Martin by Harman MAC Ultra Performance

By: Mike Wood

Figure 1: Fixture as tested.

It was only about a year ago that we looked at the Martin by Harman MAC ERA 800 Performance. At the time, I bemoaned that LED units were getting bigger and heavier—so much so that I could no longer get them out of the road case unassisted. (It couldn't possibly be me that's getting older and weaker!) Well, here we are again, Martin has upped its game with the MAC Ultra Performance. It offers 1,150W of white LEDs in a 97lb body.

In many ways, the Mac Ultra Performance is a natural evolution, a feature set that has become standard across the industry but with ever-increasing lumens. What makes it interesting is the way that certain features differ from previous units, and the way Martin has engineered those systems. I'll mention them as we go through the unit. The review follows my usual format, working through the Mac Ultra Performance, from power in to light out, testing and measuring as I go.

The results presented here are based on the testing, with the fixture operating on a nominal 240V 60Hz supply of a single Mac Ultra Performance unit supplied to me by Harman Professional (Figure 1). Note: Testing 240V-only fixtures got a lot easier for me. I drive an electric car and the 50A, 240V charging point is perfect for two-phase lighting fixtures! I'm not sure Elon Musk considered that when designing the cars, but it's been very helpful.

Light source

The Martin-designed LED light engine breaks away from the ubiquitous Appotronics units. It uses a similar technique, with an array of eighty-four 20W white LEDs behind a set of fly-eye lenses but differs in the detailed optical construction. In particular, a final condenser lens at the output of the light engine is split into two elements placed either side of the CMY CTO dichroic mixing flags to help with color homogenization.

Figure 2 shows the rear of the unit with the large central heat sink (behind the aluminum shield) surrounded by six of 12 total cooling fans. Figure 3 shows the LED driver board surrounding the exit aperture. Visible are the output lens and the fly-eye lenses behind. One nice point for service technicians is that Martin has labeled the screws with text showing what they go into. It's extremely helpful when puzzling over which screw does what.

Every luminaire design starts with the light source, the

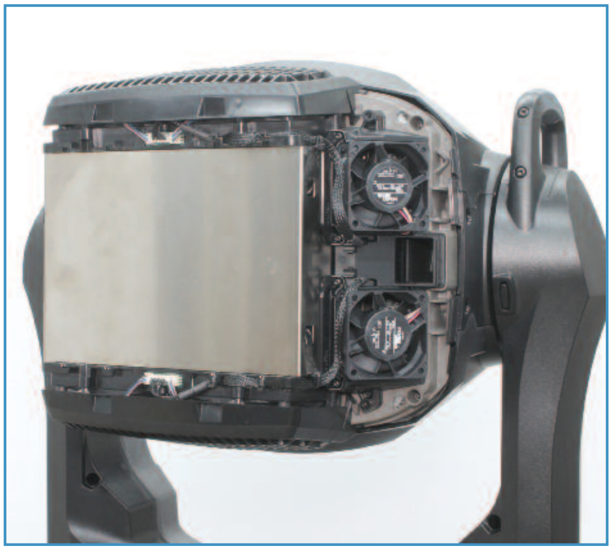

Figure 2: Head cooling.

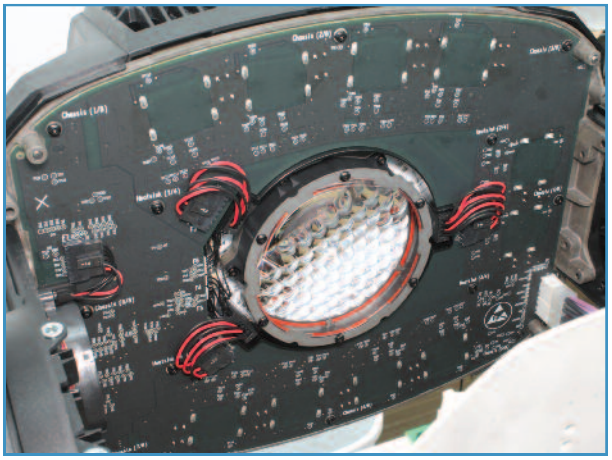

Figure 3: LED engine.

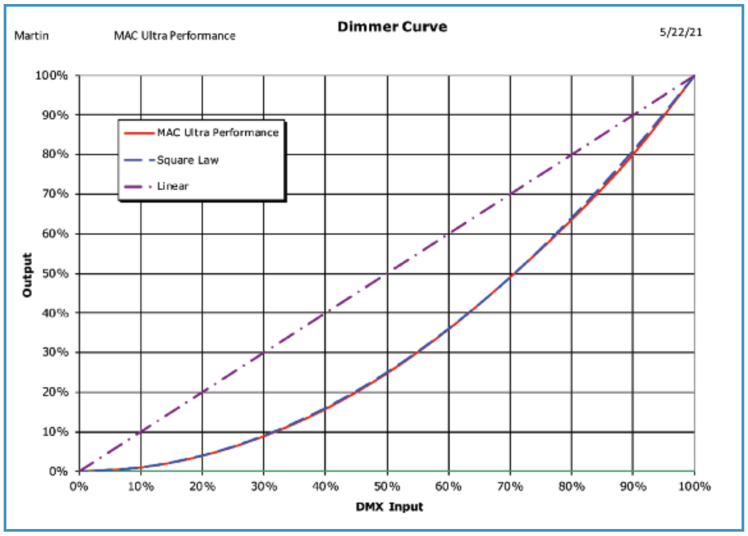

Figure 4: Dimmer curve.

optical characteristics of which largely define the remainder of the unit. In the current ongoing quest for more lumens from white LED units, the Martin team has developed a powerful light engine, but the decisions taken to achieve the required output have their inevitable consequences. Most significantly, the light engine is large in diameter, so the specter of etendue rears its head. I've talked about etendue many times before; basically, with optical systems you can choose whether the beam emitted from the light source is small or large, or you can choose whether it emits light in a narrow or wide angle. What you can't do without loss is choose small and narrow at the same time! In the Mac Ultra Performance, Martin wants output and has chosen the result with the least amount of loss, which, with such a large source, is to allow the beam angle from that source to be relatively wide. This results in two things; firstly, it's a very fast optical system, so the focal depth is small. This means that the gobos, framing, and iris need to be as close to each other as possible. Secondly, the rapidly expanding beam will require either very large output lenses or will vignette at narrow zoom angles. Martin has chosen the latter. I'll mention these design decisions later in this review as we continue through the light.

Dimming and strobe

The Mac Ultra Performance offers a range of selectable dimming curves; for this test, I used the default square law. Figure 4 shows the resultant dimmer curve as following the square law very accurately. Dimming was excellent—smooth with no visible steps at low dim levels.

The Mac Ultra Performance currently offers a single PWM frequency of 3,000Hz; however, Martin promises a firmware release later this year that will allow adjusting this through a DMX control channel.

Strobe range is adjustable up to a measured 19Hz. The Mac Ultra Performance took about 10 minutes when running at full output and with the fans in auto mode to heat up to a stable operating temperature, during which time the output dropped by 15%. (Six percent after one minute, 10% after three minutes, and 15% at 10 minutes) All the measurements in this report were taken after the unit reached steady operating temperature to include the effects of this initial thermal droop.

Color systems

As I mentioned earlier, the four color-mixing flag pairs are mounted between two lens elements of the light engine: one pair each for cyan, magenta, yellow, and CTO. The transmission of each color is shown in the table below. As you can see, the mixed colors are saturated. In particular, the cyan is fairly dark, which means that it's possible to get very deep blues and greens.

COLOR MIXING

Color	Cyan	Magenta	Yellow	Red	Green	Blue	CTO
Output	12%	9%	86%	7.8%	5.5%	0.3%	40%

Figure 5 shows the color-mixing module with its lens in the center and Figure 6 shows partially inserted flags. These days, after the color mixing flags you would typically see

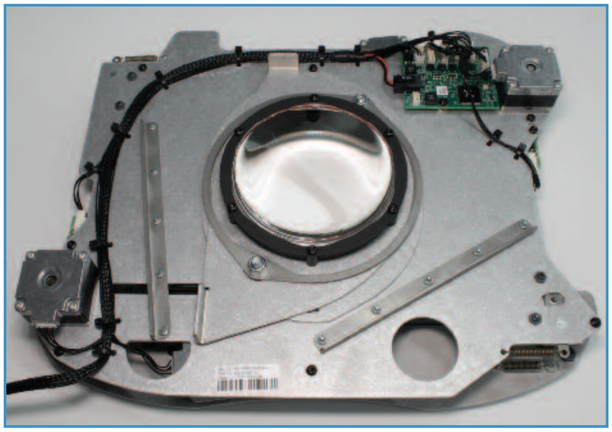

Figure 5: Color mixing module.

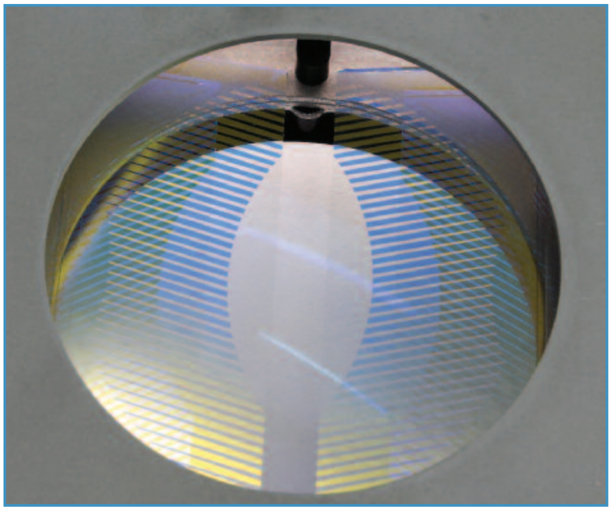

Figure 6: Color flags.

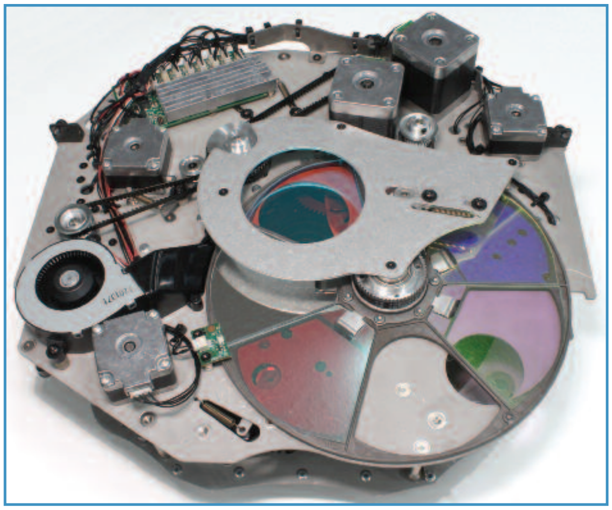

Figure 8: Color and imaging module side 1.

two or three additional optical modules containing color wheels, gobos, and framing. However, as described above, the Mac Ultra Performance has a very fast optical system with narrow depth of field, so Martin compresses the remaining systems into a single module that has been made as thin as possible to minimize the distance between focal planes.

Figure 7 shows the color and imaging module from the side, revealing how compact it is. This module contains a color wheel, animation wheel, two gobo wheels, framing, and an iris. There's no space wasted!

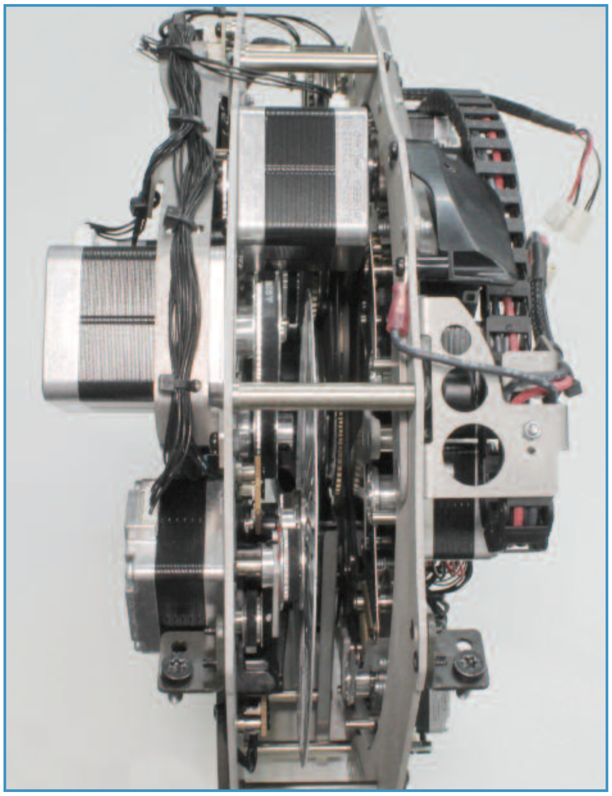

Figure 7: Color and imaging module.

Figure 8 shows the rear face of this module and the color wheel. This wheel has six replaceable trapezoidal color filters plus open hole. Included is a minus green filter or "Spectral Enhancement Filter," as Martin describes it. Diagonal split colors are also possible as shown in Figure 9.

Figure 9: Split colors.

COLOR WHEEL

Color	Minus Green	Blue	Dark Green	Orange	Navy Blue	Deep Red
Output	65%	4.3%	25%	24%	0.4%	4.1%

I measured the spectrum and color rendering of the Mac Ultra Performance in open white both with and without the minus green/Spectral Enhancement Filter in place. The results are shown in Figure 10. The filter increased color ren-

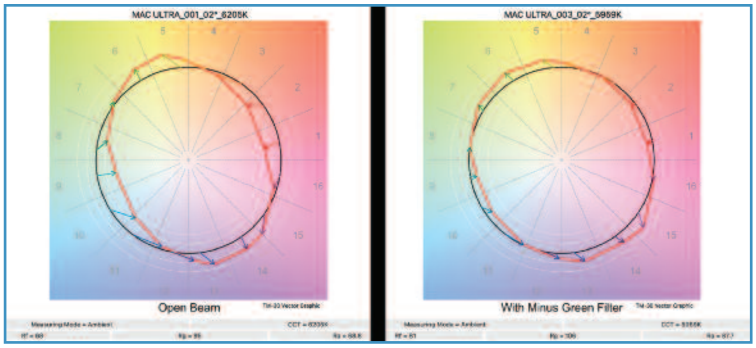

Figure 10: Minus green.

dering with TM-30 Rf going from 68 to 81 and Rg from 95 to 106 (CRI Ra from 69 to 88). This filter inevitably reduces light output, in this case to 65% and also drops the CCT slightly to 5,959K from 6,205K. Other color-rendering and CCT values were as follows:

Filters	TM-30 Rf	TM-30 Rg	CRI Ra	CCT
Open	68	95	69	6205
Full CTO	86	103	90	2923
Minus Green	81	106	88	5959
Gobo in + Correction On	70	95	69	6154
Gobo in + Correction Off	67	93	66	5419

You'll see two extra rows in this table, for gobo correction on and off. What's that about? Well, Martin noticed that, when a gobo was inserted on the Mac Ultra Performance, quite a lot of light was reflected backwards from the opaque mirrored portions of the gobo into the light engine. This reflected light excited yellow phosphors in the array of white LEDs, resulting in more light. This was, perhaps, good, but the light was yellow, so it noticeably reduced the color temperature (from 6,154K to 5,419K in my tests). To compensate for this, and only when in open white, the unit automatically inserts a small amount of color mixing flags to cancel out the yellow when a gobo is inserted. The net result is that the color temperature is unchanged to the eye. It's a neat solution to the problem.

Overall, the MAC Ultra Performance color system works well; there is some color fringing at the edges of shadows of defocused gobos, but that is as much to do with optical chromatic aberration as the color mix system.

Imaging systems

The imaging components—two gobo wheels, an animation wheel, iris, and framing—are squeezed into the remainder of the module. I can't show you a picture of the gobo wheels, as they are pretty much hidden from view. A downside of this compact arrangement is that gobo replacement requires long-nosed pliers and a steady hand—preferably not something you want to do while the light is on the rig.

First in the chain, however, is the animation wheel. This is the standard Martin design with a large aluminum breakup pattern that can be moved across the beam and then rotated off-axis to give a pseudolinear motion. It takes 0.5 seconds to insert or remove the wheel and, once in place, it can be rotated at speeds varying up to 12rpm at any angle from horizontal to vertical. Next to this are the two rotating gobo wheels. These are identical, each with five replaceable glass patterns plus open hole using a cartridge slot system to change out individual patterns.

ROTATING GOBO SPEEDS – BOTH WHEELS

Gobo change speed – adjacent	0.5 sec
Gobo change speed – worst case	1.0 sec
Maximum gobo spin speed	0.475 sec/rev = 126 rpm
Minimum gobo spin speed	528 sec/rev = 0.114 rpm

Rotation and indexing on both wheels were very smooth with almost no hysteresis. However, the reason for this is slightly odd. I reported above that a gobo change takes about 0.5 seconds; however, this is just the time for the gobo to get close to its final position. It then slows right down, and the final few degrees takes a further 1.5 seconds as the gobo inches into place. Both gobo wheels use a quick-path algorithm to minimize change times. Figure 11 shows an example of a gobo morph, pulling focus through from gobo wheel one to gobo wheel two.

The rear of this combined module has the framing and iris. Figure 12 shows the iris in front of a partially inserted shutter blade. Again, it's hard to show you a better view of the framing system as it is hidden within the module. I could see enough to recognize it as a five-bar linkage system similar to other Martin products. In case you're wondering what is meant in these by "five-bar" and "three-bar" linkage systems, take a look at Figure 13, which shows the two most common framing shutter systems in automated lights. Each

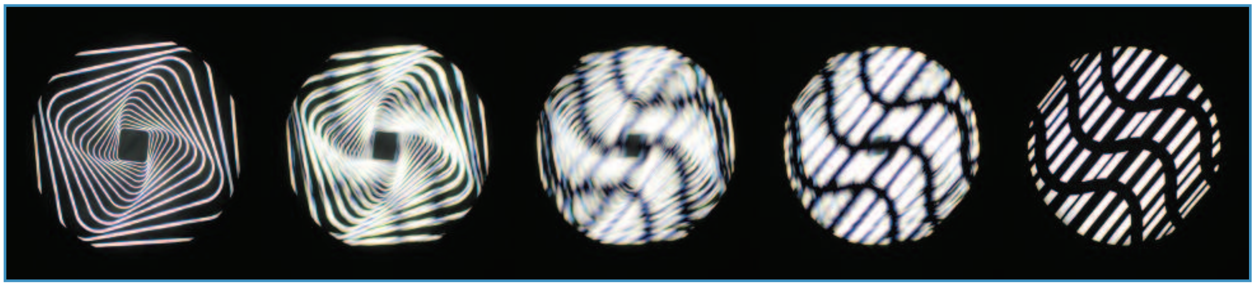

Figure 11: Gobo morph.

has a pair of motors linked to two corners of the shutter blade. As the motors rotate, the shutter position and angle can be adjusted. The difference is in the links from the motor to the blade. In a three-bar system, each motor has a single bar to the blade, making three bars in total: the bar from motor one to the blade, the blade itself, and the bar joining the other side of the blade to the second motor. A five-bar system introduces an extra linkage in each side using a jointed bar. Each has its advantages and disadvantages. A five-bar system is more compact, with greater freedom of movement, and can potentially achieve greater angles than one with three bars, but its movement is more complex and potentially subject to jamming and hysteresis. The Mac Ultra Performance uses a five-bar system with long-enough arms to allow full 100% coverage and a large range of movement. Each blade has +/- 29º of rotation and can maintain that angle as it is moved across the entire beam. The entire mechanism can be rotated by up to 166º. Figure 14 shows the possible angle of each blade. Figure 15 shows the entire mechanism at its rotation extremes with a black plastic cable chain leading power and data into the rotating section.

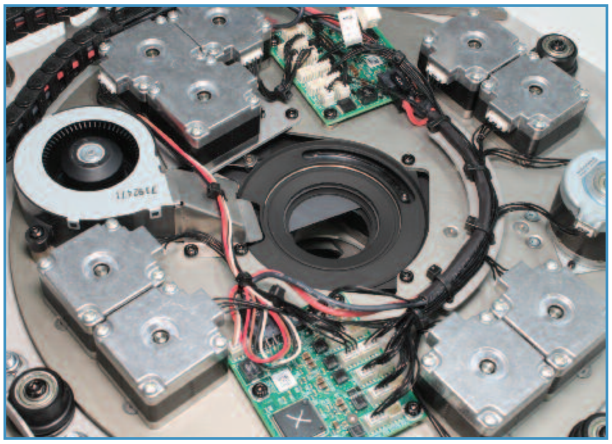

Figure 12: Color and imaging module side 2.

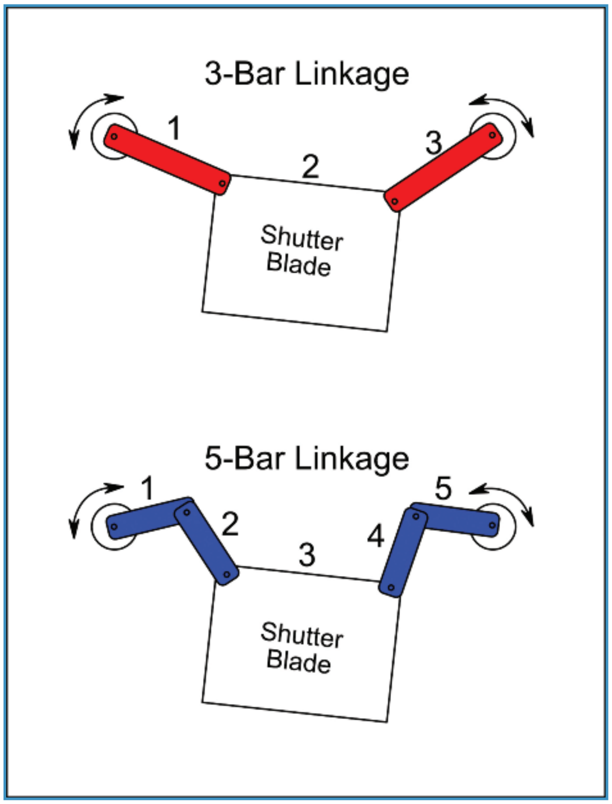

Figure 13: 3-Bar and 5-Bar.

There is a slight downside to these shutter blades, because of the high etendue and short focal depth of the optical. In order to keep the four shutter blades in focus as much as possible, Martin has mounted opposing blades in the same focal plane. This means that opposite blades can't move past each other and there is some collision-avoidance software to stop you from crashing them together. To my mind, this makes for slightly tricky programming. You have to be aware of this limitation and be careful not to accidentally push one blade out of the way with another. It's an interesting decision point: The enhanced functionality of the shutter blades, with full coverage and angle maintenance, is excellent; is it worth a little extra programming work to get that? Figure 16 shows the four blades set for a square cut with the system hard-focused on the top and bottom

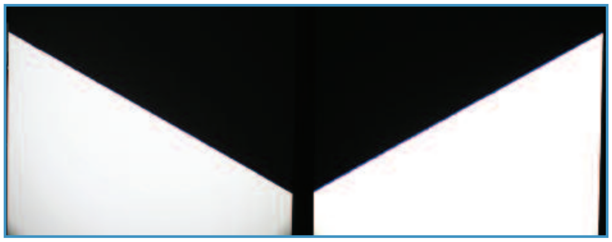

Figure 14: Shutter angle.

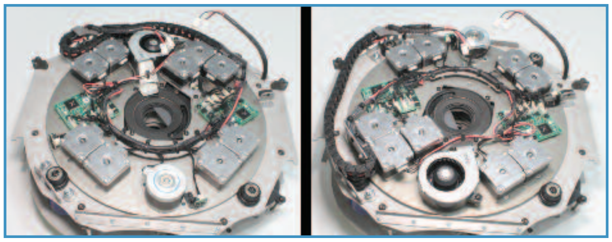

Figure 15: Framing shutter rotation.

Figure 16: Shutter focus.

blades. The side blades in this photograph are very slightly soft-focused, and this would be much worse if the blades ran in four separate slots rather than two.

Prism and frost

The final optical effects in the Mac Ultra Performance are the prism and frost flags. A single four-facet rotatable prism and a single variable-frost flag are mounted next to each other on, and traveling with, the output side of the rear lens group. Figure 17 shows that lens group with the frost flag above and the prism below the aperture. The prism can be inserted or removed in about 0.75 seconds and then rotated at a wide range of speeds.

The single variable-frost flag is a medium-level frost. As with many units of its type, the frost in the Mac Ultra Performance acts as a contrast reducer rather than a frost for much of its travel, only softening the focus when fully inserted. Figure 18 shows the effect as frost is inserted.

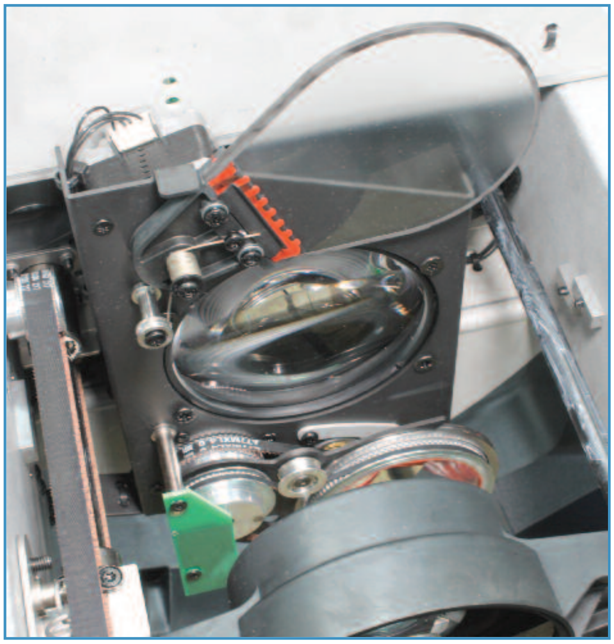

Figure 17: Frost and prism.

Lenses and output

The Mac Ultra Performance optical system is all about output. It uses a standard three-group lens, two groups that move for zoom and focus, and a fixed output group. I measured the zoom group as taking 0.85 seconds to travel from end to end with the focus group taking 0.75 seconds. The output in wide angle after allowing the unit to reach thermal equilibrium settled at just over 47,000 lumens at a field angle of 42.7°, ramping down to 24,000 lumens at 7.5° field angle at the narrow end. (Remember the initial discussion about allowing vignetting at narrow angles because otherwise the output lenses would be too large? That's why the output at full narrow is so much less than at wide. All engineering is about compromise. Many automated spot manufacturers made this choice, the center beam candlepower is still much higher in spot than in flood, and that's what the user needs even if there are fewer lumens overall.) Figures 19 and 20 show the beam distribution at both extremes.

Pan and tilt

I measured the pan and tilt range of the Mac Ultra Performance at 540° and 268°, respectively. A full-range 540° pan move took 4.5 seconds to complete, while a more typical 180° move finished in 2.5 seconds. Tilt took 3.6 seconds for a full 268° move and 2.8 seconds for 180°. Much like the gobos, I could not measure any hysteresis at all. However, this means it's a stiff system and you see some ringing and wobble when it comes to a stop. Again, all engineering is compromise: You can have ringing with a stiff system, or hysteresis with a damped system; which would you prefer? Engineering, like life, is unfair and you don't get to choose an option with neither.

Noise

The LED cooling fans are the usual suspects for background noise. The noisiest movement parameter by far was zoom, followed by pan and tilt.

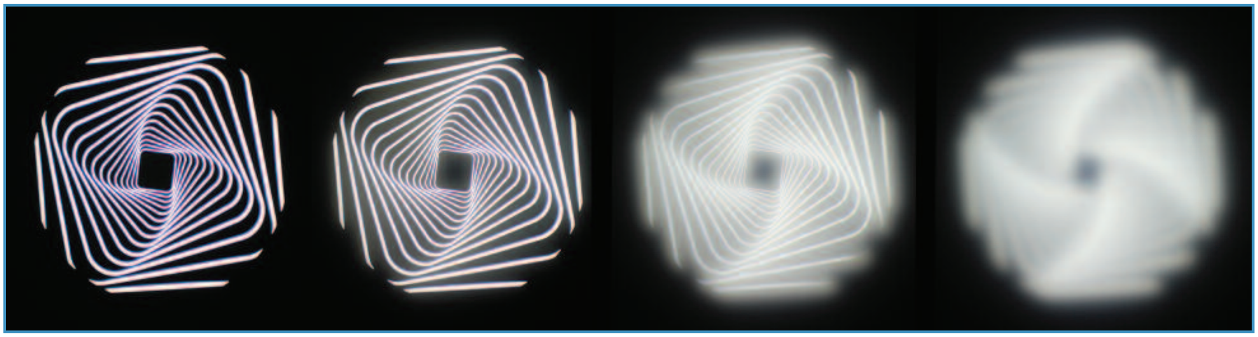

Figure 18: Variable frost.

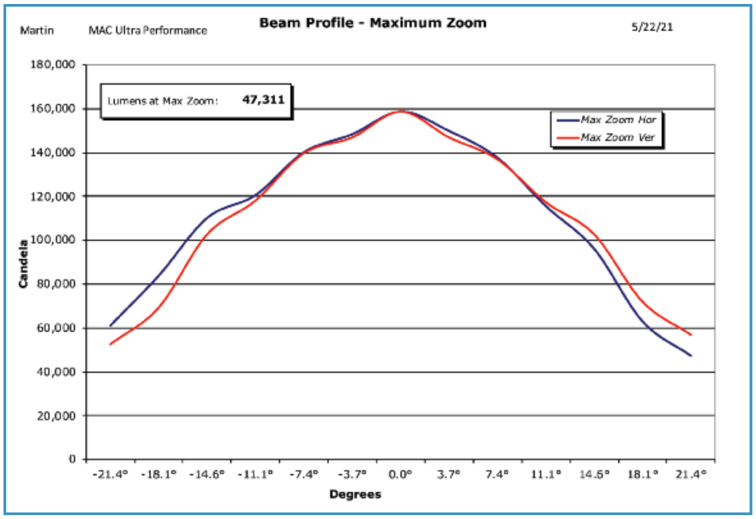

Figure 19: Output at maximum zoom.

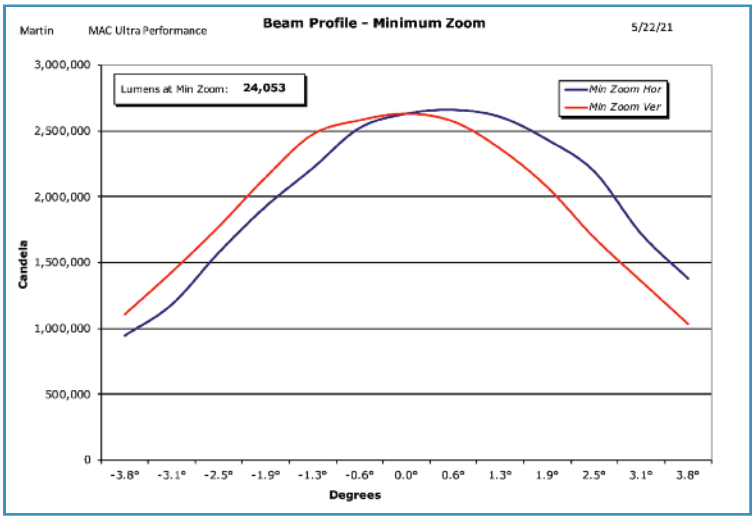

Figure 20: Output at minimum zoom.

SOUND LEVELS

	Normal Mode
Ambient	<35 dBA at 1m
Stationary	43.0 dBA at 1m
Homing/Initialization	54.3 dBA at 1m
Pan	58.3 dBA at 1m
Tilt	50.8 dBA at 1m
Gobo	43.2 dBA at 1m
Gobo rotate	43.8 dBA at 1m
Zoom	60.6 dBA at 1m
Focus	48.3 dBA at 1m
Animation wheel	43.2 dBA at 1m
Framing	45.3 dBA at 1m
Frost	43.0 dBA at 1m
Prism	43.5 dBA at 1m

This was with the fans running in auto mode. With the fans in high mode, the fan noise increased to 63.4dBA at 1m and output increased by 8.5%.

Homing/initialization time

Full initialization took 74 seconds from a cold start and 61 seconds from a DMX512 reset command. Homing is well behaved in both cases. The fixture fades out smoothly, resets, and keeps the LEDs off before fading up again after all reset movement is finished.

Construction

The Mac Ultra Performance follows the standard Martin model with the vast majority of the head components on these modules. Both the CYM CTO and main optical modules were easy to remove and replace. Figure 21 shows the overall head layout.

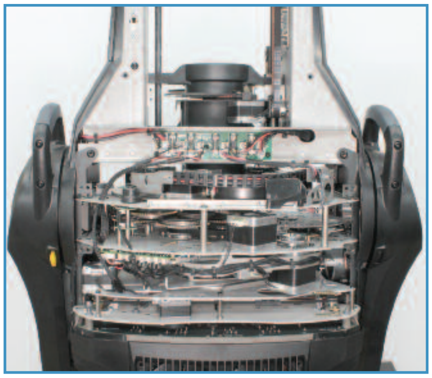

Figure 21: Head modules.

Electronics, power, and control

The Mac Ultra Performance has the standard menu-and-button system used in many Martin by Harman products. This provides access to a comprehensive array of setup and service functions, including RDM and Ethernet protocols (Figure 22). I tested RDM using a City Theatrical DMXcat and had no problems. The unit behaved correctly, offering the normal RDM service and maintenance features. The connector panel is adjacent to the menu system and provides Neutrik True-1 power input along with standard five-pin DMX512 connections and Ethernet in and through ports. A battery allows setting of menu parameters when mains power is off.

Figure 22: Menu and connectors.

That about covers it for the Mac Ultra Performance Profile. It features some interesting design choices, particularly with the framing system and optics. It enters an extremely busy area of the market at a time when we are starting to peek over the parapet into a post-COVID world. Does the Mac Ultra Performance have what you need in that brave new world? As always, that's your choice to make.

Mike Wood provides design, research, and development, technical, and intellectual property consulting services to the entertainment technology industry. He can be contacted at mike@mikewoodconsulting.com.