New Business Research and Design Study

An overall development strategy for a Manufacturing Execution System in the pharmaceutical industry in a marketing, technical and organisation framework



A research project for Huatek, China as a final assignment for the Bachelor Degree Industrial Engineering & Management at the University of Twente

Authors:

Vincent Bakker S0043583 Oscar van Lavieren s0046795

Date: 19 April 2007

Table of Contents

TAB	SLE OF CONTENTS	2
SUN	IMARY	
INT	RODUCTION	4
1.	BACKGROUND	5
2.	RESEARCH FORMULATION	6
3.	METHODOLOGY	9
4.	COMPANY CHARACTERISTICS	
5.	SCREENING IDEAS	
6.	PRELIMINARY VENTURE ANALYSIS	
7.	DETAILED BUSINESS ANALYSIS	
8.	STRATEGY PROPOSAL	
9.	CONCLUSIONS	
REF	ERENCES	
APP	ENDIX I – MARKETING ASPECTS	
APP	ENDIX II – TECHNICAL ASPECTS	
APP	ENDIX III: STEPS AND EXPERIENCES WITHIN OUR RESEARCH	
APP	ENDIX IV: INTERVIEW WITH SHELLY YUE	

Summary

By adjusting the Calantone's and Di Benedetto's [1] new product development process for an existing software product, we have conducted a product development research on how Huatek can enter the pharmaceutical industry with a MES offering. We reviewed the organisational structure, conducted market research and created technical designs & generalisations to produce a basis on which Huatek can continue its MES development.

At first, information was gathered on the company formulating its goals & strategy, structure, culture, environment and past experience. Huatek is a Chinese software outsourcing company with the majority of its customers located in the US. The organisation was characterised as mechanistic in combination with a mission culture; employees are focused on reaching goals set by the senior management and delivering projects on time.

Through the market research we initially identified current problems in production environments, based on which we analysed MES benefits in terms of problem solving, such as real-time information and paperwork loss, and progress, such as an increase in efficiency in production through lower inventories and more efficient production schedules. Next, we analysed the pharmaceutical industry in light of MES, we found the market most suitable to be divided in large research driven and medium-sized genericfocused companies. The competition consists of large, professional MES vendors and the tendency for small vendors is to focus their efforts on specific areas or modules. Currently, there are no vendors offering price-competitive MES solutions. We concluded that the Chinese pharmaceutical industry is suitable for a potential Huatek MES offer and that Huatek should focus on creating a basic MES offering for a relatively low local price.

Initial research showed that MES is a central communication system in an automation environment which actively exchanges information and executes orders, thus complementing separate systems such as Enterprise Resource Planning (ERP). The review of products of current MES vendors gave us an overview of the demands in terms of services and technology, additional research defined 11 standard functions. These technical requirements and details helped us clarify MES by designing structural overviews, context diagrams, dataflow diagrams (MES & Report Design) and we defined required services. With this information we could generate the key success factors for Huatek.

With these key success factors, we brainstormed to create four alternatives. Assessing them led to two suitable courses of action:

1. Enter the 2nd tier market of MES vendors (be a vendor of vendors) through positioning Huatek as a cost-effective, professional outsourcing partner

2. Enter the Chinese pharmaceutical industry by developing a complete MES offering in working together with a Chinese medium or large sized pharmaceutical company.

These two options do not cancel each other out, separate marketing departments will be concerned with each option and will use the same knowledge base. Therefore our advice was to simultaneously approach these markets.

For both options a list of follow-up strategies was set up to explain the marketing, technological and organisational steps to be taken from the current situation until the moment a client has been found. Each option has potential if the correct preparations are made in terms of professional documentation, presentations, contacting current MES vendors, and attendance of automation and production conventions. Internally, the basis of a software platform for constructing MES modules can create a launching pad for Huatek, by using technical ISA knowledge to match industry jargon and standards it can be shown to potential customers through web documentation. Furthermore, Huatek employees must learn to define software needs and be innovative themselves, especially when approaching the Chinese pharmaceutical industry. Huatek can achieve significantly growth in the coming years and expand its customer base for years to come if it approaches MES and the pharmaceutical market proactively.

Introduction

This assignment is the final report of the Bachelor assignment of Vincent Bakker and Oscar van Lavieren. From September 2006 to March 2007 we performed both our Bachelor Assignment as well as our Minor International Management (for which we refer to our Minor Report) at Huatek Software Engineering Co, a medium-sized software company in China.

Within the company, our assignment consisted of developing the steps in order to create and sell a Manufacturing Execution System (hereafter MES). It can be defined as a central communication system in an automation environment which actively exchanges information and executes orders, thus complementing separate systems such as Enterprise Resource Planning (hereafter ERP). We have translated this assignment into a design problem, making it line with the Bachelor assignment requirements. We will elaborate on the design problem in this report.

In the background chapter, we will explain our research by introducing the company and our assignment within the company.

Next, we defined the main problem and the supporting research questions according to our new product development process, with which our research approach and structure is formulated.

Our methodology chapter comprehends the literature and models used throughout the project, creating a scientific base for our research. We applied and combined them with information we found in the results & findings chapters (chapter 4 to 14) to answer the research questions. With the results, we generated follow-up solutions based on our initial problem definition and recommend a specific course of action for Huatek's MES. In the recommendations section we provide additional advice and reviews for Huatek as an organisation, these are more generalised and fall outside the scope of our research project.

The course of action which we eventually recommended for Huatek is explained in chapter 14, in this section we define it as a strategy for Huatek to further assist them in their continued work on MES in the future. By defining the critical success factors and creating follow-up strategies according to the working methodology of Huatek the requirements for a potential MES offering are illustrated.

Furthermore, a personal reflection on both the assignment and our professional activities is provided to give insight in our work and experiences at Huatek.

The assignment was done together by Vincent Bakker and Oscar van Lavieren, because of the scale of the project and the location it took place. This means the report was created in a team effort, with the only exception being our personal experiences, interpretations and reflections.

We would like to thank dr. ir. De Boer for his help both in the preparatory phase of our internship as well as during the internship, where we could rely on his quick and diligent feedback on our interimreports. We would also like to thank ir. Van der Meer for his suggestions and hints before our departure and the time he took to read and evaluate our report.

At Huatek our supervisor was Shelly Yue, who was a great help in reviewing our documentation, critically analysing our conclusions and motivating us to take our research to a higher level. We would like to thank her for giving us the opportunity to conduct our research assignment at Huatek and taking the time out her busy schedule to assist us on countless occasions.

1. Background

In this first chapter background information is provided on our research project, giving a brief overview of Huatek and the team with which we will work, followed by an introduction to our task and role, as defined within the organisation. For more detailed organisational information we refer to chapter five.

1.1 Company background

History

Huatek Software Engineering Co. Ltd is a medium-sized software outsourcing and off-shoring company with offices located in California (USA) and Shanghai & Xian (China). The office in California mainly serves as a marketing and support (legal and financial aspects) office, Shanghai serves as a consultancy office and contract centre in China, and core engineering operations are located in Xian. Huatek was founded by Dr. Chining Liu in 1993.

Products

Huatek produces internal and commercial software solutions. For each project a team is built, the client can choose to manage the team remotely. Some offered products are the integration of legacy systems with new applications and databases, as well as providing enhancements, re-engineering, and support services. There are several large customers with which Huatek has built up a relationship over the past years, some examples are Quovadx, Agilent, Merck, Michelin and Motorola. The size of the project teams varies from 8 tot 50 employees, spread out over the various offices. These teams work closely with the customer throughout the development of the IT systems, thereby not developing their own systems but rather software solutions specifically for a customer.

Specialisation

Huatek's workflow capabilities minimise development time and costs for the customer, decreasing the overall risk of any project. Huatek can offer a cost advantage compared to IT companies located in the US or Europe due to lower labour costs. With a team of experienced engineers Huatek can provide a wide range of solutions for problems such as internal communication, process control and data management. Using the newest as well as the most commonly-used tools, platforms, built environments and middleware for every type of operating system. Huatek works with open source (J2EE), Microsoft-compliant (.NET), Sun (java), and database (Oracle, MySQL, DB2) tools and systems. With this broad knowledge Huatek can propose the best platforms or systems to meet the customers requirements for a relatively low price.

Organisation

The three basic principles of the culture at Huatek are:

- 1. Customer always comes first
- 2. Advancing technologies
- 3. Care about people

1.2 Company Assignment

Project

Huatek noticed an interest in MES at Merck and wants to profit from this growing market. Therefore they want to investigate their capabilities and expand their expertise on the subject. To do so, Huatek has decided to form a team exploring the possibilities in the field of MES. Management wants to know how Huatek could create their own (partial) MES offering, thus a MES including an actual product, the associated services and other associated elements. Since Huatek is a software outsource and offshore company, there is limited knowledge on developing a product from scratch. Furthermore there is no marketing department, but only a new business team to respond to proposal requests.

We have been hired as interns to work in the team designing and researching a MES. The team consists of six people, of which we are the only employees full-time devoted to this project. The other employees have to do this project next to their daily tasks.

The team is divided in a technical team, consisting of two employees working on the technical details of MES, a marketing team consisting of the two of us researching the pharmaceutical industry and MES, one employee reviewing relevant past experience on related projects and the project team supervisor. The marketing team in this case has the leading role: sharing initial research results with the technical team.

The duration of our involvement in the project was six months, although the total time needed for the research was uncertain, we were able to expand or narrow down research aspects to fit the schedule.

The end date of the entire MES project is flexible, the development will continue after we leave. It is a long term project which requires employees with more developed business knowledge and marketing skills to gain the necessary insight. Our time will be divided between Shanghai and Xian, going back and forth every six weeks.

Company objectives

Huatek's primary goal for this project is to enable its involvement in the pharmaceutical industry concerning MES, thereby expanding its product and services range. In case of the successful (partial) development of MES, start approaching potential customers and introduce the MES offering to the market. With an offering we mean the set or selection of the system, services and other elements offered to the customer.

A secondary goal is the learning experience that is created by going through a new product development process. Huatek will gain knowledge and experience by independently developing a product to approach a certain segment of the IT (outsource) market, combining the theoretical background provided by us with the practical experience of local IT employees.

Task

We researched MES, the MES market and Huatek's organisation. Our contribution to the company will be the knowledge on how to continue with the MES development. We define our final deliverable as:

The most beneficial course of action for Huatek to take in its MES development along with a company-wide strategy in terms of technical, marketing and organisational recommendations on how to develop a MES offering.

University requirements

The purpose and requirements for the bachelor assignment are provided in Appendix III, because we are making a research assignment of the MES project the university requirements had to be taken into account.

2. Research Formulation

In this chapter, the company and the Bachelor requirements are combined to formulate a research assignment, containing a research problem, research approach, deliverables, constrains of our research and the structure this report will follow.

2.1 Problem identification & formulation

The main problem which forms the basis of our assignment:

What is the best strategy for Huatek to independently develop a Manufacturing Execution System offering and approach the pharmaceutical industry?

This process of researching on how Huatek can develop such a offering first requires an understanding of MES in structural and functional terms. For this we worked closely with the technical team to develop the MES product. We led the other teams, in such a way that their technical design and remarks followed our market research and rough technical ideas.

2.2 Research Structure

The main problem of how Huatek can develop its MES offering is solved by researching and designing MES and creating a suitable strategy. The research followed a new product development research, as described by Calantone and Di Benedetto [1], which describes technical, marketing and evaluation processes, interacting with each other. During each step of the research, literature, reports and articles as mentioned in our methodology chapter (chapter 3) are used. Note that MES already exists and the scope of our project was narrower than a total product development, therefore we have adapted their model to fit our research: the preliminary environment research is limited to the nature of the firm, since the direction of the project and the market has already been given. Our research is concluded by a Detailed Business Analysis, describing the steps Huatek should finally take, rather than the commercial entity proposed in the original research structure. The Detailed Business Analysis provides input for the design part of our assignment, namely the Strategic Proposal.

We have adapted Calantone and Di Benedetto's model to our own research model:



Figure 1: Our research model

Every research component is translated into a research question, by answering these research questions, we conducted our research according to this model.

2.3 Research questions

In order to solve the problem we set up research questions, following the 11 steps of our research model, where three of them are evaluating steps and seven of them are research steps for decision support, leading to a final design. We translated the three evaluating steps into design questions for analysis and comparison, with the research questions functioning as support steps in the research. The final design step is also translated into a research question. Each research step is answered in a separate chapter (chapter 4 to 9).

- 1. Environments: **How can Huatek's relevant characteristics be described?** The nature of the company has to be described in terms of organisational structure, culture, strategy, environment and its products, relevant for MES.
- 2. Screening ideas: How can pharmaceutical companies benefit from MES? Combine the knowledge on MES with the shortcomings in the pharmaceutical industry to identify benefits potentially offered by MES.
 - a. Product Research: What is the concept of a Manufacturing Execution System? Look up literature and other information on MES to understand its concept.
 - b. Identifying Customer Needs: What production-related problems are encountered in pharmaceutical companies?

Research on current shortcomings in the pharmaceutical industry, specifically larger and medium sized companies with a significant production line and technology level.

3. Preliminary Business Analysis: What direction should product development take in light of Huatek's organisation?

Combining the rough system lay-out, the pharmaceutical industry and Huatek's characteristics, we can describe a MES in terms of targeted market, distinguished competencies and features, which would fit Huatek best.

a. Preliminary Design and Technical Feasibility: What role does MES play within an organisation?

To deliver the benefits from the first step, we will create a system definition on MES, to identify its role and rough structure within a manufacturing facility.

b. Preliminary Market Assessment: What does the pharmaceutical industry look like in relation to MES?

Explore the pharmaceutical industry, to find out its characteristics and the different segments, products, technologies and possible MES competition.

4. Detailed Business Analysis: How can Huatek create a MES product offering?

Taking Huatek's characteristics into account, we want to define the steps to successfully turn the ideas into a product and service offering ready for the market.

a. Product Development: What should a MES structure and its associated services look like?

The description of the Huatek MES can be translated into a system design (data flow structure et cetera), furthermore the services to offer are to be identified.

b. Market Research: What is the size of the targeted markets?

By using the description from question 3, what are the sizes of Huatek's markets?

5. Strategic Proposal: What is the best strategy in terms of organisational, marketing and technical tactics on how to create, market and sell a MES offering? With the detailed business analysis from question 4, we can define the documentation, restructuring training and action requirements for Huatek to enter the MES market for which

restructuring, training and action requirements for Huatek to enter the MES market, for which we can define a strategy in order to pursue this option.

The first four questions and their supporting questions are not an end-product, but support the decision making steps of question 5. After answering question 4a, we have defined Huatek's MES in structural and service terms. By answering question 4b, we know the targeted market. Finally, after answering question 4 completely we can define what the key elements for success are. Continuing on this basis we can create a comprehensive course of action on how to develop, market and sell a MES offering.

2.4 Deliverables

Our research finally answers the question, "What is the best strategy for Huatek to independently develop a Manufacturing Execution System offering and approach the pharmaceutical industry?". In our research, we systematically take technical, marketing and organisational aspects into account. The answer to question 4 however does not provide sufficient information for Huatek; the steps proposed needed to be translated into a strategy to guide the company, which is done by answering question 5. This strategy leads to more than to only develop the system; services, marketing and other elements must be defined to create a complete offering, a total set of the product and associated services, rather than just a product. To outline the proposed strategy for Huatek in concrete terms, we formulated the task:

Using market, organisation and product research, to create a company-wide and detailed strategy, in terms of tactics, milestones and a rough planning on how to create, market and sell a MES offering.

The answer to our main research question provides this strategy, it is the final part of our research project. It is a review on how we think the strategic ideas can be implemented within Huatek and what steps the company needs to create and bring its potential future MES offering to the market. With this strategy, we fulfilled our company task as described in chapter 1.2.

2.5 Research Constrains

To prevent extending our project too much, the boundaries of our research must be defined.

Market

The research project is limited to a MES product suitable for the pharmaceutical industry in China and the US. These two countries are the only places with which Huatek is familiar and has experience in. The specific segmentation of and focus on the potential market are defined in chapter 6.2 and 7.2 using the literature of chapter 3. The knowledge and documentation of this research project should however provide a basis for other options in the future.

Product development offering

Our research project as well as our company assignment provides a course of action and advice on how to develop, market and sell a MES. We will only provide an outline for the system (namely its technology and functional design) and describe the related services to offer, we will not develop the product in-detail. This is done by the technical team. The research is thus limited to setting an initial course of action for Huatek to use for approaching the pharmaceutical industry with a MES offering. Once a potential client shows interest further technical research needs to be done.

3. Methodology

The research is formulated in research questions, which all require specific input. Next to the information on MES, the pharmaceutical industry and Huatek, the information has to be translated into models and definitions to use it in a structured manner. We used theories in the field of development theory, which will provide the basis of our research structure, market research, organisational structure review, information system theory and business-to-business marketing to translate the system and services into a useful and applicable offering.

3.1 Product design & research

The product development theory will consist of Calantone and Di Benedetto [1] as presented in our research structure in paragraph 2.2, thus conducting marketing and technical research until the research questions are answered.

3.2 Market Research

To define the market and size estimations we will follow the steps provided by Kotler [12], thus reviewing the market information systematically in terms of available, potential and target market. Ford et al. [11] will provide a wide understanding of business-to-business marketing. Next to designing a system, a total product offer has to be composed, including services, after-sales, et cetera.

3.3 Organisation Research

We will use Porter [described in 19], Gertz, D L & Baptista J. P. A. [16] and Daft [19] to find Huatek's organisational characteristics, referring to structure, working methods and current strategy. We can use these characteristics to model Huatek and make sure our strategy fits within Huatek's organisation as well as to propose it in a structural manner.

3.4 Technical research

Knowledge of IT as taught within the courses Information Systems, Business Process Support and Business Function Support provides basic knowledge of common dataflow models and information systems. By applying this knowledge MES can be translated into easy to use models. However, MES communicates with the organisation in more ways than can be drawn, therefore only a basis of models for a potential design is created, showing the main functions, processes and data flows. The technical team will go in-detail with these models.

3.5 Research steps defined

Our research followed the model as presented in figure 1. Guided by literature, we are able to define ways to find information and analyse the data. In our approach, we will first answer the support questions before answering the decision-making questions.

1. How can Huatek's relevant characteristics be described?

Input: Organisation theory and information on Huatek from personnel, website and documentation

Action: Apply literature on Huatek and conduct interviews

Result: Theoretical description of Huatek

A foreign company situated in a complicated cultural environment is difficult to fully understood but with the help of literature on organisation theory we came across during our study we were able to analyse the relevant aspects of Huatek for our research.

2.a What is the concept of a Manufacturing Execution System?

Input: Literature on MES from internet, scientific articles, software vendors and conventions/forums.

Action: Reading, reviewing and summarising

Result: Concept understanding

Looking up literature on MES will provide an understanding of its concept.

2.b What production-related problems are encountered in pharmaceutical companies?

Input: Benchmark reports, scientific articles, white papers and product surveys

Action: Reading, describing and listing

Result: List of current problems connected to their source

Benchmark reports and scientific articles will give insight in the current production problems.

2. How can pharmaceutical companies benefit from MES?

Input: 2.A, 2.B and basic production management theory

Action: Describing all the benefits and matching them with the production related problems.

Result: Documentation of the benefits of MES for the pharmaceutical industry.

By combining our definition of MES with the encountered problems and applying additional literature, we can describe the possible benefits of MES.

3.a What role does MES play within an organisation?

Input: See 1., white papers, benchmarking, information system theory (system design, business process support), technical diagrams

Action: Summarize diagrams and define role of MES within automation environment

Result: Rough high-level model on MES defined and example of MES architecture

Using theory on information systems we can translate the benefits offered by MES into role descriptions and architectural concepts.

3.b What does the pharmaceutical industry look like in relation to MES?

Input: Economic reports, benchmark reports, scientific reports, organisation theory, product surveys, et cetera.

Action: Describe the pharmaceutical and automation industry, find similarities, research competition, define market trends and demands

Result: Division in and descriptions of different segments within this industry

With the use of various sources on the pharmaceutical industry we will get insight in this industry, its product and technology. We than segment this industry and further conduct research in the competition, analysing present US and Europe based MES vendors.

3. What direction should product development take in light of Huatek's organisation?

Input: See 2.A, 2.B, 2., 3. B and cooperation with the technical team working on MES.

Action: Conduct a SWOT analysis of Huatek in combination with MES to summarize previous findings, choose industry segment to fit Huatek and design the product accordingly.

Result: Choose target market and tailor product description to fit Huatek best

Deciding which segment of the pharmaceutical industry fits Huatek best and define the needs for this segment in terms of a simple technical diagram. We design our general MES model for Huatek, together with its distinguished competences, features and services. We than chose a target market and specify the MES product.

4.a What should a MES structure and its associated services look like?

Input: See 2, 3.B and literature on business-to-business marketing and information systems.

Action: Describe the system on a high level, its functions and features, technology, and the associated products and services

Result: A potential design for Huatek of a complete MES offering, thus including all the required functions within an automation environment.

We fill in the outline of question 2 and 3.B into a high-level product design and offering. It will contain the system model, the features and the associated services to be offered.

4.b What is the size of the targeted markets?

Input: See 2 and 3.A, literature on market research, benchmark reports, product surveys, economic reports and competitors information.

Action: Conduct market research in the Chinese and American pharmaceutical industry and narrow down the scope of the target market of Huatek.

Result: Thorough understanding of our target market, in terms of size and competition

By systematically reviewing and segmenting the market we can narrow it down and numerically state the number of potential customer which fall within the target market for the US and China.

4. How can Huatek create a MES product offering?

Input: See 3.A, 3.B, theory on business-to-business marketing, organisations, information systems and the conclusions made in chapter 7.1 and 7.2.

Action: Interpret the previous findings in terms of structure, market and product, than formulate a summary of demands and restrictions for Huatek's potential MES offering.

Result: A review of our research providing do's and don'ts for Huatek.

5. What is the best strategy in terms of organisational, marketing and technical tactics on how to create, market and sell a MES offering?

Input: All information and analysis from preceding questions.

Action: First, we will define various alternatives which suit the restrictions and opportunities as formulated in 4. By conducting a decision analysis the best opportunity is identified. The chosen course of action can than be further defined and analyzed in terms of market, technology and organizational impact on Huatek.

Result: A concrete and complete strategy for Huatek according to the selected alternative.

4. Company Characteristics

How can Huatek's relevant characteristics be described? (research question 1)

According to Daft [19], there are six organisational dimensions. With these we described Huatek, using information from documentation and interviews with employees. An interview with Shelly Yue, senior manager at Huatek, is provided in Appendix IV. Other interviews with senior management and co-workers were informal and not documented elaborately.

4.1 Goals & Strategy

Huatek's mission is stated on the website:

Huatek's project management and engineering capabilities provide many cutting edge technologies to provide a competitive advantage.

Its business is primarily focused on software engineering outsourcing and business process outsourcing services. Within these services, communication with and integration of legacy systems is one of its core competencies.

In our opinion this is a very narrow description of Huatek's mission, a more suitable description would explain that they take on any kind of software service assignment which a preference towards large American customers. Thus involving simple outsource work, testing, administrative work, etc. Defining one overall mission is thus almost impossible, it is a very flexible organization capable of taking on a wide variety of challenges in many market and environments.

The company has a focused low-cost strategy according to Porter, with a product focus on the integration of legacy systems and process support software in the outsource and offshore project market. This means they offer their product at a lower price than the client can produce it.

4.2 Structure

Huatek's organisation chart is shown below in figure 2, the numbers represent the number of employees in that department. For some departments, not all the employees can be placed in subdivisions (e.g. testing), those departments have general employees too.



Figure 2: Organisation Chart

Huatek is organised in a functional way, since employees are grouped based on their functions or work processes, namely developer or programmer, tester or communication assistant. The people working in a team for the key customers have a fixed function within that team. Within generic projects, employees are ordered based on the technology they use. Due to the organisation size, horizontal linkage is limited. Project leaders need to coordinate large teams and are (partly) involved in multiple functions. Top management is small too; although not visible in the organisation chart, Business Development, Key Customer Programs and Generic Projects are managed by the vice-president; another senior manager is in charge of Information Technology, Testing and Quality, and Process programs.

Despite the uncertainty in the client base, Huatek's organisation is mechanistic. Goals are defined for employees and decisions are mainly made by top management. Every task within the organisation is translated in a process. The reasons for this approach are the low level of experience when employees enter the company, the general preferred method of working in the Chinese culture and the fact that CMM-3 (capability maturity model) requires it.

When top management acquires a project, a team is composed or the project is assigned to an existing team. With one small exception, every project of Huatek has been initiated and defined by the customer, who has a certain information need. The level of definition differs per project, sometimes precise schemes are provided but sometimes only a vague description is given. In the latter case, the exact schemes and descriptions are set up together with the customer. Huatek thus hardly has experience with

product development on its own initiative and limited experience with defining information needs. During a project, the on-site employees or the project manager are the contact for the customer.

A small exception is CN100, a cardiograph-device which connects to a common PC rather than to expensive medical equipment. This product has independently been developed and marketed by Huatek. It is used by several hospitals around Shanghai and by clusters of hospitals in other provinces throughout China.

4.3 Culture

An obvious aspect of Huatek's culture is that employee participation and initiative is low, they expect and prefer to be given instructions. This is one of the reasons why a large power distance is present between senior management and other employees. Several attempts however have been made in the past couple of years by senior management to introduce a new thinking style at project management level to overcome the lack of an innovative spirit and adaptability, of which the MES team is an example.

Although employees' tasks are strictly defined, Huatek has established an open and flexible environment when it comes to accessibility of senior management, defining own work times et cetera.

4.4 Technology

Huatek uses common and open-source software and hardware technology to deliver their products. Several in-house built applications are used for project management, with which they are able to create flexible systems.

4.5 Size

Huatek has about 160 employees, of which 115 (Engineering and Testing) are directly dedicated to their products. This excludes the marketing office in California.

Huatek has the characteristics of a small company in several aspects. Most of the new clients are brought in by the CEO's personal network. There are few management level positions. Communication (especially horizontal) is done verbally. New plans or projects are easily started since Huatek's size offers flexibility. Finally, there is high dependency on these senior managers for guidance.

4.6 Environment

The external environment of the company can be described by 10 dimensions [19]. We will only describe the market and international dimensions, both part of the task environment. The other eight dimensions are not relevant for our research.

Market: Huatek aims at the software outsource and off-shoring market. Each project is gained individually, although many of them derive from a successful relationship. Most of the clients are initially brought in by the CEO's network.

International Context: Huatek aims for customers worldwide, especially in the US, where costs for integrating legacy systems or performing standard engineering tasks are very high due to labour costs.

4.7 Past experience

Several activities Huatek performed in the past provided experience relevant for MES. In 2003 several projects were received and initiated with Merck, which is currently the third largest pharmaceutical company in the US. Each project started out as a small one, which served as a test for Huatek, allowing them to demonstrate their experience and quality. In 2004, several larger projects were outsourced to Huatek and a closer relationship was built up; currently, Merck still delivers follow-up projects. These projects created the initial interest in MES for Huatek's senior Management. The most important projects were:

- Development of an equipment ordering system to manage the supply chain of machines, pipes and tubes through their lifecycle. This included ordering, purchasing, assembling, dispatching, tracking, collecting, cleaning and discarding processes
- Development of an alert database to track alarms in the production line and server remotely, booking relevant alarms as notifications by e-mail and to pagers
- Updating of the tracking system of incubator production cans throughout their lifecycle using barcode technology to track and access real-time equipment information in the supply department with handheld computers with wireless connections
- Development of a process data collection system, which collects parameters in control systems and uses it in combination with the raw data from business intelligence to judge whether the streamline adjustment in production is satisfactory

These applications were developed for production lines in one specific factory of Merck, they are limited in scope and size.

4.8 Conclusion

Huatek is a company focused on software outsourcing assignments. Its core competency is meeting goals and deadlines while offering the same level of low-cost development as its local competitors, trying to think along with the customer and cooperate in setting up functional requirements to some extent. Huatek is organised in a traditional manner, with highly defined tasks and employees fixed to a function and a client. Customers are mainly brought in by management's network and the main customers account for the greater part of the projects. There is some experience in systems aiding the pharmaceutical manufacturing industry and a little knowledge on own product development and product marketing.

5. Screening Ideas

5.1 MES concept

What is the concept of a Manufacturing Execution System? (research question 2a)

MES is an information system to support production. Although several forms of MES have circulated in the automation environment for the past 20 years, it has only officially received its name in recent years. Several definitions were found:

"MES is to provide the information and control decision link between the production planning at higher level and the equipment control system at the lower level." [13]

"MES bridges the gap between the planning system and the controlling system using on-line information to manage the current application of manufacturing resources: people, equipment and inventory." [3]

MES is thus defined as communication software which assists separate systems and users to conduct their responsibilities, assisting entities within a production environment (systems, employees or departments) in two ways:

Firstly, it automatically provides them with any information necessary in real-time and in a ready-to-use, analysed form. For instance, plant managers can check up-to-date production data, maintenance receives alerts and instructions on machine breakdowns.

Secondly, it extends and automates the control of these entities by automatically passing on their decisions, requests or information to other parties within the automation environment. Especially

emphasised in literature is the translation of the rough, high-level planning created by the Enterprise Resource Planning (ERP, the system responsible for keeping track of orders, materials and planning the production, at an enterprise level) into a detailed low-level planning, passed on to the production personnel and the machinery. MES complements an ERP system with several benefits which will be described in the following chapters.

5.2 Pharmaceutical Production Problems

What production-related problems are encountered in pharmaceutical companies? (research question 2b)

According to Adler et al. [17], the main problems encountered in the pharmaceutical industry are:

- Regulatory compliance: high level of documentation required from the Food and Drug Administration (FDA)
- Deviation avoidance: too much deviation in a produced drug causes that not only a single object can be thrown away, but the entire batch will need to be destroyed
- Monitoring realities: the planning department and plant supervisors are not aware of up-to-date information until manually transmitted or inserted in the ERP
- Unnecessary high inventory levels: because of current scheduling procedures a high inventory level is necessary
- Long lead time: only 30% of the lead time comes from within the production itself, this means 70% of the lead time is eligible for reduction without any machinery or technology changes
- Paperwork: schedules, production orders and information is transported back and forth on paper, adding unnecessary administration and leading to duplicates, version problems and lost papers

Furthermore, the patents on drugs expire after several years (20 in the US), permitting anyone to produce it without extensive research or testing; FDA approval is easy to acquire for these so called 'generics' [27]. Organisations attempt to decrease product cycle times and production costs to still profit from their invention after the patent expires, the market and types of products will be further explained when answering 3b.

5.3 Benefits of MES

How can pharmaceutical companies benefit from MES? (research question 2)

MES connects all systems in an organisation; by connecting the planning and production layers the production schedules can easily be updated on manufacturing machinery. In return, machines can keep the planning system informed in real-time through various technologies such as machinery information, bar coding systems, digital signatures, et cetera. Other involved systems like inventory and maintenance systems are connected to MES, making all production and planning data available in real-time reporting throughout the organisation and clearly visible for plant management.

With effective data distribution, MES solves problems and furthermore offers improvements in various other areas. To start with the current problems, MES solves the problems as described in chapter 5.2:

- Regulatory compliance: since documentation is stored centrally, producing the right documents can be reduced to just a click on the button
- Deviation avoidance: active quality control will detect problems earlier and narrow down the scope of the problem, thereby reducing waste
- Monitoring realities: by real-time data, current status can be monitored at any time
- Unnecessary high inventory levels: inventory can be reduced through active planning and realtime information on current inventory levels
- Long lead time: reduced by better planning and management insight into bottlenecks
- Paperwork: virtually eliminated, as information is distributed digitally

• With a more efficient production, the inventor of a drug can still produce and sell it at a competitive price after the patent expires

Most benefits are caused by the speed at which information is delivered as well as the extensive analysis performed on the information provided (reports are provided rather than raw data) both improving decision efficiency.

More benefits offered by MES can be found in literature and business analysis by software vendors. We set up a list as complete as possible (appendix I, table 4), listing any benefits found in [3,5,6,8,13,17,21]. We found MES capable not only of 'problem-solving' (solving existing problems with facilities, such as diminished paperwork), but also of 'progress-offering' (benefits improving facilities, such as higher efficiency), at several levels within an organisation.

6. Preliminary Venture Analysis

6.1 Role of MES

What role does MES play within an organisation? (research question 3a)

Function span

One of the main roles of MES is creating the detailed planning; an ERP system generally defines what needs to be produced and when it needs to be finished, where MES fills in the details, such as specific scheduling of materials, machinery, maintenance, documentation (when/where/who/what/how), etc. ERP uses up-to-date information and the planning is communicated immediately. MES can overlap with an ERP system in some areas[22], depending on the level of development of the ERP system and in which industry we are conducting the comparison. A detailed list of possible overlap is displayed in Appendix II (figure 10).

The level of involvement and participation a MES should have differs in literature: some describe MES as a system only forwarding and requesting information, whereas others give it an active and execution role in starting machinery, setting up batches et cetera. During the course of the project we will assume MES as having an active role, i.e. it has the possibility to execute orders.

In white papers and scientific articles, other production-related systems such as equipment tracking and maintenance systems are found to be connected to the MES or operating as sub-systems, included in a MES. In either case, these systems should be provided with all the necessary information if an event relevant to that system occurs (for example a machine breakdown is relevant for the maintenance system) and if the system requests for information. In return, these systems are to provide information on internal events (such as finishing a repair by the maintenance) and if the MES requests for it; thus a real-time information flow is established.

Since MES will have the central communication role, users must be able to log in the system in order to receive instructions and information and manually input information. The MES must translate the data into useful reports e.g. production reports for management, regulatory documents for quality control and instructions for production personnel.

Structure

Literature and information from MES vendors gave us some insight in possible structures and roles. Those companies which want a MES will have machinery which can be connected to and will most likely already have an ERP system of some sort. Uncertain however is what other production systems are present in the facility. It must be possible to connect these systems to the MES as well as to connect new systems in the future (be it in-house built or third party acquired).

The ideal situation presented in the literature is that of a holistic Enterprise Production System [4], combining all systems in and around an organisation into a single one. Because of the lack of available standards, budget and experience, this ideal is still an utopia.

Within his simulation model, Scott [21] suggests a MES design to look like this:



Figure 3: MES architectural concept

This structure provides an interface where other systems (be it planning systems, operational systems or users interfaces) can connect to, allowing them to communicate with each other. Certain systems are already present in the automation environment where others are offered as a module within MES. A MES thus offers a generic data layer to which systems connect. It has a central data-warehouse where all information is stored. The information is received when the MES asks for it (on-request) or when anything occurs within the automation environment (on-event). Information is sent to systems when they ask for it (on-request) or when an event is noticed by MES (on-event). A system with this set-up will be able to deliver the benefits as described previously if properly designed and developed.

6.2 MES in the Pharmaceutical Industry

What does the pharmaceutical industry look like in relation to MES? (research question 3b)

To understand the pharmaceutical industry we first introduce its products, followed by information on both the US and Chinese pharmaceutical industry. Some key figures are presented on MES, ERP usage and IT integration. Furthermore, the competition on MES is researched, their market focus, offered services and trends will be presented.

Products

Two distinctions can be made in pharmaceutical products: branded vs. generic drugs and prescription vs. over the counter drugs. Branded drugs are medicines protected by a patent. When a company invents a new drug, a patent will usually be granted, lasting 20 years [26]. After extensive testing by the Food and Drug Authority in the US (hereafter: FDA) a company can commercially market a product, leaving several years (usually between 5 and 15) to make use of its monopoly.

Generics are drugs without a patent, sold under the name of their active ingredient. They may be brought into the market when the patent of a branded drug is expired. To gain FDA authorisation to sell a generic drug, the drug has to contain the same active ingredient and be bioequivalent to the branded drug [27]. Generic drugs can be sold much cheaper than their branded equivalents, because the generic producer does not incur the research, regulatory and marketing costs. This makes the entry barriers for generics much lower, competition harder and margins smaller.

Prescription drugs can only be bought with a doctor's prescription whereas over the counter drugs can be sold freely. There is no general relation between branded or generics and over the counter or prescription drugs.

Industry Figures

Pharmaceutical companies can best be divided in research-driven companies, focusing on the research and development of new drugs and generic focused firms, focusing on generics [24]. The industry-average profit margins for the former one are twice that of the latter (20% vs. 10% [15]). Industry figures from the US and Chinese industry are found in table 1.

	US China		
		Total Industry	Domestic Companies (78%)
Patented Drugs (% of total prescriptions)	53 %	9%	3%
Generic Drugs (% of total prescriptions)	47 %	91%	97 %
Prescription Drugs (sales in billion)	\$ 200	\$ 16	-
Over the Counter Drugs (sales in billion)	\$ 30	\$ 4.2	-

 Table 1: Pharmaceutical Industry Characteristics [25, 28, 29]

Surprisingly, in the US, companies focused on patented drugs (research driven companies) also account for 50% of the total generic sales [29].

Generic-focused companies are usually medium-sized and the competition is very hard. They are less advanced than the companies which develop medicines; they use more common technology and their research budgets are usually smaller.

Numerous small companies exist, they have only one or a few products, or possibly even never sold anything, waiting for a breakthrough in research. Generally, they only have one factory and several employees. In our definition we have qualified small companies as those having less than 50 employees.

MES Usage

In order to gain insight in the current presence of MES within the pharmaceutical industry several sources of data needed to be combined. From market research reports [5,6,7,8] several figures were derived which gave an overview of the presence of ERP in the production industry. It was not possible to find specific data concerning ERP or MES presence in the pharmaceutical industry; we could only analyse the automation production industry as a whole to review current ERP and MES usage. This is acceptable because the data has come from surveys which have only included larger sized global production companies. These are relatively advanced compared to the average production company, and the pharmaceutical industry is relatively advanced compared to other production industries. We thus assume the technology level of global production companies will be roughly comparable with that of the pharmaceutical industry. With this assumption we can apply the figures from the survey directly to the US pharmaceutical industry.

- Currently 88% of global production companies use ERP
- Of all production companies 50-80% wish to integrate more of their IT functions
- Currently MES usage in global production companies is 35%
- Global wish for implementation of MES within the next 24 months is 36%

These figures will be applied in our market research in combination with the target market definition to produce a better overview of the pharmaceutical companies which fall within Huatek's target market.

The 50-80% estimate of companies which wish to integrate more IT functions is very broad, various sources gave a wide range of data. We will take the average and estimate 65% of pharmaceutical

companies wish to integrate more IT functions. This is supported by the number of industries requiring a MES and the number of products per market. Of 18 industries the pharmaceutical industry ranks third with at least 18 MES products offered by vendors. A graphical overview of this is shown in appendix I, figure 7.

Competition

MES vendor business statistics

Research of the competition in the MES market disclosed the following factors [22]:

- MES is a western product: 59% of the vendors is North American, 38% is European and the last 3% is Australian
- Vendor size differs: 52% has more than 150 employees but a vast 29% has less than 50
- High vendor age: 66% of the vendors was established before 1990.
- 61% of vendors provide their services to the pharmaceutical industry but the majority do not make it their primary focus.
- 7,8% of all MES projects are in the pharmaceutical industry (6th largest MES market in terms of number of projects, no differentiation made in size of project) Project sizes are however relatively large with a high number of specific requirements due to complicated FDA and production regulations
- There is an increasing trend towards a focused product, 72% of vendors supported at least three different types of production typologies (continuous, batch/semi, make to stock, make to order and engineer to order) in 2005, this was 84% in 2004

An analysis of marketing material and industry information shows that none of the current vendors are situated in the low-cost MES market because they all offer high-quality, sophisticated, mature systems. Please refer to Appendix I for a detailed vendor assessment.

Market focus

The current trend is that larger IT companies provide the entire MES product and that smaller subvendors focus on one or more key applications or suites. Expectations in recent years were that a shakeout of vendors would occur [22], however the opposite has happened and a steady growth continues, the current trend therefore is for MES vendors to focus their products on specific industries, sectors, processes or geographies. By tightening their focus there are less products positioned on the market as 'one size fits all'. Through a significant presence of vendors, the pharmaceutical industry has had the luxury to demand higher quality. The introduction of niche products has increased the quality of development, configurability and implementation. Larger companies such as Rockwell have made use of this and either absorb a smaller vendor or form a partnership with them to allow them to keep their identity. Through this, larger companies do not need to narrow their focus within the market and can offer a high quality product to each segment.

In the past, vendors' focus has been more on creating a general but configurable IT solution rather than a MES specifically for one industry. Of the systems currently offered very few were initially created for a specific industry. See appendix I, figure 8 for a graphical overview of the level of focus of various MES products on the market in 2003.

Offered functionalities & trends

One of the major differences between products is the level of configurability and required customisation. This has a significant effect on the price for the customer, however in the long run a high configurability will lead to lower lifecycle costs. The figure below (figure 4) shows the average configurability percentages of MES products, information specifically on the pharmaceutical industry is not available. Due to the complexity of products and FDA restrictions we can assume the pharmaceutical industry has at least equal or higher 'Custom Made' percentages.



Figure 4: Average configurability of MES [22]

Below is a list of some MES product trends and various market expectations in terms of functionalities:

- Batch orientated production in the food and pharmaceutical sectors is subject to more strict regulations every year on tracking and tracing, there is a need for better integration with ERP and better reporting
- 66% of MES products comply to FDA's "21 CFR part 11", 63% is deployed in a regulated production environment
- Helpdesk and 24/7 support for MES products was located in Asia and pacific region for 46% in 2005, in 2004 this was only 25%; there is a trend to outsource certain MES services
- 12% growth in support for mobile and wireless solutions in 2005 concerning MES. This indicates market interest in this field and is an area in which Huatek has experience

It was not possible to find specific data on market trends & functionalities in China due to the lack of professional documentation, Chinese companies are not as strict in recording or reviewing these aspects. The second barrier was the local language, documentation is mainly in Mandarin and thus difficult to find and translate.

Market Demands

A list of basic demands can be created to which vendors must qualify [20,22] :

- Real and proven focus of the vendor on customer's market
- on-site support by the vendor
- fit of product with customer's type of industry
- Sufficient support according to ISA-95 and FDA rules
- Availability of appropriate preconfigured solutions
- Availability of support with customers' major functions
- The system must be configurable to match customer specific processes
- Availability of adequate Internal Quality System
- Rapid FDA validation of product

Conclusion

The pharmaceutical industry consists of high-tech research driven and medium-tech generic-focused companies. Research-driven companies play a major role in the US pharmaceutical market, where the smaller Chinese market consists mainly of generic-focused companies. There are many MES vendors, mainly US and Europe based but variations in size, of which a reasonable number has some focus on the pharmaceutical industry. The market is mature; the quality of the offer is high, vendors are specialising their product and looking for opportunities to lower their costs. Customers expect a MES product to offer high levels of configurability and to come with various services.

6.3 Direction of Development

What direction should product-development take in the light of Huatek's organisation? (research question 3)

Huatek's MES should develop a distinctive value proposition that meets needs of the target markets better than competitors. We first sum up the previous research by showing the values of Huatek in combination with MES benefits in a SWOT diagram (table 2).

	Strengths	Weaknesses				
International	Knowledge & experience in certain pharmaceutical areas Consulting experience in process improvement and administration automation Outsourcing and off-shoring experience Rapidly development environment Experience Integrating Legacy Systems Reaching project deadlines & staying within budget Strong management ideas and leadership	Lack of in-depth knowledge in production Limited experienced employees Limited research budget Insufficient network in pharmaceutical industry Dependant on senior management individuals Low employee initiative and creativity No industry standard knowledge (ISA-95)				
Compared to US competitors	Provide lower general costs Large number of Chinese university graduates	Lack of FDA knowledge Weak marketing skills Lack of brand name Geographical distance Language barrier				
Compared to Chinese competitors	CMMIII-approved Marketing office in California Experience with end-user Security of sensitive material during development Capable of thinking along with customers					
	Opportunities	Threats				
International	Growing American pharmaceutical industry Use of potential customer contacts Potential partnering or subcontracting possibilities Large cost concious medium sized market Potential sale of MES modules Future market in Europe and Japan Easy starts of new plans Growing Chinese pharmaceutical market Being the first Chinese and low-cost MES vendor	Small window of opportunity Larger and more advanced competitors Small customer base Large investment requirements for MES development Uncertain time frame for product development Uncertain client base				

Table 2: SWOT analysis of Huatek

Competition

Other competitors are already offering their systems to the market, these are companies with more expertise in automation environments and the pharmaceutical industry. They furthermore claim to have the top of the pharmaceutical industry as their customers; Huatek can not compete with them, mainly due to the lack of knowledge, experience and brand name. Huatek however can offer a major cost advantage compared to western companies, who sell more expensive, complete systems and incur higher implementation and service costs.

Market

Looking at the industry characteristics we found that size and product are the best classifying properties. If a company is large, it will have more advanced and very sophisticated processes. Small companies do not have advanced planning methods and will most likely only have one production line or even only one product, they do not need a MES. Medium-sized companies have less advanced technology though advanced enough to support MES. Companies selling branded products are too advanced for Huatek, they use the newest in production technology. Generic producers however compete at costs and efficiency and use common technology. Medium-sized, generic-focused companies are thus the ideal market for Huatek.

In China, almost every pharmaceutical company competes on price and given the weaker insurance system as well as the lower income from the population [28], competition is harsh and companies will be very eager to lower their costs.

Technology

Our proposed concept of Huatek's MES will have the following structure:



Figure 5: Concept architecture

This structure varies slightly from the previously shown diagram (figure 3), showing more detail in the integration aspects with ERP and production equipment. Existing systems can be connected to our proposed MES, but an entire system can be installed too. With this structure, there is no need to replace effective systems; suites or applications can be implemented alongside current software and hardware and so can future systems. A useful aspect here is that Huatek's core competency is the integration of legacy systems and has gained experience in some production-related systems. The time scale gives an indication of the interval of information updates throughout the organisation.

Conclusion

Huatek should compete at its core competencies that correlate with the potential development of MES, namely cost-effectiveness software development and integrating legacy systems. Huatek's MES should focus on delivering a modularised, configurable system at a competitive price, capable of a high level of participation and involvement within the automation environment and providing a long term solution. The various planning and operational systems must be integrated through a central generic data layer and providing appropriate interfaces for the various users. They can minimise the costs for the customer by allowing present and future systems to be integrated.

Their target market consists of medium-sized generic-focused pharmaceutical companies, in the USA or in China, who want to receive the basic MES functionalities for the lowest possible price. This market shows the most potential in terms of market trends and ease of market entry. The pharmaceutical industry producing generics is especially large in China, which are potential customers with the appropriate level of technology and automation complexity for Huatek's MES offering. This potential MES product at a competitive price would still be concerned with the entire production facility, thus requiring services to assist in the implementation and after-sales services are necessary to create a complete offering.

7. Detailed Business Analysis

7.1 MES Offer Development

What should a MES and its associated services look like? (research question 4a)

A product offer needs to consist of a product, services, logistics, advice and adaptation possibilities [11]. In our research, the product consists of the actual information system. The services element incorporates all the services offered alongside with the software. The logistics is not an issue and will be left out of the offer design. The advice (consultancy aspect) is important given the complexity of MES. The adaptation possibilities imply any software customisation or necessary integration.

Product

Since the purpose of this research project is not to develop the entire system but give a general design, we will only review the main functions the system must contain. The following 11 functions should be included in a MES technical design and will deliver the benefits stated in chapter 5.3 and appendix I (table 4). Their significance and designs of functions will of course vary between industry automation environments. The standards functions of MES are [20,21,22]:

- Operations/Detailed Sequencing

- Dispatching Production

- Product Tracking & Genealogy
- Labour Management
- Process Management
- Data collection & Acquisition

- Resource Allocation & Status
- Document Control
- Performance Analysis
- Maintenance Management
- Quality Management

A detailed description of these functions can be found in Appendix II (figure 9). Figure 6 shows the context of the MES system; it shows the main data-flows between MES (represented by the circle) and other entities (represented by squares). It only contains the major information flows and ignores communication between other departments and functions outside the MES.



Figure 6 : Context Diagram of Huatek's MES

Two more diagrams are shown in Appendix II, a layer 0 data flow diagram (figure 11) which shows the 11 standards functions of MES, followed by a level 1 diagram of the reporting function (figure 12) which plays a central role in terms of performance analysis. These do not directly contribute to our main research question and are therefore shown in Appendix II, they could be useful for Huatek.

Next to the functions, there are demands on the technology used:

- Communication technology:
 - o Wireless access, as presented in chapter 6.2, this is a major trend
 - Web-Based user interfaces and a virtual monitoring centre, according to feed-back from Merck, easy remote access is a top priority
 - Remote access and monitoring according to feed-back from Merck, easy remote access is a top priority
- Security
 - HTTPS: a secured internet connection is necessary to prevent intruders from 'playing' with the factory
 - Data encryption: next to a secure connection, data must be encrypted when sent over the internet
 - User technology: users should only be able to use the functions they should have access to
 - Auditing: with a good auditing and history functions, any error, mistake or abuse can be traced and found
- Legal
 - o Comply with FDA rules
- Configurability
 - o Easy integration with various existing and future systems, using open source software
 - o Users must be able to configure the MES if products, processes or machinery changes

Services

In order to satisfy the customers' demands the MES offering must in our opinion be able to provide the following services:

- Implementation (on-site)
 - On-site real-time support for system deployment, factory acceptance test, installation and data migration
 - o Training and detailed documentation
 - Pilot project prototyping
 - Support & Maintenance (after-sale)
 - o Onsite troubleshooting
 - o Continuous upgrading of MES solution with enhanced features
 - Strategies for ongoing maintenance

Advice

A potential customer might be unsure about its current needs and to what extent these are fulfilled by acquiring an unknown product [11]. A MES vendor should be able take away uncertainties a customer might have, by offering business, process and technical consultancy services.

Adaptations

Because no factory is the same, some customisation is necessary for every client:

- Integration services with legacy systems
- On-site customisation
- Helping the customer to configure the system by providing a modularised MES (make sure any function is available in a module, thus minimising customisation efforts)

With this product offer, the basic functionalities of MES and the services necessary for the customer are offered. Huatek can offer enough implementation assistance to lower the barrier for companies to buy the MES offering.

Conclusion

Huatek's MES should cover the eleven basic functions found in literature. Our diagrams give insight in the data flows within the system and between the MES and its environment. Just delivering the software package is not enough; customers expect certain technologies and services to come with a MES.

7.2 Market Analysis

What is the size of the targeted markets? (research question 4b)

Based on the data found in chapter 6.2 we reviewed MES in light of Huatek's organisation, competition, types of pharmaceutical products and industries. We determined the US and Chinese medium-sized, generic-focused pharmaceutical companies to be Huatek's best target markets. The Chinese market offers the highest potential growth rate, but the need for MES is more developed and higher in the US. Next to this, top management wanted to enter the US market at the time of our research. For this, we decided to analyse both the US as well as the Chinese pharmaceutical industry. To gain insight in the market, we need to define and measure the potential, available and target markets [12].

- The market consists of medium-sized, generic focused pharmaceutical companies
- The potential market are those companies without MES and wishing to further integrate their IT functions, thus having interest in MES
- The available market consists of companies with a sufficient size to support MES, namely having more than 50 employees
- The target market are those companies already using ERP; Huatek can not offer an ERP themselves but having one present in the organisation is critical for the success of a MES

US market

Some numerical facts in order to further define the market:

- According to 'pharma-info' [14] there are 680 pharmaceutical companies in the US.
- According to 'Yahoo Finance' [15] there are about 400 pharmaceutical companies
- In 1990, the EPA [18] records 1500 pharmaceutical companies (of which 1000 have less than 50 employees)
- US pharmaceutical companies invest an average of 17% of their sales in Research & Development [23]

Market - Sources vary in the total number of pharmaceutical companies. Estimation on this number will be too rough, therefore skipped.

Potential Market - Since the wish for current integration is about 65% and companies not using MES account for 65%, the potential market is estimated at 42% of the generic industry.

Available Market – pharma-info and yahoo finance do not display small companies and EPA lists 500 companies larger than 50 employees; we know that 500 companies have sufficient size to support MES in the US. We do not know how many of them are generic-focused companies, but since 50% of the prescriptions are generic drugs and 50% of the generics are produced by research-driven companies, we estimate 25% of the companies are focused on generics. This includes the 58% of the companies using MES or, on the opposite, lacking the wish for further integration. We therefore calculate the available market for Huatek to consist of 53 companies in the US.

Target Market - 88% of the companies already use ERP. Since we are using a build-up formula, we can multiply 53 with 0.88, leading to 46 companies eligible for Huatek's (partial) MES offering.

Chinese Market (based on PWC [28,30] and Access China [31])

The technology level in China is lower than that of the US industry. No exact data could be found on this topic however. We assume the wish for integrating IT services equal to that of the US, since competition is harsh in both markets. We estimate the current technology use to be half that of the US. Although this is a strong assumption, we only use our market estimation to get some insight in the markets rather than to create precise figures.

Market - there are approximately 3700 companies producing drugs in China, of which 78%, thus 2886, are domestic.

Potential Market – We found in chapter 6.2 that the generics account for 97% of the total sales volume of domestic companies. From this we estimate 97% of the companies are focusing on generics. This is a strong assumption because no numerical data was available on generic companies, but since the patented drugs account for only 3% of sales, the deviation can not be big. Since we estimate the Chinese technology use to be half that of the US, we can deduce MES usage will be 17.5%. The wish for further IT integration is estimated at 65%; the potential market is thus 1548 companies.

Available market – The 10 biggest pharmaceutical companies account for only 20% of total sales (compared to about 50% in the US or Europe), the industry is very fragmented and even the largest companies can be called medium-sized. A lot of small companies exists too, with such fragmentation, we make the assumption that at least 2 out of every 3 companies will be small. We estimate 33% of the companies to be medium-sized, Huatek's available market consists of 515 companies.

Target market – 44% of the companies use ERP. What remains is Huatek's target market's size, which is 257 companies, making it approximately four times the size of the US target market.

Critical note

The data above assumes that Huatek will and can individually create an entire MES offering. However the option of creating a partial MES offering or working together with other MES vendors (see Rockwell, chapter 6.2) remains open. Huatek's partial MES offering could for example be added on top of existing MES offerings currently operating in the pharmaceutical industry. The target market would obviously be much larger in the US pharmaceutical industry because of the widespread usage of MES. But due to the lack of knowledge which applications Huatek could specifically offer and which would be compatible with other MES there are no market estimates in this research report concerning these options.

7.3 Detailed Business Analysis

How can Huatek create a MES product offering? (research question 4)

Introduction

In this chapter, the findings from the previous chapters are translated into a list of all the arguments to be taken into account when proposing a strategy for Huatek. Hereafter, several statements are deducted, which have to be taken into account when proposing a strategy. With this high-level statements, the detailed business analysis is finished.

Interpretation of findings

Answering the preceding questions provided us with information and insight in the MES topic and Huatek's possible position. Several arguments and conclusions will be taken into account when proposing a course of action for Huatek, these are divided in organisation, market and product-related. **Structure**

- Current company strategy is focused on defined outsourced work rather than design for market (4.1)
- Huatek's core competency is cost-effective work and meeting deadlines (4.1)
- There is a lack of practical experience, theoretical knowledge, understanding of production practices and management systems (4.7)
- Huatek has some experience with certain modules which play a role in MES (4.7)
- Mindset of employees and working environment is not in line with development of an in-house built product (4.2 & 4.3)

Market

- MES market has hard competition as well as an increase in specialisation by vendors, with which Huatek cannot compete (6.3)
- MES market is maturing, vendors are niching and outsourcing (6.3)
- High demands of MES customers in terms of trust in vendor (6.2)
- Huatek should target medium-sized generic producers due to market saturation, competitiveness and technical complexity (6.3)
- Geographic barriers exists between China and the USA; all MES vendors are US-based or have large development centres located close to the customer (6.2)
- Demand figures for MES look promising in China and USA (11)

Product

- MES should cover the 11 basic functions (Appendix I)
- A MES should be configurable to match the customer's situation and integrate existing systems (7.1)
- High level of technology required by MES offering in order to offer all the functionalities and be configurable with current systems (7.1)
- Many services must be offered next to the system itself (7.1)
- Huatek should focus on a basic MES offering for a low price (4.7)

Conclusions

The arguments presented above lead to the following summary statements:

Huatek Should Find a Partner

Huatek does not have enough experience in the pharmaceutical manufacturing/automation environment as well as in product development. This lack can not be overcome by looking up literature on these subjects or doing extensive research. Huatek thus needs knowledge from another party to develop their MES offering, only by working together on a project can Huatek have access to this knowledge, experience and a real manufacturing environment.

Shortcomings for Huatek in Developing Capabilities

The company lacks the experience in product development. Although Huatek thinks along with customers to some extent, Huatek has no experience in developing a product in-house or from-scratch design work for an entire market. Next to this, Huatek has limited experience in marketing. Acquiring clients is usually done through the board of directors' network and marketing focused on the company's quality rather than a single product.

US Market Too Difficult

The MES market in the United States consists of several suppliers with a well developed product. Although there are generic-focused low-cost producers who might find the current vendors too expensive, it will be very difficult for Huatek to attract these customers.

The Chinese Industry Looks Promising

MES is not very common in the Chinese pharmaceutical industry, the technology level is lower than that of the US and Europe. There are many companies in this market but the vast majority is rather small in size (probably most of them owning only one plant). Almost all of them produce generics and government policy forces them to keep their prices low. They are thus very low-cost focused and eager to cut costs. They are also Huatek's domestic market, this industry offers a lot of prospects for Huatek.

MES Vendors Are Maturing

MES products are improving dramatically and competition between vendors is increasing. The trend which has followed from this is that vendors are offering more services, modules, long term solutions, options and even specialising their products.

High Investment Necessary

Developing a complete MES takes a lot of time and resources. The basic functions to be provided are extensive assignments themselves, but creating an appropriate architecture for the data layer and user interfaces will also be considerable time-consuming. During this entire process ERP and other systems will need to be taken into account for future implementation. If Huatek is to develop a MES a considerable number of employees will need to be assigned to the project.

8. Strategy Proposal

What is the best strategy in terms of organizational, marketing and technical tactics on how to create, market and sell a MES offering? (research question 5)

8.1 Introduction

The detailed business analysis lead to several statements which are critical in proposing a strategy. With these statements, we will define several options for Huatek. After evaluating this options with company criteria, the strategy to achieve the selected solution is formulated, by first defining the critical success factors and then applying them into low-level, concrete steps.

8.2 Strategic Choice

Alternatives

Based on the previously defined target markets, market trends, management reflections/interviews and previously stated follow-up assumptions we have brainstormed and defined 4 options which Huatek can take following their initial MES research.

8.3 Option 1: Second-Tier MES vendor market

Explanation

Enter the 2nd tier market and become a partner with a current MES vendor to assist in the development, implementation, maintenance and support of their product. This would mean Huatek receives outsource work from the MES vendor, but not take part in the actual marketing, sales or ownership of the software product. In the long run possibly develop an in-house built system, but Huatek will always remain a market follower. In this case Huatek can profit from the MES market without having to make a large investment or bear excessive risk.

Advantages

- Current knowledge level feasible (except for ISA-95, the automation terminology and model standard)
- Fits current capabilities and competencies
- Acquiring one assignment generates many future assignments
- Only market investment necessary

Disadvantages

- MES vendors more likely to cooperate with US-based partners for critical services
- Initially simple low-margin assignments
- Great dependency on single client

8.4 Option 2: Chinese Pharmaceutical Industry

Explanation

The Chinese pharmaceutical industry looks promising when it comes to software needs. Huatek can partner-up with one or more Chinese companies and develop a MES stepwise, for a very low price. In return Huatek has access to a real-life pharmaceutical automation environment. After finalising the MES for this company, the system can be generalised for other companies and thus develop the first low-cost MES and become the only Chinese MES-vendor.

Advantages

- Huatek gains a personal product
- Each customer gained offers a big assignment
- Each assignment improves & expands the product
- Evolve to product-developer, move up the value chain
- Gain monopoly on low-cost MES as well as Chinese market
- No dependency on major clients

Disadvantages

- Major lack of knowledge
- Investment risk (though shared with partner)
- Convince relatively low-tech industry of benefits
- Extensive training necessary
- Great dependency on market efforts

8.5 Option 3: Offer components

Explanation

Offer only several components & applications, based on past projects, to the pharmaceutical industry or MES vendors to include in their current software systems. This would mean Huatek leaves the option of producing a complete MES offering and generalises its past projects into applications.

8.6 Option 4: ERP

Explanation

Develop a MES in cooperation with a Chinese ERP vendor. By sharing knowledge with this local vendor, a MES can be designed which works alongside this ERP. This system can be sold through the ERP partner's network separately or in combination with their product. A Chinese ERP vendor will be much more willing to cooperate than a US ERP vendor.

Decision analysis

To select the alternative Huatek should focus on, we used SMART in which normalised direct rating and swing weights were applied. Our main criteria were market attractiveness, technology and risks and organisational aspects, making sure the criteria would match our research topics. These categories were subdivided into sub-criteria. We first assigned weights to the main criteria to make sure each category gained proper importance, hereafter we assigned weights to the sub-criteria. The weights were assigned in cooperation with top management. We gave a score to each criteria using a scale from 1 to 10. We later normalised the scores to a 0 to 100 scale. For the complete figure of the one shown below refer to appendix III, table 6. The weights of the criteria are based on our own judgement and confirmed by top management, which was interviewed. Results are shown in table 3.

	2nd tier Market	Chinese Pharmaceutical Industry	Components and Applications	Chinese ERP partner
Total score	65,0	60,4	46,1	30,6

Table 3: Results of SMART analysis

8.7 Follow-Up Strategy

The options which ranked first and second received the scores 65 and 60, this is too close to make a solid decision on which direction to focus future MES efforts. This might however not be necessary considering the target markets do not overlap; the 2nd tier MES vendor market and Chinese pharmaceutical industry can be approached simultaneously. Both options depend on interest from potential customers and both markets will be approached by a different department within Huatek (the MES vendors by the US sales department, the Chinese industry by the Chinese marketing department), so approaching two markets simultaneously is no problem. Cooperating with either of them will potentially generate large projects for Huatek to perform.

The 2nd tier market does not lead to a complete MES offering as we intended to. However, by actively participating in the development of the vendor's MES, Huatek will offer more than simple outsourcing tasks. It will help us to understand MES further and to gain assignments Huatek feels comfortable with, with relatively little investment. Huatek can move up the value chain and continue its developments.

Cooperation with a Chinese pharmaceutical company is the best way for Huatek to develop a MES themselves. Heavy investments will have to be made and it will take a long time for the first complete MES to be finished. However after completion, Huatek will have an in-house built product and will be the only local vendor based in the rapidly growing Chinese pharmaceutical market. Most likely, they will be the cheapest MES provider worldwide.

Our advice for Huatek is therefore to concentrate their effort on these two alternatives.

In this section we will give our recommendations and steps for Huatek to take in order to properly carry out these alternatives. Our advice is split up according to our research model: approaching the market, acquiring the necessary technology and changing the organisation. This advice is meant to guide Huatek in its initial effort; the span of this advice is from Huatek's current situation to the moment of signing a contract with a partner (be it a MES vendor or a pharmaceutical company). By starting a partnership, our detailed business analysis has been fulfilled and the boundary of our proposal is reached.

8.8 Critical Success Factors Second Tier Market

Market

The main goals of the marketing effort are:

- Convince MES vendors of the value of cooperate Not all MES vendors are outsourcing their tasks. The market must be aware of the costs that can be saved by cooperating with a software service company.
- Show Huatek's capabilities and experience Take away the market uncertainty, show potential clients that Huatek is a good and competent partner by showing their capabilities, such as thinking along with the customer, low costs and their experience such as Merck-experience
- Get into contact with MES vendors

Technology

- Gain necessary knowledge (ISA-95) Huatek has insufficient knowledge in using industry terminology
- Learn about automation environment Huatek must learn more about production-related systems and about factory physics to truly understand MES

Organisation

- Improve and expand marketing department, dedicating members purely to MES
- Increase professional capabilities To perform more advanced tasks for MES vendors, employees must improve their English, must learn how to identify system needs et cetera
- Share ideas, knowledge and efforts between technical and marketing people

8.9 Follow-up strategy Second Tier Market

To fit Huatek's method of working, we have divided the follow-up strategy into four main categories:

Training

- Gain knowledge and understanding (enough to prove Huatek worthy) of:
 - o ERP, MRP and other production-related systems
 - o Industry terminology and jargon such as ISA-95
 - o Manufacturing environments (visit an automation environment)
- Train Marketing department to sell Huatek as a reliable partner thinking along with the customer, these people have to attend congresses and conferences.
 - o Train on representative activities
 - Practise explaining added value
 - Prepare engineers to potentially work on-site
- Improve English level, MES vendors are all US or Europe-based
 - o Set up mandatory English courses by the CA's
- Continue cultural developments within organisation
 - o Learn to develop system from vague definition

Documenting

- Create marketing material explaining Huatek's added value to MES vendors
- Document company experience and in-house knowledge of MES to show Huatek's current level of understanding
- Get a marketing company or external consultant with which to review and finalise documentation.
- Further prepare organisational presentations and other marketing materials concerning the company and MES understanding to present to MES vendors
- Set up a website to attract customers
- Prepare demonstration environment to show capabilities to visitors or at conferences
 - Including an integration example
 - o Proving manufacturing environment experience
 - Showing design capabilities

Restructure

- Set up a cross-functional MES team
 - o Include marketing and technical people
 - o Technical team passes knowledge to marketing
 - o Marketing passes findings from customers to technical team
 - Manage team by setting goals and keep track of progress
- Set up a conference task force, responsible for preparing participation or visitation of events. They should know how to network and explain Huatek's ideas.

Action

- Attend forums and conventions on MES, automation and ISA
- Use current and new contacts; through Merck approach Honeywell, Werum and other known MES vendors, inform outsourcing consultancy bureaus of ideas
- New-Business development department should get in contact with MES-related companies and develop material for stands at conferences

Conclusion

For the 2nd tier market we mainly focused on the marketing and technology follow-up strategies, this was because this MES approach fits very well within the current working environment of Huatek. The main problem is to find initial vendors willing to work with Huatek as a partner, for which good lobbying is required. Internally only preparation work such as familiarising with industry terminology and basic understanding of surrounding systems is needed.

8.10 Critical Success Factors Chinese Pharmaceutical Industry

Market

- Be able to raise interest in MES by Chinese pharmaceutical companies, since MES usage is low within this industry
- Exhibit Huatek as a local professional IT company with international capabilities
- Convince market of value of pilot project rather than buying expansive package
- Get in contact with Chinese pharmaceutical companies possibly through current contacts

Technology

- Create the platform and user interface MES will use
- Design application concepts
- Gain knowledge on ERP/MRP and manufacturing environments
- Learn industry jargon and standards

Organisation

- Create a well-guided MES team with full-time devoted employees
- Improve design capabilities Learn employees to understand information needs and design systems by themselves
- Expand and improve marketing department The marketing department must learn to actively approach customers and explain MES.

8.11 Follow-Up Strategy Chinese Pharmaceutical Industry

Training

- Understand basic industry terminology to create a professional image towards potential customers
 - o Buy ISA material and follow offered courses
- Train employees to be able to analyse a system needs and design accordingly
 - o Give workshops on drawing diagrams
 - o Train customers on identifying demands
- Continue cultural developments within organisation on innovation, independence and teamwork
- Train on ERP/MRP to understand their functions and data requirements
- Train on production environments
- Teach marketing people to sell MES and represent Huatek

Documenting

- Document company experience, case studies and in-house knowledge of MES
- Create professional marketing documentation explaining Huatek's purpose to approach pharmaceutical companies in Chinese and English
 - o Emphasise low costs
 - Hire external consultant or marketing company to review and finalize documentation
- Use a marketing company or external consultant to review and finalise documentation
- Prepare architectural presentations of the ideas for the pharmaceutical industry
- Create a website on Huatek's MES attempts
- Develop demonstration software
 - Showing platform and user interface
 - Showing MES benefits quantitatively

Restructuring

- Set up cross-functional teams to create a MES platform and lobby within target market
 - Members should be devoted full-time
 - Interaction between technical and marketing to incorporate market demands in the development and to keep marketing up to date
 - Assign members to subprojects to stimulate developments
- Set up a marketing or branding department within Huatek rather than just a sales department to actively market and sell a product rather than search for outsource assignments
- Hire an external advisor to assist the development process of MES
- Let senior management decide and develop a plan on this MES team and be responsible for this team to provide good guidance

Action

- Attend forums and conventions on pharmaceutical topics
- Organise forums and conventions on MES to create an awareness in the Chinese pharmaceutical industry of the benefits
 - o Invite all Chinese pharmaceutical companies (not all may attend)
 - o Make sure other parties (ERP vendors, EPS vendors) are welcome too

- Make it interesting for the visitors
- Use current contacts to search for medium or large sized Chinese domestic pharmaceutical companies which fall within the target market
- Create a basic platform on which MES can be built, so Huatek has taken the first step towards producing a complete offering before even having the first customer and can show its understanding
- Create architectural diagrams explaining how different functions are provided by MES

Conclusion

For the Chinese pharmaceutical industry we placed an emphasis on the marketing and organisational follow-up strategies which are necessary for this new style of project. Because of a lack of experience in the majority of applications in Huatek it might be difficult to find a pilot company which is interested in this offering. Therefore, creating awareness of MES in the automation sector in China is necessary when approaching the potential market, by presenting professional marketing and technical documentation. Further in-depth research in specific MES functions can be limited; as soon as a pilot company is found there should be enough opportunities to get practical experience and insight. The only thing Huatek can start to develop is a suitable platform for MES, this basis can be used in the future to incorporate currently existing functions at the customer and create new software.

The organisational strategy is limited in the sense that a development plan or system must be created, however this mainly depends on the knowledge at the time of commencement and on the customer for which the MES will be developed. Senior management at this time should assist the MES team with setting guidelines and a development process which they can follow in the creation of Huatek's MES offering.

8.12 Complication

Approaching both sectors simultaneously seems illogical because Huatek would have to divide their resources over two markets. Choosing one course of action can be simpler in terms of focus and further development. We have three reasons to suggest a dual approach:

Firstly, the marketing departments resources responsible for the Chinese and American market are separated geographically, operate independently and do not overlap with each other in their efforts, because of the different target markets and offerings.

Secondly, both target markets depend on opportunities for Huatek to show its capabilities to potential customers; forums and conventions only occur occasionally and do not guarantee any future projects and not every customer will invite Huatek to show its capabilities. Because of this high dependence Huatek's opportunities and thus necessary efforts are limited.

Thirdly, during this marketing phase, the knowledge applied and presented in both scenarios would be very similar: Huatek is to show their capacity and their MES understanding. By approaching the target markets simultaneously each marketing department can approach local opportunities with the shared knowledge and the chances of success are increased significantly.

The potential revenues of the assignments compared to the marketing costs make it attractive to at least approach and explore local prospects. When eventually a customer is found in either of the markets the progress of the other needs to be reviewed, in case it shows no potential it can be discontinued.

9. Conclusions

9.1 Conclusions

The purpose of this research report was to analyse and choose a course of action on how Huatek can create a MES offering and approach the pharmaceutical industry. This was completed through analysing Huatek in light of challenges to developing a MES offering and reviewing the various markets.

We started out by defining MES as an extensive information system with a primary role of communicating and connecting the various systems inside an automation environment, taking on an active execution role rather than simply transferring data and creating reports. The market has high demands in terms of the functionality, the technology used, configurability and the services offered due to the presence of many vendors. However Huatek has limited development skills and industry experience in developing their own product, not sufficient to develop their own MES in a competitive environment or compete with the current vendors if a product evolves. This limits their current options for a potential MES offering and market.

Partnering up is therefore a critical success factor for Huatek's attempts to enter the MES market. Huatek can become a 2nd tier partner for current MES vendors or develop its own MES conjointly with a Chinese pharmaceutical company. For both options, Huatek has to improve its marketing (active branding) as well as their technical capabilities (development skills and manufacturing knowledge) in order to create a professional, capable and trustworthy image.

Both the 2nd tier market in the US as well as the MES market in China are likely to grow in the future. Although it is possible to enter both markets now it would be beneficial for Huatek to continue further preparations in terms of training and education, especially for the Chinese pharmaceutical industry. This process of improvement on both marketing and technical capabilities should be guided by senior management. Ideas need to be carried out rather than spoken of, thus visiting conventions, approaching possible customers on the marketing side and getting trainings and visiting manufacturing environments on the technical side.

Our analysis has provided two suitable courses of action for Huatek to follow and we defined success factors and strategies. For both options several key changes need to be made in the structure of Huatek in combination with training their personnel to reach a required level of professionalism towards the potential customers. If this strategic process is properly acted upon we are convinced Huatek can enter the pharmaceutical industry with a MES offering and acquire numerous assignments in the coming years.

9.2 Reflections

In this section we will give a short reflection on our originally stated research objectives and the process we went through in order to produce the necessary documentation, for more detail refer to appendix III. Because it is uncommon to conduct a bachelor assignment together we decided it would also be useful to reflect upon our teamwork and cooperation throughout the course of our internship.

Research project objectives

To review whether the research objectives of our project are sufficiently accomplished we need to refer back to our initial tasks (1.2), problem (2.1) and deliverables (2.4). We have accomplished our objective, through creating and using our own new product development process we systematically reviewed and analysed our marketing and technical research to form a knowledge base of MES information for Huatek. Early in the project, we started to notice the difficulties of actually creating a complete MES offering and got an insight in Huatek's organisation. We then needed to widen the scope of the research project. We adjusted our initial task by not restricting our research project to the pharmaceutical industry in the US and a complete MES offering. Through this we eventually gave Huatek extra options about how and which market they can attempt to enter with a MES offering. Of these options we have determined the right course of action accordingly for Huatek and have provided sufficient useful information to guide Huatek in their attempts to enter the MES market.

The changes in the scope of our research concerning the type of market and product did not contribute to the overall efficiency of the project. Endless reflections and revisions of our initial objectives and research questions made the research tiresome. This was the main difficulty in matching a product development study with our bachelor assignment, however eventually we found the right match and through strenuous checks we managed to form this research document.

Research process

The challenge in the research process was to find credible and recent sources, often we were forced to restrict our research due to limited resources and time constraints. Initially we created and adjusted an existing 'new product development process' which would be compatible with Huatek. This proved to be a very useful model; it helped us in the development of our research report and guided the MES project. Looking back on our work, there is a very clear structure throughout the research which continues in the analysis sections, separating the marketing, technology and organisational details. It makes the report much easier and pleasant to read.

Teamwork

The main challenges we encountered in conducting and following a new product development process was constantly communicating ideas and preventing overlap. Because we were working in separate offices half the time, it challenged us in effectively communicating and focusing the research. This usually went quite well over the course of the project and created a learning experience for us. We had the advantage of having worked together before on projects during our university study, however this surpassed those teamwork activities by far and asked for a much higher level of cooperation. We both never hesitated to discuss decisions, courses to take and the text of our report, all of which happened in good atmosphere improving the results significantly.

Working together with the technical team of MES was extremely difficult because of the different interpretations people had due to their backgrounds. The technical team was focusing on MES in light of Huatek's past experience and their limited knowledge of IT automation systems. Rather than taking the creative approach which we took, they preferred to restrict their mindset to what they already knew. It was our task to conduct the market research and with this knowledge we tried repeatedly to open the eyes of these employees. For us it was a rather awkward situation because as interns we did not expect to be leading several software engineers. It was a learning experience and forced us to transfer knowledge weekly.

9.3 Recommendations

In this part of the project we will give additional advice which we think is applicable for Huatek but falls outside the scope of our research project. Because of the differences in culture and working styles we think it is useful to make some general remarks reflecting on the organisation, these might not be as obvious to the local senior management as it would be to foreigners working inside Huatek.

Become a MES retailer

Through the course of the research assignment we have defined several courses of action, in a later stage however we discovered an additional option, which is the possibility for Huatek to become a retail partner of an existing foreign MES vendor in the pharmaceutical industry. Huatek would offer the vendor's product to the Chinese market. Huatek would translate relevant software or interfaces to Chinese, offer local implementation and other services to Chinese pharmaceutical companies. The challenge in this scenario is to acquire a customer willing to share its profit and product with a foreign outsource company, rather than setting up its own office in China. The main advantages for Huatek are the low investment requirements and low risk, the learning experiences and the creation of dependency of a foreign MES vendor on Huatek. Obviously, before a MES vendor would outsource its sales and services locally a level of trust needs to be built up through knowledge sharing and demonstrations of capabilities.

Sell separate or individual parts

Huatek has performed projects for many companies in the past 14 years and thus built up a significant database of past projects, knowledge and experience. Although these projects were sometimes very specific, such as the integration of custom-made legacy systems or current-product engineering, many projects were partly or completely stand-alone solutions to business problems. These solutions may not only be useful for the intended customer, but might also be useful for other companies. By changing these specific solutions into general software, Huatek can create a range of products with relatively little effort. This software can be sold to individual companies and in the case of MES/ERP vendors even offered as a module. The process itself of generalising the former projects will learn Huatek to identify customer needs and create software for a specific market.

Make turnover decision

After gaining some work experience, training or being sent abroad, people tend to leave Huatek for other jobs offering a higher wage or better opportunities, or both. There are attempts to prevent outflow and to some extent work is documented to cover the loss of human capital. Huatek should make a decision to either focus on documentation which will minimise lost knowledge and enable Huatek to continue hiring young graduates, or to prevent the outflow by increasing the incentives for employees to stay. Options such as offering them higher or more wage increases, more training opportunities, possibility for extra more attractive work assignments and a clear promotion path. By tracking employees progress and history their needs, desires and opportunities can be identified. The last option will obviously increase costs but will enable the built-up of knowledge and the expertise of Huatek's personnel.

Develop Middle Management

We noticed some employees could have no tasks for weeks, while their colleagues from the same project team were working overtime every day. Senior management is not aware of this and other issues within project teams. The cause of these problems is a weak middle management, which consists mainly of project managers. They became project managers by getting promoted from developer or tester, often lacking the capabilities to manage a team and to take care of their members, they only focus on the project goals. It is very difficult to find qualified and responsible managers in China. The experienced developers therefore remain the best source for project managers. It is necessary that they share knowledge and experiences with each other, follow workshops on human resource management and other topics and more communicate thorough with senior management.

Hierarchical Limitations

The strong hierarchical structure of Huatek has its positive elements; for example it is easy for management to implement new ideas. However it does make people passive; we noticed on several occasions that employees did not say or do anything when there were more senior programmers present in the room, neither will employees go to the management to propose ideas or share their complaints. For an IT company which operates in an unstable environment, it is important for management to be aware of problems quickly and involve employees in development processes. By actively asking employees for their ideas or experiences, throughout meetings as well as in the office, management would be more aware of problems while also receiving fresh input and new ideas from employees.

Increase general skills

During workshops, meetings and other activities we used practices learned at the university, such as brainstorming, giving presentations or having a meeting on a new idea. However, participation by Huatek's employees is low in brainstorming sessions, presentations are created with too long texts and bad outlines and there is little awareness of the common goal to be reached in a meeting. Rather than attempting to come to an agreement through a discussion, employees enter a meeting with their opinion and try to force their own ideas on others through seniority or stubbornness. Giving trainings on how to

brainstorm, how to give presentations, how to have effective meetings et cetera will improve the creativity, knowledge-transfer and cooperation within Huatek.

Change of mind-set

We noticed the presence of barriers for open discussions, sharing of knowledge, teamwork, et cetera. Partly, these might have evolved naturally through the Chinese culture, way of working and traditions. Employees prefer for example to have their work defined for them by senior management and solve the given problems through defined processes. As stated before Huatek has received CMM3 certification, which means Huatek is process orientated, which is exactly in line with the preferred method of working for most employees. However in order to reach the next level of certification, CMM4, these processes need to be ignored and employees must be able to think for themselves in order to work towards a solution. If Huatek wants to take on larger and more technologically advanced projects, keep up with local and international off-shoring competitors and not remain dependant on senior management, it needs to take several steps. A change to an assertive mind-set is required for the majority of these employees, either through direct influence or indirectly with changes in the working atmosphere. The external method would be to open the eyes of employees to the international environment through working abroad and interaction with foreign culture. The internal method to influence the working environment would be the continued presence of foreign internship students to create a more innovate and creative working atmosphere and trainings encouraging assertiveness within the company.

References

- 1. Calantone, R.J. & di Benedetto, C.A.. An Integrative Model of the New Product Development Process. *The Journal of product innovation management* 1988:5:201-215.
- 2. Krishnan, V. & Karl, T.U.. Product Development Decisions: A Review of the Literature. *Management Science* 47(1):1-21 (January 2001).
- 3. McClellan, M. (2000). *Introduction to Manufacturing Execution Systems*. Phoenix, Arizona, USA: MES Conference & Exposition.
- 4. McClellan, M. (2000). Evolving to the Enterprise Production System (EPS). Orregon, USA: MES Solutions, Inc.
- 5. Aberdeen Group, Inc.. (2006). *Global Manufacturing: MES and Beyond Benchmark Report, May 2006.* Boston, Massachusetts, USA: Aberdeen Group, Inc.
- 6. Aberdeen Group, Inc. (2005). *Manufacturing Transparency, December 2005*. Boston, Massachusetts, USA: Aberdeen Group, Inc.
- 7. Aberdeen Group, Inc. (2006). The Manufacturing Performance Management Benchmark Report june 2006. Boston, Massachusetts, USA: Aberdeen Group, Inc.
- 8. Fraser, J. (2004). The MES Performance Advantage: Best of the Best Plants Use MES. Newburyport, USA: Rockwell Automation, Inc.
- Trombetta, B. (2005). 2005 Industry Audit. Retrieved 20 October 2006, from Advanstar Communications, Inc. Web site: <u>http://www.pharmexec.com/pharmexec/article/articleDetail.jsp?id=177964</u>.
- School of Management and Governance, University Twente (2007). Handleiding Bacheloropdracht. Web site: <u>http://www.mb.utwente.nl/onderwijs/bachelor/bacheloropdracht/algemene_informatie/handleidingBAOpdr.pdf</u>
- 11. Ford et al. (2001). The Business Marketing Course. Chichester: John Wiley & Sons, Ltd.
- 12. Kotler, P. (2003). *Marketing Management*. Upper Saddle River: Pearson Education.
- 13. Chung, S.L. & Jeng, M.D. (2002). Manufacturing Execution System (MES) for Semiconductor Manufacturing. Taiwan, R.O.C.: IEEE SMC.
- 14. Pharma-Info. *List of pharmaceutical companies in the USA*. Retrieved on 25 September 2006. Web site: <u>http://www.pharma-info.org</u> (25-09-2006).
- 15. Yahoo Finance. Drug Manufacturers Industry. Retrieved on 25 September 2006. Web site: <u>http://finance.yahoo.com</u>.
- 16. Gertz, D. L., Baptista J. P. A. (1995). Grow to be Great. New York, USA: The Free Press.
- 17. Adler, D.J. et al. (1995). Does a Manufacturing Execution System reduce the cost of production for bulk pharmaceuticals?. Indianapolis, USA: Elsevier Sciences B.V.
- 18. US Environmental Protection Agency (1997). Profile of the Pharmaceutical Manufacturing Industry, Washington D.C., USA: US Government printing office.
- 19. Daft, R.L. (2001). Organization Theory and Design. Cincinnati, Ohio, USA: South-Western College Publishing.
- 20. Visser, R. and Snoeij, J. (2003). MES product survey 2003. Arnhem, The Netherlands: Logica CMG.
- 21. Scott, D. (1996). *Comparative advantage through Manufacturing Execution Systems*. Toronto, Canada: Institute of Electrical and Electronics Engineers.
- 22. Visser, R. and Snoeij, J. (2005). *MES product survey 2005, 2nd edition*. Arnhem, The Netherlands: Logica CMG.
- 23. Danzon, P.M. (2006). *Economics of the Pharmaceutical Industry*. Retrieved on 14 December 2006 from National Bureau of Economic Research. Web site: <u>http://www.nber.org/reporter/fall06/danzon.html</u>.
- 24. Scott Morton, F.M. (1998). Barriers to Entry, Brand Advertising, and Generic Entry in the U.S. Pharmaceutical Industry. Chicago, USA: School of Business.
- 25. Public Citizen Congress Watch (2003). 2002 Drug Industry Profits: Hefty Pharmaceutical Company Margins Dwarf Other Industries. Washington, USA: Public Citizen.
- 26. US Government (2006). *General Information Concerning Patents*. Web site: www.uspto.gov/go/pac/doc/general/index.html.

- 27. Bae, J.P. (2000). Drug Patent Expirations and the Speed of Generic Entry. *Health Services Research* 32:1:87-101.
- 28. Friend, S. et al. (2006). Investing in China's Pharmaceutical Industry. Shanghai, PRC: PriceWaterhouseCoopers.
- 29. Get Hooked on Health (2006). *Brand Name vs. Generic Drugs*. Web site: http://www.gethookedonhealth.com/brandnamevsgenericdrugs.htm.
- 30. Henderson, B. et al. (2004). *China: prescription for Growth*. Shanghai, PRC: PriceWaterhouseCoopers.
- 31. Wu, X. (2005). Chinese Pharmaceutical Industry (Summary). Nanjing, PRC: Access China.

Appendix I – Marketing aspects

MES Benefits

This is complete overview of the MES benefits for the pharmaceutical industry in terms of improvements and problem solving abilities.

	Solves Problems	Offers Progress
Entire Company & Management	Eliminates lost paperwork All data securely available anywhere in real-time Integrates all computer systems FDA compliant manufacturing process	Increased profitability Increased efficiency Reduced overhead due paperwork Central information storage in data warehouse Improved flexibility Reduced classroom training for employees Smaller number of personnel
Planning & Support	Accurate, real-time data for management Integrate ERP with operational level Management support through automatic reports Electronic work communication to employees	Reduces data entry time Reduced validation Times FDA Overview of WIP Helps negotiate scheduling problems Improved on-time delivery Increases workstation management Real-time insertion of orders Automated and distributed support services Sophisticated history functions
Production Department	Accurate, real-time data for plant management Shorter and less unexpected breakdowns Less employee overtime Immediate event notification Integrates ERP with production floor Narrowing of problem scope for possible errors Administration department provides quick/accurate data	Reduces average cycle times Reduces WIP Reduces paperwork between shifts Reduced inventory levels Reduces lead Times Reduces and simplified production controls Reduces scrap, waste and rework costs Higher productivity(growth) Communication of maintenance schedules Increased exception management Allows easy implementation of new concepts such as TQM or Six-Sigma

Table 4: MES benefits

Current MES Products

By comparing the number of products (vertical axis) per industry (horizontal axis) below in figure 7, an industry focus can be determined. The pharmaceutical industry has a significant presence of MES vendors, third largest MES market after electronics and food & beverage.



Figure 7: MES products per market [20]

The figure below shows the number of industries which MES is offered to on the vertical axle by a certain MES product. The majority of vendors offer their products to a wide majority of industries.



Figure 8: Level of focus of MES products [20]

To assess the products of different vendors, we analysed available materials on every vendor to qualify their product. We used the criteria Size of Company, off-the-shelf product (to what extent is customisation necessary), focus on the pharmaceutical industry and the expected quality for the pharmaceutical industry. We assigned a score from 1 (very bad) to 5 (very good) to each of the first three criteria. With these three values we could estimate the expected quality of the product for the pharmaceutical industry. Below the results are shown in table 5.

	-	1	1	1	1	1		1		1	1	1		т
	Honeywell	Rockwell Automation	Werum	Camstar	Stratus	HCL	Aegis	Brooks	Eyelit	iTac Software GmbH	Visiprise	Omnirim	Siemens	Citect Ply Ltd.
Country of Origin	US	US	Ger	US	US	Ind	US	US	Can	Ger	US	US	Ger	US
Size of company	4	5	3	4	5	5	3	4	3	3	4	4	5	3
Off the shelf product	4	3	4	4	3	1	4	3	2	3	3	2	4	3
Focus on pharmaceutical industry	3	2	4	2	1	2	3	2	3	2	3	2	2	2
Expected quality of product for pharma ind.	4	5	3	4	4	2	3	4	4	3	5	4	5	3
	Aspen Technology	Propack Data GmbH	Mountain Systems, Inc	IBASEt	Viewlocity Software Ltd	ELAN Software	Datasweep, Inc	Bizibit NV	Tecnomatix Unicam, Inc.	CIMNET, Inc	Wonderware Corp	HMS Software Ltd.	PEC Info	Motorola
Country of Origin	US	US	US	US	US	US	US	NL	US	US	US	FR	BE	US
Size of company	4	3	4	4	4	4	3	2	3	3	4	3	2	5
Off the shelf product	4	2	4	3	4	4	1	3	4	3	4	3	4	3
Focus on pharmaceutical market	4	4	2	1	1	4	2	2	1	2	3	1	2	1
Expected quality of product for pharma ind.	5	4	2	2	2	5	3	3	2	3	4	2	3	4

Table 5: vendor assessment

External marketing definition

Given Huatek's characteristics, Huatek should approach the market by offering a system which offers all the benefits the customer requests at a very competitive price. Next to the technical definition of MES, Huatek should work with a definition which better suits the goal of adding value for the customer.

MES is a configurable plant-level execution platform for integrating automation \mathcal{C}^{∞} information systems, which provides analysed real time information and drives business processes, achieving operational excellence in managing processes at plant-level management.

Investigating organisational competencies, the market and technology, we can find the best direction for Huatek.

Appendix II – Technical aspects

Function description

Eleven basic functions of MES are found in literature., these can be described as follows:

Function	Description
1. Resource Allocation and Status	Manages resources including machines, tools labour skills, materials, other equipment, and other entities such as documents that must be available in order for work to start at the operation. It provides detailed history of resources and insures that equipment is properly set up for processing and provides status real time. The management of these resources includes reservation and dispatching to meet operation-scheduling objectives.
2. Operations / Detail Scheduling	Provides sequencing based on priorities, attributes, characteristics, and/or recipes associated with specific production units at an operation such as shape or colour sequencing or other characteristics which, when scheduled in sequence properly, minimize set-up. It is finite and it recognizes alternative and overlapping/parallel operations in order to calculate in detail exact time or equipment loading and adjust to shift patterns.
3. Dispatching Production Units	Manages flow of production units in the form of jobs, orders, batches, lots, and work orders. Dispatch information is presented in the sequence in which the work needs to be done and changes in real time as events occur on the factory floor. It has the ability to alter prescribed schedule on the factory floor. Rework and salvage processes are available, as well as the ability to control the amount of work in process at any point with buffer management.
4. Document Control	Controls records/forms that must be maintained with the production unit, including work instructions, recipes, drawings, standard operation procedures, part programs, batch records, engineering change notices, shift-to-shift communication, as well as the ability to edit "as planned" and "as built" information. It sends instructions down to the operations, including providing data to operators or recipes to device controls. It would also include the control and integrity of environmental, health and safety regulations, and ISO information such as Corrective Action procedures. Storage of historical data is provided as well.
5. Data Collection/Acq uisition	This function provides an interface link to obtain the intra-operational production and parametric data, which populate the forms and records, which were attached to the production unit. The data may be collected from the factory floor either manually or automatically from equipment in an up-to-the-minute time frame.
6. Labour Management	Provides status of personnel in an up-to-the-minute time frame. Includes time and attendance reporting, certification tracking, as well as the ability to track indirect activities such as material preparation or tool room work as a basis for activity based costing (ABC). It may interact with resource allocation to determine optimal assignments.
7. Quality Management	Provides real time analysis of measurements collected from manufacturing to assure proper product quality control and to identify problems requiring attention. It may recommend action to correct the problem, including correlating the symptom, actions and results to determine the cause. May include SPC/SQC tracking, management of off-line inspection operations and analysis in laboratory information management systems (LIMS) could also be included.
8. Process Management	Monitors production and either automatically corrects or provides decision support to operators for correcting and improving in-process activities. These activities may be intra-operational and focus specifically on machines or equipment being monitored and controlled as well as inter-operational, which is tracking the process from one operation to the next. It may include alarm management to make sure factory person(s) are aware of process changes, which are outside acceptable tolerances. It provides interfaces between intelligent equipment and MES possible through Data Collection/Acquisition.
9. Maintenance Management	Tracks and directs the activities to maintain the equipment and tools to insure their availability for manufacturing and insure scheduling for periodic or preventive maintenance as well as the response (alarms) to immediate problems. It maintains a history of past events or problems to aide in diagnosing problems.
10.Product Tracking and Genealogy	Provides the visibility to where work is at all times and its disposition. Status information may include who is working on it; components materials by supplier, lot, serial number, current production conditions, and any alarms, rework, or other exceptions related to the product. The on-line tracking function creates a historical record, as well. This record allows traceability of components and usage of each end product.
11.Performance Analysis	Provides up-to-the-minute reporting of actual manufacturing operations results along with the comparison to past history and expected business result. Performance results include such measurements as resource utilization, resource availability, product unit cycle time, conformance to schedule and performance to standards. May include SPC/SQL. Draws on information gathered from different functions that measure operating parameters. These results may be prepared as a report or presented online as current evaluation of performance.

Figure 9: The original description of the MESA-11 [22]

Overlap

MES can overlap with several other systems:

Overlap of MES with	Aspects
ERP	- Finance & Controlling
	- Human Resources
	- Order Control
	- Purchase
	- Capacity Planning
	- DRP
	- Distribution
	- Master Planning
	- MRP
LIMS	- Quality Control
	- Test Results
	- Test Planning
	 Instrumental Interfaces
	- Lab Samples
EBR - SCADA	 Batch Creation & Approval
	- Batch History
	 Operator Instructions
	- Data Collection
	- Visualisation
SPC - SQC	 Operator Instructions
	- Data Collection
	- Visualisation
PLC	 Operator Instructions
	- Data Collection
	- Visualisation
	 Process Data History
	- Machine Interfaces

Figure 10: Aspects of possible overlap of MES and other systems [22]

Additional functional design

The layer 0 data flow diagram below is designed (figure 11), to show the high-level data transformations and data flows throughout the MES. Data transformation processes are represented by circles, external entities by squares and data storages by two parallel horizontal lines. In the diagram the factory model is a database providing any information on the current factory (raw materials, machine set-up, available personnel, system errors et cetera) and also contains all the historic information, events from the past. This is an essential piece for reporting, but in the pharmaceutical industry it is even more important because of the product tracking and genealogy functions, many of them required by the FDA.



Figure 11: Level 0 data flow diagram of Huatek's MES

Since the Performance Analysis function covers many of the basic functions and is one of the most essential elements of MES, we described this function in more detail in the level 1 data flow diagram in figure 12, shown below. The elements within the dotted lines represent the detailed interpretation of process 6 in the level 0 data flow diagram. The user interface appears twice in the diagram to prevent some overlapping lines. The Active Alert System can send e-mails, instruct printers or use wireless devices to contact personnel actively if necessary.



Figure 12: level 1 data flow diagram of the Performance Analysis process

Appendix III: Steps and experiences within our research

Bachelor requirements:

Since we have taken this assignment to acquire our Bachelors degree, the requirements from the university have to be taken into account. Our company assignment already complies to some of the requirements. The most important requirements furthermore requested are [10]:

- Define a problem-formulation for the chosen research and design assignment
- Include research & design questions and a execution plan
- Use definitions and theories within the field of study
- Define research and design results and link them to the problem formulation and research & design questions
- The assignment should have scientific relevance, meaning it shows new facts, theories, methods, techniques, instruments or field of appliance

For more detailed requirements, please refer to our university [10].

Data collection Experiences

The collecting and interpreting of the data came with some challenges. We would like to tell for each main research step (namely question 1, 2, 3 and 4) how we managed to find the data and how we used it.

How can Huatek's relevant characteristics be described? (1)

Some management models do not apply for Asian companies due to cultural differences. The low cost of labour makes a big difference in the way organisations are managed; employee efficiency is not the main cost driver. We have reconfigured some models through some basic assumptions to make them more applicable for Asian organisations. It therefore took a long time before we could get the project underway because an initial understanding of the company was needed, we were not familiar with the culture and working atmosphere inside a IT company.

How can pharmaceutical companies benefit from MES? (2)

To find out the idea behind MES and the production-related problems within pharmaceutical companies, we searched for related articles on the internet. An article purely on the concept of MES was not found, most articles relate MES to a production plant, to other technologies or industries. Through in-depth research enough articles were found and we could create a holistic understanding on the concept of MES. The same accounts for the production problems; an abundance of articles has helped us to take every aspect into account. With basic understanding of the production problems and MES, we have been able to set up a list of possible benefits offered and how they can be delivered, this was the basis of our design.

What direction should product development take in light of Huatek's organisation? (3)

When it came to gathering the industry and marketing data, it proved hard to find reports with information specific enough to use as literature. Multiple reports found gave contradictory information, were not industry-specific or just elaborated on one segment. Throughout our data collection chapter, we will make various assumptions and connections on which data is applicable, relate or scale them to the pharmaceutical industry.

How can Huatek create a MES product offering? (4)

To get a good overview of the various projects within Huatek we needed to discuss our MES research and understanding with the technical team involved in order to discover past projects. This still remained a challenge because of the language barrier and the fact that even the technical team did not have a complete overview of the past experience. The solution was to talk to Jim, the president of Huatek and to Shelly who is our supervisor and project leader of MES. Every single step therefore took longer than expected, the project did not progress as rapidly as we often would have liked.

4.A. What should a MES structure and its associated services look like?

Developing the MES structure and its associated services required several information sources and techniques, even since we were only creating an overview. The list of sources which were available caused us to be very selective with information and required a lot of discussion to determine the right course for Huatek's MES.

By conducting a comparative analysis on current vendors it was possible to get an overview of the basic demands of a vendor and the type of structure and services in each industry. This information varied greatly and therefore we discussed the findings with various employees who had past experience with the pharmaceutical industry. By using their feedback and our own understanding we created the MES configuration, reviewing the demands a customer has on a vendor and the past experience of Huatek to create a basic list of associated services was setup.

Because of the size of the project in combination with the boundaries of our research report it was rather vague to what extent it was possible to define the architecture and data flows for a MES, which would lay the foundation for Huatek's understanding and further development. We discovered our experience offered limited understanding and capabilities to draw an overview. Using the courses Business Function Support and Information Systems we were able to draw basic context diagrams, these diagrams were than discussed with the technical team to test our ideas. It would have been possible to go into more depth, but the quality of the diagrams and any conclusions would be questionable.

4.B What is the size of the target markets?

Although the market was defined when this project started it was still necessary to segment this market more on the basis of the organisational characteristics of Huatek. Information on the size of this market was a challenge, this information was never up to date and varied among sources showing contradictory information. After finding several sources on this subject we could estimate what the market should look like.

A second problem was that we soon found the American pharmaceutical industry, the original market, to have high demands and packed with MES vendors. We had to expand our research project and include exploring the Chinese pharmaceutical industry which directly showed a more promising market. Including a new market halfway in our research was a time-consuming process but it gave it an extra dimension which proved to be very interesting to Huatek.

To select the best option for Huatek, we performed a SMART analysis to assess the various courses of action. The detailed figure including the weights, normalised scores and total benefit is shown below:

Criteria/Opties	Weights	2nd tier Market	Chinese Pharma Industry	Components and Applications	Chinese ERP partner
Market attractiveness	20,0				
Project Size	3,6	33	100	0	17
Market Size	3,6	100	20	40	0
Financial benefits/margens/profit	1,8	67	17	100	0
Ease of market entry	3,6	100	29	86	0
Low degree of competition	7,3	67	100	83	0
Technology and risks	40,0				
Level of research currently available	10,0	57	0	100	0
Quck startup time & ease	4,0	100	29	71	0
Feasibility of producing a complete MES product	8,0	29	71	0	100
Level of guidance/steering	10,0	100	25	75	0
Ease of cooperation/access to information sharing	4,0	25	88	100	0

Independancy of other parties	4,0	44	67	100	0
Organisational aspects	40,0				
Suitability with Huatek's structure	2,1	100	29	71	0
Suitability with Huatek's culture And way of thinking	8,4	100	22	44	0
Geographical/language suitability	10,5	50	100	0	100
Learning experience for employees	8,4	43	100	0	86
Future and long-term potential	10,5	60	100	0	40
Total:	100,0				
Aggregate Total Benefits:		65,0	60,4	46,1	30,6

Table 6: our SMART analysis

Appendix IV: Interview with Shelly Yue

How are projects acquired?

For Merck, they will ask us to make a proposal, containing costs and time estimation when they think of a new project or function. After deciding about the necessity of the project they may decide to let Huatek take on the assignment. Also, Huatek may see some room for improvement and propose to Merck to do this improvement.

Verigy and Quovadx are 'product-based' customers, they have several tasks to maintain or update their product ('current product engineering'). On a year-basis, an agreement is made, which may be adjusted quarterly. This agreement tells how many engineers (junior or senior) are dedicated to these products. These customers offer more stability since the project size is only partly adjusted every year.

Next to these assignments, Huatek has one product of its own, a cardiograph device which can be connected to a PC rather than expensive medical equipment. It is used in several hospitals in Shanghai and other groups of hospitals in several provinces.

What's the size of key customer projects compared to small projects? Are those Chinese or international projects?

About 15-20% of the engineers are working on smaller projects (not Merck, Quovadx or Verigy). I don't know if this equals contract value since we have no insight in these figures. Most of the projects are for US-based companies. Some of these projects may come from Chinese companies, but those are often affiliates of US-based companies.

How is a project started?

When the investigation is done in order to make a proposal, an internal plan is created parallel to the proposal on how to allocate engineers to these projects. Then a contract is signed, stating the detailed deliverables and milestones. Some clients might provide detailed functional descriptions and diagrams, some might only provide a rough description. In the latter case, Huatek sets up functional descriptions and diagrams together with the customer, Huatek tries to do more than just the simple pre-defined tasks. For every milestone, engineers are assigned to specific tasks. Usually they are assigned based on their skills or knowledge, distinguishing clearly between tester or developer; an employee is either a tester or a developer.

Is Huatek's organisational structure suitable for own product development

No, there's not enough budget or resources to develop MES. We will focus on this however in 2007.

Is Huatek's culture suitable for own product development?

No, an innovative culture has been set-up, but different people within the company have different understanding or ideas. These differences are the biggest between different levels, from senior management to junior engineers. We need to support the culture more and improve the communication within Huatek.

There are many supporting departments in Huatek's organisation chart

A lot of supporting departments are necessary, such as HR, IT et cetera. There are however several supporting people mapped differently, this causes communication errors.

The Communication Assistants are very important. They help engineers to communicate, by helping them with English, showing them a way to communicate and having a pro-active attitude (making people talk to each other). Engineers sometimes are not able to write down what they want in a clear way, even in Chinese. The customer on the other hand might also use very bad language. The CA's however sometimes do not understand the technical language; this is a great problem.

There is both a marketing and a new business development team

The marketing team is mainly busy with representation. The new business team is responsible for talking to potential customers, setting up proposals et cetera. MES is more a marketing-orientated element.

Jim seems to be bringing in a lot of customers

Jim is the CEO and Chening is the chairman of the board. Verigy and Merck are brought in by Chening's network, while Quovadx is brought in by Jim's. A lot of the smaller projects are brought in by Jim as well.

How are new employees brought in?

Huatek does campus recruitment, internship programs and works with references. This attracts enough young graduates.

What's the role of the HR department?

They're concerned with recruiting, but also with attendance and composition

How can employees be promoted?

An employee which performs well might get more responsibilities and a higher salary. They can also earn a bonus at the end of the year. When employees take on more responsibilities and perform well, they can also discuss their preferences about tasks or trainings they want to perform or follow to the management. I don't know exact details about promotions and the salary increases, since this information is not public.

Why are many people leaving Huatek?

There's a shortage of engineers with working experience. After a few years of experience, their market value is increased significantly and they might leave. Also, when they are sent to America, they receive lots of training which earns them a lot of experience.

They don't only leave because of the higher salary earned, but also because of the opportunities the new employer might offer. Some people leave however because they can not handle the pressure.

What does Huatek do to handle the high turnover rate?

We adopted new policies, making people to sign contracts to work at least for some time after receiving a training. It is difficult to implement these contracts (also because of Chinese legal structure), but some people just take advantage of the opportunities Huatek offers.

We aim more at controlling the damage inflicted by people leaving rather than trying to let them stay. We are now documenting their reasons for leaving, what they have done within Huatek et cetera. We focus on good documentation within projects, this however does not compensate the loss of Human Capital.

In the workshop week, I noticed Arden and Gabrial to be quiet and taking notes, while letting Alex and David do the thinking.

Alex and David might just think they don't need to make notes. Arden and Gabrial are probably afraid to say something stupid rather than they think they should contribute. Furthermore, Chinese people tend to let a senior decide when they're junior.

Which projects are the most useful for MES?

Not only the Merck projects. A lot of concepts and approaches we applied on former projects can be used.

To what extent have we experience in MES?

We lack the actual knowledge of pharmaceutical industry, industry practices, production systems et cetera; the basic knowledge necessary for MES.

What has to be done to enable Huatek to produce an entire MES?

Action! We have to make a choice whether we will create a platform where applications will run on or create an interface where separate applications can connect to, but the most important thing is that we start creating those applications. We lack however sufficient knowledge to create the entire system.

According to you, what is the best course of action concerning MES?

The second tier market, it fits our company better. If we think together with the customer, we will not only be performing simple tasks

Is Huatek ready to handle and promote its own product? Yes, we're doing it with our cardiograph device too.

What are the reasons for Huatek to bring in Dutch interns?

They contribute to the English level, they can bring in some fresh ideas, they can help establish an open culture (making people talk to each other rather than staring to their computer screen) and they can get employees used to an international environment.

What works well and what doesn't concerning interns?

The management of the interns is difficult, we didn't manage them from the beginning, didn't give them specific tasks and we did not communicate with them about it before arrival. We should have communicated about their tasks before arrival, mad a proper planning and made clear what expectations Huatek has from them.

Letting interns work together closely with a team (Peter with Quovadx, Oscar en Vincent with MES) works good.