JVC DLA-RS35U

1080p D-ILA® Front Projector

Greg Rogers

JVC's Crown Jewel

The new DLA-RS35U D-ILA® video projector is the crown jewel of JVC's recently updated 1080p Reference Series of home theatre projectors. The DLA-RS35U ($9,995) utilizes selected optical components, and selected and matched D-ILA devices, to become the industry leader in native contrast ratio performance. The RS35 easily surpassed last year's RS20, to produce the highest native contrast ratio I have ever measured from a lamp-based projector.

The 1080p Reference Series also includes the new DLA-RS15U ($5,495) and DLA-RS25U ($7,995). They replace the previous-generation DLA-RS10U and DLA-RS20U, but have the same contrast ratio specifications of 32,000:1 and 50,000:1 respectively. The RS35 has the same feature set as the RS25, but its selected components raise its contrast ratio spec to 70,000:1, and its warranty has been increased to three years. All three of the new projectors now include inverse-telecine processing to re-create the original 24p frame rate from 480i or 1080i film-sources, and JVC's 120 Hz Clear Motion Drive video processing.

Display Technology

The RS35 incorporates 0.7-inch, 16:9 D-ILA™ (Direct-drive Image Light Amplifier) devices with enhanced wire-grid polarizers. D-ILA is a vertically aligned Liquid Crystal on Silicon (LCoS) technology. Each of the projector's three D-ILA devices have the same 1920 x 1080 pixel resolution as the 1080i and 1080p high-definition video formats.

The projector utilizes a 200-Watt UHP (ultra-high-pressure) mercury projection lamp. The light from the projection lamp is split into red, green, and blue beams that each reflects off one of the D-ILA panels. The brightness of each pixel is controlled by varying the polarization of the light as it passes through the liquid crystal layer of the panels. The reflected red, green, and blue light is directed through the lens to create a full-color image on the screen. The three-panel design eliminates the need for a color wheel and the potential rainbow color separation artifacts of single-chip DLP projectors.

The RS35 has a 17-element lens with ED (extra-low-dispersion) glass to reduce color fringing and improve image sharpness. It includes a 16-step adjustable Lens Aperture, so users can optimize contrast versus brightness for their particular screen size. It also has a fully adjustable six-axis Color Management System (CMS) that allows the projector's color gamut to be calibrated to industry standards.

Appearance

The RS35 case is virtually identical to last year's RS20. It has a glossy piano-black finish, except for the flat black front bezel and some gold trim. The zoom lens is offset toward the side of the bezel rather than centered. An automated lens cover protects the lens when the projector is not in use. Cool air enters an inlet on the front bezel and hot air is expelled through an exhaust vent on the side of the projector, to direct thermal air currents away from the lens. The video inputs are located on a recessed panel on the side of the projector, along with the power cord socket.

Set Up

The RS35 projection lens includes remote-controlled focus, zoom, and lens shift. The 2.0x zoom lens provides a throw distance between 9.88 and 20.11 feet for a 16:9 100-inch diagonal (87.2 x 49-inch) screen. Optimum focus is essential, and the user can turn off the built-in green-only crosshatch patterns and supply their own test patterns while focusing or adjusting the zoom and lens shift.

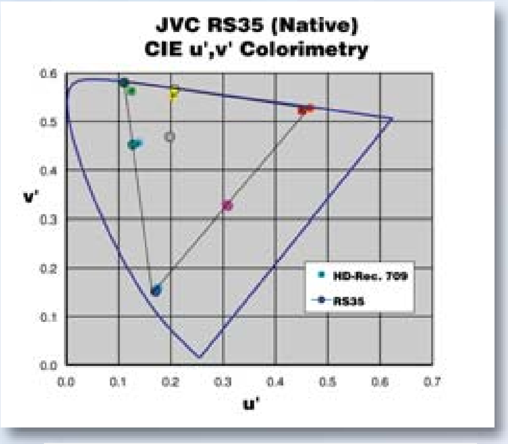
The motorized optical lens shift provides additional flexibility when mounting the projector. The center of the lens can be positioned up to 30 percent of the screen height above or below the screen, and 34 percent of the screen width to the right or left of screen center, although the maximum shifts can not be applied simultaneously. There is also electronic keystone adjustment, but avoid it and use the optical lens shift function and proper mounting instead. Like all electronic keystone adjustments, it will cause moiré patterns on closely spaced lines.

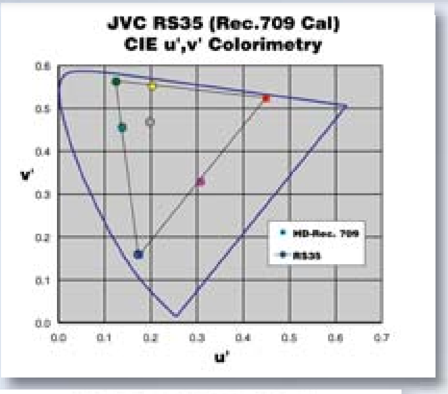
Connections

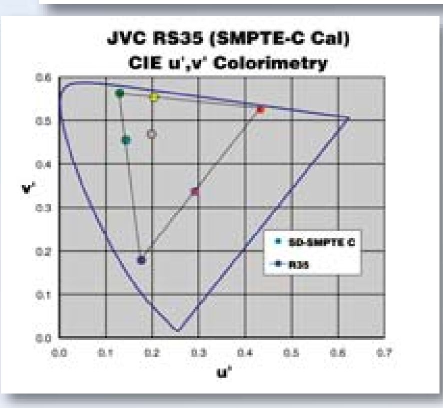
There are two HDMI inputs, a YPbPr/RGsB component input (three RCA connectors), an analog RGBHV input (15-pin VGA-style connector), an S-video input (4-pin mini-DIN), and a composite video input (RCA connector). There is one 12-volt trigger output to control a screen or anamorphic lens. An RS232 controller port is also included, and the RS232 commands are in the user manual.

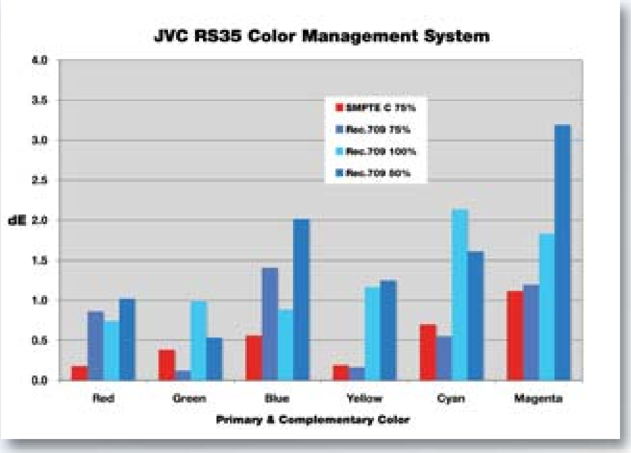
The YPbPr/RGsB analog input is compatible with 480i/p, 576i/p, 720p60/50, 1080i60/50, and 1080p60/50/24 video formats. (The 1080p analog formats are not listed in the specifications.) The analog RGBHV input is compatible with PC signals up to 1920 x 1080 (60 Hz). Black level setup (0 IRE or 7.5 IRE) can be selected for composite and

PERFORMANCE









S-video signals, but not analog component signals. There is no manual color decoder selection (ITU Rec. 601 or Rec. 709) for analog YPbPr signals, but the automatic selection worked correctly.

HDMI Compatibility

The two HDMI 1.3 inputs accept 480i/p, 576i/p, 720p60/50, 1080i60/50, and 1080p60/50/24 digital video signals, and up to 1920 x 1200 (60 Hz) digital PC signals. The HDMI inputs accept 4:2:2 YCbCr signals, and RGB or 4:4:4 YCbCr signals with up to 12-bit Deep Color. Those signal types can be automatically or manually selected in the on-screen menu. Manual selection of the signal type is important so a user can override automatic selection if there are problems with any particular type of source signal.

The correct color-decoding matrix (Rec. 709) was automatically selected for high-definition YCbCr signals, but was incorrectly selected for standard-definition YCbCr signals. Only RGB signals produced correct color with a 480i/p or 576i/p HDMI connection. JVC needs to correct that problem and should consider also adding manual selection of the Rec. 601 (SD) and Rec. 709 (HD) color-decoding matrices because there have been multiple upconverting DVD players that output YCbCr signals with the wrong color encoding.

Automatic or manual selection of Standard and Enhanced HDMI/DVI levels is provided. The Standard mode is intended for YCbCr and RGB-video input signals (black at digital code 16 and reference white at 235), and the Enhanced mode is intended for digital RGB-PC input signals (black at 0 and reference white at 255). However, the Standard mode clipped incoming digital signals below level 16 (black) and above level 235 (reference white). Although signal levels below black aren't intended to be seen, the headroom above reference white (digital level 235) is provided for video signal excursions that may occur in video sources during capture and processing. To prevent possible signal clipping, use the Enhanced mode and recalibrate the Brightness and Contrast controls for the proper black level and headroom above reference white.

Controls

A new 2-inch wide, silver remote control replaces the previous black version provided with the RS20. The new remote still has 33 illuminated buttons with easy-to-read nomenclature on their surfaces, but it has a better selection of functions. There are now six dedicated buttons for source selection rather than a single Input button. There are nine Picture mode buttons, including the THX® mode, which was missing on the RS20 remote control. There are also buttons to bring up the Picture Adjust controls, the Lens Aperture, Color Temperature, and Gamma modes. Finally, there are buttons to navigate the on-screen menus, cycle through Test Patterns, change aspect ratios, control the lens, and Hide (blank) the image.

The top of the projector includes buttons for menu navigation, input selection, hiding the image, and a Standby/On button. There are also three small, non-intrusive warning and status indicators.

On-Screen Menu

The on-screen menus have an icon/title bar that includes six submenus: Picture Adjust, Input Signal, Installation, Display Setup, Function, and Information. Items with variable levels can be adjusted within the submenus or they can be temporarily collapsed into a narrow control bar at the bottom of the screen so the menu doesn't block the image while it's being adjusted. The Test button provides "Before and After" comparisons while making Custom Gamma and Color Management System adjustments.

The Picture Adjust submenu includes Picture Mode, Contrast, Brightness, Color, Tint, Color Temperature, Gamma, Advanced

(Sharpness, NR, CTI, Color Management, Clear Motion Drive), Lens Aperture, and Reset.

The Sharpness function includes separate adjustments for edge sharpness and detail enhancement. The Noise Reduction function includes individual adjustments for random noise, mosquito noise, and block noise reduction. The CTI (color transient improvement) function (Off, Low, Middle, High) sharpens color edges. The NR and CTI functions are not available for HD or PC signals. I'll discuss the Gamma adjustments, the Color Management System, and the Clear Motion Drive function in separate sections.

The Input Signal submenu includes HDMI (Standard or Enhanced levels, Auto, YCbCr 4:4:4, YCbCr 4:2:2, or RGB Color Space, CEC Control), Component (YPbPr, RGB, SCART), Video/S-Video (0 IRE/7.5 IRE Setup Level, Color System), PC (Auto Alignment, Tracking, Phase, Picture Position), Picture Position (horizontal and vertical), Aspect (ratio), Computer (aspect ratio), V-Stretch (On, Off), Over Scan (On, Off), Mask (2.5%, 5%, Off), and Film Mode (Auto, Film, Off). The Video/S-Video color system selections include Auto, NTSC, NTSC4.43, PAL, PAL-M, PAL-N, and SECAM.

The Installation submenu includes Lens Control (Focus, Zoom, H/V Shift, Image Pattern Internal/External, Lock), Pixel Adjust, Style (Front/Rear Ceiling/Table mounting), Keystone (Horizontal/Vertical), and Screen Adjust (Off, A/B/C).

The Display Setup submenu includes Back Color (Blue, Black), Menu Position (5 positions), Menu Display (15 seconds, On), Line (Input Format) Display (5 seconds, Off), Source Display (On, Off), Logo (On, Off), and Language (12 choices).

The Function submenu includes Lamp Power (Normal, High), Trigger (Off, Power-on, V-Stretch), Test Pattern (6 patterns), Off Timer, and High Altitude Mode. The Information submenu displays the current input, input source signal format, PC resolution and H/V frequencies, Bit depth (including Deep Color), and total lamp hours used.

Picture Modes

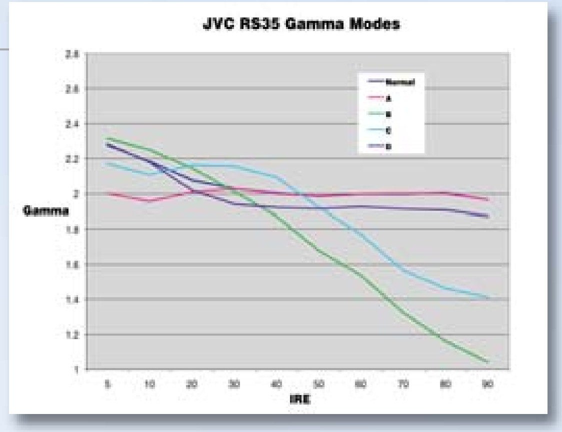
There are seven pre-defined Picture Modes (Cinema 1, Cinema 2, Cinema 3, Natural, Stage, Dynamic, and THX) and two user-defined Picture Modes (User 1-2). The user can modify the Contrast, Brightness, Color, Tint, Lens Aperture, and Advanced Settings (Sharpness, Noise Reduction, CTI, and Clear Motion Drive), and select the Color Temperature, Gamma, and Color Management modes. A Reset function is provided to return each individual Picture Mode to its default settings. The Advanced Settings (except for Clear Motion Drive), and the Color Temperature (6500K), Gamma (Normal), and Color Management modes are not selectable in the THX mode.

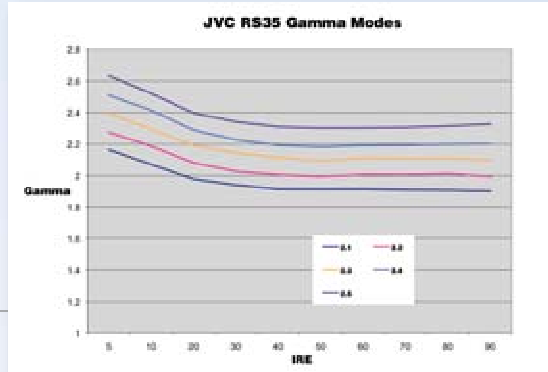
Aspect Ratios

There are three Aspect Ratio modes for video signals—16:9, 4:3, and Zoom. The 16:9 mode is used for high-definition sources and for 16:9 standard-definition DVDs. The 4:3 mode displays full frame 4:3 pictures in the center of a 16:9 screen with black sidebars. The Zoom mode displays 4:3 letterboxed frames by expanding the image proportionally in the vertical and horizontal directions to fill the width of the screen. The Zoom mode is not available for high-definition signals.

There are also three Aspect Ratio modes for PC signals—Auto, 1:1, and Full. The Auto mode expands the PC image both horizontally and vertically, maintaining the original PC aspect ratio, until the screen height is filled. The Full mode expands the PC image to fill the entire 1920 x 1080 pixel frame without maintaining the original aspect ratio. The 1:1 mode maps each incoming pixel directly to one pixel of the 1920 x 1080 frame, thus maintaining the original aspect ratio without scaling. Unfortunately, there's no 1:1 mode to display video input signal formats other than 1080i/p without scaling, which is a useful mode to examine input signals for edge ringing and other source artifacts.

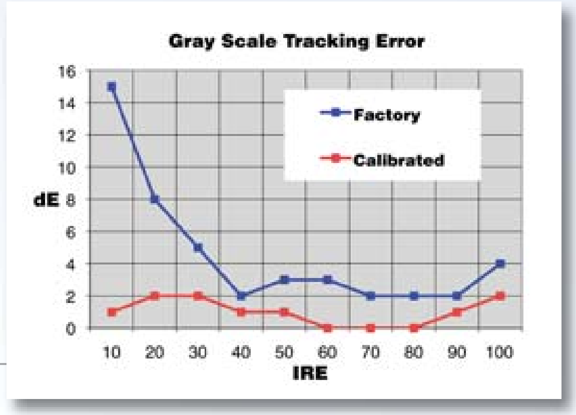
GAMMA MODES





GRAY SCALE

JVC RS35				
Gray Scale Tracking 1080p				
	HDMI Factory	HDMI Calibrated	HDMI Factory	HDMI Calibrated
IRE	°K	°K	dE	dE
10	5577	6563	15	1
20	6022	6372	8	2
30	6244	6399	5	2
40	6406	6454	2	1
50	6531	6555	3	1
60	6531	6508	3	0
70	6587	6508	2	0
80	6587	6508	2	0
90	6523	6447	2	1
100	6662	6579	4	2



The V-Stretch mode allows an external anamorphic lens to be used. It stretches 2.35:1 images to fill the 1920 x 1080 pixel frame vertically, which are then restored to the original aspect ratio when projected through an anamorphic lens.

Lamp

The projector utilizes a 200-watt UHP (Ultra High Pressure) projection lamp. The average lamp life is specified as 3,000 hours in the Normal lamp power mode. The lamp is user replaceable and priced at $399.

Gray Scale

An AccuPel HDG-4000 Video Calibration generator (www.accupel.com) was used to generate test patterns for measuring light output, contrast ratio, gray scale, and color accuracy. The factory Color Temperature modes (5800K, 6500K, 7500K, 9300K, and High Bright) measured 5849K, 6615K, 7565K, 9492K, and 9633K respectively at 70 IRE with the lens aperture fully open and Normal lamp power. With the lens aperture set to -15, the 6500K mode measured 6587K with dE = 2. The deviation from D65 (x = 0.3127, y = 0.329, dE = 0) was 2 dE or less from 40 to 90 IRE, increasing to 4 dE at 100 IRE, but reached 15 dE at 10 IRE. The latter is a larger out-of-the-box deviation than I've seen in previous RS series projectors.

A new feature in the RS35 allows the user to preset each of the Custom 1/2/3 color temperature modes to any of the factory settings (5800K, 6500K, etc.) and then adjust the gray scale based on those initial settings. There is a full set of RGB gain and offset (bias) adjustments to calibrate the gray scale tracking for each Custom mode. In addition, the Custom Gamma adjustments can also be used to further fine-tune the gray scale tracking if desired, by individually varying the RGB amplitudes at 12 levels over the gray scale range.

I adjusted the Custom 1 Color Temperature using the RGB Gain and Offset controls, but without using the Custom Gamma adjustments, to produce exactly D65 at 70 IRE with a maximum deviation of only 2 dE or less from 10 to 100 IRE. That calibration is shown in the accompanying Gray Scale Chart. I always adjust reference white (100 IRE) to 2 dE for making brightness and contrast measurements to ensure that all projectors are measured with comparable calibration. Introducing more deviation at 100 IRE would increase the contrast and brightness measurements, but would also begin to degrade color accuracy.

The calibrated gray scale performance was so good that I didn't take time to use the Custom Gamma adjustments to further optimize the gray scale. But I had previously used those additional adjustments in the RS20 to achieve a gray scale within 1 dE of D65 from 5 IRE to 100 IRE.

Another new feature of the RS35 is the Screen Adjust function, which shifts the color temperature slightly to compensate for differences in the spectral reflectivity of various screens. There are four modes, including Off (the normal mode). The A, B, and C modes shifted the color temperature toward red (6 dE), green (3 dE), and blue (4 dE) respectively. However, I would prefer to precisely recalibrate the gray scale for the particular screen being used.

Brightness And Contrast Ratio

I made light output and contrast measurements using an HDMI input with the gray scale calibrated to D65, as indicated above. The brightness and contrast ratio produced by a projector is a function of the f-number of the lens, which with the exception of ultra-expensive 'constant aperture' zoom lenses, varies as the throw ratio is changed. The brightness is maximized and the contrast ratio is minimized at the short-throw end of the zoom range, and conversely, brightness decreases and the contrast ratio increases at the long-throw end of the zoom range.

The RS35 also has a user-adjustable 16-step lens aperture. The aperture size can be increased to produce more light with a lower contrast ratio, or decreased to produce less light with a higher contrast ratio. The user can select the minimum aperture, and therefore, achieve the maximum contrast that provides the desired brightness for any combination of screen size and throw ratio. But unlike a dynamic iris, once the aperture is selected it remains fixed for all images, so there's no black-level breathing and no brightness compression artifacts.

All of the following light output and contrast measurements are for the High lamp power mode. The Normal lamp mode produced about 70 percent of the brightness (lumens) of the High lamp mode.

The RS35 measured approximately the same brightness as the RS20, but produced significantly higher full-field (on-off) contrast ratios. At the zoom lens minimum throw ratio the RS35 produced 872 lumens and a full-field contrast ratio of 28,900:1 using the maximum lens aperture (0). Reducing the lens aperture to minimum (-15) produced 507 lumens and a contrast ratio of 52,300:1.

At the zoom lens maximum throw ratio the RS35 produced 645 lumens and a contrast ratio of 42,600:1 with the maximum lens aperture. With the minimum lens aperture the projector produced 312 lumens and an unprecedented 60,600:1 contrast ratio.

For review purposes, I mount projectors about 12.75 feet from my 1.3 gain, 87-inch wide, 16:9 Stewart Filmscreen StudioTek G3 screen. That produced 438 lumens using the minimum lens aperture, which is equivalent to 19.2 footLamberts (fL) from the screen. The contrast ratio was still an extraordinary 56,100:1.

The RS35 has by far the best native contrast performance I've measured from a lamp-based projector, and yet it still produces excellent brightness for moderately large home theatre screens. The minimum aperture contrast ratios averaged about 40 percent higher than the RS20, which is a significant achievement.

Another important performance parameter is intra-image contrast, which describes the ability to differentiate contrast differences when there are bright areas near darker areas in the same image. The intra-image contrast ratio is much lower than the full-field contrast ratio because light from bright areas will be scattered over the image obscuring darker areas. The light scattering occurs within the lens and the optical system of the projector, but it may also occur within your theatre as light reflects around the room and back onto the screen.

My modified "ANSI" contrast ratio is a figure-of-merit to characterize intra-image contrast performance. It is designed to minimize the influence of room reflections and other variables that would affect measurement accuracy. The modified "ANSI" (m-ANSI) contrast ratio measured 315:1. That is good performance, but nearly the same as the RS20, and considerably less than the best 1080p DLP projectors.

Gamma

The RS35 has a large set of highly flexible gamma features. It has five preset gamma modes (Normal, A, B, C, D) and three user-adjustable Custom gamma modes. The Custom modes provide preset gamma values from 1.8 to 2.6 in 0.1 increments. Those gamma values can be used without modification, or custom gamma curves can be created starting with one of those as a reference curve. The Custom Gamma Adjust function provides an on-screen graph to modify the reference gamma curve at 12 points from 5 percent to 95 percent signal levels (5 percent, 10 percent, and 15 percent at the dark end of the gamma curve). The R, G, B signal components can be adjusted individually or simultaneously. The former can be used to optimize the gray scale tracking, and the latter used to create an overall custom gamma curve for the projector. Copy and Paste functions make it easy to produce multiple Custom gamma curve variations, which can be compared by switching between the three Custom modes.

The accompanying charts show the measured results for the predefined gamma curves and the 2.1-2.5 Custom gamma modes. The extraordinary full-field contrast ratio of the RS35 allows one of the higher gamma values to be used without obscuring near-black shadow detail.

I calibrated Custom gamma curves that remained level at 2.3 and 2.4. They produced images that are more CRT-like than projectors with a 2.2 or lower gamma. The higher gamma values substantially increase the perception of image depth, which is why CRT projectors produce excellent depth despite their very low ANSI contrast ratios.

Color Management System

Color accuracy requires an accurate D65 gray scale, and primary colors that match the SMPTE-C standard for standard-definition video, and the ITU Rec. 709 standard for high-definition video. The RS35 native primaries, particularly green, are much more saturated than the primary colors specified by the Rec. 709 standard, or the even narrower SMPTE-C color gamut. But the RS35 includes an excellent Color Management System (CMS) that can be calibrated to match the standard color gamuts.

The 6-axis (RGBYCM) Color Management System allows the hue, saturation, and luminance (Y) of each native primary (red, green, and blue) and complementary (yellow, cyan, and magenta) color to be individually adjusted to create a pseudo color gamut within the boundaries of the projector's native color gamut. Because the RS35 native color gamut entirely encloses the SMPTE-C and Rec. 709 gamuts, the CMS can be calibrated to accurately produce color corresponding to those standards.

Some 6-axis CMS implementations are incomplete and only provide hue and saturation adjustments. That may allow the primary and complementary colors to be at the correct locations on a CIE x,y diagram, but not allow the luminance (Y) of those colors to be individually adjusted, which is also critical to achieving color accuracy in accordance with the standards. The errors from having the wrong RGBYCM luminance values can be more visually significant than having the wrong CIE x,y values. The RS35 CMS implementation is complete with the necessary luminance (Y) adjustments for each individual RGBYCM color. (Technical note: It is possible for a 6-axis CMS system to automatically calculate and adjust the luminance of the colors, but most do not. Alternatively, a 3-axis RGB CMS system normally does not require luminance adjustments separate from RGB gray scale adjustments.)

Specifying Color Accuracy

As I explained earlier, it is not sufficient to plot the color gamut on a CIE diagram when using pseudo primaries. The correct luminance relationships that are inherent when adjusting the color temperature (and gray scale) using native primaries are no longer inherent when creating pseudo primary and complementary colors with a 6-axis CMS. Errors in the standard luminance relationships between those colors contribute significant errors to the measured and perceived color accuracy.

Although we can measure the CIE x,y (or CIE u'v') and luminance (Y) deviations for each color, the individual values do not convey the perceived magnitude of the color accuracy errors in a meaningful way. Instead, we must calculate the dE (delta E) deviation of each color from its corresponding standard reference color. In this application the dE value incorporates both the error in the CIE u'v' location and the error in the luminance of the color. We can't use CIE x,y values directly to calculate dE because the CIE x,y color space is not perceptually uniform. The CIE defined the more perceptually uniform CIELUV color space in 1976, and I use dE values based on that color space. A dE deviation of one (1) is considered the just noticeable difference (JND) between two colors in a test pattern under optimum comparison conditions, but in practice dE values of three (3) or less in the 1976 CIELUV system are usually insignificant in real video imagery (however, smaller dE values may be significant in other color space systems). Note: Although dE values are given below with one decimal place of precision there is little practical distinction between fractional differences in the 1976 CIELUV dE values.

SPECS

3-chip D-ILA® (0.7-inch diagonal)
Resolution –1920 x 1080 pixels
Projection Lens – 2x zoom lens (1.4:1 – 2.8:1) V̂ with motorized focus/zoom
Lens shift – (V) ±80%, (H) ±34% motorized
Screen Size (16:9) – 60" to 200" diagonal
Lamp – 200 W UHP Average Lifespan: 3000 hours (normal mode)
Brightness – 900 Lumens
Contrast Ratio – Native: 70,000:1

Video Inputs – Composite (1), S-Video (Mini DIN) (1), Component (1), HDMI 1.3 (2), PC 15-pin D-sub (1)

Input Signals
Analog: 480i/p, 576i/p, 720p60/50, 1080i60/50
Digital: 480i/p, 576i/p, 720p60/50, 1080i60/50, 1080p 60/50/24, PC signals to 1920 x 1200 @ 59.94 Hz
PC Input (Analog/Digital) – VGA/SVGA/XGA/WXGA/WXGA+/SXGA/WSXGA+/WUXGA (digital only)

Serial Control – RS232C x 1 (D-sub 9-pin)
Trigger Output – 12V
Noise Level – 19 dB (Normal mode)
Power Requirement – 110 V – 240 V AC, 50/60 Hz
Power Consumption – 310W (Standby mode: 0.7W)
Certifications – ISF and THX

Specifications
Dimensions (WxDxH) – 14.37 x 6.58 x 18.82 (in inches)
Weight – 24.69 lbs
Price: $9,995

Manufactured In Japan By:
JVC Professional Products Company
1700 Valley Road
Wayne, NJ 07470
Phone: 973-317-5000
http://pro.jvc.com

(No color space is perfectly perceptually uniform, so the CIE has developed a number of color space models since 1976 that each produce somewhat different dE values. The various models have advantages and disadvantages in different applications, but many video engineers, including myself, still prefer the 1976 CIELUV system for video displays.)

For video enthusiasts that perform their own display calibration, I designed a Display Calibration Calculator to compute dE values for adjusting Color Decoders and Color Management Systems for standard and custom color gamuts, and to compute dE and gamma values for adjusting Gray Scale Tracking. PC and Mac versions of the Display Calibration Calculator are free to download from the AccuPel website (www.accupel.com).

Color Accuracy

The native color gamut of the RS35 is shown in the accompanying CIE u',v' diagram compared to the Rec. 709 (HD) colorimetry standard. The YCbCr to RGB color decoding matrix for high-definition digital signals is accurate and produced virtually an identical CIE diagram (not shown). But as noted earlier, the wrong color matrix is used to decode standard-definition YCbCr signals, so for 480i/p use digital RGB signals.

Each native primary is oversaturated compared to the Rec. 709 standard, but the primaries are well balanced, to produce complementary colors with nearly perfect hues. (Hue is the angle, and saturation is the distance from the white reference in a CIE diagram.) The primary colors are even more oversaturated compared to the SMPTE-C standard because the specified standard-definition color gamut is smaller.

Oversaturated primaries affect each film differently, depending on the specific color content of the images. Although some people prefer oversaturated colors, which produce a richer, more vivid color palette, other people, including myself, find that those exaggerated colors often produce unnatural skin tones, unrealistically green vegetation, and occasionally excessively exuberant reds. The built-in Color Management System is intended for people like us.

The THX mode is intended to comply with the Rec. 709 high-definition color gamut. The primaries were slightly undersaturated, but were dramatically better visually than the native primaries. However, I preferred to optimize the Rec. 709 color accuracy by manually calibrating the Color Management System.

I used 75 percent color window patterns from an AccuPel HDG-4000 to calibrate the Custom 1 mode of the CMS to the high-definition Rec. 709 color gamut. I obtained a maximum dE deviation of just 1.4, which is nearly visually perfect. However, it is also critically important that the CMS exhibit good linearity and maintain excellent color consistency, regardless of input signal amplitude. Therefore, after calibrating the CMS with 75 percent color windows, I also measured the color accuracy using 50 percent and 100 percent color windows from the AccuPel generator. The results are shown in the accompanying chart. The maximum dE deviation with 100 percent color windows was 2.1, and the maximum dE with 50 percent color windows was 3.2. This is excellent performance with negligible perceptible color errors in actual video images.

Next, I calibrated the CMS Custom 2 mode to obtain just a 1.1 dE maximum deviation from the standard-definition SMPTE-C primary and complementary colors. Once again, this is nearly perfect compliance with the color standard. The SMPTE-C color gamut is extremely important not only for standard-definitions sources such as DVDs, but also because until recently most films have been transferred to high-definition video using professional CRT monitors that still have SMPTE-C primaries. In that case the SMPTE-C color gamut should be used to display the same high-definition image colors that the telecine colorist saw. However, with the introduction of professional LCD monitors and color-management systems, more and more high-definition content is being produced using the Rec. 709 color gamut. Hence, optimum home theatre color accuracy requires a CMS that can be switched as needed between the Rec. 709 and SMPTE-C color gamuts.

White Field Uniformity

Brightness uniformity on a 75 percent white field test pattern with the minimum lens aperture varied by 8 percent or less at the sides and 10 percent or less at the top and bottom of the screen. Color uniformity varied by only 1 dE at the top and bottom of the screen, and 3 dE at the sides of the screen. The color variations were smoothly distributed across the screen and unnoticeable in films.

"Black field" color and brightness uniformity were exceptional and a total non-issue while viewing films. There were no visible bright corners or other noticeable non-uniformities, even when I allowed my eyes plenty of time to adapt to a black field test pattern. There was negligible light spill outside the screen.

Lens Quality And Convergence

All three-panel projectors are susceptible to convergence errors from panel misalignment. The RS35 menu includes a Pixel Adjust function to horizontally and vertically align its red, green, and blue images, but the adjustments are limited to full-pixel increments. Panel mounting tolerances in multiple axes can result in sub-pixel misalignment that isn't uniform across the screen, so some residual misconvergence may remain. Misconvergence produces color fringing on bright edges, and may reduce sharpness and resolution. Fortunately, the convergence was superb on my RS35. I would estimate there was less than a quarter pixel of misconvergence over the entire screen.

Sharpness, resolution, and color fringing (from chromatic aberration) are also a function of lens quality. The RS35 lens had excellent color correction—the red, green, and blue focus tracked together exceptionally well. As a result, there was virtually no chromatic aberration. There was also negligible astigmatism or curvature of field from a 1.75:1 throw ratio.

Overall, images are not quite as sharp as the best single-chip 1080p DLP projectors, which don't have to contend with three-panel convergence. But I was quite satisfied with the sharpness, which exceeds any CRT projector, and film images never look artificially edgy. The lens had better chromatic aberration than I've seen on some much more expensive DLP projectors, and color fringing was never visible at any reasonable viewing distance, even on test patterns.

1080i/p Pixel Perfection

The RS35 produced spatially "pixel perfect" images from 1080p60, 1080p50, and 1080p24 HDMI signals. No pixels were blanked, and each incoming pixel was precisely mapped to a single projector pixel without scaling. The projector's Reon-VX video processor also deinterlaced static 1080i test patterns to "pixel perfect" 1080p images.

Scaling And Overscan

The RS35's scaling produced only 1 to 2 (1080p) pixels of extremely faint outlining around 720p horizontal and vertical lines. The 480i/p scaling produced about 2 to 4 pixels of very faint outlining.

There was zero overscan on all formats with digital signals. There was also zero overscan on analog signals, except for about 0.5 percent overscan on the sides of 480i signals, and 1 percent on the sides of 576i signals.

> **"The RS35 has by far the best native contrast** performance I've measured from a lamp-based projector..."

The Overscan function, which is only available for standard-definition signals, produced about 2.5 percent overscan on each edge of the image. The Masking control (0, 2.5, 5 percent), which is only available for high-definition signals, provided 0, 1.25, or 2.5 percent blanking at each edge of the frame. The masking is electronic blanking rather than scaling, so "pixel perfect" mapping without scaling artifacts is still maintained for 1080i and 1080p formats, but the visible area of the active video is reduced. The zoom lens can be used to restore the size of the image to fill the screen if masking is used. The Sharpness control adds horizontal and vertical edge enhancement, while the Detail Enhancement control improved fine detail without significantly affecting edge outlining. There is also a CTI (Color Transient Improvement) function for standard-definition signals that increased the edge sharpness and visibility (brightness) of fine color detail without affecting monochrome imagery.

Deinterlacing

The RS35 uses Integrated Device Technology's HQV Reon-VX Image Processor developed by Silicon Optix for deinterlacing, scaling, and video processing. The Reon-VX features 10-bit 4:4:4 video processing. It includes film-mode (inverse-telecine) and per-pixel motion-adaptive deinterlacing for standard-definition and high-definition video.

Motion-adaptive deinterlacing for 480i video sources has become essentially irrelevant since most of the video broadcasting that we are likely to watch in a home theatre is now high-definition. However, 1080i motion-adaptive deinterlacing is important for high-definition broadcast video. It produced a somewhat softer image than a Gennum-based external processor when viewing *The Tonight Show With Conan O'Brien* or the CBS *Late Show With David Letterman*. While the Reon-VX was extremely effective at eliminating jaggies and line twitter, it also produced slightly more resolution pumping. Resolution pumping (breathing) is an artifact of motion-adaptive deinterlacing that occurs if the image resolution and sharpness suddenly decrease with movement. Nevertheless, I found the 1080i motion-adaptive deinterlacing very pleasing with broadcast sports, including basketball, which can be very challenging to display without deinterlacing artifacts.

Inverse-telecine (film-mode) deinterlacing for 480i movies is still useful because many films are not yet available in high-definition and won't be for years to come. Inverse-telecine deinterlacing is an ideal process that can convert interlaced video transferred from film to progressive video without artifacts or loss of resolution if the processor can stay locked onto the video's 3-2 field pulldown cadence. However, some recent deinterlacing processors that are also designed to deinterlace less common cadence sequences, such as those sometimes used for animation or anime, do less well on some film-to-video transfers.

The Reon 480i film-mode deinterlacing worked well on some DVD movies, but not as well on others. The scrolling yellow text at the beginning of *Star Wars: Episode IV — A New Hope* exhibited more line twitter than it does using a DVDO iScan™ video processor, or the deinterlacing in my Blu-ray Disc™ player. There were also various instances of line twitter on moving space vehicles that weren't present with other processors. However, you can easily avoid those potential issues by using the 1080p output from an upconverting DVD player or Blu-ray Disc player for your DVD movies. An even better option is to use an external video processor, such as a DVDO iScan, to produce 1080p24 signals and avoid 3-2 frame repetition judder, as discussed in the next section.

24 Hz Display

Judder (irregular stuttering motion) is created when 3-2 pulldown is used to convert 24-frame-per-second film to 60-field-per-second interlaced video, or 3-2 frame repetition is used to create 60-frame-per-second progressive video from film sources. Many people have become conditioned to ignore the stuttering motion after years of watching movies on broadcast television. However, other people are greatly disturbed by this temporal artifact, and even those accustomed to the judder of broadcast movies are usually quick to appreciate the smoother motion provided by displaying film sources at an integer multiple of the original 24-frame-per-second film rate.

Fortunately, movies are stored on Blu-ray™ (and HD-DVD) discs with their original 24-frame-per-second film rate, and all current players output 1080p24 native video. Some standalone video processors can also deinterlace and upconvert DVD movies to produce 1080p24 signals without 3-2 frame repetition judder. The RS35 accepts 1080p24 signals through its HDMI inputs and displays them at an integer multiple of the 24 Hz frame rate. I believe this is so important to reproducing the look of film that I wouldn't consider purchasing a projector or a video processor without those abilities.

A new feature has been added to the RS35 that allows it to perform inverse-telecine deinterlacing on 480i and 1080i signals from film sources and then display them at an integer multiple of the 24 Hz film frame rate, rather than displaying them at 60 frames per second using 3-2 frame repetition. The Film Mode must be set to Film (not Auto) to take advantage of this capability. This built-in feature is particularly valuable for viewing high-definition movies from satellite or cable.

Motion Effects

There are infrequent occurrences of contouring around bright lights in motion, which was present on previous RS-series projectors. Examples of motion-induced contouring (MIC) can be seen on the stadium lights at the beginning of Chapter 3 of *Cars* (2006) (Blu-ray Disc), and around the wall lamps starting at 1:44:03 of *Basic Instinct* (1992) (Blu-ray Disc).

Previous RS-series projectors also produced faint red and cyan color tinting on closely spaced black and white lines in motion test patterns (e.g. moving resolution wedges and zone plates). That artifact seldom occurred while viewing movies, but sometimes appeared in the striped shirts of officials during sporting events. Those effects were negligible on the RS35.

Eye-Tracking Motion Blur

Clear Motion Drive is JVC's video processing technology to reduce eye-tracking motion blur. It has been introduced into the RS-series for the first time in the RS35, RS25, and RS15. But before I discuss the feature, some background is necessary.

Eye-tracking motion blur is a well-known visual effect that occurs when watching film or video, but it has recently been the subject of increased discussion and controversy. Our eyes naturally follow the motion of objects as they move across the screen. Eye tracking is very important because it allows us to see detail in a slowly moving object because its image remains in a fixed position on the retina even though it is moving. Conversely, if the eye were fixed on a single-screen position, the edges of the object and any detail within it would smear a path across the retina producing a blurred image as the object moves.

However, objects in motion don't move continuously across the screen because film and video is created and displayed in frames. A moving object actually remains in the same position for an entire frame interval before moving to another position in the next frame. But eye tracking smoothly follows the path of a moving object, even though it's actually displayed in a series of fixed positions. LCoS, LCD, and DLP projectors, unlike CRT projectors, display each frame for nearly an entire frame interval. (There are relevant technical differences, but they are beyond the level of this introductory discussion.) Consequently, the image of a rapidly moving object is smeared across the retina because the projector is emitting light as the eye tracks the path of the motion while the object remains fixed during each frame.

It's important to realize that motion blur is inherent in film content and is also introduced when film is projected at a cinema. Slow shutter speeds are used in motion picture film cameras to reduce strobing artifacts, at the expense of creating additional motion blur in the film content. Then in the cinema each film frame is projected for approximately half the frame interval, which introduces the same type of eye-tracking motion blur discussed above for video projectors. So why is there currently

> **"I was quite satisfied with the sharpness, which exceeds any CRT projector, and film images never look artificially edgy."**

so much attention to eye-tracking motion blur in video projectors?

I think there are a variety of reasons. One reason is because CRT projectors have been considered the holy grail of video projection, and they are virtually immune to this type of blur. CRT projectors scan images onto the screen so each pixel is only "on" for a very short portion of the frame interval. CRT projectors actually display less blur than we see at the cinema. However, CRT projectors suffer from strobing, so we don't want to duplicate all CRT projector characteristics. Another reason that motion blur is getting so much attention is that original broadcast video content has less blur than film. Video field and frame rates are faster, and camera shutter speeds are usually faster, so there is much less blur in the video content. Plus until recently we have been accustomed to watching broadcast video on CRT monitors. So it makes sense to find a way to reduce eye-tracking motion blur for broadcast video, even if that may be questionable for movies.

I can think of a number of other reasons, but I'll spare you that list and jump to probably the most important reason of all. The technology now exists to do something about it. So with that, I have come full circle to JVC's Clear Motion Drive.

Clear Motion Drive

JVC's Clear Motion Drive (CMD) is a frame interpolation technology that synthesizes a new frame that is inserted between each existing frame. Each interpolated frame tries to depict the intermediate positions of moving objects at a time halfway between existing frames. Therefore, eye-tracking motion blur will be significantly reduced if additional images with correct motion positions are presented to the retina at twice the frame rate. (Dark frame insertion is another technique that can be used to reduce eye-tracking motion blur, and more closely duplicates the duty cycle of a film projector. However, dark frame insertion dramatically reduces video projector brightness and is not used in the RS35.)

Temporal frame interpolation is one of the classic video problems without a perfect practical solution. In fact, it is one of the more difficult challenges of video technology. But like many difficult video challenges, high-density, high-speed integrated circuit technology has made it possible to approximate theoretical solutions.

When the RS35 receives 60 Hz non-film-sourced video (typically 480i, 720p, or 1080i), the video is scaled or deinterlaced to 1080p60. Then the CMD frame interpolation and insertion can be applied, which converts the 1080p 60 Hz frame rate to 120 Hz.

The situation with film-sourced video is more complex. The CMD function will not be effective if the projector receives 480p (60 Hz frame rate) or 1080p60 video for a movie because the 24 Hz film frame rate has already been converted to 60 Hz using 3-2 frame repetition. Inserting new interpolated frames will not create uniform motion between frames, and therefore, has little ability to improve motion blur.

For the CMD to be effective, the film-source video must be 24 Hz, which matches the original film frame rate. Either the projector must receive 1080p24 video from an external source, or the projector can use its new inverse-telecine function to create 24 Hz from 480i or 1080i film-sources. As mentioned previously, the RS35 Film Mode must be set to Film and not Auto for that to happen, otherwise it will create 60 Hz video with 3-2 frame repetition. Once the projector has 24 Hz video, the CMD function interpolates a new frame between each of the original film frames to double the frame rate to 48 Hz. (The projector then repeats each of those frames twice and display a 96 Hz frame rate, but that is mostly superfluous to eliminating eye-tracking motion blur.)

Clear Motion Drive Results

Based on my previous experiences with other frame interpolation technologies, I didn't have high expectations for the Clear Motion Drive function. Moving resolution wedges and zone plate test patterns immediately revealed severe random pixelization, blurred resolution, and some color tinting, when CMD was enabled, although the artifacts were much less severe on 60 Hz video test patterns than 24 Hz film-based test patterns. However, as intended, moving text was definitely clearer to read with both types of source material. Although I didn't have time to watch a lot of broadcast sports, I was surprised that basketball and football showed subtle improvements in reduced blur, with few disturbing artifacts.

Film sources, however, were another matter. The most positive effect of CMD on movies is the improved readability of moving text, or text that was being panned by the camera. A superb example can be found on the Blu-ray Disc of *Layer Cake* (2004). There is a long horizontal camera pan across a shelf of distinctively labeled products near the beginning of the movie (1:35). The camera starts and stops as it pans, and each time it is in motion the labels are blurred and hard to read. But with the CMD turned on the labels are much clearer and easy to read. However, in the next scene Daniel Craig walks along a fence that breaks into severe pixelization as the camera pans across the balusters at an angle, which generates a variety of shifting spatial frequencies. Changing the CMD from High to Low had little effect on the severity of the artifacts. Other scenes and other films revealed edge ghosting along with pixelization breakup.

Even if those obvious artifacts were completely eliminated, I still wouldn't have liked Clear Motion Drive on movies. I want film to look like film, and it doesn't with frame interpolation. Motion looks like it occurs in a viscous fluid, even on the Low setting. It's the opposite effect of 3-2 pulldown, which makes film motion irregular. The CMD makes the 24 Hz film motion look and feel like video motion. It's instantly recognizable that it's no longer film.

I watched *Body Heat* (1981) on a Blu-ray Disc, which is one of my favorite modern noir films. Each time I watch *Body Heat* I recall the first time I saw it on a cold, blustery wet night at the cinema. Despite the miserable conditions outside, I vividly remember feeling totally immersed into the sweltering, humid environment of the film, and I have the same reaction each time I see it again. Such is the power of film, and so it was with the RS35 until I turned on the CMD. Then the illusion was lost, and I suddenly felt like I had accidentally channel surfed into an afternoon TV soap opera instead of a steamy, classic film.

Viewing Impressions

I've been using a JVC DLA-RS20 as my reference projector since I reviewed it for Issue 141 of *Widescreen Review*. There are many important characteristics I look for in a projector, but I believe color accuracy and image contrast are key differentiating factors that distinguish a large screen reference display. The RS35 surpasses the RS20 in contrast performance and image depth, and equals it in all other respects.

All of my DVD and high-definition movie viewing utilized the 24p display capabilities of the RS35 (and RS20) to eliminate 3-2 frame repetition judder. That is a critical factor in duplicating the experience of watching film at a cinema.

The Color Management System (CMS) of the RS35 (and the RS20) provides the ability to match the SMPTE C (standard-definition) and Rec. 709 (high-definition) standards with virtually perfect colorimetric accuracy. Although consumers are ultimately at the mercy of telecine colorists to get the color right when films are transferred to video, the vast majority of color problems that I have witnessed are the result of projectors that lack a complete CMS, or have an incorrectly calibrated CMS.

One DVD that seems to most perplex projectors is *The Thomas Crown Affair* (1999), which is a vividly saturated film that produces unnaturally deep or reddish skin tones on displays with an over-extended color gamut. Even when some films are marginally tolerable on those projectors, Pierce Brosnan's skin tones are unacceptable in this movie. But his Caribbean tan looks completely natural when viewed with SMPTE-C colorimetry. (For some reason I'm much more willing to tolerate inaccuracies in Rene Russo's skin tones, which are abundantly displayed throughout the film.) I'm happy to report that Pierce (and Rene) looked perfect on the SMPTE-C calibrated RS35.

prisingly *The Game* (1997). The most revealing scene in Grand Prix takes place when James Garner's BRM is recovered from the water at night. This new projector was even more amazing than its predecessor in its ability to render both the darkest areas of those images and their brighter highlights with crystalline clarity. Their high contrast made it easy to discern the deep British racing green color of the car in the near darkness, and there wasn't a hint of haze or veiling from either projector. However, the faint reflections in the water were more prominently visible with the RS35, which increased the perceived image depth in that scene.

The Game is an extraordinarily dark film that is often punctuated with bright highlights. The elevator scene was incredibly impressive

"The JVC DLA-RS35U video projector produced the most outstanding film images I've experienced in a home theatre."

I used either my SMPTE-C or Rec. 709 CMS color gamuts on high-definition movies for the reasons I discussed in the color management section. For instance, the distinctive mid-60's color palette of *Grand Prix* (1966) was accurately reproduced using the SMPTE-C gamut, as were the fleshtones. Conversely, I chose the Rec. 709 CMS gamut for *Notting Hill* (1999), which is a much warmer film, filled with brilliant hues.

The key characteristic in which the RS35 excels beyond the already exceptional performance of the RS20 is image contrast. The modified-ANSI (m-ANSI) contrast, which primarily affects intra-image contrast in brighter images, is essentially the same. But the RS35 has about 40 percent more full-field contrast than the RS20, which translates into greater contrast in darker images. Their exceptional contrast ratios also permit higher gammas to be used without obscuring shadow detail, which greatly enhances perceived image depth.

One thing I instantly noticed was how really dark the fade-to-black and black frames are while watching movies. There normally isn't time for the eye to fully adjust to that level of darkness, and the screen momentarily appears truly black.

Image depth is dependant on a complex interaction between resolution, sharpness, and intra-image contrast. The latter is a function of the full-field contrast ratio, the m-ANSI contrast ratio, and gamma. Depending on specific scene content, image depth may be influenced more by the visibility of fine detail or by the delineation of brightness differences (intra-image contrast). While the best DLP projectors have a slight advantage in sharpness and a higher m-ANSI contrast ratio, the far superior full-field contrast ratio of the RS35 and its subsequently higher useable gamma results in better image depth in most scenes.

My favorite DVD for assessing contrast and image depth is *Star Wars: Episode IV — A New Hope* (1977). It's a superb standard-definition transfer, but the RS35 contrast improvements only made an incremental difference over the RS20. The clarity and shadow detail surrounding the droids imprisoned in the dark interior of the Jawa Sandcrawler was slightly increased, but there was no visible haze from either projector. The twilight scenes amongst the craggy cliffs of Tatooine revealed extraordinary depth and detail within the rocky textures, but there wasn't a compelling difference in image depth between the projectors.

The desert scene where Arnold materializes from the future in *Terminator 3: Rise Of The Machines* (2003) is extremely revealing. A projector must have an exceptional full-field contrast ratio or the images appear veiled or hazy, and if the gamma is too low the desert images look extremely artificial. The RS35 excels in those requirements and looked absolutely stunning on that difficult scene.

The films that most demonstrated the benefit of the RS35's higher contrast were somewhat surprisingly *Grand Prix*, and not at all surprisingly *The Game*...

on the RS20, but the RS35's even higher full-field contrast ratio revealed dim details in the darkness more distinctly before and after the intense flashes of bright light in that scene. This fascinating mystery is a marvel of high-contrast cinematography, which can look awful on a lesser projector, but looked superb on the RS35.

I also examined film images and test patterns for noise and other artifacts related to digital video processing. The AccuPel 1 to 10 percent gray scale pattern demonstrated excellent near-black linearity and was completely free of visible noise. There was no fixed-pattern noise or banding at any brightness level. Film grain appeared natural, and compression artifacts weren't exacerbated by the CMS or other digital processing. Of course, the three-panel D-ILA system is completely free of sequential color artifacts (rainbows), which can still be a problem with some single-chip DLP projectors.

Summary

The JVC DLA-RS35U video projector produced the most outstanding film images I've experienced in a home theatre. Its native full-field contrast ratio is an amazing technical achievement—surpassing its predecessor as the new leader in the industry. It produces superlative black levels and unprecedented contrast in dark scenes, which allows a CRT-like gamma to be used to render exceptional image depth in brighter scenes. The fully adjustable 6-axis color-management system (CMS) permits the color gamut to be precisely calibrated to both standard-definition and high-definition colorimetry standards. The CMS and built-in gamma creation functions, combined with unrivaled native contrast performance, make the DLA-RS35U my preferred reference projector. **WSR**