Integrating Data, Performing Quality Assurance, and Validating the Vehicle Model for the 2004 Prius Using PSAT

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Accelerating Data Processing & Analysis

- Argonne performs extensive vehicle instrumentation (>100 sensors) and numerous tests (>100) for advanced vehicles => Huge amount of data
- Current test data analysis performed manually with EXCEL => Process long and painful
- Advance in computer tools allow the development of an automated process, from test data QA to analysis and validation
- 2004 Toyota Prius tested at Argonne National Laboratory will be used as an example

Generic Methodology: From Test to Validation

1- Import Test Data into PSAT

2- Individual Sensor Evaluation

3- Sensor Comparison

4- Calculate Effort/Flow from Sensors

5- Sensor & Calculation Comparison

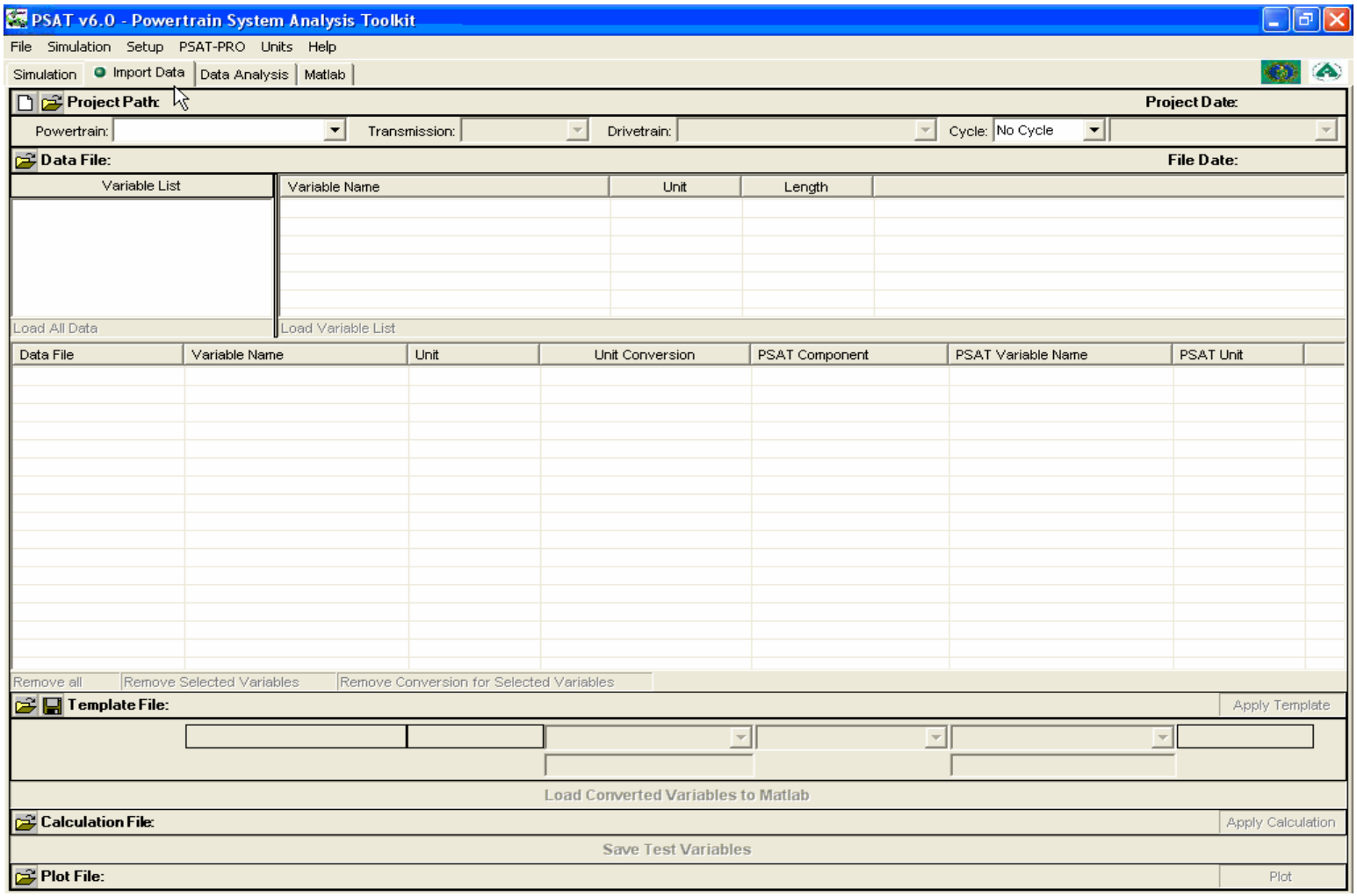
Quality Analysis (QA)

6- Control Strategy

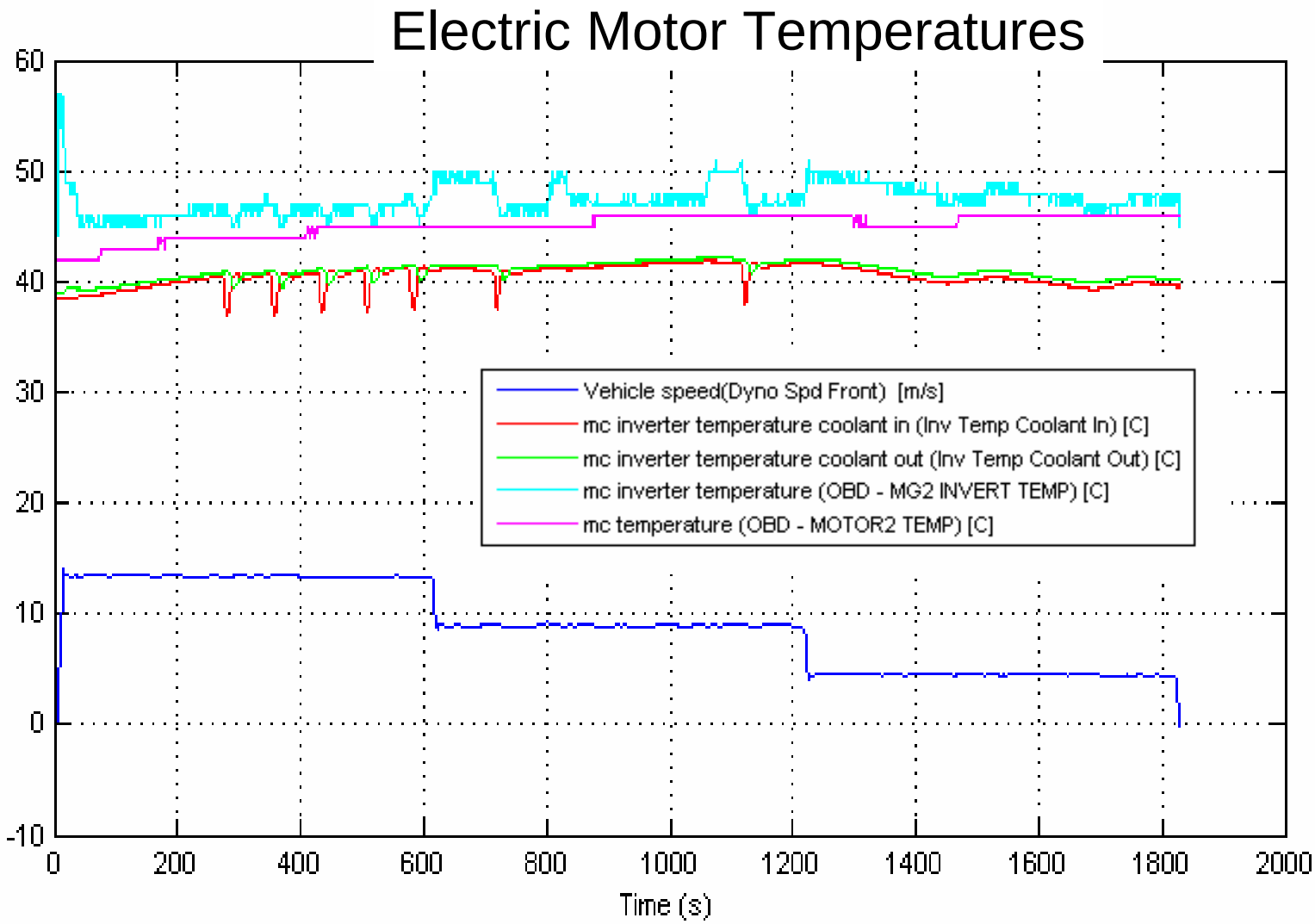
7- Model Validation

Analysis & Validation

Test data are renamed, rescaled, and imported into the same environment as simulation

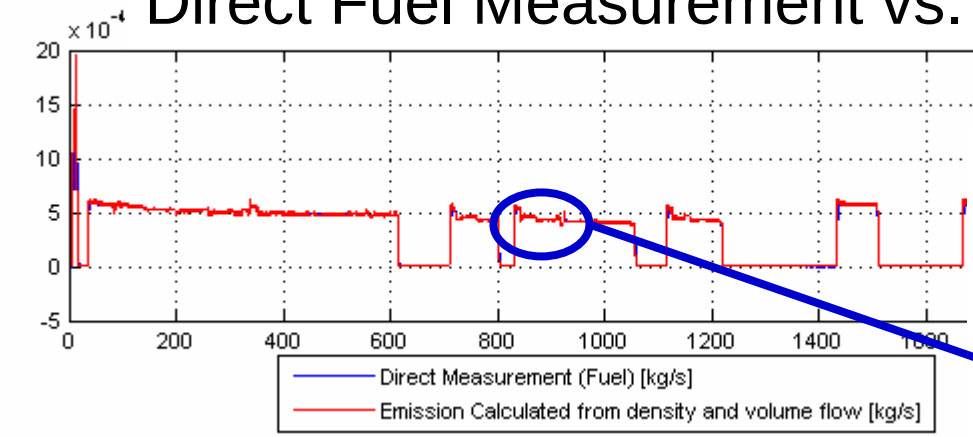


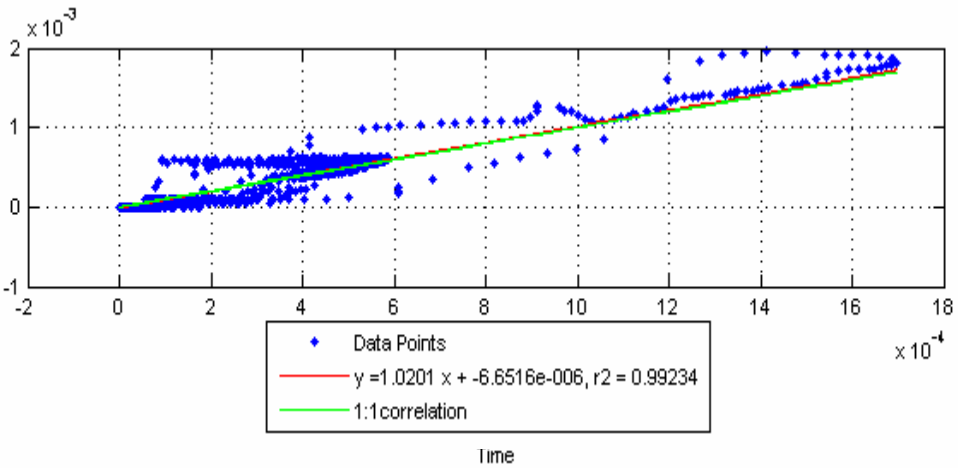
Individual Sensor are Evaluated to Find Major Issues (Range, Sign…)

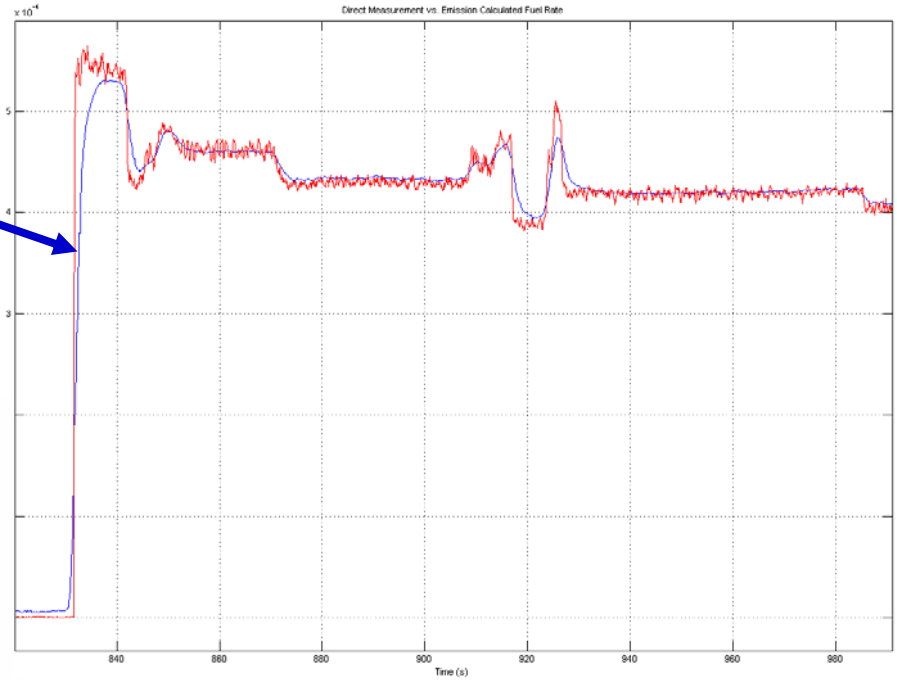


Redundant Sensors Are Compared

- Direct Fuel Measurement vs. Bench



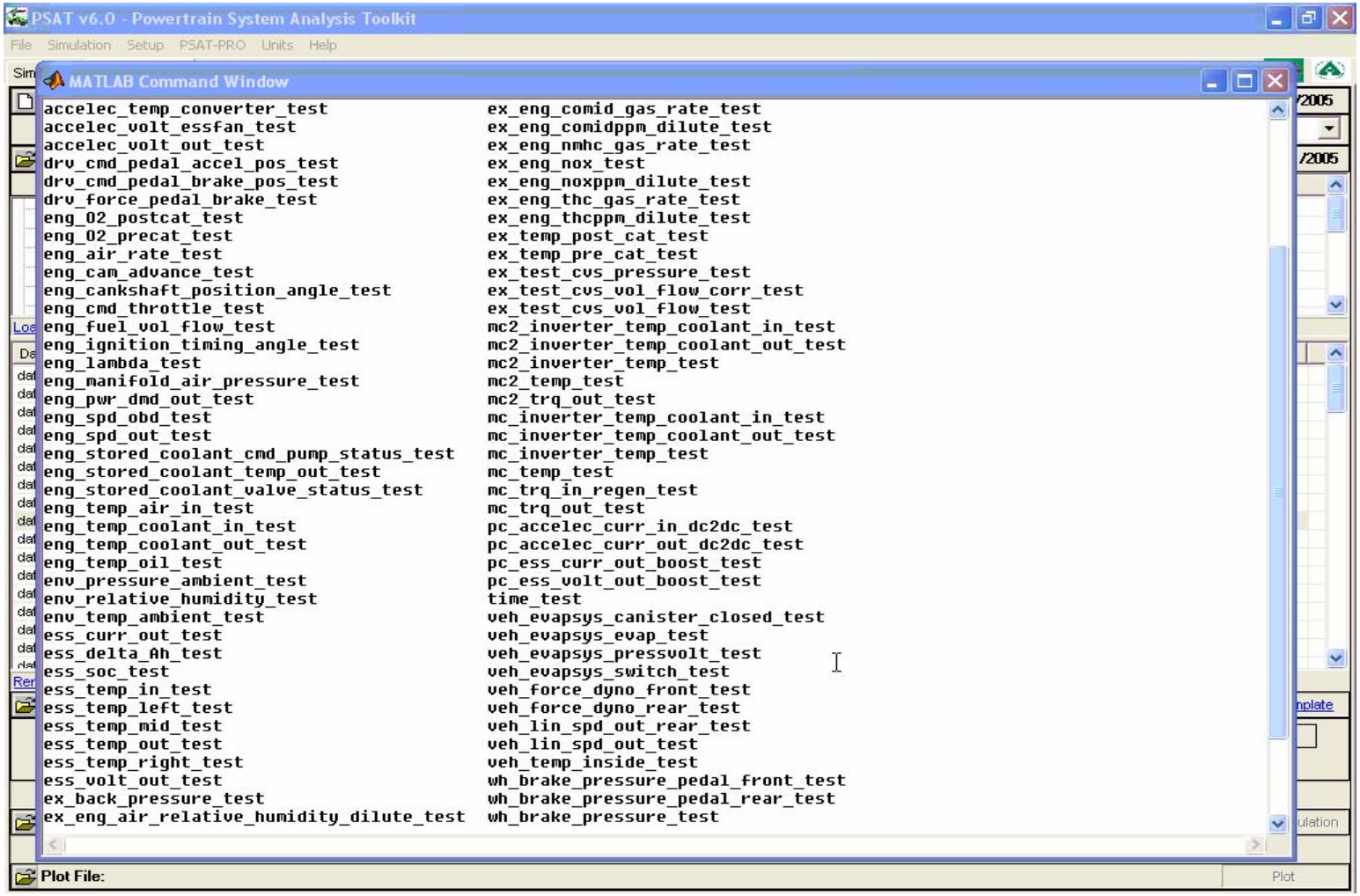




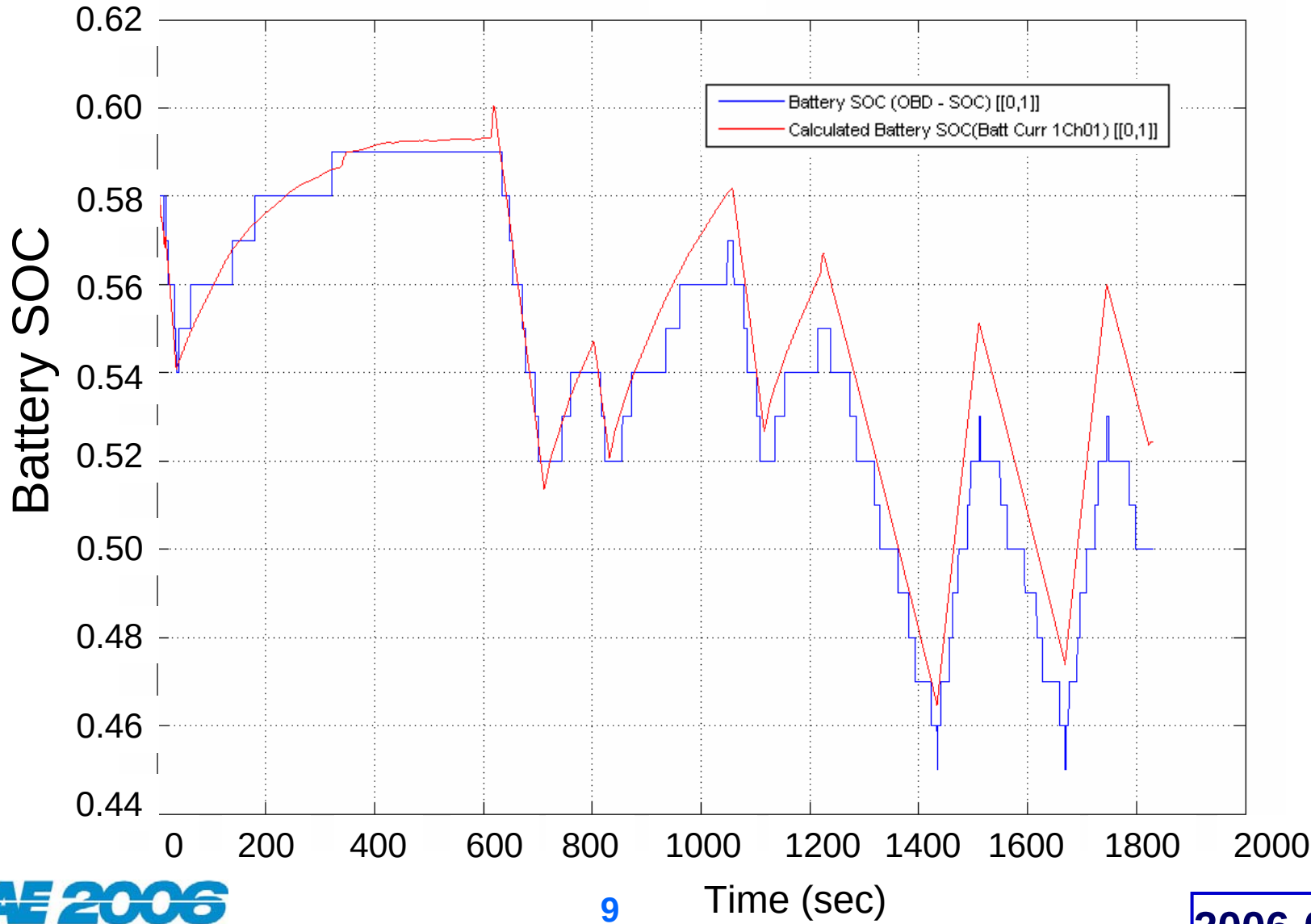
Summary Table Highlights the Main Results of the Comparison

Component / Range	Compared to... / Range	Absolute Difference	Relative Difference	Correlation Coefficient
Sensor(Dyno Spd Front) / [-0.098912,13.9334] [m/s]	OBD (VEHICLE SPD) / [0,128.0917] [m/s]	71.7453 [m/s]	7.9419 [m/s]	0.99971
Sensor (Eng Spd 1Ch15) / [-0.18268,3016.4307] [rpm]	OBD (ENGINE SPD) / [0,2976] [rpm]	20.1937 [rpm]	-0.26785 [rpm]	0.99032
Direct Measurement (Fuel) / [-9e-007,0.0016963] [kg/s]	Emission Calculated from density and volume flow / [3.745e-007,0.0019567] [kg/s]	1.0226e-005 [kg/s]	-0.26594 [kg/s]	0.99234
Boost voltage in(OBD - VL) / [192,238] [volt]	Battery Voltage out(Batt_V_1Ch02) / [198.4637,244.6811] [volt]	7.1356 [volt]	0.032908 [volt]	0.98596
Sensor(Boosted_V_1Ch03) / [206.9815,506.3051] [volt]	OBD(VH) / [204,498] [volt]	3.8596 [volt]	-0.013229 [volt]	0.90283

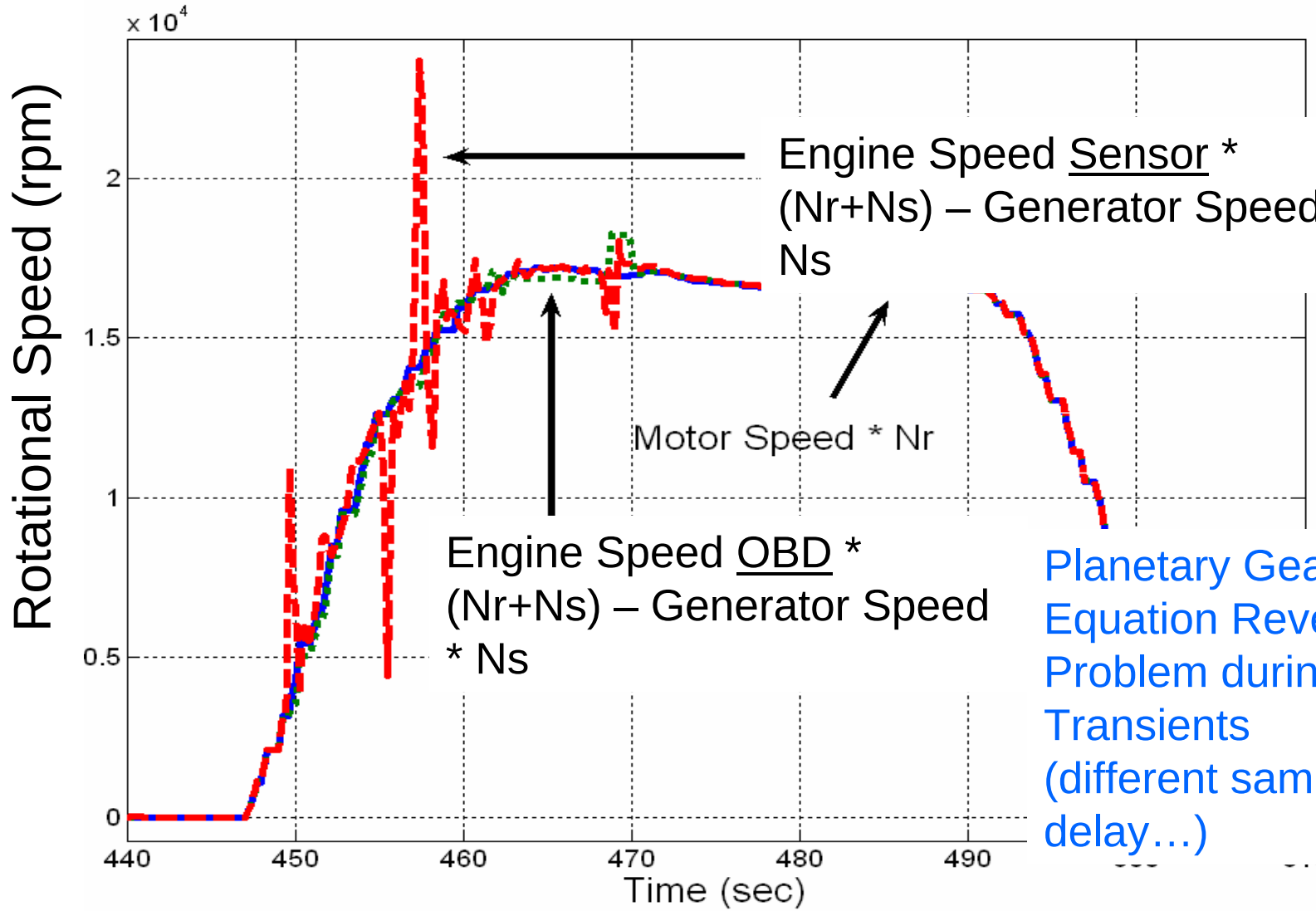
Additional Efforts/Flows Are Calculated



Calculated and Measured Signals Are Compared

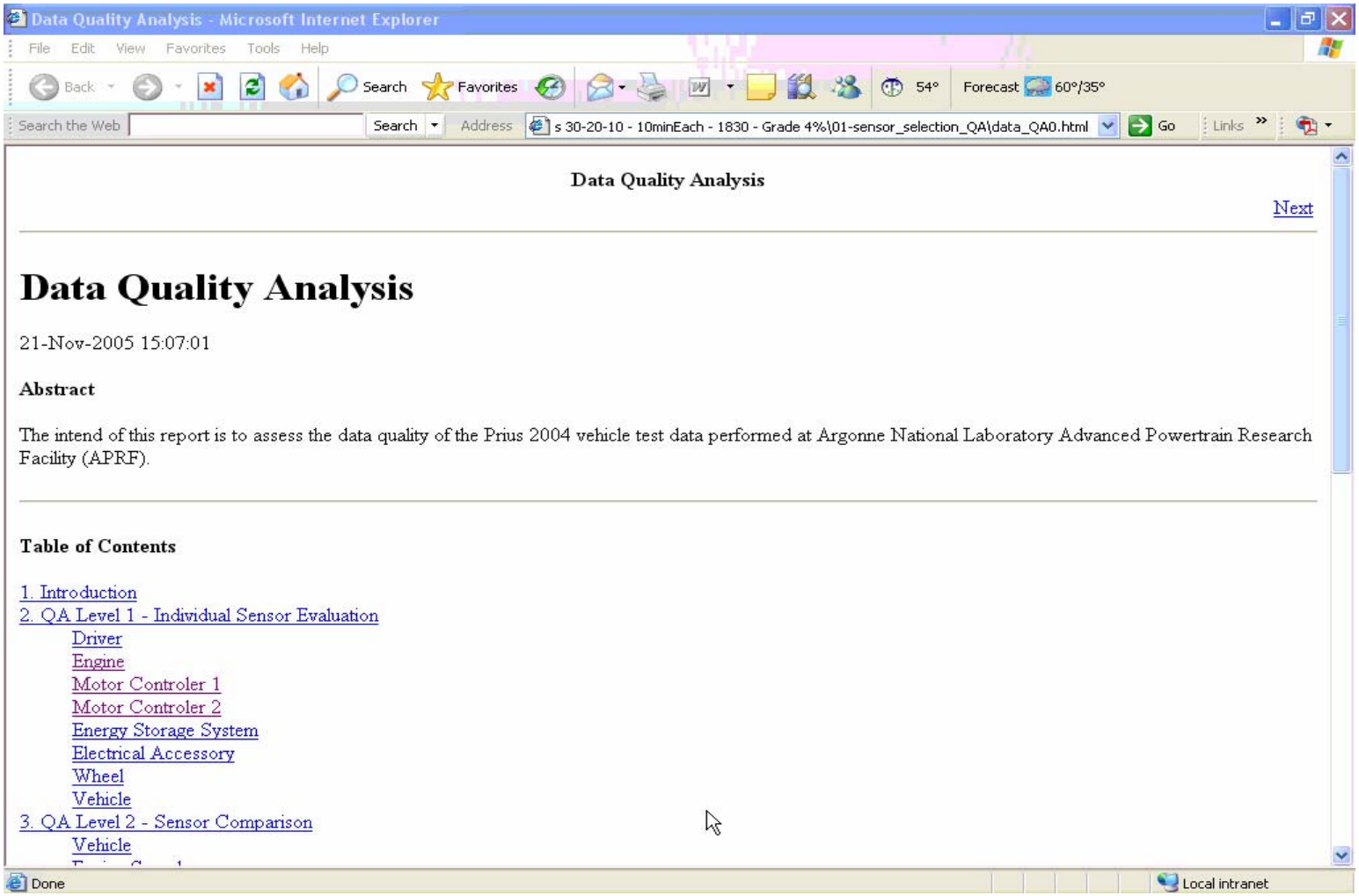


Using Sensors from Different Sources may Lead to Added Uncertainties



Planetary Gear Equation Reveals Problem during Transients (different sampling rate, delay…)

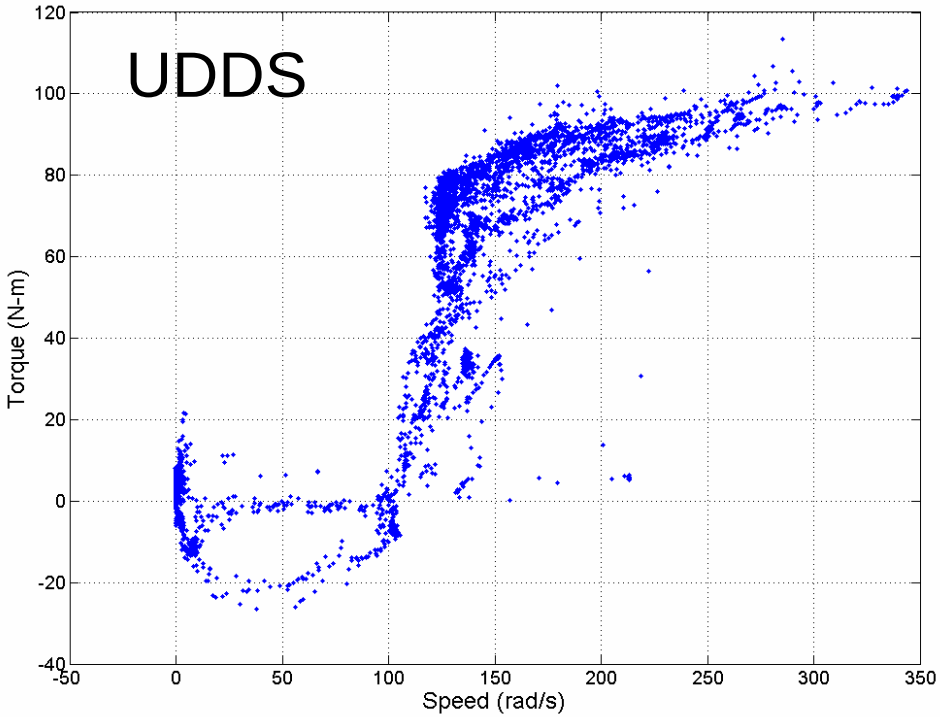
Web Document Generated to Accelerate the Process



Parameters Selected According to Detailed QA

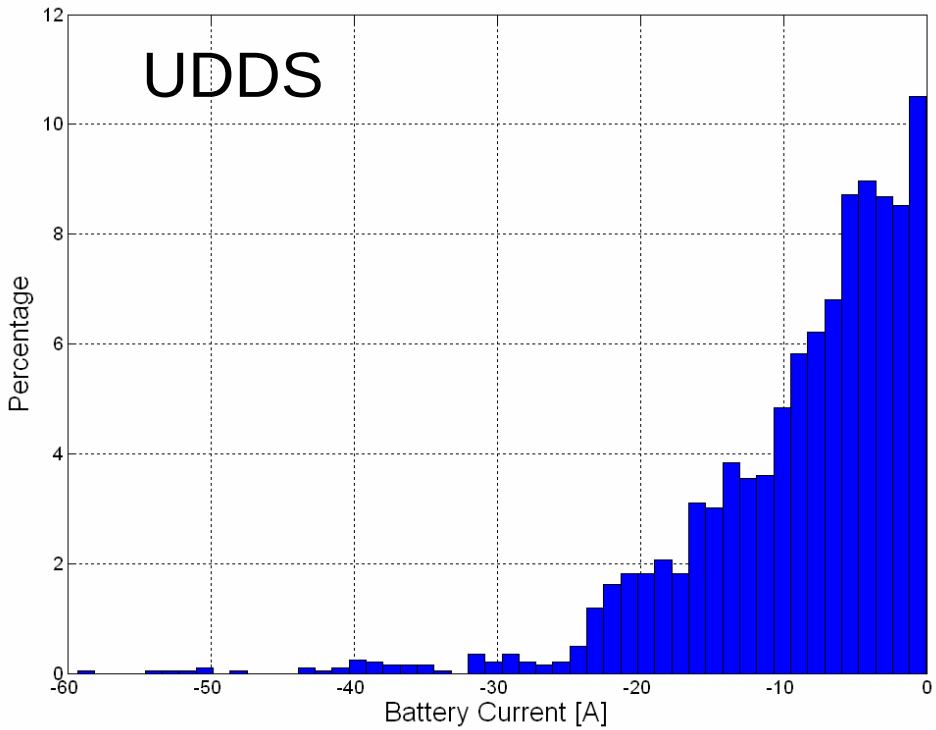
- Signals with low correlation coefficients or that appeared suspicious from the visual check are scrutinized.
- Sensors installed by test engineers are preferred to OBD or dynamometer signals.
- Ensure consistency in the mathematical relationships.
- Signals from the OBD were not recognized (issue with units or with meaning).

Control Strategy Understanding

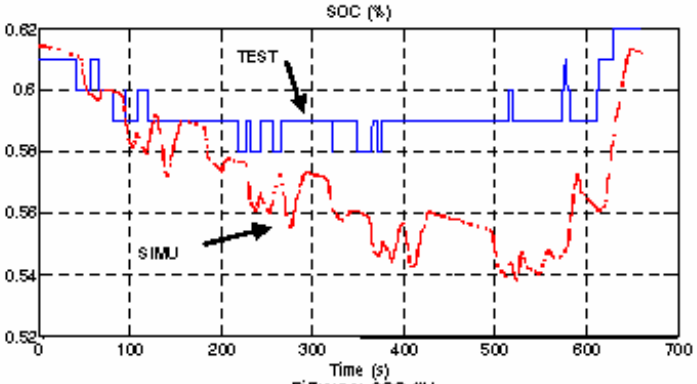


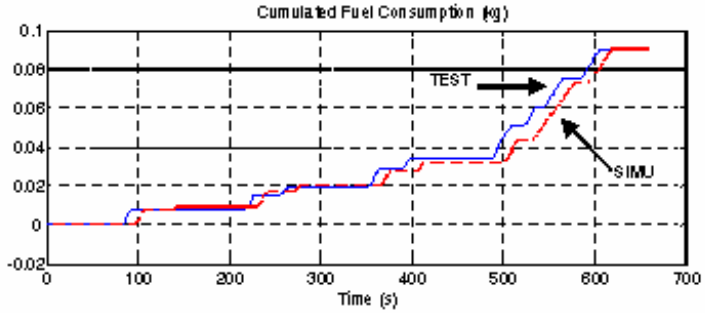
Engine operating conditions

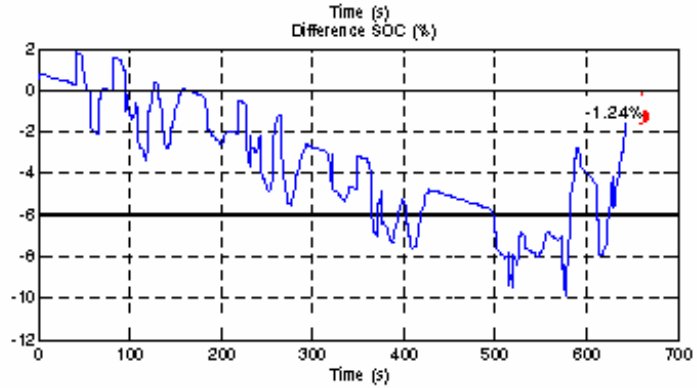
Battery Current Histogram during Regenerative Braking

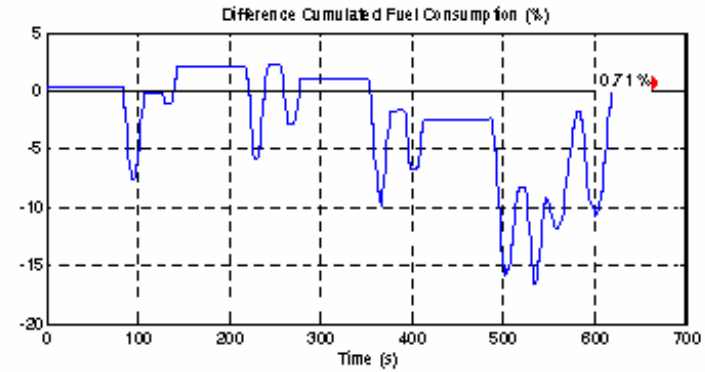


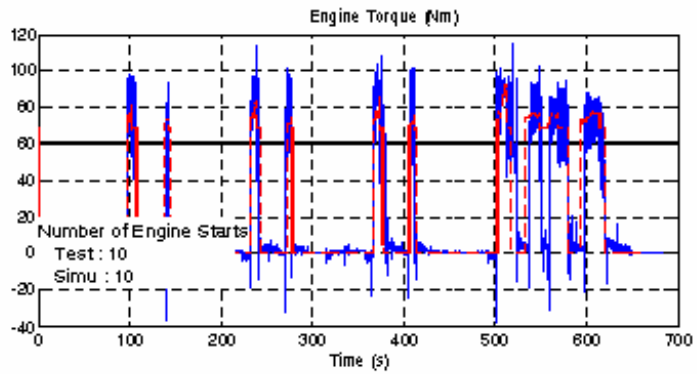
PSAT Model Validated Based on Test Data

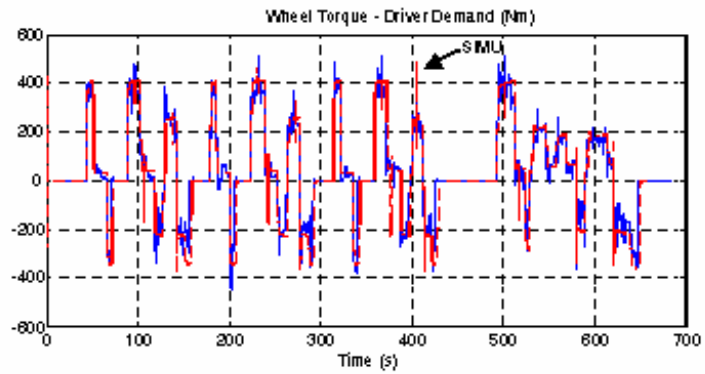












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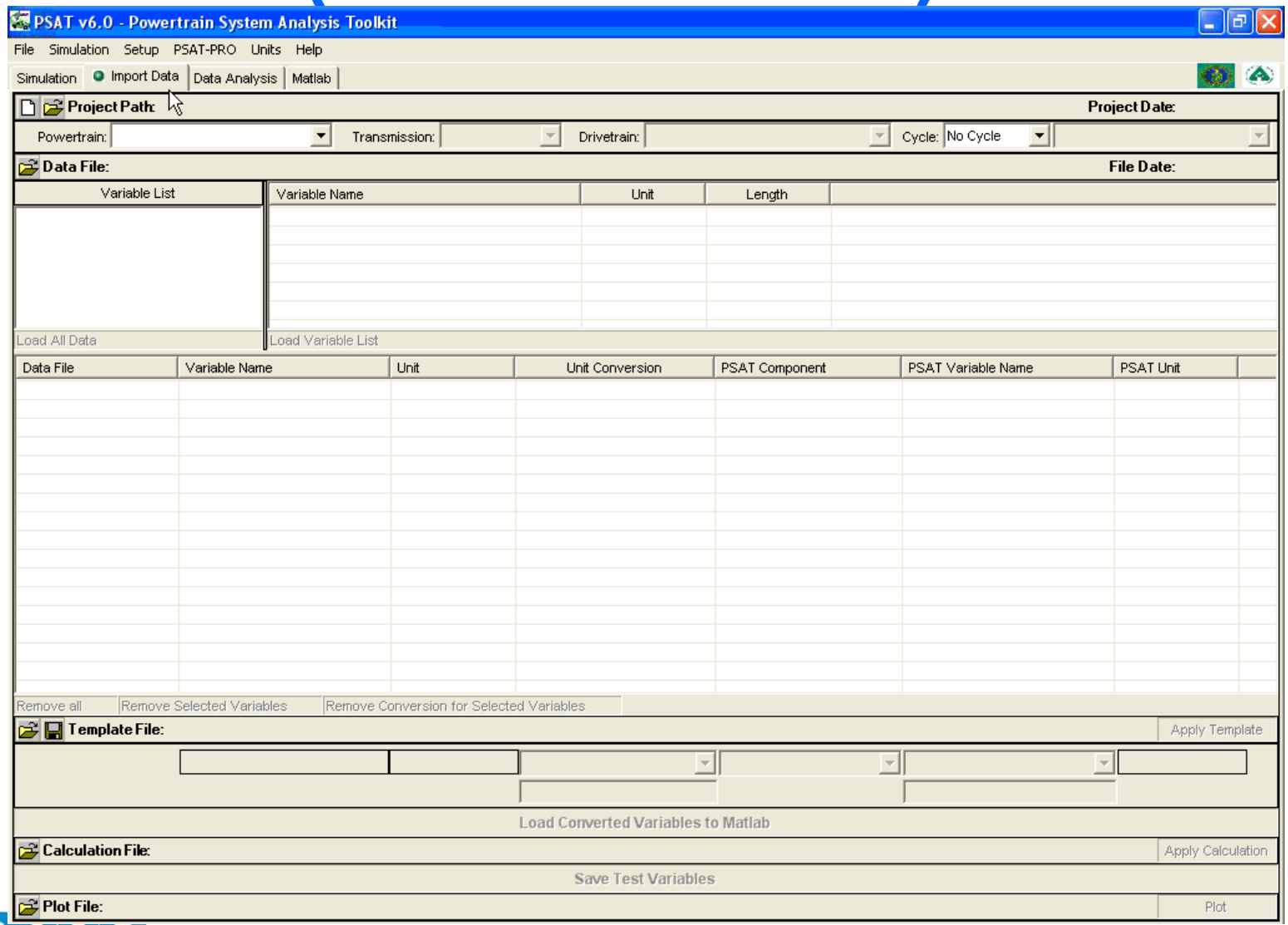
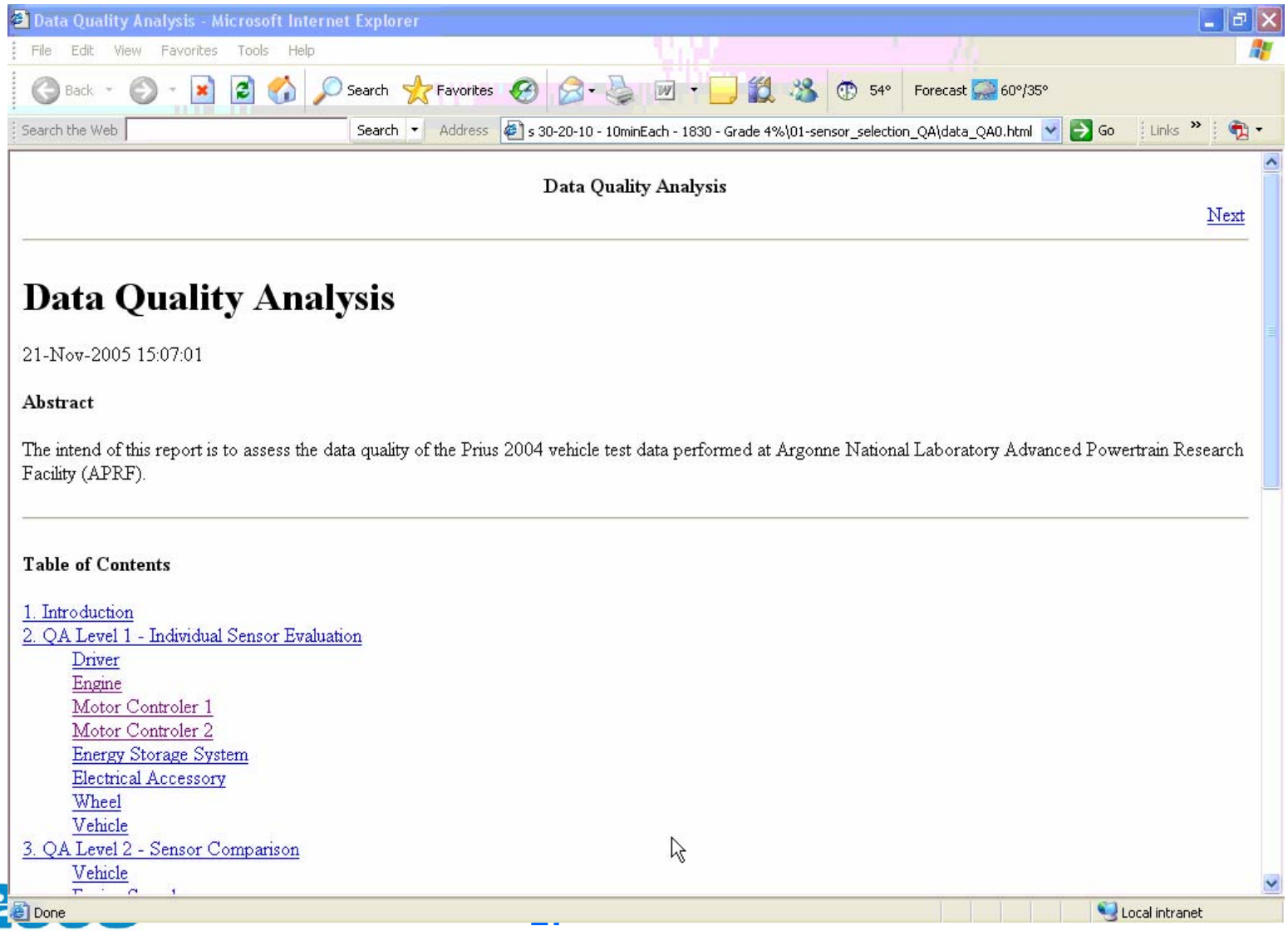
Conclusion

- A generic process allowing automated data quality analysis and facilitating vehicle model validation has been presented.
- In addition to significantly accelerating the process, the methodology allows an in-depth analysis of test sensor uncertainties and vehicle control strategy.
- Reports are generated in minutes as opposed to days, accelerating both the analysis and the validation process.
- Prius 2004 Model has been validated within 5% fuel economy and battery SOC for several driving cycles
- Additional work needs to be done to characterize the acceptable test and validation errors as well as cumulative signal uncertainties.

Import Data (click to see video)



HTML Report (click to see video)



Test Calculation (click to see video)