Control for Energy and Sustainability Workshop – March 24th 2010

The Drive for Improved Powertrain Control

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Content

- Steering Committee Meeting 12/03/10
  - A few thoughts
- The future of control in automotive industry
  - A Brief History of Control
  - Increasing complexity of powertrains and the need for improved control.
  - Possible solutions.

Steering Committee Meeting 12/03/10

- Industrial representative for Transportation Theme group
  - Lewis Dale from National Grid for Power System Theme
- My role on steering team
  - Put industrial angle
  - “Fresh (non-technical) eyes”
- Welcome to put suggestions through me.
- Website
  - http://divf.eng.cam.ac.uk/cfes
- Project Vision
  - This is an extraordinary EPSCR grant and we need to do something drastic with it.

    Ian Postlethwaite (chairman).

A Brief History of Powertrain Control

- In 1965, the US Congress passed an amendment to the Clean Air Act providing for the creation and enforcement of automotive emission standards.
- This was followed shortly by the establishment of the California Air Resources Board and, in 1970, the US Environmental Protection Agency.
- These regulatory developments encouraged automotive manufacturers to reduce fuel consumption and vehicle emissions, and brought about several technology breakthroughs in the 1970s:
  - electronic engine control
  - the catalytic converter
  - exhaust gas recirculation
  - common application of electronic fuel injection.
- Also in the 70s, emission regulations began to be introduced in Europe and Japan.
- In the 1980s, closed-loop air-fuel ratio control was made possible by the invention of the heated exhaust gas oxygen (HEGO) sensor, and the three-way catalytic converter became a standard feature on vehicles in Japan and Europe as well as North America.
- The 1980s also witnessed the increased application of control theory and modelling in the development of automotive powertrain systems.

A Brief History of Powertrain Control

- In the 1990s, powertrain development became obsessed with systems. Engine technologies such as variable valvetrains and direct injection and continuously variable transmissions required a multivariable approach to control.

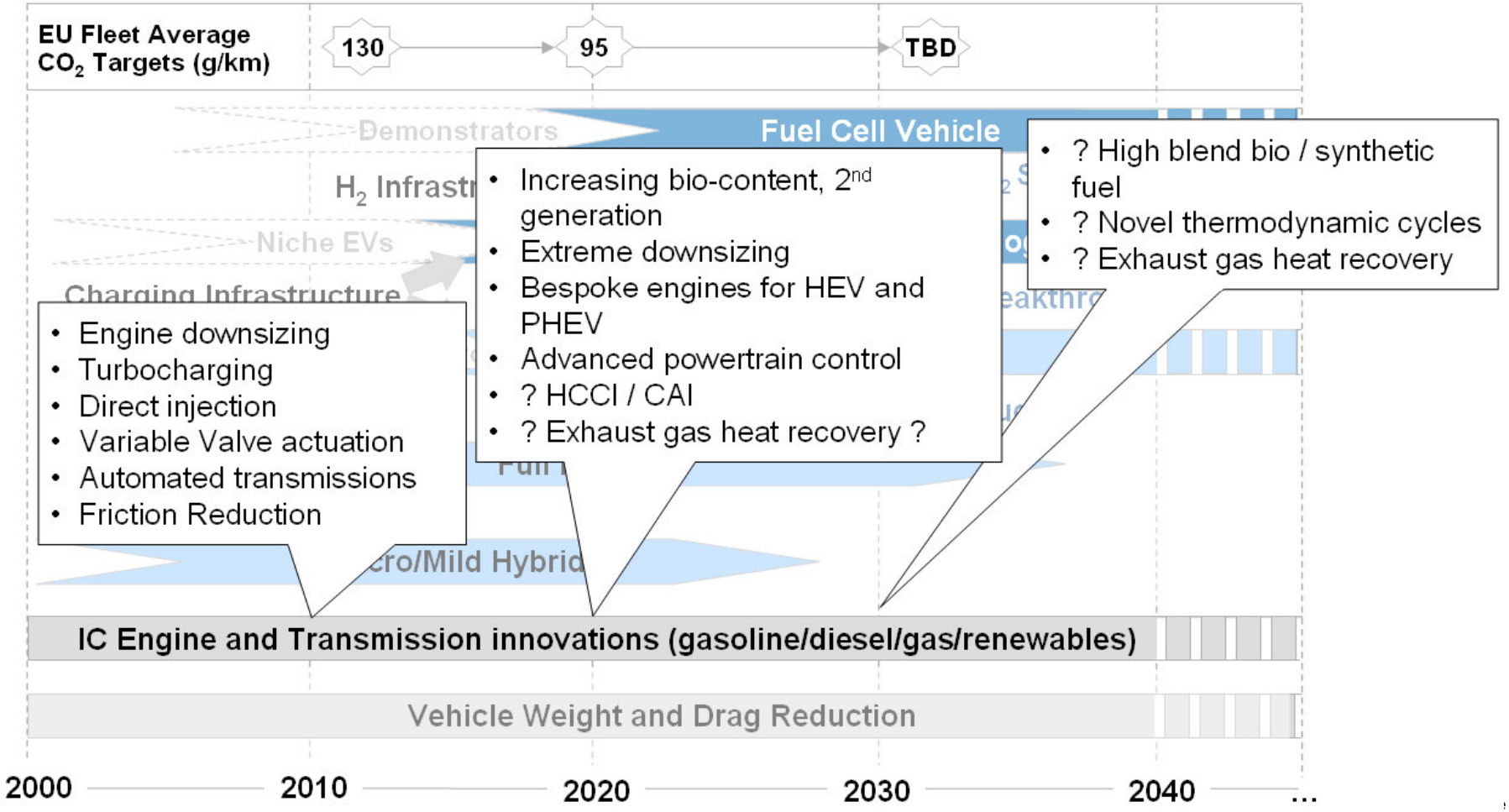
- Now, in the 21st Century we see a continued drive to improve fuel economy and emissions. In Europe, the automotive industry failed to be self-regulated by ACEA and now face legislation on CO2 as well as emissions.

- This changes the business case for new technology radically.
  - In 1990's a change costing $5 per % FE improvement (per vehicle) may not be developed.
  - By 2019 legislation will impose a "value" on CO2 of €95 per gram CO2/km or $100 per %.
  - By 2020 Fleet CO2 target will be 95 gm/km (down from about 150 gm/km in 2010).

- To meet these demands, we must look at ever more radical changes to the internal combustion engine
  - Get the very best out of what we have
  - Re-assess old ideas and look at new ideas including a range of hybrid technologies.
  - Every 0.1 percent is crucial. But how do we measure this accurately and repeatably?

NAIGT - Low Carbon and Technology Expert Group

IC engines and transmissions will develop to become lighter, more efficient and to meet the specific needs of hybrid and plug-in applications



The need for improved control – complexity

- 1980
  - Mechanical techniques to measure air, inject correct fuel and ignite mixture.
- Now
  - EcoBoost

> Ford secures Government support for low carbon vehicles

2 tweets

retweet

Ford's development of low carbon engines is to receive new financial support from the Government, it has been revealed.

Business Secretary Lord Mandelson today announced that the Government has agreed to back Ford's proposed £1.5 billion investment over five years for development of a new generation of environmentally friendly engines and vehicle technologies.

The Government is to provide £360 million in loan guarantees towards six projects through its Automotive Assistance Programme (AAP). The guarantee will back a proposed loan of £450 million which is being considered by the European Investment Bank (EIB).

ECOBOOST

"2009 has been a breakthrough year for Ford, leading with the launch of EcoBoost…. Our commitment to delivering affordable, fuel-efficient vehicles for millions has never been stronger or better demonstrated."

– Sue Cischke, Group Vice President, Sustainability, Environment and Safety Engineering

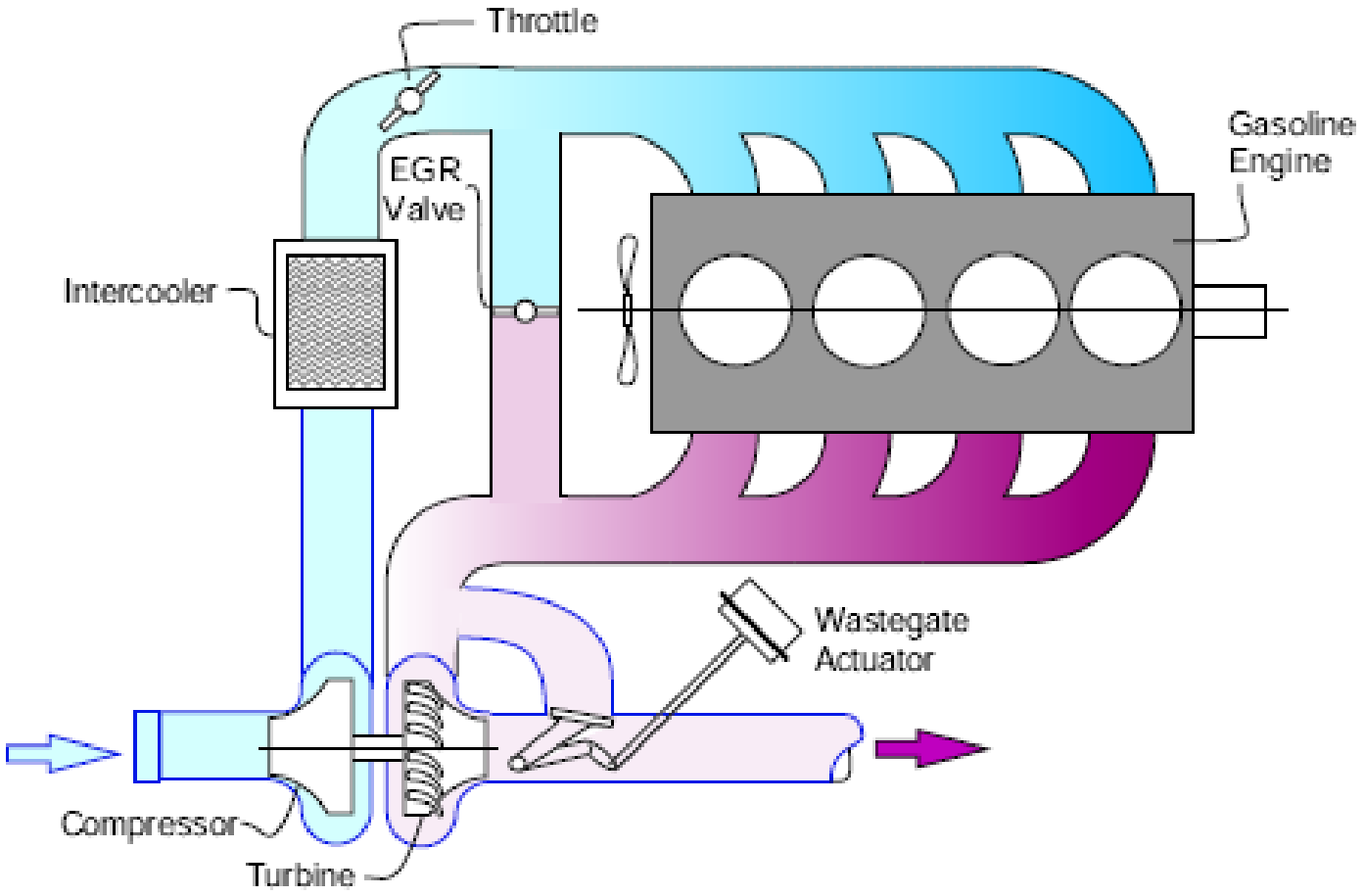
Features:

- Direct Injection
- Downsized
- Turbocharged
- Variable Valve Timing

1.6-litre EcoBoost engine will be built at Bridgend for market introduction in 2010.

EcoBoost.avi

Feel the difference



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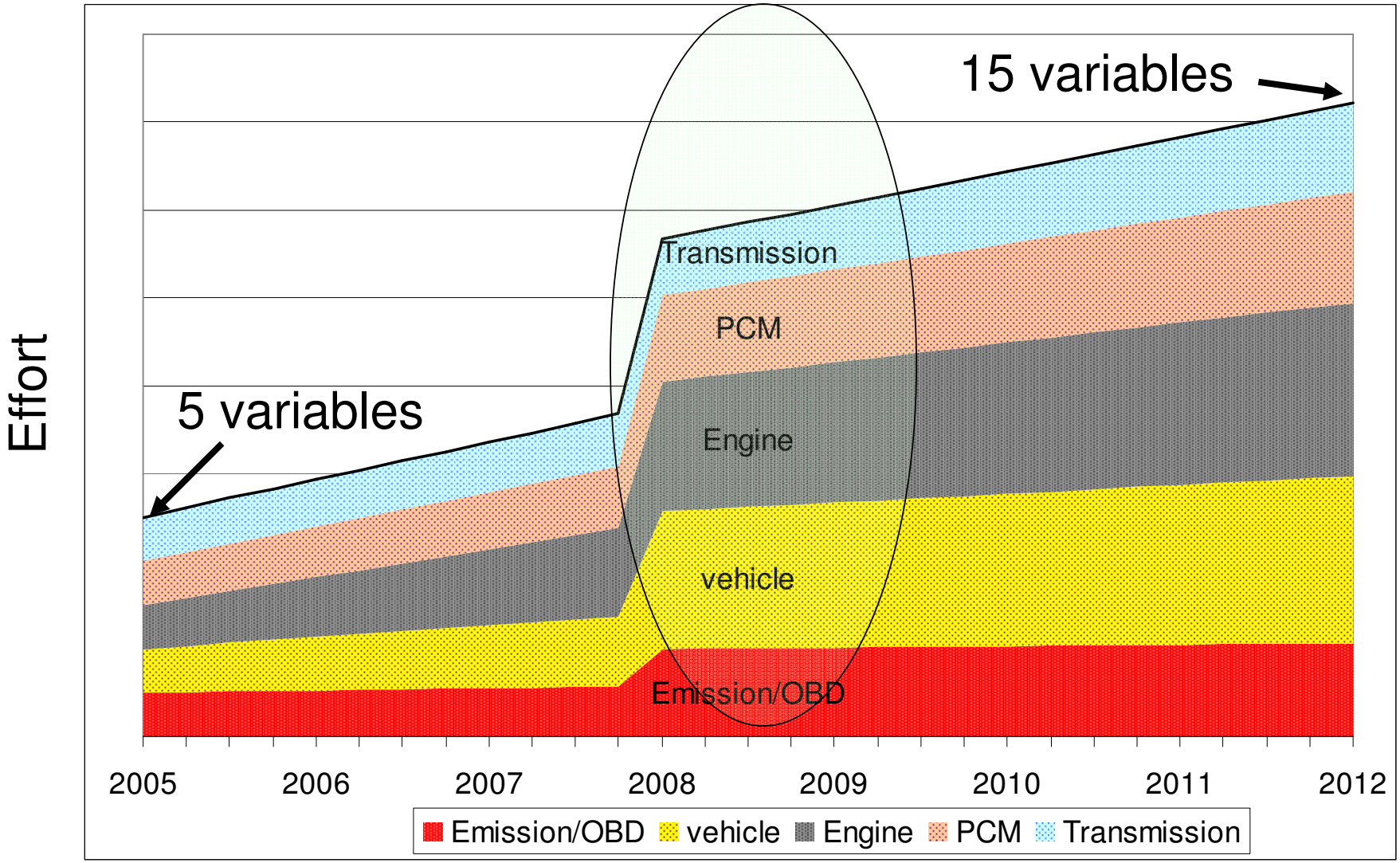
The need for improved control – Controller

- 1980
  - Early electronic injection with 4kB RAM.
- Now
  - 144kB RAM
  - Up to 4MB Flash
  - 40 ADC / Inputs
  - 130 Digital I/O
  - 128 CAN messages

The need for improved control - Variables



Feel the difference

The need for improved control – Variables

- Techniques exist to optimise non-linear system with up to 8 variables in a sensible time.
- A few more can be tolerated if some can be decoupled.
- The process we have is too inefficient.
- More effort is not the answer when costs are being driven down.

The need for improved control – Other drivers

- Legislative
  - On Board Diagnostics (OBD)
  - Safety
    - Daylight running
  - Noise
- Customers
  - Driveability
  - Comfort
    - Cabin heating
  - Performance
    - Beginning to change
  - Environmental
- Competition
  - More models with more regular updates.

Feel the difference

The need for improved control – Solution

- 2 possible solutions:
  - Develop new techniques to optimise calibration for entire existing strategy. Minimize CO2 while meeting all other needs.
    - 20000 variables
    - 1500 sub-routines
    - Millions of car miles gives confidence in existing strategy.
    - Strategy changes are expensive to verify for production.
  - Develop a new control strategy
    - Required to quickly demonstrate the potential benefit of new hardware.
    - Could evolve into production solution.
- Probable production solution will include new control strategies and new tools to optimise them.

Conclusion

1. Drive for improved CO2 while still meeting legislation and customer needs of performance, comfort and driveability.
2. Threat of penalties and environmental pressures have changed the business case for change.
3. What are the best technologies to meet these pressures?
4. Whatever the solutions, they are likely to be more complex and will need new control techniques to deliver them to their full potential.
5. As soon as possible please.