Energy Requirement Calculator for Passenger Vehicles Using Parameter Based Vehicle Model Developed in MATLAB

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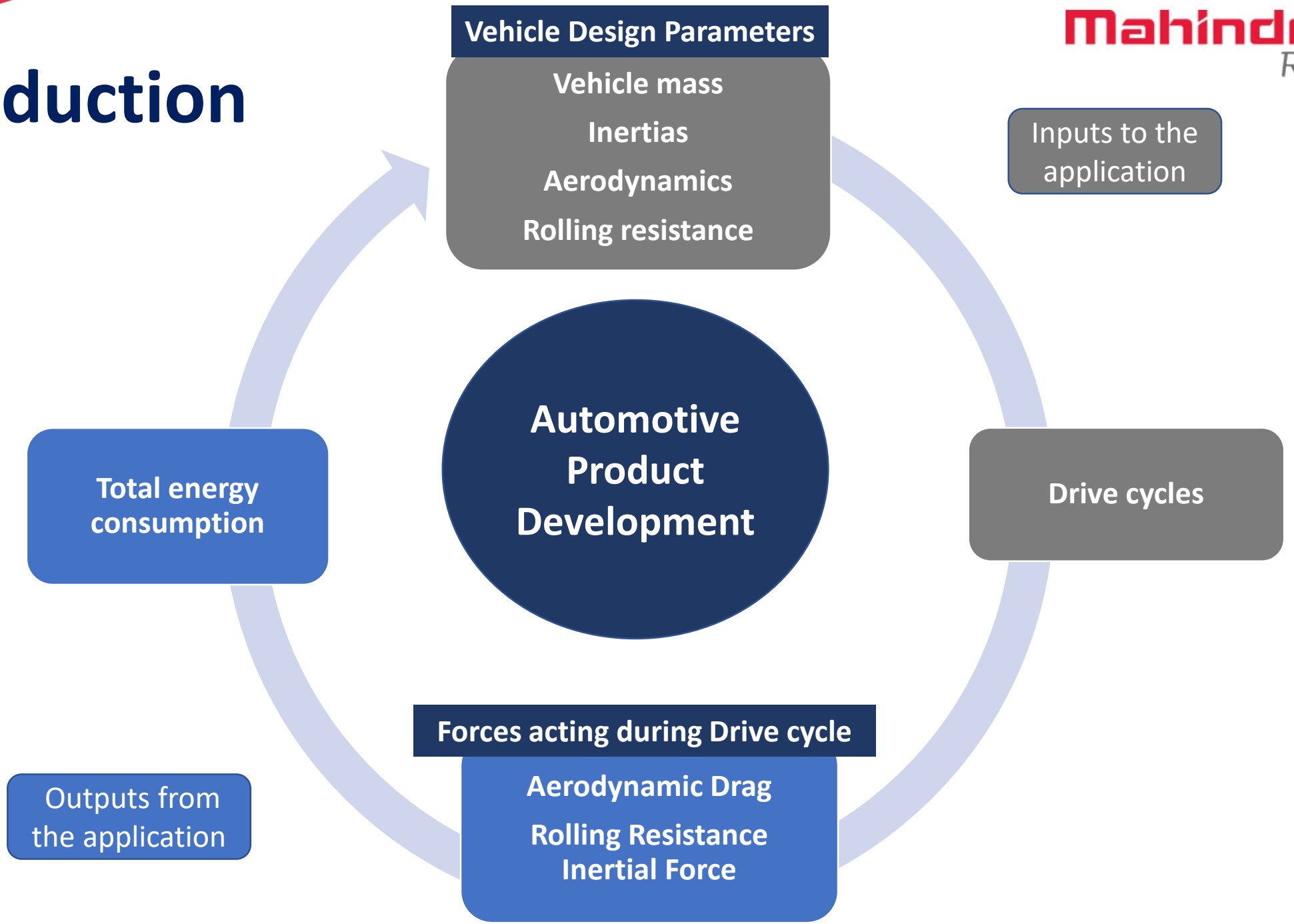
Introduction



Vehicle Energy Calculations

Total Tractive Force and its components

$$F_{tot} = F_{RR} + F_{AD} + F_I$$

where,

F_{tot} = total (resultant) force

F_{RR} = force due to tire rolling resistance

F_{AD} = force due to aerodynamic drag

F_I = force necessary to overcome inertia (acceleration, deceleration, and traversing a grade)

Tire rolling resistance

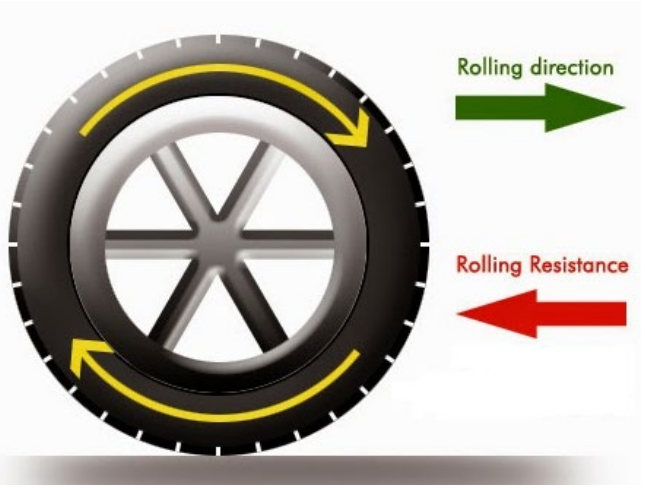
$$F_{RR} = mgC_{rr}$$

where,

m = vehicle mass (kg)

g = 9.81 m/s^2 (gravitational constant)

C_{RR} = coefficient of rolling resistance (dimensionless)



Source: http://www.virtual-car.org/wheels/hybrid_road_load_model.html
https://www.carswithcords.net/2015/01/rolling-resistance.html

Vehicle Energy Calculations

Total Tractive Force and its components

Aerodynamic Drag

$$F_{AD} = \frac{1}{2}\rho C_d A_f v^2$$

where,
rho = density of air (kg/m^3)
C_D = drag coefficient (dimensionless)
A_F = projected frontal area (m^2)
v = average velocity during a time increment of the driving cycle (m/s)

Inertia Force

$$F_I = m\,{}^{\mathrm{d}v}/_{\mathrm{d}t} + mg\sin\alpha$$

where,
m = vehicle mass (kg)
dv/dt = acceleration (or deceleration) rate
g = 9.81 m/s^2 (gravitational constant)
α = grade of the road

Source: http://www.virtual-car.org/wheels/hybrid_road_load_model.html
https://gr8autotech.wordpress.com/2013/06/16/vehicular-aerodynamics/

Vehicle Energy Calculations

Tractive Power

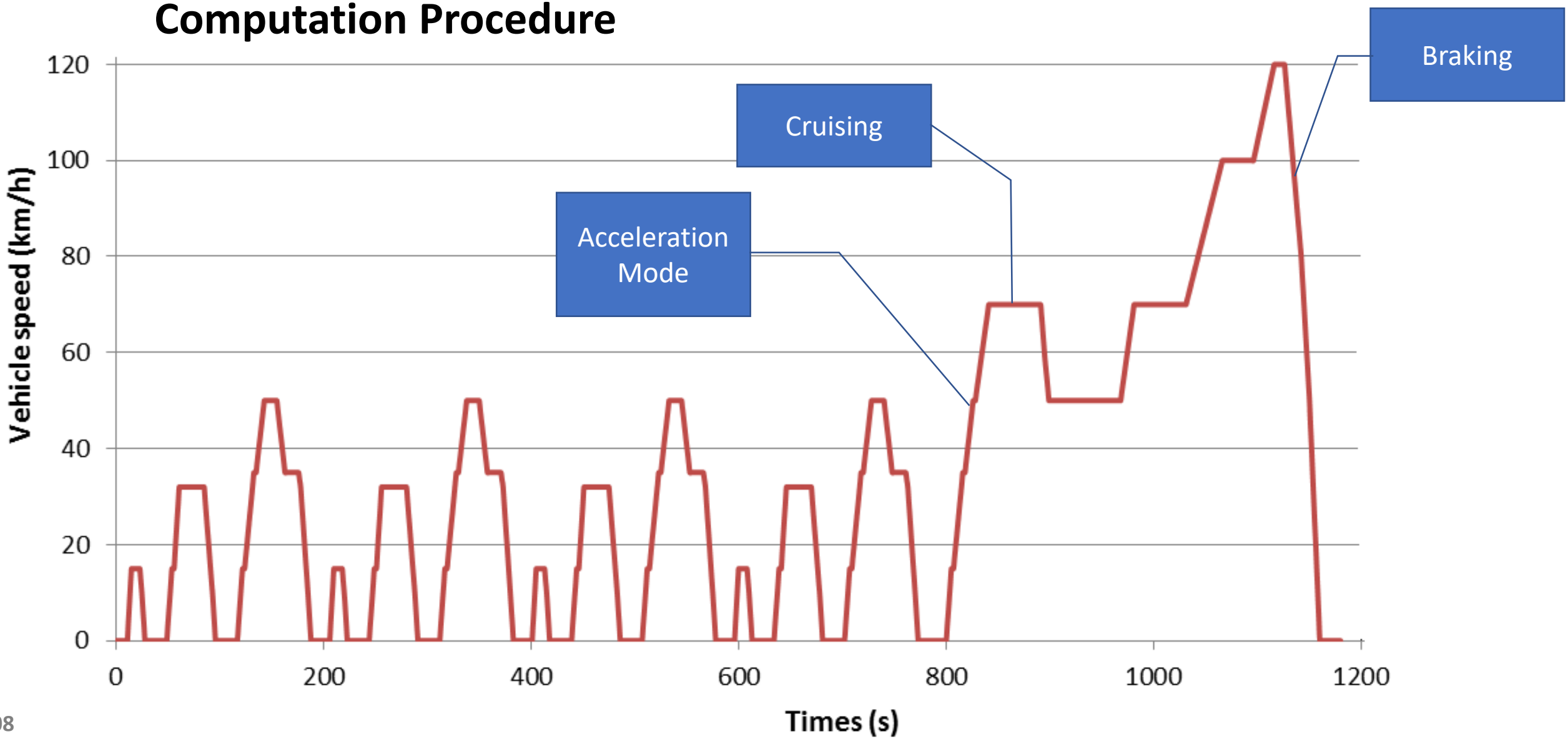
$$P = (F_{RR} + F_{AD} + F_I)v$$

where,
v = average velocity during a time increment of the driving cycle (m/s)

Source: http://www.virtual-car.org/wheels/hybrid_road_load_model.html

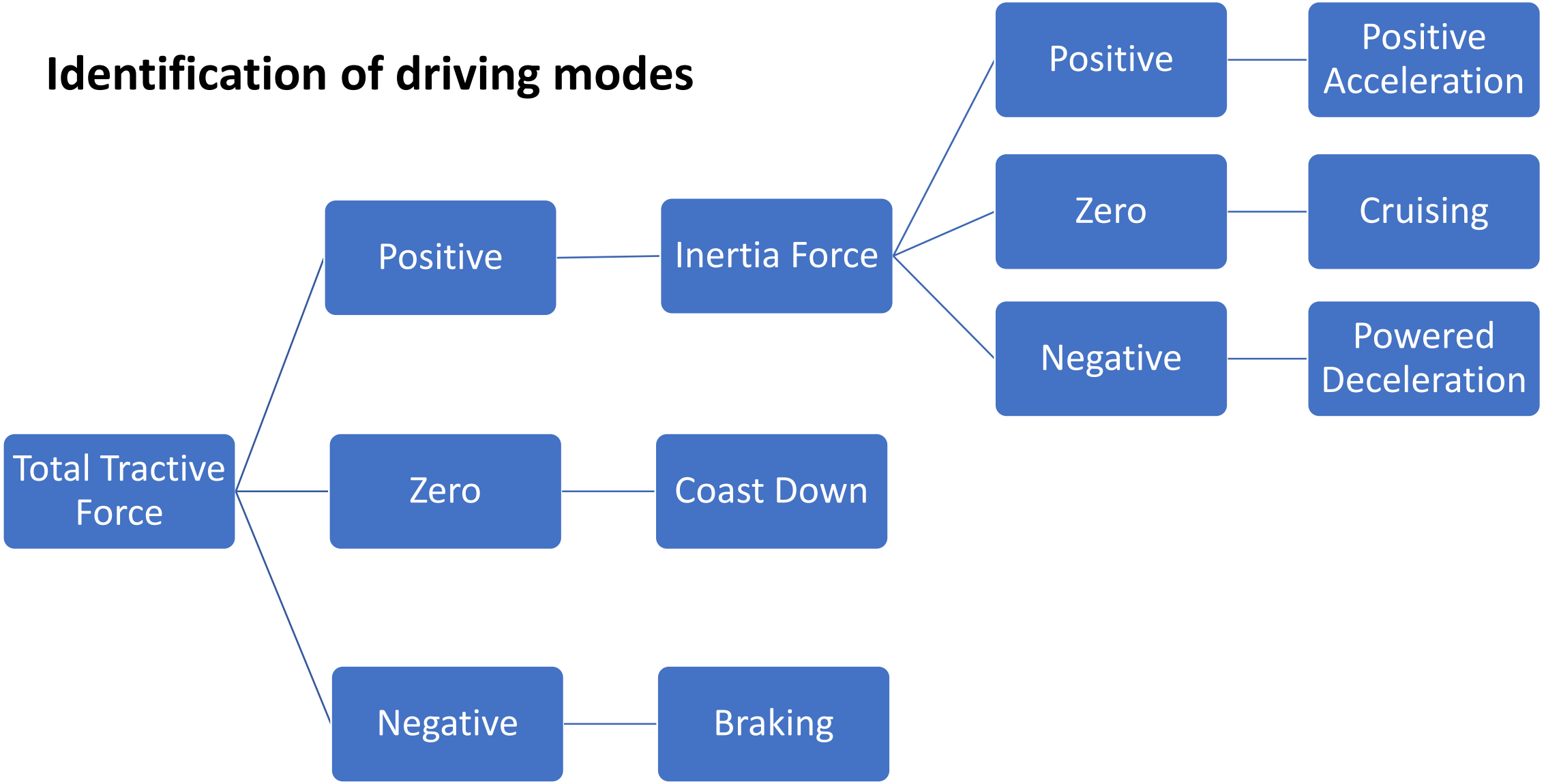
Approach to Problem Statement

Computation Procedure



Approach to Problem Statement

Identification of driving modes



MATLAB Application Interface

Input Tab

Output | Plots

Weights

Kerb Weight: 1500 kg

Payload: 200 kg

Aerodynamics

Cd: 0.3

Frontal area: 1.8 m^2

Air density: 1.2 kg/m^3

Rolling Resistance

Crr: 0.008

Efficiencies

Drivetrain Efficiency: 90 %

Wheel diameter: 280 mm

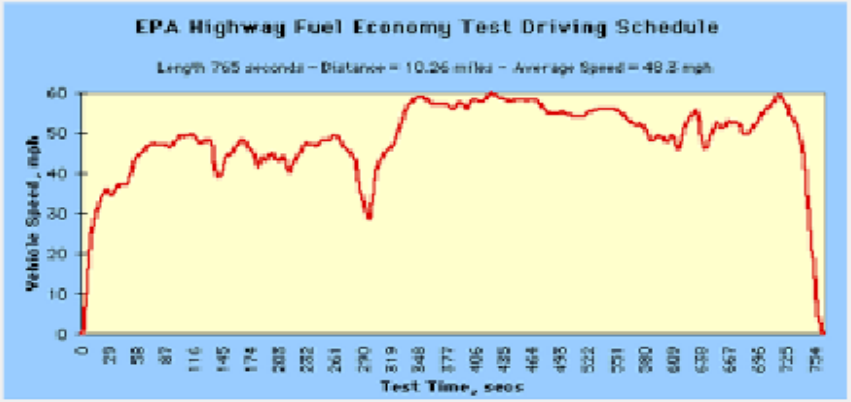
Grade: 0 deg

Rotational Inertia factor: 1.03

Drive Cycle

Select the Drive Cycle: HFET

Units: mph/sec / kmph/sec



Select the Custom file: Browse

Calculate

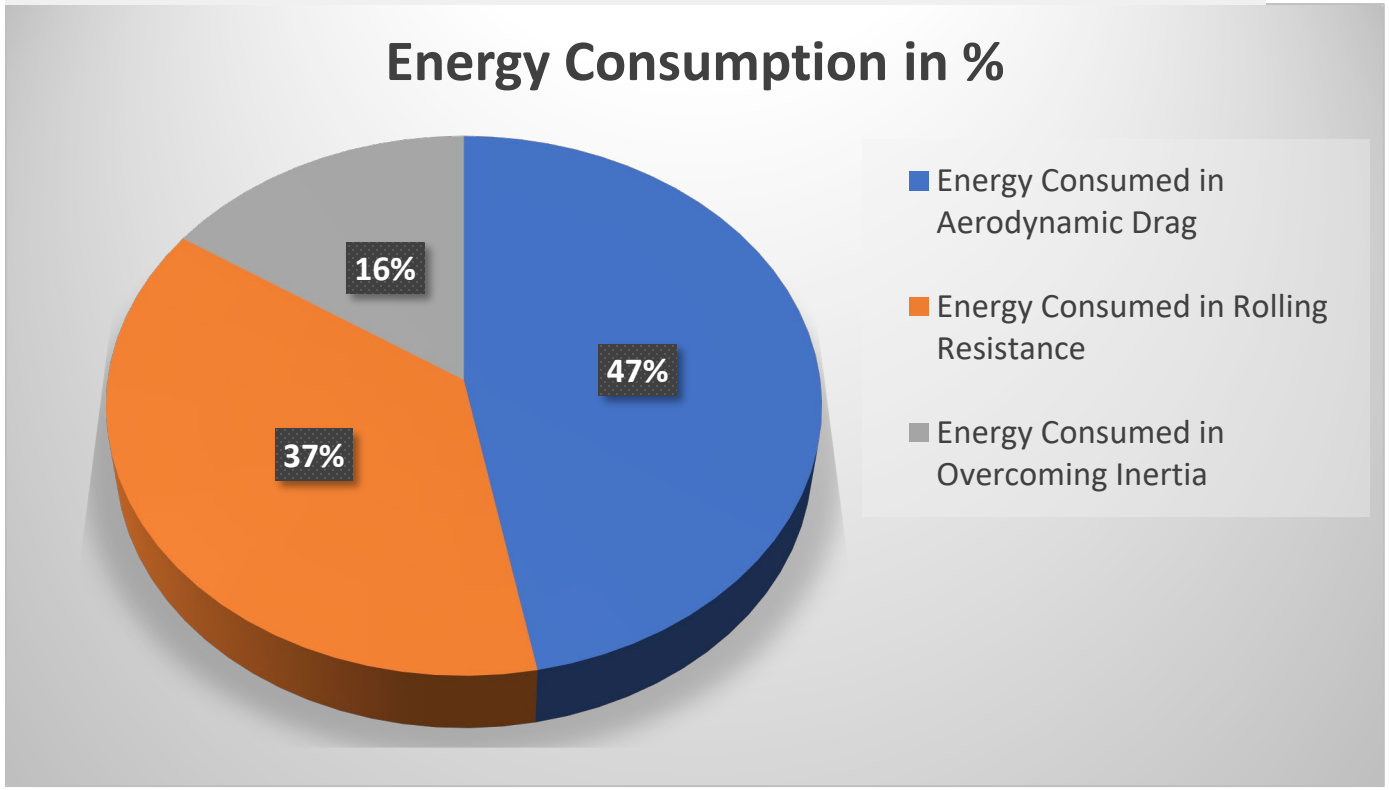
14 standard drive cycles stored as .mat files

Option to input custom drive cycle

Results

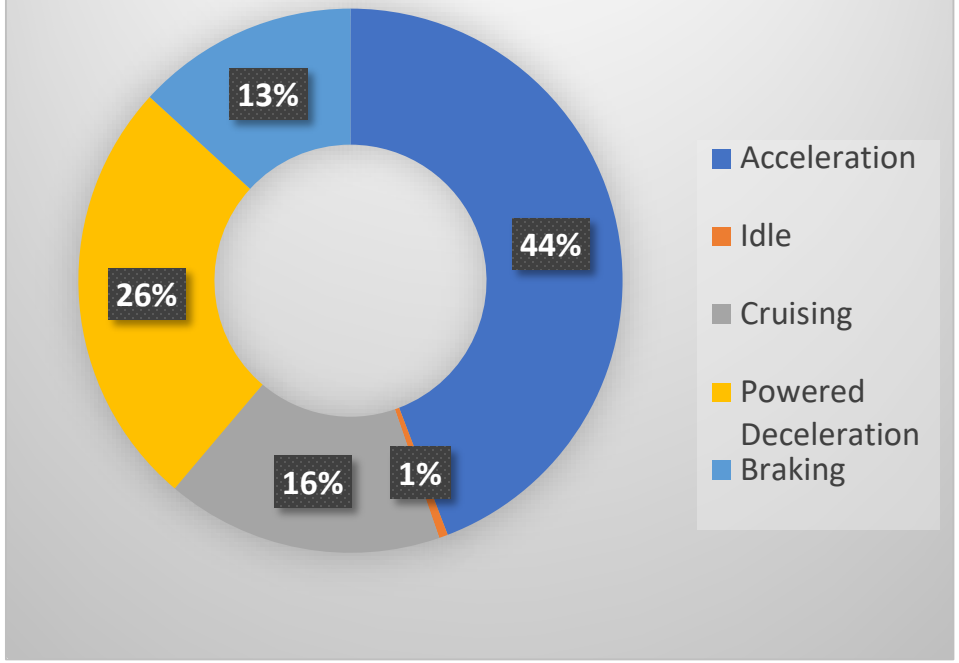
Energy Analysis

Total energy consumed	1.816	kWh

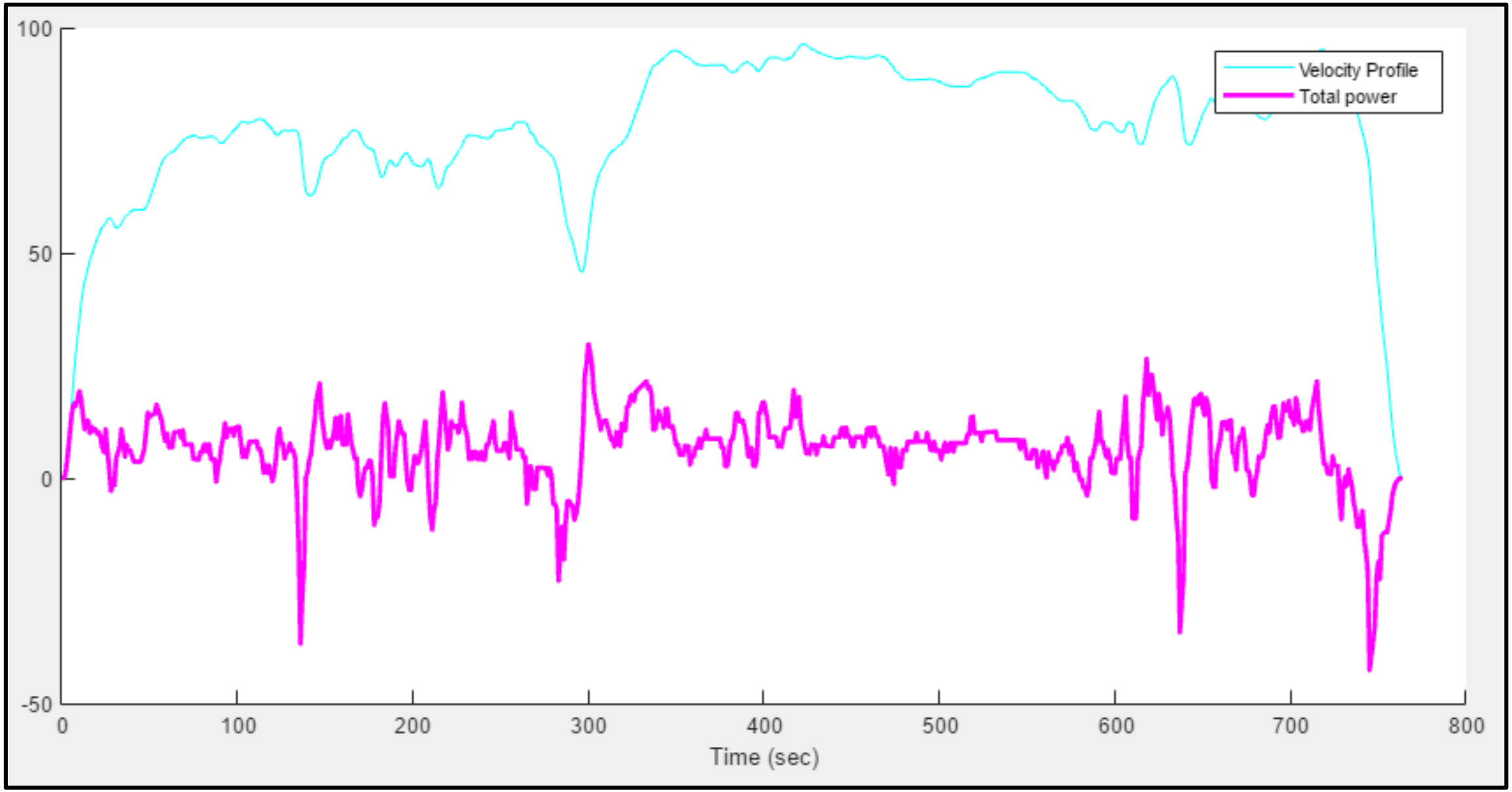


Time Split

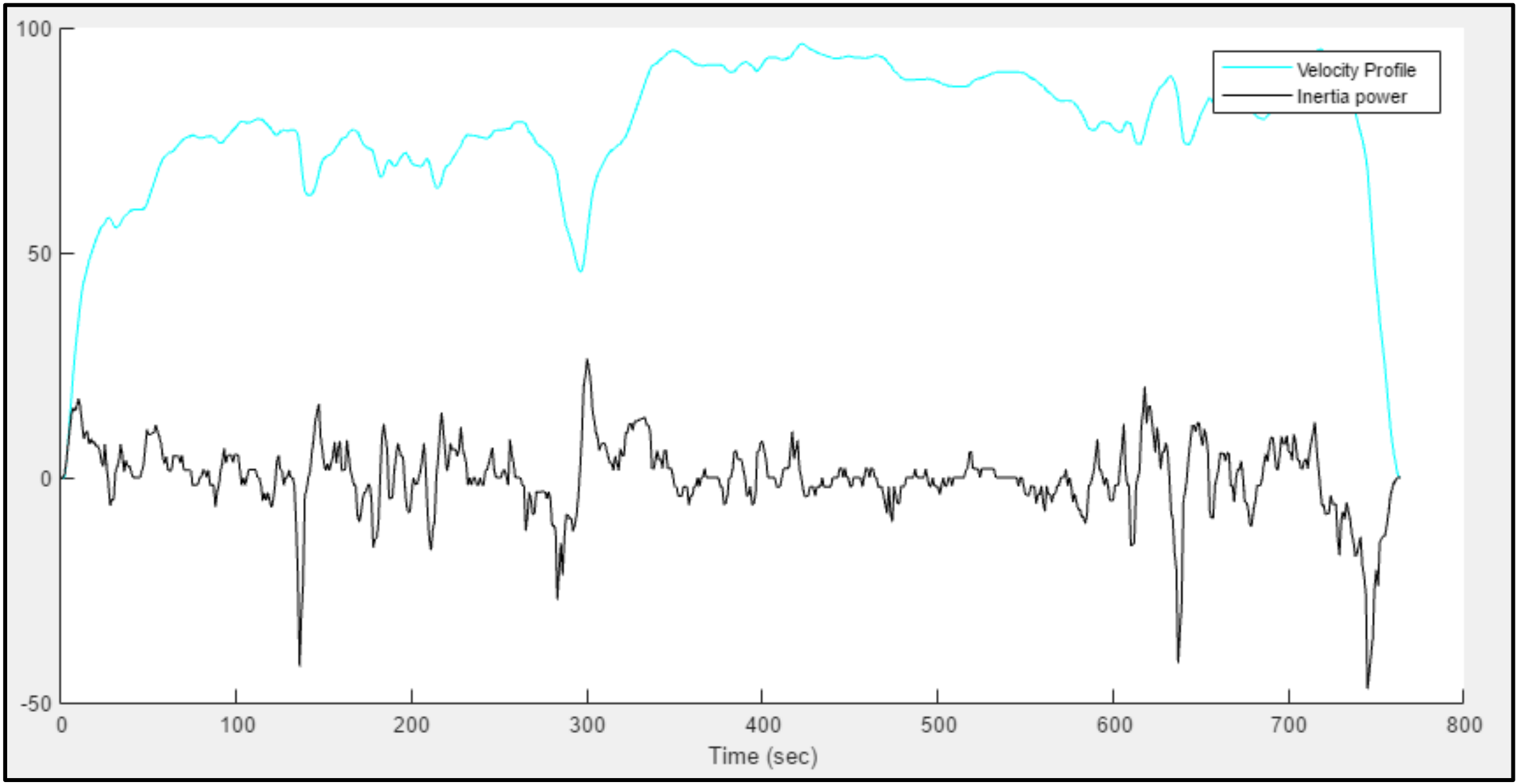
Total Time	765	sec



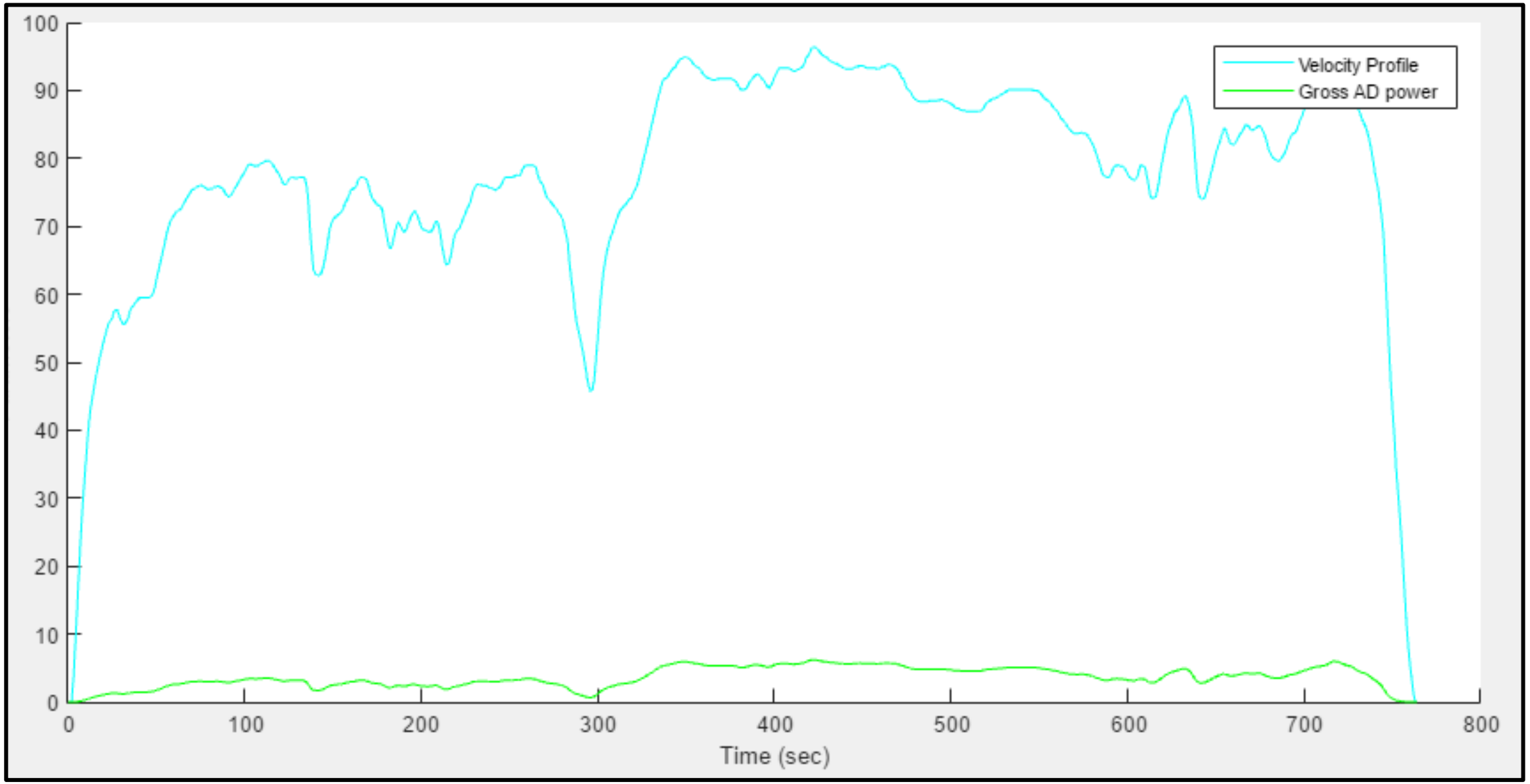
Representative Plots- Total Power



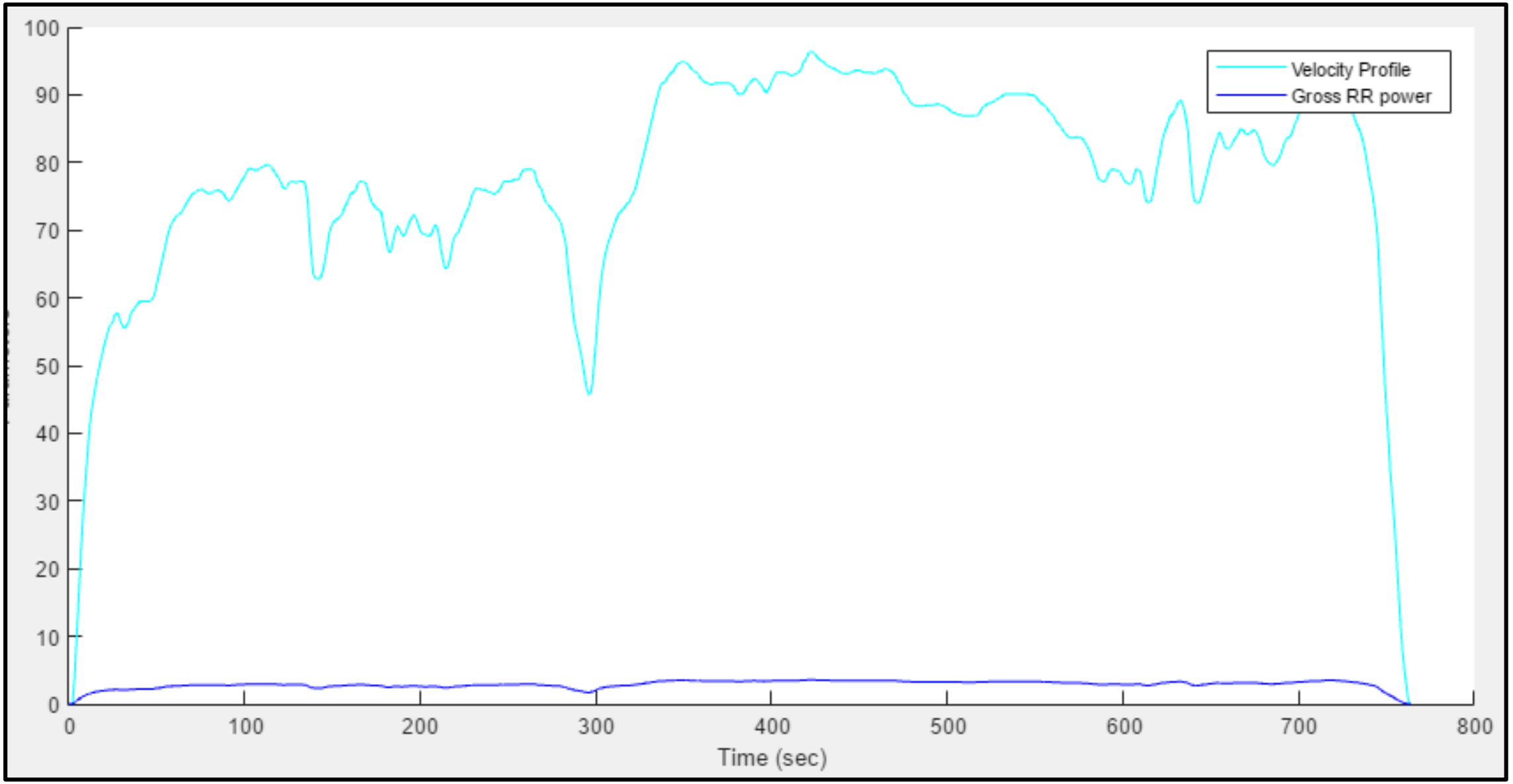
Representative Plots- Inertia Power



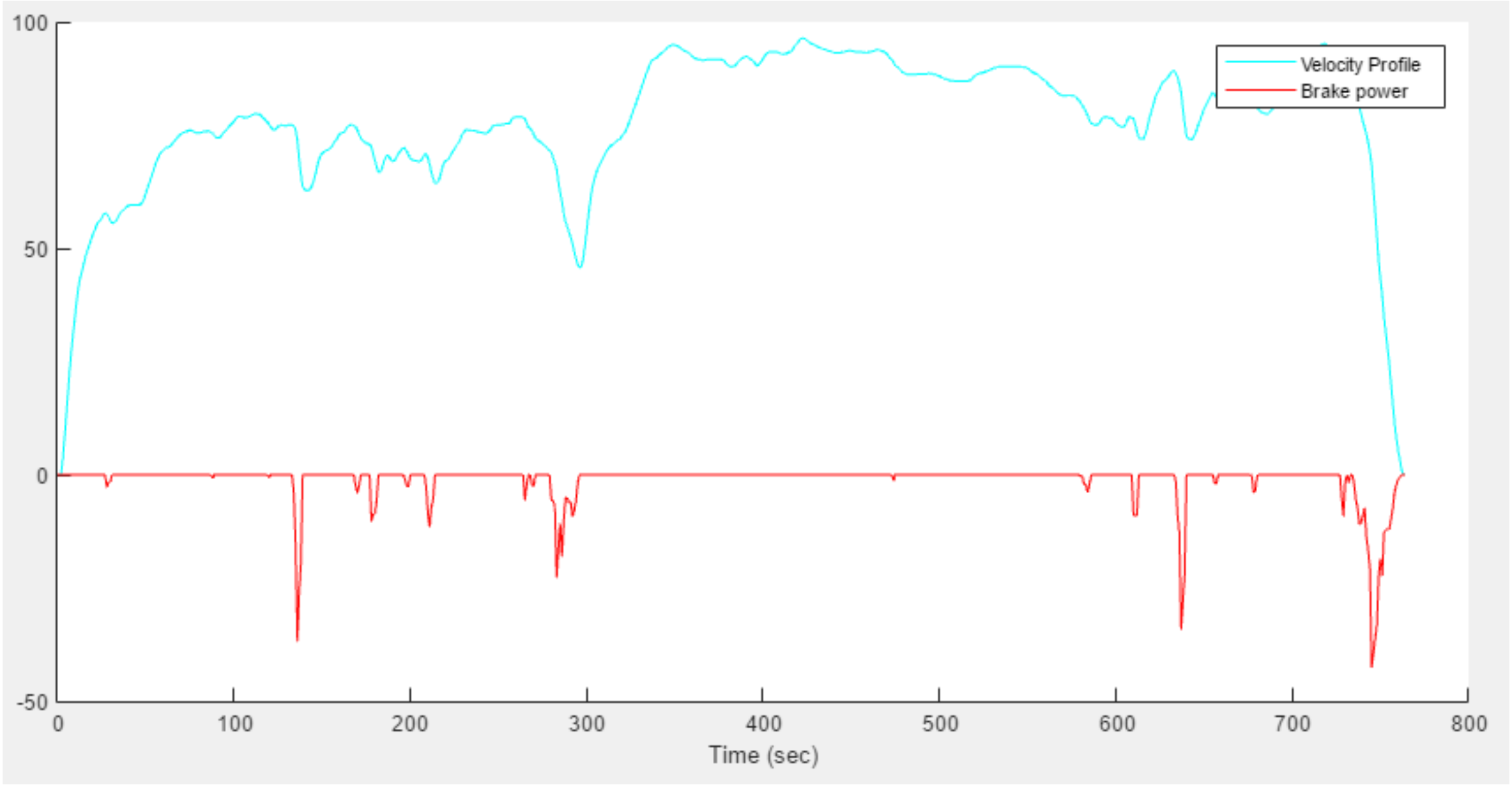
Representative Plots- Aerodynamic Drag



Representative Plots- Rolling Resistance



Representative Plots- Brake Power



Use of MATLAB Tools

- Application was created with the help of App Designer interface in MATLAB
- Executable (.exe) file for the application created with MATLAB Application Compiler
- This application has been deployed in our Mahindra server based centralized application platform, MathApps

Conclusions

- Quick and easy to use calculator , beneficial to design and platform engineers
- The designers can evaluate multiple design iterations
- The results can be further used for feasibility analysis
- Plots can help to visualize the performance of the vehicle and can aid the designer in his decision-making process

Questions?

Thank you

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