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GHOST IN THE SHELL

JESS HALL, BSC
PUSHES DIGITAL BOUNDARIES

PLUS:
GALE TATTERSALL ON GRACE AND FRANKIE
LUCA BIGAZZI ON THE YOUNG POPE



Not Quite Human

For the cyberpunk thriller *Ghost in the Shell*, Jess Hall, BSC employs large-format digital capture and multi-camera “motion photogrammetry” to help create a dystopian world that blurs the line between human and machine.

By David Heuring



Ghost in the Shell is a live-action take on an iconic Japanese manga series by Masamune Shirow. The source material is a cultural phenomenon that has been described as a cyberpunk meditation on design, philosophy, technology,

identity and consciousness. In a dystopian, mid-21st-century Japan, the Major — the story’s main character, played by Scarlett Johansson — is a highly developed human-cyborg hybrid whose brain is vulnerable to hacking, and who is haunted by snippets of memory from her human childhood. The production worked mostly in Hong Kong and at Stone Street Studios in Wellington, New Zealand, and the cast includes Michael Pitt, Pilou Asbæk, Chin Han and Juliette Binoche.

Director Rupert Sanders and Jess Hall, BSC led the team of highly skilled pros who brought this tale to the screen. The duo had previously collaborated on a hyper-real commercial for Microsoft’s *Halo 5: Guardians*, a sci-fi video game for Xbox One. That experience showed Hall the potential of Arri’s Alexa 65. He had previously been known for shooting on film, as he did on *The Spectacular Now*, *Creation* and *Transcendence* (AC May ’14) — the latter with a full photochemical finish.

“As someone who is drawn to anamorphic, working with the intrinsic shallow depth of field on the 65mm sensor



Opposite and this page, top: The feature *Ghost in the Shell* follows the Major (Scarlett Johansson), a cyborg designed to be a perfect soldier devoted to stopping the world's most dangerous criminals. Above: Cinematographer Jess Hall, BSC (left) and director Rupert Sanders plan a shot.

Unit photography by Jasin Bolland, SMPSP; courtesy of Paramount Pictures and Dreamworks Pictures.

was very appealing to me,” says Hall. “Also, I’m a big fan of the Alexa because I like the way it renders color. The color space has a naturalism and subtlety that, if lit correctly, is very pleasing for a digital camera. The large format came out of our need for something subtle and sophisticated enough to rival film in terms of color reproduction, and the spatial resolution to work well with all the different distribution types, including 2D, 3D, Imax 3D, and [2D and 3D Dolby Vision laser-projection format].”

Hall’s drive for precise and refined color influenced his decisions in camera, lenses, lighting and post, and

drove his collaborators to develop custom tools and techniques along the way. That began with a desire to pay homage to the visual qualities of the manga in a way that would work in live-action cinema.

Hall elaborates, “I wanted to honor the visual style of those forms in a way that moved it forward without being deferential — a way that observes the depth of tradition there, going back, in some extent, to the traditions within Japanese visual art, with its compressed perspectives, controlled palette, symmetrical compositions and repetitive forms.”

The cameras were set up to capture data at a resolution closer to 5K, instead of employing the units’ 6.5K Open Gate maximum, which saved a significant amount on data wrangling and associated costs. Alexa 65 footage was recorded to Codex Capture Drives.

“We originally thought we’d shoot certain scenes on the 65, but once we started testing, we wanted to shoot 90 percent of the movie that way,” the cinematographer says. “So my idea was to shoot in [5K] 65mm mode, which records in 1.78:1. I wanted to frame in 1.85 anyway, because anime is traditionally 1.85, and Hong Kong is such a

Not Quite Human

With her brain as the only remnant of her human existence, the Major is haunted by memories of her previous life. The character, Hall notes, “exists between two worlds. She’s part machine and part human. The narrative is driven by her seeking her place within that.”



vertical city. In testing, it felt like we were getting a more impactful image in 1.85. It felt very strong and lent itself to what I wanted to achieve compositionally. Ultimately, on this production it made the difference between an affordable format and an unaffordable format.”

“Across two units we had five Alexa 65s [fitted with modified Panavision Sphero 65 lenses], and two [Codex] Vault 65s for downloading,” notes digital-imaging technician Michael Urban. “We also had two Alexa Minis shooting ArriRaw Open Gate, which were used as crash cameras or for tight spaces that were too small for the Alexa 65. The Minis used the modified Panavision Sphero 65s as well. We also had a [Vision Research] Phantom Flex

4K, which used Leica Summilux-C [lenses] for the 1.4 T-stop.”

The main-unit operators were Peter McCaffrey on A camera and Patrick Loungway on B. (Loungway also served as 2nd-unit director of photography.) For second unit, Cameron McLean and Richard Bluck served as A- and B-camera operators, respectively.

The large format and rich image were in tune with the filmmakers’ plan for longer, more classical shots. “The danger with a very sharp image is that you begin to see things you might not want to see,” Hall notes. “That’s where the right lensing helps.”

Hall and ASC associate Dan Sasaki — Panavision’s vice president of

optical engineering and lens strategy — developed the set of modified Panavision Sphero 65s, which delivered a classic, slightly softer look, with T-stops of mostly T2 and under. Hall owns a set of restored vintage Cooke Speed Panchros, the characteristics of which he liked for this project, but those lenses can’t cover the larger image diagonal of the 65 sensor. Sasaki therefore translated some of their traits to the Spheros. The cinematographer was looking for a certain patina and texture reminiscent of watercolor painting.

“In the anime, there’s a certain painterly quality, as well as a subtle bloom or halation around highlights,” Hall says. “The compositions are so beautiful, and they tend to flatten the perspective, but they often employ a wide-angle lens, thus creating layers of depth in the background. I needed very high-speed and high-performance lenses because we planned to shoot in Hong Kong and maximize on the potential of available lighting. The correct perspective — flatter and wide-angle, with a wide field of view but without distortion — was important. Color consistency across the range was also critical to me, and this is something that is difficult to achieve with vintage glass.

“Selecting the Alexa 65 wasn’t just about resolution, color and speed — it



The filmmakers sought to honor the style of the manga and anime tellings of *Ghost in the Shell* that preceded this live-action version. "In the anime, there's a certain painterly quality," says Hall. "The compositions are so beautiful, and they tend to flatten the perspective, but they often employ a wide-angle lens, thus creating layers of depth in the background."

was also about perspective," Hall continues. "The optical compression [achieved by using longer focal lengths with a larger format] means you're effectively flattening the perspective, which was perfect for the aesthetic that I was pursuing. It meant that we could construct some wide-angle lenses that had a flatter, more compressed perspective. Dan built a unique 29mm that could accommodate the 65mm format, and this lens, the only one of its type in the world, became very effective for us. The 35 and the 40 were also great lenses, but the 29mm became the lens that really created what, for me, are the signature shots.

"We built an entire set of prime lenses — 24mm, 29mm, 35mm, 40mm, 50mm, 75mm, 100mm, 135mm and 135mm macro," Hall details. "There were also three high-speed lenses: a 50mm, 75mm and 100mm that all had T-stops below T2. We experimented with a couple of zoom lenses in testing, but these were never used, and the entire film was shot on the custom-built primes."

In regard to combining CG artistry with footage from the Alexa 65, visual-effects supervisor Guillaume Rocheron notes that the camera's sharp,

detailed image leaves little place to hide. "It has been especially challenging on the shots in the film that we dubbed 'ghost cam,' which are long, continuous floating shots traveling through cityscapes," he notes. "The first one in the film is our first look at the world. It's about a minute and a half long, mostly CG, and it connects to a shot of Major on a rooftop. The viewer has plenty of time to study the details and the image definition, and the quality had to be on par with the practical 65mm photography. The larger sensor proved to be challenging as well for some exterior sequences shot on a greenscreen stage, because we had to work around the shallow depth of field and cheat a bit in order to make our composites look more like an f11 and provide a sense of scale."

Hall developed a specific, coordinated color palette of 28 hues to be used prominently in the lighting and design. "You can take almost any frame in the original anime and see that color is used in a very harmonious way," he says. "If it's not, there's a reason. I wanted to bring a detailed, analytical approach to color without necessarily attaching obvious meaning to each color."

Hall extracted colors from the

anime and from stills he took on the Hong Kong scout, which were captured mostly at night. He noticed that the neon and LED lighting was mediated by the humid atmosphere, which creates an ambience and contributes to the watercolor feel.

"I became interested in using colored light and trapping and mixing it in the atmosphere to create other colors," the cinematographer says. "The colors I was seeing were very subtle. In moments of the anime, the Major has an extraordinary skin tone that I called a warm gray. It's something I've never really seen before on film, and one question was how to go about actually producing this color on Scarlett's skin."

With his 28-color palette, Hall set about tweaking the RGB values on LED lamps and seeing how the camera would interpret them. He had success with Digital Sputnik fixtures that offer 16-bit, four-channel control, but he knew those lamps wouldn't serve every function, especially in practically lit interiors with integrated lighting. Those situations would require smaller fixtures, and other RGBW systems weren't giving him the nuances and secondary colors he wanted, especially in the yellow

Not Quite Human

Reprogrammed to act as an assassin, a hacked geisha android stalks its prey.



and violet ranges. He approached Mike Bauman of LiteGear, who built a prototype six-color lamp, which featured additional channels for tungsten and amber.

Bauman says that much of the film has an amber feel, or uses colors that depend on accurate amber elements. "We had been working on a six-color system emitter mix we called 'Cine 6,' and when Jess and I started talking in the early stages, it became clear that this would be the perfect tool for him," Bauman recalls. "That certainly accelerated our development process of that product. Jess also had specific size needs and our team made some custom panels using Cine 6 with very rudimentary controls, which allowed him to achieve

the color mixing he was looking for."

For LiteGear's Cine 6, each segment is a six-chip package — four colors of red, green, blue and amber. Immediately adjacent are high-CRI (color rendition index) daylight and high-CRI tungsten emitters. "Jess wanted to desaturate an amber source, and the ability to do so with a high-CRI tungsten emitter gave him the best results in our testing," says Bauman. "Especially in the digital sphere, light values are so low, using the Cine 6 chip mix allowed Jess to use much lower foot-candle levels and maintain color consistency."

Bauman, Hall, digital-imaging technician Michael Urban and GrandMA programmer Matt Ardine

experimented in Los Angeles and generated spectrometer readings for each of Hall's 28 colors. Arri's newer SkyPanel fixtures allow for punching in X-Y coordinates to generate a specific color. Oversight Creamsource LEDs were also mapped. Bauman and a team later flew to New Zealand and worked with gaffer Dave Brown and fixtures tech Warwick Peace, dialing everything in, given voltage and other variables.

In general, the lighting in *Ghost* tends toward atmospheric and environmental, which allowed Sanders to block scenes freely in the space. The vast majority of the illumination was accomplished with DS 6, DS 3 and DS 1 Digital Sputnik units; L10, L7 and L5 Arri LED Fresnels as well as Arri SkyPanel units; Creamsource Sky units; and LiteGear's custom-built, six-channel LiteMats, as well as RGBW and Cine 6 LiteRibbons integrated into sets and also constructed into a number of custom fixtures. The filmmakers likened the ability to blend and desaturate with color, warmth and coolness to color-timing on the set.

"This project really pushed all the manufacturers," says Bauman. "Everyone had to up their game, because Jess insisted on maintaining consistency all the way down the workflow line. It's an impressive goal. As a company, we really value that collaboration with cine-

matographers who are interested in pushing the envelope.”

Supervising lighting-desk operator Chris Craig used his favorite GrandMA2 console networked through to a tablet for remote access, which allowed Hall to assign a programmed color and intensity to any unit on the set. Hall enthuses, “It’s an amazingly flexible system, and it worked very well — not just for individual colors, but for how the colors could combine and change during a shot. Sometimes I’d use three different colors within a single source and animate them, with changing light coming from different directions motivated by a character’s interaction with the environment.”

“This combination of tools offered incredible control and flexibility,” Craig attests, “with levels bright enough to wash large stages with gorgeous, saturated colors, down to 1/2-percent intensity, making a visible difference in eyelight. Fabulous!”

Halon Entertainment helped with previs and postvis on more than 150 shots. “We shared the light-color palette that Jess had created so we could use it on our CG lighting,” says Rocheron. “Our general rule was to try to capture the mood of real places and locations, like Hong Kong for example, even though we knew we would replace much of it in order to create the more futuristic version required for the movie. Jess could craft the ambience for each scene, which then gave us a fantastic base to work from in postproduction.”

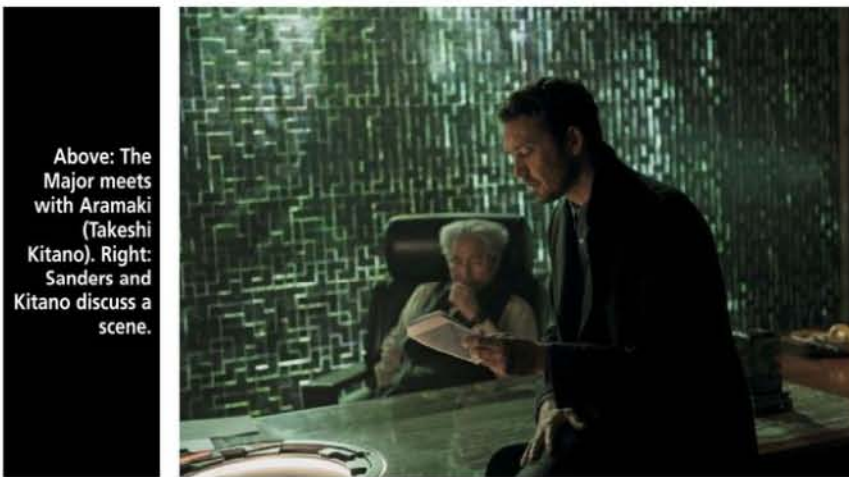
John Dykstra, ASC joined the *Ghost in the Shell* team as a visual-effects supervisor during postproduction. “John did amazing work,” Hall says.

A notable component of the movie’s narrative is the appearance of hologram-like apparitions, dubbed “solograms,” that appear in cityscape shots and function as futuristic commercials. Rocheron — an Oscar winner for *Life of Pi*, who worked closely with Hall to effectively combine effects and practi-



Cast and crew work through action in which the Major descends from a rooftop (top), smashes through a window (middle) and takes aim at her targets (bottom).

Not Quite Human



Above: The Major meets with Aramaki (Takeshi Kitano). Right: Sanders and Kitano discuss a scene.

cal photography — calls these images “giant volumetric advertising projections,” and says that creating them was one of the main challenges for the visual-effects team at MPC.

“It’s a bit like what you would see with augmented reality, but without the glasses,” Rocheron describes. “A person in these volumetric ads could be as tall as a skyscraper. Unlike holograms, which are reproductions of a subject in a different environment, solograms represent these figures but integrate them within the environment they’re projected into.”

In realizing the sologram imagery, the filmmakers made use of a “motion photogrammetry” system developed by camera-array designer Dayton Taylor.

“We needed to be able to film the actors from many different angles, with preprogrammed camera moves and

lighting scenarios in order to integrate them later into our cityscape,” says Rocheron. “But I thought that would be not only impractical but very limiting. If we could find a way to capture those actors’ performances and create a moving CG representation of them using [motion] photogrammetry, we could position them in our cityscapes, from any angle, in any size and under any lighting conditions. Unlike with traditional CG characters, the idea here was to digitize a performance so it could be [digitally] ‘rephotographed’ from any point of view. The character had to be relit in CG because of the restrictions of lighting within the dome design, but the origin of the shot remained real photography captured at 24 fps.”

“Elements from this technique were used for almost every exterior city

shot,” Hall adds, in that nearly every cityscape-shot in the movie features sologram imagery. “When I first discussed this idea with Dayton, I had wanted to use the technique for some of the Major’s action or fight scenes, but the resolution was not sufficient and the quality lent itself to the more degraded video texture we required for the Solograms. We created and processed 20 minutes of Sologram footage. [Given that] the technique generates a complete 3D scan of the actor per frame, we processed around 30,000 3D scans to generate all the moving clips.”

Photogrammetry is used extensively in video games, because a single static texture map can be loaded once and animated to look as though it’s moving, but that is also why it lacks photorealism in filmmaking. Taylor, who had first crossed paths with Sanders and Hall while working on a Nissan commercial in 2006, avoids this problem in part by making static photogrammetry scans at 24 frames per second.

Rocheron and Taylor devised a dome of 80 Point Grey Grasshopper cameras featuring Sony ICX625 global-shutter CCD sensors, a rig that shot 2.5K uncompressed frames. “The cameras recorded their images directly into 20 computer servers, with eight terabytes of storage per server — 160 terabytes total,” says Taylor, the founder and president of visual-effects and camera-array-technology company Digital Air. “The data was written to the servers’ hard drives as numbered frame sequences in DNG — Adobe’s Digital Negative — format.”

Digital Air’s software pipeline used Capturing Reality’s photogrammetry software. The hardware that Taylor designed allows perfect synchronization at 24 fps, which was key to the endeavor’s success, according to Rocheron.

As Taylor explains, “The Point Grey cameras have an auto-synchronization feature that perfectly synchronizes the timing of the shutters in all of the cameras. This is important because the photogrammetry software relies on the temporal consistency of all of the image data in order to reconstruct an accurate 3D model of the subject — all the images have to be

Not Quite Human

Right: The Major speaks with a prisoner (Daniel Henshall) whose mind has been hacked by a shadowy adversary, while (from left) Aramaki, Ladriya (Danusia Samal), Togusa (Chin Han) and Batou (Pilou Asbæk) observe. Below: Hall regards a setup.



exposed at exactly the same time, because the software triangulates the depth data by matching image features down to the pixel level. For this same reason, motion blur results in a loss of depth detail, so the cameras also have to be set to very short shutter speeds.

“We would record the performances inside this dome of cameras,” Taylor continues, “and the synchronized images allowed us to re-create a perfect moving version of the actors in the computer. We captured not only their movement but their volume, face, skin, clothes, and all the details.”

“Each frame of the resulting

sequence is a new representation of the subject based on the 80 still images that it is derived from,” he adds. “Every frame consists of a completely new 3D model and a completely new texture. This was expensive in terms of data and processing, but it saved time and labor downstream in the workflow because it eliminated the need for motion capture or having animators rig and animate static scans. Of course, doing it this way also ensured that the final results were entirely performance-driven.”

The cinematographer adds that the multi-camera capture technique lent a real photographic weight and texture to

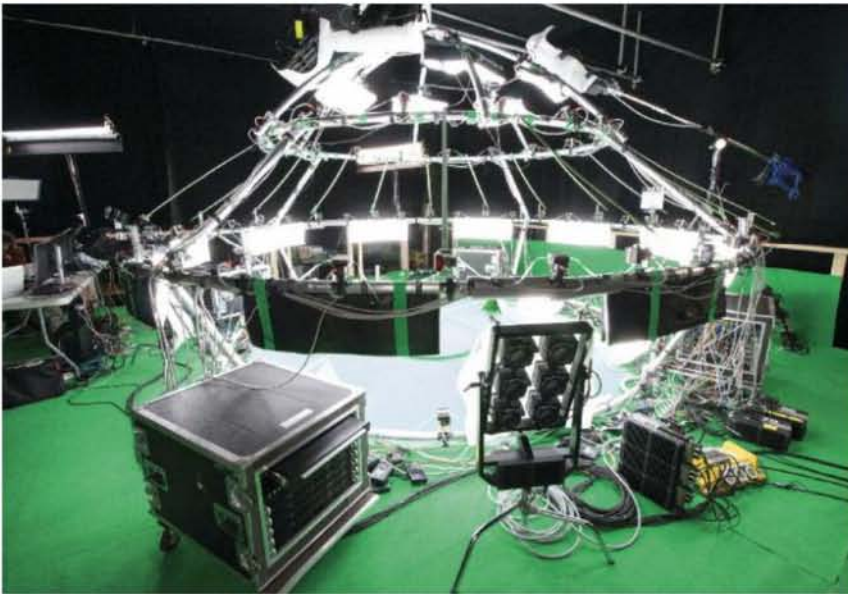
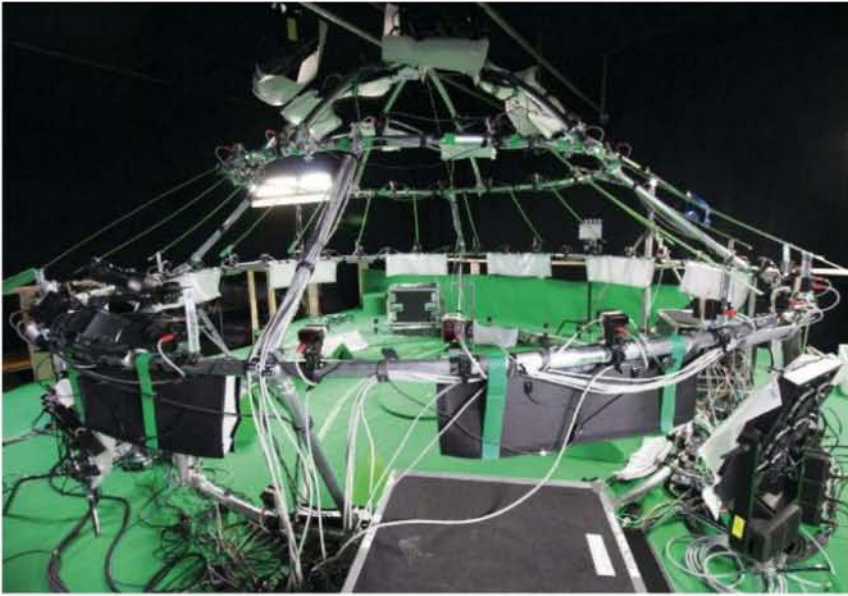
the solograms, as compared to a standard CG element. And the movement he designed into the shots brought all the elements together.

MPC used the mesh-plus-texture output sequences produced by motion photogrammetry to drive the animation for the solograms—the idea being that the enormous holograms in the movie are digital creations within this fictional world, as opposed to giant physical figures. Hall and Rocheron refer to this look as “videogrammetry,” because it creates a volumetric digital-video aesthetic.

“I felt that *Ghost in the Shell* presented an opportunity that might not come again,” Taylor opines. “Now, as a result, we’re ready to seamlessly insert actors into the next film with a much better understanding of the technology and pipeline required to do so.”

“We were able to capture [the actors as they performed] and then place them within virtual-camera moves in three dimensions,” Hall attests. “We didn’t want the film to be completely dominated by greenscreen process work. We were looking for a very tactile feel, with as much done in-camera as possible. That’s why I like this idea so much. It goes to the essence of what the story is about. Scarlett’s character, the Major,

Not Quite Human



Giant holographic apparitions dubbed "solograms" were captured with a "motion photogrammetry" camera-array system developed by Dayton Taylor.

exists between two worlds. She's part machine and part human. The narrative is driven by her seeking her place within that. I like the idea of expressing this third space she inhabits with a traveling camera that is somewhat ethereal, exploratory and unsettled."

During preproduction, Hall worked with Yvan Lucas at Shed to develop a show LUT, which was used

throughout the shoot. On the set, he worked in D65 P3 color space, in part to help maintain color accuracy. The colors in *Ghost* were designed for the camera to read, and they were controlled through the LUT to maintain consistency.

"I've always found Rec 709 to be a somewhat crude way to view things," says Hall. The cinematographer collaborated with Ian Bidgood, technical director at Park Road, to implement an on-set P3 monitoring system, which meant the production could go with

standard color gamma and push these colors farther. "Park Road Post set up the workflow so that I was monitoring P3 on set and projecting in P3 with my dailies, without shifting the LUT," Hall notes. "The result was a seamless workflow in a unified color space, which required little or no color correction."

Urban worked with the team at Moxion, "an online dailies application, to accept and display DPX frames correctly," he explains. From there, he created a secure online database to share between shooting units, post and eventually pickups in L.A. He also used Moxion to collate all the metadata using ALEs from editorial. "This enabled the DITs, post and the camera department to go back and check T-stop, lens, color temp, LUT, CDL, etc. in a still-frame database organized by scene and setup," he says.

Urban's company, The Rebel Fleet, supplied identical DIT carts in New Zealand and Hong Kong for main and second unit that included two Sony 25" OLEDs, a 17" Sony OLED, Fuji IS-Mini LUT boxes, Pomfort LiveGrade, Blackmagic Design DaVinci Resolve, Tangent Devices Element Panel, AJA Kumo routers, Teradek's Bolt 2000 and Decimator's DMON-6 splitter.

Arri's Alexa 65 requires the use of the Codex Vault 65 for initial processing of the raw camera acquisition. "Having Codex Wellington, L.A. and London on call meant we were covered around the clock, which helped, and meant they could pull in gear or expertise when needed," says Urban. "Having so many pixels meant that the noise floor was drastically reduced when going from a 5K resolution to 2K screenings. Jess based [his camera settings] at 800 EI, but we knew we could call on 1,000 EI or 1,280 EI without noticing a jump in noise." Hall confirms that he occasionally employed 1,000 and 1,280 EI "when more depth of field was required."

Park Road has been moving toward the use of one seamless color space on set, in dailies grading, in visual effects, and for the final online DI mastering for some time. The company's workflow architect Anthony Pratt notes

Not Quite Human

Hall and Sanders plan their next move.



that the advantages of a single color space show up in consistency, communication, efficiency, creativity and trust.

“Jess orchestrated an approach that leveraged the full gamut of the camera — and which clearly defined a completely unique world,” says Pratt. “On set, Jess had absolute confidence that the full gamut of the images captured in-camera tracked through,

enabling rapid creative color decisions. Jess could prelight with confidence, as the correct P3 color space was used when passing a CDL/still through to the dailies suite. Back at Park Road, we could then offer further look development using the full power of the SGO Mistika grading platform — and the looks offered tracked accurately when sent back from Park Road to the set.”

With the production based at nearby Stone Street Studios, a private fiber-optic connection direct from Stone Street to Park Road facilitated data management. Park Road’s pipeline ensures the availability of the underlying raw image. Pratt used an optimized GPU de-Bayer approach in the Mistika platform, without compromising the images. After de-Bayering, the ArriRaw media was presented as Log C wide gamut and scaled into a 2K dailies environment.

Hall and Sanders graded the final DI master at Technicolor Hollywood with supervising digital colorist and ASC associate member Michael Hatzler. Hatzler and his team used multiple Flame Premium workstations to assist him in delivering various 2K DCP packages in 2D and 3D xenon, in addition to 2D and 3D Dolby Vision laser-projection format, that benefited greatly from the P3 pipeline.

“As we began, fundamentals like overall exposure and balance, and the

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general level of highlights and shadows were in a very good place," says Hatzler. "The initial overall grade fell into place quickly, which allowed us to spend more time earlier in the DI on details like matching Jess' color palette, skin-tone variation, selective highlight halation, articulated shapes, and the light-to-dark contour from scene to scene. The LUT was very subtle, and while it did set the image up to some extent, it was never limiting or difficult to work around. The LUT didn't feel like an add-on, but rather one component of a very well-thought-out workflow that allowed me to guide each scene right to where Jess wanted it to land, at the same time making sure to protect it from the tendency of a lot of modern films to become overly cooked or pushed in the grade."

Hall says that one of his overarching goals was to create a texture he hadn't seen before. "I felt that with digital cinematography, there is a danger that things can become homogenized, without

enough experimentation and pushing of the boundaries," he notes. "I really wanted this film to look unique, and with this intellectual property, we had every right to explore a unique aesthetic. I was looking to imbue *Ghost* with an amazing amount of detail and texture, but also a real painterly quality — akin to the anime. I like taking a camera that is extremely sharp and sophisticated, like the Alexa 65, and modifying that resolution with a particular type of intervention. The quality of the light, a particular softness or imperfection in the lens, a shallowness in the depth of field, or a certain quality of atmosphere can be combined to create a unique look. I wanted to transport the audience into a world that feels recognizable, and yet unfamiliar. Like Hong Kong — which combines old and new, Asian and British, the past and the future — and like Scarlett's character, the Major, who is not quite human and not quite machine." ●

◀ TECHNICAL SPECS ▶

1.85:1

Digital Capture

Arri Alexa 65, Alexa Mini;
Point Grey Grasshopper; Vision
Research Phantom Flex 4K

Panavision Sphero 65 (modified),
Leica Summilux-C

SELECT LED 30/20 DMX

Now with Gel presets & Dial-in 360° Colors



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