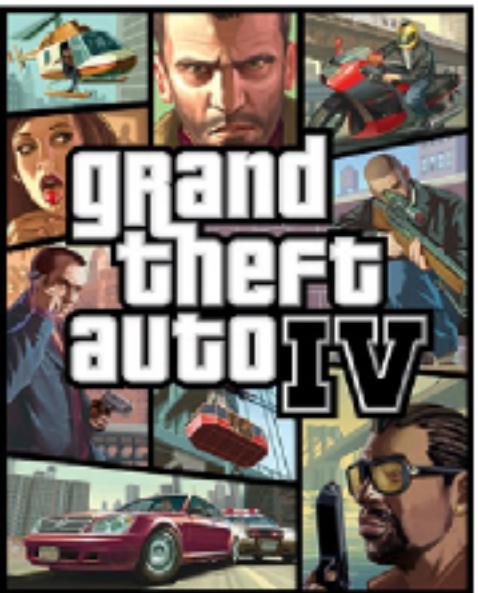


# The Sound of Grand Theft Auto V

**Alastair MacGregor**  
Lead Audio Programmer, Rockstar North

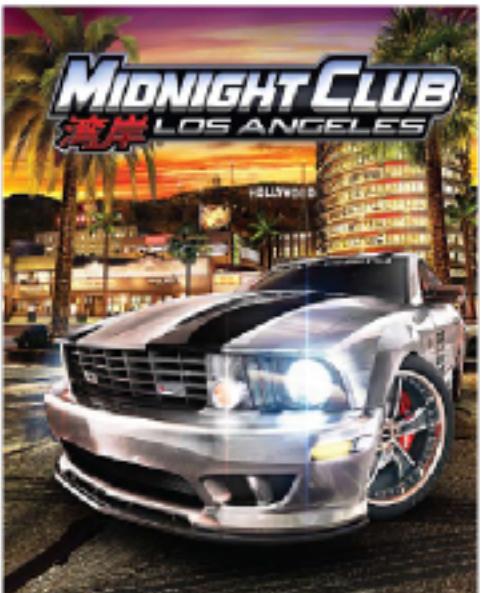


# RAGE Audio

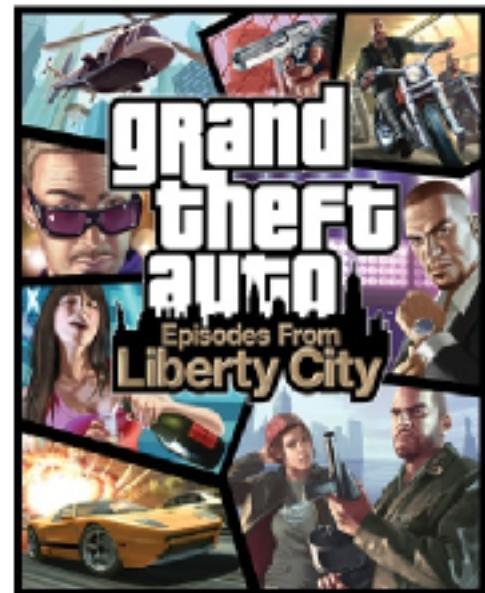


1.0

2005



May 2008



October 2008



February 2009

October 2009



May 2010



September 2013

2.0

# RAGE Audio: Core Goals

- Cross platform
  - Assets should sound as close as possible across target platforms
- Scalable to large projects
- High Performance
  - Memory efficient
  - Predictable streaming

# RAGE Audio: Core Features

- Support modular asset design
- Voice virtualisation
- Flexible routing

# Voice routing

- V uses our own mixing engine
- PCM sources generate data
- Voices filter and route into sub-mixes
- 1, 4 or 6 channel sub-mixes
- Interleaved or non-interleaved processing

# Modular Sound Hierarchies

Hierarchy Viewer

Properties Editor

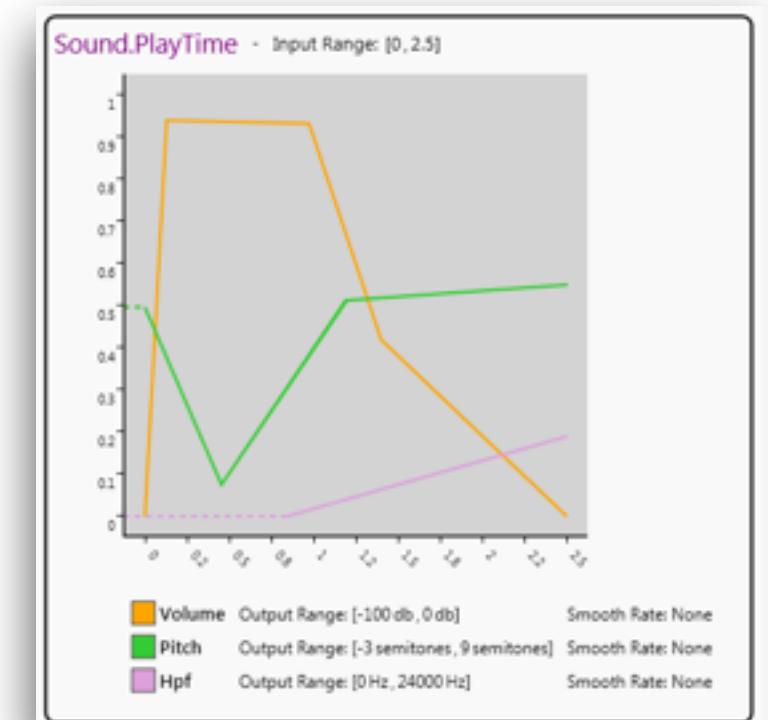
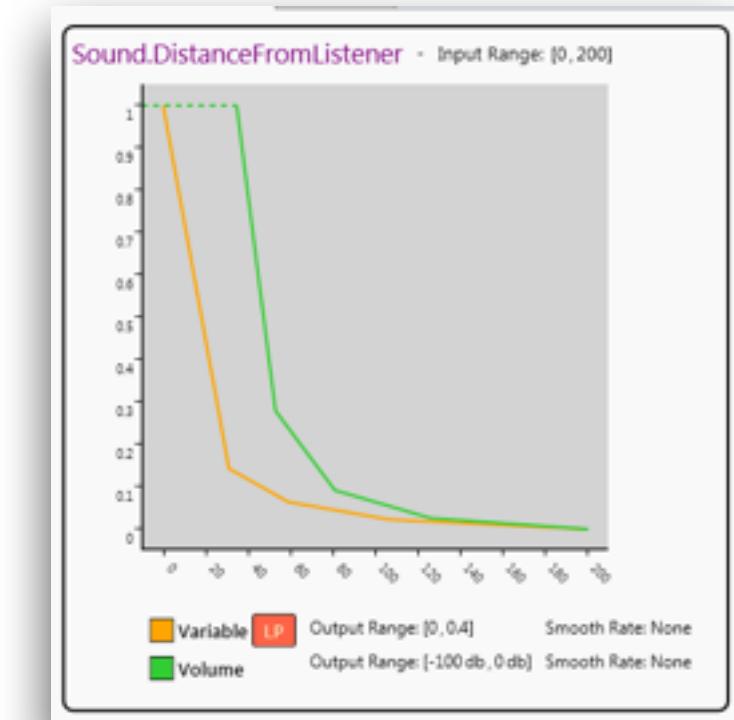
WrapperSound

Chicken\_01

Description	Value
Volume	-2
VolumeVariance	2
Pan	0
PanVariance	2
Ran	-1
RanVariance	0
preDelay	0
preDelayVariance	0
StartOffset	0
StartOffsetVariance	0
AttackTime	0
ReleaseTime	-1
DopplerFactor	1
Category	AMBIENCE_GENERAL
HPF Cutoff	14000
HPF CutoffVariance	0
HPF CutoffRate	0
HPF CutoffVarianceRate	0
MixVolume	Unspecified
StartOffsetPercentage	0
DistanceAttenuation	0
EnvironmentalEffects	0
VocalizeAsGroup	0
DynamicPrepare	0
MuteOnUserMusic	0
InvertPhase	0
Mute	0

DEFAULT\_RELEASE\_CURVE

Default Editor



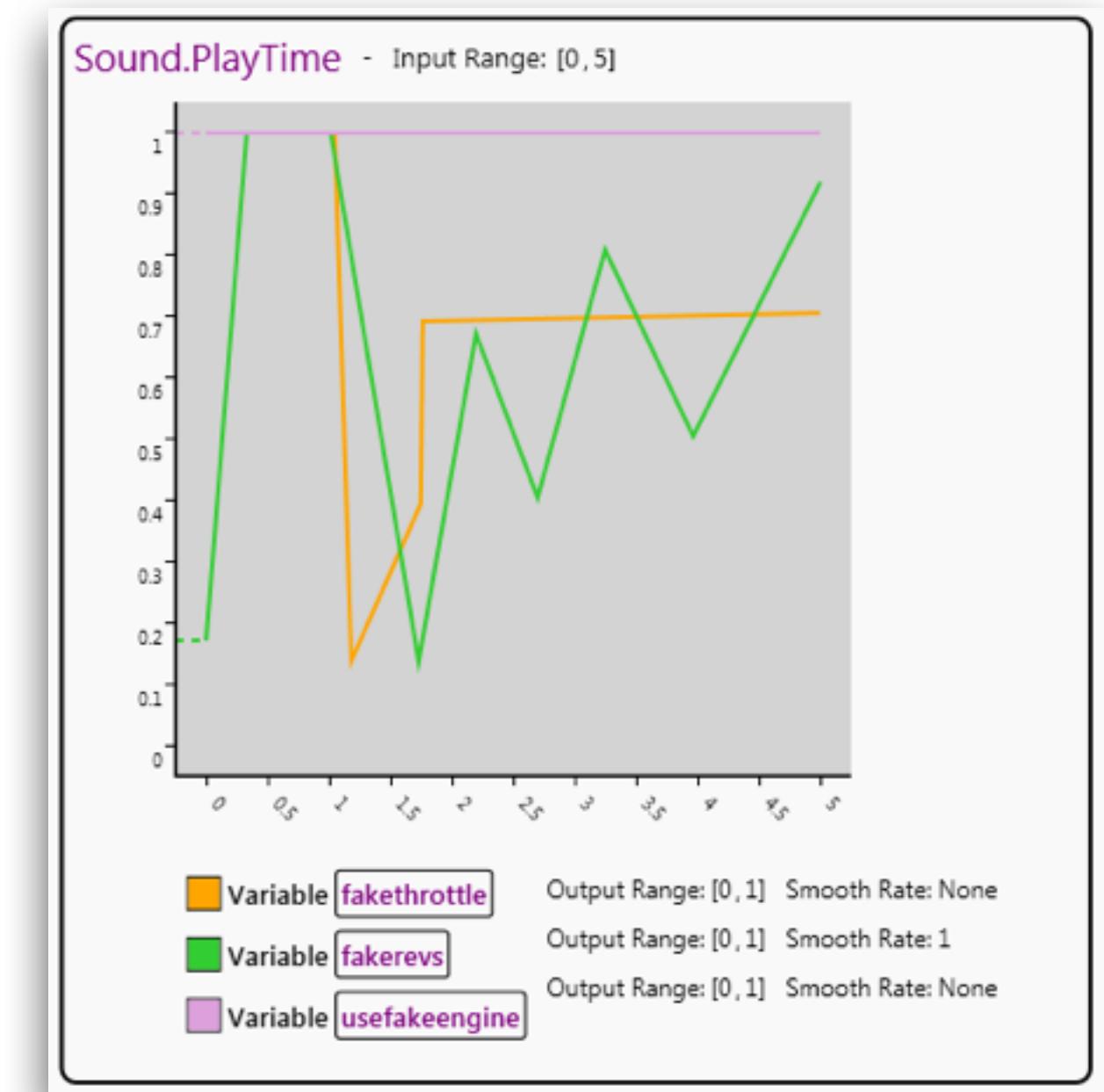
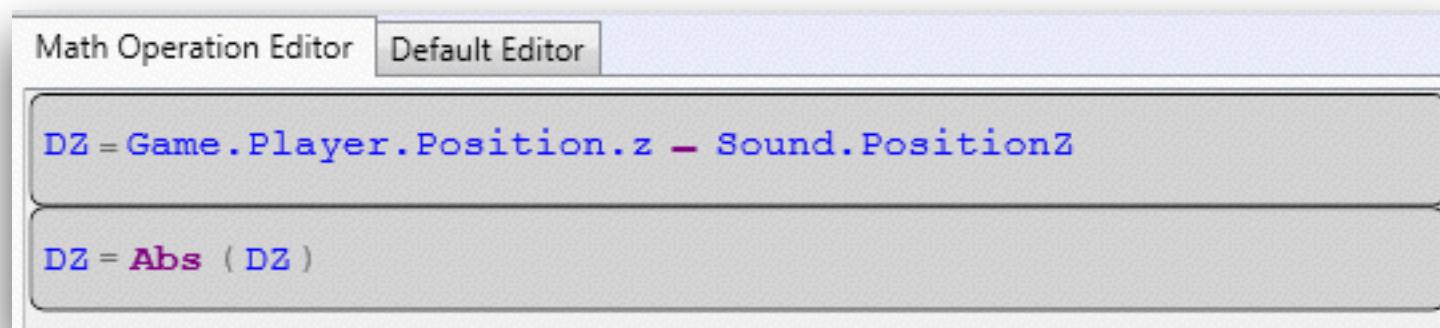
Math Operation Editor Default Editor

```

GritLoopTime = ValueInRange ( Ctrl , GritLoopTimeMax , GritLoopTimeMin )
GritVolume = ValueInRange ( Ctrl , GritVolumeMin , GritVolumeMax )
GritLoopTimeRnd = Rand ( 0 , GritLoopTime )
GritLoopTime = GritLoopTime + GritLoopTimeRnd

```

# Modular Sound Hierarchies



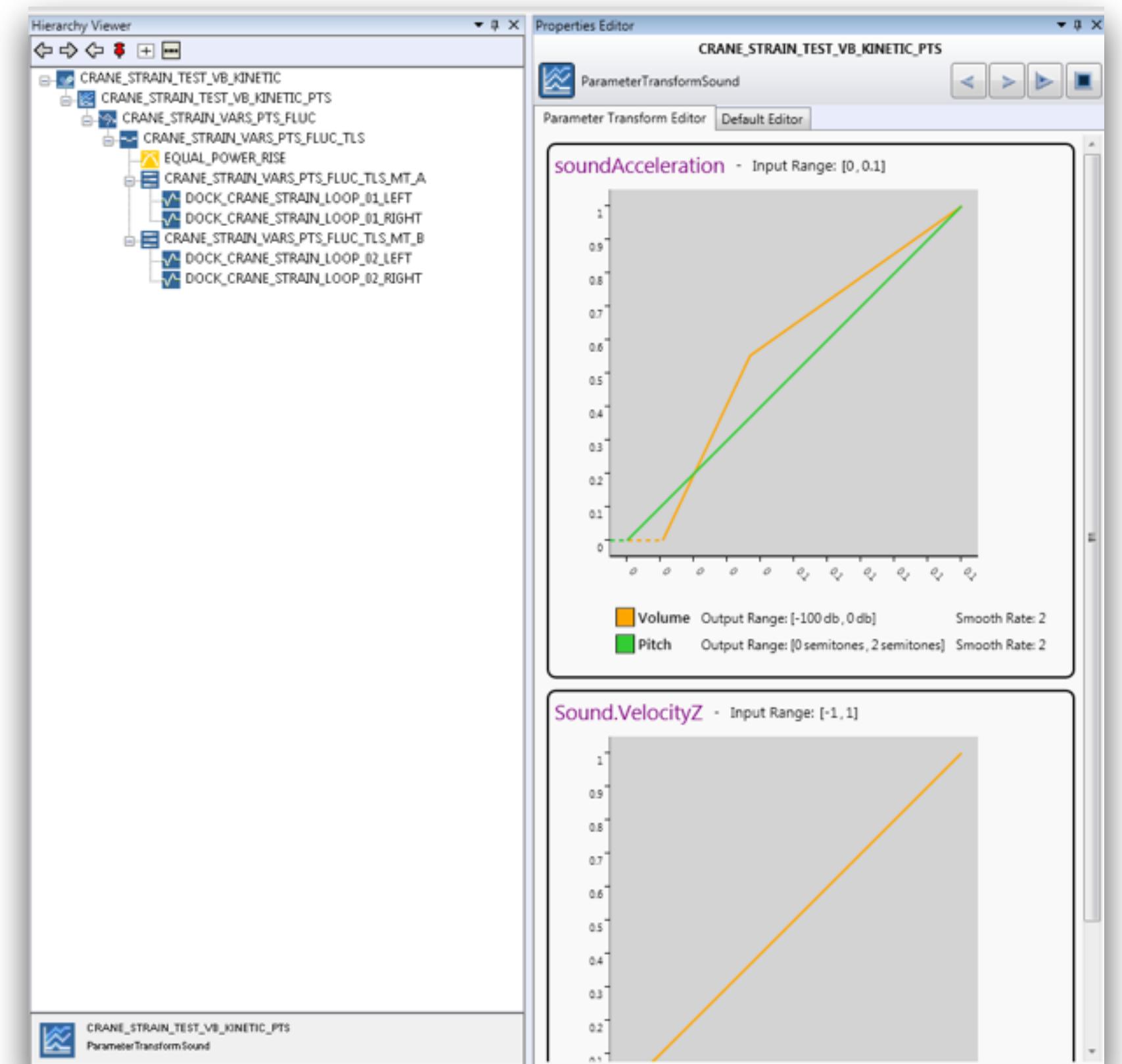
# Kinetic Sound

Properties Editor

CRANE\_STRAIN\_TEST\_VB\_KINETIC

KineticSound

Description	CRANE STRAIN TEST VB KINETIC PTS
SoundRef	<a href="#">CRANE STRAIN TEST VB KINETIC PTS</a>
Mass	100.0
VelocityOrientation	<input type="checkbox"/>
YawAngle	0
PitchAngle	180



# Sample Accuracy

- Timing guarantees
- Sample accurate:
  - Pre-delays
  - Source-chaining/splicing
- Decode latency compensation

# Asset Sizes

GameObjects  
DynamicMixer

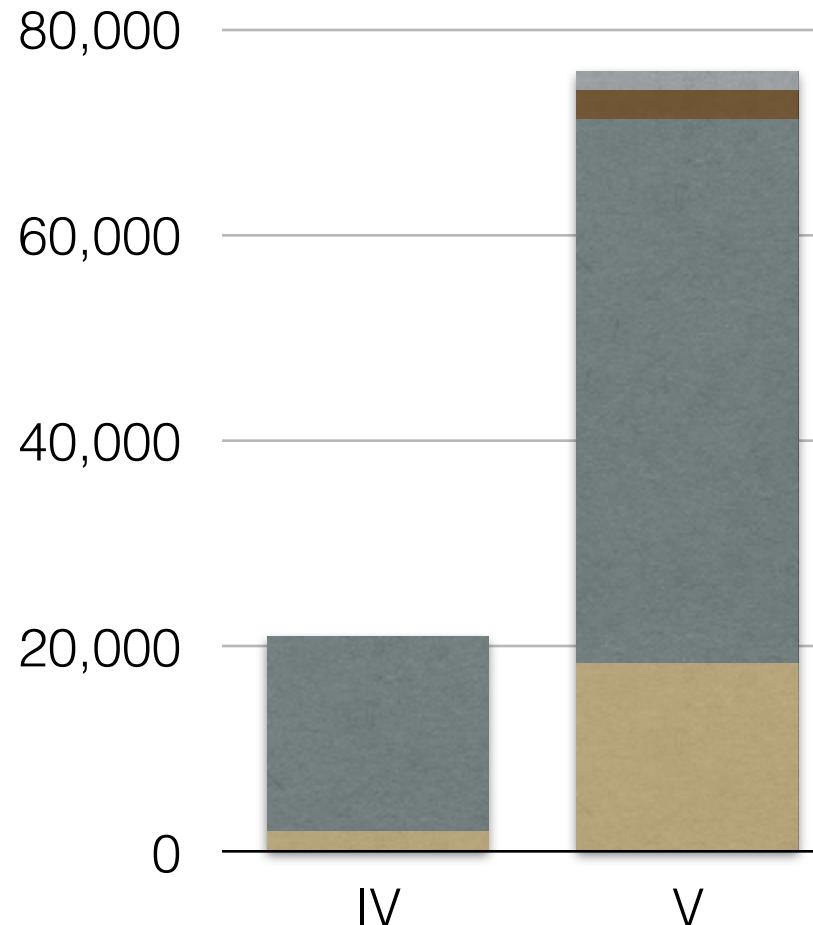
Sounds  
Synth

Radio  
Cinematics

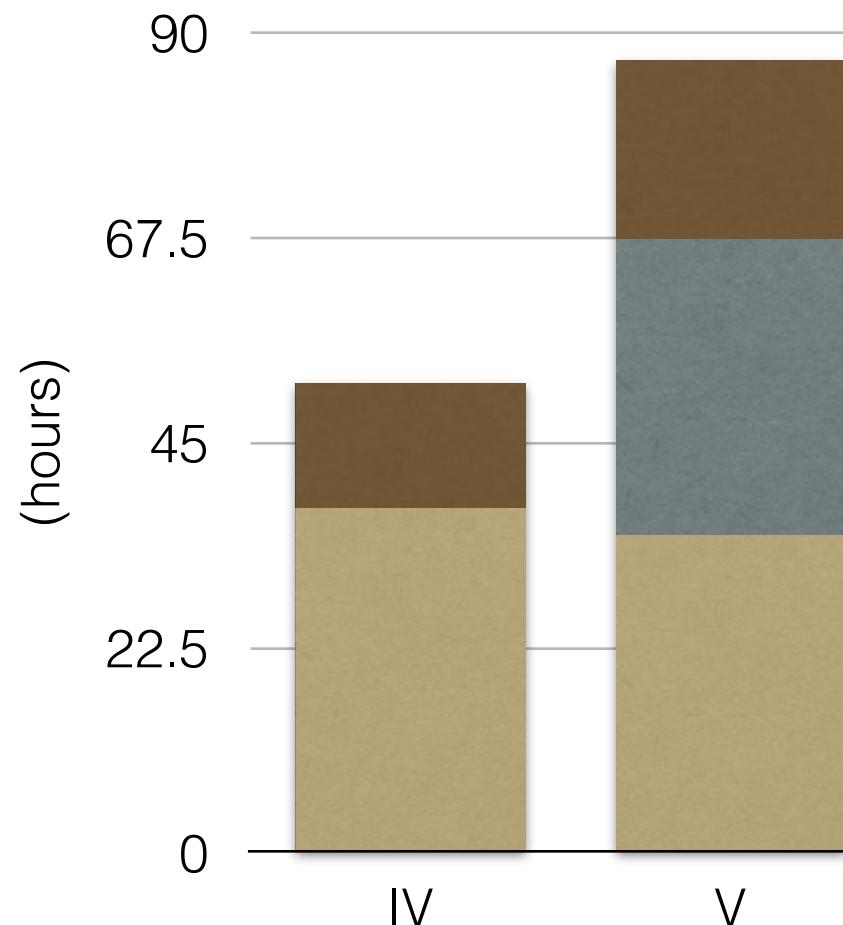
Score

Scripted  
Ambient

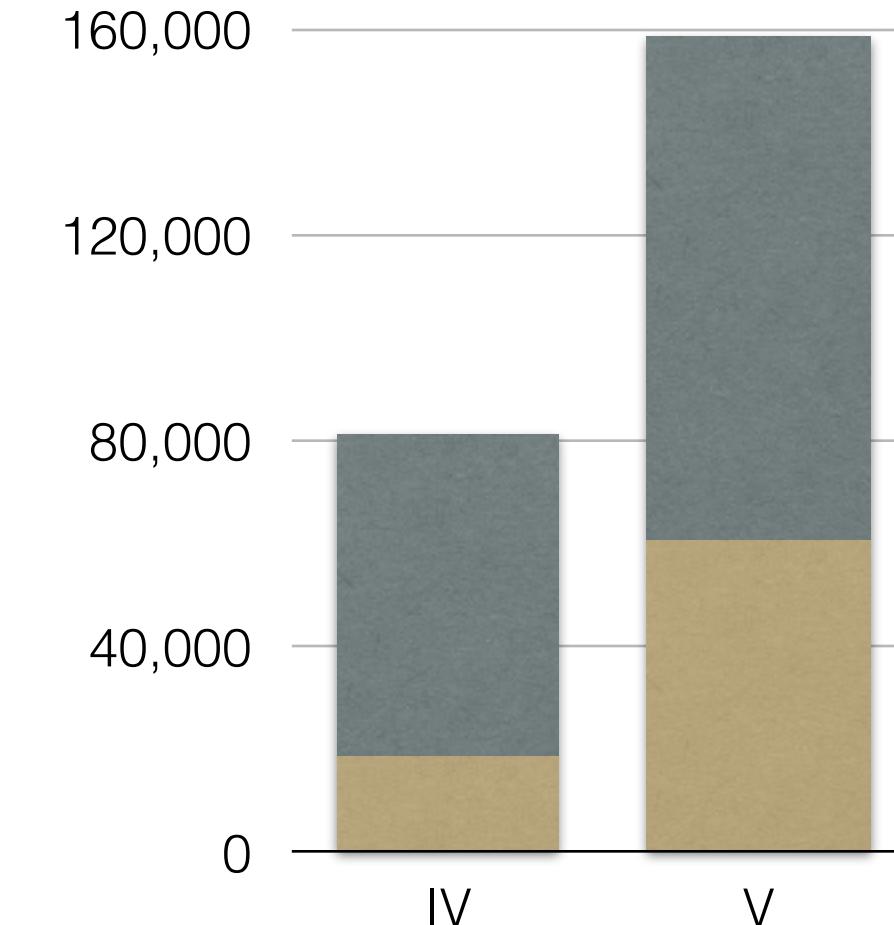
Metadata



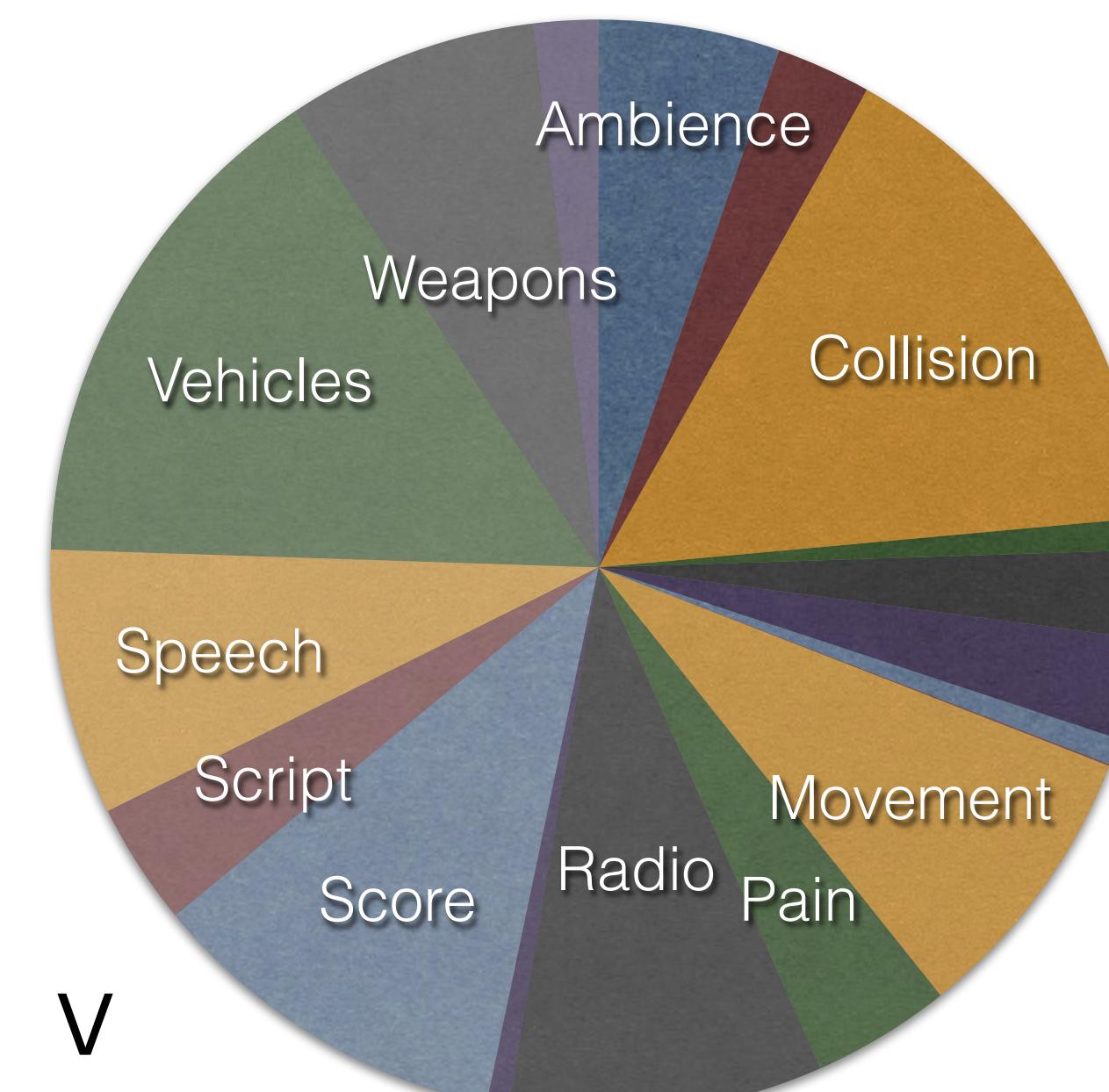
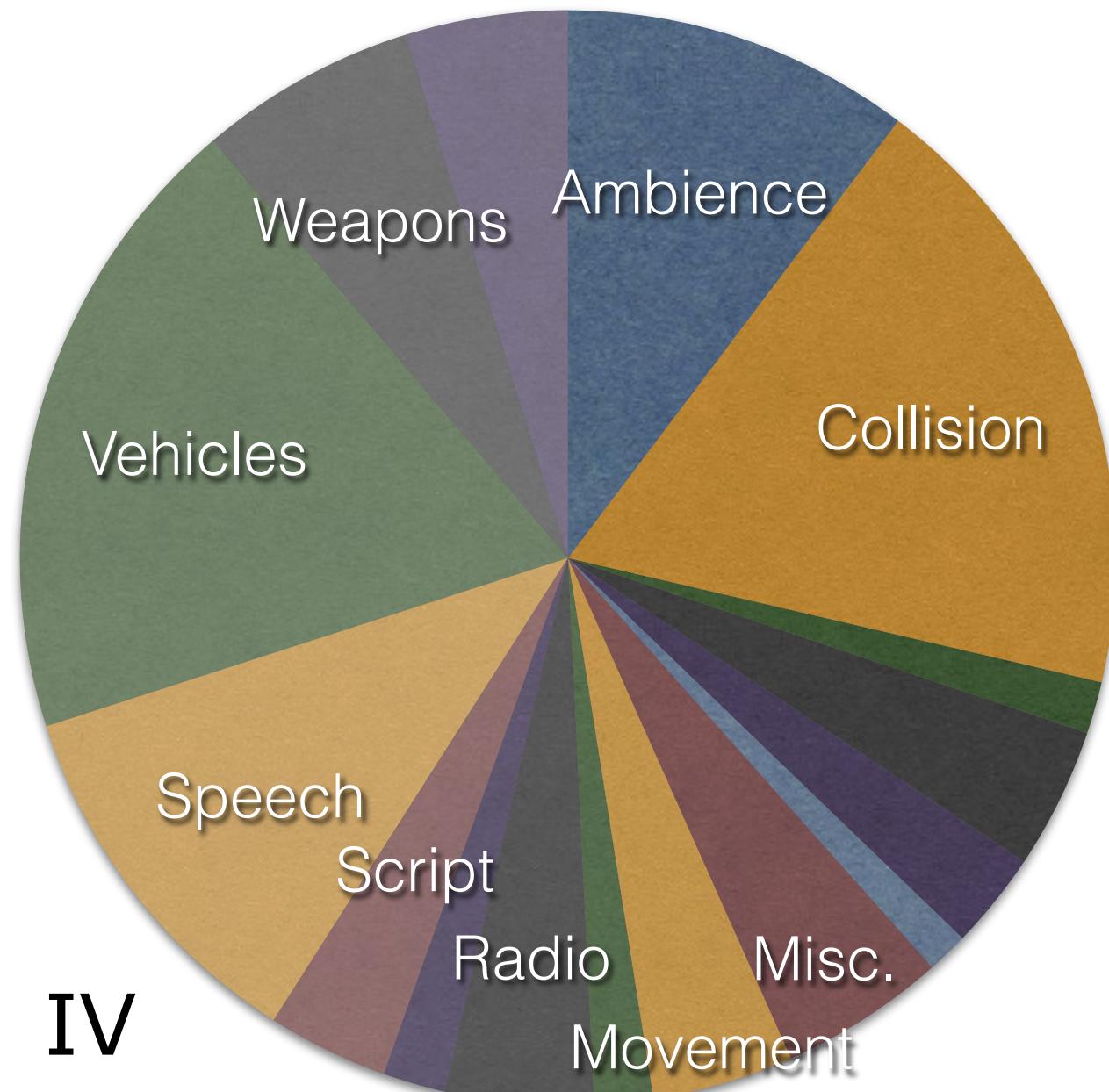
Streaming Assets



Lines of Dialogue



# Wave Memory



# Dynamic Mixing

- Audio is sliced into categories for mixing
- Patches specify changes to the mix
- Patches applied globally or to mix groups
- Scenes define mix groups and patches

# Music

- Score: 8 stereo stems plus one-shots
- 'Moods' define stem-mixes and transitions
- Events generated by script and code
- Actions optionally quantised to music

# Vehicles

- Multiple layers: detail/close, mid and far
- Highways
- Distant one-shots
- “City noise”

# Vehicles - individual detail

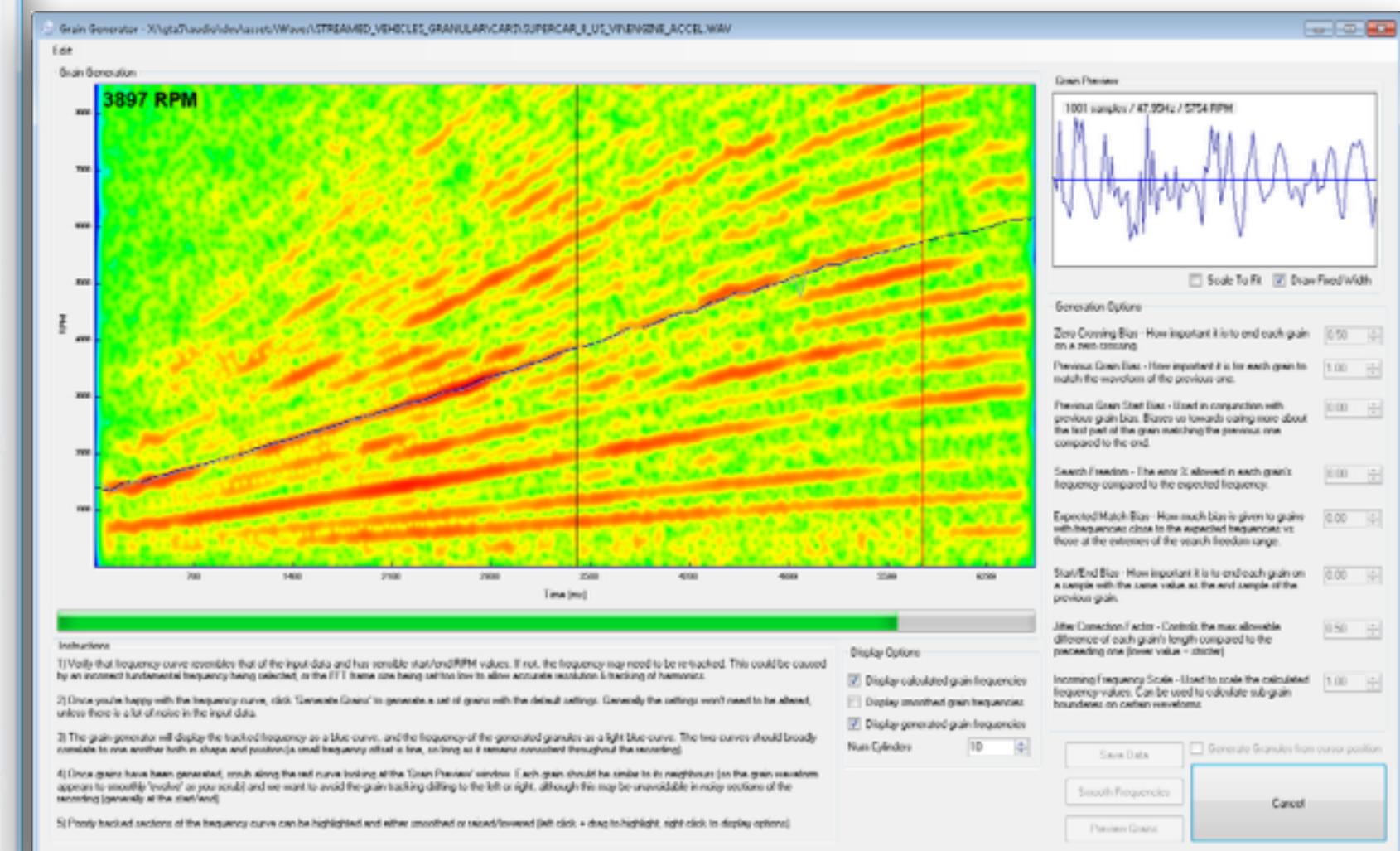
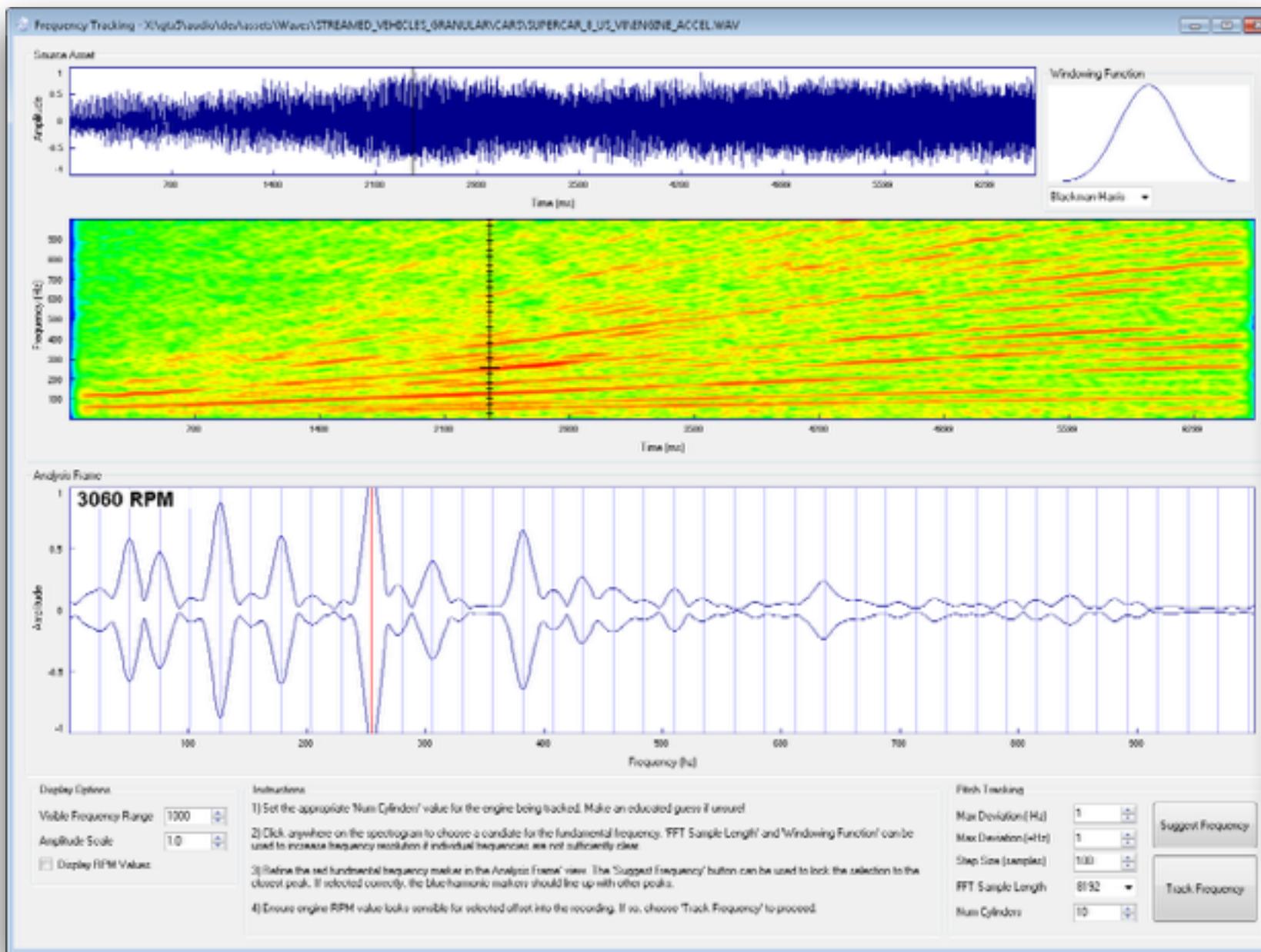
- Granular engine
- Synthesised intake/induction, transmission
- Combination of samples and synth for traction/aero
- Suspension, chassis, rumble

# Vehicles - Engine Recording

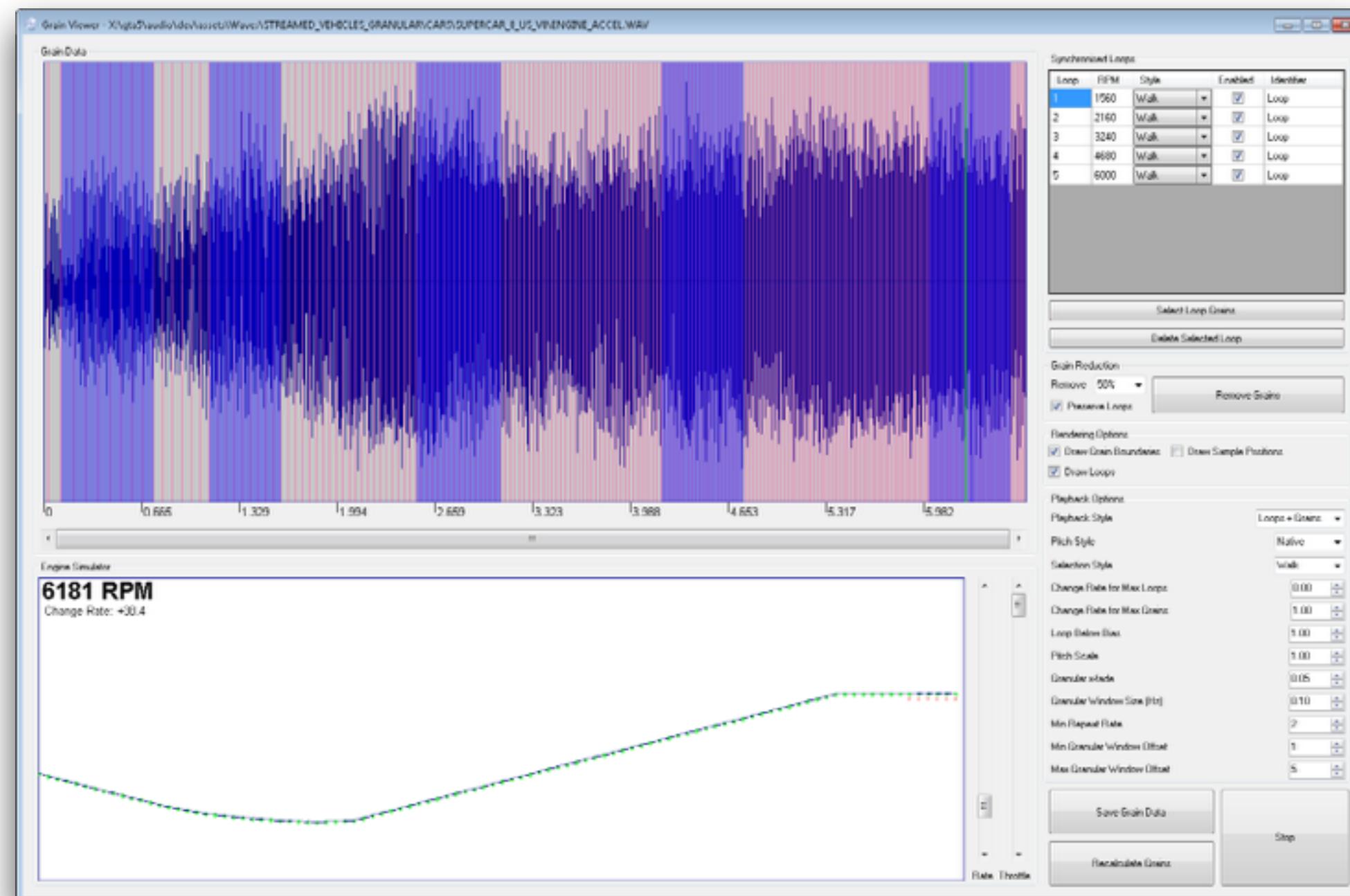
- In-motion recordings
- Mostly omni mics



# Granular Pipeline



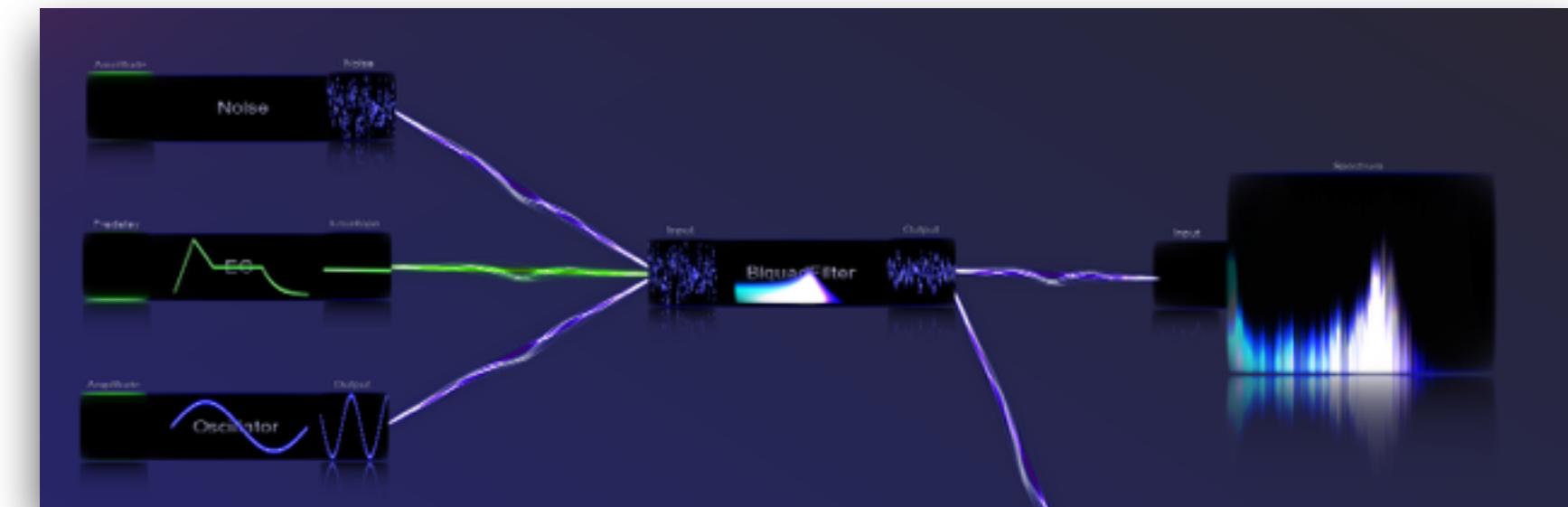
# Granular Pipeline



# Granular Runtime

- Separate engine and exhaust
- NPC engines use exported loop data
- Granular clock used to sync oscillators
- Real-time DSP post-processing

# Synthesis



- Motivation: dynamic assets, fidelity, memory
- Designed to be accessible and encourage experimentation

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**MARCH 17-21, 2014**    **GDCONF.COM**

# AMP

- Used to create a wide variety of asset components
- Particularly good for noise-based sounds
- Enabled sound-designer-authored effects chains



# AMP

- Automatic asset optimisation
- Real-time cost feedback
- Automated asset testing

```
Disassembly of synth SYNTH_AMBIENT_AIRCON_FULL, total size: 652 bytes
4 buffers, 21 registers, 18 state blocks, 21 constants, 1 output
Runtime cost = 50 (PS3: 34.13uS, Xbox360: 47.52uS)

0+0000,6      READ_VARIABLE V4 => R0
0+0006,6      READ_VARIABLE V2 => R1
0+000C,8      MULTIPLY_SCALAR_SCALAR R0, R1 => R2
0+0014,8      OSC_RAMP_BUFFER_SCALAR R2 => B0 [0]
0+001C,6      READ_VARIABLE V5 => R0
0+0022,4      SINE_BUFFER B0 => B0
0+0026,6      READ_VARIABLE V1 => R2
0+002C,8      OSC_RAMP_SCALAR R2 => R3 [1]
0+0034,6      MULTIPLY_BUFFER_SCALAR B0, R0 => B0
0+003A,4      NOISE => B1
0+003E,10     TRIGGER_LATCH R3, 0.7885 => R0 [2]
0+0048,6      MULTIPLY_BUFFER_SCALAR B0, R1 => B0
0+004E,12     RANDOM R0, 0.351, 1 => R2 [3]
0+005A,4      CONVERT_BUFFER_TO_NORMALIZED B1 => B1
0+005E,6      SUM_BUFFER_SCALAR B0, R1 => B0
0+0064,8      OSC_RAMP_SCALAR 3.77 => R3 [4]
0+006C,4      CONVERT_BUFFER_TO_NORMALIZED B0 => B0
0+0070,8      LERP_BUFFER B1, 5490, 0 => B1
0+0078,6      READ_VARIABLE V7 => R4
0+007E,12     ENVELOPE_FOLLOWER_SCALAR R2, 0.2025, 0.183 => R5 [5]
0+008A,8      MULTIPLY_SCALAR_SCALAR R1, R4 => R2
0+0092,10     TRIGGER_LATCH R3, 0.7885 => R6 [6]
0+009C,6      OSC_RAMP_BUFFER_BUFFER B1 => B1 [7]
0+00A2,8      MULTIPLY_SCALAR_SCALAR R1, 4 => R7
0+00AA,8      MULTIPLY_SCALAR_SCALAR R0, R5 => R8
0+00B2,6      OSC_RAMP_BUFFER_BUFFER B0 => B0 [8]
0+00B8,4      NOISE => B2
0+00BC,16     BiquadCoefficients_BandPass R7, 4140.79 => R0, R1, R3, R4, R5
0+00CC,16     BiquadCoefficients_BandPass R2, 60.997 => R9, R10, R11, R12, R13
0+00DC,16     BiquadCoefficients_BandPass R2, 165.992 => R14, R15, R16, R17, R18
0+00EC,4      SQUARE_BUFFER B1 => B1
0+00F0,12     ENVELOPE_FOLLOWER_SCALAR R8, 0, 0.213 => R19 [9]
0+00FC,8      COPY_BUFFER B2 => B3
0+0104,4      SINE_BUFFER B0 => B0
0+0108,12     RANDOM R6, 0.573, 1 => R20 [10]
0+0114,8      MULTIPLY_SCALAR_SCALAR R19, R19 => R2
0+011C,16     BiquadProcess_2Pole B1, 0.0696062, 0, -0.0696062, -0.928284, 0.860788 => B1 [11]
0+012C,16     BiquadProcess_2Pole B3, R9, R10, R11, R12, R13 => B3 [12]
0+013C,6      READ_VARIABLE V6 => R6
0+0142,12     ENVELOPE_FOLLOWER_SCALAR R20, 1, 1 => R7 [13]
0+014E,16     BiquadProcess_4Pole B2, R14, R15, R16, R17, R18 => B2 [14]
0+015E,16     BiquadProcess_2Pole B0, R0, R1, R3, R4, R5 => B0 [15]
0+016E,6      MULTIPLY_BUFFER_SCALAR B0, R7 => B0
0+0174,6      MULTIPLY_BUFFER_SCALAR B3, 0.3355 => B3
0+017A,6      MULTIPLY_BUFFER_SCALAR B1, R2 => B1
0+0180,8      SUBTRACT_SCALAR_SCALAR 1, R6 => R0
0+0188,6      READ_VARIABLE V3 => R1
0+018E,6      READ_VARIABLE V0 => R3
0+0194,6      MULTIPLY_BUFFER_SCALAR B2, 0.682 => B2
0+019A,6      MULTIPLY_BUFFER_SCALAR B0, R3 => B0
0+01A0,6      MULTIPLY_BUFFER_SCALAR B3, R0 => B3
0+01A6,6      MULTIPLY_BUFFER_SCALAR B1, R1 => B1
0+01AC,6      MULTIPLY_BUFFER_SCALAR B2, R6 => B2
0+01B2,6      SUM_BUFFER_BUFFER B3, B1 => B3
0+01B8,6      SUM_BUFFER_BUFFER B0, B2 => B0
0+01BE,6      SUM_BUFFER_BUFFER B0, B3 => B0
0+01C4,8      OnePole_LPF_BUFFER_SCALAR B0, 5510 => B0 [16]
0+01CC,6      MULTIPLY_BUFFER_SCALAR B0, 5 => B0
0+01D2,8      COPY_BUFFER B0 => B1
0+01DA,8      MAX_BUFFER B0, 0 => B0 [17]
0+01E2,6      SUM_BUFFER_SCALAR B0, 0.01 => B0
0+01E8,6      HARD_CLIP_BUFFER_SCALAR B0, 1 => B0
0+01EE,6      DIVIDE_BUFFER_BUFFER B1, B0 => B1
```

# Environmental Audio

- Striving to create an immersive world:
- Environment produces sound
- Affects sounds playing within it
- Responds to sound

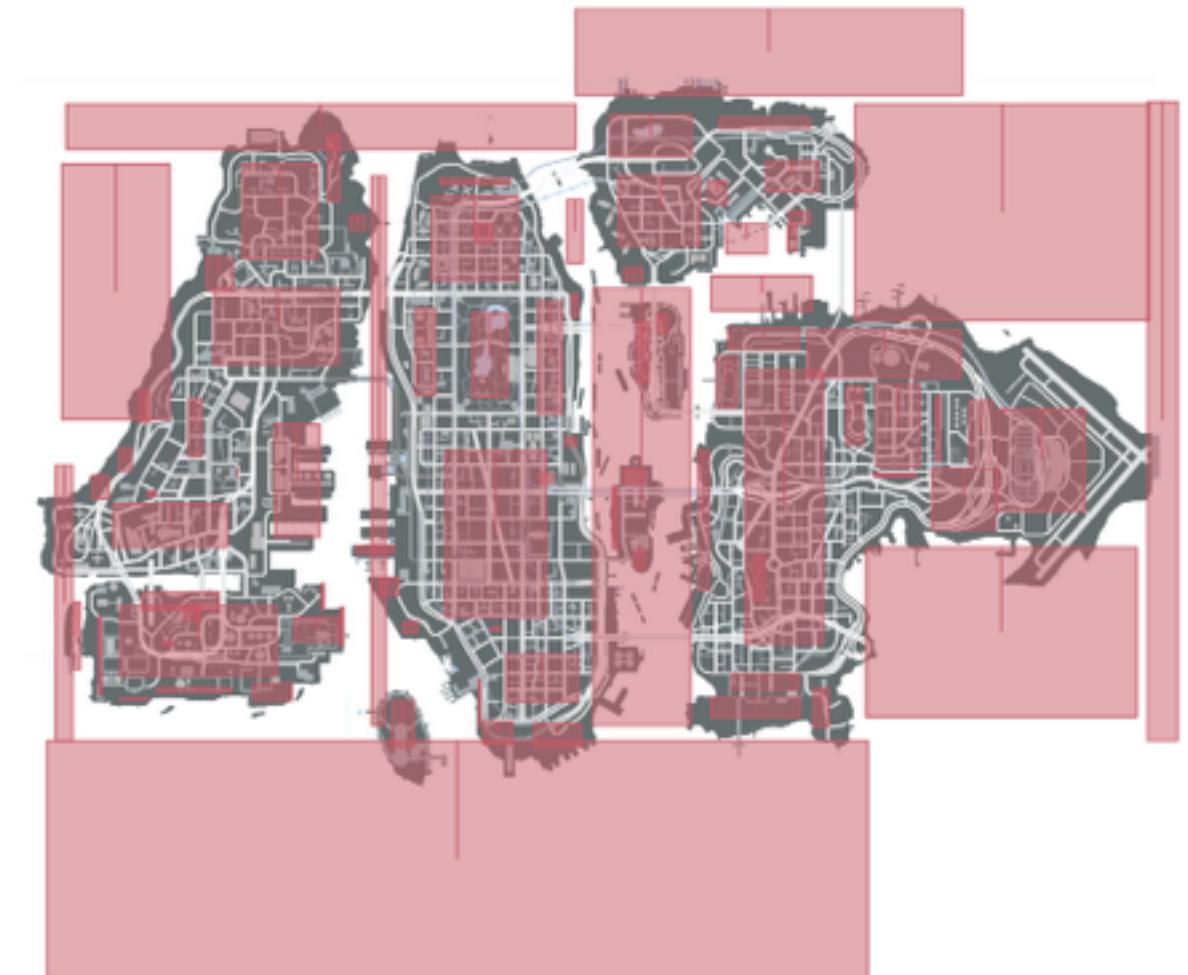


# GTA IV Ambience

86 zones

57 rules

198 static emitters

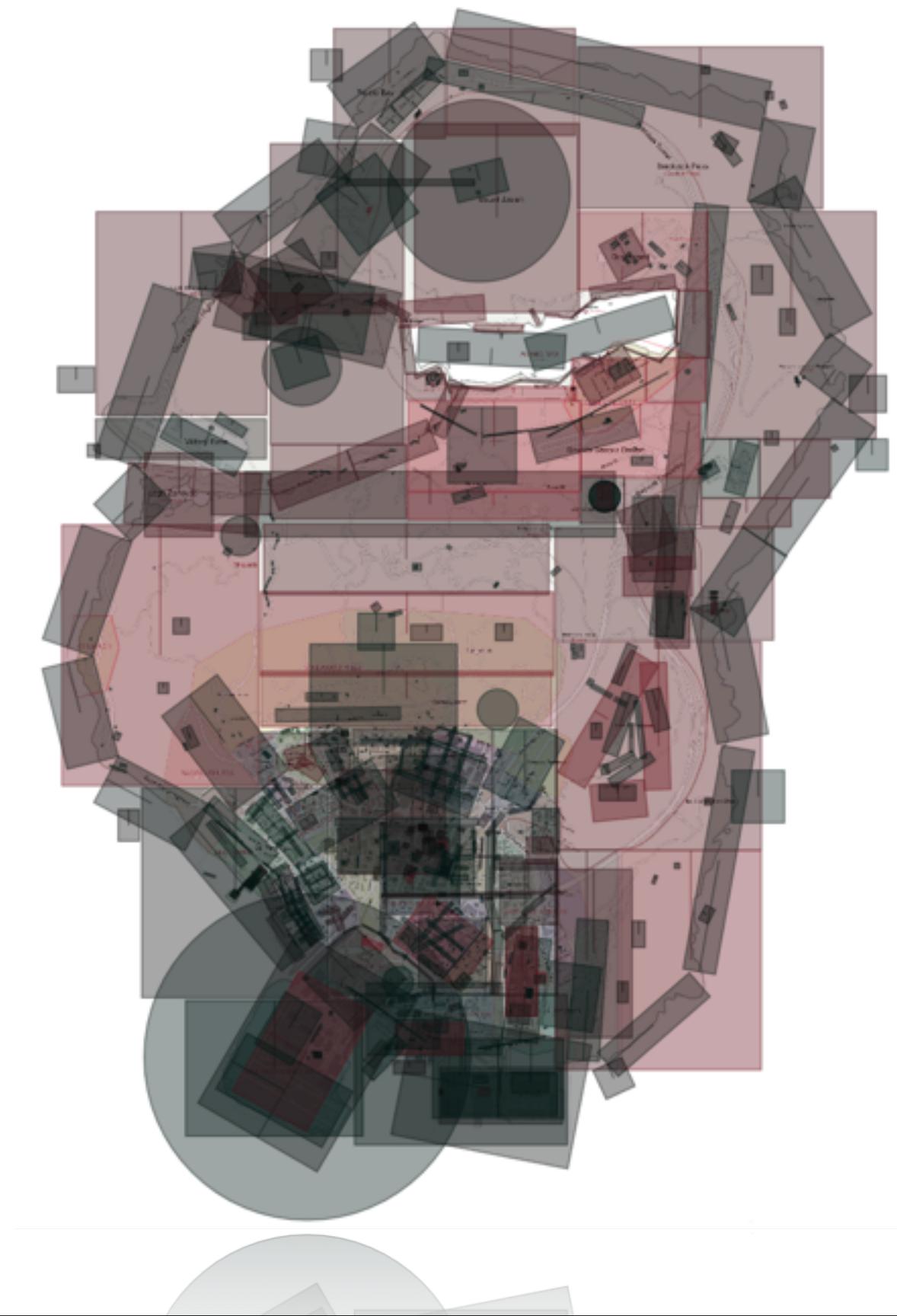


# GTA V Ambience

949 zones

1210 rules

518 static emitters



# Environmental Audio

- Distance effects
- Occlusion
- Reflections
- Reverberation



# Environmental Audio

- Resonances
- Shockwaves



- Thanks for listening!



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