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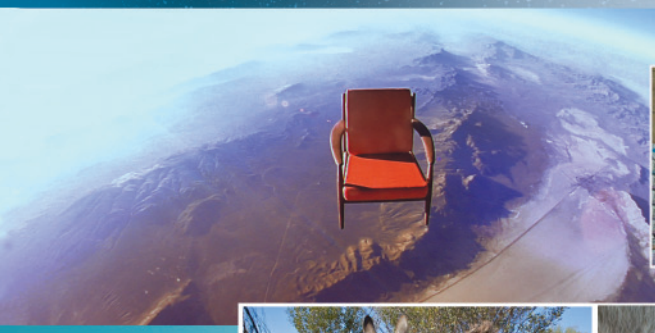

HD Video — A Travel Log

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Through the convergence of technologies, compact video camera design, improved optics, and video storage and transmission, high definition delivers incredibly diverse images from the depths of the sea to the edge of space and everywhere in between. During the past several years, the adoption of HD video formats for capture, display, and distribution has yielded imaging that offers superior clarity, resolution, and color details as never before. This article highlights several applications and many technical challenges met when applying the HD video format in different situations. While there are many HD video camera options, few have achieved the scope of industry and application as Toshiba Imaging's IK-HD1 CMOS HD camera. Chances are you've already experienced images from this camera, as it is widely used in broadcasting for international sporting events and for on-board video from a wide range of vehicles and aircraft.

HD Formatting Requirements

HD video, broadcasting, and digital cinema have formatting variations with 1080p generally regarded as full or true HD. The 1920 x 1080 resolution, 16:9 (1.78:1) aspect ratio format can be progressive (1080p) or interlaced (1080i). Some broadcasting applications use an alternate and acceptable HD format of 1280 x 720 resolution, 720p. Digital cinema, on the other hand, has an aspect ratio typically 1.85:1 or 2.39:1 and increasingly uses 4K and higher formats for cameras, processing, and in-theater projection. Since data and bandwidth requirements for HD video files are significant, compression techniques are frequently used to facilitate transmission and storage of these large volumes of data (see table 1).

Video Format	Cable Interface/Standard	Uncompressed Data Bit Rate
720p 1280x720	HD-SDI	1.485 Gbp/s
1080i 1920x1080	HD-SDI	1.485 Gbp/s
1080p 1920x1080	Dual link HD-SDI 3G SDI	2.97 Gbp/s 2.97 Gbp/s
1080p 1920x1200	DVI	3.96 Gbp/s
1080p, 3D, 4K	HDMI 1.4	10.2 Gbp/s (340 Mhz)

Table 1

Camera Design

Camera design is an art which balances trade-offs in performance, size, and cost to meet ideal mechanical, optical, sensor type, digital signal processing (DSP), and economic requirements. However, design criteria and component selection that may improve suitability for one application can make them impractical for other uses. The IK-HR1 camera (see figure 1) balances these performance attributes, including low fixed pattern noise, high signal-to-noise ratio, wide dynamic range, exceptional color accuracy across a range of lighting conditions, and a compact, rugged housing which adapts easily to a wide variety of applications.

Real-Life HD Video Challenges

The Space Chair project set a world record altitude of 98,268 feet (29,952 meters) for the highest HD television commercial (see figure 2). Conceived by Grey London advertising agency and inspired by Simon Faithfull's Escape Vehicle No. 6, this project utilized a customized balloon rig developed by JP Aerospace. Each rig had an FAA-imposed weight limit of 4 lbs. (1.8 kg) and included a suspended chair, two IK-HR1 cameras, digital video recorder, battery pack, GPS tracking, and small parachute. Among the early concerns were the stability of the cameras during ascent, the potential for lens fogging, and camera and other equipment performance in the untested near vacuum of the upper atmosphere and extreme temperatures, recorded

Figure 1: Toshiba's IK-HR1 HD camera

Figure 2: Space chair HDTV project

Cover images courtesy of Toshiba Imaging (www.toshibacameras.com); JoeyCam & low-light seal images courtesy of SeeSense (www.seesense.org, AGB Films - www.agbfilms.co.uk), and the BBC Natural History Unit (www.bbc.co.uk). Space chair image courtesy of Grey London (www.greylondon.co.uk) and JP Aerospace (www.jpaerospace.com). Surgical imaging photo courtesy of Viking Systems (www.vikingsystems.com). Cover Design courtesy of Smith Miller Moore Agency.

at –60°F (–51 C). Four complete rigs were prepared to provide redundancy and multiple lens options, and in the end more than 16 hours of video were captured and all eight cameras survived the missions, descent speeds exceeding Mach 1, and crash landing.

NASA's High Definition Earth Viewing (HDEV) project, developed by Johnson Space Center in Houston, TX, will join the International Space Station (ISS) in March 2013. Planned as a test platform to evaluate the performance and endurance of commercial off-the-shelf (COTS) HD camera technology, HDEV will provide the first continuous transmission of HD video images of earth from ISS. HDEV includes four HD cameras from different manufacturers, including IK-HR1, each equipped with fixed lens optics and positioned to provide a unique point of view from the ISS.

Four IK-HR1 cameras were selected for their compact size, light weight, wide dynamic range, excellent colors, and availability in single-piece and remote-head configurations for Virgin Galactic's (VG's) spaceship to capture interior and exterior images from the initial test flights for a National Geographic documentary series. During VG's concept development, a computer-generated animation depicted the dramatized commercialized space flights. VG and National Geographic wanted to capture, in real-time video, some of the same perspectives depicted in the animation - the earth falling away from the spacecraft during ascent and over the pilot's shoulder view visualizing the curvature of the earth.

Oceaneering, experts in remotely operated vehicles (ROVs), integrated customized stereoscopic 3D camera rigs for performance assessments of 3D visualization in underwater surveillance and construction used by the oil industry. To demonstrate and benchmark 3D capabilities for this unique application, they designed customized enclosures and fiber optic video transmission operating at depths of more than 10,000 feet (3,048 meters).

Figure 3: JoeyCam project images breathtaking HD video of the fetus' development from a kangaroo mother's pouch.

SeeSense, a UK-based video equipment company, developed "JoeyCam," integrating a light source and optics with IK-HR1, providing groundbreaking HD video of a kangaroo's fetus in its mother's pouch. This project for AGB Films and BBC Natural History Unit produced unprecedented imagery of fetal development with exceptional clarity (see figure 3).

Until recently, video cameras used on microscopes have been high megapixel cameras providing exceptionally detailed images but with video output limited to partial frame rates from 3 to 15 fps. These cameras are well-suited for capturing high-resolution single images but not for viewing images in real time from a display. The IK-HR1 provides full-motion, 30 to 60 fps, real-time images allowing the pathologist to view a monitor and quickly scan through a specimen, moving the microscope stage normally. Microscope manufacturers are now offering HD video cameras for real-time display of pathology slides supporting tumor review boards, educational applications, and in manufacturing/quality control tasks, improving ergonomics. Color accuracy is crucial for medical applications, and IK-HR1 features a comprehensive settings menu allowing precise tuning of the video output and colors.

Summary

While HD video is widely available today, emerging advancements in sensor technologies and displays bring continued improvements in resolution and highly immersive visuals. Ultra-high-definition (UHD) TV formats include 4K UHDTV, 2160p, 3840 x 2160, 8.3 MP approximately four times the resolution of 1080p and 8K UHDTV, 4320p, 7680 x 4320, and 33.2 MP providing 16 times 1080p and near equivalency to 15/70 IMAX film. As sensor technology and camera systems are becoming available for these formats, optics, displays, transmission, and storage options are limited and expensive. Digital cinema has been steadily migrating towards 4K for cameras and projection technology during the past several years, and 2013 will be a year filled with many consumer 4K display announcements. As the infrastructure, availability, and costs improve, these emerging formats will continue to stimulate our imaginations to again go where no video camera has gone before.