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Implementing ERP Systems - Organisational Implications

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Abstract
Success of Enterprise Resource Planning (ERP) systems depends on rigorous and disciplined approach to planning and implementation. This paper presents a selection and implementation methodology that has been applied to three similar companies and highlights a wide variation in outcome. The underlying reasons for the variations in success can be specifically attributed to organisational personalities and culture. Analysis of these case studies provides key lessons and concludes by summarising these lessons in a cause and effect diagram.

Keywords:
ERP Implementation, Process Industry, Organisational Culture

Introduction

This paper is based upon the practical experiences of the authors as consultants assisting with the selection and implementation of business planning and control systems (Vollmann, 1988) in three different manufacturing companies. The work reported was not designed as a structured research programme per se, but it is based on the use of a selection and implementation methodology, which was applied consistently in three very similar companies with different personalities, culture and reasons for implementing. The comparison between the companies leads to interesting lessons with respect to the organisational personalities, culture and successful implementation of the system.

The ERP Implementation Methodology

A standard methodology to facilitate the selection and implementation of an ERP system had been developed based on Oliver Wight's methodology (Wallace, 1990) and was applied to each of the three companies examined. The methodology consists of seven phases:

Phase 1 - Vision and Commitment
Implementation of a new Business Planning and Control Systems represents a major investment (Markus & Tannis, 2000). It is therefore critical that the organisation creates a common understanding of what they are aiming to create at what cost and for what benefit. During this phase the following are established:

- *A vision* into how the company should organise and manage its operations and the enabling it to maintain and improve its competitive advantage through simple, rationalised and robust systems.
- *An Action Plan* by which the above vision could be achieved with realistic time scales.
- *Define project organisation* – definition of the Steering Committee, selection of the Project Manager and the project team members
- *A total project budget* including software, hardware, communications, consultancy, training, travel, etc

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- ***A cost benefit profile*** linking operational performance improvements expected through implementation of the ERP system (expressed in terms of operational performance measures) to business results (expressed in terms of the profit and loss account and the balance sheet)

Phase 2 - Business Process Engineering

Based on the Vision the company's staff map key business processes as they are today and then move on to simplifying and rationalising these using new systems where possible.

Phase 3 - Statement of Requirements and Invitation-to-Tender

Statement of Requirements for and ERP system based on the new process models are developed. This define how the company would like to run their business using the new systems.

The Statement of Requirements (SOR) is used to develop a detailed Invitation-to-Tender (ITT) where each potential supplier has to respond point-for-point against requirements stated, this provides protection for future incompatibility issues.

Initial research is conducted and 8-12 potential suppliers selected following discussions with the project team and the steering committee. The ITT is circulated to the selected suppliers.

Phase 4 - Systems Selection and Contract Negotiation

Three to five suppliers are short listed from the responses received. The short listed suppliers are invited for presentations and further discussion. The short list is cut down to 2 or 3 suppliers where reference sites are visited by the project team.

A decision is made with one preferred supplier and the contract details are negotiated. At this stage it is strongly recommended that the suppliers response to the ITT be formally built in to the contract. This offers protection in the event of supplier misinterpreting or ignoring stated requirements.

Phase 5 - Implementation Planning

A series of workshops are facilitated to develop a detailed implementation plan. These workshops are attended by the project manager and project team, as well as the suppliers support staff.

Phase 6 - Implementation

This is done in accordance to the implementation plan agreed in the previous phase. With minimal interference from outside, the Steering Committee Meetings conduct regular reviews throughout and at critical points during the implementation.

Phase 7 - Post Implementation Review and Fine-Tuning

On completion of the implementation, once the system has settled down a review is conducted of the new systems and processes to those intended at the outset. An action report is produced to fine tune the system and processes to maximise the business benefits achieved by the system. A separate report, outlining the business benefits achieved, is also produced.

Essentially, all three companies used the same methodology consistently. Although at a micro level there were some differences between how the three companies used the methodology, these were mainly to accommodate company specific variations and, in the opinion of the authors, do not represent significant variations from the core methodology as outlined above.

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The following sections outline how each of the three companies specify, select and implement an ERP system using this methodology. In these sections emphasis has been placed in discussing and highlighting the key differences between the approaches adopted by the three companies rather than providing a detailed step-by-step account of each of the projects.

Company A – natural mineral water

Company A is a privately owned business, which specialises in the extraction, bottling and worldwide distribution of natural mineral water. It employs 180 people with a turnover of £26m.
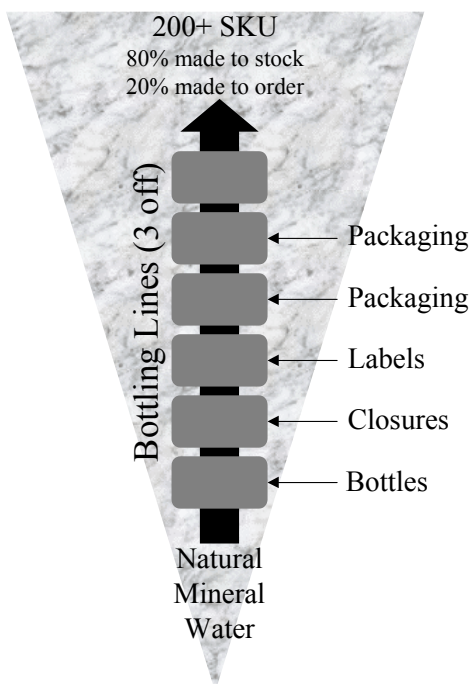

Figure 1. Manufacturing process in Company A

The manufacturing process is a V-type process as illustrated in Figure 1. The natural mineral water is the main raw material, which is then packaged along the bottling line. The process uses a variety of different bottles differing in size and material (PTA, PVC and Glass). This results in more than 200 stock keeping units (SKU). Approximately 80% of the SKUs are produced to stock and 20% are made to order.

Company A embarked on a 12 month ERP project to make its financial systems Year 2000 compliant and to instil enterprise wide functionality to cope with projected growth. To enhance the technology transfer, a government funded partnership (a TCS programme) between university and Company was used which involved recruiting graduates on two year contracts that the Company intended to (and did) subsequently retain within the business.

Vision and commitment

The vision for the project was developed as a result of the consultants capturing the views of the individual managers and then working with the management team to refine this vision. Throughout this phase the management team showed great interest and enthusiasm in the vision. They used the vision created by the consultants to develop a more detailed and refined vision. As a result the Company had ownership of the vision from the outset.

The project was managed by a director level steering committee. The committee met regularly, challenged perceived changes to plan and gave full and public support to the project. The core project team consisted of a full time project manager, two full time graduates and a part time IT manager. The full time team incorporated key individuals from the business departments.

Business process re-engineering

Phase 2 used business process reengineering (BPR) to establish the new rules and processes for operating the business. First an intensive two-day weekend basic training course in the business and operational aspects of ERP for a wide variety of staff from all areas of the business was held.

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The process teams, i.e. those people who work along the business processes, attended BPR workshops during which the facilitator used the group to clearly map out the new processes using post-it notes. During the workshops the group challenged current practice and obstacles.

The new processes mapped out were significantly different from existing ones. The individuals within the workshops developed clear understanding of the processes and worked as a team to ensure all stages of the process were covered.

Statement of requirements and the invitation to tender

The full-time project team prepared the statement of requirements based on the new process models. The statement of requirements was then given to process teams for review and sign-off. In this case this took quite a long time as the process teams and the senior managers showed real interest in the details of these processes and requirements. This resulted in several refinements to the new business processes and to the statement of requirements. Eventually, the invitation to tender was issued out to eight potential suppliers.

System selection

Both the senior managers and project team members attended almost all of the presentations, meetings and discussions with the potential suppliers demonstrating real interest in the project. Virtually every one of the senior management team and project team members was involved in the final decision in selecting the ERP solution and the supplier.

Planning and Implementation

Implementation planning involved a demanding and intensive five month programme of extensive training and system specification. The core team spent an average of 4 weeks each over a period of 8 weeks on software supplier ERP courses as well as courses on networks, servers and business intelligence. These courses brought not just familiarisation of the systems but the foundations of independence which would see a rapidly reducing reliance on the software vendor to the extent that the Company had developed system knowledge at levels to challenge the vendor.

Using an aggressive implementation schedule (Wallace, 1990) the steering committee's regular and detailed pressure on the core project team resulted in regular and detailed pressure by the core team on the software vendors. Outstanding actions were constantly monitored and quickly resolved. The increasing skill level within the Company allowed increasing independence and so new actions on the vendor rapidly decreased.

Throughout the project only one minor difficulty was encountered, which was that the vendor double booked its staff and technically failed to provide support for appropriate data transfer. Despite this one month set back the remaining part of the implementation went to time, mainly as a result of the long hours and dedication by all (not just the core team) in the Company.

In the latter stage of the implementation the Company ran the old and new system in parallel to ensure accuracy of the configuration and adherence to procedures. This led to high levels of overtime and, at times, confusion over new and old software and procedures but allowed a rich environment to develop and debug the new system. The new system went live 6 months after delivery of the software on site.

Post implementation audit

In reviewing this implementation:
  - The system was implemented within the given timescales
  - The project was completed below budget with considerable under spent in vendor support and consultancy

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- Everybody felt positive about the new system with some minor exceptions where workload had been increased in order to improve the financial and business controls
- People, as they discovered how they could use the system better, requested additional functionality to be made available resulting in the Company making full use of the systems capabilities.
- The system is core to the business operations and is used by all staff throughout the order fulfilment process.
- It is significant that since the implementation the Company's annual turnover has increased from £19m to £27m without an increase.

In this case a number of issues stand out. These are:
- All members of the Company demonstrated real interest and commitment to the project.
- The Company was quick to develop systems skills internally to support the implementation and continuously improve it afterwards with little support from the vendors.
- The culture of the Company is a can-do culture where when people commit to do something, it is expected that they will achieve it within the given time scales and budget. People do not look for excuses. When they encounter problems everybody gets involved to overcome the problem. As a Company they do not let problems jeopardise progress.

Company B – speciality chemicals

Company B is a subsidiary of a UK multinational, but it operates as a completely autonomous independent operation. It produces speciality chemicals used in a variety of specialist industries worldwide. It employs 400 people with a turnover of £40m.
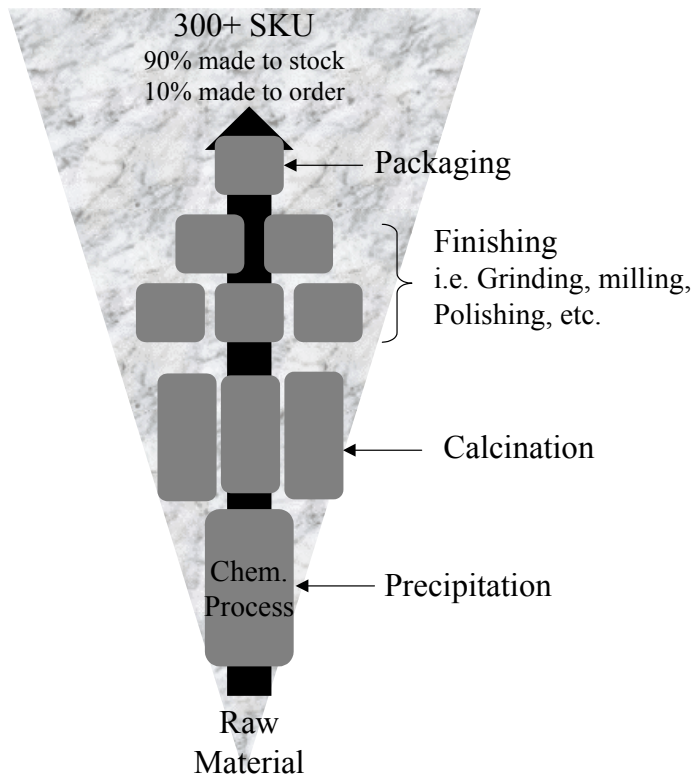

Figure 2. Manufacturing process in Company B

In this Company manufacturing process is also a V-type process as illustrated in Figure 2. The raw material is precipitated in the chemical process. The resultant by-product is either progressed directly to finishing or dried in one of the three calcinators. The product or by-product is then finished and packaged according to the product specification. The process results in more than 300 SKU's based on:
- the particle size from calcinations,
- the finishing process applied and
- packaging variations (i.e. different sizes of bags).

Approximately 90% of the SKU's are produced to stock and 10% are made to order.

Company B embarked on a 15 months ERP project in order to reduce its cost base through gaining better control over its business.

Vision and commitment

The Company's parent group recruited a consultant who was imposed on this Company. The consultant recommended that the Company should strive to achieve Oliver Wight's Class-A excellence (Wight, 1993) which was accepted by the local senior management team but with some reservation. One strand of this vision was to specify, purchase and implement an ERP system.

Through an ERP awareness session and one-to-one interviews with senior management a detailed vision statement for the implementation of ERP system was established. The process took six weeks from initiation of the overall project to completion of this first phase. Management committee and enthusiasm was high and there was a common, accepted vision of the need and results of change. In hindsight, in contrast to our experience with Company A, it was felt that the vision was accepted with little discussion and amendment by the Company staff. It is felt that the some of the senior managers, and particularly the project team, had little involvement and ownership of this vision.

The project was also managed by a director level steering committee. The committee initially met regularly but, as the project progressed, the steering committee meetings became less regular due to unavailability of some of the senior managers. The core project team consisted of a full time project manager, and a full time consultant but the key users representing functions across the business were part-time members.

Business process re-engineering (BPR)

Following initial concern by junior staff as to why they were attending a meeting with senior managers, the workshops were relaxed and productive. The BPR phase was consistent across all three companies and there was little change in style here compared to the mineral water company. Post-it note process maps from the BPR sessions were formally mapped out, approved by all levels of the Company staff. Again, whilst on the surface the BPR workshops progressed well, the project team participants were more concerned with the detail of what they were going to see on the screen of the new system and failed to understand and contribute to the overall business process. This resulted in failure to include some of the real critical detail in the process.

Statement of requirements and the invitation to tender

This phase progressed as outlined earlier. However, the company felt that the preparation of the statement of requirements and the invitation of tender from the newly defined business processes was an administrative task and decided to hire in temporary assistance. The temporary staff, although a manufacturing graduate, in one week, was able to develop the statement of requirements and the invitation to tender from the process models with little input from the Company personnel. The statement of requirements and the invitation to tender was circulated and was accepted and signed-off with virtually no modifications. Whilst the specification of requirements was believed at the time to be a comprehensive definition of the business, it was later established that missing elements and ambiguous detail contributed to the need for software modification and additional vendor consultancy.

System selection

The system phase progressed as outlined following meetings, presentations and visits to reference sites with the software vendors. In this case, the system selection was conducted primarily by two senior managers (the project sponsor and the project manager), involvement of other senior managers was limited at best. By the time the project team was exposed to the details of the system the decision was already made. In effect, the project team was only involved at the last stages of this phase as a token gesture before a formal announcement was made.

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Planning and Implementation

The implementation planning phase was perhaps the most frustrating phase and serious delays resulted. The software vendor refused to plan their initial resource allocation prior to formal contractual sign off, resulting in a month delay. Further time was spent on repeating work of the vendor's pre-sales team with the implementation consultants.

Around this time the business also started experiencing severe operational problems resulting from unreliable plant and loss of skilled staff as part of a wider redundancy programme. One of those lost from the business was the original project sponsor who had exerted constant pressure on the project manager and consultants. This occurred at a critical time when training of the Company key implementation staff was planned. Most of the staff had good operational knowledge as well as systems/IT awareness but were part-time members carrying out their full operational roles, hence the project manager's control was stretched. As operational problems emerged these staff should have been developing the knowledge of the software at such a level that they could challenge the software vendors on the detail rather than rely on them for the basic configuration. As a result of the distractions, to keep the business running and revenue flowing, key knowledge of the system was not absorbed resulting in on-going delays to the project.

Progress was slowed down further as different parts of the business did not deliver their area of the project as they suspected that other areas were behind them. A vicious spiral of slowing down resulted. Whilst the project manager reported to a steering committee, hindsight showed that the steering committee accepted delays but did not ensure detailed revised plans were adhered to. As business pressures increased, the steering committee exerted less pressure on the project manager and therefore weakened the project manager's muscle to deliver elements of the project. Apart from the project manager, the project team had a number of other full-time members. All these full-time members had technical/support roles but were all contractors to the business and this knowledge could be lost from the business at the end of the project. Despite this, due to the pressures to complete the project, these full-time members carried out significant configuration and testing work, often in place of the absent part-time members who would eventually be key users of the system.

Whilst the relationship with the software vendors was good and they insisted in calling one of their staff the project manager, however, their objective was to deliver their element of the project, not deliver the project as a whole. This attitude often resulted in problems with delivering certain aspects, for example the vendors had internal staffing problems but failed to react and refused subsequently to accept responsibility that this would result in delays to the published plan.

Initial pilots produced reasonable confidence that the system would work. But, following the initial pilots, insufficient time dedicated to the project by core employees responsible for implementing the system resulted in subsequent pilots floundering. The volume-pilot to test volume of transactions within the system contained last minute, on-the-fly configuration, which were totally unexpected.

To reduce the risk of failure the implementation was phased to replace current sales order processing followed by new manufacturing modules. The first phase gave subtle but significant benefits (such as integral forecast consumption) whilst the second phase was to bring formal planning across the remaining parts of the business.

Post implementation audit

In reviewing this implementation:
- The system was implemented with significant delays.
- The project budget was significantly overspent.
- There were mixed feelings about the new system.

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- Primaily the new system replaced the functionality of the old system with some, limited, additional benefits.

In this case a number of issues stand out. These are:
- Although the senior management team of the Company demonstrated real interest, they failed to engage in the detail of the project.
- Over the life of the project there were a significant number of senior management changes resulting in continuity problems.
- The process owners, i.e. the project team members, although appearing to be involved, were not fully engaged in the BPR and selection processes. They failed to engage themselves in the detail of the processes, the SOR and ITT.
- Due to lack of involvement at detail level and passing this responsibility to outside contract staff, the Company failed to develop critical systems skills internally to support the implementation and continuous development of the system. It now remains fully reliant on the systems vendors.
- The culture of the Company is one that expects failure. When they plan to do something they fully expect to miss the deadlines and exceed the original budget. It is as if people constantly are looking for excuses for not doing anything. In our opinion, the real problem is that most of the people want to make decisions but they want to leave implementation of these decisions to someone else.
- In general, in this Company they try to do too many things at the same time. In short, they lack focus. During the ERP project there were at least five other major projects/initiatives were running in parallel.

Company C – carbon fibre

Company C is also a subsidiary of a German-American multinational. It also operates as a completely autonomous independent operation. It specialises in production of carbon fibres from precursor, which are then used in a variety of specialist industries worldwide. Company C employs 200 people with a turnover of £16m.
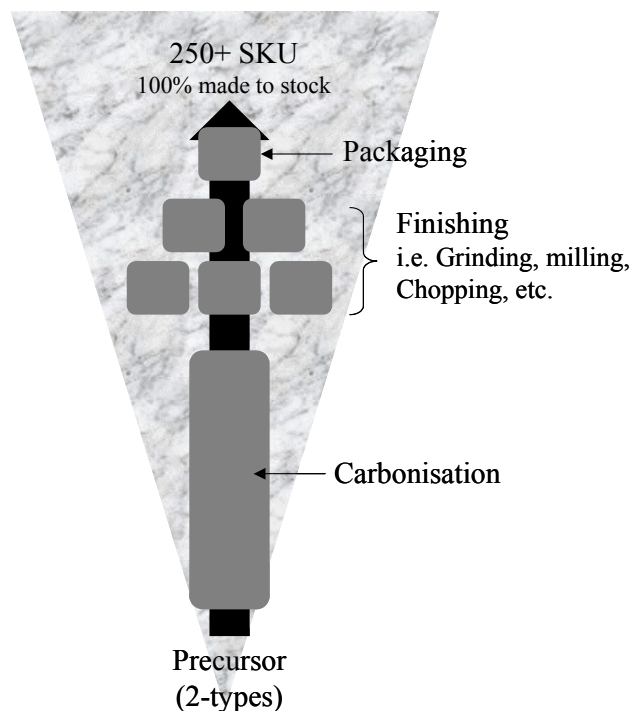
In Company C the manufacturing process is also a V-type process as illustrated in Figure 3. The raw material (i.e. Precursor) is carbonised in a series of ovens. The resultant carbon fibre is then finished by grinding, milling or chopping and packaged according to the product specification. The process results in more than 250 SKUs based on:
- the carbonisation process
- the finishing process applied and
- packaging variations (i.e. different sizes of bags).

100% of the SKUs are produced to stock .

Company C embarked on the ERP project to gain better control over its business and to cope with projected growth.

Figure 3. Manufacturing process in Company C

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Vision and commitment

About a year after the decision to implement ERP, the project officially started with the appointment of the authors as the consultants. The vision for the project was developed as a result of the consultants capturing the views of the individual managers and then working with the management team to refine this vision. Throughout this phase, the management team showed passing interest and little enthusiasm in the vision. They accepted the vision developed by the consultant as presented.

The project was managed by a director level steering committee. Virtually all steering committee meetings were either cancelled or rescheduled due to unavailability of the Managing Director who chaired the steering committee. The core project team consisted of a full time project manager, a full time IT manager and full time team incorporated key individuals from the business departments.

Business process re-engineering

This phase was conducted in an identical fashion to that with Company A. The project team members were fully involved and engaged in reviewing the existing business processes and re-engineering these to make them more streamlined, effective and efficient. This resulted in the development of very detailed business process models for the new business.

Statement of requirements and the invitation to tender

The project manager and the full-time project team prepared the statement of requirements themselves based on the new process models. The statement of requirements was then given to process teams for review and sign-off. In this case, although this the process teams demonstrated real interest and engaged themselves with the critical review of these processes, the senior managers (with the exception of one or two) showed only passing interest and just signed-off the requirements based on the say-so of the process owners. The invitation to tender was issued out to seven potential suppliers.

System selection

Just after the project team attended the first meeting with the potential suppliers the parent Company instructed the Managing Director to suspend the ERP project. This was because the new Group Finance director wanted to standardise ERP systems globally using SAP R3. Although the senior management team were relatively unperturbed with this decision, the project team, consisting of process owners and key users, virtually revolted against the group decision.

Up to this point the project was progressing extremely well, however this action by the Group organisation resulted in delays of at least six months. During this time the group organisation agreed that the internal SAP specialists would respond to the ITT as if they were an independent/external ERP supplier. The project team accepted this with some degree of caution. The tenders demonstrated that SAP R3 was more than capable of fulfilling the requirements stated. The Group Finance Directors argument was that, as the corporation had a worldwide license for SAP R3, it would also be the most cost effective option. The project team argued that SAP was more complicated than required and implementation costs would outstrip any cost savings on software licences. The objections of the project team were overruled and SAP R3 was imposed on the Company.

Planning and Implementation

Planning was done exclusively by a project team, comprising of Company's group SAP experts, who were shipped from Germany. Little consultation had taken place with the local project team, although the project manager was fully involved in the process.

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At the time of writing, the implementation was just starting over two years after the initial decision to implement ERP. For this reason we are not able to fully report on the outcome of this particular case. However we will use this case to predict the potential result of this project.

Prediction of the Project Results

Almost certainly this project will end-up a failure for the following reasons:
- In the first instance the senior management were not fully engaged in the process of implementing ERP, even though it was their decision to implement ERP in the first place.
- The implementation may have been successful due to the efforts, commitment and enthusiasm demonstrated by the project team and the amount of resources the local senior management were able to free-up and commit to the project. However, the heavy handed approach by the Group organisation completely de-motivated the project team and some of the senior managers.

Analysis and Key Lessons

The detailed description of the three companies has highlighted differences in the operating environment, business pressures, personalities and organisational culture and uncovered common themes running through each. This section summarises these observations.

Project management

Each of the companies had developed a common structure of external consultants, steering committee, project manager, core team and full team. The main differences uncovered were the make up of the steering committee and core team. Stability of the membership of the groups, and clear and constant pressure exerted by them, made a significant difference to the speed and accuracy of implementation. In the cases were timescales rarely slipped, the steering committee tended to be aggressive, questioning and attentive to detail.

Implementation philosophy

Whilst each Company had relatively little prior knowledge of ERP, there were significant differences in attention to process detail, acceptance of outside help and acceptance of changes to project plans. The companies that single-mindedly absorbed and retained system knowledge developed quickly and were able to react to changes in configuration with minimal reliance on outside help. A significant difference in culture towards commitment to deadlines was observed between companies ranging from embarrassment if caught slipping on any deadline to simply needing to avoid being caught as the one who dropped the batton.

Project team

Each Company had a combination of full-time and part-time team members. Experienced project managers with a manufacturing background were used throughout and each team had a mixed membership of business, manufacturing and IT staff. The proportions of full-time and part-time staff was similar in each Company, however, in some cases most of the core team members were acting in support roles on short term contracts, resulting in long term issues about retention of skills and independence of operation of the new systems.

ERP and IT skills

In each Company the initial level of IT skill was roughly similar, with each having on-site IT staff with good systems skills. Each Company had relatively little prior knowledge of ERP but had different rates of take up of the new knowledge, mainly as a result of business distractions rather than intent.

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Business stability and focus

There were significant differences in stability of businesses as well as their management teams. Implementations with stable management teams were swift and effective. In other implementations the varying nature of management focus was felt by the core project team as well as the wider Company staff, resulting in problems of continuity of work on the project. The continuity also resulted in time and cost inefficiencies as vendor consultants were not always fully utilised and frequently had to repeat training or configuration.

Attention to detail

Attention to detail had significant effect on project time and cost. Those companies that refused to accept plans (such as the ITT) without rigorous review and taking ownership found that subsequent progress suffered less disruption, less remedial work and a more commonly accepted vision from all staff. In particular, where the steering committee showed rigour in the review of plans and progress, this cascaded down to all aspects of the project through the project team to the Company staff, software supplier and university consultants.

Conclusions

The use of a well-defined methodology is an important foundation on which to implement an ERP system. Of the three case studies introduced there were varying degrees of success in using this methodology despite having similar process characteristics. Many of the factors that contributed to success are the conditions under which the methodology is executed, such as attention to detail, stability of team membership, ERP/IT skills, etc. Whilst there were modifications to the methodology at a micro level to accommodate company specific detail, the variation in ERP implementation success can be attributed to organisational personalities and culture.

Analysis of the three case studies leads to key lessons on project management, implementation philosophy, project team, IT awareness, business stability and attention to detail. Synthesising all the lessons learnt from these case studies into a simple cause and effect diagram, see Figure 4, enables a clearly summary to be devised. In future ERP implementations this diagram could be used as the basis for an audit check list to assess the health of project and highlight areas of concern in a structure manner.
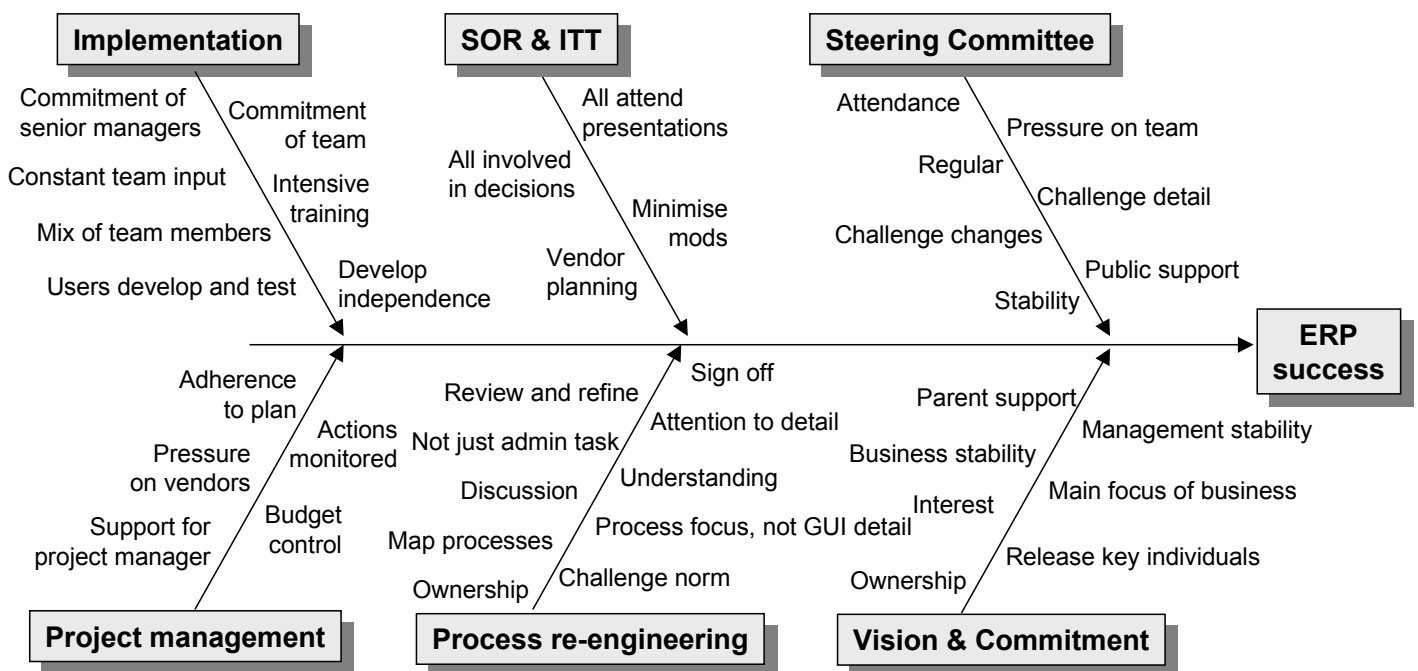
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Figure 4. ERP success cause and effect diagram

References

Markus, L. and Tanis, C. (2000). The Enterprise Systems Experience – From Adoption to Success. In Robert W. Zmud, Michael F. Price (eds), *Framing The Domains of IT Management: Projecting the Future Through the Past*, Pinnaflex Educational Resources Inc., pp. 173-207.

Vollmann, T.E., Berry, W.L., and Whybark, D.C. (1998). *Manufacturing planning and control systems*. Irwin.

Wallace, T.F. (1990). *MRP II: Making It Happen: The implementers' guide to success with manufacturing resource planning*. John Wiley & Sons.

Wight, O. (1993). *The Oliver Wight ABCD Checklist for Operational Excellence*. John Wiley & Sons.