Industry Perspectives and On-board Diagnostics

John Viera

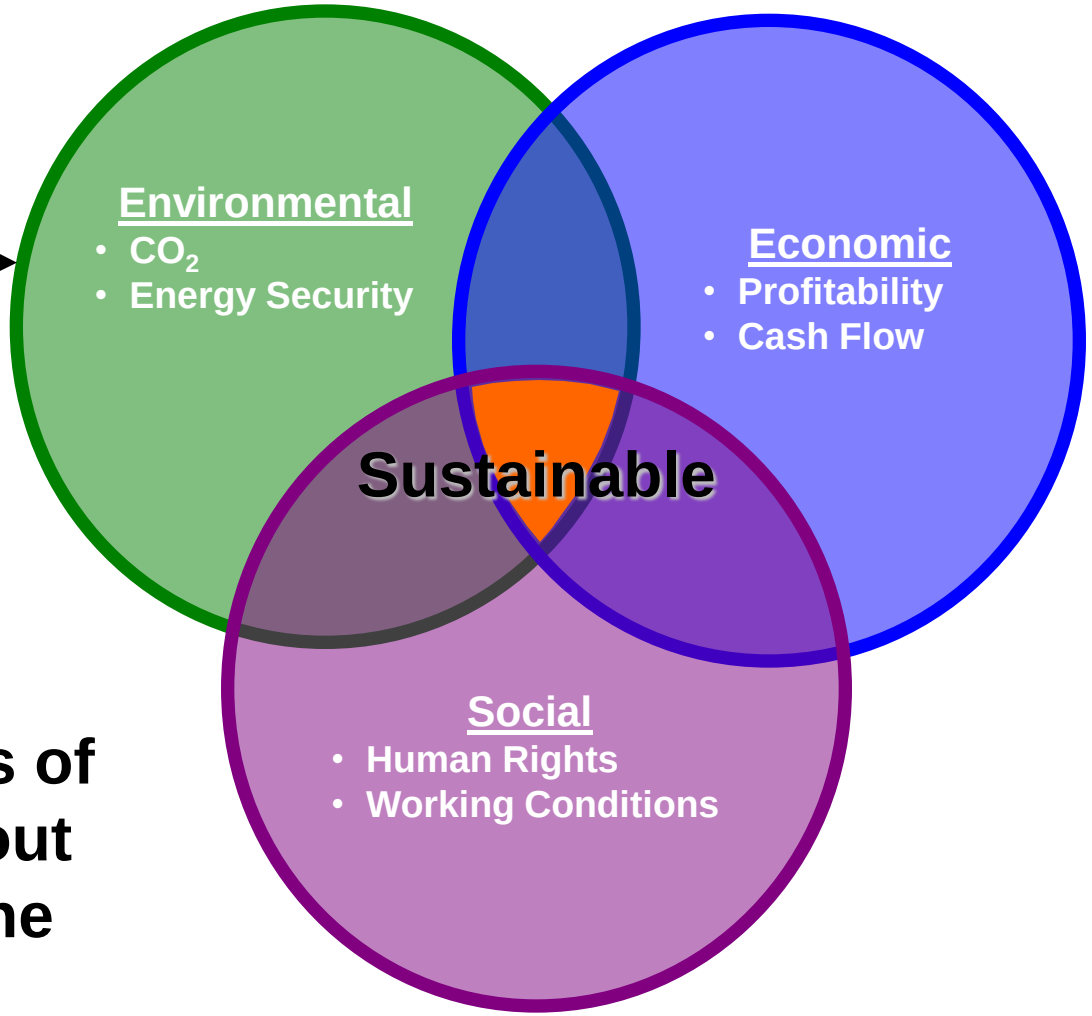
Director, Sustainability & Vehicle Environmental Matters

Ford Motor Company

Industry Perspective

Sustainability at Ford

- Product
- Process
  - Manufacturing
  - Dealers



Meeting the needs of the present without compromising the future.

Fuel Economy As A Reason To Buy

TECHNOLOGY INNOVATION PILLARS

Technology Strategy

Anticipate – Innovate – Incorporate

Sustainability "GREEN"

- Improve fuel economy; reduce CO2 emissions to leadership levels
- More renewable, recycled materials
- Improved In-Vehicle Air Quality

Safety "SAFE"

- Achieve public domain targets and 3rd Party Recommended Buys
- Safety technology / feature content equal or better than competition
- Breakthrough features for family safety

Design "SMART"

- Design leadership on each new program
- Exciting interiors: leadership in comfort / convenience, infotainment technology
- Global platforms with right proportions
- Improve emotional appeal

Capabilities & Enablers – "QUALITY"

A CLEAR TECHNOLOGY STRATEGY WHICH SETS PRIORITIES AND GUIDES ACTIONS TO ACHIEVE OUR VISION FOR BRINGING AFFORDABLE TECHNOLOGY TO MILLIONS.

Data Tracking and Recording
OBD Overview

OBD Overview

- The OBD system:
  - Monitors components that can affect the emission performance of the vehicle
  - Alerts the vehicle operator when a malfunction is detected via a malfunction indicator light (e.g. “check engine” or “service engine soon”)

  - Stores information, including a diagnostic trouble code (DTC), about the detected malfunction to aid a repair technician in accurately finding and fixing the problem.

OBD Overview (continued)

- All electronic sensors and actuators that can affect emissions are monitored for circuit continuity and plausibility.

- Certain major emissions components, sensors, and actuators have additional specific monitoring requirements called out in the regulation.

- A subset of these have <u>emissions threshold monitors</u> where MIL illumination is required when performance deteriorates to the point of exceeding an emissions threshold (e.g. 1.25 x the applicable emission standard)

OBD Overview (continued)

- While OBD regulatory requirements generally focus on detecting malfunctions and storing/communicating information about them, there are a handful of requirements that require extended tracking/logging of vehicle/system information:
  - “Freeze Frame” capture of conditions under which a fault was detected
  - In-use Monitor Performance Ratio
  - Run-time tracking requirements for Diesel vehicles and engines

OBD "Freeze Frame"

- When an emissions malfunction is detected, a manufacturer's OBD system is required to store and report in a standardized format the corresponding diagnostic trouble code (DTC) as well as relevant parameters reflecting the vehicle/engine operating conditions at the time the malfunction was detected

- Examples of parameters above and beyond applicable DTCs captured in "freeze frame" include:

  - Calculated load value
  - Engine coolant temperature
  - Engine speed
  - Absolute throttle position
  - Vehicle speed
  - Fuel control system status (e.g., "open loop")
  - Fuel trim
  - Fuel pressure

  -- Ignition timing advance
  -- Intake air temperature
  -- Manifold absolute pressure
  -- Mass air flow rate
  -- Oxygen sensor output
  -- Air/fuel ratio sensor output
  -- Mode 06
  -- …and several others as required by the regulation.

In-use Monitor Performance Ratio

- For a specific list of major OBD monitors, tracking and standardized reporting of a “performance ratio” is required:
  - Numerator is incremented whenever the monitor completes
  - Denominator is incremented whenever a “trip” (as defined by minimum vehicle/engine activity criteria specified in the OBD regulation) is completed
- Certain monitors have unique denominators with additional trip criteria (evaporative leak check monitors, monitors tied to Diesel particulate filter regeneration, PHEV monitors requiring engine operation, etc.)
- OBD monitors are required to meet minimum performance ratios as specified in the OBD regulations

Run-Time Tracking Requirements for Diesel Vehicles and Engines

- OBD regulations require tracking and standardized reporting of the following parameters for Diesel vehicles and engines:
  - Total engine run time
  - Total idle run time
  - Total run time with power take-off active
  - Total run time for each Emission-Increasing Auxiliary Emission Control Device

Limitations

Vehicle Data Recorder (Data loggers) are used on preproduction demonstration fleets for engineering validation work.

<u>Privacy Concerns</u>

- Data Loggers can not be used to identify Personally Identifiable Information such as:
  - Identify customers and what they are doing
  - Record GPS Locations

<u>Space Limitations</u>

- There is limited amount of RAM on the vehicle

The Promise of the Future

Electric Lifestyle – Supported By Ford

In-Car Info with MyFord Touch™

- Range, destinations and charge points
- Brake Coach displays regenerative brake performance
- Butterfly icons represent additional range beyond one's charge point destination – the more there are, the greater the range

At Home Charging

- Value Charging powered by Microsoft
- 3-4 hour charge on 240v home outlet
- Compact and easy-to-install charging station
- Best Buy installation partnership

Smartphone Access with MyFord Mobile

- Stay connected, monitor/control vehicle via Smartphone
- Locate charging stations and send destination to the vehicle
- Program to charge when electricity prices are lowest
- Receive alerts if the vehicle isn't charging when it's scheduled to, or if charging stops unexpectedly

Driver-Vehicle Interaction – Improved Fuel Economy, Increased Information

New concepts developed for Plug-In vehicles

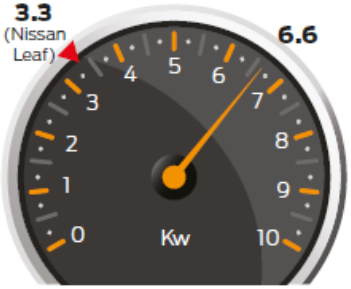
- **Charge status**
- **Butterflies/ Range**
- **Connectivity**
- **Efficiency**

Graphically Tracks Driver's Efficiency, Smartphone Interface for Charging Status

VALUE CHARGING

FOCUS ELECTRIC (BEV)

CHARGE RATE (in Kw)



COST OF LAST CHARGE

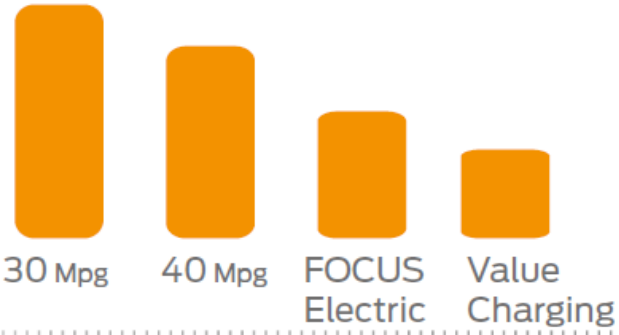
$2.10
Las Vegas Rates

=>

$2.10 → 80 Miles

MILES PER CHARGE HOUR

COMPARISON OF COSTS FOR 80 MILES



Source: IHS Global Insights

Limitless

We have the expertise to develop tools that provide useful data for engineering validation, future planning and also our customers wants and needs

Questions

Back-up

Test Results Reporting

- OBD Regulations also require standardized reporting of most recent “test results” for certain major emissions monitors
  - Test results are continuously updated each time a monitor runs
  - In addition to the test results, the OBD system must also output the test limits to which they are compared to make a “pass” or “fail” determination

OBD Service Modes

- SAE J1979 defines standardized Service Modes identified by hexadecimal numbers/addresses
- Engineers and technicians sometimes refer to these service mode numbers as a shorthand for the information provided by them
- The relevant service modes to this discussion are:
  - Mode $01 – Current Diagnostic Data (See next slide. This includes the Diesel run-time tracking counters)
  - Mode $02 – Freeze Frame Data
  - Mode $06 – Test Results for Specific Monitors
  - Mode $09 – Vehicle Information (includes in-use performance ratios as well as VIN, calibration ID, and calibration verification number/checksum)

Examples of Information Available from Service Mode $01

- I/M Readiness Data
- Freeze Frame DTC
- Fuel system status
- Calculated LOAD Value
- Engine Coolant Temperature
- Short Term Fuel Trim - Bank 1
- Fuel Pressure (gauge)
- Intake Manifold Absolute Pressure
- Engine RPM
- Vehicle Speed Sensor
- Ignition Timing Advance
- Intake Air Temperature
- Air Flow Rate from Mass Air Flow Sensor
- Absolute Throttle Position
- Commanded Secondary Air Status
- Location of oxygen sensors
- O2 Sensor and SHRFT (all banks and sensor combinations)
- OBD requirements for vehicle or engine
- Location of oxygen sensors
- Auxiliary Input (e.g. PTO) Status
- Time Since Engine Start
- Distance Traveled While MIL is Activated
- Fuel Pressure relative to manifold vacuum
- Fuel Rail Pressure
- Wide Raio O2 Lambda value and Voltage (all banks and sensor combinations)
- Commanded EGR
- EGR Error
- Commanded Evaporative Purge
- Fuel Level Input
- Number of warm-ups since DTCs cleared
- Distance traveled since DTCs cleared
- Evap System Vapor Pressure
- Barometric Pressure
- Wide Ratio O2 Lambda value and Current (all banks and sensor combinations)
- Catalyst Temperature (all banks and sensor combinations)
- Monitor status this driving cycle (for several monitors)
- Control module voltage
- Absolute Load Value
- Fuel/Air Commanded Equivalence Ratio
- Relative Throttle Position
- Ambient Air Temperature
- Absolute Throttle Position B
- Absolute Throttle Position C
- Accelerator Pedal Position D
- Accelerator Pedal Position E
- Accelerator Pedal Position F
- Commanded Throttle Actuator Control
- Engine run time while MIL activated
- Engine run time since DTCs cleared
- External Test Equipment Configuration Information #1
- External Test Equipment Configuration Information #2
- Type of fuel currently being utilized by the vehicle
- Alcohol Fuel Percentage
- Absolute Evap System Vapor Pressure
- Evap System Vapor Pressure
- Short Term Secondary O2 Sensor Fuel Trim – Bank 1&2 (use if only 1 fuel trim value)
- Long Term Secondary O2 Sensor Fuel Trim – Bank 1 &2(use if only 1 fuel trim value)
- Fuel Rail Pressure (absolute)
- Relative Accelerator Pedal Position
- Hybrid Battery Pack Remaining Charge
- Engine Oil Temperature
- Fuel Injection Timing
- Engine Fuel Rate
- Emission requirements to which vehicle is designed
- Driver's Demand Engine - Percent Torque
- Actual Engine - Percent Torque
- Engine Reference Torque
- Engine Percent Torque Data
- Auxiliary Inputs/Output Status (PTO, transmission, glow plugs, etc.)
- Mass Air Flow Sensor
- Engine Coolant Temperature
- Intake Air Temperature
- Commanded EGR and EGR Error
- Commanded Diesel Intake Air Flow Control and Relative Intake Air Flow Position
- Exhaust Gas Recirculation Temperature
- Commanded Throttle Actuator Control and Relative Throttle Position
- Fuel Pressure Control System
- Injection Pressure Control System
- Turbocharger Compressor Inlet Pressure
- Boost Pressure Control
- Variable Geometry Turbo Control
- Wastegate Control
- Exhaust Pressure
- Turbocharger RPM
- Turbocharger A Temperature
- Turbocharger B Temperature
- Charge Air Cooler Temperature
- Exhaust Gas Temperature Bank 1
- Exhaust Gas Temperature Bank 2
- Diesel Particulate Filter Bank 1
- Diesel Particulate Filter Bank 2
- Diesel Particulate Filter Temperature
- NOx NTE control area status
- PM NTE control area status
- Engine Run Time
- Engine Run Time for AECD #1 - #5
- Engine Run Time for AECD #6 - #10
- NOx Sensor
- Manifold Surface Temperature
- NOx Control System
- Particulate Matter Sensor
- Intake Manifold Absolute Pressure
- SCR Inducement System
- Engine Run Time for AECD #11 - #15
- Engine Run Time for AECD #16 - #20
- Diesel Aftertreatment Status
- O2 Sensor (Wide Range)
- Absolute Throttle Position G

Example of Freeze Frame Data

```
 Id      Acronym: Transform
     Raw Data (hex)   [mode 2]
-------------------------------------
 01     MON_STAT: *         8107E500
         DTC_CNT: 1
             MIL: ON
         MIS_SUP: YES
        FUEL_SUP: YES
         CCM_SUP: YES
        IGNITION: SPARK
         MIS_RDY: YES
        FUEL_RDY: YES
         CCM_RDY: YES
         CAT_SUP: YES
        HCAT_SUP: NO
        EVAP_SUP: YES
         AIR_SUP: NO
        ACRF_SUP: NO
         O2S_SUP: YES
         HTR_SUP: YES
         EGR_SUP: YES
         CAT_RDY: YES
        HCAT_RDY: YES
        EVAP_RDY: YES
         AIR_RDY: YES
        ACRF_RDY: YES
         O2S_RDY: YES
         HTR_RDY: YES
         EGR_RDY: YES
```

```
 02      DTCFRZF: P0300              0300
 03      FUELSYS: CL/NA              0200
 04      LOAD_CT: 62.8%              A0
 05          ECT: +77 deg C          75
 06      SHRTFT1: -2.3%              7D
 07      LONGFT1: 0.8%               81
 0B          MAP: 60 kPa             3C
 0C          RPM: 1286               1418
 0D          VSS: 58 km/h            3A
 0E     SPARKADV: 41 deg             D1
 0F          IAT: +23 deg C          3F
 10          MAF: 8.36 g/s           0344
 11           TP: 16.5%              2A
 15        O2S12: 0.885 V            B1
        SHRTFT12: 99.2%              FF
 1F        RUNTM: 354 sec            0162
 2C      EGR_PCT: 28.6%              49
 2E     EVAP_PCT: 0.0%               00
 2F          FLI: 40.8%              68
 30     WARM_UPS: 4                  04
 31     CLR_DIST: 84 km              0054
 32      EVAP_VP: -17.50 Pa          FFBA
 33         BARO: 98 kPa             62
 34     EQ_RAT11: 1.013              81C3
           O2S11: 0.012 mA           8003
 3C     CATEMP11: 586.5 deg C        1879
```

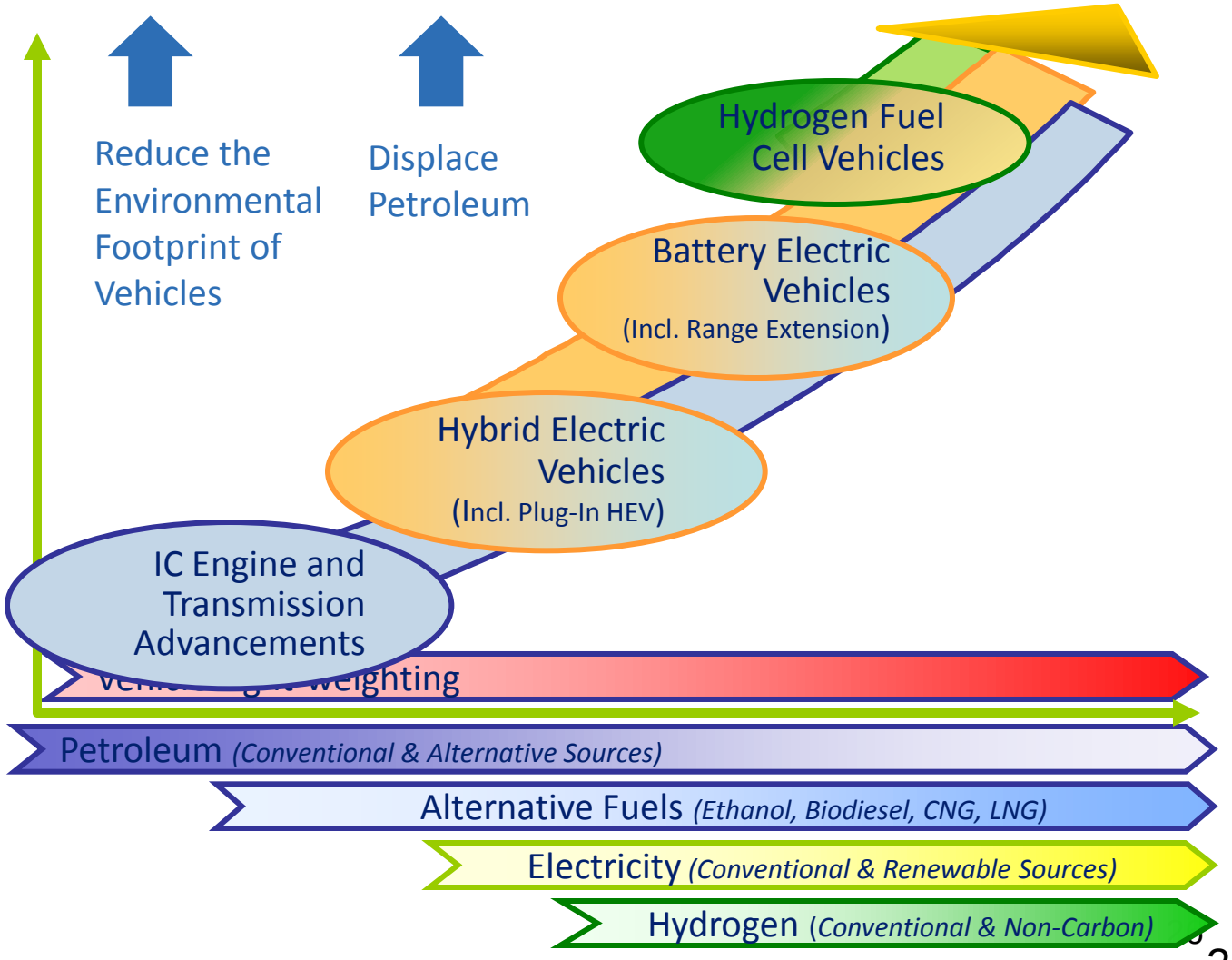
```
 41      MON_DRV: *                  00478565
          MIS_ENA: YES
         FUEL_ENA: YES
          CCM_ENA: YES
         IGNITION: SPARK
         MIS_CMPL: YES
         FUELCMPL: YES
         CCM_CMPL: NO
          CAT_ENA: YES
         HCAT_ENA: NO
         EVAP_ENA: YES
          AIR_ENA: NO
          O2S_ENA: NO
          HTR_ENA: NO
          EGR_ENA: YES
         CAT_CMPL: NO
         HCATCMPL: YES
         EVAPCMPL: NO
         AIR_CMPL: YES
         O2S_CMPL: NO
         HTR_CMPL: NO
         EGR_CMPL: YES
 42          VPWR: 13.560 V          34F8
 43      LOAD_ABS: 25.5%             0041
 44        EQ_RAT: 0.999             8000
 45          TP_R: 4.3%              0B
 46           AAT: +22 deg C         3E
 47          TP_B: 21.2%             36
 49         APP_D: 28.6%             49
 4A         APP_E: 14.1%             24
 4C       TAC_PCT: 7.1%              12
```

CARDAQ

Restraint Control Module

- Records data when there is an event (i.e. impact/collision

Efficient Vehicle and Fuel Options



Energy Security through Fuel Diversity