Forza Motorsport 2

Advanced Audio Techniques for Racing Games

GDC 2007

Agenda

- Forza Audio Vision
- Team Communication
- Cars as a Sound Source
- Modularizing Car Sound
- Engines
- Bolt-ons
  - Superchargers
  - Gear Whine
  - Turbochargers
- Tires
- Collisions

Forza Motorsport 2 Demo

Forza Audio Vision

- Improve Gameplay
- Fully Immerse the Player
- Support Car Customization

Challenge 1:
Team Communication

- Finding common ground
  - Sound Designer != Gearhead
- Drinking from the fire hose of knowledge
- Settling on terminology

Challenge 2:
Cars as a sound source

Car sounds:

- Are Numerous
- Are Continuous & Ever-changing
- Are Complex
- Are a Key Source of Driver Feedback
- “Easy to Play, Hard to Master”

Challenge 3:

Modularizing Car Sound

- Engine and Exhaust Sounds
- Bolt-on Sounds
- Tire Sounds
- Collision Sounds

Total Audio Permutations in Forza 2 = a whole lot

Engines

Think of a car engine as a complicated wind instrument.

- •Tuned-length/volume air intake system
- •Air enters cylinders through intake valves
- •Fuel mixes with air and a spark causes it to explode
- •Explosion exits through exhaust valves
- •Exhaust system changes volume & shapes acoustic quality

Pattern of pulses (e.g. rhythm) generated is key to engine sound signature

- •Crankshaft design determines pattern
  - •4 cylinder = distinct, even pulses
  - •6 cylinder = overlapping pulses (chord-like)
  - •10 cylinder = uneven pulse pattern
- •Exhaust header design can change pulse pattern


V12 5.7L
VALVE TIMING MANAGEMENT
Lamborghini
FIRING ORDER 1-7-4-10-2-8-6-12-3-9-5-11
CAUTION!
HIGH TEMPERATURE

Recording Engines

Some possible methods:

- •Neutral Revs vs. Dyno vs. Track
- •Why Forza uses a Dyno

Recording loops – Forza uses a lot of loops, and we go as high in the rev range as possible.

Mic placement:

- •maximizing rejection
- •Listening for Phase coherency – 3 to1 rule.
- •SPL! (learn to love the -20db Pad)

Cautionary tales….

- •For God's sake, get a good sounding car to start with!
- •Make sure the car runs OK before putting it through its paces (having a gearhead-type at the session is immensely helpful).
- •Beware of Wind – cars need fans! Cars also need cool-down time….
- •Beware of Heat – the great killer of mics & cables
- •Beware of Vacuum – zip ties are your friend…..


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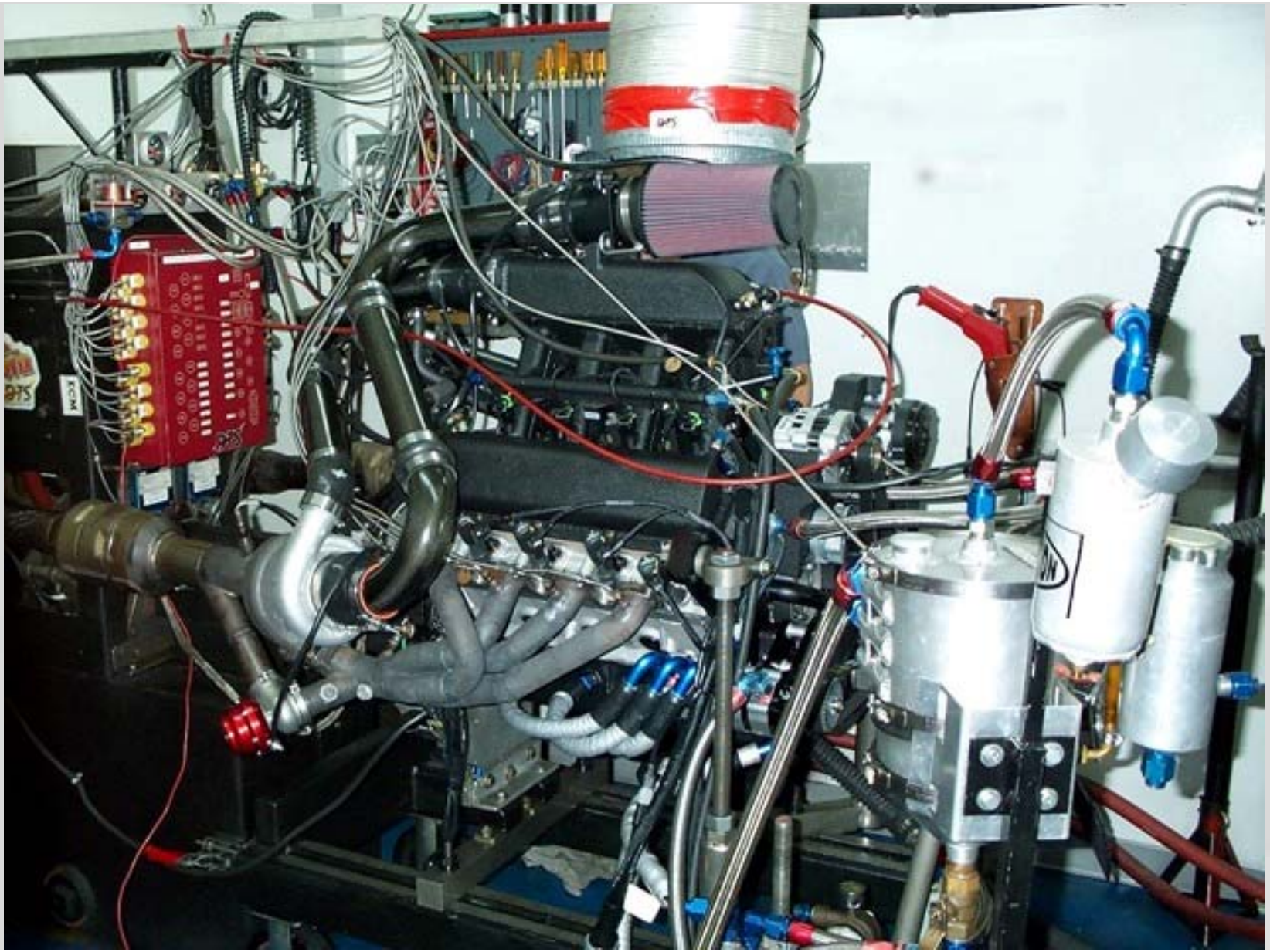

ECM

Implementing Engine Sounds

Mapping recorded engine loops to appropriate physics rpm ranges

Tuning & pitch issues with loops

$$RPM = \frac{FundamentalFrequency * 60}{\#of\ cylinders}$$

Using real-time DSP to enhance car audio behavior

- Expose as much physics as possible to audio
- Possible useful Audio physics parameters include: EngineRPM, Torque, Throttle, Power, Boost, DamageState, etc.

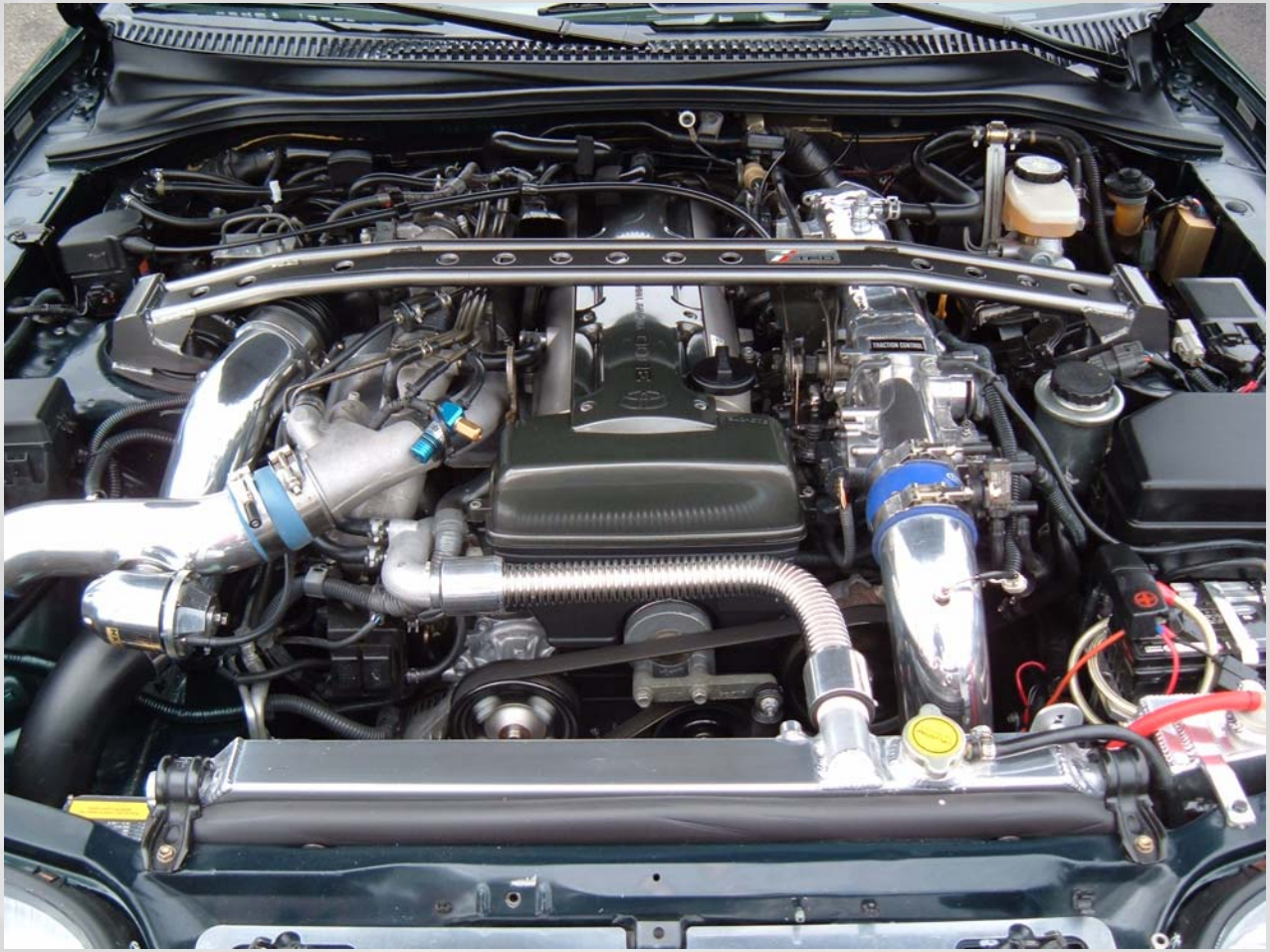
The Real world vs. the Game world

- Sometimes, über-realism just isn't fun to listen to…..

T'aint no substitute for real-life experience!

(but if you can't get it, at least get a bunch of video & audio reference!)

Bolt-ons



Superchargers

Description of sound: high frequency whine or whistle

Physical cause:

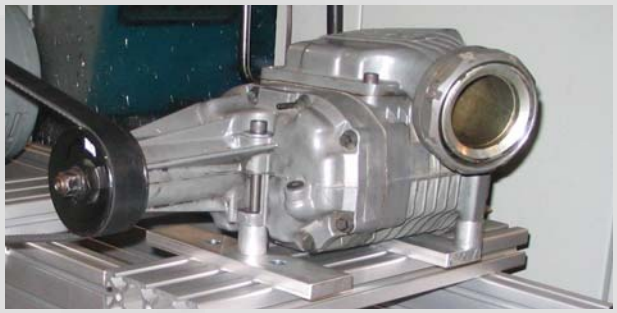
- Pulley-driven air compressor
- Speed/pitch is proportional to engine RPM
- Intensity varies with engine load/throttle
- Pitch changes rapidly during acceleration
- Internal gearing also contributes sound

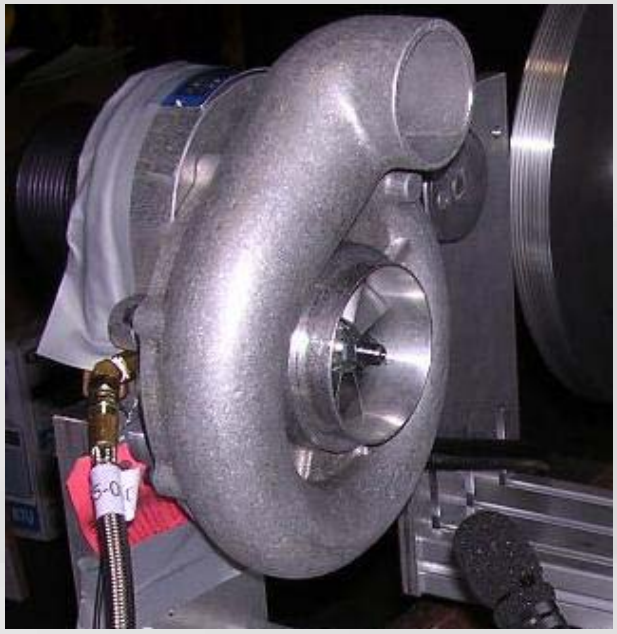
Variations:

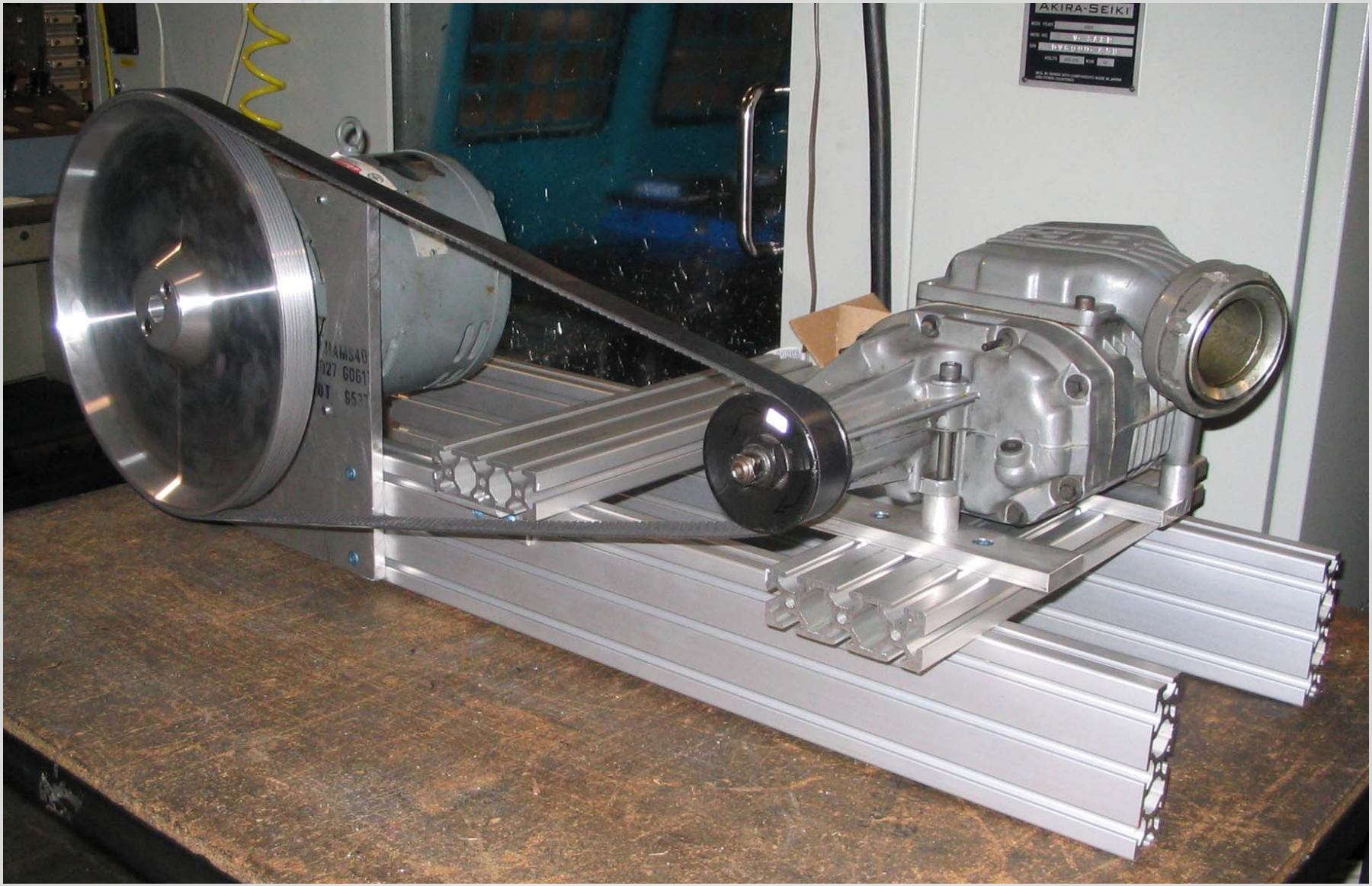
- Roots Type (most common)
- Centrifugal (similar to turbocharger)
- Twin-screw
- Size (larger displacement = louder, fuller sound)

How to record?

- Spin isolated superchargers of various types & sizes using an electric motor






AKIRA-SEIKI

Supercharger Audio

Supercharger recording notes:

- •High Pitched Induction note is actually the ‘whine’ we hear.
- •Different types of superchargers do actually make different sounds.
- •Superchargers in an open-air situation can get LOUD. Bring -20db pads.
- •Spin that sucker as high as your motor will allow, and to spin it up to real world RPM’s, you need a big ‘ol electric motor.
- •If you’re using a big ‘ol electric motor, watch out for massive ambient RFI.
- •If you’re using a big ‘ol electric motor, watch out for AMBIENT ELECTRIC CURRENT, LEADING TO ELECTRICAL SHOCK.

Note: Mike is not kidding

Supercharger implementation notes:

- •If your car has a supercharger in the real world, it very much affects the car’s induction note.
- •Possible physics parameters to use for SC implementation: RPM, Throttle, Boost, Torque & Power.


ESB
FRAGILE
EVEREADY
TRADE-MARK

Gear Whine

Description of sound: high-pitched whine

Physical cause:

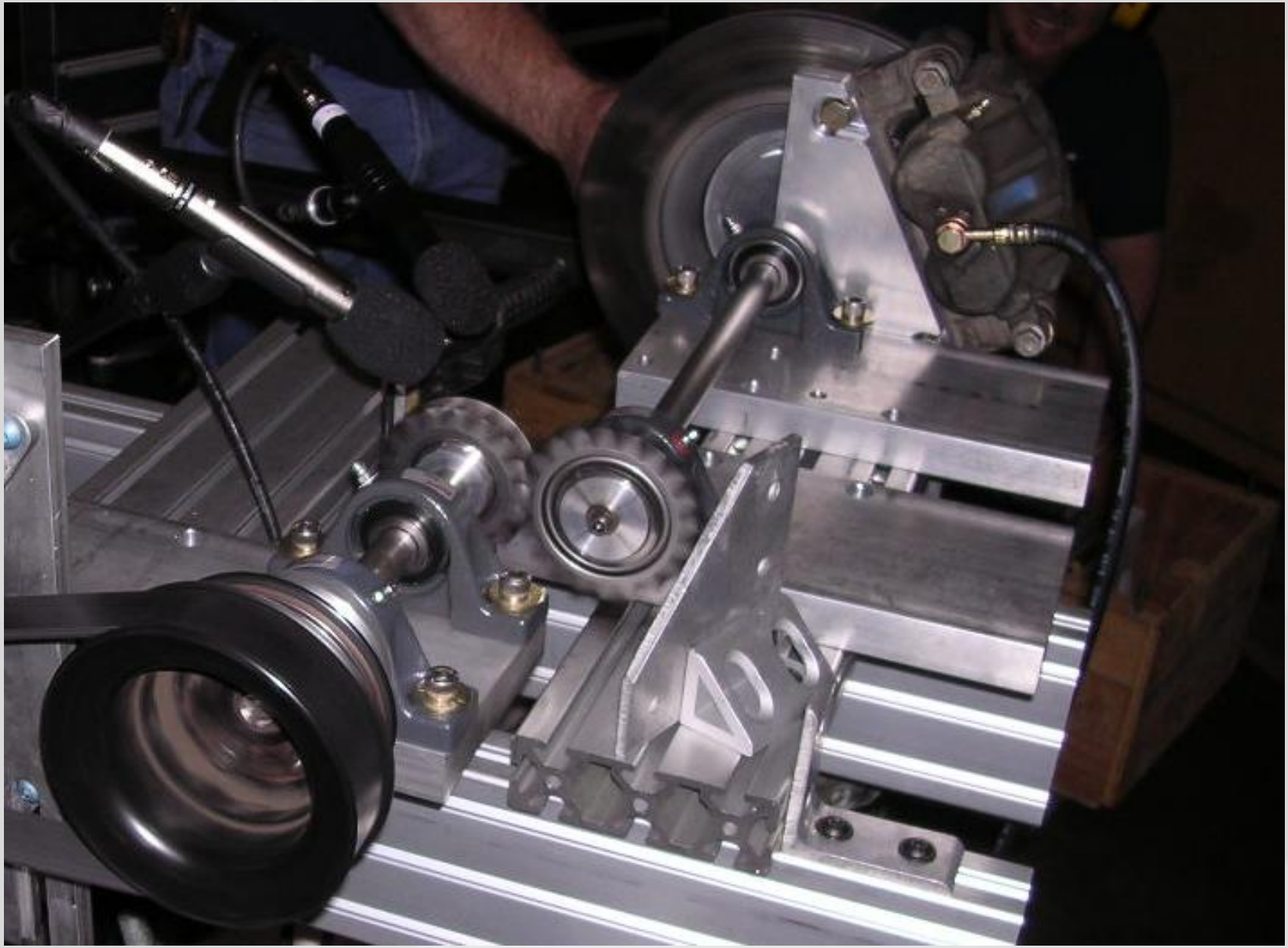
- •Steel teeth pushing together & sliding past each other
- •Higher torque = greater intensity
- •Multiple simultaneous sources, each with different pitch & character

Variations:

- •Straight cut gears = loud but strong, good for racecars
- •Helical gears = subtle, good for street cars

How to record?

- •Spin isolated meshing gears with an electric motor
- •Apply resistance using automotive brake rotor/caliper



Gear Whine Audio

Using 2 sets of gears to make 'Gear Whine':

- One gear set mapped to EngineRPM
- One gear set mapped to TransmissionRPM

Possible Physics parameters for Gear Noise:

- EngineRPM
- TransmissionRPM
- ClutchState
- Torque

Real-Life vs Game Audio: Mix racecar gears to taste. Straight-Cut gear whine WILL make you want to jump out a window if it's too loud. It should be present, but not obnoxious.

Bang for Buck: It takes some planning, cash & mechanical know-how to record these in an isolated environment, but it's totally worth it!

Turbochargers

Description of sound: high frequency whistle + white noise hiss (similar to a jet engine) + sneeze/chirp/turkey-call

Physical cause:

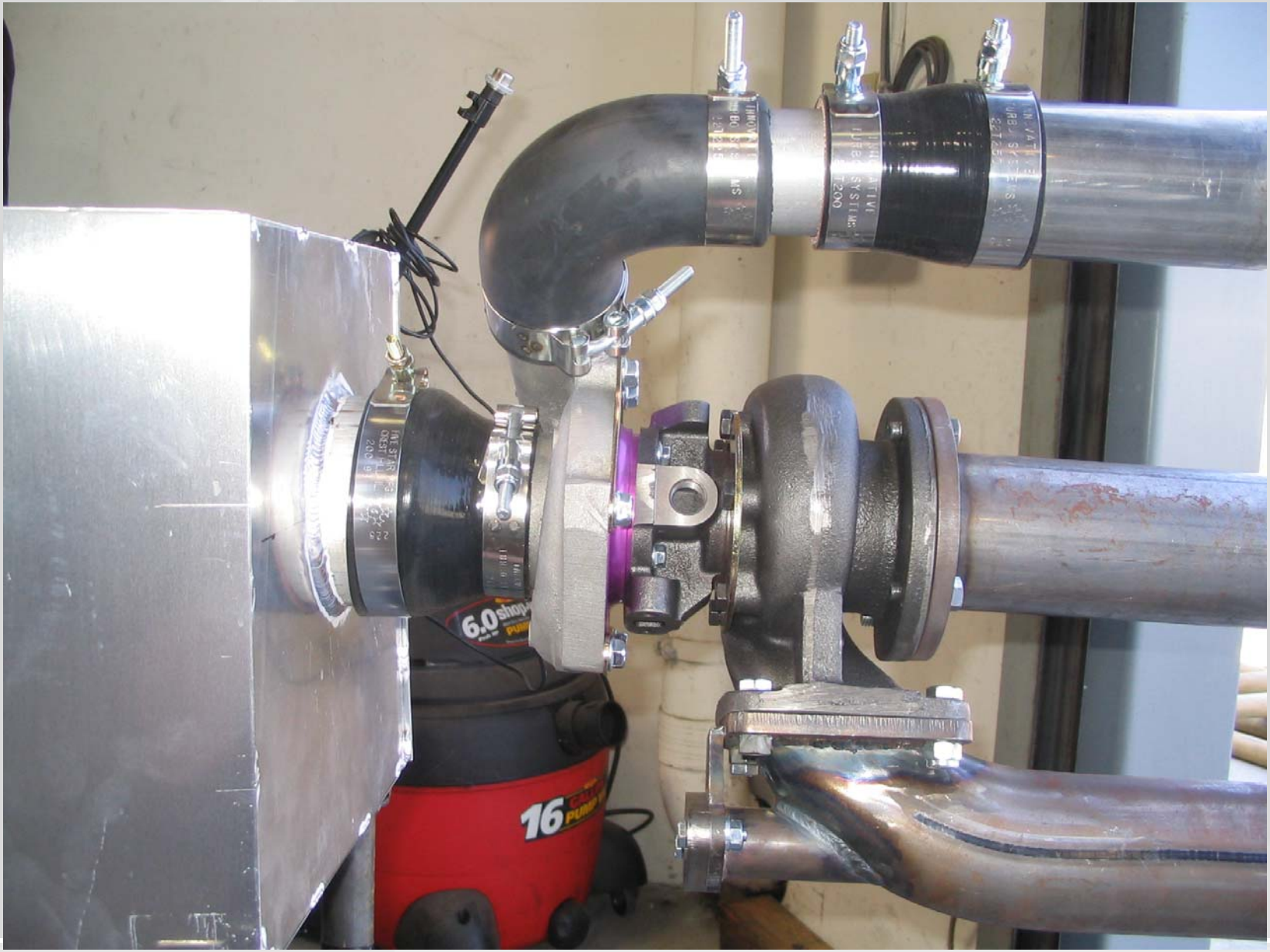
- Exhaust-driven turbine spinning an impeller at 50-100k RPM
- Pitch changes rapidly during acceleration
- Pressure is released by a valve (aka blow-off valve) when you lift throttle or shift gears

Variations:

- Size (bigger = louder but lower pitch)
- Blow-off Valve Type

How to record?

- Spin isolated turbochargers of various sizes using compressed air
- Sample blow-off valves at car recording sessions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Turbocharger Audio

Turbo recording notes:

- When isolated, a turbo has a large white noise component, along with a VERY high pitched whine. Over 20 KHz, in some cases.
- Record at as high a sample rate as you can, to maintain high frequencies when pitch shifting in post production.
- Blow-off valves can have a very wide range of sound & SPL.
- You can usually get a good Blow-off Valve sample at a car engine recording session, as the valve triggers when you let go of the throttle.

Turbo Implementation notes:

- Possible Physics Parameters for turbo implementation
  - Boost
  - TurboRPM
  - Throttle
  - ExhaustFlow
- The presence of a turbo definitely has an effect on Engine & Exhaust audio.

Tires

Description of sound: white noise + howls, scrubbing or screeches

Physical cause:

- •Rubber tire rolling across various surface types creates white noise type sound that varies in pitch according to speed
- •Small debris being crunched against the surface adds random “detail”
- •Howling begins when the tire is pushed toward its peak grip
- •Screeching begins when the tire goes past its peak grip
- •Intensity of screech increases the more a tire slides
- •Load pushing on a tire affects its pitch, lower load = higher pitch

How to record?

- •Drive and slide a car, preferably a rental ☺, on various surface types

Tire Audio

- **Traction Recording**
  - Surface Variations
  - Traction States Needed
  - How and where to record

Traction Implementation

- Multiple loops and volumes to represent actual traction state
- Most expensive audio system in the game

Collisions

The goal: Re-create ***the violence of racing***

- Most games do not properly convey a sense of energy dissipation when you crash, especially at high speed.
- Good collision sounds can greatly improve sense of immersion & danger.
- Sound helps you *feel* the surroundings & what you're coming in contact with.

The big debate:

- Is reality exciting enough?
- What do gamers expect?
- What does Hollywood do?
- Poor reference material = endless deliberation

Collisions

Session planning:

- Variations and permutations of sounds required
- How do we record such an explosive session?
- Risks:
  - Bad takes
  - Damaged Gear
  - Unimpressive results
- Reduce Risks:
  - Redundant Gear
  - Record Tons of Tracks
  - Lots of staff
  - Dry run (extreme dynamics)

Credits: The Team

- Greg Shaw (Turn 10 Audio Lead)
- Mike Caviezel (Sound Design Lead)
- Paul Newson (Audio Developer Lead)
- Joel Robinson (Lead Content Tester/Subject Matter Expert)
- Mark Price (Audio Content Coordinator/Subject Matter Expert)
- Chad Olsen (Audio Developer)
- Evan Buehler (Sound Designer)
- Marc Pospisil (Sound Designer)
- Jason Syltebo (Sound Designer)
- Matt Laverty (Audio Tester)
- Adam Wilson (Audio Tester)
- Keith Sjoquist (Recordist)
- Mary Olson (Recordist)
- Nick Wiswell & Bizarre Creations
- Alan Hartman