Digital Transformation: Engineering the Future of World-Class E-Drives

25th April 2018
Integral Powertrain founded in 1998 by its current 4 directors who met at Cosworth.
Two main strands Powertrain Engineering services, Advanced CAE deployment.
Latter strand developed into Intrinsys, the UK’s biggest Dassault BP recently acquired by Addnode group. Intelligent Engineering remains a defining feature of Integral Powertrain.
Who Are We?

Design and manufacture of ultra high power density machines for premium clients.
Development of 14, 48v automotive e-drives for high volume manufacture.
Establishment of Integral e-Drive brand to focus on developing a smart model to underpin development of the e-drive business.
Who Are We?

Rapid growth in premium motorsport and low volume production applications.
Before we go on; a bit about the product.

- Electric machines have been around for a long time but a transformation in capability is happening.
- A state-of-the-art e-drive is made possible by:
  - Rare earth magnets
  - Fast low-loss switches
  - Fast processors and control software
These items have been rapidly improving over the last decade or two and by combining them with advanced electromagnetic, mechanical and thermal design we are achieving a new generation of drives with amazing improvements in power density and controllability.

An example for fun!

<table>
<thead>
<tr>
<th>Integral e-Drive HOC</th>
<th>Audi 1.4 TFSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>120kW</td>
</tr>
<tr>
<td>Speed</td>
<td>120,000 RPM</td>
</tr>
<tr>
<td>Weight</td>
<td>3.9kg</td>
</tr>
<tr>
<td>Fully Reversible</td>
<td>✓</td>
</tr>
<tr>
<td>Moving Parts</td>
<td>10</td>
</tr>
<tr>
<td>Full to no throttle speed</td>
<td>1mS</td>
</tr>
</tbody>
</table>
How will the market develop?

- Huge projected growth rate in automotive e-drives
  - Diesel gate leaves CO₂ hole
  - RDE awareness leading to city centre restrictions on ICEs
  - OEM strategic intent (statements, investments)
How will the market develop?

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- Premium and low-volume vehicle market will not be well served by the above and represents a major opportunity
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What is the ideal solution for our target sectors

- Maintain technical leadership, build reputation for high quality, performance, reliability
- Exceptional e-drives perfectly matched to OEM requirements delivered rapidly and with low NRE
- Full service efficiently interfaced with OEM; Design, validation / application engineering, manufacturing and supply
What does this mean?

- Design and validate core subsystem technologies at rule level
- Configure bespoke products from these subsystems that are perfectly matched to client goals
- Speed and quality through intelligent joined-up end-to-end business process
- The right tools for each task with streamlined interfaces and driven by experts
- In-built continuous improvement trajectory
- Scalability / growth through manufacturing
END TO END PROCESS SHOWING SOME OF KEY TOOLS & INTEGRATIONS

QUALITY

Positions:
1. Best Fit Concept
2. Proposal/Contract
3. Concept Designs
4. Detail Description
5. Prototype Production
6. Build
7. Validate
8. Production Source
9. Manufacturing

Tools & Integrations:
- XL Tool
- Analysis
- Specs
- Terms
- Planning
- Design Templates
- B.O.M
- B.O.P
- Tooling
- Capable Suppliers
- Build Process
- Validation Plan
- Rigs
- Test Process
- S/O

PROJECT MANAGEMENT
Sales & Marketing work with clients to identify required specification using concept tool.

As specification develops, the Project Leader and Departments work on resources and timings to ensure project timelines are met.

Preliminary BOM, BOP and tooling requirements generated allowing estimation of design resource and costs.

A validation plan is generated communicating with development and allowing resource planning.

Specification and costs are developed and put into proposal document with a standard sign-off process.
As key components are specified by rule level driven templates, the whole modification process is missed. BOM, BOP and tooling requirements are updated and the procurement process can commence. An approach extremely compatible with Quality Control and continuous improvement methodologies.
Rule based design tools

- Where a problem is encountered, if the problem is eliminated at rule level, the problem is gone for good:
  - By extending to involve the supply base, this can ensure that potential downstream issues are dealt with automatically.

Example: Insufficient over-moulding draft causes quality problems. Revised draft introduced to design template.

- Rules that cost money or performance can be challenged:

Example: Analysis indicated that the heat transfer and resistive losses could be improved by reducing wire clearances. A separate off-line study optimises this critical aspect and a revised rule is introduced for future product.
Streamlined interfaces, templates and information flows

- By introducing standard, version controlled templates for key documents, analyses and tasks, the time and probability of error are reduced dramatically. The ability to form databases and form meaningful comparisons is also enhanced:
  - Analysis department now has standard import of design data with standard meshing and BC application and standard output report.
  - Analysis and validation test cases linked
  - Standard report and test templates amenable to database
  - Improved correlation and confidence over time
Key aspects of our transformation

- Core Technology Bespoke: Design and validate core subsystems at rule level

- Streamlined interfaces: Use this standardisation to develop templates that can be re-used and improve communications across organisation and enable the right tool for each task

- Continuous improvement dynamic: Correct problems at rule level and challenge rules that cost