



DriveClub Audio: From Console to VR

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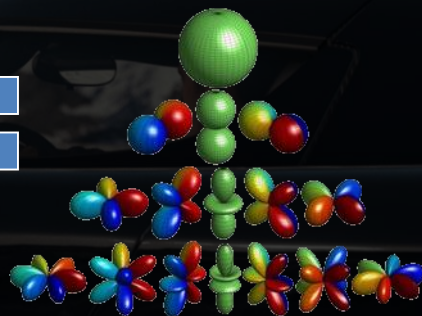
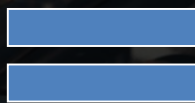
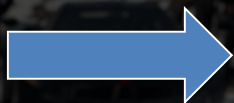


Who am I?





What is the talk about?





Background



Apex





Constraints

- Time – 7 months
- Resource – not much
- 114 tracks 80 cars
- 30fps -> 60fps





Option 1 – Stick with 7.1?

- + Little work to do
- + PSVR has virtual surround processing
- Lacks any height
- Can do better!





Option 2 – HRTF 3D Objects?

- + Good spatialization
- + Used on other projects
 - Requires for assets to be designed with it in mind
 - Mixing and DSP needs to be altered





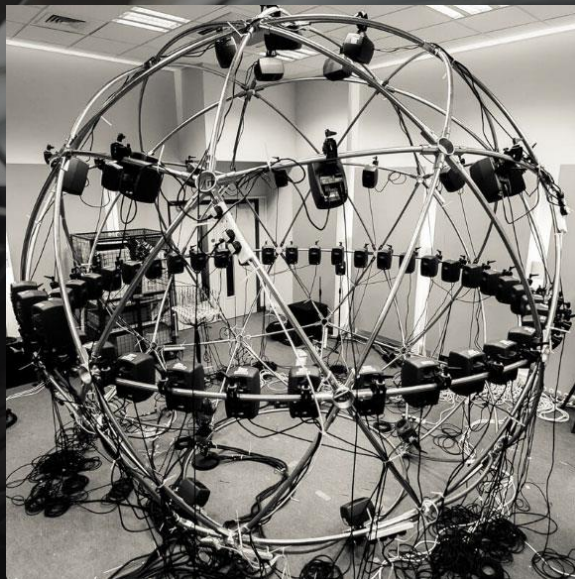
Option 3 – Ambisonics

- New feature so little experience with it
- + Provides full 3D periphonic soundscape
- + Mixer changes should be limited
- + DSP possible in similar way to console
- + Exciting!





What is Ambisonics?



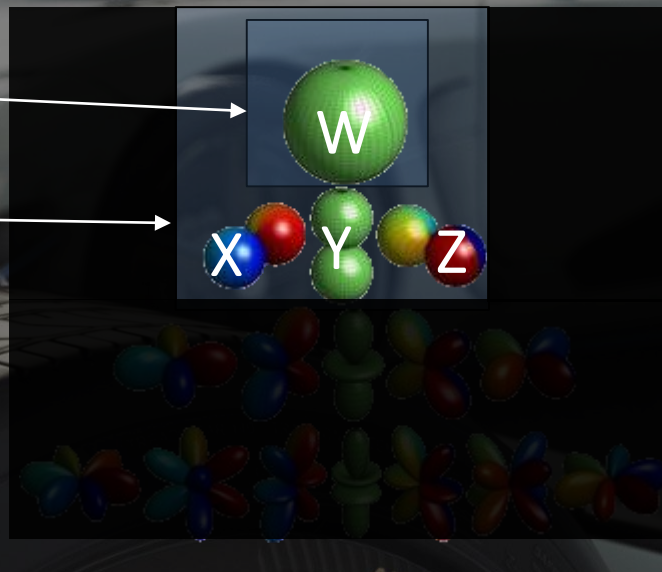


Ambisonics - Orders

Uses a minimum of 4 channels for first order to describe a 3D soundfield

0th Order

1st Order





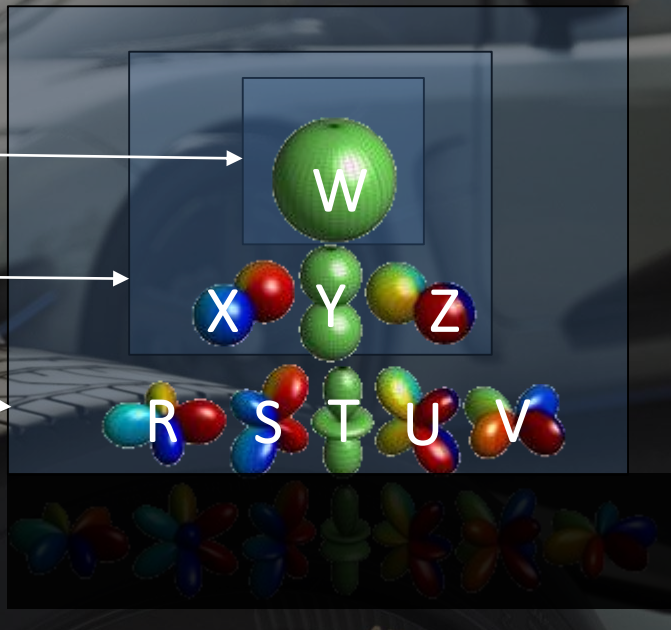
Ambisonics - Orders

2nd Order uses
9 Channels
and has better
spatial
accuracy

0th Order

1st Order

2nd Order





Ambisonics - Orders

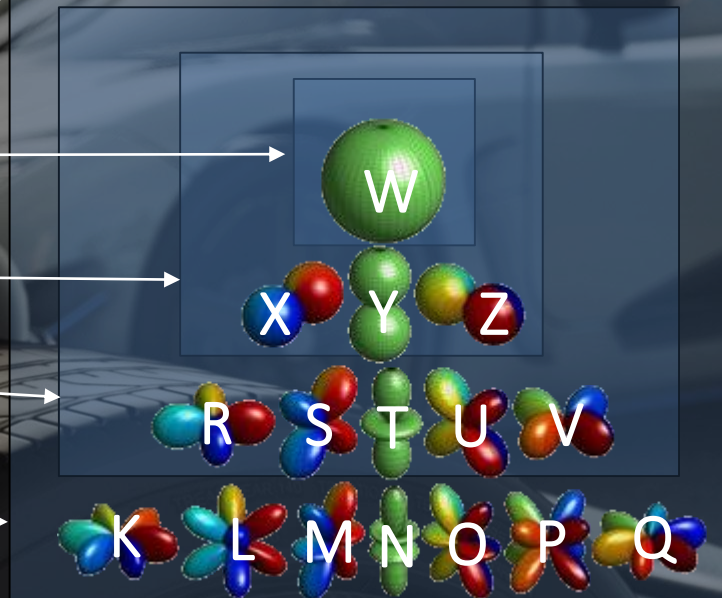
Target
platform
supported up
to 3rd order
which is 16
channels

0th Order

1st Order

2nd Order

3rd Order





Ambisonics - Mixed Orders

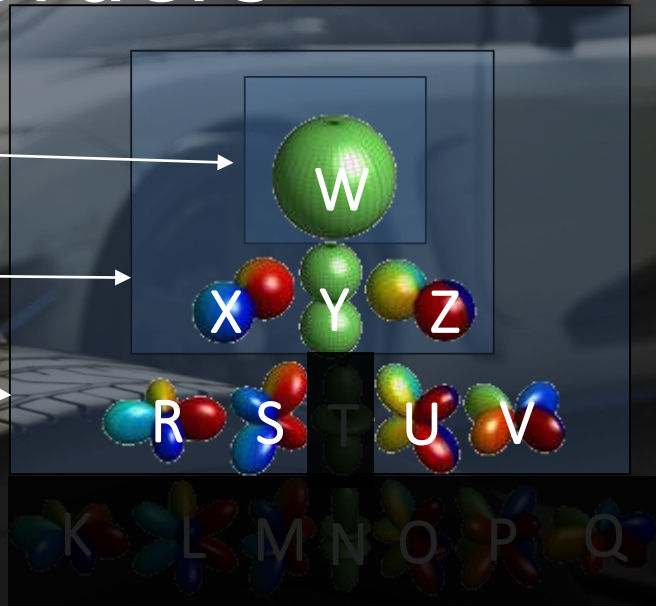
2H1V

Mixed orders
can include a
mix and match
of the
harmonics for
different orders

0th Order

1st Order

2nd Order





Ambisonics - Mixed Orders

3H1P

3H1P packs
max resolution
in the horizontal
plane into 8
channels

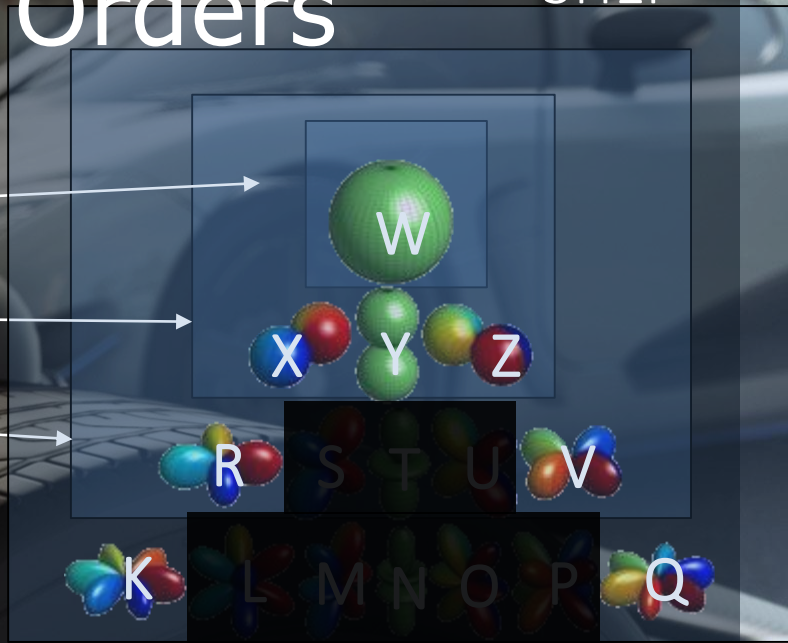


0th Order

1st Order

2nd Order

3rd Order





Ambisonics - Encoding

- Uses the spherical co-ordinates of the sound source to calculate a weight for each harmonic used
- Point source is mixed into each spherical harmonic channel using the weight





Adapting the engine - Panner

$W = \sqrt{0.5}$

1st

$X = \cos(A) * \cos(E)$

$Y = \sin(A) * \cos(E)$

$Z = \sin(E)$

$R = (3\sin(E)^2 - 1) / 2$

$S = \cos(A) * \sin(2E)$

$T = \sin(A) * \sin(2E)$

$U = \cos(2A) * \cos(E)^2$

$V = \sin(2A) * \cos(E)^2$

2nd

$K = \sin(E) * (5\sin(E)^2 - 3) / 2$

$L = \sqrt{135/256} * \cos(A) * \cos(E) * (5\sin(E)^2 - 1)$

$M = \sqrt{135/256} * \sin(A) * \cos(E) * (5\sin(E)^2 - 1)$

$N = \sqrt{135/20} * \cos(2A) * \sin(E) * \cos(E)^2$

$O = \sqrt{135/20} * \sin(2A) * \sin(E) * \cos(E)^2$

$P = \cos(3A) * \cos(E)^3$

$Q = \sin(3A) * \cos(E)^3$

3rd





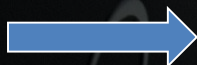
Ambisonic - Decoding

- You can sample the ambisonic soundfield for any given speaker location
- Can also do similar using HRTF impulse responses for binaural rendering

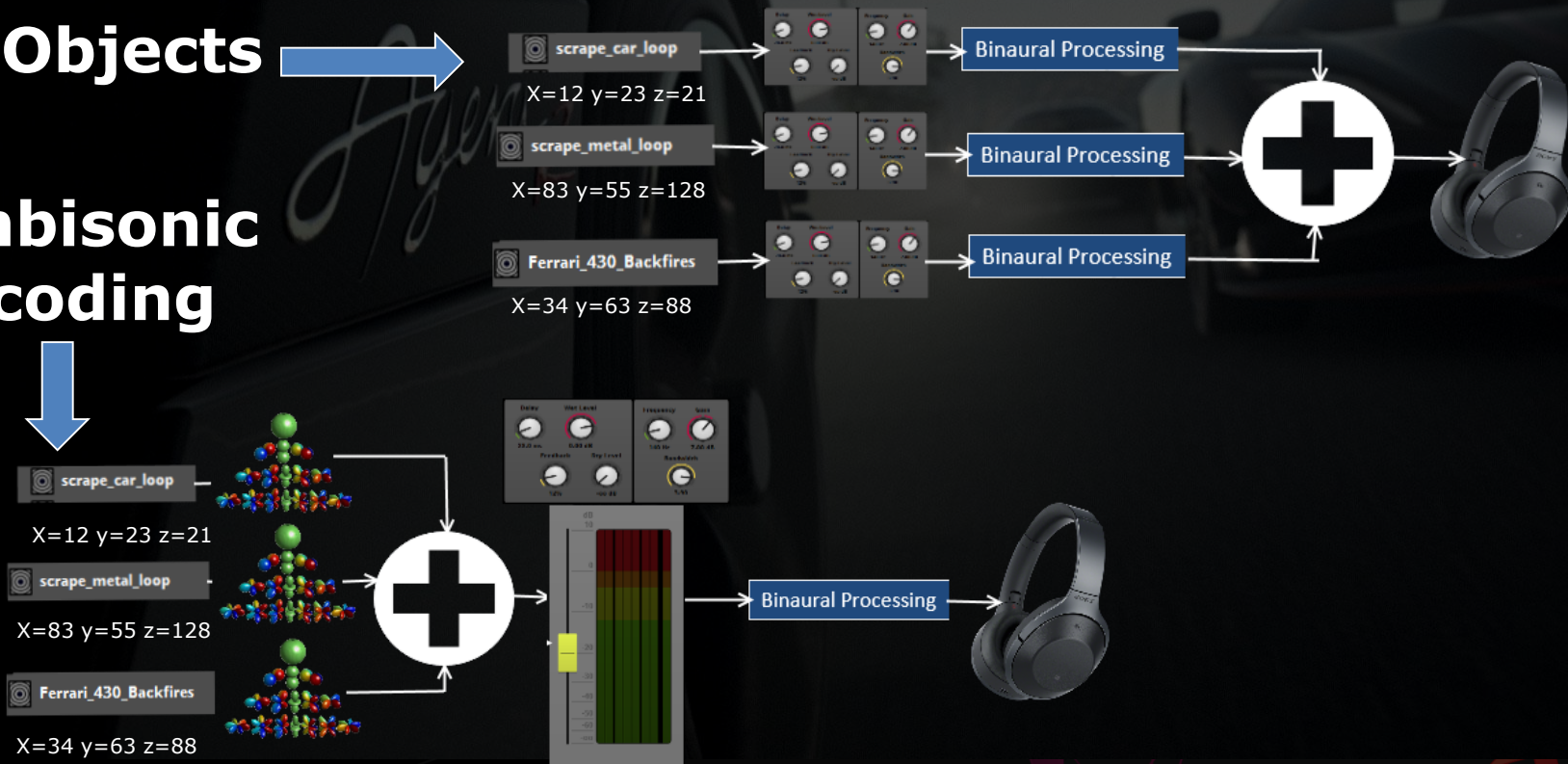




3D Objects



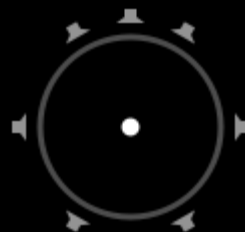
Ambisonic encoding





Adapting the engine Multi-channel

- Each channel encoded as a pint source
- Head orientation taken into account





Dealing with Music

- Binaural processing was not the expectation!
- Had to create output path for straight to headphones







Direction loudness plugin

- Scales audio in a given direction
- Uses discreet spherical harmonics transform
- Spherical t-design $t \geq 2N$

$$g(\theta) = g_1 u(\theta_c^T \theta - \cos \frac{\gamma_c}{2}) + g_2 u(\cos \frac{\gamma_c}{2} - \theta_c^T \theta).$$

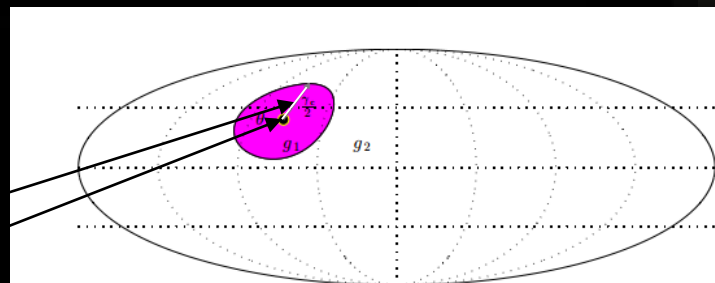


Figure 3: Spherical cap with center θ_c , size $\frac{\gamma_c}{2}$, gain factor g_1 inside the cap and g_2 outside the cap.



Ambisonic Recordings – Why?

- + 3D Ambiances
- + Natural sound
- + Augment with designed sound
- + Relatively cheap performance wise





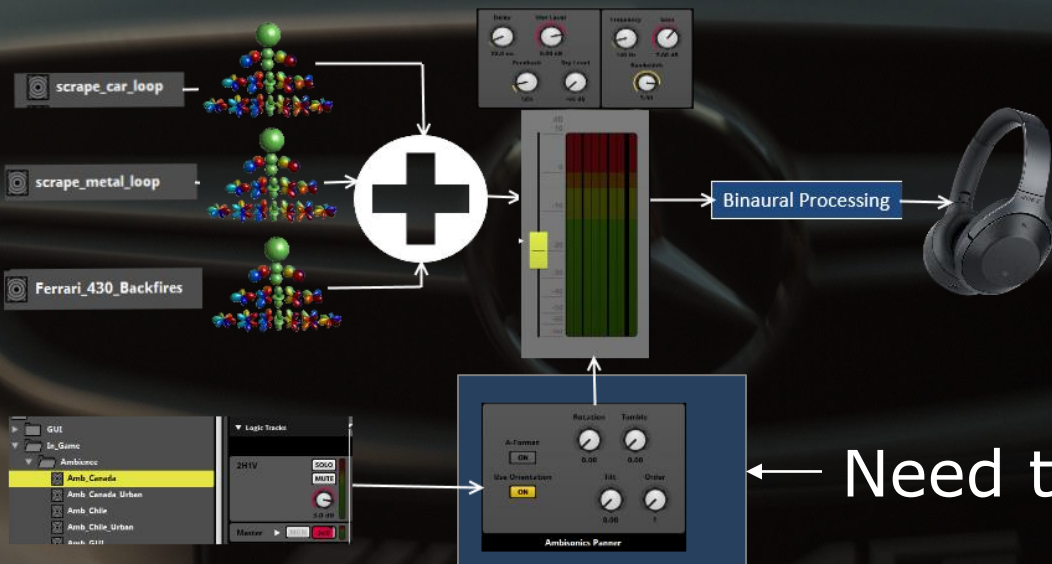
Ambisonic Recordings - How

- Used SPS200 as base
- Reaper + (free!) Blue Ripple plugins for designed elements
- Harpex up-sampling on first order recordings to 2H1V out





Ambisonic Recording - Playback



Need to write this!





Rotation Plugin

- Its complex at higher orders!

obtain $d_{00}^0 = 1$.
obtain trigonometric functions of (α, β, γ) from **R**.
obtain $d_{00}^1, d_{11}^1, d_{10}^1$ and d_{11}^1 from **R**.
for $l = 2, 3, \dots$
 obtain $d_{mm'}^l$ ($m = 0, \dots, l-2$; $m' = -m, \dots, m$)
 using Eq. (64).
 obtain d_{ll}^l [Eq. (65)] and $d_{l-1, l-1}^l$ [Eq. (66)].
 obtain $d_{lm'}^l$ for $m' = l-1, \dots, -l$ [Eq. (67)].
 obtain $d_{l-1, m'}^l$ for $m' = l-2, \dots, 1-l$ [Eq. (68)].
end-for

$$\Delta^1(\alpha, \beta, \gamma) = \begin{pmatrix} \begin{pmatrix} \cos \alpha \cos \gamma \\ -\sin \alpha \sin \gamma \cos \beta \end{pmatrix} & \sin \alpha \sin \beta & \begin{pmatrix} \cos \alpha \sin \gamma \\ +\sin \alpha \cos \gamma \cos \beta \end{pmatrix} \\ \sin \gamma \sin \beta & \cos \beta & -\cos \gamma \sin \beta \\ \begin{pmatrix} -\cos \alpha \sin \gamma \cos \beta \\ -\sin \alpha \cos \gamma \end{pmatrix} & \cos \alpha \sin \beta & \begin{pmatrix} \cos \alpha \cos \gamma \cos \beta \\ -\sin \alpha \sin \gamma \end{pmatrix} \end{pmatrix}$$





Ambisonics - Outcome

- Mix changes were minimal
- CPU / Mem in line with original
- Worked well in headphones and on 5.1 / 7.1
- 2H1V gave good overall accuracy / feel





Things that didn't make it

Car stereo





Things that did not make it

Directionally
scaled ambiances



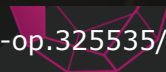


Things that did not make it

Ambisonic impulse responses for in car audio



<https://www.gtplanet.net/forum/threads/driveclub-photo-thread-interior-shots-only-read-op.325535/>





Conclusion

- We did it!
- Very similar CPU and memory footprint
- Full 3D soundscape
- Lots of interesting learnings
- Will be pursuing in other projects





Very Special Thanks

- Pedro Corvo
- Tim Shepherd
- Steve Humphries
- Richard Taylor
- Rest of the team!

Aggra 2





Questions?

