Ship production process monitoring application using QR-code technology

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Abstract. Process monitoring of ship production in Indonesia is currently still using conventional methods. Ship production has stages, preparation to the erection. Each of these stages has results that need to monitor and their progress recorded. Therefore, it is necessary to have a system that fasts, practical, and responsive monitoring directly in the work area for actual conditions; one solution is a QR-code technology-based system. The design steps are making the basic framework, diagram of the relationship between entities, prototype design, central page division. These systems are formed in a website called Ship Building Monitoring Process based on QR-code SBMQ. Technical analysis is carried out by making applications, managing system security, creating business processes and operational systems, implementing them with simulations and trials. The trial application of the SBMQ website determines the contribution of implementing the website monitoring process of ship production. The trial was accompanied by the distribution of questionnaires from samples of shipbuilding practitioners. The SBMQ ship production monitoring system can accelerate review, tracking, and report verification assessment with practitioners is 3.125 with a good category.

Keywords: process monitoring, ship production, ship building, QR-code.

1. Introduction
In the shipbuilding process, monitoring the production process is very important because it relates to a progress report that must be reported to the shipowner about the progress of the shipbuilding process[1]. There are several obstacles in monitoring the percentage of shipbuilding data because it must be done in real-time, and the extent of the shipyard becomes an obstacle in the monitoring process if it is done manually[2].

There are several weaknesses in the current shipbuilding production monitoring process, including the length of the reporting process from the production workshop to the PPC (Planning and Production Control) section, prone to errors in the data entry process. Calculating the percentage of shipbuilding progress is still manual and sometimes not by production planning documents[3].

Current technological developments allow the monitoring process to be carried out quickly and with correct data, including in the shipbuilding industry[4]. Therefore, researchers implemented shipbuilding monitoring using a monitoring system based on QR-code technology. These systems are formed in a
website called Ship Building Monitoring Process based on QR-code SBMQ. SBMQ can quickly track products and the production process status; some logs can be monitored, knowing the actual update of the percentage of ship production.

2. Literature Study
The literature study will discuss the QR-code, the concept of shipbuilding supervision, progress reports, ship production process flow, and the concept of intranet, internet and extranet.

2.1 QR-code
Quick Response Code (QR Code) is a technology that emerged due to the limited technological features of linear one-dimensional (1D) barcodes, which are also referred to as classic or conventional barcodes. The readability, accuracy and advanced functional characteristics have led to the widespread use and acceptance of barcode technology worldwide. Conventional barcodes have spread across many applications, including but not limited to their use in convenience stores and retail chains to mark goods, in tracking shipments of goods and movements, in tickets for sporting events, cinemas and transportation. The need for a type of barcode that can be printed in a smaller space and contains more information and many types/types of characters have led to the development of QR-code technology.

QR-code (short for Quick Response Code) is a trademark of the type of matrix barcode (2-dimensional barcode), which was first designed by industry in Japan. One of the QR-code readers on Android is the QR-Code Reader application which can be downloaded for free on the PlayStore. QR-code is a particular type of barcode or barcode created by the Denso Wave corporation/company. QR-codes encode text and numbers using a pixel pattern (pattern of pixels) designed to be easy for optical scanners to read.

QR-code creates a code (encoding) a series of text or sentences (a string of text). There are 4 standard QR-codes for encoding sentences: numeric, alphanumeric, byte, kanji. Each mode is encoded as a string of bits (1s and 0s), but each mode uses a different converting text to bits. Each mode is optimized to generate the shortest possible string of bits for the data type.

2.2 Shipbuilding monitoring concept
Supervision and control in the process (monitoring) ensure the proper use of resources by guiding performance, quality, program retention, and quantity. In addition, there are aspects contained in monitoring activities, namely:

1. The input aspects of the project include human labour, working hours, data, materials or materials, management, and so on that are needed to carry out project activities
2. such as research, production processes, and others.
3. Output aspects, namely aspects of a project that are related to or include the results of the process, especially those related to quantity/amount
Monitoring and evaluation are essential management tools for tracking progress and facilitating decision making. The need for funders for some type of evaluation process, the most significant advantage of an evaluation can be gathering people with structural jobs. With workability examinations, organizations can design programs and activities that are more effective, efficient, and more powerful outcomes for the community [3]. Monitoring can be defined as a continuous function whose core aim is to provide management and key stakeholders of ongoing interventions with an early indication of progress, or lack of, in achieving an outcome. Ongoing interventions allow a project, program or other things to support an outcome. Monitoring helps an organization track the achievements of a regular collection of information to help take timely direction, ensure accountability, and provide a basis for evaluation/assessment and learning [9].

Evaluation or assessment is a systematic and objective assessment of an ongoing or completed project, program, or policy. And its design, implementation/implementation and results. The aim is to determine the relevance and fulfilment/completion of objectives, development efficiency, effectiveness, impact, and sustainability. An evaluation must provide credible and valuable information, enabling the incorporation of previously learned knowledge that can be used in the decision-making process of both parties, namely recipients and donors.

3. Methodology
The methodology in this study begins with knowing the background of the problem, then retrieving primary data in the shipyard, then data processing, application creation and application processes and technical analysis for monitoring system programs using QR codes.

3.1 Data Collection
Data collection is one of the critical aspects of research. The data collected is about the process of building and calculating the progress of shipbuilding and the characteristics of shipyards in Indonesia to operational monitoring. The data collected include:
1. Calculations and monitoring procedures for the ongoing tugboat construction at a shipyard in Indonesia
2. Stages of the process of building a new ship in the shipyard,
3. Distribution of breakdown products for hull construction for 2×1600 HP tugboats,
4. Identify the material needs for the construction of a 2×1600 HP tugboat,
5. Calculation of the progress of the construction of a 2×1600 HP tugboat,
6. Current condition (existing) monitoring the ship production process in the shipyard.

3.2 Data Processing
Data processing is generally carried out quantitatively and qualitatively. Processing data also obtain the need to design a system by detailing the requirements and conditions on a ship and the stages of production. Data processing carried out, among others:
1. Identify and classify the construction materials for the 2×1600HP tugboat.
2. Identify the process and the results/products of each stage of ship production.
3. Coding of materials and ship production results by identifying material requirements and the results of each new ship production process.
4. Encoding (encoding) for QR-code materials and produce results for each shipbuilding process.
5. Decoding (filtration) of the code in the QR-code read and decoded for reporting and databases.
6. Creating a database for production processes and sub-processes based on the production process results from pre-preparation, preparation, to erection.
7. Details of the need for a monitoring system with adjustments for shipyards in Indonesia.

3.3 SBMQ Making Program
The next stage is the process of making the SBMQ Program (Ship Building Monitoring Process based on QR-code), which consists of 2 stages:
1. Design of a ship production process monitoring system based on QR-code technology.
2. Making a ship production process monitoring application based on QR-code technology with the PHP programming language and MySQL database.

3.4 Technical Analysis
Technical analysis is the stage to assess the research object so that it can answer the problem formulation and aims to get the results of the research conducted. Several stages of technical analysis in this final project are as follows:
1. Technical and use of QR-code technology-based ship production process monitoring application.
2. Trial of ship production process monitoring application based on QR-code technology.
3. Validation of ship production process monitoring applications based on QR-code technology.
4. Verification by taking a questionnaire as a user response from an expert or practitioner of shipbuilding in Indonesia.
5. Comparison of conventional monitoring systems with ship production process monitoring systems based on QR-code technology.

4. Existing Condition
In this research process, to understand the ongoing ship production process, it is learned about constructing a new tugboat at PT. X. Now at PT. X, there is a new shipbuilding project. Project N at PT. X is used as the object of research related to the monitoring characteristics of new shipbuilding in shipyards in Indonesia. The construction of this new ship is of the type of tugboat with sistership construction with the following main sizes:

- Total length (LOA) = 30.00 m
- Width (B) = 11.60 m
- Height at the centre of the ship (D) = 5.10 m
- Draft conditions for summer load = 3.80 m
- Draft in normal operation = 3.50 m
- Height on deckhouse = 2.50 m

Based on the data obtained from interviews with the production planning and control department, the development progress should be calculated through the workshop, reporting a list of the work that has been done. However, this did not work, so the supervisory department estimated the calculation by comparing the volume of work done with the weight of the entire block. Determination of progress with several aspects, namely the level of difficulty of the work, the volume of parts, the number of parts compared to the block, and the whole ship. Then it is entered into the calculation tab in Microsoft excel.

Reporting is carried out in weekly meetings, bi-weekly meetings and monthly meetings. An early warning system is also carried out at the meeting related to the projects being carried out. Internal reporting consists of what work has been done, the progress of the work, possible problems during the work. In the reporting process at the meeting, the project manager or PIC uses a physical progress report and an S-curve, as shown in Figure 2.
In figure 3 is the plan for the division of the 2 x 1600 HP tugboat block. The hull is divided into five block sections. In contrast, the building on the ship is divided into three parts. Hull notifications are issued in numbers 111, 112, 113, 114, and 115. The superstructure blocks are notified in numbers 211, 212, and 213.

**Figure 3.** Block division of N tugboat construction

Monitoring and calculating the progress of ship construction using a progress realization table. Monitoring progress is reviewed as a whole, covering all stages of shipbuilding. Starting from ordering materials to the final inspection at the erection stage. All activities that need to be monitored are made in a development progress table 1 as follows.

**Table 1 Calculation of shipbuilding progress**

| No | Block Division | Stander | Realization Progress This Month | Physical Progress |
|----|----------------|---------|---------------------------------|-------------------|
|    |                | Group  | Material               | Assembly | Erection | Final Inspection | Project Realization % | Project Real Last Period % | Project Progress % |
|    |                | %      | Confir | Down Payment | Full Payment | Shipment | Arrival at Yard | Blasting dan Shop prim. | Marking dan Cutting | Bending | Fit-up | Welding | Fit-up | Welding | Fit-up | Welding | Final Inspection | Project Realization % | Project Real Last Period % | Project Progress % |
| 1  | Block 1        | 17.97  | 2.11  | 100 | 100 | 100 | 25 | 25 | 25 | 25 | 25 | 10 | 3.71 | 1.68 | 0.04 |
| 2  | Block 2        | 38.28  | 4.5   | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 95 | 85 | 4.46 | 4.44 | 0.02 |
| 3  | Block 3        | 24.01  | 2.89  | 100 | 100 | 100 | 8  | 8  | 8  | 8  | 8  | 100 | 2.29 | 2.29 |
| 4  | Block 4        | 5.86   | 0.69  | 100 | 100 | 100 | 8  | 8  | 8  | 8  | 8  | 8  | 0.34 | 0.54 |
| 5  | Block 5        | 11.33  | 1.33  | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 98 | 50 | 1.26 | 1.26 |
| 6  | Block 6        | 1.95   | 0.23  | 100 | 100 | 100 | 8  | 8  | 8  | 8  | 8  | 8  | 0.18 | 0.18 |
| Total |               | 100    | 11.75 |                  |                     |            |              |               |               |           |      |       |       |       |       |       |               |                      |                      | 10.46 | 10.39 | 0.07 |
Table 1 shows a table for calculating the progress of shipbuilding, which is also used in the company PT. X. In the table, there are various shipbuilding activities. Each shipbuilding activity has a weight that contributes to the overall shipbuilding progress. Multiplying the workload that was completed with the weight of the activity resulted in the percentage of progress at each stage. Details of activity weights are in Table 2 below.

**Table 2 Activity weight in the calculation of shipbuilding progress**

| No | Stage | Activity                  | Weight |
|----|-------|---------------------------|--------|
| 1. | Material | Confirmation order       | 9%     |
|    |        | Down payment              | 26%    |
|    |        | Full payment              | 44%    |
|    |        | Shipment                  | 5.2%   |
|    |        | Material datang di galangan | 3.5% |
| 2. | Fabrication | Blasting & shop priming | 0.5%  |
|    |        | Marking & cutting         | 1%     |
|    |        | Bending                   | 0.5%   |
| 3. | Assembly | Fit-up                    | 2.3%   |
|    |        | Welding                   | 3.5%   |
| 4. | Erection | Fit-up                    | 2.1%   |
|    |        | Welding                   | 2.9%   |
|    |        | Final inspection          | 0.3%   |

4.1 Weaknesses of the Existing Condition of monitoring the ship's production process

In the production process monitoring method currently used, several aspects can be improved, including:

- Marking of production materials still uses manual paint, chalk, and markers because there is no cost
- Em for automatic marking,
- Tracking materials and production results for input or input is still using a system using paper-based forms which employees will enter into Microsoft ExcelTM,
- There is no system for automatic input or input in the field (workshops and production sites) that is connected to the data stored in the company's system,
- There is no system to show directly from the data in the field related to the progress of the shipbuilding production process.
- There are no tools so that parties related to the ship production process know the progress quickly and responsively. Only specific departments know about the accumulated progress, only to find out through a meeting or by asking about the actual progress in the planning and supervision department.

5. Application Design

5.1 Design of Ship Production Process Monitoring System Prototype

The design of the system prototype begins with several main stages, including the following:

1) Collecting data on the existing condition of the ongoing shipbuilding along with research for the basic needs of shipbuilding knowledge and data on tugboats used for direct and specific program needs,
2) Data processing, with 2 primary data with their respective sources and destinations,
3) Breakdown process and product breakdown of 2x1600 HP tugboats,
4) Coding is the stage in building a program with the PHP programming language,
5) The program's trial and error testing aim to ensure the program can function correctly and according to its purpose.

The website designed for the ship production process monitoring system is named SBMQ Ship Building Monitoring Process based on QR-code. The purpose of naming is to represent the function and usability of the system being built.
5.2 QR-code Visual Design

The visual QR-code displayed for materials and products resulting from the ship's production process contains the QR-code and 2 alphabets that represent each shipbuilding process. This type of QR-code with an image in the middle area is called a QR-code with a canvas area. With these advantages of QR-code design, it provides design flexibility. The pattern (design and pattern) is available to users, providing a more attractive appearance, making it easier to identify the code listed on the material from the production process's side.

![QR-code Visual Design](image)

Figure 4. Display QR-code for Pre-preparation

Figure 4 is an example of a QR-code display that has been created on the material that has been identified in the pre-preparation process. The resulting code from the encoding is visually simplified by assigning a canvas area to the QR-code.

5.3 Coding on QR-code

Coding is a process of encoding (encoding). Encoding itself is an internal process to encode the information needed in a code that has various arrangements so that it is easy to read input to a system. The coding is planned to contain 19 digits containing letters and numbers. The first 2 digits represent the process abbreviation represented by PP for pre-preparation, PR for preparation, FA for fabrication, SA for sub-assembly, AS for assembly, and ER for the erection process. The details of the third to nineteenth digits are explained in more detail in Figure 5

![Coding on QR-code](image)

Figure 5. Description 19-digit coding qrcode for SBMQ

After coding in the QR code, the next step is to create the main page on SBMQ, which consists of:
1. The Home Page or Start Page, which is called the dashboard,
2. Register Registration page, with the name REGISTER,
3. Login page, with the name LOGIN,
4. Tracking page, with the name TRACK-QR.

5.4 Application display design on Android
Designing this website can also be accessed by Android by registering a domain by renting a domain on a hosting server. Hosting is renting a place that accommodates the data needed by a page (website) to be accessed via the internet online (online), which can be accessed via the internet using either a computer or Android. Here is the SBMQ display on Android, which can be seen in the Figure 6.

![Figure 6. SBMQ webpage accessed via Android](image)

5.5 Input Proses
The program is designed to be used flexibly. The program is possible to be applied to the construction of all types of ships. For this reason, application users can change the type of material used, the critical piece parts to the existing blocks in the production planning results. The following Figure 8 is the material input application page.

![Figure 7. TRACKING QR-CODE page in Website browser](image)
The figure shows the page used to input material data by the production planning carried out. In addition to material data, data input is also carried out on the results of each stage of ship construction. Tabs are set up on the left side of the page for panel data input, panel position, and block type. Indicates the column used to enter the required material data. There is a column to select the type of material. Material name is the material used—for example, keel plate, side stringer, transverse—the remark column for adding notes if needed.

5.6 Generate QR code page
In the fabrication stage, QR code creation is done by entering piece part data. After the data is entered, the program will automatically generate a unique QR code for the piece part. So, it may not be the same as other QR code piece parts. The following Figure 9 is the column used to generate the QR code.
6. Analysis and Discussion

6.1 Progress Monitoring with QR Code

Progress monitoring with conventional methods is carried out using the shipbuilding progress monitoring form. This form is replaced with a QR code affixed to each piece part that has been completed. In SBMQ, S-curve tools and report tables are used to show or visualize the progress of shipbuilding Sub-Process.

In each Pre-Preparation to Erection process, only a realization curve is given. The two S-curves, namely the Planning Curve and the Realization Curve, are only shown in the Final Report. The Final Report covers the whole.

For example, a piece part is fabricated and welded with another piece part at the fabrication stage. That way, PPC employees go to the field only by bringing a device that has the application installed. Inside the application, we can check the QR-code one by one using the scanner inside the application. If the components that make up the panel are complete, a QR-code for the sub-assembly process can be created and affixed to the panel.

6.2 Changes in the implementation of monitoring using QR-code

In increasing efficiency, this system plays a role in the following ways:

- The input process is facilitated by scanning using an optical scanner, an Android smartphone scanner, for identifying production items from a 19-digit QR code. The input process is simplified by reducing manual recording activities using paper forms or typing production codes.
- The calculation method in determining progress in the production process is carried out by the system, with a calculation database that has been entered in the SBMQ database.

In implementing a ship production process monitoring system, several things change in a shipyard. 3 main things have changed, including:

1. Technological Change
   The use of a new system that is increasingly advanced will require technological adaptation for companies implementing it. The interaction of technology and humans who use it will determine the sustainability of the system in an organization and shipyards. Business

2. Process Changes in Shipyards
   The application of the QR-code technology-based system will touch almost all departments directly related to the ship production process. Changes in the way the shipyard works and
operations will occur during the implementation of this system. Changes in working methods/business processes/work rules cause shipyards to consider repairs and adjustments; otherwise, a new system will generally be rejected. In addition, there is a change in the ongoing system audit, where it is necessary to adjust the audit assessment for shipyards that have implemented SBMQ.

3. Changes in Shipyard Culture
   The two previous changes significantly change business processes that have implications/implications for changing the work culture of a shipyard. An example that will happen is with an integrated system. Departments that previously focused only on departmental interests are required to work together as a team to focus on the interests of shipyards in building ships rather than the interests of one department.

6.3 Trial of Monitoring System Implementation in Shipyards
   In this trial, it will be carried out aimed at getting respondents (user-responses) from shipyard practitioners. Questionnaires filled out by respondents will be assessed with a Likert scale. The Likert scale is an assessment with a scale of 1 to 4. The questionnaire obtained in this study a total of 11 questionnaire respondents from shipyards including those from the Planning and production control section, logistics staff, warehouse staff, planning and supervision managers, shipbuilding project leaders as shown on Figure 11.

![Figure 11. Filling out the Questionnaire by shipyard practitioner respondents](image)

| No | Question                                                                 | DS | N  | S  | VS | Total | Average | Result       |
|----|--------------------------------------------------------------------------|----|----|----|----|-------|---------|--------------|
| 1  | Does this application help in recording materials and products produced? | 6  | 5  | 11 |    | 3.45  | Very Satisfied |
| 2  | How easy is the SBMQ application to operate?                             | 1  | 9  | 1  | 11 | 2.81  | Satisfied |
| 3  | Does this application help in tracking materials and production results? | 1  | 7  | 2  | 11 | 2.63  | Satisfied |
| 4  | Does the SBMQ application help in monitoring the progress or development of the ship's production process? | 6  | 5  | 11 |    | 3.45  | Very Satisfied |
| 5  | How does the performance of the SBMQ application compare to the current system? | 8  | 3  | 11 |    | 3.27  | Satisfied |
| 6  | Does the SBMQ application help in the evaluation of new ship production results? | 6  | 5  | 11 |    | 3.45  | Very Satisfied |
| 7  | What is the level of security in the SBMQ application?                   | 2  | 7  | 2  | 11 | 2.63  | Satisfied |
| 8  | Can this SBMQ application be an alternative to improve the existing system? | 1  | 4  | 6  | 11 | 3.27  | Satisfied |
|    | **Average**                                                              |    |    |    |    |       |         | **3.125** Satisfied |

Based on the results of the questionnaire respondents from shipbuilding practitioners, an average rating of 3.125 was obtained with a good category, that the SBMQ application can be applied and is feasible in Indonesian shipyards. So the SBMQ application system can be applied as a monitoring system for ship production processes.
6.4 Comparison of System Advantages and Disadvantages
The comparison between the advantages and disadvantages can be considered for development and improvement to become a shipyard business line during the ship production process. Details relating to advantages and disadvantages can be the primary consideration for a structure or organization to implement a new system. The comparison of conventional systems and SBMQ can be seen in the following table:

| Advantages                                      | Existing System                                                                 | QR-code Monitoring- SBMQ                                                                 |
|-------------------------------------------------|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| • No sticker is required for marking.            | • Can quickly track (tracking) with QR-code input.                             | • Hackable                                                                             |
| • It does not require a scanner input device,    | • Activity logs can be monitored, including personnel/users who enter/change data. | • Requires an input device to read QR-code                                              |
|  either an optical scanner or a smartphone for reading QR-code. | • Accelerate the update of the current condition (actual) of the production process |                                                                                         |
|                                                 | • Without LOGIN, we can monitor materials and products for general information only, with the features on the TRACK QR-CODE page. |                                                                                         |
|                                                 | • By logging in through the QR-CODE TRACK page, we can immediately update the data without going to the process page (reducing opening web pages) |                                                                                         |
|                                                 | • Changes in data can be monitored through IP and personnel data making changes and validating user accounts through Super User and automating time logs, and updating personnel data. |                                                                                         |

| Disadvantages                                   |                                                                                |                                                                                         |
| • Marking used has not been quickly tracked.    | • Hackable                                                                     |                                                                                         |
| • Entering data takes several steps and takes more time. |                                                                 |                                                                                         |
| • Monitoring of personnel and times when data updates or changes have not been recorded automatically. |                                                                 |                                                                                         |

7. Conclusion
After designing and researching up to technical analysis, the conclusions of this research are as follows:

1. The current condition of the ship production monitoring process at one of the Indonesian shipyards, among others, is still conventional marking, paper-based material tracking, namely manually using records from the production site and then entered into Microsoft Excel, no automatic system for inputting production conditions directly with company database, no system that shows the current condition related to production progress, and there are no tools for stakeholders to monitor production progress quickly and responsively.

2. The design of the Ship Building Monitoring Process based on QR-code is carried out by determining the basic framework for designing the SBMQ system, designing a prototype system that includes QR-code visuals and material coding, dividing the main page of the SBMQ website, creating a user interface and assigning the role of SBMQ users, to the security of the SBMQ system.

3. Implementing the production process monitoring system based on the QR-code SBMQ is using a QR-code simulation for progress monitoring, making business processes and operating systems for the implementation of SBMQ, testing the system with a tugboat block structure model, trials by shipyard practitioners and comparisons. Advantages and disadvantages of conventional monitoring systems compared to SBMQ.
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