

Improving technical system maintenance by a computerized maintenance management support system

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Abstract:

Introduction/purpose: The subject of this research is the work organization and execution methodology of an organization or individual responsible for the maintenance of a technical system (TS), respectively, workshop activities related to technical system technical maintenance (TMTS). In that segment of the maintenance organization's work, the possibility and need to improve the situation through the application of a computerized maintenance management system (CMMS) are observed. The assumption is that the introduction of a CMMS, along with the simultaneous application of other modern management tools, can significantly shorten the time that the technical system stays in the maintenance system and increase its availability.

Methods: The methods used in the research are: content analysis (analysis of workshop documentation and different literature sources), multi-factor and regression analysis by using the statistical software application MINITAB (experimental testing), software prototype development and che-

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cking the improvement in the real TS maintenance organization (empirical testing).

Results: It is expected to save time in the maintenance cycle in the administrative part of TS maintenance by introducing the TS maintenance management software application in maintenance organizations, because a number of activities are automated. The objectives of the software are the following: the program automates the filling out of the Workshop Sheet and Work Order, where common fields, such as the Workshop Sheet number and date, are linked and filled in automatically. Also, when filling out the Workshop Sheet, by simply clicking on the required registration (factory) number, other data in the "TS DATA" section are automatically filled in. Filling in data about the mechanic's NB is also automated by simply clicking to select the required work from the database. Finally, the program also offers printing of the Workshop Sheet and Work Order, as well as the List of Issuance and Receipt of Spare Parts.

Conclusion: Automation of individual processes in the organization and implementation of the work of TS maintenance organizations, using computers, i.e. software information systems, is an important step towards the modernization and improvement of the maintenance process of TS. By introducing the application program "PS Maintenance", it is possible to significantly facilitate individual activities and reduce the time required for the entire process of implementing the TS.

Key words: technical system, technical systems for special purpose, weapon systems, technical maintenance, overhaul, computer maintenance management system, maintenance level, maintenance system, lean maintenance.

Introduction

The system for maintenance of technical systems (TS) represents a complex organizational - technological system. Its size and complexity depend on the size and complexity of the organizational system whose TS is the subject of maintenance. How much time the TS will spend in the maintenance system (MS), due to failure or the undertaking of preventive activities, depends on numerous factors that are defined in the design and development phases of the TS, during its production, as well as on the activities in the MS which are undertaken during the exploitation of the TS. It is possible to ensure a high degree of availability or readiness of TS, in order to increase the effectiveness of its use, only by good organization and implementation of maintenance technology at all levels of maintenance, from basic maintenance, through technical maintenance TM, to general overhaul.

Analyzing the available normative documentation that determines the organization of TS maintenance and other literary sources developed by bodies responsible for the organization and implementation of TS maintenance (mostly logistics bodies in large organizational systems), individuals and software companies decades ago with the aim of improving the planning and organization of TS maintenance (Veselinović et al., 2012; <https://www.sertica.com/maintenance/>, 2025), it can be seen that there is a constant need to improve the situation in the field of the organization and implementation of the work of the performers of TS maintenance activities.

The improvement of the organization and implementation of the work of organizational systems for the maintenance of TS, or the improvement of workshop business using computers, represents a certain problem, because experience in the organization and implementation of the maintenance of various TS in a classical, paper-based, way is needed to identify areas for improvement, as well as the commitment of the management to improve work in this way. Furthermore, the problem is often the availability of data on the organization of maintenance systems. No sense to initiate the improvement of the current state without the analysis of that data.

In this paper, the subject of research is the methodology of the organization and implementation of the work of the organization or individual responsible for maintenance of the TS, or, more specifically, workshop activities related to TM of TS. In that segment of the maintenance organization's work, the possibility and need to improve the situation through the application of a computer maintenance management system (CMMS, Computer Maintenance Management System) are observed (Epler, 2016; Epler et al., 2017; Božanić et al., 2024).

Technical system maintenance organizations can perform their tasks in the field or in stationary, workshop conditions. Regardless of the place of execution of maintenance tasks, it is necessary to plan and organize all activities that are prescribed and standardized by technical instructions and unique time norms for each TS.

The practical realization of TS maintenance in organizations responsible for TM, from documentation management to the execution of activities, operations, movements and micro-movements of specific TS maintenance, differs from one maintenance organization to another, due to differences in the training of the workforce, its age structure, workload and infrastructure conditions. It is necessary to partially automate the maintenance of workshop documentation, maintenance procedures and spare parts (s/p) stock management. In this way, the work of similar organizations or TS maintenance services in the field of workshop

maintenance documentation would be standardized. This creates prerequisites for greater operational readiness of TS.

The main and basic goal of this paper is to describe the basic technological process of TM of most relatively simple TS (e.g. motor vehicles, weapon systems, other machines, aggregates, etc.), analyze and evaluate the existing organization and implementation of the work of most organizations for TM TS, whose data are publicly available, with a focus on workshop operations, which form the base of their work, and then to propose improvements to the current situation.

Existing technical system maintenance model

Maintenance of TS, as a field of technical and technological sciences, includes a set of measures and procedures that postpone or eliminate TS failure over a certain period of time and under given environmental conditions (Kobbacy - Murthy, 2008.). The definition of TS maintenance differs only in terms of the means to which it applies. The set of measures that should be implemented within the TS maintenance program is generally not implemented at a single workplace, i.e. level.

Maintenance levels

According to Andrejić & Sokolović (2014), TS maintenance can be organized and implemented at three levels:

- User level – I level;
- Technical maintenance workshop level – II level;
- Overhaul organization level – III level.

Figure 1 provides a display model of how is TS maintenance regulated in the Serbian Armed Forces (SAF), which has a large number of TS, and whose data on the organization and implementation of TS TM are publicly available through military literature, textbooks and manuals, without delving into the specific tactical and technical characteristics of TS, which in SAF's military literature are called technical mobile assets.

At each level of maintenance, tasks, administrative and executive bodies for maintenance are defined. An example of the organization and realization of TS maintenance in the Armed Forces can be a good basis for explaining the causes and consequences of improving TS maintenance with the support of a computer-based maintenance management system.

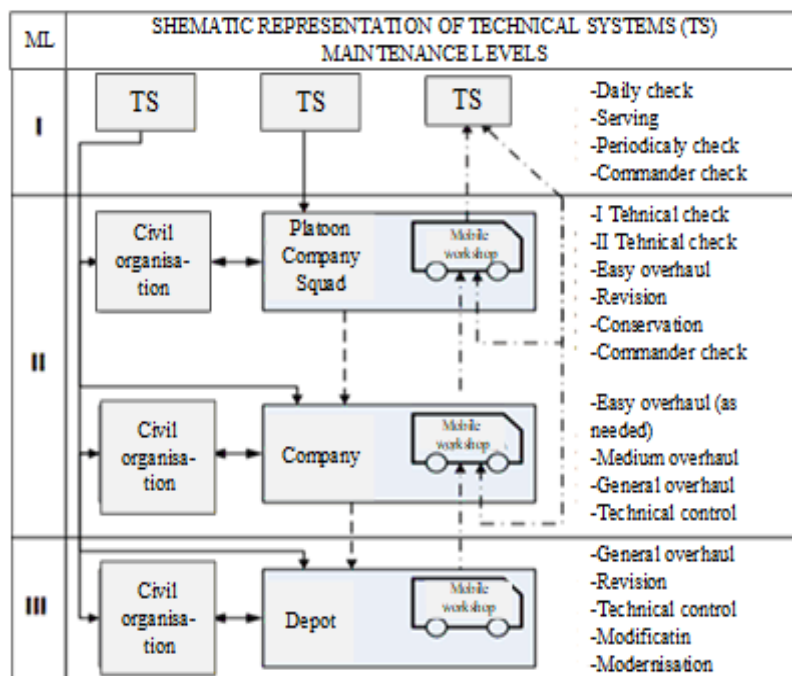


Figure 1 – Technical system maintenance levels (Andrejić & Sokolović, 2014)

Technical systems maintenance processes and problems analysis

Naumović analyzes the processes and problems in a real TS maintenance system and emphasizes that “the management of the TS maintenance process in MS, in today's conditions, is significantly more complex than before, since the requirements have increased in terms of the quality of the maintained TS, shortening maintenance deadlines, as well as in terms of maintaining increasingly complex TS. The constant complication of tasks, with the simultaneous shortening of maintenance deadlines, has created new problems and difficulties in planning and performing maintenance tasks. In addition to the price and quality of the maintained TS, the maintenance completion deadline also appears as an important factor in the maintenance market. The time reserve between the planned (standardized) cycle times for maintenance of TS (T_{cmp}) and the realized cycle times of technical maintenance of TS (T_{cmr}) was observed by analyzing the basic technological process of TS maintenance in real maintenance organizations (workshops) and the workshop documentation kept in them, which often lacks data related to the organization of the

process itself. The times due to TS waiting for work (administrative and logistical) are generally not recorded in the workshop documentation, which makes it difficult to argue for their reduction or complete elimination” (Naumović, 2025).

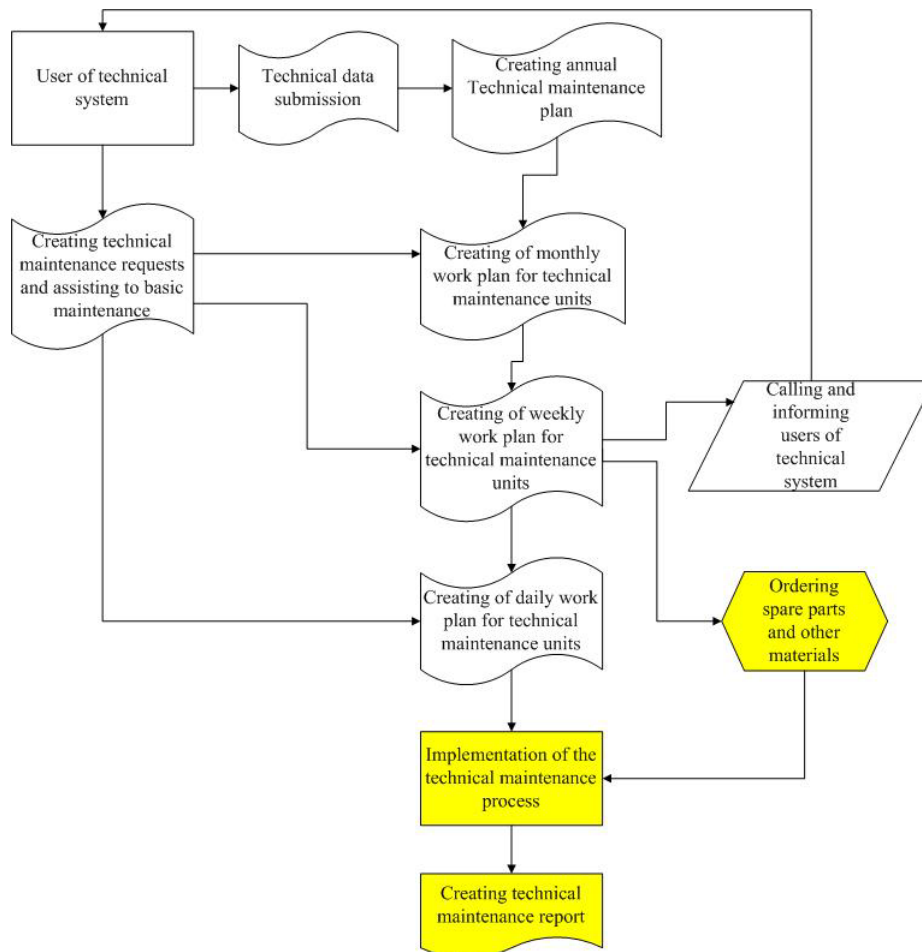


Figure 2 – Planning and organization of technical systems technical maintenance

From the above, it can be seen that today there is a lot of uncertainty and indeterminacy in most domestic MS, where maintenance management is carried out on the principles of traditional maintenance concepts (preventive and corrective). Many TS maintenance processes are not managed, under the constant excuse that this is how it should be, and this causes constant losses (material and time) in the performance of



TS maintenance. The existing technological documentation for the maintenance of most TS is “poor” from the point of view of managing the maintenance process. For this reason, the preparation of data for the use of computers, i.e. for a software information system for managing the maintenance process, is very difficult, because it relies only on currently available information from the technological maintenance process.

Algorithm of the basic technological process was created by analyzing workshop documentation and work in a real TS maintenance system, which takes place in most TS maintenance organizations, from planning to implementation (Figure 2) (Naumović, 2025).

Yellow colour on Figure 2 indicates processes that can be improved by implementing modern concepts of technical systems maintenance management that have been successfully applied around the world because the previous multi-decade efforts to organize and improve the area of TSSN maintenance management, using classic maintenance concepts, do not give satisfactory results, bearing in mind the increasing demands of the market, users and competition.

It is obvious that in such a situation, the attitude towards the management of TS maintenance processes must fundamentally change, primarily in terms of intensifying research and development of practical methods and techniques based on modern maintenance concepts, such as, for example, Lean maintenance, TPM (Total Productive Maintenance), RCM (Reliability Centered Maintenance), CMMS (Computer Maintenance Management System), etc. (Epler, 2013; Epler et al., 2017; Božanić et al., 2024.). However, this statement is easier said than done. There are many difficulties in TS maintenance management, and the most pronounced and influential are (Epler, 2016): low quality and reliability of input data contained, primarily in technological documentation; complexity of MS; long-term lack of investment in maintenance management due to the economic crisis and closure to the market where work technologies, knowledge and innovations are exchanged, and insufficient training of top management in TS maintenance to recognize and decide what is necessary and important to change in TS maintenance management to minimize maintenance process losses.

Current state of the work process and organization of TS maintenance would likely be changed qualitatively by eliminating the negative impacts of the above-mentioned factors through the application of modern concepts presented in the remainder of the paper. Qualitative changes would be reflected in (Epler, 2016; Božanić et al., 2024):

- shortening the TS maintenance cycle time (T_{cmr}),
- optimal use of available capacities,

- reducing costs per TS which being maintained.

Some modern concepts of technical systems maintenance management

Today, technical systems maintenance isn't just about fixing TS when they break; it's about preventing downtime before it happens. The Internet of Things (IoT) is transforming TS maintenance by integrating smart sensors, connectivity, and data analytics to optimize asset management. Through IoT-driven maintenance, companies can move from reactive and preventive strategies to a truly proactive approach-anticipating failures, optimizing resources and maximizing uptime (<https://traction.com/en/blog/iot-system-maintenance-management>, 2026).

Internet of Things is a technology that connects devices to the internet, allowing them to collect, analyze, and share real-time data. This turns everyday equipment into active intelligent assets capable of monitoring operations and capturing operational insights. IoT enables TS to communicate with each other, reducing the need for manual intervention. It plays a key role in Industry 4.0, integrating multiple different tools to create connected, data-rich environments. In manufacturing, IoT is redefining how we manage and optimize operations, making systems more responsive, efficient, and intelligent. One of the greatest advantages IoT brings to maintenance management is its ability to provide continuous asset monitoring. Smart sensors collect and analyze operational data, enabling early failure detection and eliminating the need for frequent manual inspections (<https://traction.com/en/blog/iot-system-maintenance-management>, 2026). We should consider incorporating such equipment into Technical systems for special - purpose (TSSP) in the military.

Historically, industries and TS maintenance relied on corrective maintenance, or fixing equipment only after it failed. This creates high costs and production downtime and TS operational readiness. Preventive maintenance improved reliability by scheduling inspections and spare parts replacements at fixed intervals. While it reduced unexpected failures, it also led to unnecessary maintenance actions. Next came condition-based maintenance (CBM), which introduced periodic measurements to assess TS conditions. Although more efficient, CBM still required manual inspections and did not eliminate unplanned failures. Now, IoT-driven predictive maintenance takes this approach to the next level, offering continuous monitoring to reduce unexpected failures and optimizing resources needed for TS maintenance.

Next picture clearly shows how IoT is enhancing reliability and efficiency across today's TS maintenance workflows.



Figure 3 – Benefits of implementing IoT in maintenance management
 (<https://traction.com/en/blog/iot-system-maintenance-management>, 2026)

Integrating IoT with CMMS is revolutionizing how industrial and TSSP maintenance is planned and executed. As IoT collects data in real time, CMMS organizes that information, automating workflows and enabling smarter, data-driven decision-making. The CMMS reads IoT-generated insights and automatically creates work orders, notifying maintenance teams about potential failures so they can take action, ultimately reducing downtime and extending asset lifespan. Beyond automation, IoT/CMMS integration builds a comprehensive asset history, helping maintenance managers identify failure patterns, optimize scheduling, and minimize resource waste.

With advancements in Artificial Intelligence, Machine Learning, and 5G, IoT is becoming more precise, accessible, and interoperable than ever before. However, achieving this level of efficiency requires a complete solution that integrates hardware and software intelligently.

Traction is the only end-to-end platform to prevent machine failures, protect production, and boost uptime. Traction's industrial IoT solution combines high-precision sensors with advanced AI, delivering continuous monitoring that detects issues before they escalate. With an intuitive platform and actionable insights, your maintenance team gains an Industrial Copilot-a system designed to make predictive maintenance effortless. If your plant implemented IoT-driven predictive maintenance, now is the time (<https://traction.com/en/blog/iot-system-maintenance-management>, 2026).

The manufacturing sector is evolving with the adoption of digital technologies, and one of the most impactful developments is the integration of the Internet of Things (IoT) with Computerized Maintenance Management Systems (CMMS). IoT involves connecting devices and equipment to collect real-time data, while CMMS manages maintenance activities and records. When combined, these technologies provide valuable insights, enabling manufacturers to monitor equipment health and streamline maintenance processes (<https://terotam.com/blog/iot-cmms-integration-the-future-of-manufacturing>, 2026).

This integration is transforming how factories operate. With real-time data from IoT sensors, CMMS can predict equipment failures before they happen, reducing unexpected downtime and improving overall efficiency. This shift towards predictive maintenance saves time and costs and also optimizes the use of resources, making manufacturing operations smarter and more effective. The Internet of Things (IoT) is transforming manufacturing by connecting machines and equipment through sensors and communication systems. These IoT devices collect real-time data on various factors like temperature, vibration, and energy use. This information helps manufacturers monitor their operations more accurately, detect issues early, and make informed decisions to improve productivity. Linking this data with other systems, like Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP), allows manufacturers to streamline operations and ensure better coordination across different processes. Beyond basic monitoring, IoT enables advanced manufacturing techniques like predictive maintenance and digital twins. Predictive maintenance uses data from IoT sensors to forecast when equipment might fail, allowing repairs to be made before problems disrupt production. Digital twins create virtual models of physical

machines, using real-time data to simulate and optimize performance. Integrating IoT with AI and machine learning can automate complex tasks, making factories more efficient and adaptable. This use of IoT is a key part of the Industry 4.0 movement, which aims to create smarter, more interconnected manufacturing systems (<https://terotam.com/blog/iot-cmms-integration-the-future-of-manufacturing>, 2026).

In addition to the above, and based on the study of the available literature and examples from the practice of other organizational systems, it can be said that the "lean" concept of maintenance management of TSSN (LM, Lean Maintenance) cannot represent an explicit concept of maintenance management, but rather a combination of developed and widely applied concepts of maintenance management in organizational systems (TPM, RCM, PdM, TQM, etc.), standard LM methods ("5S", "JIT", "Kaizen", "Kanban", Visual systems, "Layout"), software and other tools, such as tools for planning and managing projects, work orders and decision support (CMMS), whose joint action is channeled by unique principles, all with the aim of bringing order and reducing costs in TSSN maintenance, by detecting and eliminating all unnecessary activities in the TSSN maintenance process and striving to be better, more qualitative and more advanced than the competition every day. In order for the LM concept of TSSN maintenance management to have its full effect in MS, it is necessary to adapt the entire system to the philosophy of continuous process improvement and elimination of unnecessary costs or losses. The management of TSSP MS, based on the LM concept, is carried out by a small number of managers, controllers and maintenance technologists at the middle level, because most of the management comes from within, from authorized action teams, which consist of all employees trained for management tasks at a certain level. In this way, managers, controllers and technologists can spend more time in the maintenance plant, providing technical advice and guidance and recognizing, first-hand, the problems and needs of action teams (Epler, 2016).

Analyzing various repair and production processes, the author observed the characteristics of most domestic repair and production systems. He concluded that the current state of the work process and organization of repair and production systems would be qualitatively changed through shortening the repair cycle, optimizing the use of repair capacities and lowering costs per repair unit by removing the influence of negative factors. Applying the developed procedures in the design of the turbojet overhaul management model, with the support of Microsoft Project software tools, he performed an experimental verification of the model in terms of the application and impact of the three tools of the LM concept.

The results of the research gave the regularities of the overhaul cycle and the distribution of work as a function of the number of workers, priorities and spatial structure in the observed overhaul-production system, which can reliably assess the impact of the analyzed LM tools on the effectiveness and efficiency of the production process of each overhaul - production system (Marić, 2010).

The Boeing team was able to accelerate the return of the K-135 (Boeing Stratotanker is the primary aerial refueling aircraft for the United States Air Force (USAF)) from overhaul and thereby improve capability and customer readiness by implementing a series of LM initiatives at the Boeing Support Systems facility in San Antonio earlier in the year and planning their full implementation at the Pemco facility in Birmingham. At the beginning of 2005, it took an average of 214 days for Boeing and its partner to overhaul a KC-135. At the beginning of 2007, that time averaged 175 days, with a tendency to be shorter (<https://boeing.mediaroom.com/2012-03-28-Boeing-Completes-Programmed-Depot-Maintenance-on-3rd-KC-135E-for-Chile>, 2026).

In his work, Prekajski includes and explains the principles, basic methods and techniques of the LM concept. After that, he states that today the vast majority of car manufacturers, with the exception of Ferrari and a few luxury car manufacturers, apply LM methods and techniques and therefore achieve outstanding results in shortening the production cycle and saving costs in almost all company processes. The good results in the auto industry have caused interest in other types of industrial production with assembly processes, such as, for example, ship production. Shipyards that have implemented LM methods and techniques have accelerated the production process, reduced errors in welding and assembly activities, and reduced the number of spare parts necessary to produce expensive ocean freighters and for the maintenance of production machines (Prekajski, 2007).

From what has been stated so far about the modern concepts of technical systems for special purpose maintenance management, it can be concluded that the proactivity of all participants, prediction of future technical systems for special purpose unwanted states, automation of as many activities as possible, process optimization are common to all. In the practice of most production and overhaul systems in the world, the approach or management concept called Lean has proven itself well, and its CMMS tool has proven itself well and has become crucial for monitoring and optimizing the technical systems for special purpose maintenance process.

Table 1 – Results obtained by application LM tools “5S”, “VS-Visual Systems”, CMMS, “LO-Layout”, “KAN-Kanban” (Epler et al., 2017)

Function of maintenance system	Applied LM tool	Tc (h) before application LM tool	Tc (h) after application LM tool	IMPROVEMENT
Preparation of repair	5S, “VS”, CMMS	2,83	0,7	2,13 (75%)
Realization of repair	5S, “VS”, “LO”	11,1	10,2	0,9 (8%)
Spares supply	CMMS, KANBAN	1,17	0,2	0,97 (8%)
Finalization and report	CMMS	0,5	0,02	0,48 (96%)

Epler et al. (2017) proposed a maintenance management model in which, firstly, the analysis of the impact of CMMS and other lean tools is conducted, which in a relatively short period of time, could lead to reducing the repair time, improving the effectiveness and efficiency of the TSSP maintenance system. The proposed model can be considered modern, because, compared to the conventional method applied in maintenance management, it does not consider the maintenance system as a priori disordered and a large part of activities as impossible to manage. The greatest achievement of the proposed model is its holistic approach to the maintenance management, which is reflected in the consistent application of selected CMMS and other lean tools and principles in all functions and activities within the maintenance cycle, in order to achieve a greater improvement compared to the previous state. For the verification of the proposed model, the empirical and experimental testing with results analysis was performed. Empirical verification of the TSSP maintenance model was made in the workshop for technical (tactical level) maintenance. The empirically obtained results are shown in Table 1. Table 1 also shows the trend of decreasing the duration of maintenance cycle for TSSP after CMMS and other lean tools (5S, CMMS, LO, VS and KANBAN). The maximum effect is obtained when all five lean tools are applied at the same time. The data shows that the greatest improvement was achieved after the implementation of a group of tools with CMMS.

After empirical tests of the proposed model for TSSP maintenance, the 22 multi-factor analysis of the impact of the described CMMS and other lean tools is performed. The analysis of influence factors is considered in relation to the duration of the maintenance cycle time T_c , using statistical software MINITAB. For this experiment, lean tools are grouped as follows:

Factor 1: LAYOUT with two levels: 1.0 – current state and 2.0 – future state, Factor 2: group of LEAN TOOLS with the following levels: 1.0 – 5S, 2.5 – 5S+VS, 4.0 – 5S+VS+CMMS, and 5.5 – 5S+VS+CMMS+KANBAN. At the beginning of the experimental verification, a starting matrix for regression analysis and analysis of variance of the influence of factors on T_c was formed. From statistically obtained results, it could be seen that factors (LAYOUT and CMMS and other LEAN TOOLS) have an impact on cycle time (T_c). The interaction of those factors does not have an impact on maintenance cycle – time. Statistical impact evaluation test shows that factors LAYOUT and CMMS and other LEAN TOOLS affect the change of T_c , that this influence is statistically significant, and their interaction does not change T_c . In addition to this, the data show that the mathematical model for TSSP has a high level of adequacy. The special significance of the developed model is the regression analysis, the outputs of which are equations that mathematically describe the changes in T_c depending on the applied lean tools (especially CMMS) and the possibility of their spatial graphics representation. The regression equations enable one to see the magnitude of the impact of specific factors on maintenance cycle time T_c , and show that it is possible to influence them.

In Božanić et al. (2024), the authors present a multi-criteria decision-making model based on the application of two methods, DIBIR II and MABAC. The DIBIR II method was used to define weight coefficients. The MABAC method was used to rank alternatives (six tools of the Lean management concept, “VS”, 5S, CMMS, KANBAN, KAIZEN and NAGARA SYSTEM) and it was applied in a rough environment. Four experts were engaged in defining the criteria (five criteria, C1-Reduction maintenance cycle time, C2-Optimisation level of equipment and working positions, C3-effectiveness TSSP increase percentage, C4-Maintenance system efficiency increase level, C5-Reduction in the number of executors of maintenance operations) and alternatives, as well as in the relation between criteria. The model was applied for ranking the methods and techniques of the Lean organisation systems management in the maintenance of TSSP. At the end of the application, a sensitivity analysis was conducted, which proved the stability of the obtained results. The final ranking alternatives shows that alternative CMMS takes the high second place among six alternatives in the improvement of the work process and organization management of TSSP technical maintenance.

Based on the results obtained in the research described in Epler et al. (2017) and the dissertation by Epler (2016), this paper continues with a proposal for improving the mentioned TSSP maintenance management processes by implementing a simple CMMS software solution designed

for technical maintenance management (Naumović, 2025), which does not require much investment to demonstrate the possibility of significant improvements in TSSP maintenance management.

Proposal for improving the technical systems maintenance using computers

“CMMS is a computer-based maintenance management system, or software solution used to plan, track, report and optimize maintenance processes in companies. Such a software solution helps in the efficient management of TS, spare parts required for maintenance, reducing downtime and extending the lifespan of TS” (<https://www.worktrek.com/glossary/what-is-cmms>, 2025).

The following paper describes part of the research in the diploma thesis (Naumović, 2025) as part of which the testing and filling of the database of the software solution for managing the maintenance of special purpose technical systems was carried out earlier (Epler, 2016; Epler et al., 2017), with the basic goal of contributing to improving TS maintenance on the basis of the Lean concept of managing organizational systems, i.e. improving the current state in most real systems for technical maintenance (STM), also taking into account international standards for the effective management of technical systems throughout their life cycle, such as: ISO 55000, ISO 14224, and EN 17007. One of the goals of the thesis (Naumović, 2025) is the creation of a prototype, an internal tool for academic application with a smaller number of users, with the possibility of improvement for application in a larger real system for the technical maintenance of technical systems of special purpose, such as, for example, weapons systems. The computer tool called “Održavanje PS” (“Technical system maintenance”), was created in the Microsoft Access 2010 program package.

Microsoft Access is a simple software tool for working with databases that is part of the widely distributed Microsoft Office suite. It is intended for smaller applications and individual users or smaller teams. It allows the quick creation of tables, forms, queries and reports without much programming. The main limitations of Access are lower performance with large databases, a limited number of concurrent users, and lower reliability in demanding production environments. There are also shortcomings in areas that are important for software used for military purposes and relate to the area of cyber-security, backup/redundancy mechanisms, integration with ERP/MES systems, work in a distributed environment, data transfer problems. That is why it is often used for smaller projects, prototypes or internal tools, while for large business systems more robust database

server systems are used. In contrast, the more complex maintenance management systems described in the previous chapter work with the help of MySQL, PostgreSQL or Microsoft SQL software systems, which are intended for working with large amounts of data and a large number of users at the same time. They offer better compatibility, security, performance and advanced functionalities (transactions, query optimization, working in distributed systems).

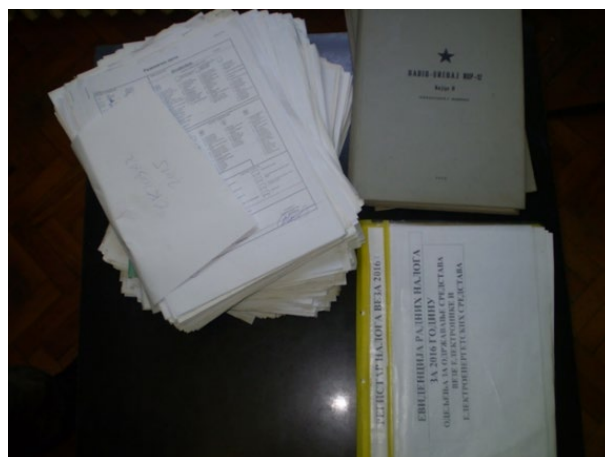


Figure 4 – Maintaining workshop documentation before implementing the “PS maintenance” software application (Naumović, 2025)

The developed software application represents a unique tool, which can be a significant segment of the TS maintenance management information system in which, for a start, activities can be automated from the acceptance of the TS into STM to the completion of maintenance and the preparation of the TM report, because after many years of observation and work in the STM (Epler, 2016) and the analysis of the workshop documentation presented by Naumović (2025), it was observed that, in the current state of the TS maintenance system, there are many activities that are unnecessarily repeated every time when the TS comes to STM, such as re-entering data about the same type of TS, activities that need to be done again, etc., and that they can be removed by automating the processes, which are partially illustrated in Figure 4.

This unique software tool also enables management of the supply of spare parts (sp) and consumables, with certain limitations, which significantly shortens the duration of the TS maintenance cycle time and introduces a certain order into the maintenance process, reducing the “paperwork” and the amount of manual work of the TM workshop manager

and work record keeper, i.e. increasing their efficiency and accuracy, as illustrated in Figure 5.

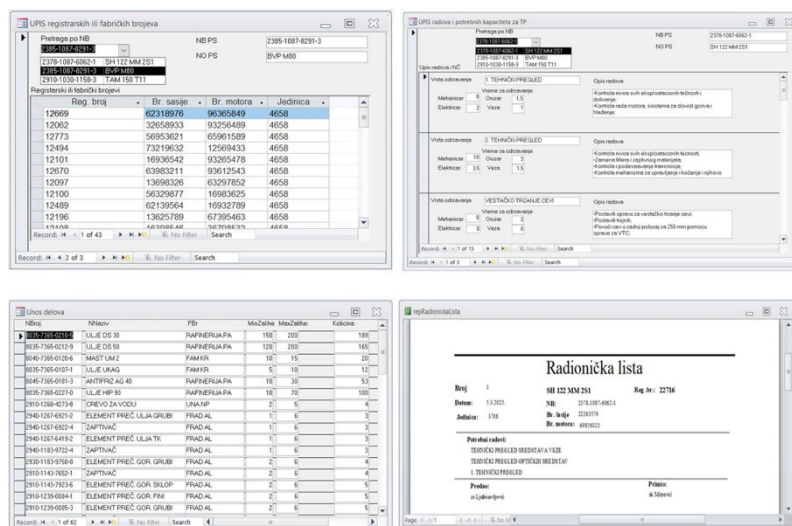


Figure 5 – Maintaining workshop documentation after implementing the “PS maintenance” software application (Naumović, 2025)

A description of the structure and operation of the software application is shown below.

Description of the structure of the “TS maintenance” application

The “TS maintenance” application was created in the Microsoft Access 2010 software package, which is intended for managing relational databases. It consists of a database that stores all entered data necessary for the functioning of the program and a graphical environment, which forms the connection between the user and the database.

The database consists of the following interconnected tables (Figure 6):

- 1) tblTMS (tblITS) – contains data on the nomenclature number necessary for TS designation;
- 2) tblSredstvo (tblSpecificTS) – contains data about the specific vehicle (registration number, chassis number, engine number and identification number of the organization to which the vehicle belongs);
- 3) tblTP (tblTechnicalInspection) – contains data about the type of corrective and preventive maintenance operations with a

description of the work and the required times (RT) for maintenance by specialty;

- 4) tblDelovi (tblSpareParts) – contains data about sp and consumables stocks in the warehouse and minimum and maximum quantities (necessary for creating requirements);
- 5) tblRadionickaLista (tblWorkshopList) – contains data about the Workshop sheet (serial number, opening date, finish date, achieved capacities by specialty and the name and surname of the person who received and handed over the TS);
- 6) tblPotrebniDelovi (tblRequiredSpareParts) – contains information about the sp required for the maintenance of a specific TS;
- 7) tblOdrzavanje (tblMaintenance) – contains information on the required type of maintenance for a specific TS.

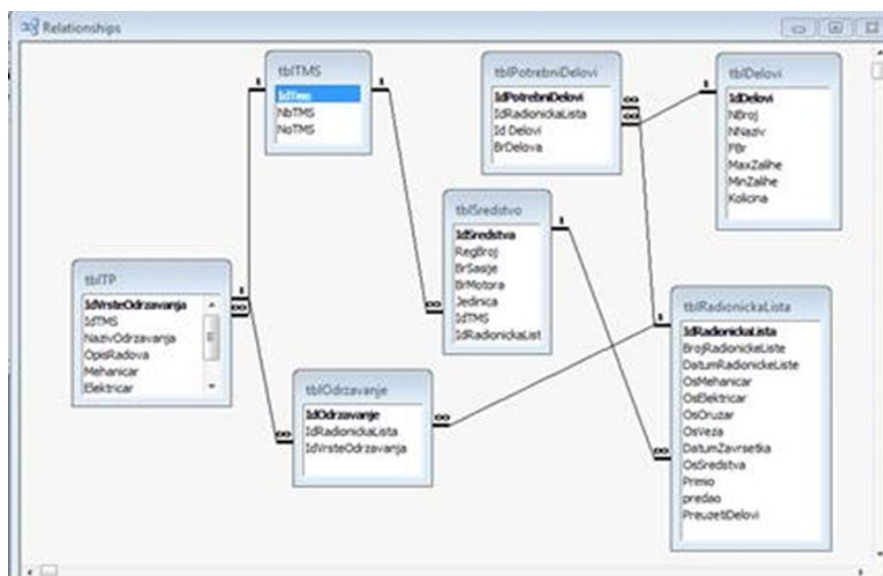


Figure 6 - Scheme of logical connections between tables within the database of the "TS Maintenance" program (Naumović, 2025)

Description of the operation of the "PS maintenance" application

When the software application is started, the initial window appears as shown in Figure 7.



Figure 7 – Initial window of the program “TS maintenance” (Naumović, 2025)

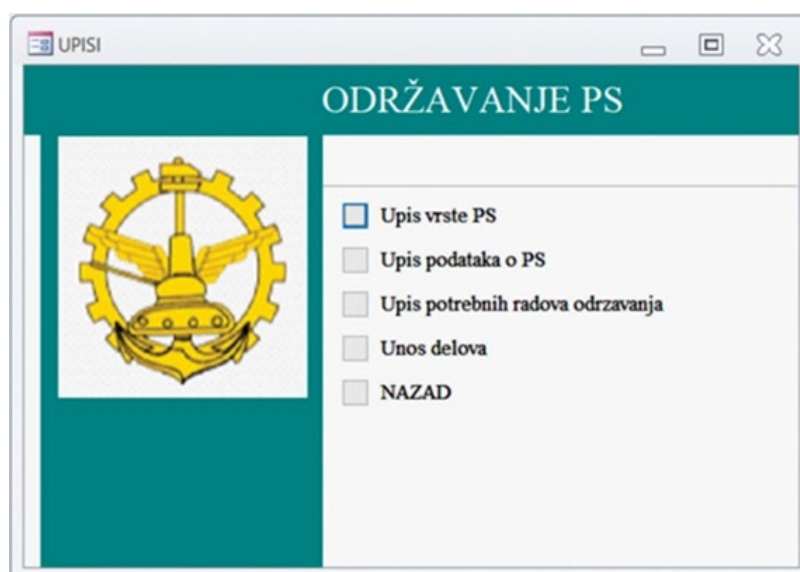


Figure 8 – Window “Entries” – for TS data entries (Naumović, 2025)

During the first access to the software application, it is necessary to fill the database with the necessary data in order to start the “RADIONIČKO POSLOVANJE” (“Workshop Business”), in order to automate it and make it more efficient. This is achieved by clicking on the “UPISI” (“Entries”) button (Figure 8).

Figure 9 – An example of a filled Workshop sheet in the “TS maintenance” application

Figure 10 –An example of a filled Worksheet in the “PS maintenance” application

When all necessary entries for TS have been made, click on the “NAZAD” (“Back”) button to access workshop operations, when clicking on the button “RADIONIČKO POSLOVANJE” (“Workshop operations”), the screen as shown in Figures 9 and 10 appears.

From the above displays, it is obvious that the “PS Maintenance” application enables automated management of spare parts inventory, but

also obtaining all necessary reports on TS maintenance activities, which makes the TS maintenance system manageable and flexible, i.e. efficient in resource management, which is very important for achieving good business results. Reports are accessed at the touch of the button “IZVEŠTAJI” (“Reports”) (Figure 11).

Figure 11 – Window “ANALIZA RADIONIČKOG POSLOVANJA” (“Workshop business analysis”) (Naumović, 2025)

Press the “Close Print Preview” button after each requested report and then the “Back” button.

Conclusion

Automation of individual processes in the organization and implementation of the work of TS maintenance organizations, using computers, i.e. software information systems, is an important step towards the modernization and improvement of TS. By introducing the software application “PS Maintenance”, it is possible to significantly facilitate individual processes and reduce the time of the entire process of implementing the TS.

It is expected to save time in the maintenance cycle in the administrative part of TS maintenance by introducing the TS maintenance management software application in maintenance organizations, because

a number of activities are automated. First, the program automates the filling in of the Workshop and Work order, where common fields, such as the Workshop sheet number and date, are linked and filled in automatically. Also, when filling out the Workshop sheet, by simply clicking on the required registration (factory) number, other data in the "TS DATA" section are automatically filled in. Filling in data about the mechanic's NB is also automated by simply clicking to select the required work from the database. Finally, the program also offers printing of the Workshop and Work order, as well as the List of Issuance and Receipt of Spare Parts.

Since the program stores each completed Workshop and Work order in the database, it is potentially possible to replace extensive Workshop registers written by hand with the database of this program.

The program also automates the monitoring of the state of spare parts and other materials for maintenance stocks in warehouses, which would reduce the likelihood of errors and omissions by the operator when monitoring and updating their levels. The program also enables the management of spare parts and other materials supply, with certain restrictions, which also contributes to saving the TS maintenance cycle time that should be minimized.

The possibility of creating a Workshop Report in the program also contributes to the improvement of the Maintenance system. By simply selecting the TS name and its registration number, the program retrieves data on the achieved capacities and parameters in a certain period that can also be selected.

The obtained results show that it is possible to develop and implement the Lean concept and tools in each function of maintenance cycle, among which CMMS has a special place and importance due to influence of which is reflected in the reduction of the maintenance cycle time, which is around 23 %, depending on the applied function.

In order for the described software solution to be applied with the greatest possible effect in a real military system or some other system for technical maintenance, the determination of the management to start improving the management of the maintenance of technical systems for special purposes, a detailed description of as many maintenance procedures as possible, the adoption of a unique nomenclature of spare parts, the procurement of hardware and software of a compatible generation and the training of as many users as possible, familiarizing users with the advantages of the upgrade, entering all the necessary data before using the application and continuously updating the changes of the entered data are necessary. The implementation results of this paper, in real terms, contributed to changing the mindset of management and

employees in a real workshop for technical maintenance, in the direction of accepting the change in a positive way.

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Unapređenje održavanja tehničkih sistema primenom računarskog sistema za upravljanje održavanjem

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OBLAST: matematika, operaciona istraživanja, industrijsko inženjerstvo
KATEGORIJA (TIP) ČLANKA: pregledni rad

Sažetak:

Uvod/cilj: Predmet istraživanja je metodologija organizacije ili pojedinca odgovornog za održavanje tehničkog sistema (TS), odnosno radioničkih aktivnosti vezanih za tehničko održavanje tehničkog sistema (TOTS). U tom segmentu rada organizacije održavanja uočavaju se mogućnost i potreba za poboljšanjem stanja primenom računarskog sistema za upravljanje održavanjem (CMMS). Pretpostavka je da uvođenje CMMS-a, uz istovremenu primenu drugih savremenih alata upravljanja, može značajno skratiti vreme boravka tehničkog sistema u sistemu održavanja i povećati njegovu dostupnost.

Metode: Metode korišćene u istraživanju su: analiza sadržaja (analiza dokumentacije radionice i različitih literaturnih izvora), višefaktorska i regresiona analiza korišćenjem statističke softverske aplikacije MINITAB (eksperimentalno testiranje), razvoj prototipa softvera i provera poboljšanja u stvarnoj organizaciji održavanja TS (empirijsko testiranje).

Rezultati: Očekuje se ušteda vremena u ciklusu održavanja u administrativnom delu održavanja TS uvođenjem softverske aplikacije za upravljanje održavanjem TS u organizacijama za održavanje, jer je niz aktivnosti automatizovan. Ciljevi softvera su sledeći: program automatizuje popunjavanje Radioničkog lista i Radnog naloga, gde su uobičajena polja, kao što su Broj i datum radioničkog lista, povezana i automatski se popunjavaju. Takođe, prilikom popunjavanja Radioničkog lista, jednostavnim klikom na potreban registarski (fabrički) broj, automatski se popunjavaju i ostali podaci u odeljku "PODACI TS". Popunjavanje podataka o NB mehaničara je takođe automatizovano jednostavnim klikom kako biste izabrali potreban rad iz baze podataka. Konačno, program nudi i štampanje Radioničkog lista i Radnog naloga, kao i Listu izdavanja i prijema rezervnih delova.

Zaključak: Automatizacija pojedinačnih procesa u organizaciji i realizaciji rada organizacija za održavanje TS, korišćenjem računara, odnosno softverskih informacionih sistema, predstavlja važan korak ka modernizaciji

i unapređenju procesa održavanja TS. Uvođenjem aplikativnog programa "Održavanje TS", moguće je značajno olakšati pojedinačne aktivnosti i skratiti vreme celog procesa implementacije TS.

Ključne reči: tehnički sistem, tehnički sistemi za posebne namene, sistemi naoružanja, tehničko održavanje, remont, sistem upravljanja održavanjem računara, nivo održavanja, sistem održavanja, lean održavanje.

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