



## Introduction

The demand for high-frame rate (HFR) virtual production is growing, driven by the need for ultra-smooth visuals, enhanced realism, and reduced motion blur in both real-time and recorded content. Supporting 120Hz virtual production presents several challenges in hardware, software, and workflows that must be addressed to ensure optimal performance. This white paper outlines the key requirements, considerations, and best practices for achieving a robust 120Hz virtual production pipeline.

## 1. Benefits of High-Frame Rate Virtual Production

### 1.1 Enhanced Motion Clarity

Higher frame rates reduce motion blur, improving the clarity of fast-moving objects and enhancing realism in action sequences.

### 1.2 Improved Synchronization with LED Volumes

120Hz operation ensures better synchronization between camera systems, LED walls, and real-time rendering engines, reducing artifacts such as ghosting and flickering.

### 1.3 Better Compatibility with Next-Gen Displays

Many consumer and professional displays support 120Hz, making it easier to produce content that can be played back natively on modern screens.

### 1.4 High-Speed Capture for Slow Motion

High-frame rate footage is often used to create slow-motion effects by capturing at 120fps or higher and playing back at a lower frame rate, allowing for smooth, detailed

slow-motion sequences.

## 2. Technical Requirements for 120Hz Virtual Production

### 2.1 Camera Systems

Cameras must be capable of capturing at 120fps with low-latency sensor readout. Key considerations include:

- **Global shutter vs. rolling shutter** – Global shutter sensors help reduce artifacts at high frame rates.
- **High-speed data processing** – Ensure camera output can handle 120fps with minimal compression artifacts.
- **Genlock capability** – Frame synchronization is critical to avoid judder and tearing.

### 2.2 LED Volume and Display Technology

LED walls and projection systems must support 120Hz refresh rates while maintaining low latency and high image fidelity.

- **High-refresh rate LED panels** – Ensure panels support 120Hz natively.
- **Low-latency image processing** – Utilize LED processors that support high-frame-rate input without excessive lag.
- **Scan pattern and PWM management** – Avoid flickering by synchronizing LED refresh cycles with camera shutter speeds.

### 2.3 Real-Time Rendering & Game Engines

Game engines like Unreal Engine must be optimized to deliver 120fps performance.

- **Efficient asset optimization** – Reduce poly counts and texture resolution where possible to maintain stable frame rates.
- **Advanced occlusion culling and LOD (Level of Detail) techniques** – Reduce rendering load dynamically.
- **Multi-GPU scaling** – Distribute rendering load across multiple GPUs to sustain high performance.

## 2.4 Video Processing & Image Pipeline

To support 120Hz, the image processing pipeline must maintain high data throughput and low latency.

- **120Hz-compatible video switchers and routers** – Ensure compatibility with high-refresh-rate signal paths.
- **High-bandwidth SDI or HDMI connections** – Use 12G-SDI or DisplayPort 1.4+ for uncompressed high-frame-rate transmission.
- **Latency minimization techniques** – Optimize frame buffering to avoid unnecessary processing delays.

## 2.5 Motion Capture and Tracking

Tracking systems must operate at high speeds to match 120Hz virtual production requirements.

- **High-refresh-rate tracking sensors** – Ensure optical or inertial tracking updates at 120Hz+.
- **Sub-frame latency processing** – Utilize fast algorithms to maintain real-time tracking accuracy.

## 2.6 Storage & Data Management

HFR content requires significant storage bandwidth and management.

- **High-speed NVMe SSDs** – Use PCIe 4.0+ SSDs for real-time 120Hz video capture and playback.
- **Optimized video codecs** – Use high-efficiency codecs such as ProRes, DNxHR, or H.265 for handling large data streams.

## **3. Major Challenges in Supporting 120Hz Virtual Production**

### **3.1 Increased Processing Power Requirements**

Rendering at 120Hz requires significantly more GPU and CPU resources compared to traditional 60Hz production. Real-time engines must be highly optimized to maintain stable frame rates without performance drops.

### **3.2 Data Bandwidth and Storage Constraints**

Capturing, processing, and storing 120Hz footage generates large amounts of data, requiring ultra-fast storage solutions and high-bandwidth connectivity such as 12G-SDI, DisplayPort 1.4+, or 10GbE+ networking.

### **3.3 Latency and Synchronization Issues**

Ensuring real-time interaction at 120Hz demands low-latency processing across all systems, including cameras, LED walls, and tracking technology. Any delay can result in motion artifacts or misalignment between physical and virtual elements.

### **3.4 LED Panel Refresh Rate and Flicker**

LED walls must support true 120Hz refresh rates while maintaining accurate color reproduction and avoiding flickering caused by PWM (Pulse Width Modulation) cycling.

### **3.5 Heat Dissipation and Power Consumption**

Higher frame rates increase hardware workload, leading to greater power consumption and heat generation. Adequate cooling solutions, such as liquid cooling and redundant power supplies, are necessary to prevent overheating.

## 3.6 Compatibility with Post-Production Workflows

Not all post-production software supports 120Hz natively. Ensuring smooth integration with color grading, compositing, and editing tools is essential for maintaining high-quality final output.

## 3.7 Generating 120Hz Genlock Signals

Since most genlock devices max out at 59.94Hz, supporting true 120Hz synchronization requires alternative approaches:

- **High-Frequency Multiplication** – Using a 59.94Hz base and a clock multiplier to generate a 120Hz reference signal.
- **GPU or Real-Time Engine Sync** – Utilizing Unreal Engine, Disguise, or NVIDIA GPUs as the master sync source.
- **Custom Genlock Generators** – Leveraging custom hardware from manufacturers like Blackmagic or AJA.
- **Dual-Sync Strategy** – Running a hybrid system where cameras use 59.94Hz genlock, while LED volumes operate at 120Hz with predictive rendering.
- **Overclocking LED Processors** – Configuring Brompton, Novastar, or Megapixel VR processors to internally double frame rates and approximate a 120Hz sync.

# 4. Implementation Strategies

## 4.1 Pre-Production Testing

- Conduct **stress tests** on rendering engines and camera systems to verify stability.
- Test **sync performance** between all systems before live production.

## 4.2 On-Set Best Practices

- Use **high-refresh-rate reference monitors** for real-time review.

- Implement **real-time diagnostics** to monitor latency, frame rate, and sync issues.

### 4.3 Post-Production Considerations

- Ensure **color grading and compositing software** supports 120Hz workflows.
- Use **optimized rendering farms** for efficient high-frame-rate processing.

## 5. Conclusion

Supporting 120Hz virtual production requires careful planning, specialized hardware, and optimized workflows. By ensuring synchronization across all components, optimizing real-time rendering performance, and maintaining low latency, high-frame-rate virtual production can deliver unprecedented visual quality and realism. Additionally, the ability to capture footage at 120fps enables high-quality slow-motion effects, adding versatility to creative storytelling. As technology advances, these best practices will continue to evolve, paving the way for even higher frame rate virtual production solutions.