

xR StGries

THE EVOLUTION OF VIRTUAL PRODUCTION?

ISSUES AND OPPORTUNITIES

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Acknowledgements

We would like to extend a huge thank you to all of our participants who contributed their valuable time and insight to both stages of our project. Without their contribution, this project would not have been possible. We would also like to extend our thanks to colleagues on XR Stories, the Screen Industries Growth Network (SIGN) and School of Arts and Creative Technologies at the University of York.

About XR Stories

XR Stories supports research and development for companies working in cutting-edge digital technologies in the Yorkshire and Humber region. We do this through a programme of funding, research collaboration and connection. We work across film, TV, games, media arts, heritage, advertising and technology to champion a new future in storytelling. XR Stories is putting the innovative and dynamic digital storytelling community of our region at the front of the global creative and cultural landscape. We draw together the University of York's research excellence and a strong business focus. We are finding new ways to tell new stories to new audiences. XR Stories is a £15M investment by AHRC, ERDF, the University of York, the British Film Institute and Screen Yorkshire.

Report published, 2023.

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1. INTRODUCTION

New technologies, market dynamics, shifts in consumer tastes and regulatory reform all contribute to disruptions in the film and TV industry. In recent years, streaming platforms, digital broadcasting, high definition cameras and 3D formats have all altered the production and consumption of screen media. The latest disruption comes from virtual production, a constellation of creative technology developments which allow final pixel quality digital assets to be captured ‘in camera’ during shooting, rather than being added in post-production. The technologies, and approaches to applying them, are evolving rapidly to allow filmmakers to generate, visualise and control digital environments in real time.

According to Grand View Research (2022) the global virtual production market was valued at \$1.82 billion in 2022, and the sector is predicted to experience an annual growth rate of 18.2%. The UK has established itself as a centre for excellence in virtual production, having seen large-scale growth and investment across the entire virtual production supply chain (Department for International Trade, 2021).

Our previous report introduced what virtual production is, and presented a research agenda for examining the growing industry. We outlined the three main approaches to virtual production – live action green/blue screen, entirely virtual worlds and LED volume virtual production. We also highlighted the prominent technologies involved in these approaches. The report examined the ‘emergent orthodoxies’ of virtual production: what the opportunities and challenges associated with virtual production are and how virtual production is changing established production workflows. The report concluded by signposting important areas for future research on virtual production, outlining four key themes around industry working practices, future technological development and R&D, skills and training, and equality, diversity and inclusion (EDI).

In this report, we start to attend to this research agenda. We outline the new issues and opportunities facing virtual production, as we come out of the COVID-19 pandemic and see the industry begin to stabilise and evolve in new ways. The report examines the environmental considerations of virtual production, which remain a key point of contestation and discussion around the technology. It also addresses questions around virtual production workflows and R&D, by interrogating the new production networks being enabled by virtual production. It introduces some of the potentials and challenges associated with digital asset technologies and artificial intelligence (AI). The report also examines the changing market structures, alongside examinations of how virtual production is continuing to intersect with issues of skills and training, and EDI.

It is important to state that the examples we present below, and the arguments participants made to us about the advantages of virtual production over traditional production methodologies, are often ideal scenarios. Technologies and workflows are still in their infancy and teething problems remain. Costs, time to adopt virtual production approaches and learning curves remain obstacles which

present problems for realising the potential benefits of this new set of filmmaking methods, and who can benefit from them. Indeed, we hope the discussion in this report illustrates the need for a research agenda which allows for the consideration of the social, environmental, cultural and economic challenges and opportunities of virtual production, alongside its technological development. It is only with the adoption of a holistic and critical virtual production research agenda that the UK will be able to retain its position as a world-leader.

1.2 Methods and Participant Recruitment

This report draws on analysis of semi-structured interviews conducted with 30 industry experts involved in virtual production. Initially participants were recruited from the researchers' attendance at three film and TV industry events. Follow up emails requesting interview participation were sent to individuals we had networked with at these events. From these initial interviewees, additional participants were recruited through snowball sampling. Further interviewees were also recruited through a post shared on LinkedIn. The interview participants worked across different areas of virtual production, from R&D and facilities, scriptwriting and pre-production, the creative and technical aspects of production, to the exhibition

and distribution of virtual production content. The geography of the participants' locations reflected the dominant geography of the virtual production sector, with many being based in the UK and US, as well as from across Europe and Australia. Many participants also had experience of working in other places, which included Spain, Brazil and New Zealand. To supplement interview discussions, we analysed over 600 secondary sources to gain a more holistic view of the future issues and challenges offered by virtual production. The secondary sources included media outputs discussing the development of virtual production, written material provided by industry professionals and commentators online, and industry publications.

Two focus groups were also conducted with thirteen individuals to inform the EDI and skills section of the report. The first focus group consisted of individuals who had previously been involved in training courses within the screen industries. The second focus group consisted of individuals who had recently attended a training course specifically focused on virtual production. Notes were made by hand directly after the focus group sessions, including key anonymised quotes from participants. The interviews were transcribed by hand and all material was coded in NVivo, including the written notes from the secondary source content. To analyse all materials, we used a mixture of inductive and deductive coding.

2. ENVIRONMENTAL SUSTAINABILITY

The Screen New Deal (albert, BFI and Arup, 2020) highlighted the huge environmental issues associated with film and television production. It showed the extent of carbon emissions (for example, one day's worth of filming is equivalent to one person's annual carbon footprint) broader fuel consumption (a tentpole production with a budget of over \$70 million, having roughly the same fuel consumption as filling a typical car up around 11,500 times) and resource use (the plastic water bottle usage of a tentpole production being the equivalent to the average use by 168 people). Many participants suggested virtual production could help address these issues and in this section we outline how.

one day's worth of filming is equivalent to one person's annual carbon footprint

2.1 Reduced travel

For large productions (with a budget of over \$70m) CO2 emissions are estimated at 2840 tonnes. Half of these emissions come from transport, with 30% being accounted for by air travel (Creative Industries Policy and Evidence Centre and Julie's Bicycle, 2022). One of the key ways in which virtual production can offer improvements in

environmental sustainability is by reducing the need for cast and crew to travel to shoot on location. Virtual production can remove the need to travel by using digital environments created from scratch using game engines. These digital assets may be based on physical objects/environments using 3D scans, existing models and photographs, generated from nothing, or built using pre-designed assets (often purchased or loaned through asset libraries).



Image 1. Filming on a virtual production stage.

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Creating virtual sets and being able to move between these in a studio setting also helps to remove the fuel usage which would have been needed to move cast and crew between different locations. This reduction in travelling also means virtual production offers opportunities for more condensed and controlled production schedules, leading to energy reductions as a result of shorter shooting periods:

“[If you] get your game environments and everything built, rather than going from location to location to location, driving miles, spending a day getting somewhere, wherever...you can do it all in [a volume] in a week.”

(Founder, film production company)

Scanning real-life environments and re-creating these environments virtually can also dramatically reduce the need to travel on location. LIDAR and photogrammetry scans are combined to create a digital asset or a ‘digital twin’. This approach sometimes involves smaller crews travelling to locations, and taking scans which can be translated into digital versions of these physical environments. These environments can then be used within a virtual studio setting.

An added environmental benefit is that environmentally sensitive areas or areas at risk of environmental degradation can be digitally reconstructed. A participant gave us an example:

“We went across to Namibia and shot there and scanned in areas...and the big thing is now a lot of these places are very environmentally sensitive areas. So, the days of having a crew of 150 or a hundred people on a location aren’t possible anymore.”

(Director/DOP, freelance)

Virtual production does not replace the use of location shoots, but the real environments can be scanned and digital twins created. These can then be used for reshoots, reducing the need to travel back on location:

“So [the broadcaster] are doing SHOW C, a new kind of shake up. They were at one point looking to use virtual production for pickups, they didn’t in the end, but they wanted to cover their bases [so] they got us to scan quite a lot of the sets just so we had them”

(Virtual production lead, international broadcaster)

The technologies involved in virtual production also offer the potential for some elements of film production to be undertaken remotely, provided those involved have a strong and stable internet connection. This is easier for certain tasks (e.g. previsualisation in VR) and particular job roles (e.g. VFX artist). This ability to work remotely removes the need for some individuals to physically travel to a studio location to interact with the content being produced, and can instead input from their own home or office location:

“They have a thing called a Bauprobe, which is where they get everybody on the stage...and they’d have all of the scenery, which would be knocked up in bits of plywood and 2x4...So last year, they had to do that virtually. That ability to be able to spread everybody around the world and not think, ‘Oh, we need to get the stage designer over [from New York]’... That virtual collaboration is going to be more and more important. I think VR is going to provide a similar sort of thing, if you can get together in a virtual space that has all of the essential characteristics of the physical space.”

(Technical director, pre-visualisation technology company)

2.2 Reduced wastage

The Production Guild of America found that large movies can generate 225 tons of scrap metal, nearly 50 tons of construction and set debris and 72 tons of food waste (O’Leary, 2014). Virtual production also offers opportunities for environmental

sustainability through reduced wastage of physical set materials. Although work has been done to make traditional production more sustainable (such as the development of companies dedicated to promoting the recycling or reuse of set materials, EcoSet, 2023) interviewees continued to share anecdotal evidence of large parts of sets not being reused and instead being discarded:

“And obviously we know all about the sustainability side [of virtual production]. The fact that I’ve been on sets where I’ve had, you know, 4 or 5 days shooting at a huge set and then you see it in a skip outside, and it’s like, huge amounts of wood and timber.”

(Director of photography, freelance)

Pre-visualisation tools used in virtual production allow for physical sets to be ‘mocked up’ digitally, with their sizing and positioning altered as needed. This reduces the need for building physical sets for pre-production, and potentially for principal photography depending on the approach used.

Reducing the time spent in principal photography (that is the main production phase where the bulk of shooting occurs), increases the environmental efficiency of the overall production. For instance, using game engine technology can facilitate quicker set re-dresses and lighting in LED volumes is easier to alter than physical lighting.

“[Virtual production] provided a much more condensed and controlled schedule as well. So the whole thing was done in several days less than we would have done on location as well. So, I knew it was something we needed to keep looking at and we’ve gone on from there really.”

(Sustainability lead, global broadcaster)

In order to realise the efficiency potentials associated with virtual production, proper planning is essential. As one participant put it:

“If you really plan everything intelligently, not only can you have a cost efficient

production, but you can have quite a carbon efficient production. So you wouldn’t have wastage, on like actors’ time, reshoots. You’d save money on fixing everything in post, because everything shot on the day would be finished – apart from the bit of touch up. So then you wouldn’t have extended delays or unexpected costs on the back end... Shooting virtually, with pre planning in mind, actually eliminates a lot of these pain points.”

(Director of virtual production, audio-visual technology company)

But many people remain unaware of the complexity of virtual production and therefore do not plan appropriately, for example, by not including adequate time to be able to test and refine the virtual environments and the associated technological testing. This lack of planning can lead to reduced efficiencies and longer production times.

2.3 Energy trade offs

Despite the claims presented above, the sustainability credentials of virtual production remain contested. This is for two reasons.

First, the potential environmental savings are beginning to be quantified and compared to traditional production. Broadcasters are starting to use established methodologies (such as the albert carbon calculator) to work out the carbon footprint of a traditional production and compare this to shooting using virtual production:

“What we were able to do was go okay: we’ve got the data, we know how much energy we’ve used, we’ve got all the travel and accommodation, set construction. We had all of that captured and we were able to punch that information into the albert calculator and give us a footprint for that particular handful of scenes that we’ve shot...and I couldn’t believe what numbers were coming out. It showed a 95% reduction compared to taking everyone

and flying them overseas and putting them in accommodation.”

(Sustainability lead, global broadcaster)

However, there remain very few studies into this area at present, and more research is needed to fully understand the potential environmental savings of virtual production when compared to traditional production (for exception, see Fryazinov and Bahri, 2023).

Second, virtual production requires large amounts of energy to power the LED stages, the game engines used to create the virtual environments, and the cloud servers used to store data:

“So there’s this spinning of sustainability [claims] where some people will be like, ‘Yeah it’s super sustainable, no more travel costs.’ And then you’ve got someone over there like, ‘Yeah, well, it’s pumping out all that electricity, and we had to reshoot and....”

(Director of virtual production, audio-visual technology company)

Some advocates claim that as the technology continues to advance, virtual production will become more energy efficient. However, there could be additional challenges related to this. For example, the heat produced by LED walls has previously been used to help heat studio stages. As LED walls become more energy efficient additional heating sources may be required to help heat such stages. Also, not all productions include a lot of travel. In these instances, travelling to use a virtual production facility may increase emissions from travel and accommodation, over and above shooting on location nearby.

Further, proponents of virtual production’s environmental savings tend to only focus on the production phase of filmmaking, therefore missing the environmental costs along the supply chain. For example, the costs of extracting the raw materials, manufacturing the equipment and then disposal once it is outdated. Work is

already underway (Willment and Swords, 2023) to understand the environmental impact of virtual production across the whole spectrum of activity, but we must understand the impacts of virtual production as the technologies evolve and are more widely adopted: from the lifecycle of equipment (from resource extraction to disposal); the energy used in the creation, storage and use of virtual environments and other digital assets; running LED volumes and virtual environments; studio construction and operation; and travel to virtual production stages.

3. WORKFLOWS, R+D AND TECHNOLOGIES

Virtual production is changing the way film and TV shows are made, with an increased emphasis placed on the ‘pre-production’ phase of content creation. This is a major shift, with greater time, human resources and budgets being spent in pre-production. This shift has been driven by the need for digital assets and virtual environments to be created before shooting. This section outlines the impacts of this shift.

3.1 Creation of new departments and new ways of working

New virtual art departments (VADs) are being formed to produce digital landscapes, props, characters, interiors, weather and lighting setups. The VAD is often responsible for creating entire scenes, or virtual worlds which allow film-makers increased flexibility for planning and shooting. For example, pre-visualisation using these virtual worlds, allows stunt coordinators to plan sequences more safely, with a greater awareness of where other crew members will be, and in certain games engines, with realistic physics.

“As a virtual art department, we are basically an art department, but virtually. So just like a regular movie, a production designer would design an environment on paper...and they would hand it to us. We would create that world virtually inside of Unreal Engine using Maya, Blender, Substance painter, whatever. And then we work closely with the traditional art department too because whatever we create, they’re going to have to create something very similar, but a physical twin of it, so that they will look seamless in front of each other...it’s also the opposite. The art department would create something first, and we would have

to create something that is the digital twin version of that.”

(VAD supervisor, global streaming service)

However, the increasing prominence of the VAD is leading to tensions within the production team which have yet to be settled. The VAD have increasingly large budgets and teams, meaning they have more influence in the production process. This is resulting in the VAD often having a prominent voice in how a film is made.

Increased time in pre-production is also due to the need to plan more, as less should be fixed in post-production. Participants explained that successful planning of virtual production shoots can facilitate multiple benefits, such as increased efficiencies in production schedules.

However, many barriers remain to realising the potentials of virtual production. A repeated observation in interviews was that many cast and crew do not account for the complexities of virtual production, and therefore do not adequately budget or prepare. This can be particularly

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problematic when crew adopt virtual production late on in the process. There also remains a resistance to the new ways of working which virtual production brings, which stems from resistance or a fear of change from traditional working practices:

“I think you have to remember that production designers, the director of photography, directors, this is all new to them this technology. It’s easy to get some misconceptions about how to use it. So definitely, the more communication that we can have early on, the better. And we’ll be pushing for that and trying to get involved in meetings as early as possible. And, of course, we have to respect the schedule of production, when they’re in pre[production], they’re extremely busy, as well as us. So we have to sort of, you know, tactfully figure out where we can get communication time, get testing time. And balance that with what actual schedule they have”

(Virtual production supervisor, international VFX company)

Indie productions may also struggle to adopt virtual production processes, as a result of the increased planning time which eats into their smaller budgets:

“We need money, not just to actually shoot virtual production but the actual days in pre-production as well, testing it out [with] different camera angles. Testing lighting as well...It’s that build up towards the actual day of shooting is where we would want to spend more.”

(Co-founder, independent production company)

On the creative side, using virtual production approaches allows more iteration and therefore interaction between more people earlier in the production process. For example:

“[Virtual production] encourages collaboration, and learning. So most department heads do need to work together from pre planning, production to post [production]. The process has completely changed. If it’s done properly,

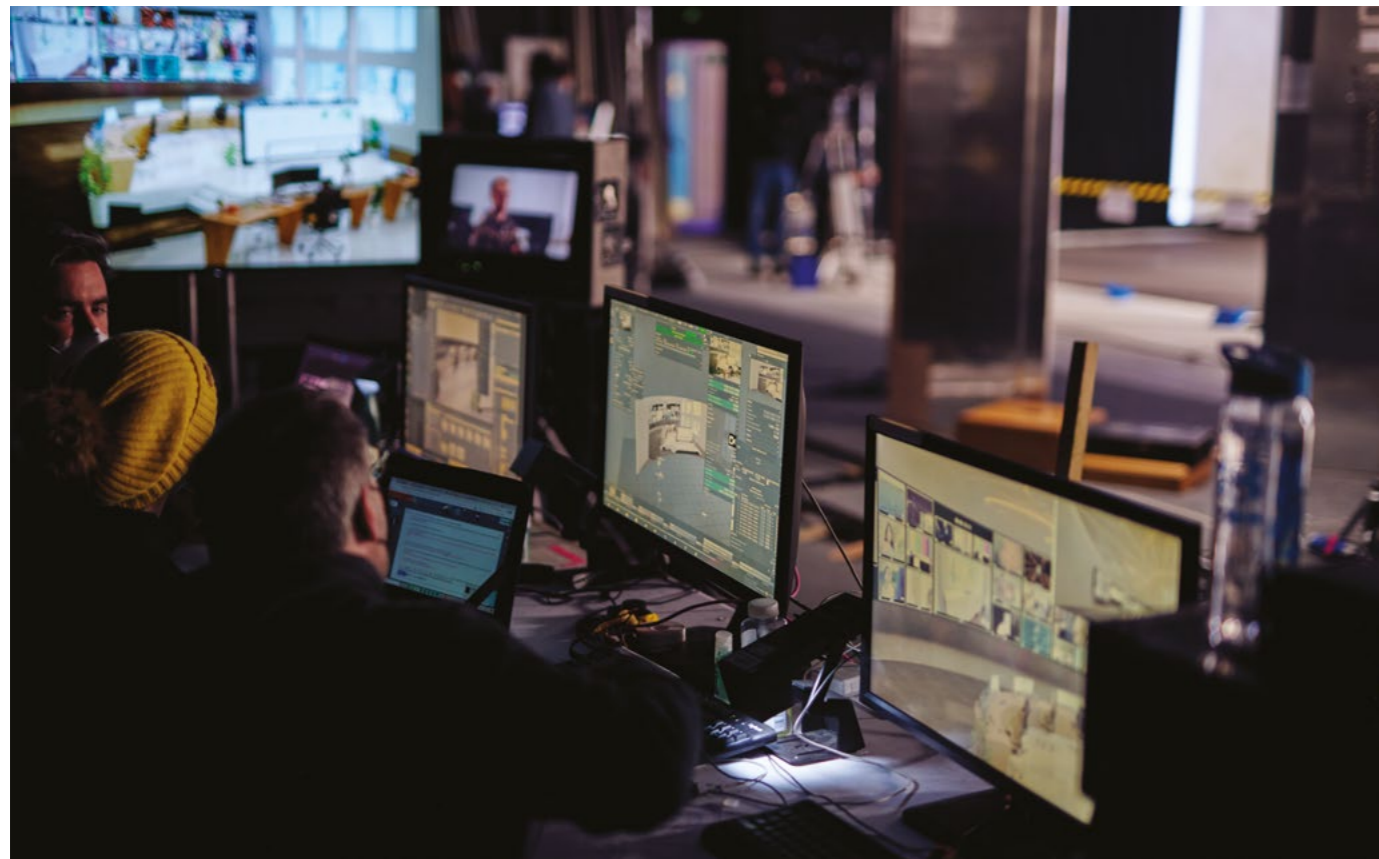


Image 2. Crew on virtual production set. Image credit: Final Pixel

it’s certainly a lot more, kind of, accessible in terms of learning new skills and making the workflow better for everyone.”

(Director of virtual production, audio-visual technology company)

The newness of virtual production and its rapid development mean that collaboration between different departments is essential and, as the above quote highlights, it can be a positive process. However, we do not always see this collaboration occurring:

“So if you get an LED technician, I bet you nine times out of ten, he won’t talk to the gaffer in the lighting crew to learn about how what he’s doing affects the lighting, because the lighting will then affect the camera crew, and the costume design and the actor. So it’s, I mean, you get a few of them, like you get your unicorn that does want to learn. But there is also no society for VP or bringing people from different industries and welcoming them into the film and TV community”

(Director of virtual production, audio-visual technology company)

AI technology can offer opportunities for more efficient production: to quickly create environments or scenes for proof of concept or storyboarding stages of production.

Beyond this, AI based machine learning is being used to replace time-consuming and labour intensive tasks within the production process (Kadnar, 2022). This includes tasks such as rotoscoping (the frame-by-frame process of creating animated sequences by tracing over live action footage).

However, these improvements in efficiency are leading to concern amongst workers that AI may replace their jobs. For example, the recent strike by the Writers Guild in America was partly facilitated by the fear of AI being used to replace human labour. As one participant put it:

“But you know, I can turn around and produce something now inside a virtual world in a week. That might have taken 30 or 40 people 2 weeks to do. So I know that terrifies people because they’re going, oh, that means I’ve lost a lot of jobs.”

(Director of photography, freelance)

There is also concern about AI not crediting workers for their creative content. AI technology ‘scrapes’ or ‘mines’ information (that is taking information directly from various sources on the internet) and uses this scraped data to ‘train’ the AI in the creation of new content (Hughes, 2023). Artists who created the material being ‘scraped’ fear they will not be adequately compensated for their work and their legal position is ambiguous:

“Most of the AI based models, the way they arrive at a solution is by mining, and being trained on reference material... What’s the legal situation on that? It’s basically like, you know, taking lots of people’s work, grinding it up into tiny pieces, creating a beach that’s made of pieces of their work, and then assembling something new out of those bits of ground up dust of their work, or big chunks. I don’t know if we have a legal sort of scenario that is set up to deal with that.”

(Virtual production consultant, freelance)

3.2 Challenges and opportunities of new technologies

New technologies being developed and utilised for virtual production are leading to new industry wide challenges and opportunities.

3.2.1 Artificial Intelligence (AI)

AI is increasingly used in virtual production with programmes such as Midjourney, Stable Diffusion and DALL-E 3 used to create digital backgrounds for virtual production. These programmes are examples of text-to-image AI technology, where individuals can write a text prompt (such as ‘create an underwater scene in the style of Picasso’) and the AI creates an image based on this prompt (Hughes, 2023).

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Actors are also concerned that AI could be used to digitally edit their performances, or to create content without their knowledge through the use of ‘deepfakes’, images of fake events created using a form of AI called deep learning.

However, AI can also provide huge benefits in terms of efficiency. Using AI in conjunction with the real-time game engines for example, can enable animators to see how their work is progressing in real-time, without having to wait for each render to complete for them to see their progress. Filmmakers we spoke to hoped it could go further:

“With AI on the scene now, developers are probably going to incorporate ways that they can use AI to streamline animation, to essentially predict how our characters should animate, Because it’s a real-time engine you can see everything that’s being done you don’t have to wait for renders to complete.”

(Film-maker, freelancer)

3.2.2 Digital assets

Digital assets such as virtual props, characters, vehicles, interiors and entire landscapes are crucial elements in building the virtual worlds through which virtual production can function.

However, there are many as-yet-unanswered legal questions which are emerging from the creation and use of digital assets. Attending to these is key for the continuing development trajectory of virtual production and will have important repercussions for who has the means to author, regulate and benefit from virtual production in the future. This section explores some of the legal issues around digital asset production and use which participants raised.

Recreating physical environments as digital assets based on existing photographs or location scans is commonplace for virtual production. Alternatively, digital

Digital assets such as virtual props, characters, vehicles, interiors and entire landscapes are crucial elements in building the virtual worlds through which virtual production can function.

assets can be created from scratch using available graphics software and game engine. Creating digital assets from existing imagery is particularly useful for re-creating areas which are inaccessible for safety or sustainability reasons:

“And I think the other ones that we’re looking into a lot at the moment, are buildings we are just not allowed to shoot in. So Parliament buildings, or anything like that. There’s probably heaps of photo references online, but you’re not actually going to be allowed in them. Another really, really good example [is] airports, things that seem very busy.”

(Head of virtual production, international broadcaster)

The re-creation of physical locations as digital assets and environments brings with it questions around how to adequately compensate location owners for the translation of their physical landscapes into digital environments:

“Two years ago when we first went [to] scan somewhere in Italy and use it as a digital twin, the first thing the location people asked was about royalties...I found that really interesting. They were already across that...people want to have royalties or you’re doing a buyer agreement on it.”

(Director of photography, freelance)

Digital asset libraries of ready-made assets are also available for purchase or licensing. These are especially useful for indie film-makers and students, who may not want to spend lots of time developing their own assets. However, there is emerging concern around licencing issues:



Image 3. Digital asset creation.

“We leverage heavily those marketplace assets. So in terms of concerns, one is, what I mentioned already, is that maybe the terms of service will change and that at some point, we might be quite far along in production, and then all of a sudden the rules change. And it could be prohibitively expensive for us to licence both the engine and the assets that we’ve used.”

(Film-maker, freelance)

Licensing and legal concerns also exist around digital asset management. Currently multiple industry standards exist, as they did for archiving and managing traditional film and TV content. The lack of standardisation is viewed as a barrier to the successful re-use of digital assets within virtual production. A hardware manufacturer explained their perspective:

“For decades, we had film as the standard for archiving of content, right?...The same thing needs to happen with 3D assets,

right? We talked to content creation companies and agencies and stuff. And it’s like, well, how do you store your assets after they’re made? [They told us] ‘Well, we just save the Maya file or the Unreal file or whatever.’

And it’s like, so what if that version of Maya you no longer have? Or where you can’t get it? How are you gonna open up [that] master asset? And they kind of look at you blankly and go, ‘Well, no one’s ever asked us to open that file’, which is not a good way to store content that could have a lot of value to you in the future.”

(Department head, graphics processing unit company)

Many of the legal issues around digital asset creation and usage remain a grey area as virtual production is so new. This is important when thinking through the application of copyright laws, and associated protections for digital assets.

Previously, works which were considered to be of artistic craftsmanship, or which demonstrated the author's own intellectual creation would be protected under copyright legislation. Yet, there is no current legal consensus around the copyright of digital assets when they are digital representations of already existing locations or buildings. As a legal expert explained it to us:

“My thinking is that actually, a virtual world, although it has this sort of simulacrum of three dimensionality, is an artistic work [and] is susceptible to copyright protection. The only slightly complicated situation that you've got, though, is whether or not stuff that you talk about [has] been recreated. So let me say, we created ourselves a three dimensional New York. And then you had a Flat Iron building or, a Chrysler Building or the New Liberty building or whatever it is. What happens? What happens in relation to those kinds of inclusions of that stuff where you could argue that someone else has copyright in that?”

(Lawyer, intellectual property and copyright specialist)

Legal issues around 'incidental inclusion' also become complicated in virtual production. When filming on location, objects, buildings or logos may be included within a shot. For example, branded shop-fronts could be seen within a car chase scene along London's Oxford Street. The reproduction of these elements may normally be legally protected, but the legal concept of incidental inclusion means there is no requirement to have agreements with brands whose logos or products are seen in the background as their inclusion is incidental, rather than the subject of the shot: they are simply part of the landscape. But incidental inclusion is much harder to argue in the case of virtual production, as the digital asset creator has had to build specific buildings or background features within the game engine software. Their inclusion is deliberate.

“I think it's much harder to argue incidental inclusion when you've actually had to sit down and build the thing. So I can see potential problems with the infringement of other people's copyright.”

(Lawyer, intellectual property and copyright specialist)

We did not come across any examples of legal action being taken for the recreation of landscape elements which would normally be covered by incidental inclusion, but it is an area which will likely become the subject of increased focus as virtual production expands.

4. MARKET STRUCTURES

Over the last few years, the increasing popularity of virtual production has resulted in companies integrating elements of virtual production technologies and/or workflows into their business operations. This section examines the different ways in which companies have entered into the virtual production market.

4.1 New business models

Virtual production can provide huge opportunities for extending a company's core business offering. Company Y, for example, began 15 years ago as a video production company operating in the advertising market, with the majority of their work involving working with clients on location. The pandemic encouraged them to set up a virtual production facility in 2020:

“We couldn't [travel] during the pandemic. So we built our own virtual production studio just to do work locally. And what we found out was that it was becoming very, very popular, and other production companies outside of ours were wanting to rent the stage. And so we developed a new brand to make studios across the US, and really allow other production companies to use this technology.”

(CEO, Company Y)

The COVID-19 pandemic (and the associated lack of work opportunities during this time) also resulted in companies having unparalleled time to undertake virtual production R&D. Companies could see how virtual production could work for them, and so developed new virtual production products and services:

“I don't think unless we'd had COVID... virtual production would be where it is now just because it was fueled by people sitting at home, studying, reading books

and reading...I spent, you know, a solid year just buried in Unreal.”

(CEO, creative agency)

Individuals and companies with the resources to pivot their operations to virtual production became first movers and gained an advantage in the current stage of the field's development. Yet, it is crucial to recognise that not every company was able to shift to virtual production and it is important to recognise the privilege to develop new capabilities while the screen industries faced ruin.

4.2 Mergers, acquisitions and partnerships

The power to make a change can also be seen in the way mergers and acquisitions have played out in the film and TV sector. As virtual production use has grown since the pandemic, larger companies have sought to gain a foothold. Acquisition of firms with the requisite expertise, products and/or services, and employee base to fill gaps in their own operations is an attractive option for companies who have not been first movers:

“Those who have come out as leaders in the space are going to be attractive to some of the larger system integrators and service companies in the world. It's an area of innovation, prime for startups to get acquired in that way, or even traditional companies...I think buying

knowledge is one of the key parts there, right, because it's an area that for a long time, and still today, we talk about the skills gap in virtual production. I think from a commercial point of view, if you see an opportunity for this in your company, then it's going to be quicker for you to go and acquire that skill set than it is to develop it"

(Department head, graphics processing unit manufacturer)

NEP Group have done this over the last two years. NEP Group (2023) are a 'leading technology partner for content creators around the globe... with a global production ecosystem of end-to-end solutions'. They provide broadcast and media solutions including infrastructure and remote production facilities for large scale televised events. In 2021, NEP Group launched NEP Virtual Studios, a new virtual production business segment. This new venture allowed NEP Group to expand into virtual production, acquiring Halon Entertainment, Lux Machina and Prysm Collective in order to 'accelerate their [virtual production] market footprint' (NEP Group, 2021). Halon Entertainment are a full-service visualisation company who contributed real time visualisation to well-known virtual production content including Star Wars: The Mandalorian. Lux Machina specialise in virtual production and are well known for their virtual production workflows and stage buildouts. Prysm Collective has also worked closely with Epic Games, receiving large-scale funding from Epic for their development of virtual production cloud workflows.

Acquisition of an existing virtual production studio also helped Sony Pictures to move into the virtual production space. In 2022, Sony Pictures acquired Pixomondo, a well-known virtual production studio operator in North America and Europe. Acquiring Pixomondo allowed Sony Pictures to access virtual production facilities and talent which would have otherwise taken years to develop.

In instances where acquiring knowledge and talent is not possible (for logistic, competitive or financial reasons), companies can opt for partnering with other organisations who have the necessary expertise. An LED panel manufacturer we interviewed discussed the importance of partnerships for R&D when entering the film and TV industry:

"Our sales teams, but also our engineers, and everybody had to make [the switch to virtual production applications] and adapt knowledge on cameras, on how films are made, the requirements of DOPs [directors of photography]. So it meant an enormous investment in acquiring that knowledge and we look out for partners to do this"

(Head of marketing, LED screen manufacturer)

Companies also sought partnerships with Universities, to assist in industry wide R&D and also to provide a talent pipeline for the virtual production workforce:

"We maintain four partnerships at the moment with universities because the real R&D, the groundbreaking R&D is done over there. Everything that has to do with applications is done on production level but the base research and the base principles are researched on [a] universities level, and you should incorporate them in your daily work. So we see that as crucial."

(CEO, virtual production studio G)

Following the COVID-19 pandemic, the market structures of the virtual production ecosystem have begun to shift and solidify. The pandemic offered companies opportunities to undertake R&D, becoming 'first movers' to take advantage of the virtual production market. Companies who were slower to react have sought to catch-up by acquiring or partnering with organisations who have the required resources, knowledge and services to help them compete.

5. SKILLS, TRAINING AND EQUALITY, DIVERSITY AND INCLUSION (EDI)

The novelty of virtual production, both in the combination of technologies and workflows, has created knowledge, skills and labour gaps. There are already huge skills and labour shortages within the UK film and TV industry (BFI, 2022). Crew shortages are present at all levels, and this shortage is already threatening the UK's ability to produce film and TV content. It is predicted that continued film and high-end TV production growth will require between 15,130 and 20,770 additional full-time employees (FTEs) by 2025 (ScreenSkills, Nordicity and Saffery Champness, 2022). There is also concern within the industry that current training provision within the screen industries is not fit for purpose, with a lack of clarity around how training maps on to career progression, and questions around the utility of training in preparing individuals for the realities of working in the film and TV industry (Jones et al., 2022).

5.1 New entrants from gaming and live events

Adapting and using game engine software for film and TV requires expertise from

companies and individuals from the video games sector. Many participants identified videogames professionals working in film and TV productions, often doing so as freelancers to take advantage of the continuing shortage of people with virtual



Image 4. Virtual production training day. Image Credit: Final Pixel.

production knowledge. This might be within the virtual art department, or working on the ‘brian bar’, helping to ensure that the game engine is running smoothly on set. Game engine developers have begun to provide training focused specifically on adapting game engines for filmmakers and working with TV training providers to increase knowledge around the potentials of game engines in film and TV content development (Epic Games Dev Community, 2022; ScreenSkills, 2022).

Videogames workers have to adapt to working in a film or TV studio, however, as the working practices are different. The timeframes of work in filmmaking are different to producing a video game and this is especially true on set, where work can be very fast paced. This is not the case for all productions, but the pace of shooting can be a shock if the workers are not used to it. As an American company owner illustrated:

“We had a guy [from video games] who’s extremely well educated...and we put them on a stage and the first day, I found them in the hallway, like breathing into a bag, like literally having a panic attack...And he’s like: ‘Well, the producer came over and she yelled at me, in the middle of the shoot.’

And I’m like: ‘Yeah, that’s what the producer does. She literally gets paid to yell at people...she’s yelling even when we’re on time. She’s just trying to, you know, get the urgency.’ And so what I realised is, this guy comes from a background where he works in a cubicle, and nobody checks in on him for like a week.”

(CEO, virtual production studio F)

There are also new entrants from the live events sector working in virtual production. The LED screens used in volumes, and software used to power them, were first used for concerts and other live events, so workers and companies crossover from live events into film and TV. LED panel manufacturers are also supplying studio facilities and rental companies with screens to build LED volumes (Roervisual.com, 2021). But not only are LED panel

makers selling their products to film and TV customers, they are having to adapt to a new market and provide new kinds of products and services to meet the demands of film and TV customers. Company Z have a history of working in live events including services for live broadcast TV and film premieres, and are moving into the virtual production area. Their director of client relations told us of the challenges:

“I’ve come in to guide them in the requirements and ways of working... especially virtual production. So utilising the resources and expertise they have, and applying that appropriately to what’s a new market.

My main responsibility is heading up the VP division...that includes bringing in new business, looking after existing business, putting together a team, looking after the operational side of, like building stages and whatnot, and helping them facilitate and launch a virtual production facility kind of, slash studio.”

(Director of client relations, Company Z)

5.2 New entrants from traditional film and TV

New entrants to the virtual production workforce are also entering the industry as graduates from film production courses, or from other parts of the film and TV industry. Even though many are used to on set working practices, there are problems when using virtual production workflows. For example, there was a consensus among participants of a disconnect between the training being offered around virtual production and the skills which the industry really wanted and valued. Courses were viewed as being too generalist, or outdated due to the pace of change within the industry:

“If I had to sum it up, I think there is a major disconnect between the courses being requested by senior members of the film and TV industry, the people who are

designing them and running them, and the working conditions in the industry and the professionals working on the front line.”

(Focus group participant 3)

Individuals who were new to virtual production from within film and TV described their access to specific skills and training beyond formalised degrees. They highlighted the diverse landscape of virtual production training available, including the large amounts of access to free training which currently exists:

“We’d always sign up to that many talks. We signed up to them, any filmmakers that we found that used the technology before we set up Zoom calls and we sit down and ask them questions. We have a good relationship with [a virtual production studio]. So that’s the only way. Yeah, it wasn’t anything degree wise or you know like paid”

(Co-founder, film production company)

Although access to training was good, successfully completing courses often did not translate into paid work, particularly for new entrants. This meant individuals often got stuck in moving from one training placement to another, instead of moving up the career ladder.

“It is already hard. It is already hard because if you don’t find an open door. Usually those open doors are related to big studios or to the [virtual production] stage. That’s my current situation and I’m trying to find a job or a paid placement to do everything that I’m telling you.”

(Post-production co-ordinator, freelance)

This is a common issue across the film and TV sector, not something isolated to training for virtual production. As Jones et al., (2022: 15) have highlighted, there is “lack of clear, structured pathways within the industry [which]...contributes to the skills gaps and shortages”. The BFI Skills Review (2022) argued that a formalised approach to hiring practices, workplace management and professional

development would help to ensure training translated into career progression. Jones et al., (2022) suggest that the introduction of a shared apprenticeship scheme to the film and TV sector would facilitate the transition of training into paid work.

5.3 Equality, Diversity and Inclusion – Potential

There was a strong belief amongst participants that virtual production has the potential to be ‘democratising’ – that is lowering barriers to entry into the film and TV industry. Various reasons were cited for this, but, as we show below, there is some way to go to realise this reality.

First, as highlighted in our first report, being studio based continued to be highlighted as a democratising opportunity for virtual production, particularly for individuals where location work is difficult. There was also a consensus that being studio based removed many of the pressures of location shooting for *all* cast and crew, including the need to work extremely long days to capture all shots whilst on location:

“Hey, for me the exciting thing is that, I actually hate [location] shoots because they are a very harrowing process and virtual production allows us to [be in a] more comfortable environment. No, I think if people are comfortable, they’re in a nice space, they have like oxygen to breathe and know that there is no like ‘we need to leave this location in 2 hours we need to get it [the shot]’. I think you can also get great things when things are comfortable and and obviously the possibilities with digital worlds are endless so that’s very exciting”

(Co-founder, film production company)

Second, the remote working possibilities facilitated by virtual production was mentioned as a way to reduce barriers. It was suggested team members could work remotely, again providing job opportunities

THE EVOLUTION OF VIRTUAL PRODUCTION

for cast and crew for whom locations or sets are disabling environments.

Finally, the hardware and software used for virtual production is becoming more readily and cheaply available. Participants suggested this is leading to a potential democratisation of the film and TV industry, with indie players able to create content without the backing of traditional financing gatekeepers. Although costs for the use/rental of LED based studios remain high, indie studios can create their own content using green screen based virtual production for example.

“You’re always limited by ‘How’s this gonna get financed?’ How can a writer from Wakefield write a screenplay set in New York and get finance in the UK? Well, I can tell you it’s just not possible... If you’re not in LA, they won’t read your stuff. But now effectively even with a green screen using Unreal actually there’s a chance you can get this finance. So that to me, it opens up a whole realm of possibilities you wouldn’t have without this technology really.”

(Scriptwriter, freelance)

5.4 Equality, Diversity and Inclusion – Reality

At its current stage of development, the virtual production network remains as exclusionary as the traditional way of making film and television. Few respondents could point to clear examples of changes increasing accessibility or inclusiveness in practice.

“I mean, only from the standpoint of speculation. I haven’t [had any] first hand experience of those things but I can certainly imagine. You know, going back to the example of a production designer, if you have mobility issues, then that’s probably a job that has been off limits to you historically. So, certainly virtual production can open up job role[s] to people that might not have been able to do them in the past if they have mobility

issues. Also, if you think about people who might have autism or some kind of other requirement that makes it very difficult for them to work amongst big groups of people or someone who might not feel comfortable being on set, I think that ability to work from home certainly opens up possibilities. Yeah, but again, that’s all speculation. I haven’t witnessed that firsthand.”

(Film-maker, freelance)

Moreover, remote working potentials enabled by virtual production could have unforeseen EDI issues, if the work is outsourced to locations or companies which do not have adequate regulations to protect and/or compensate their workers. Many participants were vocal about the industry needing mechanisms in place to protect workers:

“I think it makes a lot of roles that used to be onset roles now can be done remotely, which means that you are competing with potentially a lot more people than you used to be in those roles. And then I guess that brings the union considerations, and you know if you’re just going with the person who’s the lowest bidder who you can get the cheapest then it depends on if it’s unionised and virtual production isn’t really unionised yet...So, the result of that, unfortunately, is crews getting underpaid, often.”

(Film-maker, freelance)

The often precarious nature of project working in the film and television industry, and the need for continual job searching, continues with virtual production. As one participant put it:

“How can you create amazing art when you are shattered or constantly marketing yourself?”

(Focus group participant 7)

The importance of maintaining your reputation as a good worker means individuals remained reluctant to speak out about any injustices they experienced, for fear of being rejected from subsequent employment (van Raalte et al., 2023; Jones

and Pringle, 2015) This translated into workers often contributing their unpaid time and labour into projects because there was an expectation that they should feel ‘lucky to be there [within the industry]’ (focus group participant 5) (Aust, 2022).

“No-one discusses hours that are not compensated for within the offer of a ‘flat’ or day rate”

(Focus group participant 3)

This fear of future repercussions also led to workers staying silent on issues of exploitation and harassment which they experienced on set, and which remain rife across the entire film and TV industry (Film and TV Charity, 2021; Bull, 2023).

“It was my first time on set, as one of the least senior crew I didn’t feel I had any recourse to stir the pot and potentially get the whole lighting crew sacked, I don’t think I’d have been thanked for that.”

(Focus group participant 11)

Many individuals felt that skills and training courses in virtual production should do more to prepare individuals for the harsh realities of working within the film and TV industry, including honest discussions of how long hours are common (Swords et al., 2022) and that film and TV remains infamous for its inhospitable, sometimes toxic, working environments (Wilkes et al., 2020):

“I was kind of angry afterwards that the course leader presented such a rosy picture to us during the course and would have rather he was more up front about what problems we might be facing.”

(Focus group participant 11)

Virtual production also remains a predominantly white, male industry, and many individuals struggled to see a space for themselves, resulting in them feeling they needed to work harder to achieve success:

“You can get somewhere but you have to leave something at the door.”

(Focus group participant 6)

“Diversity is definitely a very hard thing. You know I’d like to see more women. You know we end up with guys all dressed in black hoodies on one side of the room if we’re not careful, or gathered around trying to work out how to use computers. And I think that’s a real shame. So far I found the best digital operators are women, in terms of using some of the technology. And I’d like to see more women come into it [virtual production].”

(Director of photography, freelance)

Although there was discussion of the democratising potential of virtual production in terms of geographical location, a London and South East bias still exists within the industry. This participant reflected on the realities of being based in northern England:

“There’s more opportunity in London than there is here in the North...anything being in Wakefield is a game changer if it’s done right, if we can access it. I think it could help even out [the bias towards London and the South East] because I’ve told people, my peers in London that we’ve got virtual production facilities here now in Yorkshire and that’s blowing their minds. It’s definitely something that’s gonna reduce the talent drain that we’ve always got.... We keep losing people to London. So yeah, hopefully I’m hoping like, [virtual production] could be a good game change, yeah.”

(Co-founder, film production company)

Continued investment into virtual production studios across the UK could help address this imbalance, but access to these regional studios needs to include time ring-fenced for students and indie companies if any rebalancing is to occur. Increasing inclusion is also dependent on individuals having wider access to hardware and software, with cost remaining the biggest barrier at present.

“I think the biggest inaccessibility thing I saw people struggle with was they didn’t have the hardware. To run Unreal that was like a big issue....not everyone [on the training course] was able to get loaned

laptops and I was lucky cause I was doing VR, I do VR development so I make sure I've got a good meaty laptop. Like hardware is always an issue and that's a money thing."

(XR designer, freelance)

Further access to virtual production technology could also help to fill the industry skills gap. Sharing virtual production technologies through outreach work with local schools and colleges was discussed to help further develop skills and democratise the industry:

"I think having those sorts of things [virtual production technology] in schools are also going to allow people to get more comfortable with the technology now. Everybody has a camera and kids nowadays are getting very good at filming. Allow people to get more comfortable with that [virtual production] technology. It's that sort of ability of bringing it to what's the expression, the lowest common denominator."

(Co-founder, film production company)

The opportunity is there for virtual production to improve access and inclusion to the film and TV industry, and this opportunity should be developed to affect real change. From an EDI perspective, virtual production companies need to make a concerted effort to understand the needs of all of their workers, and make reasonable adjustments to make sure they feel included within the workplace. This effort should also include a commitment to skills and training provision which places EDI at its heart, with scheme organisers demonstrating a clear understanding and commitment to diversifying the industry. Building EDI into virtual production approaches is also hinged on the development of a constellation of support, with progression opportunities available for individuals at all career stages.

6. CONCLUSION: THE FUTURE OF VIRTUAL PRODUCTION?

During the initial phase of our virtual production research, the industry was newly emergent from the difficulties of the COVID-19 pandemic. At this time, virtual production was repeatedly hailed as 'revolutionary', and the approach cited as a 'game changer' for the film and television industry and beyond. A few years on, those bold claims are being tempered somewhat, but virtual production remains an important development for film and TV. Last year 40% of UK and US industry executives stated they were already using virtual production tools, and half said that they would adopt virtual production in the next 18 to 24 months (Altman Solon, 2022). Virtual production is, and will continue to change how film and television is made, and it is important therefore that research and critical reflection continue, particularly given unanswered legal questions, the potential for addressing EDI challenges and contentious technologies such as AI.

In our first research report on virtual production (Willment and Swords, 2023), we set out a future research agenda for studying virtual production, where we encouraged academics and industry to explore the following themes and questions:

Workflows, R+D and Technologies – Which technologies are resources being focused on? Who is undertaking R&D? Where is R&D being done? How will workflows be integrated in the next iteration of virtual production technologies? How can people access virtual production and what barriers are being erected/removed?

Market Structures: Spillovers, Mergers and Acquisitions – Which companies are operating in which parts of the virtual production pipeline? Who owns the means of virtual production? Who has access to virtual production facilities? Where are exclusions occurring?

Skills and Training – Who is in the best position to provide virtual production skills? Who can help remove barriers to entry?

Equality, Diversity and Inclusion – What impacts will virtual production have on the longstanding issues of exclusion, exploitation and discrimination within the film and TV industries?

This research agenda has underpinned our thinking for this second virtual production report. The report has considered virtual production workflows, R&D and technologies through our discussion of the legal questions about digital assets and development of new technologies such as AI. The shifting virtual production landscape driven by mergers, acquisitions and partnerships has been examined as the virtual production ecosystem begins to solidify in the wake of the COVID-19 pandemic. We have also examined how skills and training provision needs to adapt to the legacy of workers coming from different industries, and to new entrants

entering the film and TV industry. Finally, the report has also investigated and lived realities of virtual production in improving EDI within the screen industries.

Finally, what is continuing to drive the development of virtual production is research and development (R&D). The UK has committed to large-scale investment into virtual production, including the £75.6 million ‘Convergent Screen Technologies and Performance in Real-time’ (CoSTAR) creative facility and network of regional labs (UKRI, 2022). The majority of virtual production R&D programmes (including CoSTAR) are focused on the development of virtual production from a technical perspective. It is crucial that CoSTAR and other R&D programmes do more than just focus on the technologies at play, instead committing to a research agenda which allows for the consideration of the social, environmental, cultural and economic challenges and opportunities of virtual production.

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