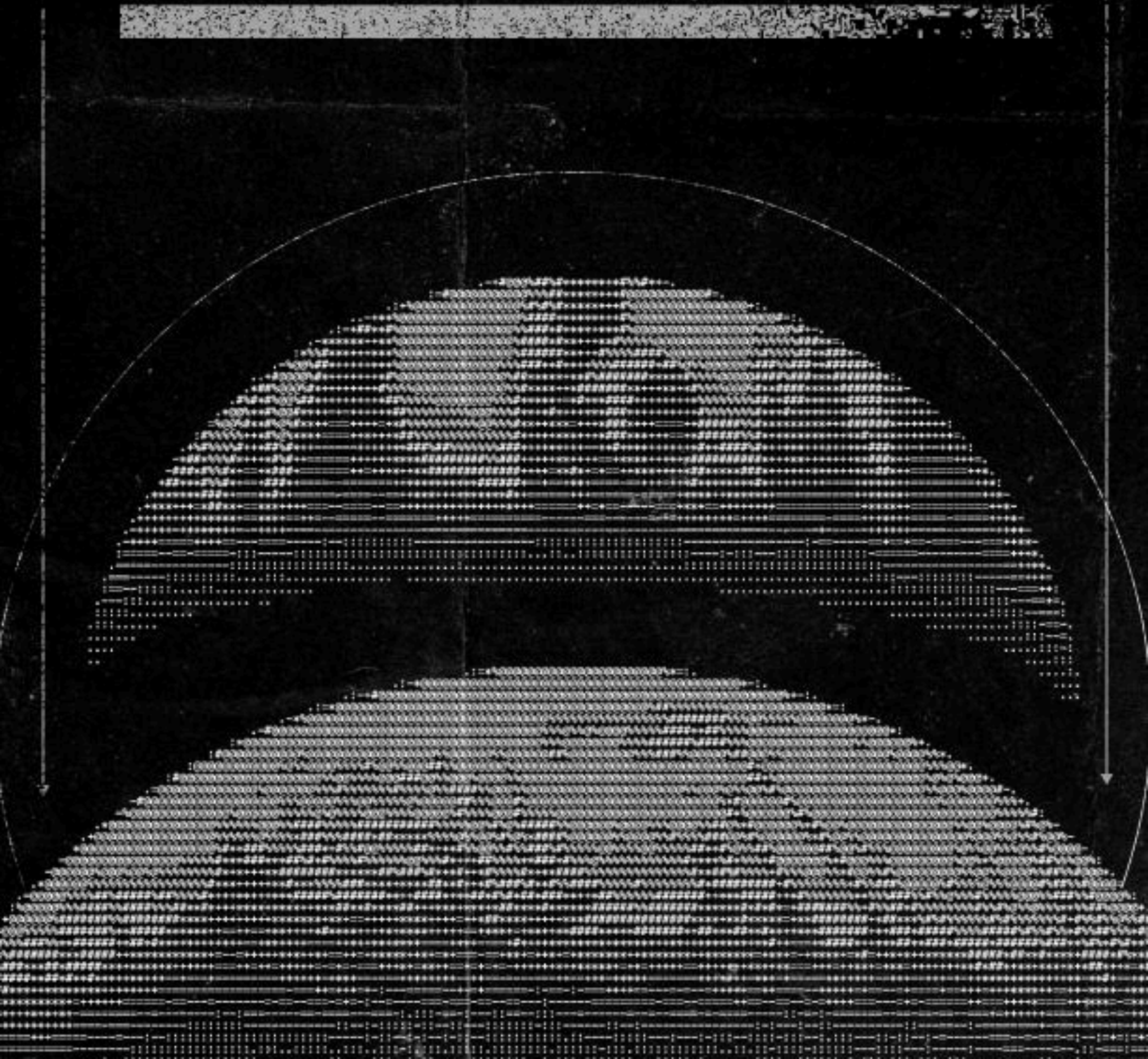


EUROPA:

AN ODYSSEY INTO ON-SET
VIRTUAL PRODUCTION

BY NOAH KADNER



INTRODUCTION

Europa is the latest production from the Entertainment Technology Center (ETC@USC), a think tank and research group whose mission is to validate new technologies and workflows within an educational framework. The short film chronicles the journey of three astronauts on a critical mission to Jupiter's moon, Europa, to extract water and save an Earth facing severe environmental decline. As they navigate the ethical and technical challenges of harvesting extraterrestrial resources, the crew confronts profound questions about humanity's place in the cosmos and the consequences of exploiting natural resources.

Prior ETC productions include *Fathead*, which explored cloud-based virtual production workflows. Another recent ETC production was *Ripple Effect*, which combined the technical challenges of virtual production with the restrictions of on-set safety protocols during the Covid pandemic.

The *Europa* team aimed to explore advanced workflows with on-set virtual production (OSVP) 2.0. This second phase of virtual production leans into the maturation of equipment and workflows developed over the past five years since the release of *The Mandalorian*, the first significant LED volume/in-camera visual effects virtual production to be released.

The principal goals for *Europa* included establishing deep metadata/ontology workflows, exploring new technologies and cross-functional teamwork with Sony, testing remote collaboration worldwide, streamlining the virtual art department and environment development workflow, optimizing anamorphic lens distortion and camera/lens metadata usage on an LED volume, expanding image-based lighting (IBL) techniques, leveraging artificial intelligence for environment development and enhanced post-production.

HOW THIS DOCUMENT IS ORGANIZED

This white paper explores the lessons learned during the creation of *Europa*. The report is organized according to the three main phases of production: pre-production, production, and post-production. Each investigation area includes anecdotes and takeaways from crew members.



PREPARING FOR LAUNCH

Though ostensibly a USC student short film, the final product results from the labor of hundreds of contributors worldwide, many donating their time. Part of the appeal of ETC is that it's not for profit. So, entities that might typically be competitors in a commercial context can collaborate in a pure spirit of discovery. This white paper explores the process of all involved on *Europa* and highlights the key players.

The team includes:

ERIK WEAVER • Sr. Director at ETC & Executive Producer

TOM THUDIYANPLACKAL • Executive Producer at ETC

CHRISTINA LEE STORM • Co-Executive Producer

JACQUELINE ROSENTHAL • Writer/Director

ERIK WOLFORD • Cinematographer

VANESSA KAO • Editor

ANGRAN LI & KRISTIN WANG • Production Designers

ERIC ROTH • VFX Supervisor

DANE BREHM • Co-Producer/Production Technologist at Cintegral

MC DEMARTINO • Associate Producer/Virtual Production Producer

TIM KANG • Principal Engineer & Image-Based Lighting
Specialist, Aputure

DANIEL DE LA ROSA • Post-Production Supervisor

SPENCER STEPHENS • Senior Vice President, Production Technology
& Security at MovieLabs

PETE HARROW • CTO, The Rebel Fleet/Konsol Metadata Specialist

DEVON MATHIS • VAD Lighting Supervisor, Torchlight

JASON FOTTER • Founder, Bind Studio

JEREMY STAPLETON • AI Editorial Specialist Universal Pictures



production & planning - pre-production & planning - pre-production & planning

INSPIRATION & VISION

ETC's mission is to select projects that offer an inclusive opportunity to USC film school students while also exploring groundbreaking areas of interest in filmmaking. Erik Weaver starts the selection process for each project, seeking candidates whose projects fit ETC's latest areas of interest.

"Jacqueline Rosenthal's script for *Europa* ultimately fit the requirements best," Weaver recalls. "We knew we were going to shoot on the new Sony/**Pixomondo** LED stage in Culver City, and one of the big areas of investigation was thoroughly testing the black levels on the LED panels. So a movie featuring the colorful blue surface of Jupiter's moon *Europa* set against the blackness of space ticked all the boxes. We also knew Sony and our other key partners had a fixed window of opportunity to get the project moving."

"Our goal coming out of *Fathead* was to push things," adds executive producer Thudiyanplackal. "One of the challenges in *Fathead* was just getting the project done during the pandemic with a lot of crew that didn't have any volume experience."

This time, we wanted to come in with enough comfort with this methodology to help the filmmakers much earlier in the process.

Jacqueline's writing was informed by what she saw as the possibilities of this technology, which led to environments in *Europa* that would take advantage of the kinds of lighting and moods OSVP excels at."

Rosenthal's primary goals were exploring OSVP, creating a visually stunning narrative, and transmitting a timely ecological message. "For anyone who wants to direct a virtual production, you have to be not afraid to leap and have the net appear," says Rosenthal. "The most important lesson from the project is to surround yourself with people who think outside the box because this is such an emerging process."

"It comes down to having a love for preparation, working with the VAD, doing previs, and creating storyboards," she adds. "The more you invest in pre-production, the more it pays off at every following stage. In the end, it's not just about making shots no one's seen before, and it's also pushing the medium forward in a believable way."

ASSEMBLING THE TEAM

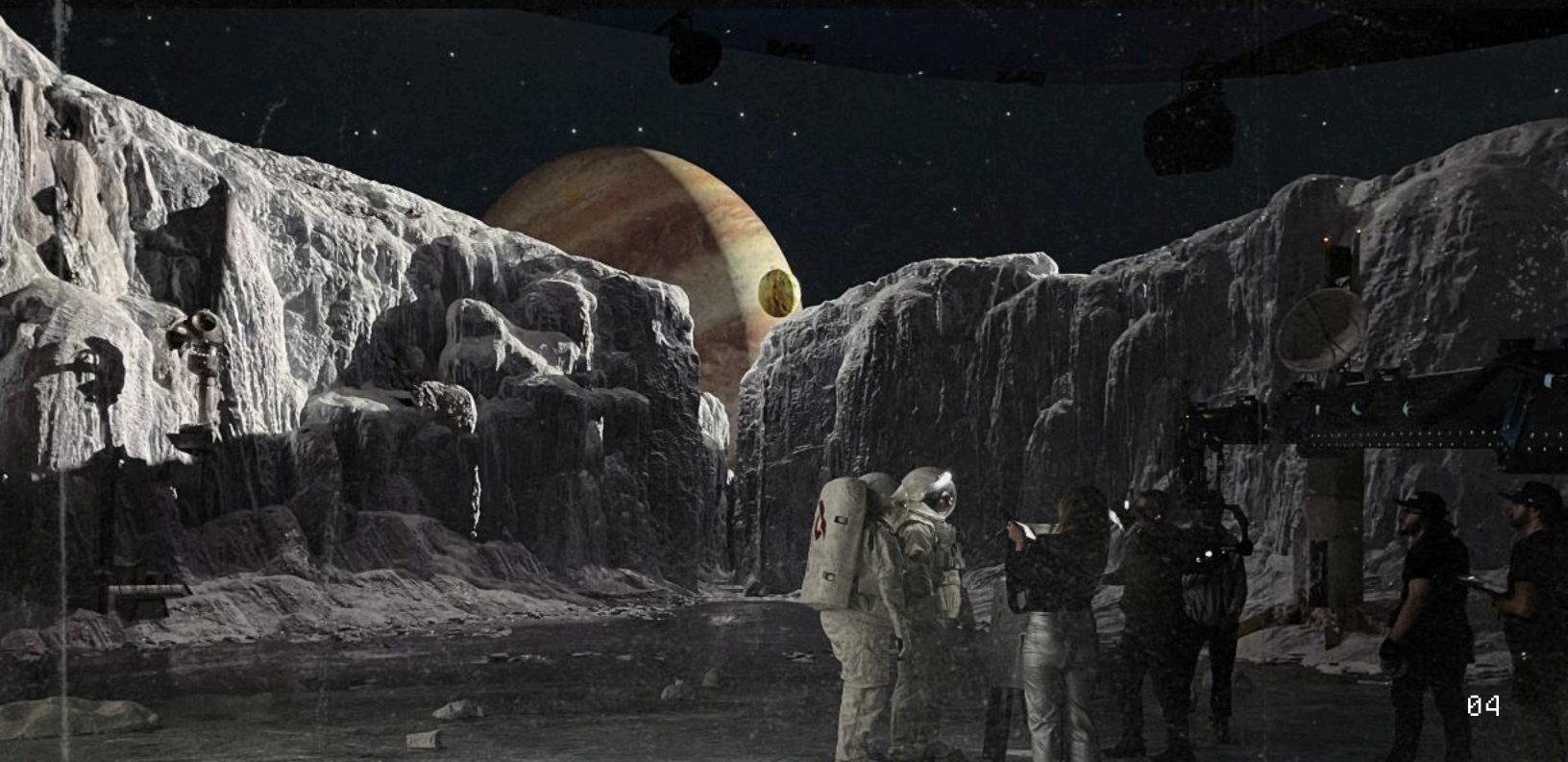
As pre-production commenced, Weaver tapped veteran producer Christina Lee Storm (*Life of Pi*, *Avatar: The Last Airbender*) to bring together more team members for *Europa*. "I believe in educating the next generation because many people haven't worked in OSVP," states Storm. "The goal of a producer should be to connect all the departments so that they're not on siloed missions. The most exciting thing about *Europa* was developing and maximizing metadata workflows. Finding the best ways to funnel all the on-set data downstream to post-production VFX, sound, color correction, etc., is beneficial so you don't leave money on the table, so to speak."

"We had a major dailies turnaround because the footage was going to places like New Zealand and India to create a 24-hour production cycle," Storm adds. "We're also leveraging a partnership with Amazon Web Services, so there's a level of cloud interoperability between companies. Getting OptiTrack telemetry, Unreal Engine files, and all of that in one place requires a level of education and offers a lot of infrastructure and knowledge."

VAD & ENVIRONMENTAL DEVELOPMENT

The Virtual Art Department is typically the linchpin of pre-production for OSVP. For *Europa*, contributors to the VAD efforts included [Sony Torchlight](#), [CG Pro](#), [ROTU](#), and [Qube Cinema](#). Part of the early efforts leveraged artificial intelligence tools for look development. "We used [Davant Systems](#), a front-end for Stable Diffusion, to do a couple of sessions with Jacqueline and her storyboard and concept artists," says DeMartino.

"That fed into our VAD teams, including an all-volunteer team from CG Pro, which got us through the previs and gray-boxing (simplified 3D environment mockups) phases," DeMartino continues. "We had a major time crunch going from pre-production in November 2023 to shooting in February 2024. So, we were pulled in many directions between the VAD, art direction and production design. The key lesson was that for something to work in a 3D environment, it has to work in 2D first."



PRODUCTION DESIGN

Juggling the virtual and physical worlds and determining what gets built for each set for each fell to production designers Angran Li and Kristin Wang. "It was challenging trying to figure out the physical builds, especially knowing that everything would be captured with anamorphic lenses," says Li. "For example, it's the icy surface of a rocky moon, so the real rocks I built had to match the virtual ones in Unreal Engine and vice versa. Eventually, the workflow was that I would do my builds, and then they would be scanned for photogrammetry and textures that would then be placed into the virtual world."

"The test shoot days become critical because you have to work with the real final colors of the set and the final virtual environment in-camera, that can't be left to the shoot days," adds Li. "That even comes down to the stage size. For example, testing within the same stage you're shooting is critical, or things don't align. We had to confirm that the VAD teams were always designing their environments to fit within the exact dimensions of the Pixomondo stage at Sony. ETC is great because they ensure every shot is blocked out at the storyboard stage."

Blending is one of the most essential aspects of OSVP- the art of seamlessly disguising the seam between the virtual environment on the wall and the real physical floor the actors stand on is a joint effort. "I go to a point where I stopped trusting my eyes and relied on the camera monitors," observes Li. "On the day, it's much simpler for the VAD to adjust its environment to match my physical set than the other way around because they can change a texture much faster than I can repaint something. Baking is also a key consideration because there comes a moment on the set when you can't change something without having to rebake the lighting, and you don't always have the time to wait. Ultimately, what ends up in the lens is the collaboration between the VAD, art director, production designer and the cinematographer."

production - production - production - production - production

METADATA & ONTOLOGY

As *Europa* went into production in February 2024, advancing metadata and ontology workflows were paramount in the minds of the filmmakers because they offered potential benefits across the entire spectrum of the project. Metadata refers to contextual information about assets, scenes, and production elements, such as camera settings, file formats, and scene descriptions. It helps streamline workflows by allowing filmmakers to organize, track, and manage large volumes of digital content efficiently.



Ontology is a structured framework for categorizing and defining relationships between different entities, such as characters, props, locations, and visual effects. In virtual production, ontologies provide a consistent way to classify and connect digital assets, enabling better integration and reusability across projects.

Pete Harrow, CTO of **Rebel Fleet** in Auckland, New Zealand, was instrumental in providing a cloud service for sharing metadata and ontology across all of *Europa*'s teams. "**Konsol** is our metadata collection, aggregation and organization platform," explains Harrow. "All the different teams can post knowledge they're capturing on set. We then have smart algorithms to attach the right metadata to the right shots."

"So you get your script supervisor's notes, camera reports, VFX reports, etc., everything based on a specific shot," Harrow continues. "Then we take it a step further with frame metadata, so, for example, we know which real-time files are being played back for volume stages and the corresponding timecodes. We even add the lens, iris and other camera metadata per frame. Due to the time offset, we could have everything QC'ed, synced, prepped and loaded back into the Avid for editing each day by the time everyone showed up in the morning."

Konsol is designed to be highly customizable since every film has unique elements and goals. "The cool thing is we're completely agnostic about what we can integrate into the system," says Harrow. "We have done nearly twenty major projects so far with Konsol, and every day, and it improves as we discover more edge cases and add more support for different workflows and integrations."

SONY CROSS-FUNCTIONAL APPROACH

As one of the leading partners for *Europa*, Sony provided the use of its Innovation Studios Stage 7 in Culver City, which features **Sony Crystal LED B-series 1.5mm panels** in a classic C configuration with a ceiling and Sony's proprietary processors. In addition to the stage itself, Sony provided the services of Pixomondo, a leader in the field of virtual production and Torchlight, a previsualization service based on Unreal Engine. Sony also offered **Venice 2** cameras, outfitted with the Virtual Venice plugin, which works with Unreal Engine to provide color science and moiré-sensing capabilities, among other specialized tools.

"In addition to shaking down Stage 7 with all of the retoolings Pixomondo did, we also wanted to work in tandem with the new Cooke anamorphic lenses and see how they interacted with our screens and provided metadata," De La Rosa adds. "Many VFX films have gotten into a habit of relying on fixing things in post, whereas virtual production flips that paradigm on its head. Preparation is the key; services like Torchlight visualization can help you work out your camera angles in advance. That's especially critical for a project like *Europa* with its complex stunt rigging and zero-gravity wire work."



Torchlight provided a host of pre-production services and assisted post-production with postvis. According to Devon Mathis, VAD Lighting Supervisor at Torchlight, the goal is to translate creatives' vision into actionable processes for artists. "We're filmmaker-friendly and filmmaker-first," explains Mathis. "We can start at the greenlight phase, where directors have ideas for sequences and want to visualize something for development quickly. We also work with the cinematographer to help work out color, mood, tone, and atmosphere- we do everything in Unreal Engine."

"At this point, we're well beyond traditional previz, and we call it advanced visualization," Mathis continues. "For *Europa*, our visualization helped guide the student filmmakers and help them collaborate with the more experienced professionals. Torchlight also acted as the bridge between the cinematography team, the VAD, and the production designer. It helped with the blending and goal of capturing as much in camera as possible."

CINEMATOGRAPHY ADVANCES

Cinematography was another important area of investigation for *Europa*, with the added complexity of cinematic anamorphic lens distortion using Cooke optics. Cinematographer Erik "Wolfie" Wolford leaped at the opportunity to dive into *Europa*. "The challenges for a cinematographer include knowing about Unreal and the etiquette for how and when to talk to the folks in the VAD," observes Wolford.

"What's great about working on an ETC shoot is you don't just punt when the technology gets stuck, but you lean into it and explore," Wolford adds. "So that means we get to try new ways to track cameras, explore new metadata filing techniques and image-based lighting systems. We also leaned into the power of the Venice 2's native 3,200 ISO, which is almost a see-in-the-dark look. We could use the wall and lighting to get the exact look we were after."

Asked about his approach to working on an educational vs. for-profit production, Wolford adds some additional perspective.



"When working with students, I love to vocalize my process, so I'll talk out loud about what lights we're putting where and how, for example," he says. "But our main area of learning was with the Cooke anamorphic lenses. Specifically, how does Unreal Engine handle the look and distortion, and how does it impact the actors' depth of field? The anamorphics have a minimum focus of three feet, so you can't get the claustrophobic close-ups of characters in their helmets we sought. So for those, we'd switch to a 68mm Cooke S7/i series spherical lens."

Because the Cooke lenses and the Venice capture massive amounts of metadata, Wolford made a concerted effort to preserve it. "Movie productions have traditionally been great at capturing metadata but terrible at organizing it and delivering it to the downstream teams who need it," he says.

"The visual effects teams benefit the most from metadata. Knowing which lens was used on which shot is a massive help in adding effects that match. Editors and colorists also benefit from metadata, so we must ensure it is preserved and available to everyone. Dane Brehm and his team at **Cintegral** were instrumental in the effort to collect and leverage metadata."

Asked about how virtual production compares to traditional VFX work, Wolford shared his perspective as a cinematographer with plenty of experience in both modes. "I remember when everyone said green screens would never look as good as everything practical, and it's often the same attitude toward LED walls," Wolford says.

"I'd love to shoot everything practically, but as we're not flying to Europa anytime soon, I want to use every modern tool available. To take advantage of these workflows, you must continuously educate yourself- take CG Pro classes and learn OSVP and Unreal Engine. Pick a wedge that you're passionate about and become an expert in that wedge."

IMAGE-BASED LIGHTING

One of the most complex and intriguing aspects of OSVP is the combination of virtual environments with cinema lighting, which dramatically enhances a shot's realism when done correctly. Image-based lighting (IBL) is a powerful tool for this purpose. It converts images and video footage into corresponding hues and intensities in physical lighting. Longtime IBL expert Tim Kang, who also sits on the [ASC MITC Lighting Committee](#), brought his expertise in this area to *Europa*, which included leveraging [Aputure's Sidus Link Pro](#) light control app.

"Tom and Erik brought me onboard because they felt the story of *Europa* lent itself to IBL," recalls Kang. "The work of ETC, especially with [Paul Debevec](#), started with investigating lighting and created the first examples of image-based lighting originally for CGI effects. Also, Wolfie loves working with Aputure, where I work. So, my two major tasks were to train the crew, including Gaffer Steve Mangurten, on the workflow and to provide technical support to ensure everything worked."

"The original concept for *Europa* was to be able to sample the environment directly and feed those values live to physical lights," adds Kang. "But it was impossible to devote an entire render node of the system for that purpose, so the compromise was to render video plates for each environment and use those to map lights. So it's the same environment being mapped, just not influencing the lighting in real-time."

Kang also worked with the team to create practical effects through lighting. "Wolfie wanted rippling water and caustic effects for the cave scenes, which we were able to achieve," says Kang. "One of the big takeaways is finding ways to convert from the RGB color space inherent in a video signal into the HSV color space that a gaffer is accustomed to using to control cinema lights. I figured out a direct way to do a handoff from a DMX console to Aputure lights with a color model that goes from RGB to HSV. The human factor is important, not forcing people to use something non-intuitive to achieve a desired effect."

For Kang, the ultimate goal of IBL is to make lighting more accurate with less abstraction. "You can only go so far with video screens as lighting sources, especially since they don't cover the full spectrum," says Kang. "Lighting professionals are looking for nuances in their lighting setups, and you need a range of tools to achieve that. You can deploy many lights, and IBL helps increase the transparency to convert from vision to execution."



COMPLETION OF PRODUCTION

Production on *Europa* lasted from February 5th to 24th, 2024. During this period, the team had approximately nine shoot days, and the remainder went toward set builds, VFX coordination, stunt planning, coordination and other related activities.

Although many shots were captured completely in-camera, as is often the case with OSVP, additional enhancements were planned for post-production. In addition to extending live-action shots, fully CG VFX shots were also part of the plan. With production completed, post continued for the next few months, with the first edit seen at NAB 2024 in Las Vegas in early April.

roduction - post-production - post-production - post-production - post-prod

REMOTE COLLABORATION

With so many of the post-production teams decentralized across the globe, a cloud-based workflow was essential. Eric Roth supported the many teams across different solutions and vendors. One of Roth's goals was to find ways to quickly scale up with VFX artists on a per shot/sequence basis. Often, VFX budgets go out of scope because the infrastructure and personnel needed to tackle a shot are not as agile or efficient in quickly gathering all the required resources.

"We worked with Jason Fotter over at **Bind Studio**," explains Roth. "Jason wanted to solve a challenge for smaller VFX studios when they get assigned a project for the short term and need to quickly scale up infrastructure and artists that aren't already on staff."

"The trick is finding the appropriate software, the compute, cloud, etc.," Roth continues. "Jason has built an agile system that you can spin up and say, 'I have hired these three artists. Here are the credentials.' You log in through **Teradici** or something like it and start working signed in through ShotGrid or whatever you want. It greatly simplifies my work as a VFX

supervisor and makes expenses and timeframes much more predictable."

According to Fotter, the pandemic accelerated remote collaboration and loosened the studio's reluctance to embrace it, but content security is still paramount. "The cloud is the internet, and we need to access tools, but we need to do it most securely," says Fotter. "In a traditional VFX environment, that typically means egress control. As a user, I can accidentally or purposefully put content media files in a place where they're not supposed to be."

"We accomplish that via networking protocols, firewalls, URL filtering, etc.," Fotter adds. "Every project has different tools approved by the show's security footprint. One project might allow Dropbox, but another requires everything through File Runner or Media Shuttle. Once we determine the parameters, we spin up the environment and then provision the users with MFA and a single sign-on. Everything is self-contained and siloed off through the Bind network."



CLOUD-BASED POST-PRODUCTION

The *Europa* team worked to optimize the dailies and editorial workflow. Collaboration was transformed out of the necessity for remote workflows during the pandemic. Before that event, typical studio post-production was done via LANs within shared facilities to avoid the potential theft of valuable intellectual property. Now, studios have leaned more into cloud-based workflows with improved sharing and security protocols.

A CLOUD-FIRST APPROACH

Dane Brehm, a Production Technologist at Cintegral Tech and an Innovation Engineer at Verizon Labs, helped facilitate *Europa*'s cloud-first workflows. Brehm says, "We're trying to take traditional production and post-production methods and merge them more with one concise cloud-first Movielabs-type approach. Wrangling all the different teams, making sure that there's interoperability and a clean handoff, that's the value add."

With much of the production team scattered across the globe, a seamless experience was paramount. "It's about how can we have partners in India

while we're at night while we're asleep work on the West Coast and how can we leverage our New Zealand partners who are a few hours behind us to do all of our dailies," Brehm says. "This enables us to have dailies within a very short period to allow our editors to start working whenever they want to. The bottom line is bringing the people to the data instead of moving drives around and setting up systems and on-prem storage just to move all that data."

For Brehm, the primary focus was the practicality of their work. "Everything we do has to be applicable in a real-world environment," he says. "We want to be able to go to Fox Studios or a production company and give them a precise estimate of the costs for a specific workflow. This applies not only to the physical production but all of the cloud costs and infrastructure necessary to support it at the best level."

CLOUD EDITORIAL

Vanessa Kao was one of two main editors working on *Europa* and made excellent use of the cloud workflow on what ended up being her first experience with virtual production. "We work on **Avid**, but we remotely sign into Sony workstations," Kao explains. "It's pretty convenient because we can sign into Avid from anywhere between myself, Thomas, the assistant editors, and Jacqueline. And we can all be looking at the same project simultaneously, which makes our lives so much easier."

Kao also appreciated the integrated script notes and other metadata provided by the team at Rebel Fleet. "Since I was brought onto the show late into production, having all the script supervisor notes was incredibly helpful," Kao says. "Europa shot a lot of footage for a short film, and many shots were combinations of scenes. Without all those notes, I would be lost."

Although many of the major effects scenes were captured live on the Pixomondo stage, some required additional effects to be added during post. "I learned to be very flexible and use my imagination to collaborate with the creative team and the VFX teams to understand the timing and angles of shots that weren't complete," Kao says. "The virtual production shots were great because so much more was there than would be on a green screen shot."

Asked for specific observations that might assist future decentralized productions, Kao offered her experiences. "It's very beneficial if all the heads of department get together before going into post to make a feasible timeline," she says. "Just knowing from everyone what's doable and what the procedures are should all be considered for the schedule. Choosing what will look best on an LED wall vs. more traditional visual effects is an important skill for filmmakers. We don't want the audience to focus on how or where something was shot. We want them to be immersed in the experience."

ERIC ROTH ON ARTIFICIAL INTELLIGENCE

Although Europa initially focused on advanced virtual production techniques, artificial intelligence tools evolved so rapidly during production that the team tested generative AI for portions of post-production with tools ranging from

Runway ML to Cuebric. Eric Roth spearheaded the effort to investigate AI to enhance some shots in post-production and generate entirely new ones.

"My process is a collage of many things," Roth explains. "Let's say I'm working with some assets in Unreal, and I might have a particle effect or a background I'm working on. I'll test out generative tools when I can't finish something under budget or time." Collaborations with AI companies like Runway and Topaz offered Roth hands-on support. He notes, "Our two main partners in the AI post world were Runway and Topaz. When we couldn't figure out something, they'd look at the shot and show me how they would do it. That was incredible because those teams know their tools better than I do."

Through his experimentations on various shots, Roth found style transfer was the strongest use case for generative AI tools. "We were working on the shot where a hand forms out of the water in the cave and touches a human hand," he recalls. "I didn't want to animate and shade it, so I tried Runway. Their team suggested dipping my hand in paint and filming that. Then I prompted it to liquefy, which looked like what I wanted to see. Doing the thing that mimics what you want to see and using that as a starting place for the AI will ultimately get you there."

"I see a world that's almost real-time—here's you on stage with your green screen, and I've changed you into the avatar or costume I want you to be with AI tools," Roth adds. "It's that same thing that we've done previously in post—make changes to what the footage looked like during production because we changed our mind or want to enhance something."

RUNWAY ML EXPLORATIONS

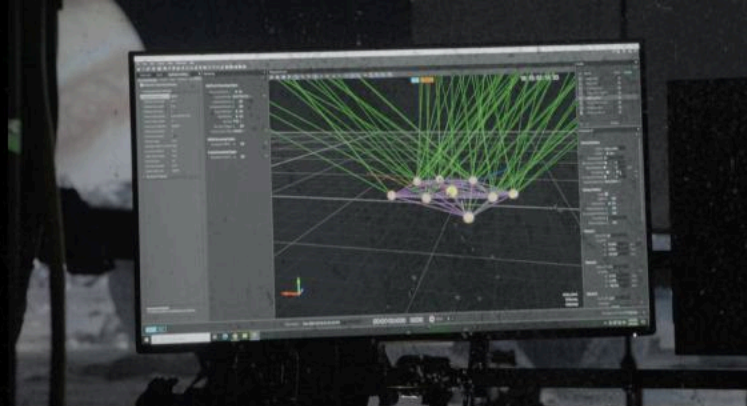
Runway ML substantially accelerated its generative AI tools for video during the production of *Europa* to the point that filmmakers looked to it as a solution in post. One sequence, in particular, involved a live-action shot on the stage with a

green screen in which an astronaut interacts with a water geyser. The filmmakers experimented with Runway to compose a background shot to composite with the live action. Runway workflow specialist Ian Sansavera worked closely with the *Europa* team.

"The geyser shot was already sound designed, so I had cues for when the geyser shut off and the astronaut fell," recalls Sansavera. "I started with a prompt for a still image, a top-down aerial shot of a geyser on an alien-looking planet with golden teal color tones, muted colors, cinematic lighting.' Then, I animated it with our image-to-video tool. We have a method where you define the first and last frames. So I reversed that shot and had the geyser gone for the last frame. Finally, I motion-tracked the original footage and rotoscoped the actor onto the generated plate."

Runway then returned the shot to the *Europa* team for further development, but according to Sansavera, today's generative AI workflows are just the beginning of its potential. "At Runway, our north star is creating a general world model," Sansavera explains. "It's a model that understands everything about the world. So you can move all around a character at will, and it should look as consistent as you do. What's true about traditional 3D programs, like XYZ coordinates and fine grain lighting controls, goes away, and the model you're working in is designed and controllable by you, but on a global scale."

With many filmmakers concerned with the disruptive potential of AI in the current job market, Sansavera offers some advice. "You're never too old to learn these new workflows and AI is new for everyone right now," he observes. "You can learn a lot by watching tutorials and experimenting on X, YouTube, etc. Find an aspect of AI that resonates with you and what you want to do in a career and search for that stuff, be it filmmaking, architecture, etc. Ultimately, we offered *Europa* a way to iterate rapidly and overcome creative hurdles by showing many possibilities."



GENERATIVE AI WITH ASA BAILEY

AI and virtual production specialist Asa Bailey also worked with Runway to experiment on a handful of VFX shots depicting the mission's arrival to Jupiter and Europa. "My process began with reference shots I received as previs," Bailey reveals. "I used the image to video in Runway and did various iterations to see what it would look like. The challenge with AI is to keep everything in a cinematic language."

Bailey is well-versed in more traditional visual effects tools, so he can note the differences AI brings. "Fluid effects are challenging and expensive for most VFX tools, while AI can accomplish those quickly and economically. I believe many fluid simulations from traditional tools will not be necessary soon."

As opposed to a fully AI pipeline, Bailey prefers a more blended approach of many different techniques brought together into a compositing workflow. "Every time you do a surface-level AI and rely solely on the model's output, you mostly get a reiteration of every visual that's come before," he observes. "There is a lot of utility in how AI tools can segment an image with an understanding of depth and content that goes far beyond typical green screen compositing tools."

Ultimately, Bailey sees emerging AI tools as leading to more efficiencies vs. a massive industry transformation. "Democratization is always a good thing; everyone wants to be able to do more for less no matter what scale you're working at," Bailey says. "What Runway is doing with their alliance with **Lionsgate Studios** is an interesting experiment. When you can train and categorize data, you have full permission to do so. That's where we should be heading."

ELECTRIC SHEEP FOR AI ROTOSCOPING

The *Europa* team also collaborated with **Electric Sheep**, a company specializing in rotoscoping visual effects shots with AI. The company developed a proprietary pipeline that can automatically detect people within a shot and separate them by layer whether shot on a green screen or not. CEO Gary Palmer explains that while the process mainly automates what's traditionally been a painstaking manual process, a human artist is still a vital part of the process.

"While we do a first pass automatically, somebody typically goes in and QC's it," Palmer explains. "So you've got this iterative artist in the loop workflow. And that allows us to handle situations like partially occluded objects."

For *Europa*, Electric Sheep's task involved separating actors from backgrounds with a fast turnaround time to create temporary composites to assist the post-production process. "The point of temp comp is to get the idea across quicker," says Palmer. "The tools we're producing now are the clues of what iterating at breakneck speed looks like—where your iteration cycles go down from days to hours. That allows you to instantly think about how you will change shooting the next day, or even the same day in some instances."

With Electric Sheep's current roadmap in mind, Palmer sees the future of filmmaking taking shape, where production techniques will become more fluid as post-production becomes more flexible and automated. "Right now, we may not have every shot be something like character extraction and then re-blurring the background and reprocessing it, but we'll get to every sort of shot rotoscoping can address," he observes.

"We're at the first step toward iterating wherever you like in the pipeline and extracting all the assets whenever you want in the pipeline to your benefit. You could easily out-paint something on an LED wall or change an object in that scene, and everything will become possible."

UPCONVERSION WITH TOPAZ AI

Many generative AI video tools were relatively new during the production of *Europa*. Many were also limited to 720p resolution during this period, typically to maintain scalability and speed. These limitations are expected to disappear as the tools mature. Because the rest of the project was at 4K resolution, the generative AI shots required upscaling from 720p to 4K. To accomplish this, the team turned to **Topaz AI**, an on-device application that offers various AI models for high-quality upconversion.

"When we first heard about *Europa*, we wanted to be involved as this is a great case study of how generative AI can be used to create imagery that's up the caliber of what we can achieve with live-action cameras," says Tony Martinez, Video AI Product Manager at Topaz. "A couple of years ago, generative AI video conversion wasn't a significant part of what we do, but now it's entirely flipped with tons of demand. Technology moves forward at an incredible pace."

"Based on my conversations with the teams at Runway and with ETC, Topaz was able to substantially increase the quality of the shot we were testing together," Martinez adds. "*Europa* is an excellent way to get a snapshot of 2024 of what's possible with AI tools. Video-to-video upscaling for the moment is very important to get that extra bit of quality out of your results."

Asked to explain how AI upconversion differs from simple upscaling and sharpening techniques, Martinez says, "Our models are generally Generative Adversarial Networks (GANs) trained on many pairs of videos at different resolutions. The model has two halves: one tries to redraw all the details in a video at a higher resolution, and the other looks at the input and output with a very discerning eye looking for consistency."

The idea of starting with lower-resolution imagery and upconverting it to the desired resolution isn't limited

to generative footage sources. "Many VFX studios have realized they can essentially use a proxy workflow," notes Martinez. "They can take previs quality CG and run that through our models for a result that's passable for cinematic presentation, but in a fraction of the time they'd need to render at full resolution."

There's also a workflow that adds not just resolution but new details to the image output. "We offer a model we call Redefine, which adds controls for realism and creativity along with a prompt," Martinez says. "So if you increase the creativity controls, it will make assumptions based on the prompt and the source footage input, and the model will create entirely new details while still adhering to the structure of your visual input."

Martinez sees the confluence of traditional CG and AI as a boon to newcomers willing to embrace the tools. "As an educational tool, this lets you step into major professional workflows," he says. "I'd expect students to make great-looking previs using generative AI tools. Training yourself to add these elements into traditional footage will enable you to create imagery that might have been out of reach, making you an asset for a professional VFX team."

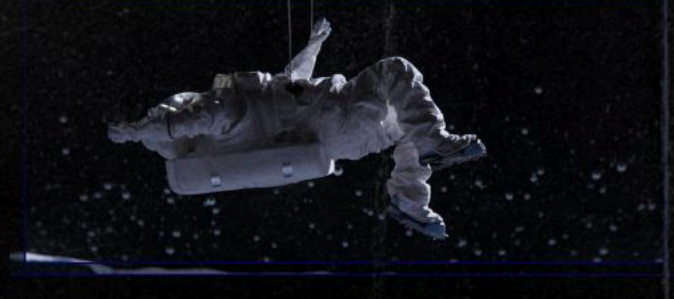
AI EDITORIAL WITH AVID

In addition to image generation, the team pioneered new ways to leverage AI for editorial. Jeremy Stapleton, Production Cloud Technology Lead at **Universal Studios**, led the effort to incorporate AI tools into Avid. "We've been heavily evolved in an ontology project, which is essentially a knowledge graph for many of our shows," Stapleton says. "Europa was an excellent opportunity to try ontology for a wider audience."

"We created a demo with a knowledge base with an LLM sitting on top of it," Stapleton continues. "It acted like a chatbot the editorial team could ask questions of, and it would pull footage and create bins based on the questions. Such as which footage contains Yvette, the character of Augustus, and what scenes they are in together."

"AI gives up the capacity to look for media in much broader ways than what's been put into the bin columns," says Stapleton. "We also have information about the script, and as long as it can be mapped back to assets, they can be found in Media Composer. It knows who's in the story and the context of everything. It gives us much power to find what we're looking for."





EUROPA: LESSONS LEARNED

"We're at a time in filmmaking where all these different processes are a way of getting the creative burst of energy from the key contributors at specific points in the production so that it influences the final frame," says Thudiyapalackal. "Also, the amount of work we did to develop our data pipeline was terrific, which also helped our VFX pipeline."

Weaver agrees that virtual production continues to evolve, and while many technical workflows have been solved, others remain. "The big challenge now is data management and understanding how valuable information flows through a system," Weaver says. "Production design is so important so you get that perfect blend between the virtual and physical set. Image-based lighting makes such a difference to the realism of the set. The different vendors came together and created a powerful and efficient pipeline."

Europa is complete and available for all to view and learn from as a project, as is this white paper. For ETC, the exploration continues toward the next milestones in cinematic technology. Each cinematic technological breakthrough, such as CGI, digital cinema, 3D/VR, and virtual production, offers opportunities and potential disruption to the status quo. With artificial intelligence next on the horizon, the human adventure of filmmaking continues.

GLOSSARY OF KEY TERMS

ADAPTIVE LIGHTING: A system where lighting on set adjusts dynamically to match changes in the virtual environment, enhancing realism in real-time production.

AI-ASSISTED COMPOSITING: The integration of artificial intelligence to streamline combining visual elements into a cohesive image.

AI-POWERED CONTENT CREATION: The use of artificial intelligence tools to generate creative content such as backgrounds, textures, or entire scenes in a production.

ALGORITHMIC IMAGE ANALYSIS: The use of algorithms to process and interpret image data, often used in virtual production for real-time adjustments.

ANAMORPHIC LENS DISTORTION: Optical distortion specific to anamorphic lenses, adding unique visual characteristics and challenges in virtual production.

AUGMENTED REALITY (AR): A technology that overlays digital content on the physical world, combined with virtual production to create interactive scenes.

CLOUD-BASED WORKFLOW: Cloud technology used to store, share, and collaborate on production assets and workflows remotely.

COLOR GRADING: The process of enhancing the color of a video or film to achieve specific aesthetic goals, often supported by metadata from virtual production.

COLOR MAPPING: The process of translating the color information from a digital or video signal to accurately match lighting in physical sets.
DMX Console: A lighting control system for managing stage lighting, often integrated with image-based lighting setups.

DYNAMIC RENDERING: The process of rendering virtual elements in real-time to match the movement and perspective of physical camera work.

EDGE DETECTION: A technique used in AI-driven post-production to identify and outline the boundaries of objects within a shot, aiding in effects integration.

ENVIRONMENT MAPPING: The technique of creating a digital replica of the physical environment for seamless blending of real and virtual elements.

FACIAL MOTION CAPTURE (FACIAL MOCAP): Capturing an actor's facial expressions and movements to animate digital characters in real-time or post-production.

FRAME SYNCHRONIZATION: Aligning frames from various sources, including virtual elements and live footage, to maintain consistent playback and integration.

GENERATIVE ADVERSARIAL NETWORKS (GANS): A type of neural network used for video upscaling, image generation, and adding new details to visuals.

GENERATIVE AI: A subset of artificial intelligence that creates new content based on training data, used for enhancing visual effects and generating backgrounds.

IMAGE-BASED LIGHTING (IBL): A technique that uses image data to generate realistic lighting conditions, enhancing the believability of virtual sets.

IN-CAMERA VFX (ICVFX): Visual effects captured live during filming, using techniques such as LED volumes to reduce post-production work.

Keying: The process of removing a background from a shot, commonly used in green screen work, facilitated by advanced software or AI algorithms in virtual production.

LIDAR SCANNING: A method of creating highly detailed 3D representations of physical spaces or sets used in previsualization and virtual production setups.

MACHINE LEARNING MODELS: AI systems that learn from data to improve their performance on specific tasks, often used in rendering, effects, and editing.

METADATA: Contextual information related to assets, scenes, or production elements, such as camera settings or scene descriptions, aiding in efficient workflow management.

MOTION CAPTURE (MOCAP): The recording of actors' movements to be translated into digital character animations, integrated with virtual production workflows.

MULTI-PASS RENDERING: A rendering technique that involves creating multiple layers of an image (e.g., lighting, color, texture) to enhance post-production control.

ONTOLOGY: A structured framework for categorizing and defining relationships between production elements, improving integration and asset reusability.

ON-SET VIRTUAL PRODUCTION (OSVP) 2.0: The second phase of advancements in virtual production, involving refined equipment and workflows developed post-initial breakthroughs.

PARALLAX ADJUSTMENT: The technique ensures virtual backgrounds adjust perspective as the camera moves, creating a sense of depth and realism.

Photogrammetry: The process of capturing and reconstructing physical objects or environments as 3D models using photos, aiding in virtual production set building.

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PIPELINE INTEGRATION: The coordination of various software and tools in the production workflow to ensure smooth data transfer and consistency in outputs.

POSTVIS: Post-production visualization simulates final visual effects before actual VFX work is completed.

PREVISUALIZATION (PREVIS): The process of visualizing complex scenes before actual production, often using 3D models and digital animation.

PROXY WORKFLOW: The use of lower-resolution versions of video files during editing and effects work to speed up workflows, later replaced by high-resolution versions.

ROTOSCOPING: A process in visual effects where elements of a shot are separated or outlined for compositing, which can be automated using AI tools.

SCENE RECONSTRUCTION: The process of rebuilding scenes digitally from captured data for better alignment with virtual elements.

SET EXTENSION: Using visual effects to create the illusion of a larger physical set by extending the environment digitally.

SIMULCAM: The real-time combination of live-action and CGI allows filmmakers to see and interact with both elements during filming.

TEXTURE BAKING: The process of pre-rendering textures in a 3D model to simplify real-time rendering, often used in virtual environments.

TRACKING MARKERS: Visual indicators placed on set to assist in post-production when aligning virtual elements with physical footage.

UNREAL ENGINE: A popular 3D creation tool in virtual production for real-time rendering and visualization of complex scenes.

VIRTUAL ART DEPARTMENT (VAD): A team responsible for creating digital environments and assets for virtual productions, crucial for previsualization and scene planning.

VIRTUAL CAMERA (V-CAM): A tool that allows filmmakers to shoot within virtual environments as if using a physical camera, providing realistic camera movements and angles.

VIRTUAL PRODUCTION (VP): A filmmaking technique that blends physical and digital production elements, allowing real-time visualization and in-camera visual effects.

VOLUMETRIC CAPTURE: A technique for capturing 3D spaces or performances, which can be viewed and manipulated from any angle in a virtual production environment.

VFX (VISUAL EFFECTS): The process of creating imagery outside the scope of live-action filming, often integrated seamlessly using virtual production and AI tools.

XR STAGE: An extended reality stage that combines AR, VR, and MR technologies for a fully immersive virtual production setup.

ZERO-LATENCY TRACKING: A tracking system that updates in real-time with no perceptible delay, essential for seamless virtual production experiences.

COMPANY WEBSITES:

- [Aputure](#)
- [Bind Studio](#)
- [Cintegral](#)
- [Electric Sheep](#)
- [Pixomondo](#)
- [Rebel Fleet](#)
- [Runway ML](#)
- [Sony](#)
- [Topaz Labs](#)
- [Unreal Engine](#)

RELATED READING:

- [AI in Post-Production](#)
- [Advancements in Image-Based Lighting](#)
- [Cloud Workflows in Film Production](#)
- [Future of Virtual Art Departments](#)
- [Generative AI and Film Effects](#)
- [LED Wall Technology in Production](#)
- [Metadata in Digital Filmmaking](#)
- [Runway ML Blog](#)
- [Unreal Engine Virtual Production Guide](#)
- [Virtual Production Overview](#)



ΕΥΡΩΠΑ

EUROPA:

AN ODYSSEY INTO ON-SET
VIRTUAL PRODUCTION

BY NOAH KADNER

