# How Low-Code Platforms Support Process Digital Twins

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## I. Introduction

Process Digital Twins (PDTs) extend the known concept of the Digital Twin (DT) [6] and provides a virtual representation of a real-world process that enables continuous real-time data sharing for monitoring, simulation, and optimization activities [2], [7], [9]. Despite the benefits, developing and maintaining PDTs is highly complex [7]. The process requires intricate modeling, continuous data integration from various sources, real-time synchronization with physical systems, and coordination between multiple actors. Traditional process modeling methodologies, such as Business Process Management and Business Process Model and Notation (BPMN) [8], are not designed to cope with the dynamic and data-driven nature of PDTs [13], [16]. From the other hand, the rapid development of Low-code development platforms (LCDPs) [14] results in a ready-to-use toolbox that users with minimal programming effort can use to quickly create, and maintain applications, reducing development time and costs. While some previous studies considered the possibility of using LCDPs for the definition of physical objects DTs [4], [5], the *actual combination of these technologies in the context of PDTs is still missing*, and *no concrete experience has been reported so far*.

We inspected the extent to which PDTs can be developed with LCDPs by (i) identifying the key characteristics of PDTs and deriving a formal representation, and (ii) practically exploring how LCDPs can support these characteristics in three different case studies to evaluate their replicability. To evaluate feasibility, we examined the effort required to implement these case studies using LCDPs. The reported experience results in a lesson learned that may influence future research.

## II. COBOL: COmmunity-Based Organized Littering

This case study presents an approach developed in the Community-Based Organized Littering (COBOL) project [1], [3]. The project aims to deliver lightweight littering reporting and engage stakeholders, including citizens, in the littering disposal process. In this project, a crowd-sourcing system may interface with humans, allowing them to contribute littering reports to the disposal process.

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***On the importance of integrating a PDT.*** Developing the process without a PDT prevents dynamic improvement and introduces several challenges in managing process variability, ensuring efficiency, and coordinating stakeholders. Without real-time monitoring, delays in waste removal may go unnoticed until they escalate, and the lack of automated tracking hinders the evaluation of each step's efficiency, leading to suboptimal resource allocation and slower response times.

Waste removal procedures can vary significantly depending on the type of litter, for instance, hazardous materials (e.g., asbestos) require coordination among multiple public authorities. Usually, the system depends on rigid, predefined rules or manual interventions, limiting its adaptability to changing conditions. Introducing such a process, a *PDT* can handle an extensive amount of variability at different levels, such as how many waste types and different removal processes the involved public administrations have, the different actors and actions to involve in each case. The specific waste-related workflow can involve several statuses, such as asbestos removal or a simple process for plastic or paper. The PDT offers a unique way to formalize processes where multiple stakeholders are involved, and the user is informed about the status of a report. This awareness helps build trust in active waste management, and being part of the process thanks to the PDT.

A PDT offers the ability to analyze both historical and real-time data, providing valuable insights for proactive decision-making. In its absence, authorities must rely on static reports or manual observations, which makes it difficult to identify patterns, such as high-littering zones or seasonal fluctuations.As a result, decision-making is often subjective, leading to inconsistencies in service delivery, where some areas may receive faster responses than others. Furthermore, as the number of litter reports increases, a system without a PDT struggles to scale efficiently. Without automated optimization, handling the growing workload requires more manual effort, making the process harder to maintain and less sustainable over time.

## III. Development of the Case Study

In the implementation of the case study we use Notion [11] as an Information System and as a Workflow Automation Tool (WAT) to represent the Digital Process Model, we used the N8N platform [10]. The platform has a collection of workflows that are triggered according to specific actions taken by the

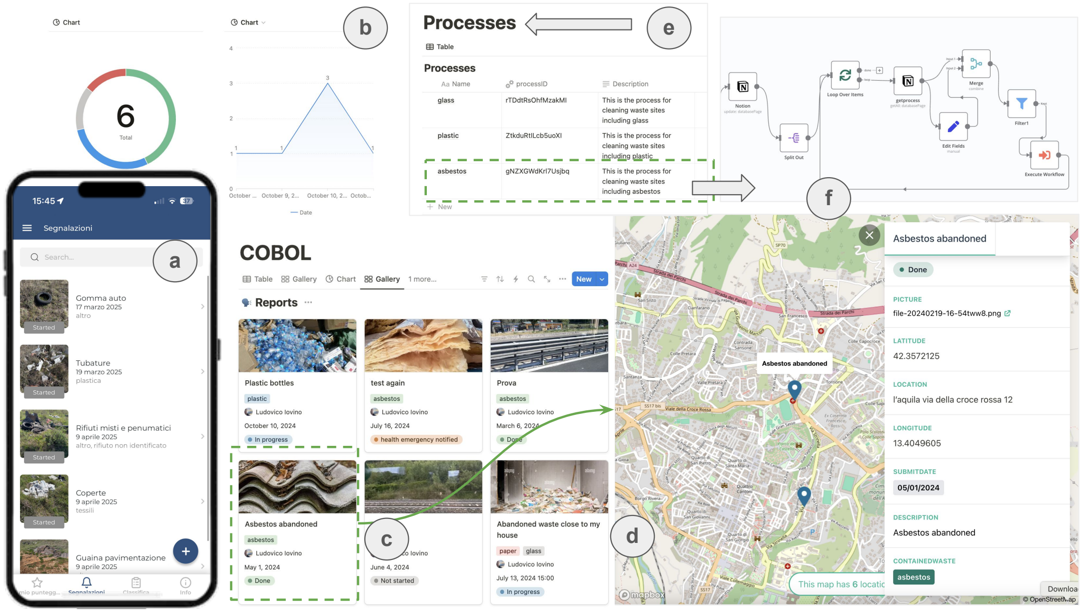


Fig. 1. Implementation of the COBOL case study with Low-code platforms

users through the information system and autonomously, as declared in the workflow, ensuring the Process Execution. Additionally, the system continuously monitors workflow performance, providing key metrics such as execution time, task completion rates, and efficiency indicators to support process performance analysis and continuous improvement.

The information system is used by both the citizens and the public administration to report waste sites and manage the removal process, with assisted status management. Also, a mobile app has been developed with NotionApps [12] (1 a). Indeed, the list of reported waste sites is grouped by status in the typical Notion screen in 1 (c), where decision-makers and operators can keep the situation constantly under control, in real-time. A dashboard, reported in (b), shows the number of reports by waste type on the left, whereas on the right, it shows the number of reports by date. This dashboard is also used for *process data analysis*, allowing authorities to identify trends, such as areas with frequent waste accumulation, seasonal variations, and response time efficiency, supporting proactive decision-making and resource allocation. Each report is also shown on a map-based view (see (d) in 1), also in this case obtained with no-code solutions. In this case study, depending on the type of waste, the system must trigger a different process for removal with a specific workflow. For this reason, we created a Notion database to map the type of waste to the ID of a process corresponding to a workflow in N8N that will be triggered, giving maximum flexibility to the administrator to add/edit and remove processes and associations (see 1(e)).

The solution used to reflect all the changes in the physical process into the *PDT* and then synchronize the PDT with the current status of the process relies on the interaction between the WAT and the information system [15]. This enables full *traceability* of each process instance, ensuring that every step is logged and can be reviewed to maintain accountability and compliance with regulations.

We used Slack to simulate a real-time notification, and a video demo can be watched at https://youtu.be/DGcxz1zb-5A. Additionally, the system can perform *process simulation* to assess the required resources and potential risks, helping authorities plan the most effective waste disposal strategy. N8N allows access to a testing environment where the process can be simulated before being exposed to production. Moreover, the process execution is stored and can be re-executed for debugging in case the process is, for some reason, problematic.

In the implemented system, a user action triggers a process status change, which can be either *implicit*, when the WAT automatically detects and reacts to changes in the information system, or *explicit*, when the WAT prompts the user to initiate the change, e.g., by clicking a link or a button. The current process status is stored as internal variables. Instead, changes in the PDT are carried out in the physical world via the information system, involving manual updates, and are reflected in real time across all system interfaces, such as (a) and (c).

**Limitation**. While *Process Optimization* and *Process Predictive Analysis* are not natively provided by the LCDP, in this case, the N8N platform, they can still be supported through workarounds, external tools, and integrations. LCDPs and in our experiment, N8N's flexibility allows it to connect with specialized systems or machine learning models to analyze and optimize workflows and predict future trends and potential inefficiencies. With the integration of these external tools, N8N can enhance its capabilities to monitor process performance dynamically and make data-driven predictions. However, these advanced features require additional setup and configuration, which can introduce complexity and reliance on external resources for effective implementation.

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