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Review: Oculus Rift DK2 - next-level Virtual Reality

13 Aug 2014 | Rasmus Knig Sørensen

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I opened the box from UPS with high expectations. Inside was the second-generation Oculus Rift, also known as Development Kit 2, or just DK2. 13 months have passed since we looked at the first edition of the virtual reality device, and despite its shortcomings it delivered an experience that was unique and novel.

For the first time, you could be transported into a 3-dimensional world, which in many ways felt real because it completely surrounds you, unlike pictures on a flat screen, or a 3D screen for that matter. It is something new and perhaps a new era of digital entertainment. Moreover, it something that is hard to explain in words; you have to try it to understand it. It just feels natural and relaxed, and it is a very special and unexpected experience for most people when they try it for the first time.



First impressions

Let me start by saying that DK2 solves most of the problems that we found in DK1, but unfortunately at the same time it introduces, or enhances, some new problems instead. We are still looking at a development kit and not an end-user product. Or at least not the typical consumer end-user product, as Oculus Rift DK2 will not work with any of the games that you already own. The games have to be programmed to work with DK2, or developers need to release a patch that adds support for DK2.



Oculus Rift DK2 (Photo: Rasmus Knig Sørensen)

The first generation of the development kit had some flaws that made it unsuitable for anyone else than developers and enthusiasts. And even for them it was a bit of a challenge to avoid the nausea. It basically has three overall issues; low resolution, slow display technology (blurring on movement) and missing positional tracking, or in other words the ability to detect when you move your head, aside from the limited tracking of direction. Especially the two latter points meant that most people would get nauseous or feel motion sickness-like symptoms during use. These three problems have been addressed with DK2, and are not issues to the same extend anymore. The motion sickness / nausea problem is almost non-existent after a little getting-used-to.





What's inside Oculus Rift DK2 (Photo: iFixit)

Hardware & improvements

So let's take a look at what improvements DK2 offers.

OLED display

The display has been upgraded from a 1280x800 60Hz IPS LCD screen (same as in the first version of the Google Nexus 7) to a 1080p 75Hz OLED screen. The screen is the same as the one in Samsung's Galaxy Note 3, and the OLED panel offers some key advantages over the IPS panel, mainly in terms of response time and a black level, which is literally perfect.

Oculus VR and Samsung have established a cooperation, which entails that Oculus VR will offer Samsung access to its technology, which Samsung can use to create its own VR glasses that you can slide your Samsung mobile device into. In turn, Oculus VR will get access to the latest display technology - something that we will certainly see in the next version of Oculus Rift. This will also give them a clear advantage over competitors.

Low persistence

*VIDEO IS RAZOR
SHARP NO MATTER
HOW HARD YOU TRY
TO SWING YOUR
HEAD AROUND*

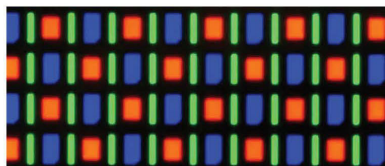
The main reason for switching from LCD to OLED is response time, and the ability to use a method described as 'low persistence' by Oculus. In short, a standard LCD panel holds the same image on the screen until a new image replaces it (60 times per second at 60 Hz). However, this method leads to a blurred image when moving your head around inside the VR world, because the same image is moving with you for 1/60 of a second, even though the image was only accurate in that few milliseconds. With low persistence the image is only shown for a few milliseconds, after which the screen becomes black until the next image appears. Thus, avoiding feeding the brain with wrong information that leads to blurring in practice. The downside is that such an effect reduces brightness a little bit, but you will not notice it with DK2 because of its high native brightness OLED display. The same thing happens on a CRT TV by the way.

The effect of 'low persistence' is overwhelming - video is razor sharp no matter how hard you try to swing your head around. The same thing could certainly not be said of DK1, where you had to sit perfectly still to get a clear and sharp image. The difference is like night and day, and an example of how much it really means to have some of the brightest minds in the industry employed (eg. John Carmack, Michael Antonov and Michael Abrash to name a few).

1080p resolution

Full HD is good enough for games on a monitor, but when stretched over a very large field of view, which is many times larger than the monitor you see in front of you, it ends up looking very pixelated. It is definitely a big upgrade from DK1, and the screen-door effect has been greatly reduced (the visible gaps between the individual sub-pixels that make up a single pixel), but it is still not enough to achieve a satisfactory level of detail on objects farther away than about 15-20 meters.

The OLED panel uses so-called pentile pixels, where sub-pixels are arranged in a diamond pattern, rather than side by side as we know it from the LCD in DK1. This makes the screen-door effect less conspicuous, but not invisible. However, it also means that there are fewer red and blue sub-pixels, and thereby theoretically lower resolution compared to the traditional RGB pixel structure. Below is a photo of how Samsung arranges the sub-pixels on the current AMOLED panels.



OLED Pentile subpixel arrangement (Photo: oled-info.com)

Strictly speaking, and visually, the higher resolution is a big upgrade, and most of the time you tend not to notice the limitations, especially when you get carried away by what you are looking at. My own guess is that 4K resolution is the level where most people would find the pixel resolution completely satisfactory, enabling you to see things at a distance or reading text. Surely 4K mobile displays will be ready in 2015 - I am convinced that this problem will solve itself with the rapid development in mobile displays.

Positional tracking

Another big change is called 6DOF or positional tracking. It is a method to determine the HMD's position in a 3-dimensional space. An obvious advantage of this is that your movements are translated visually and maybe even audibly in the game or application you use. This is an important step in avoiding simulation sickness or nausea, as the body quickly picks up any discrepancy, in what it sees and feels. Additionally, it provides the ability to look at things in the virtual environment, simply by moving your head or looking over edges or around corners. It works great and takes the feeling of presence to the next level.

Another feature of this is the ability to observe the virtual reality world in 3 dimensions: based on the parallax effect; where objects appear to move more slowly the farther they are away. Your body and head are in constant tiny movements that we are mentally unaware of, but this effect is actually used to view the world in 3 dimensions, even with a single eye.





IR leds (Photo: ifixit.com)

DK2 uses an infrared camera to determine the position of the HMD. Behind the front plastic cap are a lot of tiny infrared LEDs that light up through the black plastic. You have to mount the camera so that it faces yourself, like a webcam. The recommended distance is 1.5 meters or 5 feet. It might prove a challenge to set it up at this distance as most people tend to mount it on top of the screen, and thus only about half the recommended distance. It still works, but the space that the camera captures is so much smaller, and it is easy to get out of range. I will definitely recommend that you find a solution as it makes a huge difference.



DK2 camera (Photo: Rasmus Kfing Sørensen)

FOV (field of view)

The FOV or "field of view" is actually a bit narrower than its predecessor - at least on paper. However, this is not always true in practice. With the first development kit you could achieve a slightly larger field of view by making sure that the lenses nearly touched your eyes, close enough to touch your eye lashes. With DK2 you can achieve almost the same field of view without compromising on comfort, even if you have glasses on. In practice this is a big advantage over the more theoretical achievable FOV that DK1 offered.

SDK 0.4

One of the main problems with DK2 is definitely found in its software at this time, simply due to an unfinished and unstable SDK (software development kit) in beta version. There is no doubt that Oculus VR is working hard to solve these problems, but nevertheless you have to spend considerable effort to get the software to play along right now. It is very unsatisfactory, even when you try to remind yourself that it is a temporary problem. We have been promised an update very soon.

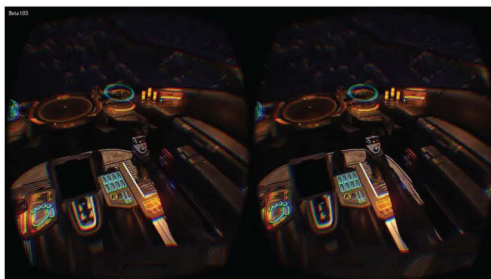
On the other hand, the new SDK (0.4) adds some brand new features. Before, Oculus Rift was treated basically like a regular monitor, but now it has its own driver, which means that each application or game can render directly on the HMD without you having to mess with all the monitor settings. This is a big step in the right direction and it feels more like a plug and play product. In addition, it comes with a configuration utility and a corresponding test program with a virtual desktop. Here you can test and adjust the distance between the eyes, height, neck length, etc. An excellent and easy application that just works.

Chromatic Aberration

An optical problem, which unfortunately affects DK2, is "chromatic aberration". It is visible around the edges of things and objects where you can sometimes notice that red/green/blue are separated, especially when the contrast is high as well as in areas that are farther away from the center of the lens. You also often notice it with wide-angle cameras as you get farther away from the center of the image. If you adjust the lenses properly you can limit the problem.

However, I - and others - have noticed that the problem is non-existent in the configuration demonstration that comes bundled with the SDK (the desktop demo). So it is possible to solve in with software, and that makes me optimistic about eliminating the phenomenon.

The photo below is taken in Elite Dangerous. It's not really an image of chromatic aberration, but rather what the software is doing to fix it. As you can see it separates the red, green and blue colors in opposite directions the farther you get to edge of the image.



Elite Dangerous - Beta (Photo: FlatpanelsHD)

Black Smearing

Even though the OLED panels solves many problems, it also introduces some new ones. The term 'Black Smearing' is new to me, but can probably be compared to good old-fashioned ghosting as we know it from the LCD era. It occurs when there is movement over solid black backgrounds. The same problem is also evident on various smartphones with OLED displays when you scroll text over a black background.

The explanations are many, but it seems that there is no official explanation yet. It is also unclear whether the cause is hardware or if software also has a role in this. The problem exists in some demos, but not in others. We are waiting for an explanation. Personally I do not think it is that distracting, but it undoubtedly looks worse in some applications.

Game tests

The catalogue of games and applications is currently incredibly small. This is partly because so few developers have managed to get their hands on DK2 so far and partly because the new SDK 0.4 is so different than the old one. In other words, existing applications need to be changed before they will work properly with DK2.

Couch Knights

The game is multiplayer and can be played by two people at a time. You are sitting on a sofa, diagonally opposite each other, and can control a little cartoony knight fighting against your opponent's knight. This UDK 4 (Unreal Development Kit) demo was demonstrated at GDC earlier this year, and is undoubtedly one of the most impressive I have seen so far in terms of visuals.

When graphics reach this level it is easy to believe in the universe and accept it. Oculus VR is talking about a state of 'presence'. This essentially means that the brain instinctively accepts it as it is - as reality. Couch Knights is an excellent example of that, and sporadically it achieves 'presence' with DK2. It is a good example of what to expect in the near future, and we should expect even more from the next version of Oculus Rift.



Couch Knights (Photo: theriffarcade.com)

Euro Truck Simulator 2

You play as a truck driver in this immensely popular simulator. When you put your DK2 on you feel just like sitting in the driver's seat of a modern truck. All instruments, including the GPS works just as you would expect, and the graphics are extremely realistic. When you start playing you sometimes get so caught up in the gameplay that you forget it is not reality.

I have invested in a steering wheel and pedals to test some for our DK2 review, and it really offers a more realistic experience. Force feedback, along with HMD, is a combination which can simply trick your brain into thinking that it is reality - at least in sporadic moments. I am really looking forward to seeing if games such as Assetto Corsa or iRacing will work with DK2. On the downside I have to mention that the resolution of DK2 puts a natural limitation on the draw distance (how far into the horizon you can see). This type of games could benefit a lot from even higher resolution.



Euro Truck Simulator 2 (Photo: FlatpanelsHD)

Elite Dangerous

Elite Dangerous is the most popular DK2 compatible game at the moment - and it is not without reason. The game has been specifically made for the purpose, partly because it takes place in a cockpit, partly because all menus appear naturally in the cockpit. And it works great with DK2. We saw glimpses of the same with Lunar Flight, but instead of being a small indie game, we are talking about a thoroughbred AAA title with deep gameplay and 100 hours of play.

If you want to demonstrate DK2 to anyone, this game is a good place to start. The view from the cockpit is phenomenal. It feels just like you are part of Star Wars or Battlestar Galactica. However, I will definitely recommend that you invest in a good joystick, or even better, a HOTAS set. The game is just not the same with a mouse and keyboard.



Elite Dangerous (Photo: Rockpapershotgun.com)

The menus in the game work in such a manner that they "pop up" when you look to the side of the cockpit. With these panes you can control every conceivable thing in your starship in a very natural way. I have never seen such a well-integrated UI in a game before, and it is excellent for the Oculus Rift.

This is surely a demonstration of how well the simulator genre works in VR, and I think it is a genre that is going to explode in popularity with VR. It finally makes sense.

Live For Speed

Live For Speed is the first racing simulator with full support for Oculus Rift DK2. The illusion of sitting in a car is complete. You can look out the windows, turn around and look at the back seats, lean forward against the instruments, and you can even see his arms move naturally - if you own a steering wheel. This is an excellent example of how well it can be done and how natural VR can feel. The combination of DK2 and a good force-feedback steering wheel is simply amazing in Live For Speed - now we just need to feel the g-force when turning.

The game is great, but a few years behind today's graphical standards. This is actually an advantage that makes it perfect for VR, because it allows you to achieve 75fps with all graphics set to max. In fact, I would dare to say that racing is far easier in VR as you have a much better sense of speed and distance. Do not pass on this game, together with Elite Dangerous this is my favorite game for DK2 at the moment.



Live For Speed (Photo: oculusvr.com)

Quake II VR

This VR mod for the original Quake II is also one of the best demonstration so far. Because it is an older game, it is very easy to achieve the very important and constant 75fps. The way that your line of sight and weapon move independently is also very well executed, and the game feels very complete.

This is indeed a great example that the number of polygons and graphics effects is not necessarily equal to a great game. Perhaps we need to scale down the graphics in order to be able to run games in VR?



Quake II VR (Photo: thefartcode.com)

Hardware requirement

Do not expect your old laptop to run any games in virtual reality, or your current desktop PC for that matter. Most enthusiasts and developers who have received DK2 have also found it necessary to invest in new computers, or at least a new graphics card. A Nvidia GTX 780 or Radeon 290X in combination with the latest generation of Intel i7 is currently recommended.

I have tried to test VR with a GTX670, and was often forced to tone down the graphics in games to reach an acceptable result. It was especially bad in graphics-heavy games such as Elite Dangerous, where I had to put everything to the lowest quality. The main issue is often 'stuttering', which means that the video stutters when you look around. If you hold your head still, everything is smooth and runs nicely, but the game needs to reach 75fps to keep up with 'low persistence' technology when using head tracking.

DO NOT EXPECT YOUR OLD LAPTOP TO RUN ANY GAMES IN VIRTUAL REALITY

It may seem a bit exaggerated, but to run a game in 1920x1080 pixels with a stable frame rate of 75 fps, in stereoscopic 3D, is a really heavy task, especially if it is a new game. The rumors says that the consumer version of Oculus Rift (often referred to as CV1) will have a minimum of 2560x1440 pixels and run at 90Hz. This means that you need to run games in at least 75fps and preferably 90fps. Even the most powerful gaming computers will have trouble doing that. There is no doubt that AMD and Nvidia love VR, but the question is just whether or not it will prove a barrier to widespread adoption.

However, this should not be a problem if VR games / applications are made from ground-up to run at a stable frame rate, to run stable at this frame rate. For example, by scaling down the graphics or using the time warp, developed by John Carmack (creator of Doom and Quake). Here is a little video that demonstrates the concept: [Oculus Rift - How Does Time Warping Work?](#)

There are, luckily, also less graphics-intensive applications that will run extremely well. I was very impressed by the VR Cinema demo for DK1, and this does not require a monster of a PC. I look forward to this type of applications for DK2.

Mouse, keyboard and Gamepad does not work in VR

The best game for VR are those that use a natural form of input. For example a racing game where you use a steering wheel or a flight simulator where you use a joystick. It is simply much easier to achieve presence in-game when you eliminate all obstacles and movement in the game is consistent with how you move your hands in the real world.

A first person shooter that requires a mouse or keyboard simply does not feel natural. Oculus VR knows that and is working on a solution, and so are other companies. Several companies are working on translating arm and finger movement into in-game movements by using sensors, and that will enable developers to create a different kind of applications in the future. It will be interesting to see in which direction it takes us.

Conclusion

The Oculus Rift DK2 hardware is not perfect, but there are so many aspects of it that are approaching the acceptable level. Higher resolution, a smaller headset and reduced weight are factors that would all make a huge difference, and in my opinion make the Oculus Rift ready to ship as a consumer product. Hence, if one disregards the software issues and the missing content, the step from DK1 to DK2 is huge, and Oculus VR is promising that the consumer version will be an even bigger step forward.

Developers and enthusiasts, like myself, can already buy the DK2 and enjoy it, as long as you are prepared to wait some weeks or months for more content and more stable software. Some of the games and demonstrations that are out are amazing, but for most people there are still too many software issues and not enough games and applications to justify a buy.

The big question now is when the product will actually launch. Unfortunately, no release date has been made public so you will have to decide whether to jump in now or wait. The price for DK2 is \$350 dollars and it can be ordered directly from [OculusVR.com](#).

positive	negative	target group
Virtual Reality version 2	Too low resolution	Games
Positional tracking & low persistence	New controllers needed	Movies
Perfect contrast, color intensity & brightness	Unstable drivers	Simulation
75 Hz	Software issues	New types of

experiences

Relatively cheap

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