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Improving the New Product Development Process through ICT Systems in the Aerospace Industry – a Report on Case Study Research

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Abstract

This paper explores the role of Information and Communication Technology (ICT) systems in the new product development process in the aerospace industry. A literature review and an in-depth case study are used to answer specific research hypothesis, reflecting the suitability of qualitative research methods in this field. The case study employed a detailed questionnaire, interviews and observation to support the literature review. Research findings indicate a strong correlation between ICT systems implementation and business process improvement. This is identified as a clear benefit for engineering/manufacturing aerospace companies.

1. Introduction

Despite the current economic situation worldwide, the aerospace industry is growing and the outlook is also positive. Reference [1] reviewed the industry worldwide and highlighted the boom in air travel. It also anticipated significant growth in the number of aircraft, mainly because current planes are not considered "green" and the global warming initiative is pressuring for newer and greener aircraft.

Reference [2] compared 2004 and 2005 UK aerospace sales and found that they were up by 25% reaching £22.67bn. Employment increased by 9%, and productivity increased by 15% per employee. The fastest growth was in the aircraft equipment sector, up by 60%, followed by engine sales, up 40%. Export sales showed a 29% increase (£15.17bn).

The complexity of the industry makes this growth a considerable achievement. The aerospace products have long lead times and they are often in place for several years. It means that, when a company gets a contract, it will often be developing that product for several years. Business competition requires aerospace firms to show high production efficiency – historical on time deliveries – and also engineering throughput to pre-calculate the product and estimate time and costs in order to get a new business. However, with recent market growth, engineers have often found themselves too busy with the day-to-day activities, so that it has been difficult to take maximum benefit from market opportunities.

Employing more staff could be a solution, but the industry has been facing a workforce and skills shortage [3]. Therefore, one possible solution is to increase engineering capacities by improving business processes. Reference [4] claims that business processes can also be improved by deploying new Information Technology systems. This paper analyses an in depth case study at an aerospace company which invested in business process improvement in order to drive business expansion.

2. Process Management

Many companies want to organize themselves around processes but they do not have any clear idea which steps to follow and which initiatives need to be taken. Others are not sure how to structure a company around processes and sometimes turn to consultancy to help them decide what to do. There are also companies that are not sure whether their current organizational structure is adequate to engage process management [5].

Trying to align themselves by process, companies tend to discover that is impossible to deploy integrated processes in an organization fragmented by the traditional functional structures. Organizations structured by tasks need to be redesigned to work by process. Some companies tend to take a few steps and give up without knowing how to progress [6]. Why is it so difficult to deploy a structure oriented by process?

The difficulties stem from a poor understanding of the concept of process. According to reference [7], companies that provide services normally think that process is a sequence of activities needed to perform transactions that help to provide their services.

The distinction between business process, auxiliary process and support process can help to identify essential processes for the company. Normally the essential processes are directly associated with company's basic business rules [5]. Childe et al [12}described the essential process of product development with the table below:

Input	Process	Output
Market/ customer requirements; The initial concept for the product	Development of the concept to completion	Completed concept describing the product in detail. i.e. the design drawing and parts list or a specification of how it is to be made

Table 1: Product development - the essential process Source: Childe et al [12]

2.1. Customer Influences

To organize the company around business processes, it is necessary to focus on external customers because business processes usually start and end with them. Processes have a line of activities which begins with the exact understanding of what the external customer wishes and finishes with the external customer gaining what he needs and requests [5].

The customer is always central within organizations structured by process and the final objective of these companies is to offer to the customer more value in less time and with less cost. Organizations are in a battle to achieve it and they are learning to think in new ways to structure the company. Staff need to learn and understand the business, assume more responsibility and work as a team [6].

2.2. Organogram

Organograms are not useful in business process analysis because they do not show how they work in practice or how activities flow within the company. Business processes reflect how the organization works and generally do not respect the limits established by organograms.

The organization of a company, which works by process, can have the appearance of a functional structure with functional areas well defined, but with processes operating effectively in an orthogonal (horizontal) way. It is not a matrix structure although there are relationships of double subordinations on organizations by process. Many times, the same people participate in various processes simultaneously [5].

In practice, functional areas do not disappear when companies structure themselves by process. When process owners assume their responsibilities for specific projects, with related structure and process roles, the functional area bosses are left to focus on staff training and resource planning and management.

2.3. Process Modeling

To define processes is a difficult task, which involves many complex factors like customers, human behavior and company structure. However, process modeling can provide a less detailed way to define process. Reference [8] said "the task of modeling, in general, aims to provide, an abstract description of one slice of reality by omitting details and thus reducing complexity which is usually inherent in real world situations. In the Re-engineering Process, modeling is the task of producing an abstract description of an actual or a proposed business process. A characteristic of a business process is that most of its elements are enacted by human actors".

Two very important issues in business process modeling are the information to be modeled and the modeling formalism. The main core business processes may contain information about:

- Activities, which are the basic elements upon which a business process is built. Usually they are defined as a unit of work that cannot be subdivided.
- The controls of a business process which describes when and which activity is executed.
- Resources which are assigned to activities. These are objects that are necessary for the execution of activities, for example documents, data etc. There are 'inputs' and 'outputs' which represent the resource flow which show how resources are exchanged between activities (see Fig. 1).
- Organizational structure which can consist of organizational units, people, roles, competence, etc. The relationship 'has-actor' represents the assignment of an object of the organizational structure to activities. These core business process objects and a number of relationships are shown in a meta model depicted in Fig. 1 [8].

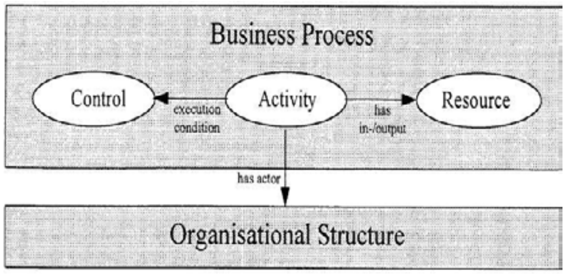

Figure 1. A model of business objects [8]

If such formalism is employed, it should:

- Be graphical and easy to understand by all parties involved in the Re-engineering Process
- Enable and encourage the reusability of the modeled components
- Be supported by algorithms and enable the employment of certain techniques (e.g. animation, simulation, statistical analysis) appropriate for the analysis and evaluation of the model
- Have clearly defined semantics in order to enable the transformation of the business process model from the re-engineering level to the implementation level [8].

2.4. Strategic Alignment

In today's dynamic markets, organizations are using strategic management to help maximize their competitive advantage. However [9] states, "the real threat to most companies is not a strategic threat from outside. Instead it is their own failure to align their organization with their strategy and thus ensure good execution". The obstacle in strategic management continues to be implementation.

Reference [10] identifies the term "Process Paradox", which is when an organization is in decline at the same time that reengineering and TQM are dramatically improving efficiency, quality, and customer service. This paradoxical situation can be linked back directly to poor alignment between strategic plans and business processes. An organization must be able to align itself with the strategic plan and turn strategy into action. Based on strategic alignment, business process improvement can be gained when organizations update their strategy; they have to analyze their current business processes and amend, modify or perhaps redefine them in order to achieve their strategic objectives and targets.

One of the key problems to be faced in analyzing, measuring and effectively evolving a business process and related supporting systems, is modeling what has to be analyzed and keeping the model updated during the evolution activities. Any formalism can be effective, provided if it is complete and easy to be used and understood. In addition, it is important that it adheres to standard requirements to facilitate the diffusion and comprehension of the constructed process models and cooperation among the main players should they be impacted if process evolution is needed.

2.5. Business Process Reengineering

Another recognized way to gain process improvement is using Business Process Redesign, also known as Business Process Re-engineering (BPR). According to reference [11], "BPR is the means by which an organization can achieve radical change in performance as measured by cost, cycle time, service, and quality, by the application of a variety of tools and techniques that focus on the business as a set of related customer-oriented core business processes rather than a set of organizational functions".

There is a discussion between authors on whether BPR is the same thing as Total Quality Management (TQM). Although TQM also focuses on business process improvement - mainly on internal and external customers - it does not consider Information Communication Technology (ICT) evolution and its impacts. In addition, BPR is more suitable for innovation, which can radically alter business processes. BPR can cope better with radical changes because TQM has as an input a process and its output is the same process with improvements [12].

On the other hand, many authors think that BPR just focuses on operational processes. Reference [13] claims that BPR has focused almost exclusively on improving the firm's internal operations having just an operational perspective. They also said that the objective of BPR is usually optimization of a single process rather than transformation of the enterprise itself.

3. Methodology

The aerospace industry is known as an industry with rigid processes difficult to be improved. One of the core processes of that industry is new product introduction, which aims to design, engineer and manufacture a new product. This paper aims to answer 3 research questions:

- What is the current new product development process in the aerospace industry?
- What areas could be improved to speed up the new product development process?

- How can information technology help process improvement?

3.1. Research Method

Reference [14] highlights that qualitative and inductive research can be done in different ways encompassing case studies, grounded theory, and ethnography, for example. Reference [15] also agrees that case studies are likely to be used as part of an inductive research approach. Reference [16] defines case study research as a “detailed investigation … of one or more organizations, or groups within organizations, with a view to providing an analysis of the context and processes involved in the phenomenon under study”.

The research method employed here is based on an in-depth case study research of new product development process improvement.

The evaluation of results was done comparing the answers of the interview and the observations made by the author. This was analyzed in conjunction with the findings of an extensive literature review, allowing empirical generalizations and a series of clear statements to be developed [15].

3.2. Data Collection Methods

There are several ways to collect qualitative data that have a case study research focus. Examples include questionnaires, interviews and observation [15] [17]. After carefully analyzing data collection methods, interviews and observation were detected as the most suitable approaches for data collection due to the opportunity of the author to go to the company everyday.

27 people were identified as being potential sources of information for this research. The first batch of interviews involved 16 of the 27, and the main purpose was to map the current new development process and computer systems used to support the process. They involved people from all levels in the company. The second batch of interviews which involved 13 of the 27 people identified, aimed to collect and analyze problems related to current new product introduction processes and procedures. Figure 2 details the process used for the second batch of interviews:

Figure 2. Second batch of interviews and analysis: process

For this second batch, ‘the suitable subjects’ were deemed to be people who had a comprehensive knowledge of the business, and who would be in a position to identify the problems the organization has to introduce new products. Reference [18] suggests that subjects must be in a position to generalize about business behavior. Only employees at the level of manager/supervisor or higher were considered for participation in the study.

All responses from both batches of interviews were documented in detail. In addition, one year of observation was also documented by the authors, which helped the research by highlighting facts that were not gathered in the interviews.

4. Findings

4.1. The Company Case Study

The company case study has more than one strategic business unit (SBU) or branch. According to its website, it is considered as a group of companies with divisions or SBUs operating across the world. The branch has a turnover of circa £17m and employs around 220 staff in Gloucestershire, United Kingdom. This company group is considered the largest manufacturer worldwide of its product specialty.

Currently, the Stonehouse (Gloucestershire) branch is accredited by a number of recognized institutions. It has got three National Aerospace and Defense Contractors Accreditation Program (NADCAP) accreditations for manufacturing operations: Heat treatment, chemical Processing and Non-Destructive Testing. It also has got the OHASAS 18001:1999 and its new version ISO 14001:2004 for been able to sale aerospace products.

It also has the AS 9104:2006 for having a quality management system for design, development, product and overhaul of aircraft engine, airframe controls, gearbox and helicopter transition products. It is also certified by their customers in several areas of the business.

Finally it is also accredited in the ISO 9001:2000. However, the ISO 9001:2000 quality system has not been used and updated. Most of the business processes are uncontrolled and sometimes it does not exist. Therefore, there was a need to detail some process including the new product development.

4.2. Current New Product Development Process

The scope of the research was the new product development process. However, because the manufacturing process depends on the product that is being developed, the main focus was on the upstream process before launching a product part to the shop floor. Therefore, it involved the customer, design, and manufacturing stages, encompassing methods, quality, purchasing, production planning and the administrative tasks on the shop floor. A list of computer systems was documented and the process was presented using a workflow diagram. The list of computer systems had more than 130 systems of which 97 were Microsoft Access databases which sometimes hold important business information. Reference [19] lists a number of limitations of Microsoft Access databases which highlights how important it is to not hold any business information within them.

The process flowchart, when printed, had a 2600cm width per 500cm height. Table 2 summaries how many activities were assigned to each business area.

Business area/ Customer	No of activities in the longer path	No of activities in the shorter path	No of decisions (shorter and longer paths)
Customer	5 tasks	5 tasks	3 tasks
Design	34 tasks	21 tasks	16 tasks
Methods	33 tasks	19 tasks	8 tasks
Quality	13 tasks	13 tasks	1 task
Purchasing	7 tasks	5 tasks	5 tasks
Production Planning	12 tasks	8 tasks	1 task
Shop Floor	19 tasks	18 tasks	2 tasks

Table 2: New product development process summary

Despite having a total of 89 activities in the shorter path, the process can have an overall shorter path of 2 activities and one decision if the designers realize it is a product that the company cannot design. Therefore, there is not much significance in the total of activities, because a process can have multiple paths.

4.3. Areas for Improvement

The questions of the second batch of interviews were formulated to get the right information to fill in a table similar to table 3. For each problem that an interviewee mentioned, a metric had to be found to measure the problem and identify what wouldl be the basis of how it could be improved.

After all 13 interviews, 88 issues on processes were found. For each problem, the authors had proposed one way of improvement and for each improvement had one or more benefit which totaled 131.

Interviewee	Problem or Requirement	Metric	Proposed Improvement	Proposed Benefit
Person's name Job title	Description of a mentioned problem	A metric that measures the problem	A possible way to improve the problem	A list of benefits if the proposed improvement was implemented

Table 3: Benefit table

Most of the issues were related to finding information which seems to be a common issue within manufacturing companies [20]. In the executive feedback, figures 3 and 4 were used to highlight the current situation.

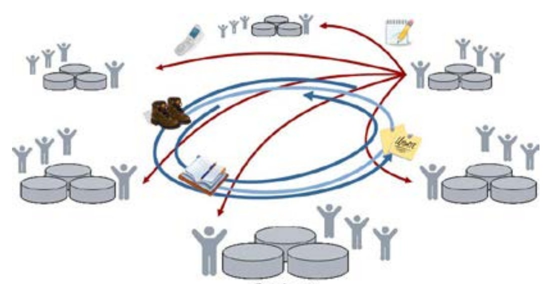

Figure 3. Findings and information: 1

Figure 4. Findings and information: 2

The criteria used in the analysis process to build up the list of real and agreed issues was if it has been mentioned by three or more interviewees. More than 20 were considered agreed issues and a more detailed analysis was performed on them. Firstly, a relationship analysis was done to find out the relationship between the issues and three key areas of improvement that were found: Knowledge capture and reuse, communication and collaboration and finally product and process management and visibility.

4.3.1. Knowledge Capture and Re-use

One issue commonly mentioned during the interviews was how much interruption key staff have during a day. The design manager, for example, estimates that his department is interrupted for 40% of the average day of work; and the Production engineering manager estimates a 30% disturbance. This means that there is a high number of non-value-added activities influencing their delivery of value-added activity. The reason that they were interrupted was because of their knowledge of either the business or the products. - knowledge, expertise, experience is often just in employee's heads, and not properly recorded or documented..

Other company information was also buried within documents, emails and spread across dozens of physical cabinets. This uncontrolled environment included 80% unstructured data and related decisions, based on 20% of the available facts, according to the former Managing Director. According to reference [21] companies expect to lose up to 20% of their staff every year and some industries expect to lose 60% of engineering staff within the next 5 years. With all that accumulated knowledge there is a clear need to adequately document this knowledge and make it accessible to other staff (and safeguard it from commercial exploitation by competitors)...

According to [22]. the deployment of a Product Life-cycle Management (PLM) system helps to have a single source of product and process information. Therefore, knowledge can be stored in an explicit way, accessible by the relevant people which should result in a reduction in day-to-day interruptions. Table 3 shows a summary analysis of knowledge capture and re-use.

Suggestion	- Single, central source of product and process information - Design Automation utilising Templates - Consistent Tools and Methods across Engineering
Impact on Productivity	- Automated creation of best-practice deliverables - Faster Reaction to change
Impact on Business Risk	- Knowledge management (Explicit knowledge) - Efficient backup and disaster recovery (Single source of information)
Impact on Knowledge re-use	- Capture agreed best practice approaches (Always one way to perform the process) - Ongoing review and development of best practices (Process to review practices)
Key benefits	**- Reduced Business Risk** **- Increased Engineering Capacity** **- Improved Knowledge Re-Use**

Table 3: Knowledge Capture and Re-use: summary

4.3.2. Communication and Collaboration

Normally, the development of a new aerospace product requires a lot of effort to produce the right and accurate information to flow from upstream processes to deliverables [23]. Figure 5 provides an example of some important data that are normally produced in the new product development process.

Figure 5. Data produced in the new product development process (example)

With this amount of information, even with proper computer systems to handle and support the process, communication has a significant effect on process efficiency and product quality. Having a single source of information helps, but what is most important for both communication and collaboration is a way to control digitally the new product development process and procedures (for example, via a workflow management system). Table 4r summarizes the findings related to communication and collaboration.

Suggestion	- Single, central source of information across the business - Aligned Tools and Methods across Departments - Workflow Managed Processes
Productivity	- Streamlined communication between departments - Concurrent working processes
Business Risk	- Effective handover between departments - Improved consistency of working methods
Knowledge re-use	- Multi-disciplinary Involvement - Wider access to product information
Key benefits	**- Reduced Product Development Lead Time** **- Improved Collaboration with Customers, Suppliers and Partners**

Table 4: Communication and Collaboration summary

4.3.3. Product and Process Management and Visibility

An example of how difficult it is to get product and process visibility and data consistency in the aerospace industry is the amount of important numbers that can identify a product. Works order number, part number, assembly number, change numbers, customer number, are illustrations of this complex issue. Tracking a batch number, a raw material reference number and a supplier number via a traceability systemr is often a complex and inefficient task. Figure 6 highlights the problem. Reference [24] concludes that Information Systems have been under-utilized in manufacturing companies, which has an effect on finding related information about product development.

Figure 6. Data produced in the new product development process

In the case study, it was established that an informal project plan was developed and just a few participants of the team knew its contents. In addition, the company was not capturing process performance information through process metrics, and even with some procedures documented, staff were not following them nor did they know of their existence in some instances. Reference [25] highlights that a project planning tool, integrated with a workflow management tool, helps to enforce processes and give visibility to product development. Table 5 below summarizes the Product and Process Management and Visibility findings.

Suggestion	- Project Planning - Ongoing capture of business metrics - Process Enforcement
Productivity	- Increased visibility of project status - Improved Resource efficiency measurement
Business Risk	- Clear and agreed project prioritisation - Missed milestone alerting
Knowledge re-use	- Provision of KPIs to enable to focus Business Improvement. - Early indication of processes bottlenecks
Key benefits	**- Support Business Process Improvement** **- Improve Capacity to deal with increased workload**

Table 5: Product and Process Management and Visibility: summary

5. Conclusion

In conclusion, the in-depth case study research supports the view that ICT systems have a strong relationship with business process improvement. The improvement was evident in management tasks as well as technical activities used by all departments and functions scoped in this research. Results strongly suggest that ICT systems adoption has a positive impact on business processes within industry.

Within the company case study, a new business culture is being introduced based on findings that references [5] and [6] have previously documented. In simple terms, the new culture is based on doing things in the right manner, first time around - “there are many ways to do tasks but only the company way can be used”. The research found that the implementation of a new workflow management system could support and enable the introduction of this new culture.

The questionnaire, interviews and observations that were at the heart of this study confirmed that improvements were to be delivered in the case study by planned ICT systems implementation in a number of areas, including:

- Knowledge capture and reuse
- Communication and collaboration
- Product and process management and visibility

Reference [3] highlighted that the aerospace industry is facing a shortage of staff and a significant percentage ofcurrent staff are approaching retirement. Therefore, capturing the knowledge of both engineers and shop floor staff has become an important task and the research showed that by having a workflow management system integrated with a single central source of product information will help to alleviate the problem.

Market pressures are forcing companies to improve their efficiency and in particular the effectiveness to develop new products [22]. The study concluded that the usage of templates and adoption of industry best practice, especially on design, methods and quality, would speed up the overall process in combination with exploitation of appropriate ICT systems..

In summary, the following statements have been developed in response to the research questions:

- 1: The new product development process in the aerospace industry needs to be changed carefully and there are definite opportunities for improvement in areas such as knowledge capture and reuse, communication and collaboration and product and process management and visibility
- 2: ICT systems adoption has a large positive impact on business processes within industry
- 3: The usage of templates and industry best practices potentially speeds up the new product development process
- 4: A single central source of information across the business helps the transformation from tacit to explicit knowledge
- 5: A workflow management system supports the statement “there are many ways to do tasks but only the company way can be used” in enforcing company processes.
- 6: A workflow management system helps to collect business process metrics.

This research will continue by selecting a sample of six new products and using the process map to collect lead times for each activity in the process. That information will help the company to find the real new product development lead times, the queue time, potential bottlenecks and potential opportunities for parallel developments and process activities.

Overall, a better understanding of the role of ICT systems in industry was achieved showing that ICT will allow an engineering and manufacturing based company to be more competitive in today’s market. The deployment of ICT systems is one way to achieve process improvement and the integration between them accelerates time to market, reduces the risk associated with human error, thereby improving new product development quality.

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