USE OF SEWIO REAL-TIME LOCATION SYSTEM IN PRACTICE: TECHNICAL PREPARATION OF HARDWARE, DATA COLLECTION AND ANALYSIS

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Real-Time Location Systems (RTLS) technology has emerged as a transformative tool in industrial settings, offering enhanced process management and optimization capabilities. This paper presents a methodological framework for the technical preparation of RTLS hardware, aiming to provide a structured approach for its implementation in industrial environments. The framework encompasses key steps, including technical capability assessment of components, preparation of components for assembly, placement of hardware in the measured object, compliance with occupational health and safety rules, consultation with company management/process engineers, initial inspection of the established network, verification of network configuration, and validation using a tester. Through a collaborative approach involving meticulous planning, consultation, and testing, organizations can effectively deploy RTLS hardware to improve efficiency, productivity, and safety in their operations. This abstract encapsulates the essential components and insights of the paper, offering a comprehensive overview of the methodological framework for implementing RTLS hardware in industrial settings.

KEYWORDS

RTLS system, Sewio, location, data collection

1 INTRODUCTION

GPS is commonly used in industrial logistics for tracking vehicles over long distances. However, in enclosed spaces such as warehouses, it is less effective due to signal inaccuracies and high energy consumption. In such cases, Real-Time Location System (RTLS) is a more suitable alternative. RTLS provides precise real-time tracking of objects or individuals indoors, where GPS fails. This technology, belonging to the Internet of Things group of technologies, is crucial in sectors such as logistics and manufacturing for its ability to collect and analyse large amounts of data, enabling more efficient responses to challenges in internal management and market competition.

Systems for acquiring vast amounts of industrial data are a key tool in modern industry, as they provide valuable information for efficient digital management of production processes [Krenicky 2022]. RTLS technology, an automated data collection system, plays a crucial role in industrial spaces in modern manufacturing and logistics [Zoubek 2021]. These systems utilize various technologies to gather, process, and analyse data from production environments. The goal is to optimize processes, improve efficiency, track resources, and ensure quality [Dyadyura 2021, Trishch 2021]. Among these technologies is Ultra Wide Band (UWB) - a technology that is increasingly becoming more widespread in the industrial sector.

This study is driven by the emerging potential to utilize RTLS within the framework of Industry 4.0 to enhance safety standards and operational effectiveness within industrial enterprises, addressing a significant demand for such integration [Svetlik 2014 and 2021]. The increasing reliability and affordability of RTLS have opened up new avenues for real-time monitoring and tracking of various objects or individuals within specific area or environment. Certainly, the requirements of Industry 4.0 underscore the imperative to integrate RTLS technology into daily operations, given its capacity to analyse and optimize processes instantly [Mostafa 2019].

In this article, our objective is to delve deeper into the RTLS technology offered by Sewio Networks company, detailing the technical preparation and methodological framework essential for applying this technology effectively in the industrial enterprise.

2 LITERATURE REVIEW

In recent years, there has been considerable interest in indoor positioning and Real-Time Location Systems (RTLS) technologies. This heightened interest is largely attributed to the ability of accurate localization to facilitate efficient management of assets and resources within large enclosed spaces [Alarifi 2016]. Currently, there exist several technologies for indoor position tracking within warehouses. The most prevalent among these include Ultra-wideband (UWB), radio frequency identification (RFID) systems, vision systems, and Wi-Fi technology. However, the performance of these technologies varies in terms of accuracy, cost, and flexibility [Doiphode 2016] (see Fig. 1).

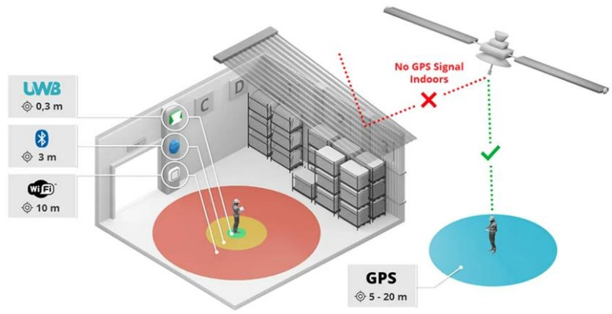

Figure 1. Accuracy of RTLS technologies compared to GPS [Sewio Networks 2024]

Therefore, a thorough assessment is essential to select a precise, resilient, and cost-efficient system within enterprises. Ultra-wideband (UWB) technology has demonstrated efficacy in indoor positioning, utilizing a transit time methodology known as Time of Flight (ToF). This approach measures the time taken for light to travel between an object and multiple receivers (anchors). A notable advantage of UWB for indoor positioning is its high level of accuracy, typically ranging between 0.1 to 0.3 meters. Furthermore, it enables 3D positioning with vertical accuracy ranging from 1 to 2 meters [Alarifi 2016]. Despite the promising tracking capabilities offered by UWB-based positioning in theory, accuracy may diminish if factors such as time synchronization and anchor placement are not meticulously adjusted [McElroy 2014]. The placement of anchors within the industrial enterprise environment is constrained by various factors, including layout considerations and safety concerns. Practical implementation of Ultra-wideband (UWB) technology reveals that the precise placement and spacing of anchors significantly influence the accuracy of monitored objects/individuals [Murcinkova 2013, Li 2016].

RFID stands out as one of the foremost RTLS technologies, utilizing radio waves for the retrieval and capture of data from tags. An RFID system typically comprises a reader, antenna, tag, and software components. Functionally, RFID operates by tags receiving signals from the antenna, transmitting data to the reader, and subsequently to a computer [Doiphode 2016]. Numerous research studies have leveraged RFID technology to furnish localization data about forklifts [Ding 2008, Poon 2009, Zhong 2015]. Notably, RFID boasts resilience in challenging operational conditions. However, it is encumbered by certain limitations: difficulty in tracking 3D movement, susceptibility to reader and tag collisions, potential costliness, and limitations in localization accuracy for certain applications [Doiphode 2016].

Another technology under consideration is Wi-Fi, which finds applicability across various indoor settings [Seyedzadegan 2011]. Wi-Fi operates via a wireless network commonly referred to as a wired backbone, offering multifunctionality such as location tracking, file transfer, internet access, and email services. To track objects using Wi-Fi technology, a minimum of three reference points (receivers) is required to gather two-dimensional location data. The system architecture of Wi-Fi-based RTLS typically involves interconnected receivers forming a mesh network, a device linked to the internet via Ethernet or Wi-Fi, and tags or smartphones transmitting signals to the receivers. Despite its utility, Wi-Fi suffers from limited localization accuracy, typically ranging between 5 to 15 meters [Schrooyen 2006].

3 RTLS – TECHNICAL PREPARATION OF HARDWARE

Sewio Networks is a technological company specializing in the development and delivery of advanced RTLS systems utilizing UWB technology and has established a significant global presence prioritizing high accuracy, reliability, and scalability in its solutions, enabling it to meet the needs of a wide range of industries. In addition to technological innovations, the company is recognized for its focus on sustainability and environmental aspects of its operations, striving to minimize its impact on the environment, with notable clients as Volkswagen, Toyota, Budweiser Budvar, TPCA, Skoda, and ENEL [Sewio.net 2024].

The primary objective of this article is to delineate the methodological implementation of UWB Sewio RTLS technology within the manufacturing operations of an industrial enterprise and to elucidate the technical preparation involved. One of the RTLS technologies that Sewio offers is the RTLS UWB Wi-Fi Kit. In the following sub-chapter, we will discuss its hardware.

3.1 Sewio RTLS UWB Wi-Fi Kit

The RTLS Wi-Fi Kit, utilizing the Time Difference of Arrival method, integrates hardware elements featuring a Decawave module operating on UWB (Ultra-Wideband) technology, along with the RTLS Studio Software. Both the hardware components and software license provided in the kit are transferable and can be effectively utilized in subsequent projects. The RTLS Wi-Fi kit is conveniently pre-configured and comes equipped with five Anchors Vista Omni and four tags designed for object tracking: two Leonardo Personal tags and two Leonardo Asset tags (see Fig. 2).

Figure 2. Mobile version - Sewio UWB RTLS Wi-Fi Kit

Additionally, the kit comprises five USB-to-PoE converters to facilitate powering the anchors via standard power banks, along with a wireless router and accompanying accessories. In the following Figure 3, we can see the final version of the Sewio UWB RTLS Wi-Fi Kit, assembled hardware with descriptions of individual components, ready for deployment in an industrial enterprise.

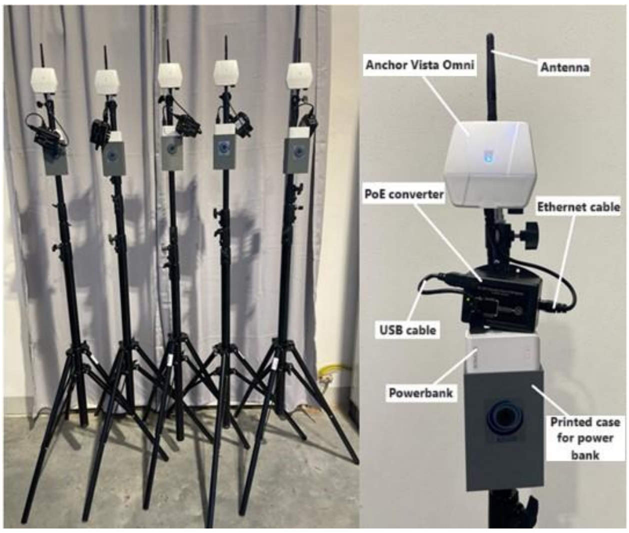

Figure 3. Assembly and description of components

For the purpose of securely mounting the power bank on the tripod, we utilized 3D printing to produce 5 cases and 5 brackets for the tripods (see Fig. 4).

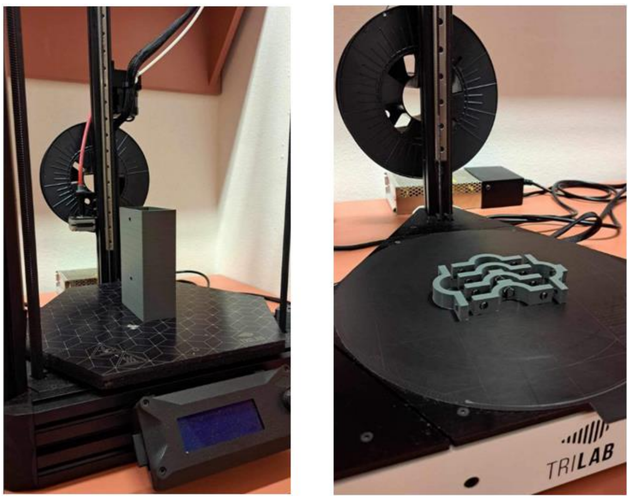

Figure 4. Case and brackets for mounting the power bank on the tripod

3.2 *Anchors deployment*

A crucial part of hardware preparation involves properly securing anchors to the tripod and ensuring their correct positioning and height within the measured space. The Vista Omni anchor is equipped with an omnidirectional antenna, so it should be installed in such a way that the antenna points directly upwards or, in some cases, downwards. To achieve optimal performance, it is essential to mount the anchor correctly and avoid bending the antenna. A minimum of four anchors is required for position calculation, enabling the creation of a proper localization cell for precise position determination. Anchors should be installed at similar heights, with a maximum difference of 100 cm, and not higher than 6 meters above the tags. It is also important to mount anchors on provided brackets, not directly on the wall or ceiling. If an anchor is close to the ceiling, it should be installed with the antenna facing downwards.

The master anchor needs to have a clear line of sight to at least three other anchors nearby, but direct line of sight between all anchors is only required within the same localization cell. Each cell must have at least one master anchor configured via the RTLS Manager. For seamless wireless synchronization, it is crucial to place anchors above moving objects, including those to be localized.

Another important step during technical preparation of hardware is to keep a square geometry during the deployment of anchors (Fig. 5). Because of the dilution of precision phenomenon, the optimal strategy involves "squaring" the location cell. To attain the utmost accuracy, the ratio between the two sides should not exceed 3:1.

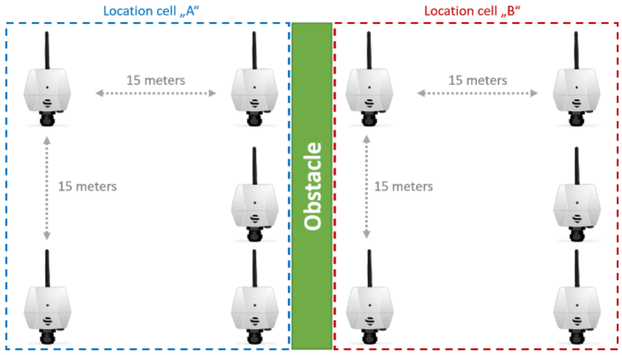

Figure 5. "Squaring" approach during anchors deployment

4 USAGE OF THE RTLS SYSTEM IN PRACTICE WITH BENEFITS

Real-Time Location System (RTLS) is a technology that enables precise tracking of the location and movement of various objects or individuals in real-time. This technology has many practical applications and brings several advantages.

One significant advantage of RTLS is the improvement of efficiency and productivity across various industries. For example, in industrial plants, RTLS can enable tracking of the movement of raw materials, components, or finished products, facilitating better organization of manufacturing processes and minimizing downtime. In hospitals, RTLS can help improve access to healthcare by allowing staff to quickly locate healthcare professionals, patients, and equipment, leading to better coordination and faster service delivery.

Additionally, RTLS can help enhance safety and security in various environments. In areas such as warehouses, RTLS can track the movement of equipment and materials, helping to prevent theft and loss. With the precision of location data, RTLS can also be useful in monitoring workplace safety or locating lost or stolen items.

Another advantage of RTLS is the improvement of inventory storage and management. With accurate location information of objects, organizations can plan storage and logistics more efficiently, leading to cost savings and increased product availability.

Overall, the utilization of RTLS in practice is highly diverse and offers many benefits across different areas. From increased efficiency and productivity to improved safety and inventory management, RTLS can provide valuable insights and tools for optimizing processes and enhancing the performance of organizations.

One potential disadvantage of Real-Time Location System (RTLS) in industrial practice is the initial cost of implementation and maintenance. Setting up an RTLS infrastructure typically requires investment in hardware such as sensors, receivers, and network infrastructure, as well as software development and integration. Additionally, ongoing maintenance and calibration of the system may require dedicated resources and expertise, adding to the overall cost of ownership.

Another challenge with RTLS systems is the potential for technical limitations or inaccuracies in location tracking. Factors such as signal interference, obstacles, or environmental conditions can affect the accuracy and reliability of location data. In industrial settings where precise tracking is crucial, any inaccuracies or disruptions in the RTLS system could impact operational efficiency and decision-making.

Furthermore, RTLS systems may raise privacy concerns, particularly in environments where employees are being tracked. Employees may have reservations about being constantly monitored, leading to potential resistance or decreased morale. Additionally, there may be regulatory or legal considerations regarding the collection and use of location data, requiring organizations to implement appropriate privacy safeguards and compliance measures.

Another challenge is the integration of RTLS data with existing systems and workflows. Incorporating location data into operational processes and decision-making may require significant changes to existing systems and workflows, as well as training for personnel. Without proper integration, the full potential of RTLS to improve efficiency and productivity may not be realized.

Finally, scalability can be a concern with RTLS systems, especially in large industrial environments. As the size and complexity of the facility increase, scaling up the RTLS infrastructure to cover the entire area while maintaining accuracy and performance may pose technical and logistical challenges.

In summary, while RTLS systems offer numerous benefits for industrial applications, including improved asset tracking, efficiency, and safety, there are also potential drawbacks to consider, such as initial cost, technical limitations, privacy concerns, integration challenges, and scalability issues. Organizations should carefully evaluate these factors and weigh them against the potential benefits before implementing an RTLS system in industrial practice.

4.1 *Direct application of the RTLS system in the collection of movement data and its analysis*

Testbed is a testing center for various companies and companies. This TestBed is located on the ground floor of the Department of Industrial and Digital Engineering. The RTLS localization system in Testbed was already integrated at the beginning of its birth. In this case, six UWB anchors with the type designation Vista Omni were used in Testbed. This type is also from Sewio's product portfolio.

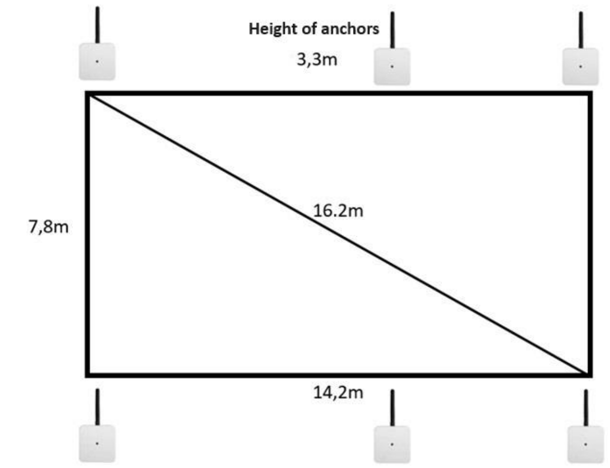

Figure 6. Map of the dimensions of the distribution of anchors in Testbed 4.0

The digital basis for motion data collection is drawn in classic graphics software, as no specific layout or other type of drawing documentation was available. It is important to note that this aspect does not affect the functioning of software such as RTLS Studio and its functional model.

In this Testbed, zones are created according to the logical arrangement of simulation workplaces, their focus and character. As can be seen in fig. 7., zones are labeled Z1 to Z5. Zones Z1, Z2, Z3 are work zones from which movement data is primarily collected, and zones Z4 and Z5 are in most cases taken as information zones.

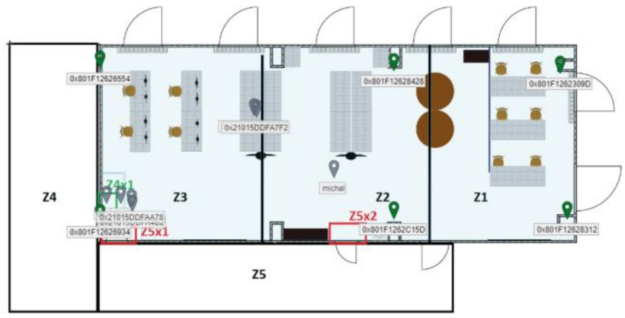

Figure 7. Floorplan TestBed with individual RTLS parts

In fig. 7 you can see the specific distribution of job positions that represent TestBed's simulation workplaces. These are twelve tables and one workplace with a collaborative KUKA robot and its rotary table. There is also a training workplace on the given layout, which is used for various trainings and workshops.

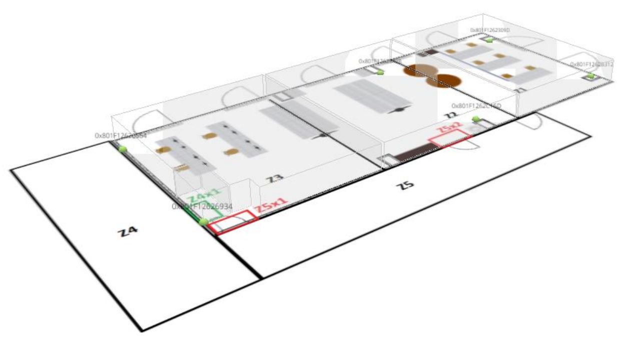

Figure 8. 3D model of virtual zones in TestBed 4.0

In fig. 8, it is possible to see the created virtual zones in a three-dimensional version, which is created using one of the RTLS Studio modules, namely 3D Sensmap. These three zones were primarily the target of measurement and data collection in TestBed.

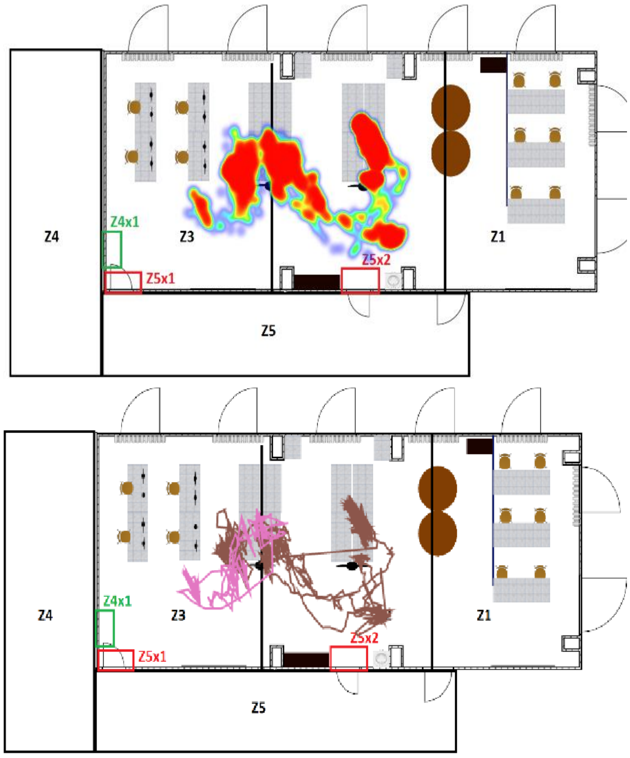

Figure 9. Heatmap and spaghetti diagram of movements in TestBed 4.0

In fig. 9 shows the movements that were created in the connection of tags and anchors of the RTLS localization system. These movements were simulated with the help of the TestBed 4.0 concept workers.

Heatmaps and Spatograms are useful tools in the Real-Time Location System (RTLS) concept to help visualize and analyze real-time location data.

Heatmaps are often used to visualize the density or frequency of occurrence of certain events in space. In the case of RTLS, heatmaps can show areas with the highest concentration of objects or people, making it possible to identify areas of greatest activity or congestion. This information can be useful when planning to optimize spaces or work flow to minimize bottlenecks and improve efficiency.

Spaghetti diagrams, also known as "spaghetti diagrams", are used to visualize the movement of objects or people in space. These diagrams track the routes taken by objects or individuals to identify patterns of movement, overlapping routes or areas of increased movement. In the case of RTLS, twine diagrams can provide valuable information about the flow of material or work processes in industrial plants, helping to identify areas of current or potential problems in logistics or organization.

4.2 Methodological Framework for the Technical Preparation of RTLS Hardware

Based on the theoretical and technical insights gathered thus far, the methodological framework is designed to delineate the primary steps involved in the technical preparation of RTLS technology hardware. Leveraging existing knowledge and understanding, this framework aims to provide a structured approach for the deployment and setup of RTLS hardware components. The following developmental diagram outlines the key stages and procedures essential for the successful technical preparation of RTLS hardware, ensuring optimal functionality and performance within industrial settings (Fig. 10).

The initial steps of the methodological framework for the implementation of RTLS hardware involve several key processes. Firstly, a comprehensive assessment of the technical capabilities of individual components is conducted to ensure their suitability for integration into the RTLS system. Following this, the components are meticulously prepared for assembly, including inspection and organization to facilitate smooth integration. Subsequently, the placement of hardware within the measured object is determined, taking into account factors such as signal strength and coverage to optimize performance. Additionally, adherence to occupational health and safety regulations is ensured during the placement process to maintain a safe working environment. Consultation with company management or process engineers is sought to align the implementation with organizational objectives and technical requirements. Upon the establishment of the network, an initial inspection is performed to verify its integrity and functionality. Subsequently, the configuration of the network is verified to ensure compliance with system specifications. Finally, the functionality and performance of the RTLS module within the network are validated using a tester to ensure accurate and reliable operation. These initial steps lay the foundation for the successful deployment of the RTLS hardware within the industrial enterprise.

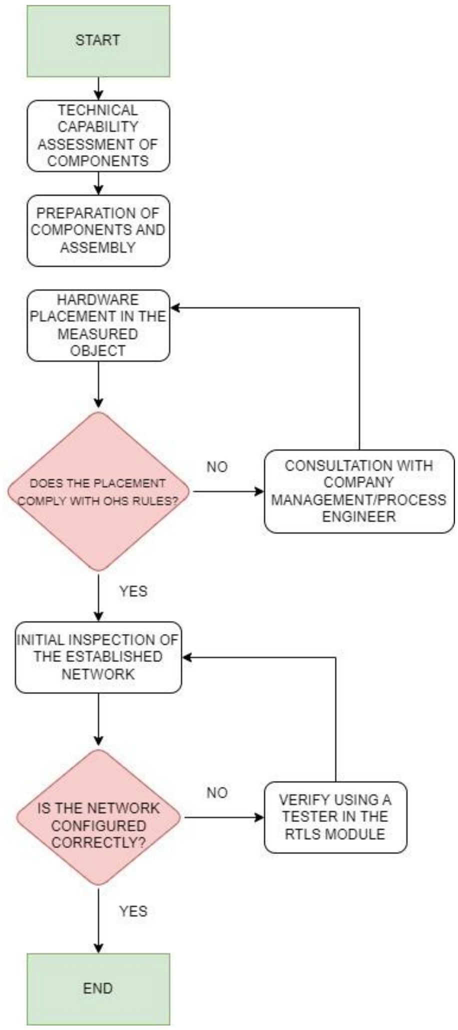

Figure 10. Development diagram - Procedure of technical preparation of RTLS hardware

5 DISCUSSION AND CONCLUSION

The implementation of Real-Time Location Systems (RTLS) technology, particularly in industrial environments, presents a significant advancement in the management and optimization of processes. Throughout this paper, we have explored the methodological framework for the technical preparation of RTLS hardware, encompassing various crucial steps and considerations.

Our investigation began with a comprehensive assessment of the technical capabilities of individual components, ensuring their suitability for integration into the RTLS system. Through meticulous preparation and organization of components, we facilitated smooth assembly and integration, laying the groundwork for optimal system functionality. The placement of hardware within the measured object emerged as a critical aspect of the implementation process. By strategically determining hardware placement based on factors such as signal strength and coverage, we aimed to optimize performance and accuracy. Moreover, adherence to occupational health and safety regulations was paramount throughout the placement process, underscoring the importance of maintaining a safe working environment [13-15].

Consultation with company management and process engineers played a crucial role in aligning the implementation with organizational objectives and technical requirements. This collaborative approach ensured that the RTLS system met the specific needs and goals of the industrial enterprise. Upon the establishment of the network, rigorous inspection and verification procedures were employed to confirm the integrity and functionality of the system. By validating network configuration and conducting thorough testing, we aimed to guarantee accurate and reliable operation of the RTLS hardware.

In conclusion, the methodological framework outlined in this paper provides a structured approach for the successful implementation of RTLS hardware in industrial settings. By following the prescribed steps and considerations, organizations can harness the full potential of RTLS technology to enhance efficiency, productivity, and safety in their operations [16,17].

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