BREAKING THE 4K BARRIER
NASA and AWS Elemental Engineer the First Live 4K Broadcast from Space
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INTRODUCTION

On April 26, 2017, NASA achieved another breakthrough in its remarkable history of innovation in film and video technology. At 10:30 a.m. US Pacific Time, NASA Astronauts Dr. Peggy Whitson and Jack Fischer appeared live before attendees of the National Association of Broadcasters (NAB) Show in Room N249 of the Las Vegas Convention Center (LVCC). Whitson and Fischer were 250 miles above sea level, traveling at 17,500 miles per hour aboard the International Space Station (ISS). Both addressed the audiences live in 4K Ultra-High Definition (UHD) video – the highest resolution ever broadcast live from the space station.

During a 15-minute conversation with AWS Elemental CEO Sam Blackman, Dr. Whitson – who, having recorded the most time in space of any US astronaut, is well accustomed to history-making events – and Fischer treated viewers to insights and stunning visuals from her work aboard the ISS, revealing in never-before-seen detail the benefits of live Ultra High-Definition video to support NASA’s mission.

“Live 4K UHD streaming will help take our research to the next level,” Dr. Whitson observed. “Obviously, 4K detail is riveting; higher resolution images reveal more information when we’re observing events like the Aurora Borealis, solar flares and moon phases. Live 4K UHD streaming will enable NASA’s astronauts and scientists to observe, uncover and adapt new knowledge of orbital and deep space. Now we can share discovery, deep space events and research as they’re happening – not just after the fact.”

A home to scientific discovery staffed by tireless explorers from around the world, the ISS has been a source of inspiration and research breakthroughs since its first crew boarded in November 2000. Advanced video technologies have been a critical part of NASA’s research since the first Apollo missions and the ISS is no exception; from day one, live and archived video have been used to record and monitor experiments aboard the vessel, bridge the 250-mile divide between astronauts and the scientists and engineers on the ground while also educating viewers along the way.

A PLAN TAKES FLIGHT

The challenges in bringing the first live 4K video streams from the ISS to Earth were considerable. Together, NASA and Amazon Web Services (AWS) engineered a complete, resilient workflow that brought this industry-first to NAB Show attendees and viewers everywhere, offering lessons for video producers and network architects who are looking ahead to a future where live events, agile workflows and dynamic, cloud-centric video processing unlock new opportunities to bring compelling content to their audiences.

The process of establishing a successful end-to-end live 4K transmission began on a launch pad in Cape Canaveral, Florida in 2015, when SpaceX CRS-5 cargo resupply mission traveled to the ISS carrying a RED Epic 4K camera aboard to anchor the workflow. In December 2016, an AWS Elemental Live encoder appliance arrived at the ISS via the Japan Aerospace Exploration Agency (JAXA) H-II Transfer Vehicle.

QUALIFYING FOR SPACE FLIGHT

The AWS Elemental Live video processing solution was chosen as the live encoder for 4K video. NASA evaluated the system against stringent requirements dictated by the unique working environment of the ISS. Size and power consumption are key: every ounce of weight, inch of space and watt of energy is carefully measured and managed, so the encoder needs to be as small and efficient as possible. The
AWS Elemental solution is small enough to easily attach to the wall of the ISS with Velcro and requires very little power from the station’s solar arrays.

Environmental considerations are another priority: the AWS Elemental solution was evaluated for loudness, fan speed, and chemical composition of every component as well as heat capacity and exothermic release. NASA conducts human factors engineering testing as well, to ensure systems meet crew needs from an interface and usability standpoint.

“Ease of installation, usability and remote management functionality via the ISS network were vital considerations for NASA,” noted Keith Wymbs, Chief Marketing Officer at AWS Elemental. “Astronauts are among the most sophisticated technical experts you’ll ever see but their time is far too precious to spend learning complex, unintuitive processes. The user experience needs to be simple and it has to fit how they work.”

**DESIGNING A COMPLETE SPACE-TO-SCREEN WORKFLOW**

Once the AWS Elemental Live system was aboard, NASA astronauts quickly set it up for seamless integration into a real-time 4K HEVC workflow anchored by the 4K camera. Video was set up, controlled and managed over an IP network from a single, user-friendly AWS Elemental user interface. The AWS Elemental Live system encoded video in HEVC (H.265) and sent it in a UDP transport system (UDP/TS) over the ISS network to Johnson Space Center (JSC) in Houston along with a separate HD audio stream.

*NASA End-to-End Live 4K Workflow*

The 4K video signal was decoded at JSC and combined with the audio signal to produce a 4K video/audio stream. Taking into account the unique complexities of broadcasting from space, the production team opted to utilize two diverse signal paths to enhance resiliency and high availability for the live video workflow. The combined signal was then routed to two AWS Elemental Live encoders, which transcoded two HEVC video outputs for distribution; the primary signal was distributed to the LVCC via satellite with the second, redundant signal carried by IP network directly to the convention center.

On site at the LVCC, a Roberts Communications Network satellite downlink truck received the primary signal and delivered it to Room N249 for the live event, where two Christie projectors displayed the live video in full 4K resolution during the session.
BRINGING LIVE 4K TO MULTISCREEN DEVICES

With the live 4K video workflow well established, the production team challenged themselves with a new idea: What if they could bring this history-making event live, in 4K, to viewers everywhere? Many options were considered. In the end, the team designed a solution that allowed off-site viewers to watch the event live on multiscreen devices by utilizing AWS Elemental Live encoders and AWS Elemental Delta in the cloud to provide a multi-bitrate stream from the Las Vegas Convention Center.

In this workflow, the redundant adaptive bitrate HLS streams were sent to two separate regional AWS Elemental Delta cloud instances which provided origin services. These origins provide IP delivery of HTTP Live Streaming (HLS) outputs through Elastic Load Balancers to the Amazon CloudFront content delivery network (CDN). Amazon Route 53 provided Domain Name Services, redundancy and routing policies to better manage the flow of traffic and failover to reach regional AWS Elemental Deltas. Amazon CloudFront and Amazon CloudFront Regional Edge Caches provided the global CDN for delivery to multiscreen and connected devices everywhere, with network monitoring performed by Amazon CloudWatch.

The workflows from the ISS to Room N249 in Las Vegas, and from Las Vegas to viewers worldwide, brought Dr. Whitson and Jack Fischer to audiences through clear and stunning 4K visual clarity. The astronauts captivated audiences at the LVCC and online over the course of their conversation with Blackman, demonstrating the kinds of visual experiments that NASA scientists conduct in low- and zero-gravity; in doing so, Dr. Whitson spotlighted the unique value that live 4K video will unlock for NASA. As she noted in her remarks:

“4K UHD is a valuable tool, and until now 4K had only been available to NASA as a means of acquiring information for scientific record or on-demand content for public viewing. Live 4K will also help NASA inspire the next generation of scientists and explorers, helping to go beyond textbooks to supplement classroom activities and learning as we expand humanity’s presence into the solar system.”

To watch the video of the first live 4K video from space and the NAB Show Super Session panel, visit https://live.awsevents.com/nasa4k on your connected device.