CAPABILITIES TO ENABLE FUTURE PLANETARY SCIENCE

J. B. Plescia

The Johns Hopkins University, Applied Physics Laboratory, Laurel, MD 20723

VORTICES

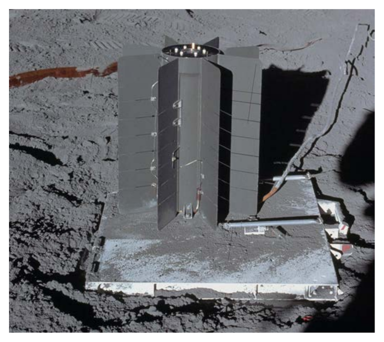
JOHNS HOPKINS APPLIED PHYSICS LABORATORY

Robotic missions have been returning a wealth of data from bodies across the Solar System. Missions have followed the general pattern of flyby, orbit, land, rove and eventual sample return. Sample return from a large planetary body was only accomplished at the Moon by the Soviet Union, driven by the politics of the 1960s and 1970s. More recent planetary sample return concepts have proven to be prohibitively expensive and risky and would seem to likely be one off events should they occur.

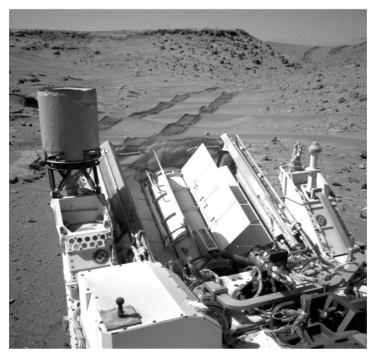
As our understanding has grown, the questions that are posed, and the techniques to address those questions have grown increasingly complex. We must now develop systems that are significantly more capable than scratch-and-sniff. In order to facilitate future exploration and increase both the capabilities and resiliency of the missions, a number of critical technologies, capabilities, and approaches are required.

POWER

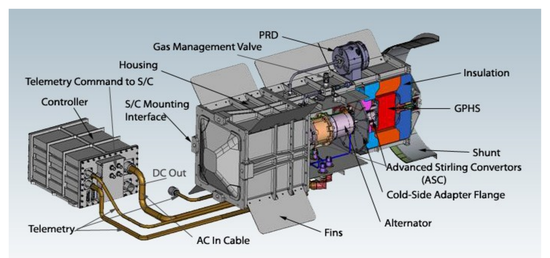
Power requirements vary by the type of mission. Orbiting mission that can rely on solar power are relatively straight forward. Landed mission that have to endure a diurnal cycle or those that might land in permanent shadow (with correspondingly chilly temperatures) are more challenging. Nuclear power is the only real option for systems in permanent shadow; fuel cells can work in situations where they are periodically exposed to sunlight to recharge. Regardless of the type, the greater the power availability; the greater the performance and the greater data return. ASRG offer increased efficiency relative to older systems.



Apollo RTG



MSL RTG

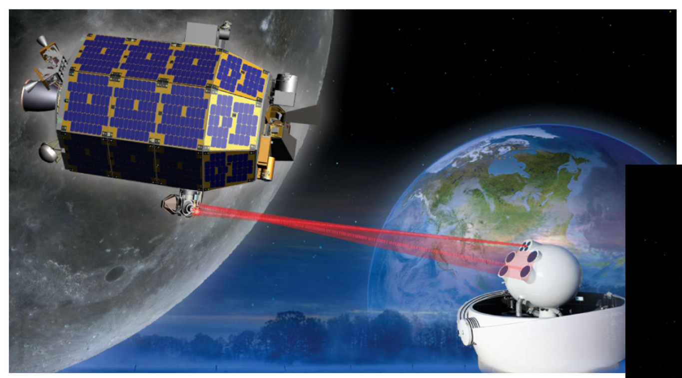


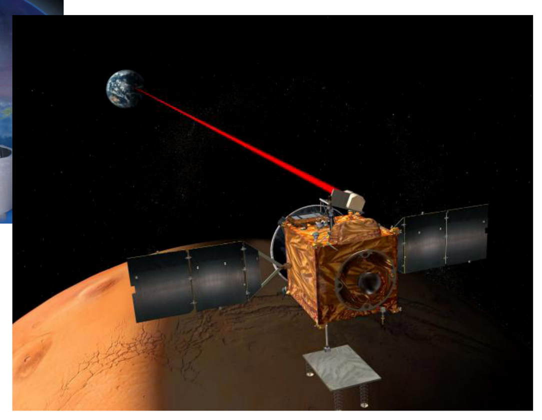
ASRG

COMMUNICATIONS

Communications is a real constraint on mission ops and data return. For orbiting missions, a periodic occultation is usually not a problem. For landed missions, a diurnal hiatus or the complete lack of Earth visibility (e.g., PSRs) present different challenges.

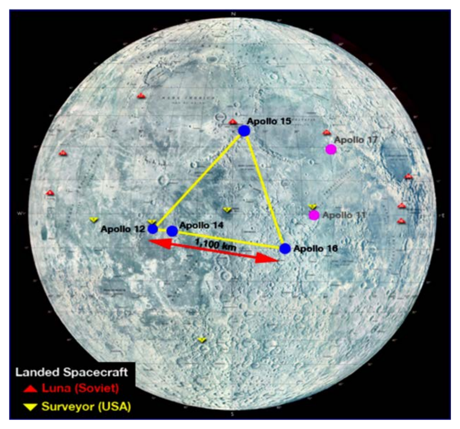
Two technologies address this: orbital comm. infrastructure and optical com. A rudimentary infrastructure has been deployed at Mars, but could be significantly expanded. An infrastructure would be required for lunar PSR or far side missions. Optical communications has been demonstrated on several times, but not employed as the primary comm technology. Optical communication offers the potential to vastly increase the data return, a particularly important aspect for missions with imagers and spectrometers.



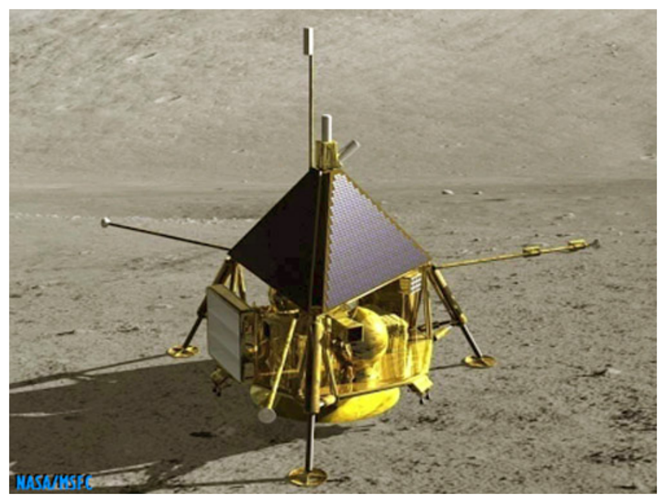


NETWORK SYSTEMS

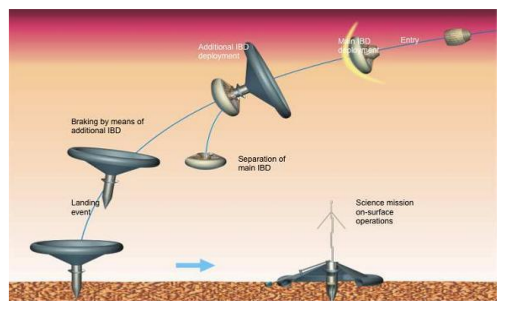
Meteorology (assuming you have a measurable atmosphere), geophysics and solar wind / surface interaction studies require long-term, continuous measurements from an array of stations deployed across the surface. The Apollo seismic experiment demonstrated the value of such a system, limited though it was. Concepts for lunar and martian seismic networks and a Mars met network illustrate the interest in such systems. In order to truly address such questions, small, long-lived network stations (and deployment spacecraft) need to be developed and employed.



Apollo network



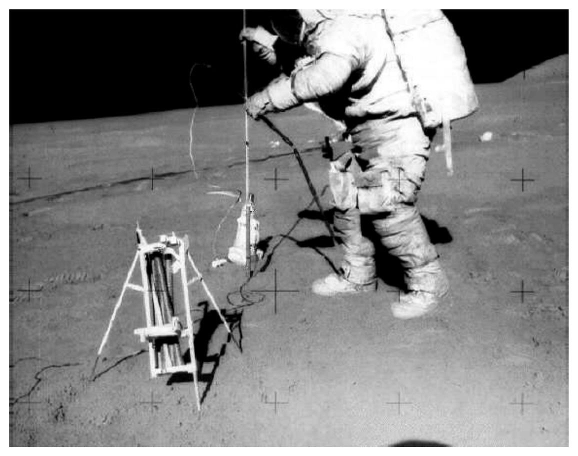
Lunar network station



Mars met net

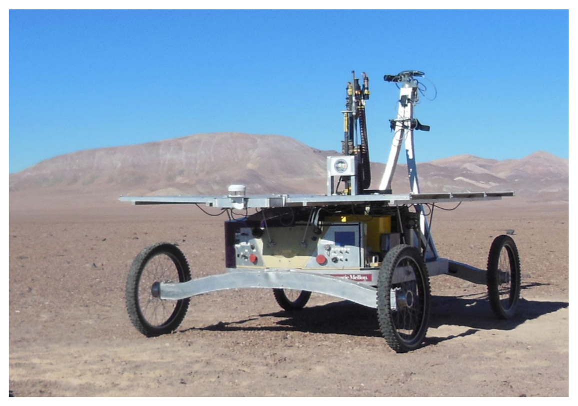
SUBSURFACE ACCESS

In order to acquire samples appropriate for various objectives, subsurface access is required. To date, the only complete deep samples, up to 2 m depth, were those returned by the Apollo program using both drive tubes and rotary drill. For Mars, subsurface access has been limited to scooping, scraping and shallow drilling (50 mm). In order to examine the nature and evolution of the lunar regolith and polar ice deposits and the sedimentary and climatological history of Mars, samples must be acquired from depths of many meters. This will require not only high-reliability drilling mechanisms, but the ability to operate at cryogenic temperatures and with a variety of rock types. Such drilling mechanism could be deployed on both stationary and mobile platforms. Concepts have been prototyped and tested, but none have yet been deployed on a robotic mission.



Apollo drill

Honeybee deep drill



CMU rover with drill

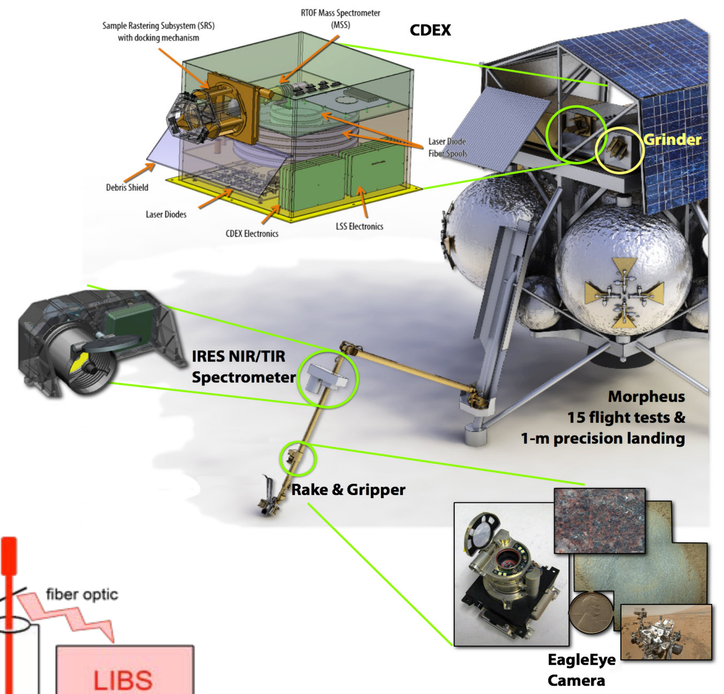
IN SITU SCIENCE

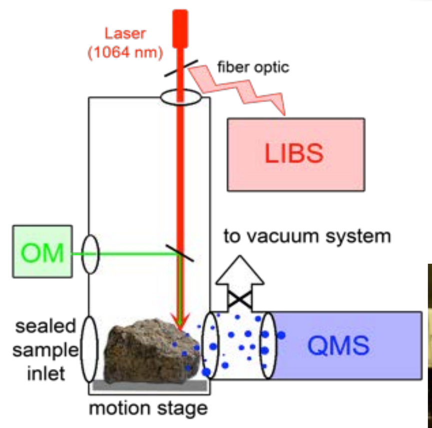
A variety of instrumentation has been flown to analyze the atmosphere and surface materials of different bodies. There has, however, been a sentiment that many types of analysis can best / only be done on Earth with a returned sample.

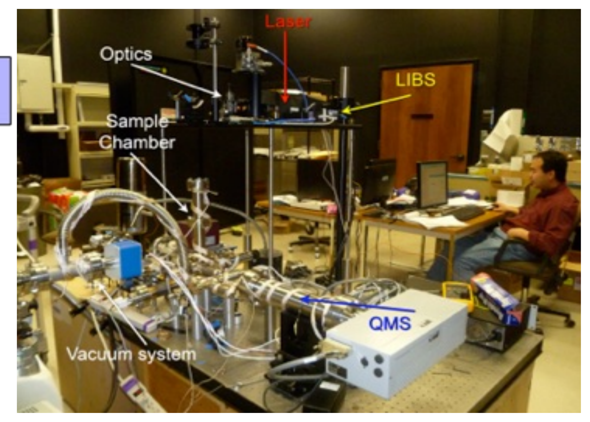
For example, radiometric dating: There is no question that a more precise analyses can be done with a sample in a terrestrial laboratory. However, sample return missions are complex, risky, expensive, and are unlikely to be frequent. Using the age dating example, for both the Moon and Mars an in situ radiometric age, with the current precision capabilities, of key surfaces would provide critical information about the cratering rate and the volcanic and geologic history of the bodies. Such experiments for the Moon are consistent with Discovery class missions.

Additionally, expanded in situ analyses could be used to provide a range of data that would allow a sample return mission to find the most appropriate samples and ensure that the primary science question for that sample is indeed answered.

Rb/Sr concept. S. Anderson SWRI







K/Ar concept. B. Cohen MSFC

SUMMARY

Our understanding of the processes and events that have occurred within the Solar System over the last 4.5 Ga has grow with time. Every planet (including an ex-planet) and many smaller bodies have been visited. We have basic knowledge about each and the simple questions have been answered. Now, the questions being posed are complex and will require not only additional missions, but capabilities and approaches that have not been used in the past, or used in only a limited fashion. Having all of these capabilities would be an incredible boon to robotic missions. However, even a few of them would allow faster and deeper progress than the current capabilities.