IV. Session 4: Space Shuttle Propulsion Finishing Strong

A. Crossing the Finish Line – J. Owen

Numerous lessons have been documented from the Space Shuttle Propulsion elements. Major events include loss of the SRB's on STS-4 and shutdown of an SSME during ascent on STS-51F. On STS-112 only half the pyrotechnics fired to release the vehicle from the launch pad, a testament for redundancy. STS-91 exhibited freezing of a main combustion chamber pressure measurement and on STS-93 nozzle tube ruptures necessitated a low liquid level oxygen cut off of the main engines. A number of on pad aborts were experienced during the early program resulting in delays. And the two accidents, STS-51L and STS-107, had unique heritage in history from early Program decisions and vehicle configuration. Following STS-51L significant resources were invested in developing fundamental physical understanding of solid rocket motor environments and material system behavior. Human rating of solid rocket motors was truly achieved. And following STS-107, the risk of ascent debris was better characterized and controlled. Situational awareness during all mission phases improved, and the management team instituted effective risk assessment practices. These major events and lessons for the future are discussed. The last 22 flights of the Space Shuttle, following the Columbia accident, were characterized by remarkable improvement in safety and reliability. Numerous problems were solved in addition to reduction of the ascent debris hazard. The propulsion system elements evolved to high reliability and heavy lift capability. The Shuttle system, though not a operable as envisioned in the 1970's, successfully assembled the International Space Station (ISS) and provided significant logistics and down mass for ISS operations. By the end of the Program, the remarkable Space Shuttle Propulsion system achieved very high performance, was largely reusable, exhibited high reliability, and is a heavy lift earth to orbit propulsion system. The story of this amazing system is discussed in detail in the paper.

B. Project Management Best Practices - J. Singer

During the Program a number of project management processes were implemented and improved. Technical performance, schedule accountability, cost control, and risk management were effectively managed and implemented. Award fee contracting was implemented to provide performance incentives. The Certification of Flight Readiness and Mission Management processes became very effective processes. Perhaps the most important aspects of success were related to relationships developed with the prime contractors, which evolved to become very successful government/industry partnerships. A key to the success of the propulsion element projects was related to relationships between the MSFC project office and support organizations with their counterpart contractor organizations. Both teams worked diligently to understand and satisfy requirements of the project. Frequent team building, daily communications, continuous feedback, and operating with openness created a climate where teams cooperatively resolved challenges and continually looked for ways to learn and improve. Even at the material suppliers and their sub-tier suppliers periodic visits were made to improve understanding and importance of Space program requirements, and their impact on mission success. Teams used visits, presentations, videos, symposiums, seminars, other events to share the importance of product consistence. The project management approaches and experiences from the propulsion elements are explored in detail within the paper.

C. Evolving to Future Launch Systems – C. Singer

The Shuttle Propulsion elements are highly reliable, flight proven systems which offer the opportunity for evolution to heavy lift, beyond low earth orbit, flight capability. The solid rocket booster and solid rocket motor can be configured in a four segment configuration, identical to Shuttle, or in a five segment configuration, currently in development testing. The Space Shuttle Main Engines exhibit the proven reliability from 135 flights and 35 years of ground testing, and exhibit the highest performance of any earth to orbit liquid rocket engine. The engine can be configured in a reusable or expendable configuration, with a goal of reduction in manufacturing cost for the expendable system. The External Tank structural efficiency can easily be extended to in-line launch vehicle configurations and, for a 27.5 foot diameter vehicle, tooling is available for manufacturing with state of the art processes. System studies indicate that payload to orbit can be achieved in the range of 70 to 100 metric tons. The building blocks for upper stages and earth departure stages are in development. The modifications to ground support systems are understood for a shuttle derived vehicle. Development of a shuttle derived heavy lift system represents a cost effective and reasonably quick approach for achieving a human exploration capability beyond earth orbit. Some concepts, options, and challenges are discussed within the paper.