



Google Pixel vs Samsung Gear VR - The first VR device performance comparison between the Challenger and the Veteran

1. Introducing VR as a measurement topic

One of the hottest topics in tech news is Google's new virtual reality (VR) platform, codenamed Daydream. This new platform is Google's first serious step into an otherwise emergent market of VR capable devices. The recently released Pixel phone is the first official device to support Daydream. Contrast that with a mobile VR veteran, Samsung, who first released the Innovator Edition of their Gear VR over two years ago. The Gear VR relies on Facebook's Oculus head mounted display (HMD) technology and external inertial measurement unit (IMU) system. When combined, this technology provides a strong VR user experience (UX).

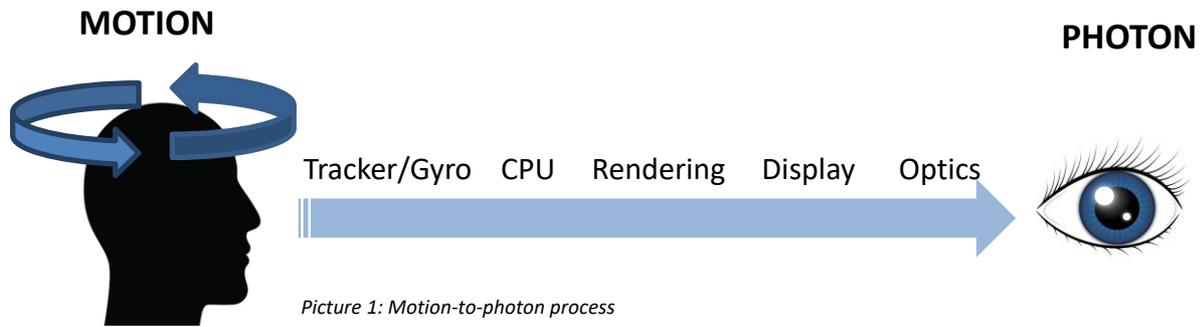
Building a strong VR experience relies on conquering many challenges but the most important are temporal performance, latencies (specifically motion-to-photon also known as M2P), low motion blur characteristics on a display, update speed, and frame update speed. These challenges are considered the main pillars necessary to build a strong and capable UX. With that said, we were anxious to see what Google has determined to be the baseline UX for the Pixel line of devices and to see how a relative newcomer to VR, holds its own against the veteran, Samsung's Gear VR.

2. How did we measure the performance

Until now VR device's performance has not been publicly measured and compared. We have developed a measurement system especially for VR performance measurement. The system is called [OptoFidelity Video Multimeter xR performance measurement system](#) and in this study the system was used to find out the exact values for M2P, display framerate, and persistence. Our method is based on optical flow, and can record both display persistence and M2P latency accurately by analyzing the content flow from the user interface (UI) on a display. This measurement method is non-intrusive, meaning that special hardware or software for instrumentation is not required.

Before continuing, one common misunderstanding is that the content update frequency of a display restricts the M2P of a device when in reality, this is not true at all. For example, a 60Hz and 120Hz display both could have the same M2P latency with the M2P of the 60Hz display set much lower than the frame interval time (16.67ms). Theoretically, there is no reason why the M2P could not be equal to zero. Mobile VR systems have a high data acquisition rate for the gyroscope (typically 1000Hz) that is combined with a motion prediction allows for reaching low motion-to-photon latencies.

A simple real-world example clarifies this phenomenon: rotate your head from side to side and blink your eyes at the same time. Is the scene lagging? No, it is not. Similarly, with mobile VR, the location is updated with near 1ms latency. Like eye blinking, a low persistence display is just showing short millisecond glimpses of the scene. Take for example that 60Hz display from before, the update interval on this display would be 16.67ms.



3. Results - the bar is set both high and low

Measured devices:

- Google Pixel + Daydream View
- Samsung Galaxy S7 + Gear VR SM-R323

A default panoramic 360 photos viewer was used to measure the M2P with both devices.

When comparing the display characteristics of both devices, they both show a similar refresh rate of 60Hz when low motion blur mode is active. In practice, all Mobile VR OLED displays operate at 60Hz when in VR mode. Unsurprisingly, this is the lower limit for an adequate VR performance, but what is surprising is that Google’s Pixel phone follows the low standard set by the mainstream VR industry.

Measurement results

	Google Pixel + Daydream View	Samsung Galagy S7 + Gear VR
Display refresh rate (VR mode)	60 Hz	60 Hz
Persistence	5.1 ms	3.4 ms
Motion-to-Photon latency	< 10 ms	< 10 ms

Persistence

This neat term means, how the objects are blurred on the display while an eye tracks objects from the display. There is not any standard for the persistence value, but a state of the art PC with VR will achieve a persistence value of around 1-2ms. The limit where the subjective experience for some people starts to worsen seems to be around 5ms. The Pixel's 5.1ms persistence value seems to just barely meet that threshold. On the other hand, the Gear VR's 3.4ms persistence value seems to be much closer to the high end of VR capable devices. For example, the brand-new Sony PS4 VR platform has a persistence value of 2.5ms.



Picture 2: a demonstration how persistence blur effects

Motion-to-photon

Both devices achieved a sub 10ms latency, which is a great number for Mobile VR. Google clearly shows with their Pixel phone that it does not require an external IMU to have respectable M2P performance.

4. Conclusions

For both devices, the most critical VR Performance factor - motion-to-photon latency - is in control. Samsung's co-operation with Oculus does not appear to bring any measurable advantage in terms of latency. However, the persistence value is surprisingly high in the Pixel phone. This could potentially cause motion blur that might be distracting for some users. The root cause for this high persistence value remains a mystery. Depending on the OLED technology supplier, there might be some restrictions or even performance issues. One probable explanation could be that Google would like the Daydream ecosystem to be as large as possible. Still, setting the bar this low could lead to an overall compromised VR experience, but only time will tell how the forthcoming Daydream capable devices perform.

Are you interested to learn more? Contact OptoFidelity CTO Kimmo Jokinen,

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Who We Are

At OptoFidelity we thrive for the ultimate user experience by simulating and testing user interactions for smart devices. We are globally recognized pioneers in testing, and our humanlike robot assisted technology platforms are widely used in product development, production and quality assurance. Our products are all equipped with easy-to-use SW tools for test parametrizing, results analysis and reporting tools. We work with the world's largest device manufacturers.

Tight and loyal cooperation with our customers is a key to successful test system delivery. We enable our customers to focus on their own expertise, and ensure the ultimate performance, quality and functionality of their products.

5.



Our People

We are a team of multitalented professionals in the fields of test automation, robotics, machine vision, signal processing and software development. 90% of our people have an engineering degree, and 100% of our people have a hands-on, problem-solving oriented mindset.

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WE'D LOVE TO HEAR IT!

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