

THE BROADCAST AND LIVE EVENTS FIELD GUIDE

By Will Freeman
Presented by Epic Games



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Image courtesy of Moment Factory

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CHAPTER 1:

Introduction

Broadcast and live events are both well-established mediums. Live broadcast goes back almost 100 years, while in-person events have existed throughout human history. As we'll see in this guide, both are incredibly powerful in their ability to connect people with moments in time through shared experiences, and both remain highly relevant and popular today.

The long history of broadcast and live events doesn't mean that the space is free from innovation and progress—far from it, in fact. Both live broadcasts and live events each provide a foundation on which to build new experiences, and could even be considered blank canvases for innovation.

In recent years, real-time technologies have facilitated an explosion in innovation around broadcast and live events, giving creators a means to mix digital content with reality, seamlessly and in a single space.

Real-time technologies have also enabled a tremendous increase in the breadth of what a broadcast or live event can be. A real-time-embellished event might reinvent familiar forms such as concerts or theater, but could equally see a group woodland walk transformed into an immersive educational experience, or cities reimaged as galleries where buildings are draped in dynamic, evolving digital art works.

Over in broadcast, a similar revolution is underway, also powered by real-time technology. Traditional entities such as live sports and video journalism are finding new ways to connect and communicate with audiences, while realms like esports are using real-time to forge entirely new broadcast concepts made from the virtual and real.

The creative and commercial opportunity there is immense. But a real-time project requires a quality real-time pipeline. Fundamentally, a real-time pipeline is like many others, bringing together the technology and workflows required to take a project from early concept to final delivery. However, in the case of the exact technologies and experience required, real-time pipelines can be highly distinct, and feel deeply complicated.

At Epic Games, we understand that complexity, having provided the video game industry with a real-time solution that sits at the heart of thousands of game development pipelines. Over the years, we've seen increasing sectors from outside games adopt that technology, Unreal Engine, to harness the potential of

real-time. With a profound belief in that opportunity, over time we've built up specialist internal teams and developed Unreal Engine features to directly support sectors like broadcast, live events, architecture, automotive, virtual production, and more.

Establishing new skill sets, technologies, pipelines, and processes for real-time broadcast and live events has been a highly collaborative process, with shared learning at its heart, as technologists, studios, hardware manufacturers, storytellers, and more come together to establish collective knowledge.

This guide shares a great deal of that knowledge, being shaped by expert interviews with those involved in successful real-time broadcast and live events projects, together with insights from Epic's teams and veterans of the wider world of broadcast and events.

This guide also offers insight on the opportunity, challenges, and future of real-time in broadcast and live events, as well as practical guidance on establishing pipelines and workflows, rethinking team hierarchies and skill sets, and best practices for the craft.

Throughout, we've also spotlighted many of the best and most impactful real-time broadcast and live events projects, sharing interviews with the teams and individuals behind them.

This guide is not intended to be a piece of technical documentation or a highly detailed guide on the machinations of pipelines, but rather a welcoming, thorough overview of the broad technologies, themes, and approaches that make this possible. It is designed to help you or your organization identify the reality of the real-time opportunity, while informing decision-making and strategy—and sharing a bounty of practical tips along the way.

Who is This Guide For?

This guide explores best practices in building, using, and maintaining an effective pipeline for successful broadcasts and live events that embrace real-time elements—and the critical role of the game engine in those pipelines.

However, it is not a piece of instructional documentation, nor does it require deep technical knowledge or hands-on experience in the field. Through interviews and analysis, the guide also explores themes related to pipelines, such as training, the relevance of existing skill sets, and other considerations that impact the planning, production, and delivery of live real-time experiences.

Epic's Broadcast and Live Events Field Guide is for those looking for a starting point in understanding the typical industry challenges and the opportunity present, or who need to deepen their familiarity with the space. While it will provide value and insight to

technically minded readers, including technical artists and software developers, it equally serves founders, C-suite executives, team managers, producers, and directors looking to understand the opportunity while future-proofing their businesses or projects. Contractors, freelancers, and specialists will also take a great deal of practical insight from this guide.

If you feel intimidated by the technology, or unsure about the reality, there is even more reason to read on. While pragmatic and frank, you will also find realistic encouragement informed by experience. The real-time opportunity is immense, and you are very likely more equipped to embrace the technology than you might imagine.

Put another way, if you work in any specialty or discipline related to broadcasting or live events and wish to keep pace with the frontrunners in your industry, consider this an essential read.

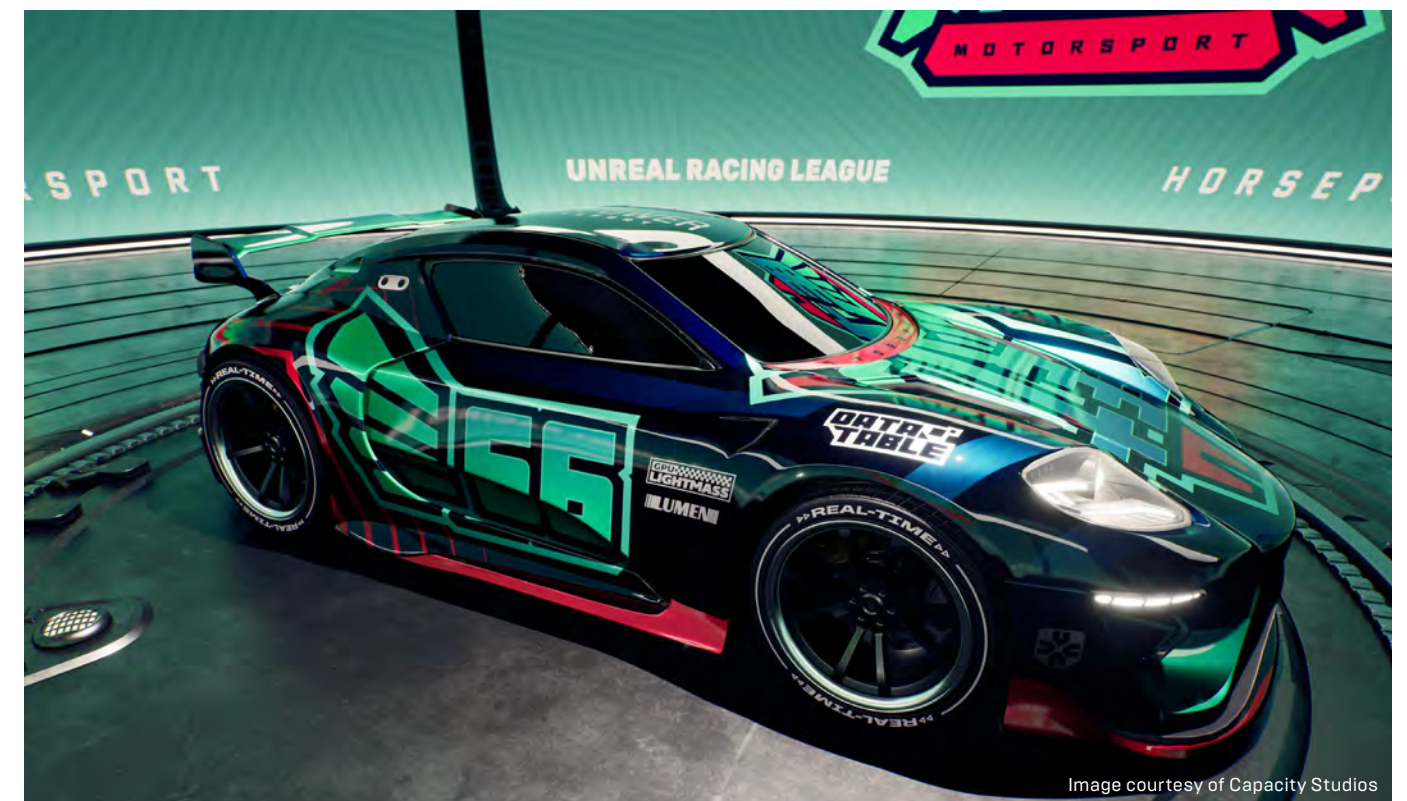


Image courtesy of Capacity Studios

The Rise of Real-Time

Live music and theatrical performances have existed since the earliest days of civilization, bringing audiences and performers together for experiences unique to the moment they occurred. Centuries on, when television arrived, so too did the modern counterpart of those ancient forms; namely the live broadcast, which has remained a popular method of entertainment and presentation despite the proliferation of pre-recorded options.

Today the evolution of real-time technology has reached a point where it can facilitate live experiences well beyond these modest beginnings, both reinventing in-person live events with large-scale interactive animated displays and bringing up-to-the-minute, dynamic graphics to live television.

We are seeing interactive real-time elements become increasingly commonplace at concerts, art exhibitions, sports arenas, and other events, and also permanent installations such as building facades or corporate lobbies. Those in-person real-time experiences can empower visitors to be active participants as well as passive audience members, bringing profound opportunities to artists, performers, brands, and those that host events. Over in the live broadcast space,

real-time technology enables teams to embellish live action with visuals that make tuning in more memorable, personal, or impactful.

Meanwhile, the rise of devices like VR and AR in the consumer domain, new pipeline and R&D approaches, adoption of technologies from other industries, and fresh paradigms for blending the digital and physical worlds are bringing a bounty of creative and commercial opportunities.

While the production and delivery of live real-time experiences is inherently complex, the potential is significant—and the challenges have become far from insurmountable. Emerging standards, technological refinements, and user-centric approaches equip teams with the ability to work efficiently, creatively, and ambitiously. Understanding how to establish an appropriate high-quality, robust pipeline lays the foundation for increased success in broadcast and live events empowered by real-time technology.

Game engines have emerged as an ideal and significant element of those pipelines. Simply put, a game engine is a software framework with tools for both creating video games, and powering them at the

point of consumption. Why would a tool from an entirely different industry be relevant to real-time content in events and live broadcast? As interactive entities, video games are defined by their real-time nature. They have to respond instantly to a constant stream of user inputs, providing highly polished experiences that dynamically adapt while remaining as a cohesive whole. As such, the video game industry has spent decades establishing tools, techniques and conventions, today serving an audience of over 3 billion users.

As we are seeing live events and broadcasts embrace real-time technology, the expertise and practice of game development has become more relevant than ever to those fields. At the same time, game engine providers like Epic Games have not only adapted their tools to better serve broadcast and live events, but have built up support and internal teams to serve those sectors.

Look across real-time event and broadcast outfits such as [Myreze](#), [Creative Works](#), [Moment Factory](#), [XR Studios](#), [disguise](#), and [The Famous Group](#), and you'll see that game engines—specifically, Epic Games' Unreal Engine—are already a mainstay of real-time

production in those spaces. Today, game engines offer a highly relevant element of those pipelines, coming from an industry defined by the interactive, real-time nature of its medium. Equally, understanding the skill sets, studio models, and collaborative techniques of game development paves the way forward for the use of real-time technology in other sectors.

Broadcast and live events have always been about innovation, experimentation, and working with the cutting edge, and that remains the case. What has changed is the capacity for impact, engagement, and success.

In this field guide, Epic Games discusses the elements that constitute an efficient and workable pipeline all the way through design, content production, and delivery; various approaches to implementing them; the place and value of a game engine; and the tools and techniques required to evaluate and optimize. The guide also explores how best to seize the broader opportunity, bringing in expert insight and advice from practitioners that are deeply experienced in the craft of real-time broadcast and live events.



Image courtesy of Illuminarium Experiences



Why Real-Time Content Creation?

by Laura Frank
Founder & Creator Advocate at frame:work

Courtesy of XR Studios

The language of digital production technology is constantly adapting to new developments and practices. In a landscape of terms like XR, virtual production, and in-camera visual effects (ICVFX), it's hard to know where to invest one's efforts and which process is best for your project. Workflows developed for one style of creative video production find their way into other disciplines, adapting the terms used and further disrupting the establishment of a clearly shared paradigm. However, there is one common technology that ties all our production lexicon together no matter the production style, and that is real-time content creation.

Real-time content creation is the result of generating visual media from some combination of image assets, code, and external data on demand. We often talk about real-time content creation as if it were new, but video content rendered in this manner is as old as computer history. As long as there have been computer displays, motion graphic imagery has been generated in real time. The first video games and generative video artists have their origins in the 1950s. Compositing those graphics with live camera feeds for broadcast television has been in use since the late 1950s. So, what drives the rush to adopt real-time right now?

Currently, we are experiencing a collision of technologies across many entertainment production disciplines that redefines what can be achieved with real-time content creation. In the last decade, we've seen incredible advances in position tracking, GPU development, 3D model generation, media servers, and LED screen display technology. These tools embody the best capabilities of many entertainment technologies, and when combined, they fundamentally alter creative video content production.

There are a number of ways to combine these exciting technologies. Successful application of real-time content creation is knowing when it's the best process for your production, and which aspects of their use best serve your needs.

Let's look at the motivation to use real-time content creation. There are already many software applications currently in use to create motion graphics and narrative video content. What is the impetus to switch from your current content production workflow to a real-time solution? A real-time solution does the following:

Shortens rendering time during production. Real-time content creation platforms eliminate the rendering process. This time-consuming factor of traditional content creation software can add hours for a team to see the result of a small change. Instead, the real-time content file is executed on demand, generating imagery instantly even after a content edit.

Provides resolution- and platform-independent output. Since it's not rendered at a specific resolution, real-time content is resolution-independent and can be scaled or re-framed live without the need to re-render. Its output is platform-independent, and works well for transmedia applications. The same assets could be used to provide visuals for the stage, overlay graphics on the live stream, and create a mobile companion application.

Gives more creative flexibility. Working in a real-time content platform gives the creative team the ability to make detailed adjustments to content and see the results rendered immediately at full quality, and distribution of the update is smaller and faster. Content variables can be altered as the content is playing, with the results visible immediately. Compare with a traditional process, where change notes are delivered to the motion graphic artists, and the result is re-rendered, re-delivered, re-distributed, and played again for review. Ultimately, real-time content creation tools allow for faster iteration and more opportunities to refine the creative.

Simplifies interactive content production. The result of an interactive video display is dependent on external triggers to inform image creation. Just like a video game controller defines what is displayed on the game viewing screen at 60+ times per second, a person, object, or other external input seeds generative content creation with action. While there are a number of software programming languages that have dominated interactive content creation for decades, their use has been largely limited to installations that can support long project development timelines. Real-time content platforms are purpose-built to be interactive, making them faster to use and more amenable to entertainment production schedules.

Augments live video signals. To alter a live camera feed with minimal delay, a real-time content platform must be employed. As the signal is processed, the image content is augmented frame by frame. The entire frame can be reimagined with artistic effects, or graphics can be composited to the signal feed. Image analysis of the camera feed alone produces sophisticated results through tools like facial recognition and color keying. You need only to check your favorite video conferencing software to see the potential. When combined with interactive content data sources like depth sensing cameras and position location systems, we introduce the ability to enhance the camera signal with spatially reactive content.

Responds to environmental input. There are few experiences that universally elicit a state of childlike wonder as visiting an immersive interactive video installation. Projection mapping is a form of real-time content manipulation, where video content applied to a 3D surface in a virtual representation of the working environment corrects the image for use in the real world. As long as the model of the projection surface and the projector locations are accurately described to the computer, we get perfectly aligned imagery. But what happens when the projection surface moves or viewing perspective changes? The more real-world information we feed into the model of our working environment, the more types of location-sensitive content we can create. When this content is combined with interactive inputs, we can track moving scenery or a performer's position on a stage, or interact with a viewer in a creative video installation in real time.

Builds worlds. When we combine all the technologies discussed, we get to one of the most exciting aspects of real-time content creation: content generated from the perspective of the camera, which is the cornerstone of the world of virtual production. Virtual production is a real-time content creation process defined by the relationship between a physical camera and a virtual camera. The virtual camera exactly mimics the attributes and behavior of a physical camera in a simulated 3D environment, generating perspective-sensitive content. The generated content is then separated into foreground and background imagery relative to the live action captured by the camera. This can be used to generate scenery or performers composited over a live broadcast signal, or to replace backgrounds for capture in camera or composited with chroma key.

This process has applications across the spectrum of live entertainment production disciplines, and will continue to be adapted in ways yet to be imagined. All one needs is the creative vision, time, and expertise to realize the next advancements in use of real-time content creation.

Laura Frank is an entertainment production technologist specializing in content production workflow for multiscreen spaces. Her career spans work in film, broadcast, theater, concert touring and art installations. She is currently building [frame:work](#), a community platform for live entertainment and virtual production pixel professionals, and is the author of [two textbooks on screens producing and real-time content](#).



Image courtesy of The Weather Channel

About Epic Games

Epic Games was founded in 1991 by Tim Sweeney, a passionate technologist who still stands as CEO to this day. At that time, the video game industry was nearing a pivotal point in its history, where the arrival of widespread internet access and the sector's tremendous growth saw it begin to shape and influence other mediums and industries around it.

What was happening in games by the mid-1990s served as a prelude to today's online communities, social media, concepts of the metaverse, the rise of esports, and XR. Meanwhile, technologies and techniques forged in games were starting to shape VFX, computer animated films, advertising, and broadcast.

Thirty years later, Epic now has a long and rich history of not only developing games, but also of building and supporting online communities, providing robust creativity tools like Unreal Engine, and facilitating a wide range of content creation pipelines for both interactive digital experiences and linear content.

Epic is also behind the global phenomenon of popular culture that is *Fortnite*, a game that has over 350 million player accounts and 2.5 billion friend connections.

Since its founding, Epic has grown with and shaped the game industry it is part of—at the same time that the game industry has increasingly influenced the wider technological and creative landscape. As such, it is only natural that Epic's content creation powerhouse Unreal Engine has seen adoption across film and television, live events, architecture, automotive, manufacturing, and simulation.

Today, Epic Games proactively supports all those sectors and more, with Unreal Engine being used in numerous ways by myriad different creative professionals. As new opportunities emerge in real-time-powered broadcast and live events, we're excited to help shape the journey forward in these amazing spaces.

CHAPTER 2:
**Evolution of Real-
Time Technology**

We humans, at our most fundamental level, are social beings with an inner desire to be part of something big—to connect with one another through extraordinary and memorable shared experiences, the kind that inspire us and create long-lasting memories.

Live theater, concerts, and sporting events have been with us for centuries. It might seem that technology is at odds with the “live” aspect of such experiences—a film adaptation of a stage play might, for example, seem to replace the stage play itself—but audiences have shown us, through their enthusiasm for such events, that technology employed to enhance live experiences simply gives them an additional avenue to enjoy entertainment. From the *deus ex machina* of fifth-century Greek theater to jumbotron displays at sporting events, technology can enhance, involve, and engage audiences beyond their physical attendance at an event.

Today’s live events fall into very broad and diverse categories, ranging from rock concerts with digital action projected on enormous screens, to broadcast television that engages audiences with mixed reality visuals updated on the fly.

Technology and Entertainment

Audiences, after experiencing increasingly compelling technology-infused events, now expect more than ever from the entertainment sector. To be successful, creators currently have unique and challenging requirements with regard to system performance and stability as well as visual impact and creative experiences.

To keep up with audience demand, studios are tasked with producing large and complex projects that very often require an armada of display technologies, ever-increasing pixel density, and enhanced realism, all driven by synchronous media servers working together seamlessly as a whole, with no downtime. The old industry saying “The show must go on” now translates to a 24/7 mindset where the screen can never go black.

Until recently, the development of any such experience was dominated by offline rendering workflows and video playback. Now, things are different. These are

exciting times, as we witness the merging of two enormous worlds, where game engines and real-time graphics play hand-in-hand with video playback and live installations.

We are seeing more and more teams and projects all around the world embracing real-time technology as a conduit for both pre-rendered and real-time content delivery. Some creators are even integrating completely live-controlled gameplay mechanics into their offerings. Media server companies, the backbone of any serious professional execution, are embracing and adopting the support and integration of game engines, facilitating exponential and industry-wide capabilities never seen before.

Why Real-Time Technology Matters

Real-time graphics, at a most fundamental level, can be understood to emphasize the live nature of an event or broadcast.

We all know live experiences are powerful. Whether it’s taking in a monumental sporting event via a live broadcast or pushing to the front of a crowd at a concert, it is seeing events unfold before you that makes you feel part of them. Add a little mixed reality magic that dynamically adapts to what’s happening before you, and that sense of being involved in the moment is greatly enhanced.

That’s true whether you’re using real-time elements to deliver additional information and context, or simply to set tone and atmosphere. As long as it’s applied thoughtfully, mixed reality applications give audiences more reason to feel engaged in a happening.

The Emergence of Real-Time in Entertainment

The arrival of widespread computer graphics in the 1990s would eventually give us the real-time concepts we now consider so familiar that they hardly stand out—displaying score and time on a sports broadcast, for example, or updates on a news ticker.



As technology powering digital on-screen information advanced, influential companies like Vizrt emerged in the late 1990s, giving studios the means to add ever-more lavish real-time assets into broadcasts.

Around the same time, advances in other fields were beginning to usher in a new era for 3D graphics and real-time delivery. Much credit must go to the techniques, technology, and artistry developed in pre-rendered spaces like VFX and computer-animated cinema. But it is the history of video game development that really accelerated what is possible with real-time technology.

The Role of Video Games in Real-Time History

A video game is essentially a real-time environment where the player gets final say in how events play out. Narratives are carefully plotted, character assets are meticulously shaped and rendered, and environments are sculpted long in advance of any public release. And yet the game itself must be able to meet the player’s expectation to interact, giving them various degrees of control over what they see and do at any given moment. Watch 100 players make their way through an identical game, and each will see and experience something different.

As consumer expectations for games rose, new methods emerged in game development, giving animation, lighting, music, in-game weather systems, and character motion the ability to adapt on the fly as players triggered events. Over time, the concept of a “game engine” emerged to keep all these various real-time elements working as a harmonious one.

A game engine is a software framework for both creating and delivering games—it encompasses not

only the tools for game developers to construct a world and program gameplay, but also a means to compile these games into a format that can be served to consumer devices for gameplay.

Game development is a deeply collaborative process, where animators, coders, writers, artists, audio specialists, and many more come together to build interactive worlds. A game engine serves as a central hub that brings their contributions together.

Real-Time Technology in Broadcast and Live Events

As game engines advanced, it became clear that they were perfect for the emerging field of real-time graphics in broadcast and live events. For example, when *The Famous Group* unleashed a giant digital panther on the Carolina Panthers NFL team’s stadium, they created a real-time experience that was thoughtfully mixed with reality. While that highly collaborative process involved disciplines like camera operation and live streaming to stadiums, it remains fundamentally comparable to making a video game, highlighting the reason that game engines are applicable to such projects.

And so it is that we find ourselves at a point where broadcasts and events can inherit much of the real-time potential of games, mixing up the reality of a wide range of live experiences.

The opportunity here is creative *and* commercial, empowering everything from science communication and brand experiences to sports broadcast and musical performance, all with a view to attracting, engaging, and retaining ever larger and more devoted audiences.

Image courtesy of Capacity Studios

Today, these sectors find themselves looking at a tremendously promising, sometimes intimidating future where media convergence is finally happening in a meaningful way.

“The main building block of this new future is the game engine, which means Unreal Engine.”

Björn Myreze
Founder and CEO
Myreze

The Evolution of Pipelines

Every creative process, to be efficient and produce the best end result, requires a pipeline, the process and technological chain that facilitates an early concept’s journey through production to final pixels. Technological pipelines have been a mainstay of broadcast for some time, and where live events include digital assets, such pipelines are also a must.

Traditionally, broadcasters—and, to a lesser extent, those who produce events—have taken a two-pronged approach to pipelines. The most detailed, memory-draining pre-rendered motion graphics that might be made for background plates or “scripted real-time” are processed through robust motion graphic pipelines that need time to bake and render. For lighter real-time assets, specific pipelines offered by real-time pioneers such as Vizrt, Chyron, and Ross Video have long been used, and have done a very workable job of managing earlier real-time broadcasts.

Over time, however, real-time ambitions have grown in broadcast, supported by remarkable technological advances. In tandem with that movement, the video game space has blossomed into a giant industry and creative force. Thanks to video games’ common focus

on works that blend real-time interactive experiences with scripted, pre-rendered cinematic CG scenes, pipelines like those founded on games engines like Unreal Engine have evolved to serve both sides of the craft.

Put another way, game engines now offer pipelines—or cores for pipelines—that are perfectly suited for the new generation of real-time projects seen at the forefront of broadcast and live events. This development has garnered much interest in Unreal Engine from those sectors in recent years—an interest that has complemented Epic Games’ effort to build out features and provide support that precisely serve the needs of broadcast and live event users.

We are at a point where Unreal Engine now stands at the center of pipelines for so many production companies that exist far from games. There are those doing truly live, real-time mixed reality work that can harness the side of Unreal Engine forged to serve the interactive elements of video games. Others commonly use Unreal Engine to produce the types of elaborate and highly detailed pre-rendered assets once served by traditional motion graphics pipelines. And then there is another class of user—particularly in the events space—working to deliver “pre-rendered for live” assets that can use the dynamic and adaptable nature of Unreal Engine to create and deliver those hybrid entities.

That’s not to say that the solution is simply to pick up a game engine and work like a game developer. Rather, over time, industry shifts and technological evolution have seen a trend play out that now means game engines are commonly the most suitable option for broadcast and live events. It is essential, however, that the providers of such engines offer support and functionality that specifically serves those fields.

Case Study: [The Famous Group](#) | [Carolina Panthers](#) | [The Panther Project](#)

Project type: Live event/on-site broadcast

When the NFL team, the Carolina Panthers, took their first foray into real-time mixed reality, it was with fairly straightforward goals: they wanted to boost spectator energy on game days, and establish new traditions that would further cement the relationship fans have with the team.

These goals would ultimately lead the Panthers to partner with The Famous Group, a self-described “fan experience company” specializing in virtual events and mixed reality productions. Together, they would envision and deliver a remarkable experience for fans at the Panthers’ opening game of the 2021 season.

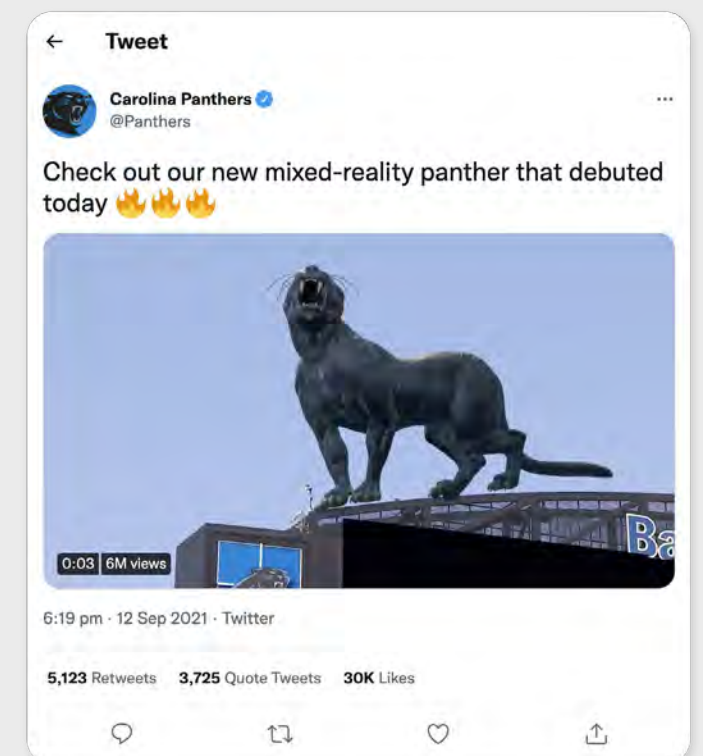
Before the game started, a giant mixed reality panther was let loose in the Bank of America Stadium. The virtual beast scaled the video board, tore down the flag of the visiting team New York Jets, leaped down to the field, and then bounded away with a roar. The spectacle unfolded on the site’s big screens before the 70,211 spectators, showing the panther moving through live footage of the event. Beyond courting a riotous response on the day, a video of the spectacle went viral online, attracting over six million views on Twitter alone.

“Right now, mixed reality has a big ‘wow’ factor,” says Greg Harvey, CIO and Co-Founder of The Famous Group. “Fans have that ‘What just happened!?’ moment. People don’t really get how these digital creatures interact with the physical world.

“The fans get super fired up now, and start yelling and screaming as soon as they hear its roar,” Harvey adds. “The impact is much more powerful than running traditional content on the video boards.”

The project took about seven weeks to complete. A scan of the entire Bank of America Stadium gave The Famous Group a 3D model for anchoring the panther to real-world surfaces during the animated sequence. On the day itself, that model sat invisibly inside the live footage broadcast from the venue to its own big screens. As camera operators tracked the panther’s pre-set trajectory in the stadium, the live footage from those cameras was sent to Unreal Engine and matched to the invisible model, the big cat was added to the footage, and the result was broadcast to the event screens.

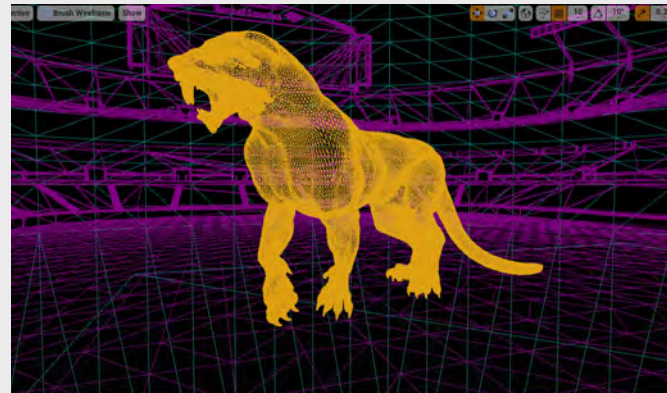
The panther was created with a traditional process, where it was modeled in Maya and exported to Unreal Engine via the FBX file format. There, the team created their own motion sequences and motion clips for the panther’s movements.



The panther, having been built to work with real-time environments, can now be deployed in all kinds of ways. “It’s very much like a video game character, which is the opposite of limiting,” says Erik Beaumont, The Famous Group’s Head of Mixed Reality. “The panther’s technical nature is letting us consider making a gamified version of this, where operators can more freely control the panther in real time like a game character, rather than just having prepared linear sequences.”

In mixed reality, The Famous Group and the Carolina Panthers found the perfect medium through which to give fans an amplified sense of being part of a special moment, fueling their support and devotion on the day and beyond. And what they’ve achieved is only the start—in the future, fans might see the panther moving to different parts of the stadium, and interacting with players on the field or groups of fans in the stands.

“There is a seismic shift happening right now,” Harvey concludes. “Immersive is the future of the live events industry, and we will see over time what form that will take—whether it is augmented reality, virtual reality, mixed reality, a combination, or something completely new.”



Images courtesy of The Famous Group

Q&A: Carolina Panthers | The Panther Project

When the football team the Carolina Panthers let a giant real-time vision of their mascot character loose at the Bank of America Stadium in Charlotte, NC, they also delivered one of the most high-profile instances of mixed reality seen in the public domain.

Envisioned as a way to introduce a new game day tradition, the Panther project also served to demonstrate the technology to millions of viewers, and has since become a touchpoint for understanding, explaining, or evangelizing the potential of real-time technology at live events. It wasn’t just that the project worked at a functional level—it thrived in terms of engagement and reach, from delighting fans on the day to attracting millions of views and engagements across social media.

To get an inside view, we spoke to the Panther’s Senior Director/Executive Producer of Game Presentation & Production, Mike Bonner, who drove the ambition of the project from the football team’s side.

What were the Carolina Panthers looking to achieve by embellishing live action with real-time assets?

The Carolina Panthers are committed to bringing new and innovative live experiences to our passionate fans at Bank of America Stadium. We are extremely excited to be one of the first teams to incorporate unique mixed reality content into our game production. So far, the response has been excellent.

The live element was extremely important in creating an incredible game-day atmosphere. Our fans love to see the panther on the video board, and it turned into a truly viral moment with how it was embraced on social media.



Image courtesy of The Famous Group

What were some of the challenges you faced with this project?

Calibration, calibration, calibration. We utilize mixed reality with multiple cameras, all of which need to be calibrated, and it takes quite a bit of time to get it looking just right. To make the project work, we had to make the commitment to leave the cameras in place for the entire season.

We also learned that with mixed reality, it's okay to push the envelope of believability—we don't need to only show the sequence when the field is empty. In the first game, we ran it 13 minutes prior to kickoff, and in the second game, during the game with players on the field. The fans erupted when it was played during the game.

Do you see this kind of deployment starting to have a profile in sports beyond the NFL?

We actually started the conversations about real-time mixed reality with the Charlotte Football Club [FC]—the MLS [Major League Soccer] team owned by David Tepper, who also owns the Panthers—with an initial conversation around activating at their games. It just so happened that the NFL [National Football League] season started before the MLS season, so the Panther project came first.

The incredible success and magic of the Panther project only reinforced the excitement to do something like this with Charlotte FC. The mixed reality panther proved to be an incredible season-long test run for what we were planning for our Charlotte FC broadcasts. The results, and the reaction from fans, make us proud of the unique mixed reality deployments as part of both professional teams within Tepper Sports and Entertainment.

What would you tell other production teams looking to embrace mixed reality?

Don't be afraid to try new things. We'll continue to see an increase in these types of experiences, especially as the technology continues to improve, and we see more interoperability with existing equipment like SkyCam and handheld cameras.



CHAPTER 3:

Building a Real-Time Pipeline

When it comes to the contemporary real-time opportunity in broadcast and live events, pipeline is everything.

A quality pipeline enables and connects every element of a production from ideation to final pixel, while bringing efficiency and performance to the entire process.

With that in mind, to successfully embrace today’s real-time opportunity, you’ll need to establish a pipeline constructed with real-time in mind. If that same pipeline can also be capable of handling the pre-rendered elements, all the better. Fortunately, assembling such a pipeline isn’t likely to push traditional broadcast and events teams too far beyond familiar territory.

As we’ve already seen in this guide, game engines have now emerged as a particularly fitting foundation for real-time production pipelines.

Unreal Engine for Real-Time Experiences

As games have become more ambitious both as technological entities and narrative works, the long-predicted concept of media convergence is finally happening in meaningful ways, as live news, esports events, concert performances, sports broadcasting, immersive experiences, and games all borrow from and inform one another.

Myreze, a motion graphics, branding, virtual production, and real-time studio, sees this convergence as an exciting opportunity. “The main building block of this new future is the game engine, which means Unreal Engine,” says Björn Myreze, Founder and CEO. “Unreal Engine can adapt to all kinds of uses as we see all these new opportunities and approaches emerge.”

He adds that Myreze sees Unreal Engine right at the heart of every pipeline for their real-time experiences, so much so that the studio is ready to try all manner of new projects, each of which uses these technologies differently.

“That’s exactly why we love what game engines bring to these new opportunities,” Myreze continues.

“Whatever I need to build, Unreal Engine will be the main ingredient in our vision.”

Flexibility as a Standard

Myreze himself has touched on a key point echoed by almost every real-time professional we spoke to for this field guide: few real-time productions are alike, which means there is no one-size-fits-all approach when it comes to pipeline. Fortunately, that doesn’t mean constantly rebuilding pipelines on a per-project basis. Rather, real-time pipelines from broadcast and live events need to be flexible.

This sentiment is echoed by Erik Beaumont, Head of Mixed Reality at [The Famous Group](#). Because not all customers are the same, he says, the pipeline has to be highly flexible. In addition, clients all want to push things a little bit further than what they’ve seen others do with real-time before, and that’s just not possible if the pipeline is too rigid.

“They want something like our Panthers project, but better,” says Beaumont. “That ambition is great. It means we’re not doing the same thing over and over. We can’t work by formula because every single client is very different, from the visual style they pursue to their willingness to experiment.”

That logic extends to differences in how given clients prefer to collaborate, provide assets, and maintain brand and style with bespoke assets.

Contrasting Pipeline Approaches

At this point, it is worth briefly comparing and contrasting a traditional pre-rendered pipeline with an example of an adaptive real-time pipeline.

At a glance these two pipelines can appear very similar in terms of required source assets, needed expertise, and increasingly, the fidelity of their visual output. However, they significantly differ in their overarching philosophies. Primarily, one is geared towards the offline while the other is completely real-time.

A traditional linear pipeline focuses on pre-rendered assets, meaning it better serves projects or parts of projects that demand much more precise control over final asset details, where rapid iteration or interactivity is not required. Real-time, meanwhile, offers immediate results and iterations, reducing the time to render to almost zero, while allowing for interactivity of content. As such, real-time pipelines introduce a significant shift in design approach, content creation possibilities, and ‘over the approval’ process for changes. That means content can be rapidly and reliably adjusted right up until delivery, enabling, for example, assets to be reworked to fit atypical or changing display hardware.

That’s certainly been the case over at [disguise](#), a studio that provides turnkey solutions for broadcast and live events, where Unreal Engine is deeply integrated into a platform that puts flexibility at the forefront. And that flexibility is simply a reflection of how much variety real-time technology enables.

disguise’s projects might include projection, LED screens, or both; might fall into the categories of AR, MR, or both; and might be for broadcast or live events. For each client, disguise produces a flexible platform that works for that client’s specific needs.

The common theme across all these types of projects, says Solutions Manager Peter Kirkup, is that they come down to complex pixel manipulation. “Often, we’re working on projects where pixels take a weird configuration on a stage, something very different from a standard 16 x 9 monitor,” he says. “These non-standard setups are where we really add value. And we can’t really add that value with a rigid or ‘standard’ pipeline.”

disguise serves clients that might need to send pixels to a vast moving stage space as seen on the likes of *Eurovision Song Contest* or the *BRIT Awards*, where highly unusual aspect ratios may change on the fly. It’s a striking example of how much variety modern real-time pipelines need to adapt to.

Kirkup explains that the many ways disguise can work with content in Unreal Engine reflects the way the artistic teams view pipelines themselves.

“For us, a pipeline is just a combination of layers in the timeline, layers that we composite and blend.”

“We think of Unreal Engine as a layer on that timeline, a layer that we can comb for assets and even textures, and bring them into the worlds we support,” Kirkup says. Building out assets might include mapping content onto surfaces or cutting pixels out from a render that’s happening in Unreal Engine in real time and putting those pixels on a different part of the stage. The team might also bring in other layer types as textures, such as pre-rendered imagery or web-based content from an HTML5 source.

TRADITIONAL LINEAR PIPELINE



REAL-TIME PIPELINE



Figure 1: Comparison of pipelines with traditional rendering and real-time rendering



Image courtesy of creativeworks.london

disguise offers an encouraging example of how a modern, flexible real-time pipeline can function in a way that should be familiar to anyone who's done digital video editing. Kirkup helpfully frames the disguise pipeline as fundamentally comparable to a real-time video editing tool that just happens to be working on big-pixel canvases with complex shapes.

Kirkup describes disguise as “very focused on pixel delivery.” As a way to help users understand the real-time process, disguise encourages them to think of it as a layered composition, with layers stacked on top of one another. Kirkup gives the example of a possible real-time setup for a full LED display: the setup could bring in an Unreal Engine layer rendered out of a particular cluster into a different world, then apply a mask on top of it, blend something on top of that, and multiply that by a factor that gives a soft vignette around a circular LED screen. Then the system could push out the resulting imagery to a full LED display.

At a company like disguise, the pipelines themselves are consistent, but utilize a workflow that can be applied in many different ways.

“However you approach it, that’s what pipelines need to be in this space,” Kirkup states.

Why Games Are Relevant

If the sound of new pipeline approaches built around tools from the game industry is starting to sound a little too alien, be assured that the roots of platforms like Unreal Engine in game development only strengthen their suitability for real-time production, while being more welcoming than you might imagine.

Many thousands of games, from big-budget hits to brief, experimental artworks, have used Unreal Engine as the foundation for their pipeline—from ideation to final product—and none of those projects are the same.

This is part of why teams like The Famous Group have started to think of real-time production in terms of game development, including steps like production and post-production, where the steps are very much like game development. The difference, says The Famous Group’s Beaumont, comes in when you consider the aesthetics and visual quality of the output. “You need to combine these two worlds where all your design and creative is living in the broadcast space,” he says, “but your technology is all living in a space similar to game development.”

Game engines’ core ability to manage both true real-time and pre-rendered assets means they offer a highly suitable solution here. Adopting even just a few game development practices will give a significant boost to any effort to work with the kinds of real-time projects this field guide focuses on. That could mean hiring from games—with roles like Game Producer or Director bringing in all-around experience. Equally, you might want to speak with engine specialists or tech leads from the gaming space—perhaps in a consulting or recruiting capacity.

But the way forward isn’t only about hiring. In an era where game development has become so welcoming that small or single-person teams make and release commercially triumphant titles, many broadcast and event teams have taken the route of building their own game as an internal project. It’s a powerful way to

enable your entire team to explore the fundamentals of real-time process, practice, and technology. And as the audience of people making games has grown vast and diverse—with Unreal Engine now serving millions of individual users—it has also become a necessity that thorough, detailed documentation and clear tutorials (including those at the entry level) are provided and constantly updated.

Game development, as a craft, isn’t something one picks up overnight, but today it’s a great deal more friendly and familiar than you might imagine. That internal game project might be more powerful than you think, and can provide an impactful way to empower the wider team as they move towards working with a real-time pipeline.

A ‘Storytelling First’ Mindset

Some teams find it useful to think of real-time technologies as just another means for storytelling, often a simpler way than they’d previously been using. Myreze takes this approach, making use of the widely varied technical skill sets the company’s team possesses along with a shared understanding of narrative and storytelling.

Jørgen Steinheim, Partner and President at Myreze, explains that while the opportunity in real-time includes the embracing of new technologies, at the same time you need to ensure that teams continue to focus on storytelling as the main goal, rather than leaving teams to get lost in the technical details. “Remember, those traditional skills—that understanding of your audiences—that’s something you already have, and that’s going to carry you through the technical challenges,” he reminds us.

You’ll need real-time specialists on your team, and a basic familiarity with the core concepts across the creative and technological workforce. But it’s equally important, Steinheim says, that you have an individual or small team that can expertly talk to the client about real-time opportunities and limitations in a clear, welcoming, and engaging way.

Facilitating such attention to storytelling is the maturing of real-time technology, where we now see integration between tools in the ecosystem.

Björn Myreze, Founder and CEO at Myreze, reports that the company is now able to create a variety of projects, from opening sequences to idents to virtual studios, inside a single pipeline. He sees Unreal Engine as more than just an interesting option—the company has found that Unreal Engine truly works in harmony with the tools the team is familiar with, and with other real-time specialist solutions.

“What’s exciting is that we’re seeing all these technologies that struggled to work well together in the past, now become a full, efficient, powerful pipeline—a place where everything really works together.”

“That’s an important development that makes it much easier to build these pipelines,” Myreze points out.

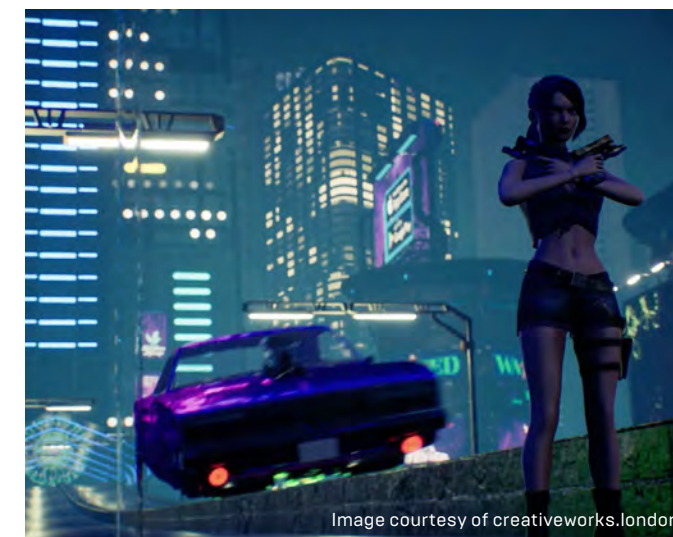


Image courtesy of creativeworks.london

Building Custom Tools

A game engine can also be used as a means to develop your own internal tools, or extensions that add abilities to the engine itself or to your pipeline in general. This approach presents another way to keep your real-time pipeline flexible, adaptable, and ready for the dynamic production and delivery that defines real-time.

For real-time mixed reality projects, studios find that custom tools provide a necessary bridge to the physical world. For example, studio [Moment Factory](#), which specializes in real-time and mixed reality experiences hosted in public spaces, might need to work with multiple real-world and digital elements for a single event—elements like cameras, trackable displays, moving objects, and projection. To facilitate the process, the team creates tools to connect with the lights, sound systems, digital content, and sensors, resulting in an integrated toolset for the event. “It’s really about creating tools that enable visualization, being able to create the tools to interlink multimedia such as audio, light and real-time content—that lets us really work well in the hybrid space that mixed reality presents,” explains Céline Mornet, Innovation Producer at Moment Factory.

Building a real-time pipeline doesn’t require a dramatic pivot into the unfamiliar. Rather, by embracing a little from the mindset of games, familiar concepts and technologies that bear comparison with your existing pipeline will empower your effort to embrace real-time. And you can be sure most of your team’s existing experience, pipeline, and process will be deeply relevant to this opportunity.



Image courtesy of Illuminarium Experiences

About Version Control

Version control is a fundamental part of almost any collaborative creative process. In its simplest form, it offers a means to track and manage changes to a project or its assets. In many software applications, it is also referred to as “source control”.

To gain an understanding of version control, let’s look at a simple example: collaboration on documents. If two writers are co-authoring a single article, Google Docs provides ample version control—each author can see updates, and even work simultaneously without spawning multiple new versions.

On other straightforward projects, such as creating illustrations for a book, a basic spreadsheet might suffice for tracking the filename and folder path of the latest version.

Real-time projects, of course, are many times more complex than a written article or a set of illustrations. When a single project involves live broadcast, physical sets, real-time assets, pre-rendered content, and elements of virtual production, robust version control is critical.

As an example, consider two different specialists working on the same animated character model. Without version control, a texture artist and facial animator might simultaneously make changes, leading to two distinctly updated versions. Version control brings efficiency while maintaining quality, preventing the chaos of multiple files with spiraling version numbers.

Version control frameworks currently used for broadcast and live events are built to serve more traditional pipelines. As there are considerable parallels between real-time production and game development, well established version control tools from the games industry bring highly applicable options to real-time content makers.

[Perforce Helix Core](#) is a common choice for game development, with its ability to precisely manage a central database and a master repository of file versions. It’s also highly compatible with Unreal Engine—and widespread use of Perforce means that beyond official documentation, a vast community exists that are eager to help with problems and blockers. Helix Core is emerging as the Google Docs of real-time—currently, 44% of Unreal Engine broadcast users have adopted it into their pipeline.

As an alternative to Perforce, [Git](#) is a free and open source distributed version control system that focuses on a branching and merging workflow. Popular platforms for Git include [Github](#) and [Gitlab](#).

A detailed guide to enacting version control or getting the most from your chosen platform is beyond the scope of this guide, but rest assured that putting just a little effort into understanding version control will save significant amounts of time overall, help deliver better results, and let you focus on the work that matters most.

Case Study: Illuminarium | SPACE: A Journey to the Moon & Beyond

Project type: Location-based immersive experience

The team at Illuminarium employs a blend of pre-rendered and real-time technology to pursue a goal that is, at least in principle, fairly straightforward.

“We create experiences with the goal of eliciting an emotional response,” offers Brian Allen, Executive Vice President of Technology and Content Integration at Illuminarium Experiences. “This could be triggering a memory, or coming away with a question or just a feeling of wonder. We aim to democratize the world’s most extraordinary experiences.”

There, Allen has got to the crux of one of real-time’s greatest powers: in mixing realities, the distant, unreachable, or fantastic can fire up imaginations and give audiences an experience that stays with them well after it’s done.

That’s very much evident in the latest experience available at Illuminarium venues, called *SPACE: A Journey to the Moon & Beyond*. The SPACE experience sends audiences to the inside of a nebula, to the moon, or to the middle of an asteroid field, all from the comfort of the company’s current sites in Atlanta and Las Vegas.

Illuminarium ultimately provides venues that audiences can visit and walk through in an exploratory manner, much like a museum or gallery. Here, however, visitors step into a world spun from real-time and pre-rendered assets, cutting-edge sound technology, and even haptic and scent-based elements. Using systems such as 4K projection, LiDAR-based movement sensors, and spatial audio, the walls, floors and scenery within an Illuminarium theater can be filled with highly realistic visuals and sensory triggers to create a remarkably immersive experience. The venues are also entirely reprogrammable, meaning they can be refitted with new content and experiences as often as needed.

For the foreseeable future, pre-rendered content will be key to Illuminariums, as it allows for high fidelity on large projection surfaces that audiences can view close up. But blending those pre-rendered elements with real-time, game engine-generated content has always been part of the Illuminarium plan, with a view to providing increasing levels of dynamism and even personalized content. As such, real-time rendering is part of the team’s pipelines, workflow, and infrastructure, with Unreal Engine sitting close to the heart of each project.

“Unreal Engine has been a great fit for us,” Allen says. “Moving into interactive and generative development at our scale was no easy task. We are still learning with every new build and show we are introducing.

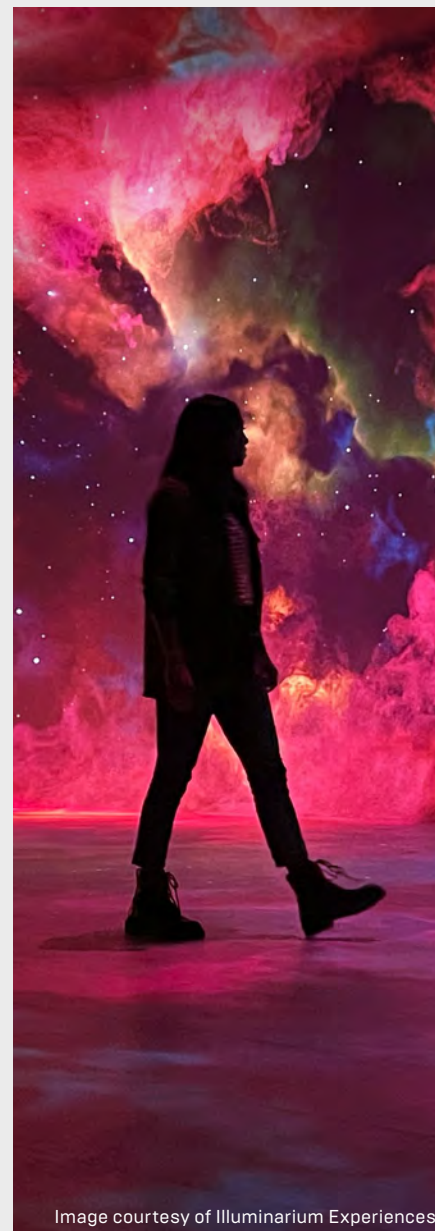


Image courtesy of Illuminarium Experiences



Image courtesy of Illuminarium Experiences

“It’s a vastly different process to producing pre-rendered content at Illuminarium sizes. Using Unreal Engine within the disguise architecture allows us to manipulate parameters in real time from our media server playback software, which is great for quick changes and the creative process.

“We can have editor machines running and making new builds while we are testing the current build, all within the venue. Once up and running, the process is straightforward. We have solved the scale problem with what may be the largest Unreal Engine nDisplay cluster in the world. We can generate pixels at a scale in the hundreds of millions. The possibilities have widened considerably for us because of this technology.”

As we’ve seen throughout this guide, the tools should always serve the story, and never the other way around. In the case of Illuminarium, however, it works both ways—building the right pipeline to enable their vision has, in turn, led them to envision new stories to tell.

“For Illuminarium, most challenges are caused by our scale,” explains Allen. “Some issues can involve multiple manual operations across many machines. Our solution to this has been to automate as much as possible while keeping a healthy balance.

“Rendering for our space has also been challenging,” he continues. “In the beginning, we quickly realized that we needed to develop a custom nDisplay Mesh Policy to get the images to render correctly for our space. After delving deeper into that, we realized that the Mesh Policy is heavily dependent on what the creative is—different visuals require different configurations for projection.”

Illuminarium believes the future of immersive entertainment is real-time and interactive, so much so that the company plans to establish a dozen or more venues globally in the next five years, with increased interactivity and more personalized experiences. “Are we making video games?” Allen asks rhetorically. “No, but we have a large-scale immersive and communal space where you can step into any world that we can create, along with your friends and family.

“To have characters that understand who you are, and that can react with audience members, will create new opportunities for narratives to unfold that the world has never seen before.”

CHAPTER 4:

Real-Time Graphics Content for Live Events

When it comes to live events, the real-time opportunity is about making audience experiences more dynamic, engaging, and interactive by embellishing reality with digital content. It's a commercially and creatively exciting prospect for anyone in the space, and today a number of advancements in the field mean much greater ambition is possible, while barriers of complexity fall away.

First, a new generation of LED displays and projection methods have emerged that allow for new levels of innovation in terms of set design and performance. Robust, compatible pipeline ecosystems have simultaneously emerged, and the companies already working in the field have established much collective knowledge in the space, all while conventions continually emerge that bring more consistency and efficiency to working processes.

At the same time, as the pandemic put live events on hold across the world, audiences became considerably more familiar and comfortable with the concept of mixed reality, and the value digital, real-time assets bring to live experiences. From concerts hosted in *Fortnite* to music festivals that take place within live games, the general public has not just become used to mixed reality performances, but even expects some real-time elements as part of the live experience.

Many more venues and sets are now also furnished with adaptable LED screens and projection systems, and even moving stage elements, unconventional screen shapes, and LED floor displays, presenting

extraordinary canvases and opportunities for real-time experiences across the globe.

There will always be something special about the traditional unembellished on-stage performance. The magic of seeing emerging talent in a tiny, dark, low-ceilinged venue, for example, might never be replaced by technology. But that is not the aim of the real-time movement. Rather, modern technology is allowing for a far greater variety of live experiences, and richer diversity of creative expression.

We are not only talking about traditional stage crafts such as live music and theater. As consumer interest in mixed reality and on-site interactivity increases, entirely new experiences that put real-time front and center of their offering are proving themselves to be commercially successful and popular. A prime example are the Illuminarium venues, which welcome audience members to reprogrammable immersive theaters. Using a combination of 4K laser projection, LIDAR-based movement sensors, and even digital scent technology, Illuminarium drapes the interior walls of its theaters with a variety of interactive experiences that visitors can explore together.

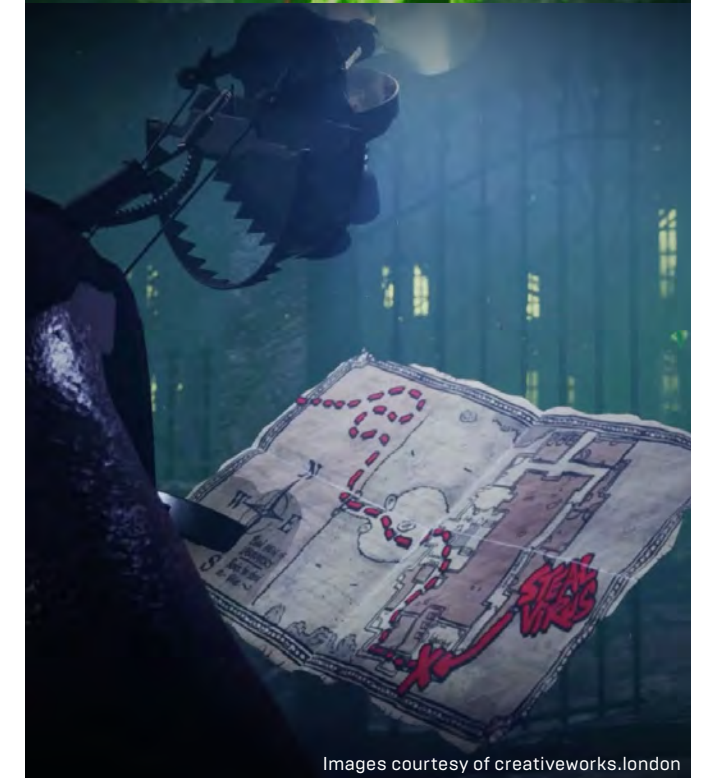


Image courtesy of creativeworks.london

Brian Allen, Executive Vice President of Technology and Content Integration at Illuminarium Experiences, explains that the company's offerings spring from audience demand: in this ever-evolving world of immersive experiences, he says, people have come to expect them to be interactive, personalized, and refreshed often. The company has found that real-time content generation is the best way to accomplish this, especially from a user journey standpoint.

“Real-time means we can deliver a fully interactive, ever-changing, and even narrative-driven experience to our guests, We will continue to produce large-scale, pre-rendered shows, but the path forward for us is the flexibility and opportunity to have audiences truly interact with our content that comes from game engine-generated content.”

Elsewhere, popular esports events, where professional competitive players compete in front of live arena audiences while thousands more tune in live via streaming platforms, have become commonplace globally. Their blending of sports broadcast convention, live audiences, and video-game content makes them especially fitting for real-time embellishment. Such broadcasts have become so familiar that it's hard to imagine these types of events without an impressive mixed reality presentation.



Images courtesy of creativeworks.london

Real-time for events is now more achievable and approachable than ever before, as the standards of what is possible constantly climb. That, however, does not mean there are no challenges. As processing power grows, so does the ambition to offer ever more grand experiences on vast screens—event hosts always want content at the cutting edge. Screen and technology setups can differ from venue to venue, presenting difficulties for touring shows. And until very recently, the pipelines that serve these experiences continually struggled to communicate consistently.

Orchestrating an event that might include live performers, ceiling projection, fully interactive real-time assets and moving LED screens is a complicated business. And yet that complexity is a symptom of the profound opportunity here.

The first questions, then, are “Does my live event need real-time?”, and “What kind of real-time is required?”. Answering those involves a little more understanding of the technology and platforms involved here, which we’ll continue in this chapter, after a closer look at how Creative Works added new dimensions to performances by rock icons Guns N’ Roses—and what they’ve learned about working with clients and getting real-time live events right.

Key Considerations

As client and consumer interest in real-time live events continues, there are increasing motivations to augment those experiences.

Should your or your client’s next live event project be real-time? Unless there’s value in leaning into the traditional live experience, the answer is increasingly “Yes.”

Some theater productions thrive through minimalism, and there real-time may be a distraction. At a given point, a band as a brand might have much to gain from asserting that it still plays traditional concerts. More and more, though, there is a place for adding digital assets to live experiences.

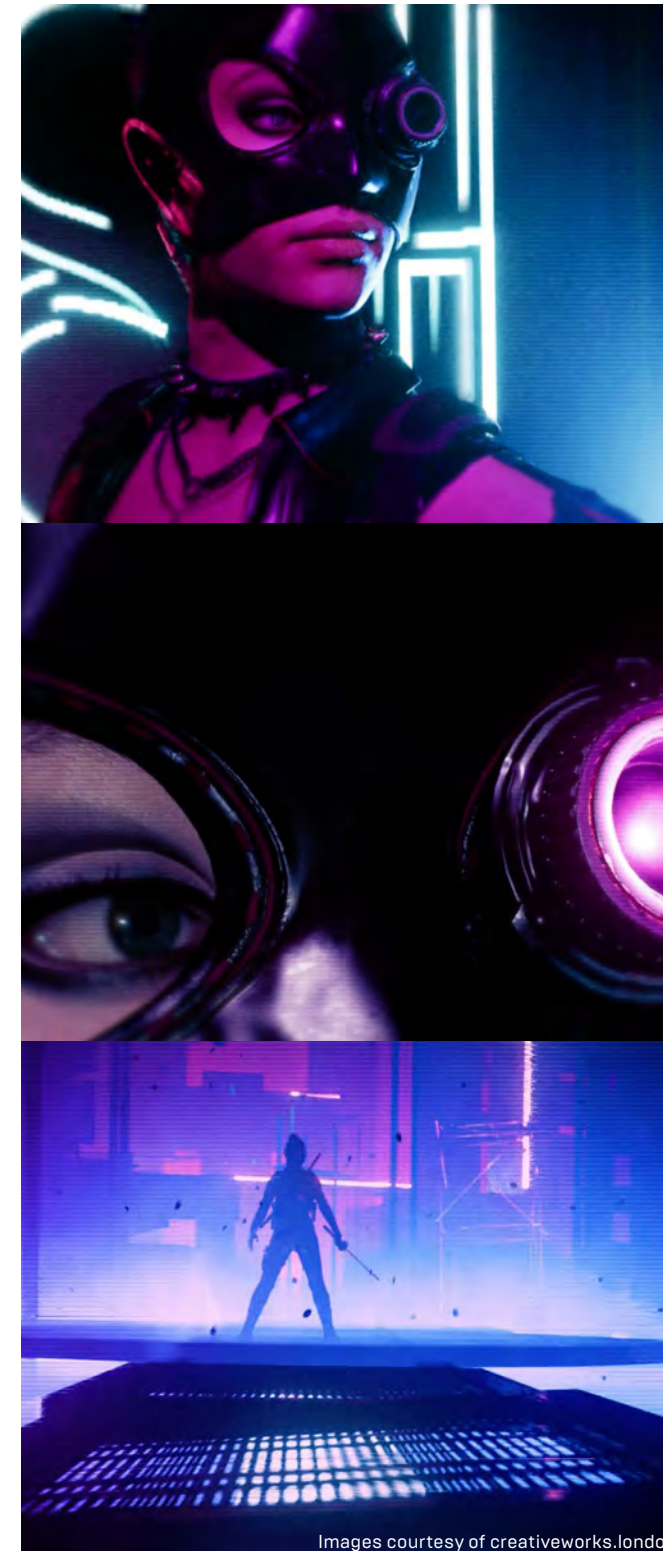
As seen in the case of Creative Works and Guns N’ Roses, animated scenes played out on towering LED screens serve to extend the narrative of a show while celebrating the performers’ heritage. The same animations served as cues for the band and a means to build excitement and energy in the crowd before a performance. Across many other large-scale gigs, mixing realities can emphasize key moments in the music, and generally serve to give audiences a more engaging, engrossing, and memorable experience.

In esports context, such assets can bring informational value and analysis, while in those and many more contexts, the opportunity for memorable brand experience is plain to see.

And yet with all that considered, the question, “Is real-time right for this project?” still needs to be asked. By going the route of delivering pre-rendered, linear content to screens and projectors via a familiar media player, you get reliability and predictability; everything is set in place, and you get the foundational simplicity of “playing a video”. On simpler, smaller, and lower-budget projects, that may well suffice.

For a moment, let’s forget about the real-time, deeply interactive live experiences that let the performer or audience dynamically and immediately affect the digital assets around them. Without those forms of interactivity, it might appear that simply sending pre-rendered content to screens via a media player is the best way forward.

And yet real-time brings many other strengths beyond dynamic interaction. It allows much faster iteration and rapid prototyping at the start of a workflow. It brings the same speed advantages to blocking out early iterations to guide creative teams or inform clients. It’s ideal for building VR experiences that creators or clients can visit to get a better sense of a project as it might be seen on site. Real-time is also significantly more economical when it comes to memory and server use. Consider that the pre-rendered approach increasingly demands tremendously large files that



need to be stored on media servers, potentially making for great expense in terms of memory and cost—and suddenly real-time offers another advantage.

Real-time content and engines are also more accepting of multiple users working on single assets or projects, as multiple changes from multiple users or machines can be simultaneously or near-simultaneously updated.

Additionally, while the digital content for an arena show by a touring artist might not be interactive in itself, venues themselves can be considered dynamic spaces, and as such present a challenge. As touched on in the case study on [Illuminarium](#), not all venue screens and projection canvases are the same. Special events at atypical venues may also mean working with temporary and highly distinct display ecosystems. In those cases, content made in a real-time pipeline based around a game engine like Unreal Engine can adapt quickly to a unique setup.

“It used to be a real challenge when working with local venues’ display setups,” says Dan Potter, Creative Works Co-Founder and Executive Creative Director. “Now that we’re using Unreal and disguise, we don’t worry about that anymore. We don’t have to reconfigure anything because we know the disguise pipeline can handle whatever screens we throw the content to.”

As an example, Potter cites a show at The Colosseum at Caesars Palace in Las Vegas, where the team found out on the day that they had to get some 16:9 content ready for a full wall with an entirely different aspect ratio, and they had only minutes to sort it out. “We were standing there—me, and Jeremy, and the Guns ‘N’ Roses manager—and the manager tells us he wants to move all the tour’s usual lights out the way so we can make use of this wide, full screen.”



Image courtesy of creativeworks.london

Three or four years ago, that would have meant degraded, pixelated imagery. Instead, a technician from disguise was able to reconfigure the system to high-resolution 24:9 imagery—all within three minutes. “It was pixel-perfect in this super-wide, huge format, with the show soon to start,” says Jeremy Leeor, Co-Founder and Managing Director at Creative Works. “That is why we are using Unreal Engine. That is why real-time is so powerful.”

Over on projects like Illuminarium—and at live events using interactive output—there is a case to be made that that is the ultimate realization of real-time. Not knowing exactly how a show or event will play out each time will certainly feel nerve-wracking to some practitioners, but video games have been getting interactivity right for decades—and it is Unreal Engine’s heritage as a game engine that makes it fitting here.

Finally, one can fully leverage the capabilities of real-time pipelines for design and content production, and bake the end result as high-quality video assets for final delivery. At the end of the day, it’s a question of figuring out the best strategy for your project, deciding on what matters most to you.

Technical Challenges

There are three important technical factors in the successful deployment of real-time in live events:

- Adaptation to multiple displays of different sizes, shapes, and curvatures.
- Synchronization of all displayed content and other elements of a live event arrive at once, with millisecond-accurate timing.
- Implementation of redundancy, so if a single machine fails, the show will go on.

Addressing those factors starts with a brief look back at the evolution of the science of sending real-time content to displays.

Around 20 years ago, as the complexity of real-time video games increased, greater power was needed to render at a rate of around 16 ms/frame to achieve a playback speed of at least 60 fps, a standard speed for realism and believability.

This advance was facilitated by, and stimulated improvements to, the power of graphics processing units (GPUs), with machines imbued with more cores and ever greater on-board memory. This evolution continues, giving creators the means to drive graphical fidelity to stunning levels. However, GPU advances are ultimately focused on the performance of one host machine, and as such do not address the

problem of driving simultaneous displays at increased resolutions. Equally, multi-GPU solutions have their own limits—they do not properly distribute and scale real-time rendering beyond the scope of one PC.

Even a handful of years ago, those issues presented a serious challenge. In a relatively short time, though, much progress has been made, mainly in terms of pipeline capability, software compatibility, and standardization around displays.

Media Server Integration

Integration with media players and media servers is now much more reliable and frictionless, with Unreal Engine and many other pipeline tools now better supporting a wide range of platforms and products.

Within the industry, we are seeing an increase in high-quality integrations leveraging various techniques, such as transferring real-time UE content through IP video or using Texture Share mechanics, to have both applications processes cohabit on the same PCs. These newly available solutions are paving the road to the future by providing solid products to the marketplace which are not only real-time enabled, but also scalable to never-before-seen complexity.

nDisplay Technology

For driving complex and large display systems requiring clustered rendering, Epic Games has developed the [nDisplay system](#) for real-time practitioners. nDisplay technology extends Unreal Engine by distributing the rendering of a camera view over any number of machines and then displaying the rendered images on any number of display mechanisms. nDisplay was designed to address issues introduced by the limitations of GPUs or older cluster-based rendering method’s limitations in pushing synchronized imagery to multiple displays in real time. The system supports proper frame/time synchronization, correct viewing frustum based on the topology of the screens in world space, and deterministic content that is identical across the visualization system.

DMX

Additionally, standards born in the live events sectors—such as Open Sound Control (OSC) and DMX—have become established over time as standards for communicating between light fixtures, sound, and video systems in real time. Conceived and used as a means to send control information between instruments, computers, and lighting consoles, they now offer a base of convention that real-time content can and should plug into.

You can view these protocols as the main language or base communication layer that makes Unreal Engine part of a seamless live-broadcast ecosystem. By supporting DMX, you can use Unreal Engine to help design and previsualize an entire live show. Alternatively, you can control and trigger gameplay mechanics via DMX or OSC cues (or vice versa), or use Unreal Engine to control external devices such as lighting fixtures. The list goes on and on.

Equally, [disguise](#) offers OSC and DMX support either natively or via extension apps. With the whole tool ecosystem now fully supporting OSC and DMX, the display and synchronization of real-time content with other systems or devices is increasingly straightforward.

Redundancy

With regard to redundancy, that remains a hardware issue. [disguise](#) and others have moved to counter the problem, and now offer systems whereby backup machines can immediately and seamlessly step in if any prime machines fail during an event. [disguise](#), [AV Stumpf](#), [7thsense](#), [Smode](#), and others now also offer their own blend of powerful physical media servers and software tools that operators can use to prepare, arrange, rehearse, and orchestrate the delivery of shows.



Image courtesy of Illuminarium Experiences

may be ideal for first forays into real-time live event development and production, especially where you can be absolutely certain of the display setup for a show that will not change with each delivery. Bear in mind, however, that as your ambitions around visual fidelity and screen size increase, so will the need for considerable storage space.

Another approach is to deliver a project made up of both pre-rendered and real-time content at the point of consumption by the audience, letting you harness the gains of both approaches. It may mean slightly more complex pipelines, media server structures, and display approaches, but considering so many technologies in this space serve both real-time and pre-rendered content, you wouldn't necessarily need to double up on technical intricacy.

The hybrid approach is put to stunning effect by [Moment Factory's AT&T Discovery District project](#), which uses the power of Unreal Engine to explore how buildings could adopt new ways to set or enhance the tone of the local area. The project saw a vast 104-foot tall, 6K media wall and an LED-powered trellis wrapped around the corner of a real Dallas building, which displays gradually evolving visual content designed to inspire, relax, or engage. The display hosts blended pre-rendered and real-time content—the pre-rendered visuals have been rendered with high visual fidelity, while real-time content is fed in to reflect changes in the time, weather, or season. Moment Factory's work of "media architecture" is deeply impressive and affecting, and showcases what a real-time live event can be.

With the industry still experimenting with the many ways real-time content can engage viewers, we've only scratched the surface of the real-time spectrum. We're eager to see what the creative teams of the future dream up to entice, inspire, and astonish us.

Setup and implementation of media servers, synchronization, and redundancy are complex matters, but there is no doubt that through technological improvement, increases in power, and the establishment of new standards and conventions, delivering real-time events now comes with much more consistency and robustness. In short, real-time is something users can rely upon because it is now scalable to display setups of arbitrary size and complexity.

Real-Time Approach as a Spectrum

At the start of this chapter, we discussed the idea of choosing whether to use real-time technology as a basis for a project, and when to consider a more traditional pre-rendered approach. Practically speaking, it isn't as simple as making a binary choice. There are several hybrid models that you may want to consider; in this way, it's helpful to think of the real-time opportunity as existing across a spectrum.

Some may use real-time technology for a preparatory step because of its rapid iteration, collaboration, and flexibility, before developing and baking final assets to be delivered as a pre-rendered, static video. That

Case Study: [Creative Works London | Guns N' Roses | 2021 Tour](#)

Project type: Live performance

Emmy-nominated Creative Works' tagline, "Make It Live," amply sums up the focus of the UK-based agency: brand-centric, narrative-driven, real-time content for live events. To the team in London, that might mean building video game-worthy assets, plotting out short form animations, shaping XR content, or bringing mixed reality to broadcast. Having integrated the core of their pipeline with [disguise's RenderStream Plugin](#) and Unreal Engine, the London team has become something of a pioneer in working with "as live" real-time projects.

Among Creative Works' most celebrated projects is the show opener and backdrop the agency produced for the 2021 Guns 'N' Roses live tour *We're F'N' Back!*. The mad laboratory-themed opener, presented on a vast LED screen behind the stage, is designed to grab the crowd's attention, build hype and noise in the moments before the gig begins, and even cue the band onto the stage. The goal was to make each Guns N' Roses show feel thoroughly contemporary and deeply engaging.

At each show, a live operator controls what fans see on the LED screens, choosing visuals that sync to or augment the band's performance on the stage. This not only creates a unique fan experience at each show, but also takes advantage of Unreal Engine's ability to adapt its output to virtually any LED screen's shape or size.

Guns N' Roses typically tours with its own hardware including LED screens, and the entire event team endeavors to replicate the same stage environment at each show. But that isn't always possible, and there are cases when content needs to be sent to a screen of a completely different size and aspect ratio than originally expected. Within the narrow window allotted for setting up for a live show, the Creative Works team, in collaboration with [disguise](#), have been able to adapt content to new constraints in as little as three minutes.

Dan Potter, Creative Works Co-Founder and Executive Creative Director, adopted a game development approach to building the content for the show, where the team handled everything from initial ideas and concepts to producing final pixels, and making sure everything is running smoothly on the day.



Image courtesy of creativeworks.london

“We’re working with venue and tour teams, and embracing both the visual strength of offline and the flexibility of real-time,” Potter reveals. “The parallels with game development, and what live events can learn from that process, is key here.” He adds that the team used a lot of the same tools a game developer would, such as 3ds Max, Blender, Cinema4D, Substance Painter, and ZBrush. Once Creative Works has built out the content, the team can import it into Unreal Engine to get real-time assets that work well with, and adapt to, the live stage environment.”

Creative Works also stands as a key proponent of educating clients in the real-time opportunity from the earliest days of the project, with the end goal of delivering the best results. While there are clients who are happy to trust the team to work autonomously, Potter says, there can be a strong advantage in involving the client at every stage of a project’s evolution. In the case of Guns N’ Roses, Creative Works had built up a considerable relationship with the band after partnering on smaller projects as far back as 2012. As the real-time opportunity for the 2021 began to take shape, Creative Works found that involving the Guns N’ Roses team helped guide the narrative, style, tone, and aims of the project.

Potter describes such an approach as “highly collaborative, playful, conversational, and rapidly iterative,” and recommends that creators go this way whenever possible—there is so much space for innovation and new ideas, he says, and the client might not initially understand the opportunity or its potential.

For the Creative Works team, Unreal Engine has proved ideal for engaging clients early on to gain insights for steering the project toward its goals. The Guns N’ Roses project is a prime example of how this synergy works between agency and client. Kristin Oldershaw, Creative Works Technical Lead and the one responsible for deploying real-time assets, explains. “The world-building capabilities of our creative team using Unreal Engine, accelerates the process of bringing big ideas to life in a rapid and iterative way,” Oldershaw says. “We can, in a matter of days, build a visual blueprint for the entire project to work further ideas into, and quickly and confidently share these visions with clients to keep them in the conversation at every stage.”

“We want to push the audience’s expectations, but to do that in the right way, we need to understand them,” explains Jeremy Leeor, Co-Founder and Managing Director at Creative Works. “This means we need to understand the musicians, understand where key points in the songs are, and understand where the musicians feel that the show is. All that is key to understanding what the audience is coming for.”

For Creative Works, Unreal Engine is at the center of this type of collaborative effort. “With a game engine in our pipeline, we can do that rapid iterating,” Potter adds. “We can get content made up and blocked out very fast, and give the client a sense of what’s possible, what we’re planning, and how it matches their aims. In that way, a game engine is really central to what we do.”

In fact, for Creative Works, the devotion to inheriting practice and workflows from the game industry goes a little deeper. In 2021, they released their internally developed game *Daisy’s Revenge*, which explores the themes and music of rock supergroup The Dead Daisies.

“If you want to understand real-time and how to get it right, make a game,” asserts Leeor. “Even if it’s just an internal exercise, it’s a really powerful process.”

Q&A: disguise

disguise is a software and hardware platform that enables creatives and technical producers to deliver real-time live events, virtual productions, and location-based experiences. Founded in 2000 and with over 10 established locations around the world including London, Hong Kong, Los Angeles, and Shanghai, the company has powered numerous real-time productions for music artists such as Katy Perry and Billie Eilish, film and episodics for Netflix and Amazon Prime, corporate presentations for Siemens and Verizon, and live broadcast programs from Eurosport, MTV, and ITV. disguise has also contributed significantly to knowledge sharing, community building, and the establishment of conventions for delivering deeply engaging experiences.

Here, Solutions Director Peter Kirkup sheds some light on what he and his colleagues strive to achieve. Kirkup’s passion for event production began at age seven, when he would operate the lights during school plays. It’s fair to say that what he does—and what is possible—has come a long way since that formative experience.

How do you describe what disguise does?

We are a manufacturer of service and software workflows that enable people to deliver amazing events in spectacular locations around the world.

These days, we transcend a lot of sectors, but we actually came from the music concert touring world—we used to do shows for the bands U2 and Massive Attack back in the day, visuals-to-screen for stadium shows and arena shows. We started out as a creative agency making the content for those screens, and then we started making our own software to deliver that content in shows.

Over time, we worked in theater, on corporate events, on product launches, and on other types of projects. We saw this blurring of the lines in so many spaces, which is when we started our move to support broadcast and virtual production. We’re currently working with LED screens, projection, installations, and setups on the exteriors of buildings, all kinds of things, and we essentially do all that through a software-on-hardware model.

In terms of the overall project workflows, where does disguise fit in?

We make our own software that does all of the last-mile delivery. This means making pixels light up in time and in sync across an almost unlimited scale, which involves all those hard technical bits—pixel control, EDID [Extended Display Identification Data] management, genlock, and so on.

Scale is becoming an increasingly important issue as projects grow in ambition. For example, we’ve been doing projects involving 200 projectors and the world’s tallest buildings, with lots of interlinked servers to serve those large-scale ambitions.

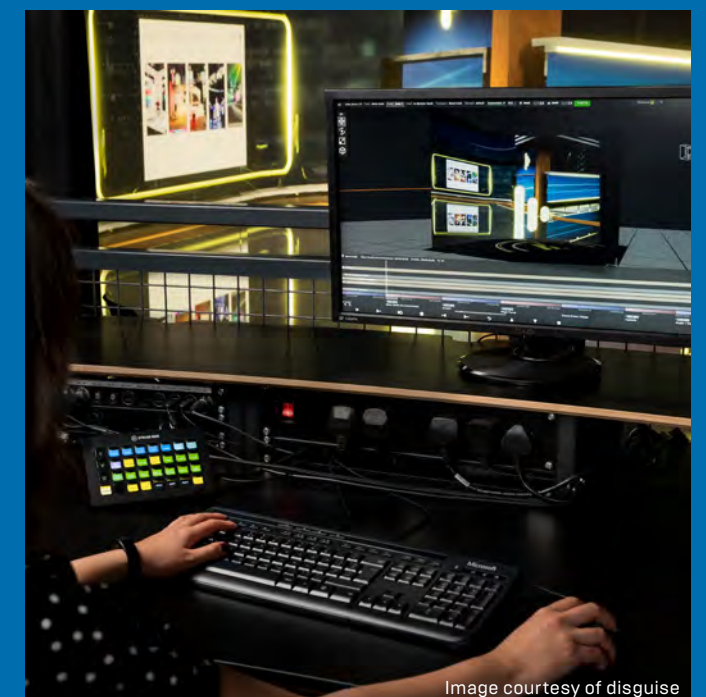


Image courtesy of disguise

Unreal Engine is an important content creation platform in the space, so we've made sure everything we do on the hardware and software side can be deeply integrated into the engine. We have servers that do the connectivity to the outside world, and we also have a render farm that we built, which basically turns Unreal Engine into a content source for our system. And we leverage nDisplay to do that, and it all works over video-over-IP. It taps into various different bits of the engine, but also uses our own custom plugins.

“The cool thing about this setup is that it leaves artists and animators free to focus on the creative side of content, using Unreal Engine as a creative tool without having to get bogged down with the technical details of displaying the content.”

In software, and through infrastructure, we handle decisions about which pixel map an LED processor needs in order to sit on this screen in this stadium. That's a key part of what disguise does—we do the heavy technical lifting so the creative people can focus on using the game engine to create content.

In fact, when we're talking to potential clients about a new project, we don't call Unreal Engine a game engine. We call it a “content engine,” because that's really what it's doing—scene building and animation, and real-time rendering and output, which is content creation. This can be a really helpful way to communicate about the technology, especially to people new to these types of opportunities.

How does disguise address the unique pressures of live events?

Away from the technical side of things, what we're actually doing at disguise—particularly on the live event side of things—is addressing the fact that the stakes are higher. At a live event, a technical error on the display might be seen by 70,000 people simultaneously, and a serious technical failure at a major event might make the front page of a newspaper.



Image courtesy of disguise



Image courtesy of disguise

That's why we've built this ecosystem of dependability and reliability of hardware and software, and we focus heavily on making sure those reliability mechanisms are in place. We surround it with SLAs [synchronous line adapters], and we build redundancy into the systems so if something goes down, something else takes over.

How is disguise able to support so many different types of projects?

At disguise, we've produced a platform that is incredibly flexible and will work for whatever the needs of the client are. We work on projection projects, LED-based projects, VR projects, AR broadcast projects, and more.

Sometimes the project calls for a rigid screen that sits there throughout the whole show. Other times, we're dealing with something like the *Eurovision Song Contest* or the *Brit Awards*, where the stage is moving apart and then coming together, and things are flying out.

Each of these types of projects is different, but the common theme is that it's all complex pixel manipulation—it's not a standard-sized monitor showing a standard HD video file, it's pixels in a unique configuration on the stage. That complex pixel manipulation is generally where we really add value. Our system is designed to just handle all these situations, and pretty much whatever else our clients can dream up.

Where does Unreal Engine fit into the picture?

We think of Unreal Engine as a layer in our timeline—it's a layer of content that we can comp, and bring into our world and manipulate.

We can map it onto surfaces, or we can cut pixels out from a render from Unreal and put them somewhere else on a different part of the stage. We can bring in other layer types so we can play our traditional pre-rendered video, or we can bring in web-based content from an HTML5 source, or we can bring in content from any number of other content creation platforms. In a way, it's all just layers in a timeline—layers that we compose and blend, just as with traditional photo editing and video editing.

It's complex stuff, but we handle it all. The opportunity for real-time content is really just about using real-time video editing tools that just happen to be working on big-pixel canvases with complex shapes. At disguise, we're very much focused on that pixel delivery, and on making it possible for clients to deliver engaging and entertaining content in these new ways, so audiences and viewers can enjoy it.

Augmented and Mixed Reality for Live Productions

Today, we regularly see cinematic and televised works created through virtual production (VP).

The technique empowers storytellers to build worlds that are extremely realistic or believable, and present information in deeply engaging ways. But VP is really about the day of a shoot, using various methods to blend live-action and computer-generated content on set, with real-time technology providing immediate feedback to the cast and crew so as to inform performances and production decisions.

In the era of *Star Wars: Episode I - The Phantom Menace* (1999), the film industry first started to explore the benefits real-time technology could bring. Things have come a very long way since then, and now *The Mandalorian* series stands as a shining example of how seamlessly real-world performers can be convincingly placed in virtual worlds via VP.

This chapter focuses on live productions that mix realities, whether AR or MR, broadcast or streamed, and also those that include an on-site audience.

AR/MR and Virtual Production

Live mixed and augmented reality productions share considerable parity with virtual production—they can reasonably be framed as part of a singular movement within film, television, broadcast, and streaming.

Live mixed reality productions are distinct from cases like *The Mandalorian*, in that the latter is freed from the pressures of being shown to audiences live. The teams creating the series work to meticulously plotted deadlines, but also have the luxury of polishing and correcting work, or even reshooting when required.



Courtesy of XR Studios

Meanwhile, live is live, where there's no room for any of that polishing. However, real-time is increasingly affording creators, agency staff, operators, and AV teams ways to adapt or adjust content during the delivery of such productions.

Ultimately, in the case of live mixed reality projects, there is no hiding of errors. Everything must be final pixel—meaning delivering final image quality live, “in-camera,” and without requiring subsequent visual effects work. And yet the proximity of the well-established virtual production approach and newer live mixed reality production methods does mean the former is informing the latter in various ways.

Over in virtual production, for example, there is a move to “in-camera visual effects” (ICVFX) models. In those cases, a shoot might be based around large LED volumes that display realistic output from real-time engines behind performers. Images on the screens move in synchronization with real-world camera tracking as actors are followed. This approach can produce final-pixel imagery completely in camera—the current state of the art method for virtual production, and a means to help cast and crew on set visualize the digital world around them, rather than have to make guesses in a green-screen volume. In those cases, though, much would still be done in post; the physical complexity of ICVFX favors productions that get generous attention in post, rather than for straightforward linear live broadcasts. Further into the future, though, ICVFX may have some role to play in live productions.

Elsewhere, motion capture (mocap) methods such as performance, full-body, or facial capture are regularly used in virtual production, lending performer's movements to digital entities, or embellishing actors with virtual elements. Real-time mocap models are becoming more practically workable, which presents an option for live productions where a performers' movements could be captured in real time, guiding the movements of an animated character during an event.



Meanwhile, LED walls and motion capture are sometimes used in live and broadcast real-time applications as a visualization tool in the early stages of a workflow. Technological advances will likely make LEDs and mocap more commonplace in live contexts. However, the fact that live broadcasts need to be technically robust and truly final pixel in the moment of the shoot or performance means a more significant reliance on more proven approaches such as green screen.

Equally, with live, a great deal more planning is required to capture everything in the single moment of a shoot or performance. That means camera changes, animations, and performer hand-overs are precisely plotted and timed, right down to sub-second levels. Long before the final live broadcast, cable wattages will also have been mapped out and set in stone. Anyone with experience of such a shoot might tell you there's no such thing as being over-prepared, and that no detail is too granular to be considered at the planning stage.

Practice Makes Perfect

Rehearsals also play a more significant role for live mixed reality productions—not just in terms of giving performers and crew an opportunity to prepare to work with precision and timing, but also to establish and refine tracking data for guiding the live shoot itself. In these cases, rehearsals are as much about data generation as they are practice.

It might be something of an oversimplifying contrast, but it remains helpful to consider that at a fundamental level, the effort of live virtual production exists in pre-production up until the shoot, while virtual production for entities like film places a far greater emphasis on post-production.

But what of the actual opportunity of real-time live-virtual production? It provides a means to make live broadcasts more distinct, creative, or engaging. [The Weather Channel has used such approaches](#) to make education and even critically important science education more welcoming and effective.

The real opportunity, though, is in facilitating and delivering a new form of hybrid live spectacle; a form that has significantly risen in presence and popularity as a result of the COVID-19 pandemic. Only a few years ago, broadcasts of concerts, event TV, fashion shows, sporting occasions, or esports competitions typically focused on capturing the experience of attending in person. While viewers watching remotely would make up far greater numbers than those attending personally, such events were always framed and structured as in-person experiences first and foremost.

Then the pandemic put an end to most large in-person gatherings. As a result, new ways of presenting major events had to be concocted. Billie Eilish playing to an empty physical arena or theater simply wouldn't cut it. Mixed reality and virtual sets initially offered a means through which to compensate for the lack of large crowds and the sense of performances or events

taking place in empty spaces. Eilish's empty room could be embellished with all manner of dynamic real-time content.

Now, however, with the pandemic's impact significantly less present as it stands, a new medium or format has emerged; one that leans into concepts of mixed reality and frees itself from the old conventions of physical events. The pandemic just happened to give creators, performers, operators, and—importantly—audiences, a chance to become familiar with the new way of doing things.

Beyond fan-centric events, live mixed reality production got its truly mainstream moment as teams all over the world used the approach in their coverage of the Beijing 2022 Winter Olympics. There, COVID-19 restrictions meant a dramatic shift in how pundits and commentators could report on live sports, which in turn afforded an opportunity to do new things. Presenters on a virtual set could suddenly be placed halfway up a mountain, right beside the action—delivering insights while surrounded by dynamic elements that communicate data and results from live competitions.

Esports provides a defining example of the potential of mixed reality production for a live audience, where an already successful format has been reinvented in a way that is powerfully fitting for its subject matter.

Case Study: [Myreze](#) | [Valve Corporation](#) | [The International 10](#)

Project type: Esports broadcast

On the heels of its successful esports events during the pandemic, gaming giant Valve wanted to put all the learnings into a single project that would set a new standard for delivery of competitive gaming to global audiences.

The event was The International 10 in October 2021, which brought together the world's best players of video game *Dota 2* for a share of a record-breaking \$40+ million prize pool.

To meet their ambition for The International 10, Valve charged Norwegian agency Myreze with the task of establishing a virtual set and live stream production workflows at a grand scale. It's fair to say the results were exceptional—in addition to attracting millions of viewers, the production earned an Outstanding Esports Coverage Emmy for Valve in 2022.

As part of the event, 125 hours of live content were delivered to audiences globally, culminating in a grand final viewed or rewatched by 100 million individuals (numbers do not include China's viewership, the game's largest single market). The event was also the third-most-watched video ever on streaming platform Twitch.

To understand why and how so many fans were engaged—and why real-time matters to the success—it's best to start by taking a look back to a time before COVID-19.

A traditional esports competition plays out in a sports arena or other large venue in front of energetic on-site crowds. While presenters and commentators—'casters' in esports parlance—augment the audience experience with observations and commentary, the real focal point is the gameplay. The venue includes rows of gaming hardware where players and teams sit down to compete, and the live gameplay is fed to large screens so the audience can see the action. Camera operators capture the entire event for broadcast or live streaming, with the broadcast team switching between live-action and in-game footage. To the audience at home—often made up of loyal fans of a particular team or player—the event unfolds like a live sports broadcast, right down to on-screen data visualization of statistics and results.



From early esports events like Nintendo PowerFest '94 to the huge *Dota 2* and *League of Legends* competitions of 2019, the crowd in attendance has always contributed significantly to the event's energy.

And then the pandemic happened. The International was postponed in 2020 due to COVID-19 concerns, and Valve looked to October 2021 as a safe date to reboot the traditional model of holding the tournament before a large in-person crowd. But when more concerns about COVID-19 cropped up less than a week before the first round, Valve elected to pivot to a virtual-only event.

Appetites for esports competitions certainly didn't wane during the pandemic, but without the energy of the live crowd, something new was needed. Real-time virtual production quickly emerged as a solution to that problem.

Mixed and augmented reality are not new for esports—in fact, streaming coverage of The International in 2018 had featured AR game characters on an LED stage. But for the 2021 tournament, the concept was one that Myreze—in partnership with virtual production specialists Pixotope—were able to take to dazzling new places, using a real-time production pipeline to deliver a seamless experience that placed casters, competitors, and live performers in a single *Dota*-inspired world, despite the fact that all were in different physical locations.

The International for 2021 was held at Bucharest's Arena Națională stadium, as originally planned, but without an audience in attendance. Instead, casters presented from a main AR stage and four green-screen studios within the event's venue. Two additional remote caster green-screen stages were hosted in Brazil and Peru, while one more with an LED screen was used in China for that vast local audience.

In Bucharest, the workflow was shaped to display assets such as a player's in-game character in the volume alongside real-world casters. Meanwhile, an on-site LED screen gave casters and players a means to visualize the position of those assets, giving them an impression of the perspective enjoyed by viewers at home.

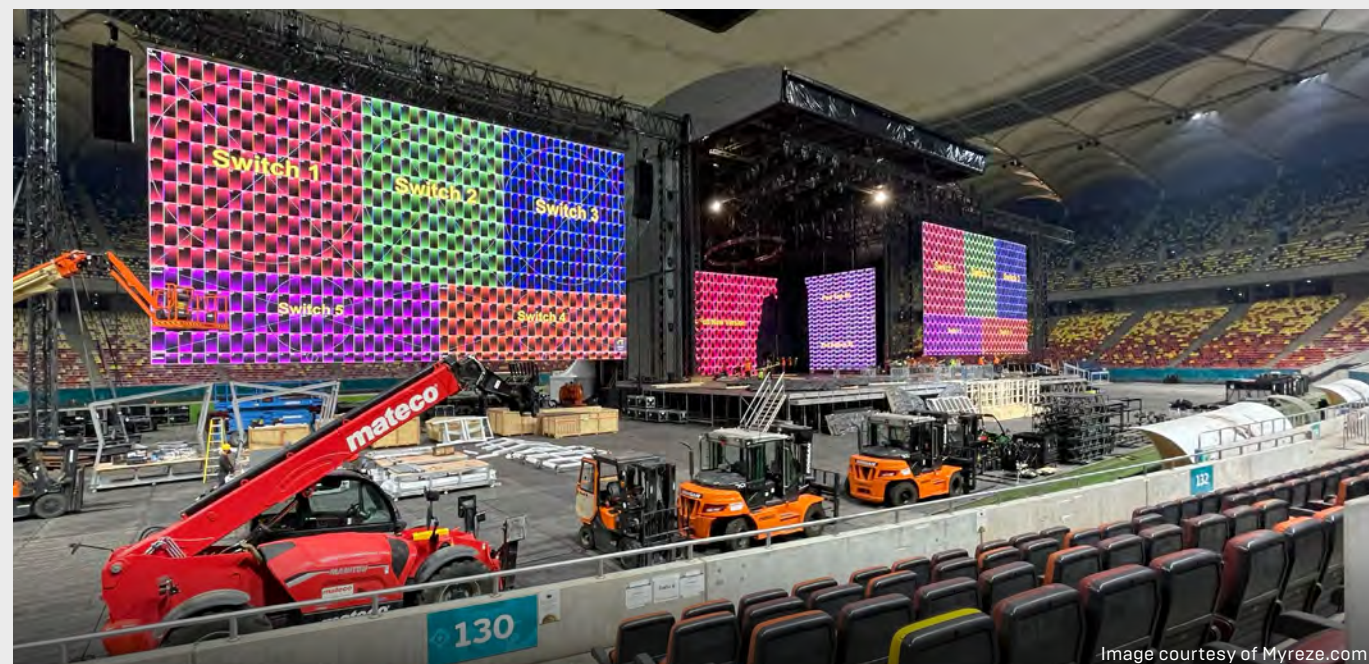


Image courtesy of Myreze.com



Image courtesy of Myreze.com

Across the stages, 15 Grass Valley cameras required precise tracking, which is where rehearsals proved their value. With each rehearsal, tracking data could be carefully refined and realigned. In fact, those rehearsals were just as valuable when replayed as when enacted; an essential process and a strength of the real-time approach, where so much can be captured beyond performances.

Myreze chose to bring together Blackmagic Design HyperDeck Studio 4K Pro broadcast decks and Teranex Mini Audio to SDI I2G converters as a way to capture audio and video data from those rehearsals, ultimately generating reliable timecodes. The audio and video recordings could then be played back on the broadcast decks, and carefully aligned with tracking data in Pixotope, where the virtual set and on-screen graphics were created in a pipeline that also included Unreal Engine, 3ds Max, and Blender.

On the day, after so much preparation, it came down to the effort of teams from Myreze, Valve, Pixotope, the hardware operators, the professional players, and the casters, who collaborated under a carefully arranged hierarchy and structure. Reworking the conventions of on-set hierarchies, and welcoming new roles while evolving the responsibilities of AV providers and creative agencies, is where much of the innovation and progress is being made in this space.

The result of the collaborating companies' effort was remarkable in meaningfully blending so many elements virtual and physical, and has set an inspiring new standard for what is possible through live mixed reality production. The International 10's award-winning presentation has successfully asserted the case that this new format is not just novel or interesting, but in many cases improves on traditional approaches by bringing more meaningful and relevant ways to share live happenings with global audiences.

Case Study: The Weather Channel | IMR Studio

Project type: Live mixed reality production

Weather broadcasting has long been a pioneering form when it comes to mixing realities. The earliest examples of green-screen-based forecasting may seem primitive by today's standards, but they were an important part of the early history of mixed reality and real-time embellished broadcasting.

Over at The Weather Channel, which provides forecasting and weather information to a global audience, that pioneering spirit has never faded. When Michael Potts joined the team in 2013, he came with a clear vision of employing immersive storytelling to deliver engaging weather information. By 2018, the broadcaster's Vice President of Design had spearheaded a project with The Future Group to create special immersive mixed reality segments on lightning and tornadoes, and later in the year, on storm surges and wildfires—all by using Unreal Engine, real-time rendering, and virtual production methods. These pre-recorded segments certainly impressed their audience, with the tornado section winning an Emmy award.

But Potts and his team wanted to do more. They set out to use live immersive mixed reality (IMR) to tell stories in the moment, bringing viewers up-to-the-moment data from a virtual set where the presenter could use dynamic computer-generated assets to visualize and communicate information.

"We all use our phones today to glance at the weather, and get a little information on highs and lows and precipitation. Those are great tools, but they don't tell you the full story," Potts explains. "There's no room to communicate the nuance of the weather, or explain why things happen, or even communicate weather safety. We knew there was this whole communication ecosystem missing where we could fill in the gap, and that's what led us to committing to live immersive mixed reality."

Weather is also complex, and can feel abstract or extremely hard to visualize. What happens inside a cloud formation or under the surface of water, for example, are concepts that aren't easily described with traditional reporting.



Image courtesy of The Weather Channel



Image courtesy of The Weather Channel

This is where the power of The Weather Channel's IMR studio comes in. Building on the virtual set established for the pre-recorded real-time work, and using Unreal Engine at the core of its pipeline, The Weather Channel established a volume that is half physical and half virtual, where presenters and experts can move between the two worlds seamlessly. From there, real-time visualizations of meteorological phenomena, live forecast data, and more can be broadcast live. Essentially, the system uses visual storytelling to make it easier for a vast and diverse audience to understand the weather, its impacts, and its systems.

The highly realistic outdoor environment that surrounds the studio's virtual element can also change to reflect the current topic on air, shifting from stormy mountains to a coastal or snowy area as needed. That's not just a gimmick, but a means to help viewers imagine the experience of the conditions, making the broadcast more engaging and the information more useful and consumable.

Potts says the opportunity real-time brings is about leveraging technology at the intersection of weather data and science to share things that can't simply be captured as video—such as the inside of something incredibly small, a bird's-eye view of a large-scale event, or the impact of a potential future catastrophe—one example is the use of a city model to show what six feet of flood water actually looks like. With real-time and live immersive mixed reality, The Weather Channel can present such visuals so its audience can be better prepared for such a situation.

The workflow for pulling together a given piece of storytelling for a segment starts with identifying stories that will benefit from an IMR delivery. From there, a collaborative process begins, involving science editors, a director, presenters, artists, creative directors, technical specialists, and Potts himself. Once they've chosen the story, they begin work on a storyboard and script.

"At this point, we can start gathering the data and information and get our artists to work building things that are realistic, informed by science, and captivating for viewers," Potts explains. He adds that this stage of production is a lot like traditional broadcast, but that things really start to feel different at rehearsals.

"What you see on your computer often feels different when it's suddenly in the studio," he says. "There we can really use one of real-time's strengths, which is editing and adjusting on the fly."

The whole process, from initial concept to delivery, takes four to six weeks. Potts says that the talent is key here, because they bring not only meteorological knowledge, but also those all-important science communication skills and the ability to be really engaging. “And that’s important,” Potts says. “All this technology should really serve your storytelling and talent, and not the other way around.”

In terms of technical pipeline, everything is very much founded on The Weather Channel’s broadcast heritage, using cameras and a green-screen set, which run in tandem with Zero Density’s Reality Engine, an Unreal Engine-based real-time broadcast compositing system. The team also harnesses the power of Zero Density’s Reality Keyer, an innovative real-time image-based keyer that runs on a GPU. Rather than assuming a single color value for the entire background as seen with chroma keying methods, image-based keying contrasts the captured video with a clean plate, enabling subtle transparent details and shadows to be retained, upping the realism and fusion between the virtual and physical.

“Beyond establishing all the technology,” Potts concludes, “you have to ask yourself a lot of questions before committing too much. Do you want to do something as a one-off event or a regular spot? Are you going to integrate things with broadcast infrastructure? What are the key milestones and deadlines you need to hit? What are the story highlights that really deserve attention? Why does the story even matter? Who is the right talent? Why is immersive and real-time the right choice?”

A great many of those things, Potts is quick to point out, are not in any way real-time specific, but that is the point here. IMR and real-time should never be adopted for their own sake, and much of the craft of telling visual stories remains unchanged.

“Getting this right starts with good storytelling and before that, it starts with a vision,” Potts says. “You have to get those things in place to succeed with this opportunity. To us, Unreal Engine is a tool that makes going immersive and real-time effortless and efficient. But good storytelling and good talent remain the most important things we have at our disposal.”

Practical and Technical Considerations

The live mixed reality production is still an emerging form, which means processes and best practices are still forming. Having explored the evolution and potential of live mixed reality productions, let’s consider some of the practical and technical considerations.



Image courtesy of The Weather Channel



Image courtesy of Moment Factory

New Roles, New Skills

The very fact that this remains an emerging form means there is a way to go in terms of establishing convention in the space. First, the roles and hierarchies of this space are yet to solidify.

For now, many live mixed reality productions still adopt a structure loosely based on traditional approaches that sees three broad teams collaborating to pull off an event on the day. There’s the performer and their support staff, a creative agency handling any video

or computer graphics presented on screens, and the AV team who take responsibility for hardware. At a fundamental level, that trio of elements—performance, visuals, and hardware—are still at the foundation of the delivery of live mixed reality productions. But introducing new technology or more complexity—multiple simultaneous locations, LED screens of various shapes and complexity and 4K projectors, tracking systems, and new pipelines—means there is a great deal of change to consider.

Training up your existing team to understand the practice and delivery of these new forms is key to embracing this opportunity. And that might not be as intimidating as you expect. In almost every interview conducted for this field guide, it came up that traditional broadcast and event roles and skills still remain highly relevant, and retraining is only about augmenting and tuning existing staff’s expertise.

The team at Myreze, for example, comes from wide and varied production backgrounds. Knowing about game engines and new technologies is important, says Jørgen Steinheim, Partner & President at Myreze, but at the same time, it’s still all about storytelling, and building an engaging piece of viewing.

“It’s just ways to do more with storytelling, and it’s important to remember that,” says Steinheim. “With the skills across our team we can make the most of Unreal—we have the technology people, those with traditional broadcast experience, and the understanding of narrative and storytelling informed by that.”

Steinheim adds that traditional skills, and the ability to understand audiences, are key to being successful in this space. “You need a diversity of skills and experiences in your team,” he advises, “so it might be about retraining and rehiring.”

For the artists and designers using DCCs, the core craft remains largely unchanged. Those employees are likely going to need to reconsider assumptions around factors such as screen sizes and resolutions, and embrace the concept of real-time removing how scripted things can be in some instances. But it is the teams working on rehearsals and the final live production that may see the most profound change.

We are, however, seeing new roles appear in tandem with the growing real-time opportunity, although there is little established agreement on how to frame or title those roles.



Images courtesy of Myreze.com

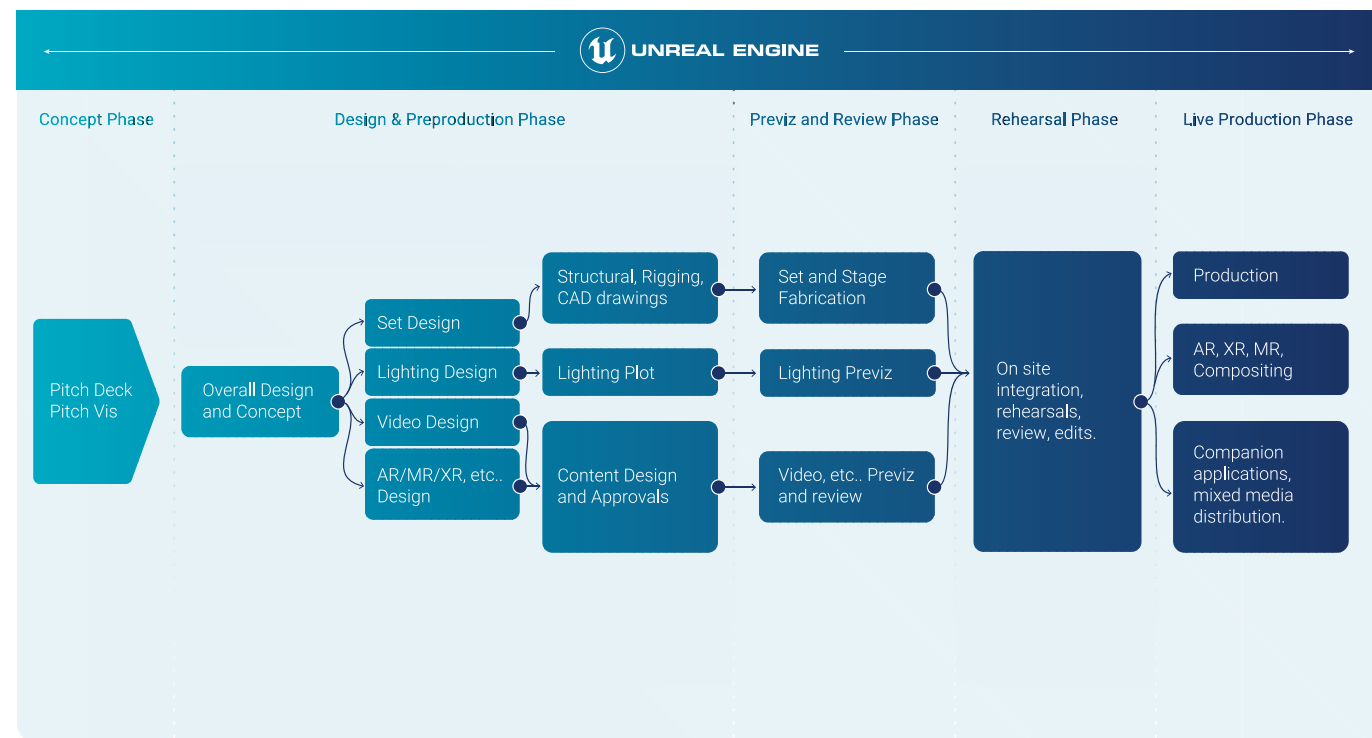


Figure 2: Life cycle of a live event project, with Unreal Engine as the central hub for assets and controls.

Many speak to the value of securing a “system integrator” or similar team who can handle the technical side of connecting content with infrastructure, while also serving as a go-between who smooths the interactions between hardware people, performers, and content providers.

Elsewhere, many virtual mixed reality productions are happening with a “screen producer” sitting high in the food chain, an individual effectively charged with taking responsibility for what appears on screen, and thus coordinating the related technology and teams.

Others spoken to for this field guide put forward the idea of a generalist “Unreal Engine specialist” or even “Unreal Engine wizard,” meaning somebody that can understand the game engine and its interaction and integration with the wider ecosystem both in rehearsals and on the go-live day.

None of those roles are established or recognised as including a specific skill set or authority within production hierarchies. The best way forward may simply be to give more time than you might imagine to establish a team hierarchy while pursuing specialist hires. Hire through skill set rather than job title, and consider engaging with the games industry to employ hires or freelancers that are well versed in the wider

world of real-time production and delivery. It can work particularly well if you pair up gaming engine specialists and senior AV staff, as that combination covers much of the skills needed in a real-time live mixed reality production.

Equally, be aware that as much as you may need to retrain, educate, or augment your existing team, educating customers to manage expectations is equally key here.

Testing, Calibration, and Assumptions

Away from considering how your team and hardware communicate and integrate, it is important to note that—relative to traditional production—rehearsal, calibration, and testing matter a great deal. While the granular nuance of camera tracking technology and technique is beyond the scope of this guide, quality camera tracking for mixed reality broadcast in particular forms the keystone of quality. With that in mind, considerable thought, time, and effort needs to be put into factors such as time of day and weather for outdoor events, or crowd size and how that may interfere with the robustness of a connection.

Geography can also be a factor—at a music festival in the middle of a desert, for example, remote access to one-server tech such as version control and

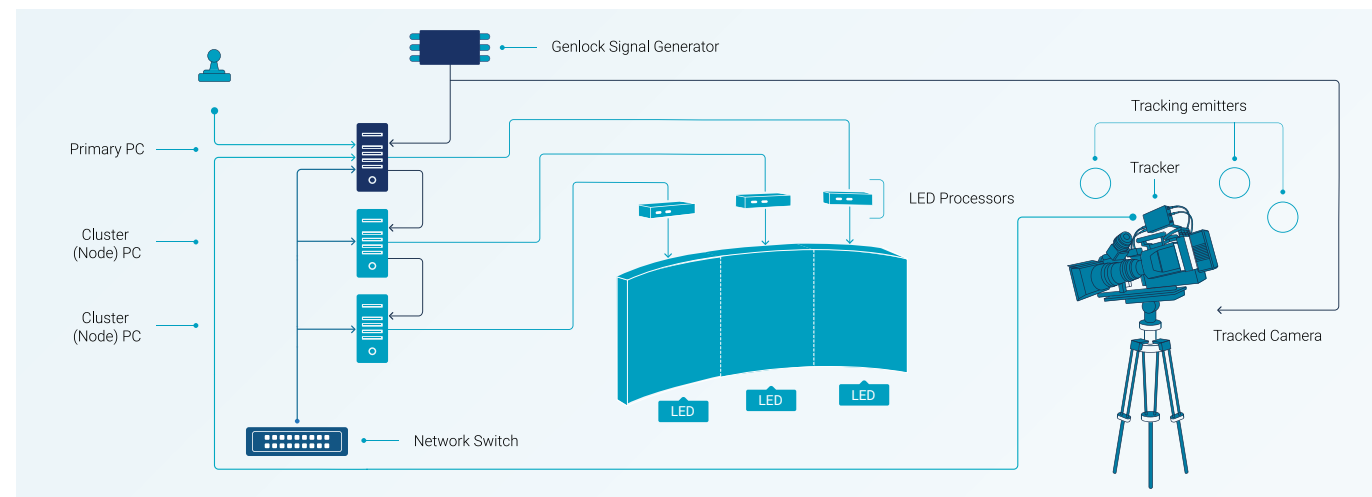


Figure 3: Sample setup for a system utilizing LED panels and a tracked camera. You can find more technical details and setups in the white paper [nDisplay Technology: Limitless scaling of real-time content](#).



Image courtesy of Capacity Studios

storage may be put under significant strain. In short, thoroughly test and calibrate absolutely everything, particularly where it involves a wireless or internet connection or data flow such as camera tracking data, and consider variables such as weather conditions. In addition, schedule ample time not just for multiple rehearsals, but also post-rehearsal sessions to break down, interpret, and test your data.

Working on real-time live mixed reality productions isn't just about overcoming challenge and complexity. The shift to real-time here also brings main gains in efficiency and even simplifications of process.

When live productions send pre-rendered content as video to on-site screens, the process is more familiar. While the opportunity for dynamic, adaptive content is not available, many will see it as an inherently less risky approach. But going with pre-rendered content often means much of your effort is duplicated—where artists can block out and prototype assets in simpler DCC software, high-resolution versions of those assets often have to be reconstructed from scratch in CAD software.

Moving to work in a real-time pipeline via a game engine, meanwhile, means using a single solution from early concept to final pixel. Real-time is often a much

more expedient model when it comes to live mixed reality production, but the greatest time savings might actually be found in the long term. Real-time assets made in a game engine can still have a considerable lifetime after the live production wraps, thanks to being easy to rework or apply to other types of media.

Should a customer later want a mobile game for the same brand, or an entirely new live production, the real-time nature of the assets means they can readily be adapted and reused. In other words, you can consider the real-time workflow for a live mixed reality production as simultaneously establishing a funnel that could be used to generate new content from existing assets, for weeks, months, or years into the future.

Turnkey Studios

New pipelines, software, engines, and formats are still emerging, and in terms of the physical interconnected hardware systems required on the day, things are not yet entirely standardized. Things are progressing fast, with companies like [disguise](#) offering a line of fully integrated media server hardware, software, infrastructure, training, community, and support that endeavors to provide a complete ecosystem for such events—Unreal Engine being part of that ecosystem.

However, we are also seeing studios emerge that cater specifically to broadcast and live events clients who want a production experience that closely resembles familiar workflows. Such studios will mitigate some of the pain points and challenges of acquiring hardware and training staff that clients might face if attempting to create their own real-time setups and teams.

XR Studios has taken this approach, offering a full-service production studio built for XR and MR, with the team supporting everything from concept to final delivery, and a highly flexible, permanent LED volume at the heart of things. By providing the location, hardware, pipeline, and creative process as a single integrated ecosystem, XR Studios removes many of the challenges of adapting a traditional live production setup to serve as a live mixed reality production offering, and frees up customers and creatives to focus on performers, performance, and creativity.

XR Studios' goal is to provide the most complete canvas for XR creativity, explains Scott Millar, XR Studios' CTO, to ensure that when a client comes in with their idea for the LED volume, there are no technical barriers or concerns about integrations.

To that end, the studio is building its tools and pipeline, and integrating with disguise, to establish an environment that feels just like a broadcast studio.

"That's our number one priority," says Millar. "The studio has the same controls and familiar setup, but it just happens to have a massive, multi-million-dollar LED screen at the end with specific media servers running it."

Millar adds that he sees more studios going with such a solution in the future. "It's a way to help creative teams embrace this opportunity, without them having to relearn nearly everything."

XR Studios' LA-based location is able to host everything from single performers to full orchestras via esports events and even game shows. That kind of blank-canvas concept may be critical to the future of live mixed reality production, and to the wider broadcast and live events real-time movement. But some productions will always need to be site-specific—not every project will be able to take place at an XR location.

Case Study: [Psyonix](#) | [RLCS Hype Chamber](#) | [Capacity Studio and Partners](#)

Project type: Esports broadcast

The Rocket League Championship Series (RLCS) Hype Chamber is a remarkable project that deftly captures the potential of real-time technology to intersect opportunities in broadcast, live events, gaming, mixed reality, and even virtual production.

Developed by game studio Psyonix, Rocket League has emerged as a star of esports' global rise. In offering an automotive take on soccer, the game follows the great arcade tradition of being easy to pick up and difficult to master. Its knack for delivering dramatic clashes has drawn huge audiences to esports broadcasts like the RLCS esports tournament—with all eyes fixed on the in-game arena in which each match plays out.

Long-time Psyonix collaborator and experienced creative agency Capacity Studios saw an opportunity to extend that arena and deliver a digital broadcast concept that brought fans, professional players, and the game closer together. The RLCS Hype Chamber project is a joint collaboration between many forces from Epic Games, Psyonix, Capacity, and DreamHack.

"The Hype Chamber was designed as a launching point to reimagine what a sports broadcast might look like for a digital-first audience," explains Jasveer Sidhu, Art Director at Capacity Studio.

The Hype Chamber offers an imagined extension to the game's motorsports arena, presented as a virtual stage where vehicles are displayed before rolling out onto the pitch and taking their places. Its role is to present a transitional space between a studio broadcast and the gameplay itself, where teams can be introduced, hype can be built, and winners can be announced. In other words, it serves a multifunctional role in RLCS broadcasts—and it proved so popular that it has now been reimaged as a physical space.

The design of the physical iteration consists of a 360-degree set of curved LED screens. Those screens are fed outputs from the Unreal Engine version of the scene, recreating the digital Hype Chamber environment on stage as a real-time entity. Competing teams can sit in real seats on either side of the Hype Chamber while game assets are displayed between and around them.



Image courtesy of Capacity Studios



Image courtesy of Capacity Studios

Offering a dynamic virtual stage with reconfigurable geometry, the physical Hype Chamber can display screen content that adjusts automatically according to image composition and the teams present in the space. The Capacity team is even exploring ways to make the graphics on the physical stage interactive, where viewers can influence the content.

“There are a couple of dynamics specific to RLCS that make the real-time nature of interacting with the Hype Chamber special,” says Ellerey Gave, Executive Creative Director at Capacity Studios. “The open format of the league means that there are usually new teams competing each week. In traditional pipelines, this would either equate to a ton of additional work and rendering each time a new team is added, or it would lead to the add-on teams receiving a less special treatment than the established teams. With the way the Hype Chamber is wired up in Unreal Engine, we can swap out logos and team colors very quickly, and instantly have the same high-quality assets ready to go for that weekend’s broadcast.”

The digital version of the Hype Chamber can be used in a number of additional ways, thanks to real-time technology’s capacity to rapidly generate content for a reworked environment. It can serve as a storytelling platform, or even as a showroom for team car skins available to fans within the game.

The physical version is similarly flexible. “Because the Hype Chamber was built in Unreal Engine, there are a number of ways these same assets can be leveraged for live events,” explains Benji Thiem, Creative Director and Partner at Capacity Studios. “Since we developed an entire scene that exists in 360 degrees, we were able to map the portions of the space we wanted to feature onto a set of real LED screens, creating a dynamic backdrop for the live event, which already had much of the functionality for team customization built in. We further expanded on this package by including custom graphics, as well as a toolkit of video loops that could drive other smaller screens in the space.”

The project has been made available to Unreal Engine users as a sample project, giving them the opportunity to get under the skin of the design, development, and delivery of the RLCS Hype Chamber.

Ultimately, Capacity has created combined real-world and virtual spaces that serve as bridges to seamlessly move between different realities, fusing concepts of events, broadcast, and gaming.



Image courtesy of Capacity Studios

CHAPTER 5:

Summary

Throughout this guide and its interviews and case studies, several challenges to adopting real-time technology in broadcast and live events have presented themselves. In this section, we will highlight and consider some of the most significant of those challenges, and the available solutions. This section is intended to summarize threads that pass through the wider guide, providing an “at a glance” list of key practical considerations for those looking to embrace the real-time opportunity in broadcast and live events.

New Skills and Retraining Staff

In many interviews for this guide, users expressed concerns around hiring suitably experienced specialists when the talent pool is small, and also retraining existing staff to adopt real-time approaches. This is admittedly a complex challenge, as many real-time specialties and roles are still emerging.

The Solution

While the problem here is surmountable, the challenges are a reality, and there are no quick and easy universal solutions. Rather, there is nuance—many interviewed for this guide pointed out that most “traditional” skills in broadcast and live events remain highly relevant, and can be adapted to real-time technology without too much friction or disruption. The fundamentals of understanding audience, storytelling, and engagement in existing TV, broadcast, film, video, and event sectors can be broadly applied to real-time.

Despite this fact, embracing real-time skills can’t be rushed. Give it time: start with a smaller or exploratory project, hire specialists when needed, and immerse yourself in the events and online activities of the real-time broadcast and live events community.

That community can be key. With a shared interest in growing the real-time space and establishing convention around technology, technique, and hiring, there is much interest in knowledge sharing, partnerships, and formal and informal collaboration. Connecting with that community is a strong starting point. Ultimately, a more immediate solution may come from hiring a real-time specialist; if you go this route, base your job listings on needs and skills, rather than hiring for a specific title or existing role.

Establishing New Roles and Production Hierarchies

The established hierarchies, structures, and roles found across more traditional broadcast and events production often need adjusting to better serve real-time; and yet the roles required to plug gaps

are yet to solidify or be consistent. Ultimately, many arrangements can lack a liaison between the creative team providing assets; the A/V team managing hardware, displays, and media servers; and entities such as the artist and venue team.

The Solution

Hiring is a likely solution here, and the real-time community may help fill those roles. Many productions thrive when served by a floating liaison who is adept with real-time technology and Unreal Engine, and can move between creative, hardware, artist, and venue teams. Elsewhere, screen producers with comparable skills have a senior position and take responsibility for everything appearing on screen, an alternative framing of a go-between for various on-site teams.

Many speak to the value of securing a “system integrator” who can handle the technical side of connecting content with infrastructure, while also serving as a go-between who smooths the interactions between hardware people, performers, and content providers. Ultimately, and at this stage in the industry’s forward journey with real-time technology, hiring experts to complement your team is likely more sensible than restructuring or reinventing your existing team.

Adopting Unknown and New Technologies

With so much of timeline-based production software and motion graphics well established, and with many practitioners having used the tools needed to create them for years, moving to work with new real-time technology and platforms can be intimidating. It can be easy to assume such tools are unwelcoming, or will take months or years of training to embrace and understand.



Image courtesy of Moment Factory

The Solution

Adopting a game engine does not mean a wild leap from working with other design, editing, and production software. Many of the fundamental principles will apply, and you may be surprised to realize how much the Unreal Engine Editor compares to other software environments you or your team use on a daily basis. Beyond immersing yourself with the broadcast and live events real-time community, you will find a vast support network and a large quantity of documentation across the Unreal Engine community, provided by both Epic Games and users on their own channels.

Having spent years serving game development teams from vast operations with hundreds of staff to tiny studios literally based in garages, Epic has learned much about developing training and documentation that serves a range of needs and experience levels. Self-teaching may not be the ultimate solution at scale, but many in the space are self-taught.

In other cases, the documentation and community around Epic (and related technologies that sit in a real-time pipeline) are about individual users empowering themselves enough to start to explore the wider opportunity, while making them literate enough in the technology and practice to engage more meaningfully with conversations and learning across the sector.

If you’re interested in finding out about premium support and custom, private training, [contact us](#) and we’ll let you know about all of the available options.

Time-Saving and Budgetary Misconceptions

Many mistakenly believe that real-time may be cheaper, while also saving time. In reality, that perception oversimplifies the situation.

Sometimes real-time broadcast and live events productions can go from initial idea to completion in staggeringly short time frames. In the case of broadcasters who have established real-time-ready studios with everything in place, incredible things can repeatedly be achieved in very short windows of time.

Other real-time projects may take months of planning and implementation—for example, a real-time-embellished music tour might require updates and maintenance constantly, and for years. The most ambitious projects can require long periods of planning simply to get started.

Equally, while some real-time productions cost relatively little, others might demand vast custom stages, or towering bespoke LED screens or projection systems.

The solution here, as much as there is one, is to free yourself from assumptions that real-time always means time and money savings. A more accurate statement is that going with real-time technology offers more options for engaging your target public, and can lead to stronger relationships with audiences that benefit you in other ways—sold-out shows, great reviews, returning customers, or word-of-mouth marketing.

New Hardware Choices

Traditional video-based media servers and display systems offer a known, familiar entity: the projection or display of canned footage or pre-rendered animations to a screen in a linear fashion. Conversely, a real-time workflow often involves displaying dynamic content to contemporary options such as LED screens or high-resolution, multi-projection systems.

Additionally, real-time's strengths mean it has expanded interest in displays of non-traditional ratios, shapes, and sizes—and even moving or uneven display surfaces, and display on the sides of buildings. It can feel like embracing these opportunities demands an intimidating change or upgrade to unfamiliar infrastructure, which in turn may impact efficiency, quality, or budget.

The Solution

Although a fundamental understanding of real-time media servers' function, role, and essential workings is helpful, for now the reality of such productions likely means partnering with an individual provider who will deliver both physical infrastructure and expertise—and even on-site staff in many cases.

The same is often true in live events, so you can consider the solution here as comparable to hiring any A/V provider. Practically, that currently means working with a provider of real-time capable media servers. Many providers of that kind of infrastructure can also provide insight, consultation, on-site staff, and more, letting you embrace the potential of real-time without a significant investment in internal infrastructure, skills, and staff.

Equally, we are likely to see more models in the vein of that provided by [XR Studios](#), where a provider offers a flexible, adaptable studio space made for real-time, meaning all hardware and hardware integration is offered as part of the service. Once more, partnership and collaboration are key.

Does it Have to be Real-Time?

This last challenge is the most defining and persistent. It can be hard to know if real-time is right for your project or aims. Oftentimes clients, artists, or brands might push for real-time because they have seen rivals succeed with it. But to adopt real-time methodologies and approaches simply for the sake of it—practicing

“theater of real-time”—is never advisable, and could lead to less impact, more time and budgetary sink, or even failure to deliver on a brief.

The Solution

Be open-minded to game engines and real-time workflows, and endeavor to explore their potential through practice, but never pick a real-time approach just to tick a box or impress your clients with your toolset.

There are so many reasons to be excited about real-time not only because it is a new or innovative way of producing or delivering content, but because it is a completely new way of thinking. Once you embrace it, you will understand the added values it brings, and in what capacity it will fit your project. It's not an all-or-nothing approach—you get to pick exactly where, or in what capacity, it will fit your project. Should you do your project entirely in traditional pre-rendered workflows, or leverage real-time platforms only when a project calls for high levels of interactivity or reactivity, remember that the choice is entirely up to you. Essentially, pick real-time in the desired capacity because it is adding value to the experience, to the workflow, or to your time-cost analysis considerations.

Should you or your team be concerned about the required knowledge and learning curve, we suggest you jump right at it and start internal, experimental, or exploratory real-time projects to test the water and learn practically. Some even advocate for making a simple video game to understand the fundamental concepts—consider that today, code-free game development platforms exist that are aimed at children under the age of 10—and such a project may be more welcoming and achievable than you assume.

Consider the gains game engines and real-time workflows can bring, and endeavor to explore their potential through practice, because once you or your team get the hang of it, it's very hard to go back!

Profile: [Moment Factory](#) | [AT&T Discovery District](#)

Project type: Live multimedia experience

AT&T and global architecture firm Gensler were looking to establish an immersive and engaging multimedia experience in the heart of downtown Dallas. That meant mixing the realities of physical buildings and digital works—which, in turn, meant real-time was the perfect solution. With that in mind, AT&T and Gensler enlisted Moment Factory, a multimedia studio specializing in creating experiences that bring people together in public spaces.

The mandate included overseeing strategic project development and experiential design, including content and digital platform integration.

Moment Factory delivers a very distinct form of live mixed reality experience. With over 20 years of experience, the team has learned a lot about the value of established skills, the power of storytelling, and the potential in using a game engine to make your own tools—all of which proved powerful in delivering content for what became known as the AT&T Discovery District.

It was a project that perfectly demonstrated Moment Factory's playful mantra: “We do it in public”.



Image courtesy of Moment Factory

“Everything we do is about bringing people together,” explains Annie Leclerc-Casavant, Communications Advisor at Moment Factory. “We work to create a form of entertainment that offers people new experiences they can share together. We use multimedia to create a context where people can experience what we call “modern day gathering places”. It could be a concert, or a brand event at a flagship store, or something at an airport, in a forest, or at a theme park. In all those contexts, what’s really important for us is to inspire connections and a collective sense of wonder. And everything we do is about the physical, real world. There might be a virtual element, but the real world is always part of it.”

The AT&T Discovery District is one such gathering place in the real world. At its heart is the AT&T Dallas headquarter building, fitted with a towering 104-foot tall, 6K media wall and LED-powered trellis that displays evolving visual content designed to fit the tone of the local area, helping those passing through to feel relaxed, connected, or inspired. The screen can even output sporting content or film screenings, reinterpreting a corporate building as a cultural destination.

The content is delivered as a blend of pre-rendered and real-time content deftly adapted to time of day, weather, and season, with attention to the visual fidelity required for such a vast screen space.

Moment Factory has also reimagined spaces in the Tokyo subway, the Notre-Dame de Reims cathedral, the Resorts World Las Vegas on the city’s famed strip, and other distinct and iconic locations.

Crucially, while Moment Factory has completed many truly innovative and technologically cutting-edge projects since its founding in 2001, the team sees what they do in places like Dallas as simply taking a different approach to the well-established craft of storytelling.

“We are essentially trying to understand how to engage people, and the basic nature of people engaging with each other,” explains Moment Factory’s Multimedia



Image courtesy of Moment Factory

Director Alberto Ramirez. “The answers there aren’t just about technology. What works in storytelling, and what works with human nature—those things are the same whether we are talking about a real-time display on the side of a building, or more traditional art forms.”

Half of what Moment Factory does, he says, is still done with traditional skills and methods. “But the other half,” he continues, “is working towards giving people this connection with different mediums, different formats, or different types of interaction, the kinds that are only possible through current and new technologies.”

Achieving these connections means a rethinking of many of the old rules and approaches, but not necessarily learning everything all over again, Ramirez tells us. “It’s not as intimidating as people might think,” he says. “It’s more like we’re discovering this change, and new ways to think about old things like storytelling.”

It’s also about picking the stories that need to be told through those technologies. “We don’t just use technology because it is there,” says Moment Factory Innovation Producer Céline Mornet, who worked on the AT&T project. “We are not looking to find ways to use some new AI algorithm just because we can, or build new hardware when it isn’t required. Our purpose as a team is to be multiskilled and understand many different ways to be creative and use technology, and then scan any industry to understand the creative needs. From there, we can find the right tool to achieve those creative needs.”

“We like to say we ‘hijack technology,’ and that means we use and repurpose any technology that helps deliver the creative vision.”

In other words, it should never be about starting with a technology and then concocting a means to use it. As we’ve heard throughout this guide, story should always come first.

A game engine, however, can serve as a means to connect skills both emerging and established, while providing a consistent content creation platform that is highly compatible with most other tools required for a given project. So while Moment Factory is platform-agnostic, Unreal Engine has provided a reliable foundation for so many of their pipelines, enabling artists to work in familiar environments while serving highly atypical end destinations—such as a display on a large Dallas building.

Another strength the game engine brings is the ability to use it to build tools—something game makers have expected of engines for many years. Those game developers might build custom tools in Unreal Engine to connect various elements of a game’s environment and interactive systems. In the case of Moment Factory, that proved highly useful because of the wide variations in their projects, some involving custom-built or oddly shaped displays, or highly unusual display spaces.

“It’s really about being able to make the tools to create an interface with the physical world,” Mornet confirms. “We work with a game engine to create the tools to connect with the lights, the sound systems, the augmented reality, and the sensors. With Unreal Engine, everything becomes an integrated process.”

“We can also use Unreal to simply facilitate our daily lives, to keep things running more smoothly,” adds Ramirez. “We’ve built our own library of assets and systems, and so on. But Unreal is also this huge sandbox and immense toolbox, and we’re still finding new ways to take advantage of its tools.”

Profile: XR Studios

Project type: Turnkey studio for broadcast and live events projects

XR Studios is a full-service, turnkey production studio in Los Angeles, CA, specializing in the merging of real and virtual worlds for AR, MR, and virtual production projects. With a client list that includes Billie Eilish, Riot Games, Katy Perry, Twitch, Amazon, TikTok, and Post Malone, XR Studios represents a powerful example of where the technology has got to today, and where the future of production might take us.

The company provides both in-studio and remote services, for projects ranging from small corporate event videos to commercials, massive concerts, and major livestreams of awards shows.

XR Studios features a stage with a calibrated LED volume, effectively offering a blank canvas that is primed for XR projects, and providing an environment where clients can be free to explore creative ideas. “We hide the complexities as much as possible,” explains XR Studios CTO Scott Millar. “We want people to feel free to work toward the end vision, and not worry about the technology.”

That core location in Los Angeles presents a striking example of what a modern production studio can be. Central to the concept is that XR Studios can handle every element of a project, from conception to production logistics to technical execution, giving clients unfamiliar with the nuance of mixed reality projects a complete service for delivering powerful work, all without having to retrain their teams or rebuild their pipelines. It’s an approach built to eradicate the technical barriers typically present when a creative agency or similar group decides they want to embrace mixed reality, and work with virtual production methodologies, LED screens, and projection to atypical displays.

“We’re also a creative agnostic technical solutions provider, meaning that we partner with different content, virtual teams, project agencies, and so on, to make sure the creative team gets to the finish line,” explains Executive Producer Francesca Benevento. “That flexible and collaborative approach is really central to what we do, and central to making XR projects more workable and welcoming.”

The team at XR Studios is mindful of the potential to have a wider influence around mixed reality, and feels a sense of responsibility to the industry as a whole.

“With our permanent studio, we’re trying to not only deliver quality and reliability, but also help set a new standard in the industry when it comes to working with this technology,” states XR Studios President J.T. Rooney. “We want to lead by example, and create a space for everyone—from clients and record labels, to companies and creative agencies—to not feel rushed with their projects or feel like they are left with poor-quality content. We understand the importance of investing our time, resources, and care in executing first-rate experiences; that is what’s going to make a huge impact on the industry, and help the space overall.”

The work can be difficult and challenging, he admits, particularly because it’s new and complex. Rooney encourages companies looking to get involved with real-time projects to carefully consider what their vision or project requires, and to speak to experienced teams specializing in XR to get a realistic idea of these challenges.

As for XR Studios, the permanent, highly adaptable location provides the company with a built-in opportunity to improve and refine, taking learnings from one shoot and implementing them before the next. “That’s a big part of our approach,” he explains. “When we’re not doing shoots, we’re very focused on making our offering better, and working to further it.”



This focus on R&D in between productions, says Rooney, is part of the company's contribution to the XR space at large: "We have had years and years of buildup and learning. There is more shared knowledge and experience in some areas, such as live concerts with real-time elements, but there is still so much for us to explore and expand on. Working with an advanced set up like real-time in a volume with tracked cameras gives you a whole set of different challenges. And this really excites us."

Even before choosing a facility for your XR project, Rooney advises, one should really consider whether extended reality is the right medium for the job.

"A lot of people, particularly in the world of live tours, ask for real-time content without having a real reason to go that way," Rooney reveals. "And there has to be a reason—there has to be a foundation. Entertainment with live music is a great example of when real-time makes sense, because real-time can happen with the performance. It's happening with something that is reactive, that is unpredictable, and that is changing, so real-time can really achieve something that complements or extends the performance."

Millar points out that real-time technology works well even for content that isn't intended to be photoreal. "The best-looking real-time content on show is the content that's not trying to look real," he says. "It's trying to be interesting and engaging, but it uses stylization and other aesthetics away from pure realism."

To finish, Benevento offers something fascinating and encouraging in equal measure. While any team working on a real-time project would love to have months to work on it, the reality is that XR Studios usually gets four to six weeks, or even less, to prepare. That, however, can be understood as an opportunity as much as a challenge.

"Sometimes, the limitations of the schedule can be a way to harness creative freedom," Benevento says. "If you have only two weeks to turn something around, and don't have the opportunity for preparation or post-production that other approaches can bring, you can see that as an opportunity to get very creative. So we talk with our clients about these fast projects essentially being scientifically-minded projects, exploring what we can achieve or discover with real-time, when it has this amazing ability to create content fast."

Benevento cites the recent example of XR Studios delivering six music performances to TikTok in two days. "The end result was, we gave TikTok a new format for sharing music that really worked for their platform," she says. "So, again, it's about managing client expectations, being open-minded to finding new ways, and really going with real-time when it's right."

It's Showtime!

In this guide, we have aimed to demystify real-time workflows for broadcast and live events. We hope this guide has shown you what's possible with real-time technology, and has encouraged you to explore the possibilities with Unreal Engine.

We encourage you to [download Unreal Engine](#) so you can start building your own pipelines and infrastructure.

Epic Games remains committed to the broadcast and live events community, and we look forward to you continuing the journey with us. As you delve into the world of real-time workflows, be sure to connect with our [vast and diverse community of users](#) to get tips and connect with others doing similar projects. You can also find more resources at our [Broadcast and Live Events hub](#), or reach out to the Unreal Engine team directly [via our contact form](#).

Glossary

Augmented reality (AR)

A technology that integrates CG elements into a physical environment.

Blueprint

Script created from the Blueprint visual scripting language in Unreal Engine—defines how an asset interacts.

Central processing unit (CPU)

The main computer chip that performs a wide variety of calculations. Compare with GPU.

Cinematic

A pre-rendered, noninteractive sequence in an otherwise interactive experience. Also called "cutscene".

Cluster

A group of PCs on a network designated for a specific task, forming a single system.

Clustered rendering

Rendering by a group of PCs that have been designated as part of the same cluster (group).

Distributed rendering

Multiple instances of an engine processing the same scene in parallel to achieve much higher total resolution.

DMX (Digital Multiplex)

A protocol for digital control of lighting and effects. Originally developed for real-world stages, the standard is now used for all-digital lighting and effects as well.

Extended reality (XR)

An umbrella term for VR, AR, and MR, and all future realities such technology might bring.

Frustum

The region of a virtual world that appears as a viewport to the camera.

Final pixel

Final images at a quality sufficient for the purpose, without the need for additional post-production.

Game engine

A software-development environment designed for the creation of real-time interactive content, initially for video games, but now used in many other applications.

Graphics processing unit (GPU)

A specialized type of microprocessor optimized to display graphics and do very specific computational tasks. Modern real-time engines rely heavily on GPUs for performance.

Head-mounted display (HMD)

A device used to display CG content for VR, AR, or MR.

Latency

The delay between when a signal is sent and when it is received at its destination; experts consider under 10 milliseconds of latency to be critical for real-time camera operation.

LED display

A panel that emits lights and colors as pixels for a video display, using an array of light-emitting diodes (LEDs).

Media server

Hardware and/or software for storing and delivering digital media such as video, audio, or images.

MIDI (Musical Instrument Digital Interface)

A long-established protocol for connecting electronic musical instruments, computers, and other audio devices for playing, editing, and recording music.

Mixed reality (MR)

The process of anchoring virtual objects to the real world and enabling users to interact with them.

Motion capture (mocap)

The process of recording actions of human actors, and using that information to animate digital character models.

nDisplay

A system within Unreal Engine that distributes the rendering of content across a network of computers, generating images to displays with proper frame/time synchronization and viewing frustum based on real-world topology of screens. See the white paper [nDisplay Technology: Limitless scaling of real-time content](#) for more information.

OSC (Open Sound Control)

A protocol for networking sound synthesizers, computers, and multimedia devices for shows and performances.

Performance capture

An advanced form of motion capture that includes faces and/or fingers, and captures subtle expressions. For more information, see the white paper [Choosing a real-time performance capture system](#).

Ray tracing

A rendering technique for generating an image by tracing the path of light as pixels in an image plane and simulating the effects of its encounters with virtual objects.

Real-time rendering

The translation of a scene into display pixels fast enough for instantaneous playback at real-time (live) speeds. In contrast, traditional offline rendering may take minutes or even hours to produce each frame, with 24 frames required to display a second's worth of animation.

Refresh rate

The frequency with which an electronic display is refreshed, usually expressed in hertz (Hz). Higher refresh rates can make motion appear smoother.

Timecode

A sequence of numeric codes that record the exact time a signal was generated, such as the exact date and time when video was recorded. Timecode is used for synchronization in video production and live show control to synchronize various actions.

Virtual camera (Vcam)

A camera in a game engine that can be driven using a device such as an iPad.

Virtual production (VP)

The cross section between physical and digital worlds, using real-time technology to view and interact with virtual environments and characters.

Virtual reality (VR)

An immersive experience using reality headsets to generate the realistic sounds, images, and other sensations that replicate a real environment or create an imaginary world.

Volume

A physical, enclosed space that houses any of various systems for virtual production such as LED walls for in-camera visual effects, cameras to record performance capture, etc.

XR

See Extended Reality.

Links

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11	disguise	https://www.disguise.one/
11	XR Studios	https://www.xrstudios.live/
11	Moment Factory	https://momentfactory.com/home
11	Creative Works	https://www.creativeworks.london/
11	Myreze	https://myreze.com/
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21	Carolina Panthers	https://www.panthers.com/
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23	The Panther Project	http://www.panthers.com/news/mixed-reality-panther-a-hit-at-season-opener
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66	Sample project	https://www.unrealengine.com/en-US/spotlights/enter-the-rocket-league-hype-chamber-a-new-sample-for-broadcast-and-live-events
71	Contact us	https://www.unrealengine.com/en-US/license#contact-us-form
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73	AT&T Discovery District	https://discoverydistrict.att.com/
73	Moment Factory	https://momentfactory.com/home
76	XR Studios	https://www.xrstudios.live/
79	Contact us	https://www.unrealengine.com/en-US/license#contact-us-form
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79	Epic Games dev community	https://www.unrealengine.com/en-US/community
79	download Unreal Engine	https://www.unrealengine.com/download
80	Choosing a real-time performance capture system	https://cdn2.unrealengine.com/Unreal+Engine%2Fperformance-capture-whitepaper%2FLPC_Whitepaper_final-7f4163190d9926a15142eafcca15e8da5f4d0701.pdf
80	nDisplay: Limitless scaling of real-time content	https://cdn2.unrealengine.com/Unreal+Engine%2FnDisplay-Whitepaper-V1.8B-9d99c6448fd96bcd5a8d0770cl2c22387683778.pdf



Courtesy of Moment Factory

There's a shift happening in the broadcast and live events industry, one that engages and excites audiences in ways never seen before—a shift to real-time content and experiences.

From rock concerts and sports/esports broadcasts to weather reporting, interstellar journeys, and more, real-time changes the way broadcast and live events are designed, delivered, and consumed. By immersing viewers in a fresh, new world, real-time brings new ways to produce interactive or mixed media that will keep audiences coming back for more.

With this guide, join Epic Games on a journey to developing real-time immersive experiences, with Unreal Engine at the core of this new type of pipeline.

