Replicating or Exceeding the Imagery from Apollo for Artemis Missions. Rodney Grubbs, NASA Marshall Space Flight Center, Alabama Rodney.Grubbs@NASA.Gov

Introduction: If you ask a person their impressions of the Apollo Moon Program, most likely the response will include a reference to imagery. Imagery is the most powerful and effective way to engage the public for human exploration of space. As we now embark on a new chapter of human space exploration with the Artemis Program, the expectations for the quantity and quality of imagery present a host of challenges.

During Apollo, NASA had three sources of imagery: live television systems, motion picture film, and still frame film. The live television during Apollo was crude by today's standards. The motion picture camera was similar to the 16MM cameras used in harsh environments on Earth. The still frame film camera was a very high-resolution professional class camera using 70MM film.[1] In the modern era, it is likely there will be no need to have separate cameras for motion imagery and still imagery. Modern cameras are capable of live and recorded motion imagery and high-resolution still imagery. But replicating the quality of the still imagery will be very difficult.

Comparing Analog to Digital: During Apollo, the motion picture and still imagery cameras used photographic film. The film was returned to the Earth, processed, and produced many of the iconic images and motion imagery. During Artemis, cameras will likely record the highest resolution on digital data cards, while simultaneously transferring lower resolution files or streams (in the case of motion imagery) to Earth while the mission is on-going.

While today's motion imagery and television standards far exceed the quality of the Apollo era's television and motion picture photography, replicating the quality of the 70MM still film camera with a digital equivalent will be very difficult. While it is difficult to compare the resolution of film with digital imagery, the imagery from the cameras used on Apollo is considered to be roughly 100 Megapixels [2]. While digital cameras capable of 100 Megapixel camera imagery exist, they would be very impractical to fly due to the large size of the cameras, lenses, and data sizes. Fortunately, electronic processing and other factors should allow for comparable, of not better, quality with smaller cameras that have image between 30 and 50 Megapixels.

Technical Challenges: Imagery data will by far exceed all other sources of data to be transmitted to Earth during Artemis missions. The primary enabling capabilities to support digital imagery from the moon will be: robust wireless communications (for imagery during EVA's on the Moon's Surface), large capacity solid state data storage, and high-bandwidth data links from the Moon's surface to the Earth.

Artemis missions envision longer, more numerous, Extra Vehicular excursions on the Moon's surface, that go much further away from the lander or a future base camp than Apollo missions. Scientists and ground controllers will need a steady stream of imagery data from the crew during these excursions. Should the astronauts stumble upon something unique or unexpected, an image beamed back to Earth quickly will enable quick decision making to determine whether to leave the sample, or pick it up and bring it back to the spacecraft for return to Earth. Wireless communications, either from the camera to a suit outfitted as a wireless access point, or directly to a relay or the spacecraft will be required to enable this real-time transmission.

Due to practical bandwidth constraints, any imagery transmitted to Earth during an excursion will need to be compressed to small file sizes or streams (in the case of video). The higher resolution imagery will need to be recorded on or nearby the camera. That will require very high-capacity solid state data storage. Files sizes for RAW still imagery can be up to 60 Megabytes per file. Less compressed Ultra High Definition video can consume 100 Megabytes per minute of recorded video. This recorded data will be the equivalent of the film from the Apollo missions, containing the high-resolution imagery that will be seen and shared for generations.

Probably the most critical enabler of imagery from the Moon will be the data links back to Earth. Imagery will require orders of magnitude more data than other sources of streaming data, such as voice, telemetry, guidance, command and control data. For example, heavily compressed streaming Ultra High Definition Television could require up to 10 Megabits-per-second of bandwidth. That compression is very vulnerable to jitter and missing data packets, so the entire communications system must be scaled for the requirement. Proxy still images using JPEG compression will still be large files, likely between 4 and 10 Megabytes of data per file.

Summary: We live in an era where cameras are everywhere—on our phones, in our doorbells, on our cars, on every street corner. The public will expect to be able to ride along with the crew when we return to the Moon. Imagery will be the primary method of engaging the public and maintaining their interest. Replicating the quality of imagery we had during Apollo can be done in the digital era, but care must be taken to make sure the enabling technologies are in place. It is much easier to build these technologies into the system during the design and planning phase, than to retro-fit the spacecraft later in development.

References:

[1] https://www.history.nasa.gov/apollo_photo.html

[2] https://en.wikipedia.org/wiki/Comparison_of_digital_and_film_photography