SMART WAREHOUSE SYSTEM SHIPMENT PLANNING OPTIMIZATION
ORS RULMAN TÜRKİYE

Project Team
Ayşe Naz Güvez
Ece Sude Kılıç
Irmak Pehlivan
Selin Güngör

Company Advisor
Alptekin Demiray

Academic Advisor
Assist. Prof. Dr. Kamyar Kargar

PROJECT SUMMARY

Ortadoğu Rulman Sanayi (ORS), established in 1982 at the crossroads of three continents, is a bearing manufacturer known for its outstanding quality, advanced production and information systems, top-level design expertise, experienced workforce, and customer-focused strategy.

Within the scope of the project, both the smart warehouse layout and the shipment system of the company were examined. Based on observations and interviews, it was determined that the company faces several issues that directly affect the efficiency of the smart warehouse shipment process. The primary issue identified is that the weekly shipment planning of the smart warehouse system cannot keep up with the required pace.

Upon analyzing the current system, it was observed that decisions regarding all weekly orders are made by warehouse employees. After being informed of the number of products and delivery deadlines, employees rely entirely on their personal experience and unwritten plans, making spontaneous decisions on how to proceed. The current structure is fully experienced-based, with no modeling or mathematical software used in scheduling. Consequently, weekly orders often fail to be fulfilled on time.

Although the current system and the problems it creates are apparent, ORS has not yet implemented a solution. Therefore, this project aimed to eliminate the experience-based nature of the current workflow and to optimize the shipment planning of the smart warehouse system.

Following extensive observations, interviews, and brainstorming sessions, the objective was to develop a model that would produce a weekly shipment planning schedule to meet the company's weekly orders in the most optimal way. The developed model separates the processing times of workers and robots, considers both basic demand constraints and robot capacity constraints, ensures that no delivery deadlines are missed, and guarantees the completion of all jobs. The objective function minimizes the total maximum processing time for all jobs, resulting in an optimal schedule.

Once validated via the GAMS software, the model was tested against various scenarios and feasibility limits to ensure the accuracy of the optimization approach. The GAMS code was then translated into Python to allow integration with a user interface. Through these software tools, the scheduling system was transformed from a manual, experience-based process into an automatic and faster system.

Another key objective of the "Smart Warehouse System Shipment Planning Optimization" project was to conclude with the most beneficial outcome by incorporating decision support tools. Two decision support tools were used:

1. A user interface designed to support the model and make the solution more practical and visible for the company.
2. The Analytic Hierarchy Process (AHP), a well-known method selected to assist the company in making subjective decisions during urgent order prioritizations.

Both decision support tools were successfully integrated into the project. The interface allows the company to enter all necessary weekly job data and, upon execution, produces a weekly schedule showing which robot should handle which task and in what order, displayed in an Excel file. The AHP method, on the other hand, was used to prioritize customers based on criteria affecting delivery priority when subjective decision-making was required.

The project was successfully completed by transferring the developed deterministic model into software tools and supporting it with decision support mechanisms.

As a result, in the project titled "Smart Warehouse System Shipment Planning Optimization" conducted with ORS, the company's existing experience-based shipment planning system was transformed into an automatic, faster, and optimal planning system. This new system uses time and resources more efficiently, minimizes robot idle times, and predicts daily workload and overtime needs with the support of a user interface. It was observed during the project that the main cause of the weekly shipment delays is the operational style of the current system. Therefore, implementing the proposed model—enabled by acquiring only a Gurobi license—is strongly recommended to help ORS generate timely shipment schedules and achieve optimal planning.

Keywords: Smart warehouse system shipment schedule, Decision support tools, Analytic Hierarchy Process.

DISCONNECTOR LINE BALANCING AND LAYOUT OPTIMIZATION
EMEK ELEKTRİK

Project Team
Alper Özer
Doğuhan Özdemir
Hüseyin Batuhan Arı
Begüm Pektaş

Corporate Advisor
Nurkan Aktaş

Academic Advisor
Assist. Prof. Dr. Kamyar Kargar

PROJECT SUMMARY

Emek Elektrik Endüstrisi A.Ş. is an independent, internationally operating manufacturer of measuring transformers. Its reliable and high-quality products have been repeatedly tested in both local and international laboratories. With over half a century of experience, strengthened by transformers operating in the field, the company has continuously developed and renewed itself over time.

With 250 employees, Emek Elektrik operates in Ankara on a facility with 27,000 m² of open area and 11,000 m² of covered space, producing medium and high-tech products. As of 2019, the company exports to 118 countries and continues to expand its global presence by actively following emerging markets, increasing both its country and customer reach as well as its growth day by day.

Emek Elektrik's main activities include the production, testing, marketing, and sales of transformers, capacitors, disconnectors, and electromechanical equipment, as well as conducting research and development to create new production areas.

It has been observed that Emek Elektrik does not currently have a systematically functioning production line suitable for line balancing. Production is order-based, and no prior measurements have been conducted on the production line. The number of operators in production is not fixed; additional workers are temporarily assigned from other departments depending on workload, and the overall efficiency and capacity of production have not been clearly defined.

Before visiting the Akyurt facility, several assumptions were made, including whether operator-job compatibility would affect performance. However, the company stated that they preferred all operators to be versatile rather than specialized in specific tasks. To better understand the line balancing problem, a U-shaped layout design was initially considered. A simulation model was developed using Arena software based on assumed parameters after initial investigations.

After forming these assumptions, collaboration with the company was initiated to optimize the system and ensure balanced operation. Since the company had not conducted any prior studies in the department under analysis, the project began with on-site measurements in the disconnector production line. Time studies were conducted on a product selected by the company to determine how long each operation took per operator. Based on dependent and independent variables, necessary station assignments were made.

Following a literature review, the most appropriate mathematical model was selected for the problem, and all constraints were integrated into the model. The collected statistical data was then implemented in the GAMS software to determine the production capacity of the disconnector department.

Results showed that production capacity was limited, and bottlenecks in the process could not be avoided. By simulating changes in the number of operators within the model, the optimal point was identified.

By utilizing the model results, Emek Elektrik can achieve time and cost savings. The company will be able to determine the required number of operators and allocate production resources more effectively. In addition, costs can be reduced through informed decision-making. The developed model is expected to reduce cycle time by approximately 25%.

Considering the company's vision and mission, line balancing work was conducted at Emek Elektrik. Problems such as irregular production processes, unclear capacity levels, and role changes among operators based on workload were addressed. As a result, the disconnector production line was balanced, and the findings were shared with the company.

Keywords: Line balancing, bottleneck, U-shaped line design

WAREHOUSE LAYOUT OPTIMIZATION
FNSS

Project Team

Doğa Can Akyol
Bensu Gökmen
Damla Ardıç
Selin Salcı

Corporate Advisor

Selin Deniz

Academic Advisor

Assist. Prof. Dr. Vedat Bayram

PROJECT SUMMARY

The system design for FNSS involves maintaining a continuous flow of materials and the products in which those materials are used. Within this flow, the company manages both the procurement process for necessary parts and the procedures that follow procurement. The supplied parts are intuitively stored in the warehouse based on certain groupings (such as project group or station group). However, improper placement of parts that belong to the same groups leads to inefficiencies, such as increased time and labor during order picking, ultimately affecting the overall efficiency of the system.

At this point, it becomes crucial to assign parts that need to be picked together to appropriate warehouse zones and to do so in alignment with their contents and groupings. One of the existing or potential issues faced by the company is the prolonged duration of the part-picking process in response to product demands, which in turn disrupts the internal workflow of the system.

The objective of this project is to strategically place newly received products in the warehouse so that they can be picked in the shortest possible time. The warehouse location assignment problem determines which storage areas will be used and which products will be placed in which locations, aiming to reduce order picking times. The goals include minimizing the number of storage zones used, reducing the distance between products that belong to the same project group, and minimizing the distance between products assigned to the same station groups.

To address this, a nonlinear mixed-integer optimization model was developed. The performance criteria defined for the study were order picking time and the total distance traveled by workers while picking products in the warehouse. The problem was solved using GAMS software and its interface, along with the CPLEX solver.

The solution includes the assignment of products to storage locations, the quantity of products assigned to each location, and identification of which storage areas are utilized. As a result of the study, a new warehouse layout was obtained. The developed model successfully reduced the distances between frequently picked parts belonging to the same project and station groups, and also reduced the time operators spent in the warehouse. Based on the results, it is estimated that the proposed solution could yield an improvement of approximately 83.18% in the system's performance.

Keywords: Storage location assignment, warehouse layout optimization, nonlinear mixed-integer programming

WAREHOUSE LAYOUT PLAN OPTIMIZATION
TIRPORT

Project Team
Kaan Altan
Mert Başbarut
Murat Deniz

Corporate Advisors
Şeyda Nur Boztepe
İsa Çağlar

Academic Advisor
Assist. Prof. Dr. Ali İrfan Mahmutoğulları

PROJECT SUMMARY

TIRPORT is a digital logistics platform that, through its location-based technologies and personalized business models, enables drivers to access suitable loads within seconds. It connects transport companies, shippers (factories and firms), and transport cooperatives, while providing an effective system for managing and monitoring logistics operations. Its primary goal is to connect shippers with TIRPORT-approved reliable drivers and to build a community (TIRPORT Community) where drivers can live and work under better conditions.

In this project, TIRPORT's know-how in the logistics sector was utilized to conduct a study on warehouse layout plan optimization. The aim of the project is to determine how products can be placed in the warehouse by traveling the shortest distance. At the same time, the project seeks to increase efficiency during the in-warehouse transportation process, minimize energy consumption, and save time.

For the warehouse layout plan, we developed an optimization model based on the Traveling Salesman Problem (TSP) formulation. This model was implemented in Python and designed to be used both with the TSP formulation and the Nearest Neighbor Heuristic independently. Using this model, we aimed to place ordered products in the warehouse in a way that minimizes travel distance. Products that appear in different order lists are placed together to be transported jointly, and the most optimal route is calculated accordingly. Additionally, products are placed closer to the warehouse entrance based on their demand frequency. This allows the most efficient routing and assignment to be carried out for each incoming order.

Based on the case analyses performed with the developed model, it was concluded that optimal assignment and routing results can be obtained. The Python implementation allows for changes in warehouse size as well as the addition of new orders, providing a flexible solution that can be adapted to various types of warehouses.

Keywords: Warehouse Layout Plan, Traveling Salesman Problem, Nearest Neighbor Heuristic, Routing and Assignment

INVENTORY AND DEVIATION IMPLEMENTATION OPTIMIZATION

MAN TÜRKİYE

Project Team

Öykü Saraçoğlu

Hazal Düger

Elif Melek Mutlum

Bora Gökbayır

Corporate Advisor

Ergün Yıldırım

Academic Advisor

Assist. Prof. Dr. Vedat Bayram

PROJECT SUMMARY

MAN Türkiye A.Ş. is the Turkish branch of the German-based heavy commercial vehicle manufacturer MAN Truck & BUS AG. The company was established in 1966 as a joint venture between MAN and Ercanlar A.Ş. under the name MAN Kamyon ve Otobüs Sanayi A.Ş. Its headquarters and production facility are located in Akyurt, Ankara.

In MAN Türkiye A.Ş., a *deviation* is defined as a change occurring in a part used during production. It was observed that in the deviation management system, deviations are recorded by the Technical Approval Department, while the implementation timing of these deviations is manually determined by relevant employees. This process frequently involves deviations for different types of parts, and in some cases, it leads to high amounts of scrap and cost.

Since the decision on when to implement deviations is made manually, the company requires an industrialized system to determine the optimal implementation time that minimizes scrap. Although purchasing decisions and quantities are made by considering potential deviations, the high number of parameters increases the likelihood of excessive scrap. The company typically delays deviation implementations to consume existing inventory and empirically reduce scrap amounts. However, since deviation implementation decisions alone aim only to reduce damage, they are insufficient to optimize system efficiency. Therefore, a decision support mechanism is needed that considers all related costs (procurement, holding, and scrap costs), deviation uncertainty, and jointly optimizes purchasing, inventory holding, and deviation application decisions.

This study develops a mathematical optimization model that forms the foundation of such a decision support system. The model incorporates a piecewise linear concave function to represent economies of scale in part purchasing costs. The objective is to minimize total cost, which includes purchasing, holding, and scrap costs. The model simultaneously determines the optimal purchase timing and quantity, inventory levels, and deviation implementation time. The problem was solved using GAMS software and its interface, with the CPLEX solver.

With the model's decisions, the technical personnel responsible for recording deviations can now anticipate potential outcomes and view associated scrap costs without manual calculation. The model also serves as a valuable support tool for less experienced engineers. Implementing deviations at the optimal time allows the company to maximize inventory consumption, minimize part-related costs, and keep ordering and storage costs at their lowest during the production process. Additionally, the developed decision mechanism helps reduce the workload of departments such as procurement, logistics, and technical approval involved in cost evaluation.

Keywords: Deviation system, Deviation implementation time optimization, Procurement and inventory optimization

FINANCIAL RATIO FORECASTING TOOL – KOVAN

HAVELSAN

Project Team

Ecesu Demirtaş
Elif Kalkan
Fatma Aybüke Babacan

Corporate Advisor

Efe Saltık

Academic Advisor

Assist. Prof. Dr. Ali İrfan Mahmutoğulları

PROJECT SUMMARY

HAVELSAN was founded in 1982 as a subsidiary of the Turkish Armed Forces Foundation. With its extensive experience, expert personnel, and high-tech, software-intensive original solutions and products, HAVELSAN is one of Turkey's largest software companies. It provides solutions in command and control and defense technologies, training and simulation technologies, information and communication technologies, internal security, and cybersecurity.

HAVELSAN is listed among the “Defense News Top 100,” which ranks the world's top 100 defense industry companies. The company has an annual turnover of around 300 million USD, with R&D investments amounting to approximately 450 million TRY. It operates five certified R&D centers and is ranked among the top five globally in simulation/simulator technologies and holds 153rd place in the ISO500 list.

To ensure secure, efficient, and traceable management of internal processes for public institutions, military entities, and private companies, HAVELSAN has initiated the development of KOVAN, Turkey’s first domestic and national ERP system. The main motivation for creating this system is the absence of a locally developed ERP platform, which has led to significant challenges, including:

- Security Risks: Almost all ERP software used in Turkey, especially SAP, is foreign-sourced. This can result in indirect data transfer abroad, posing serious national security risks, particularly for companies within the Turkish defense industry. Even if data confidentiality agreements are signed, international political tensions may compromise data privacy.

- High Costs: Foreign ERP systems like SAP are expensive due to licensing in foreign currency and incur additional in-app costs post-purchase.

- Complexity & Usability Issues: SAP systems are known for their complex structure, increasing the likelihood of user errors. They are difficult to learn, which results in time loss for users and financial loss for companies.

To address these issues and ensure a local and national ERP solution, HAVELSAN launched the KOVAN project. The Finance module, one of the first three components planned within KOVAN, includes the development of a Financial Ratio Forecasting Tool.

The primary goal of this tool is to accurately forecast the financial ratios for the upcoming period, minimizing prediction error. Financial data of various companies were extracted from the Public Disclosure Platform (KAP), and key ratios—Current Ratio, Short-Term Liabilities / Total Liabilities, and Inventory / Current Assets—were calculated quarterly, semi-annually, and annually from 2009 to 2020. The data for 12 companies were compiled into separate CSV files.

Forecasting models and programming languages to be used in the tool were then selected. The models implemented in Python included Simple Exponential Smoothing, Linear Regression, Moving Average, Holt-Winters, and Autoregression. To preserve the seasonal structure of the data and improve analysis accuracy, the datasets were extended using Python. Each company's financial data was processed through the algorithm, and the predicted values were recorded.

To evaluate model accuracy, Mean Squared Error (MSE) was calculated using both forecasted and actual values. For better visualization of deviations, 2D plots were also created in Python. The results of all analyses were presented in a single output for the user's convenience.

The resulting outputs of the Financial Ratio Forecasting Tool indicated that all models yielded predictions with very low error margins. However, it was observed that error levels varied across companies and sectors, likely due to differences in seasonality and trend characteristics. The tool enables users to view predictions from all five models, compare MSE values, and analyze the results graphically.

Data from 12 companies between 2009 and 2020 were used to test the application as part of this graduation project. Prior to public release, HAVELSAN may expand the dataset and conduct further testing for full deployment.

Keywords: Financial Ratio Forecasting Tool, Simple Exponential Smoothing, Linear Regression, Moving Average, Holt-Winters, Autoregression

LAST MILE WAREHOUSING
TIRPORT

Project Team
Bora Kaan Sarıözlü
Eda Demirci
İbrahim Bilal Zorlu
Ozan Kartal

Corporate Advisor
İsa Çağlar

Academic Advisor
Assist. Prof. Dr. Vedat Bayram

PROJECT SUMMARY

TIRPORT is a digital platform that connects shippers and carriers, providing instant access to suitable loads for truck drivers and enabling shippers to access thousands of verified truckers with real-time end-to-end shipment visibility. TIRPORT offers products and services in logistics, information technology, transportation, last-mile delivery, and SaaS (Software as a Service).

The main objective of this study is to ensure that products requested by customers are delivered accurately and rapidly to the final delivery point within 30 minutes through strategic facility placement (main warehouses and Last Mile Warehouses - LMW) within Istanbul, covering both the European and Asian sides. The term *Last Mile Warehouse* refers to urban depots strategically positioned on both sides of the city to facilitate fast delivery to customers. These warehouses operate with a relatively simple flow: logistical operations begin at high-capacity supplier hubs or main warehouses located outside the city center, which transfer relevant products to LMWs. Then, using various vehicles (motorbikes and vans), the ordered products are delivered to the end customer within 30 minutes.

What distinguishes the Last Mile Warehousing system from traditional warehousing is its value-added service approach. For project owners and users, this model addresses a critical gap in short-haul delivery operations that typically do not offer value-added processes. Therefore, the Last Mile Warehousing concept is poised to play a leading role in the near future within the logistics sector.

The mathematical model developed for the project is bi-level and guarantees delivery within 30 minutes. Key parameters in the model include the distances between main warehouses, LMWs, and customer locations, facility setup and fixed costs, warehouse capacities, planned shipments, and the time constraint. The objective function aims to minimize facility setup costs, transportation costs, and inventory holding costs. A penalty cost is also included in the objective function to account for failures in meeting the 30-minute delivery window.

Decision variables represent product flows from main warehouses to LMWs and from LMWs to customers, determine which facilities should be opened, and track inventory levels at each LMW. The model was implemented and solved using GAMS software and the CPLEX solver.

For the study, Istanbul was divided into the European and Asian sides. In the Asian region, 21 densely populated neighborhoods were considered, and 12 candidate LMW locations were identified. Results showed that in the European side, 22 of the 45 candidate depots were opened, but one region incurred a penalty cost due to late delivery. For the Asian side, 9 out of 12 candidate depots were opened, and all deliveries were successfully made within the target time.

Beyond the core 30-minute delivery scenario, alternative delivery windows were also explored. It was observed that extending the delivery time reduces costs and the number of depots required. Therefore, it was recommended that the system on the European side be configured based on a 60-minute delivery window to reduce high costs. Meanwhile, the Asian side can maintain a 30-minute delivery standard without logistical issues.

Keywords: Facility location, Logistics, Last mile delivery, Last mile warehousing

IMPROVEMENT OF MATERIAL FEEDING METHOD AND QUANTITY,
REDUCTION OF IN-PROCESS INVENTORY LEVELS
ERKUNT TRAKTÖR

Project Team

Dilan Bingöl
Destan Çırakoğlu
Buket Kömürcüoğlu
Begümsu Özer

Corporate Advisor

Özlem Sarıkaya

Academic Advisor

Assist. Prof. Dr. Ali İrfan Mahmutoğulları

PROJECT SUMMARY

Erkunt Traktör is one of Turkey's major players in the tractor manufacturing sector. Established in Ankara in 2003, the company continues its production activities in the same city. Erkunt Traktör was the first company in Turkey to produce a domestically designed tractor and is ranked among the top 500 industrial enterprises in the country. Through its subsidiary brand ArmaTrac, it has also become the first Turkish tractor company to export its products, with operations in 17 countries.

In the manufacturing sector, many factors can reduce production efficiency. One such factor is the storage and timely delivery of materials and parts to the correct location during production. Erkunt Traktör aimed to address this issue by improving material feeding methods and reducing in-process inventory levels.

The company sought the development of a model to minimize the time spent locating and delivering parts to production stations. Additionally, due to the bulky nature of items like wheels and engines, reducing the occupied space during production was another key objective. To ensure sustainability, the company also wanted a decision support tool for ongoing problem-solving.

Erkunt Traktör uses both make-to-order (MTO) and make-to-stock (MTS) strategies. Materials are transported using four main feeding methods: SPS, Kanban, Jundate, and Line-Side Feeding. Each transport vehicle varies in terms of capacity, compatible materials, and weight limits.

The project began with a literature review focused on warehouse and transport problems. In the first phase, a prototype optimization model was developed and solved using GAMS software. Following discussions with the company, the model was enhanced with real-life data and solved using Gurobi.

The proposed mathematical model determines which transport vehicle should deliver which material, and when, during the production process. The aim is to ensure materials are delivered as close as possible to the exact time they are needed. Solving this model requires an optimization solver; however, recognizing that such software may not always be accessible, a heuristic method was also developed. This heuristic, coded in Python, assigns orders to vehicles based on transport durations and desired delivery times and generates a schedule for each vehicle.

As a result of the project, the proposed mathematical model allows for the optimization of material feeding methods and the reduction of in-process inventory. Moreover, the developed heuristic provides an easy-to-use, software-free solution that the company can apply independently.

Keywords: Material feeding optimization, In-process inventory, Heuristic algorithm

ASSEMBLY LINE BALANCING
Emek Elektrik Endüstrisi A.Ş.

Project Team
Deniz Dağlar
Ezgi Kurşun
İpek Elçin Demirel
Aslıcan Çınar

Corporate Advisor
Nurkan Aktaş

Academic Advisor
Assist. Prof. Dr. Vedat Bayram

PROJECT SUMMARY

Founded in 1969, Emek Elektrik Endüstrisi A.Ş. is a company specialized in the electromechanical sector. Emek Elektrik manufactures instrument transformers, capacitors, and disconnectors to supply both local and global markets. As one of the largest producers in Europe within the electromechanical industry, its main products include current transformers, voltage transformers, epoxy products, high-voltage capacitors, disconnectors, and grounding switches.

One of the main problems identified at Emek Elektrik is the lack of a designated assembly line. Because operations are not performed in a specific sequence, at designated stations, or by assigned workers, the production speed is unpredictable, making it impossible to estimate how many products can be completed in a single day. To address this issue, it was determined that a mathematical model minimizing cycle time while also assigning the appropriate number of stations, workers, and tasks would be suitable.

In the initial phase, measurements of the current system were taken. For the most commonly produced product — ATH-170 — it was found that the assembly of a single transformer (excluding oven time) takes 105 minutes. The current number of workers in the assembly area is 18, and 37 distinct tasks were identified throughout the process.

A nonlinear mixed-integer mathematical formulation was developed to minimize cycle time. The model includes the following constraints:

- Each task must be assigned to exactly one station.
- Task assignments must respect task precedence.
- The number of workers at a station cannot exceed the total available workforce.
- The number of workers at a station must not exceed the usable area for that station.
- The area assigned to each station must be equal to or greater than the total area required by the assigned tasks.
- The completion time of tasks at any station must not exceed the cycle time.
- The total area used by all stations must not exceed the available assembly floor area.
- The area assigned to a single station must not exceed the station’s maximum allowable area.

The problem was modeled and solved using GAMS software and the CPLEX solver, resulting in a significant improvement — reducing the product completion time to 28.4 minutes.

To explore alternative solutions, sensitivity analysis was conducted. Two additional models were developed with different objective functions:

1. Minimizing the total number of workers,
2. Minimizing the total number of stations.

Additionally, further variations of model parameters were tested, resulting in seven alternative scenarios.

As a result, after evaluating all developed models and solutions, the most practical configuration was found to be the model that minimizes the number of stations with a cycle time of 1000 seconds, allowing the completion of one product in 66.67 minutes. By implementing this optimized model, Emek Elektrik Endüstrisi A.Ş. could nearly halve the current completion time per product, thereby achieving a significantly more efficient production line.

Keywords: Line balancing, Worker and task assignment, Cycle time minimization

PERSONNEL AND WAREHOUSE PLANNING
FNSS

Project Team
Eda Onay
Mehmet Genç
Yiğit Şan Yayalar
Çetin Elmadağ

Corporate Advisor
Melis Ürgen
Cem Küçükaslan

Academic Advisor
Assist. Prof. Dr. Kamyar Kargar Mohammadinezhad

PROJECT SUMMARY

FNSS is a globally recognized land defense systems company that designs and manufactures customized, efficient, reliable, and innovative tracked and wheeled armored vehicles. With a long-term approach to customer satisfaction, FNSS aims to provide support even beyond the lifecycle of its delivered products. It distinguishes itself through dependable partnerships that allow it to adapt to emerging needs. The company's Product Support Department provides training and after-sales services throughout the product lifecycle, continuously developing new applications, optimizing spare part supply chains, and strengthening customer support to enhance speed and efficiency.

To improve service delivery and ensure optimal stock management, the Product Support Department of FNSS plans to establish regional warehouses in locations where vehicles are deployed and to assign technical representatives responsible for each warehouse. The main goal of this project is to determine the optimal number and locations of these warehouses and the required personnel. The problem to be addressed includes creating an inventory management plan and ensuring high operational readiness levels for deployed vehicles by strategically positioning warehouses.

After FNSS vehicles are delivered under warranty or post-warranty maintenance contracts, they are distributed across various regions. Therefore, the project also aims to resolve warehouse location and stock planning through an integrated logistics approach.

Studies have been carried out to determine:

- the number and locations of warehouses,
- the appropriate shelf types for storage,
- the number of personnel to be assigned,
- the optimal stock levels for parts,
- and inter-warehouse stock transfer rules.

The main constraints in the study include transportation costs (based on inter-regional distances), the maximum number of warehouses, warehouse capacity limits, and the number of personnel per warehouse. Additionally, key parameters provided by FNSS included the number of vehicles, part/material sizes, vehicle usage rates (in kilometers and hours), and geographic location data.

To solve the company's problem, a mathematical model was developed using insights from academic literature, particularly inspired by the P-Median and Maximum Coverage Location problems. Initially implemented in GAMS, the model was later transitioned to Python. The model's objective is to determine the optimal cities and number of warehouses to open, minimize transportation distances (and hence costs), and optimize the distribution of parts and materials.

To enable this, a scoring system was devised for all demand points by combining the number of vehicles in each region with their usage levels (based on kilometers and hours), using data provided by FNSS.

Furthermore, the mathematical model was integrated into a Python-based interface, visualizing the map of Turkey, the number of each part available in each warehouse, and instructions on which warehouse should supply the requested part to a given region. Additionally, warehouse types for each selected city were determined based on the total storage volume required for that city's inventory. While these are operational decisions, they can serve as long-term planning benchmarks.

A sensitivity analysis comparing the minimum (8) and maximum (12) number of warehouses was also conducted. The analysis revealed that the optimized model could yield a cost reduction of up to 77.76%.

Keywords: Personnel and warehouse planning, P-Median Problem, Maximum Coverage Location Problem, Sensitivity Analysis