HUMAN FLIGHT TO LUNAR AND BEYOND – RE-LEARNING OPERATIONS PARADIGMS

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ABSTRACT[3]

For the first time since the Apollo era, NASA is planning on sending astronauts on flights beyond Low-Earth Orbit (LEO). The Human Space Flight (HSF) program started with a successful initial flight in Earth orbit, in December 2014. The program will continue with two Exploration Missions (EM) to Lunar orbit: EM-1 will be unmanned and EM-2, carrying astronauts, will follow.

NASA established a multi-center team to address the communications, and related navigation, needs. This paper will focus on the lessons learned in the team, planning for the missions' parts that are beyond Earth orbit. Many of these lessons had to be re-learned, as the HSF program after operated for many years in Earth orbit. Fortunately, the experience base from tracking robotic missions in deep space by the Deep Space Network (DSN) and close interaction with the HSF community to understand the unique needs (e.g. 2-way voice) resulted in a ConOps that leverages of both the deep space robotic and the Human LEO experiences.

Several examples will be used to highlight the unique operational needs for HSF missions beyond Earth Orbit, including:

- *Navigation. At LEO, HSF missions can rely on Global Positioning System (GPS) devices for orbit determination. For Lunar-and-beyond HSF missions, techniques such as precision 2-way and 3-way Doppler and ranging, Delta-Difference-of-range, and eventually on-board navigation will be used.*

- *Impact of latency – the delay associated with Round-Trip-Light-Time (RTLT). Imagine trying to have a 2-way discussion (audio or video) with an astronaut, with a 2-3 sec delay inserted (for Lunar distances) or 20 minutes delay (for Mars distances).*

- *Balanced communications link. For robotic missions, there has been a heavy emphasis on the downlink data rates, bringing back science data from the instruments on-board the spacecraft. Uplink data rates were of secondary importance, used to send commands to the spacecraft. The ratio of downlink-to-uplink data rates was often 10:1 or more. For HSF, rates for uplink and downlink, at least for high-quality video, need to be similar.*

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