Design and Implementation of Shop Floor Management Information System at BOSCH Rexroth AB

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Xin Li
Abstract

This master thesis is conducted as a conclusion of Master of Science degree in Production Engineering and Management at KTH Royal Institute of Technology. The focus of this thesis work is to make the work more convenient and improve production efficiency by building a management information system (MIS) thus replacing manual and decentralized information management mode on the shop floor. With the use of the computers in the office and tablets beside the machine of each work center on the shop floor, personnel can have access to the necessary information easily and quickly.

This management information system is built according to the actual production situation and needs in Bosch Rexroth AB in Mellansel. First, research on the production process and the management mode in the factory is conducted. Then, the form and the architecture of the system are decided. After thorough understanding and comparison, web application form and currently widely used Browser/Server (B/S) architecture are adopted. Finally, during the detailed design and system implementation process, databases and functional modules are developed. Microsoft Access is chosen as the database implementation. Microsoft Visual Studio.NET combined with C# language and IIS (Internet Information Service) is chosen as the application development tool. When conducting the user trial test on the shop floor, functions of this application system well meet the requirements, and associates can easily and quickly access the information. This application system can speed up the information flow in production, realizing more scientific, standardized and efficient management, which ultimately promotes the production and management of the enterprise.

This management information system realizes the following functions in a digitized way: 1. system security management: user registration, log in and permission settings; 2. drawings viewing; 3. instructions viewing; 4. maintenance recording and checking; 5. deviation reporting and processing; 6. process confirmation recording and checking.

Keywords: Management information system, web application, ASP.NET.
Sammanfattning

Denna masteruppsats är slutuppgift för civilingenjörsexamen i produktionsteknik och management på Kungliga Tekniska högskolan. Uppsatsens fokus är att skapa ett mer anpassat arbete samt öka produktionseffektiviteten genom att skapa ett informationshanteringssystem (MIS) och därmed ersätta manuell och decentraliserad informationsstyrning på verkstadsgolvet. Genom att använda datorer på kontoren samt surfplattor vid maskinerna på varje arbetsstation kan personalen snabbt och enkelt få tillgång till nödvändig information.

# Table of contents

Acknowledgements........................................................................................................... 1

Abstract............................................................................................................................... 2

Table of contents.................................................................................................................. 4

Chapter 1 Introduction........................................................................................................ 7
  1.1. Background ................................................................................................................. 7
  1.2. Purpose and significance .......................................................................................... 7
  1.3. Scope and delimitation ............................................................................................... 9
  1.4. Research methodology .............................................................................................. 10
  1.5. Outline of the thesis ................................................................................................. 11

Chapter 2 Theoretical reference ......................................................................................... 12
  2.1. Management information system (MIS) ..................................................................... 12
  2.2. The development method of MIS ............................................................................. 12
     2.2.1 Prototyping approach ......................................................................................... 12
     2.2.2 Object-oriented developing approach ................................................................ 13
  2.3. System architecture .................................................................................................. 14
  2.4. Modeling methods .................................................................................................... 15
     2.4.1 IDEF0 and IDEF1X modeling methods .............................................................. 15
  2.5. Development tools .................................................................................................. 17

Chapter 3 Requirements analysis and feasibility study..................................................... 20
  3.1. Requirements analysis .............................................................................................. 20
  3.2. Feasibility analysis ................................................................................................... 25
     3.2.1 Technological aspect ......................................................................................... 25
     3.2.2 Economical aspect ............................................................................................ 26
     3.2.3 Operational aspect ........................................................................................... 26

Chapter 4 Development methodology ............................................................................ 27
  4.1. General design ......................................................................................................... 27
  4.2. Database design ....................................................................................................... 27
  4.3. Functional modules design ...................................................................................... 29

Chapter 5 Implementation ................................................................................................ 35
  5.1. Database implementation ......................................................................................... 35
  5.2. Functional modules implementation ......................................................................... 36
  5.3. Web application publish .......................................................................................... 40

Chapter 6 Field test ............................................................................................................ 41

Chapter 7 Recommendations for future development .................................................... 43

Conclusion......................................................................................................................... 44

References.......................................................................................................................... 46

Appendix ............................................................................................................................. 47
List of figures

Figure 1 The scope of the thesis ................................................................. 9
Figure 2 Different kinds of manufacturing process related information ................. 9
Figure 3 The topological structure of C/S mode .............................................. 14
Figure 4 The topological structure of B/S mode ............................................. 15
Figure 5 The basic IDEF0 construct ............................................................ 16
Figure 6 An example of IDEF0 model ........................................................ 16
Figure 7 An example of IDEF1X model ...................................................... 17
Figure 8 .NET framework ...................................................................... 18
Figure 9 ASP.NET working mechanism ...................................................... 19
Figure 10 The main functions of the web application .................................... 20
Figure 11 An extension of the system functional model .................................... 21
Figure 12 An extension of deviation report module ....................................... 22
Figure 13 Users’ needs in authentication module ............................................ 22
Figure 14 Users’ needs in drawing module ................................................... 23
Figure 15 Users’ needs in instruction module ................................................. 23
Figure 16 Users’ needs in maintenance module ............................................. 24
Figure 17 Users’ needs in deviation report module ......................................... 24
Figure 18 Users’ needs in process confirmation module ................................... 25
Figure 19 The overall structure of the web application .................................... 27
Figure 20 Overall information model for the system ....................................... 28
Figure 21 Procedure specification of registration process .............................. 29
Figure 22 Procedure specification of login process ......................................... 30
Figure 23 Procedure specification of drawing module ..................................... 30
Figure 24 Procedure specification of instruction module ............................... 31
Figure 25 Procedure specification of maintenance data record sub-module ........ 31
Figure 26 Procedure specification of maintenance data check sub-module .......... 31
Figure 27 Procedure specification of showing maintenance plan sub-module ...... 32
Figure 28 Procedure specification of filling in and sending deviation report sub-module ..... 32
Figure 29 Procedure specification of deviation lifecycle record sub-module ...... 33
Figure 30 Procedure specification of process confirmation document creation sub-module ... 33
Figure 31 Procedure specification of process confirmation check sub-module ...... 34
Figure 32 Staff registration database .......................................................... 35
Figure 33 maintenance record database ...................................................... 35
Figure 34 deviation lifecycle database ........................................................ 35
Figure 35 The code which helps an ASP.NET application connect to the backup database ... 36
Figure 36 Login interface ...................................................................... 37
Figure 37 Registration interface ............................................................... 37
Figure 38 The interface of drawing module .................................................. 37
Figure 39 The interface of instruction module ............................................. 38
Figure 40 The interface of deviation module ................................................. 38
Figure 41 The interface of creating item in deviation report lifecycle map .......... 38
Figure 42 The interface of filling in maintenance result sub-module ............... 39
Figure 43 The interface of checking maintenance result sub-module .............. 39
Figure 44 The interface of showing maintenance plan sub-module ............... 40
Figure 45 The interface of process confirmation module ............................... 40

Figure A1 Login page .......................................................................... 47
Figure A2 Registration page .................................................................... 47
List of tables

Table 1 The comparison between a web application system and working methods nowadays..................8
Table 2 The IDEF family..............................................................................................................15
Table 3 The comparison between C/S mode and B/S mode..........................................................26
Table 4 Staff registration table.....................................................................................................28
Table 5 Maintenance record table...............................................................................................29
Table 6 Deviation lifecycle table................................................................................................29
Table 7 Interfaces of the MIS application.....................................................................................36
Chapter 1 Introduction

A management information system (MIS) is a people-led man-machine system. It can realize information collection, transmission, processing, storage, updating and maintenance by the use of computer hardware, software, network communications equipment and other office equipment. It has the advantages such as supporting enterprise high-level decision-making, middle-level control and shop floor operation so that it can improve efficiency and maximize profits [1].

1.1. Background

With the rapid development of network and computer technologies, networked information management has become an inevitable trend of development of all walks of life. For manufacturing enterprises, the fourth industrial revolution has approached gradually. In such a rapidly changing society and harsh market competition environment, the one who can first use the advanced information management technology could grasp the market opportunity and provide high quality products to customers. Therefore, changing production management mode from manual and isolated management, to information and networked management is ineluctable. The Internet-based or web-based applications are increasingly being demanded by the community.

For enterprises, various types of static and dynamic information such as customer orders, production planning, warehouses, parts, semi-finished products, finished products, customers, suppliers, production quality and production process are the companies’ vital assets. Storing these data centrally and using them rationally, has become a key factor to reduce production costs and improve the competitiveness of enterprises. At the same time, with the extensive use of management information systems, personnel in companies start to get used to the web-based information management model so that a web-based network management mode could have a smooth development in the company.

BOSCH Rexroth is a world leading manufacturing company. In the Mellansel factory, the main products are different kinds of hydraulic motors. At present, the decentralized management information mode and the oral or paper sharing information exchange are dominant on the shop floor. This results in lag in the information transmission, which means that information can not be accurately and timely delivered among production, procurement, transportation and other departments. This leads to an uncoordinated strategy between enterprise’s management planning, implementation, and other processing stages, resulting in data loss and poor efficiency. In order to improve this situation, a project named MOE4.0 is introduced, aiming to integrate and digitalize production process related information in a management information system so that associates can easily access them on each computer in their offices or portable devices on shop floor beside the machine.

1.2. Purpose and significance

This thesis research is a pilot test of MOE4.0 project. Due to time limitation, the main research questions are limited as below:

- Find the right system architecture and developing tools to design and implement a shop floor management information system for manufacturing;
• Design the functional modules and their interfaces according to production regulations;
• Test the system’s effectiveness.

The benefit of such a system is that it can create a user-friendly way for associates to access the information, speed up the information flow in production, and realize scientific, standardized and efficient management so that the lead-time and production cost can be reduced and production efficiency can be improved.

The significance of establishing such a web application system is that it helps to straighten out and strengthen the management of enterprises to achieve production and operation automation and decision-making intelligence. Such a network management system is conducive to use existing resources rationally. It can also reduce production cost, save capital and raw materials. It is helpful to accelerate the flow of information within the enterprise to achieve rapid updates, effective integration and rational use of the information.

The comparison can be seen from the Table 1 below.

<table>
<thead>
<tr>
<th></th>
<th>Working method nowadays</th>
<th>MOE4.0 application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper use</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Training</td>
<td>time consuming</td>
<td>time saving</td>
</tr>
<tr>
<td>Information spread speed</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Inspiration</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>expansibility</td>
<td>no</td>
<td>yes and easy</td>
</tr>
<tr>
<td>Value added benefit</td>
<td>-</td>
<td>yes</td>
</tr>
</tbody>
</table>

*Table 1 The comparison between a web application system and working methods nowadays.*
1.3. Scope and delimitation

The scope of the thesis (pilot project of the MOE4.0 project) is mainly on information management in the manufacturing process along the supply chain (marked with orange color in the Figure 1 below).

![Figure 1 The scope of the thesis](image)

The main consideration is using this system to provide associates easy access to the data available for each work center and to record information that is important to ensure the quality in the manufacturing. Typically, there are five types of important information which relate to the manufacturing process in one work center. They are process confirmation, maintenance, drawings, instructions and deviation report.

![Figure 2 Different kinds of manufacturing process related information](image)

There are a lot of work centers on the shop floor. As the pilot test and first step of building such a MIS application, this thesis work only focuses on one milling machine work center, which is the 6519 Gildemeister GMX400. This prototype of the MOE4.0 application system connects the information needed for this work center together. If this prototype system is user friendly
and can improve the production efficiency, later this system will be introduced to all work centers in real production.

1.4. Research methodology

This thesis project uses the use case diagram to collect and summarize users’ needs then uses IDEF0 diagrams to build the system functional model. Later in detailed design phase, sequence diagrams are selected to illustrate the design of the functional modules and the IDEF1X diagram is used to build the information model and illustrate the database structure of this system. Then the implementation method is selected and the application interfaces and databases are designed. Finally debugging and publishing the web application system through the company’s intranet are conducted.

This thesis can be divided into five stages: information collection stage, analysis stage, modeling stage, design stage and implementation stage.

• Information collection stage

First, interviewing relevant people (operator, team leader on the shop floor, supervisor, supply manager, production manager and other senior managers) in the company is done. The purpose is to fully understand the roles of different kinds of production related activities and master the basic situation and functional requirements from various departments.

• Analysis stage

The first task in this stage is to summarize the requirements and analyze their practicability. Use case diagram is adopted to record the requirements which will be fulfilled by this web application. Secondly, feasibility analysis is carried out to assess the viability of building this web application.

• Modeling stage

During this stage, IDEF0 diagrams are adopted to present the overall function of this web application.

• Design stage

Firstly, the system architecture, development platform and development tools are determined. Next, the overall system framework, the functional modules and the databases are designed. The UML sequence diagram modeling tool is used to expatiate the design thought of each functional module and an IDEFIX diagram is used to describe the overall database structure.

• Implementation stage

The final implementation is accomplished by coding on the computer platform and publishing the web application through the intranet in the company. A complete user instruction document is provided. Then the user trial test is conducted. Finally, future development suggestions are proposed.
1.5. Outline of the thesis

The contents of each chapter are:

Chapter 1: Elaborate the background, purpose and significance of this thesis project, define the scope and finally explain the methods in brief.

Chapter 2: Explain the relevant theoretical concepts, including the web application design theory, use case diagram, IDEF0/IDEF1X modeling methods and the chosen implementation platform.

Chapter 3: Illustrate the requirements analysis and feasibility study work.

Chapter 4: Use modeling diagrams to illustrate the design of this MIS application. The main contents are the design of all functional modules and the design of the databases.

Chapter 5: Show the user interfaces of this web application and illustrate the instruction of how to use the application to realize the designed functions.

Chapter 6: Report field test results.

Chapter 7: State the future road map of this web application.
Chapter 2 Theoretical reference

2.1. Management information system (MIS)

The information here refers to the data that would afford managers in the company a better understanding of their own environment and of themselves therefore enabling them to make more accurate decisions. An information system is an organized system for the collection, organization, storage and communication of those information. In detail, according to the definition given by Andreu, Ricart and Valor, the information system is a formal set of processes that, working from a collection of data structured depending to the company’s needs, gathers, processes and distributes the information necessary for the company’s operations and for its corresponding management and control activities, thereby supporting, at least in part, the decision-making processes necessary for the company to perform its business functions in line with its strategy [2].

Given the complexity of information processing and the varying degrees or levels into which data and processes can be structured, several categories of information systems are required to deal with all the organization’s information needs. According to Arjonilla and Medina, information systems can be divided into three main types: transaction processing systems, management information systems and decision support systems [3].

A management information system (MIS) can be defined as an information system which processes the information through computers and other intelligent devices to manage and support managerial decisions within an organization. The main purpose of management information systems is to provide managers with the information they need to take decisions and solve problems. Management information systems are supported by corporate databases, which include data generated by transaction processing [4].

2.2. The development method of MIS

The development of a MIS is systematic work. With the continuous development of computer technology, a number of methods are developed for building a MIS, for example, life cycle approach, structure approach, prototyping approach and object-oriented developing approach [5]. These methods have had an important impact on MIS development practice.

In order to increase customer satisfaction and reduce system development time and cost, prototyping approach and object-oriented developing approach are combined to develop this MIS application.

2.2.1 Prototyping approach

The prototyping approach does not focus on the comprehensive and systematic investigation and analysis before building a system. Instead, a prototyping model of the system is rapidly built after general understanding the users’ needs, and then modified and improved according to users’ trial test feedbacks. Finally complete the new system development and meet users’ needs.

Specifically, the development procedure for the prototyping approach can be divided into four stages:
• Identify the basic needs
During this process, the basic needs of the users are determined although the needs are described roughly. These needs refer to the requirements of the functions of the system, the interfaces, the requirements for contents and format of the report. The purpose is to collect information for the initial model and establish a simplified model.

• Design the initial model
During this process, an initial model of the application system is built. It is not required to be complete for the initial model, but it is important to meet the basic needs and have a quick development speed.

• Trial test and evaluation
During this process, users are asked to try using the initial model. Then, their feedbacks are gathered for future improvement.

• Modification and improvement
During this process, the initial prototype is modified according to the feedbacks. After modification and improvement, the new prototype system is built. Then trial test, evaluation, modification, and improvement procedures are repeated, until forming a satisfactory system. The development process for prototyping approach is such a cycle.

2.2.2 Object-oriented developing approach

The object-oriented developing approach is a kind of advanced method which conforms to the human thinking mode. It is gradually formed by the computer language community after long exploration. The object-oriented system development process can be generally divided into three stages: object-oriented analysis, object-oriented design and object-oriented implementation.

• Object-oriented analysis
The requirement analysis is the main task in this stage, and the process is described as follows: various modeling technologies are used to identify the system function and the entities within the problem domain; the relationship between the entities are then identified. The models which are obtained from the analysis phase form a description of the problem with a certain level of relationship. This model is easy to modify and to expand.

• Object-oriented design
The task of this phase is to determine the entities’ attributes and implementation methods through the analysis of the entities.

• Object-oriented implementation
This stage is mainly about using the program to implement the system on the basis of the models established from the object-oriented design phase. The specific tasks include the choice of programming language, debugging, and trial test.

The use of object-oriented thinking method making the description of the system corresponds to the human thinking habits. Users and developers could communicate well. The development cycle can be shortened thus the system development efficiency could be improved. The
concepts and characteristics within the object-oriented technology greatly improve the software consistency and the independence of the modules. It has broad application prospects.

2.3. System architecture

One of the key elements of application system design is the architecture of the system. The architecture determines how each part of the application interacts, and also determines the functionality of each part. At present there are two main kinds of architecture in developing a management information system. One is called Client/Server (C/S) mode, of which the main development process happens on the client side. The other one is called Browser/Server (B/S) mode, of which the main development process happens on the server side [6][7][8].

- **Client/Server mode**
The C/S mode is a distributed application structure that partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters, called clients [9]. Servers are classified by the services which they provide. For example, the web server or the file server. In general, total distributed control system (DCS) and multisite monitor system often adopt this mode. C/S mode has several clients to gather signals, but it has only one server, which transmits instructions to bottom clients or monitors bottom testing equipment and acts as a database. Clients and servers exchange messages in a request–response messaging pattern. The client sends a request, and the server returns a response. Two design aspects need to be considered for developing an application system of this mode. One is the design of the program for data acquisition and transmitting data to remote computer, the other one is the design of client program that is used to receive data by clients.

![Figure 3 The topological structure of C/S mode](image)

- **Browser/Server mode**
B/S mode is very convenient for users to publish data through web. As a rule, users only need to install a browser to visit the test web directly. B/S mode has three tiers to achieve the distribution, which are the data resources layer, the represent layer and transaction layer. A represent layer is composed of the browser and dynamic web pages to receive and process the users’ requests. A transaction layer acts as a server. Data resources layer correspond to the database server, which achieve the management of the database and data updating [10]. The main work of developing an application system of this mode is the design of the web server program.
2.4. Modeling methods

2.4.1 IDEF0 and IDEF1X modeling methods

The IDEF suite of modeling languages arose in the 1970s out of the U.S. Air Force Integrated Computer Aided Manufacturing (ICAM) program [11]. The goal of ICAM was to leverage computer technology to increase manufacturing productivity. A fundamental assumption of the program was the need for powerful and usable modeling methods to support system design and analysis. Consequently, the program undertook the development of a suite of “ICAM.DEFinitions”, or IDEF methods. Currently there are 16 members of the IDEF family as shown in Table 2 below [12].

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>IDEF0</td>
<td>Function modeling</td>
</tr>
<tr>
<td>IDEF1</td>
<td>Information modeling</td>
</tr>
<tr>
<td>IDEF1X</td>
<td>Data modeling</td>
</tr>
<tr>
<td>IDEF2</td>
<td>Simulation model design</td>
</tr>
<tr>
<td>IDEF3</td>
<td>Process description capture</td>
</tr>
<tr>
<td>IDEF4</td>
<td>Object-oriented design</td>
</tr>
<tr>
<td>IDEF5</td>
<td>Ontology description capture</td>
</tr>
<tr>
<td>IDEF6</td>
<td>Design rationale capture</td>
</tr>
<tr>
<td>IDEF7</td>
<td>Information system auditing</td>
</tr>
<tr>
<td>IDEF8</td>
<td>User interface modeling</td>
</tr>
<tr>
<td>IDEF9</td>
<td>Business constraint discovery</td>
</tr>
<tr>
<td>IDEF10</td>
<td>Implementation architecture modeling</td>
</tr>
<tr>
<td>IDEF11</td>
<td>Information artifact modeling</td>
</tr>
<tr>
<td>IDEF12</td>
<td>Organization modeling</td>
</tr>
<tr>
<td>IDEF13</td>
<td>Three schema mapping design</td>
</tr>
<tr>
<td>IDEF14</td>
<td>Network design</td>
</tr>
</tbody>
</table>

Among them, IDEF0 business function modeling method and IDEF1X data modeling method are the most widely used ones. IDEF0 is a functional system architecture tool, the purpose is to analyze the system function. IDEF1X is the expression of information relationship in an information model. It is also a good tool to provide relevance database analysis in order to meet the system required information and rules.
2.4.1.1 IDEF0

IDEF0 uses top-down decomposition method and models to represent a system. It is suitable for research and analysis of large and complex systems. Furthermore, IDEF0 diagrams is standard. The expression of information is comprehensive and coherent. The hierarchy structure is also easy to understand and emphasize the details of the system.

Figure 5 below shows the basic IDEF0 construct and an example of the IDEF0 model. The basic IDEF0 construct is composed by a function box and arrow segments. The function box represents a special kind of activity and arrow segments represent ICOMs (inputs, controls, outputs and mechanisms). Boxes and arrow segments are combined in various way to form IDEF0 diagrams. Finally, an IDEF0 model is a hierarchically arranged collection of IDEF0 diagrams as shown in Figure 6.

![Figure 5 The basic IDEF0 construct](image)

![Figure 6 An example of IDEF0 model](image)
2.4.1.2 IDEF1X

IDEF1X introduces a specialized ontology and a corresponding language to build database models. It is a semantic modeling technology which applies the entity-relationship method to the semantic data model for the establishment of system information model. IDEF1X has three basic ontological categories, which are entities, attributes and relationships.

Entities are simply classes of actual or possible things in the world. Things comprised by a given entity are known as the instances of the entity. Entities can be divided into two categories, which are independent entities and dependent entities. Independent entities which are shown by boxes with right angles do not need to be identified by other entities. Dependent entities which are shown by boxes with fillets must be identified by other entities. Every entity has an associated set of attributes. The attribute for every instance of a given entity should have a unique value in the same attribute set. Attributes can be divided into key and non-key. Key attributes for an entity is a set of attributes that jointly distinguish every instance of the entity from others. Relationships are classes of association between instances of two entities. An example of IDEF1X model is shown in Figure 7 below.

2.5. Development tools

2.5.1 Microsoft.NET development platform

Microsoft.NET (.NET in short) is a cross-platform and open source development platform launched by Microsoft. It is a new generation of software development and deployment. With .NET, various of complex distributed applications such as web, mobile and desktop applications can be built with multiple programming languages. It also simplifies Internet-based web applications’ development in a distributed network environment. .NET framework is the foundation of .NET development platform.
2.5.2 .NET framework

It includes a large class library which is named Framework Class Library (FCL). FCL provides standard ways to realize user interface building, data access, database connectivity, cryptography, web application development, numeric algorithms, and network communications. Programs which are written within .NET Framework execute in a software environment (in contrast to a hardware environment) which is named Common Language Runtime (CLR). This is an application virtual machine that provides services such as security, memory management, and exception handling. FCL and CLR together constitute the basic .NET Framework.

Figure 8 .NET framework

2.5.3 ASP.NET

ASP stands for Active Server Pages. ASP.NET is a compiled and .NET-based environment. It is an open source web application framework which is designed for web development to produce dynamic web sites, web applications and web services with .NET [13]. It is a component of the .NET platform which uses CLR and FCL to develop a powerful and stable enterprise-class web application.

ASP.NET creates web applications which are hosted on Microsoft's IIS. ASP.NET pages, known officially as web forms, are the main building blocks for application development in asp.net. Web forms are contained in files with a "aspx" extension. Additionally, dynamic code, which runs on the server, remains in an .aspx.vb or .aspx.cs or .aspx.fs file (depending on the programming language used) [14]. When a user makes a request from an .aspx file through a browser, the web server, in response to the request, invokes the ASP.NET engine to parse it into the source code and then compile it by the compiler. Finally, the standard HTML page is generated by the web server and send to the client browser. This working mechanism is demonstrated by Figure 9 below.
2.5.4 Microsoft Visual Studio

Microsoft also issues an integrated development environment largely for .NET software called Visual Studio. It is a complete set of development tools used to develop console and graphic user interface applications along with ASP.NET web applications, XML web services, desktop applications, and mobile applications [15].

*Figure 9 ASP.NET working mechanism*
3.1. Requirements analysis

After interviewing people from different departments as well as understanding Bosch Rexroth’s production processes, the main function of this web application can be summarized by an IDEF0 model as shown in Figure 10, Figure 11 and Figure 12 below.

![Figure 10](image-url) The main functions of the web application
Figure 11 An extension of the system functional model
According to the analysis of the system’s overall function, the application should consist of six functional modules, which are: authentication module, drawing module, instruction module, maintenance module, deviation report module and process confirmation module. Users’ requirements for each module are demonstrated by the use case diagrams as shown in Figure 13-Figure 18 below:

**Authentication module:**

**Drawing module:**
All users have the same requirements in this module. Their need is to easily access the right part drawing in the latest version through this application. Updating drawings should be done by designers but this is not in the scope of this application design.
**Instruction module:**
Different kinds of instruction documents are designed to help relevant staff understanding the regulations and processes. For example, in work center 6519, there are working, problem solving, measuring, maintenance and process confirmation instruction documents. All users have the same requirement for this module. They want to directly access these instruction documents by using this application instead of finding them on the shelves. Moreover, updating the content of the instruction is done by the senior level directors but this is not in the scope of this pilot application design.

**Maintenance module:**
Maintenance chart is a record chart which operators need to fill in after checking the status of the machine according to the schedule. It includes daily, weekly, monthly, quarterly and half-annually check. Team leader’s responsibility is to check the maintenance checking results. But they do not have edit permission. There is already another system to process the problems so problems processing is not in the scope of this system design.
Deviation report module:
This module is about reporting the deviation of the produced parts if the part has any defects. First deviation report is generated from the operators. Then it is passed to the senior directors for further suggestions and final decision. Finally, it returns back to the work center. During these steps, it is desired in the future that the processing status can be transparent to all involved people. The specific requirements from different users can be summarized by Figure 17 below.

Process confirmation module:
Process confirmation is a structured method of applying routine confirmation and support to key issues within the business. Staff involved in it should go to where the work is actually being done and confirm that the way is in accordance with the organization’s policies and procedures. Staff in different positions have different focus and their own checking templates. Moreover, senior directors should check subordinate staff’s checking results.
3.2. Feasibility analysis

Feasibility analysis is a measurement of the benefits of an information system to a business. The purpose of the feasibility study is to determine whether a problem can be resolved in the shortest possible time with the minimal cost. In this project, feasibility analysis is to study whether the development of this new system has the necessary resources under the current conditions. The general feasibility analysis of this project is demonstrated from three aspects, which are technological, economical and operational aspects.

3.2.1 Technological aspect

As elaborated above, there are two development modes to build a management information system: C/S (client/server) mode and B/S (browser/server) mode. The comparison of these two modes are shown in Table 3 below [16].

<table>
<thead>
<tr>
<th></th>
<th>C / S mode</th>
<th>B / S mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>advantages</td>
<td>The task can be reasonably allocated to the client and server side, reducing the system communication costs.</td>
<td>The user interface is achieved entirely through the web browser. Main transaction logic is achieved on the server side. This development mode can save development costs and reduce the difficulty of administrator maintenance.</td>
</tr>
</tbody>
</table>
The disadvantages of the system installation is in the client, which is not a small trouble for system deployment. Especially when the system need to be upgraded. It can introduce processing overhead that can decrease performance and force the user to wait for the page to be processed and recreated.

| disadvantages | The system installation is in the client, which is not a small trouble for system deployment. Especially when the system need to be upgraded. | It can introduce processing overhead that can decrease performance and force the user to wait for the page to be processed and recreated. |

Table 3 The comparison between C/S mode and B/S mode

According to the comparison, B/S mode has the main advantages of easy publishing and maintenance, which fits for the situation in the company. So B/S mode is adopted as the system’s architecture.

When developing web applications in B/S mode, ASP.NET is a suitable platform. In the company, technological support is sufficient for using ASP.NET to build this web application. Microsoft Visual Studio is an ideal development software which has a set of standard and powerful tools. Microsoft Access is a robust software to design and save databases, IIS (Internet Information Service) is a user-friendly tool to publish web application. Finally, in the company, there is a server which can migrate the web application to after design and field test phase.

3.2.2 Economical aspect

On one hand, the use of advanced MIS and the development of networked office system, is a good way to deepen the effective reform of enterprise. At present, many companies have established a management system for production, these systems improve the management level and production efficiency to a large extent therefore they create higher profits for the whole company.

On the other hand, compared with other technology, the development and future maintenance cost for this system is low by adopting ASP.NET to develop such a MIS application. To sum up, the use of this platform has high economical feasibility in the actual development of the management information system.

3.2.3 Operational aspect

By applying B/S development mode and ASP.NET platform to build this MIS, users can easily access the system by using the web browser installed together with the operating system, no matter PC or tablets. The user interfaces are unified, so it is easy to use.

The design of the production MIS is based on the actual production process on the shop floor. Taking the average age of employees into account, the interfaces are designed as simple as possible. Moreover, at the beginning of the application design, views and suggestions from the related users are collected. After the design, the detailed user instructions are provided. So there is no big problem in personnel adaptation.
Chapter 4 Development methodology

4.1. General design

The main role of this production MIS application is improving the current information transmission efficiency on the shop floor, changing the manual information record mode to the networked operation, and achieving the data sharing. Users at all levels can have easy access and edit the information within their authority.

The overall objectives of this web application design are shown as below:

- **Functional integrity**
  This is the basic requirement for system or application design. The main function of this web application system should be in accordance with the production processes and meet the users needs at all levels as analyzed above as much as possible.

- **Friendly operation**
  I. Friendly installation:
  Operators and senior level directors are not expert in computer science. Thus it should be easy enough to install and do deployment and backup work by using this application.
  II. Friendly user interface:
  A simple and clear interface could reduce erroneous operations and erroneous data generation. So it should be taken into consideration when design user interfaces.

- **System security**
  Production information are vital assets for a manufacturing company. Therefore, the security and confidentiality of the MIS system is crucial. Users should have different permissions when using this application.

According to the production regulations and users’ requirements, this application should contain six main functional modules. Some functional modules have their sub-modules. *Figure 19* demonstrates the overall structure of this web application:

![Figure 19 The overall structure of the web application](image)

4.2. Database design

A MIS application bases on database system to store related data. Therefore, the design of the database system is the core and foundation of management information system design. Database design quality would have direct impact on the functions and efficiency of the entire management information system.
The overall information model for this system is shown by an IDEF1X diagram as Figure 20 shown. Blocks which are filled with white color are the databases which already exist in the company. Blocks with yellow background color are the databases that need to be designed. Blocks with blue background means the relationship can be easily built by linking the URL address. Blocks which are filled with green means the relationship will be realized by creating a folder and saving the required documents into this folder.

![Figure 20 Overall information model for the system](image)

According to the IDEF1X diagram above, there are three databases which need to be built. The design of these three databases for the production MIS are shown by Table 4-Table 6. Each chart represents a database.

<table>
<thead>
<tr>
<th>Column name</th>
<th>Type of data</th>
<th>Null?</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMP_NAME</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>DEP_ID</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>EMP_TITLE</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>EMP_EMAIL</td>
<td>varchar(50)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>PASSWORD</td>
<td>varchar(50)</td>
<td>Not null</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 4 Staff registration table*

<table>
<thead>
<tr>
<th>Column name</th>
<th>Type of data</th>
<th>Null?</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEEK</td>
<td>number(10)</td>
<td>Not null</td>
<td>Record time</td>
</tr>
<tr>
<td>TIME</td>
<td>date</td>
<td>Not null</td>
<td>Record operator’s name</td>
</tr>
<tr>
<td>EMP_NAME</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>Maintenance check results according to the maintenance plan.</td>
</tr>
<tr>
<td>ANY PROBLEM</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>DAILY</td>
<td>number(10)</td>
<td>Not null</td>
<td>Maintenance check results according to the maintenance plan.</td>
</tr>
<tr>
<td>WEEKLY</td>
<td>number(10)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>MONTHLY</td>
<td>number(10)</td>
<td>Not null</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 5 Maintenance record table

<table>
<thead>
<tr>
<th>Column name</th>
<th>Type of data</th>
<th>Null?</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Number(10)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>QUANTITY</td>
<td>Number(10)</td>
<td>Not null</td>
<td>Quantity of deviation parts</td>
</tr>
<tr>
<td>ITEM_ID</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>Part ID</td>
</tr>
<tr>
<td>ITEM_NAME</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>Part name</td>
</tr>
<tr>
<td>MANU_PROCESS</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>Manufacturing process produces this deviation part</td>
</tr>
<tr>
<td>FIND_PROCESS</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>Manufacturing process finds this deviation part</td>
</tr>
<tr>
<td>MACH_CENTER_ID</td>
<td>number(10)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>OPERATOR</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>People in different roles dealing opinions for the specific deviation</td>
</tr>
<tr>
<td>TEAM_LEADER</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>BEREDARE</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>CONSTRUCTION</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>-</td>
</tr>
<tr>
<td>FINAL_DECISION</td>
<td>varchar(20)</td>
<td>Not null</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 6 Deviation lifecycle table

4.3. Functional modules design

#### 3.1 Authentication module
The function of this module is ensuring flexibility and security of this web application. Only personnel in the company have access to the system so that when they register themselves as new users, they need to verify by providing email address. Everyone has their own working responsibilities, so they also need to choose their department and title when register. Later every time when they log in, they can have their own permissions based on their department and title.

![Figure 21 Procedure specification of registration process](image-url)
3.2 Drawing module
Drawings in digital version of all parts are saved in SmarTeam cloud storage in *.dwg format. Every document has its own URL address. According to the requirement analysis, the main function of this module is providing users easy access to the drawing documents in pdf format of the parts produced in the exact work center. This is designed to be realized by editing on the URL address (in order to change the format) then linking them with the correct part number buttons on the user interface.

3.3 Instruction module
All kinds of instruction documents are saved in SmarTeam cloud storage. Every document also has its own URL address. Based on the requirement analysis, the function of this module is providing users easy access to the instruction documents of the exact work center. This is designed to be done by linking the document’s URL address with the correct buttons on the user interface.
3.4 Maintenance module

There are three sub-modules in this section: data record, data check and maintenance plan. 

**Data Record:** Only operators have permission to this sub-module. They accomplish machine status check then mark whether machine has problem and record concentration level and save other information to the database in this sub-module.

**Data check:** Team leader need to check whether maintenance check is done on time or not.
**Maintenance plan:** Maintenance plan is an Excel chart stored in Atlas system (SharePoint cloud storage). This chart is shown on the interface of this sub-module.

![Image](image1.png)

*Figure 27 Procedure specification of showing maintenance plan sub-module*

### 3.5 Deviation report module

This module is about reporting the deviation of the produced parts from the exact work center if the part has any defects. The digital template of the reporting chart is saved in Atlas system (SharePoint cloud storage). There are two sub-modules in this section: *Fill in and send deviation report* and *Record on lifecycle chart*.

**Fill in and send deviation report:** Only operators have permission to this sub-module. Other users directly receive and send deviation reports through email system in the company. When operators click the button to access this sub-module, the template will be downloaded and opened. Then operators fill in the information and send it to team leader through email system.

![Image](image2.png)

*Figure 28 Procedure specification of filling in and sending deviation report sub-module*

**Record on lifecycle chart:** In order to make deviation processing status transparent to everyone, a lifecycle chart of all deviation reports generated from the exact work center is shown on the main page of this sub-module. Operators add a new record at the same time when they send
deviation report. Then senior directors directly edit the processing status of the exact deviation record on the lifecycle chart when they have finished processing the deviation.

3.6 Process confirmation module
There are two sub-modules in this section: New record creation and Check record.

New record creation: When users click the button to access this sub-module, process confirmation template will be downloaded and opened. This is an Excel chart that contains a list of checking activities, which should be marked yes, no, not applicable and notes when checking them around the work center. The template is saved in Atlas system (SharePoint cloud storage). After downloading, users add marks in this document and save it into the correct folder according to their position.
Check record: senior directors need to check subordinate staff’s checking results. The folder which contains all checking result documents for this work center is linked with this sub-module. When senior directors access this sub-module, this folder will open and they can choose the exact result document which they need to check.

Figure 31 Procedure specification of process confirmation check sub-module
Chapter 5 Implementation

5.1. Database implementation

Microsoft Access is used as the implementation tool for data recording. According to the database design section above, there are three databases need to be built. The final implementation results are shown in Figure 32-Figure 34.

Microsoft’s Jet database engine provides a way to connect to the database. OLEDB (Object Linking and Embedding, Database, sometimes written as OLEDB or OLE-DB), an API which is designed by Microsoft, allows accessing data from a variety of sources in a uniform
manner. An ASP.NET web application accesses the Access databases and executes various operations through this connection.

```csharp
using System.Data;
using System.Data.OleDb;
string strConnection = "Provider=Microsoft.Jet.OleDb.4.0;" + "Data Source=C:\BagASPNET\Northwind.mdb;";
OleDbConnection objConnection = new OleDbConnection(strConnection);
......
objConnection.Open();
objConnection.Close();
......
```

*Figure 35 The code which helps an ASP.NET application connect to the backup database*

5.2. Functional modules implementation

According to the overall framework and the design for functional modules, the task in this phase is programming to obtain the interface and business logic, in order to achieve all functional demands in requirement analysis and have a smooth flow for business processes.

The presentation layer is directly providing an interactive interface for displaying data to the users. Although a system has good performance, it is still a failed project if the user interfaces are not comprehensible and easy to operate.

On the basis of the importance of the interface implementation, Microsoft Visual Studio 2013 with C# programming language is chosen as the implementation tool to build the functional modules’ interfaces for this application system. According to the functional modules design section, there are six functional modules and ten interfaces in total as shown in *Table 7* below.

<table>
<thead>
<tr>
<th>Functional module</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authentication module</td>
<td>Login.aspx</td>
</tr>
<tr>
<td></td>
<td>Registration.aspx</td>
</tr>
<tr>
<td>Drawing module</td>
<td>Drawing.aspx</td>
</tr>
<tr>
<td>Instruction module</td>
<td>Instruction.aspx</td>
</tr>
<tr>
<td>Deviation module</td>
<td>Deviation.aspx</td>
</tr>
<tr>
<td></td>
<td>Lifecycle.aspx</td>
</tr>
<tr>
<td>Maintenance module</td>
<td>Fillin.aspx</td>
</tr>
<tr>
<td></td>
<td>Checkresult.aspx</td>
</tr>
<tr>
<td></td>
<td>Maintenanceplan.aspx</td>
</tr>
<tr>
<td>Process confirmation module</td>
<td>Processconfirmation.aspx</td>
</tr>
</tbody>
</table>

*Table 7 Interfaces of the MIS application*
Login.aspx:

![Login Interface]

*Figure 36 Login interface*

Registration.aspx:

![Registration Interface]

*Figure 37 Registration interface*

Drawing.aspx:

![Drawing Interface]

*Figure 38 The interface of drawing module*
Instruction.aspx:

Instruction Documents

Working Instruction  Measuring Instruction  Instruction in Video Version

Back to Main Page

Figure 39 The interface of instruction module

Deviation.aspx:

Deviations

Create new item in Lifecycle Map
Fill in and send deviation report

Figure 40 The interface of deviation module

Lifecycle.aspx:

Lifecycle of Deviation Report Document

Item name:  
Item number:  
Antal avvikande detaljer:  
Tillverkad:  
Uppritande Plagge:  
Ovakande Plagge:  
Maskin:  
Preliminary State:  

Create  View

Figure 41 The interface of creating item in deviation report lifecycle map
Fill in.aspx:

![Fill in Maintenance Result](image)

*Figure 42 The interface of filling in maintenance result sub-module*

Check result.aspx:

![Check Maintenance Result](image)

*Figure 43 The interface of checking maintenance result sub-module*
5.3. Web application publish

In the test phase, my computer is chosen to be the server and Internet Information Service (IIS) is used to publish the built web application to the intranet in the company. So every computer and tablet using company’s intranet can have access to this web application system by typing the exact URL address.
Chapter 6 Field test

Date: 18th, May 2017
Location: On the shop floor beside 6519 machine
Participators: the operators and team leaders of machine 6519, supply manager Moa Bergström, supervisor Christer Lumio and production manager Sören Liv.

After the web application has been published, a field test is carried out on the shop floor. Participators are invited to use this MIS application on a tablet to test its utility. After their trial use, results and feedbacks have been collected, which are listed below.

1. Authentication module:
   • They like the concise interface of this module. But some of the users hope that it could be possible for them using the same user name and password of their personal computer to log in to this system.

2. Drawing and instruction module:
   • Comparison results:
     Before: It takes them several minutes to find a correct drawing or instruction document on the shelves. Storing these drawings needs dozen pieces of papers and space on the shop floor.
     Now: The whole procedure happens within several seconds. It is convenient to find the correct document. No paper and space waste.
   • Feedback: All the users are satisfied with the design of these two modules.

3. Maintenance module:
   • It is the same procedure to do maintenance work as before.
   • Operators’ feedback: they think doing the work on a tablet brings them a lot of fun.
   • Team leaders’ feedback: they said that having this MIS app saves their time and makes their work more convenient. A team leader is responsible for several machines. By having this web app in the future, they can check maintenance results of these machines at any time in their office instead of going to every machine’s location on the shop floor. Moreover, because time saves automatically, they can check whether the operators doing maintenance on time or not, which is really important for production. This is another advantage which they like very much.

4. Deviation report module:
   • Comparison results:
     Before: A piece of paper recording the detailed deviation generates by the operators then passes to other superiors. The main problem is time consuming during the passing process.
     Now: Passing process is done via email system. it saves time so that deviation can be solved quickly and the influence to the production is small.
   • Feedback: In this module, they think that having such a lifecycle chart is a good idea so that they can know the status easily. They also like sending deviation report via email. But some of the users gives suggestions that they hope the template can be attached within this application so that they do not need to log in to another system and download it.
5. Process confirmation module:
   • Comparison results:
     Before: The process confirmation are paper-based documents. Saving these documents needs dozen pieces of paper and space on the shop floor. As the result, when superiors check records, it takes time for them to find the right piece of paper.
     Now: It is the same working process as before but working on a tablet. Paper cost and space is saved.
   • Feedback: They like this module, but they hope the templates can be attached within this application also.
Chapter 7 Recommendations for future development

Production management information system is a comprehensive and systematic interdisciplinary. It is a combination of the computer hardware and software knowledge, database technology, production management and other disciplines. Due to my limited ability and time limitation, the system also has some shortcomings. If they can be improved in the future, a more complete and efficient production information management system for the company can be developed. According to my understanding during the developing process and users’ feedback, it can be summarized as follows:

1. Make the web application more user friendly.
   The users’ feedback indicates a direction of future development. By discussing the feasibility and forecasting the contribution of these feedback, some constructive suggestions are listed below for future road map.
   • (Deviation report and process confirmation module) try to attach the templates within the application.
   • (Authentication) if possible, link the staff information database in the company with this system for user verification so that they do not need to remember one more user name and password.

2. Integrate a measurement finish notification function in this system.
   In the deviation report section, operators generate new deviation reports when they receive the measurement reports from the measuring room and find that some quality problems are reflected in the report. This procedure is without the scope of this thesis. Because measurement reports are collected together with the measured parts by the operators from the measuring room on a regular basis, time delay for the deviation processing and follow-up production may occur. It would be more efficient if there is a notification to remind the operators when the measurement reports are generated.

3. Decorate the user interface and make the application more attractive.
   Considering that the work on the shop floor are repetitive and the average age of the associates are 42, it would be great if they can have a more attractive working environment. Making some decoration on the user interfaces is worthy of consideration, as well as attaching speech recognition function and grading module in this system in the future.

4. Make full use of the characteristics of the database itself to improve the performance and optimize the data structure. Many characteristics of the database, such as indexes, views, triggers, etc., can play a very good role in database performance optimization. These are not used sufficient in the development of this system. If these features can be fully taken into account during the database analysis, the system will have a better performance.
Conclusion

In this thesis report, the design and implementation process of a management information system based on ASP.NET framework is elaborated. This thesis project is conducted from the practical point of view thus a systematic approach is used. The requirement analysis and the feasibility study are conducted at the beginning of the project. The design phase is divided into the overall design and the detailed design. After publishing the web application system, field test is done and future improvement suggestions are given according to the feedback. It has the practical significance for a variety of management information system researches. The work can be summarized as below:

1) The research on the related technologies.
   Through the study of relevant theoretical knowledge, the development ideas, system architecture and specific development tools and programming methods for designing a management information system are mastered.

2) The requirements and feasibility analysis.
   The functional requirements of the system are summarized based on the business process. UML use case diagrams are used to analyze requirements from different person. Feasibility analysis is conducted to ensure the project can be implemented.

3) The design of the application system.
   Firstly, the system architecture is determined, then the overall system framework and the detailed functional modules as well as the databases are designed.

4) The implementation of the application system.
   Microsoft Access is chosen to build the databases. Microsoft Visual Studio ASP.NET is chosen for programming. The overall system function is achieved and then validated by conducting a field test.

The field test results for using this management information system in the workshop field test are good. Building such an application system on the shop floor can not only improve the ability of information sharing and transmitting, but also improve the cooperation between departments to improve the efficiency.
References


Appendix

User manual

1. Access MOE4.0 MIS application
Type http://10.132.188.214 in the browser.

2. Registration and login
Users should login with their own account. If they do not have account yet, then first register as a new user. All fields are required.

![Login page](image1)

**Figure A1 Login page**

![Registration page](image2)

**Figure A2 Registration page**

The registration data is saved in staff registration database. This database is linked with login page for validation.
3. Main page

All the information is machine-centered. So after login into the system, users should first choose the exact machine center from the dropdown list. Here in this pilot application system, choose 6519 Gildemeister GMX400 for example.

![Figure A3 Staff registration database](image)

![Figure A4 Main page](image)

Then click on the functional module’s buttons based on the needs.
4. Drawings module
On the main page of drawings module, the part number of all the parts which are manufactured in this work center are listed. Each button is linked with the drawing of this part in PDF version. By clicking the button, users have access to the drawing documents quickly.

5. Instruction module
On the main page of instruction module, the name of all kinds of instruction documents which are used for this work center are listed. Each button is linked with the detailed instruction document in PDF or word version. By clicking the button, users can download or directly open the exact instruction documents.
6. Deviation report module

On the main page of deviation report section, there are two sub-module buttons and a process lifecycle chart of all deviation reports generated from this work center. According to requirements analysis before, these two sub-module buttons are only designed for operators to use. For these two buttons, the first one is used for creating new item in lifecycle chart below. The second one is used for filling in the detailed deviation report document and sending it to the team leader for this work center. The purpose of such a lifecycle chart is making sure that everyone can have a clear mind about the status of the dealing process of the exact deviation report.

6.1 Operator
For operators, if they find out any quality problems of the manufactured parts, then they need to report this deviation. First create a new item in process lifecycle map by clicking the first
button. The picture below is the interface after clicking that button. Fill in these important information for identification purpose then click create button, the item will be saved and shown in lifecycle map. Click view to go back to the main page of this module.

![Lifecycle of Deviation Report Document](image)

*Figure A9 Create an item in lifecycle map*

Then fill in the detailed report and send it to the team leader by clicking the second button. After clicking it, a new tab will generate and Atlas system (SharePoint virtual site in the company, saving all templates) will open so that the report template can be downloaded.

Then click the name of the report template and open it. After filling the required information, click File→Share→Email→Send as attachment, and type the team leader’s email address. Mark ID of this deviation report in process lifecycle map and urgent level in the email.

![Share](image)

*Figure A10 send detailed report (Step 1)*
6.2 Other users
After the operator generating a new deviation report, it will appear in the process lifecycle chart. This lifecycle chart shows the contents of the process lifecycle table in the database. According to the requirements analysis, other higher level directors need to deal with the deviation. First they download the attached report in email, then add their opinions or suggestions on the report and send the report again via email system to the exact person. And they should also update the status after processing this deviation.

Figure A11 send detailed report (Step 2)

Figure A12 Edit on lifecycle map

Figure A13 Lifecycle map database
7. Maintenance module
There are three sub-module buttons on the main page of this module. The first one is filling in the maintenance result after checking the machine’s condition based on the schedule. According to the requirements analysis, this button is only designed for operators. The second one is for operators and team leaders to check the maintenance results. The final one is mainly for operators in case they forget the schedule.

![Maintenance module](image)

*Figure A14 Maintenance module*

The picture below shows the interface for *filling in the result*. On the interface, the time now will show automatically to make sure the operator does maintenance on time. After clicking save button, data will be saved in the linked maintenance table in the database and shown on the *check maintenance result* page. By clicking view button, operators have access to see the maintenance results.

![Fill in maintenance result interface](image)

*Figure A15 Fill in maintenance result interface*
The picture below is the interface for check maintenance results.

This is the interface for maintenance plan. Clicking the left maintenance plan button, the chart will be shown, then the operator can check which type of maintenance activity need to be done at this time. This chart is linked with maintenance plan Excel sheet. Changes can be made in the Excel sheet by the higher level directors when necessary and these changes will appear synchronously on this interface.
8. Process confirmation module

There are two sub-module buttons on the main page of this module. The first one is used for filling in the results after checking. Users click the button, and download the template from Atlas system. First fill in the blanks in the template, then save the document into this work center’s process confirmation folder. This folder contains several subfolders due to the different positions of the end users. Users should save the document into the correct subfolder according to their position.

The second button is used for checking the process confirmation results. This button is linked with this work center’s process confirmation folder. Based on the requirements analysis, higher level directors need to check subordinate employee’s confirmation results. This can be done by clicking this button and choose the correct subfolder, the documents will be shown.
Process Confirmation

Instruction: Save the filled document into the correct subfolder

Figure A20 Process confirmation module

Figure A21 Check process confirmation (Step 1)

Figure A22 Check process confirmation (Step 2)