JAY NEMETH/RED BULL CONTENT POOL

FREE FALLING WITH FLIGHTLINE FILMS

When Felix Baumgartner made his 23-mile high jump from the stratosphere on 14 October 2012, documenting this epic feat required a 'floating movie studio' working in near space with cameras remotely operated from Earth. The Red Bull Stratos mission called in zero-gravity specialist Jay Nemeth of Las Vegas-based FlightLine Films to oversee the high-altitude photography. Howard Kayofski, a colleague of the GTC, takes a look at the camera technology behind this remarkable broadcast.

The moment Felix Baumgartner makes his leap, televised by cameras in housings (seen at the top) specially developed by FlightLine Films

According to Jay Nemeth, this project grew from an initial brief which sounded "pretty straightforward", calling for little more than some archive footage, into the very complex task of providing not only a continuous live feed to enable mission control in New Mexico to maintain visual contact with Felix, but also a global broadcast that could be viewed by millions. Red Bull Media House had specific goals to be met on the project, and engaged FlightLine Films to design a state of the art camera system that would raise the bar for all future aerospace missions.

Nemeth is one of a handful of 'zero-G' qualified cameramen and specialises in both aerial and aerospace cinematography. Experienced in zero-G and high-G environments, he has logged zero-gravity flights for a number of projects, including a shoot with Apollo 11 astronaut Buzz Aldrin. Through his company FlightLine Films, Nemeth provides aviation and motion picture customers with cinematography services, and has pioneered visual documentation systems for private and commercial space programmes since the start of the private space industry. The company can provide zero gravity-qualified crews, HD cameras for use in the vacuum of space, and housings that allow traditional motion picture cameras to operate in the most extreme circumstances.

Faster than the speed of sound

The Red Bull Stratos challenge was for freefall specialist Felix Baumgartner to become the first man to travel faster than the speed of sound without an aircraft or space shuttle, reaching an estimated speed of 833.9 mph. In so doing he would break the record for the highest ever freefall (previously held by retired US squadron commander Joe Kittinger, who would be the Flight Operations Director and Baumgartner's mentor on the Red Bull mission).

Incredibly, former test pilot Kittinger had jumped to Earth from 102,800 feet way back in 1960. For the Red Bull project Baumgartner would climb to 128,100 feet in a helium-filled balloon (some five miles higher than Kittinger's leap 52 years earlier) and his trip back to Earth would take 9:09 minutes. Kittinger, as the only person who had ever survived anything similar, would be Baumgartner's primary point of radio contact throughout the ascent.

Technology then and now

It is interesting to note that, despite obvious advances in camera technology, the images from the Kittinger jump, some of which are included in the Red Bull documentary, are surprisingly good. Aerial cinematographer Ken Arnold had used three very basic motion picture cameras and every technique available at the time to keep the cameras functioning, even attaching hot water bottles to them. The footage from the jump is clear, providing a powerful record of that pioneering project. Nemeth pays tribute to his predecessors: "What the camera unit did in 1960 was utterly remarkable but the technology was quite simple and so there was actually far less that could go wrong. What we faced were multiple points of potential failure given the complexity of having more than 35 cameras and so many new techniques involved."

In 2012, the cameras used would comprise: video and stills cameras mounted inside and outside the capsule in which Baumgartner would make his ascent, which would relay continuous information to mission control about his physical and mental state, as well as the condition of the capsule and balloon; specially developed cameras rigged on Baumgartner's pressurised suit to capture the actual fall; a Cineflex rig and other HD cameras mounted on a tracking helicopter.

From the outset, Nemeth wanted to capture 4K images of the jump so that any kind

Cameras Used

Inside the space capsule:

- Nine proprietary HD cameras recording to Panasonic P2
- Three 4K (4000 x 2000-pixel) cameras (modified RED Ones)
- Three high-resolution DSLRs (modified Canon 5Ds)
- Pressurised electronics 'keg' containing more than 125 electronic components and approximately two miles of wiring

On the pressure suit worn by Baumgartner:

- Five small HD video cameras: two on each thigh and one on Felix's chest pack (modified GoPro Hero 2s)

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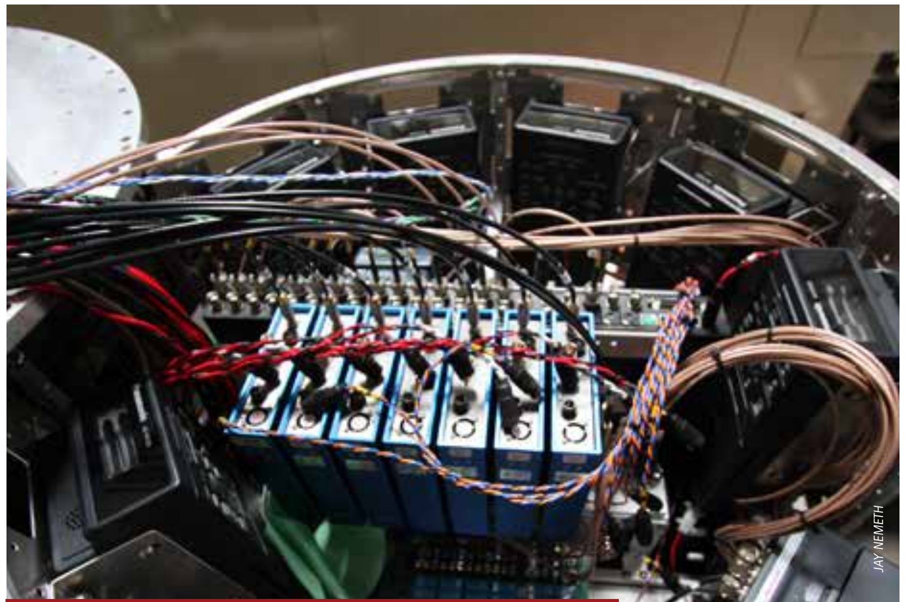
Crew members at mission control in Roswell, New Mexico



JAY NEMETH

Inside the specially developed camera electronics cage

JAY NEMETH

Inside the camera housing

Felix Baumgartner (right) with his mentor and previous record-holder Joe Kittinger

Over-shoulder view of Felix during his ascent in the capsule

The helium ballon that transported Felix to 128,100 feet for his jump

of future use, right up to IMAX, would be possible. At the start of planning for the mission, the RED Epic was not yet available. Many modifications were made to the RED One and the telemetry control software was written specifically for it. By the time the Epic was finally released, it was too late to redo all the mods and change the telemetry software so they stuck with the RED One.

For recording Nemeth chose solid-state RAM. FlightLine Films had already found Panasonic P2 to be great for aerial and Zero-G work, so it was a natural choice for the HD cameras. The RED Ones used a 512 GB RED RAM and the suit cameras recorded to SD cards.

Working in the 'cold vacuum of space'

The list of potential technical problems that can prevent cameras working in space are pretty extensive:

- In the cold vacuum of space, parts of the camera get so cold they no longer work, while at the same time others are overheating because there is no convective medium to take the heat away; some heat is lost as radiation, but not enough.
- This mixture of extreme hot and cold can cause circuit boards to bend, much like a thermostat made of dissimilar metals and, in turn, this warpage can cause traces and components to crack.
- Other components such as electrolytic capacitors will fail in a vacuum.
- High voltages can arc across circuits when there is no air insulating them.
- Solar radiation can cause components in the sun to overheat on the sunny side, while they are way too cold on the shaded side.

Many of these issues can be dealt with by placing cameras in a pressurised housing to create a stable atmosphere, and allowing fans to circulate nitrogen to cool any parts that are overheating.

Capsule and suit cameras

The process of capturing images from the capsule and pressure suit, ended up involving more HD cameras than most 45-foot television production trucks, as well as three dedicated channels of microwave video, which could be dynamically assigned to selected cameras. The nine HD video cameras, three 4K cameras and digital stills cameras were all controllable from Earth – they could be stopped and started, colour-matched and most other functions controlled by a specially designed telemetry system at the imaging station in mission control – not unlike having a mini OB truck inside the capsule.

For the control system a graphic user interface was created by Riedel Communications to FlightLine's specifications. This used a two-way telemetry radio system that communicated with an onboard computer in the 'payload' or camera section of the capsule. The computer spoke to various devices through serial data connections, and activated GPIO systems that could operate equipment not natively capable of being remotely controlled.

Special thought also had to be given to the suit cameras which would need to function in near-space conditions for up to 20 minutes as well as at supersonic speeds and in any orientation, such as when Baumgartner went into a rapid spin while freefalling.

JLAIR equipment

- HD P2 camera (up to 60 fps): HPX500 with Fujinon 13.5x42 lens
- 4K (4000 x 2000-pixel) camera (up to 120 fps in 4K mode): RED Epic
- Shortwave infrared camera

Felix climbs into the fully rigged capsule

Although the speeds were quite high, the air density was practically zero at the higher altitudes, so there was no problem. By the time the air started to become thicker at the lower altitudes, Felix's speed was beginning to slow. Other specific challenges thrown up

Quick Facts

- Most cameras required modification or special electrical and thermal systems to function in near space.
- All cameras were tested in a chamber that simulates the conditions of high altitude and space and some were placed in custom pressurised housings and filled with nitrogen gas.
- Four of the capsule cameras were space-rated units attached to the exterior base of the capsule.
- Eight were in the pressurised housings also on the exterior of the capsule and three within the capsule.
- All were remotely controlled from the Mission Control Centre

Pilot Felix Baumgartner Technical Project Director Art Thompson celebrate the successful leap

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by the mission were that higher-than-normal ND filters were needed on the HD and 4K cameras due to the brightness of the sun in the upper stratosphere.

Broadcasting from space

To achieve the live broadcast from 23 miles above Earth, a ground-based long-range optical tracking camera system called JLAIR (Joint Long-range Aerospace Imaging and Relay) was developed. This included features not previously available to the private space industry or production companies, carrying a variety of high-powered zoom lenses and large telescopes attached to an 8000-pound motorised pedestal, previously used to track Space Shuttle launches. The JLAIRs could easily see Felix step off the capsule.

While a fairly accurate prediction could be made of where Felix would jump and land, there was still some uncertainty due to weather changes. So, two JLAIRs were deployed to increase the chance of one being in the prime location and also for redundancy in case one of these highly complex units suffered a malfunction. As it turned out, they both performed perfectly, and Felix landed close enough to JLAIR 1.

JLAIR 1 included an optics payload of more than 1000 pounds, an air-conditioned control room, an onboard generator for the tracker and subsystems, and encoding and satellite transmission of HD video. JLAIR 2 shared the same features but employed a traditional trailer-mounted pedestal with separate control truck for mission flexibility.

Tracking helicopter

A tracking helicopter was in the air during much of mission. This was mounted with a Cineflex V14 HD gyro-stabilised camera, with optics precise to a subpixel level and the camera was rigged with a 13.5x42 lens. Inside the helicopter were two HD cameras, three HD recorders, a 2GHz microwave transmitter and a 16-port HD switcher.

The Red Bull Stratos project and FlightLine Films have redefined how high altitude and space missions will be documented from this point forward. Never before has an aerospace mission been covered with so many cameras of so many types, and with such quality and immediacy. The resurgence of space exploration when it happens will not be seen as the fuzzy and ghostly low-resolution images we're accustomed to. Instead, these stories will be told with impactful and compelling pictures that transport the viewer on these journeys to the heavens.

Fact File

Jay Nemeth has worked as an aerial cinematographer since 1984, using various airborne camera systems to produce images for feature films, commercials and documentaries. He has extensive experience of rigging and designing systems for everything from light aerobatic planes to military fighters and helicopters. He is one of a handful of Zero-G qualified cameramen.

In 2007, Jay founded FlightLine Films to respond to the emergence of private space programmes, the goal being to provide state-of-the-art camera technology for these projects while not losing sight of the artistic quality of the images. Having a background as a traditional cinematographer, Jay tries to make all imaging decisions based on producing the most compelling and impactful pictures.

In the quest to keep costs down, Jay has found that commercial off-the-shelf equipment can often be adapted. Testing is conducted in a special chamber (a pump removes the air to create a vacuum that simulates space conditions) and the team has found that it is surprising how much standard equipment can actually be made to work, sometimes just by changing a few electronic components; other items will be placed in housings specially designed to simulate the environment of Earth.

See more about Jay's work at: *http://flightlinefilms.com* and all about the Red Bull mission at: *http://www.redbullstratos.com*