

Developing a Decision Support System for Supply Chain Component

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Abstract

Increased competition has led businesses to compete with each other in streamlining supply chain processes, especially in the manufacturing sector. Supply Chain Management (SCM) determines the success of industrial business processes because it regulates product flow regarding integration, performance, and information. However, several problems have emerged in the supply chain process, such as a lack of coordination in the production queue, difficulties in forecasting trending products, and suboptimal production capacity. To address these issues, the role of information technology is crucial for implementing a Decision Support System (DSS). This study aims to develop a DSS to improve the supply chain processes. The research method used is Extreme Programming (XP) with a qualitative approach through a questionnaire. The research process involves collecting data, defining boundaries and problems, and designing, coding, and testing the system. As a final step, evaluation is carried out by distributing surveys to obtain valid satisfaction results. This research produces a DSS that has applicability in marketing, accounting, and production processes. The application of DSS in the furniture manufacturing industry can help manage the movement of resources, optimize strategic networks, and assist decision-making in the supply chain process.

Keywords

Decision Support System; Extreme Programming; Furniture Manufacture Industry; Supply Chain.

Introduction

Competition in the industry today is getting tougher. Currently, the Industry is oriented towards improving product flow processes by analysing suppliers, intermediate points, storage facilities, and end customers (Izdebski et al., 2020). The role of suppliers, transportation companies, and distributor networks is essential in overcoming this competition (Afrac et al., 2021). To produce cheap, fast, and quality products, it is necessary to pay attention to supply chain management (SCM). SCM is a concept or mechanism to increase the total productivity of the industry's supply chain by optimizing the time, location, and flow of material quantities (Andry et al., 2022a). SCM is divided into three components: integration, performance, and information (Machado et al., 2020). Integration in the supply chain is related to maintaining cooperative relationships with suppli-

ers, providing periodic information to customers, and developing strategies to meet customer needs. Effective and efficient SCM begins with relationships with outside parties who provide raw materials for production (integration with suppliers; (Tiwari, 2021). Supply chain improvements can minimize costs to a large extent (Abushaega et al., 2021). The manufacturing industry must also pay attention to its external partners in formulating strategies, practices, and inter-organizational processes into a collaborative approach (integration with customers). Customer needs are fulfilled by defining collaborative procedures and practices (intra-organizational integration).

The next supply chain component is performance, which is related to activity costs, asset utilization, increased reliability, and quick response to demand. The manufacturing industry can improve performance by enhancing the reliability of time, quantity, and quality (supply chain reliability; Delfani et al., 2022), as well as increasing flexibility in responding to market demand (supply chain flexibility). The third component relates to information in the supply chain. It involves sharing information with suppliers, customers, sales, and intra-organization. The information-sharing relationship in the supply chain context is limited to the extent to which essential and proprietary data is avail-

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able to supply chain members (Saber et al., 2019). The entire process that the supply chain goes through in the manufacturing industry is a condition that needs attention in applying technology. However, the manufacturing industry faces challenges in acquiring reliable and high-quality resources to support these efforts. Several problems arise in the process of realizing productivity improvements in the manufacturing industry. The issues faced by the manufacturing industry include difficulties in managing the availability of raw materials, forecasting product demand, optimizing production capacity, and ensuring the timely distribution of information. Of course, these problems become an obstacle for the manufacturing industry to provide products quickly and on time.

Technological developments in the industry are at the peak of the global economy and are bringing changes to the era of information digitalization (Durrakbasa & Gencyilmaz, 2020). Advances in digital technology allow automation in the manufacturing sector by implementing a Decision Support System (DSS). The application of DSS aims to support strategic decisions not only limited to company operations but also to win the competition (Kamariotou et al., 2022). The use of DSS in an industry is essential because it assists management in the economic decision-making process (Dwivedi et al., 2020). Teniwut and Hasyim stated that DSS improves decision-making regarding the processes and outcomes of business activities (Teniwut & Hasyim, 2020). Developing DSS in the manufacturing industry can increase efficiency, profits, and customer satisfaction by solving existing issues in supply chain components. The method used to develop DSS is Extreme Programming (XP). It is designed for software development projects that have changing or uncertain requirements (Sohaib et al., 2019).

Based on the problems described previously, the DSS is essential to increase customer satisfaction. Therefore, this research is limited to developing a DSS using XP methods to meet the needs of the supply chain process. The manufacturing process begins with system requirements planning by conducting interviews and observing internal business flows in the manufacturing industry. The results of the initial planning are then realized in the outline of the system process in the form of user interface outputs and the creation of Class Responsibilities Collaboration (CRC) cards. The model is realized in a programming language that produces a prototype DSS. As a final step, system testing is carried out on the features and functionality of the entire application. User evaluation is also conducted by distributing surveys to obtain more valid satisfaction results with

the system. This study aims to map the needs of the supply chain process user experiencing problems and overcome them by creating a system. The use of DSS in supply chain components can improve integration, performance, and information-sharing activities. Thus, the supply chain control process can be more effective, especially regarding strategic network optimization, product design, and decision-making.

Literature review

Extreme programming

Extreme Programming (XP) is a software development model that tries to simplify various stages to be more adaptive and flexible (Gunawan et al., 2021). Figure 1 shows the stages of XP including planning, designing, coding, testing, and software increment. The planning stage involves creating a user story describing the software's output, features, and functionality (Saeed et al., 2019). The design stage applies a user story through system modelling and user interfaces. The coding stage involves system modelling using a programming language. Then, the system is tested to identify errors.

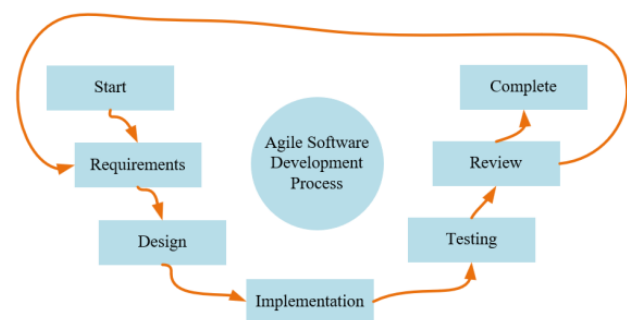


Fig. 1. Extreme programming (XP; Neelu & Kavitha, 2020)

Supply chain components

The supply chain components and their sub-components can be visualized in the form of a fishbone. The supply chain manages the procurement of goods and services for industry (Andry et al., 2022b). Figure 2 shows the three components of SCM—integration, performance, and information. Integration in the supply chain means the strategy of working with supply chain partners, such as suppliers, customers, and intra-organizational stakeholders (Hofer et al., 2021). Supply chain performance means the fulfillment of end customer requirements related to cost,

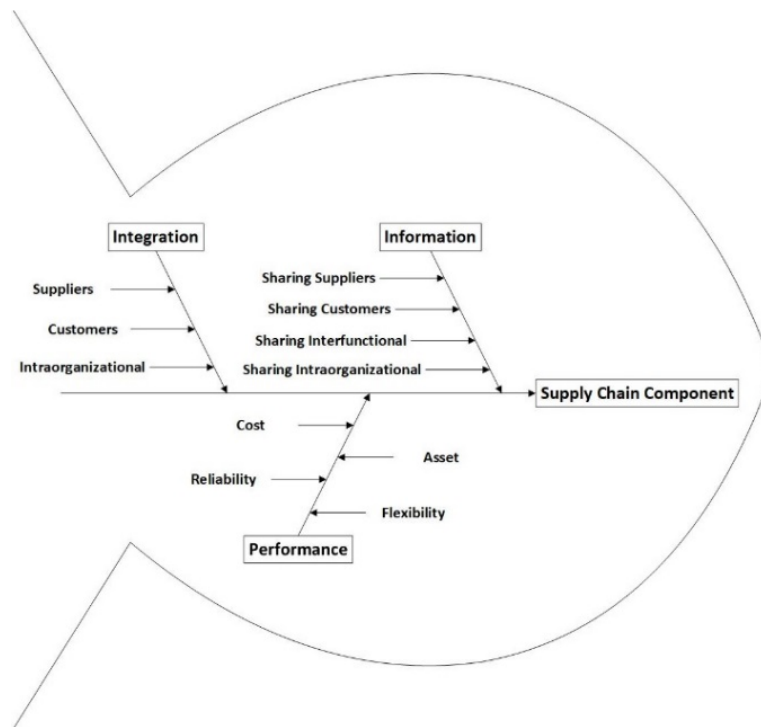


Fig. 2. Overall control structure (Valashiya & Luke, 2022)

assets, reliability, and flexibility. Information sharing in the supply chain involves the satisfaction of information requirements of suppliers, customers, and inter-functional and intra-organizational participants.

Decision support system

A Decision Support System (DSS) is part of a computer-based information system to support decision-makers in solving semi-structured and unstructured problems in an organization (Yuda Irawan, 2020). DSS components are built from several sub-systems, including the data management sub-system (database software), model management sub-system (software analysis), knowledge management sub-system (system supporting components), and user interface sub-system (Ramathilagam & Pitchipoo, 2022).

Materials and methods

Data collection

This study uses a qualitative approach, which reveals a problem in individuals, groups, communities or organizations in the form of behaviours and actions (Huddiniah & Mahendrawathi, 2019). A qualitative approach is useful to focus on the current manufacturing business process problems of the entire supply

chain. This study used interviews and direct document collection to research subjects to ensure that the SCM process obtains support for implementing a good and easy-to-use information technology system.

In addition to using a quantitative approach, data analysis techniques also use a quantitative approach after the manufacturing industry uses the DSS. The quantitative approach in this research is in the form of surveys and questionnaires to directly research subjects using numbers to analyse information about what you want to know (da Silva, 2020). Questionnaire data collection was addressed to 50 system users in the furniture manufacturing industry. The distribution of questionnaires focuses more on assessing user satisfaction with several forms of DSSs (Stacy et al., 2022; Ji et al., 2021). The level of user satisfaction was assessed with the help of a Likert scale.

Research stages

To achieve the final results in this study, the stages of research that must be carried out are shown in Figure 3.

Figure 3 shows the stages of research that need to be passed to produce a DSS. These stages include the following (Sudarsono, 2020; Ariza et al., 2021):

1. *Literature Study*. At the initial stage, the required data is collected through interviews and direct observation of the manufacturing industry.

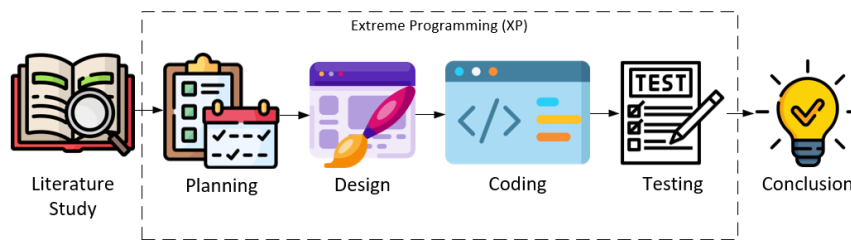


Fig. 3. Research stages (Ivgantius & Andry, 2019)

2. *Planning the Scope of Research and Defining the Problem.* This stage is the first step in system development and involves identifying the problems and analysing the needs. Planning begins with listening to a collection of activity requirements from the system.
3. *Diagram Design.* The next stage is modelling activities divided into system, architectural, and database modelling. However, this study uses UML, namely the CRC card, to determine the system's interaction or relationship between objects.
4. *Implementation of Features in Source Code.* This stage involves the application of modelling activities that have been made into the form of a user interface using a programming language.
5. *System Testing.* After the coding is completed, a system test is carried out to determine what errors arise when the application is running and whether the system built is in accordance with user needs.
6. *Conclusion.* Finally, the use of DSS in overcoming supply chain problems is evaluated based on

a survey of user satisfaction in the manufacturing industry.

Results

Planning the scope and defining the problem

The planning stage in XP involves gathering requirements that help the technical team understand the business context of the DSS. For manufacturing companies, it includes the interview process and the observation of internal business processes that have issues. System planning has been adjusted to the supply chain components: integration, performance, and information. Table 1 describes the issues faced by each division in the manufacturing industry.

Table 1 gives an overview of the problems experienced by the marketing, finance, and production departments. A needs mapping was carried out to understand the systems involved. Some of the DSS's needs

Table 1
Defining the Problems of Supply Chain

Sub-component	Impact	Problem
<i>Integration</i>		
Supplier	Production	Provision of raw materials and late communication
Customer	Marketing	Negative feedback on product quality, lack of detailed product information
Intra-organizational	All Divisions	Sharing of data between divisions is delayed and incomplete
<i>Performance</i>		
Cost	Finance	Budget planning is inadequate, procurement of goods is hampered, and unexpected costs arise
Asset	All Divisions	Delayed debt collection, wrong investment
Reliability	All Divisions	Late delivery, inappropriate customer requests, incomplete financial documents
Flexibility	All Divisions	Delay in production, reduced orders
<i>Information</i>		
Supplier	Production	New product information not delivered
Customer	Marketing	Inability to reach new customers
Inter-functional	All Divisions	Difficulty determining new product innovation
Intra-organizational	All Divisions	Lack of long-term planning, rise in production costs

included issues related to users, orders, sales transactions, production, payments, stock, and reports. After getting an overview of business needs, user stories were created to list the requirements. Table 2 details the user stories of each user involved in the supply chain process.

Table 2
User Stories for DSS

Task	User story	Estimation (day)
Authentication	As a marketing/finance/production user, I want to log into an already-registered account.	3
	As a marketing/finance/production user, I want to get menu access rights based on the role.	5
Sales	As a marketing user, I want to manage the address data for shipping goods.	7
	As a marketing user, I want to make a letter of order.	7
	As a marketing user, I want to manage user data and obtain master data from other divisions.	6
Transaction	As a finance user, I want to access the entire account's postal data, cost codes, customers, and financial reports.	7
	As a finance user, I want to update sales transactions and return goods.	7
	As a finance user, I want to collect data from the marketing division.	6
Stock	As a production user, I want to access the raw material master data.	5
	As a production user, I want to access purchase data and production letters.	7
	As a production user, I want to make proof of receipt of finished goods leaving the warehouse.	7

A user story is a description of system requirements from the point of view of product users. Problem mapping focuses on four things: authentication, sales, transaction, and stock. The creation of user stories was adapted to various problems in the manufacturing industry. Considering the user story results, the system creation estimation was based on the effort required to complete the user story implementation.

Diagram design

The diagram design focuses on the application of user stories defined at the planning stage by developing specifications regarding program architecture, interfaces, and supporting elements. The design begins with creating the CRC card and a prototype solution (Ibrahim et al., 2020). In addition, system modelling is carried out using case diagrams that aim to show business processes and actor interactions with the system.

Table 3 shows the results of the CRC card design and solution prototype. For authentication, the prototype focuses on registering and logging in. It deals with the order form, delivery address, and code master in the marketing section. Then, to support the finance department, the prototype focuses on the master code account, financial statements, sales transactions, and returns of goods. Finally, in the production section that covers stock, the prototype consists of the raw material master, purchase, production letter, and receipt of goods. Furthermore, the DSS design is described in a use case diagram, which is a model to describe the system's behaviour, as outlined in Figure 4.

Table 3
CRC Card Design Results and Solution Prototype

No	Task	CRC card	Solution prototype
1	Authentication	All Users	Register
			Login
2	Sales	Marketing	Order Form
			Delivery Address
			Code Master
3	Transaction	Finance	Account Code Master
			Financial Statements
			Sales Transactions
			Return of Goods
4	Stock	Production	Raw Material Master
			Purchase
			Production Letter
			Receipt of Goods

In the system depicted here, there are three actors, namely marketing, accounting, and production. Marketing is responsible for creating orders, adding shipping addresses, and accessing master data from the form code. Accounting is in charge of managing master data of account codes, financial reports, sales transactions, and returns of goods. Production is in charge of collecting raw material master data and

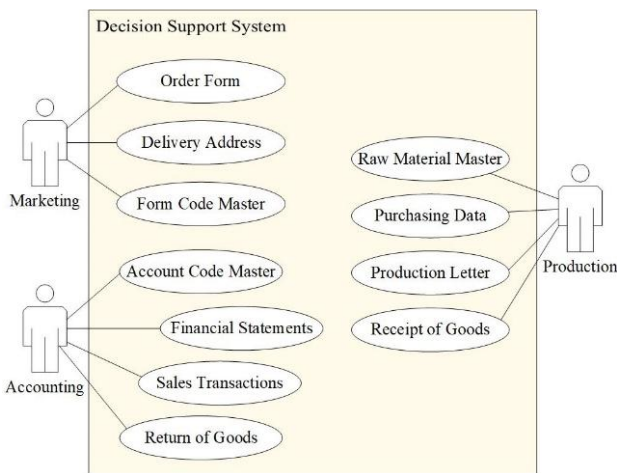


Fig. 4. Use case diagram for DSS (Source: Authors' own conception)

sales data and creating production letters and proof of receipt of finished goods. Next, the user interface is developed for the DSS.

Implementation of features in source code

The next stage is to implement the design that has been made into program code that can be done iteratively. Developers write unit tests according to the specifications and business processes of the system desired by users (user stories). After creating unit tests, developers write program code to complete unit tests until they pass without errors. Developers refactor the program code by changing the program structure to make it easier to understand and modify. The system coding results in a prototype program. Figure 5 shows the result of one of the prototypes that was realized in the production section.

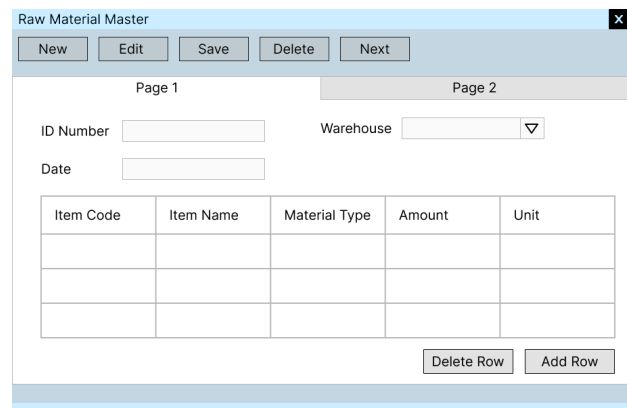


Fig. 5. DSS prototype (Source: Authors' own conception)

Figure 5 depicts the form used by the production department to manage raw material data. Users can add, delete, and update data. In addition, they can view raw material data at specific warehouse locations. In addition to designing prototypes in the production department, the system development continued in the marketing and finance departments.

System testing

System testing is carried out on each module at this stage. It aims to ensure that the system developed addresses the requests and needs of users. Table 4 describes the test scenario for one of the menus in the DSS. The test is conducted using the black-box testing method. For example, the test focuses on the menu in the production section, namely the raw material master. This test is the final stage of developing a product to validate that the system built is as per user needs. The test scenario is divided into six parts: number, test case, pre-condition, test steps, expected, expected

Table 4 Application test scenarios

Test case	Pre-condition	Test steps	Expected result	Actual result
Add New Data	All fields are empty	1. Click the "New" button 2. Fill in all fields 3. Click the "Save" button	Data added successfully	The newly entered field has been successfully added.
Edit Data	All fields are filled and locked	1. Click the "Edit" button 2. Fields open 3. Change one field "ID Number" 4. Click the "Save" button	ID Number successfully changed	The selected field has been changed successfully.
Delete Data	All fields are filled and locked	1. Click the "Delete" button 2. A confirmation dialogue box pops up 3. Click "Yes"	Pop up will appear and selected data will be deleted	The pop-up appeared and the data has been deleted successfully.

Table 5
 Evaluation of DSS

No	Task	CRC cards	Solution prototype	Satisfaction level
1	Authentication	All Users	Register	4.30
			Login	4.22
2	Sales	Marketing	Order Form	4.24
			Delivery Address	4.16
			Code Master	4.24
3	Transaction	Finance	Account Code Master	4.18
			Financial Statements	4.20
			Sales Transactions	4.16
			Return of Goods	4.30
4	Stock	Production	Raw Material Master	4.24
			Purchase	4.20
			Production Letter	4.22
			Receipt of Goods	4.22

result, and actual result. System testing focuses on the functionality of the buttons, such as adding, deleting, modifying, and storing data. In addition, testing is also carried out to validate data deletion actions.

In addition, testing also aims to determine how the system's quality is seen from the user's point of view. As a final step, an evaluation of the use of the system is carried out. The questionnaire was distributed to 50 respondents after running the prototype system created. Table 5 shows the evaluation results of the use of the DSS.

The results of the DSS evaluation for each condition use an assessment from a range of 1 to 5. A value of 1 indicates a high level of dissatisfaction level. A value of 2 indicates a lesser level of dissatisfaction. A value of 3 indicates a sufficient level of satisfaction. A value of 4 indicates a higher level of satisfaction. A value of 5 indicates a very high level of satisfaction. Every user is pleased with the implementation of this system. This is evident from an average satisfaction score of higher than 4 out of 5 for each form above.

Discussion

This research focuses on developing a DSS to maximize the efficiency of the supply chain processes. Supply chain improvement focuses on several sub-components, namely integration (supplier, customer, intra-organizational), performance (cost,

assets, reliability, flexibility), and information sharing (with suppliers, customers, inter-functional, intra-organizational). The research begins with gathering business needs by mapping each division's business processes and problems in the manufacturing industry. Every problem in the supply chain sub-component impacts the production, marketing, and finance processes. Formulation of system requirements assists the technical team in working within the constraints of its creation. Generally, before developing the system, a conventional business process mapping of the current operations is carried out. The business process starts with marketing and searching for customers. The customer makes a purchase order which is processed by marketing and forwarded to the accounting department. The accounting department submits a production assignment letter to the production department. Details of units produced are recorded in the production module. The production department makes a letter of receipt of finished goods as evidence of the release of goods from the warehouse. The accounting department makes delivery documents to send goods to customers and collect payments. The business description and problems in the manufacturing industry are then described as a user story. User stories can also be used as benchmarks for product development purposes that are updated regularly. The summary of user stories in the DSS has covered several things. The results of the user stories describe the estimated time or effort the technical team needs to implement the system. The value of this effort is influ-

enced by the complexity and risk when implementing the user story. The estimated workload increases significantly with the difficulty of completing the user story and the risk faced during its implementation. Next, architectural specifications are made to describe the user story. The design begins with developing a CRC card and a prototype solution. Furthermore, the DSS design is described as a use case diagram. For the user experience to be maximized, the design is implemented in the program code and prototype system. Then, to minimize errors in program code implementation, the next stage focuses on system testing. System testing focuses on checking compliance with specifications, and testing the functionality. The final step involves collecting user feedback, focusing on 50 respondents by running the prototype system. Every user is satisfied with the implementation of this system. This is evident from the high average satisfaction score for each of the forms. Users provide different feedback regarding supply chain components that have been positively affected by the implementation of the DSS.

1. Each user can register for an account and get their respective access rights according to their responsibilities.
2. The provision of raw materials is faster and there is better coordination with suppliers.
3. Data exchange between marketing, finance, and production divisions is faster.
4. Budget planning for procurement, production of goods, delivery, and returns is more precise.
5. Billing debts to customers and estimates of the use of the stock of materials are more accurate.
6. Goods are delivered to customers in the right quantity, on time, and with complete documents.
7. There is faster feedback from customers.
8. Responsiveness to customer needs has increased; satisfaction surveys are conducted often.

Developing a DSS for supply chain processes in the manufacturing industry results in significant improvements. The findings from this study indicate that SCM has an important role in improving company performance, especially in terms of economic development. The development of logistics management, finance, and marketing can create a competitive advantage by saving production costs, accelerating the process of making furniture, helping managers make decisions, and increasing profits in the long run. Future research can project supply chain requirements according to customer requirements, which are then implemented in the system. SCM can play a crucial role in improving company performance by providing customer satisfaction, increasing revenue, lowering costs, and increasing asset utilization.

Conclusions

The rapid development of technology creates excellent opportunities for the manufacturing industry to participate in global business. One way to increase the competitive value of the manufacturing industry is to implement efficiency in the supply chain that focuses on integration, performance, and information. However, the manufacturing industry currently faces challenges in preparing reliable and quality resources. The issues faced by the manufacturing industry today are related to the marketing, finance, and production divisions. The marketing department experienced a lack of data at the time of the order, incomplete customer data, and sending data to other divisions took a long time. The finance department experienced difficulties in financial reporting that were not organized systematically, collection of late payments, and finding transaction data was complex. The production department experienced difficulties with stock differences, the manufacture of production letters was not detailed, and production reporting was late. Of course, the emergence of these problems becomes an obstacle for the manufacturing industry. Therefore, making a DSS is essential to increase customer satisfaction. Making the system using the XP method with a qualitative approach. The initial stage begins with defining the problems experienced by each section. After explaining the problem encountered, the user story's description of the functionality is realized. The results of the user story are made into CRC cards and system modelling is performed through use case diagrams that show the interaction of actors with the system. Next, the user interface for the DSS is made, which is then realized in the prototype program. As a final step, system testing is carried out on the features and functionality of the entire application. Evaluation is also carried out on users by distributing surveys to obtain more valid satisfaction results with the system. The assessment of the DSS for each form indicates that the user is satisfied with the implementation of this system. This achievement is proven by the average satisfaction of each state above number 4. The practical implication of this research is that applying a DSS enables the manufacturing business to react more quickly to maximize integration between divisions, production performance, and information disclosure. Developing a DSS is related to several phenomena in the current industrial era, namely the Industrial 4.0. The Industrial Revolution 4.0 is a transformation effort towards improvement by integrating the online world and production lines in the industry. All production processes run with the internet as

the main support. The DSS has had a good impact on the industrial economy, especially in the Industrial Revolution 4.0 era, namely increasing furniture production, minimizing costs, helping managers make decisions, and increasing long-term profits.

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