



電動車両の加速感開発におけるドライビングシミュレータの活用

Utilization of Driving Simulators in Electric Vehicle Development

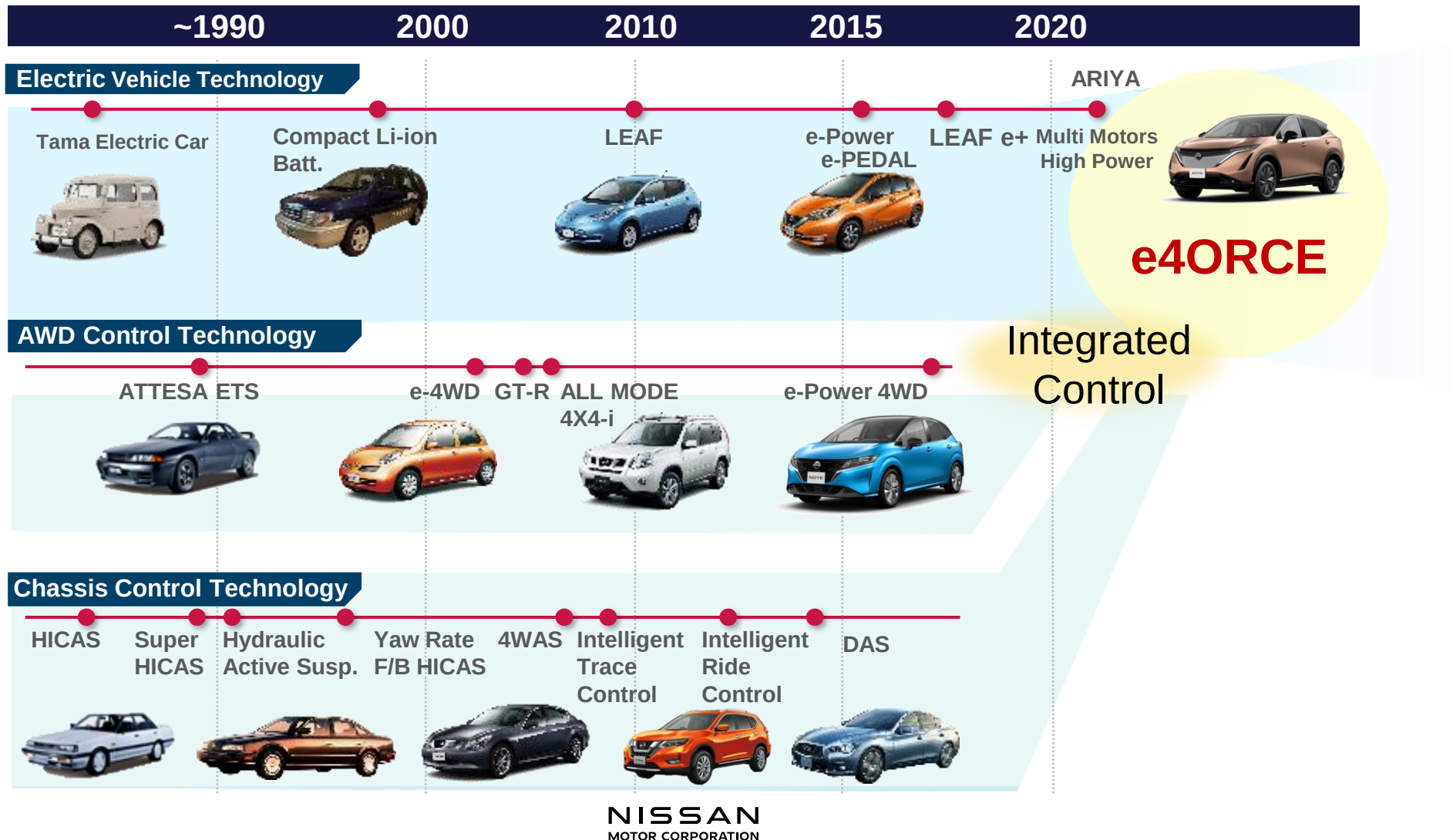
実験技術革新部

Customer Performance and Test Engineering
Methodology Innovation Department

Naoya MACHIDA

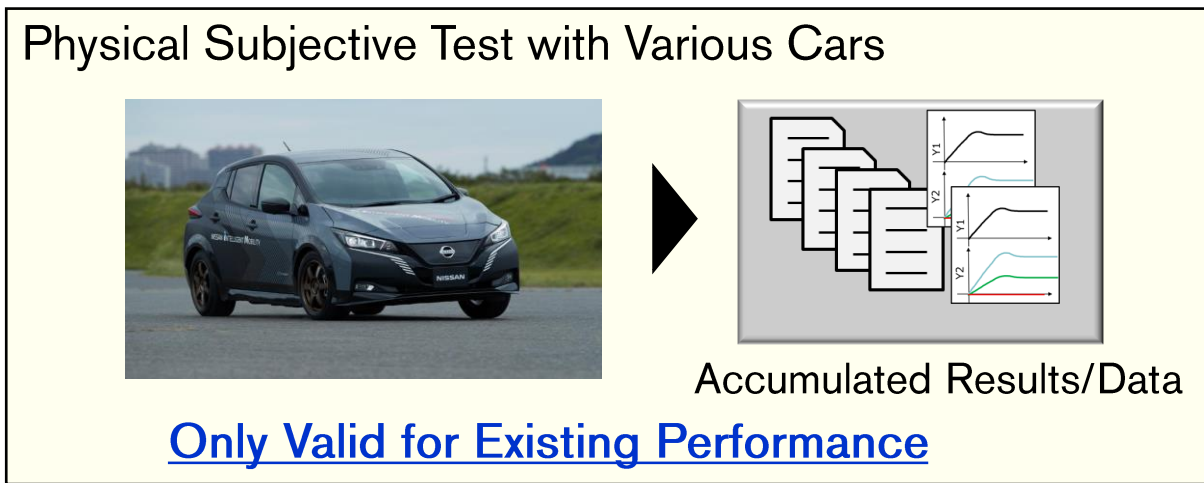
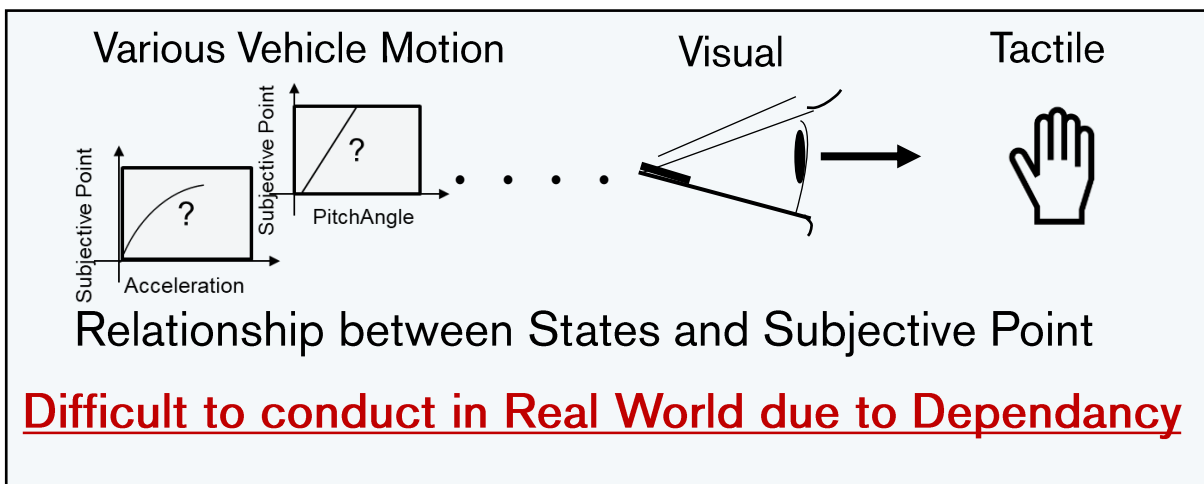
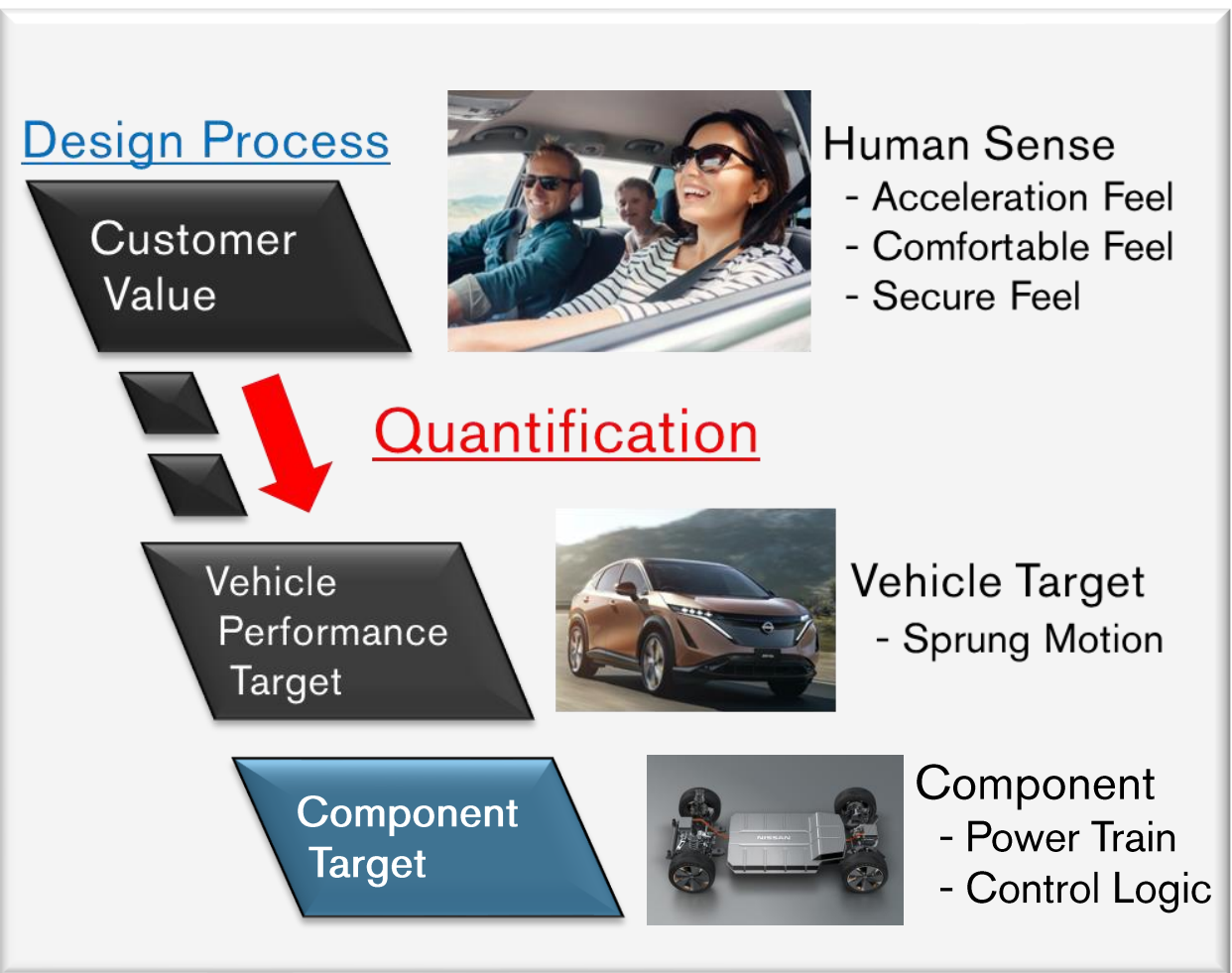
History of Nissan Driving Force Control Technology

In the competition for electrification, it is becoming important to provide new value to customers. Finding the value and connecting between the value and design of the vehicle is a key factor



Issue for Designing the Vehicle with Human Sense

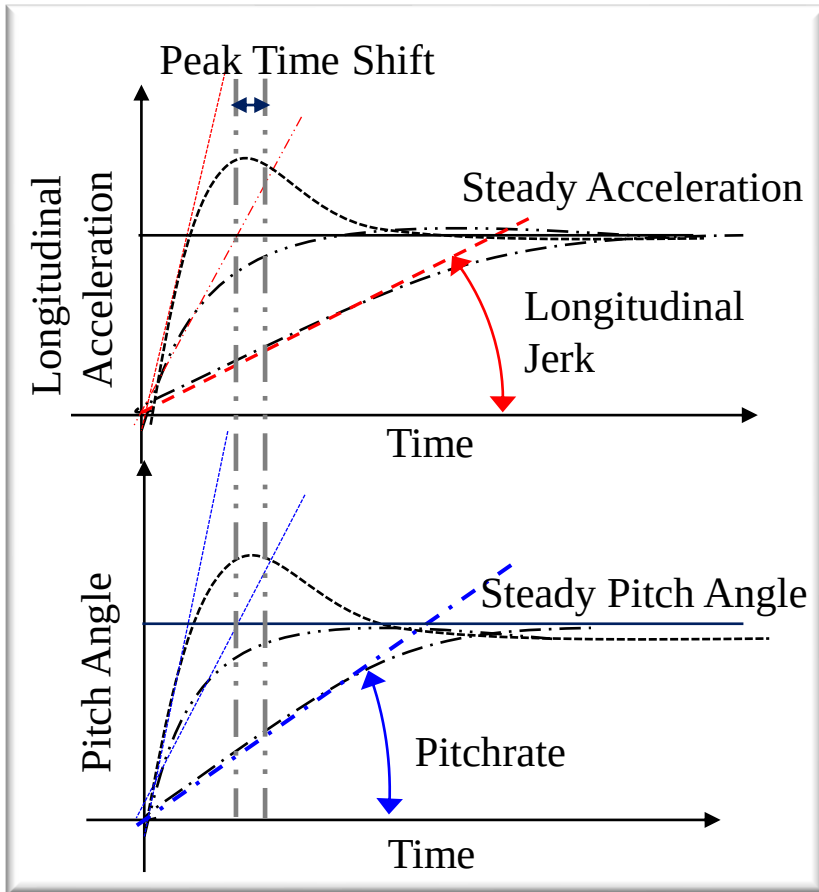
Quantification of human sense must be required in order to specify the target from the value.
But sensitive analysis of variable states are difficult to conduct with physical vehicle test.
It makes the design including human sense difficult, and the improvement of the process is required



Acceleration Feeling Development of Electric Vehicle

Sensitive subjective analysis is impossible to evaluate with physical test and simulation, but possible with the driving simulator

For Acceleration Behavior: Longitudinal Acceleration, Jerk, Pitch Angle, Pitch Rate, Peak Time Shift, and Vertical Acceleration



Acceleration Phenomena

Dynamic Driving Simulator

- Phenomena can be **Independent/Dependent**
- **Subjective** Evaluation is possible

Subjective Sensitive Analysis is **"Possible"**



Physical Test

- Phenomena is **Dependent** (Follow the Physics)
- **Subjective** Evaluation is possible
- Important for over all subjective evaluation

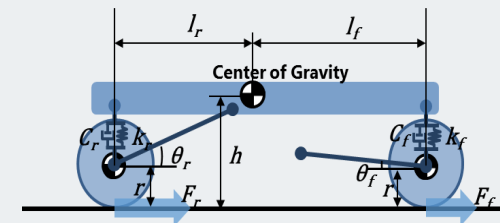
Subjective Sensitive Analysis is **"Very Difficult"**



Vehicle Simulation

- Phenomena can be **Independent/Dependent**
- Only **Objective** Evaluation is available
- Useful for numerous settings study

Subjective Sensitive Analysis is **"Impossible"**



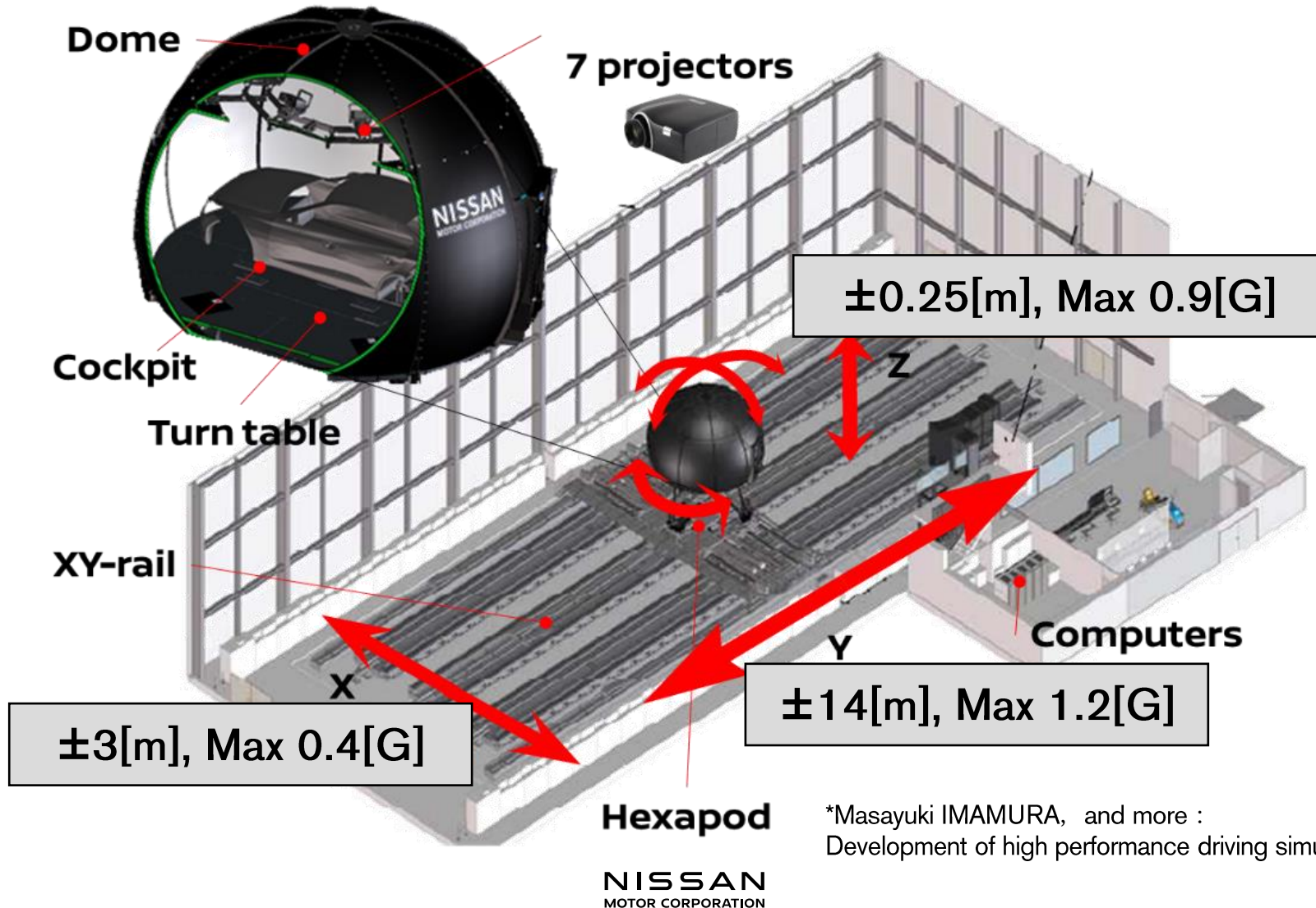
Nissan Dynamic Driving Simulator

One of the strongest to change the development process is the driving simulator

NISSAN have been launched and utilized a dynamic simulator for vehicle development since 2019

Nissan Dynamic Driving Simulator

The dynamic driving simulator is able to reproduce 6DoF motion.
It is possible to conduct the subjective sensitive analysis with human



*Masayuki IMAMURA, and more :
Development of high performance driving simulator, Nissan technical report

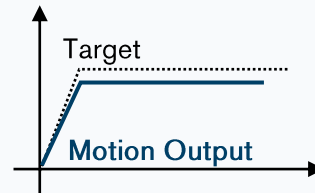
Type of Strategies and Motion Cueing

In NISSAN, 2 types of motion cueing has been used according scenarios and evaluators. Scale type has been used for quantification of human sense.

Scale Type

Reproduce acceleration and rotational movement with actual scale

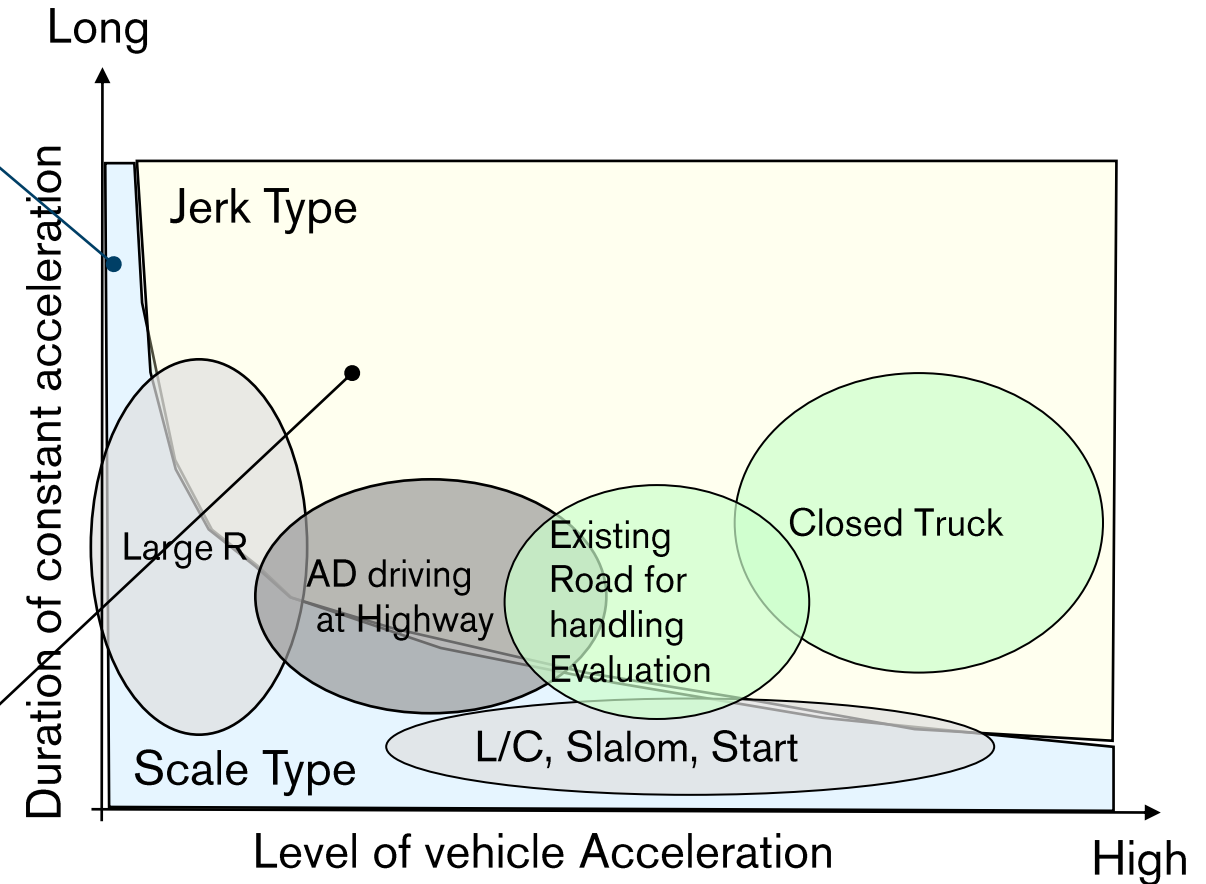
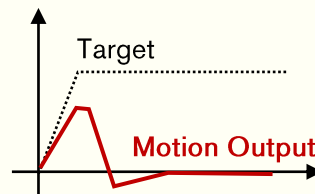
Evaluator	General/Professional Driver
Workspace	Adjust by Scenario
Course	Ideal Couse
Software	NISSAN in-house



Jerk Type

Reproduce the change of vehicle movement to keep motions system inside workspace

Evaluator	Professional Driver
Workspace	Adjust by Cueing
Course	Existing Road / any
Software	VI-MotionCueing

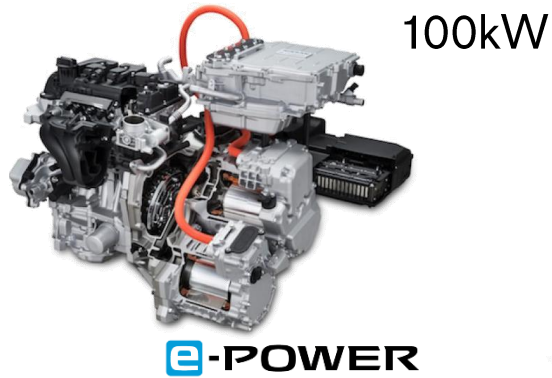


Case 1. Note Aura ePower Acceleration Feeling

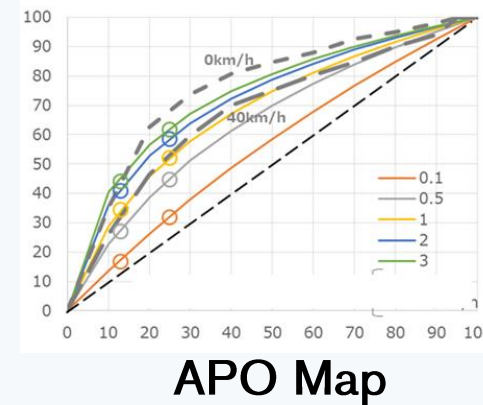
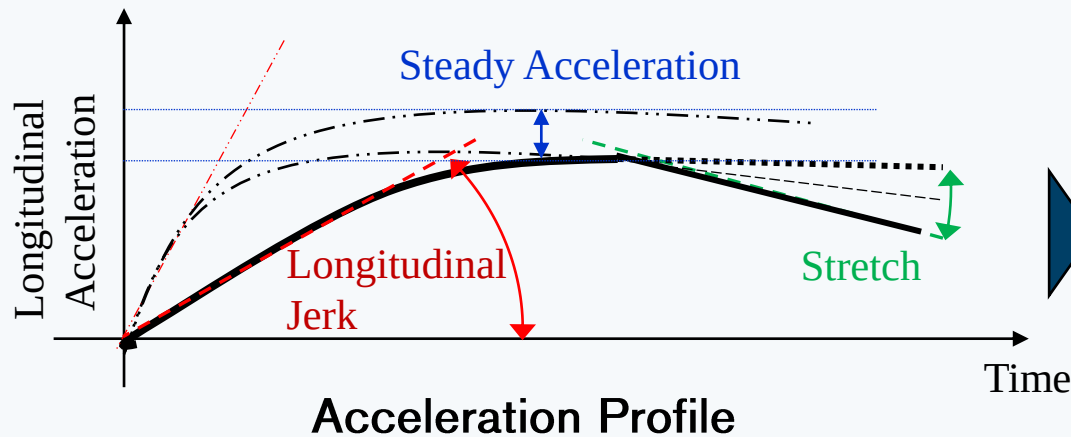
Note Aura e-Power Acceleration Feeling

In order to provide the customers with sporty acceleration by using same powertrain as standard, It is necessary to create a sense of acceleration in areas that are not determined by maximum torque or maximum power.

◆ e-Power NISMO



nismo



Subjective Point Change

Case 2. e-4ORCE* Comfortable Acceleration Feeling

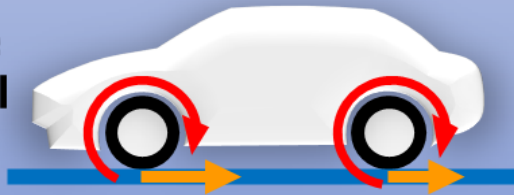
*e-4ORCE is an electric drive 4-wheel control system that freely controls driving force through integrated control of two front and rear high-output motors and brakes

Driving Force & Pitching Control by Electric AWD system

The multi-AWD system is able to improve comfortability by controlling driving forces and distribution. Occupant feeling must be considered together with vehicle motion in the design phase.

The electric AWD with front end rear motors can control the vehicle's attitude by driving force.

Power Sources are also able to control **Deceleration**

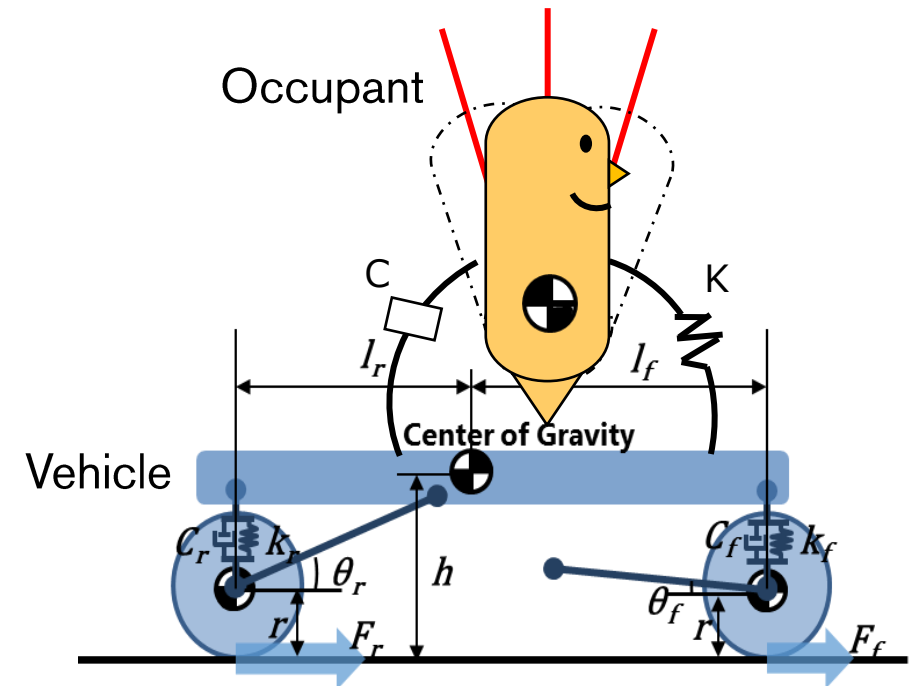


Power Sources are also able to control **Pitching**



Attitude control can be realized only by driving force control in the electric AWD without using devices such as air suspension.

Human body motion must consider together with vehicle motion to improve de/acceleration feeling



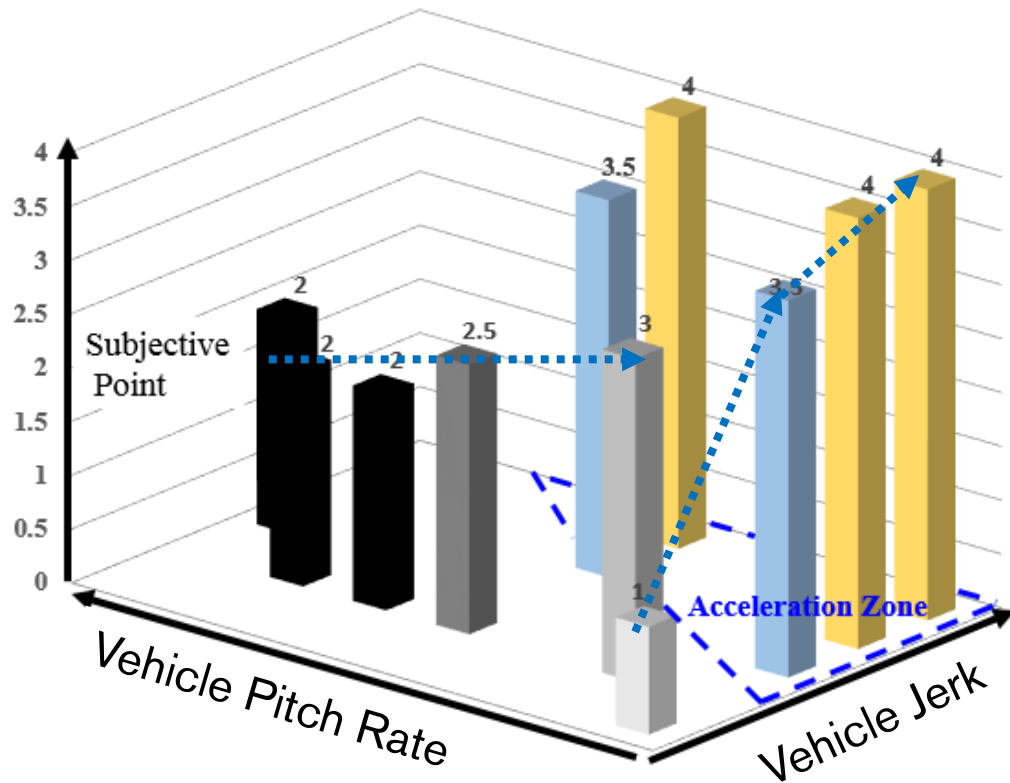
Pitching control by front-rear driving force

Subjective Analysis Result of the Driving Simulator Test

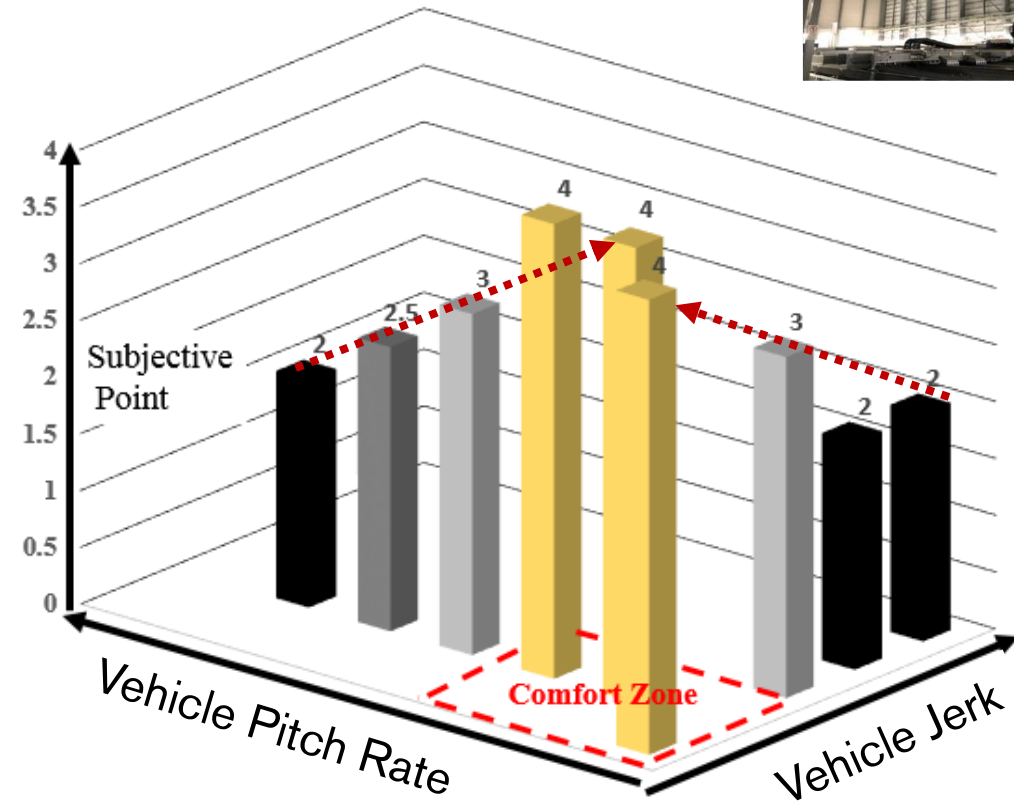
Subjective analysis with independent vehicle motion was enabled by using the simulator

Acceleration feeling: **High Longitudinal jerk** and **Low Pitch Rate** are desirable

Comfortability: **Low Longitudinal Jerk** and **Low Pitch Rate** are desirable



Subjective Evaluation Point for “Acceleration Feeling”

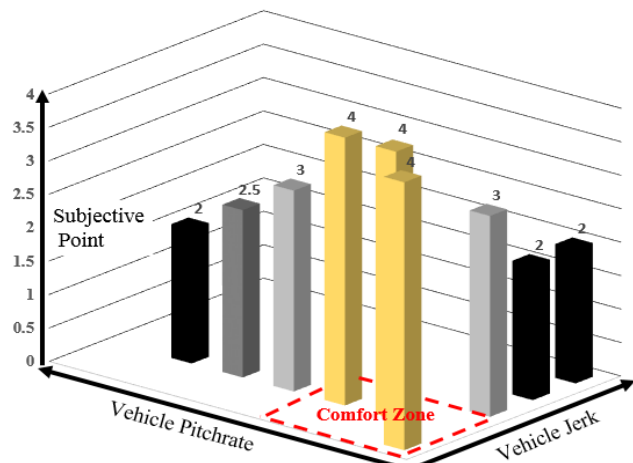


Subjective Evaluation Point for “Comfortability”

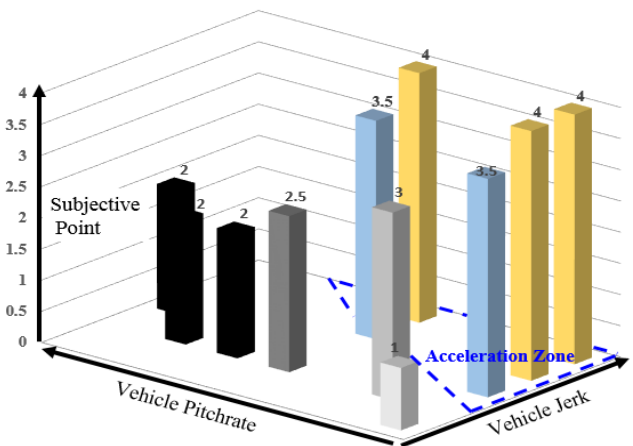
Analysis of Subjective Feeling - Jerk -

High jerk make the occupant uncomfortable due to the unnecessary motion

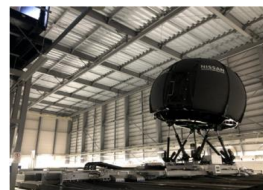
As the jerk increases, the Muscle Energy also increases



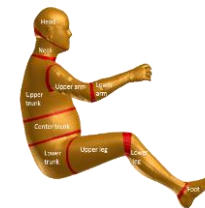
Subjective Evaluation (Accle. feeling)



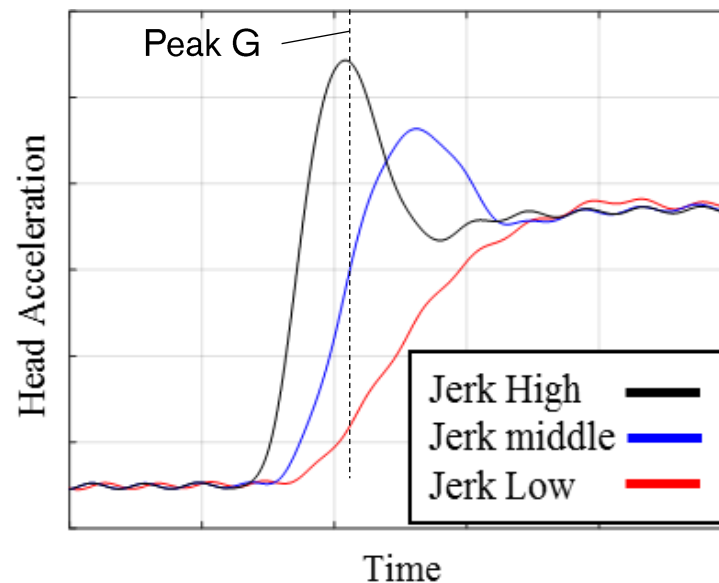
Subjective Evaluation (Comfortability)



Driving Simulator

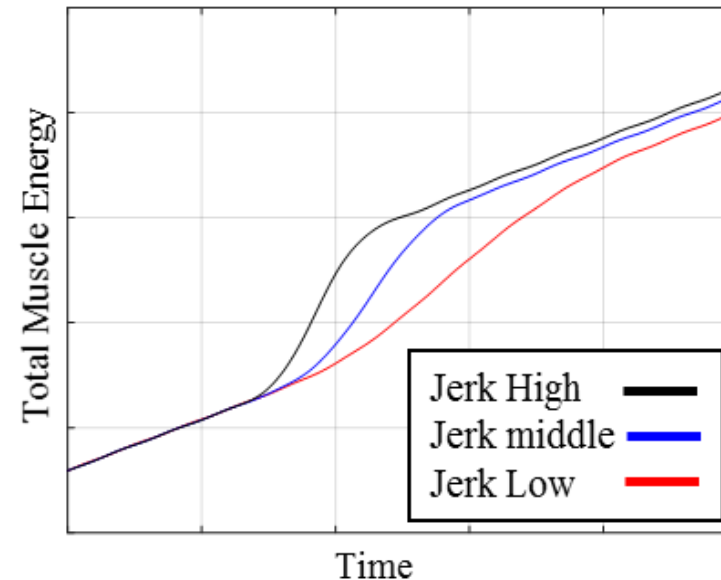


Simulation



Head acceleration with jerk change

* Simulation Prediction



Total muscle with jerk change

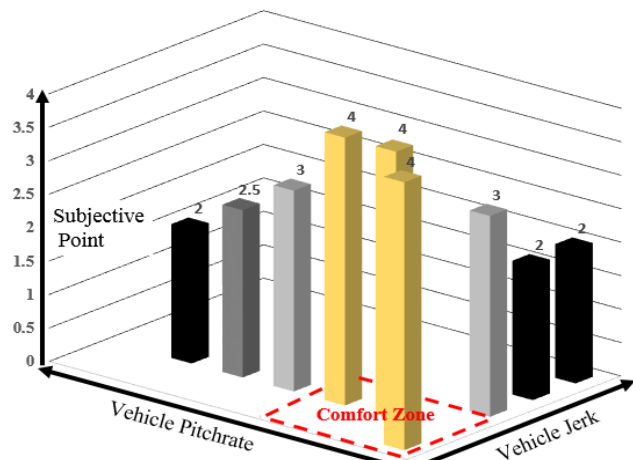
* Simulation Prediction

Target Value is same level as "Jerk Low" Condition

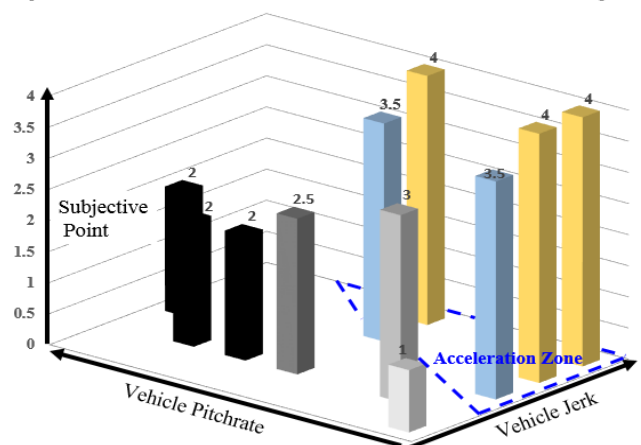
Analysis of Subjective Feeling – Pitch Rate -

High pitch rate make the occupant uncomfortable due to the unnecessary motion

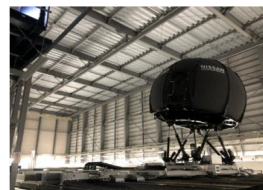
As the pitch rate increases, the Muscle Energy also increases



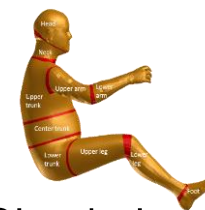
Subjective Evaluation (Accle. feeling)



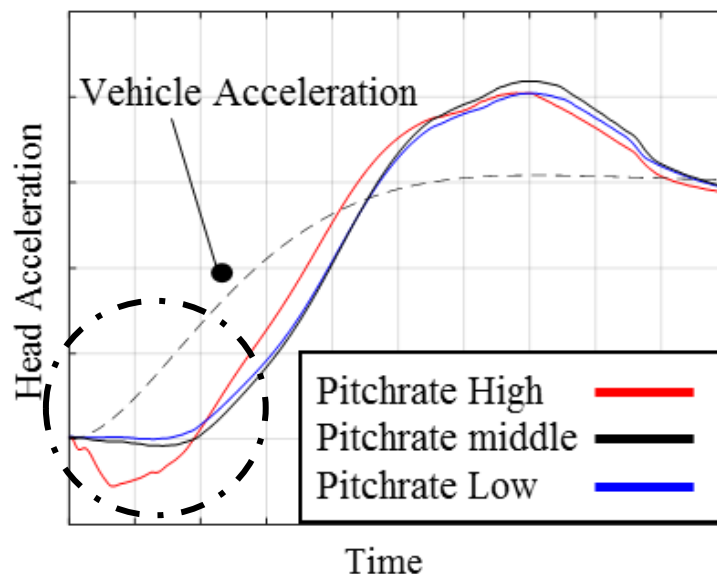
Subjective Evaluation (Comfortability)



Driving Simulator

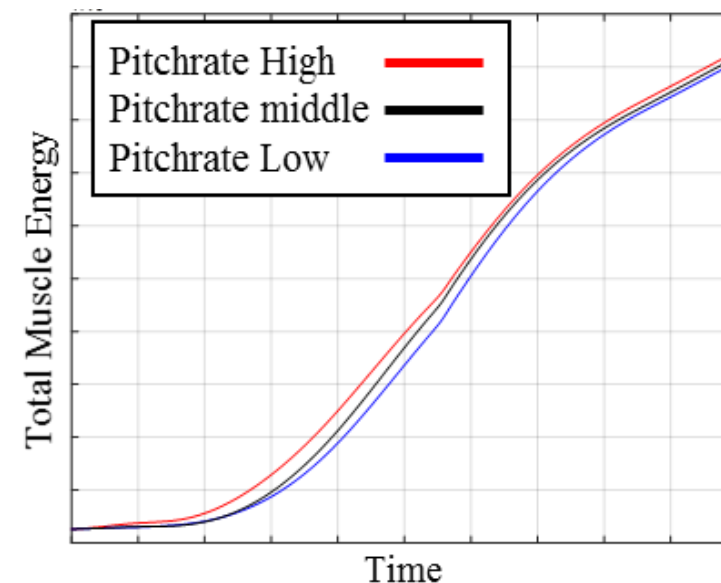


Simulation



Head acceleration with pitch rate change

* Simulation Prediction



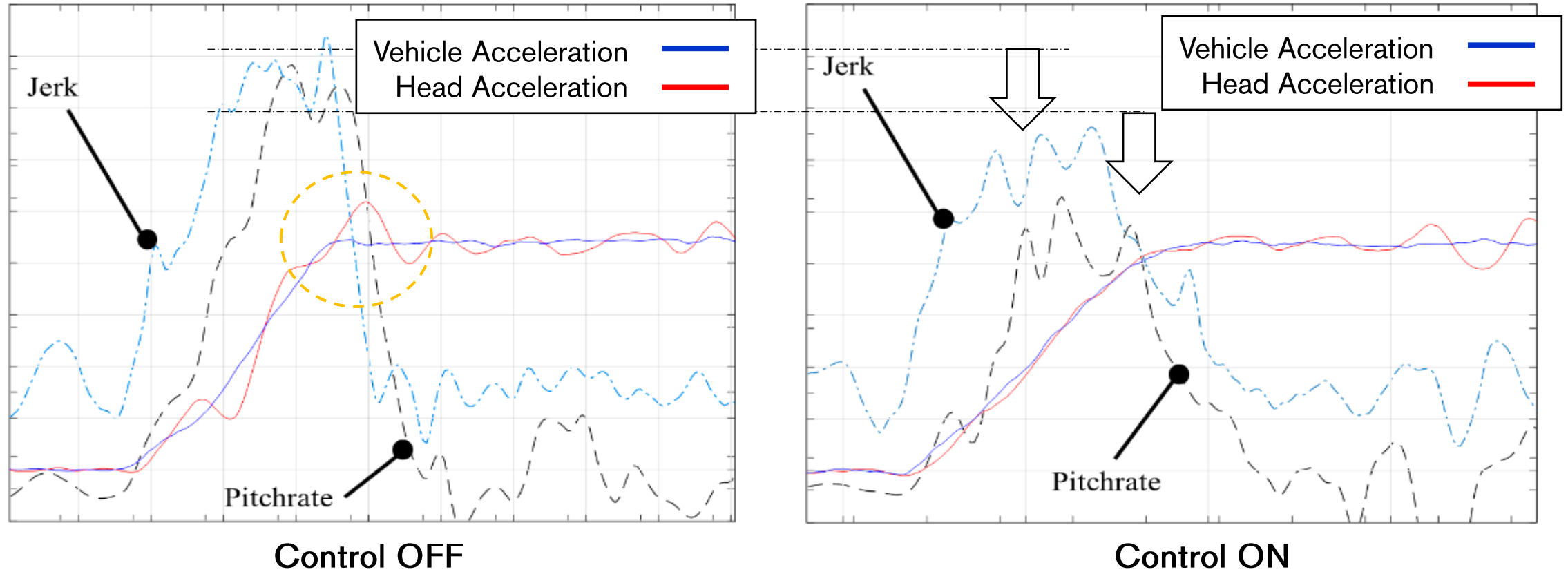
Total muscle with pitch rate change

* Simulation Prediction

Target Value is same level as "Pitchrate Low" Condition

Vehicle Physical Test Result of Control

The proposed design value make the occupant stabler than w/o control
It is shown that the proposed value is verified



Conclusion

Utilizing driving simulator has allowed us to

- obtain vehicle target definition from human sense systematically
- experiment with stable and efficient way to minimize the development time

Vehicle Target Definition from Human Sense

by using sensitive analysis of the simulator
which is difficult by actual car

Design Process

Customer
Value



Human Sense

- Acceleration Feel
- Comfortable Feel
- Secure Feel

Quantification

Vehicle
Performance
Target



Vehicle Target
- Sprung Motion

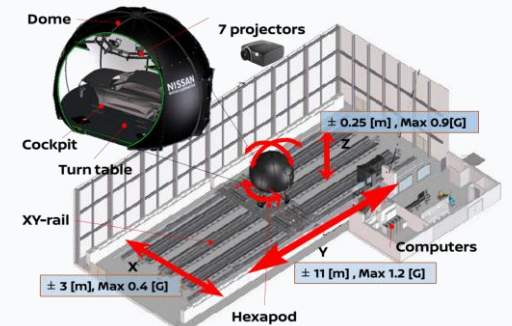
Efficient and Stable Way

If same amount of pattern and test
carried out with actual vehicle ...

130 Pattern Trial



6weeks



3days

90% reduced
Approximately

NISSAN
MOTOR CORPORATION

Thank you for your attention