THE MULTI-MISSION RADIOISOTOPE THERMO-ELECTRIC GENERATOR FOR THE MARS SCIENCE LABORATORY: LESSONS LEARNED THAT MAY BE APPLICABLE FOR THE MARS 2020 MISSION

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Introduction: The successful launch and execution of National Aeronautic and Space Administration's (NASA) MSL mission, which is still ongoing, was enabled by the use of the very first multi-mission radioisotope thermo-electric generator (MMRTG). The MMRTG was developed under a contract with Rocketdyne for the Department of Energy (DOE). DOE was under contract with NASA to provide this technology for this mission and other missions. The contract was placed with Rocketdyne (then a division of Boeing) by DOE in the Summer of 2003 with the intent of providing power for a Mars mission with a launch date of September 2009. The DOE team involved with this overall effort included, in addition to Rocketdyne and their subcontractors: Oakridge National Laboratory, Los Alamos National Laboratory, Idaho National Laboratory, Orbital Sciences Co. and URS Co. This effort culminated in a fully fueled MMRTG in the Spring of 2009 ready to ship to Kennedy Space Center (KSC). Once at KSC other MMRTG-specific activities would take place such as: a hot fit check with the flight rover-Curiosity, outfitting it with flight hardware and integration with the rover contained within the fairing on the Atlas 541 rocket immediately prior to launch. Due to extenuating circumstances the MSL mission actually launched in November 2011, a 26 month delay from the original launch date. This paper will discuss various lessons learned that may be of interest for the upcoming effort of providing a similar MMRTG for another rover for the Mars 2020 mission which is scheduled for a Summer 2020 launch.

Discussion: The lessons learned fall into two categories: communications external to the DOE team, and unfamiliarity with operations within a DOE nuclear facility.

Communications external to the DOE team, especially those with the MSL mission team, left something to be desired in terms of efficiency and candor. The time allocated for fueling and performing flight acceptance testing was roughly 6 months, thus a start date for initiating the 3-4 week duration fueling operations was picked as October 2008. This gave enough time, with some schedule margin, to accomplish the INL fueling and testing operations. The concept was to ship the generator to KSC in approximately May 2008, which would give sufficient time for the various KSC ground operations to take place prior to the September 2009 launch window. The MMRTG was fueled in October-November 2008 with a completion date of November 6, 2008. The decision to delay the mission from 2009 to 2011 was made known to DOE in December of 2008. The early fueling of the MMRTG led to an additional 26 months of degradation of the power output of the generator. It is likely had this information been communicated earlier that a similar delay in the fueling would have transpired and that the power level of the generator would have been several watts higher when it arrived at Mars.

The need to have a pathfinder exercise at KSC 12-18 months prior to launch of a nuclear-enabled mission is very well known. A pathfinder exercise is a dry run through all the RTG handling procedures with an emphasis on the interactions between the different organizations. This exercise took place in May 2008 with KSC, United Launch Alliance (ULA), Jet Propoulsion Laboratory (JPL) and the DOE team participating. The scope of the activities should have been the following: arrival and unpackaging of the MMRTG at the RTG facility (RTGF), transportation to the payload hazardous servicing facility (PHSF) to simulate a hot fit check, transportation back to RTGF and then transportation to the vehicle integration facility (VIF) and covering all operations at the VIF. The readiness of the entire team to conduct this scope was not what it should have been; therefore, the scope at the VIF was attenuated to exclude the integration activities and only the lift was effectively demonstrated. JPL and the INL team did mock up the integration activities at a much later date in early 2011 at JPL. This was deemed acceptable but far from optimal. It is possible that the complete team could have been ready sooner than 2011 if the launch date had stayed in 2009 but May of 2008 was the identified window to perform this activity and coincided with the work force being available from the INL. The May 2008 pathfinder date was also consistent with the launch window of September 2009.

The protocol for establishing nuclear facilities under the purview of the DOE is clearly defined in 10 CFR 830 [1]. This was implemented for several facilities at KSC that would house the MMRTG or MMRTG-related activities. This included the unreviewed safety question (USQ) process, which is applied to all procedures to be utilized in those facilities when the nuclear item was present. This process is used to ensure that the operations to be performed in a nuclear facility fit within the analysed realm of operations, possible events that could lead to release of nuclear material to the public, and technical safety requirements established to mitigate the consequences of any nuclear safety incidents. This was done using a graded approach and with formal documentation since at times the MMRTG was present in a facility for a matter of days and sometimes for several months. The outreach to other groups to inform and train them on the processes involved that were implemented by the INL was conducted but its effectiveness was less than envisioned. This led to some confusion, inefficiency and some just-in-time approaches to clearing the procedures for use via the USQ process.

This paper will focus on those issues that will be of importance to Mars 2020 to aid in a more efficient flow of events and a better utilization of resources for a successful Mars 2020 launch.

References:

[1] 10CFR830, Nuclear Safety Management, Jan. 1, 2011.