Virtual Production Ecosystem Mapping

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#VPecosystem I 2023

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UKRI Arts and Humanities Research Council

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Contents

Introduction

1.1 Purpose and context

In late 2022, CRAIC (the Creative Research and Innovation Centre) at Loughborough University London and BOP Consulting conducted a mapping of the various advanced media and creative capabilities associated with the Virtual Production (VP) ecosystem in the UK.

This mapping exercise aimed to provide a baseline overview of the VP landscape in terms of the geographic distribution of assets, organisation type, facilities offered, the technologies at stake, and capabilities, as well as the connections between assets and their relationship to different creative industry sectors. It intended to signpost strengths and opportunities, and to help inform support which aims to foster wider and more advanced industry use.

It is largely based on a survey that was run during the course of the application process for the Arts and Humanities Research Council's (AHRC) Convergent Screen Technologies And performance in Realtime (CoSTAR) funding programme. This major UK Research and Innovation (UKRI)-AHRC research and innovation infrastructure investment programme (estimated £75.6 million investment over six years) funded primarily through the UKRI Infrastructure Fund, will support a network of experimental labs to research the development and use of convergent technologies in the creative sectors.

The launch of the CoSTAR funding programme gave a particular impetus to this research by providing a timely opportunity to survey a number of organisations operating in the VP landscape. The survey response collection timeframe was aligned with the CoSTAR application period, running to the end of January 2023. The survey gathered sufficient information to generate a nuanced mapping of the VP activity across the UK, as well as to provide a platform for future research activity.

1.2 Previous research

This report is informed by an earlier research project undertaken by CRAIC on the mapping of the VP ecosystem.[1] Two other recent studies were pivotal in the genesis of this work: the work led by StoryFutures Academy on skills, which developed the 'Virtual Production Mandala' – a visualisation of the cyclical nature of the VP process[2], and which was the first report to illustrate the convergence of real time technologies, which is a distinctive feature of VP; and earlier work done by CRAIC to develop a Creative Technologies Framework[3], helped assess the different ways in

[1] Hitchen, G., Ekmekcioglu, E., Ozcinar, C. 2022. *Mapping the Virtual Production Eco-System Report.* Loughborough University London.
https://craic.lboro.ac.uk/wp-content/uploads/2023/02/Virtual-Production-Report-Dec-22_-Final16.pdf

[2] Bennett J, Heath C, Kilkelly F and Richardson P. 2021 "VIRTUAL PRODUCTION A Global Innovation Opportunity for the UK". Available at: https://www.storyfutures.com/uploads/docs/VP_Skills_Report_202121.pdf.

[3] Chitty A, Hitchen G, Roche C. 2021. Creative Technologies Framework. Available at: https://craic.lboro.ac.uk/essays/creative-technology-framework [Accessed March 2023].

which technology disciplines are being deployed across different Creative Industries sub-sectors.

This work informed the development of the survey which forms the basis of this report.

1.3 Definition

VP is the most recent manifestation of what is a fast-moving advanced creative and media technology landscape. It is a complex and broad term referring to a spectrum of visualisation methods and computer-aided production. It is also a collaborative process that, by marrying the physical world of filmmaking with the digital world in one process using real-time technology, is revolutionising the filmmaking and content production process by changing established production workflows.

As this field is driving efficiencies, reducing costs and allowing more flexibility for the creative process, it has shown great potential applications into other sectors including performing arts, fashion and sport broadcasting.

For the purpose of this research, we used the following definition: Virtual production is the use of game engine and performance capture systems to create a real-time production process which brings together development, pre-production, production, and post-production.

1.4 Methodology

This report represents the completion of the second phase of work in the mapping of the VP ecosystem, building on the earlier research undertaken by Loughborough University London[4]. Over a five-month period from May 2022 to October 2022, the CRAIC team devised a framework for data-capture for the UK's VP ecosystem through a range of methods: a literature review, data mapping, an expert survey and a collaborative design of the framework.

As a result of this iterative exercise, the research team was able to build a robust understanding of VP and its related capabilities, and developed a Virtual Production Capabilities Framework (Figure 1). This Framework established what data needed to be captured in our survey to assess where in the value chain the key assets in the VP ecosystem are, and what it reveals in terms of the gaps and opportunities for the discipline's development over the coming years.

A total of 62 assets are captured in this work, 46 responses to the survey, to which we added 16 key assets identified in the initial phase of this project. It is estimated this number represents about a third of VP assets in the country.

[4] Hitchen et al (2022). *IBID*

Key findings:

- The geographic distribution of organisations operating in the field largely reflects the Creative Industries Clusters in the UK: London and the South East have the highest concentration of VP assets.
- The majority of organisations at Technology Readiness Level (TRL) 9 are based in London which is also the region that hosts organisations across all TRLs.
- There are two main types of organisations occupying opposite sides in the value chain: the ones focussed on training, education, and research (55%) and the ones focussed on production – companies, studios and technology (39%).
- Organisations undertaking R&D and those at TRL 9 use and own the widest range of technologies.
- Most TRL 9 organisations own the technologies that comprise what is currently named *virtual production*: LED volumes, real-time render engines, in-camera VFX, visualisation and editing technologies.
- An important proportion of organisations operating in the VP landscape (33%) do not have in house facilities.
- Most organisations operating in the VP field offer training and education.
- There is a strong established relationship between the industry and HEIs.

- Affordability and access to kit seem to be what is slowing down a faster and wider adoption of VP.

The Virtual Production Assets in the UK – Capabilities Framework

Profile

Geography	Type	Focus
▪ Post code	▪ Training or educational establishment ▪ Research institution ▪ Production studio ▪ Government agency or similar ▪ LA or similar	▪ Training / education ▪ Research ▪ R&D ▪ Production ▪ Funding ▪ Business support ▪ Consultancy

Place within the ecosystem

Role / Service	Longevity	TRL	Sector(s) of application	Relationship with HEI
▪ Training / education ▪ Research ▪ Facilities ▪ Technology ▪ Consultancy ▪ Production	▪ Current year ▪ In pandemic ▪ Pre-pandemic	▪ Early R&D ▪ R&D ▪ Commercial demonstrator ▪ Commercial deployment	▪ Film ▪ TV ▪ Games ▪ Music ▪ Performing arts ▪ Sports broadcasting ▪ Advertising & mkg ▪ Museums / galleries ▪ Heritage	▪ From HEI ▪ Access to kit ▪ Access to space ▪ Access to researchers ▪ Future talent / skills ▪ Project collaboration

Facilities & technologies

Owned / Utilised / Offered				Purpose
▪ LED screen ▪ Real time render engine ▪ Visualisation (Previs, Techvis, Stuntvis etc.) ▪ Motion capture ▪ Facial capture	▪ AI / ML ▪ Haptics ▪ VP editing ▪ XR / (AR / VR) ▪ Green screen	▪ Volumetric capture ▪ Fabrication of physical props ▪ Editing (post-production) ▪ Light Projection ▪ LIDAR scanning	▪ Live streaming capability ▪ Filming in camera vfx / camera tracking ▪ World / asset building	▪ Training ▪ Research ▪ R&D (internal / with collaborators) ▪ Commercial use

Future development

Driving factors and opportunities

Figure 1 Virtual Production Capabilities Framework

2. Virtual Production assets profile

2.1 Geographic distribution

A comprehensive geographical mapping of the VP assets in the UK is yet to be produced. This research exercise has captured the leading organisations operating in the field, and our maps provide an emerging picture of the VP landscape by displaying the geographic distribution on the territory.

Based on the data we have gathered, the geographical spread of the VP assets is characterised by **an uneven distribution of agglomerations across the UK**. The concentration of VP assets is particularly **high in London and the South East** (50% of organisations), followed by the Yorkshire and Humber region (10%) and the North West of England (10%). Smaller centres have been established in Scotland (8%), the North East (5%), and the South West (5%).

Not surprisingly, these clusters broadly follow the distribution of organisations operating in creative industries. As a study developed by Nesta in 2018 confirms, creative industries are highly clustered in the UK for three main reasons: creative talent tends to locate in places with high levels of creative activity to insure itself against market uncertainties, the colocation of facilitates, collaboration and knowledge makes businesses more competitive, and proximity to clients and audiences helps firms gauge changes in demand and find new business opportunities more easily[5].

Indeed, the VP assets identified in our research broadly map on the Nesta Creative Nation mapping, particularly to the Film, TV, Video, radio and photography and IT, software and computer services industries.

The Studio Map[6], a London-based independent publisher of film, TV and cinema guides, produced a mapping of 87 film and video studios available for hire in the UK, many of which have VP facilities. Analysing the spread of our VP assets in comparison with the Studio Map's geographical distribution, the following findings emerge:

- While the listings only have 9 organisations in common, the geographical distribution of the assets is very similar across the two maps.
- London and the South East have the highest concentration of Film and TV studios and organisations working in VP.
- Other significant clusters of activity are located in the North West, North East, Yorkshire and Humber, and Scotland.
- There is least activity in the South West region and Wales.

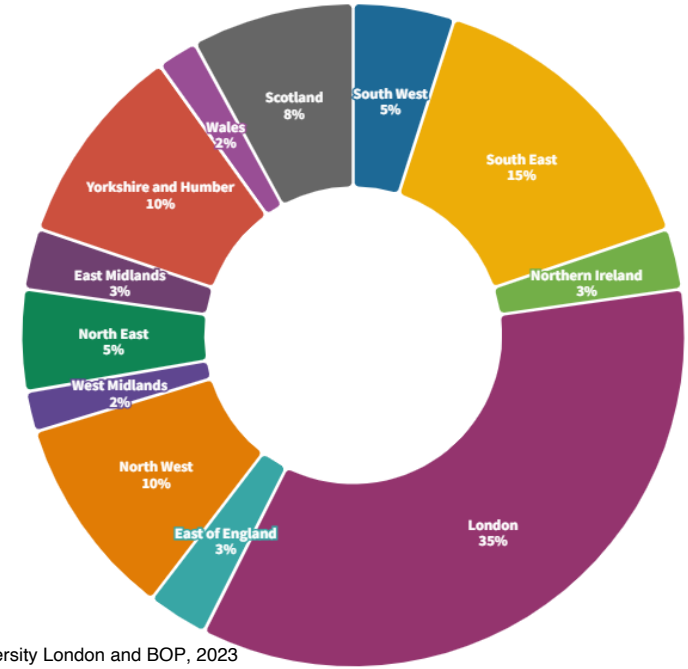
[5] Garcia, Klinger and Stathoulopoulos. "Creative Nation: How the creative industries are powering the UK's nations and regions." Nesta, February 2018. Available at https://www.nesta.org.uk/publications/creative-nation

[6] Listings - The Studio Map (2022). Available at: https://thestudiomap.com/listings/?region=uk&sort=a-z.

It is worth noting that higher education institutions play a vital component in our mapping exercise, as they represent almost half of the organisations represented in our study. In that sense, the geographical spread of organisations working in VP is also linked to the location of university centres.

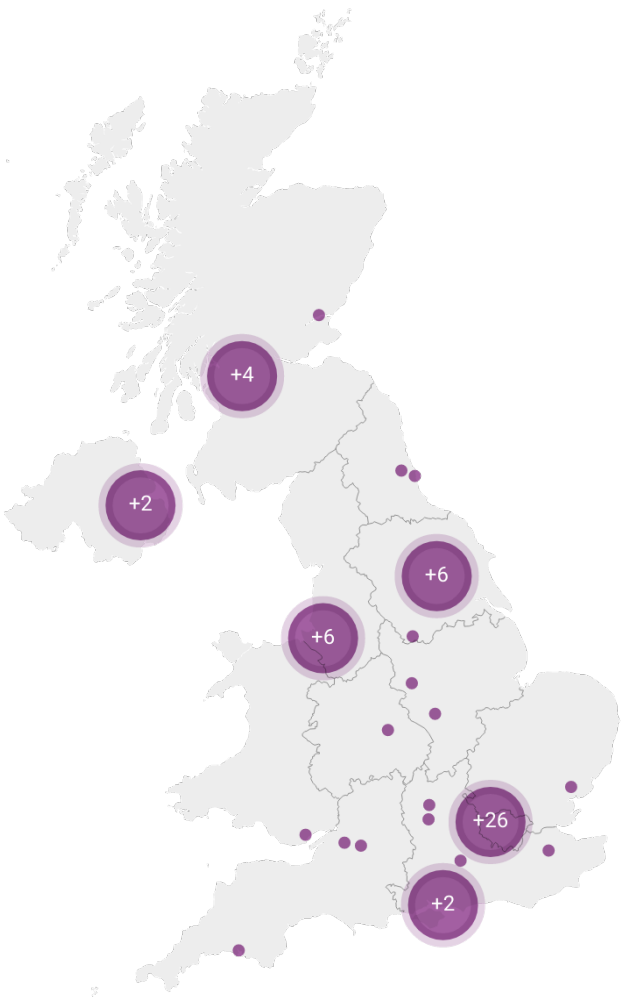
Moreover, with the popularisation of portable kits and flyaway studios that can be set-up anywhere in a matter of hours, the physical distribution of VP assets is progressively becoming more dynamic and less localised.

Figure 2 Regional distribution of VP assets



Source: Loughborough University London and BOP, 2023

Figure 3 Geographical distribution of VP assets



Source: Loughborough University London and BOP, 2023

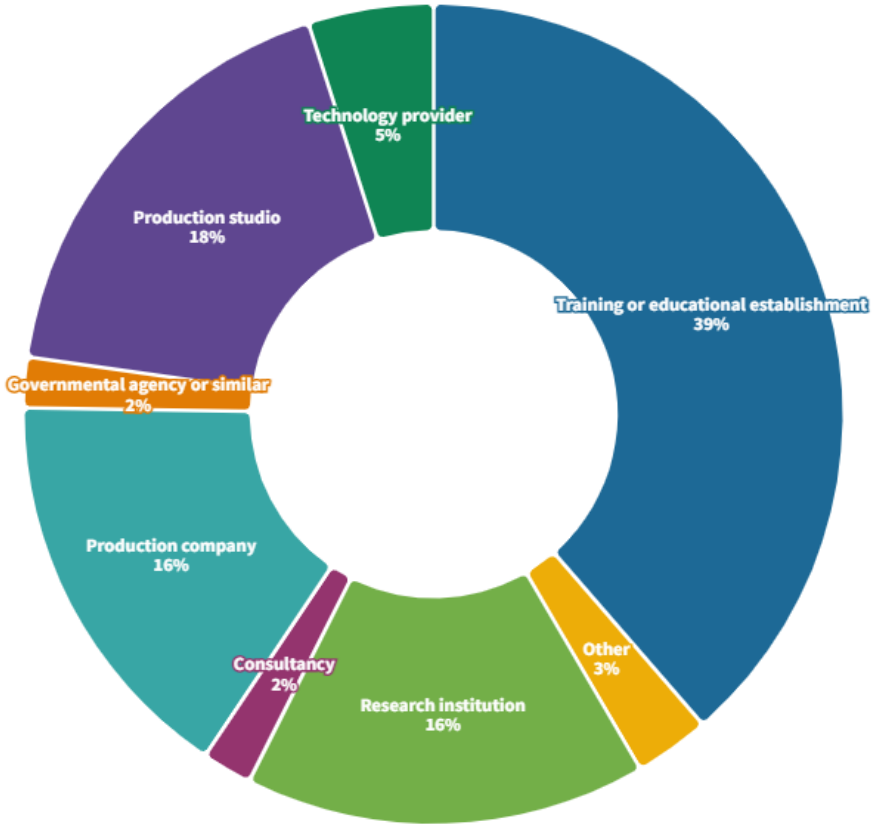
2.2 Type & focus

The majority of our survey's respondents and other assets generated from this research are made up of training or educational establishments (39%), production studios (18%), production companies (16%) and research institutions (16%).

The remaining 11% of the ecosystem are three technology providers, one consultancy, as well as one governmental agency. The governmental agency that responded to our survey owns and manages a digital production facility and the consultancy specialises in advising creatives and producers on VP technologies.

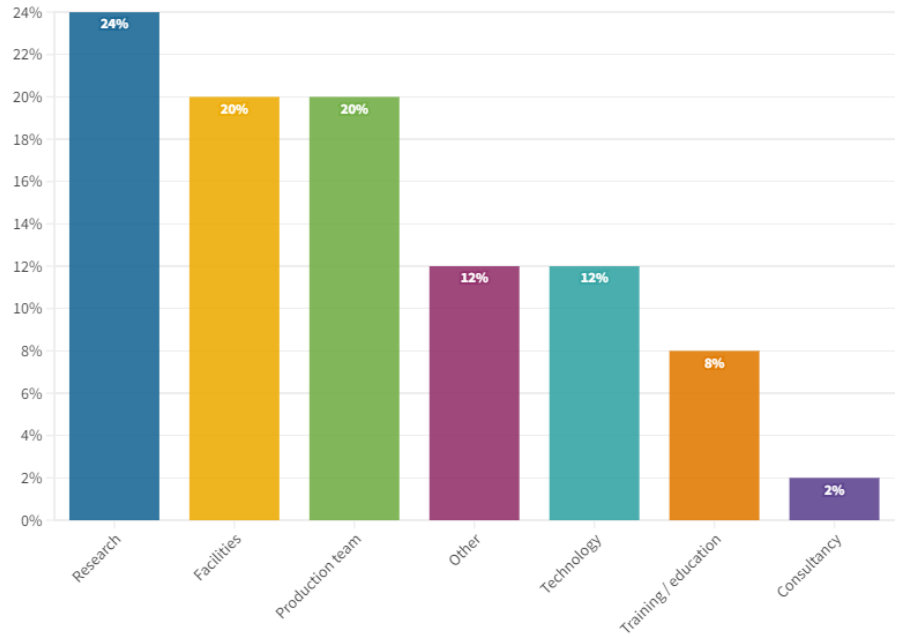
The roles that these types of organisations play in the VP ecosystem vary. There is a relatively equal split between organisations focusing on research (24%), those which provide facilities (20%) and the ones providing production teams (20%). 12% are technology providers, while the other 12% have a combination of multiple roles, without a particular focus on just one. Fewer organisations focus on VP training / education (8%) and consultancy (2%).

Figure 4 Types of organisations in the VP ecosystem



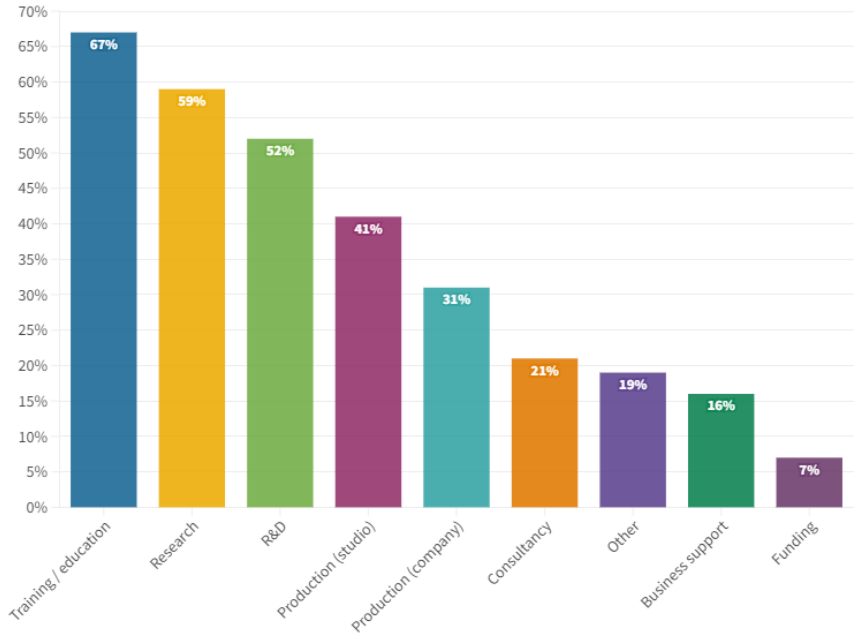
Source: Loughborough University London and BOP, 2023

Figure 5 Role in the VP ecosystem



Source: Loughborough University London and BOP, 2023

Figure 6 Activities fulfilled by organisations working in VP



Source: Loughborough University London and BOP, 2023

Looking at the activities they fulfil provides a fuller story. **Training and education, research and R&D are the most significant services** being offered.

Figure 7 shows a good spread of organisations focusing on VP R&D across the UK, which is also the case for training or educational establishments and research institutions. These are more distributed around the UK compared to other specialisms that are more divided geographically:

- Most production companies (60%) and production studios (54%) are based in London and the South East
- All technology providers are based either in London (67%) or in Yorkshire and Humber (33%)
- All organisations from East Midlands and Wales focus on VP research.

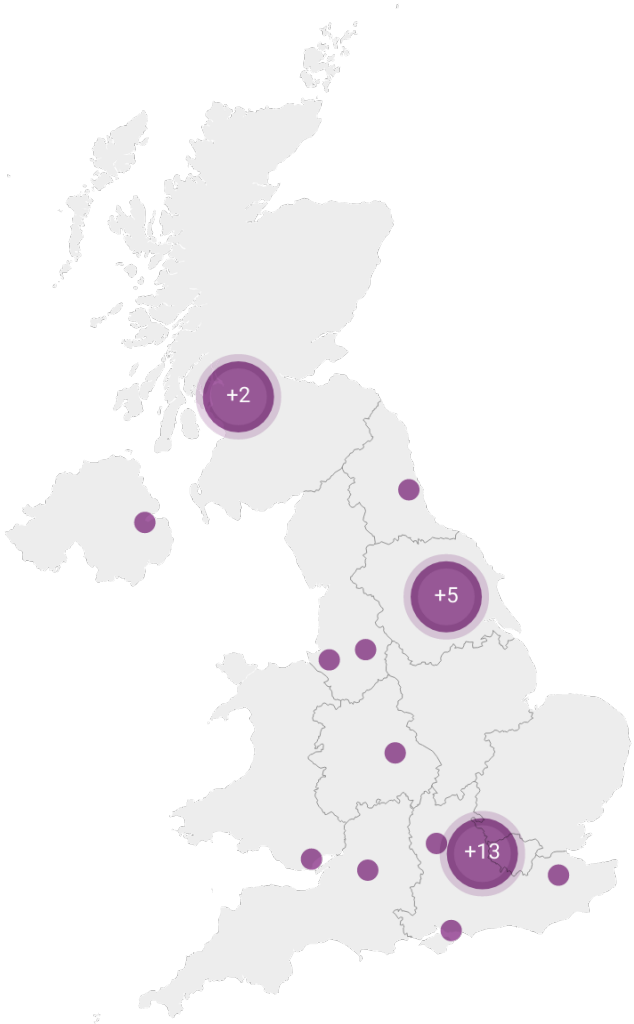
The distribution of the VP assets pre-pandemic differs from the post-pandemic picture. Prior to the pandemic, 30% of assets were concentrated in London and the South East (8%); since the pandemic, there has been a fast growth across the UK and organisations have been established across the country in a more balanced manner. The spread of organisations working in VP established since the pandemic is: Yorkshire and Humber (10%), London (10%), South East (8%), North West (6%), South West (4%), Scotland (4%).

All organisations working in VP in Wales and East of England which are part of our study have been established since the pandemic, suggesting there has been an acceleration in technology-facilitated production.

2.3 Longevity

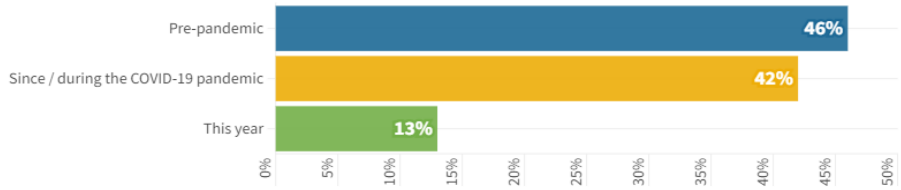
VP started to grow and develop in application during the COVID-19 crisis; it offered an attractive option to the practical limitations imposed by the pandemic. The majority of our survey respondents and other assets generated from this research (55%) have only been operating in the discipline since or after 2020, with 13% of them beginning their VP activity very recently, in 2022.

Figure 7 R&D activities in Virtual Production



Source: Loughborough University London and BOP, 2023

Figure 8 Longevity of organisations in VP



Source: Loughborough University London and BOP, 2023

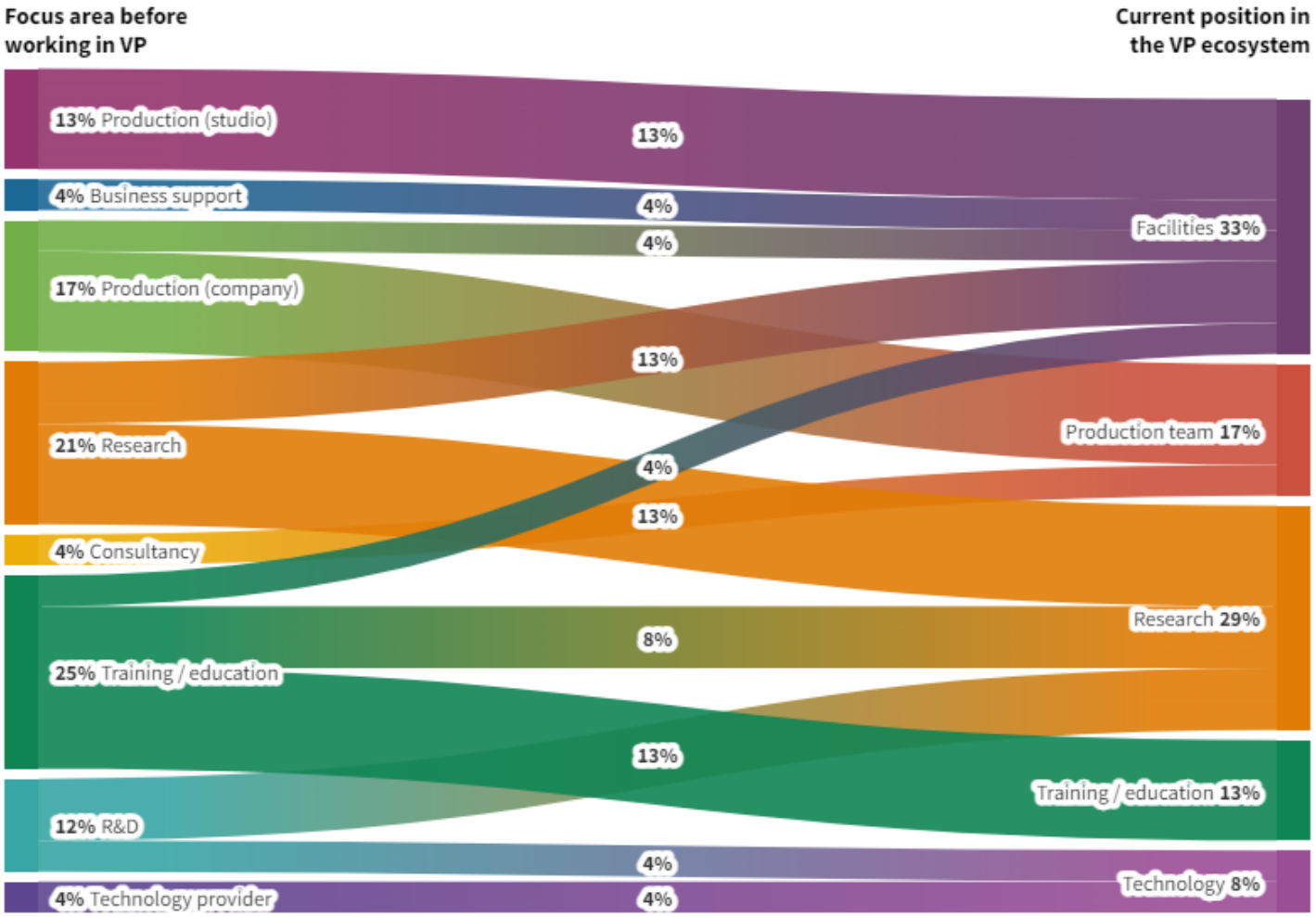
Looking at the type of organisations operating in the VP ecosystem and their activity focus in comparison to their longevity has revealed the following:

- The proportion of organisations that provide production teams (23% before and 20% after) and research (18% before and 24% after) have generally stayed the same for both organisations operating before and since the COVID-19 pandemic.
- More organisations established since the COVID-19 pandemic provide facilities (9% before and 32% after) and training and educational activities (5% before and 12% after) compared to the ones operating before the pandemic.
- While more organisations established prior to the COVID-19 pandemic held multiple roles in the VP ecosystem, (i.e. a combination VP training, research, facilities, technology, consultancy and production (23%)), the majority of organisations established since the pandemic (96%) hold a place in the VP ecosystem that is centred around one specialist VP area.

Overall, **producing and providing technology is the role of the more established organisations that work in VP**, while the provision of facilities is a more recent development.

Figure 9 shows that prior to working in VP, most organisations used to focus on production, either as companies or studios (30%), training / education (25%) and research (21%). Other organisations provided R&D (12%), business support (7%) or technology (7%). **The majority of assets identified now position their post-pandemic offer as: facilities (33%), research (29%) and production teams (17%) to the VP ecosystem**.

Figure 9 Focus in creative industries before working in VP and current position in the VP Ecosystem

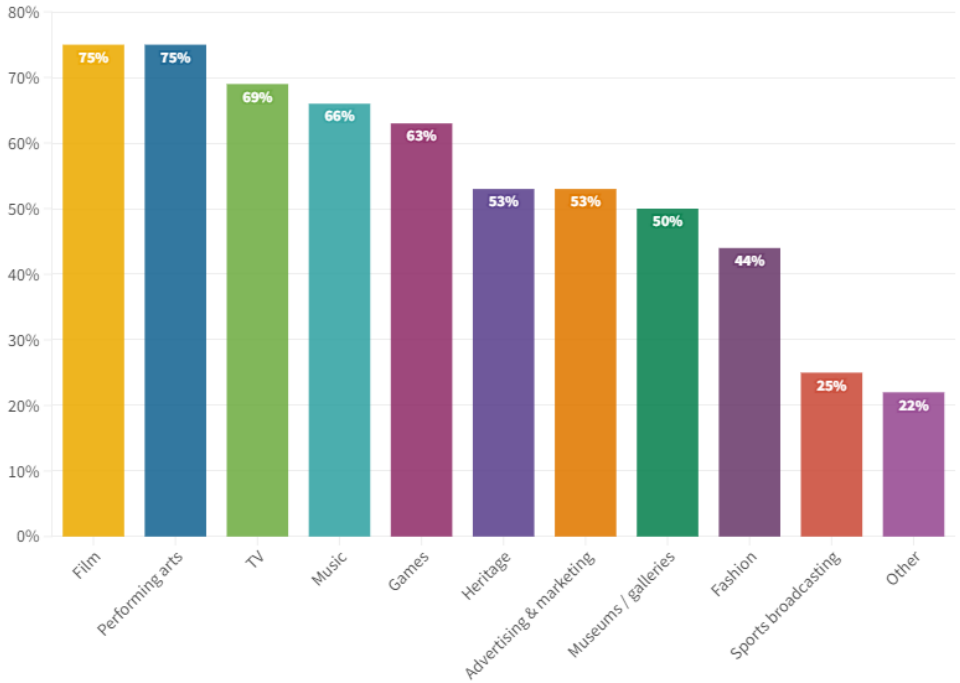


Source: Loughborough University London and BOP, 2023

2.4 Sectors of application

Another key aspect of this study was to ascertain which sub-sectors of the creative industries organisations working in VP engage with. A clear finding was that **organisations working with VP operate across multiple sectors**. On average, organisations tend to work across about 6 (out of a list of 10 proposed options) creative industries sectors.

Figure 10 Creative Industries sectors organisations are working across



Source: Loughborough University London and BOP, 2023

- The top sectors organisations are working in are **performing arts** (75%) and **film** (75%).
- Noting that the categories used in our survey do not map directly onto established DCMS Creative Industries sub-sectors, the most significant sub-sector for VP is Film and TV.
- Perhaps surprisingly, Performing Arts and Music is not far behind a very well represented sector (with 'performing arts' identified by 75% and 'music' by 66%), which might be surprising since it is considered to be a more established and less digital sector.
- **Gaming** is another important sector engaging with 63% of organisations.
- Findings show a surprising level of engagement in sectors such as Fashion (44%), which do not obviously align themselves to real-time performance.

3. Virtual Production assets place within the ecosystem

3.1 Technology Readiness Level (TRL)

Figure 11 below illustrates the simplified version of the TRL scale we used to position the VP assets in our study to establish their technical maturity. Our research used four statements to match the organisations against the original TRL scale that is made-up of nine levels, from early-stage research (TRL 1) to commercial deployment (TRL 9).

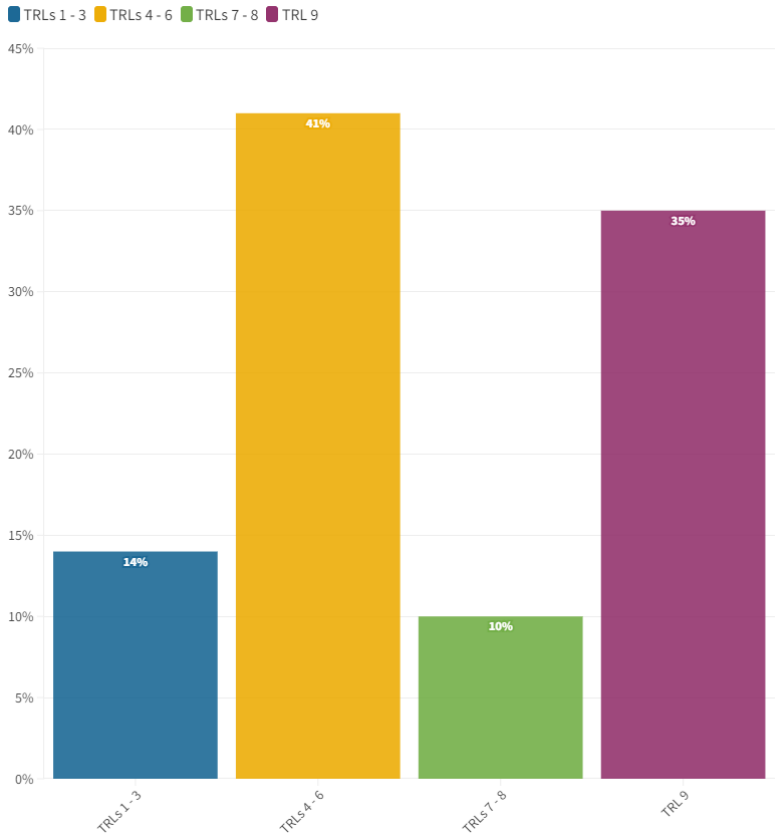
Figure 11 TRL scale utilised in our study

TRL scale utilised in our research	TRL scale
Early/pre-R&D (working on specific areas of components of the VP pipeline/working towards proof of concept)	1-3
R&D (working on proof of concepts and pilots/demonstrators)	4-6
Commercial Demonstrators (Commercial quality pilots/demonstrators)	7-8
Commercial Deployment (Commercial quality full productions)	9

Source: Loughborough University London and BOP, 2023

Most organisations describe their technology readiness as closer to working on proof of concepts and pilots/demonstrators (TRLs 4-6 – 41%) or commercial quality full productions (TRL 9 – 35%). TRL 1-3, early R&D, and TRLs 7-8, commercial deployment, represent 14% and 10% of our respondents respectively.

Figure 12 Virtual Production assets by TRL levels



Source: Loughborough University London and BOP, 2023

As expected, most organisations that focus on R&D (86%) and early R&D (71%) are training or educational establishments and research institutions. Likewise, most VP organisations at TRL 9 are production studios (56%), production companies (28%), and technology providers (11%).

That being said, 25% of **production companies are still operational in the early R&D phase**. Also, noting that VP is an emerging technology application, there is a surprisingly **large number of companies** (76%) that **employ VP at commercial and market-ready level.**

- TRL 9 VP organisations work mostly in advertising & marketing (100%), music (88%), TV (88%) and performing arts (75%), less so in games (25%).
- Most early R&D organisations work in film (80%), games (80%) and TV (60%) and less in advertising & marketing (20%), music (20%) and sports broadcasting (20%).
- Organisations undertaking R&D work mostly in industries such as film (86%), games (86%), performing arts (79%) and least in sports broadcasting (7%).

Juxtaposing TRL and geographical clusters reveals the following:

- **The majority of organisations at TRL 9 are based in London** (50%), followed by the South East (17%), the North West (17%) and the South West (11%).
- In Wales and Northern Ireland, all organisations are currently at TRL levels 4-6.
- London is the only region that hosts organisations across all technology readiness levels.

Overall, the higher technology readiness levels map broadly onto the same clusters of creative industries activity – London and the South East.

The technology readiness level is also influenced by organisations' longevity in VP:

- **Most organisations operating at commercial deployment (TRL 9) have been established pre-pandemic (67%).**
- Most organisations established in the past three years are operating at TRL 4-6 (42%), followed by TRL 9 (23%).

3.2 Focus on research and R&D

Most VP organisations engage in research and R&D with a slight advantage for research (59% of organisations' activities focus is on research versus 52% for R&D). The distinction between the two areas of focus gets more noticeable when considering the organisation type:

- 100% of research institutions, the consultancy and the governmental agency and 90% of training or educational establishments focus on early-stage research.

- Likewise, all technology providers, the consultancy and the governmental agency focus on R&D.
- 60% of production companies focus on R&D rather than on research (10%).

The more advanced the TRL, the likelier organisations are to focus more on R&D rather than research. Organisations at TRLs between 4 and 8 tend to focus more on R&D and research than those at TRL 9[7].

3.3 Provision of training and education

The majority of organisations offer training and education (67%). Looking more closely at this focus amongst our survey respondents and other assets identified in our research, we have found that:

- 100% of training or educational establishments, technology providers, the consultancy and the governmental agency offer training and education.
- Most research institutions provide training and education (88%).
- All organisations operating at TRLs 7-8, most organisations operating at TRLs 4-6 (86%) and 1-3 (71%), provide training and education.
- Only 39% of organisations that are closest to market (TRL 9) provide training and education.

3.4 Role of HEIs in the Virtual Production ecosystem

HEIs are at the centre of the VP ecosystem. Beyond constituting 40% of the organisations in our research, they collaborate with all the other organisation types. Project collaboration (82%) and future talent/skills (65%) are the most cited reasons for collaboration. Another 47% collaborate with HEIs for access to their researchers.

"The growth in research collaborations between universities and creative industries suggests an increasing role for universities in creative innovation systems."[8]

[7] TRL 4-6: research (90%), R&D (62%); TRL 7-8: research (60%), R&D (80%); TRL 9: research (22%), R&D (50%).

[88] Garcia, Klinger and Stathoulopoulos. IBID

4. Facilities & Technologies

VP is an activity deeply linked to the use of a cluster of facilities and technologies; the combination of LED volumes, real-time game engines and in camera VFX comprise what is currently named VP.

There is a range of other technologies and facilities available for VP activities that are used according to different requirements. We have investigated the availability, popularity, and usage in the market of all these technologies to understand and assess the industry's capabilities.

4.1 Facilities owned and provided

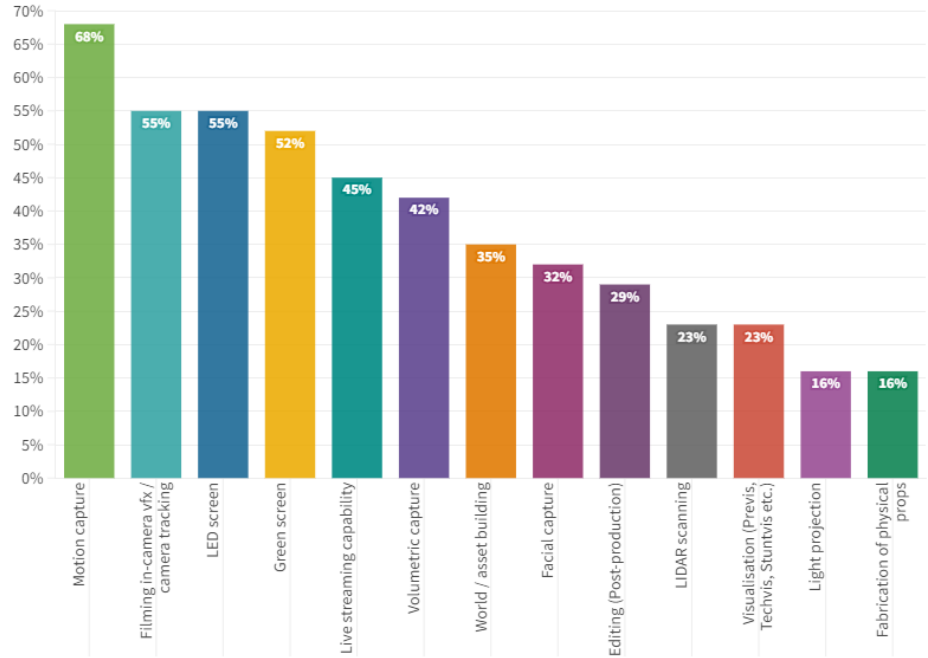
More than half of the organisations we surveyed have in-house facilities (67%). Out of these organisations that own assets, a quarter have between 1 and 3 in-house facilities, the vast majority (61%) have between 4 and 10 facilities, while 13% have 10 or more facilities. It is worth noting that **33% or organisations working in VP do not own any assets.**

- The most widely available in-house facilities are motion capture (68%), filming in-camera VFX (55%), LED screens (55%), green screens (52%) and live streaming capability (45%).
- The least available facilities are the fabrication of physical props (16%) and light projection (16%).
- All production studios and the majority of research institutions (80%), training or educational establishments (79%) and production companies (63%) **have in-house facilities**.

These facilities are used for multiple purposes:

- **Most organisations that have in-house facilities use them for R&D with collaborators (95%)**.
- 84% use them for training, research and internal R&D.

Figure 13 Availability of in-house facilities



Source: Loughborough University London and BOP, 2023

A majority of organisations offer their facilities as readily bookable on a commercial basis (70%) while 8 out of 30 restrict them to in-house team and partners.

Of the organisations that offer their facilities for hire:

- Most offer LED screens (67%), motion capture (67%), filming in-camera vfx (52%) and green screens (52%).
- The least offered facilities are the fabrication of physical props (10%), light projection (14%) and LIDAR scanning (14%).

4.2 Technologies used and owned

By comparing technologies owned and technologies used we wanted to understand discrepancies between their need and availability in the ecosystem.

- **XR is both the most utilised (93%) and the most widely owned technology (88%).**
- Other popular technologies are real-time render engine (85%), world/asset building (74%) and motion capture (70%).
- The least utilised are fabrication of physical props (26%), Haptics (30%), as well as light projection (33%).

Analysing what technologies are used by organisations in their VP projects, as well as which of those technologies are available in house (as opposed to hiring them), we have noticed that some technologies are in demand, but are not as well provided-for in the ecosystem. For example, **volumetric capture, projection mapping, light projection, AI / ML and haptics are all more widely used by organisations working in VP than they are available in house**. This might highlight a gap in the provision of these technologies.

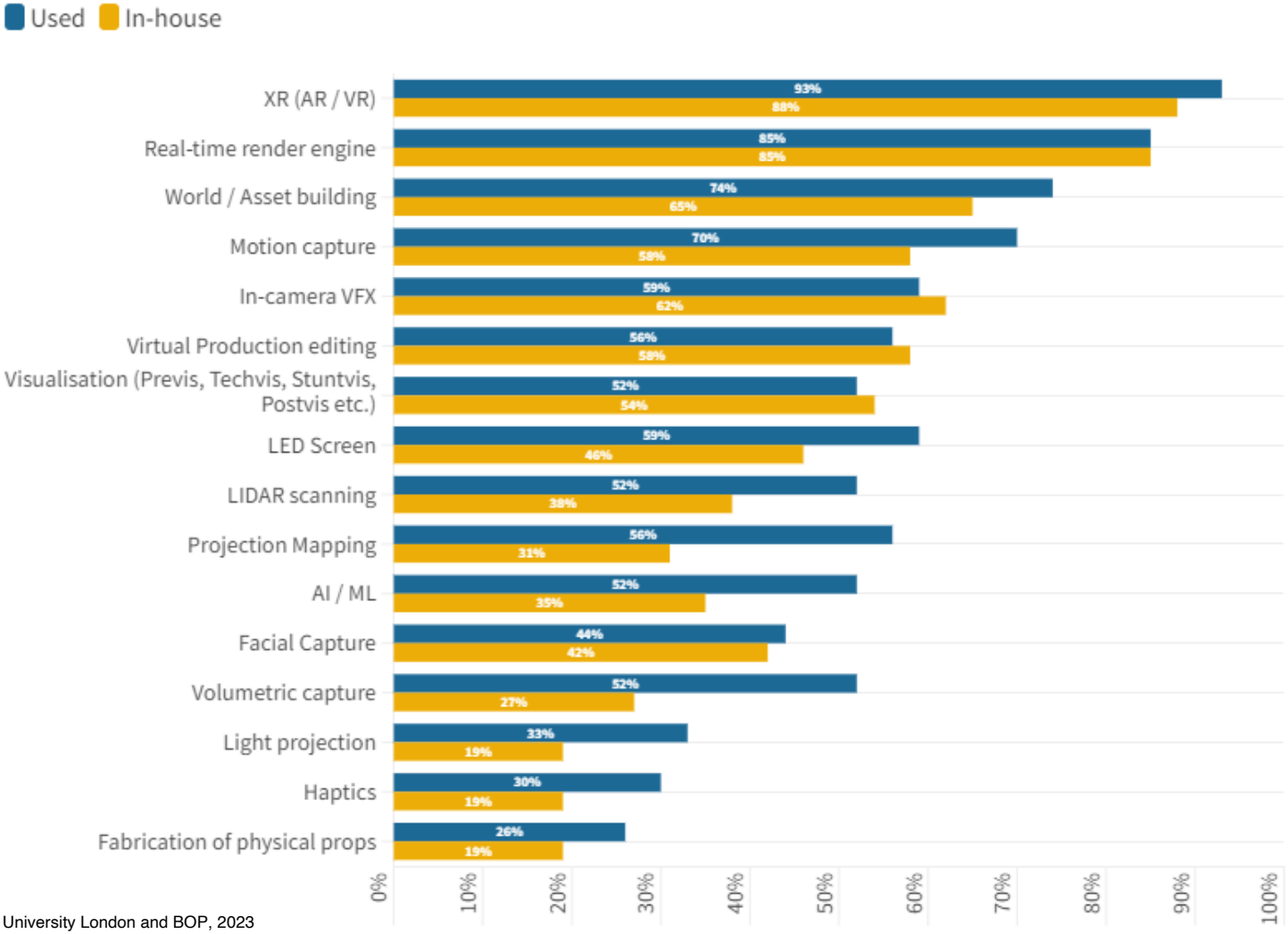
Looking at TRL in conjunction with the technologies utilised reveals that there is a correlation between organisations' TRLs and their use and access to technology: **organisations at TRLs 4 to 8 utilise a wider realm of technologies, while organisations at early R&D level tend to use a smaller selection.**

- Organisations operating at early-stage research/R&D own fewer technologies, with less diversity of technologies, while organisations operating at R&D level own the biggest spread of technologies.
- Organisations operating at early R&D level in the VP ecosystem have less access to or use of VP technologies, particularly those that might be more costly or that require more in-house skills and knowledge to be used (In-camera VFX, facial capture, LED screens, real-time render engines, AI / ML).
- Organisations operating at R&D level use and have access to more VP technologies: volumetric capture technologies (80%), haptics (60%) and LIDAR scanning technologies (60%) than organisations at other TRLs.

- The majority of light projection (60%), LED screens (58%), visualisation (50%), real-time render engines (42%), in-camera VFX (48%), VP editing (41%) technologies are owned by organisation operating at TRL 9.

Overall, we have noticed that both the **organisations operating at R&D level and those at TRL 9 use and own the widest range of technologies**. This might imply that organisations working on proof of concepts and pilots need most technologies available to be able to advance their work, while the most advanced organisations working in VP maintain their commercial quality full productions as a result of access to most VP technologies. **The most advanced organisations working in VP (TRL 9) have most access to the combination of technologies that comprise what is currently named *virtual production*: LED volumes, real-time render engines, in-camera VFX, visualisation and editing technologies.**

Figure 14 Virtual Production technologies used and owned



Source: Loughborough University London and BOP, 2023

5. Reflections on the future development of Virtual Production

In order to help inform future strategies to support the application of advanced technologies in creative industries, our survey asked what factors VP organisations identify as crucial for its development and what technologies they think offer the greatest opportunity for its advancement in the next 5 to 10 years.

5.1 Technological forecasting

Not surprisingly, XR and real-time render engine are the most in demand and widely owned technologies in the VP field while volumetric capture and projection mapping are more in demand than they are available. **So balancing demand and offer on technology seems to be an important starting point**.

The top three technologies our survey respondents selected when asked which would offer **the greatest opportunity for the development of the field are game engine, AI and machine learning, and XR**, in order of importance.

> **"If you're trying to use virtual production as a tool to empower fewer people to do more amazing things, then let's start removing all of these unnecessary complications, and we can do that with AI. So you can walk into an empty room and say, "Give me a 1940s-era Western frontier town, and oh, let's make it winter." You got natural language processing converting it to an asset library, and you could talk your way through this as an individual"[9]**

However, "Advances in technology" only comes in fourth position out of five options, after "level of adoption within the wider sector", "funding" and "affordability of the technology", as the main driving factor for the evolution of VP. In fact, most of the technologies at the centre of VP are not necessarily new, it is how they work together and their impact on production workflow that needs to be explored further.

5.2 Main factors driving future Virtual Production activity

Access seems to be the central barrier to a wider and faster adoption of VP. Access here is to be understood in terms of technology **affordability, skills and availability.**

Indeed, equipment supporting VP is often expensive, not abundant nor easily portable, and only a few people are trained in their operation. Put together, **affordability and funding are what 43%**

[9] Visual effects supervisor and virtual production supervisor, quoted in Epic Games' Virtual Production Guide

of respondents selected as being the main driving factor for the discipline evolution.

Another 37% chose a "higher level of adoption within the wider industry" which can be a consequence of an economic improvement of the facilities and technologies, as well as, more generally, referring to an environment favourable to collaborative learning and innovation for the field.

"I think the exciting thing is to be able to continue to work together where different companies are focused on different aspects of virtual production, then we can come together and do something that none of us can do on our own. And I think the continued fraternity between all of these different companies is really important to moving this forward. There's always competition but I find that there's also always been a lot of collaboration in the field of virtual production, and I don't see that changing. All of us are constantly sharing ideas and moving forward and benefiting from each other's research and development."[10]

Beyond the need for upskilling, there is primarily a need for greater awareness of what VP technologies can achieve. It has been reported that many film professionals do not fully know or understand the possibilities of VP. Furthermore, even the terminology to articulate VP processes is not fully developed. As raised by Hitchen et al (2022)[11], VP also brings challenges linked to the mixing of skills and experiences, of new roles along with little standardisation in how they work together.

Another factor not covered by our survey but worth noting here is consumer adoption, since it often plays a key part in shaping the use and the dissemination of new technologies. Involving consumers in the testing of some VP technologies could lead to interesting findings on technology usage.

"I think a lot of the stuff we're prototyping today will soon be available to consumers and home content creators, YouTubers, and the like. A lot of what Epic develops also gets released in the engine. Money won't be the driver in terms of being able to use the tools, it will be your creative vision."[12]

[10] Executive producer quoted in Epic Games' Virtual Production guide

[11] Hitchen et al (2022). *IBID*

[12] Glenn Derry, founder and vice president at Fox VFX Lab, quoted in Epic Games' Virtual Production Guide

5.3 The main benefits of Virtual Production

While still being a relatively new or emerging discipline, VP is a promising and fast-growing one. With such a comprehensive impact on the production landscape, VP has enabled a variety of operational and cost benefits in comparison to location-based work, and certainly been boosted recently by the practical limitations of the pandemic era.

"Virtual production, as a concept, has been elevated into the production zeitgeist. There has been an acceleration of adoption, normalisation, and cultural synergy surrounding virtual production across the industry, at a pace unseen before."[13]

The new efficiencies and flexibilities offered by VP and associated creative technologies bring enthusiasm and new possibilities in areas beyond product innovation including the **reduction of carbon emissions** and advancement **in the democratisation of the workforce**.

However, this is not straightforward. While VP certainly brings many benefits, it also comes with new problematics – for example, the low-carbon potential of VP needs to be considered alongside the requirement for huge amounts of data to be generated, moved and managed. And the need to address skills shortages needs to have a clear commitment to equality, diversity and inclusion - a longstanding issue for the Film industry as highlighted by Swords and Willment (2023)[14].

[13] Girish Balakrishnan, Director of virtual production for Netflix, quoted in the Epic Games' Virtual Production guide)

[14] Swords and Willment. 2023. *What is Virtual Production? An Explainer & Research Agenda.* University of York. Available at: https://xrstories.co.uk/wp-content/uploads/2023/01/What-is-VP-final2.pdf.

6. Conclusions

This study provides some interesting insights from an examination of 62 key VP assets on the current landscape and outlook for advanced creative and media technologies.

The current ecosystem has grown quickly (accelerated by the COVID-19 pandemic), and geographically around existing creative industries clusters. It is relatively healthy and diverse, operating at different technology advancement levels, within a variety of creative sectors.

This study suggests that technology sophistication is not the central condition nor the starting point for the advancement of the field. A wider adoption of the various technologies associated with VP seems to be more important. This is connected and can be facilitated by easing accessibility and affordability to technologies and facilities.

This needs to go hand in hand with an awareness-raising effort, combined with upskilling and training for the workforce, to address the novelty of the technologies and their applications to the existing workflows.

While enthusiasm, interest and engagement in the field are encouraging for the future of VP, strategic support is required to encourage the strengths and successes identified so far, while also addressing imbalances to drive innovation and progress in VP.

Based on this initial baseline study, the following are suggested as target areas for the AHRC and its counterparts across UKRI:

- The need to address geographical imbalances, through the provision of support for dormant spots and using the current strong clusters to support them in addressing skill and facilities gaps.
- To encourage the natural healthy collaboration between HEIs and other organisation types in the ecosystem, in particular to facilitate the tackling of disparities in skills and R&D.
- To tackle challenges in technology access and affordability.

A more exhaustive study into the VP ecosystem in the UK that builds on from these findings will be beneficial to help test and strengthen this baseline and confirm some of the hypotheses, especially around TRL typologies. Repeating it periodically would allow a close monitoring of development and a targeted allocation of resources.