Experimental model as CAT supporting tool for supporting CAE

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The configuration of the next generation's Testing Concept

Real Vehicle Testing: VMS

VMS: Quantify the feelings of the test driver
e.g. Shift Shocks

Model, based on Real Measured data: MBS

Reproduce real vehicle Testing: **RR-Sim**

Engine
T/M
Steering
Suspention

Crank Shaft
Cylinder control
Engine Mount

(Realization of100Hz Bench)

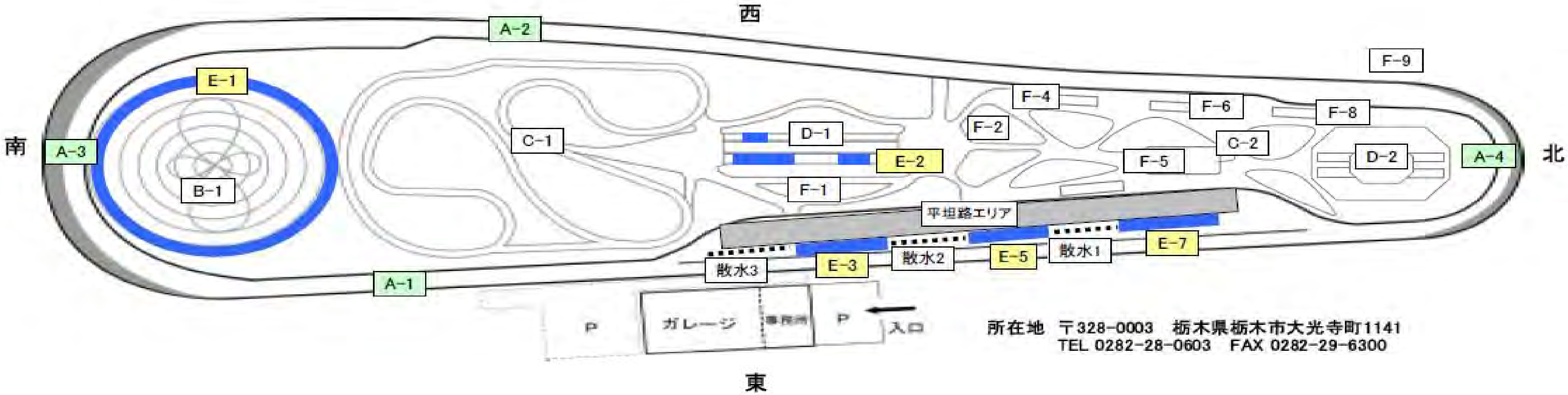
Correct Measurement
↓
Correct Control
↓
Correct Testing

e.g.
Shift Shock

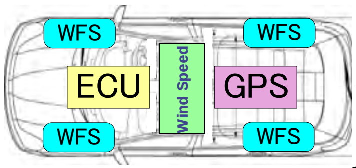
Variation of combustion conditions

Drivability

VMS Data acquisition of Real vehicle at the test course.



VMS（Vehicle Measurement System）



WFS(Tyre) Data
4Wheel 6Components
4Wheel RPM
2Wheel Yoa

ECU(Vehicle) Data
*Engine Speed
*Axle Openness
*T/M location

CAN channel can be increased more than 200

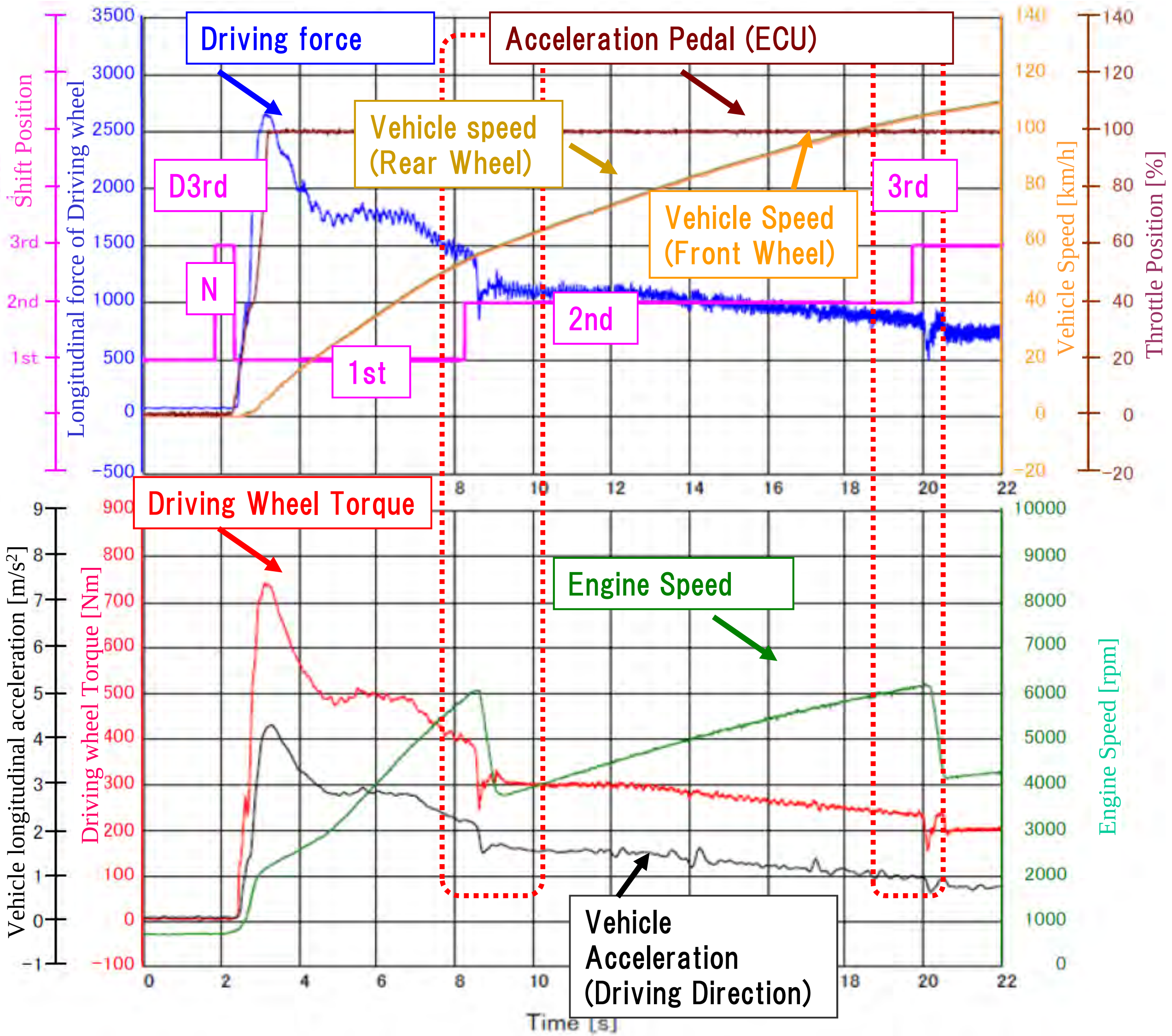
GPS(Vehicle) Data
3WheelAcceleration
3WheelRate
3WheelBalanceAngle
GPS location

Wind(Environmental) Data
Velocity/Direction
Temperature

Data Computation
+Estimated Computation
Slope, Velocity
+Logic Computation
Driving Friction
Slip Detection
Slip Factor
Road Surface (Mu)

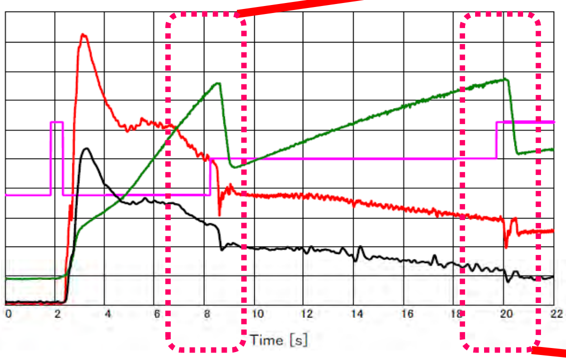
Real vehicle behavior is measured with VMS
VMS Measured Data

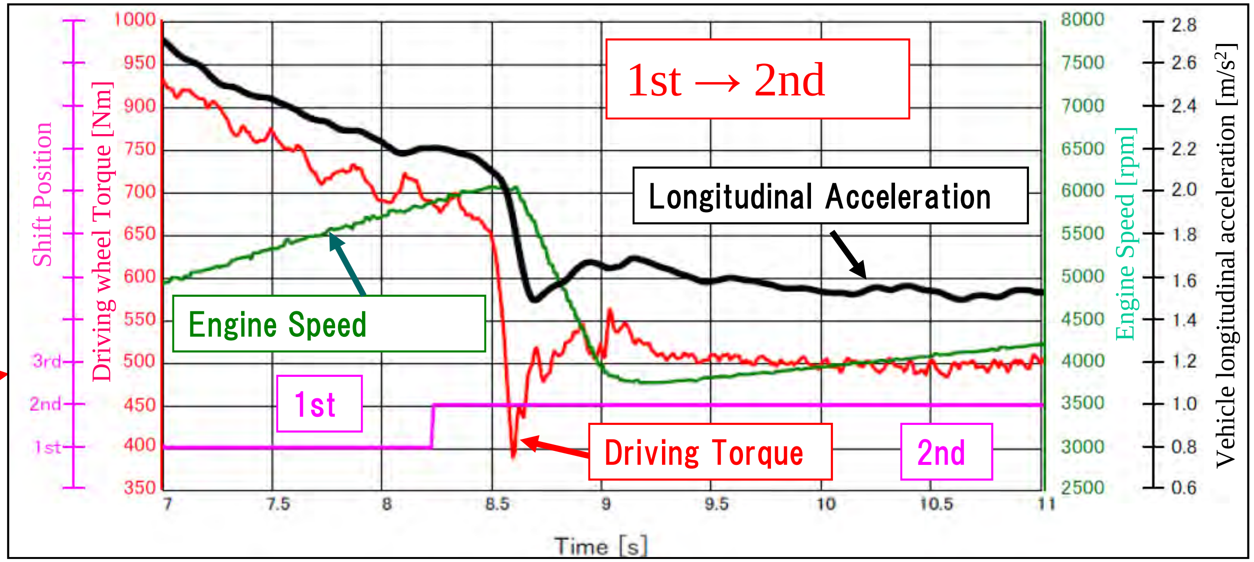
Starting and shifting shock data can be measured at the real vehicle with VMS.

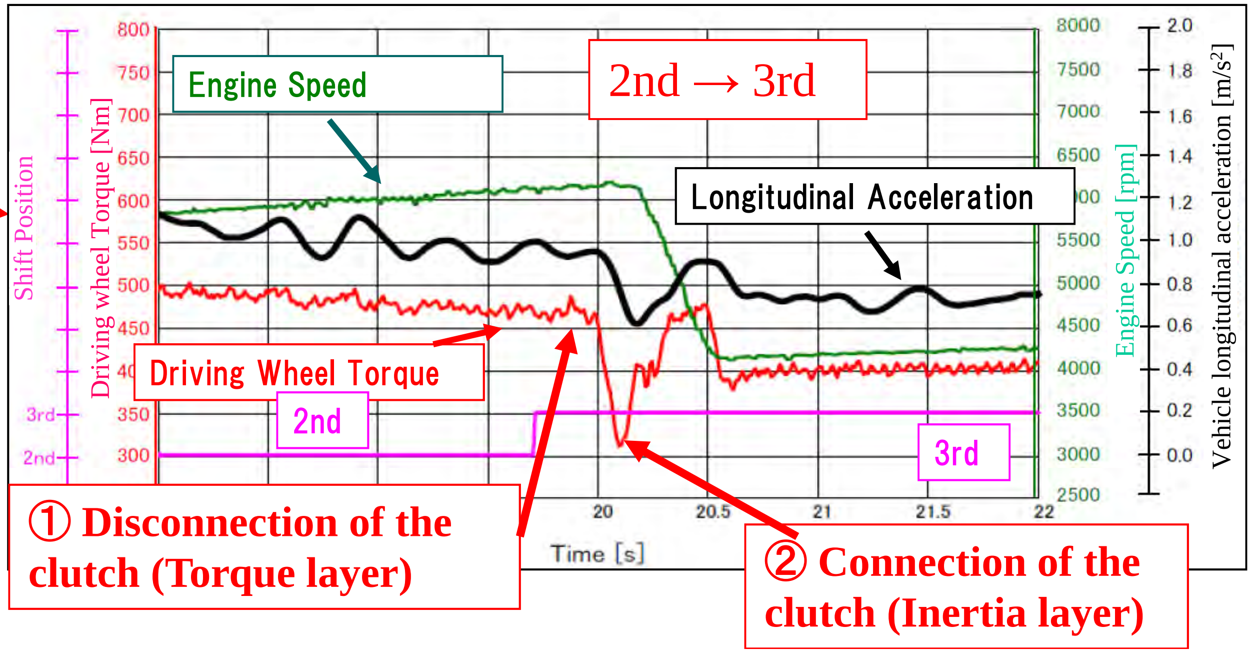


VMS Measured Data (Expanded data)

The shift shock impact can be observed at the longitudinal acceleration.





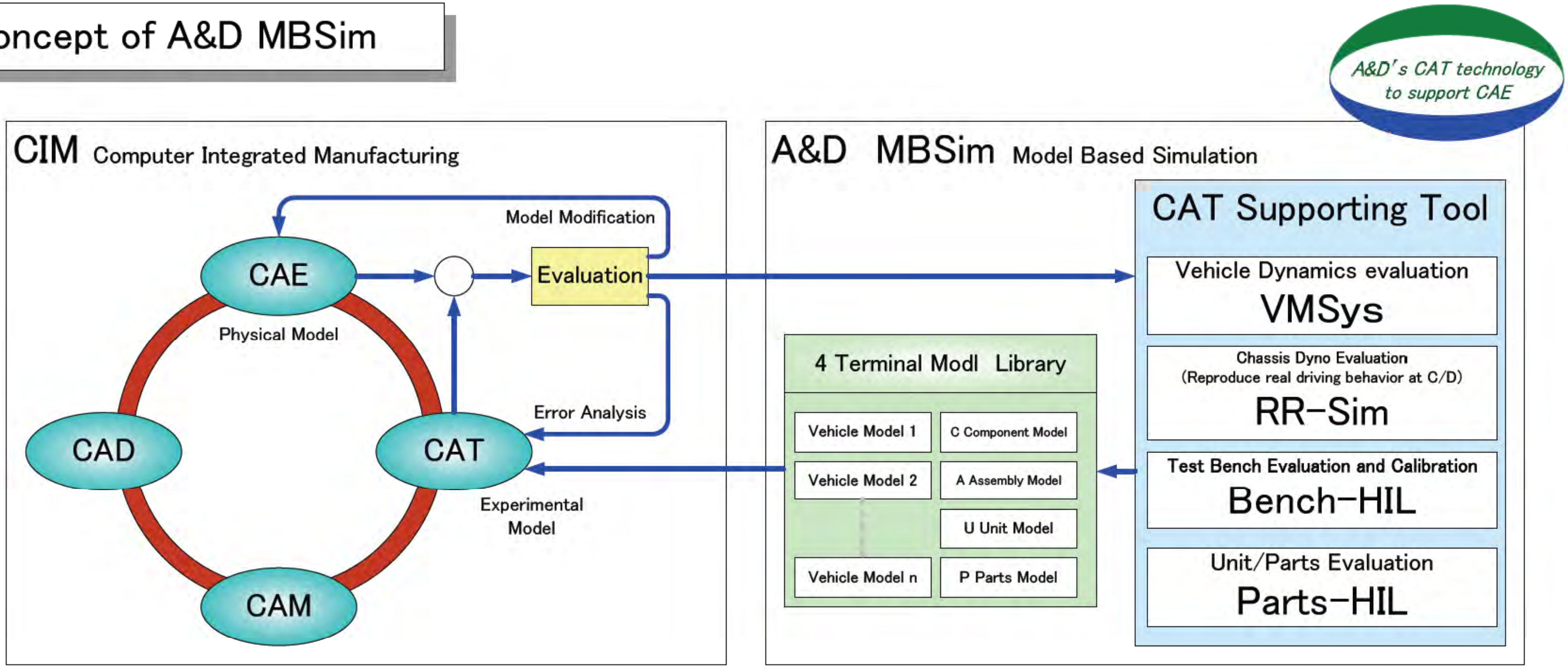


① Torque down due to the disconnection at the clutch (Torque Layer)

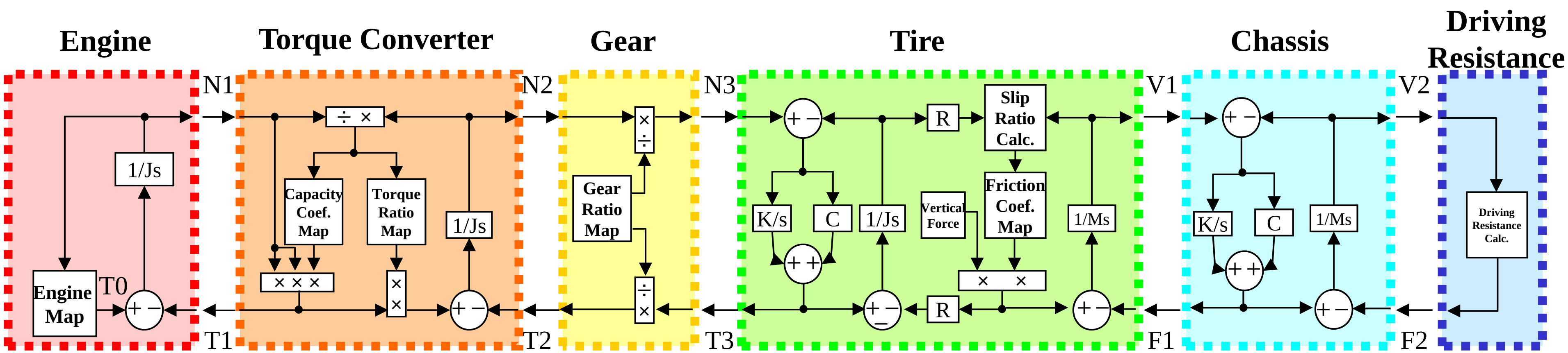
② Torque increase due to the connection at the clutch (Inertia Layer)

MBSim Concept

Concept of A&D MBSim



Basic Structure of the Vehicle model



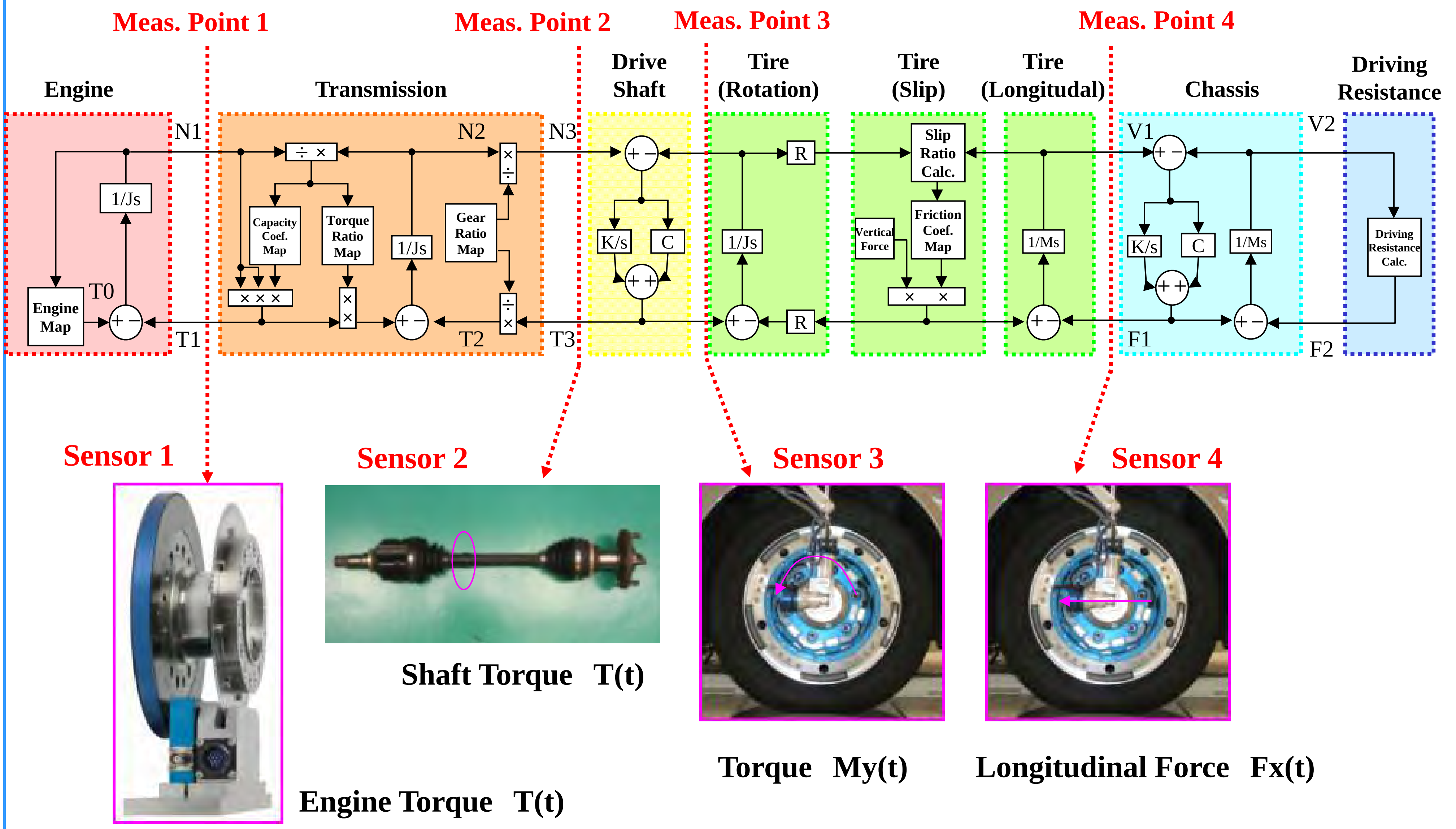
・Basically, these are the **object model** of Sprig-Mass 4 terminal model

・Terminal interface is **physical parameters** which can be measured with the sensors

・Model is expressed as Gray-Box model. Gray-Box model is the combination of Black box model which expresses the Non-Linear components with Map constant determined from real measured data, and white-box model which uses mathematical approach.

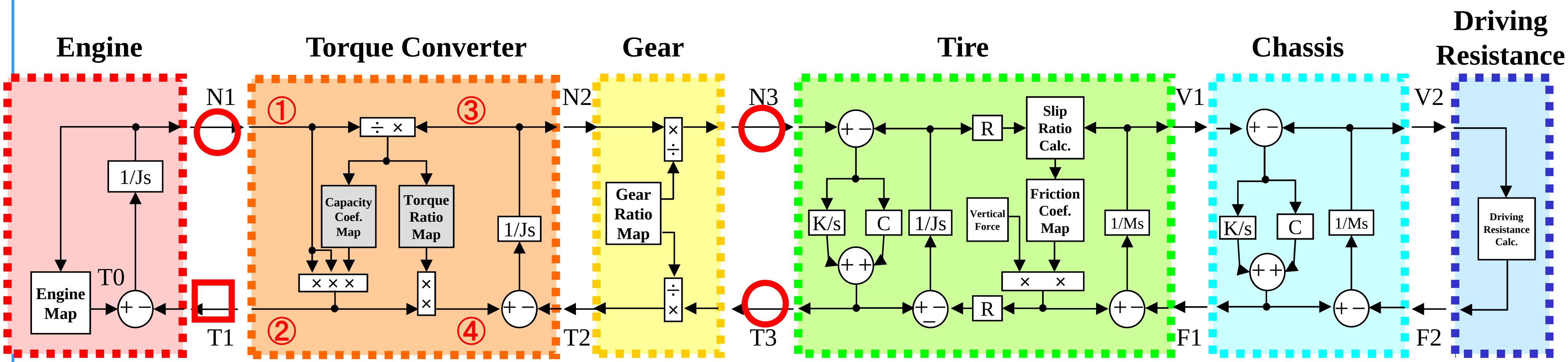
・The model is designed as **layered Structure**, which can be divided according the powertrain configuration parts.

Model terminal and sensor measurement points

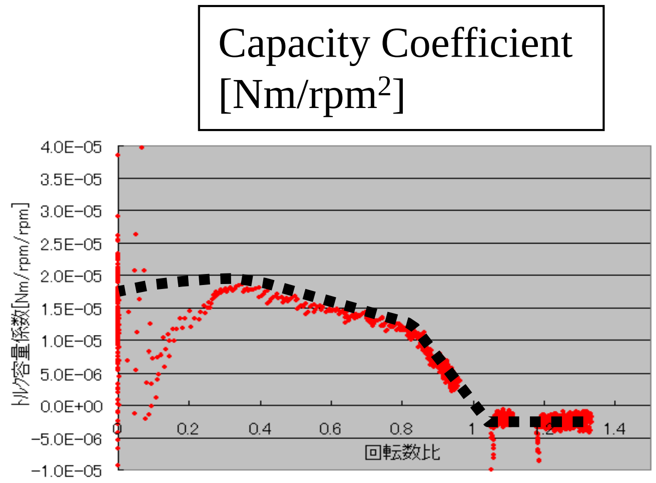


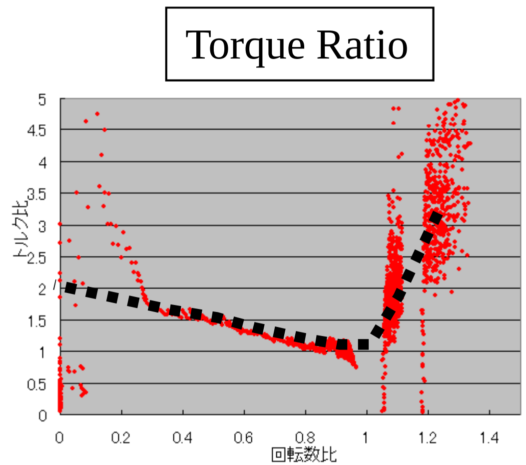
Model Identification example "Torque Converter"

Capacity Coefficient Map and Torque Ratio Map of the Torque Converter will be identified from real measured data.



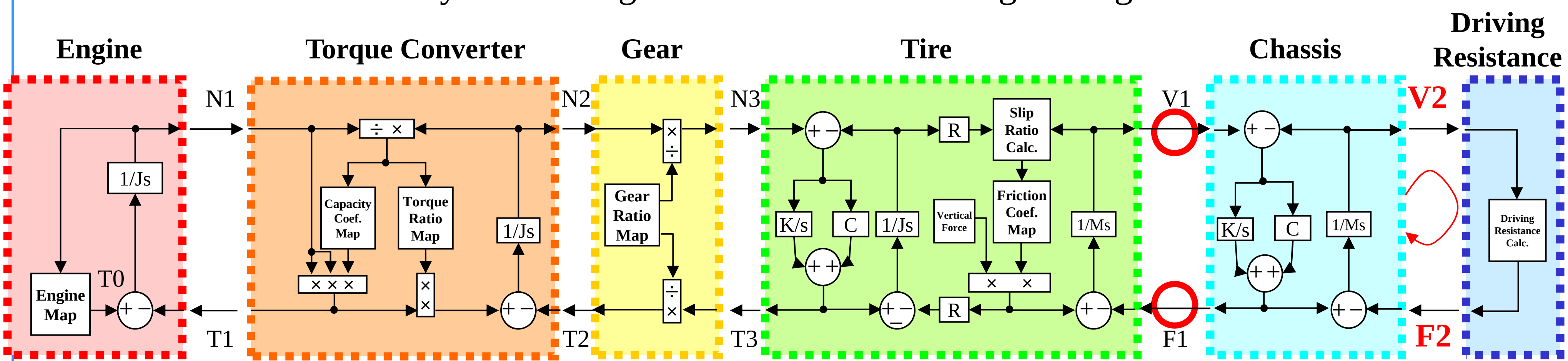
①⇒Real measured data from VMS
②⇒Calculate from T0 and J1×dN1/dt
③⇒Calculate from multiplying the Gear ratio to N3
④⇒Calculate from Gear Ratio,T3 and J×dN2/dt





Model Identification Example "Driving Resistance"

Identify the Driving Resistance from coasting driving data



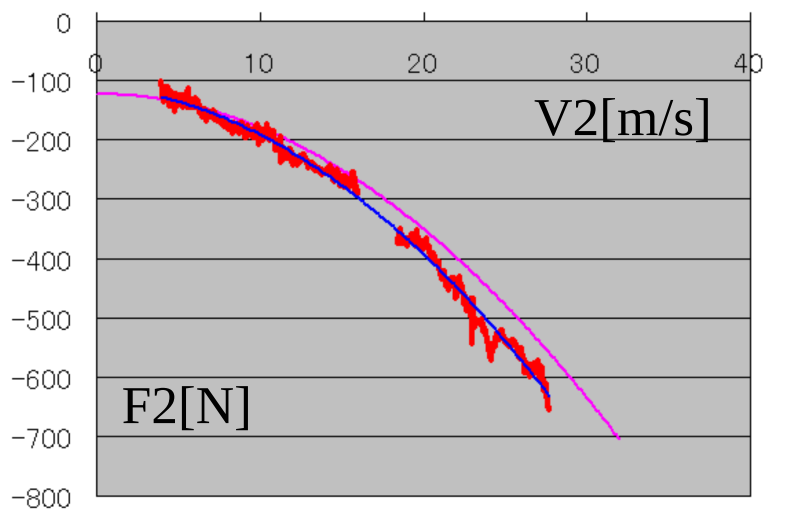
V2⇒F1 =0 when vehicle is coasting, therefore the equation of the loop will be V2＝1/Ms*F2

Parameter will be fitted with 2nd order formula of the velocity.

$$F2[N] = -(a \times V2^2 + b \times V2 + c)$$

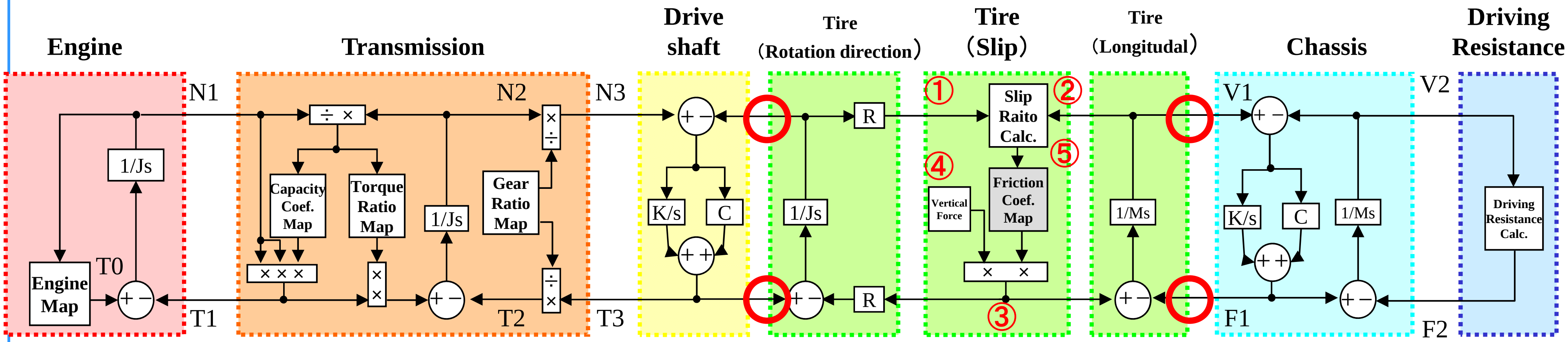
Fitting from the measured data→（a=0.61、b=1.8、c=111）

Fitting from vehicle parameters→（a=0.57、b=0、c=123）

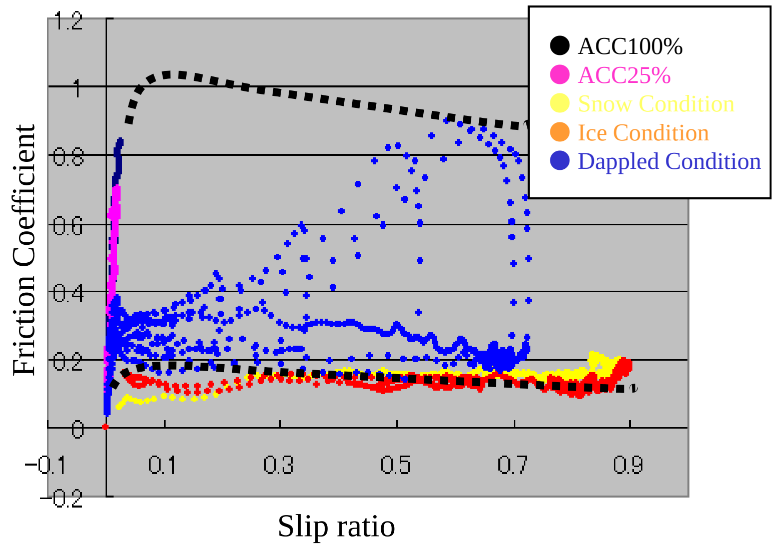


Model Identification Example " Friction coefficient of the tire"

Identify the driving friction coefficient map from low μ driving data

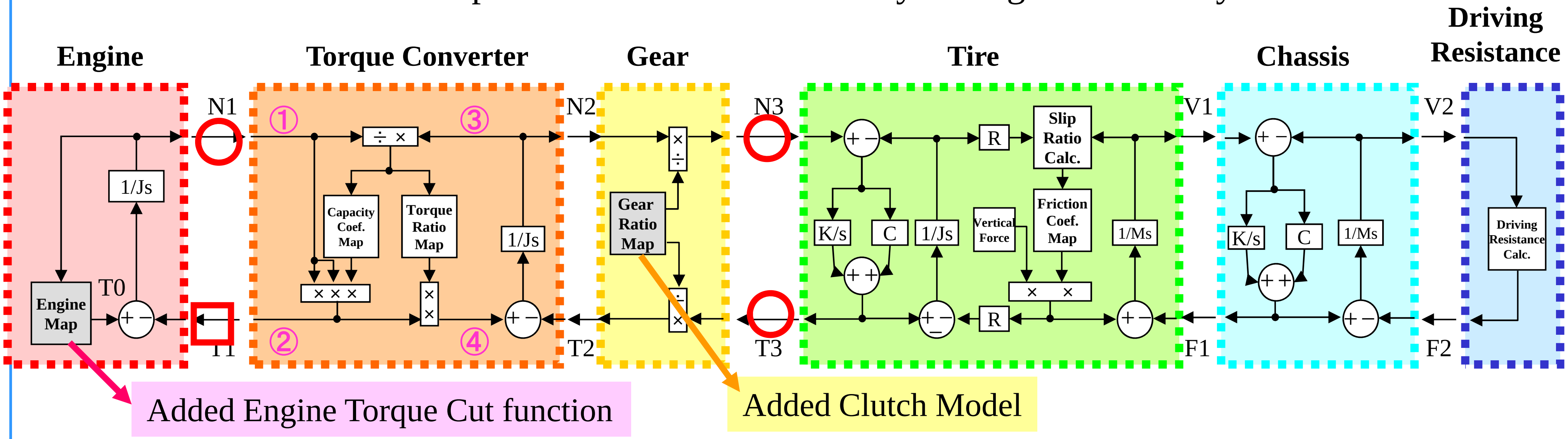


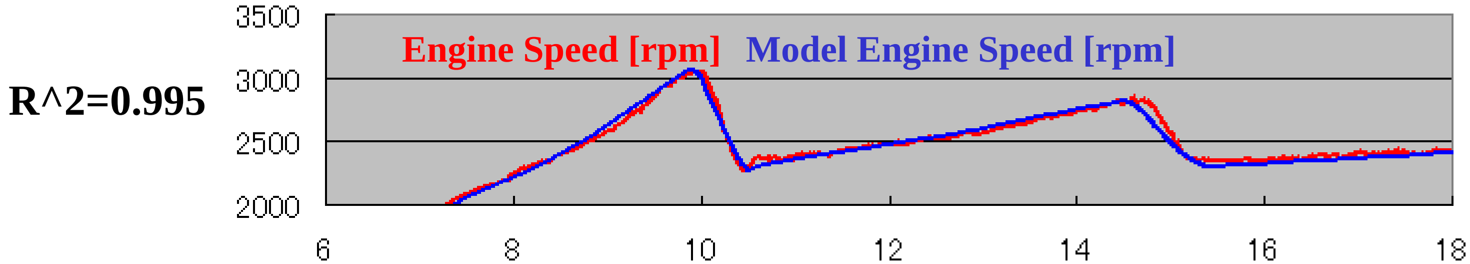
①⇒Front wheel rotation speed, VMS(Vf), Driving wheel
②⇒Rear wheel rotation speed, VMS(Vr), Non driving wheel
③⇒Longitudinal force, compensate VMS(Fx) with M
④⇒Vertical force, measure with VMS(Fz)
⑤⇒Slip ratio, Formula calculation （①−②）÷①

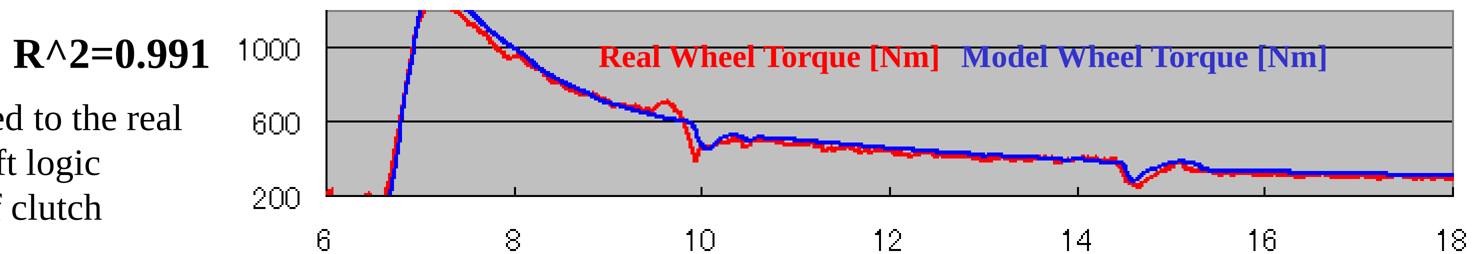


Identification Example "Shift change logic"

Identify the shift change from the engine speed and wheel torque curve data.
Evaluate the reproduction of the behavior by adding the necessary functions.

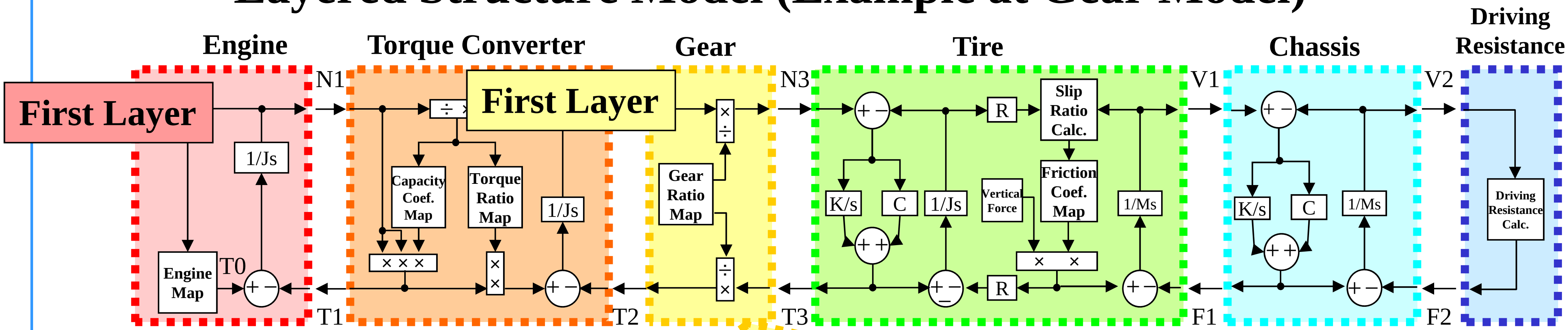




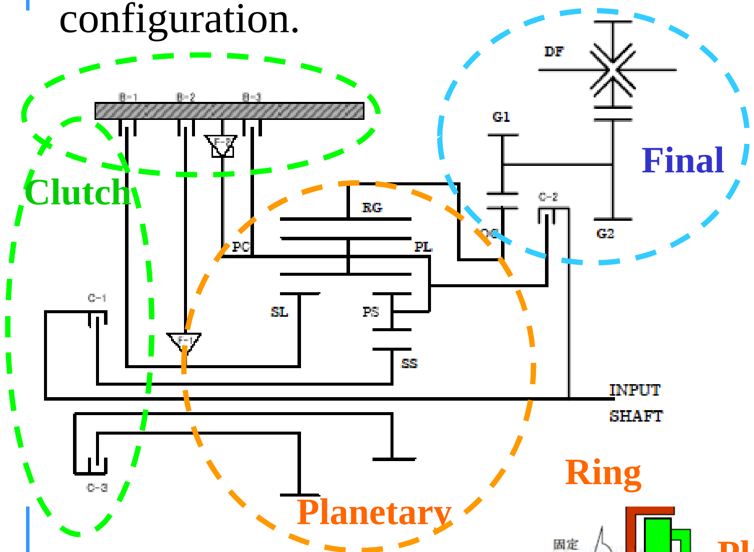


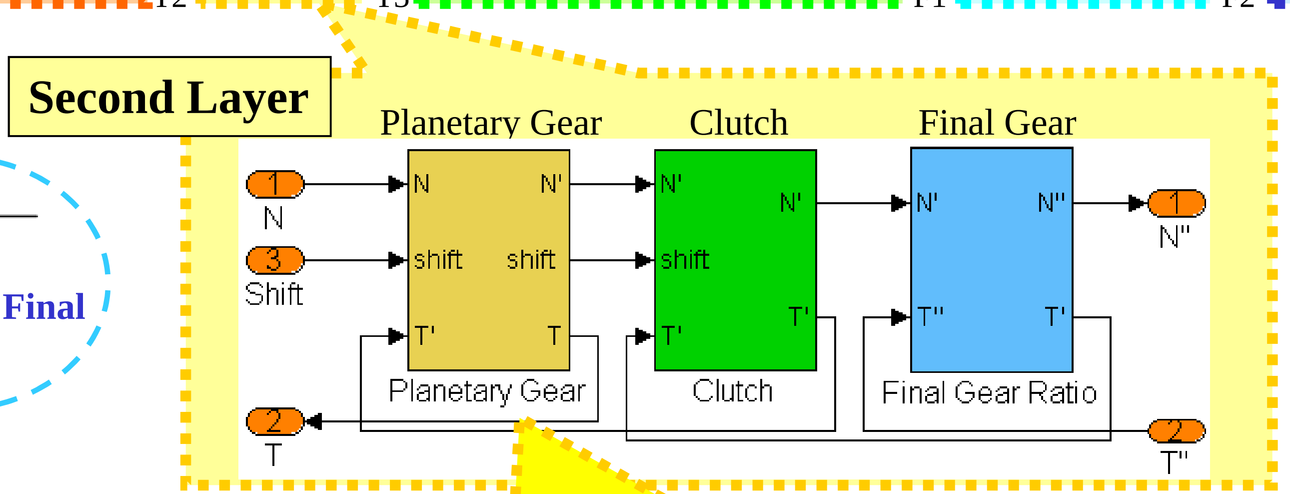
Simulated Behavior matched to the real measurement by tuning shift logic (Added Torque cut and half clutch model)

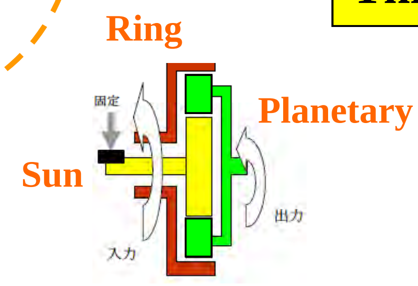
Layered Structure Model (Example at Gear Model)

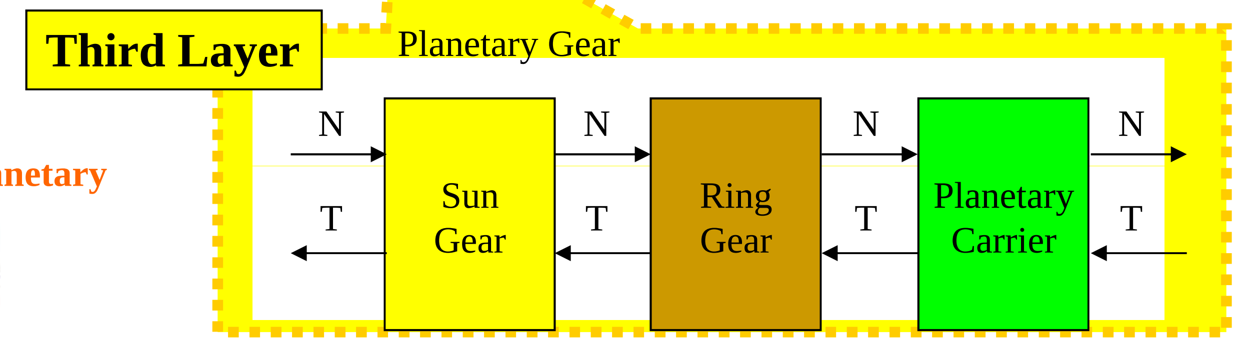


Design the model layer according to the parts configuration.

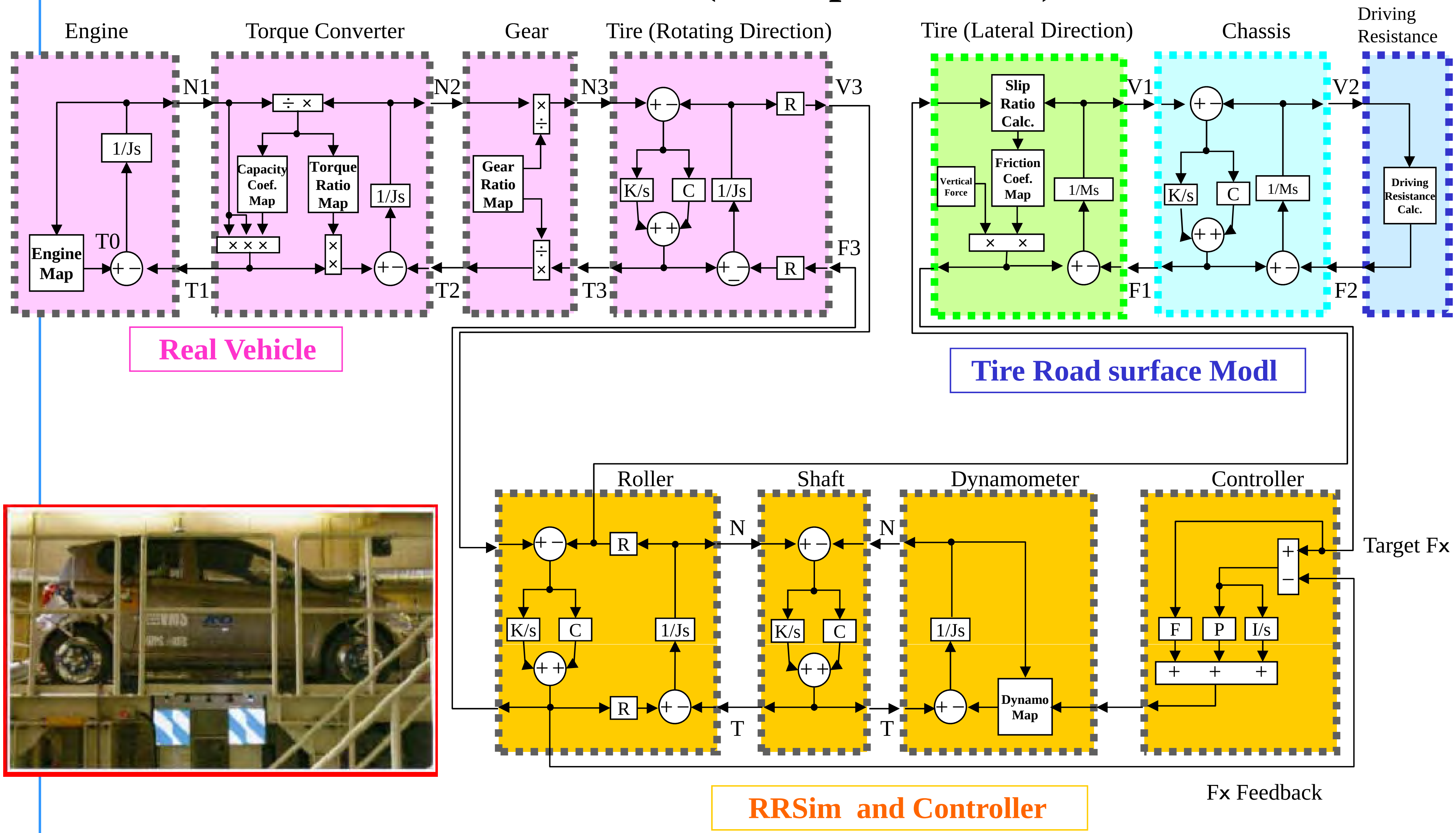








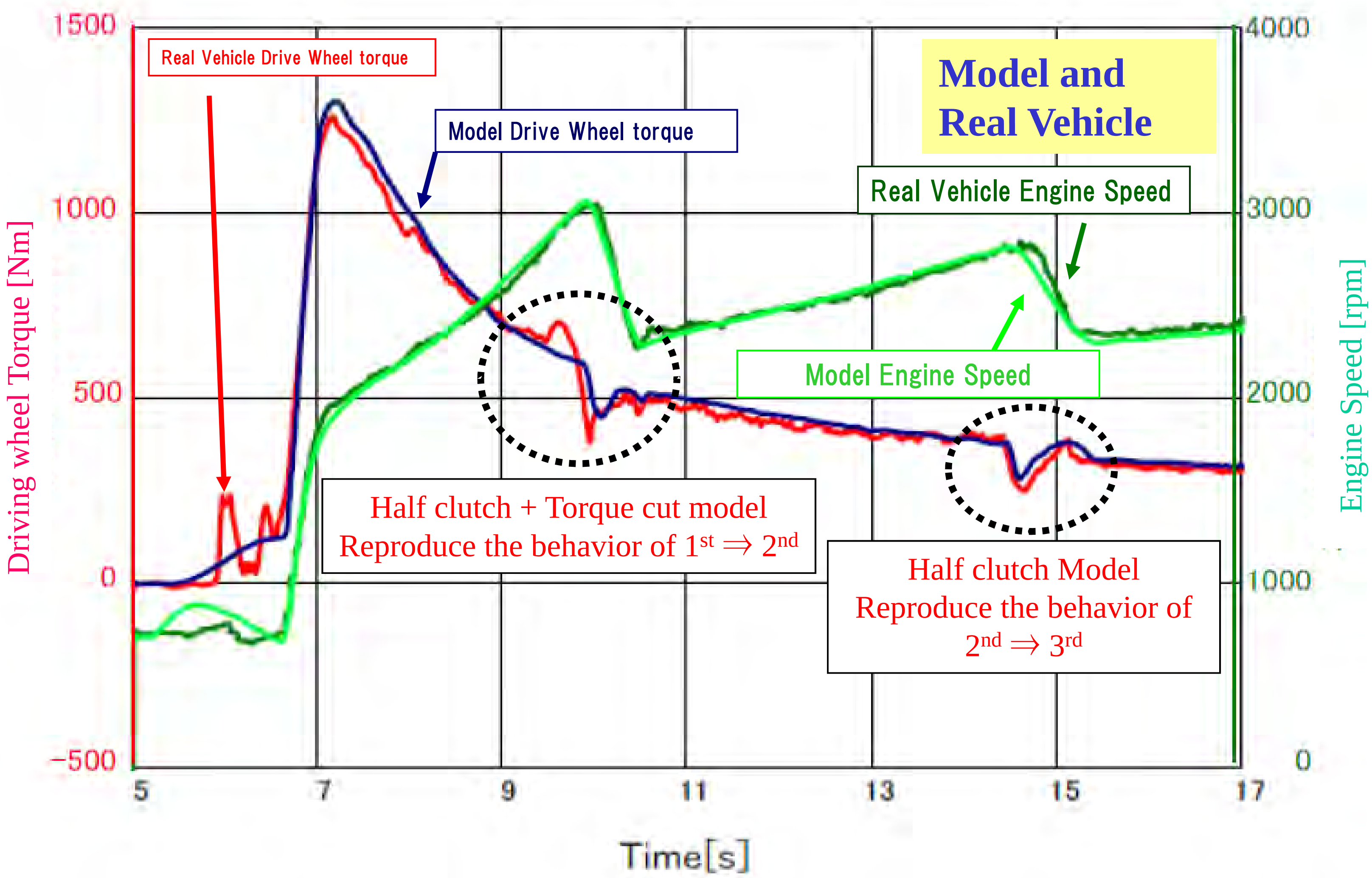
Bench & Model (Example:RRSim)



Can be considered as the converter of model to real.

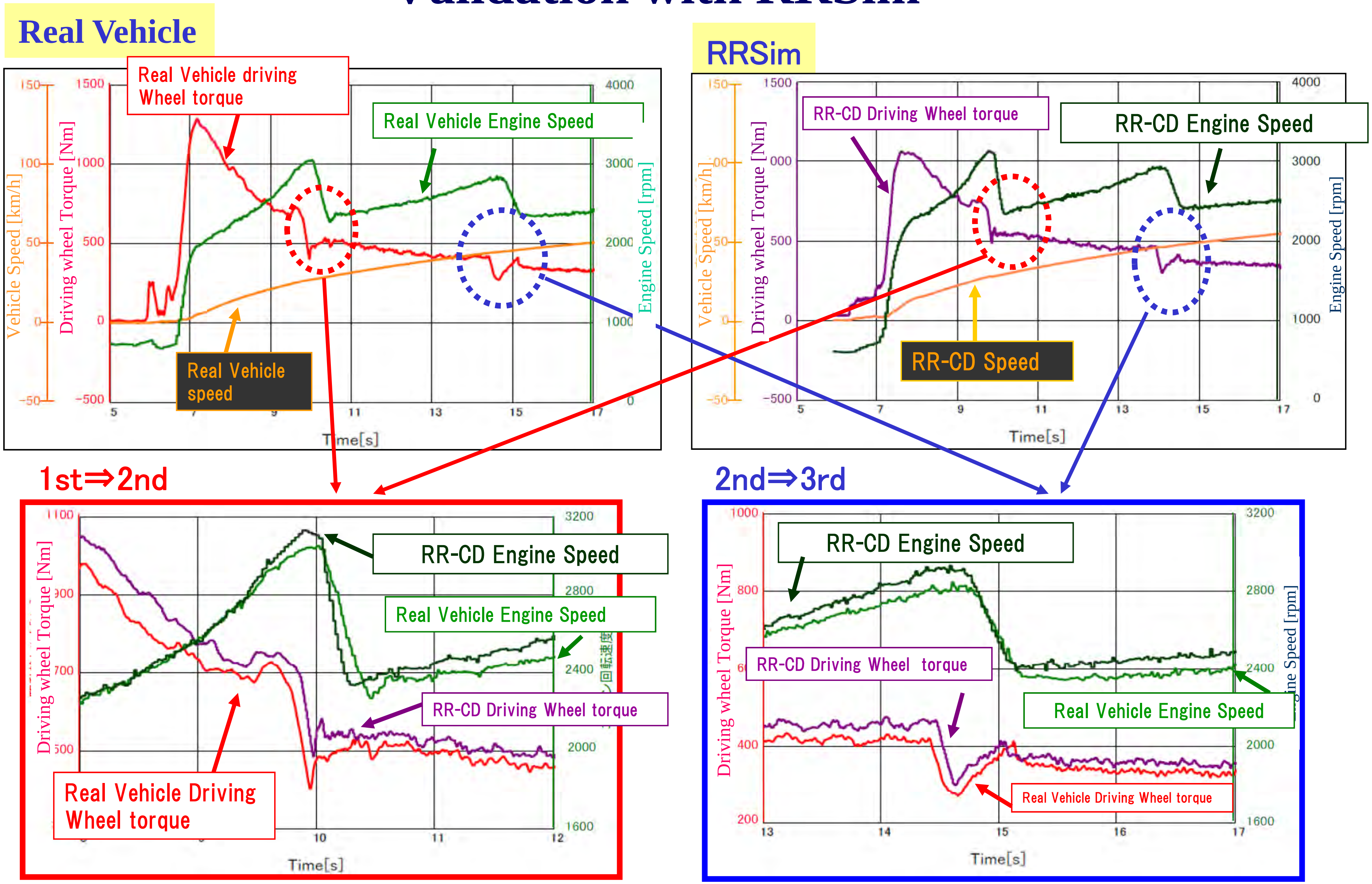
Validation of the Experiment Model

Validate the reproduction of the vehicle's behavior.
Comparison with real vehicle testing data and simulated data from Experiment Model

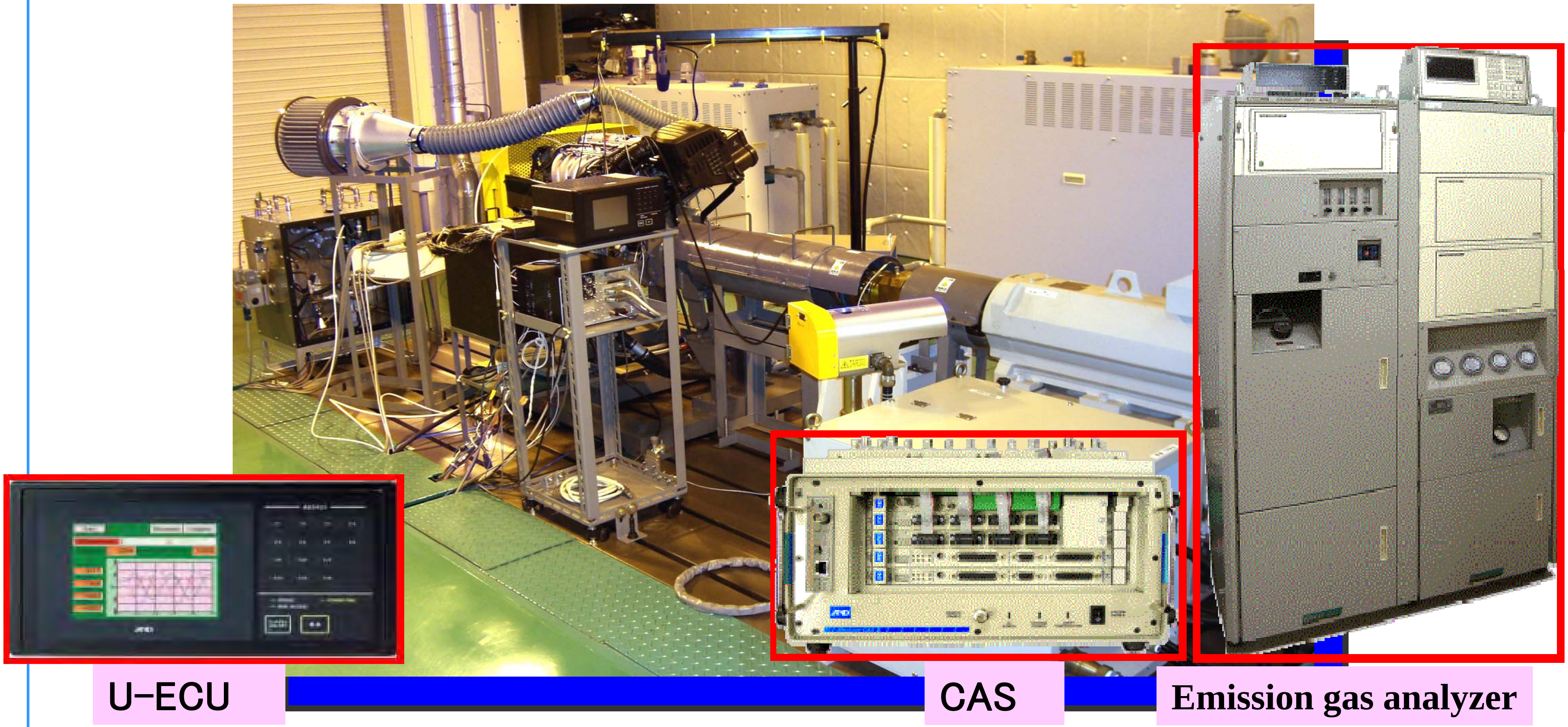


RRSim （Real Road Simulator）

Validation with RRSim



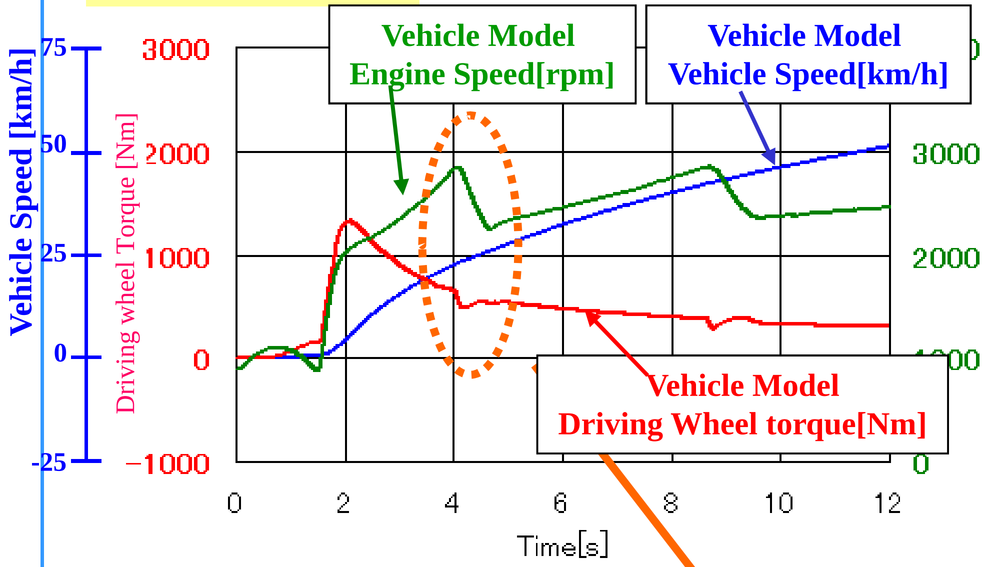
Engine Bench System



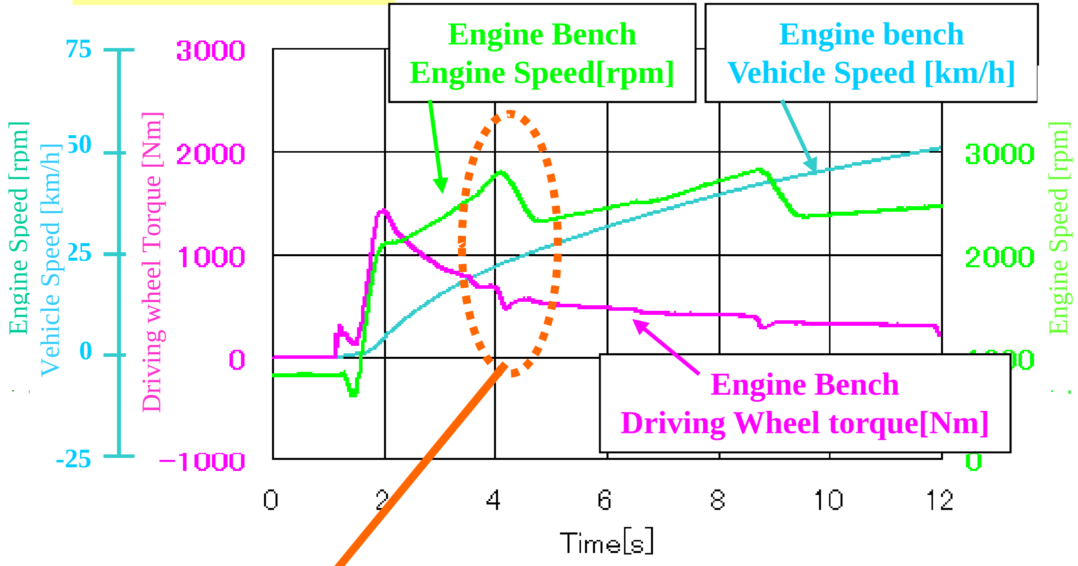
- Capable to measure the transient behavior of the Engine.
- Able to change the spark timing from using U-ECU
- Measure each combustion pressures from CAS System
- Installed high response exhaust emission gas analyzer system.

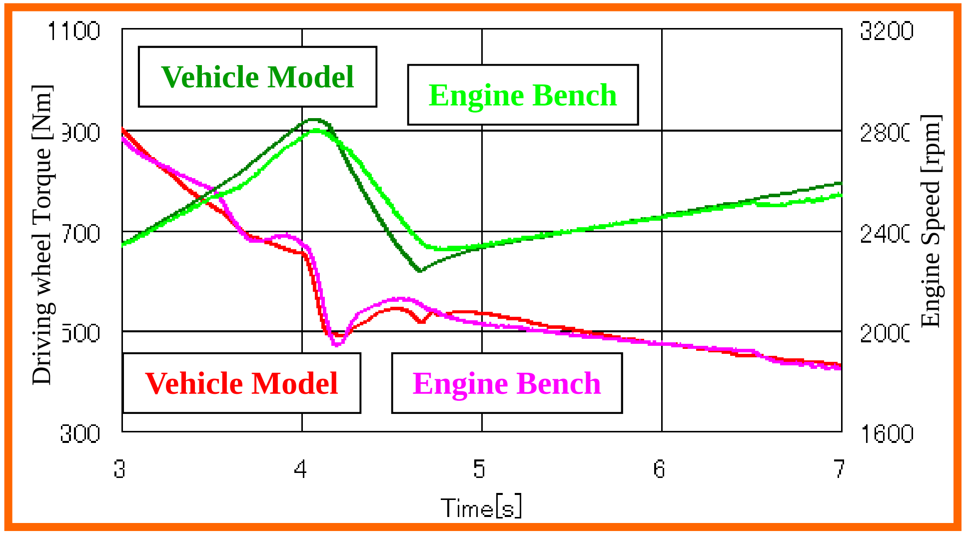
Validation from Engine Bench System

Vehicle Model



Engine Bench

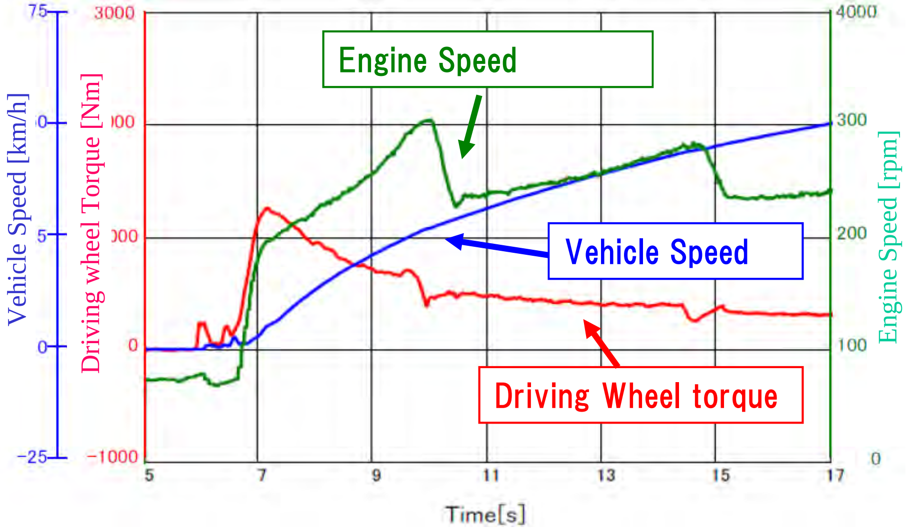




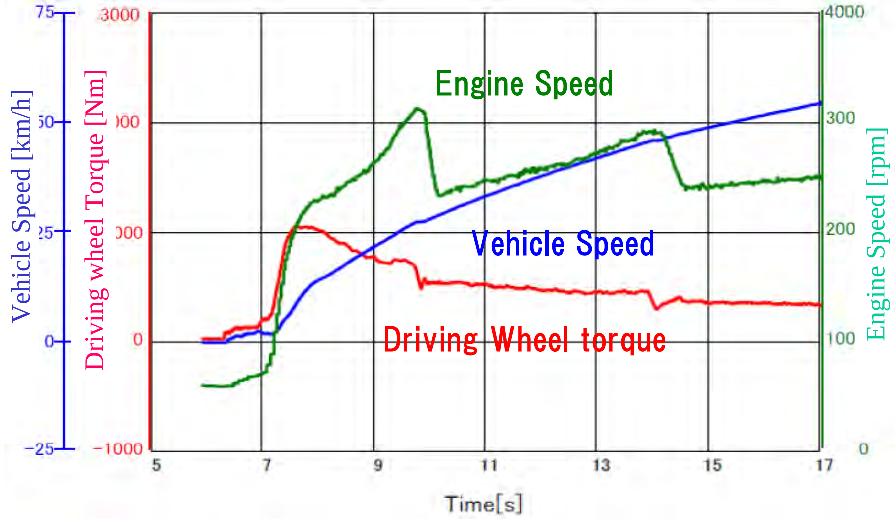
Engine used at the bench is different from the modeled Engine.

Comparison of 4 Systems
(Real Vehicle, Model, RRSim, Engine Bench)

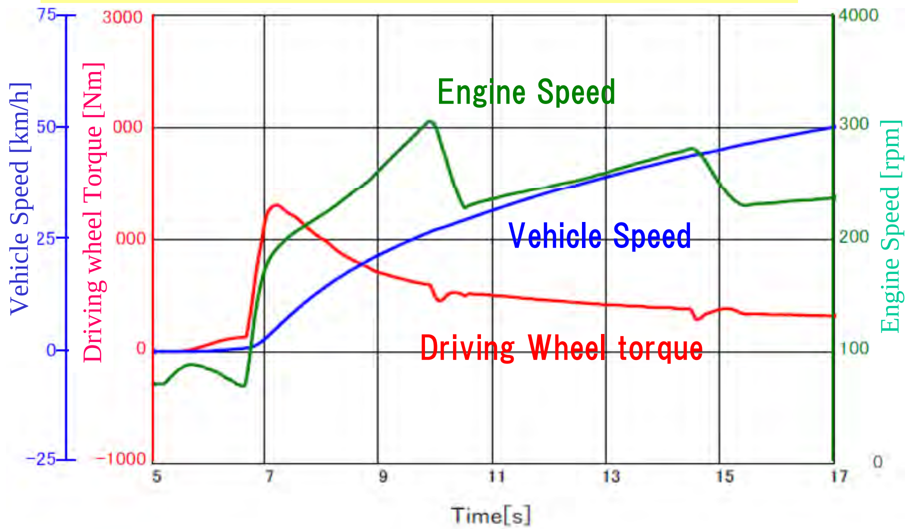
Real Vehicle Measurement (VMS)



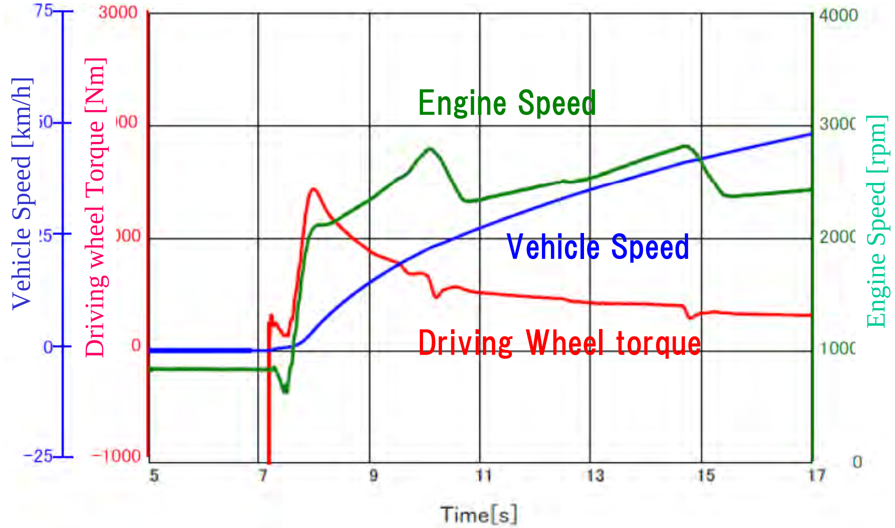
RRSim



Vehicle Model (Offline Simulation)



Engine Bench



We introduced the Experiment Model as one of the technology of CAT (Computer Aided Tool).

Unfortunately, we had to omit the detail explanation of the technology due to the available time.

A&D will continue to offer CAT supporting tool to support CAE.

Thank you for your kind attentions