OZO

# OZO AND 360 CAMERA MOVEMENT

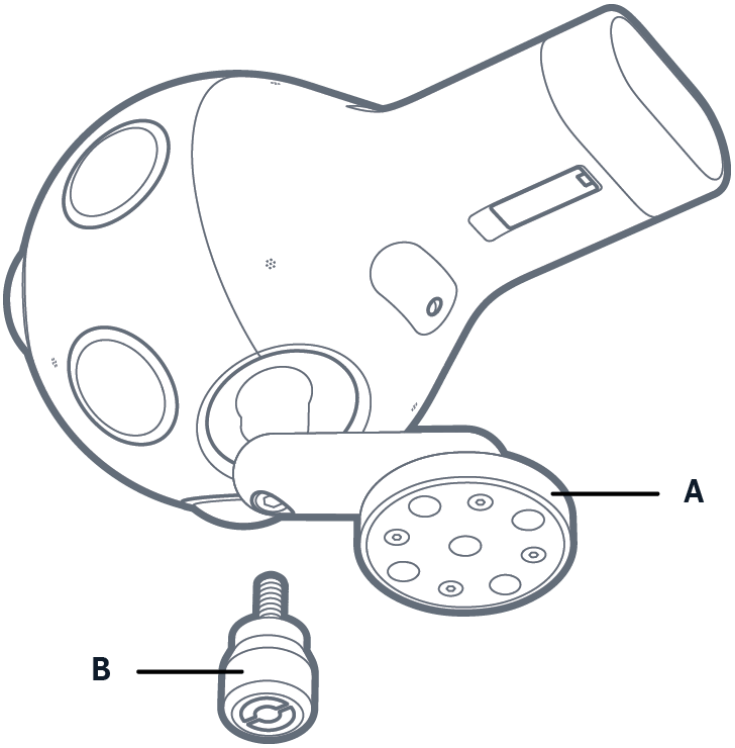
**Updated 11-30-2016**

# Overview

The following manual describes general guidelines for camera movement for both 360 video and OZO specific shooting. The intent of the document is to discuss some technical obstacles and matters of taste. As such, most of the information herein should be considered opinion and not hardened fact.

## Basic Capture Information

- 30fps
- Global and Synchronized Shutter
- 9.3 lbs / 4.2 kg
- Exposure controlled through exposure time/shutter.
- 3/8” 16 mounting point in Small Tripod Adaptor (B), multiple points in Large Tripod Adaptor (A).




## Technical Obstacles

Shooting with OZO removes many of the technical obstacles associated with camera movement on 360 degree shooting. Synchronized sensors and a global shutter means that motion is captured at the identical moment in time across the entire field of view. There are no rolling shutter or sync issues, and the camera can be mounted on moving platforms. The remaining motion considerations flow from the limited frame rate and exposure controls.

Just like a film camera, fast horizontal movement across the field of view can appear “juddery,” especially in bright lighting conditions. This characteristic is a function of temporal aliasing induced by the relatively low

frame rate of image capture and display (typically 30fps). If the scene is brightly lit, the exposure timing will need to be fast and will create this “juddery” effect. The images will be *less* choppy than if created with a mechanical shutter camera and might have a surprising amount of motion blur as compared to other cameras with same shutter settings, but testing and observation should take priority. Note that objects traveling towards or away from the camera are not subject to this effect.

If you plan on doing lots of fast camera movement it is preferable to control the light by dimming, shading or diffusing your sources. This will generate more pleasing looking motion by introducing an acceptable amount of blur.

OZO captures at a frame rate of 30fps. At this speed, it can be challenging to capture detail in very fast moving objects. Often, the best case scenario is to embrace motion blur. Slowing down the shutter, while losing detail, will often make motion look more visually pleasing by introducing an acceptable amount of blur.

## Stitching

Stitching is discussed more thoroughly in, “Shooting for Stitching.” It is strongly suggested that this manual is read before embarking on a 360 video shoot with OZO.

https://cdn.ozo.nokia.com/media/custom/upload/docs/Shooting-for-Stitching-updated-10_05_16.pdf

Creator has two options for stitching, Normal Quality (fast) and High Quality (slow). Normal uses a geometric warp/blend stitch and High uses geometric warp/blend stitch plus an optical flow process. For optical-flow-based stitching; faster movement, non-linear movement, and Inconstant movement tend to be harder to stitch.

For example, a hand-held camera will be doing several different kinds of movement (horizontal, vertical, and even z-axis movement) at different rates of acceleration, deceleration and velocity. Because it is human-controlled, the movement is unpredictable, inconstant and non-linear. As a result, stitching a hand-held shot can be exceedingly difficult. On the contrary, a slow telescoping shot from a telescoping crane or a slow cable-cam shot can work very nicely and stitch well. In some situations, stitching camera movement with Normal (fast) stitching will deliver better and faster results than using High (slow) stitching.

For example, consider a shot where a camera is moving through a large room. The walls are far away, with one person moving in an arc in close proximity but in the opposite direction of the camera. The person is wearing a black and white striped shirt, and the walls are gray. The walls, while moving in each frame, will most likely look good with only a geometric warp/blend. The person, on the other hand, will most likely confound the optical flow algorithm. In this case, the fastest and easiest way to stitch is the following:

- Export using a Normal (fast) stitch.
- Export separate frames per lens where the person is in a seam area.
- Rotoscope or perform additional visual effects work for those frames only.

In essence, cut the person out of the background for those frames that are different in each lens and composite them into the warped/blended background.

# Best Practices

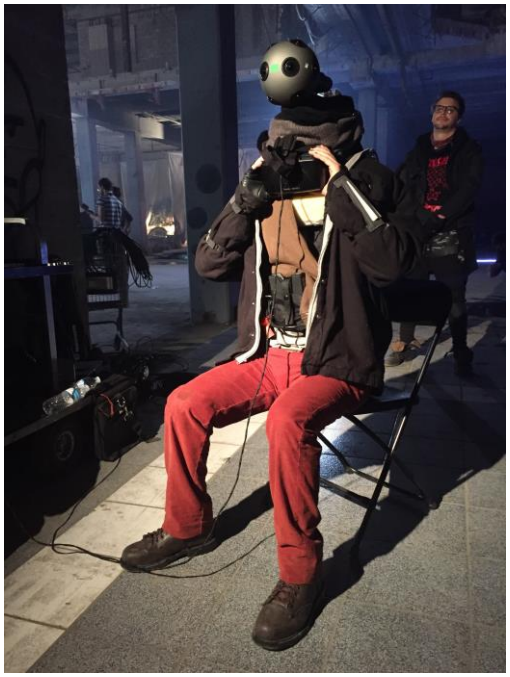
This section will discuss camera movement best practices. The focus is for content intended for playback in VR headsets. Should you wish to deliver to YouTube or another flat/2D player, many of these suggestions do not apply. What we would like to strongly warn against is attempting to apply the same techniques that worked in conventional cinematography to this new medium. Many techniques that are tempting to use in 360 video, may result in audience nausea.

In 360 video, nausea tends to happen when visual imagery seen with the eyes presents conflicting information to the information from the inner ears. This is a complex way of saying that when it LOOKS like we are moving, but we are in fact stationary, we can become nauseated. The inner ear and sense of equilibrium is not registering signals of movement, but the eyes are telling the brain that we are moving. The result is nausea. With this in mind, we can begin applying some techniques for camera motion.

**Speed of movement** will amplify any nauseating effects. The slower the movement, the easier it is to get away with many different types of movement without sickening a viewer. Many things we encourage people NOT do, can be done well if done VERY slowly. If experimenting with movement in 360 video for the first time, it is nearly always better to err on the side of being too slow than too fast. Move the camera much slower than normal, and you will be pleasantly surprised with the results.

**Direction of movement** relative to camera orientation is very important in 360 video shooting. For POV like shots, certain directions work better than others. For example, we typically experience forward movement in “real life.” We experience this type of movement when we walk, run, and drive. As a result, this movement can be quite pleasant. Up-and-down and side-to-side movement tends to be more difficult to integrate gracefully, but can be done well. Slow rising jib or crane movement and slow scanning strafes can be pleasant. Again, speed is key, keep it slow.

**Consistency of movement** is a consideration when moving OZO camera. The part of movement that tends to be jarring is the first few moments of a new movement. For example, if the camera is placed in a car, the acceleration or deceleration of the car will cause the most discomfort. But if the car maintains a constant speed, the jarring will quickly fade and any nausea will quickly subside. The opposite of consistent camera movement is hand-held. Hand-held movement is inconsistent in both speed and direction, and will nauseate viewers if not stabilized.



Example of a camera support that will benefit from very controlled movement and stabilization in post/VFX

**Panning and tilting** tends to cause the most discomfort and dizziness in viewers. Viewers tend to fight the motion and continue to look at the point in space before the pan or tilt. If a pan or tilt is used creatively to invoke this sense of struggling against the perspective, then it might be desirable. Otherwise it is not good practice.

**Stationary Reference Points** can greatly reduce nausea and disorientation. A stationary reference point is anything that maintains its relative location to the camera. Good examples of stationary reference are; dashboards, cockpits, wings, and window panes. For example, a shot that closely follows behind a walking person will appear more stable and less disorienting than the same camera movement not following a person. A shot will be more stable if the camera maintains a consistent distance with the foreground subject.

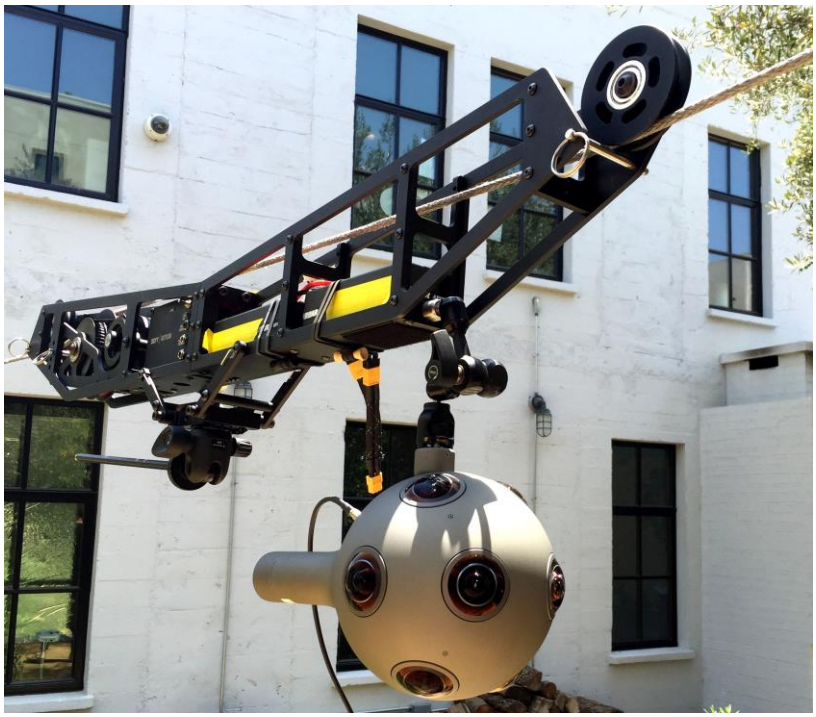
OZO shot with race car cockpit as stationary reference point

## Recommended Supports

It's not sensible to create an exhaustive list of recommended rigs. Generally speaking, we favor camera supports that promote gentle, linear, and consistent movement. The **cable cam** has been a favorite. We have also had good results with **jibs**, particularly with attachments that keep the horizon level. If used to create slow movement, a jib can work well. The slow telescoping movement of a **Technocrane** have produced great results, and can be used to create exhilarating imagery while keeping nausea minimal.

Hand-held, helmeted and Steadicam rigs are challenging. Hand-held and helmeted rigs introduce a lot of chaotic movement that can disorient, jar, and nauseate viewers. That being said, if used very carefully, a helmet rig can work well as a POV mount if the operator stays very still and moves in an extremely slow and controlled fashion. It is also a novel solution to the problem of concealing or painting out camera support.

Steadicams create the same motion challenges as helmeted, with the added obstacle of an operator who must be painted out in post. This is really difficult to pull off, and we have yet to see someone execute Steadicam well without incurring huge post production costs or blacking-out a large amount of the 360 panorama.



The OZO mounted on a cable cam. This support creates consistent and linnear movement.

# CONCLUSION

The guides above are meant to be suggestions only.  We realize we know only the little gained from a couple years of projects. The field is growing and changing daily, and as a result, the techniques outlined in this guide will need to be updated frequently.  The main purpose of this manual is to *emphasize the importance of testing when planning a shoot around camera movement*. There are many techniques to move the camera that have not been tried yet and the most exciting thing about 360 video is the sense of innovation and experimentation

we can all bring to the medium.  Remember, VR is fun, don't hurt your audience and we are all in charge of forging new paths and sharing our experience and knowledge with others. Please do not hesitate to update the **OZO Forum** with any trials and tribulations you may encounter.

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