Ablators for Human and Robotic Exploration of the Moon, Mars and Beyond

When Apollo was designed to carry astronauts safely back from the Moon, at return speeds exceeding 11 km/s, it required development of a new lightweight ablative material to protect the capsule and crew from the intense heat of entry. Soon after the Apollo program, successful Mars Viking Lander missions employed a different and much lighter ablator in more benign entry conditions. On the other hand, the Pioneer-Venus and Galileo Probe missions that followed required yet another ablative system, to manage the extreme heating at those destinations, which was like flying a ballistic missile nose tip into a thermonuclear explosion. NASA had to invent a new heat-shield concept based on the rocket nozzle and ballistic missile ablative materials. In the mid 1990's, as the Science focus returned to Mars, advances in manufacturing, testing and materials technology led to innovative lightweight ablators that enabled comet and asteroid sample return missions and facilitated large lander missions such as MSL and Mars 2020. NASA's current plans for robotic and human exploration of the Moon, Mars and beyond introduce different constraints and new expectations for ablators. Human missions to Moon and Mars, sample return missions from Mars, and exploration of Uranus and Neptune, the two planets we are yet to explore, will require ablators that can withstand extreme environments, with verifiable robustness, and with raw materials and manufacturing approaches that are sustainable in the longer term. This talk will review the history of ablators as well as current ablative TPS development that addresses the requirements for future missions to Moon, Mars and beyond.