and energy density (230 Wh/kg) than chemical batteries (Table 1). Carbon fiber composite strength actually increases as the temperature decreases. High speed, ironless magnetic bearing increase efficiency and reduce cost, weight, and complexity.

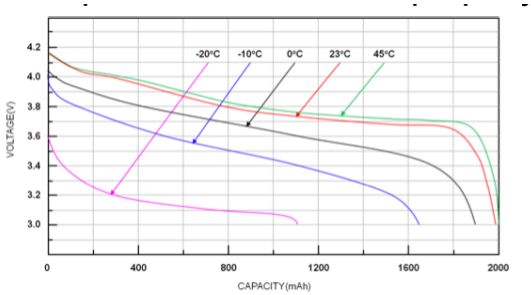

Figure 1: Chemical Batteries Operational Temperatures

Material	Yield Strength	Density g/cm^3	Total Energy
Steel	250/4	7.85	2.21
Titanium	1260/4	4.5	19.44
Carbon Fiber	3500/4	1.25	194.39
Glass Composit	2500/4	2.44	71.13

Figure 2: Properties C-fiber Energy Storage

Application: A generic/reconfigurable thermal/mechanical/energy storage system utilizing these components would make it possible to fly a small payload capable not only of surviving but of operating during lunar night. Such packaging could be made available as a standardized 'wrapper', part of lander 'interface' and transportation infrastructure (analogous to your car). It would not need to be developed from scratch by individual users, and thus lower the cost of payload development.

References: [1] Bugby et al. (2022). Planetary and Lunar Environment thermal Toolbox Elements (PALETTE) Project Year Two. a major challenge for the lunar surface, 51st Intl Conf on Environmental Systems, Minneapolis, July 2022, ICES-2022-423.