

## System Analysis & Design

### Manufacturing Downtime Analysis

#### 3.1 System Architecture

The project follows a standard Business Intelligence architecture:

1. **Data Source:** Excel Flat Files (Line Productivity, Line Downtime, Products, Operators).
2. **ETL Layer (Power Query):** Data extraction, cleaning (type conversion, unpivoting), and transformation.
3. **Semantic Layer (Data Model):** Star Schema implementation with DAX measures.
4. **Presentation Layer (Power BI):** Interactive dashboards and reports.

## Data Modeling

### Data Model

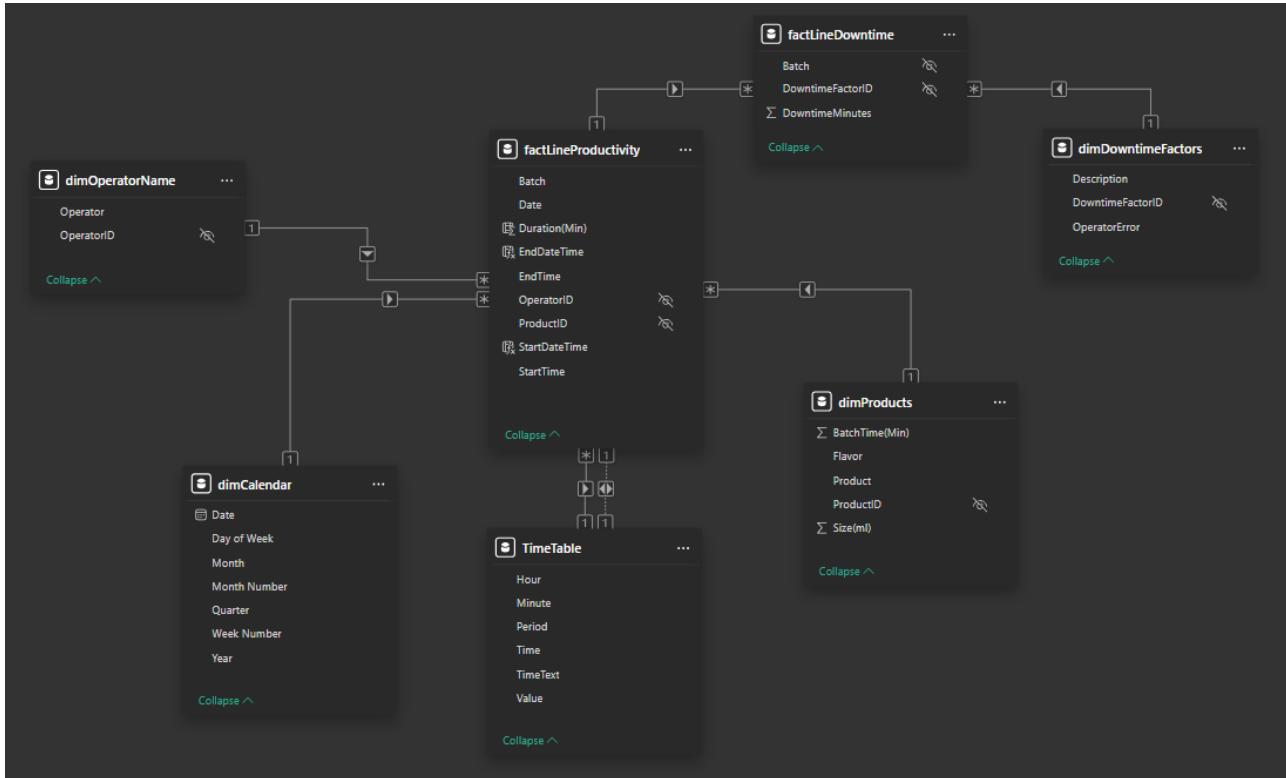


Figure 1: Data model

### Data Model Description

#### Model Overview

The Power BI data model integrates production and downtime information to evaluate overall manufacturing performance. It follows a **star schema**, centered around two main fact tables — **factLineProductivity** and **factLineDowntime** — that connect to several descriptive dimension tables. This design allows for flexible analysis by product, operator, date, and time, supporting KPIs like *Average Production Time*, *Average Downtime*, and *Operator Efficiency*.

## Meta data

### 1. Table: factLineProductivity

**Description:** Stores production event data including duration, batch, operator, and product. It acts as the primary fact table for measuring efficiency.

Column Name	Data Type	Description
<b>Date</b>	Date	The date of the production run <sup>2</sup> .
<b>ProductID</b>	Whole Number (Int64)	Foreign key linking to dimProducts. Used to identify the product being manufactured <sup>3</sup> .
<b>Batch</b>	Text	Unique identifier for the production batch. Converted to text to align with other tables <sup>4</sup> .
<b>OperatorID</b>	Text	Foreign key linking to dimOperatorName. Identifies the operator responsible for the batch <sup>5</sup> .
<b>StartTime</b>	Time	The specific time production started <sup>6</sup> .
<b>EndTime</b>	Time	The specific time production ended <sup>7</sup> .
<b>StartDateTime</b>	DateTime (Calculated)	Combines Date and StartTime into a single timestamp for accurate duration calculations <sup>8</sup> .
<b>EndDateTime</b>	DateTime (Calculated)	Determines the actual end date/time, accounting for operations that cross over midnight (End Time < Start Time) <sup>9</sup> .
<b>Duration (Min)</b>	Whole Number (Calculated)	Calculates the total duration of the operation in minutes (Difference between StartDateTime and EndDateTime) <sup>10</sup> .

## 2. Table: factLineDowntime

**Description:** Captures machine downtime incidents, including the specific factor (reason) and the duration of the stoppage.

Column Name	Data Type	Description
<b>Batch</b>	Text	Foreign key linking to factLineProductivity. Associates the downtime with a specific production batch <sup>12</sup> .
<b>DowntimeFactorID</b>	Text	Foreign key linking to dimDowntimeFactors. Represents the category or reason for the downtime <sup>13</sup> .
<b>DowntimeMinutes</b>	Whole Number (Int64)	The duration of the downtime event in minutes <sup>14</sup> .

### 3. Table: dimProducts

**Description:** Contains product master data such as flavor, size, and target batch times. Used for analyzing performance by product type.

Column Name	Data Type	Description
<b>ProductID</b>	Whole Number (Int64)	Unique identifier for the product. Generated via Index in Power Query <sup>16</sup> .
<b>Product</b>	Text	The name or code of the product (e.g., CO-600) <sup>17</sup> .
<b>Flavor</b>	Text	The flavor variant of the product <sup>18</sup> .
<b>Size(ml)</b>	Whole Number (Int64)	The volume size of the product in milliliters (cleaned from text like "2 L" to 2000) <sup>19</sup> .
<b>BatchTime (Min)</b>	Whole Number (Int64)	The <b>Target</b> minimum time required to produce a batch of this product. Used to calculate if a batch met its target <sup>20</sup> .



#### 4. Table: dimOperatorName

**Description:** A dimension table containing information about machine operators, ensuring standardized names and IDs.

Column Name	Data Type	Description
<b>OperatorID</b>	Text	Unique identifier for the operator <sup>22</sup> .
<b>Operator</b>	Text	The full name of the machine operator <sup>23</sup> .

#### 5. Table: dimDowntimeFactors

**Description:** Describes the reasons for downtime (e.g., "Machine Failure") and categorizes whether the issue is related to operator error.

Column Name	Data Type	Description
<b>DowntimeFactorID</b>	Text	Unique identifier for the downtime cause <sup>25</sup> .
<b>Description</b>	Text	Descriptive name of the downtime reason (e.g., "Machine adjustment", "Inventory shortage") <sup>26</sup> .
<b>OperatorError</b>	Text	A flag ("Yes"/"No") indicating if the downtime factor is attributed to human/operator error <sup>27</sup> .

## 6. Table: dimDate (dimCalendar)

**Description:** A generated calendar table for time-based analysis (Year, Month, Day). It supports trending metrics over time.

Column Name	Data Type	Description
Date	Date	The specific calendar date <sup>29</sup> .
Year	Whole Number	The 4-digit year (e.g., 2025) <sup>30</sup> .
Quarter	Text	The quarter of the year (e.g., "Q1") <sup>31</sup> .
Week Number	Whole Number	The week number of the year (1-52) <sup>32</sup> .
Month Number	Whole Number	The month number (1-12) <sup>33</sup> .
Month	Text	The full name of the month (e.g., "January") <sup>34</sup> .
Day of Week	Text	The full name of the day (e.g., "Monday") <sup>35</sup> .

## 7. Table: TimeTable

**Description:** A DAX-generated table with one row per minute (0-1439). It is used to analyze performance by hour and shift.

Column Name	Data Type	Description
<b>Value</b>	Whole Number	Sequential index representing minutes since midnight (0 to 1439) <sup>37</sup> .
<b>Time</b>	Time	The actual time value (e.g., 08:30:00) <sup>38</sup> .
<b>Hour</b>	Whole Number	The hour component (0-23). Useful for hourly trend analysis <sup>39</sup> .
<b>Minute</b>	Whole Number	The minute component (0-59) <sup>40</sup> .
<b>Period</b>	Text	Indicator for "AM" or "PM" <sup>41</sup> .
<b>TimeText</b>	Text	Readable string format (e.g., "08:30 AM") for slicers <sup>42</sup> .
<b>Shift Time</b>	Text (Calculated)	Classifies the time into "Day Shift" (AM) or "Night Shift" (PM) <sup>43</sup> .

## Relationships Summary

From Table (Foreign Key)	To Table (Primary Key)	Relationship Type
factLineProductivity [OperatorID]	dimOperatorName [OperatorID]	Many-to-One (Single)
factLineProductivity [ProductID]	dimProducts [ProductID]	Many-to-One (Single)
factLineProductivity [Date]	dimDate [Date]	Many-to-One (Single)
factLineProductivity [StartTime]	TimeTable [Time]	Many-to-One (Single)
factLineDowntime [DowntimeFactorID]	dimDowntimeFactors [DowntimeFactorID]	Many-to-One (Single)
factLineDowntime [Batch]	factLineProductivity [Batch]	Many-to-One (Single)

## Model Characteristics

- **Schema Type:** Star Schema
- **Primary Relationships:** Based on surrogate keys (IDs and Dates)
- **Cross-Filtering:** Primarily single-direction for performance; bidirectional between downtime and productivity where batch alignment is required
- **Purpose:** To enable combined performance insights, such as total production vs. downtime, per product, operator, and time frame.

## Visualization and answering business questions

### Wire framing



### UI Wireframing and Dashboard Design

#### Purpose

The wireframe was designed in **Figma** to visualize the structure, layout, and interaction flow of the **Manufacturing Downtime Analysis Dashboard** before implementation in Power BI. This step ensured that all required insights — such as productivity trends, downtime factors, and operator performance — were clearly represented with a user-friendly interface.



## Overview

The wireframe defines:

- **Dashboard layout:** Placement of KPI cards, charts, and filters
- **Navigation flow:** Logical grouping of downtime analysis, production metrics, and operator performance
- **Color scheme and hierarchy:** Consistent with professional manufacturing analytics dashboards
- **Data storytelling flow:** From high-level performance (KPIs) down to root cause analysis and downtime trends

## Design Tool

- **Tool Used:** Figma
- **Purpose:** Create a visual mockup to align stakeholders on report structure and user experience prior to Power BI development.

## Integration with Power BI

The wireframe guided the following design aspects in Power BI:

1. **Page Layout:** Balanced visual hierarchy between KPIs, charts, and filters.
2. **Color Usage:** Consistent use of blue, orange, and gray tones to emphasize status and categories.
3. **Navigation:** Logical flow from overall production efficiency to detailed downtime causes.
4. **User Experience:** Optimized for intuitive interpretation by managers and operators.

## Outcome

The Figma wireframe acted as the **visual blueprint** for building the Power BI dashboard, ensuring:

- Faster report development
- Alignment between data engineers and stakeholders
- A consistent and professional visual identity