MEEN 432 –Automotive Engineering

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Lecture 9: EPA Cycles and Driver Model

- EPA Cycles
- Driver Model

Evaluating the vehicle powertrain

- There are two fundamental dimensions in which the vehicle's "powertrain" is evaluated
  - How fast?
  - How Efficient?

- The key is to come up with "standardized" tests that can then be used to compare across vehicles
  - These tests need to be described so a human driver would be able to perform these tests, in a relatively repeatable fashion

How Fast – i.e. Performance

- Wide Open Throttle (WOT) Tests
  - 0 to 60 mph time (on flat roads)
  - 55 mph gradeability

- Transient
  - 30 to 60 mph time (evaluates passing performance)

- Simulated Tests:
  - Initialize your vehicle according to the test
  - Input "open loop" profiles for your throttle and brakes to determine performance

# How Efficient – i.e. Energy Efficiency

- Fuel economy is primarily determined by typical driving conditions

- This can be abstracted as a desired speed profile over which energy efficiency is measured
  - Note: Fuel Economy will be used interchangeably with energy efficiency, though fuel economy strictly is applicable only to vehicles that use on-board fuel

- A real test will be specified so a human driver could adopt
  - Example: "Crank the engine", "accelerate at a certain ramp to reach a certain speed", "hold speed for certain time", "decelerate at …" etc.
  - Multiple preparatory instructions are included such as hot-start, cold-start, etc.

- For our scope, the tests will be governed by the "speed duty cycles" – i.e. traces of speed vs. time

EPA Cycles

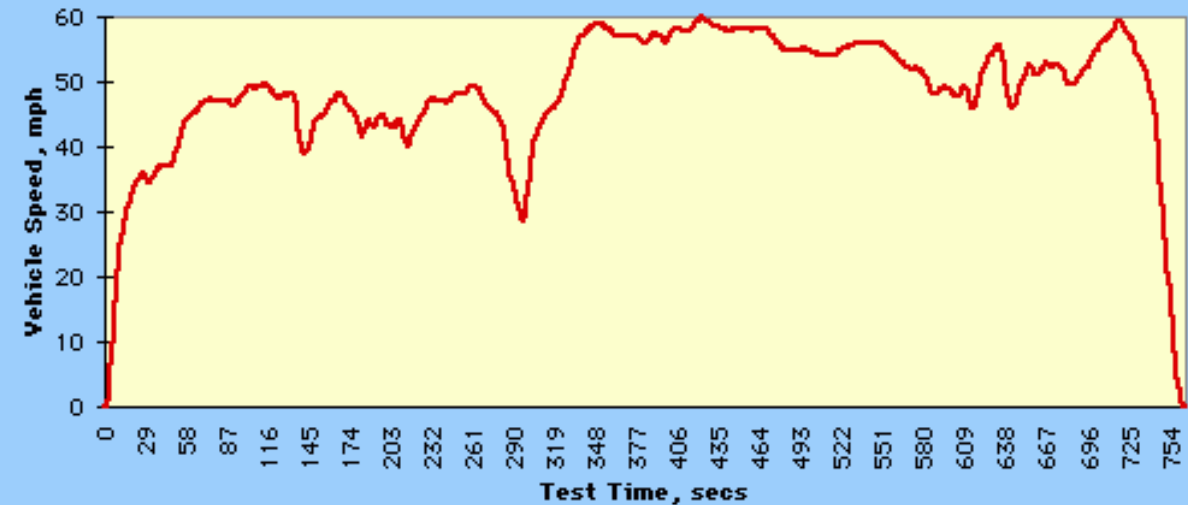- https://www.epa.gov/vehicle-and-fuel-emissions-testing/dynamometer-drive-schedules

EPA Urban Dynamometer Driving Schedule

Length 1369 seconds – Distance = 7.45 miles – Average Speed = 19.59 mph
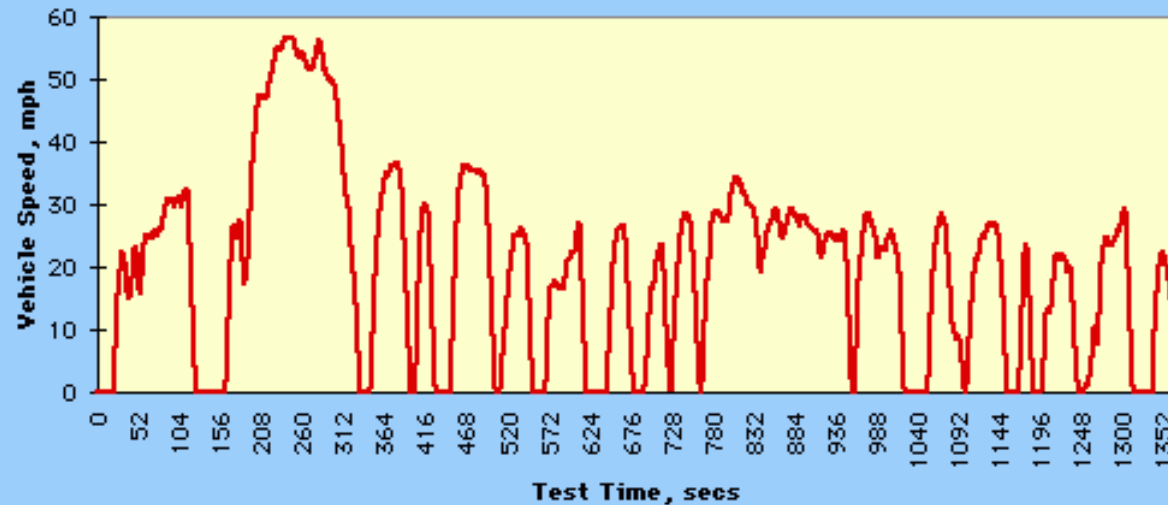
EPA Highway Fuel Economy Test Driving Schedule

Length 765 seconds – Distance = 10.26 miles – Average Speed = 48.3 mph

Driver Model

- A simple, and often effective, driver model is a PID around the desired speed error:
  - $\alpha_{driver}(t) = PID(v_d(t) - v(t))$
    - α_{driver} is the command from the driver – that represents the percentage of torque request on the powertrain
    - $v_d(t)$ is the desired velocity obtained from the duty cycle definitions
    - $v(t)$ is the actual velocity of the vehicle
  - α_{driver} will get translated to a powertrain torque according to the powertrain and brake models
  - $\alpha_{driver} \in [-1, 1]$

- The driver command also needs to be further split into the command to the powertrain and the command to the brakes
  - $\alpha_{driver} \rightarrow (\alpha_{PT}, \alpha_b)$

Driver Model

- Note that for an ICE, we can only ask for positive torque (neglecting any engine braking). Therefore an easy split is as below:
  - $\alpha_{PT} = \alpha_{driver}$ if $\alpha_{driver} \geq 0$ else 0
  - $\alpha_b = -\alpha_{driver}$ if $\alpha_{driver} < 0$ else 0
- However for electric vehicles, we can ask for both positive and negative torques from the powertrain. Thus:
  - $(\alpha_{PT}, \alpha_b) = energy\_strategy(\alpha_{driver}, v, \dots)$
  - i.e. the split between powertrain and brake torque is according to some strategy that needs to be implemented