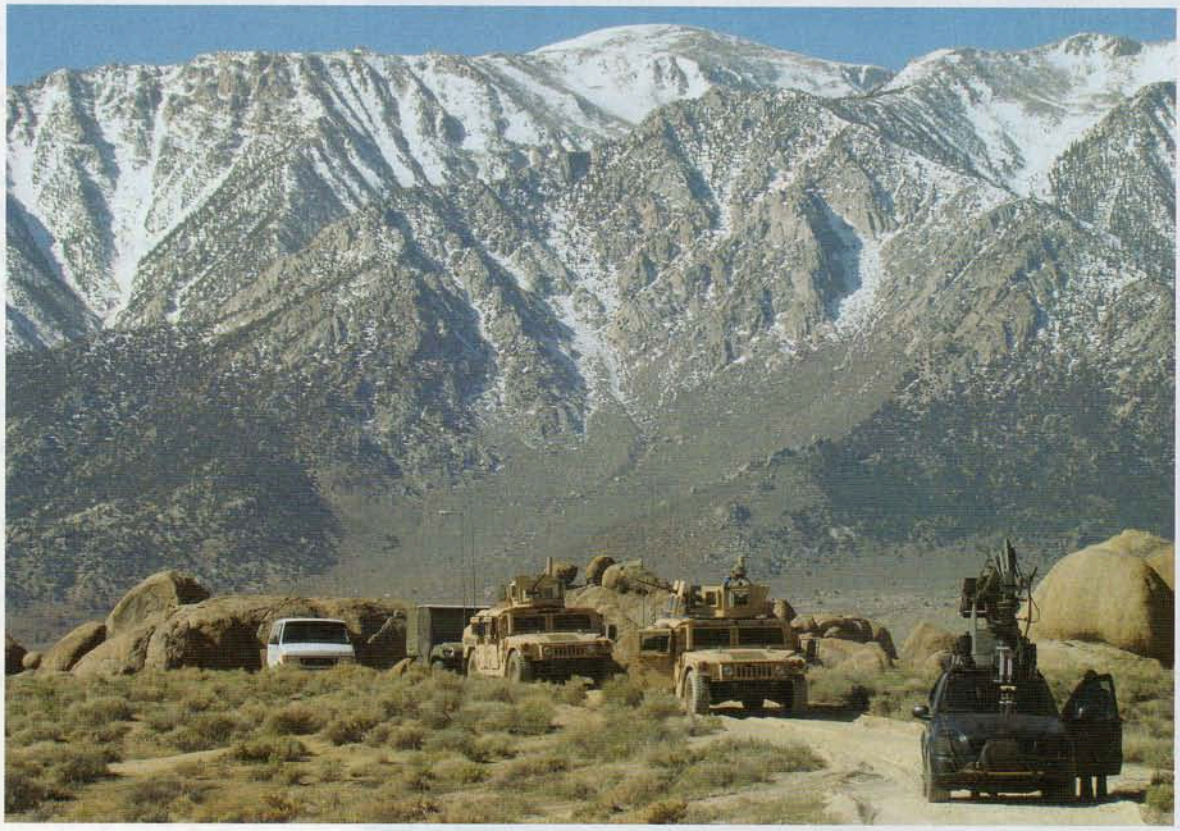
Filmmakers' Forum

Simulating Danger for U.S. Soldiers

by David Stump, ASC



A production convoy captures footage for a motion simulator designed to teach U.S. Army soldiers how to detect and avoid Improvised Explosive Devices.

I was recently asked by a group called RL Leaders to photograph material for a motion simulator designed to teach U.S. Army soldiers how to detect and avoid Improvised Explosive Devices, which the Pentagon has determined are the single biggest danger our soldiers face in current battle theaters. This project, directed by Randal Kleiser, turned out to be the most unique and fulfilling one I've ever undertaken.

The simulator is designed to give soldiers several scenarios in which IEDs are concealed along a travel route. They will sit inside an up-armored Humvee and feel the motion of the vehicle as it goes through the preset path. The driver will have no control over the vehicle; that variable was eliminated so the soldiers could concentrate only on identifying the signs of IEDs. When the soldiers believe they see an IED in the training simulation, they follow their procedures and stop the vehicle, calling in the Explosive Ordnance Disposal unit to investigate and disarm the device. The footage we shot has parallel action streams to create a kind of choose-your-own-adventure scenario. If the soldier correctly detects the signs of an IED and stops the vehicle convoy, then the playback switches to one path in which the EOD unit comes in and clears the convoy to continue. If the soldier does not correctly identify the signs, then a separate stream plays and designates a CG detonation. Every step of the project was incredibly complex and required a great deal of planning and coordination.

Technifex Inc. of Valencia, Calif., built a 6-degrees-of-freedom motion-base simulator that holds a modified version of an up-armored Humvee surrounded by about 300 degrees of HD projection. In order to put live-action content on that screen, we had to build a camera rig that would see 360 degrees and yield enough resolution to make a believable simulation for spotting IEDs from a moving vehicle. It was a terribly difficult task to figure out how to acquire the images, stitch them together, turn them into a continuous band of image and then put them on a cylindrical screen at a size that would enable the soldiers to see something that felt realistic.

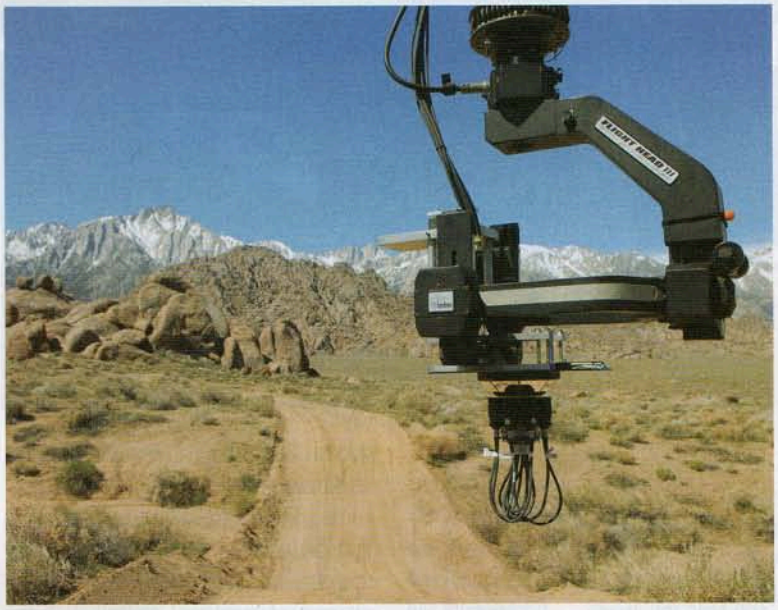
Photos courtesy of RL Leaders.

Through testing and discussion, we determined we would need five projectors to create a 300-degree field of view with approximately 10 percent of image overlap between the projectors. These would project an image onto a cylindrical screen that would surround the Humvee on the motion platform and cover 100 percent of the soldiers' perspective out the windows and in the mirrors. Anywhere they look from the inside of the Humvee, or from the gunner position on top of the vehicle, they'll see screen with seamless HD projection.

We shot the material with a camera rig constructed by Carlos Acosta that held eight Iconix HD-RH1 cameras under 45-degree half-mirrors to generate eight 1920x1080 streams that would be stitched together to form a single 15Kx1080 progressive image. The rig was reminiscent of the old CircleVision camera, with modern tweaks. To accommodate the stitching of the individual image streams into one image, I had to find a camera configuration and lens combination that would give me a slight image overlap of 6-8 percent. Once the streams were stitched together, some sections ended up being 12 minutes long, and at 15Kx1080 30-fps progressive, 12-minute parallel-stream files create a data-management nightmare!

In the field, the streams from the Iconix cameras were sent to four Codex Digital Portable recorders (two HD streams per recorder) and two HFV HD video recorders. The playback system comprises five 2K Christie projectors mounted on a truss rig over the Humvee and positioned to create one seamless 300-degree image. The 15Kx1080 stream is sliced into five independent 20 Mb/s (server spec, the highest server data rate we could do in our configuration) 30-fps 1920x1080 Mpeg streams that are played out of multiple CoolLux servers. The same servers also host the master controls, the user interface and the 7.1 Surround soundtrack for all the streams, and have to play back all the streams in perfect sync.

In the field, the Iconix rig was mounted to a Flight Head on a Z Crane attached to the top of a Mercedes ML55 SUV that was driven by Ross Jordan. We had military advisers on the project every step of the way, and we followed very specific military procedures, including the speed the drivers were trained to maintain and how they would execute each maneuver on the road.



Left: The crew prepares to shoot on location in the Alabama Hills near Lone Pine, Calif. Below: The camera rig, which comprised eight Iconix HD-RH1 cameras, was mounted to a Flight Head III on a Z Crane attached to the top of a Mercedes ML55 SUV.

We shot the sequences in the Alabama Hills near Lone Pine, Calif., which has rough, rocky terrain that is similar to terrain in the Middle East. I knew I needed a gyro head to keep the camera stabilized over the rough terrain; I also knew that would be a problem because of the way movie gyro heads work, but I didn't have an adequate alternative within our budget and timeline. Movie gyro heads are made to keep their heading no matter what happens to the platform below it. We had the Flight Head out on the arm in front of the camera car, but when the vehicle turned right, the head compensated and panned the camera to maintain the original heading. We wound up having to operate the camera to compensate for every turn and bend in the road, which turned out to be an enormously difficult task, but we got most of the way

Right: Cinematographer David Stump, ASC (left) shows off the camera rig. Below: Constructed by Carlos Acosta, the rig positioned the eight cameras beneath 45-degree half-mirrors, generating eight 1920x1080 streams that were sent to four Codex Digital Portable recorders and two HFV HD video recorders.

there through careful operation.

Unfortunately, we didn't succeed 100 percent in the field, so, after stitching together the images to create the 15Kx1080 image, I had to manually pan-and-scan the image — horizontally slip it frame-by-frame to match the movements of the car on the road — so it didn't appear to the soldiers that their vehicle was magically sliding across the desert. In this kind of immersive experience, with the visual field, sound track and motion platform working, it's very easy to induce motion sickness if just one of the variables isn't in perfect sync with the others. We were keenly aware of that every step of the way and went to painstaking lengths to make sure the experience would not induce vertigo or motion sickness. I used Final Cut Pro keyframing to slip the image to match the simulator heading and then sent that to our Adobe artists, who did the final eye match to my QuickTime files.

The next challenge was how to get the field-of-view that was necessary to achieve a 360-degree image with 6-8 percent of overlap. I started with the assumption that I needed the smallest HD camera I could get my hands on; at the time, this was the Iconix. Next, I had to find a lens for the ⅓" Iconix that would render a field-of-view of more than 45 degrees, something that's incredibly difficult with a small-chip camera. It turned out that there was one lens in Los Angeles, a 4.8mm sample from Fujinon that had a field-of-view of 48-49 degrees. That lens provided just the right amount of overlap.

The funny thing is, one of the first things you worry about with a super-wide lens is image distortion. The Fujinon 4.8mm is really well made and only has slight distortion, but I actually had to reverse-engineer the lens in post and warp each camera's image in After Effects; I had to build distortion *into* the image in order to make the streams seamlessly overlap! If I were to manufacture a lens specifically for this project, I would make a pure spherical lens, not the typical aspherical lens, because we needed the pure image and distortion to make the objects move from one stream to the next without appearing to distort. That might seem contradictory, but it all has to do with the science of lens optics, which I learned a lot about from my work on *Stuart Little* and this project.

When you design lenses, you design them knowing that the world is round and the film plane is flat, so you build curvature into that lens by grinding an aspheric — not perfectly round — lens. To get proper perspective without distortion, the lens is ground to actually change focal length from the center of the lens to the edges in a kind of bull's-eye target concentric circle fashion. Each of the different rings is a different focal length to correct the perspective overall. For a wide-angle lens, the edges are ground a little more telephoto than the center of the lens, and the total diagonal of the lens is what actually determines the "focal length" of that lens. The focal length in an aspherical lens is never the same across the entire distance of the lens; rather, it changes from one formula to another according to the mathematics of perspective correction in aspheric grinding.

The problem, especially on this project, is that in order to make a pleasing and pretty picture in a normal situation, you've changed the path that a moving object takes across the lens, especially in the extremes of the top and bottom of the lens. An object traveling horizontally across the last 10 percent of the top or bottom of the frame follows some funny transitions in angles to get there, because it's going through several changes in focal length in a short space. To get all of those funny angles to line up at the corners when you're overlapping two images, you have to reverse-

The simulator presents several scenarios and varying terrain in which IEDs are concealed along a travel route.

engineer all the aspheric aspects of the lens so that perspective lines don't meet at angles from the extreme right side of one camera/projection to the extreme left side of the adjoining camera.

In After Effects, I had to undo the perspective correction of each lens individually, add barrel distortion in order to get the material to match, and make sure any object passing from one projector to the next across the image seam would pass continuously rather than change direction. It was a very time-consuming process, but the result is a seamless 300-degree image around the motion platform.

Getting proper perspective was a challenge as well, and we actually ended up with a bit of a compromise. The Humvee has a gun turret on the top, and in our experiments, we determined that in order to get the size of projection we needed, with the proper space between the Humvee and the screen, we had to exaggerate the size of our projection slightly to fill the screen and make sure the gunner wasn't seeing the edge of the image. We had to slightly horizontally squeeze the image to get a slightly taller final picture to fill the screen. This also cut down on the strobing effect. At the end of the day, there was a lot of pulling and tugging, digitally speaking, to get the most picture on the screen.

Through testing, I found that the Fujinon lens started to lose performance very quickly beyond an F8. I wanted as much depth-of-field as I could get, but I had to find the sweet spot between depth-of-field and lens performance. I found it in the F5.6/8-split range. I wound up ND'ing down to that stop, but we had to start our first day of shooting before the custom ND filters arrived. I started with ND gel behind the lens, but that created focus problems, so we switched to the glass filters as soon as they arrived.

Another issue, especially with a cylindrical screen, was crosstalk destroying the image contrast. We used a Stewart low-gain screen for the projection, but there was still a great deal of light bouncing off one side of the projection into the other and mucking up the contrast levels. We had to compromise by switching to a lower-gain screen, as there wasn't a suitable solution for eliminating the bounce crosstalk effect.

The most meaningful aspect of this entire project was that I was able to contribute experience and knowledge I'd gained by making Hollywood movies to a project that would help save U.S. soldiers' lives in Afghanistan and Iraq. I am very proud to have been part of this project, and if it saves just one soldier from an untimely demise, then every effort that went into the project will have been well worth it. ■