Optimising Visualisation Practices in Theatre Production

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Introduction

Visualisation in theatre is at an intriguing juncture within the industry. Despite its potential benefits, it remains an area that lacks dedicated roles or departments. Often, responsibilities for visualisation fall to set designers, associate set designers, lighting designers, or lighting associates. In commercial theatre, production teams typically do not allocate specific time and resources to visualisation, largely due to a misconception that it incurs additional costs. However, this perspective overlooks the significant financial advantages visualisation can offer, such as the resulting effects of optimising sightlines, including maximising ticket sales and reducing the number of seats on hold. The industry is yet to fully embrace these benefits, resulting in a reluctance to invest in visualisation.

A critical issue contributing to this hesitation is the chicken-and-egg problem of data availability. Effective visualisation depends on high-quality data from both productions and venues. Historically, such data libraries were non-existent until the development of 3D models of venues began. Today, many venues possess these 3D models, providing a solid foundation for visualisation. However, there is still a significant gap in awareness and understanding among production teams. This gap is partly due to the industry's lack of recognition of visualisation as a valuable resource and partly due to venues not promoting it as part of their technical specifications.

Furthermore, there is often a disconnect when individual departments independently handle visualisation tasks. For example, in a production of *Moulin Rouge!* on London's West End, the producers used a 3D model to manage sightlines and ticket sales, but the lighting department created a separate visualisation file due to a lack of awareness about the existing resource. This scenario highlights the need for a unified approach where visualisation resources are shared and utilised across all departments.

To address these challenges, I advocate for the creation of a dedicated role: the production visualiser. This role should be a standalone position rather than an additional responsibility for existing staff. The production visualiser would act as the custodian of the digital twin of the production, integrating and disseminating information from all departments, including lighting, set design, automation, video, and more. This consolidation ensures that all necessary files and data are accurately maintained and shared, facilitating a cohesive workflow.

One key aspect of implementing this role is recognising that each department in theatre has established software preferences and workflows - examples include AutoCAD, Vectorworks, and Capture. Attempting to standardise these processes with a single software solution is impractical in the short term. Instead, the focus should be on developing a framework for efficient data exchange between these systems. This approach will present its own challenges, but it is essential for achieving a seamless integration of visualisation within theatre productions.

The role of the production visualiser also extends to the sustainability aspect of visualisation. As the industry evolves, theatre productions will likely face similar environmental standards as those in other industries such as construction manufacturing. For instance, reducing the carbon footprint associated with international travel for designers for venue site visits could be achieved through effective visualisation. Currently, these environmental impacts are not fully accounted for, but this is expected to change in the near future.

Overall, visualisation is transitioning from being perceived as a luxury to an essential component of theatre production. The numerous benefits, including time savings and revenue generation, particularly for commercial productions, underscore its value. Even subsidised productions can realise cost savings through time efficiency. It is crucial for the industry to invest fully in visualisation, recognising it as a vital asset rather than a mere accessory.

Tools

CAD Software

When discussing software tools in theatre, it's important to acknowledge that many of the main tools used today were not originally designed with theatre in mind. One of the primary tools is AutoCAD, predominantly favoured by set designers. Despite its widespread use, AutoCAD was not created for theatre applications, and many essential theatre-specific tools have been retrofitted or users have devised workarounds to make the software suitable. This is particularly true for its 3D functionalities. With its steep learning curve, AutoCAD is heavily oriented towards the architecture, engineering, and construction (AEC) industries, rather than the entertainment industry. Nonetheless, it has become a standard, especially for set designers, who frequently send their drawings to scenic shops in the form of DWG files, making it a common practice in the industry.

Another widespread tool is Vectorworks, which is more commonly used by lighting designers. Unlike AutoCAD, Vectorworks includes entertainment toolsets, making it more versatile for live events and theatrical applications. The software suite covers a broad spectrum, from commercial and residential building design to landscape gardening, and importantly, it has dedicated tools for entertainment purposes. Vectorworks Spotlight, its lighting plugin, offers robust visualisation capabilities, allowing users to create or import venue data, including raw point cloud laser scan data directly, and utilise a comprehensive library of lighting fixtures. However, as highlighted in the interview with a leading lighting programmer in the West End detailed later in this paper, many lighting designers do not fully utilise these libraries. Instead, they often draw lighting fixtures using basic shapes, which hinders the full potential of the visualisation tools. For instance, if a designer represents a Source Four fixture with a simple labelled shape rather than the correct symbol, the system cannot interpret, visualise it, or export it accurately, despite the available capabilities.

In 3D modelling, there are two primary methods of drafting: polygonal meshes, composed of individual polygon faces, and solids. When working within AutoCAD or Vectorworks, users draw with solids, creating intelligent objects with properties and information, similar to how Revit operates in BIM. These smart objects can be assigned to libraries, making them highly functional within their native software. However, a major challenge arises when exporting these solids to other software. During import, these solids are often converted into polygonal meshes, and often triangulated, which is a one-way process. Converting polygonal data back into solids for use in AutoCAD or Vectorworks is problematic and cannot retain the original properties and information, posing a significant issue for seamless integration across different software platforms.

SketchUp is another tool used by some designers due to its lower barrier to entry compared to AutoCAD and Vectorworks. Although it offers decent export capabilities, its import functions are less robust. Despite these limitations, SketchUp remains in use among a portion of the design community.

Rhino is also gaining traction, particularly among set designers. Popular for its powerful, node-based, programmatic, and modular design capabilities, Rhino allows for the creation of both organic and industrial shapes. Its flexibility makes it a valuable tool, though it is still less common compared to AutoCAD and Vectorworks.

In conclusion, the majority of designers in theatre continue to rely on AutoCAD and Vectorworks for delivering drawings, however the landscape of software tools is diverse and evolving. The main driving factors that dictate an individuals' preference continue to be familiarity and the software's integration with existing pipelines and toolsets.

Software	**Pros**	**Cons**
AutoCAD	Widely used among set designers; Standard practice for sending drawings to scenic shops; Extensive feature set	Not originally designed for theatre; Steep learning curve; Limited 3D functionalities; Requires workarounds for theatre-specific needs
Vectorworks	Includes entertainment-specific tools; Strong visualisation capabilities with Spotlight; Supports import of point cloud laser scan data; Comprehensive lighting fixture library	Expensive; Some lighting designers do not fully utilise available libraries, which can limit the tool's effectiveness; Complex for beginners
Rhino	Powerful node-based, programmatic and modular design capabilities; Suitable for creating organic and industrial shapes; Increasingly popular among set designers	Not as widely used as AutoCAD and Vectorworks; Can be complex to learn; Integration with other theatre software can be challenging
SketchUp	Lower barrier to entry; Decent export support; Still in use by some designers	Poorer import support; Less robust compared to other tools; Limited functionalities for complex theatre applications

Lighting Pre-visualisation

When it comes to lighting visualisation software, there are a few key players in the industry: wysiwyg, Capture, Depence and the visualisers integrated directly into lighting desks, such as ETC's Augment3d and GrandMA 3D. Each of these tools has its own set of advantages and disadvantages, but a common sentiment among lighting programmers and designers is that using these tools often feels like duplicating efforts.

The integrated desk visualisers, like ETC's Augment3d and GrandMA 3D, mitigate this issue by allowing pre-programming and pre-visualisation on the same device used for actual show programming, unlike wysiwyg and Capture which can require significant setup time and effort.
wysiwyg, for instance, often has challenges importing data, as it tends to favour its proprietary drawing tools. This software struggles when handling high levels of detail, and importing existing models often necessitates optimisation. Capture faces similar challenges, where the most reliable method for importing existing files involves using an intermediary like SketchUp, rather than standard industry file formats such as Autodesk’s FBX.

ETC's Augment3d excels in this area due to its architecture being built on top of Unity, a well-established game engine. Unity's robust 3D model import capabilities seamlessly translate to Augment3d, making it highly efficient: if Unity can open a file, so can Augment3d. This ease of importation is a significant advantage over wysiwyg and Capture.

Capture, however, is often praised for its superior photometric accuracy and visual representation of light. It is considered to have the best photometrics in the industry, offering a visually appealing and accurate depiction of lighting. ETC's Augment3d also boasts an impressive library of many fixtures, each with measured photometrics to ensure accurate recreation within the software.
MA3D's tight integration with MA lighting desks circumvents the need for duplicated efforts, aligning pre-visualisation directly with the actual programming environment.
Despite these strengths, no single tool stands out as the definitive choice due to the significant effort involved in setting them up. As discussed in an interview with Elliot Smith, a leading lighting programmer, the consensus is that the current process demands too much effort to reach a ready-to-go state, and most productions do not budget for the necessary time and resources.

Depence R3, the latest version of Syncronorm's visualisation software, stands out for its focus on photoreal rendering and advanced features tailored to modern visualisation needs. Among its key capabilities are integrated VR, allowing immersive design experiences, and sophisticated crowd systems for simulating audiences. Depence R3 also includes atmospheric effects, enabling designers to create realistic environmental conditions.
Its node-based routing framework makes it unique against its counterparts; while familiar to those experienced with video software, it may pose a learning curve for users accustomed to CAD tools or lighting desk software which typically do not have node-based frameworks.

Lighting Pre-visualisation - Consideration of Time

Lighting programmers are often expected to undertake this extensive setup work without additional compensation or time allocation.

The process of preparing a file in Capture, Augment3d, or wysiwyg can take several days to weeks, a timeframe that is rarely accounted for in production budgets.

If productions recognised the potential time savings and cost efficiency of investing in visualisation software, especially in expensive theatres in the West End or on Broadway, they might allocate the necessary resources.

However, this requires a shift in industry education and mindset to fully appreciate the long-term benefits of pre-visualisation in lighting design.

Lighting Programmer Interview

As part of this paper, I conducted an interview with West End Lighting Programmer Elliot Smith. Smith's credits include *Stranger Things: The First Shadow; 2:22 A Ghost Story, and Life of Pi.* Below is a summary of the points discussed.

Introduction and Purpose:
- The discussion centres on the role of visualisation in professional workflows, focusing on lighting and set design. The goal is to identify current challenges and explore potential solutions for better integration and efficiency.

Current Role of Visualisation:
- Visualisation is not well integrated into current workflows.
- The task often falls to lighting programmers or designers who have the technical skills to handle it, but there is no dedicated role.
- Workload and lack of a dedicated person are significant barriers.
- In places like the Royal Opera House, a central visualisation role has been successful. This person integrates set models and lighting rig models into a useful format for the team.

Challenges in Visualisation:
- Visualisation is labour-intensive and often seen as an additional, uncompensated workload.
- In many productions, visualisation is used minimally due to time constraints and scheduling coordination.
- Lack of streamlined processes means tasks are often duplicated across different stages and software.

Software and Tools:
- Vectorworks allows import of set models but lacks the advanced visualisation capabilities of software like WYSIWYG or Capture.
- Specialised software such as Capture and WYSIWYG provide better renditions but require rebuilding models, leading to redundancy.
- Unreal Engine 5 (UE5) is emerging as a robust tool for visualisation with its advanced photorealism and compatibility with multiple file formats.

Integration and Efficiency:
- A chicken and egg scenario exists where the initial time investment in visualisation tools is seen as a hurdle.
- Producers and production managers have mixed views on the cost-saving potential versus the traditional workflow without visualisation.
- Lighting programmers with 3D skills are limited, and those without such skills face additional learning curves.

Professional Use and Investment:
- Professionals are more likely to engage in visualisation if provided with the necessary files in the correct format and if it is part of their paid work schedule.
- There is reluctance to invest personal, unpaid time in visualisation.
- A more structured approach, such as booking pre-visualisation time within the production schedule, could increase adoption.

Ideal Visualization File and Integration:
- A centralised software solution that allows direct plug-and-play with lighting desks would be ideal.
- Integration should minimise the need for re-importing and re-building models in different software.
- Software like Capture and UE5 are preferred due to their capabilities and ongoing development.

File Formats and Technical Integration:
- The integration of 3D data into visualisation software needs to be seamless.
- Capture allows imports from Vectorworks but requires careful handling of formats like OBJ and SketchUp files.
- UE5 supports a wide range of file formats and offers advanced photorealism, making it a strong candidate for central visualisation software.

Departmental Integration:
- Visualisation processes need to cater to both lighting and set design needs.
- A centralised person or role to manage and merge information is critical for effective integration.
- Different departments require different levels of detail and information in their visualisations.

Adoption and Future Trends:
- Education and demonstration of visualisation benefits are crucial for wider adoption.
- Unreal Engine 5 is likely to become more prominent in the visualisation space due to its advanced capabilities.
- Visualisation can save time and improve accuracy, but it requires buy-in from all stakeholders.

Key Takeaways:
- Visualisation is currently underutilised due to workload and coordination challenges.
- A dedicated visualisation role can streamline the process and improve integration.
- Professionals are open to using visualisation if it is integrated into their workflow with proper support.
- Future developments in software like UE5 may drive greater adoption and effectiveness of visualisation in productions.

Conclusion:
- Visualisation has significant potential to improve workflow efficiency and production quality.
- Overcoming current barriers requires a combination of better tools, dedicated roles, and education about the benefits.
- As technology advances, particularly with tools like UE5, the adoption and impact of visualisation in professional workflows are likely to increase.

In our discussion, Smith suggested that the most advantageous approach to previsualisation would be the implementation of a virtual tech session, or "e-tech," overseen by a Stage Manager and conducted in the same manner as a traditional in-venue tech rehearsal. One of the current challenges with visualisation is that it is predominantly seen as the responsibility of the lighting department, often resulting in it becoming an isolated component of the production.

I will explore this concept of an e-tech session further later in this paper.

3D Modelling

Modelling Techniques and File Formats

Overview of Modelling Formats in the Industry

Various modelling techniques and file formats are employed to create and manage digital assets. The two primary types of 3D modelling formats used are polygonal models and NURBs (Non-Uniform Rational B-Splines) or solids.

A useful comparison to draw is how raster and vector graphics both fulfil different purposes in imagery and graphic design - raster images are composed of individual pixel values, whereas vector graphics are mathematical relationships between points. The same is true for polygonal meshes and solids. Each has its own applications, advantages, and limitations:

Polygonal Models:
Polygonal models are constructed using vertices, edges, and faces, forming a mesh of polygons, usually triangles or quads. This method is widely used due to its simplicity, versatility, and interoperability.

Pros:
- **Versatility:** Polygonal models are compatible with a wide range of software, making them highly adaptable.
- **Detail and Complexity:** They can represent highly detailed and complex shapes, which is useful for intricate set designs.
- **Performance:** Polygonal models are generally more performant in real-time applications, such as lighting visualisation and pre-visualisation.

Cons:
- **Precision:** Less precise than NURBs for certain applications, such as architectural modelling.
- **Topology Issues:** Can suffer from issues like non-manifold geometry, flipped normals, and detached faces, which can complicate further processing and editing.
    - Even when software can, on paper, import a specific file format it may result in topology defects which can introduce a lengthy process to manually clean-up.

NURBs/Solids:
NURBs and solids represent 3D geometry using mathematical formulas, providing smooth and accurate surfaces.

Pros:
- **Precision:** Highly accurate representation of curved surfaces and complex shapes.
- **Flexibility:** Easier to modify and refine shapes with precision.
- **Smooth Surfaces:** Ideal for creating smooth, flowing surfaces without the limitations of polygonal faceting.

Cons:
- **Complexity:** More complex to create and manipulate, requiring specialised knowledge and software.
- **Compatibility:** Not as widely supported across different software platforms as polygonal models. When imported into polygonal-based systems, such as most 3D modelling software and game engines, they will be automatically converted into polygonal meshes losing this data.

Best Practices for Modelling in Theatre Production - Polygonal

Here are some key guidelines when modelling 3D polygonal meshes:

- **Optimise Geometry**: Maintain a balance between detail and performance by keeping polygon counts reasonable. High-poly models can significantly slow down real-time visualisation and rendering processes, so focus on simplifying geometry where possible without compromising essential details. Part of this process involves ensuring that any reused assets, such as those purchased online, maintain the same standard. 3D assets purchased online have wildly varying levels of detail, with some having polycounts that are far too excessive for real-time visualisation.

- **Use Standardised File Formats**: To facilitate smooth transitions between various software applications, use standardised file formats such as FBX, OBJ, or 3DS. These formats are widely supported and ensure that models can be easily imported and exported across different platforms and tools used in theatre production.

- **Maintain Clean Topology**: Ensure your models have clean and efficient topology. Avoid non-manifold edges, overlapping vertices, and other common topology issues that can complicate further editing and cause problems in downstream applications. Clean topology enhances the model's integrity and makes it easier to apply modifications or animations.

- **Document Assets**: Comprehensive documentation is vital for the effective use and management of 3D models. Include detailed notes on the model’s construction, such as layer names, materials, textures, and other relevant metadata. Proper documentation ensures that anyone working with the model can understand its structure and components, facilitating easier troubleshooting and adjustments.

- **Use Efficient UV Mapping**: Proper UV mapping is essential for texturing and applying materials to models. Ensure UV maps are laid out efficiently to minimise stretching and distortion, which helps in achieving high-quality textures and realistic visual effects. Well-made UV maps can also be useful assets for the video department, who will likely use UV maps of scenery or building architecture for projection mapping. It is worthwhile clarifying if this is the case beforehand as UV mapping correctly can be a lengthy manual job. However, if creating models for future uses, it's best practice to do this regardless so the data is there for future use.

- **Leverage Instancing and Modular Design**: Where possible, use instancing and modular design techniques to reduce redundancy and save on processing power. By reusing components and creating modular assets, you can enhance both the performance and scalability of your models. However, it is worth noting that most visualisation software will break instances apart into individual components open import, so this is primarily useful for management of assets within the 3D scene as it's built.

- **Clean-Up Geometry Overspill**: When 3D modelling polygonal shapes for visualisation, it is easy to create overspilling geometry that extends beyond the bounds of the space. This is typically not an issue in a visualiser or game engine, however it can create issues from unclear visuals when brought into CAD software.

- **Test in Target Environment**: Regularly test your models in the environment they will be used, whether in visualisation software or a live rendering setup. This helps identify any performance bottlenecks or compatibility issues early in the development process.

By following these best practices, theatre production professionals can create polygonal models that are not only visually appealing but also efficient and versatile, ensuring a smoother workflow and more effective integration into various production stages.

Future-Proofing And Archiving Digital Assets

As the industry evolves, the importance of future-proofing digital assets with versatile and robust file formats becomes increasingly apparent. There is little point going to the effort of creating high quality data libraries if in the future it will not be possible to access them due to file formats or software packages becoming obsolete.

Two such formats are USD (Universal Scene Description) and GLTF (GL Transmission Format).

USD (Universal Scene Description):
USD, developed by Pixar, is a powerful and flexible framework for interchange of 3D graphics data.

Pros:
- **Versatility:** Supports complex scenes, including hierarchies, instances, and variants.
- **Interoperability:** Widely adopted across various industries, promoting a standardised approach to 3D asset exchange.
- **Efficiency:** Optimised for performance, allowing efficient loading and manipulation of large scenes.

Cons:

- **Complexity:** May be overkill for simpler projects, requiring a more in-depth understanding of its capabilities.
- **Adoption:** Still gaining traction in some areas, meaning not all software may support it fully.

GLTF (GL Transmission Format):
GLTF is a royalty-free specification for the efficient transmission and loading of 3D models.

Pros:
- **Efficiency:** Designed for speed and size efficiency, making it ideal for real-time applications.
- **Ease of Use:** Simpler and more straightforward compared to USD, making it accessible for a wider range of applications.
- **Broad Support:** Supported by many modern 3D tools and platforms, ensuring broad compatibility.

Cons:
- **Limitations:** While efficient, it may not support the same level of complexity and flexibility as USD.
- **Detail Loss:** Some detailed data might be lost in the conversion process, impacting the precision of highly detailed models.

FBX (Filmbox):
FBX is a popular, widely-accepted format used in the entertainment industry for 3D asset exchange.

Pros:
- **Wide Adoption:** Supported by virtually all major 3D software, making it a go-to choice for interoperability.
- **Rich Feature Set:** Supports a wide range of features, including animations, materials, and camera settings.

Cons:
- **Proprietary Format:** Being proprietary, it can sometimes present compatibility issues or require specific software for optimal use.
- **File Size:** Can result in large file sizes, which might be a consideration for storage and transmission.

Futureproofing Conclusion

Selecting the appropriate modelling techniques and file formats is crucial for efficient and effective theatre production. Understanding the strengths and limitations of different formats, such as polygonal models and NURBs, as well as leveraging future-proof formats like USD and GLTF, can greatly enhance the workflow and ensure compatibility and longevity of digital assets. By adopting best practices and staying informed about industry standards, theatre professionals can create robust, versatile models that meet the demands of modern production environments.

Long Term 3D Asset Archive

In addition to picking a file format that can be suitable for long term futureproofing, it's also worth considering file size of assets. CAD files themselves are rarely particularly large, with clean CAD that does not have embedded material textures often being 50MB or smaller. With the cost of modern HDDs, SSDs and cloud storage, the cost of storing files of this size is too negligible for complex consideration.

However, 3D scan and mesh data can often be much larger and consideration must be made for how to effectively store these. For example, Preevue's raw scan data of the RST auditorium alone exceeds 100GB uncompressed.

Compression Libraries - Draco

The Draco file format, developed by Google, is a highly efficient compression library for 3D geometric meshes and point clouds. Designed specifically to improve the storage and transmission of 3D data, Draco offers significant reductions in file size without compromising quality. This makes it an ideal choice for archiving 3D models and scan mesh data, where maintaining high fidelity is crucial. The format supports lossy and lossless compression, enabling users to choose the best balance between compression ratio and visual quality for their specific needs.

Furthermore, Draco's support for standardised file formats, such as glTF, enhances its interoperability, making it easier to share and collaborate on 3D assets. As the demand for high-quality 3D content continues to grow, the Draco file format stands out as a robust solution for efficiently archiving and managing complex 3D models and scan mesh data.

Compression Archive Formats

An alternative to a compression library such as Draco is using compression archives, such as traditional zip file compression or a stronger alternative format like .7z, by 7zip.

Known for its robust compression capabilities, 7zip offers an "ultra" level of compression that significantly reduces file sizes, making it ideal for storing large 3D models and scan data. This ultra compression mode utilises advanced algorithms to minimise file size while maintaining all data. By compressing assets into smaller archives, storage costs can be reduced, and data transfer times can be minimised, which is particularly beneficial when dealing with limited storage resources or bandwidth constraints.

7zip is free open source software which enables traditional compressing and decompressing, as opposed to converting a file into an entirely new format.

With our internal workflow at Preevue, 7zip reduces the size of our laser scan mesh files by approximately 5x.

Capturing and Archiving Assets

In this section, we explore the importance of scanning and archiving theatre assets, focusing on the various methods and their applications. This process serves multiple purposes, from visualisation and future planning to digital archiving for sustainability.

For productions that are in repertory, scanning and archiving sets can be immensely valuable. By digitising and archiving these assets, theatre companies can use them for future visualisation purposes or send them to receiving houses ahead of a production's arrival. The Royal Opera House, for example, has begun sending comprehensive production data - including lighting show files, 3D models of sets, and previsualisation files - to venues around the world. This practice not only facilitates smoother transitions but also enhances preparation and planning for productions in new locations.

Digital archiving also plays a significant role in sustainability. As the industry moves towards reusing production elements, maintaining a comprehensive dataset and library of models is crucial. For large-scale set designs, LiDAR scanning provides an efficient method of capturing detailed point cloud data, which can be converted into 3D CAD geometry. Although the scanning process is straightforward, the equipment can be costly, with terrestrial LiDAR scanners ranging from £25,000 to £50,000 or greater. While more expensive scanners (£50k+) offer greater accuracy and range, they are often unnecessary for standard theatre environments.

The process of converting point cloud data to usable 3D CAD data remains labour-intensive and requires a human touch to achieve photorealistic results while maintaining optimised CAD data. Tools like RealityCapture, now bundled with the professional licence for Unreal Engine 5, excel at creating high-resolution meshes. However, these meshes often contain hundreds of millions of polygons, making them impractical for use in software like AutoCAD, SketchUp, or Capture due to their sheer density.

Looking ahead, advancements in neural networks and machine learning hold promise for automating the conversion of dense point cloud data into clean CAD geometry. This technology is likely to mature within the next few years, potentially automating tasks that are currently time-consuming and manual. As such, productions should consider archiving raw scan data and mesh data without immediately converting them to CAD formats, as future technological advancements may streamline this process.

Emerging technologies such as NeRF (Neural Radiance Fields) and Gaussian Splatting are also rapidly changing asset capture. These methods allow for 3D scanning using standard cameras or even smartphones, producing reasonably good 3D scans. The technology is essentially structure-from-motion (SfM) enhanced with neural networks to enhance the quality of the captured data. Although the resulting geometry from these methods is currently of lower quality, it can be anchored to a reference LiDAR scan for better accuracy. These technologies are rapidly advancing and are already being utilised in practical applications.

Photogrammetry, another well-established technique, involves taking multiple photographs of an object or scene to create a 3D model. While effective, photogrammetry lacks inherent scale accuracy, unlike LiDAR, which is factory-calibrated to millimetre precision. Scaling photogrammetry models requires referencing known measurements, which can introduce errors. The resulting data often needs significant cleanup to be usable in CAD-focused programs like AutoCAD or Vectorworks.

For more advanced 3D modelling, software such as 3DS Max, Maya, and Blender can handle photogrammetry and LiDAR data. These tools are adept at managing high polycount meshes and integrating them into production workflows. UE5, particularly with its Nanite technology, can efficiently manage dense meshes, although further processing is required to make the data usable for the broader production team.

It's also worth noting the growing accessibility of mobile LiDAR scanners, such as those found in iPhones and iPads. While these devices offer a more affordable scanning solution, they come with limitations in range and point density. The data captured by mobile LiDAR scanners is unstructured, lacking the ordered context provided by terrestrial scanners, which affects the accuracy of meshed point clouds.

Another important consideration is the existing disconnect in production workflows regarding LiDAR scans and asset scanning. Often, venues may already have LiDAR scans as part of their technical specifications that many departments are not aware of. In addition, individual departments, such as video, may independently commission additional LiDAR scans without sharing this data with the rest of the team. This siloed approach highlights the need for a centralised role and system to ensure that all data is accessible and beneficial to everyone involved in the production.

For instance, Preevue conducted a laser scan of *My Neighbour Totoro* at the Barbican Centre, and this data is now stored with the video team. However, this information could also benefit other departments, such as the box office team, when reviewing sightlines for future production transfers. Currently, the box office team may be unaware that such data exists, which underscores the need for a unified approach to data sharing.

By centralising the management of these digital assets, all departments can work from the same data, eliminating redundant efforts and fostering collaboration. This shift requires not only a change in processes but also an educational and cultural shift within the industry. Everyone needs to be aware of the available resources and understand the value of sharing data. By doing so, scan data and other digital assets become core resources that enhance the efficiency and effectiveness of the entire production.

In summary, the scanning and archiving of theatre assets are crucial for both current productions and future sustainability. While technological advancements continue to improve the efficiency and accuracy of these processes, it is advisable for productions to archive raw data and anticipate future improvements that will facilitate easier conversion and integration into various production tools.

The Use of Virtual Reality in Theatre Visualisation and Production

Virtual Reality (VR) has emerged as a tool in theatre visualisation and production. It is my view that it's a powerful tool with limited scope, with misunderstandings regarding use in the wider scheme.

This area is particularly relevant as when I founded Preevue in 2016, the core idea was to utilise VR technology to allow producers and designers to step into a virtual model box built at a 1:1 scale. The aim was to address the common issue where a design, once built, did not meet the producer's expectations based on plans or traditional model boxes. By providing a VR model, producers could better visualise and understand the design before construction began, thus reducing the likelihood of costly and time-consuming revisions.

One notable success was the use of VR in the Broadway production of *Harry Potter and the Cursed Child*. The VR technology was instrumental in demonstrating to producers the proposed refurbishment of the Lyric Theatre. Amongst other uses, one successful iteration of the VR included integrating a semi-transparent model of the venue refurbishment within the laser-scanned existing theatre, which producers could walk and fully grasp the transformation. This practical application underscored VR's potential as an invaluable tool for visualising complex projects. International Technical Director for *Harry Potter and the Cursed Child* noted at the time:

> "Preevue's unique tailored virtual reality system was incredibly useful for developing the re-design of the Lyric Theatre and made communicating design changes in virtual reality to our transatlantic teams a possibility."

VR's greatest strength lies in its ability to bridge the gap between those who can interpret technical plans and those who cannot. Set designers, who are skilled at visualising their designs at full scale, may not see the need for VR. However, for producers and other stakeholders who struggle to interpret 2D plans and small-scale models, VR offers a lifelike, immersive experience that clarifies spatial relationships and design intentions.

Above - *Hamilton* set designer David Korins viewing a visualisation of the show in VR in 2016

Challenges and Realisations

Initially, I developed VR tools aimed at allowing set designers to work directly within the virtual environment, selecting elements from libraries and modelling in real-time. However, it became clear that this approach was not practical. Designers preferred to work within familiar software environments like AutoCAD and Vectorworks. The additional complexity of learning new VR-specific tools proved to be a barrier rather than an aid. Set designers, accustomed to visualising their work accurately within traditional software, found the VR tools unnecessary and cumbersome.
In addition, set designers are not the correct audience; they *do* understand what their design is going to look like at true scale once built.

Simplifying the Workflow

The optimal solution was to use VR as a presentation and communication tool rather than a design tool. This approach involved designers continuing to use their preferred software, with a production visualiser converting these designs into a VR format. The VR setup would then be used to present the designs to producers, enabling them to make informed decisions quickly. This workflow proved effective in other commercial productions, including *Come From Away, Moulin Rouge!*, and further productions of Harry Potter, including the Canadian production in Toronto, where in-house production managers and producers used VR to explore and modify lighting states and set designs.

Practical Considerations and Time Constraints

One of the critical insights gained was the need for simplicity in VR interactions. Producers typically have very limited time - often just five to ten minutes - to review and make decisions. Therefore, any VR system must be intuitive and require minimal explanation. Complicated control schemes or detailed instructions on how to use the VR tools were counterproductive. Instead, having someone on hand to manage the VR setup and guide the producer through the experience proved far more effective. For example, moving nearly all controls from VR controllers to a keyboard with an operator nearby, leaving just teleportation on the controllers.

VR for Sightline Review

A significant advantage of VR is its ability to accurately depict sightlines and spatial relationships from any seat in the theatre. Traditional flat screen renderings can distort these perspectives, creating challenges in accurately conveying what an audience member will experience.

Challenges with Flat Screen Displays

Flat screen displays inherently limit the field of view (FOV) and can introduce distortions that do not accurately represent human vision. The human eye perceives a field of view slightly over 180 degrees, but when this is displayed on a flat screen, it either significantly distorts the image or limits the scope of what can be shown.

1. **Distortion of Stage Size:**
   - When trying to display the entire 180-degree FOV on a flat screen, the image must be stretched. This fish-eye effect distorts the perceived size and scale of the stage. This can

mislead designers and producers about the actual dimensions and spatial relationships of the set elements, and the view from each seat.

2. **Restricted Scope of Space:**
   - Conversely, if the image is kept to scale without distortion, the scope of the space is severely limited. This means that only a narrow portion of the stage and surrounding area can be displayed at once, requiring constant adjustments and making it difficult to get a comprehensive view.

Advantages of VR for Sight Lines

VR overcomes these limitations by providing a true-to-life, immersive experience that matches human vision more accurately. By using VR for sightline analysis, several benefits are achieved:

1. **True Depth Perception:**
   - VR provides stereoscopic vision, where each eye sees a slightly different image, mimicking natural human depth perception. This allows for a realistic assessment of how the stage will look from any seat, including the nuances of distance and spatial relationships.

2. **Accurate Spatial Representation:**
   - With a 1:1 scale model in VR, users can explore the theatre from various vantage points, ensuring that all sightlines are clear and unobstructed. This is crucial for identifying and rectifying potential visual obstructions that might not be apparent in flat screen renderings.

3. **Interactive Exploration:**
   - Producers, designers, and other stakeholders can virtually walk through the space, sit in any seat, and see exactly what the audience will see. This interactive exploration is not only intuitive but also quick, allowing for immediate feedback and decision-making.

The simplicity of VR - just putting on a headset and walking around - makes it incredibly effective for quick assessments. Producers can make decisions in a matter of minutes, confident that the visual experience will meet their expectations and provide the best possible audience experience. This immediacy and accuracy are what make VR an indispensable tool for sight line analysis in theatre production.

Practical Implementation

In practice, setting up VR for sightline analysis involves creating a detailed and accurate VR model of the theatre and set. This model must be calibrated to reflect true-to-life dimensions and include all relevant elements such as seating, stage, and any set or lighting configurations. Once the VR environment is prepared, stakeholders can use VR headsets to explore and evaluate the sight lines and spatial dynamics.

This experience can be enhanced further with the VR visualisation calibrated to match real life elements. An example of this was Preevue’s involvement with visualising early plans for the new King’s Head Theatre. As part of this, our VR visualisation was calibrated to a 1:1 scale mockup of the balcony structure, enabling stakeholders to experience the sightlines whilst being able to experience the real balcony (pictured below).

Stakeholders of the King’s Head Theatre reviewing plans in VR.

Ensuring correct floor-alignment is critical to ensure that sightlines are being accurately relayed. With respect to this, outside-in tracking that relies on external sensors (as opposed to inside-out tracking which uses sensors built into a headset) can provide more accurate tracking.

In addition, VR headsets that use outside-in tracking predominantly use external processing on a PC instead of built-in processing. This enables the use of considerably more processing power to drive the visualisation, reducing the time spent on optimisation and maximising rendering quality.

Conclusion

VR remains a powerful tool for theatre visualisation, particularly in its ability to communicate complex spatial designs to non-technical stakeholders. While it may not replace traditional design tools for set designers, it offers an unparalleled medium for producers to understand and approve designs. By using VR to bridge the gap between technical plans and visual expectations, theatre productions can achieve greater alignment and efficiency, ultimately leading to more successful and satisfying outcomes for all involved.

It is my view that efforts to use a VR environment itself as a design tool are misjudged, as the reality of both creatives’ preferences and production timeframes minimises any individuals’ willingness to work with a new

In a similar vein, between approximately 2017 and 2020, most lighting visualisation software began incorporating support for VR. However, this integration often yields limited benefits. In the context of theatre production, where the majority of setups are framed by a proscenium arch that occupies approximately 30 degrees of the field of vision from a traditional tech desk position, the additional 330 degrees offered by VR are rarely necessary.

Moreover, the extra processing power required to support VR can detract from the primary purpose of the software—high-quality lighting rendering. When systems are burdened with VR's overhead, the rendering performance can suffer, compromising the core functionality of the visualisation tools.

Compounding these issues, poor implementation of VR can negatively impact user experience. Low frame rates caused by incompatible systems, coupled with poorly designed navigation tools—such as floating camera perspectives that are not grounded—can induce motion sickness in users. This not only hampers the effectiveness of VR but also tarnishes its reputation as a valuable tool in the theatre making process.

VR can be an incredible tool - when used appropriately.

E-Tech (Digital Tech)

The concept of an e-tech, or digital tech, emerged from discussions with industry professionals. Traditionally, visualisation responsibilities fall to the lighting department, limiting its benefits to that department alone.

Elliot Smith, a lighting programmer interviewed for this paper, advocated for an e-tech session led by a stage manager. This session would involve representatives from all relevant departments, functioning much like a traditional tech rehearsal but conducted in a virtual environment.

Structure and Benefits of E-Tech

1. Structure of E-Tech:
- **Central Coordination:** An e-tech session would be coordinated by a stage manager, ensuring it runs like an actual tech rehearsal.

- **Virtual Participation:** The session could be conducted either in-person or virtually, with participants joining via Zoom or similar platforms.

- **Scene-by-Scene Progression:** Each scene would be stepped through methodically, addressing lighting, set, video, and other elements in detail.

2. Benefits of E-Tech:
- **Cross-Departmental Collaboration:** Involving representatives from all departments solves more problems collectively than isolated efforts by the lighting department.

- **Cost Efficiency:** Conducting e-tech sessions in a visualisation suite or virtually is significantly less expensive than tech rehearsals in a theatre.

- **Comprehensive Problem-Solving:** With all departments present, potential issues can be identified and resolved early, improving overall production quality.

- **Virtual Accessibility:** The ability to conduct e-tech sessions virtually makes it easier for geographically dispersed teams to participate, enhancing flexibility and collaboration.

Mindset Change and Implementation

1. Addressing Perceptions:
- **Current Perception:** Visualisation is often seen as a time sink, particularly by those outside the lighting department.

- **Proposed Change:** Reframe visualisation as a valuable investment that saves time and money in the long run.

2. Top-Down Support:
- **Producer and Manager Involvement:** For e-tech to be successful, it needs buy-in from producers and production managers. Their endorsement can drive the necessary cultural shift.

- **Resource Allocation:** Allocating specific days for e-tech sessions within a studio or visualisation suite should be seen as a strategic move, reducing the need for prolonged, costly theatre time.

3. Practical Implementation:

- **Initial Investment:** While there may be an initial investment in setting up the necessary technology and training staff, the long-term savings and benefits outweigh these costs.

- **Regular Sessions:** Incorporate e-tech sessions into the standard production schedule, ensuring that they become an integral part of the rehearsal process.

The concept of an e-tech or digital tech session offers a potential improvement to production pipelines. By fostering cross-departmental collaboration, reducing costs, and enabling early problem-solving, e-tech sessions could enhance efficiency and reduce costs. Implementing this approach requires a shift in mindset and strong support from leadership, but the potential benefits make it a worthwhile investment.

Production Visualiser - Workflow Framework

Separating the “Visual Twin” and the “Digital Twin”

I propose that the most efficient workflow would be simultaneously maintaining two master reference visualisation files - the “Visual Twin” and the “Digital Twin.

The concept of having both a "Visual Twin" and a "Digital Twin" is driven by the need to address the distinct requirements of various stakeholders while leveraging the strengths of different technologies. Here’s the logic behind separating these functions:

Visual Twin

The Visual Twin is intended to provide a highly realistic visual representation of the show, constructed from the 3D data provided by all departments. The primary purpose of the Visual Twin is to create a photorealistic model of the production in the venue, which serves several critical functions:

1. **Identifying Potential Clashes:** By visualising the entire set-up, the Visual Twin helps in spotting any conflicts, such as rigging points that overlap with set pieces or other equipment.

2. **Sight Line Analysis:** The Visual Twin enables accurate analysis of sight lines, which is crucial for ensuring that every seat in the house offers a good view of the stage. This data can also be connected to the box office to optimise seating arrangements and ticket sales.

3. **Design and Directorial Insight:** Directors and designers can use the Visual Twin to understand how the show will look in the actual space. This helps in making creative decisions and adjustments before the physical set-up begins.

4. **Producer Approval:** Producers can use the Visual Twin to visually sign off on the production design, ensuring that all elements meet their expectations before moving forward with the actual build.

5. **Collaborative Tool:** Tools like UE5 are ideal for building the Visual Twin because they support a wide range of file formats, offer best-in-class photorealism, and facilitate collaboration through features like pixel streaming and cloud-based sharing.
While the Visual Twin is essential for these visual and collaborative tasks, it is not suitable for all members of the production team due to its focus on photorealism and polygon meshes. This brings us to the necessity of the Digital Twin.

Digital Twin

The Digital Twin retains all CAD details and smart object properties, ensuring the data is optimised for technical and production purposes. This twin is crucial for maintaining the integrity and functionality of the production data across different software and workflows.

1. **Data Integrity:** The Digital Twin preserves detailed technical information, such as dimensions, properties, and specifications of set pieces, lighting fixtures, and other technical elements. This data is essential for tasks that require precise measurements and properties.

2. **Technical Workflow Optimisation:** Different departments, such as lighting and set design, use specific software tools (e.g., AutoCAD, Vectorworks) that are optimised for their workflows. The Digital Twin ensures that these tools can operate with their native data formats, retaining smart object properties and metadata.

3. **File Format Compatibility:** For instance, the lighting department may receive a Vectorworks file with the pros, stage, and balcony fronts, which does not need to be photorealistic but must retain all intelligent data for technical purposes.

4. **Efficient Data Handling:** By separating the visual and technical aspects, the Digital Twin allows for more efficient data handling and avoids the complications of converting high-density polygon meshes into usable CAD data.

5. **Archiving and Future Use:** The Digital Twin acts as a robust archive, preserving all technical data for future productions. This is invaluable for repertory theatres, touring shows, and revivals, providing a detailed reference that can save time and resources in the future.

The separation of the Visual Twin and the Digital Twin is driven by the need to cater to the distinct requirements of visualisation and technical precision:

- **Visual Twin:** Utilised for photorealistic visualisation, sightline studies, design insights, producer approvals, and collaborative efforts.

- **Digital Twin:** Retains detailed CAD data and smart object properties, optimising workflows for technical departments, ensuring data integrity, and serving as a comprehensive archive for future use.

By maintaining these two separate but complementary functions, the Production Visualiser ensures that all aspects of the production are managed efficiently, leveraging the appropriate tools and technologies to meet the needs of different stakeholders.

Workflow

Framework for Best Practices: The Role of a Production Visualiser

Preparation of Production Files - Venue Digital Twin

The first responsibility of the Production Visualiser is to prepare the venue digital twin files in formats suitable for distribution to all departments. This ensures that each department can seamlessly integrate these files into their specific workflows.

1. Creation of Department-Specific Files:

From a central master venue file, prepare multiple versions tailored to the needs of different departments. The required formats include:

- **AutoCAD:** DWG
- **Vectorworks:** VWX
- **General 3D:** FBX, OBJ
- **Detailed Twin:** FBX_DT (Digital Twin FBX, with embedded materials and high detail)
- **Basic CAD:** FBX_BC (Basic CAD FBX, without materials, lower detail, and no high-poly geometry)

2. Ensuring Consistency:

It is crucial to ensure that all production and creative team members use the supplied 3D CAD file instead of any pre-existing files they may have. Continuing to use outdated or separate CAD data undermines the goal of a centralised resource and can lead to inconsistencies.

3. Naming Conventions and Version Control:

Adopt a consistent naming convention to facilitate traceability and version control. Recommended naming format:

- VenueName_FullDate_VersionXX.fileExtension
- Include an attached changeLog.txt noting any changes from the previous version.

This practice ensures that all team members are working with the most up-to-date information and can easily track modifications.

4. Maintaining World Space Positioning:

Ensure that all team members do not alter the supplied CAD file's world space positioning. Maintaining the original file origin across all files simplifies the process of merging and aligning various files from multiple sources. This consistency is crucial for efficient production visualisation and avoids the time-consuming task of realigning disparate files.

By adhering to these best practices, the Production Visualiser can ensure a smooth and coordinated workflow across all departments, facilitating accurate and efficient production visualisation.

1. Creating a Visual Twin

The Visual Twin is a purely visual representation of the show in a venue, integrating 3D data from all departments. This representation will be built using Unreal Engine 5 (UE5), leveraging its powerful photoreal visualisation capabilities and good integration with multiple file formats.

Steps to Create a Visual Twin:

1. **Data Collection:**

- **Set Design:**
  - Export 3D models from AutoCAD in the DWG format.
  - Ensure all objects are converted to solids to maintain geometric integrity.

- **Lighting Design:**
  - Export from Vectorworks using the internal symbols and libraries to ensure compatibility.
  - Use the MVR (My Virtual Rig) format for exporting the lighting rig, which maintains fixture details.

- **Video Design:**
  - Export 3D meshes as an OBJ.
  - If working in Mapping Matter, ensure that "Show All Projector Beams" is enabled in the Viewport Settings panel.

- **Sound Design:**
  - Export speaker placement data in an OBJ or FBX.

2. **Importing Data into UE5:**

- Import DWG files from AutoCAD, ensuring they are converted to compatible formats (FBX or OBJ) using intermediary software like 3DS Max or Blender.

- Import MVR files from Vectorworks directly into UE5 or via a supported plugin (such as Carbon) to maintain lighting fixture data.

- Import OBJ files for projectors directly into UE5.

3. **Integration and Optimisation:**

- Ensure all imported data is optimised for real-time rendering in UE5. This may involve reducing polygon counts and optimising textures.
- Use UE5's Nanite technology to handle high polycount meshes, ensuring smooth performance.

- Align all elements to the venue's coordinate system to maintain spatial accuracy. Establish production-wide worldspace coordinates with every department to ensure that files seamlessly integrate with no need to realign, maximising efficiency.

4. **Collaboration and Updates:**
   - Set up a shared repository using version control systems like Git or Perforce to manage updates and changes.
   - Regularly update the Visual Twin as new data becomes available from different departments.

2. Creating a Digital Twin

The Digital Twin retains CAD details and smart object properties, ensuring the data is CAD-optimised and interoperable.
The focus of the Digital Twin is less on photorealism and more on maintaining the integrity of the information across various software platforms.

Steps to Create a Digital Twin:

1. **Data Collection and Export:**

   - **Set Design:**
     - Maintain original DWG files with smart objects and properties.
     - Use DXF or IFC formats for interoperability with other CAD systems.

   - **Lighting Design:**
     - Keep the original Vectorworks files (.vwx) with all internal symbols and libraries.
     - Export in MVR format for integration with visualisation tools like Capture.

   - **Video Content:**
     - Maintain native project files (e.g., After Effects, Cinema 4D) and export as FBX for interoperability.

2. **Data Management and Integration:**

   - Use a centralised data management system like Autodesk Vault or Vectorworks Project Sharing to manage files.
   - Ensure all exports retain maximum fidelity, using original or lossless formats where possible.
   - For lighting designs, ensure MVR files maintain fixture data and are tested for integration with visualisation tools.

3. **Optimisation and Interoperability:**

   - When optimised CAD is not required, retain point cloud data as source point clouds, subsampled point clouds, or mesh data generated from RealityCapture.
   - Ensure all files are tagged and documented, maintaining a clear log of versions and changes.

4. **Archiving and Future Use:**

- Archive all raw data (point clouds, mesh data) and processed CAD files.
- Use cloud storage solutions like Autodesk BIM 360 or similar for secure, long-term storage.
- Plan for periodic reviews and updates to ensure data remains relevant and useful for future productions.

Best Practices for File Formats and Interoperability

Set Design:
- **Export from AutoCAD:** DWG, DXF
- **Import to UE5:** Convert to FBX or OBJ via 3DS Max or Blender

Lighting Design:
- **Export from Vectorworks:** MVR, VWX
- **Import to UE5:** MVR via plugins or direct import
- **Integration with Capture:** Maintain MVR for visualisation and VWX for detailed work

Video:
- **Export Content from Software (e.g. After Effects):** H264, H265, HAP, HAP-Q
- **Export Surface and Projector Mesh Data:** FBX/OBJ
- **Import to UE5:** Direct FBX/OBJ import of

Workflow Summary

1. **Centralised Role:**
   - Appoint a Production Visualiser to manage and coordinate all digital assets.

2. **Data Collection:**
   - Gather data from all departments, ensuring compatibility and completeness.

3. **Integration and Optimisation:**
   - Import data into UE5 for the Visual Twin.
   - Maintain and optimise CAD files for the Digital Twin.

4. **Collaboration:**
   - Use shared repositories and version control to manage updates.

5. **Archiving:**
   - Securely store all raw and processed data for future use.

By adhering to these best practices, the role of the Production Visualiser ensures a seamless integration of digital assets, enhancing the efficiency and effectiveness of theatre productions.

Distribution of Data - File Formats

Once the Production Visualiser receives and consolidates data from all departments, the next task is to distribute updated information to various team members.
Each member of the team requires specific files tailored to their role and needs within the production.

Below is a breakdown of the distribution process, outlining the recommended types of files each team member will receive and the purpose they serve.

Creative Team Members

Set Designer:
- Files: VWX, DWG, FBX_DT
- Purpose: To provide detailed updates on set elements, ensuring that all modifications are integrated into their design workflow and maintaining high detail for continued work and adjustments.

Lighting Designer:
- Files: VWX, MVR, FBX_DT
- Purpose: To include all set and rigging updates, ensuring accurate lighting design adjustments and compatibility with visualisation software like Capture or Augment3d.

Sound Designer:
- Files: DWG, FBX_BC
- Purpose: To incorporate structural changes and ensure that sound design aligns with the physical layout and acoustic properties of the venue.

Production and Technical Managers

Production Manager & Technical Manager:
- Files: VWX, DWG, FBX_DT, changeLog.txt
- Purpose: To have comprehensive oversight of all production elements, ensuring that all changes are tracked and integrated into the overall production plan.

Administrative and Logistical Team Members

Box Office Manager:
- Files: View from Seat Data (via VR headset or 360° images), Sightline Reports
- Purpose: To assess and optimise seating arrangements, ensuring that sight lines are unobstructed and enhancing the audience’s viewing experience.

Marketing Manager:
- Files: Photoreal Renders (from UE5)
- Purpose: To create marketing materials that accurately represent the production’s aesthetic, attracting audiences with realistic visuals of the set and venue. And to understand any specific sightline adjustments the show is making to the auditorium.

Other Key Team Members

Director:
- Files: Photoreal Renders (from UE5), View from Seat Data
- Purpose: To visualise the entire production, make creative decisions, and ensure that the staging aligns with their vision.

Choreographer:
- Files: Photoreal Renders (from UE5)
- Purpose: To understand the spatial layout and design movements that fit seamlessly within the set environment.

Workflow and Communication

1. Data Consolidation:
   - The Production Visualiser consolidates all updates into the master files.
   - Ensures that each update is reflected accurately and consistently across all relevant files.

2. File Preparation:
   - Files are prepared in the appropriate formats for each team member.
   - Naming conventions and version control are strictly adhered to, ensuring clarity and traceability.

3. Distribution:
   - Files are distributed through a centralised digital platform (e.g., project management software or a dedicated server).
   - Notifications are sent to each team member to inform them of the availability of updated files.

4. Feedback Loop:
   - Team members review the files and provide feedback if necessary.
   - The Production Visualiser incorporates feedback into subsequent updates, maintaining an ongoing cycle of communication and refinement.

By systematically distributing tailored files to each team member, the production visualiser ensures that everyone has the information they need to perform their roles effectively. This structured approach enhances coordination, reduces misunderstandings, and supports the smooth execution of the production from concept to final performance.

It is crucial that all information is routed through the production visualiser to ensure updates are consistently propagated across the team. For example, even if a set designer wants to send a quick update to the lighting designer, who happens to be a close friend, it must go through the production visualiser. This ensures robust data integrity and guarantees that all team members have access to the most current and accurate information.

This centralised approach prevents discrepancies and maintains a cohesive, up-to-date dataset for the entire production team.

Distribution of Data - Visuals and Streamed Media

Pixel Streaming

Overview:
Pixel streaming is a powerful method for distributing high-quality, interactive 3D visualisations over the internet. This technique allows users to access and interact with complex 3D environments from any device with a web browser, without the need for high-end hardware on the client side.

Implementation:

- **Setting Up:** The 3D environment, created in UE5, is hosted on a high-performance server.
- **Streaming:** The server streams the rendered content to users' devices, allowing them to interact with the 3D environment in real-time.
- **Access:** Team members can access the visualisation by simply clicking on a link, making it incredibly user-friendly and accessible.

Benefits:

- **Accessibility:** Allows team members to interact with high-fidelity 3D models from any location without needing specialised hardware.
- **Real-Time Updates:** Changes made to the model can be instantly reflected and accessed by all users.
- **Ease of Use:** Requires no additional software installation, only a stable internet connection and a web browser.

Twinmotion

Overview:
Twinmotion is a robust visualisation tool that enables the creation of high-quality visual experiences and real-time rendering. It is particularly useful for distributing visual data to team members who need to interact with or present the information dynamically.

Implementation:

- **Model Integration:** The 3D model from the Digital Twin can be imported into Twinmotion, where additional details and animations can be added.
- **Export Options:** Twinmotion allows for various export options, including high-resolution images, videos, and interactive presentations.

Benefits:

- **Interactive Presentations:** Users can navigate through the 3D environment interactively, exploring different viewpoints and scenarios.
- **High-Quality Outputs:** Twinmotion produces high-quality visuals that are useful for presentations and stakeholder engagement.
- **Versatility:** Supports a wide range of formats and is compatible with most major CAD and 3D modelling software.

Distribution of Standalone Executables

Overview:
Distributing standalone executable files (.exe) allows team members to run the 3D visualisation locally on their computers. This method ensures that users can interact with the model without the need for an internet connection.

Implementation:

- **Packaging:** The 3D model and interactive elements are packaged into a standalone executable from UE5.
- **Distribution:** The executable file is distributed to team members via secure file transfer methods such as cloud storage services, USB drives, or internal servers.
- **Execution:** Team members can run the executable on their local machines, providing them with a fully interactive experience.

Benefits:

- **Offline Access:** Enables team members to access and interact with the model without requiring an internet connection.
- **Performance:** Leverages the local hardware capabilities of the user's machine, often resulting in smoother performance. However this requires users to have internal components capable of running the program.
- **Simplicity:** Provides a straightforward way to distribute complex 3D visualisations without the need for additional software installations.

Choosing the Right Distribution Method

The choice of distribution method depends on several factors, including the technical capabilities of the team, the nature of the interaction required, and the available infrastructure. Here are some considerations:

- **Pixel Streaming:** Ideal for remote teams and stakeholders who need real-time access and interaction without the need for high-end local hardware.

- **Twinmotion:** Suitable for creating engaging presentations and providing a versatile tool for interactive exploration and high-quality visual outputs.

- **Standalone Executables:** Best for situations where offline access is necessary, or where high-performance local rendering is required.