Process Mining

Powered By Nokia

WoodCorp O2C Process Mining

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1. Introduction

This report was developed within the scope of the Process Mining powered by Nokia discipline. The course aims to equip students with both theorical and practical knowledge on the application of process mining techniques in a real business environment, using *Celonis* platform.

In today's competitive and data-driven business landscape, organizations must continually try to improve their operational efficiency and customers satisfaction. One of the critical processes in any manufacturing company is the *Order-to-Cash cycle* (O2C), which covers the entire journey from receiving a costumer order to the final payment collection.

This project focuses on *WoodCorp Inc*. as a case study. *WoodCorp Inc. is* a fictional German wood manufacturing company. It produces pellets and crates, with multiple factories across different locations in Germany. The company is currently facing frequent challenges in meeting promised delivery dates, which is a threat to its reputation, trustworthiness, and competitive urge. In response, the company has shown interest in adopting a process mining approach to gain a better understanding of its O2C process and to identify valuable opportunities for improving operational efficiency and on-time delivery performance.

The project involves analyzing real event data extracted from the company's ERP system, with the objective of building insightful and interactive dashboards, and automated action flows that leads to; bottlenecks and problems identification, and diagnoses to deliver business value for *WoodCorp Inc*.

This report outlines the project's main goals, methodology, developments, and findings, contributing to the construction of a business case that supports *WoodCorp's* potential investment in the *Celonis* platform.

2. Background

In recent years, organizations have increasingly relied on digital tools and data analytics to enhance their decision-making processes and improve operational performance. Among these tools, process mining has emerged as a powerful methodology that enables businesses to extract insights from event logs generated by their information systems. By reconstructing and analyzing actual process flows, companies can detect inefficiencies, compliance violations and constrictions that are often hidden in complex operational environments.

WoodCorp Inc. operates in the manufacturing sector, producing wooden pallets and boxes for transportation. Its operations involve multiple departments and production sites, as well as both automated and manual warehouse systems. Within this context, the O2C process plays a crucial role, covering all steps from the reception of a sales order to the final delivery and payment.

Despite providing estimated delivery dates to costumers, the company frequently fails to meet these deadlines, which can negatively affect customer satisfaction and business reputation. Delays may result from several factors like different process, resource constraints, rework, or systemic inefficiencies. However, without full visibility into the actual execution of the O2C process, it becomes difficult for the management to identify root causes of the problem and implement effective improvements.

The availability of transactional data from WoodCorp's ERP system provide a unique opportunity to conduct a comprehensive process mining analysis. The goal is to offer evidence-based recommendations that demonstrate the value of investing in the Celonis platform and support informed decision-making to enhance delivery performance.

3. Developments

3.1 Data Understanding and Preparation

The analysis was based on two main datasets provided by WoodCorp's ERP system: the Activity Table (event log) and the Case Table (case-level attributes). These were processed and uploaded into the *Celonis* platform to enable process discovery, conformance checking, and performance analysis.

Data Description

- **Activity Table (Event Log)**:

  This table captured the sequence of events related to each sales order. It includes the following keys fields:

  - CASE_KEY: unique identifier for each sales order.
  - ACTIVITY_EN: name of the activity performed (e.g., Order received, Confirm sale, Start Production).
  - EVENTTIME: timestamp of when the activity occurred.

  This information was used to reconstruct the actual process flow using Celonis' Process Explorer, enabling time-based and sequence-based process analysis.

- **Case Table**:

This table provided static attributes and outcomes metrics associated with each process instance. These were used for segmentation, KPI evaluation, and support some insights. Relevant variables included:

- DELIVERED_DATE and PROMISED_DATE: used to calculate delivery performance.
- PRODUCT_TYPE, FACTORY, CUSTOMER_MARKET, DELIVERY_COMPANY: used to segment and compare delivery KPIs.
- ORDERED_QUANTITY, DELIVERED_QUANTITY, UNIT_PRICE, ORDER_VALUE: used to evaluate sales volume, fulfilment gaps, and value/financial impact.
- ORDER_TOLERANCE_MET and ORDER_DATE_MET: Boolean flags indicating compliance with contractual and internal performance expectations.

3.2 Tools and Functionalities Used in Celonis

The following core functionalities of Celonis were employed to extract insights and generate business value:

- **Process Explorer:** Used to reconstruct and visualize the actual execution flow, identify variants, and detect inefficiencies.
- **Conformance Checker:** Enabled comparison between the observed process execution and the expected process (Happy Path), highlighting deviations and their impact on throughput time.
- **OLAP Tables:** Facilitated multi-dimensional analysis across variables such as product type, delivery company, factory, and customer market.
- **Action Flows:** Used to demonstrate automation potential, such as automatically flagging and sending notifications for late deliveries or excess delivery cases.

3.3 Overview of Developed Analyses

- **Sales Order Overview:** Provided a global view of all sales orders, including volume, value, and segmentation by market, product type, and country.
- **Delivery Overview:** Focused on fulfilment performance, highlighting late deliveries, and tolerance breaches.
- **Process Discovery:** Mapped the end-to-end O2C process using event data, highlighting the most frequent paths (Happy Path) and less frequent variants.
- **Conformance Analysis:** Identified and quantified process deviations, their frequency, and their impact on throughput time and steps per case.
- **KPIs and Action Flow:** Included automated monitoring of key performance indicators and triggered alerts for non-conforming cases, helping to support proactive decision-making.

4. Dashboard Overview & Key Findings

4.1 Sales Order Overview

The Sales Order Overview dashboard provides essential insights into WoodCorp's overall sales performance, summarizing key metrics such as total sales volume, order types, costumer market, and the effectiveness of order fulfilment. This overview highlighting both strengths and potential areas for improvement.

Key Metrics:

- Total Sales Orders: 10,040
- Total Number of customers: 120
- Average Quantity per Sales Order: 1,478 units
- Total Value of Sales Orders: €93,169,411
- Orders Outside Tolerance: 40.59%

While the total order volume and value indicate a healthy sales pipeline, the high percentage (over 40%) of orders outside tolerance is a clear concern. This indicates frequent delays or systemic inefficiencies that impact the company's ability to meet the promised delivery performance.

Market and Order Type Analysis:

The Retail segment dominates the customer base, followed by Construction and Transportation sectors. Regarding orders type, "Crates" constitute the majority of orders, with only two categories appearing in total.

Yearly Sales Trends:

The time-series data reveals a sharp increase in sales volume during between 2017 and 2018, followed by a slight decline in 2019. These fluctuations may be tied to seasonality, production capacity, or external market factors.

Country-Level Performance:

Sales are highly concentrated in specific countries. Notable Australia (AU), which accounts for 414,216 sales order positions and over €2.5 Million in value. Other key markets include Sweden (SE), Poland (PL), and Slovenia (SI).

4.2 Delivery Overview

The Delivery Overview combines two complementary dashboards that offer both strategic and operational visibility over *WoodCorp's* delivery performance.

- **Delivery Overview I – General Delivery Performance**

This sub-section focuses on key aspects of delivery punctuality, client segmentation, and temporal trends. Analysis reveals a predominant client presence within the Retail Market, followed by Construction and Transportation sectors. Logistics are primarily handled by DHL, with UPS and FedEx also serving as significant de-

livery partners. The distribution of delivery dates indicates operational stability with occasional peaks in volume. Geographically, substantial delivery volumes are direct towards Germany (DE), Australia (AU), and Switzerland (CH).

Key Performance Indicators (KPIs):

- On-time delivery rate: 92%
- Late deliveries: 8%
- Average Days Late: -2 (suggesting early deliveries in some cases)
- Total ordered quantity: 10,040
- Total revenue: €89,731,373

- **Delivery overview II – Factory and Tolerance Focus**

Analyzing the Delivery Overview II dashboard, we can observe that 40.59% of deliveries are outside tolerance limits, and if we assume the financial risk of a client returns of out-of-tolerance deliveries, the estimated loss of €2,912,847.

Key insights derived from Factory-level:

- Aachen is the largest contributor to delivery volume, especially in Crates (over 9 million units), but also shows the widest tolerance range (from -40,620 to +47,555), signaling a major quality control concern.
- Essen follows with over 4 million deliveries and also exhibits substantial deviations (up to ±20,330 units for Crates).
- Other factories such as Crefeld, Duisbur, Bonn, and Wuppert contribute smaller volumes, but still show signs of misalignment.

Regarding product type, “Crates” consistently exhibit higher volumes and a greater incidence of tolerance issues when compared to “Pallets”. Conversely, “Pallet” deliveries demonstrate superior consistency, particularly from the Crefeld and Essen factories. A visual comparison, represented by a bar plot, clearly identifies “Aachen Crates” as the category presenting both the highest volume and the highest associated risk.

4.3 Process Overview & Happy Path

In this phase we analyzed the Happy Path, which is the most common variant (the variant with the most cases), a variant is a specific sequence of activities / unique path from the very beginning to the very end of the process. In this case it represents the most common and ideal sequence of activities in WoodCorp's Order-to-Cash process, covering all 10,040 cases.

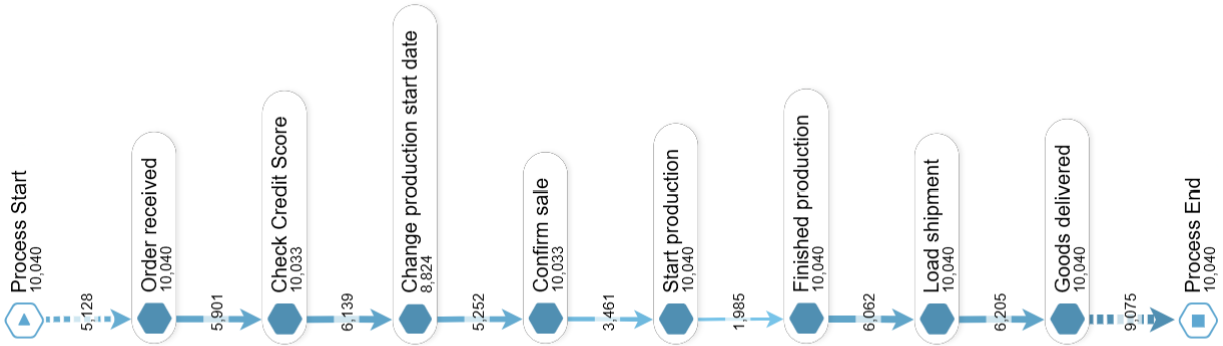

Figure 1: Happy Path

Key activity flow:

- Order Received: Marks the formal initiation of the process, where all 10,040 cases begin.
- Check Credit Score: Almost all orders (10,033) experience a credit validation step, reflecting strong financial control policies.
- Change Production Start Date: This step is executed in 8,824 cases (88%), suggesting frequent manual or system-driven schedule adjustments before confirming the sale. This may indicate planning constraints or dynamic prioritization.
- Confirm Sale: It is present in 10,033 cases, showing alignment between the credit check and order confirmation steps.
- Star Production and Finished Production: All cases proceed through production without divergence, indicating a consistent manufacturing process once an order is confirmed.
- Load shipment and Goods Delivered: All orders are successfully moved through logistics, suggesting minimal disruption post-production.
- Process End: Every case reaches completion, confirming high process completion and throughput.

The full alignment across core activities (production, shipping, delivery) shows operational stability once the order is approved.

4.4 Conformance Checking and Process AI

This section presents a conformance checking analysis, comparing actual process executions with the expected model to identify where the process does not align with company standards.

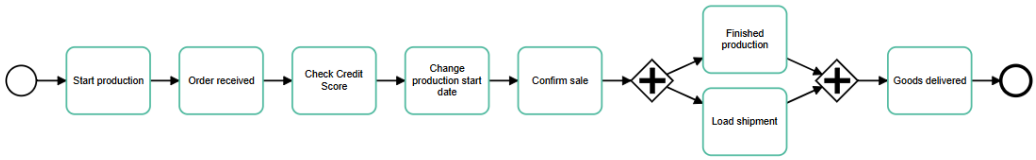

Figure 2: Reference process model

A total of approximately 6,800 non-conformance cases were identified, meaning these orders did not follow the ideal process. Most issues were due to changes in quantity (4,641 cases), changes in price (3,903), or changes in delivery date (3,701), with an overlap between categories. **Among all cases with violations, 55% did not meet the expected product delivery tolerance range (compared to 11% in compliant cases), and 12% were delivered after the promised date (compared to 0% in compliant cases)**. Almost all non-conformances (98.8%) occurred in just three factories: Aachen, Essen, and Crefeld, which shows that nearly all problems are concentrated in these locations.

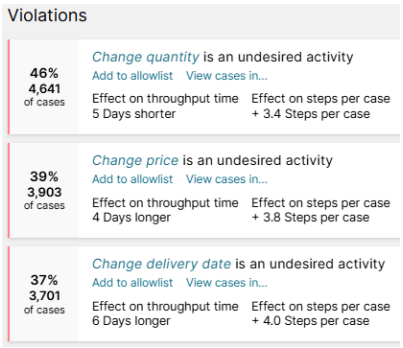

Figure 3: Relevant violations

The **'Crates**' product was involved in **57% of non-conformance cases**, despite only previously accounting for 39% of total orders, making it a clear risk area. The **Construction market** segment also stood out, representing 16% of non-conformances, higher than its overall share. Financially, these process issues are serious: **54% of non-conformance cases failed to meet delivery quantity tolerances** (vs. 11% in compliant cases), and **if customers returned excess goods, the company could lose up to €2.8 million**. Service was also affected: 12% of non-conformance cases resulted in late deliveries, with an average delay of 9 days.

For quantity changes, 74% of affected orders failed tolerance, and 'Crates' was involved in 83% of these cases. Four customers—Kirchner, Fritz, Wiegand, and Jurgens—were responsible for one third of all quantity change non-conformances; Kirchner had particularly high rates, with 90% of their orders failing tolerance.

Price changes were especially frequent in the Aachen (2,062 cases) and Essen (1,242) factories, and in orders to Sweden, Switzerland, and France (25% of price changes). Steinbach, Meibner, and Adam KG together accounted for over a quarter of the price change issues, with Steinbach 2.5 times more likely than average to experience this problem.

Delivery date changes were linked to late deliveries in 18% of cases (versus 8% overall). The Crefeld factory was often involved, especially when dates were changed after order receipt but before production. The Construction market, and customers Steinbach and Meibner, were again overrepresented. Deliveries handled by DHL and FED were involved in 21% of these cases, with higher incident rates than average.

Key findings:

- 98.8% of non-conformances came from three factories: Aachen, Essen, and Crefeld.
- 'Crates' product (57%) and Construction market (16%) had the highest rates of process issues.
- Four customers (Kirchner, Fritz, Wiegand, Jurgens) and three more (Steinbach, Meibner, Adam KG) were involved in a large share of quantity and price non-conformances.
- DHL and FED were linked to many delivery date problems.
- Non-conformances have a potential financial impact (up to €2.8 million) and have led to frequent late deliveries and missed tolerances.

On top of this, a Process AI analysis was performed in Celonis by generating an additional layer of intelligence for process exploration. The purpose of this was to validate the findings from the conformance checking analysis and potentially uncover new root causes.

The analysis revealed that only 13% of all cases (1,326 out of 10,040) follow the ideal or “happy path,” indicating significant process variation in the remaining 87%. Regarding the root causes, the same inconsistencies identified earlier were also detected by the Artificial Intelligence, reinforcing the relevance of the conformance checking findings. These insights can lead to a significant improvement in process performance if properly addressed.

4.5 OLAP Table

The OLAP Table provides a comprehensive and customizable view of WoodCorp’s Order-to-Cash performance across multiple business dimensions. It allows for slicing and dicing of operational and financial KPIs by factory, customer, country, product type, customer market, and delivery company, supporting targeted decision-making and performance diagnostics.

This OLAP structure will enable to the:

- Identification of performance outliers by segment (e.g., most delayed customers, highest losses by factory)
- Cross-analysis of operational KPIs such as on-time delivery, throughput time, tolerance deviation, and average delay
- Integration of financial impact (e.g., order value vs. delivered value vs. losses)
- Exploration of hidden inefficiencies (e.g., 100% delivery performance but still negative profit margin)

This table It is particularly useful for: prioritizing process improvement areas, monitoring key customers and regions, validating the impact of known bottlenecks (e.g., crates, construction market), supporting strategic decisions on logistics partners, customer segmentation, and factory planning

4.6 Action Flow

To demonstrate how Celonis can proactively generate value through automation, we designed and implemented two Action Flows in the context of the Order-to-Cash process. These flows are configured to automatically send relevant email alerts to stakeholders based on specific business logic and process condition.

- Action Flow – Sales Order with Invoices

This flow automatically sends a summary report to stakeholders with detailed information on sales orders that already have invoices issued. The content includes order and delivered quantities; Delivery companies; Product type; Factory of origin. This Action Flow is scheduled to trigger regularly, and sales managers and finance teams receive timely updates.

- Action Flow – High Risk Order Alert

This other action flow acts as a proactive alert system. It identifies and notifies responsible teams about orders flagged as high risk, specifically:

  - Orders from factories_ Aachen, Essen, and Crefeld.
  - Product Type: Crates.
  - Customer Market: Construction.
  - Orders where quantity, price, or delivery date have been changed.

These patterns were identified as root causes of process instability and customer dissatisfaction during the Conformance and Process AI analyses.

These two actions flows improves alignment between logistics and invoicing teams, ensures traceability of orders, automates a repetitive and manual reporting task, encourages early intervention in volatile orders, reduces operational risk and customer complaints.

5. Conclusion, limitations & Future Work

This project demonstrated the power of process mining in discovering value opportunities for WoodCorp Inc. By leveraging the Celonis platform to analyze the company's Order-to-Cash (O2C) processes, we were able to optimize the actual process flows, detect key deviations, and generate actionable insights that support performance improvement.

The analysis revealed that a substantial proportion of sales orders, more than 40%, were outside tolerance limits, indicating frequent delays and process inefficiencies. Key bottlenecks areas were identified. These included several non-conformities; in the manufacturing of Crates, in the Construction market segment and in factories such as Aachen, Essen and Crefeld. In addition, changes in quantity, price and delivery dates were highlighted as significant unwanted activities that contributed to these deviations, often leading to financial losses and delivery delays. The implementation of Action Flows also demonstrated the potential of automating the O2C process, allowing for proactive alerts on high-risk orders and better interdepartmental alignment.

Despite these comprehensive conclusions, the project has inherent limitations. The analysis was based on historical ERP data, which may not fully capture real-time operational dynamics or the external factors that influence performance. Although specific causes were identified, an in-depth analysis could be conducted later for granular level problem identification (e.g. specific resource constraints, systemic bottlenecks).

For future work, several avenues can be pursued to build upon these insights. Firstly, a more detailed investigation into the root causes at the Aachen, Essen and Crefeld plants is warranted, potentially involving on-site observations or interviews to understand the underlying operational challenges. Secondly, the impact of the "Change production start date" activity, which affects 88% of cases, merits further analysis to determine its precise effect on delivery times and overall efficiency. Thirdly, expanding the scope to include additional data sources, such as customer feedback or supplier performance data, could provide a more holistic view of the O2C process. Finally, a rigorous cost-benefit analysis for implementing the proposed automated action flows on a larger scale would solidify the business case for *WoodCorp's* continued investment in the *Celonis* platform. These steps will ensure that *WoodCorp* can not only diagnose existing problems, but also proactively optimize its O2C process for sustained efficiency and greater customer satisfaction.