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The Business Engineering Process in a complex production environment - a case study

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Abstract

The Business Process Reengineering (BPR) approach is proposing a radical "turn-around" of an enterprise from functional orientation to a process oriented structure. Key elements of the concept are the process view, the blueprint approach and the IT-focus.

The authors experience from a wide range of restructuring projects is that the BPR approach runs a high risk of failure and can lead to severe disturbances and agony when old structures are simply destroyed. Short term gains in efficiency through cost cutting measures do not deliver sustainable competitive advantage.

The case study decribes how enterprise modeling supports their comprehensive approach to Business Process Engineering (BPE). The key feature of the BPE approach is an integration of different methods and tools into a comprehensive methodology which leads to a process organization. BPE supports the long term and continuous enterprise development. The project described in this paper is focusing on IT infrastructure planning. The case highlights the complexity of such a task. When used within a comprehensive framework taking into account processes, organizational issues and IT systems enterprise modeling can be a powerful tool for the support of change.

Keywords

Business Process Reengineering, system analysis, business process, IT support, implementation, IEM, MO^{2}GO, production management.

G. Doumeingts et al. (eds.), *Modelling Techniques for Business Process Re-engineering and Benchmarking*

1 INTRODUCTION

Rethinking operations and the organizational structure is most important in order to meet the requirements of the market. Today, the market requires high level of customer orientation reflected in fast and reliable delivery of high quality products. Product-innovation in terms of product-functionality does not ensure competitive advantage. A high and widely unused potential lies in process innovation. However, this is hard to achieve. Processes have to be designed individually. Scope, responsibilities and IT support have to be clearly specified. In addition this has to be done consistently throughout the enterprise. Processes do involve people and information technology. Both are subject to a high level of inertia if not even resistance to change. This is why appropriate methods and tools for planning and implementation of new enterprise structures are required.

The attention of planners, which had been for a long time on a high resource utilization shifted to fast reaction. The availability of information, i.e. relevant data, does largely determine the effectiveness of processes. This is why IT systems planning is crucial for success.

In real life, a tendency to develop department specific processes and software supporting them can often be identified. Patches are developed to overcome particular problems. This approach bears a high risk of suboptimization. In addition it is very likely that the overview on systems functionality is lost partly - or completely - within a short period of time.

Other shortcomings do include the focus on technological issues. Very often processes are adjusted to IT solutions.

IPK has a different approach. The Business Process Engineering framework is looking at the proactive design of a market oriented enterprise. With the Integrated Enterprise Modeling (IEM) method it is possible to design processes, organization and IT systems and their interaction in an integrated fashion.

This contribution gives an an indepth view into an IPK Business Engineering Project for a manufacturer of aero-engines. The paper outlines:

- the goals of the project
- the project approach
- the method and tool applied
- results from the first project phase
- the future direction

The authors intend to provide an understanding of potentials and risks of a real-life business process engineering project. Being aware of the fact that scope, timeframe and consequences of such a project are often underestimated, the idea is to demonstrate how a comprehensive approach combined with a powerful method and tool for enterprise modeling can help to succeed.

2 THE COMPANY

The company is a manufacturer of aero-engines for long range business jets. It is a multinational firm producing at three different sites. Site A, which is responsible for the assembly operations and product development, is subject of this contribution,. The assembly operations do include development build and production assembly. Two production plants supply around 80 % of the parts and components. Production assembly at site A is just about to start. The transition from development build and test assembly with its project organization to production assembly is a major challenge for the company. Appropriate processes and IT systems have to be designed.

3 THE PROJECT

Under the pressure of delivery schedules for the first production engines becoming tighter different departments like engineering, configuration, materials management, production planning and assembly operations had developed their own understanding of future processes and systems. The binational character of the company and the different background in aero-engine development and production also led to different perceptions on how things should be tackled. Partly solutions in terms of IT systems have been implemented on department level. Systems have been chosen and introduced. The choice was made due to historical reasons on the one hand. Patch solutions to enable different local systems to talk to each other have been developed to get the job done. The different perceptions of how processes and systems should look like were not consistent.

The company initiated a project to design a system aiming to support planning and control of the production assembly. The system should support the assembly methods planners and the fitters which carry out the actual assembly operations. In addition the intention is to link the software and databases used by the designers, the materials management people and other departments. This is required to ensure proper documentation and traceability for every engine, which is a requirement of international law. Therefore the design of robust and well-defined processes is of utmost importance.

The IPK assignment was targeted to support the Assembly Planning System (APS) project.

4 THE APPROACH

Figure 1 illustrates the Business Process Engineering approach developed at the IPK Systems Planning Division.

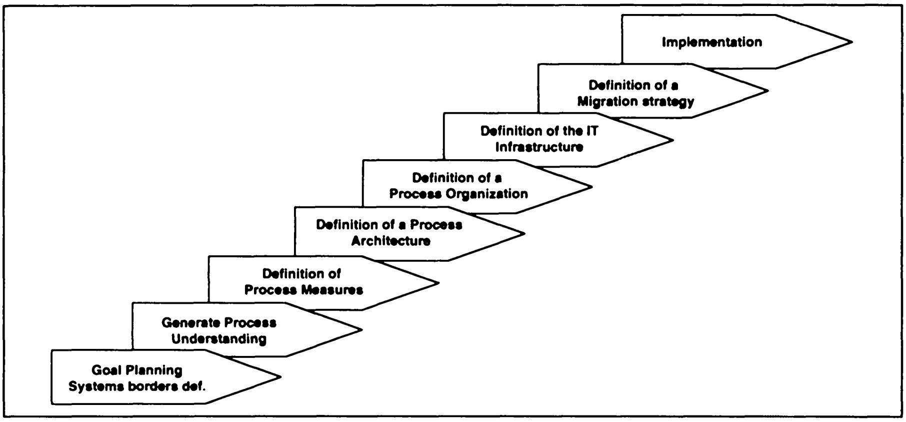

Figure 1 IPK approach to Business Process Engineering.

The framework consists of eight phases leading to a process organization. It is unquestioned that Information Technology (IT) does provide opportunities which can completely change the way a company is doing business. However, many projects today are IT-driven, i.e. a given IT infrastructure and bought-in software functionality determines process architecture[1].

The basic idea of the IPK approach is to balance this approach and to devise IT requirements and organizational structure from the process architecture. The objective is to implement processes with decentralized and thus clear, quick and manageable control loops. This requires a clear definition of process-chains and measures. Enterprise modeling supports the implementation of this framework from the analysis and the design phase including the development of migration strategies. The particular strength of IEM models is a consistent representation of complex systems comprising processes, IT-systems and organisation.

In the first phase of the assignment the IPK project team concentrated on the identification and integration the different planning states.

5 ENTERPRISE MODELS

Based on interviews with staff and management of various departments from engineering, production planning, assembly and materials management a process framework with beginning and end of process chains has been defined. Two process models were generated:

- Model A illustrates the current state of processes and systems at the factory. In this case the Assembly Planning System (APS) supports the production planning activities only.
- Model B shows the future state of processes and systems. In this case the APS supports the complete chain of activities from production planning to despatch. Model B refers primarily to planning with some exceptions most notably the introduction of the *Assembly Control* process. At this point it has to be stressed that this process & IT infrastructure is not yet what IPK would consider as ideal world.

Throughout the project the methodology Integrated Enterprise Modeling (IEM) and the object-oriented tool MO2GO based on IEM have been applied. Method and tool are both in-house developments of IPK (Spur, 1996). Figure 2 illustrates the basic structure of the IEM models.

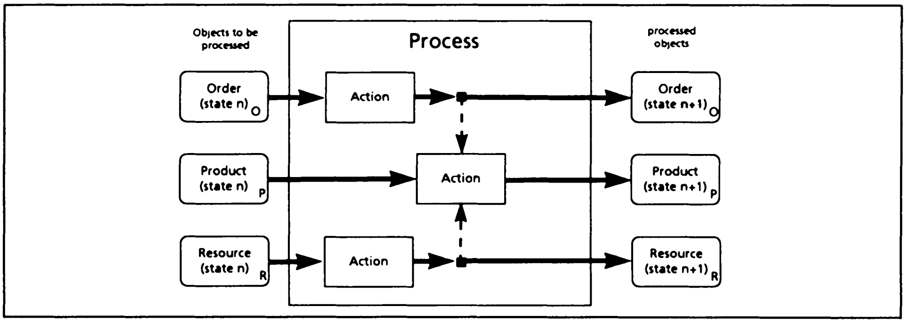

Figure 2 IEM classes and basic example for the modeling approach.

[1] We are aware of the fact that custom-made software is expensive and therefore we advise a well balanced make or buy decision on the basis of an evaluation of required functionality and standard packages.

Within an information model all object types identified within the enterprise are structured in terms of the generic classes order, product and resource.

The process model consists of Actions which link different object-states. The actions can be hierarchically decomposed so that a process framework can be mapped. The setup of the models is such that each horizontal level represents a process associated to a particular object. Product processes are located in the center of each page. Order processes control product processes. They are therefore located on top of each page. Resource processes, in this particular case the focus is on IT systems as resource objects, support the product processes. They are located at the bottom of each page. Figure 3 shows a cut out of the Assembly Methods & Supply Planning & Control subprocess of model A. The systems landscape supporting the actual process is mapped at the lower level of the diagram. During this first project phase it has been demonstrated that mapping down to data-object level is possible. The IEM models can therefore be used as specification for software.

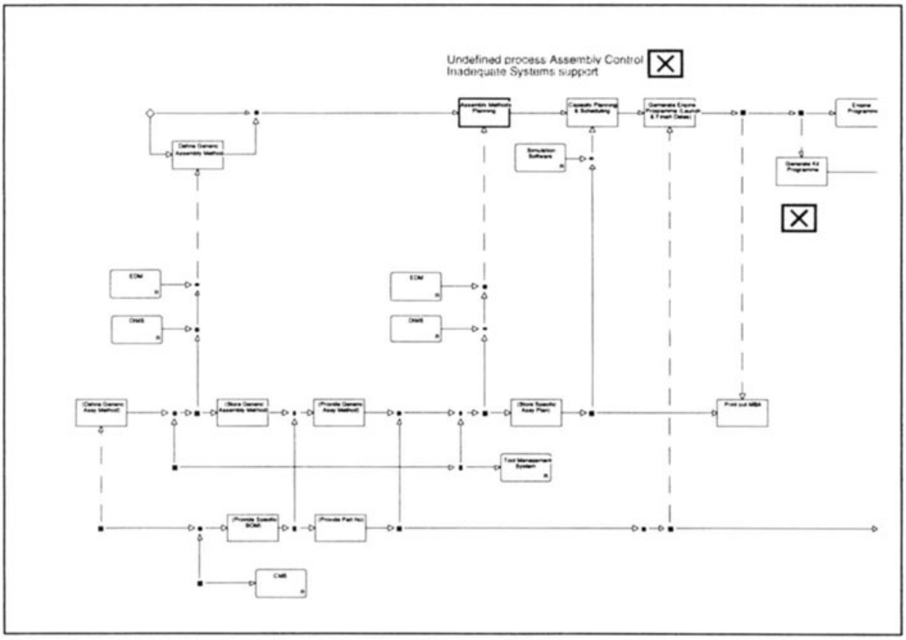

Figure 3 Cut out of a subprocess.

6 FINDINGS

In both models critical and undefined subprocesses, missing IT support and inconsistencies are highlighted. This applies currently in particular to the processes and the systems landscape and not to the organization. Two key aspects are evident:

1. First of all transparency with respect to processes, organization and IT-systems is not given. A consistent documentation of enterprise data does not exist. This refers in particular to:
   - An enterprise-wide consistent product documentation and parts classification. An example is the different product structure in the Configuration Management System (CMS) and in the Production Planning & Control (PPC) system. These systems are maintained by Engineering Department and the Material Management Department respectively.
   - A consistent description of the systems landscape. A documentation of all systems in use, their interfaces and their approximate functionality is not available.
   - A classification and a consistent documentation of processes within the firm is missing. An example are the widely used non-standardised process-maps.
   - The organisational responsibilities (process owners) are not transparently defined. In some cases, i.e. *Assembly Control*[2], such a specification does not exist at all.
2. Second, a number of symptoms for inconsistencies, undefined processes etc. were identified. These symptoms are at least partly the result of this intransparency. Some of these are:
   - Different planning states within various departments. Planning results are not consistently documented and as a consequence not sufficiently communicated within the firm.
   - Differences in expectations concerning APS systems functionality.
   - Fragmentary process design:
     - Undefined processes. An example is *Assembly Control* which is not defined concerning process structure, responsibilities and IT support.
     - Processes and systems at the three sites are not integrated. Artificial boundaries inhibit a smooth workflow. An example is the *Tooling Procurement* process where technical responsibility is at site A whereas commercial responsibility is located at site B.
   - Fragmented IT systems. The current design of the systems landscape supports processes partly only. Typical symptoms are:
     - Rekeying of data. Planners for example do have to generate and update two different versions of the Product Assembly Structure (PAS). The underlying reason is an incompatible data structure.
     - Redundant data which is kept in different systems databases. An example is the BOM which is kept in CMS and PPC respectively.
     - Incompatible systems. The fact that PPC cannot represent a full assembly sequence together with the respective part numbers results in an inadequate kit structure for assembly.
     - Missing interfaces between CMS, APS, PPC and other systems. Again the BOM is a good example. It is not transferred automatically from CMS to PPC.
     - Missing support of parts of the process chain. Even the current planning state of the APS system lacks support for a significant part of the planning process, refer to *Assembly Methods Planning*.

Besides the complexity of the planning task, missing transparency, i.e. an integrated view on processes, organisation and systems is a major reason for many problems. This problem is recognised throughout the company. The widely used non-standardised process mapping

[2] For clarity all processes and subprocesses are in italicised and underlined throughout this document

methods indicate that people are looking for solutions, for means of unification and communication at all levels. The disadvantage of the methods in use is that they are only intuitive to the people who generated them. They provide inconsistent representations of the facts only. Most likely critical aspects are hidden within arrows and data-store representations. Snapshots of the overall system are produced. Their reusability is relatively low and the effort for changes to existing maps is high.

With IEM models it was possible to integrate different planning states in a consistent model. Undefined processes and inconsitencies could be highlighted. Possible solutions can be communicated.

7 POSSIBLE EFFECTS AND RISKS

The challenge is the management of a controlled change from development build to production assembly. Current procedures are largely based on the informal structure of the development teams. This simultaneous engineering approach is certainly adequate for the development build phase. However, with processes, their deliverables, degree of freedom, responsibilities and last not least their IT support not being defined to a certain extend the company runs a high risk that inefficient structures will develop. Powerful departments within the firm might succeed in developing a process and systems infrastructure which is tailored to their needs rather than supporting global optimization.

A tendency to develop department specific processes and software can already be observed. At this point the solution strategy to obtain an appropriate kit-structure highlights the problem: The kit-structure provided to the fitters by stores does not represent the assembly method provided by the planners. In this particular case the root cause is that the PPC cannot represent the full Product Assembly Structure (PAS). However this problem is not treated directly. Rather a patch solution is developed. This strategy bears a high risk of suboptimization. In addition it is not safe concerning future requirements.

The fact that a piece of software is getting outdated within a certain period of time through the patches that are inevitably added to provide additional functionality requires a very rigorous and detailed planning of the data-infrastructure. If this is not done from the very beginning it is very likely that the overview on systems functionality is lost completely within a few years.

8 FURTHER ACTION

At this point, with its new plant site A just at the start of production assembly, the company stands a unique chance to develop an innovative process, IT and organisational infrastructure. It is evident that at the beginning of production assembly with a product range of size one complexity is still manageable. Once the number of product variants is increasing data complexity and volume is rising as well, not even taking into account history-data. Based on this BPE framework, the next steps to take within this project are:

1. The redefinition of the systems border and the scope of the enterprise model. The processes which link this plant to its suppliers and customers will be included, figure 5.
2. A further refinement, consolidation and extension of the existing enterprise models:
   - Review and extension of the existing information model. This does in particular focus on the following points:
     - The IT-systems analysis. In order to simplify the systems infrastructure the complete infrastructure has to be mapped in the first place.

- The product structure and
- The internal and external order-types

The Product, Order and Resource-objects and their class structure are defined via their attribute structure. These attributes have to be further developed.

- Review and extension of the existing process models. The required extensions to the process structure have to be defined. An additional representation of the organizational structure is appropriate for further evaluations of the model.

This results in an integrated model of processes, IT infrastructure and organisation: Figure 5 overleaf indicates the elements Process Structure, Product Structure, IT structure, Document structure, Order Control Structure and Organisational Structure.

The understanding of systems complexity is the basis for complexity reduction and the management of the remaining complexity.

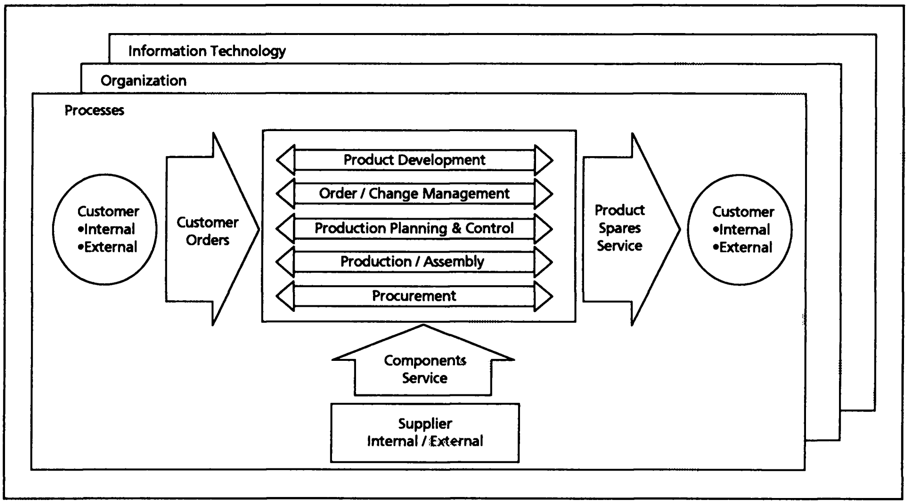

Figure 4 Scope of the target IEM model.

3. The definition of a consolidated process framework. The future process model should comprise all processes and cover the whole supply chain of the site A plant. In particular it is required to define:
   - Beginning and end of the process chains,
   - Process deliverables and responsibilities,
   - Process measures. They are building blocks for the installation of an efficient controlling system. In this context this does not refer to a management controlling system in the first place. Rather the objective is a to give the process owners the means to manage their process.

   The definition of a process framework also involves the redesign of existing processes e.g. supply, tooling procurement, etc. and the design of new processes e.g. production control. It also includes the development and evaluation of new structures for the assembly e.g. engine cells.

4. The development of a concept for the IT-infrastructure comprising the specification of interfaces etc. and the mapping of all requirement on the IEM-models.
5. The development of an organizational infrastructure supporting a decentralised control e.g. team structure in production control, tooling supply, or the evaluation of different options for manufacturing cell structures.

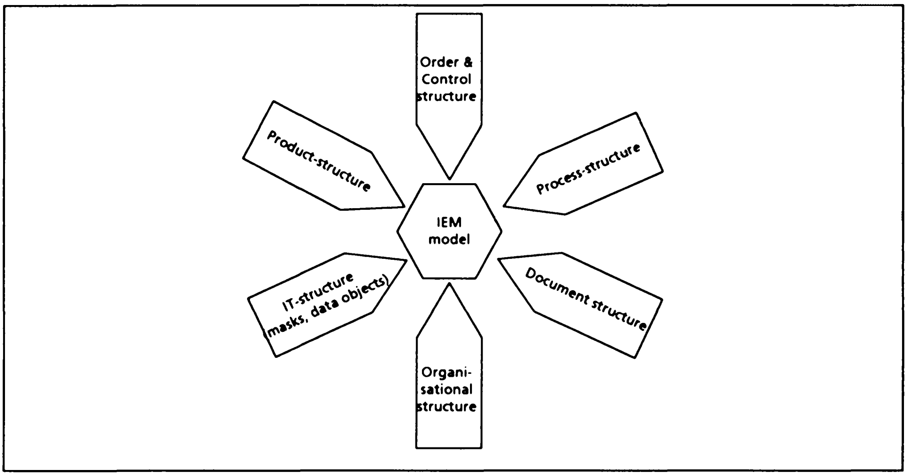

Figure 5 Scope of the IEM model.

6. The development of a migration strategy. For a successful implementation of the planned structure it is essential to develop a detailed migration plan with a specification of the steps required to achieve the new architecture.
7. The implementation. This step requires to set up an appropriate project structure. Based on the process measures defined earlier on an efficient controlling system has to be implemented.

The BPE framework is designed to avoid suboptimization within functions through an integrated view on processes, organisation and IT systems. A combined top-down and bottom-up approach is a key element of the practical approach. Enterprise modelling helps to reduce and to manage complexity after having generated an understanding of the systems complexity in the first place. The future IEM models will be based on the existing ones. This highlight the fact that enterprise models are not static but are capable to reflect changes to the structure. The result will be a model comprising not only processes but also the IT infrastructure and the organization. An implementation plan, i.e. the definition of migration strategies indicating how to get from current state to the desired future state will also be devised and visualized by IEM.

A further relevant aspect not yet mentioned are the evaluation functionalities of MO^{2}GO. In particular MO^{2}GO models do provide support for:

- The evaluation of processes and their alternatives:
  - Who performs a particular activity ?
  - What are the requirements / which conditions have to be fulfilled ?

- Which activities belong to a particular process ?

These queries are carried out via the attribute structure of the product- order- and resource-objects defined within the model

- The automatic generation of ISO-9000 documentations from an enterprise model. Again the strength of MO^2GO models are updates and modifications which are easily generated (Mertins, 1995).
- The specification of software functionality down to the data-object level. IEM can be combined with OOS (object-oriented specification method) which has been developed at IPK (Wilksch, 1994).
- The evaluation software systems. A scheme for process & software match has been developed (Neubauer, 1995).
- The development of migration-strategies. The steps to achieve the desired future state can be derived and visualised.
- The specification of simulation models. MO^2GO can be interfaced with any simulation tool. An interface to the IPK tool MOSYS does already exist. This will enable the planner to test control algorithms and simulate an enterprise in the near future.

9 CONCLUSION

The paper describes how IPK used its IEM method within the Business Process Engineering framework in a complex production environment. The enterprise models themselves prooved to be of lasting value. Besides the fact that a common basis for communication between systems analysts, planners, managers and specialists within the departments has been established and short-term gains are already visible, the real benefit of enterprise modelling lies in its long-term opportunities.

It has to be pointed out that enterprise modeling is an art. There is no method or tool that does deliver a transparent description of processes automatically. In this respect methods and tools for enterprise modeling are comparable to mechanical design technology and CAD systems. The benefits in terms of reduced time for modifications, the ease to generate alternatives and an increase in planning quality are undoubted.

Decentralization does not imply that an effort to integrate planning activities is not required any more. Efficient decentralized structures do not develop somehow automatically. In fact such structures do probably require even more sophisticated and comprehensive planning methods and tools. Decentralized decision-making requires a common basis of facts which is consistent and maintained on an ongoing basis. Efficient communication processes are of key importance. This is exactly what IPK is aiming at within the future phases of this project.

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11 BIOGRAPHY

Dr.-Ing. Kai Mertins, born in 1947, studied Control theory in Hamburg and Economy together with production technology at the Technical University of Berlin, he became member of the scientific staff of the University Institute for Machine Tool and Manufacturing Technology (IWF), Berlin. Since 1983 he had been head of the department "Production Control and Manufacturing Systems" at the Fraunhofer-Institute for Production Systems and Design Technology IPK (President: Prof. Dr. h.c. mult. Dr.-Ing. G. Spur), Berlin, where he is Director of Systems Planning since 1988.

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