



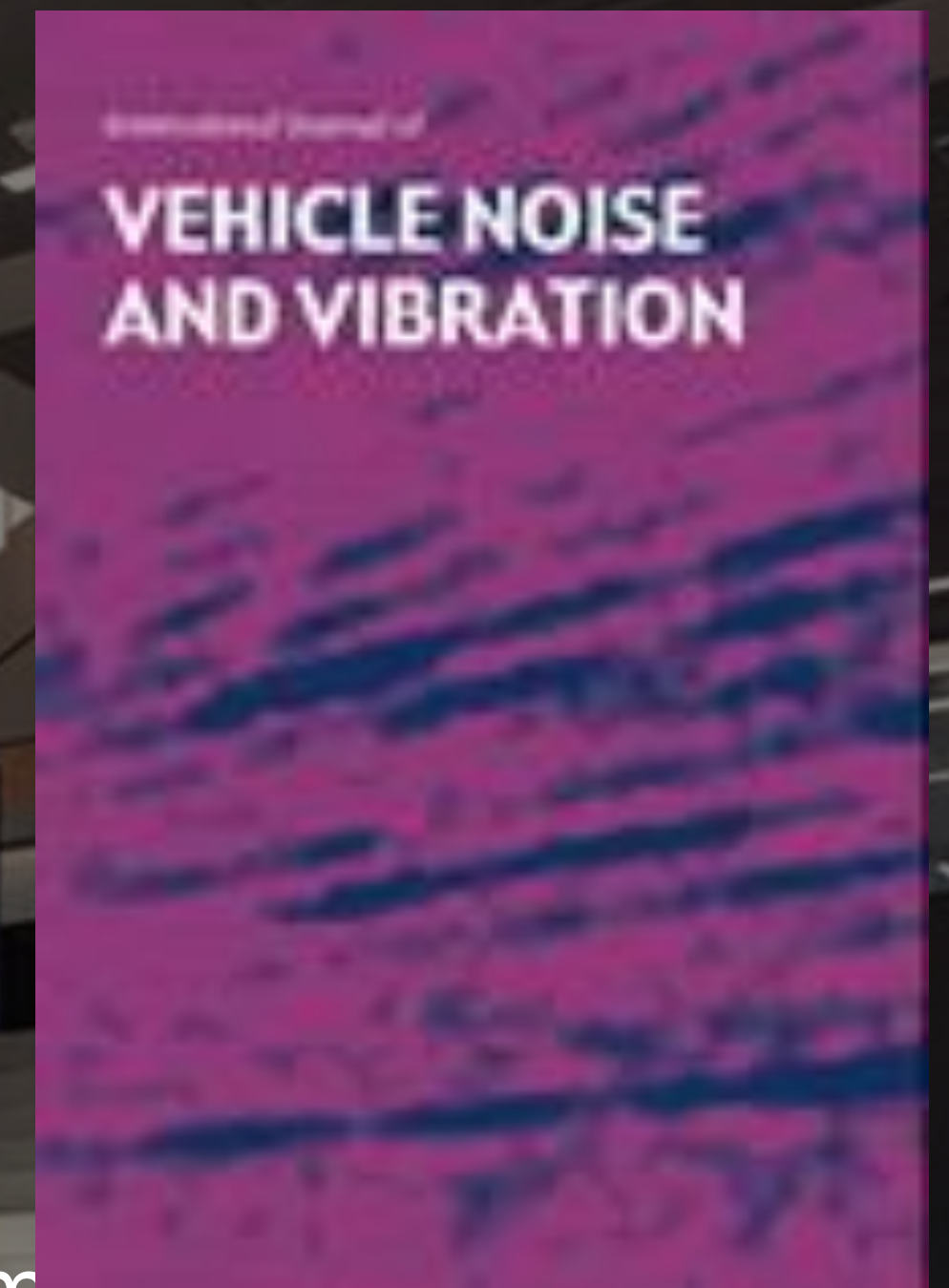
**GAMEABOVE COLLEGE OF
ENGINEERING & TECHNOLOGY**
EASTERN MICHIGAN UNIVERSITY

NEW NVH CHALLENGES FOR A TRANSFORMED AUTOMOTIVE INDUSTRY

Dr. Mohamad Qatu, Dean
GameAbove College of Engineering and Technology

THE TRANSFORMATION IN THE AUTOMOTIVE INDUSTRY

- Electrification
 - Electric vehicles have a rich history that expands more than 100 years
 - Internal Combustion engines were dominant for the last 100 years
 - New electrified vehicles started with having more electrically driven systems (steering, ...)
 - Hybrid vehicles were introduced in 1997 (Prius)
 - Modern electric vehicle were introduced in 2010 (Leaf)
 - Electric cars had 22% of market share in 2022 and is expected to grow significantly in the next 5-15 years



THE TRANSFORMATION IN THE AUTOMOTIVE INDUSTRY

- Computerization
 - Started as early as 1970s to handle transmission shifting and ignition timing
 - Engine Control Modules became common in modern vehicles
 - Computerization impacted safety, comfort and other functions
 - Lower levels of autonomous cars started in the 1980s and advanced rapidly since then
 - Various levels of autonomous behaviors exist in most vehicles today
 - Technologies like machine vision, artificial intelligence and embedded systems are finding their ways in today's vehicles
 - High levels of autonomy exist in today's automotive market and is expected to grow

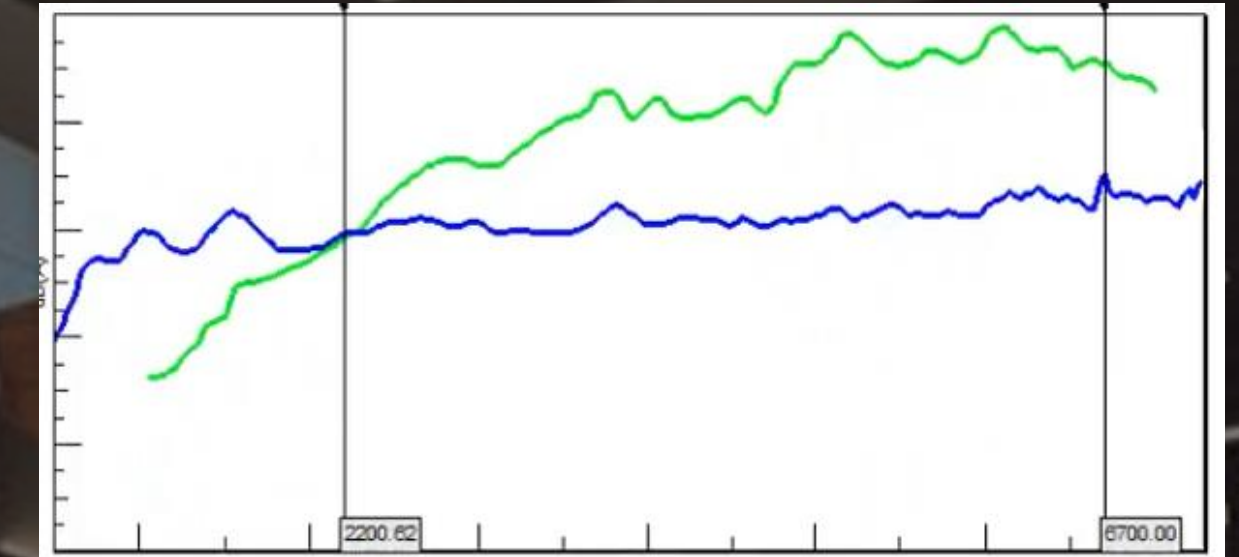
IMPACT ON NVH

- Main sources of NVH in traditional ICE vehicles
 - Powertrain (mainly combustion, includes transmission, exhaust/induction, driveline, gears)
 - Road and Tire NVH
 - Wind NVH
 - Other electromechanical devices/systems
- NVH in modern vehicles
 - New high frequency noises from the motor and related systems
 - Different sound quality signature
 - Road and Tire NVH
 - Wind NVH
 - Other electromechanical devices/systems

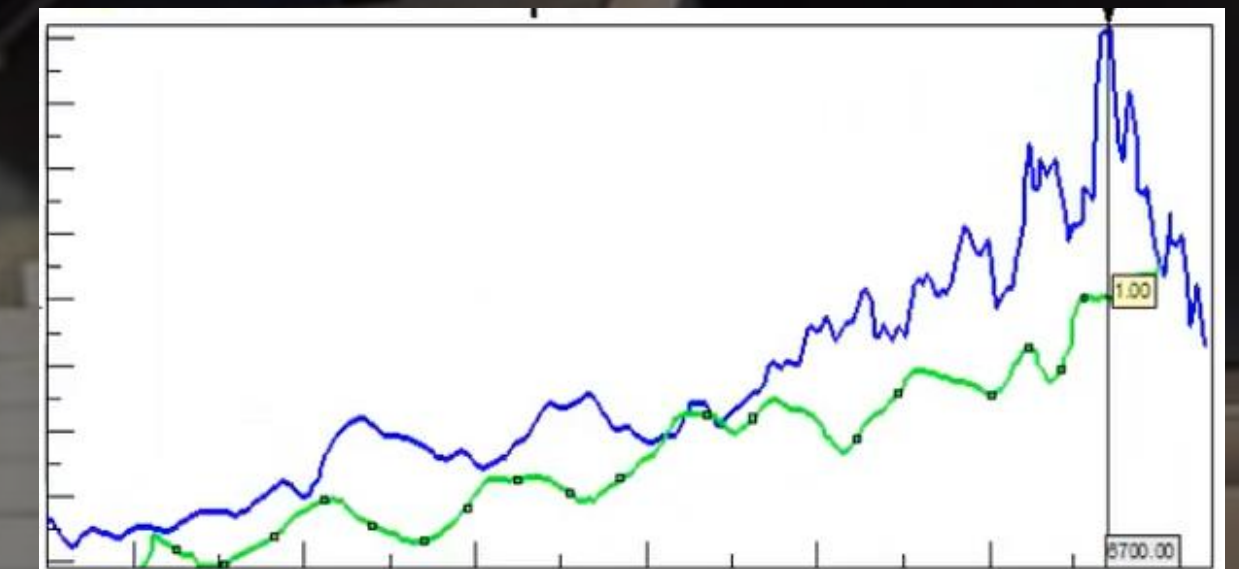


NEW NVH CHALLENGES

- NVH Characteristics
 - Lower overall levels
 - No low-frequency engine noise masking
 - High motor orders and frequency sounds
 - Resonances at different excitations from electric motors
 - Emphasis on sound quality
 - Sharpness
 - Audible and prominent tonal sounds
 - Transient NVH (start/stop shock)
 - Subjective assessment becomes very important
 - Psychoacoustics challenges (the absence of the powerful sound of ICE)
- Sound quality is more important than sound levels in EV



EV Vs. ICE: OVERALL SOUND



EV Vs. ICE: SHARPNESS

EV NVH

<https://www.youtube.com/watch?v=2kXoOZDN0Nw>

- Begin assessment at the receiver
 - Objective and subjective evaluation
 - Source – Transfer path – Receiver analysis
- A system engineering approach (source, transfer path, receiver)
 - V-Design system approach
 - Test/simulate at the component level
 - Evaluate at the integrated subsystem level
 - Simulate/Test as-installed
- Simulation and Design Optimization
 - CAE is very important in predicting NVH performance and optimizing solutions
 - Software and tools may need to be modified, sometimes created
 - Prediction of high frequency NVH performance requires more advanced models and can be computationally demanding
- Testing and experimentation
 - New test benches for electric motors/devices

EV POWETRAIN NVH

- Electric Motor (simulation, testing or combination)
 - Simulate/test an electric motor (electromagnetic forces replace combustion pressure)
 - Simulate/test structural behavior
 - Integrate motor with the structural behavior to obtain:
 - radiate noise (air-borne noise – ABN)
 - structural-borne noise – ABN
- Transmission/Gear (simulation, testing or combination)
 - Transmission specification (transmission error, bearing noises, ...)
 - Structural behavior
 - Noise radiation (including gear whine) and vibration

NVH for EV

- Wind Noise
 - Important in EV
 - Fundamental differences in body structure between ICE and EV (material, geometry, modal analysis)
 - EV s have an aerodynamic shape to minimize drag
 - More laminar flow behavior
 - Local turbulence behavior
- Road/Tire Noise
 - Specific characteristics as EV s are heavier
 - Typical source-path-receiver analysis
 - Optimize mounts, natural frequency coupling, and
- Other NVH
 - Mechatronics systems (electrically driven mechanical system : steering systems, wiper systems)
 - Cooling systems (battery cooling, HVAC, ...)

ACTIVE SOUND SYSTEMS

- Active sound systems
 - Exterior sound generation
 - Alert public
 - Directional (e.g. sidewalk)
 - Brand strategy and identity
 - Interior sound
 - Sound cancelation
 - Sound masking
- Focus on low-weight NVH solutions (e.g. light-weight dampers)

NVH for EV

- Fast pace of design, manufacturing, marketing of EV s. This requires
 - Fast pace design processes
 - Advanced testing and simulation tools
 - Creating components that can be used in multiple platforms
 - Develop testing and simulation libraries for components and subsystems
 - Embed technology that can be used for
 - Noise cancelation,
 - Sound generation,
 - and other possible applications
- Automotive Industry with **ZERO PROTOTYPES**



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Q & A

