PRODUCT MATURITY THROUGH PARTNERSHIP

Sanjiv Sharma, Aymen Mussad, Simon McCleery
Airbus UK Limited

Keywords: *Collaborative working, procurement contracts, validation, verification, maturity.*

Abstract

This paper explains, in generic terms, an approach taken by Airbus UK Limited to address product maturity through Partnership, with some extensions indicating the areas where collaborative working assist in designing complex systems through multidisciplinary teams.

Some indications are also given on procurement and contractual issues, e.g. Intellectual Property Rights (IPR).

1 Introduction

As aircraft sub-systems become more complex, the maxim of "right first time" becomes increasingly significant. Generally, complex systems cannot be proven merely by test of the end product. It is not always possible to exercise all possible states of the system to check that it functions correctly. Especially, if there are erroneous states with a low probability of occurrence.

Problems discovered late in the design have significant impact on costs, time scales and ultimately customer satisfaction.

Design of such aircraft sub-systems requires multi-disciplined teams.

- These teams may not be located in close proximity. Transfer of relevant information between them will need to be established.
- The teams may have different local working languages. An understanding of each other's problems should not be "lost in translation".
- In many cases, some team members may be outside our direct control, e.g. Suppliers. These team members may have specific skills, and knowledge of trends in current research and technology within their core business. Their participation may be paramount in providing the optimum solution for the problem.
- The various teams will progress at different rates. Therefore different aspects of the system will also evolve and mature at varying rates.

So, who are the partners that assist these multidisciplinary teams? In the context of this paper, we define the "Partners" as all stakeholders who have an interest in the **correct** design, development, manufacture, use, and disposal of the product.

Particular emphasis is placed on the customers as an essential Partner in making the product successful. By repeatedly purchasing the product, they provide the perfect validation.

Working with these Partners, one starts to understand the requirements, and proposes candidate solutions. As the solutions evolve, one starts to crystallise a specification, establishing the criteria to realise the solution.

Typically, the system is partitioned into functional elements and, possibly, separate suppliers are selected to provide those elements.

The system integrators (Systems Engineers) will manage the interfaces and interactions that occur between these elements. Through requirements validation, equipment verification, and systemic approach, they provide answers to the questions "Although these sub-systems perform correctly in isolation, will their performance conform to the requirements when assembled?"

Traditionally, for aerospace applications, the first time these sub-systems come together would be on an Iron Bird, or even during the ground tests. Surprises (severe shocks!) at this stage are costly, set time to market back, and destroy reputation amongst customers.

This paper explains, in generic terms, an approach taken by Airbus UK Limited to address product maturity through Partnership, with some extensions indicating the areas where, in the authors perspective, enhancements can be made.

Maturity, in this context, is a measure of operational readiness of the system. The definition of such a Maturity metric is outside the scope of this paper.

We start with the assumption that the technology for collaborative working does not necessarily create obstacles, but commercial, organisational and contractual items can be a problem.

2 Process Overview

There are key Partners who provide specific requirements at each level of system granularity, [1]. The Partners viewpoint will dictate the types of requirements being placed, e.g. the requirements may be functional, operational, procedural, etc. Have we understood the requirements [5]?

Engineering decisions have to be based on these ill-structured, ambiguous and inconsistent requirements, for engineering the system. Have all Partners had their say; i.e. are the requirements complete? The first pitfall!

Through analysis, modelling and review processes, these requirements are crystallised into a specification; i.e. translated to engineering language. The second pitfall!

The specification becomes a set of requirements for the next level of system granularity… yet more translations, and further pitfalls of the second kind!

Specification, which is to do with design, quality and maturity of a product, and conformity, which is to do with manufacture and process quality that is achieved – are of particular importance to customers. Ultimately, these two factors determine the maturity levels provided by an organisation to its customers.

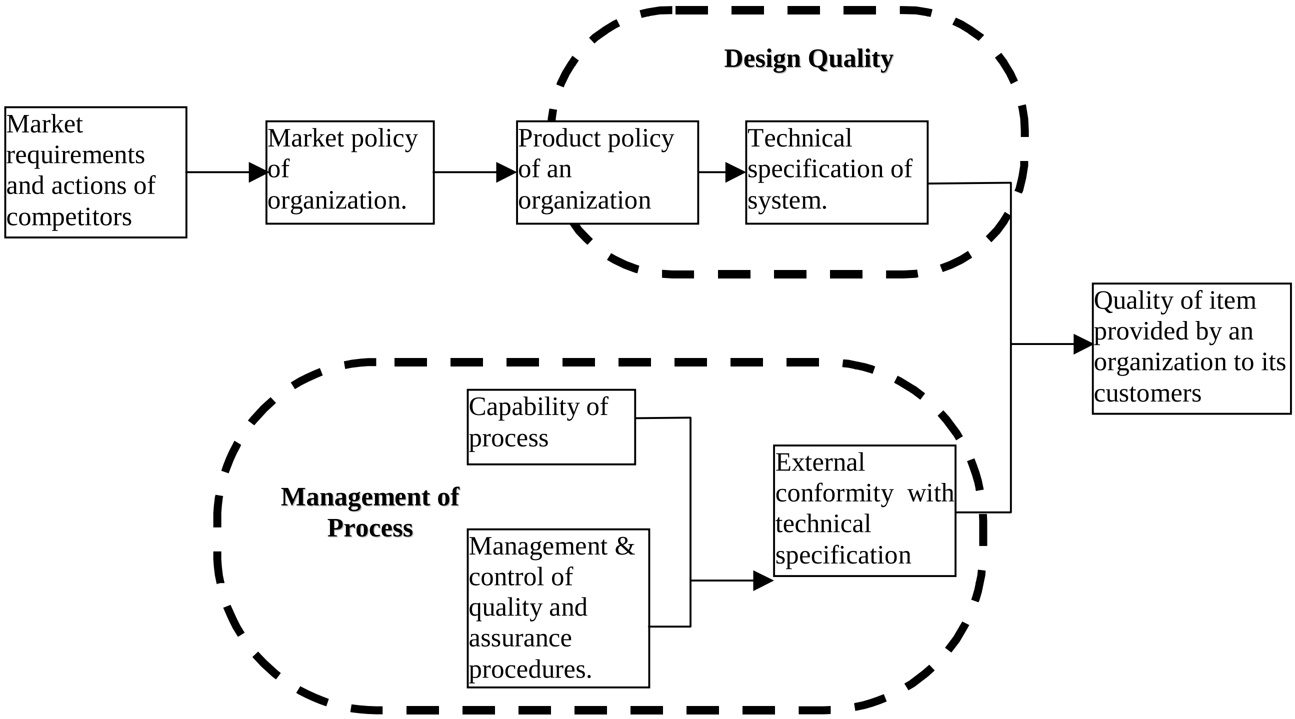

Figure 1 Factors influencing the quality of a product as provided to a customer.

However, these two factors themselves are determined by other factors, see Figure 1.

Frequently, the system elements are supplied by different suppliers. Have the interfaces been correctly defined? In this scenario, suppliers optimise at sub-system level, on the assumption that the specification given to them is a statement of requirements for an optimised system level. Pitfalls of the integration type!

The traditional route is for the Aircraft Manufacturer to produce the specification, pass it to the Supplier ("over the wall") who raises a response to the specification, and the process slowly iterates until a satisfactory solution is reached.

The obvious solution is to devise a framework where the effect of these different articles can be assessed. This framework can be used to identify problems earlier in the product design cycle. Collaboration amongst all team members is required at a very "early stage" to insure that the framework supports their viewpoints.

3 Process Details, with enhancements

Living Systems Theory [2] defines the verb "to genopersist" to mean Conceptualise, Evaluate, Market, Design, Prototype, Test, Produce, Deploy, Operate, Support, Evolve, Retire **and** Manage. Genopersistation implies recursion, for example, suppliers genopersist to instantiate system elements, the system integrators genopersist to instantiate systems, the project teams genopersist the projects…

The concepts of genopersistation, specifically with its recursive implications, suggest a framework of carrying out the system elaboration tasks consistently, whilst involving the complete environment in which the system will operate, see Figure 2.

At the various levels of system granularity, the authors believe that such a framework would remove the first and second pitfalls, as identified above. For example, at the operational level, it would involve all users of the system, thereby improving requirements capture.

The specification is determined because of an organisation's product requirement policy [3]. This in turn depends on its market policy. This further results from its consideration of market or customer needs and requirements and the activities of competitors.

Suppliers should no longer be considered as simply "supplying the bits". Even at the conceptual design stage, the strategic suppliers should be working closely towards the common goal. Such shared knowledge development should ensure smooth transition from the conceptual stage to the detail design stages and

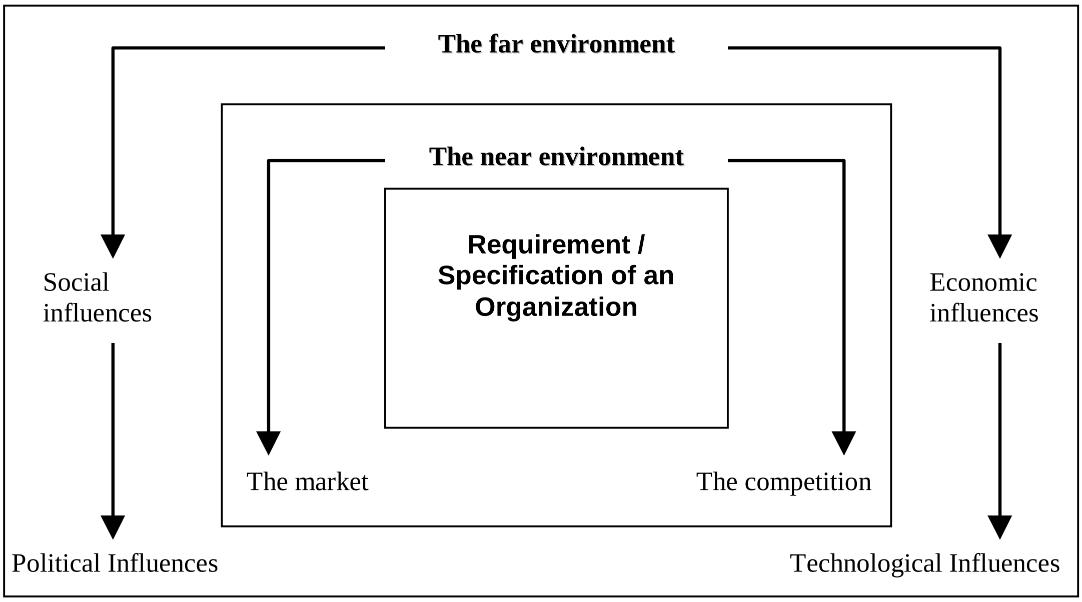

Figure 2 The organization in its environment.

beyond.

"… many successful people have depended on a partnership in which the second party has supplied qualities needed for the success of the first party." - Edward de Bono [4].

3.1.1 Substantiate Requirements

The degree to which the product conforms to the technical specification is influenced by the capability of the conversion process [7]. If the conversion process is incapable of producing products at the level required by the specification then it must follow that the product provided to the customer will be inferior. However, the fact that a conversion process is inherently capable of producing or providing according to a specification will not necessarily ensure that the product is of an acceptable standard. Airbus UK thus developed a maturity process to ensure the conversion process used in the appropriate fashion would ensure that the product specification would be achieved. Thus maturity is the capability of an organization's management or control of assurances and procedures.

Establish design concepts, and philosophy. Detect and rectify any anomalies in the design concepts before any equipment is specified.

Provide a consistent method for **establishing** (validation) that the design is evolving correctly, from the earliest design stage possible.

Early information from the Partners will assist in analysing the various design concepts, and carrying out initial trade-off studies between them.

Specifications need to be prepared in a collaborative environment, so that as knowledge about the requirements is being accumulated, all parties attain a common understanding.

3.1.2 Demonstrate Design Evolution

Establish test concepts, and philosophy. Detect and rectify any anomalies in the design features before any equipment design is finalised.

Provide a consistent method for **demonstrating** (verifying) that the design has evolved correctly, again from the earliest design stage possible.

Predicted performances, from the Partners, for the equipment and sub-systems can be introduced into the analysis. The first virtual integration can be performed in the form of mathematical models, the Virtual Aircraft. Changes can be made to the equipment and sub-systems to optimise the solution and to establish its robustness.

As the system design evolves, use of hardware-in-the-loop techniques can be used to progressively transform the mathematical models into test rigs, and finally integrate the systems on to the physical aircraft.

At each stage, the interaction of the system elements can be checked, problems identified earlier and efficacy of proposed solutions established.

3.2 Contractual Issues

The commercial process can cause a chill in a cosy partnership if the parties do not play to the rules laid down in a Memorandum of Understanding (MoU) for collaborative relationship.

Points of debate can be centred on such issues as:

- Guaranteed Mean Time Between Unscheduled Removal (MTBUR)
- Direct Maintenance Costs (DMC)
- Intellectual Property Rights
- Price, Spares, Mark-ups, etc.
- The contract agreement in general.

The way to manage these issues is to agree reasonable starting points for negotiation and to ensure that a fair and equitable result is evident.

3.2.1 Data Exchange & Intellectual Property Rights

For any system design and choosing suppliers for the system development and delivery, a certain amount of sensitive technical information is required.

Encouraging a good initial burst of information is often achieved through partnership on other existing programmes. Clearly if an existing product works well and the customers like it, it can be brought forward to the new product.

Ultimately, it is a risk that suppliers need to take when deciding how much sensitive information is revealed at the early stages.

Similarly, Intellectual Property Rights (IPR) is an issue that is best decided at the contractual stages. The management of the protection is well tried and tested; however policing any infringements can be difficult. Within a collaborative relationship, save guards must be set so that infringements never knowingly happen.

3.2.2 Procurement Issues

When Maturity is mentioned, suppliers would initially see the mirage of their spares revenue dwindle off into the distance. In this instance, maturity should not be confused with reliability, however if a product has a low Mean-Time-Between Failure (MTBF) customers would not be poorly thought of if they considered the product immature.

Clearly, a mature design at the point of installation to the aircraft production line will save cost, effort and product image. On the other hand, one can see that with differing design standards delivered to different aircraft, the management and retrofit efforts would require use of resources that would be scheduled for other tasks; subsequently consuming programme float.

4 The Benefits

Increased chances of having a complete set of requirements.

- The ability to conduct trade-off studies between competing designs in a consistent and representative manner.
- Provide a consistent method for establishing that the design is correct at the earliest possible stage.
- Provide a consistent method for demonstrating that the product meets all its requirements and will satisfy customer needs.
- Allow impact of changes to equipment to be assessed before committing to changes.
- Reduce probability of anomalies remaining undetected until aircraft testing.
- Produce a set of tools that will allow new engineers to gain understanding of various aspects of systems integration in a safe environment. Creating an environment where best-practices, knowledge gained (not repeating mistakes is also knowledge gained) are shared.

5 Summary

Agreement for closer working with Partners needs to be established at a much earlier stage. Where the Partners have worked together in other research activities, a work ethic can be readily developed.

Mechanisms for flow of information between the Partners need to be agreed and developed.

The configuration control of information needs to be addressed - is the information valid, correct and to the latest issue?

Partners Intellectual Properties needs to be protected, without effecting the successful completion of the project.

Finally, to ensure a successful approach to maturity requires

1. The development and faithful execution of a capturing tool or method.
2. The open and truthful use of communication.
3. The use of clear and direct language to enable solutions to meet actions to be attained.
4. The dedication of sufficient resources, people (specifically an internal champion and a multifunctional task force) and money.
5. Devotion of time and attention.
6. Important decisions that visibly reinforce the message need to be made – people and resources.

6 References

[1] Heylighen F, Structuring knowledge in a network of concepts. *Workbook of the 1st Principia Cybernetica Workshop*, *Principia Cybernetica*, Brussels-New York, pp. 52-58, 1991.

[2] Dean E B. Genopersistating the system. *AIAA 1993 Aerospace Design Conference*, Irvine CA, AIAA-93-1031.

[3] Wild R. *Essentials of production and operational management*, Holt, Rinehart and Winston, 1985

[4] de Bono E**.** *Tactics - The Art & Science of Success*. 7th Impression, Fontana/Collins, 1989.

[5] Morgan McCartor M, Simpson J J, Concept mapping as a communications tool in systems engineering. *Proc Ninth Annual International Symposium of INCOSE*, Brighton, Vol. 1, 2.2.4, pp. 255-262, 1999.

[6] Ostroff F. *The horizontal organization*, Oxford University Press, 1999

[7] Anderson A H, Dobson T. *Effective Marketing*, Blackwell Publishers 1994