Digital Transformation of Workforce Task Monitoring in a Logistics Operational Center

Guilherme Prata Guedes

Masters Dissertation

Supervisor at FEUP: Prof. AméricoAzevedo

Supervisor at Garland Logistics, Lda: Eng.º João Pedro Loureiro Barbosa

U. PORTO

FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

Master in Industrial Engineering and Management

2025-06-27

“A man who wins is a man who thinks he can”

Roger Federer

Resumo

Num cenário de crescente complexidade operacional e expectativas cada vez mais exigentes dos clientes, os operadores logísticos enfrentam pressões intensas para garantir eficiência, transparência e controlo de custos. Embora os WMS (Warehouse Management Systems) já sejam amplamente utilizados para rastreio de inventário, a monitorização da atividade laboral permanece, em muitas organizações, dependente de processos manuais. Esta dissertação aborda essa lacuna através do desenho, implementação e avaliação de um sistema digital para o registo automático dos tempos de tarefa dos trabalhadores no armazém CLG2 da Garland Logistics, em Vila Nova de Gaia.

O projecto visou eliminar as ineficiências do fluxo de trabalho manual existente, no qual os colaboradores preenchiam folhas de monitorização no final de cada dia, baseadas em estimativas e sujeitas a erros de transcrição. Essas fichas eram posteriormente integradas em bases de dados internas e serviam de base à imputação de custos e facturação a clientes.

Dada a natureza dos objetivos e do problema em questão, nomeadamente a complexidade do ambiente logístico na CLG2, onde a tecnologia, o comportamento humano, as rotinas organizacionais e a infraestrutura estão profundamente interligados, uma abordagem de investigação qualitativa através de estudo de caso revelou-se o enquadramento adequado para analisar a interação destes elementos de forma abrangente e estruturada. Tendo isto em conta, foi adotada uma metodologia estruturada em três fases: 1) Análise do Sistema e Contextualização; 2) Desenho da Solução e Arquitetura; 3) Implementação Piloto e Testes.

A solução proposta introduz uma alternativa digital que aproveita a toda a infraestrutura já instalada: cartões NFC (Near-Field Comunication), registos de acesso do sistema de segurança ATS (Access-control Tracking System) e formulários de declaração de tarefas desenvolvidos em Oracle APEX (Oracle Application Express).

Um elemento nuclear da nova arquitectura, a Tabela de Transações Unificada (UTT) agrega entradas de fontes heterogéneas, criando um registo cronológico, por trabalhador, das actividades realizadas. O sistema reconstrói o dia de trabalho completo, identificando inícios e fins de tarefas, pausas e clientes/serviços associados. Para garantir a correcta integração entre sistemas, foi também criada uma tabela de correspondência que alinha todos os identificadores de trabalhadores nos existentes sistemas.

Implementou-se um piloto em paralelo com o sistema manual, possibilitando a comparação direta de exactidão e usabilidade. Alguns resultados preliminares apontam para maior granularidade de dados, redução da carga administrativa e melhor visibilidade em tempo real. O feedback dos stakeholders foi positivo entre o pessoal administrativo e dividido, mas construtivo, entre equipas operacionais e supervisores. Embora os benefícios operacionais estejam ainda a ser quantificados, o piloto confirma a viabilidade técnica e a relevância estratégica da solução.

Esta dissertação entrega não só um modelo escalável de rastreio digital de tarefas para a Garland, como contribui para a discussão mais ampla sobre a digitalização da força de trabalho em ambientes logísticos. Por fim, recomenda-se, para trabalhos futuros, a expansão do sistema a outros armazéns, a incorporação dos formulários de tarefa em RDTs (Radio Data Terminal) e a reavaliação de abordagens baseadas em máquinas via integração de APIs (Application Programming Interface).

Abstract

In the context of increasing operational complexity and rising customer expectations, logistics companies face growing pressure to ensure efficiency, transparency, and cost control. Despite the widespread adoption of Warehouse Management Systems (WMS) for inventory tracking, the monitoring of workforce activity remains largely dependent on manual procedures in many organizations. This thesis addresses this gap by designing, implementing, and evaluating a digital system for automated worker task time tracking at Garland Logistics' CLG2 facility in Vila Nova de Gaia.

The project aimed to eliminate inefficiencies in the existing manual workflow, where employees filled out monitoring sheets at the end of each day, often based on estimations and subject to transcription errors. These records were later integrated into internal databases, forming the basis for cost allocation and client billing.

Given the objectives and the nature of the problem in hand, namely the complexity of the logistics environment at CLG2, where technology, human behavior, organizational routines, and infrastructure are deeply interlinked, a case study qualitative research approach provided the necessary framework to analyze the interplay of these elements in a comprehensive and structured manner. With this in mind, a structured three phase methodology was adopted: 1) System Analysis and Contextualization; 2) Solution Design and Architecture; 3) Pilot implementation and testing.

The proposed system introduced a digital alternative, leveraging existing infrastructure, including NFC-enabled company cards, ATS (Access-control Tracking System) security access logs, and a task declaration forms developed in Oracle APEX (Oracle Application Express).

A central element of the new architecture is the Unified Transaction Table (UTT), which consolidates inputs from heterogeneous sources into a chronologically ordered, worker-specific activity log. The system reconstructs full workdays by identifying task start and end times, pause periods, and associated clients and services. A mapping table was developed to align all identifiers, ensuring accurate cross-system integration.

A pilot implementation was conducted in parallel with the manual system, allowing for direct comparison of accuracy and usability. Early results indicate improved data granularity, reduction of manual workload, and enhanced real-time visibility. Stakeholder feedback revealed positive reception among administrative staff and mixed but constructive responses from operational teams and supervisors. Although the system's operational benefits are still being fully quantified, the pilot confirms its technical feasibility and strategic relevance.

This thesis not only delivers a scalable model for digital task tracking within Garland but also contributes to the broader conversation on workforce digitalization in logistics environments. To conclude, recommendations for future work include expanding the system across additional facilities, embedding task forms into RDTs (Radio Data Terminals), and re-evaluating machine-based tracking through API (Application Programming Interface) integration.

Acknowledgements

First and foremost, I am grateful to the Faculdade de Engenharia da Universidade do Porto (FEUP) and to Garland Logistics for the opportunity to undertake this project. It has been an experience that fostered my professional development and personal growth in equal measure.

I would like to acknowledge the expert guidance of my academic supervisor, Professor Américo Azevedo, whose insight and availability over the past six months were indispensable to the completion of this work.

My sincere thanks go to Eng. João Barbosa, my supervisor at Garland, for his unwavering support and for the example he sets through his work ethics and values.

I am equally thankful to the employees of both CLG2 and CLM2, whose warm welcome and good humour made every work day a better place. A special word of appreciation is due to the entire Operational Control Department, in particular Joana Cardoso and Miguel Brás, for their constant guidance, and to the Systems Department, especially Adriano Leme, for their technical assistance and readiness to help. I also wish to thank Eng. Miguel Dionísio for his continual availability whenever I needed support.

To my friends, some of whom have accompanied me since my first school days at the Lycée Français de Porto, through Colégio do Rosário, and now at FEUP, thank you for shaping the person I have become. I am especially grateful to António Ferrão, Guilherme Mariz, Gonçalo Roque da Cunha, José Pedro Oliveira, and Gonçalo Leão for sharing the laughter, the pain, the long nights of study, and the unforgettable exam seasons that carried me through this final stage of university life.

I would also like to acknowledge everyone at Quinta de Monserrate Indoor, whose role in sustaining my physical and mental well-being over the past year and a half has been invaluable.

Finally, I owe everything to my family: to my grandparents, my unconditional supporters and greatest fans; to my sister, who challenges me every day to become better and stronger; to my mother, whose boundless love, care, and countless sacrifices sustain me; and to my father, my role model, whose experience, wisdom, and calm judgment guide every important decision I make.

This thesis is as much yours as it is mine.

Contents

Acronyms

API – Application Programming Interface

ATS – Access-control Tracking System

CLG2 – Logistics Center of Gaia 2 (*Centro Logístico de Aveiro 2*)

KPI – Key Performance Indicator

SDG – Sustainable Development Goals

RDT – Radio Data Terminal

UID – Unique Identifier

UTT – Unified Transaction Table

WMS – Warehouse Management System

Image Index

Table Index

1 Introduction

This research project was developed in the context of the 5th-year Dissertation Project of the Master of Science's Degree program in Industrial Engineering and Management at Faculdade de Engenharia da Universidade do Porto, in partnership with Garland Logistics, Lda.

Before diving into the specifics of this project, it is essential to provide an overview of the company where it is being developed, Garland Logistics. This section will briefly introduce the company, its operational context, and its relevance in the logistics sector. Following this, the project's scope and significance will be outlined, emphasizing its relevance in the circumstantial factors where the company is included. Lastly, the structure of this dissertation will be presented to facilitate the understanding of its development and key topics.

1.1 Motivation and Project objectives

In recent years, the logistics industry has become an increasingly competitive global sector, where companies are under growing pressure to optimize operations, reduce costs, and eliminate inefficiencies. As businesses strive to maintain low operational costs while adding value to their final product, logistics companies face an ever-growing challenge: ensuring efficiency in resource allocation, task execution, and real-time data management. Every activity that does not contribute to value creation must either be eliminated or minimized, making process optimization a critical aspect of maintaining competitiveness.

When analyzing the logistics sector in Portugal, this trend is especially relevant, due to its key role in the national economy. Since the pandemic, the Portuguese logistics sector has witnessed a significant increase in its dynamics driven by several factors ultimately aiming to achieve optimized and efficient supply chains. The competition for quality products has become increasingly fierce, highly motivated by more demanding requirements from tenants and stakeholders, mostly linked to non-negotiable efficiency and sustainability goals (Savills Portugal, 2024). When talking about numbers, the sector has a turnover of €14,7 Billion and grew by 31% in 2024, with the take-up level reaching 443,000 square meters, compared to 337,000 in the previous year (Supply Chain Magazine, 2024).

The logistics sector, while traditionally grounded in principles of efficiency and stability, has faced unprecedented challenges that underscore the need for adaptability and innovation. The COVID-19 pandemic, for instance, exposed significant vulnerabilities in global supply chains, prompting a reevaluation of established practices. The disruptions highlighted the fragility of long-standing supply chain models, leading to a shift towards more agile and resilient systems. This shift includes the adoption of technologies such as robotics and autonomous systems to enhance operational flexibility (Friedmann, 2020).

This dissertation is developed at Garland Logistics, more specifically, mainly in its CLG2 logistics center, located in Vila Nova de Gaia and inaugurated in 2022, as can be seen in figure 1, but also having contribution and support from the CLM2 team, located in Maia. Within this operational context, the project addresses a specific need related to how work performed by employees is tracked and recorded. While many logistics activities have already been digitalized, workforce monitoring processes remain manual, resulting in inefficiencies not only in terms of administrative workload but also in the company's ability to ensure that the actual consumption of human resources aligns with the forecasts established in commercial proposals and operational budgets.

The objective of this dissertation project is to analyze and reframe those processes through a structured methodology for collecting and integrating time-tracking data in digital form, aligned with Garland's goals of control, visibility, and cost efficiency.

The project should evolve through a methodical approach based on observation, technical exploration, stakeholder alignment, and incremental development, typical of a case-study, qualitative based approach. Each phase should contribute to distinct insights and deliverables, culminating in a robust prototype designed to address Garland's challenges while setting a foundation for broader digital transformation.

Figure 1 - CLG2, facilities of Garland Logistics, Lda located in Valadares, Vila Nova de Gaia

1.2 Garland Logistics, Lda

Garland was originally established in 1776 by Thomas Garland as an international trading enterprise. Over nearly 250 years of operation, the company has undergone significant transformations. Despite achieving numerous milestones throughout the 19th and 20th centuries, it was not until 1994 that Garland expanded its business portfolio to include logistics services. In 2006, the company introduced a unified international brand to better reflect its core values, and in 2014, it initiated its international expansion, extending operations into Spain and Morocco.

Today, Garland manages over 160,000 square meters of warehousing space in Portugal and offers a wide range of logistics services, enabling full supply chain management through outsourcing solutions. According to data from 2022, Garland completed more than 8 million warehouse picking operations and handled close to 3 million tons of maritime cargo.

The company's operations are structured into four main business units:

- **Logistics**: Focused on outsourced and in-house warehouse management, as well as domestic distribution services.
- **Transport**: Provides international transport solutions by land, sea, and air, and operates in both Spain and Morocco.
- **Navigation**: Offers maritime services, including regular line shipping, tramp shipping, and ship agency services.

- **Corporate**: Encompasses the group's shared services, including investment management and oversight of affiliated companies.

Garland’s corporate culture is shaped by three key attributes: global presence, financial and operational stability, and organizational flexibility. These strengths are built upon a foundation of integrated, global solutions, centuries of accumulated experience, financial robustness, and the ability to adapt swiftly to clients’ evolving needs. Central to Garland’s continued success is its workforce. With more than 440 employees, the company emphasizes that employee satisfaction is fundamental to achieving customer satisfaction. As such, it fosters a workplace environment where each individual feels valued, responsible, and integral to the broader Garland family (Garland, 2016).

Garland’s largest facility is the Logistics Center of Gaia (CLG2), located in Valadares. Opened in 2022, this warehouse reflects the company’s commitment to innovation and sustainability, incorporating modern technologies in energy efficiency, automated goods handling, warehouse management systems (WMS), staff training, and environmental impact reduction. The CLG2 covers 38,000 square meters and can accommodate up to 100,000 pallets, with significant portion of its operations dedicated to supporting the production of bicycles for a key client, contributing meaningfully to the municipality of Gaia’s industrial exports (O Gaiense, 2022). The workforce at CLG2 is organized into four main teams: Value-added services (SAVs), Components, Exportation, and EDC Factory.

1.3 Document Structure

This dissertation is organized into six chapters, each corresponding to a specific phase of the project and contributing to a coherent understanding of its development. Chapter 1 introduced the project’s context, including motivation, organizational setting, and objectives.

Chapter 2 presents the literature review, where key theoretical concepts related to digitalization in logistics, time-tracking systems, process automation, and data management are explored. This chapter aims to contextualize the challenges addressed in this study within a broader academic and industry perspective.

Chapter 3 provides a detailed analysis of the problem and a detailed overview of the methodological approach, establishing the foundations for the analysis that follows.

Chapter 4 provides a detailed analysis of the current system, examining the manual processes used for monitoring worker task time and identifying inefficiencies and integration gaps. It also includes an in-depth review of the existing database structure and data flows that support operational monitoring.

Chapter 5 introduces the proposed system, which focuses on the development of a new digital methodology for tracking time and tasks. It discusses the functional logic, system design, integration with existing technologies, and the strategic use of available infrastructure, particularly NFC and access control devices. It also describes the implementation of the pilot phase.

Chapter 6 presents the main results of the pilot test carried out at the CLG2 logistics center. It evaluates the effectiveness of the new methodology, highlights the challenges encountered during deployment, and discusses the impact on operational efficiency.

Finally, Chapter 7 concludes the dissertation, reflecting on the project’s contributions, and proposing directions for future work, particularly regarding system scalability and potential improvements. Project limitations are also presented.

2 Literature Review

Digital time and task-tracking have shifted from a back-office clock-punch routine to a strategic fulcrum for modern logistics. Advances in technology such as RFID/NFC, wearables and AI analytics now let companies see, often in real time, how labor, assets and information flow through the warehouse. Yet every new wave of monitoring has carried opposite narratives: operational promise on one side, and push-back over privacy, trust and ethics on the other. To unpack this tension, this review traces the evolution of workforce monitoring, examines human-centered digitalization and change-management principles, compares current tracking technologies, and explores governance, legal, ethical and value-realization dimensions. On the other hand, it also includes the data-integration layer that turns raw timestamps into actionable insight. Together, these themes provide the theoretical foundation for the digital tracking solution piloted in this project.

2.1 Historical Evolution of Workforce Monitoring

Workforce monitoring has deep historical roots tracing back to the Industrial Revolution. In 1888, Willard Le Grand Bundy invented the first mechanical time clock in New York, allowing employers to accurately record employees' work hours. This came on the heels of Frederick W. Taylor's principles of scientific management (1911), which formalized time-and-motion studies to maximize labor efficiency. Taylorism ushered in an era where productivity and efficiency became paramount objectives of monitoring, where workers' tasks were broken into measured elements to increase output, also raising throughput, simultaneously transferring shop-floor knowledge to management (Christopher e Holweg, 2022).

By the 1920s-1930s, time clocks had spread widely and were complemented by assembly line monitoring (Henry Ford's production lines) to ensure standardized pacing. However, early on it was observed that monitoring could alter worker behavior: the famed Hawthorne studies (1924–32) revealed that workers improved their performance simply because they knew they were being observed, a phenomenon later called the Hawthorne effect. This hinted at the social repercussions of surveillance, spurring the Human Relations movement as a subtle rebuttal to rigid Taylorism (Purpose & Means, 2023).

Throughout the 20th century, technological advances enabled ever more sophisticated monitoring. Closed-circuit television (CCTV) was adopted in workplaces by the 1970s, originally for security but soon to watch worker performance. By the 1980s and 1990s, computer monitoring emerged: employers tracked keystrokes, software usage, and emails as office work digitalized.

The 2000s saw GPS and telematics used to monitor vehicle fleets and mobile workers; for example, logistics firms equipped trucks with GPS to log routes, speed, and stops, leading to court cases upholding such tracking for efficiency and safety.

In the 2010s, AI-driven analytics and biometric systems began to be integrated, promising predictive insights into productivity and attrition. Especially during the COVID-19 pandemic (2020s), remote-work monitoring software that logs screenshots or idle time saw a surge (Menzies e Hupfer, 2023).

2.2 Human-centered digitalization and change management

While technology enables new heights of oversight, modern thinking emphasizes that digital transformation should be human-centric, especially in logistics and industrial environments that rely on frontline labor.

The paradigm of Industry 5.0 explicitly calls for placing the well-being and empowerment of workers at the center of industrial innovation, rather than treating people as part of an automated machine. This is particularly relevant in high-turnover, labor-intensive sectors like warehousing and logistics, where retaining an engaged workforce is as important as efficiency. Human-centered design principles aim to ensure that any tracking tools or workflow systems are intuitive, safe, and developed with worker input. Thus, involving employees in the design or selection of a new time-tracking app can improve its usability and create a sense of ownership, which makes them more open on using the app and thriving with it (Autor, Mindell e Reynolds, 2020).

Furthermost, research on digital transformation in manufacturing confirms that projects often fail when they are mainly technology-focused and neglect the human and organizational side. In fact, over 70% of digital initiatives fail, frequently due to low user acceptance and inadequate change management. Introducing participatory, user-centered methods can tap into workers' practical knowledge and ease the adoption of new systems (Autor, Mindell e Reynolds, 2020).

On the other hand, equally critical is applying change management frameworks to guide the workforce through transitions (Picado Argüello e González-Prida, 2024):

- **Lewin's Three-Stage Model:** unfreeze current habits, make the change, then refreeze to lock new behaviors in place.
- **Kotter's 8-Step Model:** create urgency, rally a guiding coalition, deliver quick wins, and embed the change in the culture.
- **Prosci ADKAR Model:** drive individual adoption through Awareness, Desire, Knowledge, Ability, and Reinforcement.

High turnover can undermine change efforts if not addressed by ongoing onboarding and a supportive culture. Studies also show that effective change management is linked to higher employee engagement and lower resistance during digital transformations (Institute for Digital Transformation, 2024). On the flip side, poor change practices can lead to stress and attrition – for example, employees may quit if they feel overwhelmed by new monitoring tools introduced without adequate consultation or training (Cheatham, 2022).

A human-centered approach in this context also aligns with Industry 5.0's emphasis on having the wellbeing of the worker at the center of the production process. This means technologies for time/task tracking should be designed with the user in mind: interfaces in the local language, minimal complexity in logging tasks, and considerations for physical comfort. Change management models provide the roadmap to implement these innovations successfully, but it is the human-centric philosophy that ensures the changes enhance work conditions rather than detract from them (European Commission, 2024).

In summary, industry leaders and scholars advocate balancing the drive for efficiency with participatory design, training, and change management, so that logistics workers see digital tracking systems as a helpful augmentation to their work, not a dehumanizing surveillance regime (Cheatham, 2022).

2.3 Workforce Time and Task-Tracking Technologies

Digitalization has vastly expanded the toolbox of technologies available for tracking employee time and tasks. Each comes with trade-offs in transparency, accuracy, user acceptance, and privacy.

2.3.1 Manual time logs

Manual time-logs are very privacy-friendly because workers can write them themselves with very little supervision. On the other hand, accuracy suffers since data can be falsified or entered incorrectly and it's hard to verify. In fact, studies indicate manual inventory counts can be as low as 63% accurate. Such methods also add administrative workload and often lack real-time visibility (CYBRA, 2024).

2.3.2 RFID/NFC badge systems

This technology improved on the previous system by letting employees tap a badge to clock in/out, making the process fast and easy while still capturing essential data (TCP Software, n.d.). Badges are relatively accurate for attendance and shift times, though they mainly log when someone started or ended work, not what they did in between. They are generally accepted by workers as a fair and familiar way to clock hours. Privacy concerns with basic badge systems are limited, since they record only entries/exits and maybe location within a facility, a scope usually seen as reasonable by employees (University of Arkansas, 2009).

2.3.3 AI-driven computer vision systems

AI-driven computer vision systems push tracking to a new level by automatically observing workers through cameras. These promise very granular data but are the most controversial. Workers often cannot easily tell what is being tracked or how images are interpreted, which can breed fear and resistance. The accuracy can be high for specific tasks, but algorithms can also make mistakes. Notably, computer vision used for employee monitoring may push the legal boundaries of what constitutes proportionate and legitimate workplace monitoring, especially as it can capture sensitive biometric data or behaviors not directly related to performance (Eurofound, 2024). Acceptance of AI surveillance is typically low: a recent Harvard Business Review piece bluntly noted that pervasive digital surveillance erodes trust and puts managers in a bind between productivity and morale (Thiel et al., 2024).

2.3.4 Wearable technologies

Wearable technologies occupy the middle ground. These include devices like wearable RFID tags, smart ID badges with sensors, or even smartwatches given to employees. They can yield highly accurate data on a worker's location, steps, or specific motions. When talking about user acceptance, simpler devices that just automate clock-ins tend to be accepted, whereas anything that feels like it might be scoring or watching the worker continuously can breed resentment unless clearly justified (TCP Software, n.d.). Technology Acceptance Model (TAM) principles apply: perceived usefulness and ease-of-use must outweigh any effort or discomfort for the wearer. UTAUT (Unified Theory of Acceptance and Use of Technology) would also note factors like social influence and facilitating conditions as key to adoption (Alshehri, Rutter e Smith, 2021).

2.3.5 Mobile apps

Mobile apps are increasingly common for workforce management, particularly with remote or field logistics staff. Apps can combine functionalities: geolocation (GPS) to confirm where work is done, digital forms to capture task completion, and even communication or gamification features (TCP Software, n.d.).

User acceptance of mobile apps tends to be moderate; many workers appreciate the convenience of using their own device to clock in or view their schedule. Under privacy-by-design principles, such apps should by default limit data collection (for example, only recording

GPS during shift hours). From a regulatory standpoint, if an app were to make automated decisions it could trigger GDPR's provisions on automated decision-making and the AI Act's requirements for high-risk AI in workforce management (Eurofound, 2024).

In summary, organizations must choose the right mix of tracking technologies by balancing precision and control with fairness and acceptance. A hybrid approach is common: for instance, using NFC badges for attendance and a mobile app for task reporting, thereby covering needs without overly intrusive measures. Indeed, guidance suggests considering WICAP factors when selecting a system: Workforce (who will use it), Integrations (with payroll or ERP systems), Compliance (labor laws, works council agreements), Accuracy needs, and Privacy concerns. Ultimately, the best solution is one that provides transparent and accurate tracking to satisfy business goals, while maintaining employee trust and privacy, thus achieving both high compliance and high acceptance (TCP Software, n.d.).

2.4 Process Governance and Rule-Based Workflows

Introducing digital time/task tracking into logistics is not just about technology, it also requires well-defined process governance and workflows to ensure the data is used effectively and fairly. Companies need to establish clear protocols for work tracking: for example, policies on how and when employees should clock in/out, log task completions, or report exceptions. These protocols translate into the configuration of the tracking system and must align with labor regulations

Modern workflow management often leverages standards like BPMN (Business Process Model and Notation) to model and automate these processes. BPMN 2.0 is a widely used process diagramming language (ISO/IEC 19510:2013) that allows organizations to map out sequences of activities and decision rules in a clear, shareable format. Using BPMN or similar, a company can diagram the entire "time tracking and approval" process: start when an employee clocks in, flows through various checks and ends with data stored for payroll. Such formalization helps ensure that tracking is systematic and not arbitrary. It also makes it easier to integrate tracking with other enterprise processes, for example linking an attendance event with a payroll calculation or an update to a production schedule (ProcessMaker, 2023).

Handling exceptions is a critical part of governance. No process runs perfectly: badges get lost, devices malfunction, humans make errors. Companies must define what happens when, say, an employee's clock-in is missed or an unusual output is recorded. Often a workflow sub-process is dedicated to exceptions: for example, generating an alert for manual review if an employee's hours exceed a threshold, or allowing a supervised override to insert a missed clock-in with proper reason codes. This not only ensures fairness but also prevents abuse. Proper exception handling rules also help in maintaining data integrity for analysis, since one cannot improve processes with data if half of it is erroneous or inconsistently recorded (ProcessMaker, 2023).

Finally, aligning with standards and compliance: ISO 9001 (Quality Management Systems) for example requires documented procedures and records, and the use of the process approach and PDCA for continual improvement. A digital time-tracking process can be part of ISO 9001 documentation, demonstrating control of operational processes. ISO standards like ISO 45001 (Occupational Health & Safety) might also intersect – for instance, limiting work hours for safety, which the tracking system can help enforce by flagging excessive hours. Even ISO 27001 (Information Security) becomes relevant, as the tracking system contains personal data that must be protected. Thus, process governance for time/task tracking not only drives efficiency but ensures compliance with legal and certification requirements (Advisera, n.d.).

In essence, successful digital tracking in logistics requires rule-based workflows that mirror business rules and an agile governance that adapts rules as the business evolves. By using formal modeling tools (like BPMN diagrams) and continuous improvement cycles, organizations can institutionalize the use of tracking data for positive outcomes, rather than letting the system run in a vacuum. This ensures that the technology implementation is accompanied by process implementation, anchoring the digital system in the operational fabric of the company (Advisera, n.d.).

2.5 Ethical, Legal and Social Implications of Employee Monitoring

The deployment of employee monitoring and tracking technologies raises profound ethical, legal, and social issues. In the European context, regulations like the General Data Protection Regulation (GDPR) and the upcoming EU AI Act (2024) set boundaries on how far employers can go in surveilling workers and what safeguards must be in place. There is also the human aspect: considerations of trust, autonomy, and dignity in the workplace.

Under GDPR, any processing of employees' personal data must have a lawful basis and respect principles like transparency, data minimization, and purpose limitation. European regulators have shown they will enforce these rights: the H&M case in Germany (2020) demonstrated that excessive collection of employees' personal details without clear necessity or transparency violates GDPR, leading to a €35 million fine (Hamburg DPA, 2020).

Companies are expected to conduct Data Protection Impact Assessments (DPIAs) for high-risk monitoring, especially when using new technologies like intelligent CCTV that could significantly affect employees' rights. Additionally, GDPR enforces transparency: workers should be clearly informed about what is being monitored, how data will be used, and their rights. On the other hand, GDPR also grants employees the right to request their data and in some cases to object to processing – an employer needs strong justification to override an objection if monitoring is seen as highly intrusive (Eurofound, 2024).

When AI or algorithms are involved in monitoring, transparency and fairness become critical. The EU AI Act, poised to be one of the first comprehensive AI regulations, explicitly lists AI systems for workforce management as high-risk applications. Providers of the AI must perform risk management and self-conformity assessments, ensuring the AI's outputs do not violate fundamental rights. There are requirements for human oversight, meaning decisions significantly affecting employees shouldn't be made by AI alone without human review. If implemented strongly, the EU AI Act will reinforce that employers must be accountable for algorithmic decisions and likely will require that employees can appeal or get explanations for algorithmic actions (Eurofound, 2024).

Ethically, pervasive monitoring can undermine the trust relationship between employer and employee. If workers feel constantly watched, it may erode their sense of autonomy and dignity at work. A peer-reviewed study by Kalischko & Riedl (2024) found that employees' perception of electronic performance monitoring (EPM) significantly increases feelings of privacy invasion, reduces organizational trust, and increases stress, ultimately even reducing job performance (Müller et al., 2021). In order to fight this, The European Court of Human Rights (ECHR) has ruled that disproportionate workplace surveillance can violate the right to privacy and, thus, national laws often require informing and consulting employees before surveillance measures; for example, in Spain and Italy, use of CCTV and geolocators at work must be disclosed and sometimes agreed with unions (Eurofound, 2024).

In conclusion, the ethical and legal landscape demands that digital tracking systems be deployed responsibly and lawfully. GDPR and the AI Act form a regulatory one-two punch ensuring data protection and algorithmic accountability, while the broader societal expectation is that workers' privacy, autonomy, and dignity are honored even as new technologies are introduced. Companies that navigate these issues well, obtaining employee buy-in, complying with the law, and respecting boundaries, are more likely to enjoy trust and avoid the backlash that can otherwise accompany too much control.

2.6 Impact and Value Realization of Monitoring Systems

When implementing digital time and task tracking, organizations seek a favorable impact on performance and value, but the outcomes can be mixed, and there are trade-offs to consider. This section reviews evidence on the benefits (productivity, quality, cost-efficiency, safety, etc.) and the risks (morale issues, stress, privacy costs) of workforce monitoring, as well as how value can be measured and realized in practice.

2.6.1 Productivity and Efficiency Gains

Digital tracking solutions significantly enhance productivity by streamlining workflows and reducing operational downtime. For instance, DHL Supply Chain documented a productivity increase of approximately 15% following the implementation of RFID-based task tracking, which replaced manual verification processes and improved real-time operational visibility (DHL, 2023). Similarly, Amazon reported improved operational throughput after adopting real-time monitoring systems that rapidly identified workflow bottlenecks, enabling proactive task reallocations (Reuters, 2023). These types of digital systems also provide precise data to reduce payroll inaccuracies, minimize administrative overhead from manual timesheet processing, and decrease instances of time theft or extended breaks. Overall, the accurate, real-time insights afforded by digital monitoring support dynamic and efficient resource management, directly translating into measurable efficiency improvements and cost reductions (PwC, 2024).

2.6.2 Quality and Customer Service

Beyond raw productivity, tracking can indirectly improve quality and service levels. In logistics, knowing exactly when tasks are completed allows for tighter control of on-time performance. For example, if a warehouse process is monitored end-to-end, the company can more reliably promise and meet shipment deadlines, because any delay in one step triggers immediate countermeasures. Some systems tie quality checks into task tracking which can reduce errors. There is evidence that well-implemented monitoring correlates with lower error rates and higher consistency, because workers follow procedures more rigorously when they know steps are being logged. However, these benefits are maximized when monitoring is not about harassing employees, but about ensuring process adherence and providing feedback loops for improvement (Gaukler & Seifert, 2007).

2.6.3 Safety and Ergonomics

Monitoring can enhance workplace safety. For instance, tracking hours ensures compliance with work-rest regulations. In Amazon’s case, the company argued that its warehouse monitoring was partly to ensure safety and efficiency in operations. When used constructively, monitoring tools can alert management to safety risks so they can intervene before an incident occurs. Lastly, there is also an environmental angle: efficiency improvements (optimized routing, reduced idle time) can lower energy use and waste, contributing to sustainability, though these benefits are less frequently measured directly (Reuters, 2024).

2.6.4 Value Realization and Measurement

Real-time workforce monitoring transforms operational decision-making from retrospective to predictive. Continuous location and activity feeds expose bottlenecks as they form, letting supervisors redeploy labor, resequencing tasks and smooth flow before delays propagate. Empirical work on supply-chain analytics shows that organizations using real-time data shorten decision cycles, recover faster from demand shocks and raise overall agility, because managers can intervene the moment throughput drops rather than waiting for end-of-day reports (Sharma e Bhardwaj, 2021).

Because savings accrue every day while the hardware and integration costs are largely one-off, payback can be rapid when a clear pain-point, such as payroll errors or chronic picking delays, is targeted. RFID Journal's industry calculator, built from documented deployments in apparel and general merchandise, shows that a typical store breaks even in under twelve months once labor savings from automated counts and the uplift from fewer mis-picks are included; after that point the system contributes directly to margin improvement (Roberti, 2019).

Yet intensified monitoring is not a free good. A recent meta-analysis covering ninety-four independent samples (N = 23 461) reports no reliable gain in average job performance from electronic surveillance, but a significant rise in employee stress ($r \approx .11$). Crucially, the same study finds that transparency and low intrusiveness moderate negative reactions, whereas opaque or highly granular tracking erodes trust and can trigger attrition that wipes out efficiency gains (Tomczak et al., 2022).

In short, real-time data delivers tangible ROI only when paired with a social contract that makes the system transparent, minimally intrusive and obviously useful to the people being measured.

2.7 Data Integration and Analytics for Operational Insights

One of the most powerful aspects of digital time and task tracking is the data it generates, which can be integrated and analyzed to drive actionable insights and real-time decision-making. In modern logistics, this often means consolidating disparate data streams into unified transaction tables or event logs, and leveraging techniques like process mining, data warehousing, and real-time analytics to optimize operations.

2.7.1 Unified Data and Integration

Logistics processes typically span multiple systems, for example Human Resources systems for time attendance, Warehouse Management Systems (WMS) for inventory and task data, Transport Management Systems (TMS) for deliveries, IoT sensors for equipment usage, and others

To get a complete operational picture, data from these sources must be merged. The best practice is creating a unified data warehouse where all relevant events are recorded with common reference points (timestamps, employee IDs, order IDs, etc.). For example, an event table might record each significant action: an order picked (with who, when, where), a vehicle loaded, a departure, etc. Integrating these allows analysis of end-to-end process performance. As one process mining solution provider notes, process mining brings together the different data sources, enabling a holistic view of the supply chain, by integrating ERP, WMS, TMS, and IoT data into one transparent model (Process Science, s.d.).

2.7.2 Real-Time Monitoring and Operational Decisions

Integrating tracking data into real-time dashboards or control towers allows immediate decision-making. Many warehouses now have live dashboards showing key. If data is streaming from the tracking system, managers can make quick decisions like reassigning staff, calling in reinforcements, or reorganizing work zones during a shift rather than after problems have already occurred. A logistics blog emphasizes that real-time data provides warehouse managers with a live view of operations, enabling them to quickly identify and rectify inefficiencies, for example by adjusting workflows or reallocating resources on the. This proactive adjustment is a key benefit – it converts the tracking system from a passive record-keeper into an active operational tool. For instance, if an unusual number of workers have not clocked back in from break on time, a supervisor sees that immediately and can investigate or temporarily shift others to cover. Or if order throughput is lagging by noon, they might extend shifts or delay a truck's departure accordingly (Daguer Logistics, n.d.).

2.7.3 Analytics and AI

With unified data, organizations can apply advanced analytics or AI algorithms to extract insights. For example, predictive analytics might use historical task timing data to forecast how many staff are needed next week or to predict which shipments might be delayed. Machine learning models could be trained on task performance data to identify factors leading to errors. People analytics might analyze time tracking alongside HR data to find correlations between attendance patterns and turnover or performance. Another emerging field is using tracking data for automated process optimization, for example algorithms that dynamically assign tasks to workers in real-time based on who is free and best qualified, essentially an AI dispatcher. These rely on continuous streams of data about task status and worker availability (McKinsey, 2024).

2.7.4 Challenges and Best Practices

Integrating data isn't trivial: systems compatibility, data quality, and timeliness are big challenges. Timestamp synchronization issues can introduce errors and imperfect log data can mislead analyses. It's important to ensure data quality by design: the tracking systems should log events consistently and with useful detail (who, what, when, context). Many organizations adopt common identifiers, such as employer IDs, across systems to ease merging. Additionally, privacy and ethical use of integrated data remains important, since that just because you can link everything doesn't mean every analysis is fair game. Aggregation and role-based access to analysis tools can ensure that, say, individual performance data is only accessible to appropriate supervisors, and higher-level analyses are anonymized (Lim, Richards e Pan, 2013).

In conclusion, data integration and analytics are the "brain" that turns raw tracking data into smart decisions. By unifying event logs and employing process mining and real-time dashboards, logistics companies can gain unprecedented transparency into their processes. This enables moving from reactive management to proactive and even predictive management. In the fast-paced logistics sector, where margins are thin and customer expectations for speed are ever rising, this kind of data-driven agility can be a decisive competitive advantage. The key is not just having data, but integrating and analyzing it in a way that directly supports decision-makers on the warehouse floor and in the planning office. Those who succeed in this will effectively create a real-time feedback loop for continuous improvement, driving both efficiency and responsiveness in their operations. As one logistics tech firm put it, the result is increased efficiency along the entire supply chain, that is ultimately a goal well worth the investment in integration and analytics capabilities (Process Science, n.d.).

3 Problem definition and methodology

3.1 Problem Definition

CLG2 currently employs approximately 60 workers, divided into two main groups: those whose work is monitored and those who are not. The non-monitored group includes directors and certain supervisory roles, whereas the monitored group comprises both operational personnel, responsible for physical warehouse tasks, and administrative staff, whose roles support the operational flow from within the site. Some of its main challenges, as is also seen across many logistic service providers, such as Garland, lie in the fact that there is high rotation on the operational staff. This phenomenon is often driven by the nature of the work itself, which can be physically demanding, repetitive, and subject to tight deadlines. Moreover, the reliance on a less stable or transient workforce, often composed of temporary workers or individuals with lower job commitment, further contributes to this instability. Thus, this can lead to several challenges, such as increased training costs, reduced productivity, and a loss of operational knowledge, which makes operational changes harder to implement.

Additionally, despite the diversity of functions, all monitored employees follow a manual procedure to report on their daily activity. At the end of each workday, each worker is expected to fill in a task tracking sheet, specifying the tasks performed, the time in each task and the clients served throughout the day. This information is analyzed, filtered, and confirmed by the Operation Control Department, and later used by internal teams for operational oversight and resource allocation purposes.

However, this process presents significant limitations. The manual nature of data collection introduces risks of inaccuracy, delay, and inefficiency, both in terms of administrative burden and the reliability of the information gathered. Moreover, the absence of automation hinders the company’s ability to ensure that the actual use of human resources is aligned with the planning parameters defined in commercial proposals and budget forecasts. In a highly competitive and data-driven industry, this disconnection between execution and planning can affect cost control, client reporting, and overall process visibility.

In response to the limitations of the current manual tracking process, this project aims to develop a structured, digital methodology for monitoring the time workers spend on each task throughout the day. Its primary goal is to automate the collection of task-related data in a reliable and standardized format, enabling real-time visibility over operational execution and reducing the administrative burden placed on both employees and support staff. Additionally, the project seeks to ensure that the recorded information aligns accurately with the planning assumptions defined in commercial proposals and internal budgeting.

By enhancing transparency and traceability in workforce management, this project should contribute directly to Garland’s strategic objectives of operational control, data consistency, and cost optimization. Sustainability improvements are also implemented in this project, due to the huge decrease in the use of paper sheets currently used in the manual process.

3.2 Methodology

While quantitative research methodologies are traditionally employed to test hypotheses through statistical analysis and controlled experimentation, they often fall short in capturing the nuances of organizational contexts, particularly when dealing with socio-technical systems. In contrast, qualitative research approaches are better suited to investigate real world processes marked by human interaction, dynamic environments, and evolving structures. They allow for a more interpretative and flexible examination of phenomena, emphasizing the understanding of meanings, experiences, and contextual factors (Creswell, 2009).

Qualitative research often involves primary data collection, typically through textual or first-hand accounts such as interviews, field notes, and observational records. Due to practical constraints, qualitative research may not allow for data collection from the entire population, which can limit the generalizability of findings. Nevertheless, it offers a rich and nuanced understanding of the studied phenomena (Taherdoost, 2022).

There are five main research strategies in qualitative research, each with a distinct function and set of applications. Analysing and interpreting people's stories and experiences is at the heart of narrative research. The goal of phenomenology is to convey the commonality of a phenomenon as it is experienced by numerous people. Creating a theory based on data that has been methodically collected and examined is the main goal of grounded theory. Ethnography is the study of a particular group's culture and collective behaviours in their natural setting. To obtain a deeper understanding of the complexities of a particular case, process, or context, the case study method is employed to conduct a thorough investigation (Taherdoost, 2022 and Creswell ,2009) .

Given the objectives and the nature of the problem in hand a qualitative research approach will be adopted. Among the various qualitative methodologies available, the case study approach is particularly appropriate for this research. According to Yin (2014), case studies are recommended when the objective is to explore contemporary events within their actual organizational context, especially in situations where the boundaries between the phenomenon under investigation and the context in which it occurs are not clearly delineated. Given the complexity of the logistics environment at CLG2, where technology, human behavior, organizational routines, and infrastructure are deeply interlinked, the case study methodology provides the necessary framework to analyze the interplay of these elements in a comprehensive and structured manner.

With this in mind, a structured three phase methodology was adopted to ensure that the proposed solution aligned both technically and operationally with the company's reality:

Phase 1: System Analysis and Contextualization

The first phase of the project will involve a comprehensive analysis of the current operational context, with a specific focus on the CLG2 logistics center. This includes the characterization of the workforce structure, distinguishing between monitored and non-monitored roles, and also the close following of daily operational routines executed by administrative and operational employees. Special attention will be paid to the procedures used for reporting work, particularly the completion of manual monitoring sheets at the end of each workday.

The analysis will also consider the degree of worker turnover, especially among operational staff, and its implications for system scalability, training demands, and process reliability. By immersing in the organizational routines and mapping the role of different departments, the goal is to obtain a grounded understanding of how time-tracking information currently flows across functions.

This phase will culminate in a process mapping of the manual tracking workflow, identifying actors, data dependencies, document flows, and pain points. This understanding will form the foundation for identifying digitalization opportunities and ensuring that any new system respects existing operational constraints.

Phase 2: Solution Design and Architecture

The second phase will focus on the design of the proposed digital monitoring solution. This includes defining a system architecture capable of automating the collection of worker task monitoring data, while ensuring its compatibility with Garland's existing infrastructure and operational requirements.

A critical step in this phase will be the reverse engineering and analysis of existing databases. Through the exploration of legacy queries, table structures, and historical SQL logic, the project aims to understand how these systems interact, what information they record, and how they are currently used for billing, internal reporting, and human resource management. This analysis will allow the definition of a replacement logic that guarantees data continuity and supports integration in the current systems.

Phase 3: Pilot implementation and testing

The third and final phase will consist of deploying the designed system in a controlled pilot environment at CLG2. This implementation will be accompanied by training sessions for all monitored staff, including interactive demonstrations and visual instructions on how to use the new forms and card readers.

During the pilot, the manual and digital monitoring systems will operate in parallel, allowing for comparative analysis and validation. Data will be collected from both systems and analyzed to assess accuracy, completeness, and user compliance. The project will also gather feedback from different stakeholder groups, including operational workers, supervisors, administrative staff, and security personnel, to evaluate usability, acceptance, and potential resistance.

This dual-pronged evaluation, quantitative and qualitative, will support an informed assessment of the solution's feasibility and added value. Insights from the pilot will guide the final adjustments needed before full-scale implementation and provide a roadmap for extending the solution to other logistics centers within the Garland network.

4 Description of existing procedures at CLG2

Before proposing any new system, it's essential to understand how things currently work on the ground. This chapter presents the existing processes used at Garland Logistics' CLG2 facility, especially the ones used to track worker time and tasks. It describes how operations are structured, how task information is collected and processed, and which systems and databases are involved. By mapping out these procedures in detail, it becomes clear where the main limitations lie, particularly, when it comes to accuracy, efficiency, and real-time visibility. These insights serve as the foundation for the digital transformation proposed in the next chapter.

4.1 Operational context

Understanding the operational context of the CLG2 warehouse is key to framing the current practices and processes. As the pilot location for this transformation, CLG2 exemplifies Garland Logistics' efforts to modernize its internal processes and tackle various organizational challenges. This section describes the physical and functional structure of the facility, workforce organization, and machinery in use, with special emphasis on the human resource dynamics.

4.1.1 Warehouse

CLG2 is Garland's largest logistics platform. Strategically located near two of the country's main highways, A29 and A44, this logistics center offers 38,000 m² of warehouse space and 56 docks, allowing high throughput of goods and diverse operational workflows.

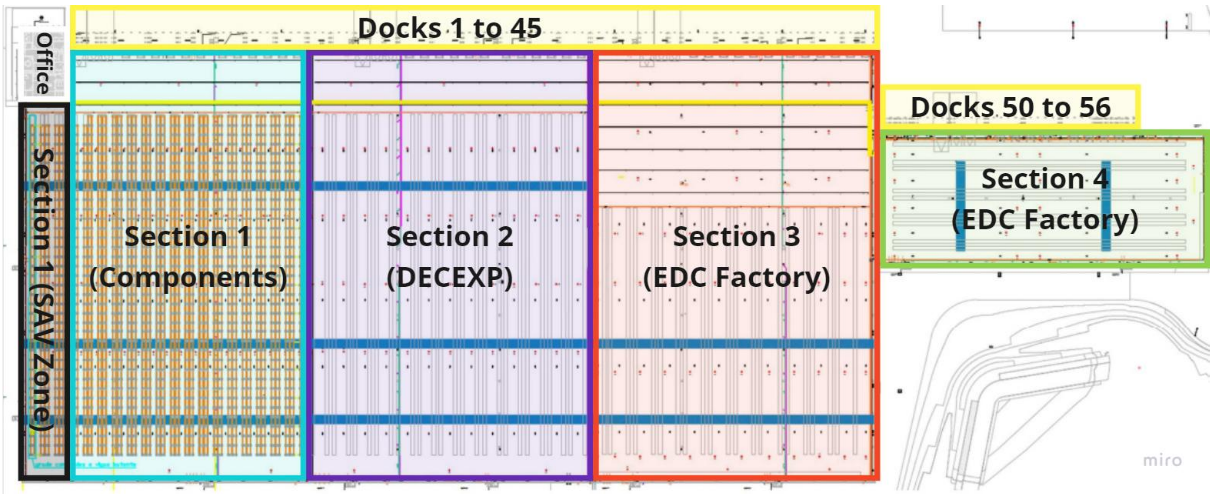


Figure 2 – Layout Organization of CLG2

The warehouse is organized into four main zones, as shown in Figure 2 — SAV (Value-added services), Components, Exportations (DECEXP) and EDC Factory. Each with specific service flows and client focus. The facility's layout enables parallel operations with minimal cross-path interference, supporting Garland's ambition for operational efficiency and high service levels.

4.1.2 Workforce

The daily operations at CLG2 are supported by approximately 60 workers, divided into three functional groups: operational workers, administrative workers, who are both monitored, and non-monitored staff such as directors and supervisors. These teams are distributed across three shifts, operating from Monday to Friday, from 07h00 to 01h00 to ensure uninterrupted operational coverage. Table 1 shows the distribution of workers per shift based on current shift planning.

Table 1 - Human resources distribution at CLG2

Shift	Operational Coordinators	Team Managers	Operators	Total
07h - 16h	1	0	10	11
08h - 17h	2	1	35	38
17h - 01h	1	0	10	11
Total	4	1	55	60

Each shift includes two scheduled 15-minute breaks and a one-hour interval for either lunch or dinner. While the shift structure is formally established, operational flexibility is routinely applied to accommodate the fluctuating demands of the warehouse. When necessary, workers may be reassigned to different shifts or teams to ensure balanced workloads and meet service requirements. Additionally, the number of employees present during each time block may vary from the values shown in Table 1, as staffing levels are periodically adjusted in response to seasonal or client-driven changes in activity.

A notable aspect of the CLG2 workforce is the high turnover rate, which is partially due to the strong presence of temporary workers supplied by staffing agencies like Randstad. Temporary workers typically operate under contracts of limited duration and only acquire permanent status (as Garland employees) after fulfilling predefined conditions, such as maintaining continuous service over a three-year period. As a result, the workforce composition fluctuates frequently, increasing the complexity of personnel management and access control.

4.1.3 Company Card

To manage the complexity mentioned in 4.1.2, Garland utilizes a Company Card system, shown by Figure 3, which assigns each worker an NFC (Near-Field Communication) based card, with unique identification, that grants access to various facilities, such as the warehouse or administrative offices, but also gives access to log in the warehouse machinery, for those who have the necessary training and capacity to use them.

Figure 3 - NFC-enabled company card

Permanent employees are issued personal cards tied to their worker profile, whereas temporary employees receive generic temporary cards without personalized identification. These cards are distributed by the security on the worker's first day and are reused across different users, depending on availability. In practice, when a new temporary worker arrives, they are assigned a random available card, which they are expected to retain while working at CLG2.

4.1.4 Machinery

In support of its warehouse operations, CLG2 is equipped with 24 handling machines including turret trucks, reach trucks, stackers, and pedestrian pallet trucks, in the quantities shown in Table 2. These machines are essential for activities such as inbound unloading, inventory repositioning, and outbound preparation. Some of them are shared across sections, while others are dedicated to specific client flows.

Table 2 – Equipment used at CLG2

Equipment	**Quantity**
Pedestrian Pallet Truck	15
Stacker	2
Reach Truck	2
Turret Truck	5
Total	**24**

All motorized equipment is equipped with an onboard login interface that requires workers to authenticate themselves using their Company Card. This feature provides an opportunity to track machine usage, shocks, equipment tracking and health. However, due to current system constraints, the data retrieved from these machines is limited since it records only the time of login and logout, without direct association to the task being performed or the client being served.

4.2 Warehouse Management Systems

In addition to the physical and human infrastructure described previously, the CLG2 logistics center is supported by a range of digital systems that facilitate operational control, data collection, and real-time decision-making. This section describes three key systems: Access-Control Tracking System (ATS), WMS Dispatcher (JDA), and the Jungheinrich machine interfaces, who are currently some of the top-end interfaces available.

4.2.1 Access-Control Tracking System (ATS)

The ATS deployed at Garland's facilities operates as the digital backbone for registering personnel movements across key control points within the premises. Every entrance and exit through designated doors, such as those at the site perimeter, warehouse access zones, and administrative areas, is logged via NFC-enabled card readers, capturing essential data for physical access monitoring. At the moment, its data is managed both by the security team and the Maintenance department.

Each ATS event records a timestamp, a reader location, and the UID (Unique Identifier) of the card presented. This provides a reliable and hardware-level record of the moments when an employee moves between different operational zones or leaves/enters the facility, additionally impeaching access to restricted zones.

Thus, the effectiveness of the ATS data is also influenced by how consistently access cards are assigned and used. While permanent employees maintain stable NFC credentials, temporary staff may be issued generic or recycled cards, occasionally without individual identification. This variation in card management can reduce the precision of access-based analyses if not reconciled with a parallel identification system.

Nonetheless, the ATS constitutes an essential part of Garland's digital infrastructure, contributing to security, traceability, and administrative control. It was not originally designed for workforce task monitoring but plays a relevant role in understanding the movement patterns and temporal distribution of labor across the facility.

4.2.2 WMS Dispatcher JDA

Garland Logistics operates a Warehouse Management System (WMS) powered by the JDA Dispatcher, a widely used platform in the logistics industry for overseeing inventory control, order processing, and warehouse task execution. This system constitutes the digital backbone of Garland's inventory-related workflows and integrates with both administrative interfaces and Radio Data Terminals (RDTs), which are handheld mobile devices used by workers on the warehouse floor.

The Dispatcher interface is used by team leaders or office staff and allows the configuration of warehouse zones, stock locations, order picking instructions, and task allocation. Meanwhile, the RDTs act as mobile extensions of the WMS, enabling warehouse operators to perform real-time inventory movements, validate task completion, and interact with the system during physical handling operations. Through the RDTs, operational workers receive task assignments, scan barcodes, confirm item quantities, and register task completion. These devices are typically connected via Wi-Fi and synchronize directly with the Dispatcher system, ensuring consistency between physical operations and their digital representation.

However, the workflow involving RDTs is not without limitations. One of the key constraints lies in data granularity and timestamp reliability. Although workers are instructed to record their activities as they perform them, it is common for operators to accumulate several actions and register them all at once at the end of the task. This lag reduces the temporal accuracy of the data and can lead to discrepancies when used for time-sensitive metrics. Additionally, the use of RDTs is directly coupled with inventory movement, meaning that tasks without material handling components, or activities not requiring barcode validation, may go unregistered in this system.

Despite these drawbacks, the WMS Dispatcher and RDT ecosystem remains central to Garland's warehouse operations. It ensures strong control over stock integrity, order execution, and task workflows, especially for those operations integrated with physical inventory.

4.2.3 Jungheinrich APIS

Jungheinrich is the equipment provider responsible for supplying a significant portion of the electric handling machines in operation at Garland's logistics centers. These machines are typically assigned to specific logistical functions such as picking, stock relocation, and inbound/outbound flows.

To complement hardware deployment, Jungheinrich offers a set of digital APIs that enable companies to interface with machine-generated data for operational monitoring. These APIs allow the retrieval of structured datasets, including machine identifiers, operator logs, timestamps of usage, and occasionally additional metadata like duration of usage, task selection, or equipment location. An example of data is retrieved is showed in Figure 5.

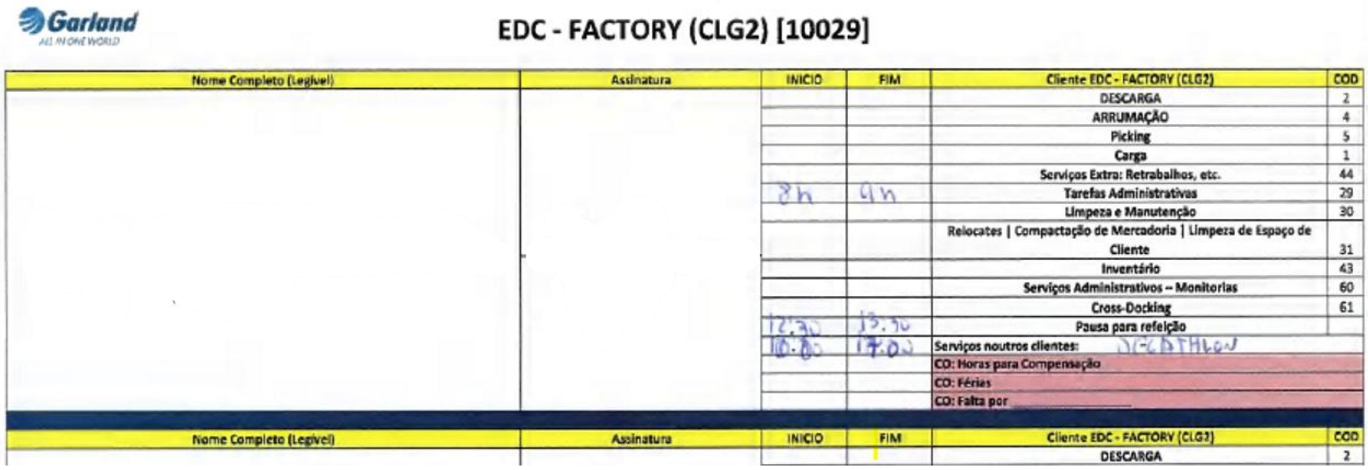

```json
{
  "equipmentNumber":"test_cw",
  "equipmentId": "790f3ce0e4d9f2e9fe51a91f826602e46bb001173de9451311892c426ce57bd8",
  "operationStartDate":"2023-03-10T17:22:22.000Z",
  "operationEndDate":"2023-03-10T17:27:22.262Z",
  "operationDuration":"0:05:00.262000",
  "reason":"timeout",
  "multiLogin":5,
  "transponderId": "1234567890",
  "employeeWasCleared": false
}
```


Figure 4 -Example of APIs output

The main objective of these APIs is to improve transparency and efficiency in fleet management by providing access to usage records, which can be integrated into broader warehouse performance analysis. This data is especially useful when it comes to evaluating equipment utilization, maintenance needs, and general task distribution among machines. In addition, there are some additional services that make this information more complete: with the use of pre-op checks, that is a set of questions that the worker must answer before being able to use the machine, data retrieved can be much more valuable.

4.3 Monitoring Sheet

At the end of each workday, every operational and administrative worker at CLG2 is required to manually complete a standardized monitoring sheet detailing the tasks performed during their shift. These sheets are organized by client and contain predefined lists of activities, allowing workers to select the appropriate tasks and assign estimated durations. Each client has its own dedicated form, with structured rows corresponding to the specific services rendered (Figure 5). Task durations must be recorded in fixed 30-minute increments, a constraint that limits temporal granularity and often fails to reflect the true variation in task lengths



EDC - FACTORY (CLG2) [10029]

Nome Completo (Legível)	Assinatura	INICIO	FIM	Cliente EDC - FACTORY (CLG2)	COD
				DESCARGA	2
				ARRUMAÇÃO	4
				Picking	5
				Carga	1
				Serviços Extra: Retrabalhos, etc.	44
		8h	9h	Tarefas Administrativas	29
				Limpeza e Manutenção	30
				Relocates | Compactação de Mercadoria | Limpeza de Espaço de Cliente	31
				Inventário	43
				Serviços Administrativos – Monitorias	60
				Cross-Docking	61
		12:30	13:30	Pausa para refeição	
		10:00	17:00	Serviços noutros clientes: DECATHLON	
				CO: Horas para Compensação	
				CO: Férias	
				CO: Falta por	
Nome Completo (Legível)	Assinatura	INICIO	FIM	Cliente EDC - FACTORY (CLG2)	COD
				DESCARGA	2

Figure 5 - Monitoring sheet for client EDC-Factory

Crucially, this process is entirely retrospective. No real-time logging occurs during task execution. As a result, the accuracy of the recorded data depends entirely on each worker's memory and subjective interpretation of their workday. In fast-paced warehouse environments where multitasking and task-switching are common, this leads to frequent approximations, potential omissions of shorter tasks, and inconsistencies in reporting break periods, such as lunch. There is also no built-in mechanism to verify whether reported times align with actual start and end moments, nor to account for spontaneous adjustments in task assignment during the day. While the standardized format offers structural consistency, the lack of immediacy and validation makes this monitoring approach inherently limited in precision and reliability.

4.4 Databasis Structure

Garland Logistics' current system for tracking workforce time and task data is supported by a chain of interdependent databases. Four core systems are involved in this process: BD Ponto, BD Tempos, BD Monitorias, and BD Custos. Each plays a specific role in transforming raw activity data into actionable business intelligence, particularly in the areas of performance monitoring, cost attribution, and client billing.

BD Ponto

BD Ponto is the primary repository for entrance and exit timestamps, collected manually via the site's security team. It logs daily presence data for each employee and serves as the baseline for verifying attendance and working hours, as can be seen in Figure 6. While robust in terms of time precision and reliability, this database is purely focused on physical presence, since it does not record which task was performed, for which client, or at what moment within the workday. Still, it is essential for validating the total working hours claimed in other systems and forms the foundation of Garland's hour bank system (Appendix A), which governs vacation days, overtime, and absence balances. BD Ponto is also central to this project's transformation scope, as its timekeeping role must be preserved even as task monitoring is digitized.

Data	idfunc	entrada	saida
05/03/2025	2454	16:06:00	01:49:00
05/03/2025	3968	16:49:00	01:48:00
05/03/2025	3761	16:04:00	01:49:00
05/03/2025	3645	08:47:00	10:27:00
05/03/2025	3559	16:16:00	01:08:00
05/03/2025	3555	07:54:00	17:09:00

Figure 6 - Table of BD Ponto, representing entrance and exit hours

BD Tempos

BD Tempos is the main database for recording task-level operational data, including the duration, type of service, client, and the employee responsible, as Figure 7 shows. This information is sourced from the manual monitoring sheets filled out by workers and subsequently manually processed by the Operational Control team. It is in BD Tempos where most of the current inefficiencies reside. Since time estimations are subjective, data is manually transcribed and reporting delays are common. Despite being the only structured record of what tasks were performed and for whom, its data reliability is often questioned due to inconsistencies with BD Ponto, vague or missing entries, and the time lag between execution and data entry. As such, BD Tempos is the primary target for digital replacement.

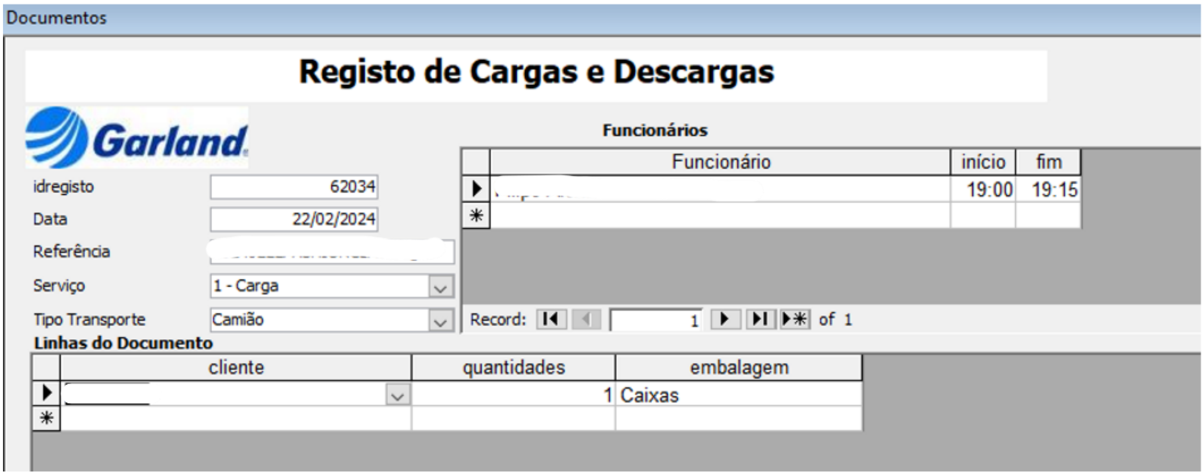


Figure 7 - Record of time and task, for a specific client in BD Tempos

BD Monitorias

BD Monitorias serves as the central aggregation layer where data from both BD Ponto and BD Tempos is consolidated. It functions as the main reference for internal monitoring, resource planning, and reporting. In addition to receiving input from the other two databases, BD Monitorias maintains worker profiles, predefined schedules, and allocation rules, creating a dynamic, rule-based model of workforce activity. Although it is not to be eliminated or replaced, this database must continue to receive all current information with equal or greater accuracy under the new system to continue to be as useful as it is. Its role is critical: not only is the only place in the company´s systems that associates a worker with a unique identifier (also known as IDFUNC), but also the downstreaming of information to systems such as BD Custos depend on it to produce reliable financial and performance insights. Figure 8 shows the main control platform of BDMonitorias, where the previously detailed information is gathered

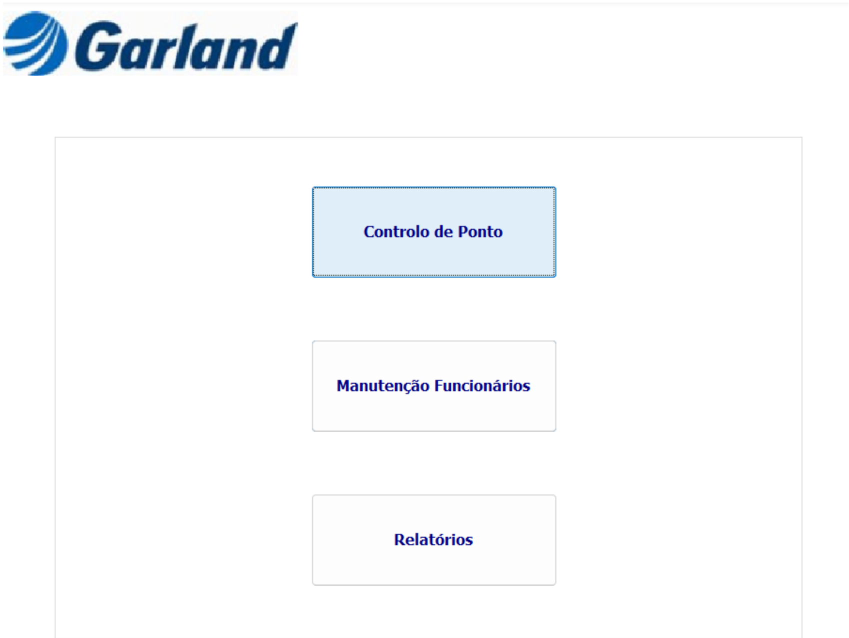


Figure 8 - BD Monitorias main forms

BD Custos

BD Custos is Garland's internal system for cost control and financial analysis. It processes validated information from BD Monitorias to determine key outputs, including:

- Cost attribution per client and logistics center;
- Labor intensity and efficiency metrics per department;
- Human resource consumption reports for budgeting and strategic planning.

Although BD Custos is not directly in the scope of the project, its output relies entirely on the integrity of upstream data. Any error or inaccuracy in BD Tempos or BD Ponto inevitably propagates downstream, compromising billing accuracy, client trust, and internal financial planning.

In summary, the current system depends on a sequential chain of data flows. As detailed in Figure 9, BD Tempos and BD Ponto serve as the input layers, BD Monitorias consolidates and enriches the data, and BD Custos interprets it for financial and strategic decision-making. The effectiveness of this chain depends on timeliness, accuracy, and interoperability, three qualities currently hampered by manual input and fragmented data collection.

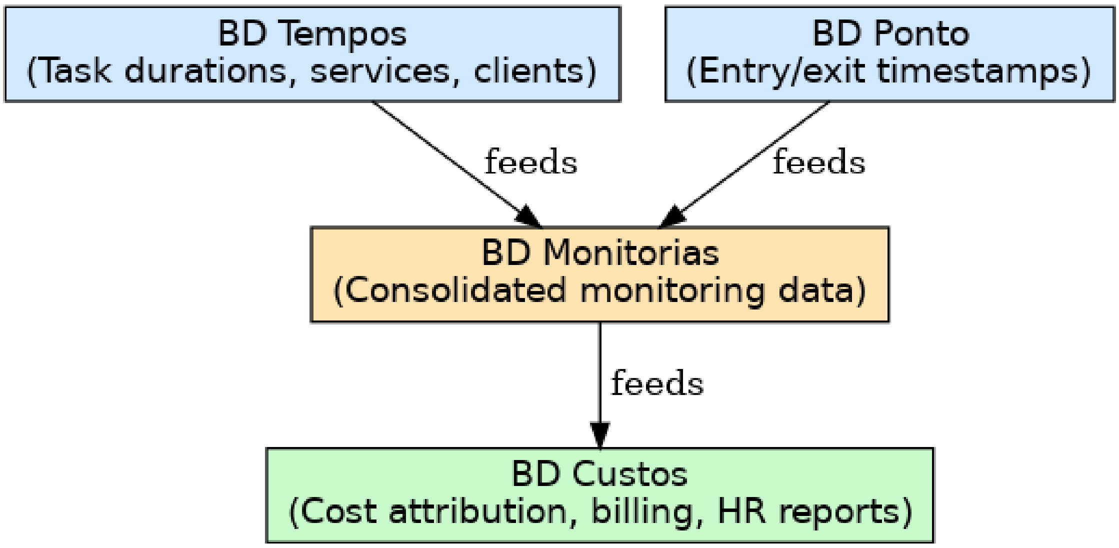


Figure 9 - DataBasis Flowchart

4.5 Task Monitoring Process Workflow

The task monitoring process currently in place at Garland Logistics is structured around a set of manual procedures involving operational workers, administrative staff, and supervisors. While this system has reliably supported the day-to-day functioning of the warehouse, it is rooted in legacy practices that depend on handwritten records and human coordination. This section provides an overview of how task time data is currently collected, reviewed, and processed, outlining the key steps in the workflow as well as the roles and responsibilities involved. Understanding this process in detail is essential for identifying areas where digital integration can enhance accuracy, streamline operations, and support the company's evolving needs.

The process begins at the end of each shift, when operational workers are required to complete the standardized monitoring sheet presented in section 4.3.

Once the sheets are submitted, the responsibility shifts to the Operational Control department. Here, administrative staff undertake a preliminary review of the reported durations. Their primary role is to verify coherence between the total task time declared on the monitoring sheet and the official attendance records stored in BD Ponto. Discrepancies are common. For instance, it is not unusual for a worker's reported start time to precede their first recorded entry in the access control system, or for the sum of task durations to exceed the length of the actual shift.

Supervisors are not directly involved in validating these records but act as intermediaries when anomalies are detected. Since they are responsible for allocating tasks and overseeing execution throughout the day, they are often called upon to clarify irregularities—such as informal break times, deviations from assigned tasks, or unplanned operational disruptions. This verification loop between administrative staff and supervisors introduces delays and adds an additional layer of manual coordination to the process.

After any necessary corrections or clarifications, the verified information is manually transcribed into a pre-formatted Excel spreadsheet (Figure 10). This spreadsheet acts as an intermediary tool to populate BD Tempos, the company's task-duration database. This data entry phase, although structured, is highly time-consuming and vulnerable to human error. Given that dozens of monitoring sheets may need to be processed daily, it is common for entries to lag behind actual operations by several days. This delay has direct implications: it postpones performance reporting, complicates feedback to workers, and hinders real-time decision-making for resource allocation.

Data	Serviço	Cliente	Funcionário	Início	Fim	Horas
24/02/2025	5 - Picking	[redacted]	[redacted]	08:00:00	12:30:00	04:30:00
24/02/2025	5 - Picking	[redacted]	[redacted]	13:30:00	15:00:00	01:30:00
24/02/2025	52 - Tarefas Distribuição	[redacted]	[redacted]	15:00:00	17:00:00	02:00:00
24/02/2025	5 - Picking	[redacted]	[redacted]	08:00:00	12:30:00	04:30:00
24/02/2025	5 - Picking	[redacted]	[redacted]	13:30:00	17:00:00	03:30:00
24/02/2025	7 - Transferências	[redacted]	[redacted]	08:00:00	10:30:00	02:30:00
24/02/2025	30 - Serviços Manutenção	[redacted]	[redacted]	16:00:00	16:30:00	00:30:00
24/02/2025	30 - Serviços Manutenção	[redacted]	[redacted]	16:30:00	17:00:00	00:30:00
24/02/2025	30 - Serviços Manutenção	[redacted]	[redacted]	16:30:00	17:00:00	00:30:00
24/02/2025	30 - Serviços Manutenção	[redacted]	[redacted]	09:00:00	12:30:00	03:30:00

Figure 10 - Excel sheet for integration in BD Tempos

Once data has been entered into BD Tempos, it is automatically transmitted to BD Monitorias through linked tables, which consolidates it with the attendance data stored in BD Ponto. BD Monitorias acts as the central layer for operational oversight, and its outputs are subsequently filtered into BD Custos. There, data reaches its final destination and, as mentioned in subsection 4.4, is used by the Operational Control department to generate core financial insights, including task-based (Activity-based Costing) client billing, departmental efficiency assessments, and human resource consumption metrics.

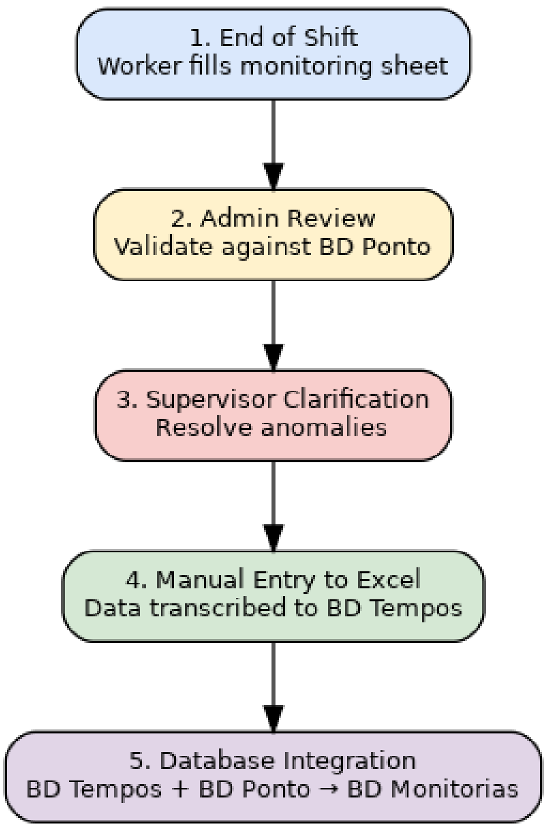


Figure 11 - Flowchart of monitoring data

Despite its structured logic, the current workflow (Figure 11) is deeply dependent on paper-based processes, memory-driven estimations, and manual coordination between departments. Illegible handwriting, vague time entries, and inconsistent task-to-client associations are regular occurrences. Moreover, the absence of validation controls within the Excel integration layer allows erroneous data to flow unchecked into critical systems. Incompatibility between task names, service codes, or client identifiers further undermine data consistency across the databases.

The lack of real-time visibility not only limits day-to-day responsiveness but also compromises Garland´s accuracy of client billing and the reliability of workforce analytics, creating a strong case for digital transformation.

5 Solution design and Pilot Implementation

As established in the previous chapters, the manual method of recording worker task durations at Garland Logistic´s CLG2 facilities presents significant operational limitations. These include data inconsistencies, delays in reporting, and an overall lack of granularity in understanding how labor resources are allocated throughout the workday. Considering these challenges, the objective of a new system is to ensure that worker activities are recorded with greater accuracy, in real time, and without additional administrative burden, while also maintaining the data integrity required by existing databases and workflows. This chapter is structured to detail the system's design requirements, architecture, data logic, integration mechanisms, and pilot implementation strategy.

5.1 Mapping and Reverse-Engineering of Current Systems and Database Logic

Prior to the design of any solution, a technically demanding phase focused on the mapping and reverse-engineering of Garland's existing database structure and information logic was required. A deep dive to understand how current systems operate and interact was necessary to guarantee that the new digital solution would replicate all necessary information flows without compromising the integrity of operational or financial reporting.

As mentioned in 4.4, there are three main databases that are responsible for the management of data monitoring:

- **BD Tempos**: Records the duration of each task performed by workers. Each record typically includes worker identification (via IDFUNC), the task performed, the client, and the duration.

- **BD Ponto**: Stores entry and exit times for each worker, recorded manually via security systems. This database is essential for verifying daily working hours, managing banked hours, and checking compliance with legal labor requirements.

- **BD Monitorias:** Acts as the central monitoring database. It is populated with data from both BD Tempos and BD Ponto and is structured to consolidate each day's full work report per worker. BD Monitorias serves as the operational backbone for internal control, being the only place where each worker is linked to a unique identifier (IDFUNC) and also retaining information about contract duration, salaries and roles.

It was determined that the new system should terminate with both BD Tempos and BD Ponto functions, whose output serves as an input of the centralized BD Monitorias, which must remain unchanged to not affect other administrative operations within the company. Thus, logically, it is essential to understand the main inputs and outputs of each of the databases, making it possible to grasp every attribute that needs to be traced by the new system, without affecting the current one.

The technical challenge of this phase derived from the lack of central documentation, the accumulation of legacy queries, and the presence of exceptions hard coded into SQL logic. Over years of use, various "patches" and incremental changes had been applied to the system to account for edge cases, client-specific rules, or operational constraints, leading to inconsistent logic and difficulty in tracing data lineage.

To address these challenges, a manual exploration of the Microsoft Access environments was carried out. This involved a systematic analysis of input fields and validation rules across each database, as well as a detailed examination of the interdependences and updates between tables. Additionally, this investigation focused on understanding the mapping rules, such as how client names are resolved or how services are categorized and ensuring consistency in date formats and timestamp alignment across the various data sources.

Finally, these were the fundamental attributes that were tracked within BD Tempos:

- **Data:** The calendar date on which the task was carried out.
- **IDFUNC:** The unique internal identifier assigned to each employee.
- **Tipo de serviço:** The classification of the task performed (e.g., picking, loading, unloading).
- **Início da tarefa:** The timestamp marking the beginning of the task.
- **Fim da tarefa:** The timestamp marking the conclusion of the task.
- **Cliente:** The client for whom the task was carried out.

And from BD Ponto, the following attributes:

- **Data:** The date of the workday.
- **IDFUNC:** The same unique worker identifier used in BD Tempos.
- **Hora de Entrada:** The first-time record captured when the employee enters the facility.
- **Hora de Saída:** The last time record captured when the employee leaves the facility.

Together, these two databasis form the informational foundation of the company's task tracking and workforce monitoring structure. The proposed solution must guarantee that these fields, and the insights they provide, remain accurately captured, validated, and available for integration into the BDMonitorias database. The correct replication of this information is crucial not only for internal management but also for external purposes such as client billing, cost control, and performance evaluation.

5.2 Definition of Data Sources

Following the comprehensive analysis of the existing manual processes and database dependencies, the first critical step in the system's development was the design of robust digital architecture. The focus of this architecture was not to introduce novel technological innovations, but rather to strategically leverage existing infrastructure and resources to construct a scalable and accurate system, allowing Garland to accelerate the project timeline while minimizing implementation risk and cost.

5.2.1 Goals and principles

The primary objective was to create a structure capable of gathering real-time, accurate, and integrated data related to worker activity, without compromising compatibility with existing systems such as BDMonitorias. The approach taken was pragmatic and low-cost, leveraging technologies that were already present within the company, rather than introducing entirely new and expensive infrastructure, namely the NFC company card, unique and owned by every single worker of the company.

A key requirement of the architecture was that it should be capable of reconstructing the entire workday timeline of any monitored employee. This includes the moments when the worker enters or exits the warehouse or facility, when tasks begin or end, and when pauses occur. For this, the digital solution had to be structured around three fundamental elements: precise timestamping of all relevant events, consistent identification of workers across different sources, and association of tasks and clients to each work event. The resulting architecture was built to support a central transaction table fed by multiple sources, with clearly defined responsibilities for each. For this, after taking in consideration all the available technologies, the following two data sources were chosen:

- ATS Access-Control Tracking System
- Task declaration form

5.2.2 ATS Access-Control Tracking System

As mentioned in section 4.2.2, the ATS system is Garland’s internal platform for managing access to different areas within the logistics centers. Every access point, whether a warehouse entrance, administrative corridor, or external site gate, is equipped with an ATS reader. Each pick (swipe), made by the NFC company card made on these readers generates a time-stamped event. These events are stored in a central ATS database, accessible by internal maintenance and systems teams.

For that, in order to have a first glimpse of this database, a request was made to see the records of specific doors and readers that would be most relevant for the project. Thus, the following was decided:

- **Entry/exit of facilities:**

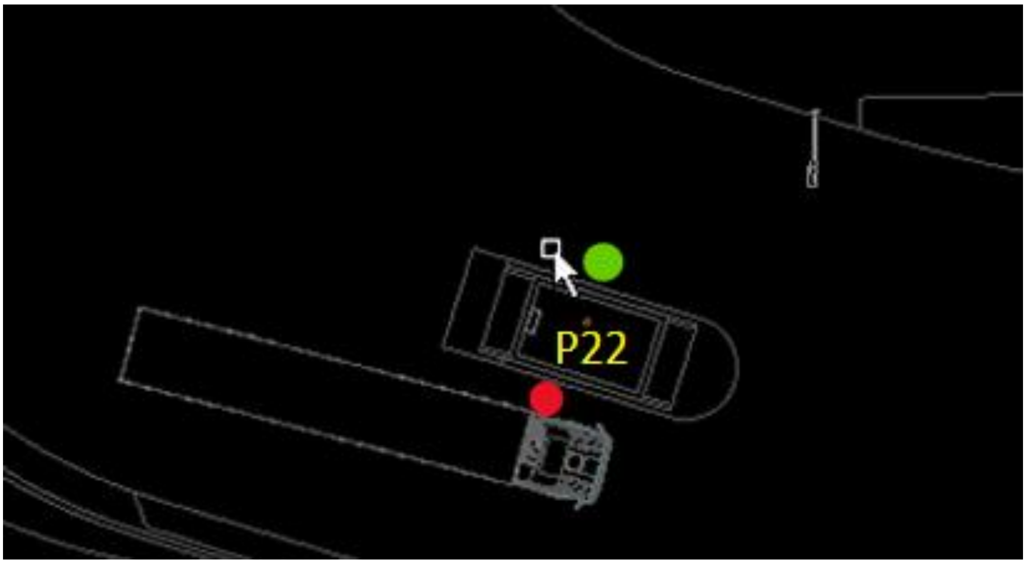


Figure 12 – Map of CLG2 entrance

Reader P22 (Figure 12), present in the main entrance gate, is within the scope of the project because it indicates the timestamp of every worker´s entrance and exit of the CLG2 facilities.

- **Warehouse, administrative and social area entrance:**

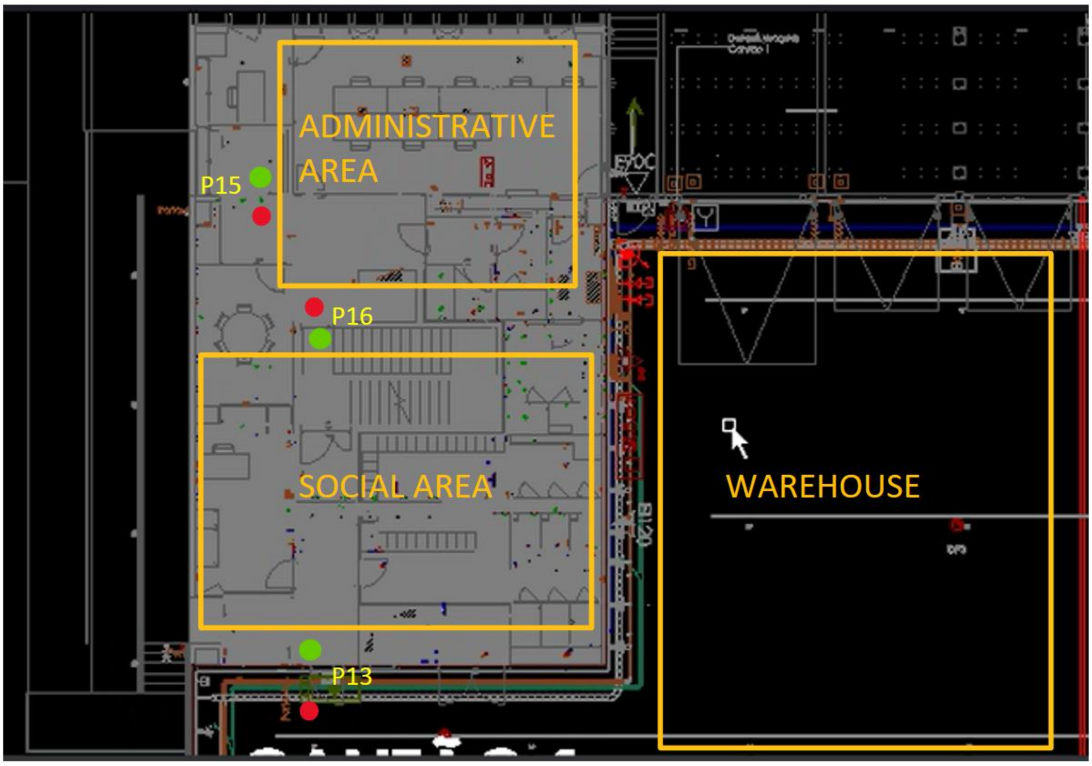


Figure 13 – Map of CLG2 operational facilities

As demonstrated in Figure 13, reader P15 represents the entrance from the outside into the administrative area, followed by reader P16 that separates the administrative area with social area, and finally P13 that marks the entrance in the warehouse.

Following the selection of these readers, in Figure 14, we can see the output from the ATS databases, where each pick with the NFC company card in the door devices generates two rows of data. Each group of two data rows indicates the timestamp, the ID generated by the NFC card, the door where the reading was made and the direction of the movement, meaning the area where the worker was originally and the one he went to.

DATA	PORTA	REGIÃO	ID
2025-04-03 13:12:13.000	P13	5-Nave´s/Armazém	1de202a5-2c22-446a-a7d3-d919071c66f0
2025-04-03 13:12:13.000	P13	3-Zona Social	1de202a5-2c22-446a-a7d3-d919071c66f0
2025-04-03 13:12:25.000	P13	3-Zona Social	1de202a5-2c22-446a-a7d3-d919071c66f0
2025-04-03 13:12:25.000	P16	4-Zona Administrativa	1de202a5-2c22-446a-a7d3-d919071c66f0
2025-04-03 13:14:15.000	P16	4-Zona Administrativa	1de202a5-2c22-446a-a7d3-d919071c66f0
2025-04-03 13:14:15.000	P16	3-Zona Social	1de202a5-2c22-446a-a7d3-d919071c66f0

Figure 14 - ATS system data output

When looking at this data and comparing it to the former databases outputs, we can extract some important attributes: date, action (entrance and exit are possible to identify) and timestamp. This information is clearly not sufficient, since no task or client are yet monitored, nor is the worker´s IDFUNC traceable. This conclusion leads us to our next data source, that aims to complete some of the missing information.

5.2.3 Task Declaration Form (APEX Interface)

A cornerstone of the proposed system for task time tracking was the implementation of a streamlined digital interface that enables workers to declare the task and client associated with their activity in real time. To achieve this, it was developed a lightweight, custom-built form using the Oracle APEX (Oracle Application Express) platform, complemented by a smart-card reader (Figure 15). This form is accessible via the operational supervisor's laptop, allowing workers to declare the type of service being performed and the client for whom the task is executed. The interface plays a central role in replacing the end-of-day paper-based monitoring sheet, offering a faster and more standardized alternative for task reporting.

Figure 15 - Smart card reader

Starting with the smart card reader it is a vital element of the success of this form. It has a specific characteristic, that when the NFC company card is read, it immediately transcripts its NFC code to the device the reader is plugged-in, for example, a laptop. This is the first step of the process that follows a straightforward but well-structured interaction:

1) Card Identification

The worker begins the task declaration process (Figure 16) by tapping their company NFC card on the smartcard reader attached to the terminal. At this stage, the system captures the unique NFC code associated with the card. While the NFC code is not yet directly mapped to the worker's internal IDFUNC the code serves as the foundational identifier that will later be cross-referenced with mapping tables to retrieve additional worker metadata.

Figure 16 – Apex form´s Log-in interface

2) Task Declaration

Once the NFC code is read, the form proceeds to the task declaration interface. The worker is presented with two fields:

- **Client**, corresponding to the customer for whom the task is being executed (Figure 17).

Figure 17 – Apex form´s Client declaration interface

- **Task Type**, chosen from a pre-configured list of activities based on the company's operational vocabulary (Figure 18).

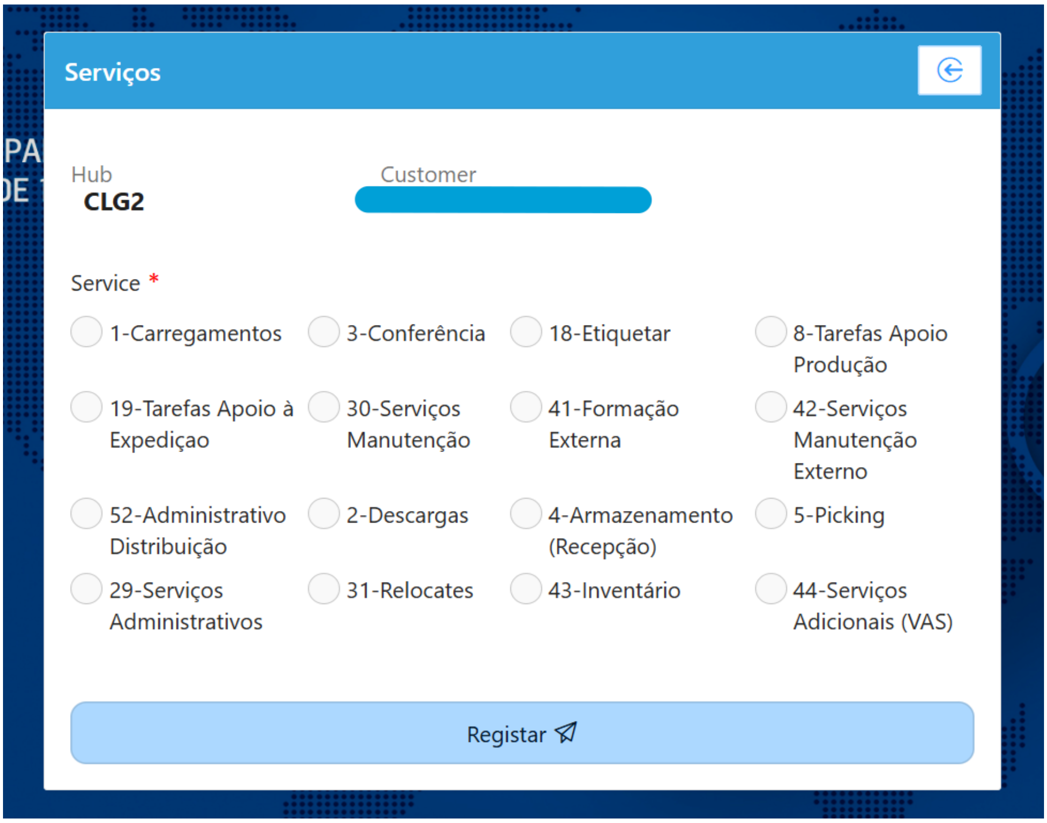


Figure 18 – Apex form´s task declaration interface

These lists are standardized across the platform to ensure data consistency with internal databases and cost monitoring systems. This controlled input mechanism ensures that the information collected is directly compatible with downstream systems such as BD Monitorias.

Consequently, upon selecting both the client and the task, the worker confirms the operation. At that moment, the system logs a new entry into the task tracking database, automatically capturing timestamp, NFC code, Task and Client, as shown in Figure 19:

NFC_CODE	CLIENT	TASK_ID	TASK_NAME	DATE	Timestamp
3015492740	DECEXP	1	Carregamentos	25.05.28	08:18:48
3015492740	DECEXP	21	Descargas	25.05.28	15:00:49
3015492740	DECEXP	42	Conferência	25.05.29	09:40:26
3015492740	DECEXP	21	Descargas	25.05.30	08:32:02

Figure 19 - Apex forms´s data output

By using this digital form, the company significantly improves the reliability and precision of task registration. This design, while simple, forms a core component of the system’s ability to transition from manual to automated worker monitoring in a scalable and robust manner.

Finally, when combining these attributes with the ones retrieved from subsection 5.2.2, it is noticeable that the only information missing from the outputs defined in the first place, is the unique worker identifier, IDFUNC.

5.2.4 Worker Identity and Mapping Structure

A central component of the proposed monitoring system is the ability to accurately associate each recorded event with a unique and identifiable worker. While all events are triggered through physical interaction, the systems in use, such as ATS and NFC-based devices, generate distinct identifiers that do not inherently provide information about the individual or their organizational attributes. To bridge this gap, a dedicated mapping table was created, linking multiple worker identifiers across platforms.

The project faced a key challenge due to the existence of two parallel identifier codes used by the company's hardware infrastructure, when reading the NFC card:

• The ATS ID, a hexadecimal string emitted by ATS security readers upon card detection.

• The NFC code, a typically decimal or formatted code, emitted by the company card when scanned by the APEX smartcard readers.

Though both codes refer to the same physical card, they are presented in incompatible formats across platforms. The solution required translating and mapping both codes to the company's internal human resource identifier, the IDFUNC, a unique code associated with each worker and used across all internal systems.

Centro Logístico	IDFunc	NFC code	ATS	Tipo
CLG2	229	1679422558	A16B8328-26DF-4E85-BFD1-1E36E83F52F4	Operational
CLG2	3423	2415998645	8715720C-8278-42C5-8003-D2F98702C040	Operational
CLG2	1028	3015492740	D74D376A-6AAB-4DD2-83CA-E924B9850988	Administrative
CLG2	3803	1213454226	7789A9FA-C56F-4EBC-8BEB-92453ED0931A	Not monitorized
CLG2	1547	3259651479	3F62B56B-2544-43FF-B1EE-293157EA975F	Operational

Figure 20 - Worker´s Mapping Table

As shown in Figure 20, this structure enables seamless integration of data coming from different technologies and systems while maintaining a unified reference to each worker. Whether the record comes from ATS or the APEX form, the mapping table guarantees correct attribution of each activity to the respective employee.

Although the mapping table includes every card holder within the logistics site, including temporary staff, directors, and security personnel, only a filtered subset of workers is subject to digital monitoring under the scope of this project. Specifically:

- **Operational Workers**, assigned to logistics floor tasks, are monitored for shift start, end, pauses, and all tasks performed.
- **Administrative Workers**, located in office areas, are also monitored.
- **Supervisors, Directors, and External Roles** are excluded from this time monitoring, though their presence in the mapping table allows for identification and control when necessary.

This selective monitoring ensures that the system focuses on roles with quantifiable and task-based activity, allowing for accurate time registration, performance evaluation, and cost attribution without overstepping into non-operational areas of the workforce.

Finally, to further contextualize worker data and ensure correct routing of records into relevant warehouse-specific systems, the mapping table also includes the Logistics Center of each employee. This attribute is critical for assigning task records to the correct physical site and supporting local operational oversight.

By centralizing and maintaining this worker mapping table, the proposed system ensures data integrity across all modules, enabling reliable digital monitoring and future scalability across Garland's broader logistics network.

5.2.5 Dispatcher and Jungheinrich's APIs Exclusion

WMS Dispatcher

The Dispatcher platform, accessed via handheld RDTs, records various warehouse operations such as picking, scanning, or inventory updates. However, its use for time-tracking posed several limitations:

- Timestamps are often recorded at the end of an activity, not at the start, reducing their accuracy for real-time tracking.
- Not all warehouse interactions are recorded consistently, depending on worker diligence and process compliance.
- Dispatcher is designed for task tracking from a product/logistics perspective, not from a human resource or time allocation angle.

Given these limitations, Dispatcher was ruled out as a reliable source for employee time and task tracking.

Jungheinrich Equipment APIs

Initially, the project explored the possibility of utilizing logs retrieved from the Jungheinrich machinery APIs to contribute directly to the transaction table. The premise was based on associating each type of equipment with one or two specific task categories, enabling a binary task inference model. While this machine-to-task mapping proved technically feasible, a significant limitation emerged regarding the attribution of tasks to specific clients. Unlike tasks, clients could not be accurately inferred based on machine usage alone, as the same equipment could be used across multiple clients and operational contexts.

To address this, an optional pre-operation interface was considered, provided through an extended API package. This feature allowed operators to be prompted with questions prior to task execution, such as the identification of the client being served. However, this approach introduced both technical and financial challenges, including the need for additional hardware and recurring subscription costs.

Given these constraints, and considering the broader objective of maintaining simplicity, scalability, and user-friendliness, the decision was made to exclude the Jungheinrich API as a primary data source for transaction generation.

5.3 Unified transaction table (UTT)

A central outcome of the proposed monitoring system is the construction of a Unified Transaction Table (UTT), which serves as the foundational layer for all time-tracking logic and reporting functionalities. This table is designed to consolidate all relevant events, such as task declarations and facility movements, into a single, chronological dataset, enabling the precise reconstruction of each worker's daily activity.

Rather than functioning as a traditional static database, the Unified Transaction Table is conceptualized as a dynamic transactional layer. It is continuously populated by multiple systems and structured in a way that allows for seamless integration into Garland's pre-existing data infrastructure. It is from this table that later rules regarding the start of a shift, pauses, and task durations are inferred, making it the operational core of the digital transformation effort.

5.3.1 UTT structure

The UTT was designed with a standardized schema that accommodates inputs from various sources while preserving semantic clarity and traceability. The following attributes form the structural backbone of the table:

- **ORIGEM**: This field indicates the origin of the record, identifying whether the entry was captured via the APEX form or ATS system. It enables source-based filtering and analytics and is critical for applying the appropriate interpretation logic to each entry.
- **IDFUNC**: The unique identifier for each worker within Garland's internal systems. This field acts as the primary reference for correlating entries across all sources and is the cornerstone of worker-level time tracking.
- **NFC_CODE**: This field stores the UID of the worker's NFC card. Though redundant with IDFUNC in functional terms, it ensures backward traceability and supports validation when integrating systems that reference workers only via NFC UIDs.
- **CL_NAME**: The logistics center to which the worker belongs. This allows filtering of operations by site and supports comparisons across different warehouse units.
- **CUSTOMER_NAME / DOOR**: This hybrid field varies based on the record's origin. When the source is the APEX task declaration form, it stores the name of the client selected by the worker. When the origin is ATS, it instead stores the specific door code through which the worker passed. This flexible field naming allows the same structural column to represent semantically equivalent "event target" data depending on the context of the source.
- **SERVICE_ID**: A standardized numeric code that maps to a specific task type. This ensures alignment with Garland's internal service taxonomy and simplifies downstream cost accounting and reporting.
- **SERVICE_NAME / REGION**: For APEX form originated records, it captures the descriptive name of the task performed. For ATS records, it logs the region or area of the facility associated with the recorded movement. This dual-purpose structure avoids redundancy while maintaining contextual precision.
- **START_DATE**: This field reflects the human-readable date and time at which the transaction occurred. It is used for timeline visualization and user-facing reporting.
- **Timestamp**: A machine-optimized datetime field used for chronological ordering of all transactions across sources. This field ensures the full sequencing of events and is critical for applying tracking logic rules such as pause identification and shift demarcation.

ORIGEM	IDFUNC	NFC_CODE	CL_NAME	CUSTOMER_NAME / DOOR	SERVICE_ID	SERVICE_NAME / REGION	START_DATE	Timestamp
ATS	1028	4294967167	CLG2	P14	0	2-Logradouro	25.05.28	08:02:28
ATS	1028	4294967167	CLG2	P14	0	3-Zona Social	25.05.28	08:02:28
ATS	1028	4294967167	CLG2	P14	0	3-Zona Social	25.05.28	08:02:31
ATS	1028	4294967167	CLG2	P13	0	5-Nave´s/Armazém	25.05.28	08:02:31
APPL	1028	3015492740	CLG2	DECEXP	1	Carregamentos	25.05.28	08:18:48

Figure 21 - UTT´s data output

All entries in the UTT are chronologically ordered by a universal timestamp field (Figure 21), allowing for the reconstruction of each worker's full operational timeline. This temporal ordering is essential for deriving key performance metrics, identifying gaps or anomalies in task execution, and applying time-tracking rules such as pause detection and shift demarcation.

The table also plays a crucial role in bridging otherwise disconnected systems. By aligning all interactions, regardless of origin, to a shared identifier (IDFUNC), the UTT achieves full cross-referencing of data across sources that may identify workers through different formats. This enables consistent and reliable identification for each transaction record.

Moreover, the structure of the UTT was carefully designed to reflect the field requirements and informational granularity previously handled by BD Tempos and BDP onto. In doing so, it preserves compatibility with BD Monitorias and, by extension, BD Custos, thereby ensuring continuity in downstream systems such as client billing, internal performance evaluation, and human resources coordination.

Finally, the UTT was developed with scalability in mind. Its scheme and logic are adaptable to future data sources and operational contexts, allowing for potential replication across Garland's other logistics centers. By recording both intentional and passive interactions, the UTT becomes a comprehensive layer of operational truth. It is from this data foundation that the following time reconstruction logic and daily monitoring outputs will be derived.

5.3.2 Workday Reconstruction Logic

Once the Unified Transaction Table (UTT) was defined and implemented, the next critical step was to develop a robust logic framework capable of transforming raw event data into meaningful time-tracking summaries. This included the classification of work periods, detection of pauses, identification of shift boundaries, and assignment of task durations for each worker.

First of all, before jumping into the rules used to keep track of time, there were some operational assumptions that had to be made to simplify data analysis:

- A task always ends when a new one begins, meaning the system assumes workers proceed directly from one activity to another unless a pause is explicitly detected.
- Short breaks are considered working time for client billing purposes but are also recorded as pause time for internal productivity analysis.
- Lunch breaks are considered non-billable and are excluded from total working hours.
- No "dead time" is allowed: Any time gap between a worker's entry and their first task declaration is attributed to the first declared task, under the assumption that it was already in progress.
- All logical processing is executed once per day, ensuring a consistent and traceable record of each worker's activities.

The system differentiates between Operational and Administrative workers, as their physical routes and access patterns are distinct within the warehouse environment. As such, separate sets of rules, using mainly the movements seen through ATS data output shown in subsection 5.2.2, were defined for each group.

Operational Workers:

- **Start of Work:**
  - Detected when the worker enters the warehouse via P13 after coming from either P14 or P16.
- **Start of Pause:**
  - Triggered by a P13 exit not followed by a P16 or P13 re-entry within one minute.
- **End of Pause:**
  - Any subsequent P13 entrance marks the end of the pause and the restart of work time.
- **End of Work:**
  - Defined as the last P13 exit recorded in the day

Administrative Workers:

- **Start of Work:**
  - Occurs with a P15 or P16 entrance, provided it is not followed by a P15 or P16 exit within 1 minute. This avoids false positives due to quick errand runs.
- **End of Work:**
  - Defined as the last exit from P15 or P16 of the day.

These rules ensure that even in complex physical environments with multiple access points, the system can reliably infer the working state of each employee throughout the day.

Finally, once all the transactions from the UTT are collected for a given day, the system executes a reconstruction algorithm that processes each record sequentially by worker and by date. This algorithm applies the predefined logic rules to identify relevant transitions between monitored zones and form submissions, enabling the precise reconstruction of each worker's activity timeline.

The outputs generated by this process include the following key performance indicators:

- **Workday Start and End Times**: Based on the first and last relevant entry and exit events, the algorithm determines the effective duration of each worker's day.

- **Time Spent per Task and Client**: Each declared task is timestamped and linked to a client, enabling the system to calculate the exact duration of time spent on each activity. Task intervals are defined as the periods between form submissions or other activity-initiating events.

- **Total Recorded Work Hours**: This includes all periods of productive activity, excluding unpaid break intervals such as lunch, but inclusive of billable micro-pauses to ensure no operational dead time is lost.

- **Total Pause Time**: For internal analysis, all identified pauses—regardless of billing relevance—are recorded and totaled. This enables the company to monitor behavioral patterns and assess compliance with scheduled break periods.

Table 3 - Workday Reconstruction Logic Output

Entrance Hour	07:59:20
Exit Hour	17:04:43
"Carregamentos" (Client: DECEXP)	05:21:26
"Descargas" (Client: DECEXP)	01:56:16
"Serviços Admin" (Client: DECEXP)	00:40:22
Total Pause time	01:36:37
Total Worked hours	07:58:04

As can be seen in Table 3, this granular dataset ensures that the full workday of each monitored employee is not only accurately recorded but also aligned with operational goals. By eliminating ambiguity in time tracking and standardizing data capture across all activities, the system significantly enhances transparency, accountability, and efficiency within Garland's logistics operations.

5.4 Card Management and Maintenance Protocol

The effectiveness of the proposed monitoring system relies heavily on the accuracy and consistency of worker identification through NFC company cards. These cards act as the primary access key for triggering system interactions, whether through facility access (ATS), machine logins, or form submissions. As such, the proper attribution and control of these cards is essential for ensuring data reliability and continuity across systems.

To manage this process, a structured protocol was developed involving two key actors: the Operational Control Department and the Security Team. This collaborative workflow ensures that all card assignments, replacements, and returns are accurately reflected in the central Worker Mapping Table, which links each employee's NFC company card with their internal identifier (IDFUNC), name, and associated logistics center.

5.4.1 Worker Onboarding and New Card Assignment

When a new worker is introduced to the company, either temporarily through external staffing or as a permanent Garland employee, the Operational Control Department creates a new entry in the mapping table with the worker's name, assigned IDFUNC, and organizational role. At this stage, the NFC card code field remains unpopulated.

In order to create a functional and sustainable card management system, a process flowchart was designed to define every task that should be done upon a worker´s arrival at the security desk, as seen in Figure 22.

Upon arrival at the site, the security personnel at the entrance area is responsible for assigning an available company card. Using a dedicated smart card reader, the card's UID is automatically captured and updated into the existing mapping record for that worker. The association is performed through a simple interface that filters for unassigned cards and ensures traceability. Once associated, the card allows the worker to begin interacting with the monitoring infrastructure seamlessly.

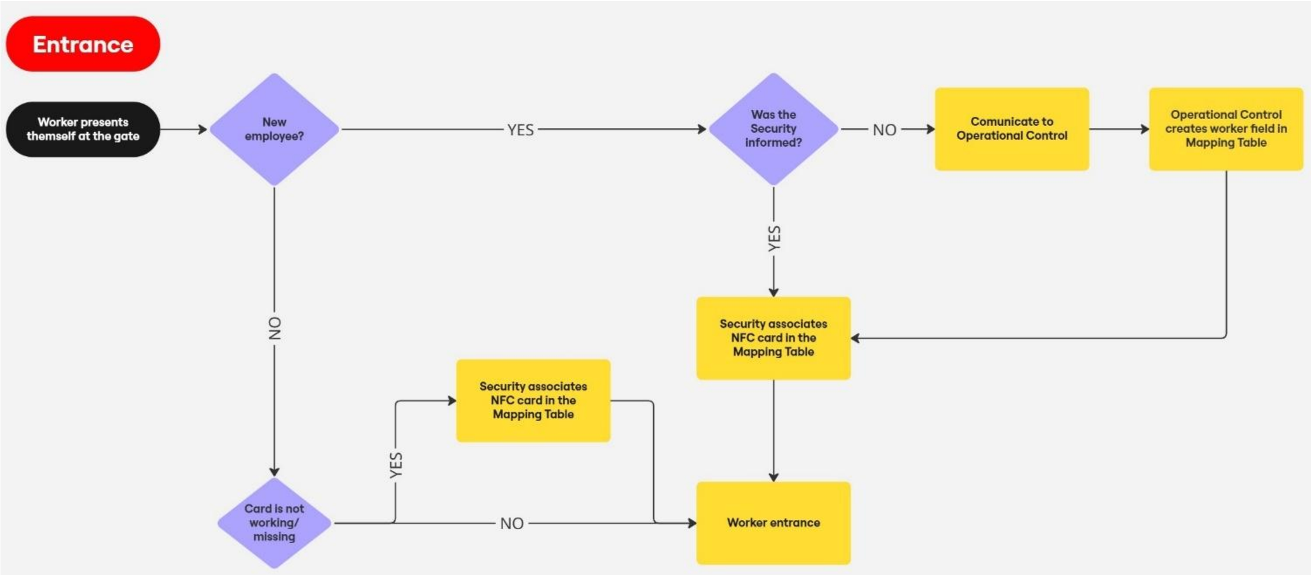


Figure 22 – Card management Process Flowchart, if a worker is entering the facilities

5.4.2 Daily Card Replacement or Reassignment

In some cases, workers may forget, misplace, or damage their NFC cards. To avoid disrupting operations, the protocol allows for temporary reassignment of spare cards by the security team. If a worker is already registered in the system, the security team simply updates the NFC_CODE field in the mapping table using the card reader, as also shown in Figure 18. No additional record creation is necessary, minimizing administrative burden and allowing flexibility for high-turnover environments.

This approach supports the reality of frequent personnel rotation in logistics environments while still ensuring that all system records are aligned under a consistent and uniquely identifiable IDFUNC.

5.4.3 Card Return and Exit Protocol

When a worker's contract ends or they leave the company, the protocol mandates that their NFC card is returned and disassociated from their mapping record. This step is performed at the site's exit point and ensures that no residual card remains active within the system (Figure 23).

If the card is in good condition, it is reassigned to the card pool. If lost or damaged, it is flagged accordingly and excluded from future circulation. In either case, security personnel update the record or trigger a reassignment procedure based on the exit condition.

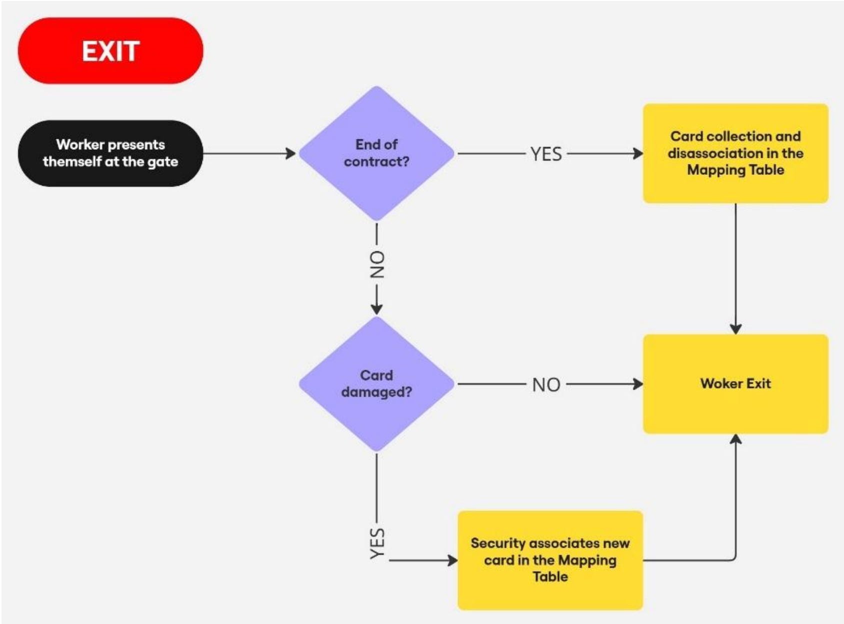


Figure 23 - Card management Process Flowchart, if a worker is leaving the facilities

5.4.4 Traceability and Control

To ensure full administrative traceability over card circulation, a digital registration form, as shown in Appendix B, was developed and implemented for internal use. This form is systematically completed whenever a card is assigned, replaced, returned, or reported lost. Each submission captures essential information such as the type of card involved, the reason for the operation (whether for a new employee, card loss, damage, or reassignment), the full name and IDFUNC of the employee concerned, the department responsible for issuing or receiving the card, as well as the exact date and time of the transaction.

The resulting dataset serves not only as a historical log but also as a tool for operational oversight, enabling the company to monitor the frequency of card movements, detect recurrent anomalies, such as repeated losses by the same employee, and identify patterns that may inform improvements in future card management practices.

5.5 Pilot Implementation

This final phase consisted of the implementation and validation of the proposed system. With the UTT functioning as intended, a real-world test environment was created. Workers began using the newly deployed form to log their task and client before initiating each activity, accessing the system via the NFC-enabled smartcard readers. Other data sources continued to feed into the system through their native channels. To ensure a controlled comparison, workers also continued to complete their manual monitoring sheets during the test period. This dual-input approach enabled the evaluation of the new system's reliability, accuracy, and potential improvements in data quality and administrative efficiency. It also provided critical feedback for refining the rules and logic established earlier, allowing for final adjustments before full-scale implementation.

5.5.1 Structured feedback

User acceptance represents a cornerstone for the successful implementation of any digital transformation initiative. To that end, a structured feedback process was incorporated into the pilot phase to capture the experiences, concerns, and suggestions of various user groups, including operational workers, supervisors, administrative staff, and support functions (security and maintenance).

This process was made during the whole development of the project, by analyzing the sentiment of the workforce when new developments were implemented. The strategy was to create an intimate and informal environment, so that the most truthful and representative feedback could be registered. These feedback sessions could happen both in groups or individually, depending on availability and workload.

5.5.2 Training and change management

The successful deployment of any digital transformation initiative, particularly in operational environments with high personnel rotation and varying levels of digital literacy, requires more than technical readiness. The implementation of the proposed worker task monitoring system at CLG2 was accompanied by a structured change management and training program aimed at ensuring adoption, minimizing operational disruption, and reinforcing the organizational benefits of the new process.

To this end, a training plan was developed and executed across all shifts. Sessions were conducted in-person with small groups to accommodate operational constraints and allow for personalized interaction. These sessions focused on three key elements: (i) introducing the rationale and objectives behind the new system, (ii) demonstrating how to use the NFC-enabled login and APEX task declaration form, and (iii) allowing participants to simulate real task logging scenarios. Supporting materials, including visual slides, printed step-by-step instructions, and live demonstrations using the smartcard reader and form interface, were also distributed, as shown in Appendix C.

6 Results discussion

Following the implementation of the pilot system at CLG2, a short-term assessment was conducted to compare the newly developed digital task monitoring framework against the traditional manual method. While the pilot period was still in its early stages and ran in parallel with the legacy system, preliminary insights already reveal valuable findings regarding accuracy, user acceptance, operational impact, and areas of potential enhancement.

6.1 Comparison Between Manual and Digital Monitoring

A direct comparison of worker activity logs collected simultaneously via the manual monitoring sheet and the newly implemented digital system demonstrates the most immediate benefit of the proposed methodology: granularity and precision.

Taking the example of the worker "1028" on the 28th of May 2025, as seen in Figure 24, the manual record indicates four tasks performed throughout the day, summarized with exact hourly blocks: 5 hours, and three 1 hour blocks, respectively. While this structure is acceptable for billing purposes, it clearly lacks detailed segmentation, omits pause durations, and ultimately represents approximations often completed at the end of the workday based on memory and informal estimations. This is a very representative example because this worker does a lot of administrative work, providing testing and confirming the success of the workday logic implementation, since leaving the warehouse does not exactly mean that the worker is in pause.

Data	Serviço	Cliente	Funcionário	Início	Fim	Horas
28/05/2025	2 - Descarga	DECEXP (CLG2)	1028	08:00:00	13:00:00	05:00:00
28/05/2025	5 - Picking	DECEXP (CLG2)	1028	15:00:00	16:00:00	01:00:00
28/05/2025	1 - Carga	DECEXP (CLG2)	1028	14:00:00	15:00:00	01:00:00
28/05/2025	29 - Serviços Administrativos	DECEXP (CLG2)	1028	16:00:00	17:00:00	01:00:00

Figure 24 - Manual monitoring data output from worker "1082"

In contrast, the digital record, shown in Table 9, produced for the same worker and day displays a detailed reconstruction of events, tracking entry and exit times at various facility zones (warehouse, administrative area, social zone) and capturing form submissions with precise timestamps.

Table 4 - Digital Monitoring Output for worker "1028"

Entrance Hour	07:59:20
Exit Hour	17:04:43
"Carregamentos" (Client: DECEXP)	05:21:26
"Descargas" (Client: DECEXP)	01:56:16
"Serviços Admin" (Client: DECEXP)	00:40:22
Total Pause time	01:36:37
Total Worked hours	07:58:04

Analyzing Table 4 results, we can understand that worker "1028" worked a total of 7 hours and 58 minutes, opposing to the 8 hours that was previously recorded in the manual monitoring. Entrance and exit hours seem to not be the origin of this difference, so we can conclude lunchtime hour was slightly longer than scheduled, remembering that smaller mid-day pauses are not recorded for task time monitoring and are included in client billing

When looking at task time accuracy, we can see a big discrepancy between both manual and digital recordings. Not only timespans look off, but also the recording of the task itself seems like it was wrongly recorded. Regarding this problem, the supervisor confirmed that the correct recording was the digital one and that the worker mistakenly confused two tasks ("Cargas" and "Descargas") when filling the manual sheet.

Additionally, the service "Picking" was recorded in the manual monitoring and does not appear in the digital one. This discrepancy can have different origins, either this task was made intermittently between the recorded tasks and the worker decided to include a full hour of it in the manual recording, or the worker forgot to move to the laptop with the smart-card reader that integrates the APEX form.

Finally, this comparison illustrates the clear advantage of systematized real-time tracking over end-of-day manual estimation, especially in contexts where billing accuracy, task productivity, and compliance with contractual service-level agreements are operational priorities.

A similar example, but displayed in a simpler manner, because of the lack of administrative work, with worker "1527", further confirms this trend. The manual system reported three activity blocks (1h, 3h, 4h), as shown in Figure 25.

Data	Serviço	Cliente	Funcionário	Início	Fim	Horas
28/05/2025	5 - Picking	EDC - FACTORY (CLG2)	1527	08:00:00	09:00:00	1,00
28/05/2025	4 - Armazenamento (Recepção)	EDC - FACTORY (CLG2)	1527	09:00:00	12:00:00	3,00
28/05/2025	4 - Armazenamento (Recepção)	EDC - FACTORY (CLG2)	1527	13:00:00	17:00:00	4,00

Figure 25 - Manual monitoring from worker "1527"

On the other hand, while the digital system reconstructed the same workday with more nuanced timing, as shown in Table 6.

Table 5 - Digital monitoring output for worker “1527”

Entrance Hours	07:57:49
Exit Hours	16:59:02
"Picking" (Client: EDC - factory)	01:43:36
"Armazenamento" (Client: EDC - factory)	06:16:57
Total Pause Time	01:30:40
Total Worked Hours	08:00:33

The difference in total recorded time compared to the one manually recorded is minimal, showing that even if the worker records its workday manually in the best way he possibly can, there are still some noticeable differences. Additionally, the distribution of activity and pause detection reveal the improved descriptive power of the digital system.

These examples provide evidence that the digital system does not merely improve accuracy, but it also redefines visibility into daily operations.

6.2 Preliminary Metrics

Although the pilot phase covered a limited period, the data collected during the first full week of digital monitoring yielded important insights regarding system use and behavioral patterns.

An initial analysis revealed that approximately 87% of workers successfully registered at least one task using the APEX form during the week. This high engagement rate reflects effective training and the clarity of the new process. However, only 62% of these users consistently registered all task transitions throughout their shifts. This points to a progressive learning curve and shows the importance of continued reinforcement through supervisor oversight and system alerts.

When talking about the administrative workers and its part of the project, even though the impact on processing time cannot yet be fully quantified due to the parallel continuation of the legacy system, early feedback indicates a strong decrease in post-processing workload. With the digital data flowing into structured databases in near real time, the necessity for data wrangling and human interpretation is very little.

Finally, in terms of coverage, digital entries were captured across all four main warehouse operational sections, including EDC Factory, Components, SAVs, and Export. This confirms that the system can handle spatial distribution within the warehouse and that infrastructure placement of terminals and card readers was appropriate.

6.3 Real-Time Visibility and Strategic Benefits

One of the most immediately tangible advantages of the system was real-time visibility. It is now possible to have the ability to track who was working, on which task, and for which client at any given moment. This capability has never been feasible under the manual system and opens the door to future integration with workforce planning, live dashboards, and performance analytics.

Even though many operational benefits such as cost reduction, error elimination, or administrative time savings are not yet quantifiable due to the parallel use of both systems, the pilot has proven the conceptual and practical feasibility of the solution. The deployment has also brought new insights into behavioral aspects of task declaration and laid the groundwork for further process improvement and system refinement.

6.4 User Feedback and Perceptions

Regarding feedback results, operational workers demonstrated a pragmatic reception to the new system. The most frequently cited benefit was the elimination of the manual end-of-day reporting task. Several workers appreciated the simplicity of tapping their card and selecting a task, which they described as "quick" and "less stressful." However, they also reported ergonomic concerns. Specifically, the requirement to approach a fixed computer in the supervisor´s workstation before each new task introduced logistical inconvenience, especially in sections of the warehouse where the distance between work zones and the input terminal is substantial. Moreover, a recurring theme among workers was apprehension about the heightened precision of tracking. Some expressed discomfort with the notion of being monitored "to the second," fearing punitive interpretations or excessive micromanagement.

Supervisors' responses varied based on the complexity of their team operations. In smaller teams, particularly in operations with fewer task types and infrequent switches, supervisors described the system as "invaluable." It allowed them to confirm worker task engagement, reduce end-of-day discrepancies, and better coordinate team activity. In contrast, supervisors overseeing high-turnover zones with many concurrent tasks viewed the system as burdensome. They noted the additional responsibility of ensuring task declarations were made in real-time, which, when not followed, required active intervention and post-hoc correction. In their view, while the system has long-term benefits, it also introduces new management overhead in the short term.

Administrative workers were overwhelmingly positive. For this group, the new system marked a paradigm shift in operational efficiency. The removal of handwritten sheets eliminated interpretation errors, rework from ambiguous entries, and the need for constant "back-and-forth with supervisors". Their alignment with the project's goals and readiness to adapt have been key facilitators of the pilot's operational continuity.

Finally, the support functions, especially the security personnel managing the card distribution and association, reported smooth adaptation. Despite the introduction of new tasks, such as associating NFC cards to newly arrived employees or replacing lost ones, these were quickly routinized. The structured flowchart guiding these processes and the complementary registration form made the system intuitive and manageable, even during peak entry periods.

Overall, the feedback underscores that while technical reliability and process efficiency were achieved, cultural factors and role-specific ergonomics must continue to be addressed to ensure the long-term sustainability of the solution.

6.5 Training Results

The training strategy proved essential in reducing resistance to change and addressing early-stage user uncertainty. Workers were able to experience the system's simplicity and understand that its intention was not to introduce additional complexity or increase surveillance, but rather to eliminate the burden of end-of-day reporting and enhance fairness and visibility into daily operations. Moreover, the sessions were used as an opportunity to collect initial feedback, clarify procedural doubts, and identify potential friction points in the interaction flow (e.g., walking distances to the form station or timing overlaps between tasks).

Finally, the training program succeeded in establishing a baseline understanding of the system, accelerating early usage, and fostering a shared sense of ownership among stakeholders. As the system evolves, further training rounds, refresher modules, and continuous support mechanisms should be considered to consolidate adoption across the workforce.

7 Conclusion, project limitations and future work

7.1 Conclusion

The overarching objective of this project was to develop and implement a robust, low-cost, and scalable digital system for monitoring worker task times at Garland Logistics' CLG2 warehouse. The primary goals included: eliminating the reliance on manual monitoring sheets, ensuring real-time visibility into operational execution, aligning recorded data with commercial and budgetary planning assumptions, and reducing the administrative burden of the current processes. Furthermore, the system needed to be integrated into existing infrastructure and databases, maintaining the continuity of cost control and billing procedures without disrupting Garland's core operations.

This dissertation presented the conception, development, and pilot implementation of a digital system for worker task and time monitoring at Garland Logistics' CLG2 logistics center. Developed in a context where manual processes still dominated the collection of operational data, the project emerged from a concrete and strategic need: to improve data accuracy, reduce administrative workload, and ensure alignment between the actual use of human resources and the expectations established in commercial proposals and budgeting processes.

Through an iterative and multi-phased methodology, the project successfully mapped the existing manual systems, designed a digital architecture that leveraged existing infrastructure, such as NFC (Near-Field Communication) company cards and ATS readers, and constructed a Unified Transaction Table (UTT) capable of consolidating input from heterogeneous sources. The system, anchored in the logic of continuous timestamp-based monitoring, allowed for a level of granularity previously unattainable through manual reporting, enabling the identification of exact working periods, pause durations, client-task allocation, and entry/exit events.

The pilot implementation demonstrated not only the technical feasibility of the proposed system but also revealed critical organizational insights. By enabling a side-by-side comparison between legacy monitoring sheets and the new digital logs, it became evident that manual systems, although useful in the past, suffered from systemic limitations in accuracy, traceability, and real-time visibility. The digital alternative offered a much richer, more reliable representation of operational dynamics.

Equally important was the recognition of how technological change interfaces with human systems. While some resistance was observed, particularly from supervisors managing complex operations or from workers wary of intensified monitoring, the project was largely met with collaboration and proactive engagement, especially from administrative teams. The system's ability to reduce cognitive load, improve validation processes, and increase transparency of task execution was widely recognized.

Although it is still in a pilot stage and functioning in parallel with existing systems, this project represents a paradigm shift in how Garland Logistics can approach workforce monitoring. It introduces a scalable, robust, and auditable framework capable of supporting broader digital transformation initiatives across the organization.

In summary, all the core objectives established at the outset of the project were fully met: the proposed system proved effective in presenting the way of automating the monitoring process, reducing reliance on paper-based documentation, aligning recorded task durations with planning standards, and simplifying administrative processing. The UTT successfully showed potential to replace the need for manual cross-referencing between disconnected systems and created a solid foundation for further expansion. This project contributes to Garland´s sustainability efforts, by eliminating the extensive use of paper in the manual monitoring process but also by being aware of its social responsibility: even with bigger control of workforce, employee´s privacy remains intact and individual work can be valued as never before, contributing to SDG 13 (Climate Action) and SDG 9 (Industry Innovation and Infrastructure) respectively.

On a personal level, this project represented an exceptional opportunity for intellectual and professional growth. It demanded not only technical skills in systems analysis, data architecture, and process modeling, but also adaptability, communication, and stakeholder engagement. Working collaboratively with multiple departments, navigating real organizational constraints, and delivering a functional prototype capable of scaling were experiences that deeply enriched my perspective as an engineer and as a future contributor to organizational transformation.

7.2 Project Limitations

Despite the significant progress made, the project encountered several limitations that are important to acknowledge both for contextual integrity and for guiding future efforts.

Firstly, the scope of implementation was limited to a single logistics center and to a short temporal window. While this was appropriate for a controlled pilot, it constrains the ability to extrapolate broader operational gains in terms of cost reduction, error minimization, and labor optimization. The use of the legacy system in parallel also limited the full immersion of users into the new process, potentially masking both challenges and opportunities that would emerge under full adoption.

Secondly, although the system was designed to automatically reconstruct workdays with high precision, it is still dependent on correct and timely user interaction, particularly in relation to the APEX form for task and client declaration. In some high-pressure or high-mobility operational settings, this can still pose a challenge, as not all workers consistently remembered or prioritized the form submission. While the system includes fallback logic to assign tasks retroactively in such cases, its accuracy still depends on user discipline and training.

Furthermore, the project did not fully integrate all available digital sources. For instance, while Jungheinrich APIs (Application Programming Interface) were explored as a potential input stream, their use was ultimately deferred due to technical and commercial constraints. Similarly, the possibility of embedding task declaration directly into existing mobile devices or RDTs (Remote Data Terminals) was identified but remains unimplemented. These integrations could significantly enhance system accessibility and robustness but required hardware changes or software upgrades outside the project's initial scope.

Finally, the project, while successful in technical terms, introduced some new responsibilities to other departments, such as security who are in charge of updating NFC card assignments, and supervisors ,who had to encourage compliance with form usage. Although these tasks are minor in operational cost, they do require sustained coordination and procedural discipline to ensure long-term viability

7.3 Future Work

The promising results of this pilot, both from a technical and organizational perspective, open multiple avenues for future development, refinement, and scaling.

A primary goal for future work is the complete elimination of legacy systems, particularly BD Tempos and BD Ponto. Once the new system demonstrates consistent reliability and user compliance, it can be fully adopted as the official source of worker monitoring data, streamlining the entire process chain from data collection to cost control via BD Monitorias and

BD Custos. This transition, from pilot mode to full working mode, will also enable cleaner system maintenance and reduce redundancies.

To address user accessibility concerns and improve task declaration efficiency, a key requirement involves deploying additional NFC-enabled terminals or tablets in strategic warehouse locations. By reducing the distance a worker must walk to record a task change, this measure is expected to improve form compliance and reduce time lost in transitions.

Another opportunity lies in the integration of the APEX task declaration form directly into Garland's existing RDT infrastructure. These devices are already used by workers for inventory and picking tasks, and embedding the form into their workflow would eliminate the need for dedicated terminals. This solution would require back-end development to ensure the necessary interfaces, but it promises seamless and intuitive worker experience.

Additionally, revisiting the Jungheinrich APIs could unlock further automation potential. Although full integration was deferred, the APIs include a "Pre-Operation Check" module that, with appropriate subscription and technical support, could prompt users to declare the task and client directly from the machine interface before initiating work. While the limitation of client mapping remains, this stream could still be useful for cross-verifying worker activity, identifying discrepancies, and enhancing task traceability.

Finally, a long-term strategic goal involves extending the system to other Garland logistics centers. The unified transaction table and logic rules were designed with scalability in mind, and the pilot at CLG2 offers a blueprint for broader deployment. Scaling will require adapting to the specific operational contexts of each site, but the foundational architecture is already in place.

On the data analytics side, future efforts can explore advanced dashboards and performance KPIs (Key Performance Indicators), drawing from the rich dataset now being collected. These insights could support real-time workforce management, shift optimization, and more dynamic resource allocation, elevating operational control to a new level of sophistication.

References

Advisera. (n.d.). "Plan-Do-Check-Act in the ISO 9001 Standard." 9001 Academy. Retrieved June 2025 from https://advisera.com/9001academy/knowledgebase/plan-do-check-act-in-the-iso-9001-standard/

Alshehri, F. A., Rutter, P., & Smith, F. J. (2021). "The Application of Acceptance Models to the Understanding of Employees' Use of Electronic Monitoring Systems in the Workplace." *International Journal of Environmental Research and Public Health, 18*(13), 6926.

Autor, D., Mindell, D., & Reynolds, E. (2020). *The Work of the Future: Building Better Jobs in an Age of Intelligent Machines.* MIT Industrial Performance Center.

Cheatham, K. (2022). "Why It's Important to Upskill Your Employees in a Digital Transformation." Third Stage Consulting. Retrieved June 2025 from https://www.thirdstage-consulting.com/why-its-important-to-upskill-your-employees-in-a-digital-transformation/

Christopher, M., & Holweg, M. (2022). "Supply Chain 4.0: Managing Supply Chains in the Digital Era." In *The Oxford Handbook of Supply Chain Management.* Oxford University Press. Retrieved June 2025 from https://academic.oup.com/book/10674/chapter-abstract/158713934

Creswell, J. W. (2009). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (3rd ed.). SAGE.

CYBRA. (2024). "Can RFID Manage Inventory?" CYBRA Corporation. Retrieved June 2025 from https://cybra.com/can-rfid-manage-inventory/

Daguer Logistics. (n.d.). "The Importance of Real-Time Data in Warehouse Operations." Retrieved June 2025 from https://www.daguerlogistics.com/blog/the-importance-of-real-time-data-in-warehouse-operations

DHL. (2023). "Digitalization in Logistics." *DHL Trend Report.* Retrieved June 2025 from https://www.dhl.com/global-en/home/insights-and-innovation/thought-leadership/trend-reports/digitalization-in-logistics.html

European Commission. (2024). "Digital Transformation in Industry 5.0: Putting People at the Centre." Retrieved June 2025 from https://research-and-innovation.ec.europa.eu/publications/digital-transformation-industry-50-people-centred_en

Eurofound. (2024). "Employee Monitoring – A Moving Target for Regulation." Retrieved June 2025 from https://www.eurofound.europa.eu/en/resources/article/2024/employee-monitoring-moving-target-regulation

Gaukler, G. M., & Seifert, R. W. (2007). "Applications of RFID in Supply Chains: A Review of the Literature and Framework for Future Research." *Production and Operations Management, 16*(6), 646–666. https://doi.org/10.1111/j.1937-5956.2007.tb00283.x

Garland. (2016). "Soluções Integradas de Logística e Transporte." Retrieved May 2025 from https://www.garland.pt/pt/

Hamburg Data Protection Authority. (2020). "Hamburg Commissioner Fines H&M € 35.3 Million for Data-Protection Violations in Service Centre." *European Data Protection Board News.* Retrieved June 2025 from https://edpb.europa.eu/news/national-news/2020/hamburg-commissioner-fines-h-m-353-million-euro-data-protection-violations_en

Taherdoost, H. (2022). "What Are Different Research Approaches? …" *Journal of Management Science & Engineering Research, 5*(1), 53–63.

Institute for Digital Transformation. (2024). "Strategy Execution: What It Takes to Make Great Transformations." Retrieved June 2025 from https://www.institutefordigitaltransformation.org/strategy-execution-what-it-takes-to-make-great-transformations/

Lim, C., Richards, H., & Pan, J. (2013). "'Lean First, Then Automate': A Framework for Process Improvement in Pure Service Companies." Retrieved June 2025 from https://www.researchgate.net/publication/254304928

McKinsey & Company. (2024). "AI Can Transform Workforce Planning for Travel and Logistics Companies." Retrieved June 2025 from https://www.mckinsey.com/industries/travel/our-insights/ai-can-transform-workforce-planning-for-travel-and-logistics-companies

Menzies, H. J., & Hupfer, M. (2023). "Workforce Monitoring and Surveillance: The Future of Trust at Work." *Human Relations.* Advance online publication. https://doi.org/…

Müller, S. D., Marx, P., Strobel, L., & Riempp, G. (2021). "Digital Transformation and Employee Stress: A Quantitative Analysis." *International Journal of Information Systems and Project Management, 9*(4), 5–20.

O Gaiense. (2022). "Novo Centro Logístico da Garland Quase Pronto." Retrieved June 2025 from https://www.ogaiense.pt/noticias/noticiario/novo-centro-logistico-da-garland-quase-pronto

Picado Argüello, B., & González-Prida, V. (2024). "Integrating Change Management with a Knowledge Management Framework: A Methodological Proposal." Manuscript in preparation.

ProcessMaker. (2023). "What Is the BPMN 2.0 Standard?" Retrieved June 2025 from https://www.processmaker.com/blog/what-is-the-bpmn-2-0-standard/

Process Science. (n.d.). "Logistics Use Case." Retrieved June 2025 from https://www.process-science.com/use-cases/logistics

Purpose & Means. (2023). "History and Origins of Employee Monitoring." Retrieved June 2025 from https://www.purposeandmeans.io/history-and-origins-of-employee-monitoring

PwC. (2024). *Workforce of the Future.* Retrieved June 2025 from https://www.pwc.com/us/en/services/consulting/workforce-of-the-future.html

Reuters. (2023). "Amazon Uses AI Cameras to Monitor Delivery Drivers, Raising Privacy Concerns." Retrieved June 2025 from https://www.reuters.com/technology/amazon-uses-ai-cameras-monitor-delivery-drivers-raising-privacy-concerns-2023-03-22

Reuters. (2024). "French Regulator Fines Amazon France Logistique 32 Million Euros." Retrieved June 2025 from https://www.reuters.com/business/retail-consumer/french-regulator-fines-amazon-france-logistique-32-million-euros-2024-01-23/

Roberti, M. (2019). *RFID Delivers Real ROI.* RFID Journal. Retrieved June 2025 from https://www.rfidjournal.com/wp-content/uploads/2019/07/289.pdf

Savills Portugal. (2024). *Industrial Market in Portugal – Report 2024.* Retrieved June 2025 from https://pdf.euro.savills.co.uk/portugal/report-il-2024.pdf

Sharma, R., & Bhardwaj, A. (2021). "Digital Surveillance and Analytics: Opportunities and Challenges." *International Journal of Data Science and Analytics, 2*(1). Retrieved June 2025 from https://iaeme.com/…/IJDSA_02_01_001.pdf

Supply Chain Magazine. (2024). "Setor Industrial e Logístico Cresceu 31% em 2024." Retrieved June 2025 from https://www.supplychainmagazine.pt/2024/11/15/setor-industrial-e-logistico-cresceu-31-em-2024/

TCP Software. (n.d.). "Time and Attendance Tracking: What It Is, How It Works and Why It's Important." Retrieved June 2025 from https://tcpsoftware.com/articles/time-and-attendance-tracking/

Thiel, C., McClean, S., Harvey, J., & Prince, N. (2024). "Surveilling Employees Erodes Trust — and Puts Managers in a Bind." *Harvard Business Review.* Retrieved June 2025 from https://hbr.org/2024/02/surveilling-employees-erodes-trust-and-puts-managers-in-a-bind

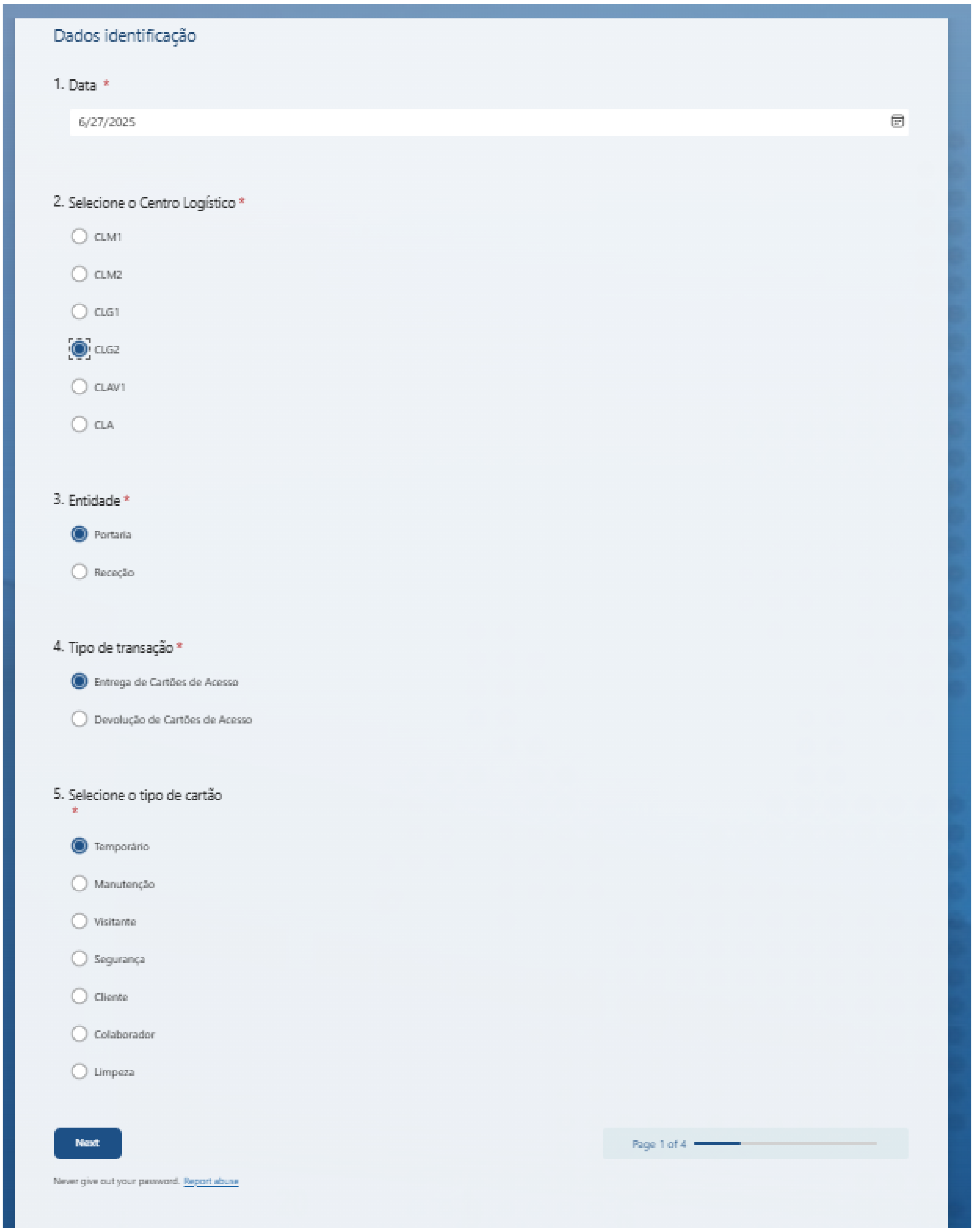
Tomczak, D. L., Medeiros, K. L., Megahed, F. M., & Butts, M. M. (2022). "A Meta-Analysis of the Effects of Electronic Performance Monitoring on Work Outcomes." *Journal of Applied Psychology.* Advance online publication.

University of Arkansas. (2009). "New Study Shows RFID Significantly Improves Item-Level Inventory Accuracy." *UA News.* Retrieved June 2025 from https://news.uark.edu/articles/14256/new-study-shows-rfid-significantly-improves-item-level-inventory-accuracy

APPENDIX A : Garland's hour bank system

NOME	C. Logístico	TIPO	01/jun/25	02/jun/25	03/jun/25	04/jun/25	05/jun/25	06/jun/25	07/jun/25	08/jun/25	09/jun/25
	CLM2	RANDSTAD		0,0	0,0	0,5	0,0	0,0			1,5
	CLM2	RANDSTAD		--	--	--	--	--			0,0
	CLG2	GARLAND		0,0	0,0	0,0	-0,5	0,0			0,0
	CLG2	RANDSTAD		--	--	--	--	--			--
	CLM2	RANDSTAD		--	--	--	--	--			--
	CLG	RANDSTAD		0,0	-8,0	0,0	0,0	0,0			0,0
	CLG2	RANDSTAD		1,0	0,0	0,0	0,0	-2,0	8,0		-8,0
	CLM2	RANDSTAD		1,0	2,0	1,0	0,0	0,0	16,0		1,0
	CLG2	RANDSTAD		--	--	--	--	--			--
	CLM2	RANDSTAD		--	--	--	--	--			--
	CLAL	GARLAND		--	--	--	--	--			--
	CLM2	GARLAND		--	--	--	--	--			--
	CLM2	RANDSTAD		--	--	--	--	--			--
	CLM2	GARLAND		0,0	1,5	0,5	0,5	0,5	12,0		1,0
	CLAV	GARLAND		1,5	0,5	1,0	0,0	0,5			Férias 2025
	CLAL	GARLAND		2,0	0,0	0,0	0,0	0,0			Férias 2025
	CLM2	RANDSTAD		1,0	2,0	1,0	0,0	0,0			1,0
	CLM2	GARLAND		Baixa	Baixa	Baixa	Baixa	Baixa			L. Maternidade
	CLM2	GARLAND		0,0	0,0	0,0	-1,5	0,0			1,5
	CLM2	GARLAND		0,0	0,0	0,0	0,0	0,0			0,0
	CLM2	RANDSTAD		--	--	--	--	--			--
	CLM2	RANDSTAD		--	--	--	--	--			--
	CLG2	GARLAND		0,0	0,5	0,0	0,0	0,0			0,5
	CLG	RANDSTAD		--	--	--	--	--			--
	CLAV	RANDSTAD		0,5	0,0	0,0	0,5	0,5			0,0
	CLM2	RANDSTAD		--	--	--	--	--			--
	CLG2	RANDSTAD		0,5	0,5	0,0	Férias	Férias			Férias
	CLM2	GARLAND		0,0	0,0	0,0	Férias 2025	Férias 2025			Férias 2025
	CLM2	GARLAND		0,0	0,0	0,5	0,0	0,0			-1,5
	CLM2	RANDSTAD		--	--	--	--	--			--
	CLM2	RANDSTAD		--	--	--	--	--			--

APPENDIX B: Company Card´s Traceability and Control Forms



Dados identificação

1. Data *

6/27/2025

2. Selecione o Centro Logístico *

- CLM1
- CLM2
- CLG1
- CLG2
- CLAV1
- CLA

3. Entidade *

- Portaria
- Receção

4. Tipo de transação *

- Entrega de Cartões de Acesso
- Devolução de Cartões de Acesso

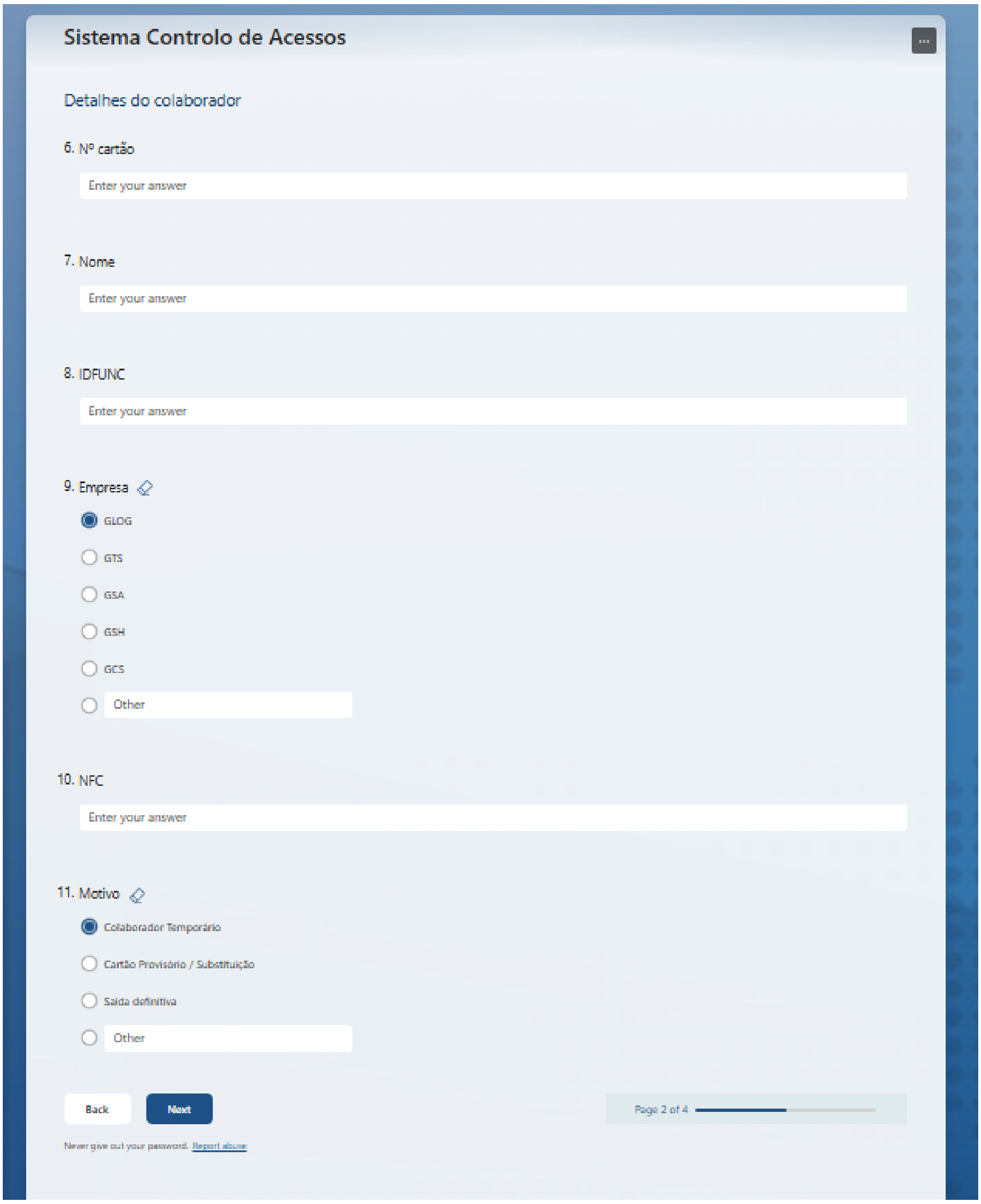
5. Selecione o tipo de cartão *

- Temporário
- Manutenção
- Visitante
- Segurança
- Cliente
- Colaborador
- Limpeza

Next

Page 1 of 4

Never give out your password. Report abuse



Sistema Controlo de Acessos

Detalhes do colaborador

6. Nº cartão

Enter your answer

7. Nome

Enter your answer

8. IDFUNC

Enter your answer

9. Empresa

- GLOG
- GTS
- GSA
- GSH
- GCS
- Other

10. NFC

Enter your answer

11. Motivo

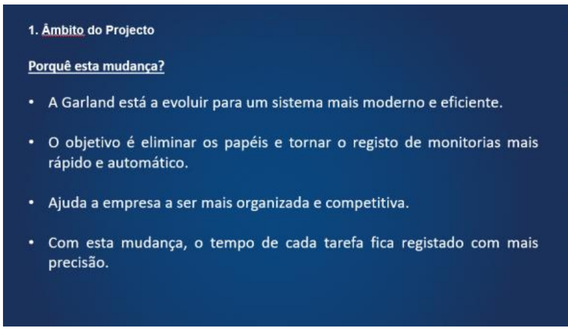
- Colaborador Temporário
- Cartão Provisório / Substituição
- Saída definitiva
- Other

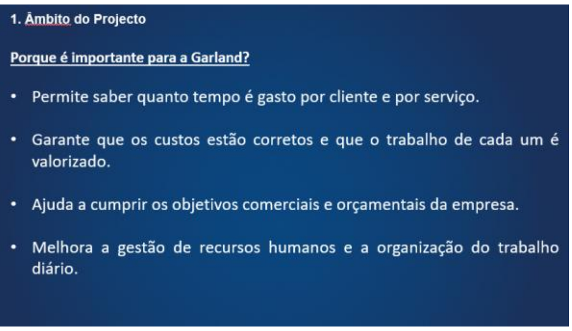
Back Next

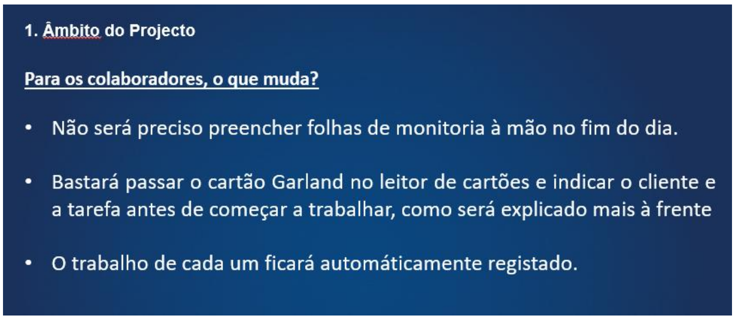
Page 2 of 4

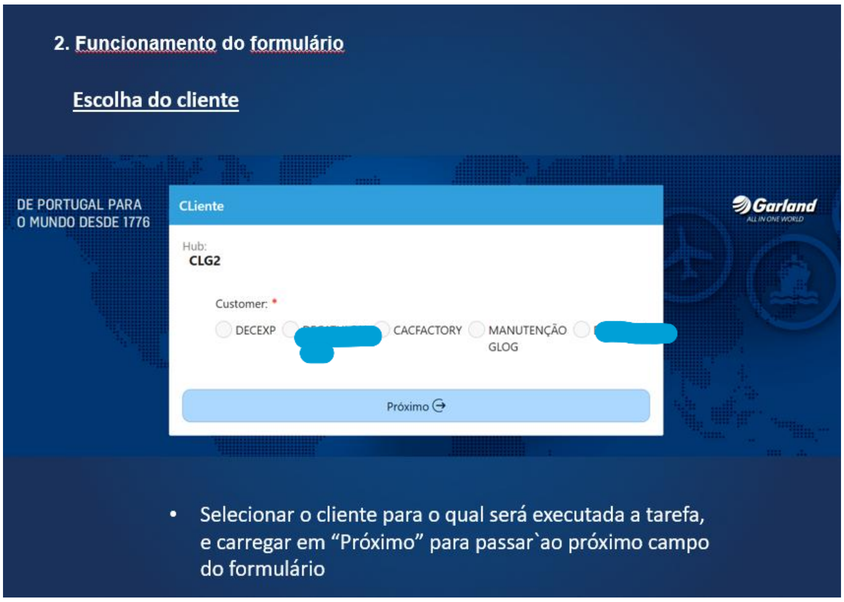
Never give out your password. Report abuse

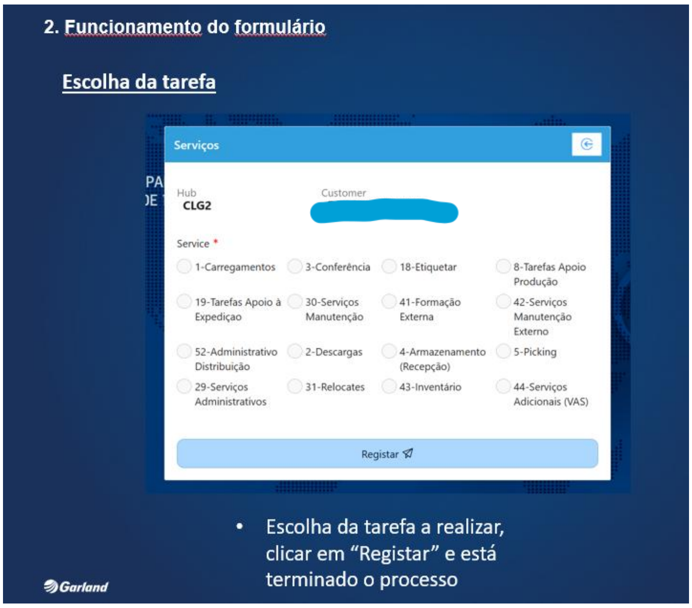
APPENDIX C: Training sessions presentation slides








2. Funcionamento do formulário
Escolha do cliente
DE PORTUGAL PARA
O MUNDO DESDE 1776
CLiente
Hub:
CLG2
Customer: *
DECEXP
CACFACTORY
MANUTENÇÃO
GLOG
Próximo
Garland
Selecionar o cliente para o qual será executada a tarefa, e carregar em "Próximo" para passar`ao próximo campo do formulário


2. Funcionamento do formulário
Escolha da tarefa
Serviços
Hub
CLG2
Customer
Service *
1-Carregamentos
3-Conferência
18-Etiquetar
8-Tarefas Apoio Produção
19-Tarefas Apoio à Expediçao
30-Serviços Manutenção
41-Formação Externa
42-Serviços Manutenção Externo
52-Administrativo Distribuição
2-Descargas
4-Armazenamento (Recepção)
5-Picking
29-Serviços Administrativos
31-Relocates
43-Inventário
44-Serviços Adicionais (VAS)
Registar
Escolha da tarefa a realizar, clicar em "Registar" e está terminado o processo
Garland


Garland
ALL IN ONE WORLD
Digitalização de monitorias