On the implementation of production management systems in the graphic arts industry

LEIF HANDBERG

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Abstract
The graphic arts industry has for a long time industrialized itself primarily by implementing new technology. Organization and management have not been correspondingly developed. This can be explained with that graphic arts is an early handicraft activity and that influences and impact from other industries has been low.

The graphic arts industry faces today many challenges, both larger competition within the industry (locally and globally) and also competition from, or need to cooperate with, other media. The graphic arts industry is no longer an industry of its own but a part of a larger media or communications industry that is facing fragmentation of markets, convergence of technologies and consolidation of companies.

In this study I have been looking at workflows at commercial printers to find common characteristics despite differences in order frequencies and volumes.

I have also used the ”multi level approach” to establish what levels that must be considered before an implementation of a production management system.

Finally I have studied organizational development and how a company can gain experience and knowledge and how a production system must support strategy and business concept development.

Organizational change and higher competence are the keywords and the need for these must not be underestimated. An implementation of a production management system is thus not only a technological matter (equipment, software and demands on functions in the system) but its success is depending also on competence at all levels in the organization and demands on routines within the organization.
Preface
I have a background in the graphic arts industry and practical experience from the implementation of a production management system. The implementation was difficult in many ways and I found little acceptance for the required changes within the organization.

Later, as a researcher I have had the opportunity to study a number of companies in the Swedish graphic arts industry that have shown interest in the need for changes in production management routines and how these shall be achieved.

The research has been done within an industry financed project which has resulted in a number of conference papers and articles, some of which form the basis for this licentiate thesis.

The project has also produced a generic requirements list for production management systems with the objective to make it easier for companies within the graphic arts industry to implement production management systems.

I wish to express my gratitude to the participating companies (Bokbinderi-bolaget, Skogs Grafiska, Posten Frimärken, STC, Interprint, Sörmlands Grafiska, Strålfors and Graphium) and organizations (The Swedish Graphic Arts Industry Federation and The Swedish National Board for Industrial and Technical Development) for their cooperation and support over many years and also to my colleagues for making it possible to increase my own competence within this field.

Leif Handberg

Stockholm October 2003

- To my peace of mind -
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Appendix I
1. Introduction
The graphic arts handicraft has a long history. A major shift in production methods came around 1450 with Gutenberg’s improvement of the printing press and the use of lead based single movable types. The technology spread fast and soon became established. The next major shift came around 1800 with the industrial revolution. Industrialization means that production and employment increases and that technology, organization and social conditions changes (SNE 1998). Since graphic arts was such a well established handicraft, it retained much of its guild based organizational culture and the development was more focused on technology. The printing presses were built bigger and could print faster due to progress in material science and the development of paper making on reels (Ridderstad 1986). The changes in organization and social conditions were still minor. The traditional structure has had the consequence that the graphic arts industry has adopted few impulses from other industries, except when it comes to technology (Giertz and Reitberger 1987). This condition has continued and is today still a problem.

Most historical descriptions of the graphic arts industry are based on developments in technology. An organizational fact is that departments have been separated due to different technologies (Arnamo 1980). Although the workflow was common there was little need for communication between the departments.

Today, the graphic arts industry is facing rapid technological development, mostly within the prepress area with totally digital workflows, and also other structural changes initiated by changes within the media, information and communication industries (Comprint 1998).

1.1 The Graphic arts industry today (2002)
The graphic arts industry in Sweden consists of around 4 000 companies and employs about 35 000 people. Most of the companies are small, only about 600 of the companies have more than 10 employees and less than 100 have more than 50 employees. Most other countries has a similar structure in their graphic arts industries (GFF 2003).
1.2 The need for production management systems
Many companies show a need for better management routines and supporting systems when the development in the companies becomes more business driven than technology driven (Aniander et al 1995).

At larger companies and smaller companies with complex production, computerized production management systems can be helpful (Olhager and Rapp, 1985).

The goal is higher productivity, better control and increased flexibility which can be achieved with the help of better systems and routines.

Tangible benefits will be inventory savings, less floor space and higher quality. Intangible benefits can be greater flexibility, shorter throughput and lead time all as increased learning within the organization (Kaplan 1986).

1.3 Production management concepts
When implementing a company wide production management system, discussions about concepts are necessary in order to have the same definition on central concepts to make sure everyone is talking about the same thing. Especially in graphic arts companies where departments have been isolated as described earlier. Definitions of concepts have a way of evolving despite standardization efforts and industry practise.

Some fundamental concepts are production, production system and order which are discussed below. In encyclopedias the definitions of these terms are often vague or strongly influenced by some particular aspect. In other literature and in the industry there are many other definitions. There is also a language problem since there may not always be an exact translation between languages, e.g. the English word management cannot be translated into Swedish.

In the following I present some of the working definitions that have been used in this study.
Production
The transformation of production factors (labour, capital, natural resources) to services and products. Normally value increasing activities in a company.

Production system
Quoting the Swedish national encyclopedia, the translated definition is "all facilities in a company for manufacturing of its products, normally only machinery" (SNE 1994). In the situation of today with more systems supporting the production, it can be argued that a production management system is an equally important part of the production system.

Production management system, PMS
The definitions in use vary from a Business management system to a Production support system. In this study, the latter has been regarded more accurate.

Process (industrial)
From latin processus=lapse, course (of events).
An industrial process is something continuous controlled by target values and tolerances. In industry e.g. paper manufacturing. The printing process has this characteristic.

Routine
A routine is a repeatable activity within an organization, e.g. order registration that may use an order registration function within a system.

Function
A function is a possible operation within a system that can be specified in a system definition. A function can also be a position within an organization.

Order
The order concept can be used in many ways. It can be a production order for one printed product. It can also be a business order consisting
of several production orders. In a company wide information system these definitions have to be totally clear. Invoicing and profitability studies are made based on business orders. Production orders form the basis for production statistics.

1.4 Existing production management systems
There are today many computer based production management systems in the market with names based on their functions or names given by system manufacturers who want to distinguish their system from others. Here are some examples:

- PMS, Production Management System
- MPC, Manufacturing Planning and Control (system)
- MRP, Material Requirements Planning (system)
- MIS, Management Information System
- EIS, Executive Information System
- ERP, Enterprise Resource Planning (system)
- SCM, Supply Chain Management (system)
- Estimating System
- Inventory System

What is important, however, is not what a system is called but how it is used. (If only the estimating function in a MPC system is used, is it still an MPC system?). In Paper IV, figure 1 is shown a scheme of modules for administrative routines within a company. The systems above cover one or more of these modules in different combinations. Production data, such as order frequency, order volumes and production (or order) complexity determine which modules that need computer system support. In many cases manual routines are good enough if they are well documented and traceable, e.g. for quality assurance purposes. Common for all the systems are that they are information systems to support the production. Thus Production Support (Information) System may be a convenient generic term.
2. Graphic arts production

In order to provide a better understanding of the complexity of graphic arts production and of the demands that this will put on supporting systems and routines in the organization, a description of the main characteristics of the production process is provided in this section.

The graphic arts production process is complex. Although the final result obviously is a printed matter it is not the piece of paper itself that is important but the texts and images that are printed upon it and what message the sender wants to communicate.

![Diagram of the graphic arts production process]

*Figure 1: Planning objects through the graphic arts production. The numbers are marked in the boxes and are also used in figure 2 to show in which production phase different planning objects are used.*
The message consisting of text and images we can call the "customer material" from the point of view of a graphic arts production company. The customer material flows through the production on different carriers and in different subsets or planning objects. The production is converging in the beginning and diverging at the end (figure 1).

With converging production is meant production where raw materials and semi-manufactured articles are processed together so that what was many pieces from the beginning in the end is assembled to one item, e.g. car manufacturing (or all assembly industries). With diverging production is meant production where the first state is one item which in the process is divided to smaller pieces, e.g. cutting-up in a slaughterhouse. The different kinds of production has different needs for production and planning routines.

In graphic arts production there are first "material deliveries from the customer" (1). These can be divided into batches and be delivered at different times with different number of pages or amount of material. These deliveries may or may not be logically related with the sheets (signatures) that will form the final product in the finishing department.

At the next stage the customer material is located onto signatures (2). Different signatures can be printed in the same print run (3). This means that one production order can consist of more than one business order. The normal case is however a one to one relationship.

Finally, the signatures are assembled in the finishing department (4), possibly together with inserts (5). Some finishing is done on-line with printing. The number of signatures depends on size capacity in the printing presses and on the design and shape of the product, e.g. some pages may have different paper quality (grammage, cclour, etc). There might also be different editions (6) consisting of different signatures or different versions of signatures together with different configurations of inserts. An edition could also be a unique delivery batch.
Additional finishing activities such as addressing, coating, bundling, packaging etc are normally carried out before delivery, usually in batches (7).

Before the advent of digital technology, the workflow was totally physical with different technologies and different handicraft skills in different parts of the production. The customers delivered their material for a printed product as a layout, manuscript pages and image originals. Text and images were separated with text handled in the typesetting department and images in the reprographic department. Eventually they were combined on a printing form, in different manner depending on the printing process. After the printing, the printed product was assembled in the finishing department. Since the workflow was completely physical it was easy to assess the status for a certain order, and since the different work steps needed totally different skills they were organized in different departments with little need to communicate between them.

Today the situation is different. The process is usually totally digital up until the making of printing forms, or even into the printing press and the printing itself. This makes it more difficult to follow the workflow in the preparation stages before printing since there are no physical objects but digital files with no visual inspection possible. There are also often incompatibilities between subsystems. This together implies a need for better tracking routines.

Another change is that the customers today often themselves do a lot of the work and deliver semi-manufactured material. This has become possible through the development of inexpensive desktop prepress systems. The delivery point from customer to the graphic arts company can differ from customer to customer depending on how much preparatory work is done. The technical interfaces to the customers can also vary depending on equipment, system platforms, versions of software etc. The customer is no longer only a customer but also a sub-supplier. Many companies find this difficult since they from a business point of view have difficulties in putting demands on, and educating, the customer
as a sub-supplier regarding delivery standards etc. Skills also differ among customers with respect to delivering their material properly. Many customers believe that they deliver correctly but the graphic arts company has to spend much time on corrections and preparations for the subsequent processes. Many companies fail to get paid for this work. The same seems to be generally true for companies that allow customers to have an influence the product and the process late in the production process.

2.1 Production and planning characteristics
The production characteristics are different in the different work phases, see figure 2.

![Figure 2: The six phases of print production.](image)

Introduced in Paper I. In this version with added planning objects, 1-7 from figure 1, for each phase.

In the manufacturing industry, design is normally the first step in the production process but in graphic arts production design is not considered as a part of the production process since it is done by the customer and the customer does not consider themselves as a part of the production. This view can be debated.

The through-put times vary heavily within graphic arts production depending on product volumes, configuration and complexity. Generally through-put times are long compared to actual production time and decided by the planning function on the basis of earlier: production and workflow measurements. This makes the operation planning situation difficult since queues are often formed before the different workstages. There is also a risk for sub-optimization within different departments if the understanding for the need for an overall production plan is lacking.
A sub-optimized department can generate bigger queues than planned for further on in the production which increases the planning complexity. E.g. if there are eight orders in a queue there are over forty thousand different ways of running them! But when a decision is made on a production sequence and the first of the eight orders are produced, a new order may have entered the queue which means over forty thousand new alternatives…

2.2 Demands on a production management system
A production management system shall be designed and implemented to support company strategy (Vollman et al 1997).

It should mirror the production with defined cost centers, work centers, operations etc. In addition to this the supporting routines to the production process should be described.

It needs to be stressed that there is a difference on demands on technical functions within a system and demands on routines and competence in the organization to use them.

Companies that have been working with quality assurance following the ISO9000 standard will have significant support from the routine descriptions therein when establishing requirements for a production management system (Forsberg and Vikström 2000). The ISO9000 standard was earlier criticized to conserve old routines. It has now been developed and a larger focus is put on customer satisfaction and organisational change (ISO 2003).

Companies also need competence to define and describe the routines. If this is done by external consultants it will not be a part of the organizational memory.

A generic requirements list that also was a result of this study can be found in Appendix I.
3. The field of research

3.1 Research questions
This study has addressed the following major research questions:

- Is there a general way to describe graphic arts production with products and flows of information and material?
- What demands does the implementation of a production management system put on competence and organizational structure?

3.2 Research environment
The study was made within a research project called Little Sister with the subtitle ”Global Production Management for Graphic Arts Production - Commercial Printing”. With global is meant ”covering the whole process from original to finished product”. (See Bellander 1996)

The Little Sister project had a precursor in the Big Brother project (see Enlund 1998). In the Big Brother project, research was carried out concerning process and production management in the newspaper industry. Newspaper production can be considered a special case of graphic arts production with its own characteristics.

The Big Brother project concentrated on developing control models and methodology, production tracking, simulation, and prototypes. The work on production tracking has been closely associated with the definition of a recommendation for an international standard, IFRATrack (Thoyer 1996). The project resulted in a prototype which has been further developed to a system commercialized in a spin-off company. It also resulted in two PhD theses (Nordqvist 1996, Stenberg 1997).

The Little Sister project had the following overall goals:

- To analyse and describe production processes and workflows in different types of graphic arts companies in order to identify bottlenecks and problem areas and to define the need for global production planning and management.
- To develop general models and methods for an integrated, global production management for graphic arts companies which are extendable also to their customers and subcontractors.
• To transfer results from the Big Brother project, especially analysing tools, management models and system principles, into the commercial printing sector.

• To develop new knowledge, methods for practical use, and technical solutions for a better global production administration at commercial printers in order to increase their productivity and competitive strength.

3.3 Other related research
I have found very little previous research related to the questions addressed in this thesis.

There are some conference papers on production management (Enlund 1998, Bäck et al 1995). The general conclusions in most of these papers are that the graphic arts industry has much to learn from other industries regarding CIM, computer integrated manufacturing, standardized protocols to describe products and production, the need for strategies and the need for competence.

Regarding the implementation of production management systems, one study made at a graphic arts company first found negative effects from a sociological point of view but in the end concluded that it could be a reasonable solution, provided development were also made in the organisation (Bowers et al 1995).

The importance of organizational development and better human resource strategies within the Graphic arts industry has been stressed by Politis (2001) and Koulouvari (2002).

3.4 Delimitations
This study does not cover the financial aspects of implementations of a production management system. The study is also limited to companies in Sweden.
4. Methods
To explore the research field, a combination of quantitative and qualitative research methods have been used.

Quantitative research methods use numbers and statistics gathered from correlational studies using surveys, standardized observational protocols, questionnaires with fixed questions etc.

Qualitative research methods use descriptions and categories and tries to find meanings and interpretations, e.g. through case studies and open-ended interviews.

This study has used a variant of grounded theory which is qualitative in its way of working but suitable for analyses of quantitative material (Glaser & Strauss 1967, Gustavsson 1998). Grounded theory is a method to shape new theoretical models that are thoroughly based on empirical data from case studies.

4.1 Case studies
During the project, eight companies in the Swedish graphic arts industry were studied during 1997-1998, see table 1.

<table>
<thead>
<tr>
<th>Company</th>
<th>Employees</th>
<th>Production phases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Pilot)</td>
<td>70</td>
<td>Finishing</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>Printing, finishing</td>
</tr>
<tr>
<td>3</td>
<td>270</td>
<td>Prepress, printing, finishing</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>Prepress, printing, finishing</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>Prepress, printing, finishing</td>
</tr>
<tr>
<td>6</td>
<td>70</td>
<td>Prepress, printing, finishing</td>
</tr>
<tr>
<td>7</td>
<td>360</td>
<td>Prepress, printing, finishing</td>
</tr>
<tr>
<td>8</td>
<td>200</td>
<td>Printing, finishing</td>
</tr>
</tbody>
</table>

*Table 1. The companies in the study.*
At one company, “the pilot company”, a real implementation of a production management system was prepared based on the generic requirements list, that also was a result of the project. Together with descriptions of the company with relevant data and descriptions of routines, the requirements list was used in a request for proposal.

The work on designing the requirements list gave strong support to the research part of the project by helping to identify the important questions and the demands on technological functions in a production management system and building routines in the production organization that would use the system.

The seven reference companies were studied in order to cover a broader selection of companies within the industry to form a basis for generic demands on production management systems.

The pilot company was visited seven times during a period of 18 months to do analyses of workflows and interviews with persons at all levels in the organization. The interviews were semistructured and open-ended which proved to be a good way of collecting empirical data from organizations and persons not used to this kind of work. Between the visits there were many additional contacts via telephone and e-mail in order to improve the quality of the data.

The reference companies were visited between two to five times during the same period with some additional contacts. Standardised questionnaires and workflow mapping methods were used to collect comparable data. This work was complemented with interviews and in some cases specific studies at the reference companies.
5. Summaries of the included papers:
Three of the papers (I, III and IV) that form the basis for this thesis where written within the Little Sister project. The fourth (II) was written in cooperation with researchers at the department of Industrial Economy and Organization at KTH where the graphic arts industry has been subject for some studies.

5.1 Paper I
"Workflow analyses in commercial printing – methods and results"

This paper deals with the characteristics of commercial printing. Generally, commercial printing embraces all print that is not newspapers. There are, however, many variations among the commercial printers regarding size, products, markets etc. The important aspects of production management relate to two things: frequency of orders and order volumes. The paper is based on case studies at eight different companies, some with similar characteristics but most with different. One company has 50 orders each year, another 20 each day.

The flows of information and material in the companies were studied and analyzed to find some common characteristics. The six phases of graphic arts production were defined. Even if the production varies, there is a need for a standard for describing products and orders. A protocol for this is essential and will together with methods for production tracking form the lowest level in a production management system.

Differences and relationships between product information and production information are also described in the paper.
5.2 Paper II

"Investigating a new production technique – the case of digital printing”

This paper deals with the assessment of new production techniques prior to an investment using an example taken from digital printing. The method described is called “the multi-level approach” and analyses the investment on five levels in a company taking in account other issues than economical issues.

The core of the method is to scrutinize a problem from several viewpoints to get a full view of the problem where the production oriented questions interact with organizational context and the business possibilities.

5.3 Paper II extension

The method in Paper II can also be used to prepare for other changes than investments. In this extension an attempt is made to describe levels in relation to a possible implementation of a production management system, based on stated, changed or developed strategies and business concepts.

It can be helpful to look at the complexity and needs at several levels to cover all aspects of a system and to avoid sub-optimization.

By looking at the implementation on all the suggested levels there is lesser risk of overlooking important matters. At each level, questions must be answered about what demands that level will put on the system and on the competence in the organisation.

In Paper II, the example for “the multi-level approach” is digital printing and the different levels that are studied are:
- Level 1: The printing principle.
- Level 2: The printing machine and its operator.
- Level 3: The print shop
- Level 4: The company and its departaments
- Level 5: Company characteristics, customers etc
The corresponding levels for printing production would then be:

- **Level 1 (Product):** Protocols to describe products and tracking data, i.e. a description of products independent of how and where production is made. Although graphic arts production varies in many ways, there is a need for a common way of describing products. Efforts have been made to achieve this for newspaper production with IFRAtrack (Thoyer 1996), and in commercial printing with JDF (Job Definition Format). JDF is an effort in parallel with CIP4, an organizational initiative for a comprehensive system integration in the graphic arts industry. In the development IFRAtrack and JDF will be connected. (CIP4 2003)

- **Level 2 (Production unit):** This level affects the equipment used in the production, i.e. a production description with instructions about how the production is to be carried out (see figure 3). At this level, production data is reported: Time points, elapsed production time, produced volumes and consumed raw material. The local production units must be able to use the common protocol from level 1 to be able to track data, or manual routines must be implemented.

![Diagram](image)

*Figure 3: How an activity in a production unit is performed on input objects, using resources through control signals, producing output objects.*

(From Enlund 1998)
• Level 3 (Department):
  This can be a local production system that covers an integrated series of
  activities. The department could also be a company with activities
  limited to some part of the total workflow. Equipment and routines
  must handle information in a uniform way and the workflow between
  different activities must be documented (see figure 4).

  ![Diagram](image)

  *Figure 4: A series of activities in a workflow.*
  *(From Enlund 1998)*

• Level 4 (Company internal, two layers):
  Layer 1
  - The company and its departments. Based on production and service
    units. The interfaces between the departments must be described,
    defining routines for material deliveries and other responsibilities.

  Layer 2
  - Production support functions within the organization connected via a
    common information system (see figure 5)
Figure 5: Level 4, layer 2: Production support functions within a company. (From Paper IV)

- **Level 5 (Company with external relations):**
  This level comprise company characteristics, customers and suppliers. The total production process including material deliveries and processing as well as information transfer in all directions (see figure 6).
5.4 Paper III
"Determining production management requirements in graphic arts companies"

This paper is about how to collect knowledge about the production within a company in order to form a basis for a specification of a requirements list for a production management system. By studying the production and answering a number of essential questions, two things are accomplished. First, a description of the company and its production. Second, a higher competence regarding production fundamentals, or an understanding of what competence that is needed for individuals and the organization.

This paper also discusses the need for a well thought-out business strategy and stresses that the production and production management system have to be consistent with that strategy.
5.5 Paper IV

"Identifying requirements for the implementation of production management systems in graphic arts companies"

This paper further explores the demands on a company and its organization and routines when attempting to implement and successfully use a production management system. Again, strategy is an issue as well as the consistency between the production management system and this strategy.

A model for administrative routines in a company is proposed as a development of traditional routines for production management.
6. Conclusion
Graphic arts production can be described in a generic way which is necessary when making specifications of requirements for production management systems.

The implementation of a production management system affects all levels in the organisation. When specifying a system, the effects regarding demands on the production equipment, competence and routines at all levels has to be considered.

To implement a production management system is a part of the organizational development which must be consistent with the strategy and business concept.

When a new system is to be implemented, discussions about concepts are important. Since all departments are involved, all need to take part in the discussions. There must not be common definitions of concepts in every case but an understanding for the different definitions in the different departments.

If this understanding does not exist, the system will work as a catalyst for the concept definition problem and the discussions will be forced during the implementation, which then will take longer than expected. What then happens in many organizations is that the system itself gets the blame for the longer implementation time.

7. Discussion
The results from this study ought to be useful for companies wanting to improve their administrative routines, with or without the help of a computer based system. Manual routines can be sufficient in many cases. Over a certain order volume, order size or complexity level however, a computer based system is necessary.

Important is to decide to what level the routines shall be computerized. This can differ considerably between companies depending on complexity in the production and competence within the organization.
Many companies have a need to increase their competence. This could be done in two ways, either by employing educated personnel or by educating the existing personnel. A good way to increase the competence is to work with the implementation of a system and take part in the process of going through the organisation to map flows of information and material and to make specifications of requirements. This is desirable to accomplish even before a system is actually implemented. It is thus important to take part in that process within the organisation and not leave the entire specification work to external consultants. Education, benchmarking and other competence increasing activities are also needed.

The suggested specification for requirements list in the appendix can be a good starting point. The list can then be revised and enhanced based on company requirements.

A recommendation is to give more status to the finishing phase and less to the printing phase since finishing operations today are more complex and are closer to the customer (or the customers customer). It is natural that the printing has been regarded most important since it uses the more expensive equipment and has demanded more skill, but this may need to change.

Another recommendation to many companies implementing systems is to change the view from:

“Since we now are buying this fine system we may need to make changes in our organization.”

to:

“To be able to survive we must first reconsider our strategy and business concept and thereafter make our production system and organization consistent with the strategy and business concept we have chosen. This implies a change in our organization. As a support for the organization and the production system we may implement a common information system – a production management system.”
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9. Author’s contribution to the papers

**Paper I**
This is a joint paper written together with my research colleague Mats Bellander and with Johan Stenberg as a discussion partner. My main contribution is the identification of the six phases of graphic arts production.

**Paper II**
The paper focuses on a method called “the multilevel approach” where the method itself was invented by my co-authors Magnus Aniander and Henrik Blomgren. My main role was the adaption of the method to an example from the graphic arts industry as an expert of graphic arts technology and graphic arts production. I support the method strongly and have applied it further in this thesis in the Paper II extension, within the summary of results from included papers.

**Paper III**
This is another joint paper together with Magnus Aniander where I have written the major part, i.e. everything except the parts on strategy.

**Paper IV**
This is a joint paper with my research colleagues Mats Bellander and Panagiota Koulouvari. My major contributions are the sections on strategy, analyses of the companies and the requirements list.