

A Study of Production Processes and Inventory Management Optimization at Kazakhstan Paramount Engineering using Visual Business Intelligence

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**NAZARBAYEV
UNIVERSITY**

School of Engineering and Digital Sciences

In partnership with

Graduate School of Business

**Moldir Sailaukhanova
Azel Tashimova
Bibarys Tileubayev**

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Supervised by
Prof. Yerkin Abdildin

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Declaration

We, Moldir Sailaukhanova, Azel Tashimova and Bibarys Tileubayev, declare that the research contained in this thesis, unless otherwise formally indicated within the text, is the author's original work. The thesis has not been previously submitted to this or any other university for a degree and does not incorporate any material already submitted for a degree.

Signatures:

Moldir Sailaukhanova 

Azel Tashimova 

Bibarys Tileubayev 

Date: May 5, 2026

Abstract

A manufacturer of armored vehicles, Kazakhstan Paramount Engineering (KPE) has complex business operations with Bill of Materials (BOMs) containing hundreds of globally sourced components. Currently, the main characteristics of BOMs created in Excel are fragmentation and decentralization, as different company departments use their own databases to track production progress. As a result, the organization faces Inventory Record Inaccuracy (IRI), which is one of the most critical challenges as physical inventory does not coincide with what is recorded. This fragmentation is compounded by inefficient purchasing and inventory, making production process transparency virtually impossible and leading to numerous missed assembly opportunities that are difficult to assess without a consolidated database.

The capstone project is aimed at solving the problem via the implementation of Visual Business Intelligence (BI) Solution in which Microsoft Power BI and Excel will play the role of the main analytical instruments. All information coming from different data sources can be combined, providing full visibility. This solution will include the following applications: (1) an Excel dashboard for tracking actual production progress by key performance indicators, (2) a Power BI dashboard for real-time monitoring of unit, (3) an Excel-based BOMs Screening and Validation tool to ensure component availability, and (4) Excel Production Gantt chart to compare planned and actual assembling progress. A Standard Operating Procedure (SOP) and User Acceptance Test (UAT) procedure are required for successful implementation.

For organization, this research offers a novel application that can build its organizational structure based on visual analytics, which can be adapted with data from their businesses. Scalability of the model also allows further extension with additional KPIs.

Keywords: Inventory Management, Business Intelligence, Supply Chain Management, Bills of Materials, Data Integration, Single Source of Truth, Dashboard Development, Production Planning

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List of Abbreviations

BI	Business Intelligence
BOM	Bill of Materials
DAX	Data Analysis Expressions
DMAIC	Define, Measure, Analyze, Improve, Control
ECP	Engineering Change Proposal
ERP	Enterprise Resource Planning
ETL	Extract, Transform, Load
IRI	Inventory Record Inaccuracy
KPE	Kazakhstan Paramount Engineering
MEM	Master of Engineering Management
NCR	Non-Conformance Report
NU	Nazarbayev University
SEDS	School of Engineering and Digital Sciences
SOP	Standard Operating Procedure
SVG	Scalable Vector Graphics
SQL	Structured Query Language
UAT	User Acceptance Test

1 Introduction

Kazakhstan Paramount Engineering, the largest armored vehicle manufacturing facility in the Central Asian region, operates at the pinnacle of advanced defense and aerospace engineering. The company offers a range of high-value armored vehicles, including the Arlan, Barys, and Nomad, which are characterized by highly complex Bills of Materials comprising hundreds of components procured from international as well as local sources.

In this highly discrete manufacturing environment, the accuracy of procurement activities, as well as the overall inventory management process, is expected to be of the highest standard, as the entire assembly cycle is of low volume, highly complex, and of high value.

Though Kazakhstan Paramount Engineering is at the pinnacle of the defense industry, the overall organizational structure of the company has not been as effective as the operations that drive the business. The core of the operations is a highly fragmented system of decentralized Microsoft Excel spreadsheets, managed independently by different departments, including R&D, Progress Planning, and Production Engineering.

This highly fragmented approach to data management has created a structural disconnect between what the system shows and what physically exists, which is formally known as Inventory Record Inaccuracy in the field of operations management. The overall effect of this is not just administrative, as it has a cascading effect on the entire procurement, inventory, and production cycle, leading to a lack of visibility of the overall production progress, as well as a lack of information that the upper management of the company is aware of.

The overall management of the Bills of Materials is also highly unstructured, as the absence of a validated BOM means that the production team may end up undertaking the assembly cycle of the overall production process, only to realize during the process that the required components are not available, leading to a lack of production opportunities, which is difficult to quantify without a unified reporting system in place.

This capstone project aims to fill these gaps by creating and implementing a Visual Business Intelligence solution. The solution will utilize Microsoft Power BI and MS Excel as the core analytics engines and attempt to combine disparate sources of information into one single and accurate model - a true single source of truth. The project

will produce four main integrated tools: an Excel KPE Production dashboard for actual production progress and key KPIs, an Excel Production Gantt chart for comparison of planned and actual assembling progress, the Power BI Assembly Status dashboard for monitoring the status of each unit and each station, and an Excel-based BOM Screening and Validation tool. This will be accompanied by a Standard Operating Procedure and a User Acceptance Test.

2 Literature Review

2.1 Inventory Management

Data-based inventory management practices have become quite common in today's industrial settings, calling for more accuracy, clarity, and cooperation. Such problems as IRI, lack of organized data, and absence of information visibility remain among major concerns for many businesses. They interfere with both strategic planning and operational processes.

As research demonstrates, efficient supply chains and procurement operations depend on accurate information as well as ability to convert that information into valuable knowledge. As a result, business intelligence, information visibility, and inventory record inaccuracy have been selected as key points of focus. This literature review focuses on four main areas related to this study:

- inventory record inaccuracy,
- information visibility and reactive planning,
- visual analytics and decision-making,
- Business intelligence as a unified tool.

These topics serve as the theoretical basis for creating a visual BI-driven solution that aimed at studying optimization of production processes and inventory management at Kazakhstan Paramount Engineering.

2.2 Inventory Record Inaccuracy

The IRI is a frequently occurring problem related to inventory and supply chain management. The term means discrepancies between inventory records and the number of inventory items. IRI is not typically caused by one mistake but is the result of multiple smaller mistakes such as incorrect inputting information into the database, delays in updating it, inaccurate counts, and disorganization of inventory.

Two main types of IRI identified in the literature include ghost inventory and hidden inventory. In ghost inventory situations, there will be an overestimation of inventory and will lead to such undesirable results as false availability, picking errors, and potential delays in manufacturing operations. Hidden inventory, on the other hand, is characterized by underreporting of inventory items which makes the company assume that there is a shortage of goods and can lead to losses related to production or sales opportunities. Both

these types of IRI are risky not only due to technical factors but can also impede decision-making process (Destro et al., 2023).

According to Destro et al. (2023), the impact of inventory errors on warehouse and distribution center efficiency is considerable. Among the most important findings, it was concluded that inventory errors should be considered the issue that can affect the entire supply chain and not a matter that should be dealt with at the warehouse level only (Destro et al., 2023).

Liniwuhi and Handayati (2025) examine the consequences of IRI using a quantitative approach. They suggest that any discrepancies, regardless of their magnitude, can affect a relatively high number of inventory units. This factor is crucial for large companies since they have to deal with big amounts of inventory which implies that any error can cause severe outcomes (Linuwih & Handayati, 2025).

External restrictions aside, information redundancy and inaccuracy occur throughout the supply chain. According to Chen et al. (2023), the phenomenon known as the bullwhip effect causes demand variations to amplify through the supply chain. Common sources of IRI include biased information and delayed processing; in particular, information regarding customer demand may become distorted due to incorrect inventory information. Distortions of this sort can cause shortages and excesses and ultimately result in improper purchasing decisions. These variations lower overall predictability, especially in case of time lags (Chen et al., 2023).

Moreover, the literature shows that besides human error, structural and organizational issues also affect the emergence of IRI. These may include such factors as diverse formats of information used, material requirements not structured consistently, and absence of a single source of data, resulting in false inventory information. Under these conditions, common solutions such as inventory audits on a regular basis often remain insufficient since they only provide temporary relief without addressing the root causes of problems (Chen et al., 2023).

Overall, IRI represents one of the crucial barriers to effective decision-making. False inventory information creates challenges for organizational planning related to purchases, manufacturing control, and collaboration between departments. At the same time, it prevents the creation of an integrated single source of data necessary for modern business practices. In addition to improved daily operations, overcoming IRI involves achieving higher levels of data consolidation and standardization, as well as implementation of tools

able to generate accurate information in real time. Thus, use of BI applications becomes necessary.

2.3 Information Visibility and Reactive Planning

Visibility of information has a significant role in supply chain management and procurement, especially for large and complicated manufacturing businesses that are involved in interdepartmental exchange of information. In simple terms, it refers to accurate, up-to-date and accessible information about inventory, demand, and procurement processes inside a company. Contemporary research has shown that good quality visibility requires reliable, timely and easily available information to make decisions.

Often in empirical evidence, the connection between visibility and decision-making is identified by researchers. High visibility implies that managers get exact and timely information which enables better decisions, whereas, poor visibility may delay decisions and make mistakes, resulting in inferior decisions. Thus, visibility leads to good quality decisions.

Ivanov (2022) stresses the significance of complete visibility in supply chains, especially in times of disruption like in the case of the COVID-19 pandemic. The researcher finds that companies which have high levels of digital transparency can react fast and solve problems efficiently, thus adjusting their procurement strategy even before encountering any problem. This shows that transparency plays an important role in enabling proactive planning (Ivanov, 2024).

In another study, Dou et al. (2022) confirm the capability of blockchain and other technologies to improve transparency in supply chains, which, in turn, increases visibility and facilitates the process of information exchange among participants. It also helps to increase organizational coordination and productivity. The researchers emphasize that while technology adoption is a prerequisite, its effective utilization and integration of information in decision-making is also crucial (Dou et al., 2025).

Despite of the current technological progress, the huge amount of firms still experience poor visibility due to scattered IT systems, ineffective integration, and data inconsistency between departments. Thus, companies respond to problems reactively, rather than proactively, such as in procurement, where they react to inventory deficiencies after realizing them instead of planning beforehand.

Poor information visibility detrimentally influences the quality of data, making it less accurate to reflect the current situation. This situation leads to various problems like placing wrong orders, delaying the manufacturing process, and lack of co-engineering between departments. As a result, it decreases efficiency and increases sensitivity to disturbances.

On the contrary, high information visibility helps make faster decisions based on collaboration among departments. If data are exchanged between departments with uniformity, mistakes become less frequent, and departments can plan proactively, allocate resources efficiently, and respond to demand and supply changes quickly.

According to extant literature, improving information visibility is not an easy task because it involves both technical and organizational difficulties. For instance, there is no one place where one can find reliable information in some enterprises since it is kept in several unsynchronized databases. Therefore, even when using advanced technologies, information visibility cannot be achieved without a consistent database (Dou et al., 2025; Ivanov, 2024).

Solving these problems presupposes integrating data and designing systems that increase information visibility. It corresponds to the goal of the current study that intends to create a BI dashboard visualizing data from different sources.

To summarize, current research displays that information visibility plays a critical role in moving from reactive to proactive planning. Also, improved information visibility transforms raw data into meaningful information that in the future can drive effective decisions and ensures optimal supply chain performance.

2.4 Visual Analytics and Decision-Making

Visual analytics is one of the most important techniques for today's data-driven organizations. As it helps users to quickly understand large and complex datasets. In production monitoring and inventory management, visual analytics turns raw data into clear insights, helping people make faster and better decisions (Molke et al., 2024).

Visual analytics can help people to understand raw data in a more effective and rapid way, as stated in most of the studies. Despite the fact that there are a large number of businesses with a huge amount of data, for managers, it is still hard to work with. This is why, in modern life, there are a variety of tools in the form of dashboards, charts, and

KPIs that help to make processes easier to understand. So, managers could make decisions even faster and identify spikes.

The main steps that visual analytics do can be separated into six categories, which are:

- collecting data,
- transforming data,
- visualizing data,
- interpreting the results,
- making decisions,
- and finally putting them into action.

Moving from one step to the next makes the whole process clearer and more beneficial for data analysis. Thus, the visualizations are great for dividing big data into understandable parts and then taking action.

The usefulness of the visual analytics is evident from Bagus et al.'s case study (2026) on the real-world application of inventory dashboards developed using Metabase. According to their study, the implementation of dashboards to track inventory results in much better performance in the monitoring of transactions and handling of problems, as well as management of assets. Some of the dashboards included in the study were those for inventory distribution, service tracking, depreciation, and locations (Bagus et al., 2026).

In addition, pie charts illustrating the distribution of resources to each department will provide users with immediate visualization of resource allocations. Likewise, the KPI dashboards that indicate the number of completed, unfinished, and pending tasks will allow an immediate understanding of how processes have progressed. In turn, visuals minimize the necessity to conduct detailed analysis manually and identify existing problems at once.

Finally, the study revealed another major effect associated with the application of visual analytics - namely, improved user experience and acceptance. According to Bagus et al. (2026), the KPI dashboards obtained 96% acceptance rate in terms of user testing, proving that visual tools are highly efficient in practice (Bagus et al., 2026).

Notably, visual analytics is not only concerned with the visualization of data but also with decision-making processes. Decision makers do not have to depend on various scattered reports and possibly stale data to make their decisions. In addition, they can get

information about what is going on in the firm in real time, which will enable them to make decisions effectively.

In addition, visual analytics facilitates easy communication among different departments because everyone in the team gets to know about what has been visualized in a similar manner. The process is essential at KPE since there must be effective teamwork among different departments in the organization.

Visual analytics will not be effective when applied to poor-quality and inconsistent data. Poor data can lead to inaccurate visuals, which in turn result in incorrect analysis and conclusions. Also, visual dashboards can enhance the operational and decision-making processes by providing efficient and shareable information in a quicker manner to enhance cross-functional visibility (Nabil et al., 2023b). Hence, data quality improvement and visualization are crucial factors to consider.

To conclude, several studies confirm that visual analytics plays an integral role in improving decision-making within inventory and procurement. Visual analytics enables organizations to convert their data into meaningful information and make informed decisions, as well as improve cooperation between departments. All these factors can explain why a visual BI dashboard should be used in decision-making at KPE.

2.5 Business Intelligence as the “Unified Tool”

BI is considered an essential element in the modern literature on data-oriented decision making in business organizations. BI includes several methodologies aimed at gathering, analyzing, and visualizing data to make more informed decisions. BI may be used to enhance inventory management in a business organization by extracting meaningful insights from Enterprise Resource Planning (ERP) data that are difficult to obtain due to dispersion and complexity (Aguiar & Alcalá, 2024).

The primary advantage offered by BI solutions lies in the ability of the system to integrate different data streams into a single cohesive model. Organizations will not have to deal with inconsistent data from multiple Excel spreadsheets or separated database files, as BI platforms can be used to create a central data model, helping eliminate problems such as inventory discrepancies and a lack of transparency (Gajera, 2023).

Most BI systems consist of three major components. First, the integration feature provides organizations with a method to merge information from various data sources into a unified structure, which, as a result, eliminates any possible inconsistencies. The second

important component is represented by interactive dashboards, which provide access to KPIs. Finally, actionable insights facilitate data analysis.

There are various benefits associated with BI as compared to conventional reporting. Conventional reports rely heavily on Excel files that have data in a static format, presenting just a snapshot of the information at the time the report was compiled. The reports tend to be highly reactive and not proactive in nature since they are produced after the incident has occurred. The creation process is cumbersome and time-consuming, producing reports that are mostly non-interactive with limited analytical capabilities (Fortune Business Insights, 2026).

On the other hand, BI systems provide dashboard presentations with automatic updating of the data presented. Unified data modeling techniques help in integrating data from all sources. This ensures accuracy and consistency. The automation of the Extract-Transform-Load (ETL) process helps in reducing the number of errors encountered during manual processing. BI promotes proactive decision-making through functionalities such as alerting mechanisms, forecasting, and real-time monitoring. Instantaneous report generation enables users to apply filters or perform drilling functions to access deeper-level data analytics (Fortune Business Insights, 2026).

The pivotal parameters, such as price, ease of use, compatibility with already installed tools (specifically Excel and Microsoft applications), data modeling, visualization quality, scalability, and ability to support AI/forecasting capabilities, have to be considered for companies such as KPE to choose the correct BI solution since they all impact the functionality and adaptability of the tool for them.

A comparative analysis of popular BI tools such as Power BI, Tableau, and Qlik Sense has revealed the unique advantages of each. For instance, while Tableau shines in its capability to create outstanding visuals, Qlik Sense shows great strengths in associative data modeling. On the other hand, Power BI outshines others in various aspects. Firstly, Power BI is considered less expensive as it comes with a free version for the desktop. Additionally, the tool features seamless integration capabilities with other Microsoft applications. Another strong point about Power BI is data modeling, which is enhanced by the use of the specialized language Data Analysis Expressions (DAX). The scalability in its design allows the transition from Excel-based systems to cloud-based services. Based on the results of evaluation studies conducted by SelectHub (2026) and Gartner (2024), Power BI performs highly in several areas (Manis, 2024; Kaur et al., 2018).

In light of the above comparison, it can be argued that Power BI would be ideal for the needs of KPE. As noted above, Power BI is one of the most affordable BI tools on the market. The similarities between Power BI and Microsoft Office products make its interface easy to work with. Being reliant on Excel currently, Power BI can provide a smooth continuation of the current processes at KPE. Moreover, Power Query helps integrate Excel data without an urgent need to switch to complex databases (LeBlanc, 2025).

The next critical benefit associated with Power BI involves advanced analytics and forecasting capabilities provided by means of DAX and embedded AI tools. The latter are especially relevant in the context of procurement planning, where demand forecasting and trends analyses play a crucial role. In addition, the product offers an efficient opportunity to scale up, enabling enterprises to begin with simple applications and progressively evolve into complex integrations involving Structured Query Language (SQL) data, for instance. The academic sources present evidence of the practical benefits of BI tools. For instance, according to Microsoft (2022), Walmart utilized Power BI to build a data model, thus ensuring reporting uniformity and standardization in making decisions. In parallel, visual representation helped the bank to get a 20% cross-sell to other products and services, other than achieving a fraud loss of 10% by identifying inaccuracies (Nayak, 2025, p.298). Furthermore, Kadam et al. (2024) demonstrate that business intelligence-enabled inventory systems can improve operational efficiency and support data-driven decision-making in the industry 4.0 era. Other case studies confirm that companies using business intelligence dashboards were able to eliminate excess inventory and reduce costs through key performance indicator management and data consolidation (Manis, 2024; Microsoft, 2022; eBlanc, 2025).

BI helps overcome operational silos by integrating various data sources. Organizations like KPE currently face operational silos due to the use of separate Excel spreadsheets, manual data collection, and disjointed systems. Implementing BI technology overcomes these obstacles, as it includes a centralized data model, automated data processing using ETL, and an interactive dashboard that provides real-time data to decision makers. Predictive analytics is another benefit, enabling more proactive procurement planning.

Summing up, one can state that the literature review has proved that BI is not only a reporting tool but a strategic system in itself. By combining all data and improving the ability to make decisions based on them, organizations can operate much more efficiently and coordinated. Therefore, BI becomes a powerful tool for overcoming the issues

addressed in this paper and the use of a visual BI dashboard for production monitoring and inventory management purposes is fully justified for KPE.

3 Methodology

This chapter discusses the methodology adopted for analyzing the problems of production process inefficiencies and inventory management encountered at KPE. The present study adopts an applied case study methodology and incorporates principles of DMAIC (Define–Measure–Analyze–Improve–Control). DMAIC offers a systematic process of pinpointing inefficiencies within an organization, gauging process gaps, determining causes, initiating improvements, and controlling processes.

The current study was carried out between September 2025 and April 2026 and addresses three key areas of operational difficulties found at KPE: data inconsistencies, poor visibility of decisions, and BOM management difficulties. These difficulties, in total, lead to IRI, inefficiencies in procurement, and production delays.

The methodology adopted in this study involves three stages: (1) Problem Identification and Diagnostic Analysis, (2) System Design and Development, and (3) Implementation, Validation, and Control.

3.1 Research Framework

For the study, a case study methodology is employed, with KPE acting as the study environment that is studied for inefficiencies in operation in terms of complexity in discrete manufacturing. KPE is the largest producer of armored vehicles in Central Asia, and its operations involve very complex BOM that comprise thousands of different parts procured locally and internationally. This study seeks to address three major clusters of operational problems, which are:

3.1.1 Data Inconsistency

The firm uses decentralized excel sheets, which are managed independently by various departments like Research & Development, Progress Planning, and Production Engineering. Lack of an integrated data system leads to problems like duplication and inconsistencies between actual inventory and recorded inventory leading to IRI.

3.1.2 Limited Decision Visibility

The management does not have the capability to monitor the real-time status of production in the manufacturing plant. There is no way to track the progress of assembly in the units, compare the plan and actual status, and identify any production bottlenecks.

3.1.3 Bill of Materials Management Challenges

BOM validation is a laborious and lengthy process because of the intricacy associated with multi-tier BOMs, which contain thousands of parts. Typically, material shortage is detected during assembly, causing procurement to be reactive, leading to production stoppages, and preventing assembly from occurring. The objective of the study is to implement a single source of truth using Visual BI software, including Power BI and Excel, by Microsoft.

3.2 Phase I: Problem Identification and Diagnostic Analysis

This first phase relates to the Define and Measure phases of the DMAIC methodology and centers around the identification of the reasons for inefficiencies in operations.

3.2.1 Process Mapping and Operational Assessment

Firstly, a thorough investigation of current operational procedures took place in departments of R&D, Progress Planning, and Production Engineering. The analysis included the following areas: procurement planning, inventory management, BOM checking, production planning, and internal reporting.

In particular, the relationship between departments and data transfer within independently managed Excel reports were investigated during this phase. Significant points of fragmentation, manual processing, and lack of central reporting were discovered.

There were several points which helped to conclude about operational issues:

- 1) departments operated independently using separate Excel reports,
- 2) BOM checking had to be done manually through thousands of items,
- 3) material shortage was detected when the delay in production had already happened,
- 4) management depended on manual communication to know the production state.

All these helped to understand that the problem was not in the process itself, but in lack of integration capabilities.

3.2.2 Data Structure Evaluation

Evaluation of data quality, consistency, and preparedness of four major operating datasets supplied by KPE to implement BI was performed. The following datasets were included in the evaluation:

- 1) BOM

- 2) Inventory Records
- 3) Procurement and Supplier Data Tracking Files
- 4) Production Build Progress Tracking Files.

Data quality issues such as duplication of records, inconsistencies in record names, lack of ID numbers, inconsistent measurements units, and inconsistency between BOM component and inventory records were assessed.

3.2.3 Root Cause Analysis

A root cause analysis was carried out to understand the correlation between data silos and production problems. It was found that the operational delays, procurement problems, and BOM validation issues were more due to lack of visibility rather than due to any production constraints. The results formed the basis of implementing a Visibility BI strategy.

3.3 Phase II: System Design and Development

The second stage aligns with DMAIC phases Analyze and Improve and involves designing and implementing the Visual BI framework.

3.3.1 Data Preparation and Standardization

The Extract-Transform-Load (ETL) methodology was used to prepare data for building dashboards. In this phase:

- redundant and inconsistent records were eliminated,
- naming of components, their units of measure, and items was standardized,
- IDs of components from the BOM list were harmonized with IDs in inventory,
- status codes of procurement were verified,
- assembly process data were aligned with 30 steps of manufacturing.

This stage was performed to increase accuracy and consistency of data prior to analytical modeling.

3.3.2 Data Modeling and Architecture Design

In order to create a reporting infrastructure that would be able to perform analytical calculations in an effective way, a star schema model was designed using Power BI. This architecture consisted of the following components:

- Fact tables that were used to track changes in inventory management, procurement activity, and production.
- Dimension tables that included information about components, vendors, production units, assembly locations, and time periods.

3.3.3 Development of BI Artifacts

According to the stated requirements, four integrated analytics tools have been created:

Assembly Status Dashboard (Power BI). A dynamic dashboard that visualizes 18 stages of assembly line for cars including the completion level for each stage and unit separately. This tool allows observing the process of assembling and switching between each unit.

Executive Production Dashboard (Excel). The tool for analyzing the actual production progress, production key performance indicators (KPI), and operational bottlenecks without having to go to the floor and verify the data manually.

BOM Screening and Validation Tool (Excel). The tool for validating and analyzing the availability of component parts according to multi-layered BOM, where procurement statuses of components may be evaluated as: Purchased, Deficient, In House, Pending Contract, and Customs Pending.

Production Gantt Chart (Excel). The scheduling chart comparing the expected vs. actual assembling progress. Planned dates are taken from project managers, while actual progress comes from the production floor.

3.4 Phase III: Implementation, Validation, and Control

The last phase relates to the Control phase of DMAIC and is concerned with sustainability and organizational implementation.

3.4.1 Standard Operating Procedure (SOP)

The development of a SOP ensured the adoption of all BI tools, including their update and maintenance. This included outlining the responsibilities of users, the frequency of reporting, data ownership, and validation, as well as dealing with inventory discrepancies. This will ensure that the adopted solution will be sustainable in the long run.

3.4.2 User Acceptance Testing (UAT)

UAT was organized in order to evaluate the practicality, usability, and functionality of the proposed Visual BI solution before implementing it at KPE.

Considering that the research used human subjects and gathered evaluative data, IREC approval from the university was secured before the testing. Each of the respondents was provided with the informed consent form describing the goals of the study, voluntary nature of participation, and confidentiality of answers provided during the survey.

In total, the UAT included five people occupying different key positions within the company:

1. Director of R&D Department
2. Senior Production Planning Engineer
3. Head of Production Planning Department
4. Chief Technologist
5. Production Engineer-Technologist

The assessment of the tool was carried out via a comparative before-after implementation method which can be found detailed in Appendix B.

In addition, respondents evaluated the usability of created tools via a five-level Likert scale (from 1-strongly disagree to 5 - strongly agree) based on four statements regarding usability, efficiency, visibility, and satisfaction.

3.4.3 Performance Evaluation

The efficiency of the visual dashboards was measured by the changes made to the visibility of the production process, decrease in manual reporting efforts, speeding up BOM validation, and early detection of materials shortage before production interruption.

As the conclusion shows, the solution implemented had a positive effect on increasing transparency, coordination among departments, and laying a foundation for further digital transformation of the company.

4 Results

This chapter includes the findings of the project, focusing on two aspects: the output of the created tools and dashboards, and the User Acceptance Testing. The company has several ongoing projects for different types of the machines to produce. For the development, we were given the assembly roadmap of the Arlan machines. Arlan was selected as the baseline model as it represents the most complete and complex BOMs among KPE's current production portfolio, making it the most suitable foundation for dashboard development and validation. That project was used as a baseline for all our deliverables.

4.1 BOM Screening and Validation Tool

KPE's BOM contains 10,000-line items per project, and previously, the planners had to review this document and filter the data in order to determine the availability of the components for a given sub-stage of the production process. This was a time-consuming and risky process since the chances of a critical shortage being overlooked until a stoppage in the assembly process occurred were extremely high.

The idea was to provide transparency for the 10,000 items of BOM, highlighting the most critical items impacting the company's production efficiency. Considering the process complexity of 32 stations + 10 substations, the decision was made to extract the critical KPI of each station/ substation, place them in the sequential order of the assembling process, and highlight the deficiencies. There have been several challenges in data cleaning since the spreadsheet is managed manually; the station names have to be written down correctly according to the assembly process, without spaces or extra characters. Although the list contains approximately 10,000 lines, many items are repeated across several stages in varying quantities. For example, the way the KPE handles that is that if a Nut HEX M8* 1.25 component with Part Number AV11-2517 is used in 5 different stations and 9 different assembling drawings, it is represented in BOM in 9 different lines. If the item is missing, for the BOM Screening Tool, it has to be accounted for in 5 different stations. In the meantime, for the regular monthly reports, it should be reported as 1 position missing. So each formula must be written with precise logic to include the main factors, exclude sub-factors that may influence the final number, and represent the inventory status. In that case, additional columns and filters have been added as shown in Figure 4.1 to account for whether the Part Number is being presented for the first time in the station or not, using the formula:

=COUNTIFS(\$K\$3:K445;K445;\$H\$3:H445;H445)=1

The results are returned as TRUE/FALSE.

Further, to identify if the item is deficient or not, it has to account for the demand and availability columns using the formula:

=IF(AND([@[First row in station (True/False)]];[@[Station demand]]>0;SUMIFS(I:I;K:K;[@[PART NUMBER]]<[@[Station demand]]);"Deficit";"")

Similar logic is applied for the first row in the table identification and overall deficiency status.

#	LEVEL	DESCRIPTION	QTY	PICKING QTY	STATIONS	QTY available	PART NUMBER	Station demand	Total demand	First row in station (True/False)	Station deficiency	Q-ty available total	Total Deficiency	First row in Table
443	8	NUT HEX M8 X 1.25 CLASS 8 TO DIN 934	1	2	PWR SUB	0	AV11-2517	60	1050	TRUE	Deficit	0	TDeficit	TRUE
3762	5	NUT HEX M8 X 1.25 CLASS 8 TO DIN 934	2	2	ELM	0	AV11-2517	180	1050	TRUE	Deficit	0		FALSE
3802	5	NUT HEX M8 X 1.25 CLASS 8 TO DIN 934	4	4	ELM	0	AV11-2517	180	1050	FALSE		0		FALSE
4912	6	NUT HEX M8 X 1.25 CLASS 8 TO DIN 934	8	8	DOOR SUB	0	AV11-2517	630	1050	TRUE	Deficit	0		FALSE
5080	6	NUT HEX M8 X 1.25 CLASS 8 TO DIN 934	8	8	DOOR SUB	0	AV11-2517	630	1050	FALSE		0		FALSE
5263	6	NUT HEX M8 X 1.25 CLASS 8 TO DIN 934	5	5	DOOR SUB	0	AV11-2517	630	1050	FALSE		0		FALSE
6068	5	NUT HEX M8x1.25 CLASS 8 TO DIN 934	4	4	EXBO	0	AV11-2517	120	1050	TRUE	Deficit	0		FALSE
8144	7	NUT, HEX M8 X 1.25 CLASS 8 TO DIN 934	1	1	HVAC SUB	0	AV11-2517	60	1050	TRUE	Deficit	0		FALSE
8234	7	NUT, HEX M8 X 1.25 CLASS 8 TO DIN 934	1	1	HVAC SUB	0	AV11-2517	60	1050	FALSE		0		FALSE

Figure 4.1. Data Sorting and Addition of Filters in BOM.

The additional columns and formulas helped to highlight the fact that the item with Part Number AV11-2517 is deficient in 5 stations of the assembling (PWR SUB, ELM, DOOR SUB, EXBO, HVAC SUB) and could be correctly represented in the Monthly reports as 1 item since the total deficiency column contains only one “TDeficit” recording.

Another example of BOM optimization is that any item might have an open Nonconformance report (NCR) with a different status Opened/Closed. The purpose is to minimize the NCR number, since the item is blocked for usage if NCR is opened. The existing BOM has the column NCR containing the NCR number but does not exactly specify the status. Since the NCR number is standardized, it made it possible to categorize the NCR for Opened and Closed/Completed using the following formula:

=IFS ([@[NCR]]="";"";ISNUMBER(SEARCH("-O"; [@[NCR]])); "Open"; ISNUMBER(SEARCH("-C"; [@[NCR]])); "Closed/Cancelled"; TRUE;"")

And the Final BOM Screening Tool could represent how many open NCR is in every station.

Each of the stations was represented by the following box as displayed in Figure 4.2, containing the station Code, Name, Total number of critical items, Percentage of the

available items, Number of Purchased and In-House items, and Deficient numbers for the Purchased/In-House Preparing/In-House Welding stages, number of opened NCR and ECP forms:

Purchased	Total PICK	Available, %	IN-HOUSE
Deficit			Def - In-House
			Def - Preparing
			Def - Welding
	SUS		NCR Open
	Установки моделирования		ECP Open

Figure 4.2. Optimized Box with all Critical Characteristics.

Then all 42 stations/substations have been placed in an assembling sequence in on page as represented in Figure 4.3:

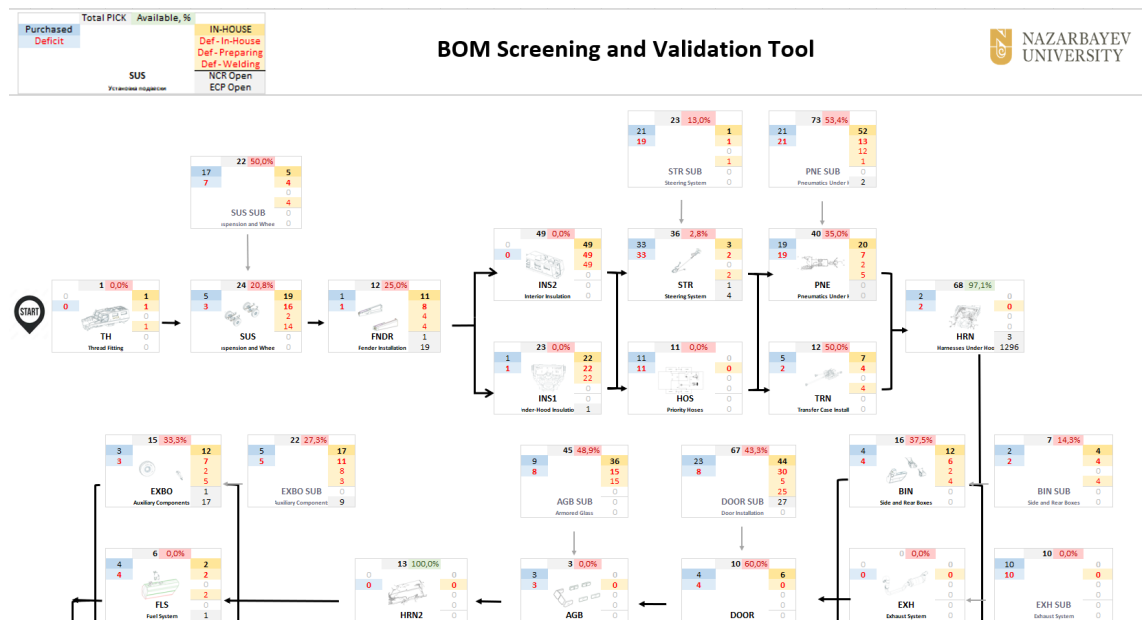


Figure 4.3. Horizontal Displacement of all Stations with Optimized Boxes.

Finally, the BOM Screening & Validation Tool (Figure 4.4) looks like that:

deficiencies, working closely with the Supply Chain department to resolve any obstacles and ensure the delivery on-time.

4.2 Production Data Input Template

That is an Excel based template (Figure 4.5) helping to track actual start/end dates of each assembling station, the current progress status in percentages, Quality Control records and the name of the responsible person. The person in charge will update the file on a daily basis to represent the progress updates for all production units and their assembling stations. This database will serve as a source of information for the further set of tools.

"ARLAN" Assembling Tracking Tool

1. Enter the name of the Responsible Foreman.
 2. Click on the Start Date cell and select the required start date from the Calendar in the top left corner—the date will be inserted automatically.
 3. Click on the End Date cell and select the required end date from the Calendar.
 4. Select from the list whether the Quality Control (QC) check was passed (Yes/No). If the answer is "Yes," the current status will automatically turn green, indicating 100%.

ARLAN			1				2				3				4				5			
Station	Description	Sub-assembly Number	Person in charge	Start Date	End Date	QC approve	Progress status	Person in charge	Start Date	End Date	QC approve	Progress status	Person in charge	Start Date	End Date	QC approve	Progress status	Person in charge	Start Date	End Date	QC approve	Progress status
TH	Искра profile	MAR18-KZ-0011_02		02.02.2026	02.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	20%				Yes	20%				Yes	20%
SWS	Проектирование и вкл.	MAR18-KZ-0007		02.02.2026	02.02.2026	Yes	20%		04.02.2026	04.02.2026	Yes	20%				Yes	20%				Yes	20%
FND06				06.02.2026	06.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	100%		06.02.2026	06.02.2026	Yes	100%		02.02.2026	02.02.2026	Yes	100%
IN11				06.02.2026	06.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	100%		06.02.2026	06.02.2026	Yes	100%		02.02.2026	02.02.2026	Yes	100%
IN12				06.02.2026	06.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	100%		06.02.2026	06.02.2026	Yes	100%		02.02.2026	02.02.2026	Yes	100%
IN15				06.02.2026	06.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	100%		06.02.2026	06.02.2026	Yes	100%		02.02.2026	02.02.2026	Yes	100%
STR				06.02.2026	06.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	100%		06.02.2026	06.02.2026	Yes	100%		02.02.2026	02.02.2026	Yes	100%
TRN				06.02.2026	06.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	100%		06.02.2026	06.02.2026	Yes	100%		02.02.2026	02.02.2026	Yes	100%
PNE1				06.02.2026	06.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	100%		06.02.2026	06.02.2026	Yes	100%		02.02.2026	02.02.2026	Yes	100%
PNE2				06.02.2026	06.02.2026	Yes	100%		04.02.2026	04.02.2026	Yes	100%		06.02.2026	06.02.2026	Yes	100%		02.02.2026	02.02.2026	Yes	100%

Figure 4.5. Production Data Input Template.

To avoid human error in typing the dates, a special Excel Add-In tool as Mini Calendar has been suggested for use. The employee just needs to select the input cell and then select the date from the Calendar in the top left corner. In case the cell is not empty, the Calendar will ask whether the content should be overwritten or not. Another hint to avoid incorrect data is to apply conditional formatting to highlight the cells if the end date is earlier than the start date. If the Quality Control has been passed successfully, the Progress status will also highlight the cell in green colour, reminding the employee to update the percentage to 100%. A Data Validation rule was also applied to progress status columns, restricting input to values between 0 to 100% only.

4.3 Production Gantt Chart

The production progress status from the Input Template is used to create an Excel-based Gantt chart as shown Figure 4.6 to track assembling delays and assemblings performed ahead of the schedule.

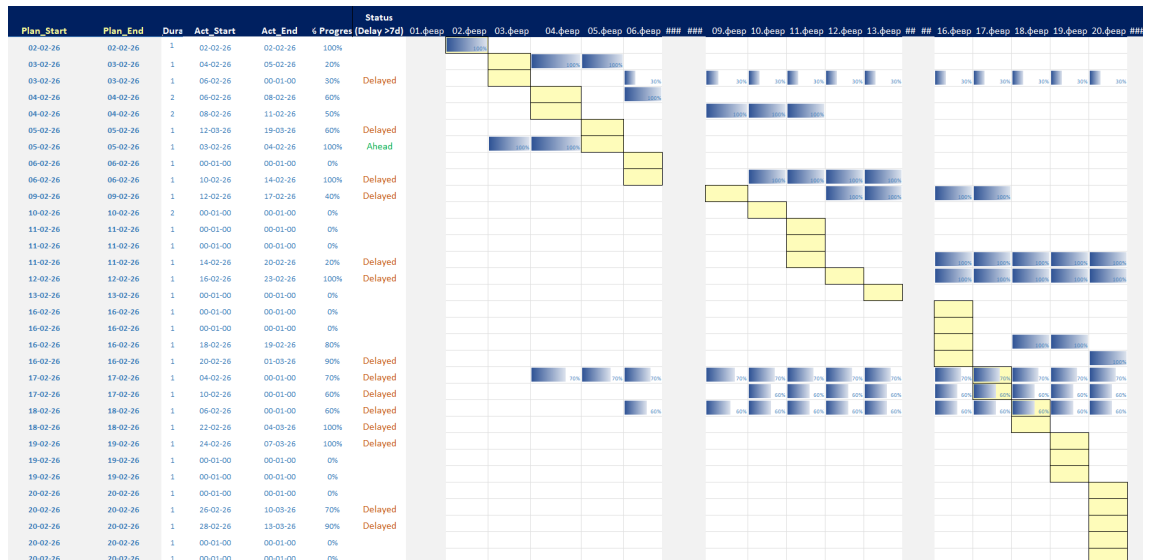


Figure 4.6. Production Gantt Chart.

It is important to update Planned Start/End dates for each of the production units before usage. The actual Start/End time and %Progress are taken from the Production Data Input Template using the INDEX+MATCH formulas:

=IFERROR(INDEX(ARLAN!\$A:\$ZZ; MATCH(\$B3; ARLAN!\$A:\$A; 0); MATCH(1; (ARLAN!\$4:\$4=\$A3)*(ARLAN!\$5:\$5="Start_date"); 0)); ""); ""

=IFERROR(INDEX(ARLAN!\$A:\$ZZ; MATCH(\$B3; ARLAN!\$A:\$A; 0); MATCH(1; (ARLAN!\$4:\$4=\$A3)*(ARLAN!\$5:\$5="End_date"); 0)); ""); ""

=IFERROR(INDEX(ARLAN!\$A:\$ZZ; MATCH(\$B3; ARLAN!\$A:\$A; 0); MATCH(1; (ARLAN!\$4:\$4=\$A3)*(ARLAN!\$5:\$5="Progress status"); 0)); ""); ""

For the Delays/Ahead Status identification it was decided to take into consideration the delays with more than 7 days to shorten the number of outliers. It was also important to consider different cases like if the process is started later but not yet finished - it should be also marked as "Delayed". The status is assigned based on the formula:

=IFS(I3=0; ""; (I3-F3)>7; "Delayed"; AND(J3=0; (TODAY()-G3)>7; "Delayed"; J3=0; ""; (J3-G3)>7; "Delayed"; J3<G3; "Ahead"; TRUE; "")

The most critical part in developing Excel based Gantt charts is to format the timeline section correctly. Each cell of the timeline has a formula to set a progress status if the date on the timeline falls between the Actual Start and End dates, excluding 2 weekends on Saturday and Sunday:

=IFS(AND(\$I4>0; \$J4>0; N\$2>=\$I4; N\$2<=\$J4; WEEKDAY(N\$2; 2)<6); 1; AND(\$I4>0; N\$2>=\$I4; N\$2<=IF(\$J4=0; TODAY(); \$J4); WEEKDAY(N\$2; 2)<6); \$K4; TRUE; "")

Further, each cell of the timeline has the Conditional formatting (Figure 4.7), which allows filling the cell with the appropriate colour to differentiate planned and actual schedules and skip the weekends:

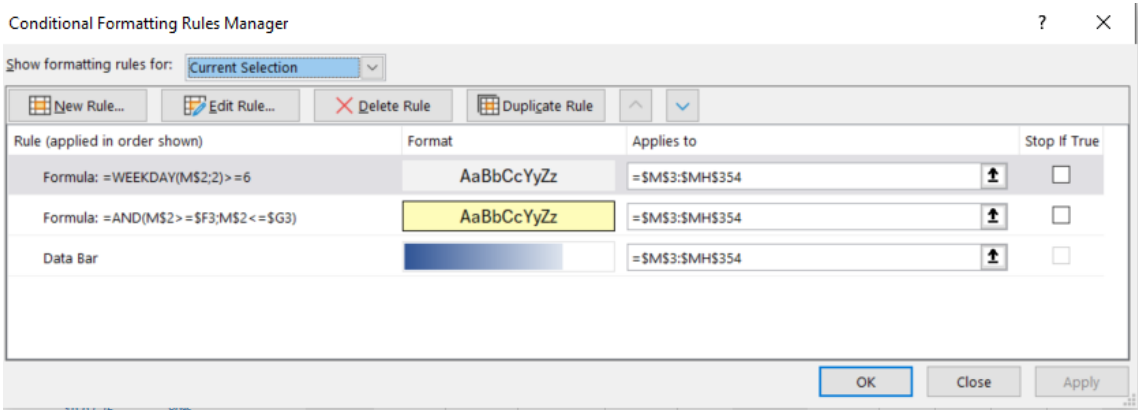


Figure 4.7. Gantt Chart Conditional formatting.

4.3.1 Intermediate Input Table

The table is created to summarize the Unit’s project name/location, and clarify the status of the Final Painting, Road Test, Shot Blast Testing activities, which are not part of the assembling process but still very important to know for the management. The table also contains the critical KPI as production stations with more than 7 days delays listed from the Gantt Chart applying the formula:

=TEXTJOIN(", "; TRUE; UNIQUE(FILTER('Gantt chart'!\$B:\$B; ('Gantt chart'!\$A:\$A=Input2!B\$2)*('Gantt chart'!\$L:\$L="Delayed"); "")))

4.4 Assembly Status Dashboard

The request was to create a visualization dashboard with colour coding of each of the assembling stages to identify the critical stations which need more attention and company involvement to progress the production. The best recommended way to visualize the progress percentage was creating SVG (Scalable Vector Graphics) Measures first and then represent them using the Card visuals in Power BI. Thus, 32 SVG Measures were created using the following DAX code (Figure 4.8):

```

1 Bar_SVG1 =
2 VAR _percentage = COALESCE ( VALUES('Статус'[1. Прогонка Резьбы]), 0 )
3
4 VAR _greenThreshold = 0.8
5 VAR _amberThreshold = 0.5
6
7 VAR _green = "#4caf50"
8 VAR _amber = "#ffb300"
9 VAR _red = "#f44336"
10
11 -- Clamp to 0..1
12 VAR _p =
13     MIN ( 1, MAX ( 0, _percentage ) )
14
15 VAR BarColor =
16     SWITCH (
17         TRUE (),
18         _p >= _greenThreshold, _green,
19         _p >= _amberThreshold, _amber,
20         _red
21     )
22
23 -- SVG dimensions
24 VAR _svgW = 140
25 VAR _svgH = 180
26
27 VAR _barW = 140
28 VAR _barH = 140
29 VAR _barX = 0
30 VAR _barY = 20
31
32 -- Ensure minimal visible height when 0%
33 VAR RawHeight = _barH * _p
34 VAR FillHeight =
35     IF ( _p = 0, 4, ROUND ( RawHeight, 0 ) )
36
37 VAR FillY =
38     _barY + ( _barH - FillHeight )
39
40 -- Center text inside filled portion
41 VAR TextY =
42     IF(
43         FillHeight > 0,
44         FillY + (FillHeight / 2) + 5,
45         _barY + _barH
46     )
47
48 -- Text color depending on progress
49 VAR TextColor =
50     IF ( _p >= 0.5, "FFFFFF", "000000" )
51
52 RETURN
53 "data:image/svg+xml;utf8," &
54 "<svg width='" & _svgW & "' height='" & _svgH & "' xmlns='http://www.w3.org/2000/svg'>" &
55 -- background track
56 "<rect x='" & _barX & "' y='" & _barY & "' width='" & _barW & "' height='" & _barH & "' fill='#e0e0e0'/>" &
57
58 -- filled bar
59 "<rect x='" & _barX & "' y='" & FillY & "' width='" & _barW & "' height='" & FillHeight & "' fill='" & BarColor & "'/>" &
60
61 -- percentage text inside
62 "<text x='" & (_svgW/2) & "' y='" & TextY & "' font-size='" & _textSize &
63 "' text-anchor='middle' fill='" & TextColor &
64 "' font-family='Segoe UI' font-weight='bold'>" &
65 FORMAT ( _p, "0%" ) &
66 "</text>" &
67
68 "</svg>"

```

Figure 4.8. Power BI DAX code.

Generally, the code above contains the details about the source data, figure dimensions, colouring rules, filling and formatting details, etc. All 32 measures created have been

visualised on the main page, taking into account the assembling sequence and parallel assembling of some stations. In fact, 32 assembling stations can be represented in 18 stages.

The Assembly Status Dashboard which is illustrated in Figure 4.9 provides a visual representation of the entire 18-stage vehicle manufacturing process, displaying the percentage completion of each step for each machine in real time taken from the Production Data Input Template. Every step of the process is represented by its technical drawing and a progress bar, with green for completed, amber for in progress, and red for blocked or critically delayed. A filter for the machine selector allows users to instantly switch between any machine under assembly. The percentage completion of each machine is displayed as a headline KPI, along with the current active step of the process, thus providing management with an instant answer to the question, "Where is this machine right now?" without having to dig into data or ask someone for updates.

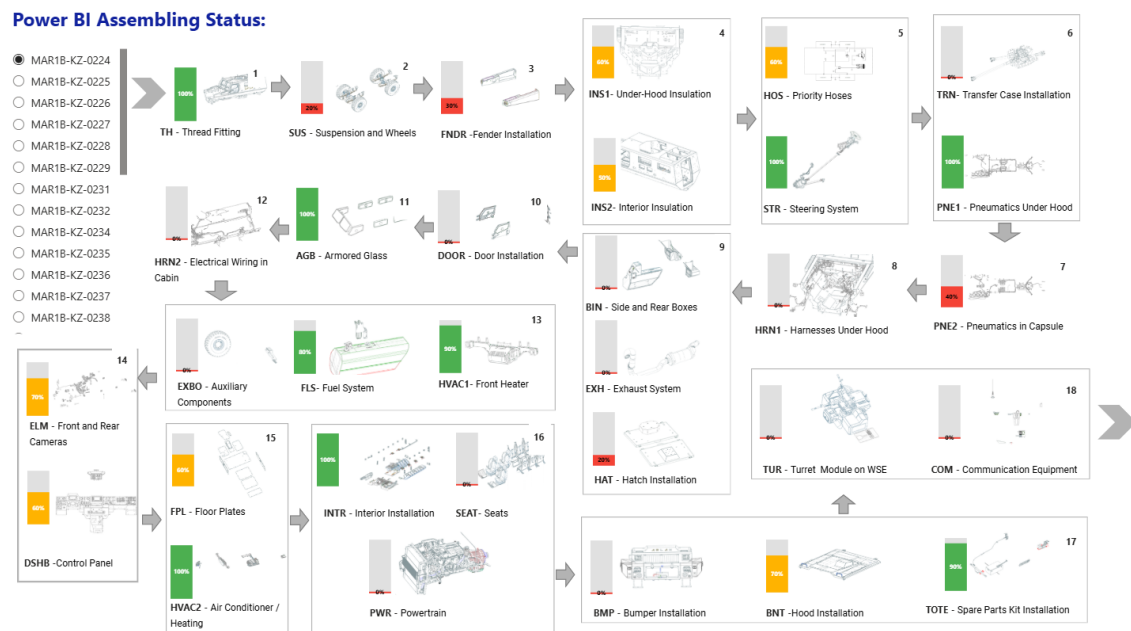


Figure 4.9. Assembly Status Dashboard.

4.5 KPE Production Dashboard

KPE Production Dashboard provides a live overview of the entire production. Each rectangular slot (Figure 4.10) of the dashboard displays the vehicle number currently assigned to it, its overall assembly progress, the location, critical assembling stages with more than 7 days delays, and status indicating icons: green for “completed”, amber for “in progress” status, and nothing for “not started” status for the Final Painting, Road Test, Shot Blast Testing activities, allowing management to assess the health of the entire production in several minutes.

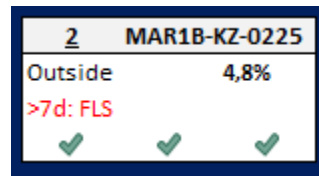


Figure 4.10. The Details of the Production Unit.

The dashboard (Figure 4.11) also shows the pie-chart diagram of units' location supporting production planning decisions around capacity and sequencing. There are also diagrams with Ahead&Delayed Stations Count information, and horizontal bar chart visualization with Final Painting, Road Test, Shot Blast Testing status data.

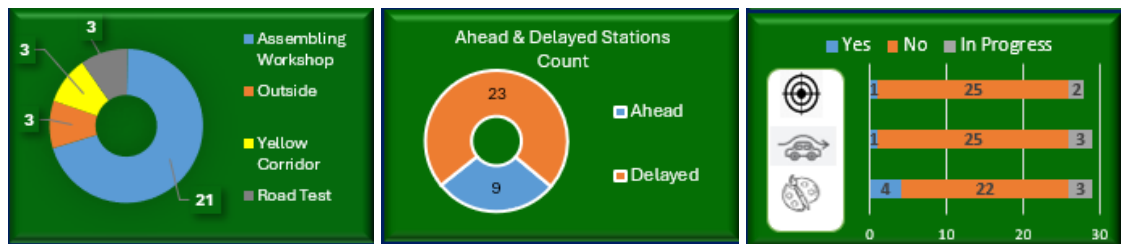


Figure 4.11. Production KPIs from the Dashboard.

Moreover, the created interface (Figure 4.12) allows to filter the represented production units by Project Title and by Location, thus non-selected options will be hidden.

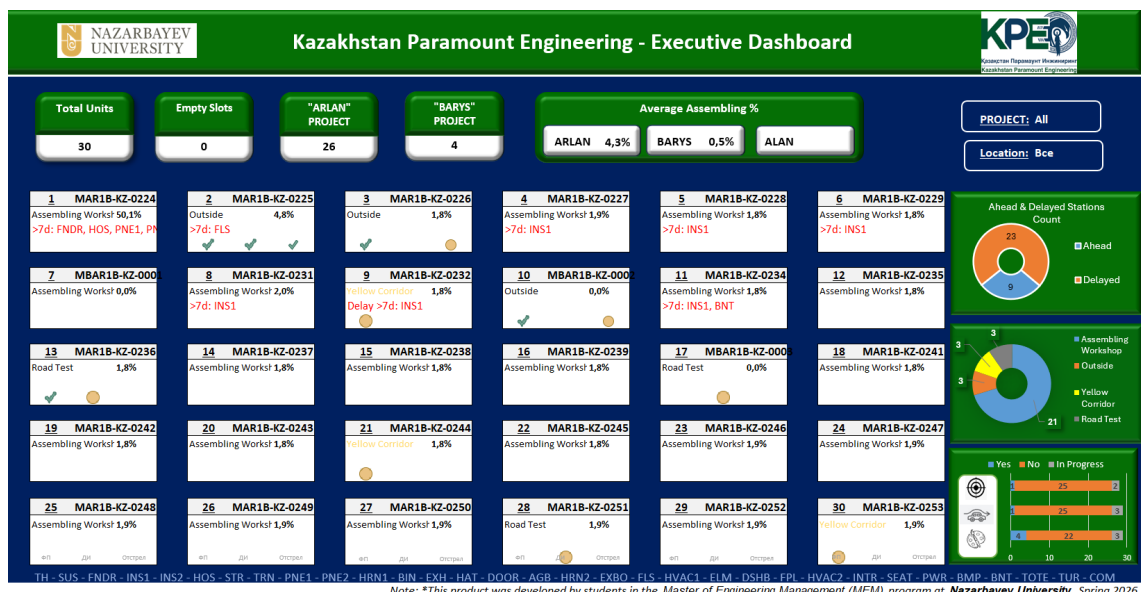


Figure 4.12. KPE Production Dashboard.

The dashboard is built using the MS Excel and the dashboard is linked to the Production Data Input Table, Intermediate input data Table. The Production Dashboard is dynamically updated as assembly progress is updated, ensuring that the user is always presented with a view of the current state of production.

4.6 Historical Data tracking template

It was identified that the company has limited Excel usage experience and for tracking any repetitive data, they have saved it in different files, changing the name of the file with the appropriate date.

A historical data tracking template shown in Figure 4.13 with incorporated Macros function was suggested to the company with a short instruction for usage.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Дата: 03.02.2026		Инструкция:			1. Обновите дату в ячейке B2									
2						2. Обновите данные в строке #5, выделенные желтым цветом									
3						3. Нажмите комбинацию "CTRL+A" - данные сохранились на строке #8									
4						4. Если ошибочно сохранили данные несколько раз, то можно в обычном режиме выделять и удалять строки, начиная от строки #8.									
5	Дата	SSA1 Предсборка двигателя	8В Установка двигателя	6А Сборка топливной системы	6В Установка полов	6С Установка сидений	9В Установка локтов	9С Установка вооружения							
6	03.02.2026	100,0%	0,0%	90,0%	30,0%	40,0%	20,0%	0,0%							
7															
8	03.02.2026	100,0%	0,0%	90,0%	30,0%	40,0%	20,0%	0,0%							
9	02.02.2026	40,0%	0,0%	70,0%	20,0%	20,0%	20,0%	0,0%							
10	01.02.2026	30,0%	0,0%	40,0%	10,0%	5,0%	20,0%	0,0%							
11															
12															

Figure 4.13. The Historical Data Tracking Template.

By changing the date and one highlighted row, and using the Macro shortcut CTRL + A, a new row is added above row 8, and the values from the highlighted cells are copied. This application is directly applicable to KPE's current practice of saving separate files for each dated instance by consolidating all historical entries into a single, easily maintained and updated file. This application is immediately applicable for tracking daily assembly progress and daily constraints in an Issues Log and is a lightweight solution that does not require additional software investment.

4.7 User Acceptance Testing

The User Acceptance Testing was done on department managers from R& D, Progress Planning, and Production Engineering once the dashboard was delivered. The testing involved five respondents, namely: Senior Production Planning Engineer, Head of Production Planning Department, Chief Technologist, Director of R&D Department, and Production Engineer-Technologist. Each respondent had to rate four statements on a five-point Likert scale (1 – Strongly Disagree; 5 – Strongly Agree as shown in the Table 4.1.

Table 4.1. User Acceptance Testing Results.

Statement / Likert Scale (1–5)	A1	A2	A3	A4	A5	Average
The tools provide clear insights that help me quickly identify issues and trends.	4	5	5	5	5	4.8
The tools are easy to use and allow me to quickly find the information I need.	4	5	5	5	4	4.6
The tools improve efficiency by reducing manual work and increasing visibility.	4	5	5	5	5	4.8
I am satisfied with the system and would use it in my daily work.	4	5	5	5	5	4.8
Overall Average Score						4.75

The Table 4.2 illustrates how dashboards influenced the time spend on internal processes before and after implementation. As a result, there is a significant decline (95%) on time to determine material availability and time to identify delayed assembly stages. Also, time to prepare production status reports significantly improved too which can positively affect the work processes.

Table 4.2. Operational Performance Before and After Implementation of Visual Dashboards.

Quantitative KPIs	Before Implementation (avg., min)	After Implementation (avg., min)	Improvement
Time to determine material availability	260	13	95%
Time to identify delayed assembly stages	252	13	95%
Time to prepare production status reports	348	13	96%

The implementation of visual dashboards resulted in a drastic reduction in lead times across all three categories as represented in the Figure 4.14. So, these improvements can be considered as beneficial for core administrative functions.

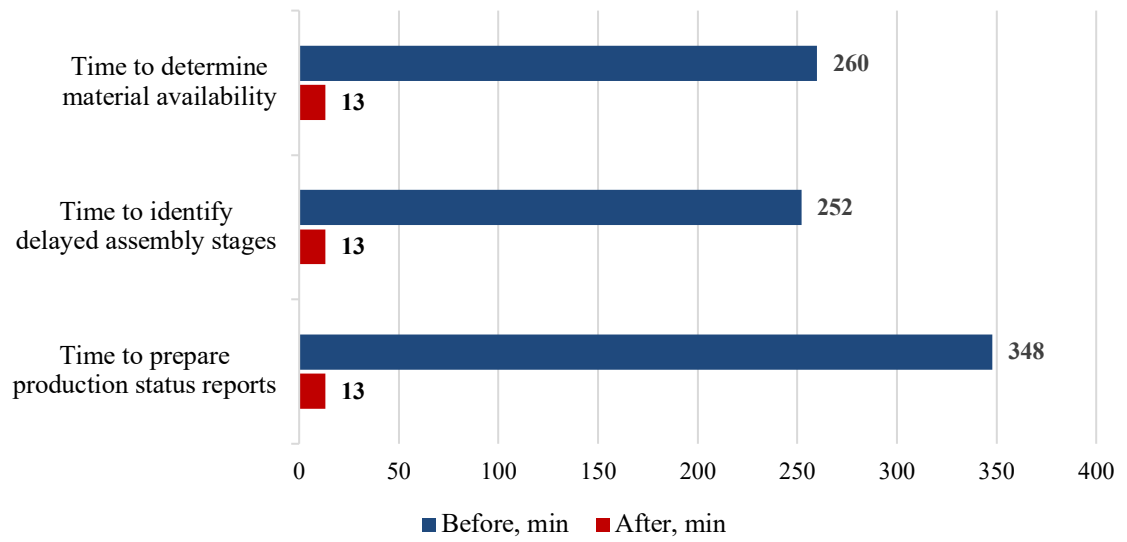


Figure 4.14. Implementation Effect of the Developed Tools for KPE.

5 Discussion

Some of the primary findings from the analysis carried out in this Capstone are that the implementation of the Visual BI solution, along with the use of the Excel toolset, could contribute to improving the production monitoring and inventory management procedures at KPE. The following section discusses these findings within the context of their relevance to the research questions and prior literature.

Firstly, one of the key results is that the information regarding the status of the operations became more visible. As can be seen from Figure 4.9 (Assembly Status Dashboard created in Power BI), it becomes possible to gain access to the current state of machines and potential delays, thus acquiring real-time visibility of the situation. These findings are supported by Ivanov (2022), who states that visibility enables faster reaction to any changes. There is no need for manual updating and interdepartmental communications because the management has all the information collected in one place and updated automatically (Ivanov, 2024).

Secondly, another critical finding from this analysis concerns the development of the BOM Screening & Validation Tool (Figure 4.4). It is used to overcome the problem of managing large BOM that consist of about 10,000 lines and require a lot of manual work. The described application helps to identify shortages and components' defects, which is essential for the further manufacturing process. By using logical formulas and rules, it is possible to detect deficiencies of components at various stations and avoid duplicate reporting.

Even slight changes in the data will lead to significant operational difficulties because of the IRI results as well as earlier findings (Destro et al., 2023; Linuwih & Handayati, 2025). The current instance is an example of how the availability of duplicates at multiple stations causes operational chaos by distorting supply chain operations. Implementation of validation logic and structured data processing helps solve the problem and ensures the accuracy of inventory data.

In addition, inclusion of the status tracker for Nonconformance report contributes to the accurate assessment of inventory readiness. Materials cannot be used in production if there is an open nonconformity report related to it, so such items should not be considered as available for assembling and should be treated individually to resolve the reported problem. Differentiation between closed and open nonconformity reports decreases the

gap between logical and physical inventory, which is one of the main issues addressed in IRI research.

Furthermore, use of colors (green, red, yellow), bars (filled, partially filled, not filled), and KPIs in the Gantt chart (Figure 4.6) and Production dashboard (Figure 4.12) allows identifying problem zones instantly by visually estimating indicators without performing calculations. This assumption is confirmed by Bagus et al. (2026), whose study suggests that visual dashboards contribute to the better perception of information and faster decisions. Complex data was transformed into actionable insights, which was achieved due to appropriate information presentation by the project (Bagus et al., 2026).

Fragmentation of data is handled by introducing a standardized data input system on a daily basis, noting the date of commencement, the date of completion, percentage of completion, QA documents, and responsible people. By using the Production Data Input Template (Figure 4.5), the underlying cause of Information Routing Issue, as highlighted in the literature as daily mistakes due to the entry into individual files within departments (Destro et al., 2023), can be addressed. The Production Gantt chart (Figure 4.6), automatically generated using an Input Template, allows for a visual comparison of expected and actual dates. Delays greater than seven days are classified without considering weekends, ensuring an accurate representation of any deviations from production deadlines, something that cannot be achieved manually. This method supports Ivanov's (2024) view that for any action to be effective, information must be accessible and accurate.

Moreover, the tools helped move toward a proactive rather than a reactive approach to planning. Previous decisions before the use of these toolkits were reactive in nature, since there was no way to detect any issues before they arose and disrupted the process. On the other hand, through the BOM Screening Tool and real-time dashboards, any problems could be detected earlier on, allowing for prevention measures. The statement corresponds to the results presented by Dou et al. (2025), showing that visibility could eliminate uncertainties and enhance supply chain coordination (Dou et al., 2025).

Furthermore, the KPE Production Dashboard (external, internal, yellow zone) is helpful in terms of making decisions since it offers information about production plans and production capacity without any manual effort needed. This helps managers analyze production schedules and detect any production bottlenecks right on the start. It is important for increasing inter-departmental coordination, especially co-engineering.

The other key benefit of the toolset is the decrease in operational fragmentation. In the previous process, all the data were located in numerous Excel files with varying structures and were manually updated on a daily basis, which required much effort and made it challenging to maintain the unified database. Also, this state increased the risk of making mistakes within the relevant departments. As a part of the BI proposal, it was suggested to integrate all the data within one system in order to decrease duplication and increase the consistency across all departments. This conclusion is corroborated by the findings of Aguiar and Alcalá (2024), who stress the importance of integrating ERP systems and operational data (Aguiar & Alcalá, 2024). Creating templates to track the historical data can be regarded as quite useful since it will help the managers assess the current digital maturity level of an organization and collect the data more efficiently. Gradually, the framework will generate trend analyses and predictions, thus enhancing decision-making processes.

Several limitations were found during the course of the project. First, data quality and standardization were challenging due to manual data input. Specifically, there were inconsistencies concerning naming and formatting the BOM data.

Another limitation associated with the issue concerns users' readiness and the overall completion of the scope of work in the case at hand. In terms of user readiness, the usage of simplified tools (such as an Excel tracking template) signals the readiness of the company for digital transformation. Therefore, the use of BI dashboards implies effective user training and the incorporation of the tool in regular operations.

The conclusions and results of the analysis fully correspond to the problem statements and research objectives set at the beginning of the paper. Specifically, the issues of accuracy and reliability of inventory data were resolved as a result of addressing the inconsistencies in data via implementing structured data models and validation logic in the BOM Screening Tool. At the same time, dashboards were introduced to provide real-time visibility into manufacturing process progress, materials availability, and operation status.

As a result, by merging the data contained in several spreadsheets into one BI solution, we managed to create one source of information according to the goals of the study. With the help of visual dashboards, cross-functionality may also increase because of the ability of different departments to access the consistent data in real-time. Finally, proactive

procurement planning allows for anticipating delays and shortages, thus minimizing decisions on a reactive basis.

UAT confirmed it too, the time taken to determine material availability for each assembly phase was cut down from 260 minutes to 13 minutes (95% improvement), thus proving the practical effectiveness of the BOM Screening & Validation Tool.

In addition, UAT represented that the time spent on identification of delayed assembling phases decreased from 252 minutes to 13 minutes, meaning that using the Gantt Chart makes it possible to detect deviations in assembling process instantly compared to previous manual procedures.

This conclusion is backed up by the following quantitative data provided by UAT participants: the time needed to compile production status reports for meetings with managers was cut down from 348 minutes to 13 minutes (96% improvement).

In general, the results confirm that the problems of decision-making at KPE can be solved using dashboards.

6 Conclusion

This research looks into operational challenges faced by KPE, emphasizing the areas of data discrepancies, lack of transparency, and reactive decisions in procurement and inventory management. The research findings suggest that using the Excel-based visual business intelligence system and its tool kit greatly improve transparency and decision-making processes.

Moreover, the findings show that there is a decrease in the difference between reported and IRI after integrating dashboards and structured data modeling. Through introducing verification and standard calculations, the BOM Screening & Validation Tool improved the accuracy and reliability of inventory status, thereby supporting the process of having one trustworthy information source - an ambition that could not be achieved before due to Excel-based applications.

The Assembly Status Dashboard and KPE Production Dashboard provide excellent visibility in the manufacturing process. In this case, the managers will be able to coordinate the progress of manufacturing and the present condition of every machine without the need for personal interaction or written documents. It shows how dashboards help to convert information about operations into useful knowledge through visual presentations.

Moreover, the Production Data Input Template and the Production Gantt Chart improve evidence. The Production Data Input Template ensures that there will always be daily records for every station and unit contained in one file, thereby solving the problem of fragmenting data that caused inventory errors. The Gantt Chart helps to compare schedules based on this data and to show delays that exceed seven days and determines whether stations are on track, early, or late.

Finally, the shift from reactive to proactive planning is another key finding. Using the BOM Screening tool, purchasing teams can act in advance, before production disruptions occur because of parts shortages. This approach eliminates unexpected delays and promotes cross-departmental collaboration, allowing the organization to better cope with its complex and expensive production operations. All five UAT participants agreed that coordination between work teams would improve greatly, having provided the tool satisfaction rating of 4.75 out of 5.

In conclusion, Capstone project results have demonstrated that even those organizations with lower levels of digitalization, such as KPE, can implement effective practices by using both traditional software applications, like Excel, and more sophisticated ones, such as Power BI. Creating a historical tracking template provides a starting point for future analysis and continuous improvement. In essence, all of the above insights show that achieving greater data accuracy, gaining more visibility, fostering cross-departmental coordination, and enhancing proactive decision-making through the use of a BI solution are consistent with the objectives of this study.

7 Recommendations

Based on the research findings, the following recommendations were formulated to improve procurement and inventory management at KPE:

1. Gradual Transition to a Fully Integrated Data Solution

Although the existing system integrates multiple data sources from Excel, it's better to gradually transition to a centralized database or ERP system. This change will improve data consistency and reduce manual work, helping to ensure a single, reliable source of information.

2. Standardization of Data Entry and BOM Structure

To ensure system accuracy and establish clear naming conventions, station codes, and the structure of material specifications, this will reduce the need for data cleanup and help avoid future errors.

3. User Training and Adoption

The success of a BI solution will only be ensured if users implement it effectively. Conduct training sessions for each department to ensure everyone understands how to use dashboards and interpret data correctly.

4. Expansion of Predictive Analytics and Forecasting

Currently, the system primarily supports transparency and monitoring. In the future, the addition of forecasting tools, such as demand forecasting and lead analysis, will facilitate more proactive decision-making.

5. Integration with Procurement and Supply Chain Systems

To maximize the solution's effectiveness, connect business intelligence dashboards to procurement systems, supplier data, and logistics information. This will provide a complete view of the entire supply chain.

6. Continuous Oversight and Improvement

Regularly update and improve dashboards based on user feedback and changing business needs. This includes updating KPIs as needed, adding new visualizations, and improving system performance.

7. Scaling the Solution Across Other Projects

Since the current configuration is based on the Arlan machine design, it would be beneficial to expand the solution to other product lines, such as Barys and Nomad. This would help achieve a greater impact across the organization.

In conclusion, this study demonstrates that using a Visual BI solution can significantly improve efficiency in complex manufacturing environments. By transforming disparate data into a single, clear, and visual system, KPE can transition to a more data-driven, open, and forward-looking management approach, which is key to maintaining competitiveness in the defense and aerospace industries.

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Appendix A: Problem Identification Meeting Log

APPENDIX A: Preliminary Site Visit and Problem Identification Meeting

Conducted: September 24, 2025 | KPE Production Facility, Astana, Kazakhstan

Participants: Head of R&D Department, Progress Planning Specialist, Production Engineer-Technologist, Procurement Coordinator, Head of Production Planning

Format: Group meeting. Individual discussions, approximately 25-30 minutes each

Language: Russian

During this visit, we have discussed overall three main topics, which are current data management practices, Bill of Materials management, and visibility of data. For the first section, we have learnt about how they track production progress daily, share and update data. As a result, understood that they encounter discrepancies between written records and actual inventory position. And, that it takes a lot of time to find out where inventory inaccuracy occurred, since mostly it comes out only when there is a consequence. The second section was about the verification of components presence at every production stage, focusing on BOM review and missing components. This issue also presents in their data storing. The last section was about visibility and decision-making, especially monitoring of the overall status of production across all vehicles. The problem was that they cannot quickly obtain accurate picture of where each machine's assembly process is in. At the end, each participant described his own vision with ideal reporting look for their role.



Figure A1. Preliminary Site-Visit (September 24, 2025).

Appendix B: User Acceptance Test Questions

APPENDIX B: User Acceptance Test Questionnaire. *Conducted: April 29, 2026 | KPE Production Facility, Astana, Kazakhstan | Participants: Head of R&D Department, Progress Planning Specialist, Production Engineer-Technologist, Procurement Coordinator, Head of Production Planning | Language: Russian*

BEFORE implementation:

1. How long does it take to determine the availability of materials for a given assembly stage? Estimate based on the number of people involved and their time spent.
 - a. ____ people for ____ minutes on average
 - b. ____ minutes in total
2. How often do production delays occur due to late identification of material shortages?
 - a. Rarely
 - b. Sometimes
 - c. Often
 - d. Very often
3. How quickly can you identify the assembly stages of machines that are behind schedule? And how many resources will this require?
 - a. ____ people for ____ minutes on average
 - b. ____ minutes in total
4. How much time does it take to prepare information to share the current production status with management at regular internal meetings?
 - a. ____ people for ____ minutes on average
 - b. ____ minutes in total

AFTER implementation (predicted impact):

1. How long will it take to determine material availability for a given assembly stage?
____ minutes
2. How quickly can you identify assembly stages of machines that are behind schedule? And how many resources will this require?
____ minutes
3. How much will production transparency improve?
 - a. Significantly improved
 - b. Moderately improved
 - c. Slightly improved

d. No change

4. Will coordination and collaboration between groups improve?

a. Yes, significantly

b. Yes, slightly

c. No

5. Can you recall a situation where this tool would have helped prevent a production delay/backlog in the last two months?

User Acceptance Test

Please, rate your experience with the developed tools (1 - Strongly Disagree; 2 - Disagree; 3 - Neutral; 4 - Agree; 5 - Strongly Agree)

- The tools provide clear insights that help me quickly identify issues and trends.
- The tools are easy to use and allows me to quickly find the information I need.
- The tools improve efficiency by reducing manual work and increasing visibility.
- I am satisfied with the system and would use it in my daily work.

Any comments

Demographic Information

1. What is your current role, and what department do you work in?

2. How much time do you work at "Kazakhstan Paramount Engineering"? (*)

Appendix C: Implementation Certificate

APPENDIX C: Implementation Certificate. Signed: April 23, 2026 | KPE Production Facility, Astana, Kazakhstan | by: Technical Director of KPE Almukhanov M.A. | Languages: Kazakh, English and Russian.

010000 Қазақстан Республикасы,
Астана қаласы, Бұйрат 20
БСН 140640000059
тел: +7 /7172/ 729-111
info@kpe.com.kz. www.kpe.com.kz



Buirat 20, Astana,
Republic of Kazakhstan, 010000
BIN 140640000059
tel: +7 /7172/ 729-111
info@kpe.com.kz. www.kpe.com.kz

№ 401-0
«23» 04 20 26

IMPLEMENTATION CERTIFICATE

This certificate is issued to Nazarbayev University students Azel Tashimova, Moldir Sailaukhanova, and Bibarys Tileubayev, confirming that the results of their master's thesis, under the supervision of Professor Yerkin Abdildin, on the topic: *"A study of production processes and inventory management optimization at Kazakhstan Paramount Engineering using visual business intelligence"* have been accepted for implementation and use in the production process of Kazakhstan Paramount Engineering LLP.

In particular, the company has implemented the following:

1. BOM (billing of materials) Screening and Validation Tool
2. Interactive Assembly Status Dashboard in Power BI
3. Production Data Input Template in MS Excel
4. Production Gantt chart (Plan and Actual data)
5. Main Production Visualization Dashboard

The use of these tools has increased the transparency of equipment assembly stages and reduced the time required to process production information. The developments of Azel Tashimova, Moldir Sailaukhanova, and Bibarys Tileubayev demonstrate high practical significance for our company.

Technical Director of
Kazakhstan Paramount Engineering LLP

Almukhanov M.A.



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Notes

This is an endnote example appearing at the end of the book.
