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

4th July 2018
Integral Powertrain founded in 1998 by its current 4 directors who met at Cosworth.
Who Are We?

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.
First full-lifecycle e-machine project for prestige hybrid production car.
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.
Rapid growth in premium motorsport and low volume production applications.
Who Are We?

Official Technical Partner and supplier of Advanced SPM Electric motors and inverters to the current 2018 Pikes Peak double record holders; Volkswagen Motorsports I.D. R
Before we go on let’s have two slides on 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
21st Century Power?

<table>
<thead>
<tr>
<th></th>
<th>Integral e-Drive HOC</th>
<th>GM 1.4 Ecotec</th>
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<tbody>
<tr>
<td>Power</td>
<td>120Kw</td>
<td>110Kw</td>
</tr>
<tr>
<td>Speed</td>
<td>120,000 RPM</td>
<td>6,000 RPM</td>
</tr>
<tr>
<td>Weight</td>
<td>3.9Kg</td>
<td>~ 100Kg</td>
</tr>
<tr>
<td>Fully Reversible</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Moving Parts</td>
<td>10</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Full to no throttle speed</td>
<td>1mS</td>
<td>1/3 Sec</td>
</tr>
<tr>
<td>Power conversion effy</td>
<td>&gt;97%</td>
<td>37%</td>
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E-Drives Are Amazing
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)
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• High volume will be dominated by total system cost vs function. Major capital deployments for standard products supplied by major Tier 1 suppliers or vertically integrated into OEMs

• 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
The Product Cycle and Organisation Structure

QUALITY

Sales & Marketing
- Commercial
- Design
- Software & Electronics
- Materials
- Development
- Testing
- Production Materials
- Manufacturing

Best Fit Concept
- Proposal/Contract
- Concept Designs
- Detail Description
- Prototype Production
- Build
- Validate
- Production Source
- Manufacture

XL Tool
- Analysis
- Specs
- Design Templates
- Terms
- B.O.M
- Planning
- B.O.P
- Tooling

Capable Suppliers
- Build Process
- Validation Plan
- Rigs
- Test Process
- S/O

PROJECT MANAGEMENT

The Product Cycle and Organisation Structure

Analysis

Specs

Design Templates

Terms

B.O.M

Planning

B.O.P

Tooling

Capable Suppliers

Build Process

Validation Plan

Rigs

Test Process

S/O
The Intelligence Within

- Objective is to capture, deploy, evolve best practice
  - Technically
  - Organisationally
  - Across the organisation
  - For the full lifecycle

- Core Technologies
  - How we do each aspect of our machines (eg electromagnetic design, stator construction rotor assembly)
  - Developed in R&D, validated and improved with each product

- Tools
  - Configuring, optimising and validating to suit specific requirements. (eg design templates, standard analysis tasks, BoM / BoP estimation)
  - Highly scalable rule level basis

- Processes
  - Complex interactions between different parts of the business.

- Connectivity
  - Tools and processes must communicate

- Adaptability
  - Organisational learning and core technology
Matching Client Requirements

- **Platform Derivatives**
  - 8 current platforms covering space between 120krpm high power derivative for turbomachinery through to 48v machine engineered for high volume automotive applications
  - Configuring key parameters (length, number of turns)
  - Substitution of core technology variants according to performance and cost requirements (e.g., active materials)
  - Minimum NRE and lead time

- **Core Technology Bespoke**
  - Fully optimised new platform based on core technologies

- **Special Projects**
  - Requiring one or more new Core Technologies
END TO END PROCESS SHOWING SOME OF KEY TOOLS & INTEGRATIONS

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Design
- Materials
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- Validate
- Validation Plan
- Rigs
- Test Process
- S/O

Manufacturing
- Production Source
- Manufacture

Commercial
- Production Materials
- Manufacturing

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 can be 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 validated rule level driven templates, a whole cycle of DFM is missed. Templates also interface directly with analytical tools.

BOM, BOP and tooling requirements are updated and optimised procurement process can commence.

Documentation and quality activities supported.
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.
IP is embracing PLM to grow intelligence within its organisation to capture, deploy and evolve best practice

- Based around a standard matrix organisation and product lifecycle
- Key aspects are captured in 3DE PLM environment:
  - Scalable core technologies understood at ‘rule’ level
  - Tools
  - Processes
  - Connectivity
  - Adaptability
Thank You for Listening