Testing & Development

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Agenda

• Why test?
• Things that MUST be done before leaving the workshop
• Types of testing
• The test site
• Test equipment
• Test planning
• Data acquisition
General

• Testing is mandatory for 4 reasons:
  - Driver familiarization and training
  - To check & improve durability and reliability
  - For tuning, set up and development
  - To provide data for use in the Design Event
Driver Training

• Every driver MUST have a government issued driver’s license
• Driving an FSAE car is very different from driving your road car.
  - Power to weight
  - Could be a 2 pedal car versus normal 3 pedal
  - Sequential gearbox
• For any driver to do well, seat time is vital.
• Many teams arrive at competition with drivers who have never sat in the car, let alone driven it!
• Get ALL drivers in the car, including back ups
• Adjust seat belts and head restraint
• Practice egress
Driver Training – cont’d

• Check ergonomics, comfort is important
• 15 minutes driving the Endurance Event is tiring
• Kart practice is worthwhile, but not a substitute
• Acceleration Event
  - Need to practice starts as front of car only 0.3 metres from the timing line
• Skid Pad Event
  - Need driveability and controlability
  - Need to know which direction
  - How many laps
  - How and where to exit
  - Get it wrong and DNF!
Durability

- No part, component or car gets to production without testing and development
- Car built of individual parts, weakest part is weakest link
- Initial design will be:
  a. Under designed and fail
  b. Overdesigned and be too heavy/costly
  c. Just right
- Chances of “c” are minimal!!
- Only about 35% of cars that start Endurance survive the 22 kms for FSAE & FS! It is 44 kms for Formula Hybrid!
- Majority of these cars have been tested
- Very often at FS, 50% of THE TOP 10 cars starting Endurance fail to finish!
Mandatory Tests before Leaving for the Competition

- Brake test
  - Lock all 4 wheels, controlled stop
  - Use old tyres (or some street tyres) for test at home, official “dry” tyres at the competition (an old set is acceptable)
  - Very severe test on steering & suspensions
  - Finds the weaknesses
  - Many suspensions break at competitions
  - No pass = no dynamic events

- Noise test
  - Simple test
  - Aim for 3 dB below the limits on each test
  - Fixing at the Competition very difficult
  - No pass = no dynamic events
Development & Tuning – Powertrain

- Need to check and tune
  - Engine steady state calibration (fuel and spark)
  - Engine transient calibration (fuel and spark)
  - Cold start calibration
  - Hot start calibration
  - Driveability
  - Cooling system performance (water temperature)
  - Oil system performance (e.g. oil pressure when cornering)
  - Fuel system performance (e.g. fuel temperature, fuel pick up)
  - Leaks
Development & Tuning – Powertrain – cont’d

- Peak power is not too important
- Driveability is vital
  - Skid Pad is a low speed event (50 points)
- Cold and hot start calibrations are VITAL
- Fuel economy is important
- Steady state tuning on a dyno is good for a base calibration
- Transients, base on dyno tests, but tune in the car.
Development & Tuning
Chassis Variables

- Suspension set up:
  - Springs
  - Dampers
  - Sway bars & settings
  - Camber
  - Toe in/out
  - Ride height

- Tyre pressures

- All of the above for both front & rear!

- Brake bias, front to rear
Data for the Design Event

- The Design Judges are looking for test data
- And they want you to explain it
- If you have not tested and have no test data, you will not score well in the Design Event
Testing

• Test time is precious
• Have a designated “test manager”
• Define the reason for the test
• Develop test goals
• Must have a (written) test plan
• Plan what changes to make
• Make incremental changes
  - Can do a DOE but 1 change at a time is easier to follow
• Always know what the baseline settings are so can return to them
• Record all the settings and results
• Write down all the changes and the results
  - Measurable and driver impressions
The Test Site

- Find a site without obstacles or parked vehicles
- Get permission
- Suggested set ups:
  - Initial
    - Circle for steady state handling/suspension set up
    - Slalom for transient handling
  - Later
    - Acceleration course
    - Then a Skid Pad
    - Mini autocross course
Test Equipment, etc

- Pylons
- Stop watches
- System to record video
- Jack
- Jack stands
- Tools, including:
  - Tyre pyrometer
  - Tyre pressure gauge
- Radios for communications around the course
- Fire extinguishers (and know how to use them)
- Safety plan (how to get to the nearest hospital, etc.)
- A person with first aid training is a plus
Data Acquisition

• Many modern ECU’s have built in data acquisition capability
• Can be fairly simple
• Can help with:
  - Chassis development
  - Engine calibration (really needs wide band O₂ sensor)
  - Driver training
• Build a channel list from your goals
Data Acquisition – cont’d

• Sensors (in no particular order)
  - Engine speed
  - Throttle position
  - Car speed
  - Engine oil pressure
  - Engine oil temperature
  - Water temperature
  - Lateral acceleration
  - Longitudinal acceleration
  - Fuel pressure
  - Fuel temperature
  - Injector pulse width
  - Brake on/off
  - Spark advance
  - Gear
  - Wheel speed (multiple?)
  - Suspension movement
  - Steering angle
  - Wide band O₂ sensor(s)
  - Exhaust gas temperature
Data Acquisition – cont’d

• Select your sensors, location & type
• Select your data logger (if not in your ECU or dash unit)
• Collect the data
• Post-process the data

• Collegiate Roadshow “Data Acquisition” presentation by Frank Whiton at:
  http://students.sae.org/cds/formulaseries/roadshow.htm
Questions?