MARS IN 3D

IMAGES FROM THE VIKING MISSION

DEDICATED TO THE MEMORY OF ELLIOTT LEVINTHAL, 1922 - 2012

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Bringing Life to the Red Planet

Is there life on Mars? Between 1976 and 1979, NASA's twin Viking 1 and 2 spacecraft orbited, landed and collected breathtaking imagery of the Martian landscape, attempting to answer one of the solar system's most fascinating riddles. The mission was written in history as one of the United States' most important space achievements since the Apollo moon landings, giving us the most complete view of the Red Planet to date.

Following the completion of the mission, 3D imagery from the orbiters and landers was transformed into a stereoscopic dual-16mm film by Dr. Elliott Levinthal of Stanford University, a member of the Viking imaging team. The innovative musical soundtrack was created at the Center for Computer Research in Music and Acoustics (CCRMA) at Stanford by composers Michael McNabb and William Schottstaedt.

In 2010, CCRMA planned to display the Martian film as a component of a concert series to be presented at a movie theater. The original director's prints were located in NASA archives, but could not be projected in a modern theater.

Enter the Mars in 3D Project – the committed effort to restore and convert the original film and its soundtrack to modern high-definition digital video and audio, using state-of-the-art 3D cinema technology and digital audio synthesis. The project conquered this seemingly extraterrestrial task and transformed the film into an out-of-this-world stereoscopic 3D experience. We had a chance to chat with Mars in 3D composer and video engineer Michael McNabb who walked us through the process of this historical initiative.

Viking I Launch on August 20, 1975

What is your association with the Mars in 3D Project?

I am one of the two composers who created the original music for the film. The other is William Schottstaedt. I led the project and donated my time for doing the film and soundtrack restoration work. The project is supported by Stanford University, the Stanford Center for Computer Research in Music and Acoustics (CCRMA) and the NASA History office at the NASA Ames Research Center.

The concept is brilliant – however, how did it all come together? How did you come across this footage?
In 1979, Dr. Levinthal was working at the Stanford Medical School developing medical imaging technology. He was the one to receive support from NASA and Stanford to produce the original 16mm film based on the 3D imagery from the spacecraft.

Dr. Levinthal approached Professor John Chowning – who, at that time, was the director of CCRMA – to help produce a stereo soundtrack for the film. Professor Chowning turned to two of his graduate students – Mr. Schottstaedt, and me – and we each produced about 15 minutes of music for the film.

The concert that motivated the project and film initiative was to honor Professor John Chowning, who encouraged and helped us to locate and obtain the original film and narration reels. An internet search led us to NASA's archives.

Since you worked on the original 16mm film initiative for Stanford in 1979, do you know how the spacecrafts obtained the original footage 30-years ago?
Each spacecraft had both an orbiter and lander component. Each lander had two cameras separated by 0.8 meters, which – when used together – could produce left/right stereo images. One purpose of that was to determine precise distances to nearby features for programming the soil scoop arm, but it also proved useful in understanding the overall geology of the surrounding landscape. It also really brought home the tremendous human and technological achievement of seeing the surface of another planet up close for the first time in human history. And although the tests for life on Mars were then deemed inconclusive, the results are still debated by scientists today, with many arguing for a positive interpretation.

CCRMA 1982 L-R David Jaffe, John Gordon, John Chowing and Bill Schottstaedt

For the orbital views, two images taken by the moving spacecraft from slightly different locations were used to produce the stereo images to reveal the topography of the large-scale surface features. The film also includes conventional stereo images taken at the Jet Propulsion Laboratory in Pasadena of the Viking test lander , which was used to test programming and procedures that were then used to operate the actual lander instruments and cameras.

And fast forward to the present – this is a tricky project, what types of software are you using to restore this primitive footage?

The film was scanned to 1080p video and processed and edited in Final Cut Pro 7. There were severe 3D issues due to the wide separation of the cameras, left and right images taken separately at different times of day with varying shadows and lighting, jitter due to the 16mm film and digital conversion process, and color fading and left/right mismatches. Sequences of scenes like this were overlapped with crossfades. It was critical to be able to target these problems in an efficient and automatable fashion, quickly switching between multiple output views, without having to leave the Final Cut Pro timeline. A variety of plugins were used, notably Stereo3D Toolbox from Dashwood Cinema Solutions, CHV Repair Collection, and Neat Video noise reduction.

In regards to the entire reconstruction workflow, is there anyway you can deconstruct it for me?

For the restoration, each reel (left and right eyes), was first processed according to the following steps:

- Original 4x3 aspect 16mm film scanned to uncompressed 10-bit 4:2:2 HD (1440 x 1080) by DeluxeMedia L.A.

- Converted to Apple ProRes 422 HQ codec and imported into Final Cut Pro.
- Final Cut Pro's SmoothCam filter applied to reduce jitter caused by both the original 16mm capture and the scanning process.
- Neat Video noise reduction and CHV Repair Collection plugins applied to reduce innumerable scratches, dust, and tears.
- Sharpen, Brightness and Contrast, and "Color Corrector 3-way" effects variously applied for fading correction and quality improvements.
- Final geometric 3D alignment and left/right color matching using Stereo3D Toolbox.
- Output to various 3D formats using Stereo3D Toolbox.

Michael McNabb at CCRMA 1980

Did everything run smoothly? Did you bump into any problems along the way?

There were several challenges to overcome. The SmoothCam filter adversely affected the left-right convergence, and differently so for each scene. There were severe 3D "fusion" problems arising from the wide separation of the lander cameras and exaggerated 3D of the orbiter images. The original film put the horizon of the lander imagery at screen depth, with the landscape coming "out" of the screen. This is contrary to current practice, where scene elements not wholly visible should appear "behind" the screen. Some of the 3D scenes involved left and right images that were shot at different times of day, leading to problematic differences in shadow orientation and color between the two.

The idea of trying to correct all these 3D problems using normal Final Cut Pro tools was daunting. It was critical for me to be able to do the final 3D alignment and color correction in one pass, with accuracy and automation, since I was operating on one long sequence with pre-existing scenes and transitions but the adjustments still varied from scene to scene, or within one scene. Stereo3D Toolbox was indispensable here.

Photo from the lander looking out at the surface of Mars

What about the soundtrack?

The original musical soundtrack was produced in 4 channels using the Systems Concepts Digital Synthesizer, a.k.a the "Samson Box" after its creator, Pete Samson. This one-of-a-kind device was one of the very first real-time digital synthesizers. Bill and I along with the other faculty, staff, and grad students at CCRMA wrote the software to control it from a time-sharing mainframe computer. Our musical efforts were very complementary. Bill's music uses frequency modulation synthesis (FM) to produce string orchestra-like music with great expression and emotional power. My music primarily uses additive synthesis, based on the analysis of real human voices, and just intonation scales, to produce choral-like music that strives for an ethereal other-wordly impression. The alternation of the two styles works very well in the film.

How was the soundtrack restored?

Coincidentally with the restoration project, Bill had begun working on some software to emulate the exact computational routines of the original Samson Box. Luckily, we were able to find the original Samson Box command files that we had computed in 1979 to synthesize the music. With a bit of digging into our memories and debugging the code, we were able to use Bill's emulator to resynthesize the original music with 32-bit resolution. The result is spectacular. Quiet passages seem to come from nowhere and louder passages are clear and undistorted. The use of Dolby TrueHD on the Blu-ray allows us to present it with zero artifacts exactly as it was created.

We were also able to digitize the narration from the original analog tapes, also retrieved from the NASA Ames History Office. The final complete soundtrack was then remixed in 5.1 surround using Logic Pro 9.

Original Film Credits:

Written by	Elliot C. Levinthal, Kenneth L. Jones
Produced By	Elliot C. Levinthal
Directed By	Kenneth L. Jones
Film Advisor and Editor	Uri Geva
Original Computer Music	Michael McNabb, William G. Schottstaedt Center for Computer Research in Music and Acoustics Department of Music, Stanford University Professor John M. Chowning, Director
Narration By	Elliot C. Levinthal
Sound Mixing	W.A. Palmer Films, Inc.
Sound	Uri Geva, Michael Silvers
Assistant Camera	Sue Miller
Viking Orbiter Stereo Photography images provide by Viking Orbiter Imaging Team	
Stereo Animation	Richard Finn, Marcy Page, CSU at San Francisco
Viking Science Test Lander Photography	3-D Cinematography Consultant — Paul Vlahos Director of Photography — Chuck Comisky
Viking Lander Stereo Photography images provide by Viking Lander Imaging Team	
Stereo Animation	W.A. Palmer Film, Inc.

Pete Samson with the Samson Box

Technical Advisors
Science Test Lander Operator — Phillip M. Coulsen
Stereo Consultants — Sidney Liebes, Jr., Stephen D. Wall
Titling — Catherine Pickering

Restoration Project Credits:

Digital film restoration (2011): Michael McNabb

Audio restoration: Michael McNabb and William Schottstaedt

Photography: Patte Wood

Blu-ray Production
Producer and graphic design: Mark Waldrep, Ph.D.
Video/Audio Encoding: Dominic Robelotto
Blu-Ray 3D Authoring: Dominic Robelotto
Interview Videography and Editing: Michael Waldrep

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Special thanks to the following people who helped with the restoration project:
Niclas Bahn, Sarah Cooper, Jay Kadis, Mark Waldrep, Glenn E. Bugos, Tim Dashwood, Fernando Lopez-Lezcano, Linnea Williams, Chris Chafe, April Gage, Peter Samson, John Chowning, Uri Geva, William Schottstaedt

Web Links:

http://www.mcnabb.com
http://www.ccrma.stanford.edu
http://history.arc.nasa.gov
http://www.aixrecords.com/catalog/bd_3d/mars3d.html

From The BD Producer Mark Waldrep:

This was a very special project for me. As a fellow composer of electro-acoustic music (having composed the first all electro-acoustic dissertation at UCLA in 1985), former faculty member at the California Institute of the Arts, associate of Morton Subotnick and computer science graduate, I have particular affection and appreciation for this genre of music and for the men and women that create it. I am also a long time space and NASA geek who still has the front page of the newpaper from the morning after Neil Armstrong and Buzz Aldrin landed on the moon. So it was with great pleasure that I learned of this project from my friend John Chowning and was able to contribute to this historic Blu-ray 3D production. I want to thank Michael and John for the opportunity!

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