

VIRTUAL PRODUCTION & BEYOND

SLAYING THE
MYTH TO
UNCOVER
THE TRUTH



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CASE STUDY: SHORT FILM

KAPRI TREMARRI CATHERINE MICHAEL NOTLIM and TIKA
LADD LIMBRICK KILBOURNE SAUNDERS with TAYLOR SUMPTER
as
"MOTHER"

FAT HEAD

A C. CRAIG FLICK



Presented by the
ENTERTAINMENT
TECHNOLOGY CENTER at
THE UNIVERSITY OF
SOUTHERN CALIFORNIA

etc

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It is available to read online at <http://www.tinyurl.com/fathead-wp-cloud>.

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The Third Floor is a pioneer in virtual production, with many early breakthroughs achieved for *Avatar* and *Game of Thrones*. They enable early planning, empowering filmmakers to visualize ideas on giant display screens and avoid traditional VFX, where filmmakers are sometimes making decisions on diminishing returns. The Unreal Engine Fellowship and adoption by productions such as *The Mandalorian* are further driving the evolution of virtual production.

[**Keywords:** The Third floor, virtual production, visualization, film, television, games, themed attractions, Fathead, COVID, The Mandalorian, decision-making, workflow, VFX, Unreal Engine, Game of Thrones, Eric Carney, Casey Schatz, previs, techvis, safetyvis, postvis, Taika Waititi, early planning, and creativity.]

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[**Keywords:** Sam Nicholson, Stargate Studios, virtual production, visual effects, predicting the future, technology, engineers, production, artistic battle plan, virtual production supervisor, Taika Waititi, Our Flag Means Death, multi-camera setups, LED wall, CG layers, compositing in real-time, resourceful solutions, novel problems, unorthodox solutions, edge of technology, limitations, pre-production, horizontal multi-plane camera, and cost-effective.]

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[**Keywords:** Kevin Baillie, VFX supervisor, *Pirates of the Caribbean: At World's End*, *Transformers: Dark of the Moon*, *Star Trek Beyond*, *Welcome to Marwen*, *Pinocchio*, Robert Zemeckis, motion capture, real-time game engines, virtual production, LED walls, virtual camera, movie set, cross-cultural assimilation, production process, post-production, creative process, workflow, culture, movie industry, hands-on experience, visual effects, and talent base.]

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Experimentation with LED panels in his garage led A.J. Wedding from being the head of production at Raleigh Studios to co-founding Orbital Virtual Studios, which acts as a go-between for technology and traditional film production. He discusses the advantages and potential of virtual production in saving time and money for shows, citing examples from the FX series *Snowfall*.

[**Keywords:** Wedding, Orbital Virtual Studios, virtual production, film industry, *The Mandalorian*, visual effects, 3D, cinematographer, LED panels, Planar, COVID lockdown, proactive testing, production experience, traditional workflow, manufacturer, investors, *Snowfall*, John LaBrucherie, FX series, video plates, translucent backdrops, infrastructure, time-saving, and cost-saving.]

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[**Keywords:** Vū, Emmy award-winning director, CEO and co-founder, Diamond View Studios, full-service virtual production, Las Vegas, Nashville, Tampa, Orlando, studio network, environments, decentralized Hollywood, 2D plates, 2.5D, 3D, connectivity, Mark Roberts motion control, Unreal Engine 5, 24K processor, and dark fiber.]

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[Keywords: in-camera visual effects, Unity Technologies, Wētā Tools, real-time visual effect, previs, 2D orientation, 3D visual environment, volumetric capture, immersion, AI graphics, color pipeline, Virtual Art Department, VP stages, SpeedTree, and XR glasses].

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Lux Machina prioritizes education through shadowing opportunities for on-the-job training. They aim to address the challenges of building out education plans at scale and adapting to the complexities of COVID. For example, troubleshooting is identified as a significant skill gap, with few educational opportunities to gain hands-on experience in the high-pressure environment of live television. In addition, the cross-section of hardware, software, and soft skills currently needs to be added to education processes for virtual production.

[Keywords: Lux Machina, education, shadowing opportunities, COVID, troubleshooting, entertainment industry, virtual production, soft skills, vocational training, university classes, high-pressure environment, live television, on-the-job training, hardware, software, film industry, corporate work, Fox upfronts, PBS, Emerson College, real-world pressures, entertainment problems, and relevant into 2024.



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[**Keywords:** Unreal Engine, Connectors Program, Epic Games, M&E (Media and Entertainment), virtual production, animation, visual effects, Unreal Engine Fellowship Program, pandemic, stipend-based program, industry professionals, real-time technology, demo reel, credits, selection process, rubric, referrals, business development community, technical account managers, upskilling, global applicant pool, academic institutions, real-time graphics, in-camera visual effects, world-building, ICVFX, storytelling, cinematography, lighting, and authorized training partners.]

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Virtual production is a new technology that allows filmmakers to create realistic and immersive virtual worlds. nDisplay is a tool developed by Epic Games that can be used to create these virtual worlds. Vitalii Boiko, the creator of nDisplay, believes that virtual production has the potential to revolutionize the film industry, and that Epic Games is playing a key role in its development.

[**Keywords:** nDisplay, multi-display rendering, unreal engine, real-time, virtual production, graphics, 3D, animation, game engine, VR, AR, LED walls, digital sets, rendering, software, hardware, NVIDIA, GPU, scalability, collaboration, remote teams, immersive, and display technology.]



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This white paper is aimed at key stakeholders in related industries attentive to the developments and inquiries into ‘virtual production’ workflow strategies and solutions. While the term has only recently been widely adopted, much to the credit of *The Mandalorian* television series, and LED volumes and stages are now popping up in every corner of the world, there is great mystery surrounding the potency of the technology.

Producers are clamoring to understand whether adopting will save them money and time. Can film and television productions of any size take advantage of the technology? Are there enough technicians and artists to meet the demand? Are we there yet?

A suite of tools and workflow integrations for merging the physical and virtual worlds to create a seamless, immersive experience for the audience is reductively termed virtual production.

The term encompasses various technologies ranging from game engines, AR, XR, VR, VFX, cloud computing, LED display walls, motion tracking, broadcast solutions, and traditional cinema tools. The convergence introduces growing pains. Beyond expanding one’s vocabulary to recognize expectations across numerous partners, there is an urgent need to match cultures to encourage synergies.

The techniques employed to achieve in-camera visual effects (ICVFX) are not new. These principles have been in use since the 1930s. Rear projection was used primarily for driving sequences, soon replaced by the front projection technique, which underwent numerous iterations.

Movies as recent as *Oblivion* (2013) and *Spectre* (2015) have utilized versions of front projection to achieve in-camera effects to avoid the tedious and pricey post-production process.

Both back and front screen projections have a common drawback — neither can produce

the illusion of 3D space, generally identified by the parallax effect. The imagery projected on these screens, commonly termed plates, is video footage captured on a high-resolution camera. These images are in 2D, where the time of day, arrangement of physical assets, and composition are locked.

Chroma key compositing involves a green or blue screen to separate foreground actors and physical environments from the surrounding regions to blend in computer-generated environments and effects by keying out the green or blue regions. It has remained the dominant method in VFX for decades.

Nevertheless, the green/blue screen compositing process is cost- and resource-intensive. The final image usually takes several months of painstaking effort involving huge teams required to key out the background, apply spill suppression, perform edge and matte cleanup, keyframe camera tracking, and, if all else fails, we employ roto-scoping. The illusion may still break at the level of color matching or fidelity.

All along, through pre-production and production, outside of privileged crew members and technicians with access to the previs and others planning materials and tools like simulcam or live, real-time composites to preview the finished frame, everyone else, including the actors, operate with little or no clue about the world in which they exist.

The LED display panels screening a 3D environment processed in real-time by a game engine only solve some challenges of working with previously available technologies and limiting production workflows. But understanding its benefits early on will help productions rely on this process and push the boundaries to deliver significant improvements.

It is imperative to disclose that our explorations on the ETC@USC short film *Fathead* are less exhaustive than we would have liked,



since we functioned through rough periods of a global pandemic that introduced unfavorable conditions where otherwise standard practices and prescribed processes were unattainable.

To cite one example, the predecessor to this paper for the preceding short film *Ripple Effect* was widely circulated, which strongly recommended using virtual scouting,

VCam sessions, and techvis. However, these valuable and essential tools were only partially explored in our current production due to earlier stated reasons and other factors that may be harder to quantify.

Other productions may experience similar disadvantages, and reporting fairly about workarounds will only encourage teams to generate more easily accessible tools and resources.

Most, if not all, of the crew and partners on board volunteered their time, expertise, and resources to the production. Volunteer time management is a challenge all unto itself. No clear incentives or penalties may be enforced to motivate these participants, and several well-meaning contributors had to leave in favor of paid work and career advancements.

Finding equally-skilled replacements is time-intensive, ballooning the timeline and adding extra strain on those who remained committed to the project. It is plausible to assume that some long-standing contributors may have experienced fatigue and burnout as the end date got extended repeatedly.

The process of making *Fathead* was a valiant effort by the many who stuck through the odds and pursued it despite the challenges, shortcomings, and a pandemic. The full potential for *Fathead's* extensively complex and rich world of lively characters was realized as best as possible. It only shows how much more remains for further exploration in successive ventures with larger budgets and inexhaustible backing. ■

AWARDS & ACCOLADES



Outstanding Short Form,
(Live Action)



Jury Award Winner Emerging
Filmmaker Showcase



8th Annual Moebius Film Festival



HBO® SHORT FILM AWARD,
Finalist



Official Selection/
Best Cinematography Nominee



Jury Award Winner,
Kids' Choice Award



Official Selection



Official Selection
for Competition



Official Selection
for Competition



RIFFA

Official Selection
for Competition



EXECUTIVE SUMMARY

The Entertainment Technology Center (ETC) is an industry think tank at the University of Southern California (USC) where leading contributors from multiple industries supporting the creation and distribution of entertainment convene to explore challenges, investigate remedies, and share findings. In this spirit of discovery and dissemination, ETC produces a short film helmed by a recent master's graduate from the School of Cinematic Arts (SCA), supported by industry professionals, technology partners, and generous resources.

Fathead is the latest offering, a short film written and directed by c. Craig Patterson, backed by over 300 people from diverse backgrounds who have invested heavily to make this poignant narrative come alive on screen. The white paper investigates the journey, the experiences, and the learning — and it will go even further to engage leading industry voices to interpret the long-term implications of the recent transformations brought along by virtual production.

The production of the 19-minute film was epic in scale, investigating numerous pipeline and workflow integrations involving freshly-minted technologies and adapting them to existing practices. These involved complex processes to generate an army of virtual humans to populate the digital environment on the LED wall, photogrammetry of several real-world assets as large as a plane fuselage, creating three digital environments in Unreal Engine, and working with several motion capture technologies. The film was shot at one of the largest LED volume stages in the U.S.

The story takes place in a fictional junkyard where unsupervised children roam free. Most of the cast were children, and only one adult actor was featured in the script. The combination of needing to be in a hazardous environment with children and many of the sequences taking place at night naturally benefited from shooting at an LED volume where any time of day or night could be achieved with the click of a button, and the perils were averted by manufacturing the environments digitally.

In most cases, the creatives and heads of departments had arrived with formal training and practical exposure

to well-established production principles and were new to virtual production. Getting familiar and gaining confidence with the novel tools and methodologies provides a solid case study with far-reaching implications. The interviews, insights, and snapshots of the processes deliver ready access for anyone wanting to dive in and adapt virtual production as a career advancement or a pipeline innovation.

The production benefited richly from the participation of three-time Academy-nominated VFX Supervisor Scott Squires, leading technologists like Digital Imaging Technician (DIT) Dane Brehm (*Avatar 3*, *Westworld*) and Post-Production Supervisor James Blevins (*The Mandalorian*), companies big and small from cloud giant Amazon Web Services (AWS) and global visualization leader The Third Floor (TTF) to the marker-less, suit-less motion capture system Move.ai and digital asset management ecosystem at the 5th Kind.

The tireless dedication of solutions architects at all our partners who devoted endless hours to listen to our needs and rapidly investigate and deliver remedies is the central pole that holds up this tent. ■

CHAPTER 03.

STATE OF THE INDUSTRY



The objective of the white paper is to acquaint the reader with the intricacies of virtual production by reviewing the experience on the ETC@USC short film *Fathead*, but it is equally vital to be aware of its implications on the path forward. The practical way to deliver this foresight is to have the pioneers offer us an exclusive look at the field from their exceptional vantage point.

We gathered insightful interviews with **Dane Allen Smith** (chief strategy officer at The Third Floor), **Sam Nicholson** (founder at Stargate Studios), VFX Supervisor **Kevin Baillie** (*Star Trek Beyond*, *Pinocchio*), **A.J. Wedding** (co-founder at Orbital Virtual Studios), **Vitalii Boiko** (inventor of nDisplay), and several others who enlighten us about the ways technological innovations have reshaped visual storytelling and what it means for the future of cinema and entertainment.

One of the compelling reasons we elected to add this chapter was a direct result of virtual production technologies advancing from one generation to the next in as little as six-month intervals. *Fathead* commenced in April 2021 and concluded only around early September 2022. During that time, Unreal Engine saw two major versions released (4.27 & 5.0); the MetaHumans arrived and soon saw a major upgrade to include the ability to have personalized MetaHumans from scanned meshes of any person.

LED manufacturers are actively investigating ways to improve several facets of these panels to align them

to filmmakers' unique needs. Image-based lighting is gaining traction, and its use cases are growing as equipment manufacturers, stage operators, and creatives take note. Stages are evolving and growing smart through faster connectivity and the ability to engage remotely. The artificial intelligence tools for a variety of tasks within these pipelines are growing rapidly and becoming more reliable.

The shared commitment among innovators in the space is to elevate the tools to match creative intuitiveness to expand the imaginable limits of artistic expression. The future is **bright**.



3.1

PHENOMENAL EVENTS, EXTRAORDINARY MEASURES



THE THIRD FLOOR (TTF) IS A LEADING VISUALIZATION STUDIO THAT UTILIZES "THE VIRTUAL WORLD TO IMAGINE, PLAN, AND PROBLEM SOLVE FOR STORIES IN FILM, TELEVISION, GAMES, VR, AND THEMED ATTRACTIONS." THE ETC TEAM BEHIND THE SHORT FILM *FATHEAD* WAS FORTUNATE TO HAVE THE BACKING OF TTF'S LOS ANGELES-BASED CREATIVE PROBLEM SOLVERS TO GUIDE THE FILMMAKERS ON THIS PRODUCTION.

WE ASKED DANE SMITH, CHIEF STRATEGY OFFICER AT TTF, A FEW QUESTIONS TO ASSIMILATE A BROADER UNDERSTANDING OF WHERE THINGS ARE HEADED IN VIRTUAL PRODUCTION. SMITH DISCUSSED HOW MOVIE MAKING IS EVOLVING FURTHER INTO REALIGNING RESOURCES TO HELP EFFECTIVELY IDENTIFY VISUALS IN THE FRAME WELL BEFORE THE START OF PRODUCTION.

IT DIDN'T HAPPEN OVERNIGHT

Some producers and creatives are more likely to adopt this approach and be open to the discipline demanded in achieving these goals. TTF paved this road with shows that required the most from each contributor, and "a cookie-cutter solution" was never an option.

"Every production starts with the same statement: 'We want to do something that's never been done before,'" explained Smith. "The Third Floor engineers solutions based on needs that organically come up."

Smith pointed out the role COVID and the success of Disney's *The Mandalorian* played in "the wider adoption of virtual production." The growing demand has "allowed TTF to build an internal R&D team." It's important to note, as Smith put it, that "the entire virtual production workflow rewards people who are in a position to make decisions early and stick to them."

However, this may be a hard sell for some productions for two main reasons: "One is the financial model," suggested Smith. "The financials of major productions typically spend the very least at the beginning." Secondly, "there's also a creative mind-set that if they commit too early, they'll be locked into something that may negate any future chances of serendipitous moments, which might inhibit their creativity."

According to Smith, once folks arrive "willingly or dragged in kicking and screaming," they soon realize that "virtual production enhances creativity." Equating it to driving with a roadmap, Smith said, you can afford to confidently take "a detour and do something cool" because "you know the way back."

Filmmakers who recognize the benefits "insist on this workflow" because when you don't, you end up making the film in post-production, "which is a traditional visual effects (VFX) pattern." Smith believes traditional VFX rooted in the editorial process is somewhat "unfortunate," as the filmmakers end up "making decisions on diminishing return." The original vision held by the creators "on day one, when they yelled 'action' is now being compromised — and it's costing more than it should."

The filmmaking process starts with interpreting words on a page, and no two people end up with an identical image in their minds. "When you use virtual production, whatever you have in your mind will be on a giant display screen for all to see." The problem of misreading or misconception vanishes.

"The savvy advocates of this technology, people like Taika Waititi and others grasp it, use it and understand it — and it empowers them creatively," noted Smith. "The results are spectacular ... visually, narratively, and in every aspect."

The show that pushed things forward at TTF was the predeces-

sor of *The Mandalorian*. Smith reminisced that *Game of Thrones* was a “moving train with ever-increasing demands, ever-increasing audience, ever-increasing budget. The only thing that didn’t increase was the schedule.”

The show won awards and wide recognition, which Smith attributed to “moving at breakneck speed and setting the bar higher and higher.”

Carving a path where none had ventured before, TTF’s CTO Eric Carney and Head of Virtual Production Casey Schatz were “traipsing around in the mud, taping things together and coming up with solutions, writing code on set to put out a fire that was headed towards them.” During these repeated trials, the team gathered enough fundamental understanding to build tools that would serve as more long-term solutions.

Around this time, **Epic Games**, the creators of **Unreal Engine**, “started to lean heavily into supporting virtual production in a very meaningful way — unlike other game engines.” This development, coupled with COVID and *The Mandalorian*, helped achieve “critical mass.” Suddenly, “people accept this as how we do it.”

Smith reminded us that TTF has been a pioneer in this arena, “going back to the original *Avatar*.” But the tools and processes “started to blossom on the episodic pace of *Game of Thrones*.”

We are witnessing “a gold rush for this technology,” said Smith.

NEW ALWAYS REPLACES OLD OR AT LEAST IMPROVES IT

When asked whether producers and key stakeholders appreciate the benefits of visualization tools such as previs, techvis, safetyvis, and postvis, Smith noted there is still “a reluctance on the part of seasoned crews who have not been on

virtual production sets.” Smith and his colleagues lead active advocacy and outreach to educate and inform members of various industry guilds “to help them understand where and when this is applicable.”

There’s still confusion about what virtual production signifies. People have associated it with “giant LED volumes, which is only a small percentage of what gets used to create content,” Smith said. “If you overlay a tracked graphic onto a live action set with a virtual camera, that’s virtual production.” Given that “most tablets can scan in real time, at that simple level, we could apply it almost anywhere.”

Smith has seen producers and technicians get the concept once you hand them “a tablet with VCam” or have them “step on an LED volume, and it is turned on.” There is a danger, as “the naked eye perceives those pixels on the stage differently than the chip in the camera.” The disconnect is because “you have to look at the output.”

A specially trained crew with “a whole host of new positions have cropped up to problem solve all of that.”

Using the VCam also poses some challenges, and a chain of command is necessary to indicate what “content is being used and where it fits into the supply chain.” A precise structure and training must be needed to avoid engaging tools carelessly. Smith conveyed how quickly crews grasp this potential, especially if they have “worked in traditional visual effects or get physically exposed to any of the tools or an LED volume.”

“WE ARE WITNESSING A GOLD RUSH FOR THIS TECHNOLOGY.”

ERIC CARNEY, ON THE LEFT, ON LOCATION WITH DIRECTOR MATT SHAKMAN, IN SPAIN, FILMING THE LOOT TRAIN ATTACK FOR HBO’S *GAME OF THRONES*: SEASON 7, EPISODE 4.





WHERE DOES IT ALL START?

Fully embracing a concept and effectively conveying it to others while increasing the potential for collaboration can be achieved by various methods, from storyboards to more evolved forms of digital and virtual tools. "It is a big paradigm shift," noted Smith.

We can date back to Disney or even Hitchcock, the practice of putting pen to paper and "drawing out every frame" — having these tacked to a foam board and available on set to "keep track of where you are, and whether you've got your shots." Technological advancements allow us to "break the z-axis and push into the frame." An artist can spin up thumbnails and boards quickly with a seasoned director.

However, Smith warned that "a call for robust boards or almost final-looking work at any point until you are on set can create unintended problems." He discourages filmmakers from such practice as "it is essentially throwaway work." Instead, he highlighted how quickly "machine knowledge" can "replace all those repetitive tasks."

"The goal is to communicate the story, make sure that all of the shots are there, and get everything into Avid," Smith said.

But surely, virtual production tools are not to be considered as "a solution for everything." Smith emphatically stated, "There has to be a compelling reason to do this."

PLANTING THE SEEDS OF TOMORROW

Smith partnered with **Lux Machina** Co-President Phil Galler and **Happy Mushroom** CEO & Co-founder Felix Jorge. Together, they toured studios, met numerous producers and showrunners, and approached everyone they could think of to create a white-label workflow. It was an educational tour — three people with top credentials explaining best practices. Smith recalled it as "a fascinating journey."

The Directors Guild of America (DGA) and Visual Effects Society (VES) welcomed this adventurous spirit, and other guilds stepped on board. Smith involved the VES board in Los Angeles, and Epic Games stepped up. "We took people displaced by COVID and put them through the Unreal Fellowship," explained Smith. The valiant effort resulted in "47 graduates, who are all working in virtual production now."

On the artist side, Smith has noted that this technology "favors generalists." In contrast to the virtual production pipeline, traditional VFX has everything "compartmentalized," where people end up honing a "specific craft." Once you break the supply chain into pieces, Smith said, "You can start to outsource, and then it becomes vulnerable."

He looked back at when he first started in VFX, "you had to know how to do everything." Whether or not a person specializes in textures, lighting, or modeling, "you had to know the value of what you're passing down the chain." The return of the generalists assures him that what was "lost in the 2000s is back now."

SCREENGRABS FROM
THE THIRD FLOOR
TECHVIS PRESENTATION
FOR FATHEAD.



DISPEL MYTHS & MISNOMERS

COVID fueled the remote workforce model and encouraged us to rely on work-from-home practices. According to Smith, “a good 20% to 30% of the people that work at Third Floor over the course of a year also work at other studios.”

This transient workforce floats around from project to project, working with one studio and then the next, wherever work shows up. The movement of this artist pool engenders “a transfer of knowledge.” Upper management and the executive branch generally see “less transition.”

One of the myths about in-camera visual effects (ICVFX) is that it may fully eliminate our reliance on VFX in post-production. “We’re always going to have post,” remarked Smith, explaining that on virtual productions, they may still “hang green screen and blue screen on LED volumes.”

While most traditional VFX practices exercised during production and post-production will continue to remain available as “another tool in the toolset,” the aspects that are likely to fade away are things like having actors stare at “a tennis ball and 90% of the screen real estate is green.”

Citing the downside of such approaches in the past, Smith shared that in such scenarios, “everybody standing behind the camera has a different picture in their head,” naturally resulting in unintended consequences, which are compounded when a VFX supervisor is brought in who wasn’t even on set. By now, “you’re spending much money,” and the director doesn’t approve anything until you get to “version 13.”

In his experience, Smith has observed that “virtual production makes that go away.” The bonus is that the team now has “many opportunities to do some amazing work in post.”

In the context of franchises, “there are multiple opportunities on set to combine puppetry, animatronics, motion capture, performance capture and see it all through

the viewfinder.” Assets and elements can be used as “a proxy that’s going to be finalized by a specialist, an artist or someone with a better eye,” said Smith. The post-production VFX pipeline works “as a contingency” and “it’s nice to have that.”

When productions don’t quite go as planned, you still have “that door open on a virtual production set.” However, if the original plan was to deal with things “in post, there is no door.” The pressure of the release date approaching forces decisions and compromises in post, where artists “would have continued working on it.”

According to Smith, “the pressure is moving to the right place — to pre-production. What happens on set and post is used for its best purpose.”

Education follows innovation. Smith contextualizes this phenomenon, noting that “Hollywood’s always in a race to be in second place.” Citing films such as *Avatar*, *300*, and *The Matrix* as examples of innovative works — “someone planting a flag.” While these original works are hard to finance at first, once they get made, “you have 50 lookalikes because we’ve already established that ‘this’ works.”

Defending this natural succession, Smith suggested that “on a technical and artistic level, you’re innovating and honing that craft until it becomes part of the toolset and common knowledge.” This progression is necessary as a new generation of filmmakers comes along, and “some other genius can plant a flag on another horizon, leveraging off of that.”

Smith teaches virtual production at the [Gnomon School of Visual Effects, Games & Animation](#) in Hollywood. Those graduating from his class are “stepping onto a stage and working on some spectacular virtual production effort that we could only do in 2022. That’s their baseline.” Pointing to the future, some 30-40 years from now, as their careers mature, Smith wondered, “What is that content going to look like?”



GNOMON SCHOOL OF VISUAL EFFECTS AND GAMING'S FIRST IN-PERSON CLASS ON THE VOLUMETRIC CAPTURE STAGE, METASTAGE — MANAGED BY CHRISTINA HELLER.

Questions such as, “What problems have we solved for new filmmakers, so they’re not expending energy on them?” excites Smith. He hopes to solve these challenges so the filmmakers “can expend that creative energy on the next level.” He reports from his experience in the field that a new baseline is forming that harkens back to film and special effects pioneer Georges Méliès.

Smith reminded us how Méliès could “look through the lens and see everything in real time,” and since “there were no computers, he had to paint celluloid.” Méliès “came up with all kinds of craft” to pull off the gags that “we now do with computers.” For his contributions, Méliès is “widely regarded as the godfather of visual effects.”

Following the same principle, “when you don’t have the option, you have to create something that can be seen through the viewfinder,” Smith noted. “So, in one way, we’ve come full circle. It’s an exciting time.”

MANAGING OVERABUNDANCE OF CHOICES & DECISION-PARALYSIS

Freeing up creatives to explore every available possibility, while noble, can present a decision-making conundrum unless certain other limitations are observed. Though the pressure of a release date does not impair the pre-production phase, “there’s always a deadline.” Smith explained that “any responsible production allocates resources and a wise contingency — a prudent reserve — to any aspect.” He warned of the dangers of “delaying pre-production too much, as the ripple effect can push the delivery date and budget off the rails.”

Adding that “there’s almost more responsibility than there’s ever been in pre-production to keep the train on the tracks,” he suggested there’s a greater demand to honor “the trust placed in us by our clients with their IP and their story,” and to guard against any “abuse of that privilege by holding the project hostage too long in pre-production.”

The process of exploration and iteration in pre-production is to avoid crises later in the game, as “a mistake that impacts 5% in pre-production” will balloon to result in “a 25% hit by the time it gets to post-production” in direct proportion to the exponential growth in the number of contributors.

Smith’s recommendation for producers is to adopt a “holistic view of the entire pipeline and allocate the proper resources for each stage, allowing an artist in post the time and effort they require to create something wonderful.” But sadly, folks in the post pipeline rarely ever interface with the art department or the cinematographer at a time when decisions are being made that profoundly affect them down the line.

As Smith sees it, virtual production is “bringing together the entire supply chain.” In earlier models of “large-scale visual effects pipelines, we got away from it a bit. We would create iterations and never get face time with the director.”

DIRECTOR’S SIGNATURE ALL THE WAY

“At The Third Floor, we’re on the front-end with the directors, shoulder-to-shoulder, designing shots. We’re there for the eureka moments,” said Smith about the proximity to the center of decision-making from its earliest stages. When inquired how much of the director’s vision can be retained in later phases once principal photography has wrapped and things move into post-production and visual effects, Smith noted how the virtual production and visualization techniques practiced at TTF put this team in a unique position.

TTF has direct face time with the director without an intermediary VFX producer or supervisor. “We’re practically standing there with the director, on calls with them, spinning ideas,” Smith said.

“If you’re granted X for a budget, nobody will care that you saved 10% if the end product isn’t compelling,” said Smith. There’s value to the “social bonding” that helps the team get “inside the director’s head, understanding the IP, and running with it.”

The director is handed a VCam and encouraged to explore, and the TTF team stands close by to “advise and steer.” The company has the advantage of working on “first-class content, and most of the supervisors have been here for over a decade.”

MATCHING STYLE & APPROACH

Do visual effects and virtual production usually work well as tools for certain styles of material and directors with a specific approach? There's debate whether stories steeped in realism or needing impromptu decision-making in how scenes are staged may lead to challenges operating in this space.

"I had the same prejudice going in," Smith noted. "But I was wrong." TTF is currently (circa summer 2022) prepping an avant-garde series. The film will be shot on an LED volume, and parts will be shot in black and white. According to Smith, every challenge described here "will happen in that production."

The director and showrunner come from a more experimental background, and so did most of the crew. Seeing the overwhelming presence of servers and Perforce Software, VCam, and computers making decisions "was terrifying at first, but they quickly grasped it."

With regular demos and testing, there's a constant search for the "corners that haven't been fully utilized," resulting in newer ways to exploit these tools — and it's "an expanding universe," where Smith can't think of "any style or anything that wouldn't benefit from this approach."

Most of the forerunners taking center stage in this industry, now offering LED volumes and XR stages, "were out on the last Rolling Stones or Beyoncé tour or creating compelling visuals for outdoor arenas or Coachella."

Franchises, on the other hand, "have a very tried and true method," and the transition over to virtual production may need "a bit of an adjustment period." Smith has observed the avant-garde crowd come onto an LED volume with an open mind and be amazed and curious.

Whether it is curiosity that draws you in or a desire to push the envelope, Smith noted that as far as he is aware, "there are no LED stages today that are empty. It's a very busy time for this type of content creation."

PRIMER EDUCATION & EXPERIMENTATION BEFORE STARTING PRODUCTION

When asked whether a week or two of primer education for crew members arriving on a virtual production project should be considered, Smith responded with a fervent "I do." He pointed out, "Thankfully, there is no end to credible online tutorials." These exhaustive resources result from the gallant efforts at most guilds to "bring together the best and brightest for doing post-mortems and exploring how this benefits content creators."

Epic Games has been generous with training. The Unreal Fellowship has



ART DEPARTMENT AND PRODUCTION DESIGN WORK WITH A DIGITAL, SCALABLE MODEL TO INFORM DESIGN AND SPATIAL RELATIONSHIPS ARE CAMERA READY USING CHIMERA, A VIRTUAL PRODUCTION TOOL DEVELOPED BY ERIC CARNEY AT THE THIRD FLOOR.

greatly benefited the industry by training hundreds of skilled professionals from varied backgrounds to get a baseline in game engine operation and an understanding of the principles of virtual production.

Whenever Smith gathered a group interested in the process, the stage companies welcomed the group "to run through a demo, get their hands on camera, and talk to people that have done dozens of productions and answered questions."

Emphasizing the importance of preparation, Smith said, "Due diligence is key because coming in with no experience will slow you down. There's some required work to be done upfront. There's a tremendous benefit to people learning more about virtual production and applying it where appropriate to what they're planning and then coming up with the right questions."

In this context, Smith shared his appreciation for the project led by Erik Weaver at ETC and said, "It is so important because you guys are picking up the gauntlet and problem-solving visibly and transparently."

WHO PAYS FOR EDUCATION & UPSKILLING?

Asked whether clients would be willing to add a line item in their budget for education to upskill the workforce, Smith disclosed that at The Third Floor, "plenty of resources are expended in two areas: R&D and learning and development."

The company conducts internal classes on directing, narrative, and storytelling. Though the focus was less on the technical side, recent efforts have augmented that with more specialized training. Skilled employees are encouraged to translate that knowledge and document it.

Speaking of the company culture to promote industry-wide understanding of best practices, Smith said, "If that shared knowledge is beneficial and it's not breaking any NDA or proprietary processes that we've developed, we will share this with clients, even competitors — because it benefits all of us to have a common language."

Studios may not be putting in a line item for training, but they are beginning to acknowledge that people with special skill sets are in limited supply. Naturally, this elevates the day rate for those who have undergone training and have a track record. It's supply and demand.

Illustrating The Third Floor's high retention levels, Smith shared that "we retain and train and build a culture," a philosophy to which he attributed the studio's "36 supervisors, most of whom have been with us over a decade."

There's a cyclical effect where bringing in interesting projects is important to excite professionals who entered this industry wanting to contribute to it. Smith said, "Why I'm able to bring those projects in is the culture and the environment that my creative and technical people work in — that is more important than the tools we offer, it's more important than our rate card, it's more important than the clients, because content artists that feel well respected and well trained, and have transparency into business development, they're going to stay, and they're going to create amazing work."

There's also a culture of natural competitiveness that Smith said is healthy. People stick around for the long term when there are incredible benefits beyond just the mental health of the artists, when "the content we create and the culture we perpetuate lead to growth."

AS TECHNOLOGY EVOLVES, STORYTELLING PRINCIPLES MAY ENDURE

Filmmakers and storytellers operating at the bleeding edge often say that when they move to a new project, they must relearn almost everything from scratch as the tools get completely replaced.

Narrative principles for visual storytelling have evolved gradually, but most fundamentals have survived for over a century. Regardless of the size of a spectacle, what grabs the audience and gains their commitment is still rooted in those basic principles.

"How much is an artist in tune with traditional education rooted in filmmaking that hasn't changed in 100 years?" asked Smith.

According to Smith, technology is essential. He said, "We can teach proficiency in technology." He equates this investment to the theory of the 10,000 hours one spends doing something to gain mastery.

Once anyone has developed muscle memory, they are aligned with the tools and processes. But Smith pointed out that the "less obvious, less technical" part of training in the industry is "how to tell a story with a camera?"

He suggested one must "turn the audio down and watch where the cinematographer is traveling with the camera." Through observation, one can start to relate camera movement to the tools used to achieve them (e.g., a Steadicam). The ease or vigor of the movement can evoke emotions. "What are you visually communicating to the audience? And how does that support building narrative tension that leads into the next scene?"

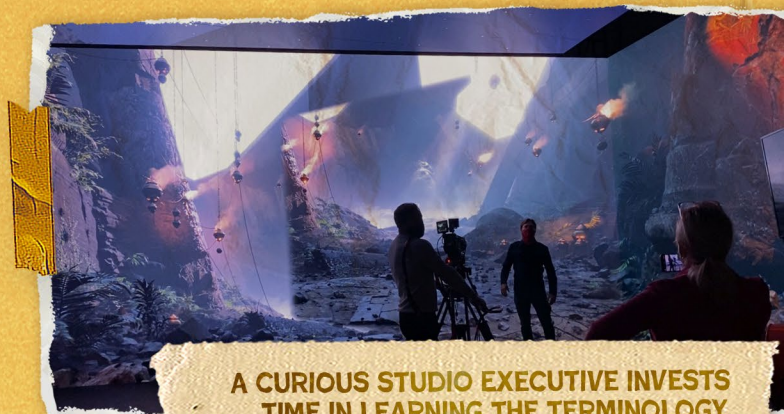
By studying the cinematic principles and film language, "things that are essential to storytelling," one can start to understand things like "lens choice, the physical properties, and limits of a camera — the glass and metal device this is all based on, and lighting direction," Smith explained.

These principles will come in handy if you find yourself "backed into a corner — you will know your options."

SUPPORTING THE STORY INVISIBLY

The hallmark of health might be attributed to the feeling that one may achieve most things without the body ever turning you down — it enables you without announcing itself. By this standard, various elements utilized to communicate story and intent must synergize and operate invisibly without overpowering other features. When the audience calls a movie a VFX film, does that tell us that these computer-generated effects may have overridden the story and emotional aspects of the experience?

We've accepted the big blockbuster releases to be riddled with fantastical visuals. These are mostly franchise projects featuring superheroes; some are not even human or have become mutants



A CURIOUS STUDIO EXECUTIVE INVESTS TIME IN LEARNING THE TERMINOLOGY, TOOLS, AND BENEFITS OF THE LED VOLUME DISPLAY OF UE ENVIRONMENTS.

or bionic. The worlds these stories are set in are otherworldly or facing extinction. There's plenty of room for inventiveness.

Naturally, the early investigations of where virtual production would fit into the overall moviemaking pipeline were linked to projects that relied heavily on visual effects. Story-driven, human-centered dramas requiring realism and believability have much to gain from adopting this new methodology — the cost savings, the ecological benefits, and the ability to capture several environments without travel and the loss of days. But will the seams show, or can the illusion of reality hold?

Three-time Academy Award-winning Visual Effects Supervisor Rob Legato presented a fascinating look behind the scenes to give us a glimpse of his visionary thought process. The 2012 TED Talk is available on [YouTube](#).

Legato shows us how he created shots of models of the Titanic in a garage three miles away from the studio to intercut with those acquired by James Cameron, who made 12 deep submersible dives to capture the wreck authentically.

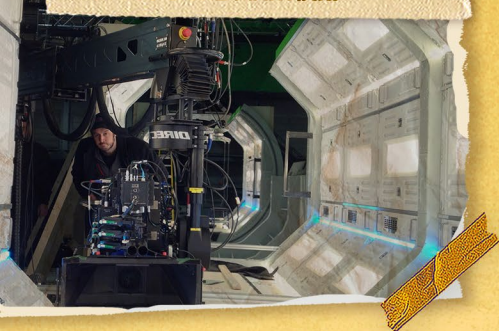
Smith referenced this talk and reminded us that Legato was the architect of *The Lion King* (2019), which earned the maestro his fifth Academy nomination for Best Achievement in Visual Effects.

Regarding Legato's model example, Smith explained, "He used models where it's obvious we couldn't get cameras down that low. The audience might feel this must be an effect. But the audience is making a social contract, and they're coming in to view content with the intent of being entertained."

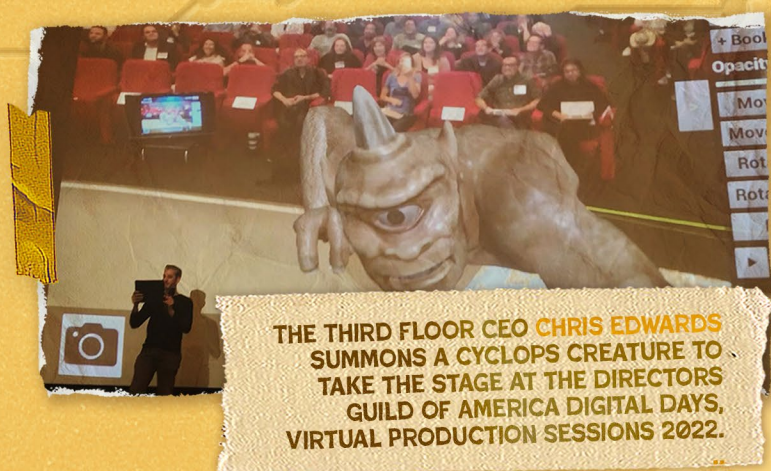
Smith emphasized that once "you set the stage and the parameters in the first few scenes or the first master scene. Then there's a debt you owe the audience that you're not going to break that visual persistence and fidelity."

"I would argue that virtual production gives you much more control over that," he stated. "And once you've achieved that, you can take them anywhere. And if you break it, people will refer to it as a visual effects film. Because you immediately break your connection with the media."

CASEY SCHATZ, HEAD OF VIRTUAL PRODUCTION AT TTF, CAUGHT IN ACTION, EXECUTING TECHVIS SUPPORT ON RIDLEY SCOTT'S *THE MARTIAN*.



"Virtual production has a unique opportunity to maintain that established sensibility throughout," Smith said, pointing to where VFX pipelines might lose the narrative "when a bad matte line or a glitch pierces the veil of suspended disbelief, and there's a sense that this feels false."



RECORD EVERYTHING, AS HISTORY GAINS PROMINENCE ONLY IN RETROSPECT

Should we have a governing body that collects data, oversees standards and certifications, and is a collection of representatives for these various groups assembled to shape this emerging field?

"Best practices will out themselves as they solve problems on set," said Smith. He draws our attention to "top industry leaders who have made a deep financial commitment" and believe they have enjoyed "much success with their specific brand of virtual production." To brand that successful model, Smith thinks these groups will contend to become somewhat of a closed system over time."

Smith does not favor "a third party coming on to name and brand things." He reminded us that these are still early days for this technology, and "there are many risks here to get it wrong."

If it were up to him, Smith wants us to "continue this glasnost, where everyone's friendly and sharing ideas ... because the demand for work is so great and the solutions are not locked in."

"It benefits the industry for us to speak to one another," he continued, describing why "it's a wonderful time."

"Right now. It's like the Golden Age," said Smith. "Things are being invented daily."

He points to *Fathead* and ETC's role in furthering these discussions and presenting an opportunity to filmmakers like c. Craig Patterson "to step in and grab the reins and do something with this technology that will become reference points along the roadmap" of how we got here.

Smith concluded with his thoughts on having a body in charge of standards and best practices for virtual production. "My concern is not so much the training or who will come up with the lexicon," he said. "Are we tracking what's happening around us right now? Because there's a seismic shift going on." ■



TRACK THE JOURNEY SO FAR

SAM NICHOLSON

Founder and CEO
STARGATE
STUDIOS



Image Credit: PostPerspective
YouTube video - Virtual Production
Workflow for 'Our Flag Means Death'

Sam Nicholson founded Stargate Studios in 1989 and built it into a leading international virtual production company with over 200 employees in seven countries. Stargate Studios has established studios and partners in Los Angeles, Atlanta, Vancouver, Toronto, Berlin, Malta, and Dubai.

WHAT IS VIRTUAL PRODUCTION?

Over the years, Nicholson has accrued over 100 credits in visual effects for leading movies and television shows where he has pioneered resourceful solutions to novel problems. On the HBO series *Run*, he engineered a solution involving 4K screens placed outside the 40 windows of a train carriage to display dynamic imagery. This technique, dubbed **ThruView**, was used to capture 3,000 shots.

Nicholson said about his approach to addressing problems head-first and arriving with unorthodox solutions ahead of the wave, "in terms of predicting the future if you look at the intersection of all the technologies, then you can kind of start reverse engineering what production will look like."

He gathers intel from engineers in the field at the top camera, lens, memory, and technology companies, as "they know pretty closely what they're going to be doing in five years."

But Nicholson believes that "technology has outpaced our creative abilities to utilize it." The edge of the virtual universe has expanded beyond known boundaries making it "easy to fall off that edge."

Nicholson prepares his clients ahead of time and builds a robust plan to predict the edge of the technology and identify "how far we can go on our real production."

When asked to describe what this proverbial edge might look like, Nicholson said, "Visual effects is a technology-driven art form. You're only as good at the pixels that you can render."

Nicholson noted, "Understanding the limitations of any technology is key to having a successful artistic battle plan that says what you are planning is going to be delivered on time and on budget."

Nicholson described the importance of an appropriate plan: "If you don't get it right in virtual production, you just cost somebody about \$100,000 for a day."

In the traditional VFX pipeline aligned with post-production, an artist could be working on wire removal in the background with headphones on, and if the computer crashed, that was not such a problem. But during an active on-set virtual production shoot, if the computer goes

down while doing playback on a virtual set, "you just shut the shoot down."

FIX IT IN PRE

Virtual production is akin to live performance. Nicholson said theater artists learned long ago that it's all about the rehearsal. You can't just walk out there and wing it.

"The higher the risk factor of failure, the more you need to rehearse, the more you need to test, and the more you need to do your research and homework to increase your chances of success," said Nicholson.

You need to have plan B and plan C. Assume that certain things will fail. An innocent request from the creative team for a Gaussian blur can make math go through the roof. GPU processors will reach their limit and crash. Citing another example, Nicholson shared that the director asked for more stars in the sky on a certain show, and everything started to drag on the wall. "We're forensically trying to furiously discover what the problem is the night before the shoot."

The team utilized Unreal Engine to create the stars procedurally, and nDisplay was employed for the off-axis projection. nDisplay adds another layer of programming compared to straight Unreal playback. When a playback in Unreal achieves 40-60 frames per second, the moment you introduce nDisplay, it can slow down to 12 frames per second due to the off-axis overhead.

Nicholson equated the role of a virtual production supervisor to "a guide in the Wild West." While protecting the team from falling off the cliff and keeping the wagons on the trail, he remains mindful not to "make the trail too tight, or it is not going to be a good experience."

Nicholson worked on the HBO Max series *Our Flag Means Death*, helmed by Taika Waititi. "We had to reverse engineer the virtual production design of that show, from how Taika likes to shoot," he explained.

The show relied on multi-camera setups to capture the complex events at sea, shot at a 165-foot by 30-foot wall constructed to surround a practical pirate ship built on set. "How are we going to set up a frustum? How are we going to have a full field of view, any number of cameras, any number of lenses?

The wall is only so high and wide, which was accurately translated in pre-production with a virtual setup that the DPs, the director, and everybody got to preview. Nicholson could then point out the edge of the virtual universe. "Here's where it works. But if you go up to 15 feet high and look down, you'll see the floor."

At that point, the options would be to fall back on the traditional green screen methods or rely on the plates if they were covered. But there's going to be a per shot cost at that point. That's where the producer gets to confer with the director and make a call.

The pre-production work helps these discussions instead of landing a surprise on set, which nobody likes.

DOES THE MEDIUM FIT SOME CREATIVES BETTER THAN OTHERS?

Nicholson pondered whether some creatives will likely take to the medium and excel at it better than others. He said, "Any background in visual effects is good because virtual production is like a giant, horizontal multi-plane camera with the background plane (LED wall), CG layers in between you and the wall, and then you have reality."

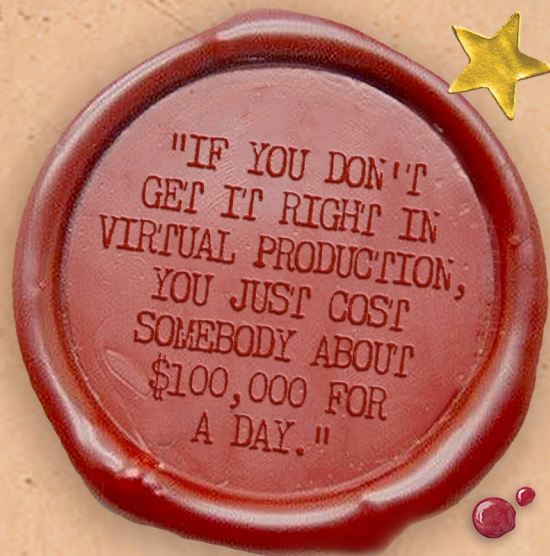
There are instances where we may introduce 3D layers in the front. Everything moves in perspective and has to be lit and balanced correctly. Nicholson said, "You're compositing in real time." The logic is the same, except it happens on a grand scale.

"When you get it right, it feels absolutely real," he explained. "You're in a position to work with all the other departments with this new technology." Citing some examples from the show, Nicholson illustrated that a person with knowledge of visual effects is likely to examine the situation differently.

When working with the production designer, one could identify that "if you build the railing of the ship six inches higher, we won't see the stage floor, and that can save a couple of \$100,000" otherwise required to cover the ground plane with relevant flooring materials. The stunt team may need to shoot at high speed, which a visual effects person anticipates and isn't worried about transferring over to a green screen.

Shooting at high speed on an LED wall may present some limitations: the size of the screen, genlock, being in sync, frame speed (Are you at 48 frames or 96?) — "You're tearing at that point; you can't do it." It might be possible on a smaller screen. That's a specialty screen that needs to be brought in. These are the things one has to solve before arriving on set.

Depending on the complexity, Nicholson advised that "it's good to at



least have a discussion with someone who's been there before to point out some of the advantages and the pitfalls."

DO IT ALL DAY LONG

The director's role is to tell the story and work with the actors, a different skill set from managing the technology. Nicholson recommended that directors need to find people on the virtual production side or in visual effects that they can trust and bring into the discussion as early as possible.

Nicholson shared that one of the greatest moments on *Our Flag Means Death* was when all the HBO execs came to the set. They walked aboard the pirate ship, rocking around with the ocean on the LED wall and the wind blowing. They all took their cell phones out and started taking selfies, and a few started feeling seasick. The horizon was being driven up and down by Unreal Engine. "The illusion worked on a physical level, not just a perceptual level," Nicholson explained.

"Keep in mind that it's Taika. This is a comedy. There'll be long takes with multiple cameras," said Nicholson. "And the more natural you can make it, and the longer you can sustain that illusion, it makes everything much easier and more fluid in the filming process. You get to be on the ship all day long. Our goal is to make it effortless."

Such an attitude would guarantee you won't last in this business very long." By developing a mindset to tackle anything that may spring up and anticipate problems ahead of time, you must learn to keep a plan B ready. When something fails, you need to kick back into action within about 30 seconds.

Implementing this attitude in practice, Nicholson said, "We didn't have a single minute of downtime in 14 weeks on either *Run* or *Our Flag Means Death*." He attributed this to the redundancy built into his workflow by having backup plans beforehand.

Citing an instance, Nicholson shared that when you're doing live tracking, one of the advantages is that you have take one, take two, take three, and so on when you repeat. The crane move is repeated, and the focus and the actors will all repeat.

If the tracking computer crashes when the director walks over to give notes and inadvertently kicks out the socket, you don't shut down the shoot. You go to a pre-recorded track from the last take, and you can drop that tracking in and cue it. "It's not perfect, but you can keep moving."

FEARLESS COMMITMENT TO EXPERIMENT

Previously far removed from the world of film production, new entrants are joining the field. Free access to tools such as Unreal Engine and Blender, along with countless hours of YouTube videos and thorough documentation explaining how to master them, has created an influx of new artists.

The high demand for Unreal operators and LED stages has attracted folks with limited knowledge or experience in virtual production, VFX, or filmmaking to dive in and set up small studios with big hopes.

Nicholson believes it's not such a bad thing after all. "If you're not falling, you're not learning," he said, recalling having made more mistakes in his career than most people. "I've learned from every single one of them."

"You don't learn unless you've got the guts to try," said Nicholson, who advises newcomers to expect failure along the road but to decide early on, "how are you going to live through it?"

Emphasizing the need for a backup plan, Nicholson said, "You can't just walk away saying, 'Oh, gee, I'm sorry, it didn't work.'"

VIRTUAL BACKLOT AND REAL-WORLD TESTING

"I see all sorts of beautiful tests with one camera," which Nicholson said falls apart on a real-world production the moment you introduce two or more cameras. On a television production, the crew generally shoots eight pages a day, which is different from one page a day on a big feature schedule with any such luxury.

If you have a one-page scene in Paris, you should do a green screen and traditional visual effects. But if you have a show where one of the characters lives in Paris, and it goes on for 22 episodes, you can have a virtual backlot in Paris. You go and shoot it, and now you can amortize its cost. You roll out an LED screen for the times that you need it.

How do you amortize repeatable sets, repeatable wardrobe, repeatable everything? Using a green screen or LED depends on how many times you can use it. If you're going to use it a lot, then you want to build a library for the show.

"We built a library of rooftops and of driving around Seattle for *Station 19*. At different times of day and night. Magic Hour. All of that stuff in Seattle." These shots were captured at 72K and future-proofed a thousand times — 72K HDRI horizontal plates. "You can derive anything you want from that," Nicholson said.

"The natural world is a 3D place," explained Nicholson. "Everything is heading towards 3D cinematography and 3D imaging cameras and sensors." He believes we'll soon look back and ask, "Do you remember when we used to shoot flat images?"

How do you derive a 2.5D model using photogrammetry? We can make cinematic images with thousands of still frames into a true 2.5D texture-wrapped model. That falls in between 2D, which is pure flat cinema, and 3D, which is completely 360 degrees. The 2.5D is derived from photogrammetry or out of stacking — treating cinematography as an image stack rather than a linear event.

Using AI to derive 3D from cinema gives you enough parallax and dimensionality to your subjects. That's what Nicholson is working on right now because building 3D Rome with every street post and brick is expensive.

You can shoot RAW and then process all those pictures into a 2.5D representation of where the camera array went. You can then derive 3D space when needed for the virtual backlot, but you can only go where the image array exists. The result is similar to photogrammetry. It's 3D with baked lighting.

Though this method doesn't offer you every option, it's relatively light in polycount and plays back fast. Photographic plates are somewhat even more lightweight. But Nicholson said, "I can take a camera out on the ocean and give you every time of day." He is clear that this isn't a scientific experiment, and the goal here is to create an illusion. He asks himself: "What's the shortest path to an effective solution?"

"You're trying to stretch your budget, meet a schedule, and increase the creative options as much as possible," said Nicholson. It fascinates him when filmmakers learn that they can control the universe, and he reminds them that it comes at a price. "Where do you want to spend your money?" he asked.

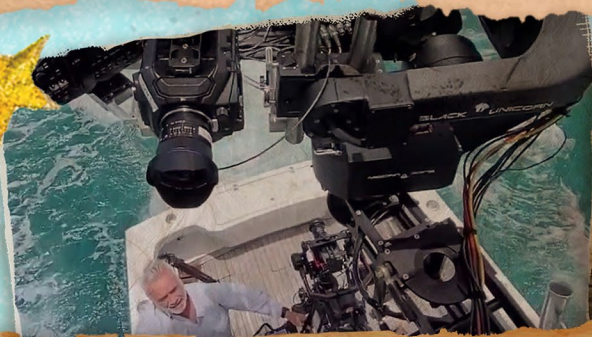
"The technology should fade into the background and be effortless and almost invisible."

REAL-TIME PAINTING ON SET

In compositing, as a visual effects artist, you're carefully putting together the foreground on the background, which came out of optical printing. You spent weeks selecting edges to pick the foreground color that would fit with the background, then put it through an optical printer and a week later see it. Then, digital cinematography comes in, and it's faster.

Most DPs are not used to dealing with multiple layers of images. They are fine-tuned for color and composition. If you can give them a real-time view, they can say, "Oh, that foreground is magenta." If the foreground was against a green screen, it's tough to tell which direction to adjust because you took away the background.

Being a good real-time virtual production supervisor, you're compositing and painting the image in real time. But it's not just one image, it's as many as six or seven images. You have six or seven screens. "How bright is the reflection? Is the reflection going right or left? Or is it a car-type scenario? It gets pretty complex."



Nicholson shot plates with five Blackmagic URSA Mini Pro 12K cameras for a total resolution of 60K in the original photography, which was stitched together and split into 8K quadrants, put those through multiple 8K Decklinks and DaVinci Resolves for full color and focus control on set. The result was a full 20K resolution LED wall with complete control; you could point anywhere and shoot it like any comedy show.

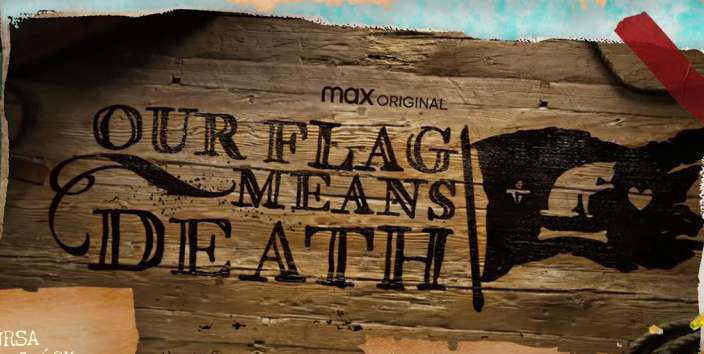


IMAGE SOURCE:
PostPerspective
YouTube Channel

https://www.youtube.com/watch?v=IAY_WXqRMAX0



Nicholson said, "The more tools you can bring to this party, the better." He recommended accessing multiple tool sets and multiple philosophies. He went to art school as a Fine Arts major and did everything from blowing glass to working with kinetic light. He understands light in its basic form. "I've been designing kinetic light forever," he said.

You must get the lighting right for the foreground and background elements. You work on getting the black levels right, setting the atmospheric mood. Those are all fundamental artistic concepts that are in Fine Arts.

Little adjustments can lead to a different look. "You're creating the illusion live," noted Nicholson. You need real-time tools that work. You need a team of people that are in sync. "It's like an orchestra playing in sync. If one instrument is way out, it's gone."

The rehearsals are important, and everybody has to be comfortable with them. You are leaning on each other because no single person can do this alone. "I can't design without my art, testing team, engineers — all those guys on set are fluid." Nicholson has worked with some of his team members for as many as 26 years. "When it comes down to being on set, you need your team there."

LET'S GET THOSE STANDARDS IN PLACE

"The natural evolution of any technology is to compartmentalize it and get it under control," suggested Nicholson. The idea is to make things predictable. "It's probably like a group of unruly children in a classroom. You can't do anything until you get them all to sit in their chairs, and right now, all the kids are running around and throwing stuff and acting crazy."

"I work on the other end of that spectrum — in organized chaos." Nicholson believes creativity comes out of chaos, making mistakes, and trying new ideas. He is not afraid to fail. "You don't fail in the World Series. If you're going to try something new, do it on the practice field."

"I think everybody wants to standardize." In the beginning, everybody had their method when it came to visual effects, even with traditional green screen compositing. Some folks became After Effects artists, and some others picked Nuke.

"I find that people are dying to bring order in their lives," he said. Where are the rules? The minute you have rules, somebody says, "We always do it like this."

"People are already saying that in virtual production. 'Oh, we always do it like this.' When these people are asked, 'How many shoots have you done?' They've barely been on one."

Nicholson added, "One of the reasons I love virtual production is because this isn't a new thing. The new part is the LEDs. Now, we can see it."

There's a romance with the LED volumes because business has realized that you can scale this thing up. If a panel costs a few thousand



dollars, you can get a thousand of those for a few million dollars. You can scale up the operation. "That's an easy thing for big businesses to understand."

On the creative side, Nicholson asked, "Do I need to be on a 180-foot screen? It makes for good bragging rights, but it's probably not going to be as good."

The hype around *The Mandalorian* has got people thinking they need the same panels and configuration. But if you're going to work eight feet away from the wall, and you don't have a very big set, it is the wrong panel and volume for your purpose.

The creative has to drive the bus. Technology does not define the creative anymore. If you have a night shoot, you're going to pick a different camera than if you have a day shoot. It affects your lens choices. It impacts all your creative decisions.

Nicholson has a great deal of respect for people like James Cameron, "who have gone out on these amazing limbs of technology development." Among them, he names George Lucas and Doug Trumbull.

"Doug is one of the finest technologists I've ever met, and he'd be the first person to say there are no rules," said Nicholson. "By the time you write a rule, the technology has changed. It is a moving target."

Nicholson believes in keeping an open mind and remaining excited about the future rather than closing up and becoming rigid. "Rules are made to be broken, but be very aware of the potential pitfalls," he warned. "And the closer you get to principal photography, the less you want to do that kind of risk-taking." Work those plans out early, he recommended.

"I'm a test pilot in the virtual universe because I'm always trying to define where the edge is, and that's what I love doing," said Nicholson. "You reach for those limits, and you learn not only a lot about the process, but you'll learn a lot about yourself and also the people you're working with." ■

3.3

WHAT ARE THE KEY LEARNINGS?

Kevin
Baillie
VFX SUPERVISOR

Baillie on a video call with Tom Thudiyapalackal for the Fathead white paper interview. To his right is the famous Wilson volleyball prop from the Zemeckis movie *Cast Away* (2000).

Kevin Baillie is a VFX supervisor with credits on films such as *Pirates of the Caribbean: At World's End*, *Transformers: Dark of the Moon*, *Star Trek Beyond*, *Welcome to Marwen*, and *Pinocchio*.

He has collaborated with Academy Award-winning director Robert Zemeckis on several movies that have utilized a range of innovations from motion capture to real-time game engines years before the hype around virtual production.

WHAT IS VIRTUAL PRODUCTION?

Addressing a common misconception that virtual production is limited to what happens around the LED wall or volume, Baillie said, "To me, it's so much more than that. It is any part of the production process facilitated by real-time technology."

In his recent work for Zemeckis's *Pinocchio* (2022), Baillie said, "LED walls are one example of that, but virtual camera work inside an animated world is a whole other part of that."

Baillie and his team did a virtual camera layout for every set and filmed and edited a nearly complete version of the movie before they shot a single frame. Some portions of the virtual world ended up on LED walls.

Key decision-makers were involved early. The DP got to experiment with lighting setups in the virtual world. They worked out the staging in this phase. Baillie said this iterative experimentation is transformative.

"We started getting input from the physical production team before we even shot." Baillie thinks, with this new approach, "instead of getting no input, now all of a sudden we're getting engagement earlier than we would have ever thought possible."

THE GREAT DIVIDE VANISHES

The live-action filmmaking and visual effects teams have operated in silos for 30 to 40 years. Baillie thinks virtual production eliminates this dark black curtain separating the two groups.

In traditional filmmaking, many directors, DPs, and production designers often come from a generational lineage or have trained under mentors for years — they have cumulative experience adding up to numerous decades. "It's unfortunate that the instant live-action filming stops, they go away."

The top creatives and technicians go off to work on another movie, and Baillie pointed out that "by the time the heavy lifting in visual effects begins, they're not around to contribute."

While the digital artists working on these teams are immensely talented, they are not steeped in filmmaking history. They perform their tasks with the best intentions and make the soundest guesses based on what was filmed in live-action, but Baillie pointed out that there's still an "absence of direct input from the people who have all the filmmaking experience."

Virtual production has enabled real-time experiences by bringing the production and post-production processes together early in prep. Baillie said, "We can have a conversation with a production designer about how their stuff is going to look at the end of the day on the screen and interactively engage in the creative process."

CROSS-CULTURAL ASSIMILATION

When asked how this confluence is affecting the process, Baillie said, "In terms of the new blood coming into the visual effects or the virtual production workflow, the developers, people from a games background, and visual effects people with little set experience are all suddenly being introduced to being on set. It's hard."

Pondering factors contributing to these growing pains, Baillie pointed out that "they're coming into a culture and a workflow that has been established for a century on movie sets," and it'll take some time to acclimate.

The trouble is not the hard skills but the soft skills required to navigate the on-set culture. "There is a chain of command on a movie set that is well established," explained Baillie. "It's known to people on movie sets. There is an expectation that people will have an answer, whether it's a good answer or a bad answer."

The terminology used on a film set is unique, and if you are not familiar with it, you may inadvertently cause some delays or disruption. Would someone new to a film set guess right that a "**dead cat**" is a furry cover for a boom mic to shield it from wind rustle? When someone yells "**stinger**" on set, they are not alerting you to a bug. It simply means a long, black extension cord.

"With the explosion of interest in virtual production," Baillie observed, "the number of people experienced on a movie set is super diluted, so everybody's learning on the job."

Baillie said about the talent base that isn't experienced enough in this evolving ecosystem, "It's exciting because it means we're on the upswing of something meaningful and impactful and new."

The visual effects pipeline was "getting a little boring." Many milestones were achieved and repeated over and over again, from CG water to CG fire and CG forests and CG blue aliens and CG humans. Baillie had himself wondered, "Now, what do we do?" He believes that "virtual production is the next frontier that is improving the production process, and it will enable filmmakers to tell stories that were untellable otherwise."

There's a definite discomfort that is brought on by change. As a professional, it might be hard to admit that "we don't have our act together." But Baillie shared that "nobody's an expert on this, and anyone that purports to have their act together when it comes to virtual production is lying through their teeth."

He recognizes the potentiality and suggested, "It's okay because that's where we were in visual effects 30 years ago. And that was an exciting time. And this is an exciting time."

GOING BACK TO SCHOOL

Baillie pointed out that the Unreal Fellowship program organized by Epic Games is a good example of "isolated efforts going on in the industry to help increase education, enabling people to get their feet under them when it comes to utilizing the toolset in this space."

Regardless, Baillie believes there is no substitute for hands-on experience in production. "There just isn't," he said. "I don't know. Other than internships, mentorships, and on-the-job training, there are very few ways to give people the level of experience they need."

Though this might not be dissimilar from any other field, for the most part, Baillie acknowledged "that the difference here is that the demand is so far outstripping the supply."

The problem at hand is a bit more complex. There may only be two production experts trying to train 15 people or more who are new to a film set. That alone would be a challenge, but virtual production technology is evolving rapidly.

The Zemeckis projects have used virtual production for nearly two decades. "There's not been one show where we've been able to reuse everything we did on the previous show because the tech is evolving so quickly," Baillie explained. "And it's even just accelerating now."

When you get a handle on one thing, there's something around the bend in another area that you better learn quickly to keep up. Baillie clarified, "It's a hard place to be in. It's painful. The only real way to do it is to prepare yourself with as much foundational knowledge and then get out there and do it."

Baillie warned that the first few jobs may test you immensely, but things will improve. In time, "you may become one of the most knowledgeable folks out there."

"I think the apprentice model is the only model that can work," said Baillie, adding that he hasn't been to college and joined the workforce straight out of high school. "I have worked with many people who came out of specific visual effects schools since then, and they were no more prepared than I was," he observed. "Maybe technically they were, a little bit."

Schools can simulate a production scenario, but Baillie pointed out, "you won't have a director screaming at your visual effects supervisor on

“THERE IS A CHAIN OF COMMAND ON A MOVIE SET THAT IS WELL-ESTABLISHED.”

the phone, and the visual effects supervisor turns to you and is like, "What the heck?"

"On-the-job learning," said Baillie, "is the only real way to develop a workforce that is sufficiently prepared to meet the demand out there right now."

Baillie recommended an overlap in the education process with the apprentice model, where the apprentices can bring back their learnings into the education system and help accelerate the process. He believes "it will help inform the curriculum in a fast-evolving field like this, which is important." Having the students, in essence, become part of the teaching can be exciting to people on all sides of this emerging ecosystem.

Asked to offer recommendations about whom one may approach for training and apprentice opportunities, Baillie said, "There are a few virtual production-focused companies out there, and developing relationships with those is a great place to start."

But he also thinks there's a catch-22 as some of these companies specializing in virtual production may not have the on-set production background needed to holistically impart training to novices and professionals switching over or upskilling.

"I'm working as an independent right now, so when our production is done, we spin down," noted Baillie, who will then spin back up when a new production comes along. He recommended that "in those instances, building a relationship with the visual effects supervisors" is vital – and remember to let them know you would be interested in future projects.

But mostly, Baillie finds that he's got so much to deal with that he relies largely on Mold3D, Happy Mushroom, Lux Machina, Halon Entertainment, or The Third Floor. He says to them, "I need you guys to own this chunk of the process." For *Pinocchio*, Baillie hired an independent virtual production supervisor.

Whether these companies have mentors on their staff or not, Baillie feels an apprentice is still learning on the job and will see everything they need to know once they're on the ground. It's just that they won't have a safety net.

WHO CALLS THE SHOTS?

The reporting structure in the virtual production pipeline is evolving, and it's being defined from filmmaker to filmmaker. In his case, Baillie said, "I have a long-standing relationship with Zemeckis, so I'm the de facto chief when it comes to anything that has to do with visual effects, whether it's virtual production or anything else."

Baillie follows through on everything done in virtual production to ensure that the post-production teams have everything they need. When the virtual production aspects turn out successfully, that yields more information for the post-production teams.

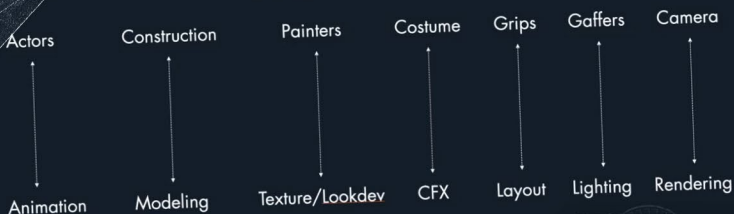
As a visual effects supervisor, Baillie finds his role to be a link trying to be the mind reader of the director. The responsibility extends as the facilitator for spreading information from other departments into the virtual production process and, subsequently, the visual effects process. This arrangement, he believes, "allows for decisions on the virtual production side to be made with as much context and sensitivity to the rest of the process as possible."

When comparing roles on physical film sets to those in the virtual production pipeline and visual effects, it's easy to spot that the actors are the same as the animators, construction people are like the modelers, and painters on the set are like texture artists.

What virtual production does, according to Baillie, is that it removes this barrier, recognizes the similarities between every department in live action and VFX, and allows them to work together and speak each other's language visually.

The role of the virtual production supervisor, Baillie thinks, will be that of an expert focusing on ensuring that the workflow succeeds and that the tools are accessible to everybody who needs to use them. "It will remain the visual effects supervisor's job to ensure that all departments, across all HODs, have what they need from the digital process, including virtual production," he added.

Live Action Production



VFX

Virtual Production

Merging the Live Action and Digital Steps of Production Using Real-Time Technologies

Image Source: Baillie's presentation at Trojan Horse was a Unicorn titled "Virtual Production: You Can Do It! With Kevin Baillie and Kristin Turnipseed"

<https://www.artstation.com/learning/courses/X/6/virtual-production-you-can-do-it-with-kevin-baillie-and-kristin-turnipseed/chapters/1x3p/part-1?>

PRODUCTION AS A DATA CENTER

COVID has accelerated the industry's need to define clear and robust standards for acceptable, safe, and distributed remote workflows. The success stories, Baillie believes, "have dramatically reduced the number of naysayers of cloud usage."

Baillie is the past CEO and current chairman of the board at Conductor Technologies, which automates production-scale rendering in the cloud, allowing artists to focus on quality and studios to take on more work. The company can offer immense scalability to any production with multi-region, multi-zone support that maximizes the available machines for each studio, with a capacity exceeding 500,000 simultaneous cores per account.

In his experience, Baillie found that filmmakers are less likely to be apprehensive of globally distributed teams and data. "It was more the studios, the ones who are funding and own the IP," a concern he empathizes with as he understands that "they pump a lot of money into this stuff, and a significant security breach can considerably reduce their ROI on that investment."

But having looked into it deeply and working closely with the technologies involved in achieving the desired outcomes, Baillie said, "The fears were not always grounded in something real." Studios refused to use a distributed workforce, distributed data set, or distributed rendering, as they didn't fully understand it.

In the previously dominant model of physical on-premises work, they had a set of parameters that defined a box. "If you checked all the parameters to land inside the box, you were okay," said Baillie. "If you missed any of those parameters, you were no longer okay." But knowing where you fell short allowed you to fix it. These parameters and checkboxes are not yet established for distributed working with cloud rendering and distributed data.

Baillie said this presented a unique problem: "It wasn't necessarily that any of the technologies or workflows were inherently unsafe,

it's just that they weren't well understood, and they weren't well defined." Consequently, "if somebody was told that they were outside the box, there was no way for them to know what they needed to do to get inside of it other than to revert to a 30-year-old understanding of what safety was."

But COVID has accelerated the creation of the checkbox. "Now, there's a clear definition of a safe cloud workflow," Baillie explained. "There is a clear definition of what distributed data can and can't be. There is an increasingly clear definition, as clear as it can be probably, of what remote work and secure remote work arrangement look like."

Baillie believes that because we know better now and there are fewer unknowns in this workflow, "we can all work together to ensure that things are as safe as they can be, regardless of whether it's on-prem or distributed."

Studios have clearly defined remote work agreements instructing the artists on best practices. There is a level of confidentiality and security expectations one must observe. Also, the technology is in place to monitor and implement these policies.

Baillie points to the work facilitated by Conductor Technologies, which he co-founded in 2014, where a single customer on the platform can spin up 100,000 cores to get a render job completed that, ten years ago, would have taken ILM's entire render farm to execute. Now, anyone can do that independently, provided they have the budget.

"It's pretty remarkable, to see what small teams can do in incredibly short amounts of time with access to tools like Conductor that are massively scalable, cloud computing resources," said Baillie.

"You don't pay for a minute more than what you use," explained Baillie. "You need 100 computers. You spin them up, and the second each computer is done, it shuts down and downloads a result back to your machine."

Looking at that level of minute-by-minute granularity makes things far more efficient than renting machines for a month at a time or spinning up a traditional render farm in the cloud where you had to remember to shut it all down when it's done.

Tools like Conductor automate all of that and even the software licensing. These solution providers address business, licensing, and technology challenges by bundling and democratizing compute and software resources in a way that hasn't been done before.

Baillie said, "From a business model perspective, especially for small studios and freelancers, it makes a lot of sense because if you have six months in between jobs that you're rendering on, you don't want to have resource overhead that you're not using."



Using such solutions, teams can now afford the tools when they have revenue coming in. When the income stops, there are no expenses. Traditionally, however, that's been one of the big problems with visual effects. The studio would have to build infrastructure geared for the worst day of the worst year. "It's silly to keep all that overhead," Baillie suggested.

Baillie speaks from experience, having run the visual effects studio Atomic Fiction. "It's very, very hard, you know." He and his partners founded the company and decided that all of their burst-rendering would be in the cloud. In 2010, however, others felt they were insane for doing that.

"And it turned out to be the company's saving grace," said Baillie. Especially when a project took forever to start, and for those three months, they'd either get to keep the artists busy on some little jobs or lay them off to pay for all the compute that was not in use.

Baillie celebrated that early decision and reminisced, "Luckily, we didn't have to make that choice. I think it is liberating."

DEMOCRATIZATION OF TOOLS IN VIRTUAL PRODUCTION

Asked whether the creatively liberating tools and processes in the virtual production pipeline will remain accessible only to the large studios and tentpole projects, Baillie said, "Like every technology in the visual effects space, it starts at the most expensive, the biggest productions, and then trickles down."

Eventually, he believes the cost of entry will become so low that anybody can do it. Photo-real quality for animated films is almost already within reach for the independent filmmaker. Baillie was at the Trojan Horse Was a Unicorn conference in Portugal with one of the virtual production leads on *Pinocchio*, where they presented jointly about virtual production.

"We decided to talk about our day jobs on *Pinocchio*, which involves a massive amount of custom infrastructure because we're doing it at a scale," said Baillie, alluding to the length of the film, about 100 minutes long, and the size of the teams with hundreds of people at different companies involved in it. MPC Film, Halon Entertainment, and Mold3D Studio worked on various aspects that needed to come together for things to work correctly. Despite working with Zemeckis, one of the biggest directors in the world, Baillie and his team decided to download Unreal Engine onto a laptop and set it up to work with an iPad as a virtual camera.

They asked themselves, "What would happen if we were independent artists?" They gave a demo to everybody showing what that would look like, and it worked.

"COMPONENT BY
COMPONENT, THE COST
OF THESE THINGS IS
GOING TO COME DOWN,
AND THE QUALITY IS
GOING TO GO UP."

Baillie recounted the realization: "It's a tool that is not as customized to our workflow as what we've spent hundreds of thousands or millions of dollars building, but it can do 99% of the tasks that an independent filmmaker would need to do."

"That's extremely empowering," noted Baillie. "The parts that are probably too expensive for an indie filmmaker are the parts that require some physical hardware like the LED walls."

To achieve in-camera visual effects, one will require LED walls that are high enough resolution to survive being filmed on a camera, which Baillie pointed out is the case, "especially if they come anywhere near in focus."

LED walls are exorbitant. Baillie shared an example of camera tracking systems to draw a comparison: "For a long time, camera tracking for that application has been really expensive. You need to set up an actual mocap system that is low latency enough where it can track the camera move within a reasonable amount of time to actually have the result move accordingly on the LED walls."

HTC announced a virtual camera tracking kit in April 2022 that caught Baillie's attention, which got him thinking: "Wow! All the stuff that we poured this custom development into, now it's this commercialized thing that is affordable."





"Component by component, the cost of these things is going to come down, and the quality is going to go up," said Baillie. "What is state-of-the-art today, the most expensive thing that only a Marvel movie can afford, it will be the entry-level thing that everybody can use two years from now."

Baillie reminded us that the trend will continue where "Marvel will still have their top-of-the-line thing that nobody else can afford." He thinks the trickle-down effect is in full play and happening rapidly.

STANDARDS & BEST PRACTICES

Baillie thinks "the question of standards in the industry is closely tied to the question of innovation and education in the industry." He said, "Obviously, as you innovate, the standards are destabilized, and as you educate, the standards become more proliferated."

Since the rate of innovation is so fast right now, Baillie infers that coming up with standards will likely prove challenging. What currently complicates education and standardization "is that all the people who are busy innovating don't have time to contribute to industry standards, nor do they have time to educate."

Companies are looking to engage various groups to work on virtual production standards and best practices to help educate people in the industry. But the people who know things remain busy with productions because there aren't enough people.

It creates an intriguing situation where "the busier you are, the less time you have to help the people around you to gain the skills to help you, and that makes you even busier."

Asked to scrutinize the potential risks of having some less informed folks voting on the standards, further reinforcing some misnomers and myths, Baillie suggested, "What we need in the virtual production space is people who can teach because it's only going to help them."

Baillie thinks "the wisest of virtual production supervisors and business leaders will recognize that growing the qualified workforce is only going to unlock future potential in their businesses." ■





CO-FOUNDER, DIRECTOR

ORBITAL
VIRTUAL
STUDIOS



3.4

ECONOMIC IMPACT, CREATIVE OUTPUT, AND EDUCATION

A.J. Wedding is the director and co-founder of **Orbital Virtual Studios**, a team of dedicated artists and engineers delivering virtual production systems and tools designed from the ground up to meet the needs of the most discerning creators. The genesis of the company leads us back to Wedding's garage.

When a friend of Wedding's reported back about the experience of working on *The Mandalorian*, Wedding was savvy enough to identify this as "the biggest change in the film industry in 50 years."

"Since there's going to be few people who fully understand it," he suggested, "this may be the best opportunity to get into a new position in the film industry."

IT DIDN'T HAPPEN OVERNIGHT

Wedding used to be the head of production at Raleigh Studios. Having worked in visual effects and 3D, in addition to experience as a cinematographer, Wedding saw an opportunity to interpret between the two worlds of technologists and traditional film production crews. Of those early experiments, Wedding said, "I became sort of a go-between for a couple of shows, early on, while I was testing the stuff in my garage."

To get his hands on the tools at the start, Wedding called Planar and asked to be sent some LED panels to "see if they're good for virtual production." They favorably responded, curious to learn from the valued perspective of an industry expert.

Throughout the COVID lockdown, Wedding had an LED wall set up in his garage where he and his friends ran tests and reported back to Planar. The LED panel manufacturer released an upgraded version in February 2021. They supplied Wedding with an enormous wall that he took to Fonco Studios. In just six months at Fonco, the team secured funding and moved into a larger independent stage.

PROACTIVE GROUND-UP TESTING & LAUNCHING

Speaking of piecing together pieces of the puzzle, Wedding said, "Well, ignorance is bliss, right?" He started with more familiar things, working his way up to more complex problems. Given his production experience, the goal was to identify how these tools and approaches would fit into the mix without altering too much of the traditional workflow.

The early problems involved getting a 3D image onto the wall. Then the team figured out how to do it using Vive trackers. Once the basics were in place, the next question was: "How do we make it better?"

Since the panel manufacturer was the first on board, Orbital delivered its findings to Planar. Recommendations included aiming for a tighter pixel pitch to reduce moiré, increasing scan rate from 60 Hz to 120 Hz, and fixing off-axis color-shift by maybe putting them deeper into the panel itself.

Wedding was excited that the manufacturer was proactive and incorporated feedback to improve the product further, of which he said, "I was shocked how fast they turned that around." On the software side, application developers also embraced feedback, responding with code upgrades within a day or two.



GROWTH IN STAGES

"I think my goal was always for it to become this," explained Wedding in describing the evolution from garage to large stage. "I had designs for this building from the day I decided I wanted to be a part of the business."

The journey of pursuing investors and brands has organically led to the right outcomes. When he found the ideal location, Wedding said that he was operating on trust: "We signed a lease before we had investors." To avoid losing the find, he asked potential investors, "Can I borrow \$50,000?" And now, in such a short duration, Wedding said, "We're buying the buildings. It's a little crazy."

Orbital has built a positive reputation by keeping its focus on "What is production's problem? Let's fix that."

ADVANTAGES OF VIRTUAL PRODUCTION

"We have good data on one of the biggest advantages. It saves you money if you're a heavy location show." *Variety* featured a story about cost savings and the environmental impact of the reduced carbon footprint.

Location Cost	LED Cost	Total Savings
\$84,000/episode	\$31,500/episode	\$49,000/episode
\$840,000/season	\$315,000/season	\$490,000/season

According to Co-EP John LaBrucherie, who did the analysis above, the FX series *Snowfall* saved almost \$500K using virtual production for Season 5 [data courtesy of John LaBrucherie].

Not every show needs to be like *The Mandalorian*, but sensing that most productions could benefit from this approach, Wedding said, "Let's find some versions of this that are helpful to production and make it look like a better show, a bigger show."

Citing what they achieved on *Snowfall* for FX, Wedding said, "We started out doing video plates." To avoid finger-pointing and confusion when a problem arose, Wedding recommended that his company be given end-to-end control and be allowed to handle every aspect of it. If anything was to go wrong, "you could yell at us."

"We know where everything exists in the infrastructure, and it worked out beautifully," he said.



The directors of photography (DP) would start the day terrified of the technology, but by mid-day, they would ask: "What else can we do?" It was a gradual exposure to the process. "By the end of that season, we had started making new versions of these plates that were 2.5D, and throwing an Ncam on there and showing them, 'Hey, look, you can do a little bit of tracking.' We did this without altering their workflow."

The producers then asked for a full virtual set. "I think that sort of 'dip your toe in it' philosophy was paying off for us," explained Wedding. Orbital was hired on another FX show — *Justified* — which was being shot in Chicago and would use many virtual production solutions.

The experience taught Wedding to introduce these tools to the makers and get them to "not be afraid of it." Taking the "show, don't tell" approach that filmmakers live by, Wedding said to the creators, "You hate those translucent backdrops? No problem. I'll put an airplane flying by it." And they responded, "Oh, my God! That's worth every dollar. Can you do that on cue?" The answer, of course, is "yes."

An understanding of the technology's potential may not happen right away. Sharing a recent experience, Wedding said, "I kind of felt like the redheaded stepchild, as nobody was talking to me." The LED wall was turned on but was barely used to its potential. It showed a scene outside the door. When the team switched to day plates, Wedding decided to mess around with it and change the scale to figure out, based on where their angle was, what would happen.

When the horizon changed, it worried the DP. When confronted, Wedding explained, "I know. Because I have car passes, I wanted them to be the right scale." When Wedding demoed the car passing, the DP exclaimed, "Oh, that's a crowd pleaser. Let's do that on this." He'd won over the DP and the gaffer.



DAMON IDRIS
IN SNOWFALL.
A FLEXIBLE
LED SOLUTION
THAT WAS
ABLE TO GET
UP AND OVER
THE WING OF
THE PLANE.

CREW POSITIONS & KNOW-HOW FOR PREPAREDNESS

When asked how he picks his crew members and what the producers on these shows like to call these new crew positions, Wedding said, "That is one of the most complex questions." He cites two reasons for this complexity.

It's an argument that Wedding believes will continue for six months or more (circa mid-May 2022). "Every union wants a piece of it. Everybody wants to put their hands on what virtual production is going to be."

As Orbital is scaling up, crewing is an area of particular focus. "If you're going to send an operator out, or two or three, they have to know not only what their job is, they have to understand production," noted Wedding. Orbital hires people with production experience such as DPs, gaffers, even stunt coordinators. "All of those different minds coming in and giving their two cents about what this should be," Wedding considers critical.

Wedding said that teaching the right people the rest of it, whether the software or working with the LEDs, is "not all that difficult." But having that decade of production experience ... "that's worth way more than everything else."

The Orbital team supports local unions regarding how they want something done. In Chicago, Wedding said, "They built everything. We sent a supervisor and taught them how to build the LED wall. Then, we sent someone to wire it properly." As for the operators, "the union has video playback operators," but for the Virtual Art Department (VAD), Wedding feels "different positions might end up in different unions."

There are no clear answers.

Until more clarity is achieved, Wedding's strategy for Orbital is to operate as a vendor. "We have a producer on our side that coordinates everything with the show producers," he explained.

The producer at Orbital asks questions such as: "When is your shoot? How many days? What size panels? Who's shooting the plates? Can we shoot the plates?" Then an operator is assigned to the project, who will report to the in-house producer, "but then they will collaborate with the DP and the gaffer."

Since no guild rates exist, budgeting for these positions is still handled ad hoc. Orbital provides a deal memo with a day rate for the walls and prep days. For *Snowfall*, Wedding said, "We're not using super mobile panels, so that wall had to sit there all season, and be guaranteed that they're going to have it. They had to pay per episode for that." If the show uses more mobile equipment, then they pay for it when they're using it.

CONTINUING EDUCATION & JOB TRAINING

The confluence of several distinct industries is required to power the virtual production pipeline. This presents the unique challenge of training individuals in hard and soft skills necessary to understand each other's languages and work cultures across the board. While traditional filmmaking crews may need to gain familiarity with the technologies involved in this workflow, artists from game development and technologists from hardware and software solution providers might have to pick up on film production methodology and expectations.

As Wedding described it, Orbital emphasized gathering a team with "filmmaking experience, especially from a cinematography side," which he said, "is worth its weight in gold." His team got a project because another company had failed to communicate well with the cameraperson. Everyone believed the LEDs were faulty because of the miscommunication.

Recent updates to the software components have made the production process much easier. "We are not writing text files anymore to get screens out," Wedding said. "Efficient virtual production is getting easier and easier."

"EFFICIENT VIRTUAL
PRODUCTION IS
GETTING EASIER
AND EASIER."

The game development, live event, and VR creators getting involved with VAD environment creations for virtual production also have to learn about film language and how to look at the world through a cinematic lens. Wedding has tried several vendors, and despite providing detailed notes and bullet points, when the files are delivered, Wedding's team has to step in to fix them on the day of the production.

All of these challenges can be solved with collaboration. Virtual production provides tools to engage deeply and do so early in the game. Tools like virtual scouting allow us to put on VR headsets and jump into an environment from wherever we are to gather feedback and try out options. "When the people involved allow for such collaboration it makes for the best productions," explained Wedding.

BUILDING A VIRTUAL BACKLOT FOR ECONOMIES OF SCALE

Creating digital environments from scratch requires a huge investment. While this may be suitable for serialized content where such assets are amortized by repeating them over time, the scale and intricacy of such creations will have to be limited for one-off use cases. For the latter, it would make better sense to acquire the license to use assets from content libraries and other creators where a base asset is already in place, and minimal effort is required to customize it.

Commenting on how Orbital satisfies these demands, Wedding said, "We're working with a couple of different companies that have the experience for building these things, but not specifically for virtual production." These companies scan historical landmarks such as Machu Picchu and the great pyramids. Wedding is helping them build "a catalog of rights management."

When tailoring made-to-order assets for large productions commissioned by studios, Wedding said, "I don't get to own the assets that I build. I don't even get to show them to people."

Currently, many of the online marketplaces, such as the one for Unreal Engine, carry files that are originally meant for games and don't satisfy the high resolution and fidelity required for filmmaking at a virtual production stage. "Because Epic is very savvy," said Wedding, "the Unreal marketplace will probably have a separate section for virtual production assets."

Until such a time, whenever folks show up at Orbital thinking, "We're doing this music video tomorrow, and we're going to download this thing from the marketplace and put it up on the wall" ... Wedding responds, "No, you're not. Not here."

Orbital plans to set up a marketplace at a smaller scale, "but for super high-quality assets, mostly landmarks."

When does it stop making economic sense to pursue creating original 3D assets and environments instead of shooting at the physical location or relying on green screens and VFX? When asked how he advises producers to enable thorough decisions, Wedding said, "It's not worth it for them to move an entire crew for a two-minute scene. There's not going to be a ton of parallax, but you can do a video plate."

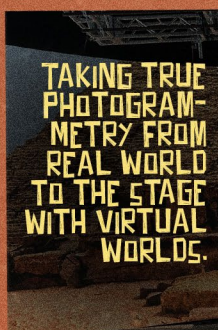
Video plates for car driving sequences have been used for a long time. But shooting car exteriors at a green screen stage introduces several challenges because of the automobile's large glass and metal reflective surfaces. Working at an LED stage or volume eliminates many of these challenges and significantly reduces the work required in post-production.

"I think the scanning technology and photogrammetry are getting faster and better," said Wedding, who is working with a company that uses a fully outfitted vehicle that captures and maps entire cities. "When you have that capability, then you pick a city, LA or New York, and there's that kind of flexibility."

Artists can now clean up people and other objects because of the combination of laser and LiDAR, making removal of unwanted items simple. In addition, these 3D captured environments offer a level of control in selecting "the time of day and switching out city locations" on the fly.

HIGH DYNAMIC RANGE ON LED WALLS

Studios and producers want to future-proof content. Therefore, teams should capture content with the **widest gamma** (the luminance range of the source content or output deliverable) and **gamut** (the volume of color available).



We pick high-end cameras with a wide **exposure latitude** (detail in the range from bright light to dark shadow) for a large dynamic range. The human eye can handle up to 20 stops of dynamic range, whereas the highest-end cameras peter out around 15 stops. RED has announced the V-RAPTOR 8K, which claims to have over 17 stops of dynamic range (circa August 2022).

While the cameras increase their performance range, they can only capture the available light. Shooting outdoors in sunlight is a different experience from production at an LED volume. Asked whether the LED panels can deliver a high dynamic range (HDR), Wedding said, "Currently, it can't. We operate our wall at 10-bit HDR."

It's not that straightforward. "Virtual production supervisors ask me what's wrong with what they're looking at," Wedding explained. The image doesn't look right because it is not HDR. The panel is set to display an HDR image, but to achieve that range, "it must be wired a certain way. You don't just daisy chain all your panels and say 'that's HDR.' They've got to have their own signals."

"Because of the lack of spectrum in an RGB diode, there's only so much you can do," said Wedding in describing the current bottleneck. "So, you're trying to get as close to your final look as possible in the wall to help out the colorist in the back."

Wedding is working with manufacturers to develop a microLED with RGBAW (red, green, blue, amber, and white) for a wider and more balanced spectral distribution. The combination will make it easier to have them stacked. Wedding said, "The stack plays a huge part for the blending. It's a lot easier to trick the camera."

IMAGE-BASED LIGHTING

Our eyes are familiar with natural sunlight as the primary source of luminance. The baseline is how colors appear under the sun, and the effect of other lighting conditions on the same sets of colors produces a variance that we can visibly distinguish.

When the images on the LED wall represent a scenario where the

light source is the sun, there is a distinct variance in the image's tonality since the wall does not produce the full spectrum of light. It is necessary to introduce secondary sources of light that better represent the color temperature, the spectral density of sunlight, and the time of day.

The same is true for other lighting conditions that the current LED panel technology cannot fully recreate. When a human subject is lit only by the ambient light produced by the LED panels, skin tones do not turn out well. We can bring traditional lighting sources used on film and television projects to complement the scene tonality. Still, these lights will produce a constant value that may not agree with the dynamic nature of the ambient light from the imagery on the panels.

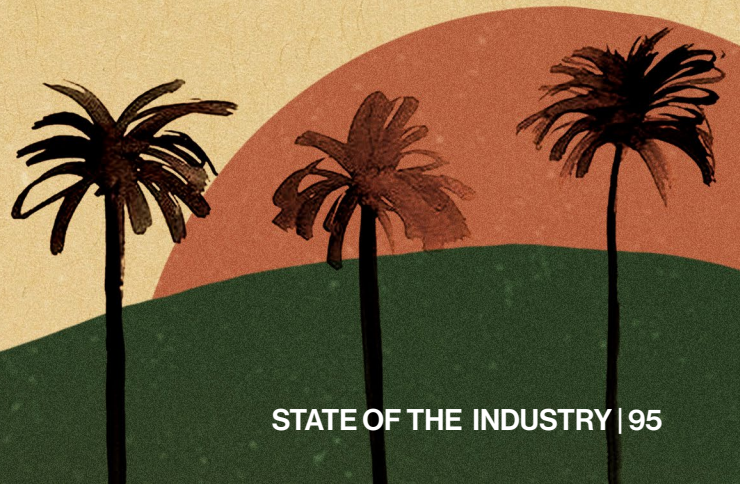
Image-based lighting employs real-world imagery to augment the realism of computer-generated scenes, which has been used in visual effects and 3D worlds, such as gaming and virtual reality (VR). Now, it can lend itself to in-camera visual effects (ICVFX) for a similar outcome.

Paul Debevec has been a pioneer in this field and has won the **Scientific and Engineering Award** at the Academy of Motion Picture Arts and Sciences (2010) for the design and engineering of the Light Stage capture devices and the image-based facial rendering system developed for character relighting in motion pictures.

When a still high dynamic range image (HDRI), obtained from combining multiple shots at varying exposures to produce a photograph with the widest range of luminance and color values, is used to create the lighting conditions, this may work well within a scene that lacks dynamic lighting.

However, suppose we are to produce effects such as a flame or a traveling scene that involves indirect light bouncing from passing surfaces and shadows and reflections from objects obstructing the various light sources. In these cases, we would need a moving image.

Tim Kang at Quasar Science, a light manufacturer making tools that help lighting technicians and filmmakers on set so that they can create art with as few limitations as possible, has collaborated with Debevec on a few experiments to introduce image-based lighting on an LED volume.



When asked about needing to rely on image-based lighting in virtual productions, Wedding smiles. "Leo, my director of photography, is over at Quasar right now. We've had them in here quite a bit." Quasar Science and Orbital Virtual Studios are about half a mile apart, separated by the Los Angeles River and connected by the 7th Street Bridge.

Wedding said, "This is a huge piece of misinformation on virtual production. You really shouldn't be lighting with the LED wall. It's nice to get some ambient light, but your actors need proper high SSI lighting."

The Academy of Motion Picture Arts and Sciences has developed a new index for the spectral evaluation of lights by working closely with cinematographers; lighting experts; lighting manufacturers; and lighting, imaging, and camera scientists and engineers. The resulting Spectral Similarity Index, or SSI, solves issues with existing indices that were inappropriate for evaluating solid-state lighting in motion picture applications.

Inadequacies of the **indices** such as the **Color Rendering Index** (CRI) and the **Television Lighting Consistency Index** (TLCI) became apparent with the wide use of **solid-state lighting** (SSL) sources such as LEDs.

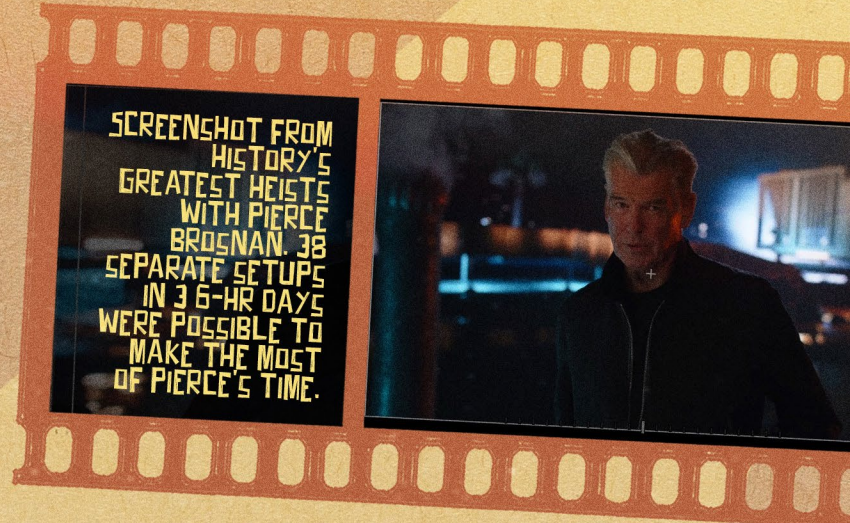
Wedding described a test that Kang and the Quasar Science team performed at Orbital recently. "We did a fire test in here that was really successful and you could never use the wall to create that," he said. "You would never be able to make that look right."

"Image quality is the most important thing," explained Wedding, "and because of that, the lights on the talent and the set need to be real and high quality." He is working with Quasar Science to create even larger lights that will start replacing some of the ceiling panels at LED volumes to adopt image-based lighting more integrally.

RATE OF INNOVATION & ADOPTION

When asked what he feels about the rate at which innovation is happening in the virtual production space and whether he fears that a radical upgrade launched too soon would jeopardize early adopters who have invested heavily in a previous version that might lose its appeal, Wedding suggested, "There are two interesting answers to that."

"Low pixel pitch makes the computing required to run them become more expensive," he said, "there are some companies dissuading people from going on the lower pixel pitch."



The investments are large and must be recouped to remain in business and continue growing as the field evolves and needs subsequent upgrades and upkeep. "If you're trying to get the big dollars, you need to have the good stuff," said Wedding, but he cautions us that "there's also a limit at some point, as you're not getting much more out of it."

Orbital has panels with a 1.5-pixel pitch, letting you get the camera within three feet of the wall before any artifacts appear. Wedding said, "I'm never going to do that, so I don't need the pixel pitch to be tighter than that." He's happy to have lucked out and "missed the first wave of the 2.8-pixel pitch panels."

PRODUCERS ARE THE ONES WHO NEED TO EXPERIENCE THE BENEFITS

Filmmaking has shifted from a physical and tangible exercise to a nonlinear set of activities required to engineer different parts that come together in various stages of assembly.

The virtual production stage is one such assembly line where the primary ingredient, human actors emoting and performing characters' inner lives, is ignited to capture a magical moment. Having these performers enwrapped by a photo-real 3D world projected on LED walls allows us to capture an image in-camera that is much closer to the final image.

Along with these many processes, everything is produced and recorded as data. The virtual production stage is, in essence, a data center with connectivity that engages all the tools and teams for uninterrupted, real-time creation of content.

How can producers, studio executives, and creatives learn enough to rely on these processes to take full advantage of the virtual production pipeline?

There are many things we don't know fully well, and everyone involved is experimenting. Early adopters like Wedding are generous with what they know so far and make frequent appearances at industry events for panel discussions and presentations. When talking to a potential client, Wedding says, "We're going to handhold this entire process, because we want you to understand it." Producers keen on this technology arrive drawn by the trendiness of this methodology, but "they have no idea what it is."


Problem-solving with creatives is easier, as most things can be tweaked and switched as needed to achieve a certain look. However, a producer has to supply more concrete decisions with a deeper impact on the production: The budget and length of production, the quality of the final product, whether images on the wall have to achieve photo-real quality, and how detailed the environment needs to be, and so on.

It's a fine art of managing expectations, and Wedding said there are times when "maybe this isn't the best choice. It's not a Swiss Army knife, and I think that people who use it well understand that."

The film industry may, at times like these, exhibit a trickle-down culture where once the studios adopt standards, the workforce takes the directive and rapidly prepares to meet the arising needs. When asked to identify the key stakeholders who might influence these decisions and need to know more about the virtual production pipeline benefits, Wedding said, "Definitely the producers, because they're the ones making these decisions."

Citing his experience on the FX series *Snowfall*, Wedding said, "The producer and I had discussions for a year before we worked on it." Initially, another company was engaged for the job, and knowledge-sharing was the best way to get them on board. Once the producers understand what they are getting out of it, "they become the biggest proponents of it."

As for the directors of photography, Wedding said that once the producers agree, the team gets on board with it. Wedding inferred that "producers are making those decisions and have to fight with the studio about the costs." It's important to give them the ammo.



**"IT'S NOT A SWISS
ARMY KNIFE, AND I
THINK THAT PEOPLE
WHO USE IT WELL
UNDERSTAND THAT."**

CHANGE IS NEVER EASY

A transition into something unfamiliar may bring about insecurities. A director of photography working on an LED volume for the first time may not immediately see the desired results, which may be discouraging. An instinct may be to return to familiar ways and dump this process. A DP may attempt to reframe the shots to avoid the wall and even influence the production designer to build things to obscure it.

When asked to provide his thoughts on how we may educate these creatives to embrace these tools rather than fight them, Wedding declared, "Experience!"

Sharing an example of how technicians and creatives who remain unaware of these new tools may inadvertently expect and demand things that may result in exponentially explosive costs, Wedding said, production designers end up asking for bigger walls, as they are used to translights that are about 150 feet by 35 feet.

"Okay, then I need three million dollars from you." is Wedding's response to this request, and they immediately realize, "That's my whole budget for all of my set."

The solution here is to go with the available wall size and make the windows proportionally smaller. These are challenges that arise often, but Wedding said when it comes to picking the locations to shoot plates or what sky to choose, he goes with what the production designer endorses. DPs may, at first, be terrified of the wall and the technology surrounding it. They may wonder, "How am I going to get a light in there if that wall's in the way?" It's never a problem, as they figure it out with a little experimentation.

There's a need for these professionals to have some time at the LED volume to play around and figure things out. But who will absorb the cost of familiarization, training, and upskilling? Are the individuals to go out of pocket, or should producers organize a short primer before the production?

"Even a couple of days would do it," said Wedding. "We're mostly training people on the job." However, this can eat into the expensive production timeline and lead to mistakes.

Wedding thinks it's a great idea for the producers to consider the primer. He even thinks introducing a small LED wall at camera houses would give DPs a chance to play with the technology when testing the gear and lenses.

What are some of the key issues we have to discuss together to shape the future of this innovation? Wedding emphatically responded, "Education! Education! Education!"

There's an obvious shortage of operators. Wedding thinks there are not enough producers willing to take this leap. Education is the only way for everyone to see the advantage and be prepared to achieve it. ■

3.5

Decentralized Hollywood

TIM MOORE IS THE CEO AND CO-FOUNDER OF VŪ TECHNOLOGIES, A VIRTUAL PRODUCTION COMPANY THAT OWNS AND OPERATES A NETWORK OF FULL-SERVICE VIRTUAL PRODUCTION STAGES ACROSS THE U.S. HE'S A THREE-TIME EMMY AWARD-WINNING DIRECTOR AND THE FOUNDER OF DIAMOND VIEW STUDIOS, A CREATIVE VIDEO AGENCY HEADQUARTERED IN FLORIDA.

"WE MOVED FROM DOING SMALL PRODUCT WORK IN VIRTUAL PRODUCTION TO HAVING A STAGE BIG ENOUGH TO HAVE SEVERAL ACTORS AND USING THE BACKGROUND JUST LIKE YOU WOULD A NORMAL ONE," SAID MOORE. "AS WE'VE DONE IT MORE AND MORE, WE'VE REALIZED THAT THE CAST AND THE CREW JUST START TO FORGET IT'S THERE AS DISPLAY AND EMBRACE IT AS THE SCENE." HE EXPLAINED THAT THE GOAL OF VIRTUAL PRODUCTION IS FOR EVERYTHING TO HAVE A REASON — THE ENVIRONMENT HAS TO PUSH THE STORY FORWARD. VŪ IS MOSTLY INVOLVED WITH SHORT-FORM CONTENT AND COMMERCIAL WORK — BRANDED STORYTELLING. HE SAID, "THAT'S OUR ANGLE ON MOST OF WHAT WE PRODUCE."



BRANDED STORYTELLING

"Most traditional commercial work is yell and sell," he said. These commercials have something to sell that gets blatantly pushed to us. "Video is such a great art form," said Moore. He likes to use the medium inventively by not even telling the audience what the product is. The viewer only gets a feeling about the brand's essence without any 'strong sell' factors. "We found that people are much more receptive to that because it's authentic. It's not like you're trying just to close them on the sale in 30 seconds. You're trying to build a relationship that's much longer," he clarified.

A LIFE'S CALLING

When Moore was 15, he responded to a pamphlet at his church for a mission trip to the Dominican Republic. He thought it would be a great vacation, but at the airport, he noticed the medical supplies and realized it was going to be a work trip. He got handed a camera bag and was officially assigned as the 'camera guy.'

He'd never shot before and landed in the Dominican Republic with a VHS camera on his shoulder to receive a Third World education on how

to shoot video. Moore said, "It was such an impactful moment for me because we went to the border of Haiti, where it goes from normal roads to dirt roads to no roads. There's this village behind what was essentially a landfill where they had taken all the trash from the island and built their homes out of the scraps that they could find. Seeing that through the lens was like, unless you're there, you don't realize how fortunate the rest of the world is." He thought, "They'd be jealous to have our problems."

When he returned to America, Moore edited the video intending to capture the essence of what he'd witnessed. It was shown to a big congregation at the church. He waited anxiously to hear the response when it stopped playing, expecting everyone to clap, but it was dead quiet.

When the lights came up, he saw that people were crying. That was the moment he realized, "Wow, this is powerful."

When the donation basket

was passed around, Moore noticed that people were wrestling for their wallets to help a country they'd never been to, for a cause they hadn't heard of until minutes ago. That's when he knew the kind of work he wanted to do. Since that approach to storytelling wasn't prevalent, he decided to build Diamond View Studios when he was 18. He counts his blessings for having found his calling and seeing the gift of an incredible way to show the need worldwide. At 18, he didn't have enough money for a camera and was usually borrowing one from a friend. But after about a year in business, his then girlfriend (now wife) bought him his first camera, and that set him off on a good track.

TRANSITION FROM PHYSICAL TO VIRTUAL PRODUCTION

Moore's had Diamond View for 13 years (circa late April 2022). He said, "It took seven years to get a studio. We were slowly building. It went from me as a solopreneur to two people, me and my business partner, Jon Davila, and we quickly grew to a staff of 40." When the pandemic impacted their portfolio of clients in sports, travel, and tourism as no one could travel to the clients in New York and Los Angeles, that's when they turned to virtual production as an alternative. The clients would send in their product or share their message, and the production was handled at the studio.

He said, "It was built out of necessity. We needed a different way to shoot. But we quickly found how effective it was, not needing all the logistics of a normal shot." If the scene required a forest or an interior, it was achieved with relative ease. That was the genesis and it has continued to grow from there. They use a combination of 2D plates, 2.5D, and 3D environments that are created using a mix of procedural methods in Houdini and other Digital Content Creation (DCC) applications. Moore said, "A lot of times, we ask ourselves, 'What's the best tool for this?' Sometimes we'll still go on set. If it's easier to do this on set, we'll do that. But we do a lot of our work in Unreal Engine because there's so much control."

All their stages have 3D tracking built into them. Often, a 2D plate gets used, especially on a tight shot. Most of their volumes are 100 feet plus. Moore explained, "If you think about being on a long lens, if the actor is in the center of the stage, that means they're 30 feet from the wall, so when you're moving around, the wall is physically 'parallaxing' with that actor. By putting a couple of set pieces, you get the same effect as if you were doing a full 3D engine." The team proceeds by asking, "What's the most intelligent way to do this?"

"WE'RE BUILDING
A DESTINATION
STUDIO MODEL."

DESTINATION STAGES

"We just opened up Las Vegas this week (circa late April 2022)," said Moore. "We're in Nashville, Tampa, and Orlando. We're looking to build Stamford, Connecticut next year." To pick a suitable location for the stage, he starts with the question, "Would this be a destination I would go to if I weren't shooting?"

Moore feels that Hollywood is about to be decentralized. He said, "People aren't going to go to the old clusters of talent. New York and Southern California became their hubs because you needed to go to a location to shoot physically. If you're physically going there, you need the director, the actors, and the crew. That's no longer the case. You can now remotely do many things." He believes it will all come down to the convenience of the A-list celebrity or a sports star. This has led them to underserved markets like Las Vegas, which also happens to be one of the most traveled cities, not only in the U.S., but in the world. The same is true for Orlando and Nashville. He said, "The commonality is that they are the three largest entertainment markets for people traveling to those destinations, so we're building a destination studio model."

"We're also hedging the bet that the old center places for talent in the past and the New Yorks and LAs will slowly start moving to some of these mid-markets," he said. Much of the work is centered on entertainment, short form, episodic, and indie. "We don't do much feature film. That's not our market. But we are looking for new media that's emerging."

ON SET FOR A
PRODUCTION
AT ONE OF
VŪ'S VIRTUAL
STUDIOS.



CONNECTIVITY BETWEEN ALL THE STAGES

All of Moore's studios use a layer 2 network. From point to point — from Nashville to Tampa — it's a fiber line. Moore said, "Even at the router, we direct patch." He asserted that the connection can carry data as fast as light can go from one side to the other. He added, "If you go to print something in Tampa, it believes that Las Vegas is on the local network. We can burst up to 25 gigs. We're about to multiplex and go 100 gigs a second."

Speaking of the huge tech stack and incredible partners who've made it possible, Moore said, "Aside from Mark Roberts (motion control) and Mo-Sys (virtual production solutions) in the studio, we use dark fiber to connect on the communication side." Major interstates in the U.S. have a dark fiber run because of a federal mandate to cover for any new communities that may spring up or to cover the growing need for fiber into the future. He said, "Most of our dark fiber is through charter, and here in Vegas, we're going through Switch, a major local data center. We look for whoever the local provider for dark fiber is over there, and then we'll pull those lines."

CLOUD & THE EDGE

His network of stages currently relies on an AWS data center. "We're building the infrastructure for an all-internal system," Moore said. "That's where I see the real advantage in the future, whoever has the digital backlot, who owns the environments, will be able to do things faster than anyone else." He explained, "The biggest thing I see about virtual production outside of control is speed, the ability to shoot something in the morning and have it on national TV at night. We've done that several times."

ASSET MANAGEMENT

In Unreal Engine 5, Moore shared that you can do levels that are full worlds and then you can just turn the virtual cameras around. He said, "It's Australia in one direction and Asia in the other direction. But being able to recall assets quickly in a 3D library is difficult. We're not at the point where you can say, 'Hey, I want a forest, I want it to look like this, and keep digging in' (circa late April 2022). It's not a search browser like Google."

The Vū approach is to re-tag assets. "We might take something pre-built, rip it apart, and then tag each asset," Moore explained. "When we're doing recalls, we can reassemble them." By having those pieces that were originally made for a different set reconfigured to fit a new environment, it follows what Hollywood's been doing for years. What may be the White House set one day is then turned into a ballroom for another shoot. The same assets are taken, broken apart, repainted, and reassembled to fit the new brief. He said, "We see tremendous value in having the main things you need and being able to adjust them quickly."

Vū has an in-house virtual art department (VAD). Moore said, "We've been building here in Las Vegas. Most of our talent is in Tampa and Orlando. But we're continuing to build across our studio network."

ENDLESS CHOICE & DECISION FATIGUE

When VAD teams can promise and deliver anything that can be sketched or imagined, where are those limits that stimulate creativity coming from? Can an abundance of choice lead to decision paralysis? Limitations usually are lessons that force us to innovate, and in this new paradigm, how can producers set some boundaries and rein in the creative teams to achieve productivity, efficiency, and an imaginative product?

Moore said, "We often consult with our clients to tell them, 'Hey, this is something that we can do quick, or here's something that will look high quality that's going to take a little bit longer.'" He gives clients some definitive parameters to recognize whether they value speed or quality, and they can choose with the knowledge that going for one may mean sacrificing the other.

He explained, "If they want it fully from scratch, extremely creative — they can do that, but it's going to take a little longer. When you give the client the understanding of how long it takes, how much it costs, and what we're able to do, then they can properly make that decision." He added, "There are still some things with Unreal and virtual production today, that's not possible, but getting people in that headspace upfront helps."



VIRTUAL PRODUCTIONS
AT VŪ'S STUDIOS.





KEEP THE BALL ROLLING

An Unreal Engine instance may crash during active production, which happens at times for various reasons. Different stages have their own formula for how they go around these issues to troubleshoot on the one hand, while keeping the production rolling using some alternative methods and workarounds. Moore shared his method: "We have an interesting infrastructure where we use a single 24K processor. When you have a screen, like the large Vū volume set up at NAB 2022 — that's a 12K resolution screen, and you're managing millions and millions of pixels."

Typically, when Unreal Engine is used to transact content to the LED walls, the screen is split into several slices, and nDisplay listens to the engine to put the image across the screen seamlessly. Moore said, "If that goes down, you lose all of your sources. Our processors have a scaler in it, as well as a switcher. You can change it to another source very quickly. If Unreal went down, we could go to a different source and have the screen live, do a different scene, or try a different shot."

He added, "We've found that over the last several months (circa late April 2022), Unreal has been extremely stable. They seem to have worked through all the bugs and are doing well. But the ability to be able to context switch, most stages don't have that — they're built just to be on Unreal. We have a lot of context switching built into ours."

Moore shared that Unreal 4.27 has been more stable with the way Vū configures nDisplay (circa late April 2022). He's impressed with the developments in UE 5.0, which was still being tested at his facilities. He believes features like lumen and nanite are promising. He said, "We love Unreal. We've fallen in love with the look of it. They know a lot needs to be developed on the user interface side. But, a year and a half ago, this was primarily a game development engine, so there's a lot that they're reacting to very quickly."

Moore discussed some areas where Unreal can improve further: "Finding assets is challenging. You have a bin of many things you have to sort through with narrow categorization. Hierarchy — they've solved a lot in Unreal Engine 5 with being able to make scene thumbnails and be able to recall stuff very quickly. But on the pre-light day, you must set everything up in advance. We could do some of that intelligent setup on the Engine side, which will streamline many things."



UNADDRESSED GAPS

Resource, in terms of skill, talent, and labor in this industry, is another main stressor that studios bring up in their conversations. If someone wants to invest in it, how can they roll it out to contain everything and get a reliable set of people on the team? That's been a major challenge — education. It's divided right now; different programs teach different models and approaches, and then you bring them all together and train them for a new protocol. How can this gap be addressed?

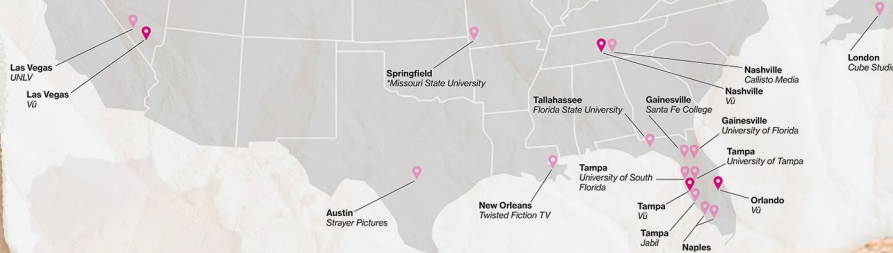
"There's a lot of workforce development that needs to happen," said Moore. "We address it by remaining location agnostic because we're a studio network. The operator can remotely control the Vegas or Nashville stage. Any operator in the network can control these stages from their monitoring view. It doesn't matter if they're not there. They can see the witness camera — which works like a security camera on stage — and the actual Unreal Engine display."

"THERE'S A LOT
OF WORKFORCE
DEVELOPMENT THAT
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"WE ADDRESS IT BY
REMAINING LOCATION
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NETWORK."

THE VŪ NETWORK MAP.

The VŪ Network



He elaborated, "We have connected comms. If you're on Clear-Com in Vegas, it's as good as being next to the person on the shoot in Tampa. But ultimately, we're going to have to farm more talent. We've been partnering with the universities. We've just donated a wall to the University of South Florida and the University of Tampa. That's mainly the area where we're helping grow talent and then dispersing it across our network."

Moore concluded, "We can build studios faster than we can teach people to operate them. We built three studios in the past four months (circa late April 2022), and we're only planning on getting more and faster, so we have to be able to have skilled labor to be able to run this."

Moore was an early adopter of digital when it transitioned from tape and film to pixels. It wasn't quite there in the first year or two but it was clear to him that it would become the standard. He sees the same thing happening for virtual production.

He said, "We're an early adopter of this, and we've been very aggressive with it. After over 200 shoots now in virtual production across our network, I can see more and more of this will go into the game engine. It's very unsettling to tell people in the industry, our gaffers, directors of photography, and directors, that their main mode of creation will change."

He predicts that in the future, people will sit behind a game console at home with an immersive display to remotely collaborate with people and make things faster than they ever have before. There won't be any barriers to where the camera can go or how we can shoot it. There won't be any physical lights because all the lights would be in the Engine.

In his keynote on the future of virtual production at NAB 2022 in Las Vegas, Moore shared his main thesis: "As our company has developed and matured, we have created the network to make things more efficient, and I can see the writing on the wall that it will go into the Engine soon. It is like the DVD by mail model that Netflix started with, as they knew they would be streaming someday but were just waiting for the transition to happen. We're building the world's largest virtual studio network, knowing that studios in the future will not be physical places. There'll be a game. And that's where we think our development and impact will be ten to 15 years from now." ■



BEHIND THE SCENES OF PRODUCTIONS AT VŪ STUDIOS.



3.6

VISUAL EFFECTS IN THE AGE OF INNOVATION



RON MARTIN
COMMUNICATION,
EDUCATION MANAGER



BRIAN GAFFNEY
SENIOR CLIENT PARTNER,
WĒTĀ TOOLS TEAM



BATTERY

Ron Martin, communication & education manager at Unity Technologies, shared that “Unity was being used for filmmaking before Unity developed a vertical for films.” The first time the cross-platform engine was used as a real-time assistant simulcast was on *The Jungle Book*. He emphasized that the power of the Unity engine being utilized outside of gaming has proved to be a progressive method of visualizing the final in-camera visual effects (ICVFX) that has increased productivity and augmented the certainty of the director’s vision while on set.

As Unity became the go-to real-time engine, emergent use cases have proliferated across the entertainment business and other areas of focus, including medical imaging, architecture, and engineering. “It started to open the minds of the engineers and the people guiding the company’s direction,” said Martin. “We saw a huge swing toward the power of real-time.”

Martin believes one of the aspects driving the initiative is that the users are the problem solvers. Using a real-time engine as a collaborative tool brings decision makers, team leaders, and in some ways, the economics of a project around resolving issues prior to hiring bigger teams or finding the right teams with the skill sets. “The openness to understanding what those tools can bring to the creative process will allow people to see how the technology acts not just as a tool but as a glue,” concluded Martin.

Brian Gaffney, senior client partner at Unity on the Wētā Tools team, sees virtual production as a technique that has helped improve “the gag we’ve been doing for years — rear screen compositing for in-camera visual effects.” Rear projections always gave away the trick. If it were not the color or lighting, then it was the parallax, which moved around. The 2D projection was apparent. Over the years, there have been some enhancements to improve the illusion, mainly camera tracking. Visual effects and green screen compositing have come a long way. “But what was always separate was that visualization process, the continuity through the process, both for the actors and the directors,” he said.

Gaffney backed Martin noting the strengths of real-time visualization where the game engine is used as a real-time visualization tool. It completely expands the possibilities for creativity through every stage of creation and execution. He said, “We’re in the early days, both in the LED volume technology capabilities and the workflow onset.” He explained how green screen use has been around for years and the basic techniques are still taught at film school and in other professional training scenarios. Just introducing LED walls to replace a green screen does not solve everything. Shooting improperly will still wind up sending everything into post to fix those errors.

“To solve the bigger picture of getting true in-camera visual effects and having previs go to the final pixel is still a work in progress,” said Gaffney. This is where Unity adds to its real-time tool kit with virtual art department creative tools like SyncSketch, SpeedTree, and Ziva Dynamics. “We’re giving VAD artists the complete tool kit that they can use to create the real-time visual effect experience,” he said.

EXPECTATIONS FOR PHOTO-REAL IMAGERY

Through COVID, largely due to the proliferation of streaming media, the production quality has been raised higher. A tentpole film and a television show are made with almost equal finesse. The consumer now expects things to be just as good in both locations. “That pushes the challenges upstream on visual effects in the previs to onset process. If you are going to make in-camera visual effects plates, they’ve got to be great and look finished to meet that expectation,” said Gaffney.

The demand for real-time is the power to quickly reiterate and decide if the shot can be done in-camera or if other methods have to be employed instead. “It puts pressure on the creative,” Gaffney explained. “But it also opens up opportunities for them. It’s an exciting time for us to come into this market.”

According to Martin, the advancements in real-time rendering are due to a combination of technology, the capabilities of new GPUs, and the power of real-time rendering. “There is a process that is still going to be part of whatever real-time we want to bring to the set,” he said. “Whether it be the collaborative end-resolve of what the DP and the final pass of the work are guaranteeing or whether it’s an ability to visualize and approximate the in-camera VFX that then influences and helps define the post process.”

Martin added that the goal is to “eliminate the amount of renders and the guesswork that goes into sizable VFX teams interpreting the vision of a director and being led by a VFX supervisor.” He also noted the importance of managing expectations for the quality of the image and the time required to achieve a desired level of photo-realism. “I find that people working in real-time gaming are often so enamored with the quality of the image that they don’t take it to that extra layer or limit that they would in a post-process,” he said. “We have a ways to go, and I don’t think we’re there yet.”

“The director might look at the previs from the beginning, telling the story with it,” said Gaffney. “But sometimes someone might say, ‘Wait a minute, we could do this better in visual effects.’ This happened for years on the color side.” Gaffney explained that a director might fall in love with a washed-out look on an editorial cut, but when film prints are put on it, the director might say, “What happened to my movie? Why does it look like this?”

Gaffney believes that the convergence of real-time game en-

gines and the continually improving power of GPUs will help answer these questions. “Debayering algorithms for cameras continue to improve every few years, making the image look better from the same acquisition,” he said. “What we can do today in real-time with VFX shading, shader graphs, and real-time ray tracing without having to do a secondary render pass is continuously improving.” He added that while real-time rendering might be good enough for some projects, depending on the budget or expectations for the final pixel, “you can constantly come back to those projects, pick them up and reiterate and improve them.” He concluded, “There’s no reason in the future why you can’t work in real-time from previs all the way till the end.”

Speaking of the types of projects, budgets, workforce, accessibility, and collaboration, Martin said, “I see a lot of projects that are going into previs that actually used previs for the pitches.” People are getting more than just the planning of shots out of these initial efforts. The exercise provides them a texture or a feeling to the production, like with any other asset. According to Martin, “This personality goes into the film, so the desired output is within reach.” The unique sensibilities and values of that creative vision become apparent to all, so everyone involved clearly sees the movie they are willing to invest in.

Martin said these early explorations will help answer questions such as, “Is it a movie they could see their distributors picking up and wanting to fit into a roster or schedule of films they want to take to the cinema? Or is it something that is better suited for another means of viewership or consumption?”

KEEPING PACE

“The problem is the technology constantly improves year over year, now you have a reason to go off and redo your pipeline because you want to bring in real-time tools,” said Gaffney. “The idea of capturing digital twins and digital humans is an area studios are researching because if a franchise is built around a character, then that character either ages beyond the storyline or passes away. You want to reference these materials in an archive for a reshoot. The question now becomes, ‘How can I turn that character into a digital asset that we can continue to monetize and tell stories through?’”

Gaffney also discussed the MovieLabs 2030 Vision, a technical initiative for content creation in the cloud, and the benefits of using Unity tools that can create content for multiple platforms. He said, “One of the beauties of the Unity

tools is that we create content that is used across all the platforms with most content consumption being on these little 2D devices we carry around called mobile phones.” Gaffney emphasized the importance of the archival process and the need to put everything into a common container to maintain continuity between shows. “Right now,” he noted, “the asset management process from ideation to real-time asset and final content delivery creation and tracking of thousands of elements is a challenge that I haven’t seen anybody glue together.”

“One of the approaches we’re taking instead of just rushing up to virtual production is trying to build the infrastructure for content creation across the creative pipeline with real-time and non-real-time tools, working in an intraoperative way in the cloud,” he concluded. “That starts on the education side.”

Martin said, “The scale at which we’re consuming media, and the number of productions that are now being demanded globally, require both consistency and the quality that a lot of film productions didn’t consider in the past.” He also mentioned that they are “educating and bringing tools to the younger generation of filmmakers, not only to inform them on what techniques are available, but we’re specifically readying them for all types of technologies — AI, ML, virtual production, and quality storytelling — which is what it comes down to.”

He believes that “we have to teach people how to do jobs and what the expectations of those jobs are in film production. The tools will help create an expedited approach or ease of acquisition, which will help them focus on the craft at hand instead of the technology supporting the visual direction.”

BEST TOOLS ARE INVISIBLE

According to Martin, “We are still emulating a 2D interface in a 3D visual environment. It has been a mouse, 2D orientation, or a keystroke, up-and-down-type of mechanics.” Martin also noted that the tools built on real-time engines, such as Masterpiece Studio or Quill, allow for “collaborative opportunities for people to be at scale in these instances that are immersive and allows people to make decisions by just grabbing a controller and not worrying about the buttons.”

“It’s these choices of lenses and light and color that can be experimented with and appreciated immersively,” he added. Martin believes that the next generation of filmmakers will embrace these methodologies as their primary source of storytelling.

VOLUMETRIC CAPTURE & IMMERSION

“Volumetric capture is quite enamored with recreating reality,” said Martin. “Being able to capture and transport that to scale phenomena.” He added that he sees “a lot of objects and recognitions and assets being created as grey boxing and toolkits,” and that once creative decisions and blocking are complete, “the finishing of those sets will go off to artists, who will then upscale, up-res, and create the realistic virtual environment from the cues that are designed, developed, and delivered in these virtual realities.”

According to Martin, the adoption of LED volumes has been accelerated due to COVID, acting as a “semi-permeable membrane of what is possible.” He explained that LED walls are a great reference point for actors, cinematographers, and directors to get as good as they can on a closed volumetric set. “I see a lot of identification and data,” he added. “I say data because all of the 3D information, the camera position, the lens choices, the lighting, and the infinite amount of data can help influence the next process that the imagery will go through, which is affecting the shooting process. It’s all there.” He concluded that as the quality grows and finishing processes become more enhanced, the viewer will expect more.

“A couple of other things happened simultaneously with COVID,” Gaffney said. “We have this pixel density of LED walls coming down from five and three millimeters. Now we’re down to 1.9 and even 1.5 or lower soon.” He continued, “It’s the convergence of all that, that I think is going to make this not be a fad, like a 3D thing. At first, it’s, ‘Hey, it’s cool,’ then as it gets too expensive, it becomes a burden. COVID was the thing that finally made people pay for it. Technology has always been there but nobody wants to pay for it. When they have to, then they’re like, ‘Oh, this makes sense.’”

He added, “It’s a technology where if we solve a couple more things and if the LED pixel density keeps improving the way it has been, and there is the AI version of Moore’s law — AI graphics and real-time render technology — as we master the lighting processes and figure out how to balance skin tones and get the color pipeline sorted from set to VFX and final color... Why wouldn’t you use this technology?”

“This comes full circle right back to the education process,” said Martin. “We’re seeing hotbeds of teams, local government, industry, and education pooling resources together to facilitate this growth and to make a destination not only about location and technology but also the skill sets to drive that collaborative ignition.”

"We are currently sitting on top of existing playback servers with just our vanilla installation," said Gaffney. "Virtual Art Department and VP stages are also utilizing our tools for their environment designs using SpeedTree and using our characters tools today for digital doubles for stunt VFX, digital face replacements and complex muscle and tissue simulation effects.

In support of real-time virtual production, we also have cluster display technology that supports multiple display configurations. The feedback is that it's easy to use and quick to set up for different volume configurations. Unity and the virtual production tools, currently in beta, support camera-tracking integration and multi-frustum support, chroma keying, live capture and amazing lighting tools. We also want to integrate further into the render pipelines between the URP and the HDRP and have color accurate post-processing tools integrated."

"I'm excited about what we have to roll out," Gaffney added. "The solution we have scales to support multiple volume or cave configurations. Combining the simultaneous camera tracking and other tools we have with our Solutions team that is helping productions start with pitchvis and support the process from visualization to layout. Where we need to further integrate our tools is making them more native to all the pipelines that we have while also supporting our clients existing pipelines."

THE ROADMAP

"With the acquisition of Weta Digital, we came along with this large customer now called Wētā FX," Gaffney said. "That guidance and feedback in support of visual effects pipelines and interoperability between tools beyond FBX to USD are high on the roadmap." He explained, "Unity is supporting every platform out there just like we do on the game side. It is the same interoperability focus we have around virtual production. We want people to be able to come onto our platform, but we know they may be going off into their custom engine, like they do in games or into Unreal or into a custom render solution and then back."

"What's cool is we have this recorder tool built into the system that allows you to export, right from your timeline, ProRes 4444 XQ files to go in your editorial to cut down shots or sync them together with your visual effects timeline," he noted. "You can export FBX and Alembic to round-trip with your DCC tools."

Gaffney concluded, "Unity is now in the mix in the visual effects world with the **Wētā Tools**, tools that are proven and can help build amazing worlds and background scenes from photo real environments to characters, both photo-real hero assets and digital doubles for stunts and background actors in a scene. As we progress forward, we want to integrate these tools and their assets into the engine even further. I am excited about the future Wētā Tools will bring to the market in support of VAD and virtual production."

SERVING ART

Artists are looking at processes that help them visualize the final result. "We are literally bending the creative process to give us as much latitude and quality as we can achieve in the time and the budget that we have," Martin said. The tools are transforming what is possible without changing our desired result. He added. "The simplicity of filmmaking and storytelling for years has been the art of creating these illusions or optimizing the illusion to create the empathy required for the story to transcend off the screen and live with the viewer."

"I bring that bit of a highbrow thought process to this because if we don't, we will keep pushing pixels until we're happy," concluded Martin. "Using the time and the technology to tell the best story we intend brings more credence to the use of the tools."

Gaffney pointed out that the new technologies are being utilized the same way, applying the craft of making movies just as it has been done for 100 years. "We still call it the film group," he said. "We still use all these film vernacular, talking 24 frames per second, but somebody's going to come out with that story that blows our mind that has a higher frame rate, AR and VR, and all these different things that tell a crazy story. Everyone wants to get a hold of the metal that'll revolutionize it." He thinks that person hasn't come along yet. "I mean, look at *Avatar: The Way of Water* and its Academy Award-winning visual effects. It's incredible. Now where do we go from here? I am waiting to see the radical use of these tools for a whole new way of telling stories."

"Somebody's got to devise a vision of how to do it," said Gaffney. Pointing to a **TED Talk performance** by **Kaleidoco's Particle Ink** that involved numerous technologies including projection mapping, AR viewed using an iPad, and live performance interactions, he said, "The problem is, you still have to hold the device. I'm not going to watch a movie like *Avatar* that way. But we'll get to a technology that allows that experience to happen

inside an immersive sphere or present it in your XR glasses instead of 3D ones with that ability." He added, "I feel that the next James Cameron that comes along and tells a story that makes everyone go, 'Wow. Did you experience that movie the way I did?' That's where we have to get to."

SHIFTING PARADIGMS

Tom Thudiyaplackal, virtual production producer of *Fathead*, inquired with Gaffney and Martin about what they thought of the cross-cultural phenomenon of pure technology folk coming into a space traditionally held by the pure cinema people. There are also people from the game world and other solution partners who are coming into the mix. "Sometimes they're not speaking the same language," he said. "They're coming at it from a different standpoint."

As a producer with a traditional film background, Thudiyaplackal argued that "because the final product that interfaces with the customer to make this venture profitable is a film, maybe the film domain needs to be seen as the dominant paradigm."

He expressed the need for some cross-cultural integration and education. "But at other times, I get enamored by the technology and the other aspects that promote our creativity," he explained. "The medium is changing. Maybe it's no longer that medium that I first entered. Maybe we need to evolve because that is happening. How does one come to that consensus anymore?"

"It has changed — even calling it film," Martin responded. This is a conversation he often has with Gaffney. "There is no film anymore," he added. "The product is either a cinematic release or a release. It is a film, as a film is the construct of the media. We are choosing to watch a subjective and passive medium in a film that we appreciate for the mindset and anticipation we have during that enjoyment. Whether it works for us or not is part of the viewer's investment in the medium."

Martin continued, "If you come away saying, 'It was terrible. I didn't like it!' It still evoked an emotion. Whereas in a video game, an interactive or an immersive environment, the challenge is based on the viewer's experiences and participation in that medium, and how much they will hope to and want to invest in it is another measurement of whether it will be successful."

Gaffney postulated, "The eventualities: If we can make LED

walls that wrap around on the stage, like what's coming out at CES 2025, you're going to be able to get your 65-inch television wrap around. It's going to wrap around you, but once you put the camera in the hands of the consumer, and now I can watch a football game anyway I want from any angle, or I can go into a movie and look at my character or the people I'm interested in, or simply look around the set. That's going to change it all. We've had this interactive one-on-one thing so far; Netflix released a couple of things with *Black Mirror*, but it's still in this 2D television world."

He concluded, "Once we match the sort of cinema or television experience to what we could do in production today and then give people that full control experience so they don't have to sit there and move their head but they can have direct camera control with their same game controller inside this personal volume would be pretty cool."

PLAY TO LEARN

Thudiyaplackal asked, "The idea of familiarity with tools is critical because you can only use what you know well. When you dream, you want to dream with those tools in your hand."

I was wondering if Unity and other technology companies are thinking of creating sandbox environments for filmmakers to play without the fear of failure, because that's where you learn the most to the point that it becomes an extension of you. Next time you dream, you're dreaming with these tools, not having to fight with them on the set or on the way to the set."

Martin said, "I will lean back on some interesting tools created for that sandbox and create on top of real-time 3D using Unity. Backlot Studios is one of them. Look at Previs Pro. It's an iPad app that uses 3D characters and allows you to import assets and do things. It works as a blocking storyboard device."

Our users are creating these sandboxes because they identify with this need. Let's prototype a movie. Let's get the story straight and take steps to create our vision to share it more effectively with others." ■

3.7 Learning Under PRESSURE



Phil Galler

FOUNDER, FORMER PRESIDENT
LUX MACHINA



PHIL GALLER, FOUNDER AND FORMER PRESIDENT OF LUX MACHINA, ADDRESSED SOME BROAD QUESTIONS WHILE ALSO ZOOMING IN ON A FEW CRITICAL ISSUES.

- HOW DID WE GET HERE, AND WHERE ARE WE HEADED?
- WHAT ARE THE FOCAL POINTS FOR THE NEXT TWO YEARS?
 - EDUCATION: UPSKILLING AND NEW LABOR FOR THIS INDUSTRY.
 - CULTURE CLASH.
 - STANDARDS AND BEST PRACTICES.

Galler had participated with ETC on the previous short film, *Ripple Effect*. His team at Lux Machina was also involved with *Fathead* indirectly once the project arrived at the Amazon virtual production stage where Jason Bayever, director of virtual production, and Lux Machina's stage team were on hand to operate the LED volume in a handoff to Amazon Studios.

Lux Machina places great importance on education, "largely 'shadowing opportunities' — putting people on jobs."

Galler listed some questions he'd like to tackle in this discussion:

- How do we get into properly building out education plans at scale? Is that possible?
- How do you deal with the complexities around that?
- How do you deal with complexities around challenges like COVID, and how has it impacted the ability to train properly on the jobs we might have done three, four, or five years ago?

"It can be negative, and we can talk about things that aren't working," Galler said. "This is a white paper, and it should be holistic enough that we can review it unbiasedly. It's completely objective." He expressed his interest in uncovering the problems to better evaluate them through the lens of 'what do we do?'

Ripple Effect was in 2020. *Fathead* was produced in 2022, and the white paper will be released in 2023. "We are probably staying relevant into 2024," Galler said. "There's some technology we're probably not ready to talk about." Regarding the things he felt comfortable sharing, he did not want to venture into the specifics but wanted to stay focused on the factors leading to the evolution — both the design process and education.

Between those two topics, Galler said, "We could write an entire white paper on, 'The education problems of the industry:'"

SOFT SKILLS NEED SHADOWING OPPORTUNITIES

"COVID was a big boon to the virtual production industry," said Galler. "It drove demand for remote production, increased labor, digital asset creation, digital art, digital operation, stage operation, and supervision." He highlighted the one major difference between vocational training and university classes: "The way the entertainment industry has worked for 30-50 years, people get trained on the job. You can get university classes on filmmaking, but you're not getting how to be on stage and deal with the politics — the soft skills."

Kris Murray, CTO at Lux Machina, said, "The biggest thing we're missing from the industry from a new skill perspective is troubleshooting."

The education process was divided into three challenges by Galler:

1. Hardware skills, 2. Software skills, 3. Soft skills

While some of these skills can be learned in a classroom setting, soft skills can only be acquired on the job. "You can't learn troubleshooting in college the same way unless you're immersed in production," Galler added. "College-level production at any scale is not the same as real-world production."

Lux Machina also does television work. Galler said, "The pressures of TV and corporate work, like on *Fox Upfronts*, where it's a live-live-show that incorporates some amount of XR and video playback, is a much more high-pressure environment where you have no choice but to learn troubleshooting skills. From an institutional standpoint, it's hard to replicate the pressure of a live show."

Only a handful of schools that host nationally televised live TV shows through PBS or their channels may replicate these real-world pressures. Galler studied at Emerson College where he worked on a live award show at the end of the year that was hosted by an array of TV producers from LA. Reminiscing about the experience, he said, "There's immediate exposure to 'we're doing something, and it's going to be on air at 8:00 p.m. on a Saturday.' That drives the need for being able to troubleshoot and think outside of the box."

Murray equated the pressure of live television to "a tape going into DI and going straight into a theater in real time."

"The film industry doesn't have that equation," said Galler. "One of the things we did before COVID was anyone who came to work with us would get on some show or do live TV, corporate, broadcast, and feature film work. That gives them exposure to a variety of pressured environments. All of us here have been through that trial by fire. That's what makes us successful."

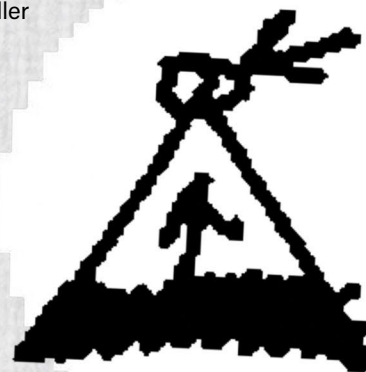
Galler recalled his early days in the field. "It was *Jimmy Kimmel Live!* in 2011, where I was standing on the ground doing a bunch of projection work, and the show was going to air in 20 minutes, and nothing was working. You're either going to do it, or you're not. If you don't do it,

"Covid was a BIG boon to the virtual production industry."


you're probably never working again. If you do it, you get to keep working and may have a good career." He emphasized, "The cross-section of hardware, software, and soft skills is currently missing, which was done organically before COVID. That cannot be done organically in the same way anymore. We need to formalize processes around it."

Galler insisted on the urgent need for a more open dialogue with clients about the risk of losing revenue from not being able to do more shows if there are not enough shadowing opportunities. "We understand there are extra costs and added challenges," he said.

Using a pyramid diagram Galler explained, "If we can't utilize the bottom of the pyramid to help drive more growth at the top, then everyone suffers. The attitude is, 'We don't want the extra people. We're not going to pay anything.'" He added, "It's a fallacy because the more we are unable to do this, the more we will fail at driving proper growth in the industry, which is what we're seeing right now."



"Many people are looking to get educated in virtual production. The currently available education processes don't teach you what matters the most on a film set: soft skills. We love the Unreal Fellowship, but this is true for that as well," Galler added. "You can have the best hardware and software skills in the world, but if you don't know how to deal with the hierarchy and politics of a film set, you will get clobbered almost immediately and never work again."



"In the broadcast industry, everyone is nice enough to tell you that you've crossed them once and are allowed to fix the problem," he elaborated. "In the film industry, they don't do that. They bury you, and you don't work again for many years. You may never know why. It largely comes down to soft skills: social and political awareness or situational awareness. How hard is it to educate on that? From a simple book process, it has to be done through exposure. The problem is that it's hard to scale exposure opportunities, especially during a pandemic."

IMPORTANT CONVERSATIONS THAT DON'T HAPPEN ENOUGH

- What processes do we have now?
- What trouble are we having?
- What dialogue needs to be created for the industry?
- How do we start that dialogue?
- What's the desired result?

"As a business, we're reticent to say to clients, 'Hey, we need to have another person,' because it always feels bad," said Galler. "But the reality is, it shouldn't feel bad because we need to remove that self-guilt that we've sort of imposed on ourselves." He shared that clients have slapped their hands a few times for having a few extra people, and he'd like to discuss why shadowing opportunities are necessary.

Corporate and TV often get lumped together, but Galler said, "Corporate clients tend to be significantly more sensitive to this." Painting such a scenario of a corporate event for a tech giant, he said the executives didn't want to see many people milling about but no one explained why. He thinks it is a perception problem. He asked, "Why does a finance executive care about how many people are in the broadcast truck?" He added, "You have to go to that finance executive and ask, 'How are you educating your team?'" It is likely the response would be, "Well, I'm bringing in interns and giving them shadow opportunities."

Galler wants production to be treated the same as most other fields

when it comes to education. Currently, production is expected to dress in black and use as few people as possible. He wants to break that mold, and despite the difficulty, he will pursue talks to get back shadowing opportunities that were lost during COVID.

He added, "We're losing more now because of a perceptual problem of 'it looks too busy.'" Clients have expressed concern about having more people in the video village. Galler wants those people in there to train them about the social awareness of when to speak and when to stay quiet and observe. He said, "We should pull all of these directors aside, who say that a video village is too busy, and we should ask them how they got into the industry." He believes, nine times out of 10, someone had allowed them to shadow and learn.


Delving deeper to investigate other contributing factors that stand in the way of these discussions, Galler pointed out the issue of compensation. He said, "If I need another engineer on a job, can I find an opportunity to cut that rate in half or put an intern in there and have a conversation with the client about, 'Hey, this is a third-tier position, and they're not going to be responsible for anything ON AIR, but we need to give them exposure? We're willing to take half that cost down, but you need the body.' There's an element of that. There's also a financial component to this. There's risk mitigation, too. What's the insurance policy?"

He is willing to absorb the cost of putting a third engineer on the job because they're training, but he asserted that they're also there to support and make the days go smoother. Galler calls it the 'dollars and cents' problem. He said, "At Lux Machina, we sense that there's a training problem, but the clients don't think they have that problem." He argued that if clients agree to help solve this problem, they'll benefit from it and will be able to put on more shows to drive more revenue and do that at a lower price because the costs will go down.

THE COST OF WORKFORCE EDUCATION

As the industry looks to scale, Galler insists that the critical question of "Who bears the cost of workforce education?" must be answered soon.

The for-profit education outfits might do a fairly decent job with the software curricula, but Galler wondered how they'll afford to put a stage together. Even if the training involved a day or more on a stage, he said, "One day at a stage does not add up to 10 years of experience in broad-



"You can get university classes on filmmaking, but you're not getting how to be on stage & deal with the politics — the soft skills."



cast." The challenge for an industry that is scaling rapidly comes down to who can afford the expensive components. He stated, "I love what Epic's done, but they've given something away for free that is relatively cheap. What would this cost me if I was going to buy it out of pocket? \$2,000 a year. Whereas the hardware might be millions of dollars? Who's affording that?"

On the question of grants to support the workforce education initiatives, Galler thinks that the EU has it way better "because they can get government grants to put up centers." He added, "The U.S. doesn't value education in the same way that Europe does. They are way ahead of the U.S. not just in financing all that but also in the risk mitigation of it all. In the EU, they're more willing to carry people on shows. It's an easier conversation with producers."

KNOWLEDGE ACQUISITION FREE OF IP

Galler pointed out that a handful of cinematographers have started their own apprenticeship programs, which he sees as them taking advantage of individuals who are struggling to get into the industry. "It feels disingenuous towards the end goal, which should be getting more people into the market," he said. "Because the more people we have, the more we can solve this problem, the more shows we can do, and the goal should be to do more shows."

Circling back to his key point around soft skills in troubleshooting and out-of-the-box thinking, Galler insisted that people must have ways to acquire those skills independent of intellectual property (IP). He reminisced about his first live TV show, and shared, "I learned a bunch of stuff prior, and then I got to put it to use. I didn't need to know anything proprietary to be able to think about how things work."

He elaborated, "The problem we see is that independent of whether it's hardware, software, or soft skills, this is what we should be digging into — people will go on a path and hit a blocker. Whether it's a soft skill blocker or a hardware blocker is immaterial. They may understand the problem but cannot break it down into its core components to solve each little problem one at a time and then move around it — it's a downward movement of breaking problems into smaller ones to solve a small problem."

Citing a likely live production scenario to illustrate the problem-solving mindset required to tackle issues on the job, Galler said, "Why isn't the video signal working? The router must be broken. Probably the router is not broken, maybe the cables are not working. Let's test all the things that lead up to the router to identify that it's working to break the problem down into its core

components." He concluded, "This gets into a big philosophical debate because the U.S. doesn't prioritize STEM degrees. If you prioritize STEM degrees, you learn programmer-level logic and software developer logic. Development is largely about solving large problems by breaking them down into all the smallest components and doing a scrum to do something in six days."

In filmmaking, breaking something down into its core components can take 15 minutes, whereas working in live TV is much different. Galler cited a recent example to illustrate how a similar problem had to be tackled in three minutes. He said, "People who don't have that type of development logic have zero chance of breaking down the problem under pressure in a live environment in three minutes. This is that pressure cooker element. We have trouble putting people into these live TV environments and high-pressure situations because of the environment and the culture right now. On the education side of things, we never get them to break down the problem in two hours, then 15 minutes, and finally, in three minutes."

Galler cautioned us about the mindset around getting free access to software and thinking, that is all one will require to gain the necessary skills to become a professional. He said, "We ignore the millions of dollars you need to build out a stack, build out a system, and then learn how to troubleshoot that system. It's a lot harder to do that with hardware. It's nearly impossible to develop soft skills because these are environmental things that must be learned." He added, "It's not until you're using a skill on a show or building art for a show before you learn the workarounds."

FILM PRODUCTION VS TELEVISION PRODUCTION

The film industry has over 100 years of evolution that has set a predetermined hierarchy of how things flow. Virtual production has introduced the possibility of 'democratization.' There's a sense that everybody has a say now because anyone can see the image early in the process. Part of that soft skills training in the film business is about where to open your mouth and where not to open it, whom to pass on the information, and whom to keep it from.

Galler explained the live TV hierarchy by scribbling out roles and reporting structures on a whiteboard. He said, "The EP is on top, then we've got a supervising producer, maybe a line producer. That's the same tier as a production designer. Below that is the LD (lighting design) and AD (assistant director), maybe costume,



and then the crew. That chain of command is easier to follow in the Live TV world.”

He continued, “Whereas episodic is far more complex, in films, you’ve got an EP (executive producer), a studio, then a line producer, and you have no supervising producer. Then you have a production designer, but in the same tier as the production designer, you will have VFX, sometimes virtual production, costume and makeup, stunts... And all of that for live TV usually falls under the production designer or art department.”

Galler explained, “Live TV is tangential in many ways. But in films, it is a big horizontal problem, and there are too many cooks in the kitchen simultaneously with totally different narrative goals. Live TV is about highly dynamic, fast-moving action that doesn’t have a strong narrative. Films are about high focus, detail, and strong narrative creation.”

Highlighting a key difference between the two production environments, Galler said, “There are about 10 steps of hierarchical separations for live TV, whereas there are only two steps for film production. Someone at the bottom of the pyramid is further away. As a grip on a live TV show, it will be hard to run afoul of the EP. Because generally, you know what’s happening and just have to look in the room and go, ‘Man, there’s chaos here.’ But you’re never invited into the writer’s room.” He added, “On a film set, it’s easy for a VP supervisor who doesn’t have much experience at something because there are so few out there who have been on a handful of productions only to be two or three steps away from an EP, and the opportunities for them to run afoul of the politics are significantly higher.”

Quoting the phrase ‘Rather keep your mouth shut than open it and prove that you’re an idiot,’ Galler reiterated his point about shadowing to gain soft skills, and said, “It’s super hard to educate on this without the exposure opportunities. The reality is that as virtual production becomes more pronounced, many people view it as an opportunity for career growth. But the reality is, it’s so close to the knife in the film industry that immediately as you are exposed to it, things become challenging.” He shared that “in live TV, everyone has the courtesy to tell you at least once that you messed up.”

Going back to his early days in the business, Galler said, “In some cases, it takes a while to navigate it and get into the industry. But once you’re in, you can find a guide stone, and they’ll take you under their wing and help you. It may not be exactly in the segment you want. For me, I had a tech manager take me under his wing, Tad Scriptor, a phenomenal gentleman who was able to navigate a bunch of the politics with me. That’s because I was 10 steps away. I was a lighting programmer. I reported to a lighting director, and they reported to a lighting designer, who reported to...”

He explained, “I was low risk, but I was high impact visually because of the work that I was doing. I was in a weird place.



A stage operator is three steps away from running afoul of an EP. These people don’t have that same thing in the film industry. People won’t usually tell you to your face. All they’ll do is they’ll never work with you ever again. They’ll cut you out of the industry. Then we start losing people.”

Referring to some things he learned from a recent conversation he had in the business, Galler said, “I heard about a certain individual who continues to call around trying to get information about how to do a thing and can’t quite politically manage things. They are in a situation where they have failed upward and ended up in a position where they make the phone call, and no one will help.” He concluded, “The difference between these environments and corporate is the political complexities of the film industry, coupled with the pressures of live TV, which is like a whirlwind of problems. These industry segments are all different in the end result or product, but they all borrow these individual elements in their creation. That’s the education problem.”


SET ETIQUETTE

Galler believes office dwellers don’t know how to behave on set and may get pushback from the people who have spent a long time already on set. He stated that the ego problem may come into play, and it’s important to investigate how to financially incentivize the people who have already been on set to accept the new group of people. He said, “The VFX people on set are perceived as the roadblocks to whatever you’re trying to do because they always take more time. How do you incentivize people to accept that the world is changing?”

Galler has to constantly field questions such as, “Why is the Unreal artist on set with me? Why are we spending the time doing this?” He said, “It’s a weird conversation. It’s only on massive shows where you have the effects team in full force, like *Avatar* or *Star Wars*. Much of it’s about, ‘Let’s shoot film and make it a good narrative.’”

He said, “Time management and the communication around it is super important. The biggest thing we’re educating our people on is to under-promise and over-deliver every time.” He finds that people who have traditionally worked only in office environments don’t follow that. They may generally over-promise and work extremely hard to deliver it but deadlines are usually fluid in those situations. In relation to that, on set, he asserted that deadlines aren’t fluid. He concluded, “You want to get as little time as possible. It’s a 10-minute rule.”

“People unfamiliar with the set environment aren’t able to communicate this, especially as they transition from not being on set to being on set,” said Galler. In an office environment, where the pressures of an active production set are absent, if someone quotes 10 minutes for a task and instead finishes it in a half hour, it won’t impact much. He added, “Tell an AD, it will take you 10 minutes, and



it takes 30 minutes — you're getting much grief. If it's your first time on set, and you're the effects guy, no one wants you there because they don't assume you're doing this complicated thing, and all of a sudden, you've lied about the time it takes."

THE OBLIVION EXPERIENCE

Quoting cinematographer Claudio Miranda, Galler said, "'Some of the best results are mistakes! It's okay to make mistakes. We all make them. Especially in art, we're guilty of this.'" But he argued that there is a relatively high bar within this particular field. He said, "Sometimes it means that we don't get jobs. It's because we're striving for something that may be unachievable. There are times when we can achieve it, and we super over-deliver. And that's a business risk."

Lux Machina had worked with Miranda on *Oblivion* (2006), starring Tom Cruise, to achieve a 270-degree wrap-around front projection measuring 500 foot wide and 42 foot tall with 21 projectors that used second unit footage captured atop a volcano in Hawaii with three cameras and stitched together to create a 15K image that played live. 1 The phenomenal results achieved in-camera might be considered to be the kernel to many of the achievements we have witnessed since in the LED volume approach, and why Galler and his team have been at the forefront of several of these implementations.

THE UNION QUESTION

Galler asked, "How do you mitigate the risk of the individual while protecting the interests of the business?" He expounded, "Not just for the business to grow revenue but to grow opportunities for everyone."

"I love the unions, but the unions in the U.S. are problematic in this regard," said Galler. "They tend to sit on a whole bunch of stuff here." He pointed out that the Producers Guild of America (PGA) has caused a massive divide by pressuring the rates down for IATSE Local #728 (lighting technicians), which has consequently increased kit rentals. He said, "That is how they are making their money. The DIT cart is rented at \$15,000 a week, and now they can charge \$400 a day. But today, it's on them to invest in and protect that technology. Because that's their income, as opposed to what it should be, which is the actual rates — and not them having to protect the kit rate."

Galler shared that a digital imaging technician (DIT) who has already invested half a million dollars into the kit that has become the only way they make a living will see a cut in their revenue. He added, "In some cases, by 60%, which is generally what we see. It's a two-third split in revenue, especially in Local #728 and Local #695 (sound, video, and projection)." He believes that the PGA has inadvertently created an ecosystem where it's hard for technicians

to evolve. He added, "Because people are trapped in this. Once they get trapped in this cycle, you're in the cyclical thing where you must spend money to make money. The only way to make money without spending money is a rate, which is way lower than it should be."

If the rates were set correctly, Galler believes people would be willing to invest in education and getting into more advanced technologies. He said, "We should probably have a conversation with the PGA. Local #695 is losing this battle every day." There are internal disagreements in Local #695 about the role of its members on different crews based on the working environments, which he thinks "the PGA is using as an excuse to not pay them."

Galler explained, "A board operator is a support operator, and they are not a programmer. They may be doing the same work that the live broadcast people are doing, where you see more technology being utilized, more quickly, and being adopted quickly." He said, "If you look at the number of films using technology in the space, in Unreal, there are maybe a dozen features that use that work this year (circa mid-May 2022). A dozen projects a month use XR technology in the broadcast and corporate industry and AR." He believes it's that way because why would a DIT take on Unreal Engine or buy a bunch of camera tracking equipment and have to learn all of that when there is no clear job classification or knowledge about how to get paid for it.

"These people can't agree that the people doing this job in the film industry are doing the same job, even though it's, in many cases, button-for-button the same job as the TV industry," said Galler. "It's a bit of a disgrace. It's embarrassing. It is super relevant." He concluded, "If it's going to change, it needs to change here first."

Galler asserted, "This is how we have to have a conversation with the client to change the paradigm. We have to tell the clients, 'This worked when you were buying a bunch of Mole-Richardson's, but it doesn't work when you're buying a bunch of high-end computing technology that evolves very quickly.' That's why the evolution and adoption in the film industry are relatively slow."

Murray said, "On the topic of Local #695, the challenge of the unions is very real, in the sense that I can put an operator on a job for six months that plays back with video at 24 frames per second, and that qualifies as 695 work. It's straightforward from the old days of rear screen projection."

He added, "If I put them on a camera tracking production with 3D assets sitting on the same stage, using the same technology, that does not count as union work. Then there is a blend where I play back 24 frames in a game engine. And that is now a





dragging question. 'Am I in the union or not?' As a driving point of exactly calling out the challenges of where we've come from, where we are now, and where we're going with the number of people we have on set, there's only a slight distinction of what puts somebody in a union."

Galler said, "There are jurisdictional challenges. The union needs to evolve."

STANDARDS FOR THE FUTURE

Galler is a part of the SMPTE RIS (Rapid Industry Solution) program that is invested in standardization. Sharing his philosophy on the subject, he said, "I'm a firm believer that we're in the singularity. An uptick is happening. We're no longer on a linear path where time is very slow. Everything is happening quickly. I don't know that standards bodies can work at this speed. The reality is that it's already invalid between the time we started talking about RIS and where we are right now."

He thinks some of the work is still relevant in certain pockets, but in general, he's concerned about the bureaucracy — that people don't understand how fast things are changing.

He said, "By the time we all get around to agreeing on how to manage color on RGB (red, blue, and green) LED walls, we will be using RGBAW (includes amber and white) LED walls. We need to talk about what we will do going forward in time and not keep discussing something that happened back there. It's a moving target."

Since predicting the future is daunting, he believes we end up taking the comforting stance of looking back and standardizing that versus investigating where we're going to be in some years and forming standards around that. "The only way we can do this is by asking where we want to be in two years," he suggested. "That's what we should be educating for now instead of coming from behind on it."

Galler wants us to focus on standardizing workflow, which is what RIS is focusing on. In the past, SMPTE would deliberate around hardware like BNC cable. He said, "Part of the problem is that the standards bodies are endeavoring to do something they've never done before. They're learning. Unfortunately, we're moving so quickly that we don't have time for them to learn." ■

"By the time we all get around to agreeing on how to manage color on RGB (red, blue, & green) LED walls, we will be using RGBAW (includes amber & white) LED walls."





FROM DOWNTIME 3.8 TO UPSKILLING



Brian Pohl

Media and Entertainment (M&E)
Technical Program Manager,
EPIC GAMES



Brian Pohl is the media and entertainment (M&E) technical program manager at Epic Games. He is responsible for designing and deploying the Unreal Engine and virtual production curriculum for the media and entertainment enterprise market vertical within Epic Games, and he also directs the educational efforts of a collection of instructors who supply live and pre-recorded courses to animation and visual effects studios. He is also the acting academic dean of the Unreal Engine Fellowship Program.¹

FIRST STEPS

Pohl said the genesis of the fellowship program “was a direct result, of course, of the pandemic.” He added, “When everyone was getting furloughed and laid off due to COVID-19, and studios were asking everybody to go home — before we had any real work-from-home solutions in place, Tim Sweeney (founder and CEO, Epic Games) and Marc Petit (VP, Unreal Engine Ecosystem) came up with the idea that this would be an excellent opportunity for us to spearhead some sort of training and education initiative.”

At the time, Pohl was working with Linda Sellheim, the head of education. The two got down to it and conceptualized the fellowship program. He said, “As we were brainstorming, Tim and Marc informed us that it would be a stipend-based program.” The plan was to run a pilot program first, for which they recruited 10 fellows and

15 auditors. “We had a higher prerequisite for candidates — they were required to have 10 years of experience,” he added.

“We wanted to ensure that people from the industry helped us create this program, so we brought them in, paid them a stipend, and created the pilot,” said Pohl. After completing the pilot successfully, Sweeney and Petit gave the fellowship program the green light. The original plan was to enroll 50 people, but they encouraged Pohl to go bigger.

Pohl said, “We were expected to do cohorts of 100 or better. We settled in on 100 people per cohort.” The first six cohorts received a stipend; every cohort since has been conducted without that benefit. An ICVFX fellowship was introduced in Q3 of 2022. He added (circa March 2023), “The latest program offered is the ‘worldbuilding’ pro-



Brian Pohl and his class of ICVFX Fellows get a demonstration from Kevin Cushing, the lab's VP Supervisor.

gram. We've released two cohorts so far. One for AMER (Q4 2022) and one for EMEA (Q1 2023)."

An 'animation' fellowship is in the works and is expected to be delivered in Q3 of 2023. The ICVFX program has been offloaded to Unreal Authorized training partner facilities, also labeled the Connectors Program. Lux Machina (NEP) offers a series of master-classes and intensive workshops based on the ICVFX Fellowship curriculum to the local guilds and unions in Los Angeles. Pohl said, "It was intended primarily to give industry professionals a chance to learn real-time technology — how Unreal Engine operated, and to start familiarizing themselves while they had all this downtime."

"Of course, the stipend was there to help alleviate the potential pressures and stress of not having any income," Pohl said. These programs have been a huge success and have steered the careers of several sincere artists along a constructive trajectory through the pandemic.

WHAT'S NEXT?

Pohl shared, "Linda and I did much to advance the program; however, its scope was limited. With the arrival of Julie Lottering, Epic's new head of education, the program was once again mandated to expand." Lottering took the existing programs to a global network of Unreal Authorized training partners and launched the Connectors Program with Epic's channels and partnership team. The newly deployed curriculum will now begin servicing diverse communities and languages around the planet.

HOW TO MAKE THE CUT?

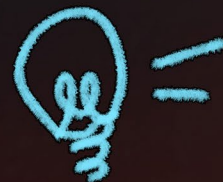
Epic Games has generously supported creatives and technologists through their uncompromising efforts at dispensing top-notch self-training resources via the [learning portal](#) and exhaustive [documentation](#). The fellowship holds a special distinction, where

entry is extremely limited. "Some of the individuals we picked were random, and others were by referral," said Pohl. "The first fellowship was all hand-picked. The second fellowship was almost entirely random because we opened an application process and had over 6,000 applicants."

Pohl and the fellowship team developed a selection process based on a rubric to assess all those applications — a series of questions and points to evaluate the candidates: The quality of a demo reel or the number of credits they had, or something else that helped someone stand out. He said, "That selection process has continued to evolve." He added, "Now, we deploy a selection committee to screen applicants and assure that with referrals from our business development community and technical account managers."

Epic now primarily works with clients focused on upskilling their artists with Unreal Engine know-how. Pohl said, "They either have potential site licenses with us or purchased training support. Part of that was, let's get them into the fellowship."

EDUCATION & PROLIFERATION



Breaking down cohorts three to six, Pohl felt that while a certain percentage was through referrals, some were from the general public through the global applicant pool, and a cluster came from academic institutions — which he acknowledged as becoming more of a precedent. Having trainers teaching at different schools and institutions "started to spread the word in the academic community." He said, "Then the Connectors Program started coming online to get training partner facilities into the mix."

"Epic's principal goal is to promote the usage of the Engine within the industry, which is critical," stated Pohl. "We created a new process using real-time graphics and in-camera visual effects — a whole new market — we have to start training people how to use that technology. That's obviously crucial." He added, "Real-time is driving the need for more talent. We're trying to train as many people as possible to send them out into the world with a real-time and Unreal Engine knowledge base. The fellowship had been that mechanism initially,

"Real-time is driving the need for more talent."

and it's starting to expand with all these other programs."

Epic Games has awarded over 1,800 grants (as of this reporting) through its MegaGrants program that has committed \$100 million for projects in game development, architecture, film production, or educational endeavors and software tool development. On average the selected projects have received \$5,000 to \$250,000, while a handful of extraordinary projects have received more. Pohl confirmed that the fellowship is not linked to the MegaGrants program in any way, and the two operate as separate entities.

Pohl shared that he has witnessed MegaGrants applications come from past fellows and also some occasions where MegaGrants projects utilized fellowship graduates to help them out. He said, "They're not tied to one another formally, but I suppose they have a relationship informally."

DISTINCT ROLES, BESPOKE COURSES

Unreal Engine has become ubiquitous to the ICVFX or OSVP pipeline for virtual production. But does Unreal Engine matter only when dealing with fully realized 3D worlds played in real-time with a photo-real resolution, as opposed to when a production has to rely on 2.5D or 2D plates?

"You're approaching this particular question from a VFX perspective only," Pohl said. "If you tie in the animation community, the idea of using Unreal Engine as a real-time full 100% 3D content engine for animation, film production, or episodic production is a major consideration." He added, "We have many clients using Unreal Engine to do 100% full 3D animated, episodic television, or film production within the Engine." He shared that the fellowship was partially geared to address these other use cases.

Students of the ICVFX Fellowship utilize Epic's educational stage to construct shots with marketplace assets.



The LA-Lab preparing for another exciting ICVFX Fellowship tour.

Delving into the curriculum for the original storytelling cohorts, Pohl said, "It has been very much about linear content creation, cinematic construction, pre-visualization, and animation — it's all synthetic and virtual." In contrast, he clarified that the ICVFX fellowship was designed around delivering technical mastery and exposure by acquainting people with the intricacies of setting up an ICVFX volume — configuring the hardware and software and optimizing a scene to transact to a wall.

Pohl hopes there'll be a third phase to the fellowship that will take the phase-one 'storytelling fellows' and combine them with the phase-two 'ICVFX fellows' who have an understanding of the more technical aspects of setting it up on stage — this hybridized fellowship will be a full-fledged production done entirely on a stage. He said, "Hopefully, in phase three, we can get more into the whole, 'here's the best way for shooting on stage with these tools. Let's create a production or a short film using those two techniques together.' That's my desire." He's working closely with several partners to realize that goal.

Additionally, Pohl is responsible for feeding fresh and up-to-date content to the fellowship programs, Unreal Connectors, and all the varied training partners teaching the Unreal Fellowship curriculum. The goal within the fellowship is to become a curriculum laboratory. It started with the storytelling fellowship, which is about pre-production and linear content. At the end of 2022, a world-building fellowship was offered, which was all around the process of creating environments, scene assembly, and production design of a world. He said, "In 2023 and 2024, I intend to build fellowships for lighting, cinematography, animation, technical effects, etc."

All the varied components would ultimately mobilize the phase three program where the world-building fellows will be in the VAD team, the ICVFX fellows will manage the LED stage work, and so forth. "We're trying to build this program to tie it all together to move people into understanding what it takes to do a production with all this tech, all these roles, and different requirements," Pohl explained.

“The speed at which Epic develops its software & how the feature set continues to change every quarter makes it so challenging to try & teach at the pace at which the developers are creating the software. It's brutal.”

“I see fellowships becoming more specialized in a sense,” he added. The ICVFX fellowship is better suited to the technically savvy, while the world-building fellowship is more for people with artistry and prior experience with Maya, Houdini, ZBrush, Substance Painter, and other 3D creation tools. The storytelling fellowship, on the other hand, was “a broad-facing, fundamentals-based program focused on purely 100% virtual and linear content creation for pretty much everybody.”

These curricula are built with training partners in mind. But with some of the newer programs, Pohl intends “to focus them on aspects of production that require emphasis: Production design, cinematography, animation, and so forth.” He added, “Whereas the storytelling fellowship was 80% entry-level fundamental classes and 20% was a little bit more advanced, it’ll probably be the opposite in these other programs.”

DIVERSITY & INCLUSION

Pohl assured, “There will still be a breakdown in every fellowship of a certain number who will be referred by industry, a certain number who will come from global applicants, and a certain number who will be educators. You need to have a little of all three because, quite frankly, having global applicants allows for better diversity. We have more women and minorities in the program. I want to ensure that continues because it’s really important.”

VIRTUAL PRODUCTION INTEGRATIONS

It’s not unusual for Pohl to be asked for recommendations on how to set things up to get rolling with virtual production. He

said, “First off, Epic can’t recommend specific hardware. We try to stay agnostic as best we can.” There are several LED processors on the market from Brompton to Megapixel, and the same goes for LED panels. He added, “Whatever tools or equipment you want, we want to be able to give you the blueprint and the specifics. Here’s what you generally need in requirements, but we’re not going to suggest you buy X or Y.”

Pohl wants to aid these industries and studios trying to create ICVFX offerings in their part of the world by providing information on what is required in terms of particular pieces of equipment and what each will do within the infrastructure. How they work all together, and the steps needed to make them work. How to optimize content for the wall and transact that content to the wall.

The setup involves a camera tracking component, a camera component, LED walls, and processors connected to a source control element to get everything to talk to one another, networking, etc. “It’s up to a small engineering degree,” said Pohl. “We’ll never be able to provide a full-fledged engineering curriculum like what’s needed to set up some of this hardware but if we can give our perspective to studios, supervisors, executives, and administrative personnel, in addition to the artists — at least they know.”

Pohl concluded, “They will feel comfortable, and it’s no longer scary to them.”

ACCESSING FREE LEARNING TOOLS

Given Epic’s generous serving of free learning content and access to Unreal Engine, Megascans, MetaHuman Creator, MetaHuman Animator, and so many of the tools and the exhaustive documentation, if somebody has the dedication to go through it all, everything needed to master it is available. But having the structure of a fellowship or the Connectors Program expedites the process and focuses the effort on mastery within a specific aspect that is of value to the participant. Can studios and organizations approach Epic to guide them on how all of this information can be accessed for there to be some structured way of training internally?

“We’re trying to find better ways to do this by reengineering our learning management system at Epic. We’re refactoring this again. We have the developers portal, but the media portal is being reconsidered, and I don’t know what we’ll go with here yet,” Pohl said. “The speed at which Epic develops its software and how the feature set continues to change every quarter makes it so challenging to try and teach at the pace at which the developers are creating the software. It’s brutal.”

FELLOWSHIP GRADUATES FILLING JOBS

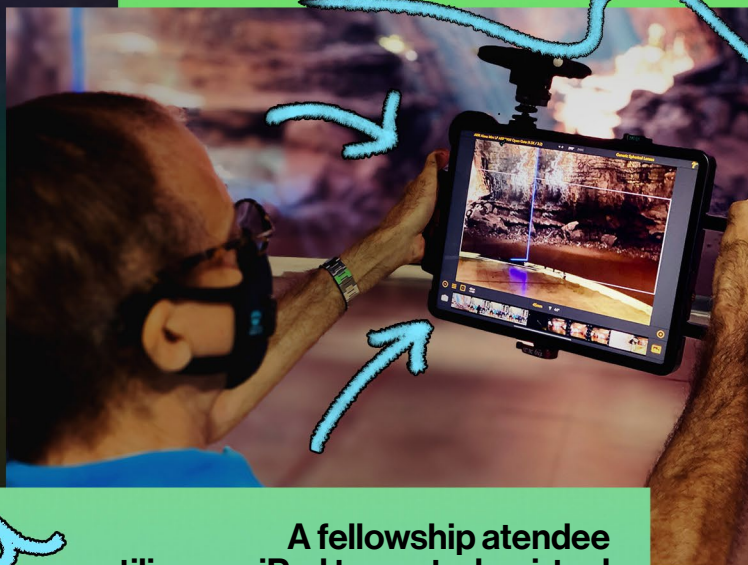
Epic Games has an internal Slack channel dedicated to the fellowship graduates to keep them connected. Additionally, during the fellowship industry experts and representation are brought on as guests to interact and provide a real-world glimpse at how the education can translate to a job skill.

Pohl said, "It's unlikely that we'll have employers on the Slack boards because it's Epic's internal Slack. But we are looking at ways to allow employers to gain better access to the community. We already do the Fellowship Alumni Career Event (FACE) sessions, but we need to do more than that."

At his last visit to SIGGRAPH in August 2022, he learned that several employers were looking for ways to connect to fellows. He said, "I've talked to multiple clients who are like, 'We need a way to help separate the wheat from the chaff when it comes to people.'"

"At a certain point, Epic says, 'That's enough. You're getting outside our bounds of what we do as a company.' We're not a talent agency or a placement agency," said Pohl. "At the same time, we want to ensure that our clients and people have access to the talent to get these projects done, which will benefit Epic. So, it's a catch-22."

Pohl feels happy every time he hears from fellows out in the field getting jobs and communicating with each other. He said, "That's the whole thing that keeps this going. It's the community that sustains it. Epic will be even more motivated to participate if the community wants it. That's where we need the community to tell Epic what it wants — not only to me but also to my bosses and people up the food chain. Tell us, 'We would like to see this,' which will be motivating. We listen." ■



A fellowship attendee utilizes an iPad to control a virtual camera within the volume.



Fellow Nhan Le assembles the Blackmagic Ursa Mini for instructor Sky Ferren.



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nDisplay

INSIGHTS FROM THE FRONT LINES OF INNOVATION

THE ROAD TO VIRTUAL PRODUCTION

Vitalii Boiko created **nDisplay**, a plugin for rendering an Unreal Engine scene onto multiple synchronized display devices. The solution has become integral to the virtual production pipeline since Epic Games acquired it and integrated it into the Unreal Engine setup. Boiko had spent over two decades in computer graphics. He started as a game engine developer at a French gaming company in 2004. Around 2008, he worked for a company that developed technology for virtual reality simulators.

"Licensing game technologies was challenging for enterprise use because of pricing and IP protection," he said, "so we were forced into building proprietary solutions." However, these homegrown technologies were not on par with game engines, as they only had rudimentary rendering capabilities.

He was working on a solution for an extensive CAVE system with many projectors connected to computers, a 270-degree wrap-around environment. It was "a big giant cube," said Boiko. "I was always fascinated by how natural the simulation looked because it was a stereoscopic environment. It looked amazing but it was awful from a rendering perspective."

Boiko had dreamed of getting it done in a "superb photorealistic quality" and became obsessed with that idea. His many experimentations around rendering stack led to the initial prototypes of the future system.

Using some existing photorealistic assets from the 3D marketplaces and simple but highly realistic custom renderers, he tested it.

The results convinced him that one day the clustering technology would get hyper-photorealistic.

When Epic made Unreal Engine open source, Boiko immediately invested most of his time and money to build his solution for the photorealistic rendering in the clustered environment. He and his team took about four months to complete the initial prototype. "It was amazing," he exclaimed. They continued the efforts for another four years and made numerous installations worldwide.

Although corporations in heavy industries, tourism, aviation, education, etc., were using the technology, the adoption pace was not enough for sustainable business. But it was gradually picking up.

Epic Games took note of the product around 2017 and approached Boiko through mutual connections. "I ended up selling the product to Epic and got a chance to spinoff the service business to the next level," Boiko said.

Boiko's team got contracted by Epic Games as part of the engineering team to continue product development. "Collaborating with Epic has put us to the next level as a company," he said. "Epic's engineering and managerial environment is top-notch. We have inherited their engineering and organizational culture by working in close collaboration with these great people. We are now moving it down the line into other departments in my organization."

Boiko and his team always wanted to "work on cool projects to keep it fun and interesting." He admitted, "We got what we wanted. Epic brought us to the fascinating and emerging world of virtual production."

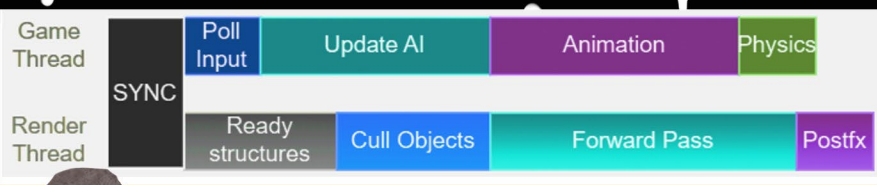


IMAGE SOURCE:

<https://vkguide.dev/docs/extra-chapter/multithreading/>

GROWING PAINS

nDisplay was originally only a clustering technology without the camera component. "You could get shots by attaching the viewpoint to the camera and tracking," Boiko explained. "It would work out okay, but complex curved shapes would not get warping and correct in-camera projection." It required pixel-perfect mapping with sensors. In collaboration with Epic, Boiko's team developed all the missing pieces for nDisplay to power up the technology that propelled the virtual production industry forward.

"Pixela Labs (the company Boiko founded) assisted many production and rental companies all over the world with setting up their LED stages," he said.

He still remembers the first shot. A dozen engineers were there just to get things functioning. "There were a lot of problems and missing tools," Boiko noted. "Back then, it was a text-based version of the configuration. All kinds of technical issues were popping up because everything was moving so fast into a new arena. Many of those problems had no solutions yet."

CLUSTERS & MAPPING

"Real-time backplate has evolved from a hundred-year-old idea," said Boiko. He explained that achieving those results involves some complications because the Engine consists of different sub-systems: Physics, particles, materials, animations, blueprint logic, scripting, networking, tracking, and many other components that must all produce a consistent visual output.

"Everything has to work 'consistently' when you have moving objects in a scene that go from one screen to another," he explained. "The technicalities involved with ensuring the Engine instances maintaining the game world state across the application instances are quite a challenge." We started in 2014, and many things are not yet fully done "because it requires deep cooperation between many parties, like hardware manufacturers and many other experts in the field."

Recalling a challenge tackled on a project in New Zealand, Boiko said, "The Engine has randomization in many of its subsystems. If two instances work together, you must ensure that all the random mech-

anisms that generate the numbers work similarly over multiple computer nodes."

We are required to manage several complications to ensure world consistency across the nodes. Boiko said, "I doubt that someone could do it faster because Epic has access to the best specialists in the industry."

Boiko explained that the problem is not about resources or getting more engineers to solve these issues. "It'll take constant improvement for the hardware and software stack to evolve," he said.

Speaking of alternative third-party cluster rendering systems, Boiko used the example of Disguise RenderStream, which he thinks "does a great job of what it was built for." He explained that the media server's job is to "ensure the stability of the failover system."

Epic released the failover system with Unreal Engine version 5.0, and all other media servers can hook up to nDisplay's failover to ensure the cluster works when something precious happens.

NDISPLAY SETUP

Explaining the nDisplay network overview presented in the Unreal Engine documentation, Boiko said, "Each node in the cluster is a separate application instance. In this case, (fig. below) we have four different nodes. We have two roles for nodes: One is the primary node, and the others are secondary nodes. The primary node's role is to drive the pace of the rendering and keep the system in a lockstep by sharing the frame timings and external inputs devices."

"REAL-TIME BACKPLATE HAS EVOLVED FROM A 100 YEAR OLD IDEA."

Pointing to nodes B, C, and D, Boiko explained, “Node D has a single computer with a single Unreal Engine instance that goes out to two projectors. Nodes B and C are essentially a single computer, but it has two Unreal instances, each with its display output. This gives us the flexibility to build up all kinds of scenarios and cases in the cluster.”

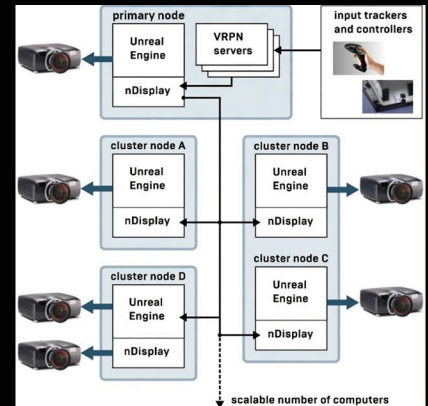
In unique scenarios presented with extensive simulations for airplanes or automobiles, Boiko shared that the visualization system can have supplementary monitors for operators or additional points of view into the digital world.

In the node diagram, Boiko pointed to the VRPN servers. VRPN is a protocol for virtual reality

peripheral networks for inputs such as tracking data and input data for virtual reality environments and CAVEs — the inputs for head tracking or joystick buttons. He said, “Unreal Engine now has a separate plugin, [Live Link VRPN](#), which is much handier than before, where you had to put everything into a text configuration file.”

IMAGE & EXCERPT SOURCE:

<https://docs.unrealengine.com/5.1/en-US/ndisplay-overview-for-unreal-engine/>



The image above shows a possible nDisplay network. Like all nDisplay networks, one of its PCs acts as the primary node. This primary node accepts input into the system from a VRPN server, which relays signals that come from spatial tracking devices and other controller devices. The network also contains several other PCs that run other instances of the Unreal Engine Project. Each of these secondary nodes drives one or more display projectors.

FALLOVER

Every installed clustered system, either permanent or temporary, is exposed to some risk of failure. Failure can be because of hardware, software, or network issues. Failover refers to how systems can mitigate the risk of failure and recover from nodes failing without terminating the entire cluster.

The current implementation of failover in nDisplay addresses the network discoverable failures of the render nodes only. In other words, when a render node becomes unresponsive, whether because of a crash or because it loses its network connection, it is dropped from the cluster after a configurable timeout value.

ENABLE FALLOVER

To enable nDisplay Failover support, open the Cluster Details panel in the [nDisplay 3D Config Editor](#) and set Failover Policy to Drop S-node on fail.

▼ Failover	
Failover Policy	Disabled ▼
► Info	Disabled
	Drop S-node on fail

When activated, this option causes render nodes to drop from the cluster should they exceed the timeout value. The timeout values used for failover can be found in the Network settings for the Cluster. Refer to [Changing nDisplay Communication Ports](#) for details on the Network settings.

▼ Network	
Connect Retries Amount	300
Connect Retry Delay	1000
Game Start Barrier Timeout	18000000
Frame Start Barrier Timeout	1800000
Frame End Barrier Timeout	1800000
Render Sync Barrier Timeout	1800000

If any of the nodes don't respond in time and a barrier is timed out, those nodes are considered as failed and will be dropped from the cluster when the failover policy is active.

NDISPLAY NETWORK OVERVIEW

Every nDisplay setup has a single *primary* computer, and any number of additional computers, called *secondary* nodes.

- Each computer in the network runs one or more instances of your Unreal project either in-game or in packaged format.
- Each Unreal Engine instance handles rendering to one or more display devices, such as screens, LED displays, or projectors.
- For each output an instance of Unreal Engine handles, it renders a viewport that shares the same view origin or viewpoint. By setting up these viewports so that their location in the 3D world matches the physical locations of the screens or projected surfaces in the real world, you give viewers the illusion of being present and immersed in the virtual world.
- The primary node is also responsible for accepting input from spatial trackers and controllers through connections to Virtual-Reality Peripheral Networks (VRPNs) through Live Link, and replicating that input to all other connected computers.

IMAGE SOURCE: <https://docs.unrealengine.com/5.1/en-US/ndisplay-overview-for-unreal-engine/>

SWITCHBOARD CONFIGURATION

"Imagine you boot up 10 Windows computers. One of them is your primary machine," said Boiko. "To launch the application on 10 computers, you need an application that communicates to all the other computers to start an Unreal Engine application or project available at a given path, with a given configuration file that defines the cluster topology." The 'SwitchboardListener' is a remote command line application that talks to the **Switchboard**, and the Switchboard sends commands to the listener to run or stop the application. The Perforce integration helps update the content.

PREREQUISITES FOR MANAGING NDISPLAY

"Five years ago, it took significant effort to get the system up and running," explained Boiko. "The complexity curve is heading down and the user experience is improving so much that you don't need to do programming or debugging anymore. All you need is some dedication to go through the **documentation**. Nevertheless, it's still quite a complex system because it requires an understanding of the hardware and software stack."

The scale of the system directly affects the size of the team required to run it. Boiko added, "A virtual production LED stage has many components — LED processors, genlock, camera tracking, and many other elements. It takes a team of specialists to manage everything." The earlier coined term for this crew was 'Brain Bar,' but that has evolved into 'Volume Control.'

He shared that many new features would be added to the upcoming Unreal Engine versions to simplify and extend the workflow. "The recently introduced cluster preview allows a director or supervisor to bring the cluster topology into the content and navigate it to preview to see exactly how it will look on an LED wall. It's an exact 100% representation of the visuals as they will appear on the wall," said Boiko. "You can do simple previs or put a character or your camera and experiment with variety of camera settings and lenses. It's all there."

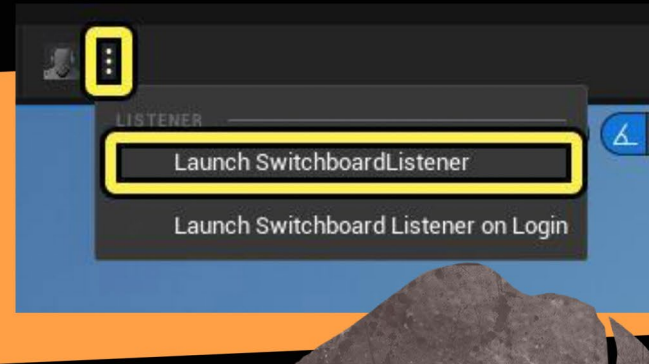
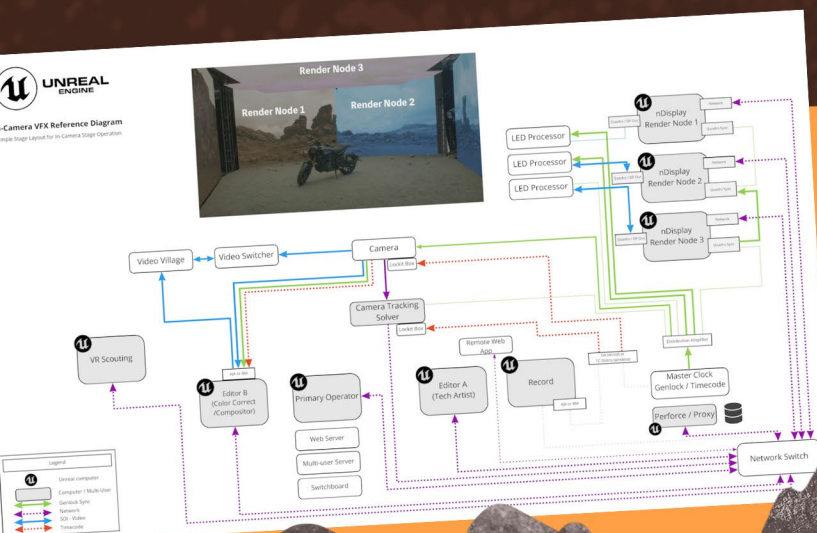


IMAGE & EXCERPT SOURCE: <https://docs.unrealengine.com/5.1/en-US/switchboard-quick-start-for-unreal-engine/>

On each device you want to connect to Switchboard, you will need to launch SwitchboardListener. In the Toolbar, select **Switchboard Options > Launch Switchboard Listener**, which launches the listener on the local machine with the default address 0.0.0.0:2980, or the address you specified for **Listener Commandline Arguments** in **Editor Preferences**.

WALL CONFIGURATIONS & CLUSTER NODES

"The core requirement is to build a digital representation of the physical display system," Boiko said. When a production accesses a vast LED system, there'll be a volume control team or brain bar capable of addressing all the issues and workflow requirements that come with it. Boiko thinks that even young people with a computer science background can put it all together with some effort.

Boiko built a website called **LEDstages.info** to list many of the LED stages available globally. Initially, his team searched on Google to locate the stages, but once there were about 100 or so, other stages started sending out registration submissions. He said, "It's interesting to observe the trends and growth of the industry. We should probably review that list and submissions more often."

Boiko has seen all kinds of nDisplay configurations come up at these stages. "There are plenty of YouTube videos about the configuration," he noted. "The team is constantly improving the user experience (UX) and interface (UI). It is going to be even simpler in the future."

IMAGE SOURCE:

<https://docs.unrealengine.com/5.1/en-US/in-camera-vfx-overview-in-unreal-engine/>

ADJUSTING TO THE VIRTUAL WORLD

The structure of film sets has changed considerably with the introduction of virtual production. There is a heavier reliance on technologists, game developers, and professionals outside the traditional production pipeline. Everyone is still trying to figure things out. A director or producer may feel somewhat challenged when working with the actor to create a moment as they are still unfamiliar with other factors that might get in the way.

With a physical set or location, it's easy to tell a production designer or the lighting crew what is needed because we can see and feel what it is. But in the digital space, one may feel lost about how to get things to feel realistic or estimate how long it will take.

Boiko said the same principles as physical production apply to the virtual production space. Citing an example of a director's decision to change a particular chair in a scene, he explained that it might be an easy fix or a complex one based on the uniqueness of the chair. If that prop isn't available locally, we'll need to transport it from another continent. We must account for that. The same calculations of time and effort will apply to acquiring or creating a digital asset. He pointed out that "the major difference is that there's much flexibility on the shoot, and directors have to think through and use it to their advantage instead of asking, 'Can we fix it in post?'"

"Those who can switch gears and capitalize on the usage of these tools will get significant benefits out of it. We must not forget that it is not a magic bullet but a powerful tool that we need to use in the right place," said Boiko. "Virtual production tools are speeding up and improving the shooting process. The industry had experienced a similar adoption process when CGI was introduced in the 80s."

TROUBLESHOOTING DURING PRODUCTION

On *Fathead*, switching the frame rate from 24 fps to 48 fps for a stunt sequence required half a day at the LED volume to get all the technicalities sorted out. Boiko feels that the genlock timing may have caused the delay. "The system setup and settings across GPU drivers, LED processors, and cameras must be changed." He added, "You have the cluster machines, camera, and tracking system. Then, there's the time code as well. When

you try to change it, it can come up with several surprises. Content performance is a big one. Once you run 24 and go up to 48, you have to render faster. You have to optimize your content. Our team at Pixela Labs are masters of content optimization."

"Though I am not sure what may have happened in your case, it can be a mix of everything together," he suggested. "Maybe it took one hour for something, then one more for this other troubleshooting, which took half a day altogether. Things will improve at some point. Many people are working hard toward improving this tech."

MULTI-CAMERA SHOTS

The inner frustum provides the maximum quality of the rendered Unreal scene because it goes into the camera sensor. The outer frustum provides lighting and reflections, which we'll set to a lower resolution for performance reasons. But if a director says, "I'm going to use three or four cameras, and I want everything in the frame to be at the highest resolution to be able to point my camera anywhere — three cameras pointing in three different directions, and they're all handheld — I want that freedom." What's the best way to go about that?

Boiko explained, "nDisplay supports SMPTE 2110, a new hardware configuration that allows rendering the inner frustum at a dedicated machine and shares the rest of the clusters for the final composition displayed over the outer frustum. Aside from that, you can overlap frustums."

He added, "It is also possible to genlock camera shutters and displays to swap content between the cameras on LED — this can result in an uncomfortable flickering effect for people on set."

MOVIE ADAPTATION

"Unreal has extremely powerful tools," said Boiko. "People in game development are using this efficiently for prototyping. The previs capabilities of Unreal make it a go-to application. You have a stage and camera preview. You can drop the content, digitize real set pieces, and create an animation to fully simulate your shots before going on set."

"This requires a little bit of preparation," he said. "Unreal Engine came from a game development environment, which has quite a different toolset than the world of cinematography. With each release, Epic will ship more tools for cinematographers."

EPIC SOLUTIONS ARCHITECT

Fathead inherited the privilege of direct access to Epic's solutions architects supporting the Amazon Studios Virtual Production (ASVP) stage team to write custom widgets and codes to solve problems on the fly. Most productions may not have that access, and any production shooting on an LED stage should consider gaining that access to the Unreal technical team. "Absolutely," said Boiko. "We have supplied many tools. It's not just nDisplay for ICVFX. You have level snapshots. All those elements did not come along on day one. It's the result of the analysis. What problems are people facing at the LED stage? What's the most efficient solution to cover many cases?"

He added, "More of those solutions will come because Epic does a great job of gathering feedback from the industry and structuring it to put it to work and get it done. And since Unreal Engine is open source, you can modify it. If you don't like something, you can change it."

UNREAL ALTERNATIVES FOR THE WALL

Boiko thinks that competing with Unreal on rendering and the virtual production tools developed over the years with some of the best film professionals overseeing the process will be extremely hard. He said, "I haven't heard of anyone else doing this on the same scale and commitment as Epic."

WATCH & LEARN

Practical use cases are a great way to document and share the benefits of virtual production and where and how it is advantageous compared to other existing methods. A producer or showrunner could say, "We have a TV show, and we repeat five locations.

The usual approach would require five company moves, which adds logistical expenses." The response on the ready should list the benefits of virtual production for that unique use

case: "You could scan those locations, create a digital twin, and shoot all five locations at the same stage. It can save hundreds of hours of travel and thousands of dollars of logistical costs."

Those kinds of practical use cases make it easier to arrive at decisions early — knowing how the scale of an operation and the frequency and longevity of use contribute to those decisions. If a shot only has two minutes of screen time, then spending two months to create a whole new 3D environment and figuring all those things out is impractical. It might be better to get 2D plates and shoot against those.

Boiko said. "When developing a tool for creatives to implement their vision, sharing their observations of how these tools were applied is essential information we need to have as an industry to excel together."

"The virtual production workflow has impacted everyone on the set," he explained. "Take a gaffer, for example. ICVFX workflow has a feature called light cards to control lighting intensity. To be a good gaffer, you must understand the available tools in a virtual environment to make a real impact. You must understand how it works, how long it takes to set up, etc."

On *Fathead*, some bright objects on the side LED walls made the blacks on the main LED wall appear milky. The gaffer worked with the VP supervisor and the Unreal operators at the LED stage to place black cards on the side walls and some on the ceiling LED to create negative fill.

Boiko concluded, "These days, many people rely on Unreal operators residing at the brain bar. Those are the people in charge of keeping things running at the LED stage, but essentially, there's a specific role on set for who is responsible for the shot, like the DP or colorist. We must empower those people with the tools to get their jobs done better and faster. I highly encourage anyone in the industry to invest more time and dedication in learning the technical aspects of virtual production workflows. Understanding the underlying tech will help mitigate risks for the project and be more efficient and creative on the set." ■

"THE VIRTUAL PRODUCTION WORKFLOW HAS IMPACTED EVERYONE ON THE SET."