



SMPTE Education Webcast Series

*SMPTE Professional Development Academy – Enabling Global Education*



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## 360/VR Production: Shoot, Post and Delivery

### Sky VR Studios



**Richard Mills - Technical Director, Sky VR Studios**

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## SMPTE Monthly Education Webcasts



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Series of monthly 60- to 90-minute online, interactive webcasts covering a variety of technical topics

Free professional development benefit for SMPTE members

Sessions are recorded for member viewing convenience.

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## Your Host



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Joel E. Welch

*Director of Education  
SMPTE*

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## Guest Speaker



Richard Mills

Technical Director  
*Sky VR Studios*

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- 1 - Shooting for VR – Camera Attributes**
- 2 - Shooting for VR – Camera Operating, Shooting tips**
- 3 - Shoot variants and Planning**
- 4 - Post production overview**
- 5 - 360/VR pipelines within a Broadcast infrastructure**
- 6 - Content Delivery – Next Steps**

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## **1- Preferred camera attributes**

The ideal camera system would have.

- **360 capture capabilities**
- **Small lens interaxial distances to enable close Camera to Subject distances**
- **Stereo imagery capabilities**
- **Sensor synchronisation and genlock**
- **Small form factor**
- **Low power consumption**
- **Easily managed data capture and transfer functions**

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## 360 Camera overview

There is currently considerable ongoing development in 360 camera market with models and manufacturers appearing and disappearing.

Design and manufacture is not a simple task, principally because the required small form factor introduces optical component quality and heat generation and dissipation issues

The majority of current 360 capture is achieved with the following camera systems

- GoPro camera-based arrays (3- to 14-camera types)
- Larger Professional Movie camera arrays
- Small twin lens systems
- Bespoke integrated 360 camera designs

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## 360 Camera attributes - GoPro camera arrays



“Diamond”



“Broadcaster”



“Explorer”

**Advantages:** Capable of close camera to subject distances, cost effective

**Disadvantages:** Poor reliability (overheating), synch issues between cameras

Complicated data management and battery charging

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## 360 Camera attributes

### Movie camera based arrays



“120° Fisheye”



“Huccio”



“HeadCase”

**Advantages:**

Very high resolution systems. Very large data volumes

**Disadvantages:**

Greater size means: greater subject to camera distances  
 Poor stereo imagery, high power consumption

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## 360 Camera attributes – Bespoke 360 Camera solutions

### Current commercially available 360 camera options



Nokia Ozo



Jaunt One



Z Cam S1



Yi HALO (Jump Mk 2)

### 360 Cameras in Development



Panasonic AW-360C10



Z Cam V1 Professional



Z Cam S1 Pro



Insta 360 Pro

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## 360 Camera attributes – Bespoke Twin-lens systems



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Ricoh Theta S



Kodak Pixpro 360



Nikon Keymission 360



Samsung Gear 360

Advantages:

Simplicity of operation, effective, small form-factor

Disadvantages:

Moderate resultant image resolution, no stereo imagery

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## 360 Camera attributes

### GoPro-based systems

#### Freedom 360 Camera arrays



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“Diamond”



“Broadcaster”



Images from Freedom 360

“Explorer”

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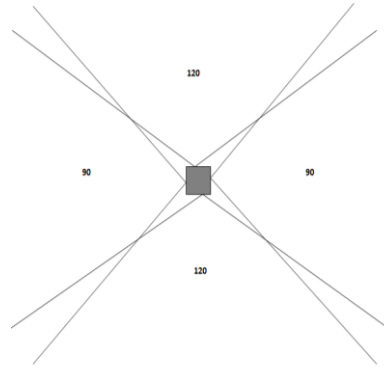
## 360 Camera attributes

### GoPro-based systems

#### Freedom 360 Camera arrays



“Diamond”



Close action “Dead-Zones”: 1m

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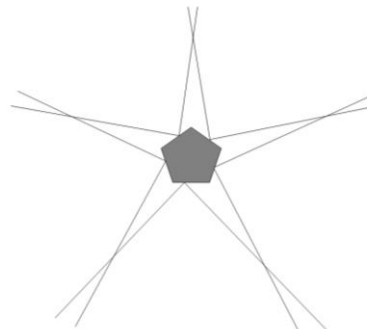
## 360 Camera attributes

### GoPro-based systems

#### Freedom 360 Camera arrays



“Broadcaster”



Close action “Dead-Zones”: 0.5m

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## 360 Camera attributes

### GoPro-based systems

#### Freedom 360 Camera arrays



#### Colour Management settings

Frame aspect ratio: always 4:3 for overlap

1920 x 1440 – “1440” mode

For high frame rate action 50, 60 or 80fps

2704 x 2028 – “2.7K 4:3” mode

For higher resolution and slower action

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## 360 Camera attributes

### GoPro-based systems

#### Freedom 360 Camera arrays



#### Colour Management settings

Protune (PT) - Advanced Colour settings

Colour balance – NATIVE (approx 5,600°K)

Colour preset – FLAT (pseudo-log capture)

Max ISO: 400 – to avoid picture noise

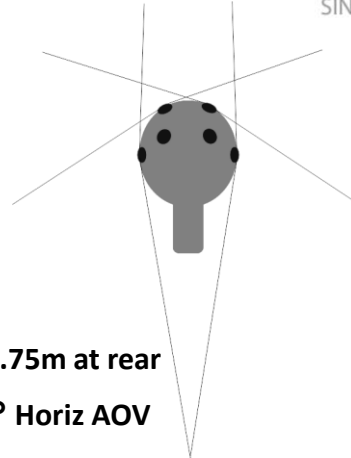
Sharpening: MED (1440), or LOW (2.7K)

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## 360 Camera attributes

Nokia OZO



Close action “Occlusion-Zones”: 0.3m at front, 0.75m at rear  
But stitch lines are adjustable as lenses are 190° Horiz AOV

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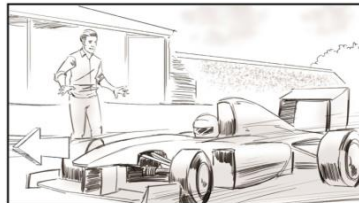
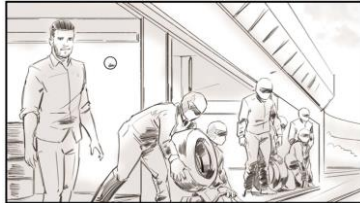
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## 2 – Camera Operating

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## Camera operating – Shooting tips



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## Shooting Tips – 360 Storytelling

**360 storytelling is similar to any movie or TV narrative**

**It works on the techniques built up over the last 120 years**

- **Framing the subject**
- **Action within the frame**
- **Attraction to a part of the scene to highlight the narrative, or**
- **Distraction of the viewer to introduce action in another part of the frame**
- **The only difference is the size of the frame**

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## 360 Storytelling dissected

- 1 - Framing the subject: Shot Composition and Lighting are key
- 2 - Action within the frame:
  - In a headset the viewer will be affected by natural defensive actions:
  - Camera motion will tend to orientate their gaze in the direction of travel
  - Moving objects in the viewer’s peripheral vision will affect the viewer
  - Objects or subjects close to the camera will have a greater presence
- 3 - Attraction or distraction – this can be Visual or with spatial Audio cues
- 4 - Orientational continuity: Shot transitions must have relevant directional cues

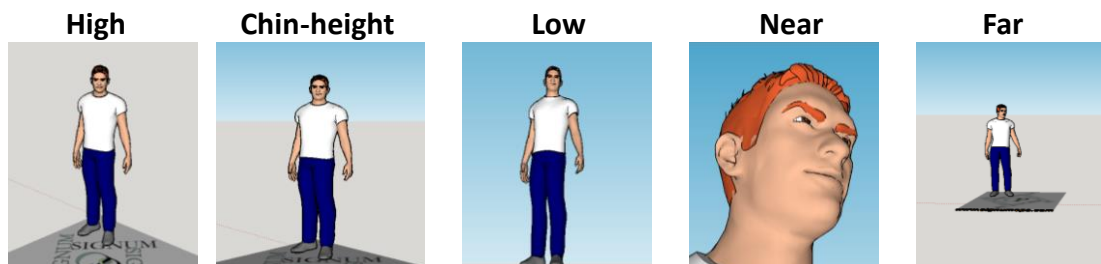
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## Camera operating – Camera height

GoPro 360 is a wide-angle perspective system

Camera height and subject distance to camera are critical factors



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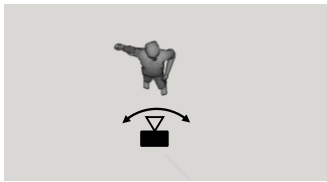
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## Camera operating – Camera Movement

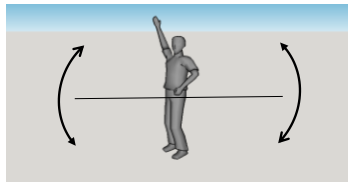
Human perception dislikes a disconnect between Visual and Motion stimuli

In ascending order of distress:

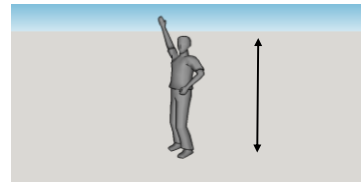
Yaw (Pan)



Roll



Vertical bobbing



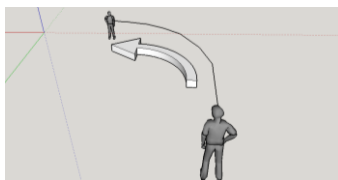
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## Camera operating – Camera Movement

Tracking from one point to another

No



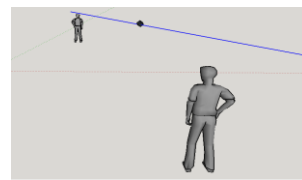
Camera turn

No



Head-Rig

Yes



Zip-wire

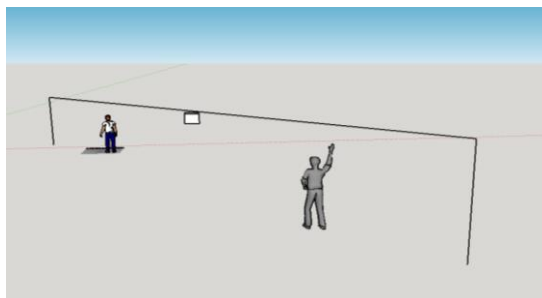
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## Camera operating – Camera Movement

The camera can be moved during a shot if the motion is credible  
or disbelief can be suspended

- Zip wire (Bird pov)
- Mounted to a vehicle
- Giving the viewer agency



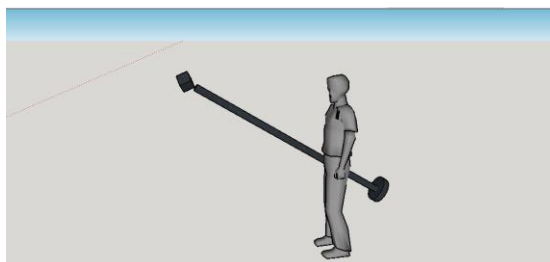
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## Camera operating – Camera Movement

The camera can be moved during a shot if the motion is credible  
or disbelief can be suspended

- Tracking shot from human POV  
eg: with Gyro-stabilised pole  
or Remote control buggy



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## 3 – Shoot variants and planning

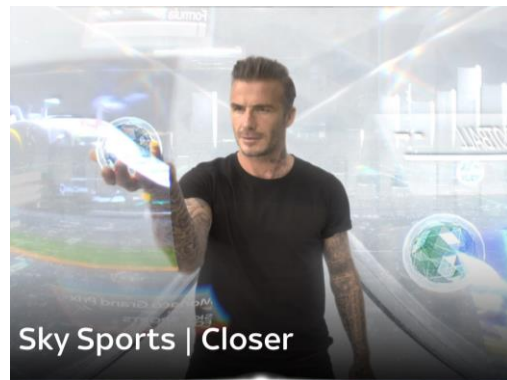
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## 360 Native Shoot or Compositing routes

**360 Shoot – Fast and effective**

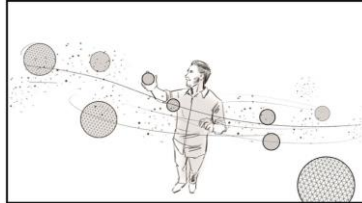
**VFX Shoot – Greater scope  
but higher cost/time in Post**



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## Sky Sports – Closer: Concept

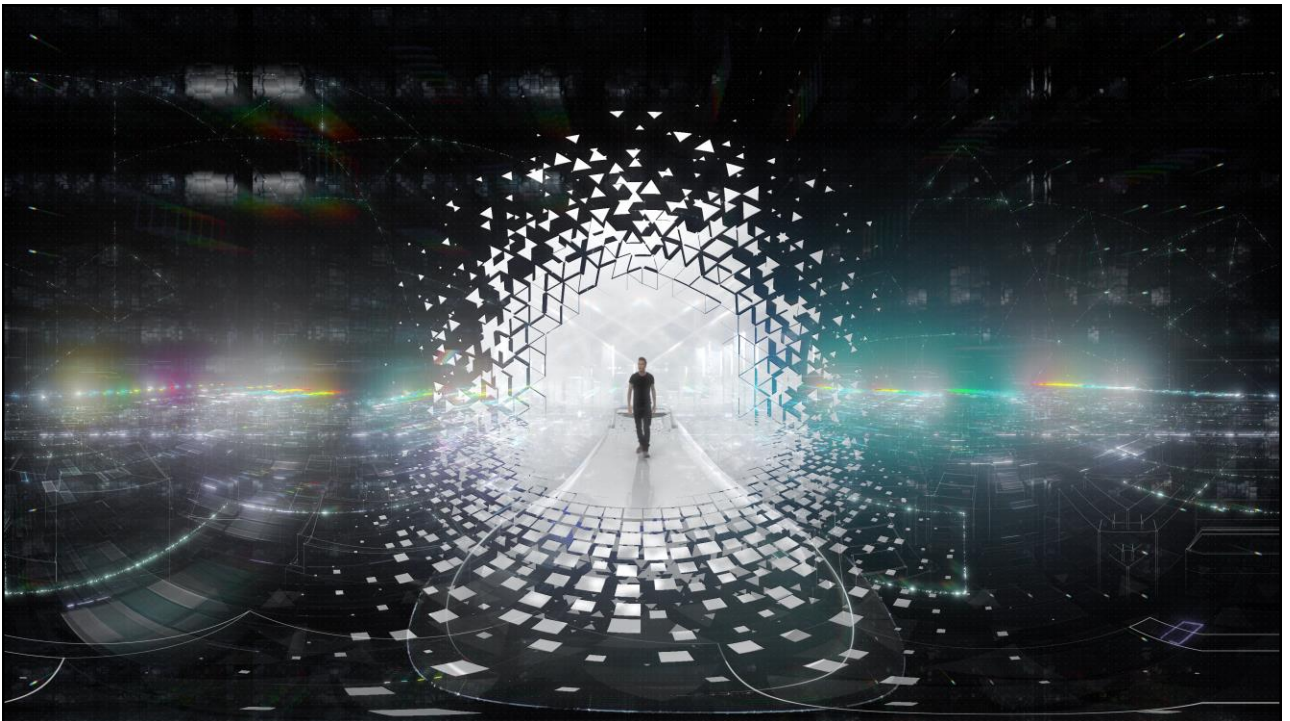


David Beckham in Virtual hub with content circulating as “Micro-worlds”

Composite shoot – Single camera Foreground, 360 Background plates

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## Sky Sports – Closer: The Shoot



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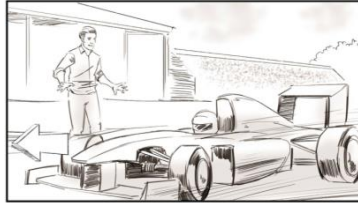
Practical prop and Lighting effects for “Micro-worlds”



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## Sky Sports – Closer: Shot Planning



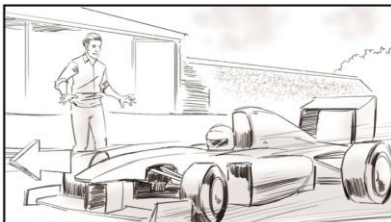
**David Beckham at Silverstone with Williams F1 Team**

**360 Silverstone Background Plate clip had been shot previously**

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## Sky Sports – Closer: Integrating action



**Resolve virtual camera height and perspective: 4K, 12mm , 10° declination**

**Measure scale and distance – walk trajectory and timing**

**Direct the action**

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## Sky Sports – Closer: Planning

### 1 - Pre-shot content – Match action

**F1: Williams**

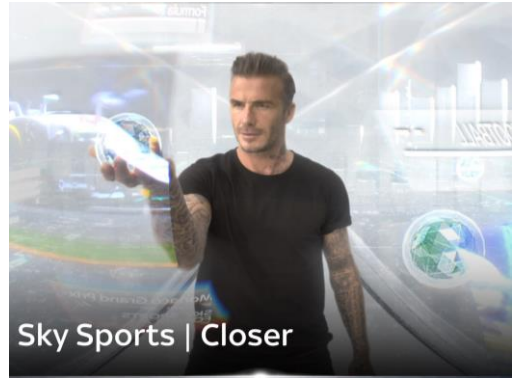
**Football: Final**

**Boxing: Anthony Joshua**

### 2 - Post-shot content–Direct the shoot

**Cricket: Lords Test**

**Golf: British Open**



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## Alternative Shooting Techniques for VR

**Giselle VR**

**with Tamara Roja**

**Director: Dan M. Smith**

**VFX Super: Richard Mills**



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## Alternative Shooting Techniques for VR

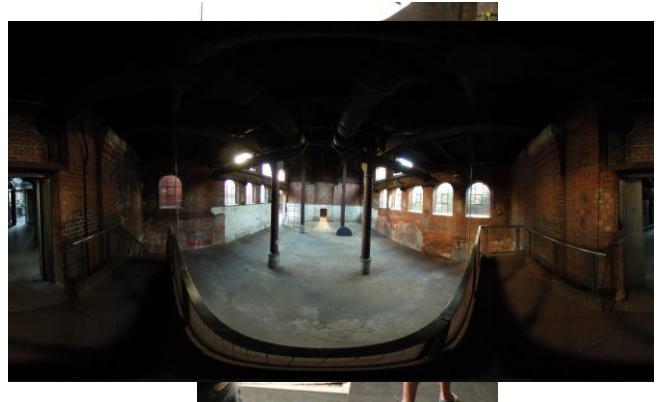
Giselle VR

3D 360

Nodal spherical arc

Freehand Camera moves

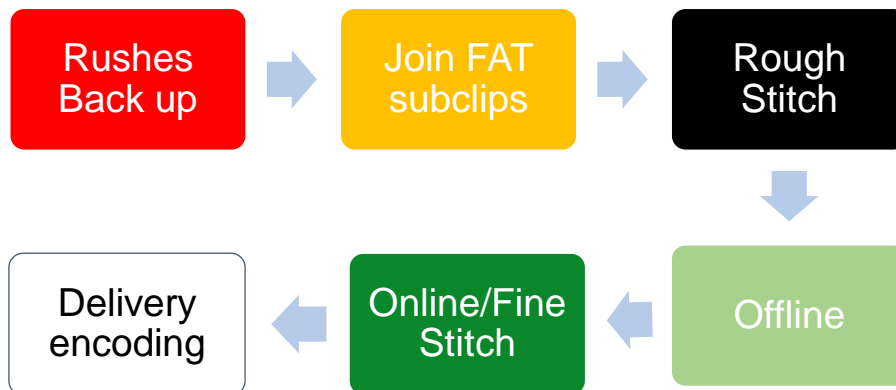
Motion Control Background



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## 4 - VR Post Production – an overview



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## 5 – 360/VR pipelines in a Broadcast Infrastructure

**Commissioning or Acquisition of 3<sup>rd</sup> party Content**

**Delivery Specification                      Compliance**

**Master programme file delivery**

**QC                      Delivery encoding                      QA**

**Comfort/Age Rating**

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## 360/VR Technical Specification

**Content Creation Guidelines – Motion, Orientation, Comfort**

**Content Technical Specification for Master file**

**4096 x 2048 , 10-bit, 4:2:2 colour sampling, Progressive 25 to 120fps**

**MXF, IMF, DnxHR HQ, ProRes 422 HQ**

**Audio: Preferably Spatial WXYZ, or 5.1, or Stereo**

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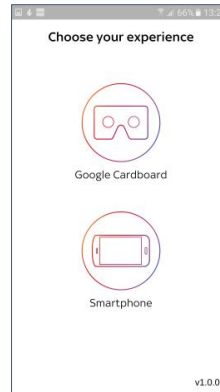
## Design and implementation of a VR App

### Sky VR App

#### Timeline:

**April 2016:** Sky VR announced

**October 2016:** App launched



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## VR App – Platform Aims

Mobile Phone, Cardboard and Tablet

GearVR Store

Oculus Rift

Facebook

YouTube



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## VR App – Content Aims

5 Sky UK Genres:

Sport



Arts



News



Entertainment



Sky Cinema



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## VR App – Content Aquisition

In-House Production

Commissioned Content

Acquired Content

26 pieces of content at launch, now average 40

20 In-house, 3 Commissioned, 16 Acquired

2 in-house productions per month going forward

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## VR App – Design Specification



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**Ease of Use – Brilliantly simple**

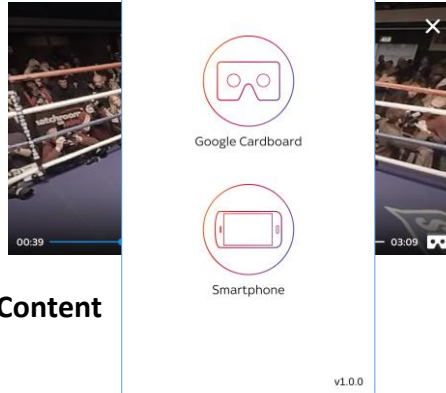
**UI designed to be intuitive**

**High quality content**

**Reliability of playback**

**Choice of Download or Streamed Content**

**Headset or Tablet mode**



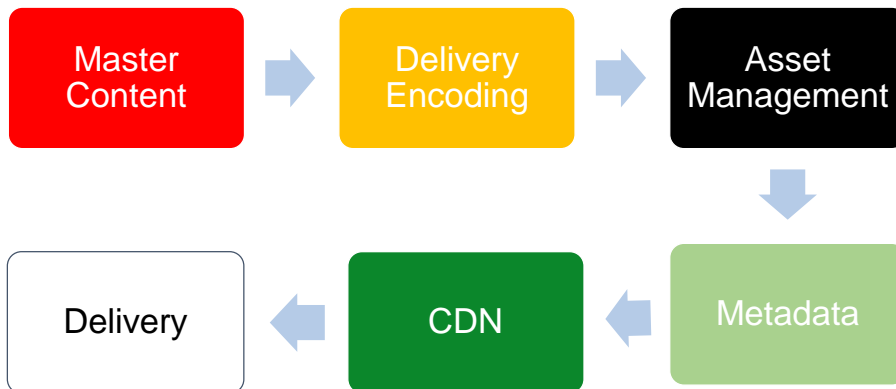
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## VR App – Content Management



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## 6 - Content delivery – Next Steps

Content streamed/downloaded: compromise – Speed, Volume vs image quality

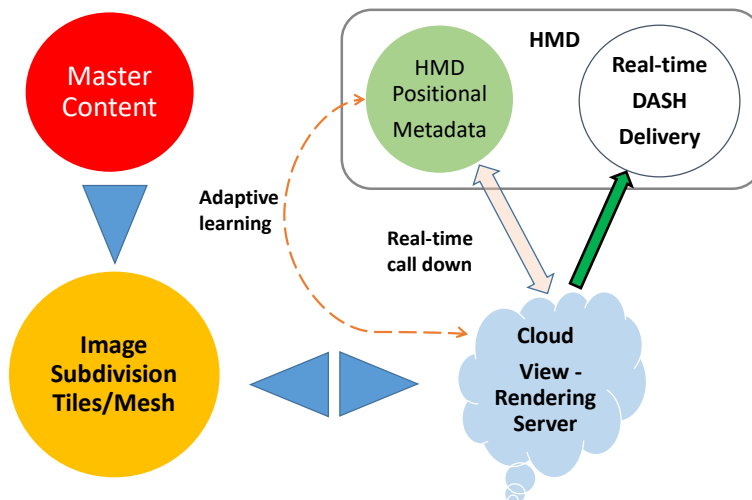
New approach: Field-of-view Adaptive delivery

- Content is resident on Cloud server – quality is better than Download
- “Viewport” is delivered to HMD in Dynamic Adaptive bitrate Streaming (DASH)
- Low latency essential to avoid user disorientation: 50 – 100ms max
- System can have pre-programmed sweet-spots or intuitive machine learning
- 4-15Mb/s with this service is equivalent to 10-60Mb/s of whole scene content

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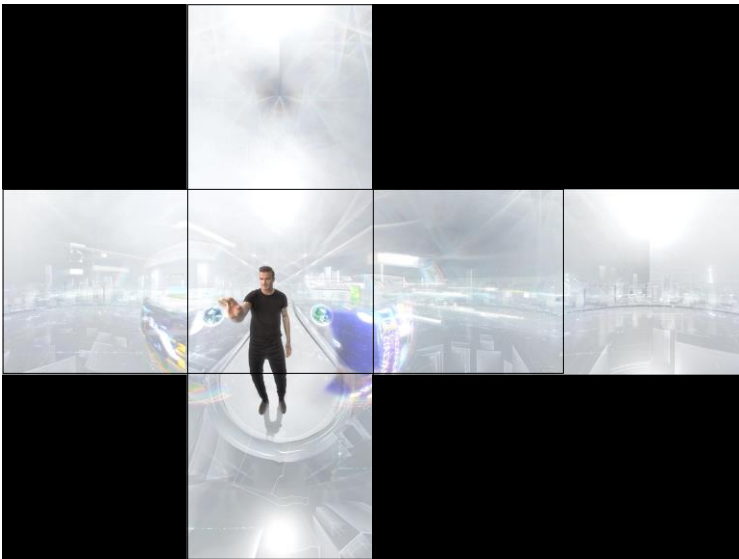
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## FOV Adaptive: Real-time delivery



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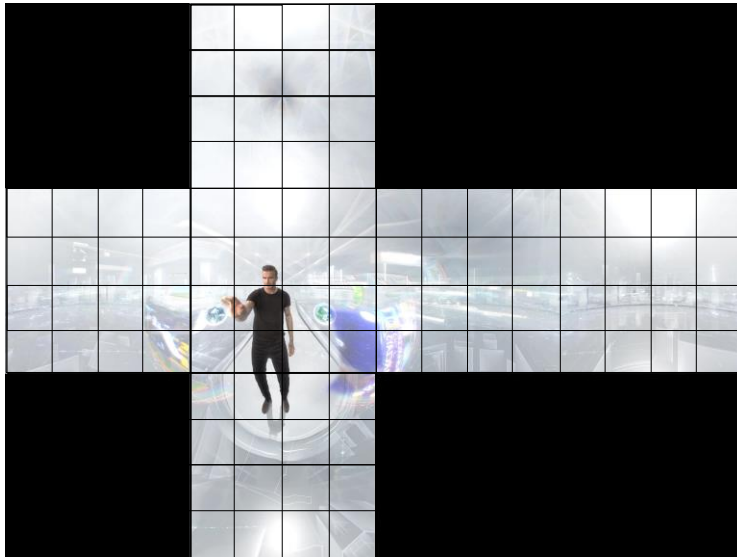


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**Project Spherical image  
as Cube Projection**

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**Subdivide Cube Projection  
into a mesh and  
Encode as tiles**

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**Using HMD Positional Info:  
Deliver respective tiles**

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## 360/VR Production: Shoot, Post and Delivery

### Sky VR Studios

Richard Mills - Technical Director , Sky VR Studios

[richard.mills@sky.uk](mailto:richard.mills@sky.uk)



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