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Cinematic XR

A Mo-Sys initiative to drive improvement in the image quality from XR volumes.



What is Cinematic XR and why is it needed?

Introduction

In the last 18 months the film and TV sector has seen one area grow substantially - **virtual production**. There are several types of virtual production (VP), but the one generating the most industry interest is shooting real-time visual effects in an LED volume.

Currently the industry refers to this type of VP as 'final pixel' or 'in camera FX', however Mo-Sys refers to it as 'on-set real-time production' as the term 'final pixel' for many VP shoots can be misleading. On-set real-time shoots can be done using large LED volumes, or smaller LED volumes with extended reality (XR), where virtual set extensions are added to the physical LED wall to enlarge the virtual studio space.

The term Extended Reality encompasses Augmented Reality (AR), Virtual Studios (VS), and Mixed Reality (MR). In virtual studios talent is placed in a virtual environment along with physical props to aid the overall illusion. In augmented reality (AR) the user is provided with additional computer-generated content that enhances their perception of reality. Mixed reality (MR) merges AR, VS, and motion captured avatars to create real-

time hybrid experiences where physical and digital objects co-exist and interact.

On-set real-time shoots enable the perspective of the virtual background scene to change to match the camera movement and field of view. The cast and crew can see the actual visual effect shot the cast are in, instead of seeing them being surrounded by green or blue screen. It's a much more immersive experience for all involved in the production.

To date on-set real-time shoots and XR have been driven by live events experts, both manufacturers and service providers. During the height of the pandemic, these companies pivoted toward virtual production as the bottom dropped out of the live event industry. This helped push on-set real-time XR forward but now a more cinematic mindset is required to push the technology to the point when high fidelity images can become the industry norm.

In this article we use the terms 'on-set real-time shoots' and 'XR' interchangeably to mean real-time visual effects shot in an LED volume, with (or without) set extensions.

A Short History

We have arrived at XR thanks to many different advances:

Blue screen 'chroma key' was developed in Hollywood in the 1930s and was primarily used at that time for scene transitions. Larry Butler was the first to use it for a special effect in 1940's 'The Thief of Bagdad' but it didn't become popular until the 1950s.

Process shots, such as back projection, have been used in movies since the 1930s. Fox was the first to use it on film in 1930 and won a technical Oscar for this. Eastman Kodak created panchromatic film stock so the background was exposed properly and more powerful projection lamps made the rear projection screen brighter too. Front projection overtook back projection as the image was sharper. The full potential of front projection was shown by Kubrick during the opening sequence of '2001: A Space Odyssey'.

During the 1970s news studios started using green screen during their broadcasts. Both blue and green are usable for chroma key as these colours are absent within human skin tones.

As CGI was developed at the end of the 1980s and the 1990s, blue and green screen allowed actors to be combined with digital special effects in a more immersive way. Mixed reality was defined in 1994 by Paul Milgram and Fumio Kishino as the virtuality continuum extending from the completely real through to the completely virtual.

Weather visualizations were the first application of augmented reality in television. With their 3D graphics symbols, mapped to a common virtual geospatial model, these animated visualisations constitute the first real application of AR to TV.

The introduction and combination of two game-changing enabling technologies has driven the current wave of virtual production adoption: Epic Games' Unreal Engine, bringing photo realism to filming backgrounds, and the invention of the Mo-Sys StarTracker camera tracking system, connecting the real and virtual filming worlds.

Using these technologies, new advances in virtual production have become possible. Broadcasters have used them to create greater realism for their virtual studios and augmented reality content. Cinematic production companies have deployed them first for onset previz and then more recently for on-set real-time shooting.

Jon Favreau employed XR while shooting The Lion King and The Mandalorian, and later recommended use of XR to the makers of Westworld. These three examples have created huge interest in the industry of the possibilities with virtual production.



XR Creative Freedoms

On-set real-time shooting offers filmmakers opportunities not previously available to them with standard green or blue screen. These include:

Lighting Scenes

Lighting a green screen to separate the talent from the green background without creating excessive light pollution and green spill, requires skill and patience. The complications that come from having to illuminate the green screen brightly, while limiting the green light spill hitting the actors and props, are a challenge on any chroma key shoot and often demand corrections to be done in post-production. Scenes shot in this way cannot be dark either, as the green screen requires significant amounts of light for quality keying.

LED screens generate lighting based on the actual images they are displaying, so it feels more natural and does not require additional lights to correct any spill. LED screens also do not need to be lit for keying and can be dimmed for a moodier scene.

Focus Pulling

Until very recently focus pulling in an LED volume was limited to being between

talent and physical foreground objects. This significantly reduced shot choice and creativity. Mo-Sys' recently released Cinematic XR Focus has enabled more creative story-telling, and allowed the LED wall virtual content to be used interactively as part of the storytelling, and not simply as a backdrop.

Art Design

Shooting a green screen scene where the talent has wild hair, produces challenges for post-production compositors. Not just because of green spill around the outline of the character, but because of the green background showing through between the hairs. LED volume shooting does not have this problem as the light being spilled over the actor's hair is scene based and feels more natural to our eyes than keyed out green screen. With the green spill solved, Art Designers, Costumers and Hairdressers can operate freely in LED volumes and can make the decisions they want to without compromises.

World Building

XR means that a virtual environment can be created from a much smaller LED volume, where there appears to be no joins and no limits to camera panning/tilting. The actors can react realistically to the environment they are immersed within. This helps with matching eyelines, visualising effects and using props more effectively. With camera tracking, advanced effects and set extensions, the scope to create huge realistic worlds is now at our fingertips.

Easier Shoots

Traditional green screen shoots require decisions made in previz to be adapted to what actually worked on set. On set previz improved the situation considerably, allowing composite shots to be previewed live by the Camera Operator, DP, or Director.

With on-set real-time shoots, all of the virtual assets are created in their final quality, and test compositing in previsualisation enables the shot to be fine-tuned before

the shoot even commences. This also aids more accurate matching of virtual and real lighting, which leads to better compositing and more seamless looking shots. Because the visuals are already created and tested in pre-production, there is no need for expensive reshoots. It also means that the weather will not disrupt these scenes.



XR Cost Savings

On-set real-time shoots produce a composited image quality that whilst not to the standard of post-production compositing image quality, works reasonably well and delivers considerable time and money savings. These savings come from:

More Efficient Pre-production

On-set real-time shoots allow for the testing of virtual sets and mocap avatars before shooting even commences. The time spent working out solutions in pre-production, means both shorter production and post-production.

Reduced On-set VFX Errors

Fixing on-set errors in post-production used to be the standard workflow used for VFX production, but it's expensive. Far better to fix any problems before they occur, which is the whole concept of on-set real-time shooting, and the pre-production stage where creative ideas are tried, developed, and proven to work before they are deployed in the production shoot.

Reduced or Zero Post-production Compositing Required

Time and money are saved because compositing happens during the shoot using final quality virtual scenes and components. A lengthening of the pre-production stage is more than compensated for with a shortened post-production stage, with minimal or no downstream compositing required.

Reduced Location Costs

Whether you are filming a globetrotting spy movie, or need to recreate one location during a reshoot, final pixel can make this a possibility without the massive spend usually attached to these types of shoots. Set locations can be scanned on location by a small team and then built into photo-realistic 3D assets that can be used as virtual backgrounds in an LED volume.

Increased Immersive Interaction

Virtual elements can be accurately positioned relative to the camera viewpoint and the talent position. Unlike greenscreen, the actors can interact more naturally with the XR environment, and the LED light landing on and around the edge of the talent helps to sell the illusion.



Current Challenges

To improve the image quality, and from a wider perspective of the overall production value of on-set real-time content, there are several hurdles that need to be overcome:

Experience

Most XR stages have been built by live events companies, with little or no experience of the demands of film production and VFX quality levels. This means that the image quality achievable may not negate post-production compositing, one of the key reasons for using XR stages in the first place.

Technology

The majority of XR stages use LED tiles, LED processors, and LED media servers from the live events sector, which require less fidelity than a VFX film production. With this technology there is often a disparity between what is possible with the virtual scene graphics, and what is possible physically within the LED volume.

Image Quality

Most XR stages use LED tiles and processors with a pixel fidelity that cannot emulate the quality of a traditional non-real-time compositing pipeline. This means that although shooting final pixel using these event LED tiles should save time in post-production, the resultant composite image quality may necessitate additional post-production, which goes against the very reasons for choosing on-set real-time shooting in the first place.

Creative Limitations

XR stages have many advantages, but they also have well-recognised disadvantages such as restricted camera angles due to moiré effects, no A/B camera shooting, mixed scene lighting and no shadows, amongst others. One of the keys to driving up the standard of final pixel virtual production is to overcome these limitations.

Real and Virtual Set Interaction

An XR stage is currently viewed as simply providing a backdrop to a physical stage, meaning there is no interaction between the physical and the LED scene which provides edge and reflective lighting on the talent. In a fully physical set, the camera can move to and focus on any part of the set, so why not within XR?

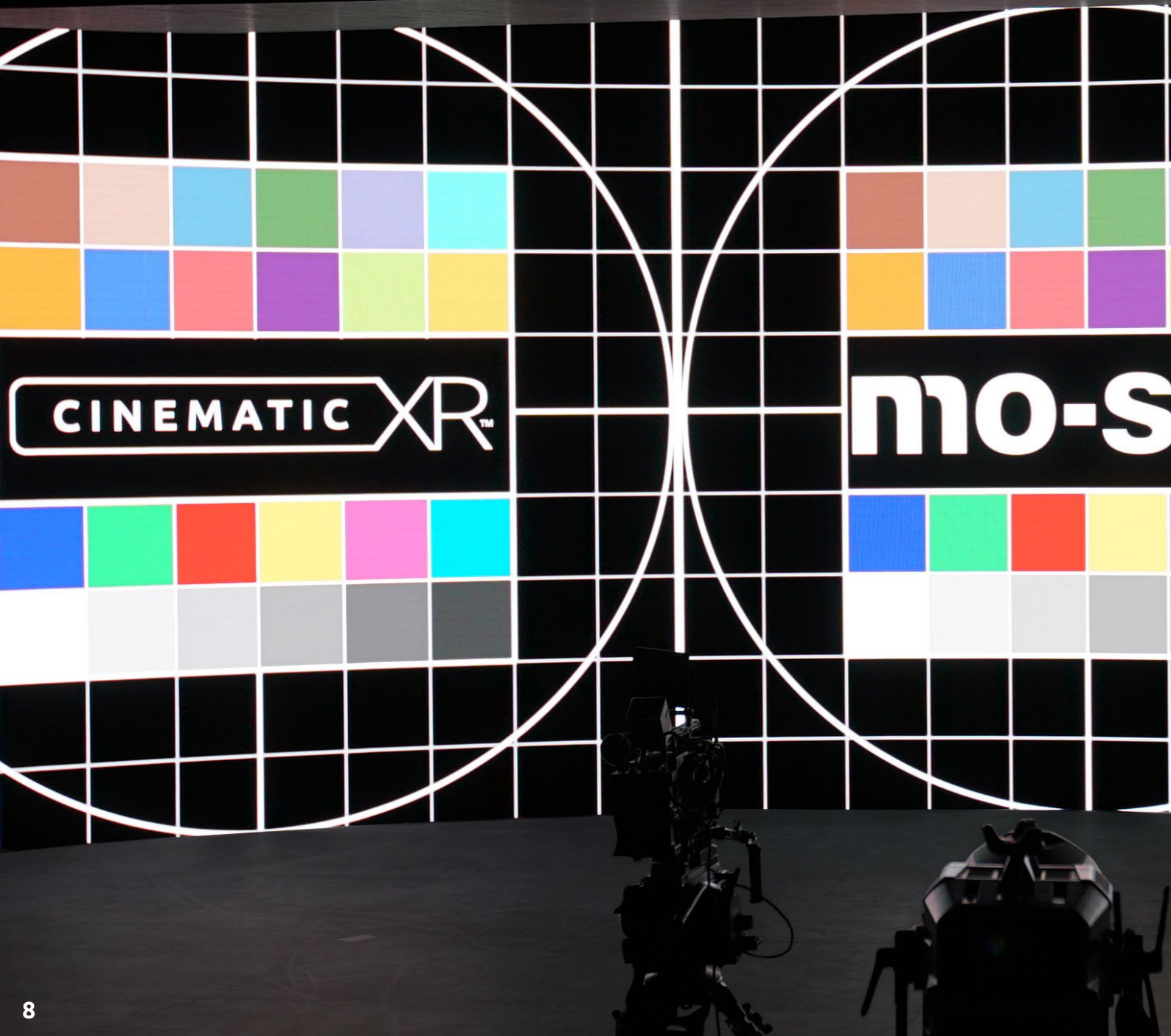
How can these issues be solved? Some, like Moiré, will always be a problem, but it can be reduced or mitigated against. Others require different choices to be made, and some require new innovations to be developed.



What is Cinematic XR?

Cinematic XR is a Mo-Sys initiative to drive improvement in the image quality from XR stages. It's aimed at both ourselves and the industry in general. It focuses on four key aspects of XR:

- Improve pixel and composite image fidelity
- Introduce established cinematic shooting techniques to XR
- Provide seamless interaction between virtual and real set elements
- Enable hybrid workflows combining on-set real-time shoots with traditional compositing, but without the cost increases



Mo-Sys VP Pro XR – The First Cinematic XR Solution

The first Mo-Sys product to be released under Cinematic XR is VP Pro XR.

VP Pro XR is purpose-built scalable XR server designed to work with any size LED wall. It utilises commodity PC hardware with an unlimited node software licence. In addition to the basic XR toolset (mesh mapping, colour correction, and set extension tracking), VP Pro XR will offer unique cinematic tools and capabilities.

It's the platform that Mo-Sys will use to deploy new cinematic XR innovations, such as the new Cinematic XR Focus (a collaboration with Preston Cinema Systems) and the first product to enable seamless interaction between virtual and real worlds.

VP Pro XR combined with Mo-Sys' Cinematic XR initiative, provides Cinematographers with an XR solution tuned specifically to their needs and expectations, ensuring creative shooting freedom and final pixel image quality are state of the art.

Why Mo-Sys VP Pro XR?

VP Pro XR uniquely addresses the key problems with current XR stages:

Experience

Mo-Sys is a well-established and trusted company, originating innovations for film and broadcast. Mo-Sys has been developing cinematic products for more than 20 years and understands the operators, workflows, and expectations..

Technology

VP Pro XR is purpose built for XR stages and has been conceived to work with finer pixel pitch LED volumes that Cinematic XR stages will require in the future for virtual production to become a viable option.

Image Quality

VP Pro XR has multiple approaches to ensuring the highest image quality possible, these include:

- Enhancing pixel fidelity from source to capture
- Improving composite image quality
- Solving inherent image challenges when shooting in LED volumes
- Enabling higher quality virtual graphics in an on-set real-time shoot

Technical Expertise

Mo-Sys has been connecting with Cinematographers, Camera Operators and Focus Pullers since the company started and their input and insight on challenges they have is what drives many of the ideas

behind Mo-Sys' innovations. Providing clever solutions to these problems is what Mo-Sys does.

Creative Limitations

Cinematic XR Focus is the first of many key capabilities that Mo-Sys is adding to VP Pro XR. These features, which are all already possible in traditional film shoots, will soon be possible within XR volume shooting thanks to Cinematic XR.

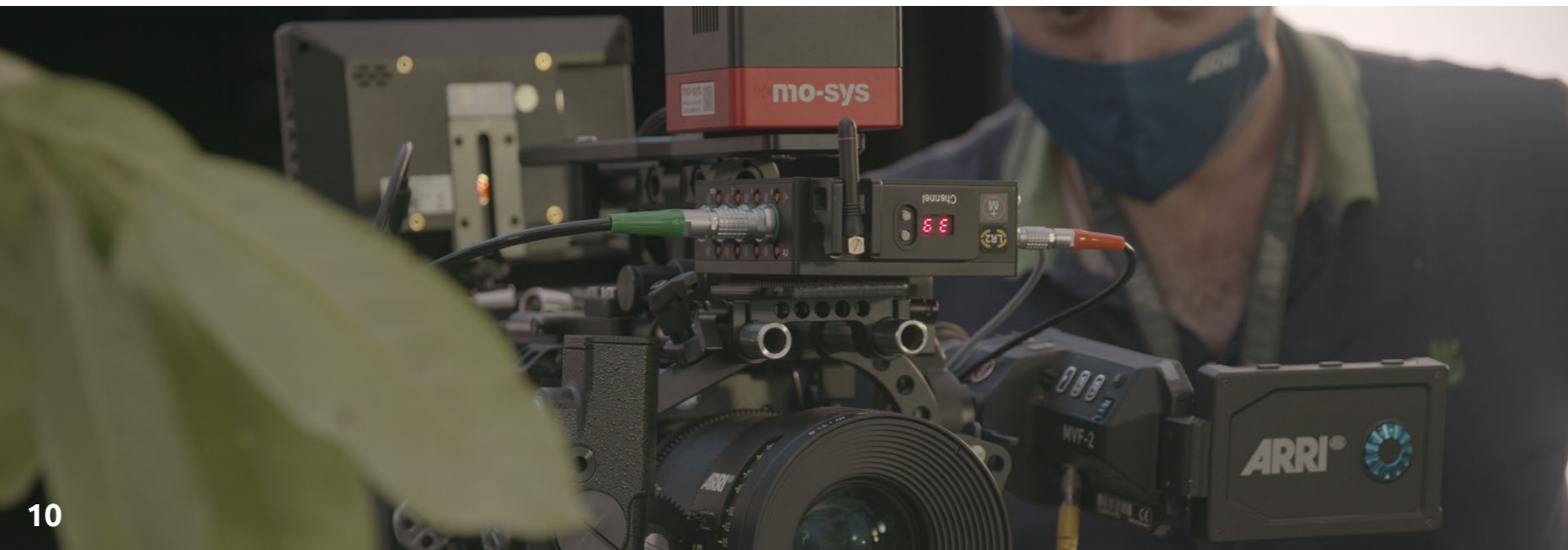
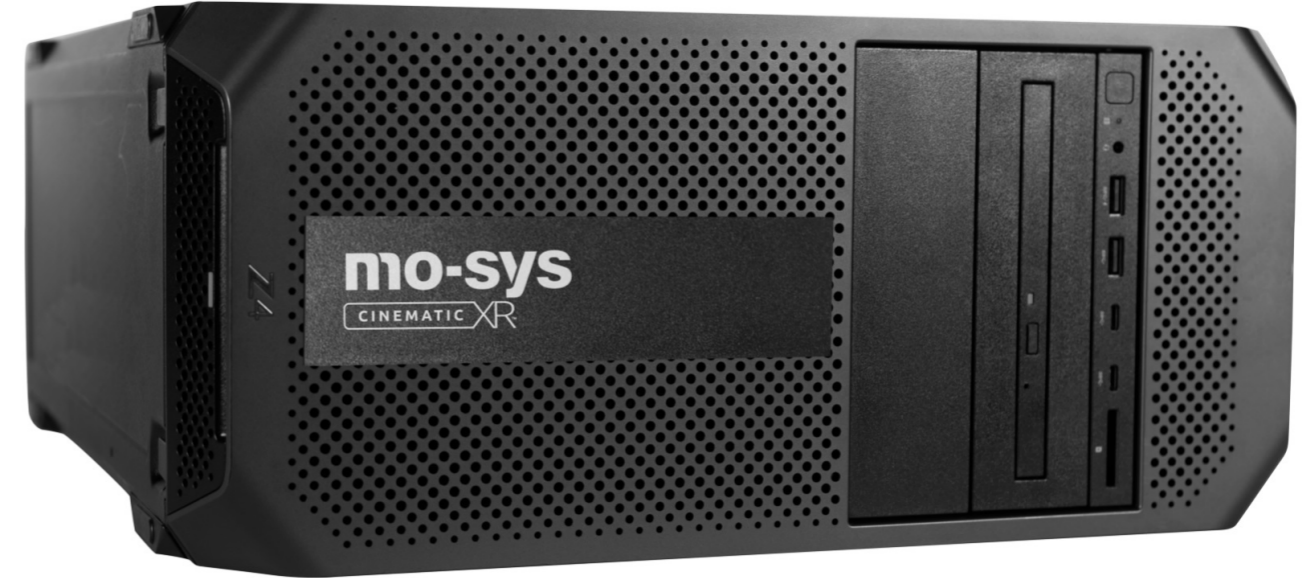
Real and Virtual Set Interaction

Mo-Sys recently released Cinematic XR Focus to ensure that, for the first time, the LED wall can be used as more than just a backdrop and can instead integrate with the real stage. Additional features that build on integrating real to virtual are currently being developed.

Delay

Final Pixel LED volume shooting has an inherent challenge that can't be compensated for – delay. It causes two issues, one being that the virtual image perspective always lags the camera's position, the other being that camera movement speed is limited.

VP Pro XR introduces just 9 frames of delay into the VP pipeline, significantly lower than the industry average at 11-16 frames, enabling greater creative freedom.



Cinematic XR - What's Next?

XR stages and on-set real-time production for film and episodic TV will continue to grow, just as virtual studios and augmented reality for the broadcast industry has grown over the last 20 years. However, for XR to deliver cinematic levels of pixel fidelity, and a composited image quality that is a closer match to traditional post-production compositing, it needs to develop further.

The first deliverable from Mo-Sys' Cinematic XR initiative is VP Pro XR, and whilst this addresses some of the problems with XR stages currently, more innovation and development is needed, and industry wide not just with Mo-Sys. The good news is that this has been ongoing at Mo-Sys for the last 12 months, and Mo-Sys will announce more XR features for VP Pro XR soon.



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