Active Sound Design – Abwägung zwischen Gestaltungsfreiheit und Ressourcenanforderung

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Agenda

Introduction

Sound Design Methods

Sound Design Example: High Performance Car

What is Active Sound Design?

Source: Youtube

*Active sound design (ASD) is a **methodology** that, in addition to **functional sound**, generates **meaningful sounds** to be **replayed in the vehicle** (internal or external) in order to **improve sound quality** (internal) and to **ensure pedestrians' safety** (external).*

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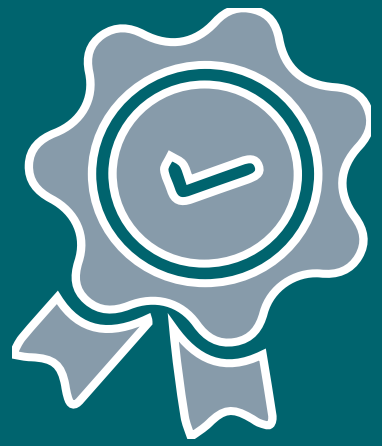
Why adding sounds to the vehicle?

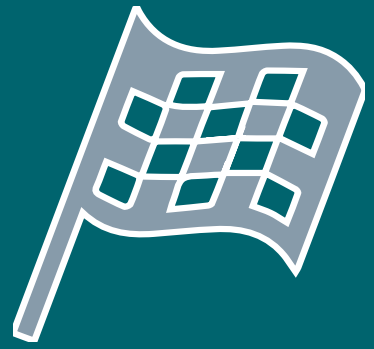
BECAUSE YOU MUST



ENSURE COMPLIANCE

BECAUSE YOU CAN

PROTECT BRAND REPUTATION



STRIVE UNIQUE BRAND VALUE

REDUCE COSTS

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A short history of Active Sound Design

Goal: generate sounds to support/build a dynamic driving sound

Innovators

- introduced for vehicles with Internal Combustions Engines (ICE), sound more sporty in spite of engine downsizing
- first usage for Electric Vehicles (EV) in 2013: Mercedes AMG SLS ED

Early adopters:

- next vehicles followed in 2018/2019 (ex. Jaguar I-Pace, Audi e-tron, Porsche Taycan…)

Next: Pushed by the legal requirements (AVAS)

Crossing the Chasm:

- today it is getting a standard for premium EV's: ex. KIA EV6
- High power sports cars take it to the limit → exhaust sound

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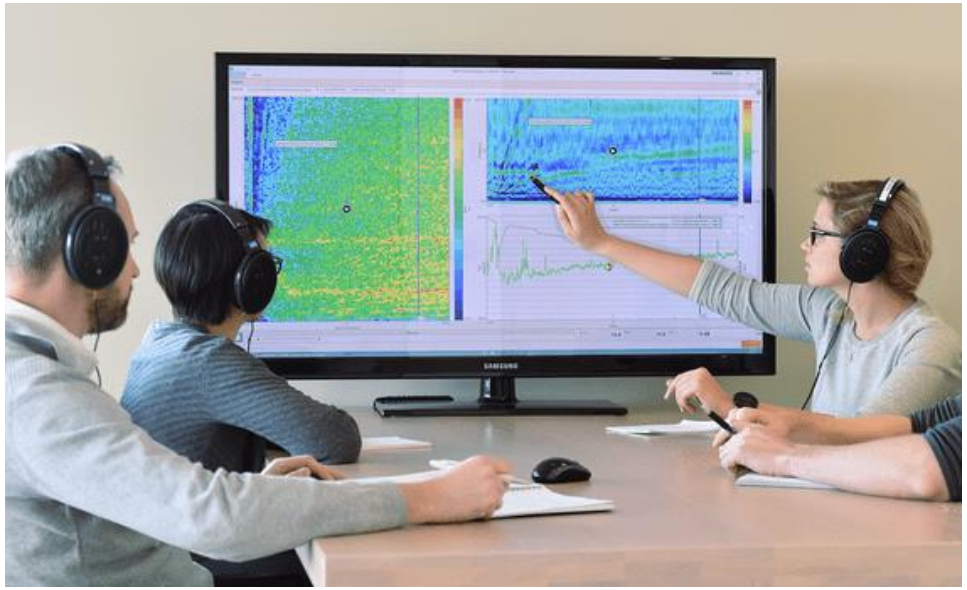
Active Sound Design vs Sound Quality



Sound Quality
- is a topic of research since decades
- several definitions of SQ are reported, a formulation can be:
  - *sound have a task, and the fulfillment of that task needs to be evaluated*
  - *sound should be pleasant, not annoying*

Context of Sound Quality of Active Sound Design
- the *Audio Quality* of the used sound generation methods → the used toolchain (technical skills)
- the *result of the creative process* → the individual esthetic process / capabilities (personal skills) – artistic process

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How is the Design phase kicked off?

- From: Exploration within Auto OEMs
- over: evaluating sound samples to proof or reject preferences with customers
- to: rule-based approach to describe unique Brand Sound
- to: a ***drivable sound***

Define design goals

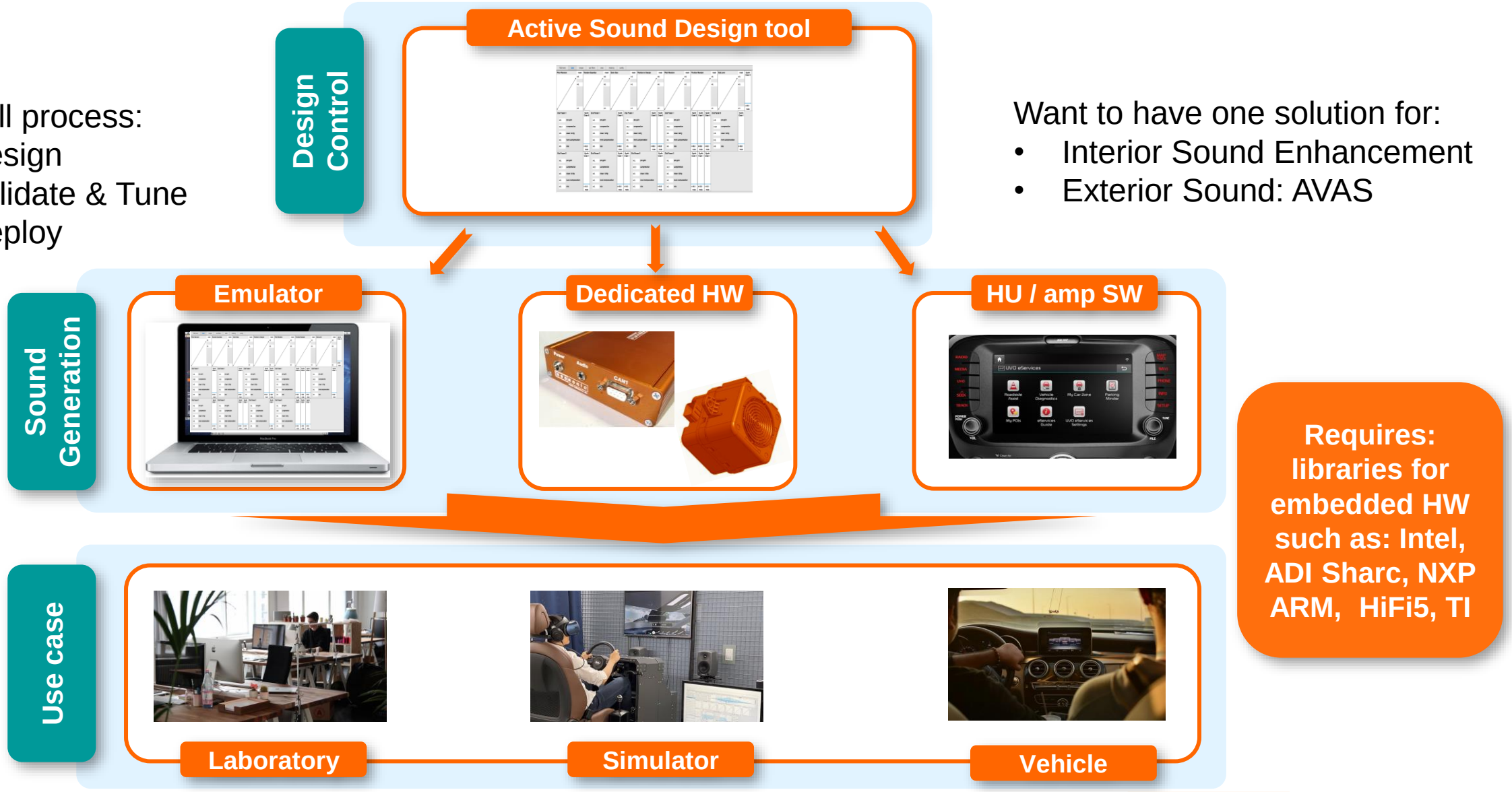
- give **feedback** about the **current status** of the vehicle
- implement a “sound floor” and **mask other component sounds** which might be annoying
- increase the **interaction of the driver** with the vehicle
- increase the **emotional expression** of the vehicle
- implement a **Brand Sound**
- allow **personalization**

Use freedom for EV’s

- no basic prominent motor sound as for ICE
- the task is to build a sound from scratch
- the sound character needs to be designed
- different sound generation methods are available

Active Sound Design Tool Layout

For full process:
1. Design
2. Validate & Tune
3. Deploy



Want to have one solution for:
- Interior Sound Enhancement
- Exterior Sound: AVAS

Requires: libraries for embedded HW such as: Intel, ADI Sharc, NXP ARM, HiFi5, TI

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Agenda

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Active Sound Design Methods

Sound generation needs to **be coupled to dynamic vehicle parameters :**

- ASD ***is not playback*** of a fixed musical composition
- sound generation must allow *to* ***precisely follow*** the *dynamic vehicle parameters*
- driver needs to get impression that the *sound is generated by the car* → ***authenticity***

Requirements to synthesis methods?

- Many sound synthesis method possible, transferred from NVH, music creation, signal theory
- all methods have their specific pros and cons with regard to
  - the **achievable sound character**
  - the **user interface / required user experience**
  - **required resources** (**MIPS**, **Memory**)

Methods:

- Order-based synthesis
- Pitched sample playback
- FM synthesis
- Shepard tones
- Granular synthesis

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Order-based synthesis

Category

analysis-related method – often analysis results are reproduced

Typical parameters

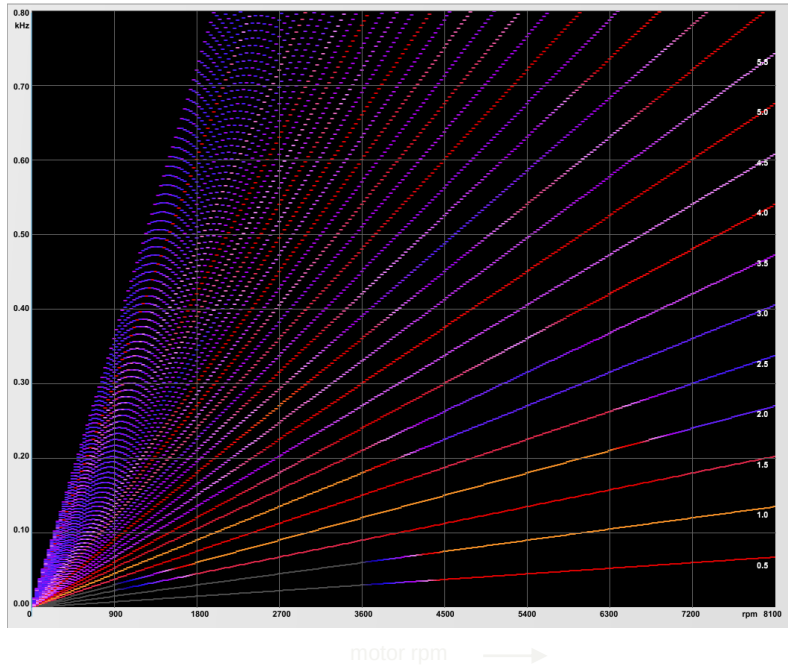
- Number of orders reproduced
- Order levels as a function of engine speed (and engine load)
- Order phases
- Randomization

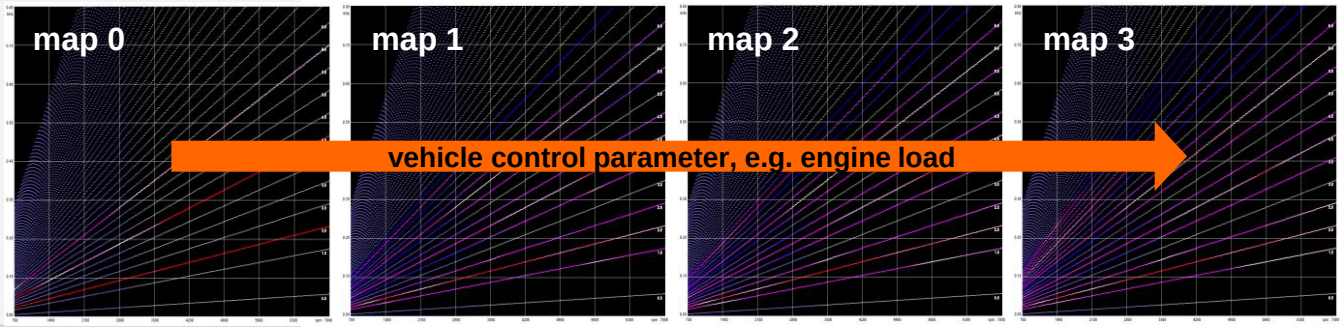
Pros:

- very predictable, defined by well understood parameters
- design approach is analytical, ICE knowledge based
- that single layer already allows variable sound
- resource-friendly with regard to memory needed

Cons:

- the achievable sound character is limited

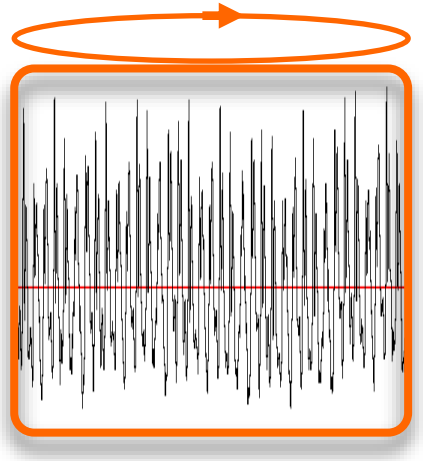


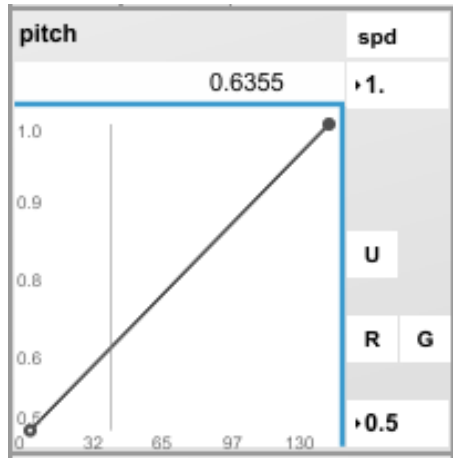


Pitched sample playback

Category
replication-related method – reproduce existing sound character
Typical parameters
• sample • pitch at a function of dynamic control parameter

Pros:	Cons:
• most predictable method • easy to reproduce desired or already existing sound features • resource-friendly (MIPS) • No deep Sound Design knowledge needed	• Static - limited character change • constraints to the sample need to be considered • highest memory resources need of all methods: number and sizes of the samples for full sound is high





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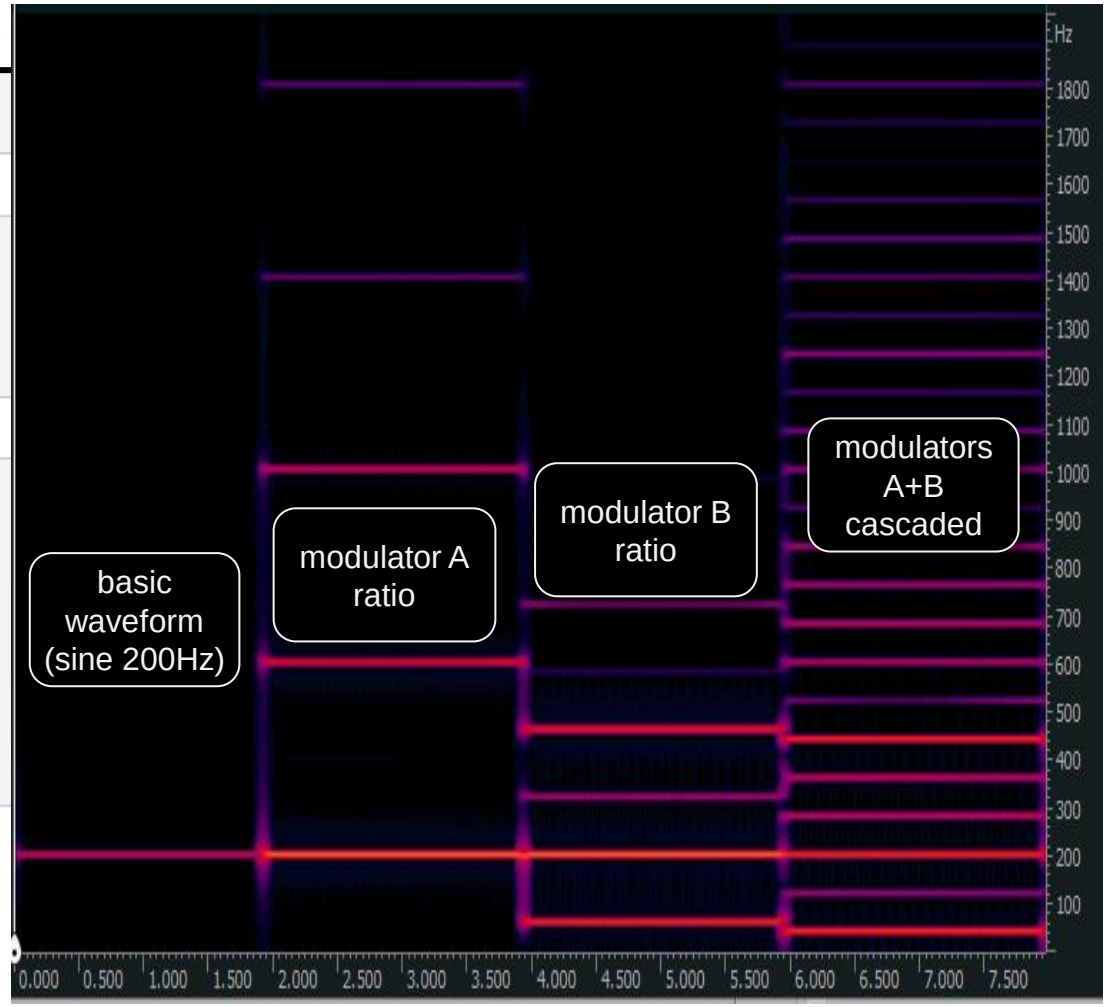
FM synthesis

Category	
synthesizer style method, creative sound generation	
Typical parameters	
• sample or base signal (or oscillator type) • modulation frequency (frequencies) • modulation index (indices)	
Pros:	**Cons:**
• common for users familiar with music synthesizers • resource-friendly for memory (very short sound sample) • resource-friendly for processing (MIPS)	• a single layer typically is not sufficient • Ressource requirements depending on the number of modulations stages



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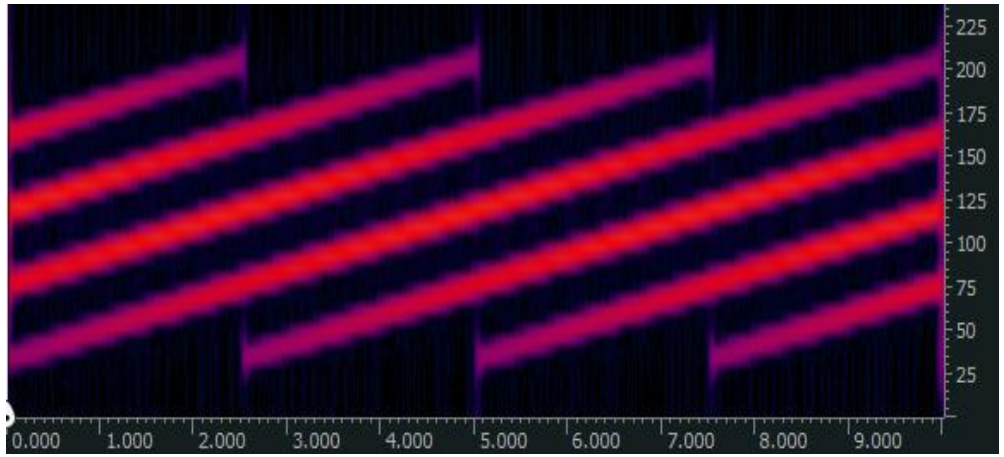
Shepard synthesis

Category	
specific add-on method – intended to complement other methods	
Typical parameters	
• number of components • min and max frequency limits • pitch shift slope	
Pros:	**Cons:**
• efficient to keep low frequencies and include variability into the sound • memory: resource-friendly with regard to memory • Processing: resource-friendly with regard to MIPS	• a single layer typically is not sufficient for variable and rich sound generation



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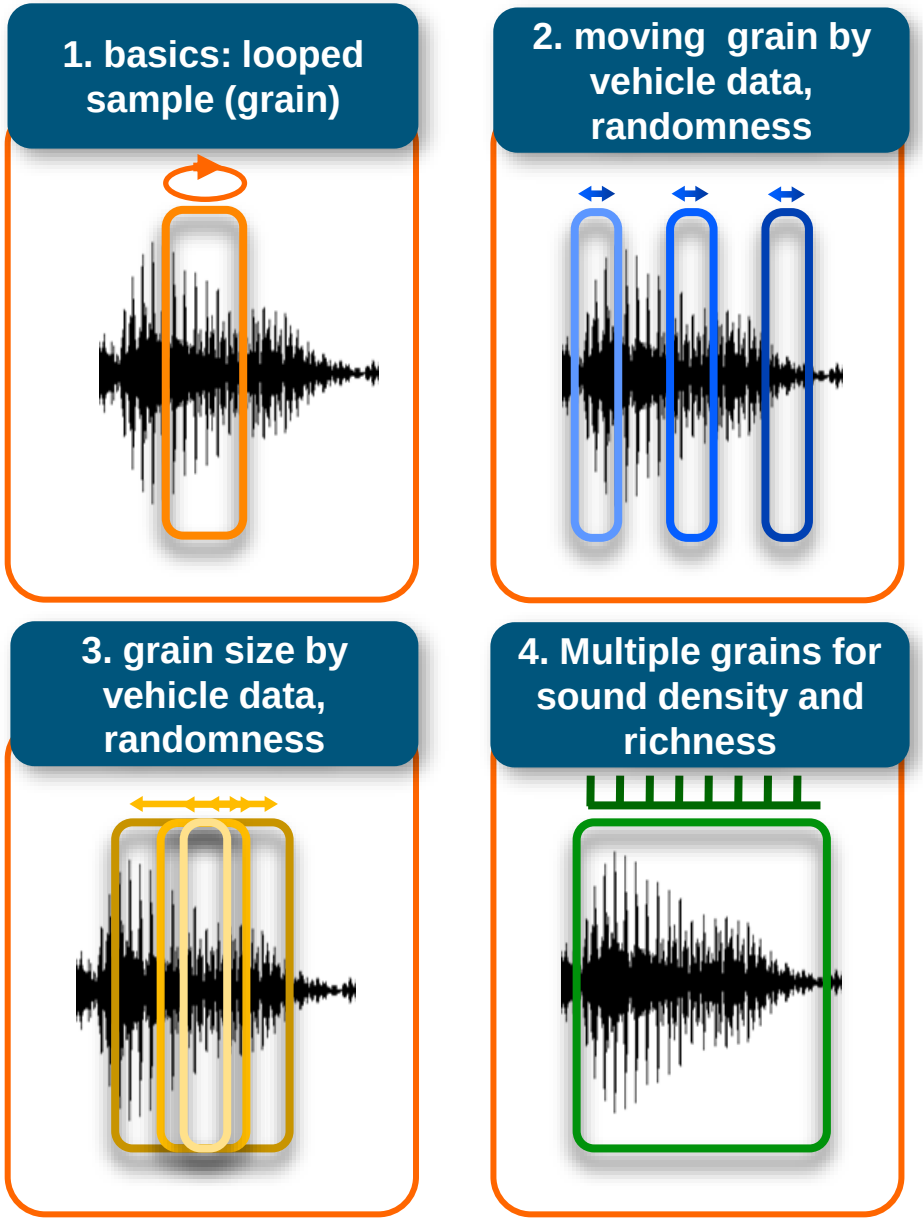
Granular synthesis

Category	
design-related method – intends to create something new	
Typical parameters	
• sample • pitch • number of grains • window function	• grain position • grain length • position and length random values
Pros:	**Cons:**
• creation of rich, vivid and variable sounds • creative design tool • single layer already allows to create variable sound • resource-friendly with regard to memory • processing: only medium MIPS requirements	• less predictable sound generation (which is not necessarily a con) • a single layer typically is not sufficient



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Choose your base character with your sound sample

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Advanced ASD Concept

How to bring sound to the vehicle

All sound generation methods have their specific advantages and disadvantages

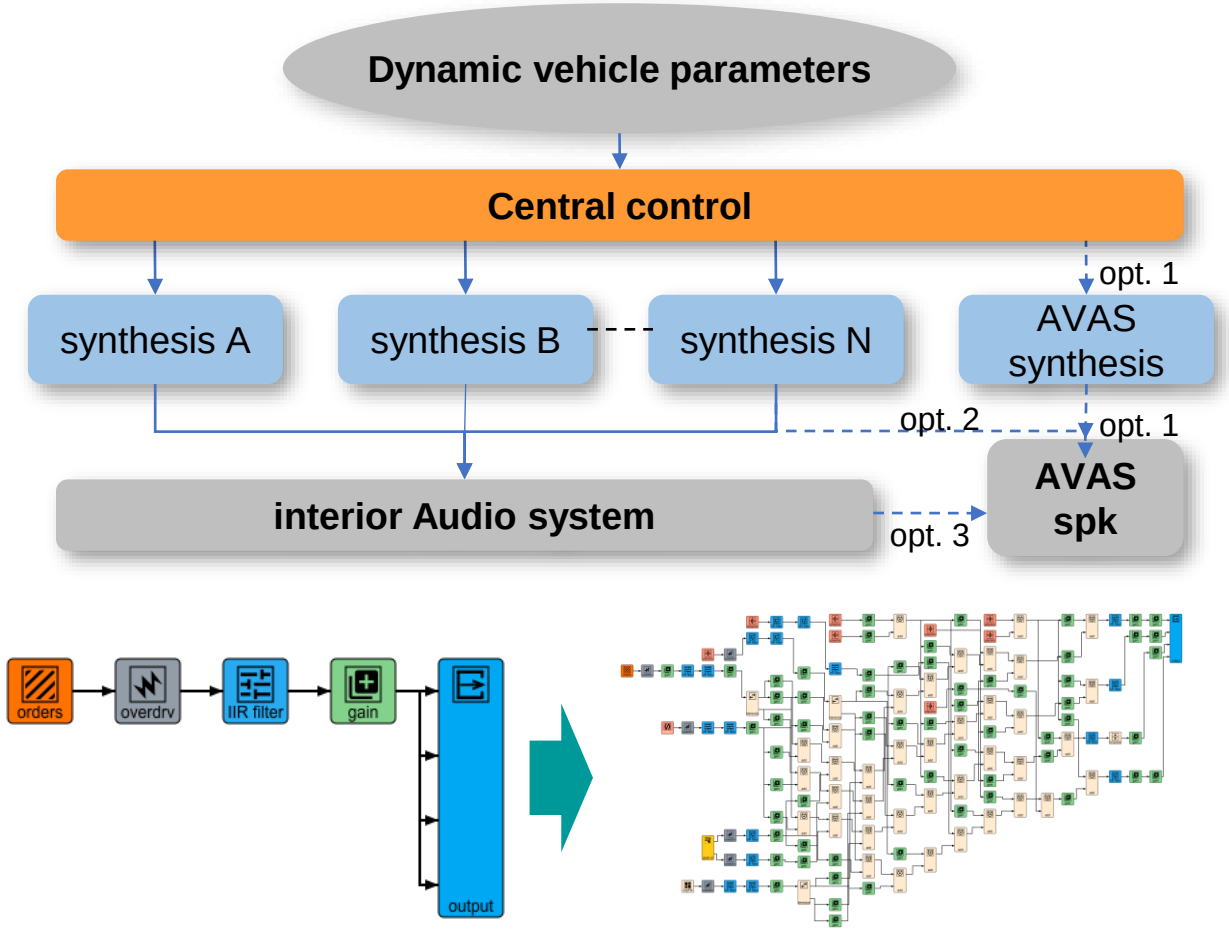
The selection of the used method depends on

- the targeted sound character
- the available resources on the mass production device
- the preferences and skills of the Sound Designer
- the tools available

Advanced ASD tools

- allow the usage of all sound generation methods
- Have a flexible layout of the signal flow to different preferences and vehicle types (EV, PHEV, HEV, ICE, …)
- Use single application for both design in the studio, validation in the vehicle, tuning for vehicle fleet handling
- Provide a device independent sound generation to allow easy transfer from design to mass production

Advanced Active Sound Design Concept



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Agenda

Introduction

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Sound Design Example: High Performance Car

High Performance vehicles
Example: Hyundai N Brand

VEHICLE SEGMENT

- High Performance is next step above High Power cars
- Still have track ability (handling, power, durability, …)

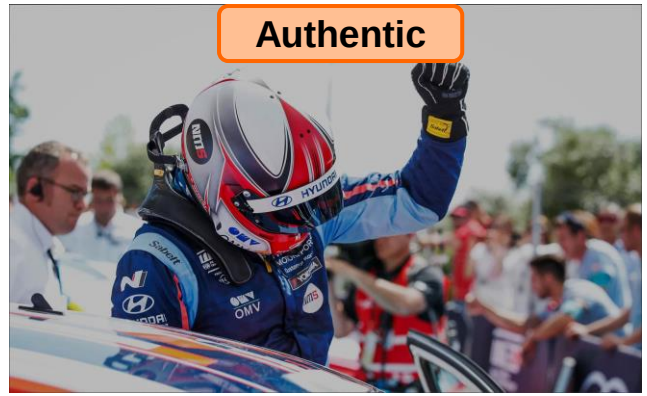
CUSTOMER SEGMENT

- car lovers, car enthusiasts
- like to go to the limits, of the car, of themselves
- head for extreme experiences

N vehicles need corresponding sounds:

- needs to be bold, can be out of conventions
- no blueprint for standard Evs
  → challenge and big playground for Sound Design – extreme expectations, extreme possibilities!

Sound plays an indispensable role



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Nsound+ Concept – transfer the N heritage

ICE SPORTY SOUND CHARACTERISTICS

strong reaction to vehicle dynamics
- strong / peculiar load reaction

loud sound level
- super sport cars are very loud (interior and exterior)

complex sound
- various sound components audible

strong roughness with engine load
- sound attributes in contrast to comfort

“dirtiness”
- untamed, “wild” sound (of a beast)

transmits endless power
- even at low load dense sound, always on a jump and can stand any attack

own special character, not mainstream
- super sport cars are not always easy to handle. the sound reflects that
- no uniform sound, some un-refined sound components
- no compromise
- attributes like ‘brute’

transfer of ICE sport attributes to the EV domain (interpretation, not 1:1 transfer!)

BEV SPORTY SOUND CHARACTERISTICS

strong reaction to vehicle dynamics
- strong / peculiar load reaction to be generated

loud(er) sound level
- super sport BEVs do not need to deliver the same level since generation is not bound to mechanics (only when needed)

complex sound
- various sound components to be generated

strong roughness with engine load
- apply roughness and modulation on load

“dirtiness”
- special sound treatment required

transmits endless power
- to be considered for sound character definition

own special character, not mainstream
- add more amount of randomness than for standard BEVs
- more randomness, to be considered in sound manipulation
- to be considered in sound definition/design
- “

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Added sounds for complete experience

IDLE REVS

- a typical “display” mode for HP vehicles is to rev up in standstill
- this by default is not included in EVs as the motor rpm is 0 in standstill, a virtual rpm can be used to enable idle rev-ups

➢ ***a very easy method to increase driver involvement and “fun”***

IDLE RANDOMNESS

- HP ICE engines run quite agitated and not smooth, indicating that the engine is eager to take of
- synthesis methods are very monotonic if CAN parameters are static, to overcome this randomness can be overlayed

➢ ***effective method to increase authenticity***

EXTERIOR SOUND

Motivation

- exterior sound plays an important role for high performance veh.
- For HP ICE vehicles the dominating sound source is the exhaust
- this strongly impacts the interior sound and creates an immersive experience to the driver

➢ ***exterior sound needs to be considered for HPEVs, too***

But keep in mind

- Added exterior sound is a controversial topic as it affects also the surroundings and thus becomes a society topic
- Therefore mainly used in track modes for driving on racing grounds, the driver can deactivate exterior sound

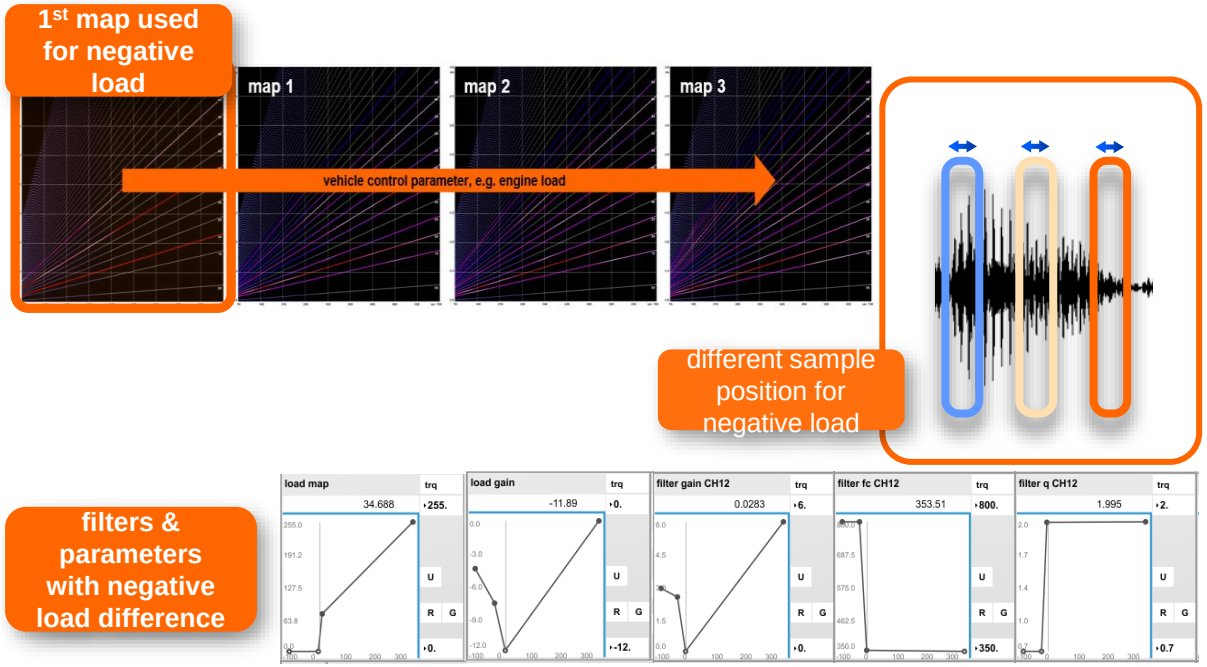
Vehicle implementation

- derivate of the interior sound, transforming for example the portions of the sound of an exhaust system and/or an intake
- design and generation of interior and exterior sound happens aligned, to speeds up the design phase and to avoid interferences

Added sounds for complete experience

RECUPERATION:

- new feature introduced by EVs
- much stronger impact than engine brake for ICEs
- dynamics play an important role for high performance vehicles
  the recuperation sound is more important than for standard EVs.
- Acoustic feedback allows to handle the vehicle in a better way!



Event Sounds: ADDITIONAL SOUND COMPONENTS

Specific kickdown sounds, express that extreme driving condition

- additional sound generation layer or dedicated after-processing

Level overshoots at specific events

- drive mode change, sound feedback for dynamic actions

Virtual rpm overshoots at events like simulated gear shifts

- simulates slight slips which occurs at clutch systems

Virtual misfires

- triggered by logics calculated in the vehicle ECU

Specific feedback signals or signal modifications for other events

- basically any dynamic action of the vehicle can be represented

N e-Shift (Virtual Gear Shift)

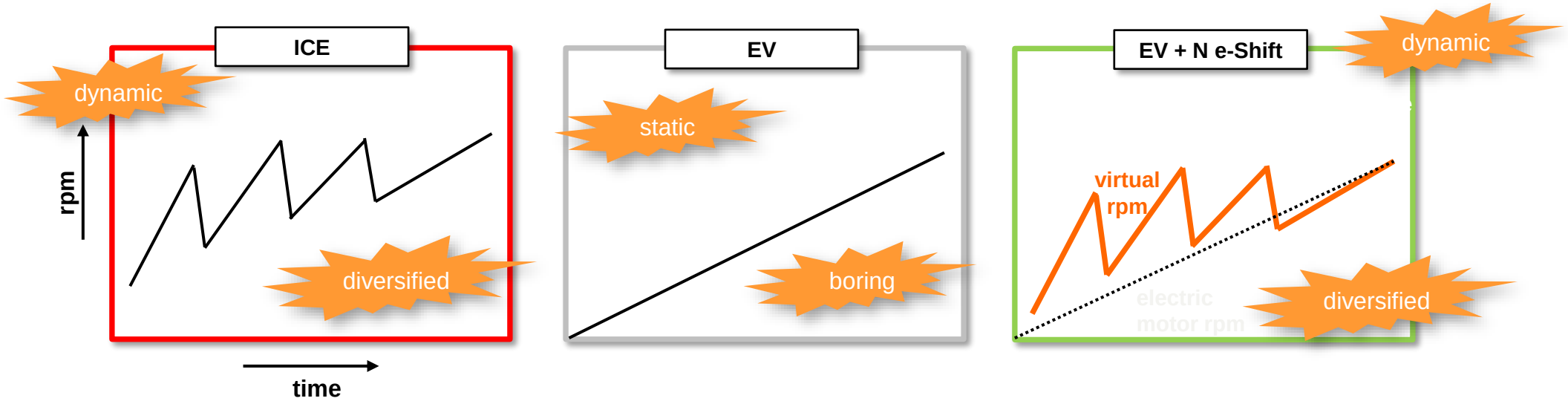
The absence of multiple gears of EVs results in a more monotonic undynamic sound, this can be broken up by virtual gear shifts.

Pure acoustic presentation can result in a mismatch of other sensory perception and thus reduce authenticity.

Hyundai developed the N e-shift technology to overcome this

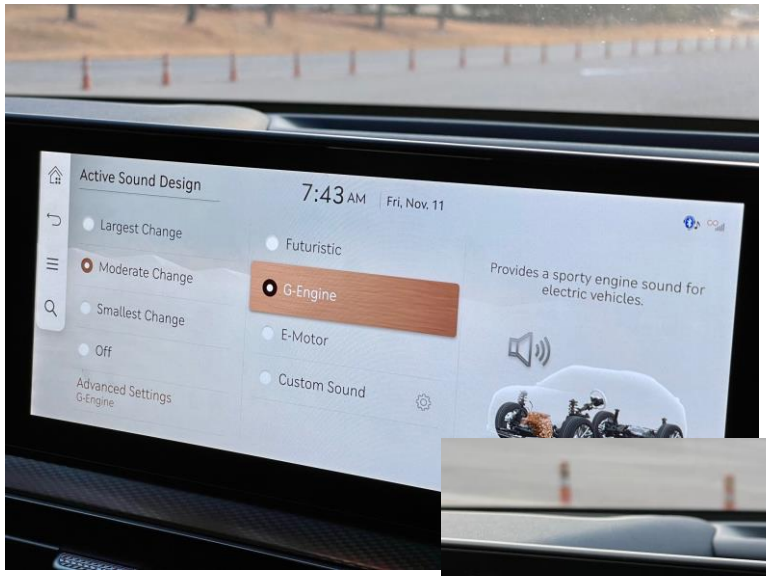
- gear shifting events determined based on an internal vehicle model
- the requested motor torque is manipulated to introduce tactile/vibrational feedback

The implementation significantly increases perceived variability and driver involvement



Vehicle Implementation

- Sound generation on separate DSP device
- communication to the audio system via A2B
- usage of the interior speakers
- exterior speakers in front and rear
- OTA ability
- customization by user via the AVN



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Experience the sound of Hyundai RN22e

https://www.youtube.com/watch?v=dffQyt1yJiQ

Virtual gear shift from 7:45

Idle noise at 12:52

Impress your co-pilot from 14:30

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Conclusions

- The process to design sounds redefines and extends the definition of Sound Quality
- Automotive sounds are no longer only shaped, but synthesized and composed
- A variety of different sound generation methods are available, with pro’s/ cons’s/ constraints
- Unlimited choice of sound characteristics

Thank you for your attention

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