Modularisation as a means of product and process integration

This item was submitted to Loughborough University’s Institutional Repository by the/ an author.


Additional Information:

• This is a conference paper.

Metadata Record: https://dspace.lboro.ac.uk/2134/2168

Publisher: © Taylor and Francis

Please cite the published version.
This item was submitted to Loughborough’s Institutional Repository by the author and is made available under the following Creative Commons Licence conditions.

For the full text of this licence, please go to:
http://creativecommons.org/licenses/by-nc-nd/2.5/
The method of product and process integration considered in this paper is that of modularity. Here we consider a product composed of self-contained units or modules that are manufactured as sub-assemblies and assembled together. Modularisation, to create a product composed of modules, provides product flexibility by means of combining developed modules together in various ways to extend the product range, Erixon and Östgren (1993). By implementing a modular strategy, product and process will naturally become more interlinked by providing a stable and common platform to design and manufacture. Modularity should thus increase the robustness and flexibility of a product and its associated manufacturing system.

An extension to the theory of modularity for product design relates the module concept to processes and also to businesses. The benefits gained by a modular product design can also be mirrored in the concept of holonic manufacturing systems and also holonic enterprises. Holonic manufacture is part of the Intelligent Manufacturing System (IMS) programme, Valekenaers and Van Brussel (1994), that addresses the so called ‘fragility’ of today’s manufacturing systems. In general, the manufacturing systems of today suffer from inflexibility and generally perform poorly when they must operate outside their normal / expected conditions. By replacing rigid and inflexible hierarchical manufacturing systems with those that are much more adaptable to change, holons act to fulfil the role of hierarchical intermediaries. Thus, holons are autonomous, discrete and co-operative units, that are capable of dealing with disturbances and yet provide the functionality to support the greater whole, and thus increase the robustness of the system. Holons may be seen as the building blocks of a manufacturing system. The holonic concept can also be taken one step further by examining the holonic enterprise. This builds on the theory of Business Process Reengineering, by defining a holonic network as a group of businesses that, cooperate in an integrated and organic manner, forming a system able to configure itself to manage each business opportunity that a customer presents, McEugh, Merli and Wheeler (1995). Holonic enterprises, holonic manufacture and modular design share many similar concepts and objectives. The development of such concepts as the holon will further aid in the integration of product and process by providing an increased awareness of manufacturing concerns, and a means of implementing them at an early stage, in addition to a system that will be able to integrate changes much more easily and rapidly throughout a products life-cycle.

Investigation and Case Studies

The investigative work done into modularity has focused on three products that are different in function, design, and scale of production. The products considered consist of; a future small car from a major automobile manufacturer, an optical scanner for the pre-press printing industry manufactured by Crosfield Electronics, and a geophysical measuring system that is used for down-hole drilling, from Geo Measurement Systems. These products also presented a range of enabling technologies; both mechanical, electronic and optical.

The investigation, complementary to existing initiatives within the companies, initially realised a number of pro’s and con’s that modularity would provide to a product and its associated process. In addition to the rational introduction of variation in a structured and systematic manner, modularisation provides further utility in design, manufacture and also, to the customer.

1. To product development, modularisation means reduced lead times due to the possibility for parallel design and manufacture of modules, and the use of bought-in modules that require no further attention.
2. Manufacture will benefit from a JIT friendly system, leaner production from reduced WIP and finished article stocks, and improved and more consistent quality-with associated reduction in test overheads.
3. Assembly benefits from a product inherently designed for assembly with modules being; of manageable size, and identical within each type (e.g. no adjustment required for fit). Modularity can also facilitate assembly by a reduction in
provide a Measurement Whilst Drilling (MWD) service, thus they
the business; GMS do not sell their products, but operate them to
modules that make up many of their products are standardised and
modules early on, as a design and manufacturing concern,
reduce the downstream activity overhead.

5. Environmental aspects may be addressed (DFE), through the
ability to group similar materials for recycling, or the ability
to reclaim the most desirable elements.

6. Finally, the customer benefits from a modular product by the
range of product choice or customisation at no extra cost, and
in significantly reduced time scales, both in terms of delivery
and also development of new products. They will also gain
improved quality, ease of service and replacement of parts,
and a simple upgrade path.

On the negative side, the modularisation of a product will
immediately increase the problems with interfaces. Module
interfaces will require careful consideration as a key enabler of the
technique. Though initially the extra effort up front in defining the
interfaces will seem excessive it will facilitate downstream
processes and will also promote the discipline of team working and
simultaneous engineering by design and manufacture personnel.

It is possible to demonstrate the benefits of a modular
strategy to product development and manufacture by examining a
number of products that have considered modularity to be a
desirable objective. None of these products were developed using
strict guidelines on how to implement modularity yet they show
how the consideration of a technique such as modularity may be
used to promote the discipline of product and process integration.

Figure 1. shows a colour scanner from Crosfield
Electronics. The company focused on a new project and
developed the product to be modular. During the project the seeds
of a strategy were developed to aid in the process of module
definition and a means to identify and analyse module interfaces
and the interactions that occur. Working with cross functional
teams and ensuring up-front effort, provided Crosfield electronics
with considerably less problems downstream, and iterations within
product development. Other advantages include; significant
reductions in part numbers and variety, assembly operations and
adjustment, floor space, testing, and complexity of the product.

Figure 2. shows a typical product by GMS. This
illustrates a perfect opportunity for modularity. The product must
be designed in this form to offer the flexibility required, but up
until now the predominant way of working has been to re-engineer
many parts or modules of the product, with little overall
standardisation in the mechanical aspects which have proven to be
secondary to the electronic concerns. The company are now into
the early stages of developing a new mechatronic product, and this
is being used as an opportunity to modify their development phase.
They aim to take advantage of previous work and designs so
modules that make up many of their products are standardised and
interchangeable. A key consideration in this case is the nature of the
business; GMS do not sell their products, but operate them to
provide a Measurement Whilst Drilling (MWD) service, thus they
must constantly be able to support existing equipment and provide
for large degree of customer requirements. With a structured
approach to modularisation GMS will be able to address their main
concerns and also refine their overall product.

Figure 2. A modular (MWD) sensor and drilling string.

Figure 3. shows a concept for modules incorporated into
a new small car. The use of modules in the automobile industry
provides a number of advantages in both product and process. The
assembly of the automobile benefits greatly through reduced
handling, fewer process steps, and component integration,
increased flexibility in tooling, equipment and processes and
higher productivity through the integration of DFA, DFM, DFS,
and DFE disciplines. Quality is improved, and through the ease of
interchangeability of modules, so too is customer satisfaction in
features and attributes.

Figure 3. The modules of a small car.

Conclusion

This paper documents the initial investigations into
modularisation as a technique for product development. The case
studies shown offer an opportunity; to examine the benefits of
having applied the technique, to apply the technique within a
company who are not untypical in their current product
development process, and to study a company who are examining
a broader strategy in meeting customer demands for the next
millennium. It has been shown that the implementation of
modularisation provides many advantages over incremental design
and manufacture. Modularisation, product or company wide under
the guise of the holon, directly meets the needs for custom
specifications, and provides mutual benefit to the producer and the
customer from the optimum development of the product through
companies who are able to configure themselves to meet specific
demands. The paper documents the ground work done in
furthering the aim to provide guidelines or checklists for the
suitability and implementation of modularisation within a context.
Modularisation provides the way forward for product
development, achieving a product and process that is capable of
dealing with customer driven needs, and that it will prove to be an
extremely valuable technique in the future manufacturing industry.

References

Erixon, G. and Östgren, B. 1993, Synthesis and evaluation tool for
modular designs. N.F.M Roozenburg (ed.), Proceedings of the 9th
898-905.

Erlandsson, A. and Yxkull, A. 1993, Product plans and their
interaction with development of the manufacturing system. N.F.M
Roozenburg (ed.), Proceedings of the 9th International Conference

Process Reengineering - Towards the Holonic Enterprise. (J. Wiley
& Sons, Chichester)

Shirley, G. 1992, Modular design and the economics of design for
manufacturing. G.I. Susman (ed.), Integrating Design and