National Aeronautics and Space Administration
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A Summary of a Recent NASA Study on Ultra-High-Definition Lunar Video for Artemis

NASA's current policy requires that the Artemis missions return imagery (videos, images) but does not prescribe its specific quality. The broadcast will heavily influence how humanity perceives the nation's return to the Moon. It will inspire others to reach great achievements and learn more about the Moon. It will show the United States as a leader in space exploration and help visualize what NASA seeks to achieve on the Moon and beyond.

The agency's chief technologist within NASA's Office of Technology, Policy, and Strategy (OTPS) conducted a study with the close participation of the Moon to Mars (M2M) program office, to assess tradeoffs and opportunities for increasing the quality of video resolution returned from the lunar surface during early Artemis missions. This internal, pre-decisional study helped to clarify the current approach of high-resolution video on the lunar surface, including that Artemis III expects to have the ability for near real time ultra-high-definition (UHD)/4K resolution video under certain conditions, and identified specific additional areas of consideration, while also highlighting potential investments for longer-term imagery improvements. We offer this public document to synthesize those findings.

The significance and benefits of UHD

The public has come to expect high-quality imagery and NASA has prioritized ultra-high-definition or 4K, content. NASA broadcast UHD video from the International Space Station as early as 2017, and the recent institution of NASA+ enables the distribution of UHD content. Acquiring imagery in UHD also aligns with the Apollo Program approach of recording missions in higher quality, which provides long-term historical and archival value for a time when UHD may be the minimum standard.

UHD video increases the amount of detail in each frame spatial detail, but not necessarily the perceived quality for the viewer. While UHD could be helpful for the science, operations, and engineering communities, the public currently drives the demand for higher-resolution video on NASA missions. Viewing data indicates that only about 20% of viewers watch NASA broadcasts on televisions, and the benefits of UHD for a viewer strongly depend on factors like the distance from the screen or the video being shown. UHD may provide a more compelling benefit to users as a prestigious label and a signal of NASA's capabilities. Further, UHD video may also simply be expected of a marquee event in an age with broadcasts of Paris Olympics in 8K, United Kingdom ceremonies in UHD HDR,[1] and the launch of all the Artemis missions broadcast in UHD.

Expected imagery on Artemis III

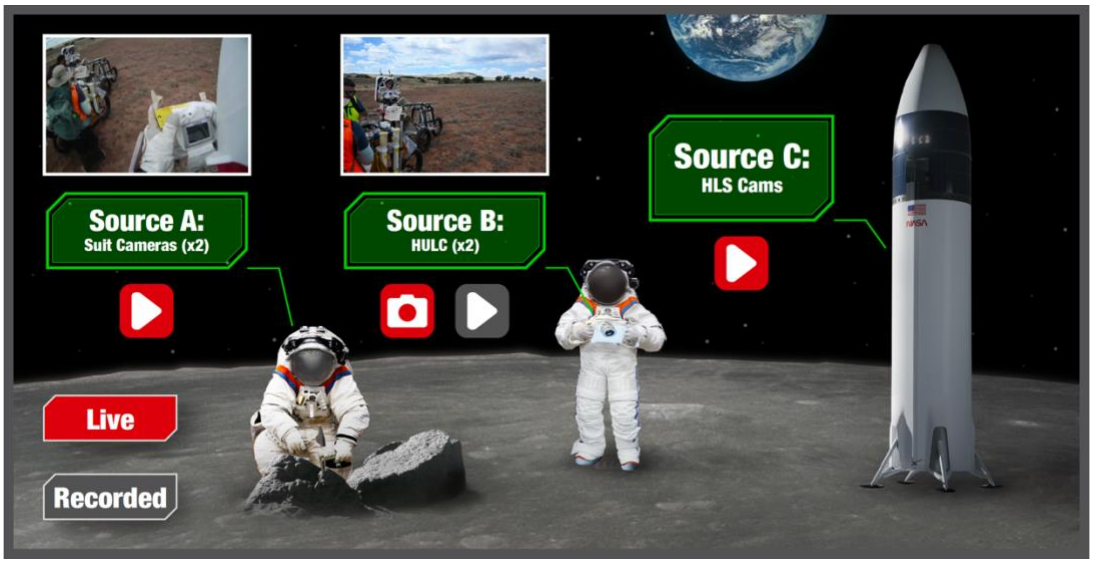
Streaming high-quality content is difficult from space and even more challenging from the Moon. The principal challenge to sharing live, high-definition content during extravehicular activity (EVA) is limited communications bandwidth, both on the surface and from the surface of the Moon to Earth. Even with the support of the Deep Space Network, UHD video requires between 10 and 20 Mbps (or greater depending on specific implementation) to maintain high quality—a high bar with the distance and other downlink demands on the mission. This also requires *in situ,* space rated encoders capable of heavily

[1] HDR–High Dynamic Range. More information on the BBC UHD HDR broadcast for the coronation can be found on BBC R&D's website: https://www.bbc.co.uk/rd/blog/2023-12-uhd-hdr-production-architecture-coronation.

compressing video at low size, weight, and power. NASA and its partners are making important strides toward overcoming such challenges.

Artemis III is currently expected to provide multiple camera views with live streaming capability, some of which could feature UHD/4K resolution, thus helping to answer the initial question for this study. As shown below in Figure 1, the surface extravehicular activity for Artemis III will feature at least three sources of imagery:

A. Similar to the suits on the space station, the suits will have a suit-mounted camera to provide operational awareness of the crew member's immediate work area.
B. In partnership with Nikon Inc., NASA is developing the Handheld Universal Lunar Camera (HULC), capable of acquiring up to 8K video and high resolution still images. HULC will transmit only compressed still images live during extravehicular activity .
C. The Human Landing System (HLS), the craft that will deliver astronauts to the lunar surface, will provide multiple external cameras.



Note: xEVA and HULC example images taken from recent Joint Extravehicular Activities and Human Surface Mobility Test Team 5 (JETT5) testing.

Figure 1. Artemis III and IV Imagery Technical Baseline During Extravehicular Activity

Further considerations

Beyond resolution, further opportunities for NASA to consider include: 1.) increasing the number of perspectives available to a viewing audience, especially perspectives of landing and ascent, 2.) the potential value of high dynamic range (HDR) video for the lunar environment, 3.) virtual reality or non-traditional media that immerse viewers, and 4.) the potential long-term value of researching imagery acquisition and processing from the Moon and Mars. This study directly or indirectly led to several follow-on activities including the Artemis in Motion listening sessions planned for March 2025, the new lunar imagery subtopic for 2025 STTR solicitations, and a follow-on study on HDR video that will likely include releasing a database of test clips in a simulated lunar environment.