S0F1NTSYS

Software and Systems Engineering Consultants

Software Architecture

A Product Line of Hybrid Powertrain Controllers

Driving Forward With You

AESIN Conference 3rd October 2017 – Stuart Jobbins, Sofintsys

1.2 Driver Behaviour – "Stereotypes"

EV – (excluding 'Sports' EVs) Get driven carefully. Not only its 'green' credentials, but because the refilling infrastructure is sparse… and over-consumption can mean being stranded, or have a (very) long delay in the journey.

ICE - A heavy right foot (for performance) is unlikely to create the inconvenience of being stranded or have a long delay… because the refilling infrastructure is plentiful, if not fuel cost sensitive!

Hybrid (PHEV) - How do I expect a driver to use one of these?
Mixed messages E.g.:

- Additional torque (performance) - at cost of AER
- Fuel economy (cost), emissions (green) – if driven like EV
- Convenience (not get stranded) – compromise performance/economy.

1.4 Engineering Challenges

So if Hybrids are an interim to help modify ‘behaviour’ then we need an …

•Ability to forecast an optimal configuration of powertrain components

…without knowing the power, geometry, efficiency, mass trade-offs

•Ability to forecast the required flexibility required in software

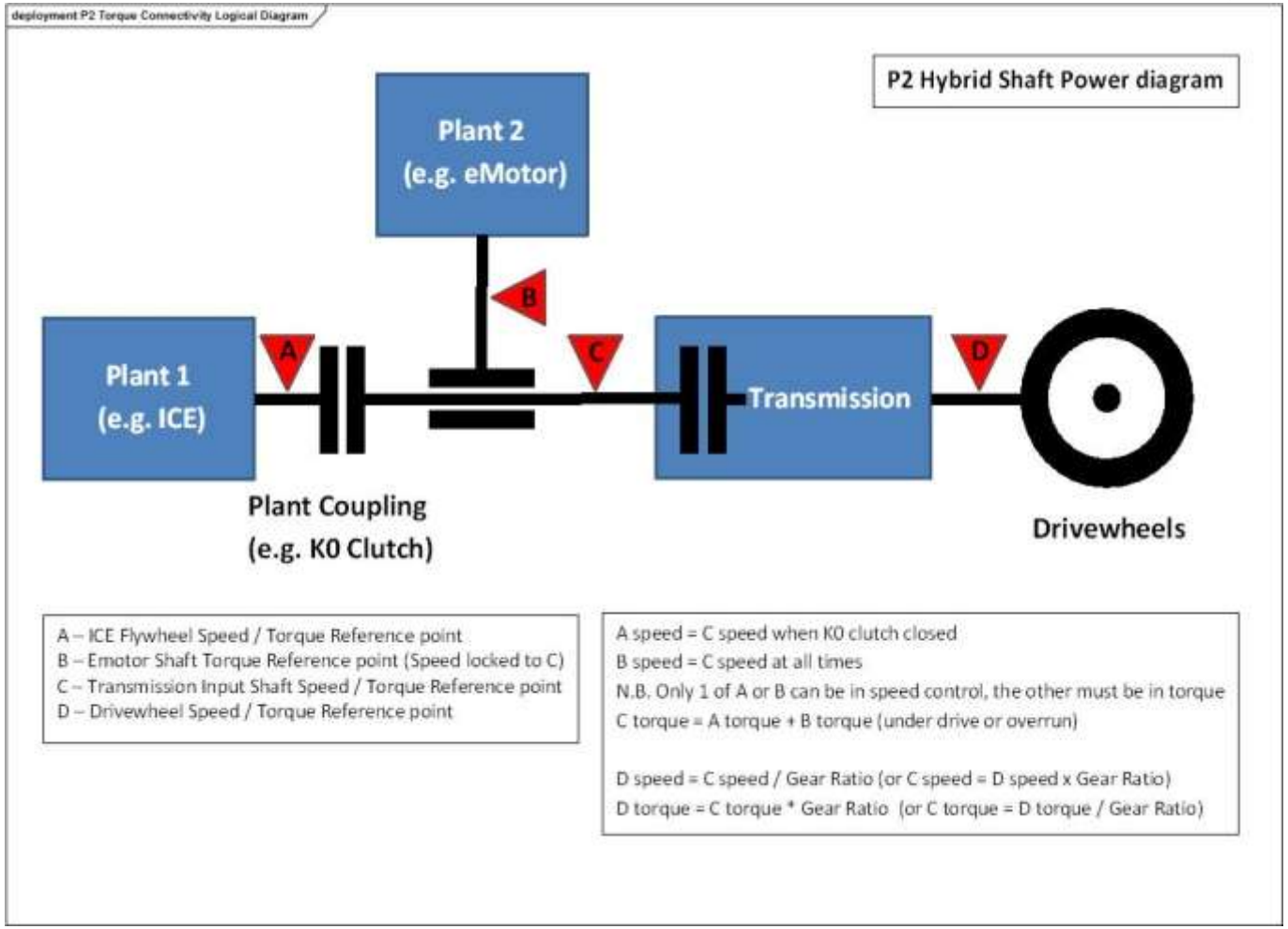
…to match all possible vehicle target book combinations

•Ability to understand consumer demand in the future

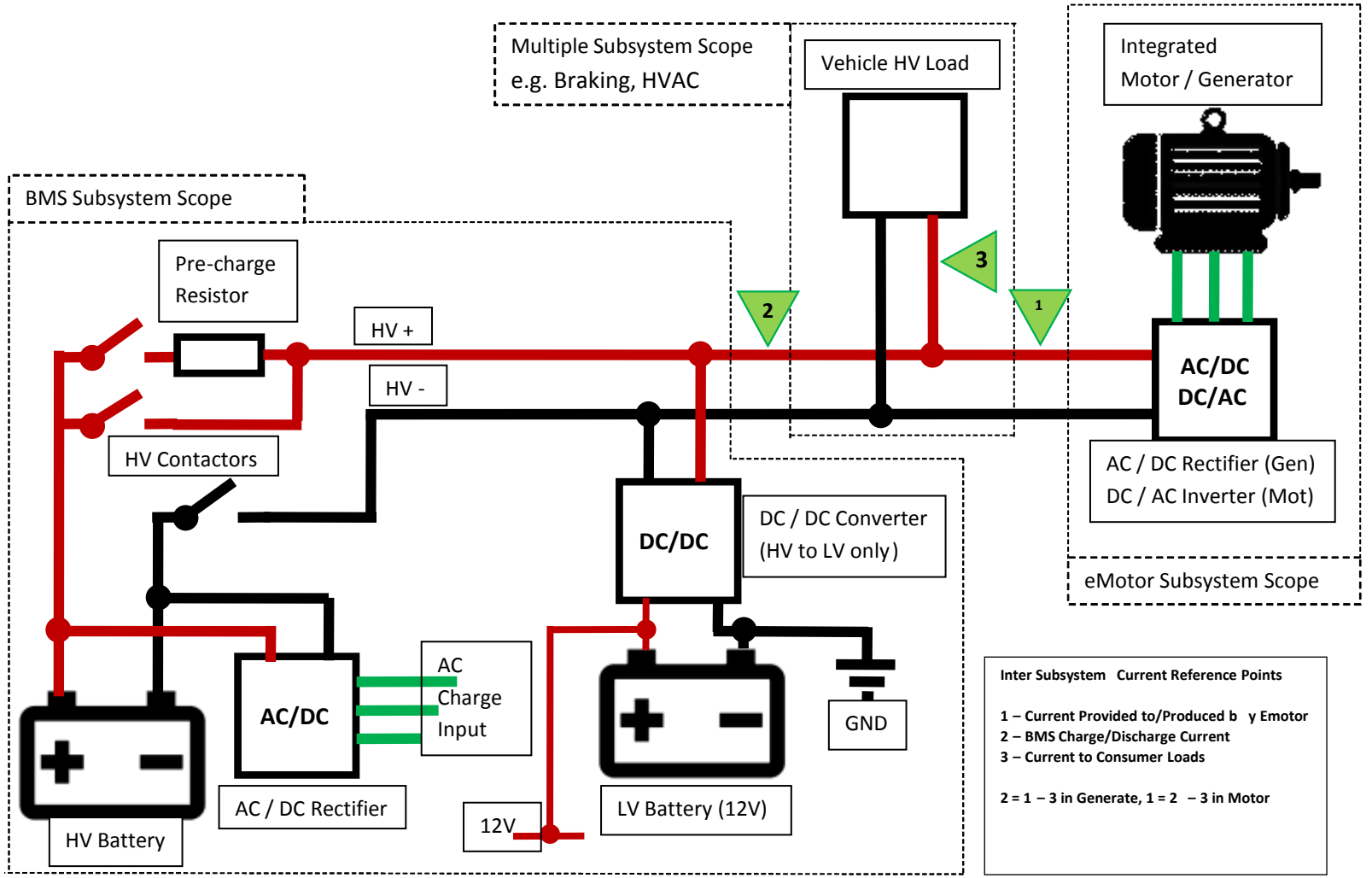
…and reasonably constrain the solution

2.1

Mechanical Shaft Power Illustration



Electrical Power Illustration



2.3

Balanced Distribution =

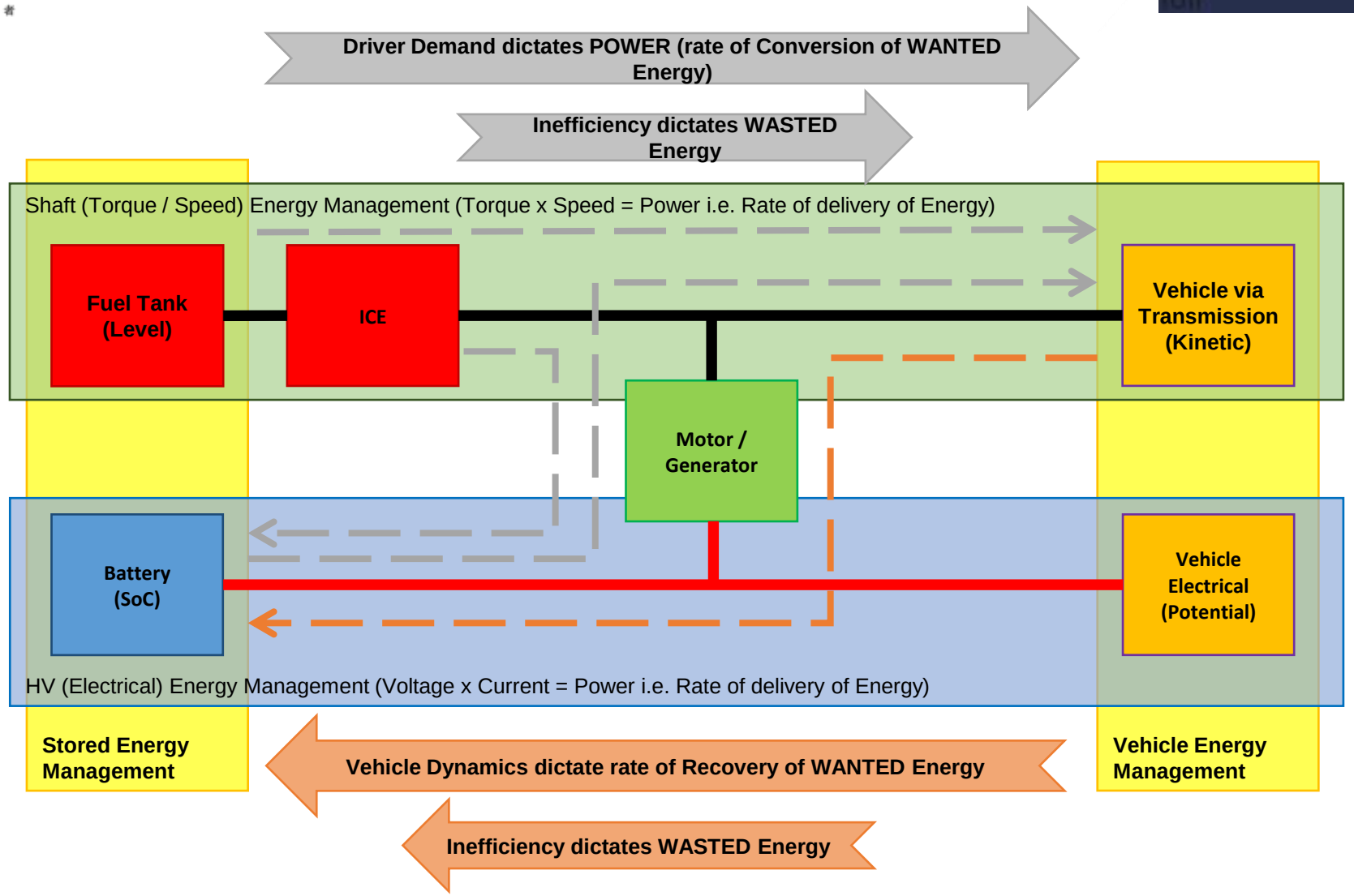
Solving

Mechanical Shaft Power

…and…

Electrical Power

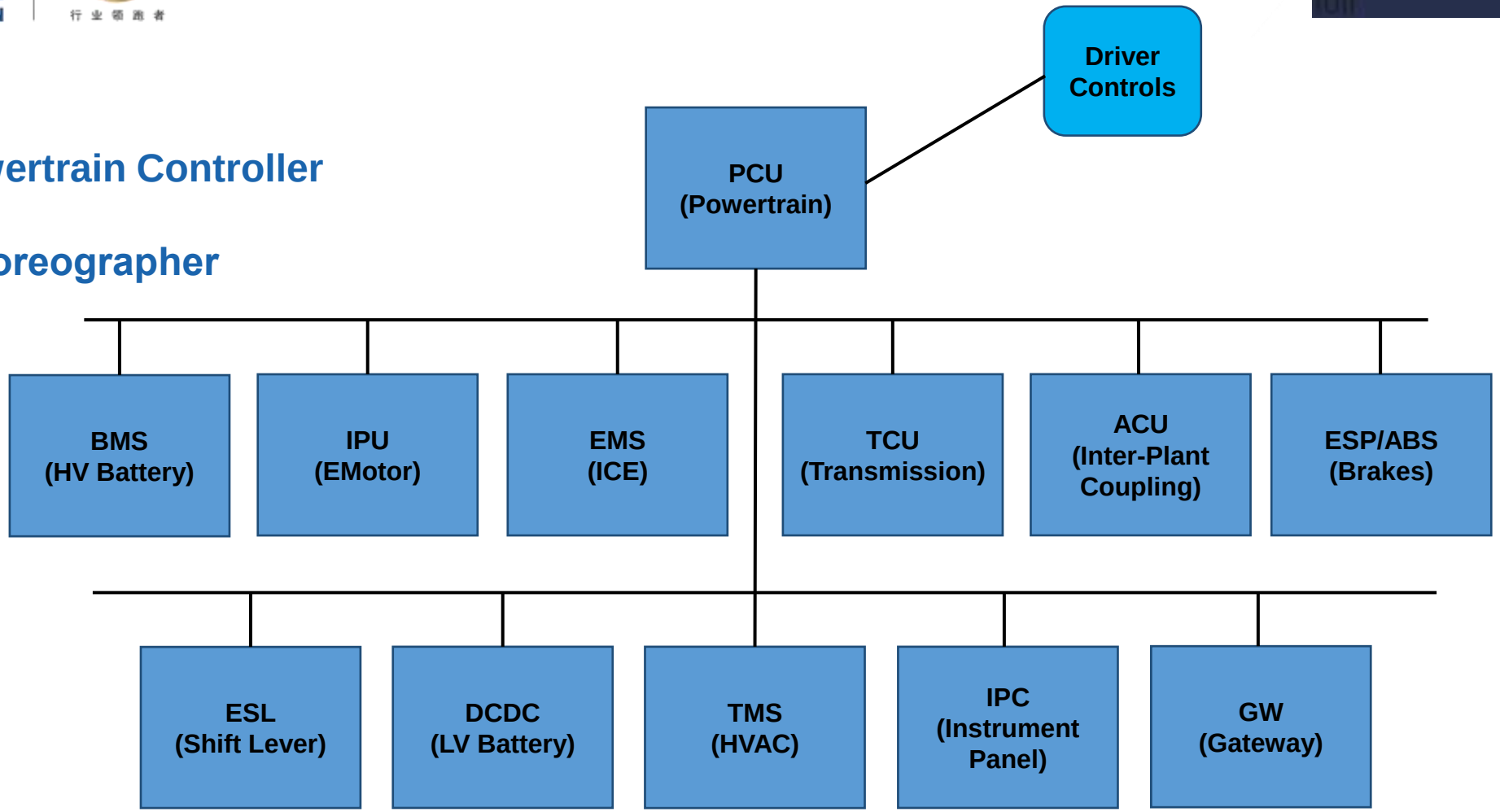
Simultaneously



3.1

The Powertrain Controller

…as Choreographer



4.1 Software Architecture of a Hybrid Powertrain Controller

Architectural Principles

- Flexibility, without permutation explosion
- Rapid evolution in response to change (at maturity, within scope of Product Line)
  - Maximise Technology independence (and Supply Chain specifics)
  - Ease of Calibration – Minimal inter-dependence between control elements
  - ISO26262 compliance – ASIL C assessment

Product Line impact

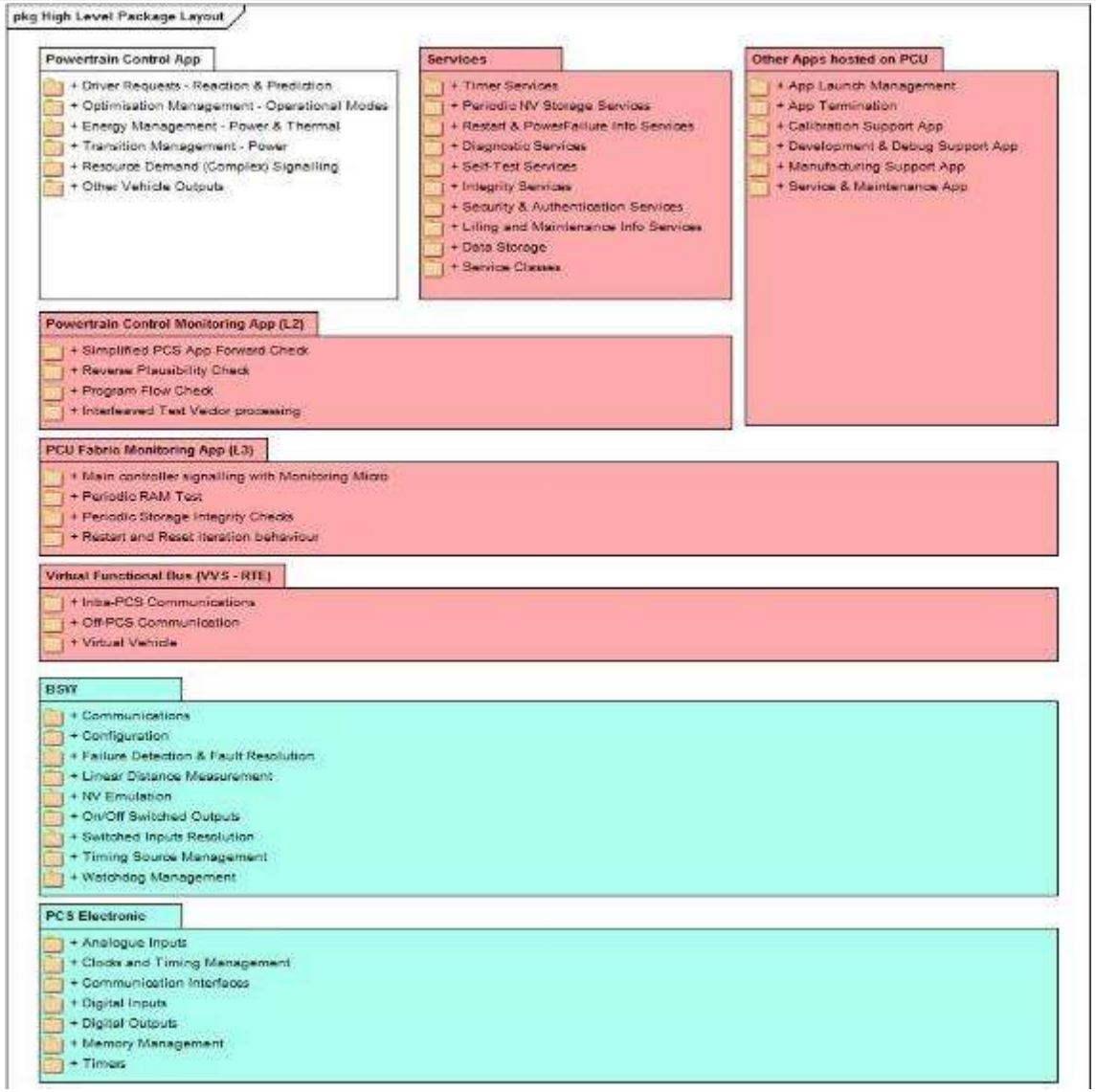
- Maximise Logical Independence between system components, clear on scope and ownership
- System-defined, vehicle-specific, fixed associations of behaviour
  - …yet retain software logical independence
- Minimise influences on functions, rather than enumeration of functions
- Simplicity first - Computationally tractable complexity
- De-prioritise processing constraints versus understandable modularity
- **Maximum Cohesion – Minimum Coupling**

5.1 Meet the PCU

The Full Controller Content

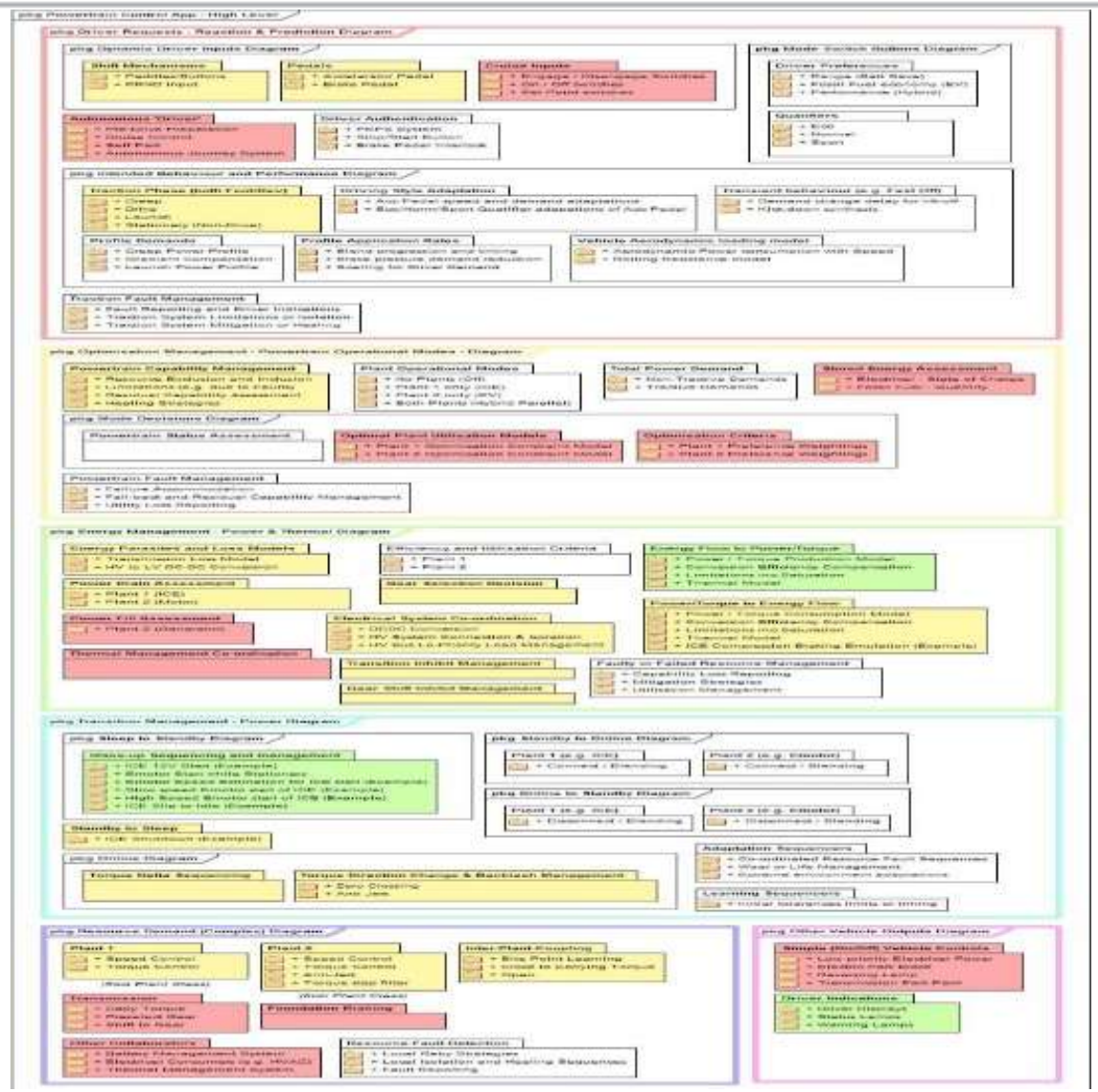
First - A Real One

To introduce Areas by colour



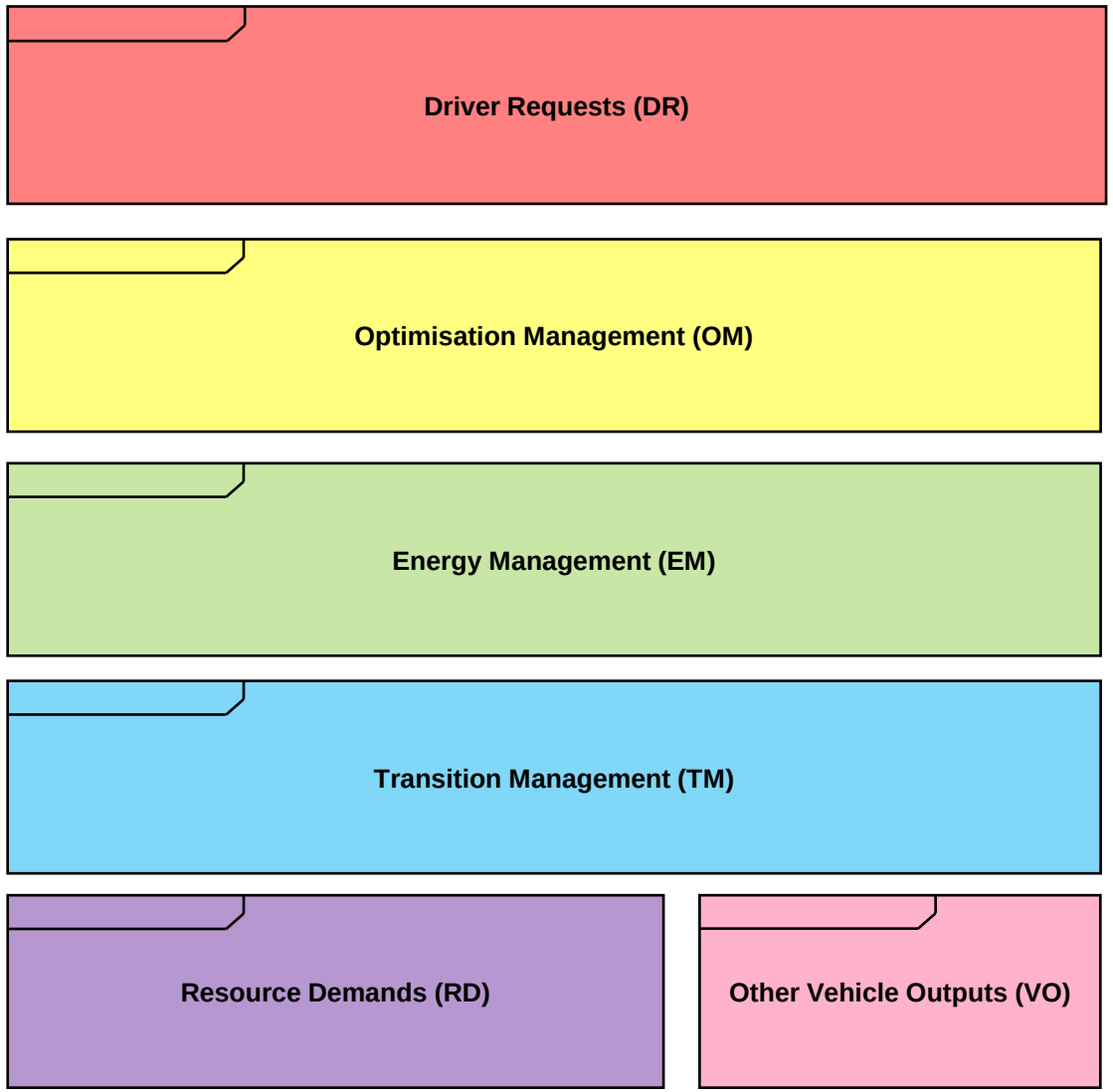
6.1 The PCU App

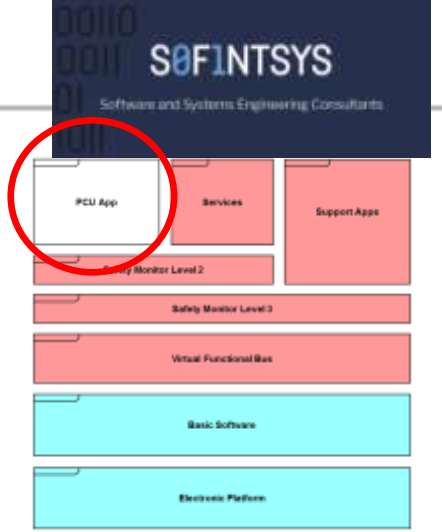
A Real One



6.2 The PCU App

An abstraction

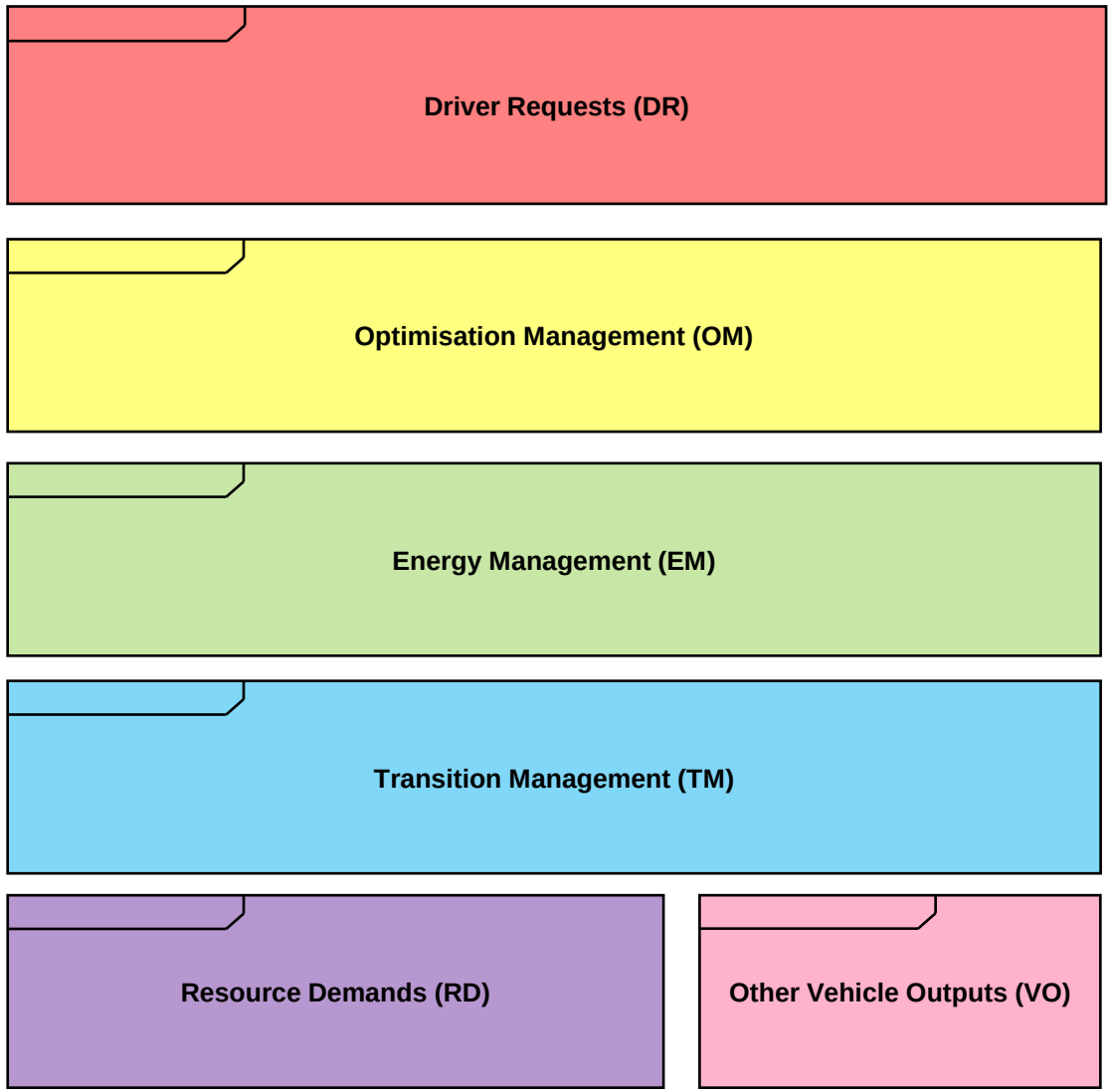




7.1 The PCU App

Layers

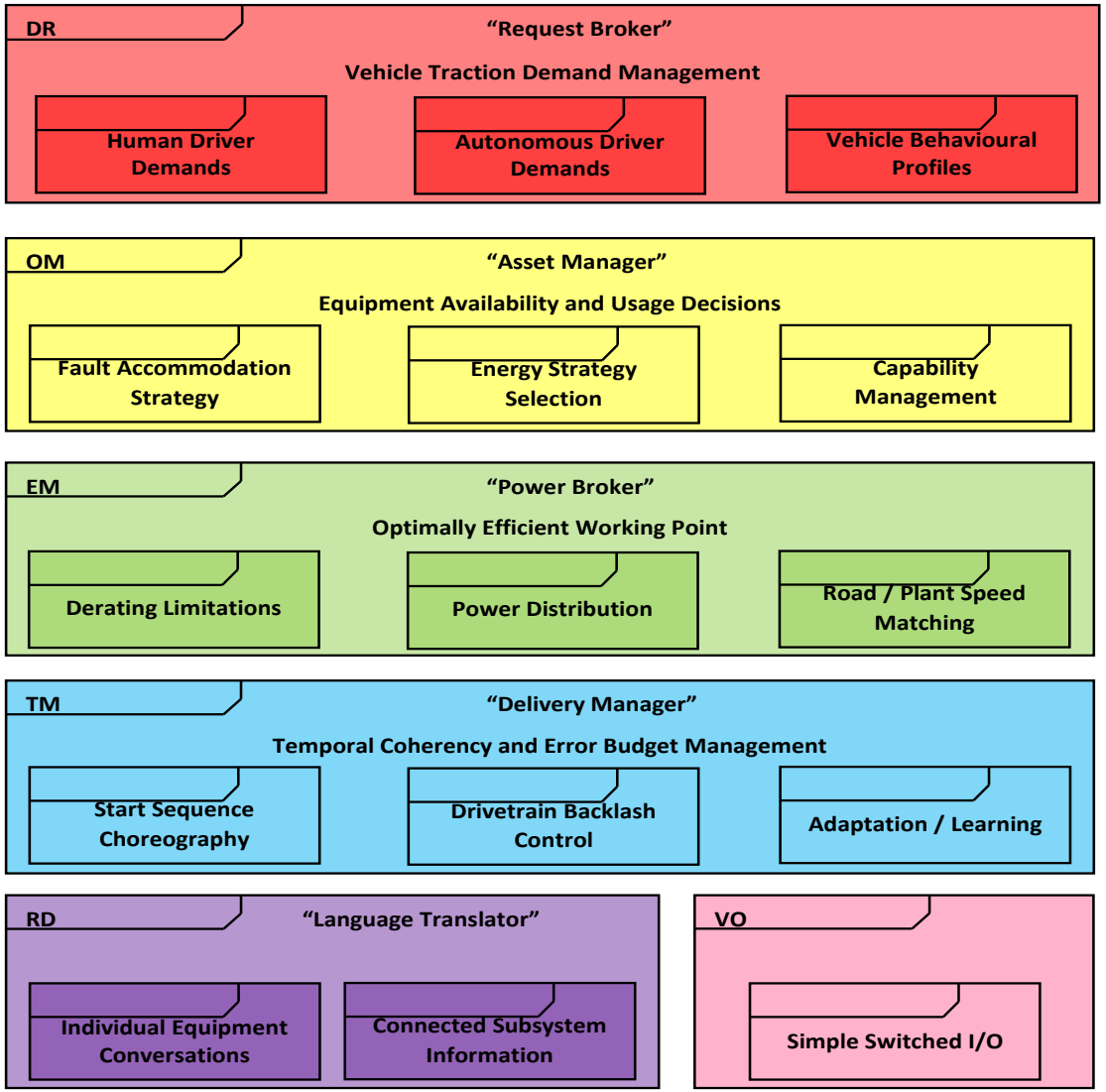
Segregation of Decision Criteria

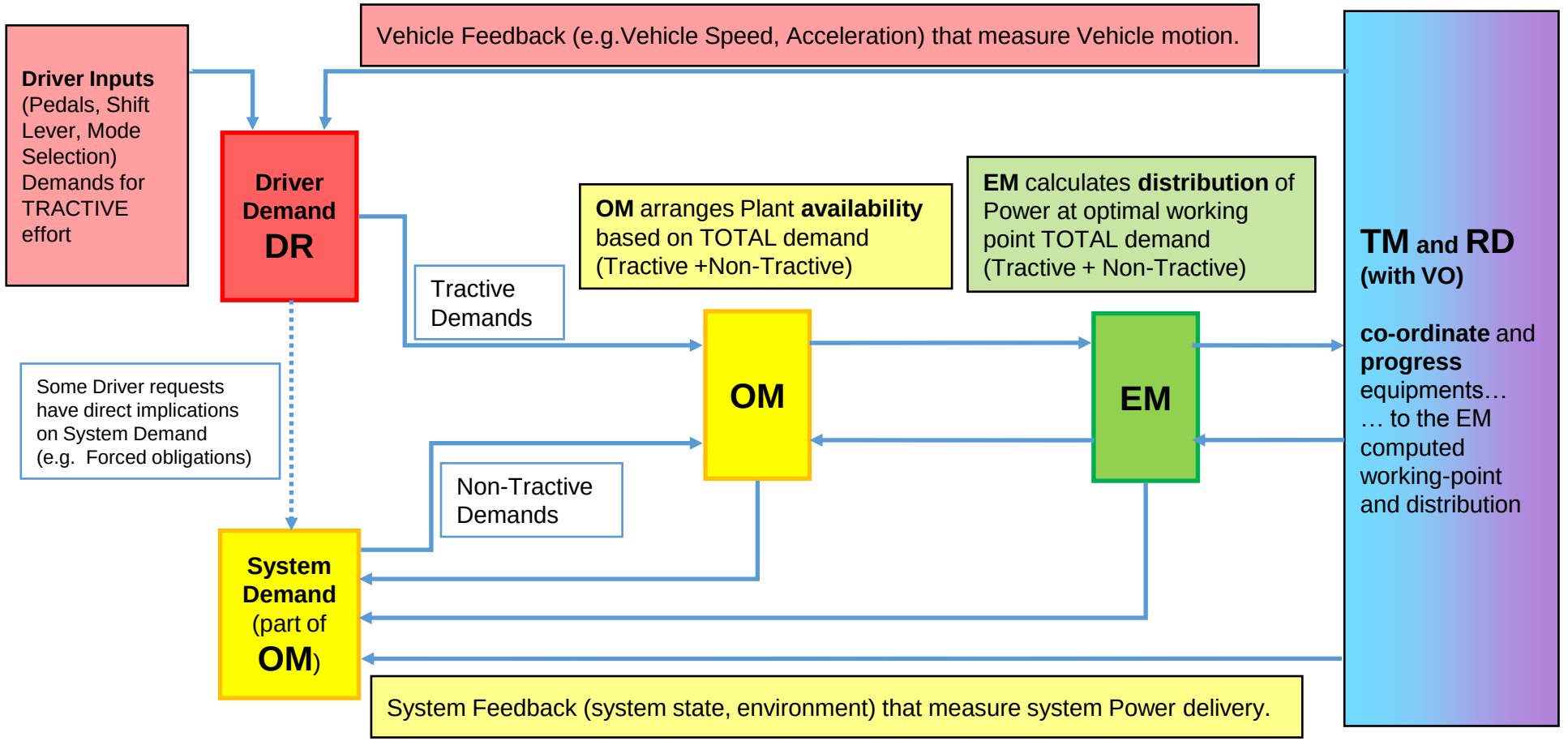


7.2 The PCU App

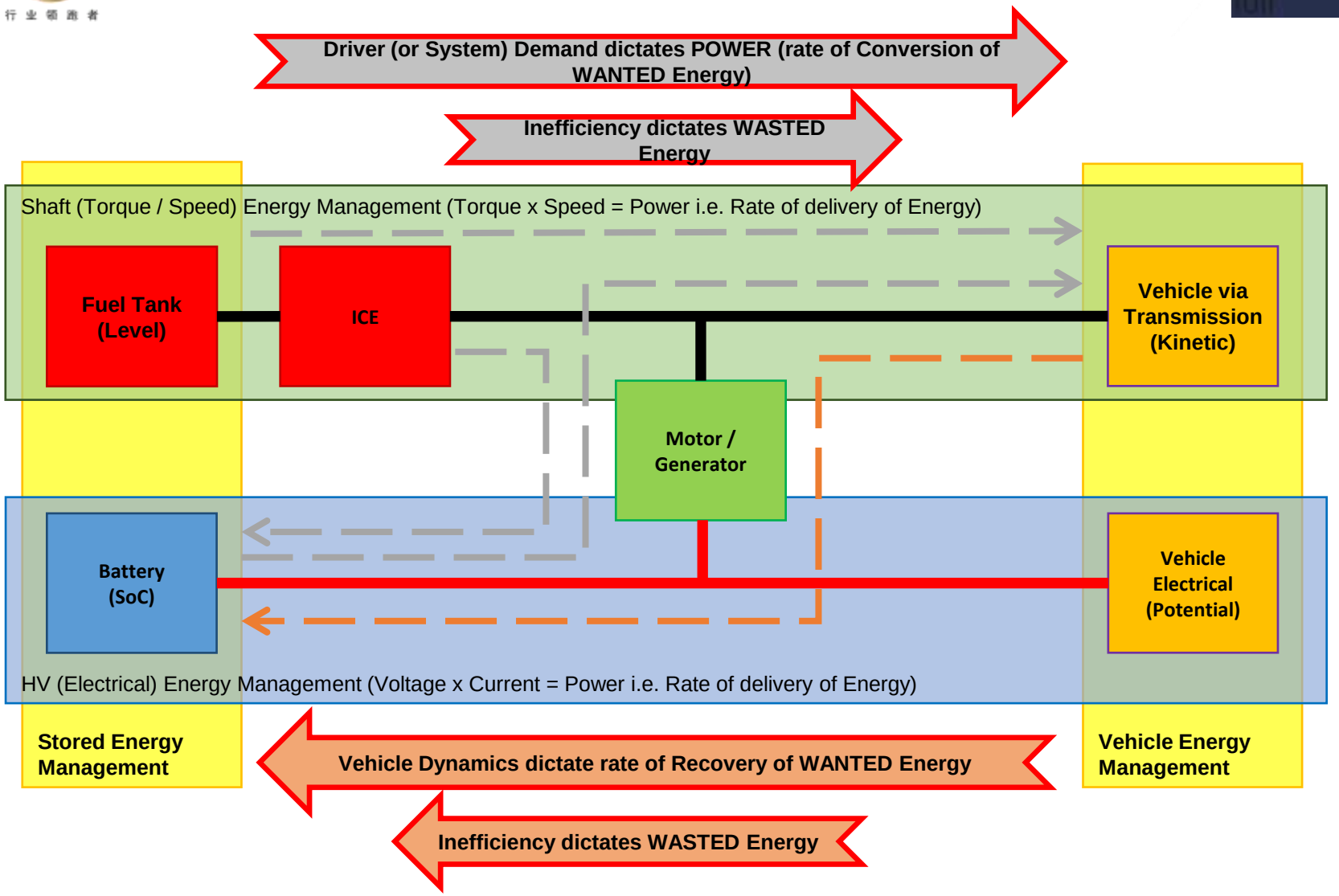
Layers

Primary Roles




Driver Inputs (Pedals, Shift Lever, Mode Selection) Demands for TRACTIVE effort
Vehicle Feedback (e.g.Vehicle Speed, Acceleration) that measure Vehicle motion.
Driver Demand DR
Tractive Demands
OM arranges Plant availability based on TOTAL demand (Tractive +Non-Tractive)
EM calculates distribution of Power at optimal working point TOTAL demand (Tractive + Non-Tractive)
TM and RD (with VO)
co-ordinate and progress equipments… … to the EM computed working-point and distribution
OM
EM
Some Driver requests have direct implications on System Demand (e.g. Forced obligations)
Non-Tractive Demands
System Demand (part of OM)
System Feedback (system state, environment) that measure system Power delivery.

8.2


Driver (or System) Demand dictates POWER (rate of Conversion of WANTED Energy)
Inefficiency dictates WASTED Energy
Shaft (Torque / Speed) Energy Management (Torque x Speed = Power i.e. Rate of delivery of Energy)
Fuel Tank (Level)
ICE
Vehicle via Transmission (Kinetic)
Motor / Generator
Battery (SoC)
Vehicle Electrical (Potential)
HV (Electrical) Energy Management (Voltage x Current = Power i.e. Rate of delivery of Energy)
Stored Energy Management
Vehicle Dynamics dictate rate of Recovery of WANTED Energy
Vehicle Energy Management
Inefficiency dictates WASTED Energy

SOFINTSYS

LANDLINE
+44 (0) 1283 575609

MOBILE
+44 (0) 7913 205457

EMAIL
stuart.jobbins@sofintsys.com

WEBSITE
www.sofintsys.com