MANUFACTURING DASHBOARD DOCUMENTATION

Author: Aleksandra Laskowska
www.linkedin.com/laskowskaaleksandra

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Contents

1. Executive Summary

This dashboard presents manufacturing performance results for a production factory. It has been designed to support both strategic and operational decision-making at management level, including Production, Process, Quality, and Maintenance Managers. The report provides a structured view of key manufacturing KPIs across three analytical layers:

- **Factory level**: offering a high-level overview of overall performance and trends,
- **Line level**: enabling comparison and identification of performance differences between production lines,
- **Machine and Team (Shift) level**: supporting detailed analysis and root-cause investigation.

The dashboard is intended to be used during regular performance reviews to monitor results, identify losses, and focus improvement actions on the most critical areas.

2. Business Context & Use Case

2.1 Data Origin and Confidentiality

Synthetic data were used for this dashboard to avoid confidentiality issues.
The data model was designed based on a realistic manufacturing structure, reflecting actual relationships between factory, line, machine, team, and shift.

Data were generated using Python with AI assistance, following defined process rules and controlled simplifications to achieve a realistic yet stable analytical model.

2.2 Manufacturing Context

The dataset represents an automotive electronics manufacturing environment characterized by high-volume, repetitive, and stable production processes.

2.3 Analytical Scope

The analytical scope of the dashboard focuses on the main types of losses typically observed in production environments:

- Availability losses, including downtime and microstops. Microstops were intentionally included in Availability due to the decision not to analyse Performance losses, which results from data model limitations.
- Yield losses, represented by scrap results at different aggregation levels.

2.4 Drill-Down Logic and Decision Support

For both loss categories, additional drill-down analysis was implemented:

- Team (shift) level analysis, primarily linked to potential human-related and work organization losses.
- Machine level analysis, combining downtime- and scrap-related losses to support equipment-focused investigation.

2.5 Management Use Cases

The dashboard is designed to support management decision-making in the following areas:

- Monthly and daily reviews, addressing questions such as: Where are we now? How far are we from the target? What level of improvement is required?
- Weekly analysis, enabling assessment of whether observed deviations represent isolated events or emerging trends.
- Root-cause exploration, supporting specialists and engineers in identifying areas requiring further investigation.

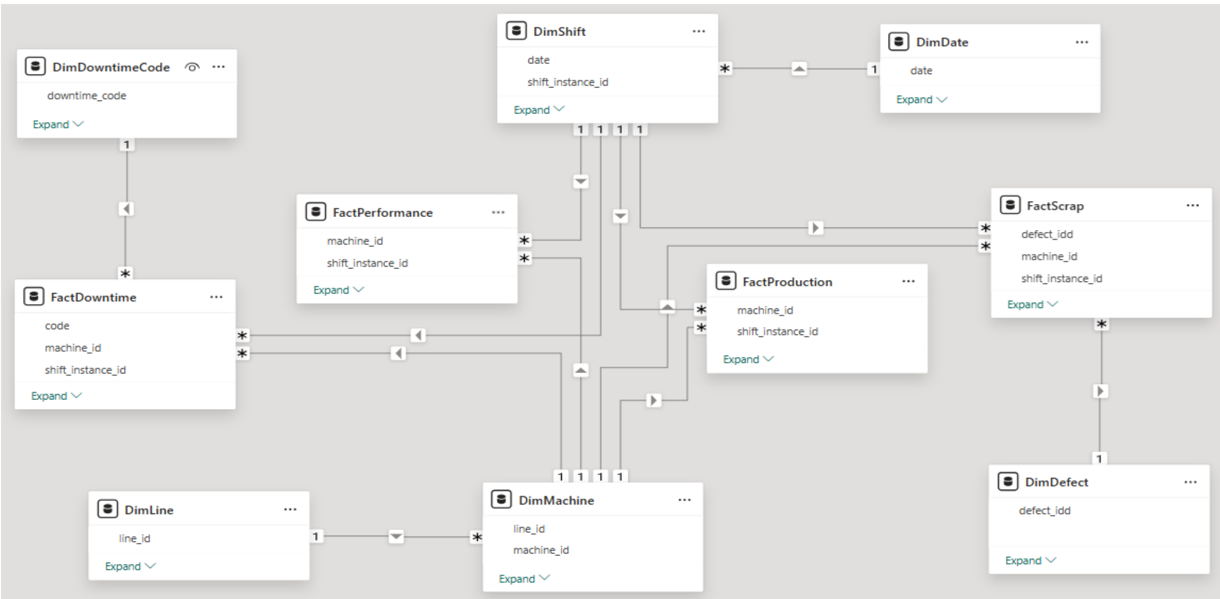
The overall concept of the dashboard is aligned with the requirements of regular management review meetings, providing a consistent and structured basis for performance monitoring and discussion.

3. Data Model & Synthetic Data Assumptions

3.1 Data Model Structure

The dashboard is based on a star-like analytical model with limited and intentional snowflaking. The model was designed to support correct calculation of OEE-related KPIs across Factory, Line, Machine, and Shift levels, with a strong focus on time-based and non-additive metrics.

The model consists of four fact tables (Production, Downtime, Scrap, Performance) and six dimension tables. All fact tables are defined at machine × shift instance granularity, which is treated as the base level of analysis. Higher aggregation levels (line and factory) are derived exclusively from this grain.



DimMachine is the central analytical dimension and acts as the bridge between machine-level and line-level analysis. Each machine belongs to exactly one production line

(DimLine). DimShift represents a single production shift instance and is linked to DimDate, enabling manufacturing-day-based time intelligence (MTD, YTD, rolling periods). Downtime events are stored in FactDowntime and linked to DimDowntimeCode, allowing categorization and Pareto-style analysis of unplanned stops. Scrap events are stored in FactScrap and linked to DimDefect, while machine and time context is derived from the fact table itself. This separation avoids ambiguity and ensures consistent aggregation of quality losses.

All relationships follow a one-to-many, single-direction pattern to prevent ambiguous filter propagation. Snowflaking is applied only where required (Machine–Line, Shift–Date) to avoid data duplication and to preserve correct aggregation logic.

The model explicitly distinguishes between additive and non-additive measures. Time-based KPIs such as Availability and Downtime are calculated at their natural grain and aggregated using weighted or contextual logic rather than simple summation or averaging. This structure ensures:

- consistent KPI behaviour across all analytical levels,
- correct handling of time and contribution-based metrics,
- stable and predictable interaction during drill-down and drill-through analysis.

3.2 Production Structure Assumptions

Fact tables are recorded either at shift level or machine level, depending on the type of event. Higher aggregation levels (line and factory) are derived from these base granularities.

The synthetic dataset represents a mini-factory in the automotive electronics industry operating under the following production assumptions:

Production structure:

- Three production lines, each consisting of five machines.
- A single product manufactured across all lines.
- Strict process flow enforcement: output from an upstream machine (good units only) defines the maximum input for the subsequent machine.
- Continuous operation in a 24/7 mode, with three shifts per day, each lasting eight hours. A “manufacturing day” concept is applied.

3.3 Core KPI Semantics

- Actual production represents total processed units per machine, including good and non-good (NG) units.
- Yield is defined as First Pass Yield (FPY). No rework is included in the model. Yield is derived from scrap generation rather than generated independently.
- Availability includes long downtime and microstops. Planned stops are excluded from Availability by design.
- Performance is derived from cycle time, availability, and a performance factor. Performance values are capped at 100% to avoid overproduction beyond plan.

3.4 Variability and Realism Strategy

The data model intentionally avoids smooth or perfectly proportional behavior. Realism is introduced through multi-layered variability, partially correlated but never deterministic, to reflect real production dynamics and avoid artificially flat trends.

Synthetic data variability strategy:

- **Monthly bias**: each production line has a month-specific bias affecting results. For most months, the bias is subtle (±0.5 pp, up to approximately ±0.8 pp). Additionally, one or two “bad months per year per line are introduced with stronger negative bias (±1.2–1.5 pp). Biases are applied softly, allowing results to drift slightly from targets.
- **Shock days**: three to four shock days per month per line, during which downtime increases by approximately 3–5 pp and yield decreases by 1–3 pp. Shock days are independent per line.
- **Bad weeks**: every two to three months, each line experiences a bad week characterized by increased downtime of approximately 2–4 pp.

3.5 Constraints and Model Limits

To maintain a realistic and consistent data structure, additional constraints were implemented:

- **Hard constraints**: no production above plan, no overlapping downtime events within the same line and shift, and planned stops generated only when production finishes earlier than scheduled.
- **Soft constraints**: service level influences planning, with limited (10–15%) soft correction toward targets to avoid perfect plan execution.

3.6 Line Differentiation Targets

To differentiate performance between lines, the following target ranges were defined:

- **Availability**: normal weeks 78–85%, bad weeks 75–77%.
- **Yield**: Line 1: 97–99%, Line 2: 97–98%, Line 3: 96–97%.

3.7 Intentional Simplifications

The model includes several intentional simplifications that influenced the decision not to analyse Performance losses:

- No labor constraints.
- No material lead times.
- A potential small buffer allowing microstops without stopping the entire line, without explicitly defined buffer size.
- No overlapping failure chains.
- No learning curves or long-term degradation.
- Input–output relationships are represented without advanced interdependencies.

4. KPI Framework & Time-Based Definitions

The dashboard implements a structured KPI framework based on standard OEE methodology used in automotive manufacturing. KPIs are calculated consistently across all analysis levels: Factory, Line, and Local (Team and Machine).

4.1 Core KPI Definitions (Line Level)

At the line level, Availability, Performance, Yield, and OEE are calculated using standard industry definitions:

- **Availability** is calculated as Run Time divided by Planned Production Time. Run Time represents Planned Production Time reduced by Total Downtime, including both long downtimes and microstops. Planned stops are excluded by design.
- **Performance** is calculated as: (Ideal Cycle Time × Total Parts) / Run Time.
  Ideal Cycle Time is defined by the bottleneck machine of the line. Total Parts include both good and non-good units.
- **Yield** is defined as First Pass Yield (FPY) and calculated as Good Parts divided by Total Parts. Rework is not included in the model. Yield results directly from scrap generation.
- **Overall Equipment Effectiveness (OEE)** is calculated as the product of Availability, Performance, and Yield.

4.2 Factory-Level Aggregation Logic

KPIs at the factory level are calculated as weighted averages of line-level results.
The weighting factor is Planned Production Volume per line.

Production Plan is derived from the bottleneck cycle time and is defined as a constant daily value. Due to its stability, it serves as a reliable reference for aggregation and prevents distortion caused by simple averaging of non-additive metrics.

4.3 Team and Machine Level KPIs

At Team level, KPIs are expressed as Effectiveness metrics rather than Contribution metrics. Team Effectiveness reflects how efficiently the available production time within a shift was utilised compared to the line reference, without implying a direct additive contribution to line-level OEE. These KPIs provide localized information while preserving the context of line-level performance. Effectiveness values should be interpreted relative to line-level results, where values above the line KPI indicate positive effectiveness.

At Machine level, KPIs are defined as Impact or Index metrics. Machine Performance Impact represents the relative speed of a machine compared to the line bottleneck reference, while Machine Availability Impact reflects the time-based influence of machine-specific downtime on overall line availability.

4.4 Time Definition and Non-Additive Metrics

Time is a critical component of the KPI framework. The base reference is Total Possible Time, defined as the number of shifts multiplied by shift duration. This represents the maximum available production time before planned stops are excluded.

Time-based KPIs such as Availability and Downtime are non-additive. Correct aggregation logic is therefore required when moving from Machine and Shift level to Line and Factory level. Improper aggregation would lead to incorrect KPI interpretation.

4.5 Operational and Strategic KPIs

Two categories of KPIs are implemented in the dashboard:

- **Operational KPIs**

It is All Month-to-Date (MTD) metrics. These KPIs support short-term monitoring and include tooltip details such as 7-day rolling values and last-day results. Operational KPIs are consistently positioned in the upper section of each dashboard page.

- **Strategic KPIs**

It is Year-to-Date (YTD) metrics and What-If scenario results.
These KPIs provide long-term context and include reference information such as previous month results, Month-over-Month (MoM) changes, target values, and deviations from target. Strategic KPIs are placed in the lower section of dashboard pages.

4.6 Tooltip Formatting and Units

For tooltips and local KPIs, selected measures are converted to text format to ensure correct unit presentation:

- MoM and Δ vs Target values are expressed in percentage points (pp),
- Downtime at Team and Machine levels is displayed in hours and minutes using DAX time intelligence,
- Downtime at Line and Factory levels is presented as aggregated hours.

4.7 Target Zones and Thresholds

Target values are defined based on industry benchmarks and model assumptions. Three performance zones are applied:

- green – target achieved,
- yellow – warning zone,
- red – critical deviation.

For Line-level KPIs, the warning zone is defined as ±1 percentage point from target (depending on KPI direction). For Team and Machine levels, the warning zone is extended to ±2 percentage points due to higher natural variability of local results.

4.8 Reference Measures

To illustrate calculation logic and aggregation rules, a reference table presenting Availability KPIs and selected DAX measures is provided in Appendix A.

5. Dashboard Architecture & Interaction Logic

The dashboard is structured as a set of landing and analytical pages, designed to support fast navigation and consistent user interaction. The dashboard architecture follows a structured analytical flow: from quick orientation at factory level, through narrowing the focus at line level, to detailed root-cause exploration at team and machine level.

The same interaction patterns, navigation logic, and tooltip conventions are applied consistently across all pages to reduce cognitive load and enable intuitive analysis. Navigation buttons are available on landing pages, while a fixed navigation panel on the left side provides access to the same set of pages across the entire report.

The analytical structure is organized into three main layers.

- **Factory Overview**

This page presents factory-level KPIs and provides a high-level view of current performance. It highlights which production line contributes most to losses in Availability, Performance, or Yield, and shows whether basic targets are achieved using Plan vs Actual indicators.

In addition to headline KPIs, the Factory Overview includes area charts for Yield and Availability, presenting short-term performance trends filtered locally by Line. These visuals support quick identification of stability issues and reinforce the narrative that Availability and Yield losses are the primary drivers further analyzed on subsequent pages.

- **Yield and Availability Overview**

These pages represent the line-level analysis and serve as the first step in root-cause exploration. They combine operational results with strategic context, showing how each line performs over a longer time horizon.

Monthly trend visuals have been replaced with area charts focused on the current month, displaying day-level performance against a defined target reference. This approach emphasizes short-term variability, highlights deviations from target within the month, and supports operational decision-making.

The visuals are filtered by Line slicers, clearly marked with green accents to indicate local filter scope.

A What-If panel is included to estimate the potential impact of improvement actions and to assess distance from target values.

- **Team and Machine Overview**

These pages are drill-through views linked to Line ID and can also be accessed via a dedicated navigation button in the bottom-right corner. They provide localized insights and enable benchmarking between shifts and machines.

5.1 Slicer and Filter Logic

The slicer logic is consistent across all pages. Date slicers are hidden within a dedicated panel and can be accessed via a calendar icon located in the top-right corner. This approach keeps the main canvas clean while preserving full time-filtering capability.

Other slicers, such as Line, Machine, Team, and Shift, are embedded directly within the pages using buttons or visual selectors.

When a slicer affects only selected visuals, this is explicitly marked using green visual accents (borders or background highlights). This behaviour applies only to the Factory, Yield and Availability Overview pages. On Team and Machine Overview pages, available slicers affect almost all visuals, reflecting the localized and comparative nature of this analysis layer.

5.2 Tooltip Design Logic

In line with the KPI framework described in Chapter 4, tooltips are implemented for most KPIs and key visuals. Tooltip content follows a clear and consistent logic:

- **Operational KPIs (MTD)** on main pages include: MTD, 7-day rolling, last day value. On drill-through pages, operational tooltips include: MTD, Line MTD reference, last day or last shift value.
- **Strategic KPIs (YTD)** include: YTD, target value, previous month result, Month-over-Month (MoM) change.
- **What-If KPIs** present: simulated value after scenario application, Δ vs Target.

Target values for selected What-If KPI cards are intentionally shown only in tooltips. This design decision avoids excessive color usage on the main canvas and helps maintain visual balance.

5.3 Visual-Level Interactions

Charts include standard tooltips that display values for the selected data point.
Tabular visuals do not use tooltips, as all relevant information is directly visible and additional interaction would reduce readability.

The overall interaction model is designed to be predictable and repeatable: users can move from high-level monitoring to detailed analysis without changing interaction patterns between pages.

6. Analytical Scenarios

This section presents selected analytical scenarios to demonstrate how the dashboard can be used in practice. Each scenario presents a possible management question and shows how insights can be derived step by step using the available views and interactions.

Scenario 1 – Monthly factory review

Question: “Where are we now, and which losses drive the current OEE result?”

Approach: The first step is to check the Factory Overview page by reviewing MTD factory KPIs and the line comparison table. The lowest OEE result is observed for Line 2, but when analyzing all KPIs from the table, Line 3 appears to be the most critical.
Availability and Yield area charts provide context for recent performance over a longer horizon

and confirm chronic issues on Line 3, particularly related to quality topics. Other visualizations give an overview of factory business conditions on a monthly or YTD scale.

Outcome: Clear prioritization of the line requiring deeper analysis, with the next steps focused first on Line 3, where Yield has the lowest value, and then on Line 2, which shows the lowest Availability.

6.2 Scenario 2 – Line-level root cause exploration

Question: “Is this issue still occurring, or is it a consequence of the first part of the month?”

Approach: To analyse the issue in more detail and define improvement areas, the analysis continues on the next page. In this scenario, Yield for Line 3 is analysed. Looking at daily trends for the current month, it is clear that the line operated unstably during the first half of the month, with visible up-and-down oscillations.

The trend shows signs of stabilization in recent days, appearing as a “straight line” on the charts. However, when focusing only on the last week (by comparing Last Day and 7-Day Rolling values from MTD Yield tooltips), the trend remains negative.
There is no clear correlation with production volume. By using time filters (accessed via the calendar icon), it is possible to track whether the issue is driven by the same defect types or if it changes over time.

The What-If panel is used to estimate the potential impact of improvement actions. By adjusting the scrap reduction value, it is possible to define how much improvement is required to close the next month at target, assuming other conditions remain unchanged and are repeated in the next period.

Outcome: Identification of the current situation: whether the problem still exists or whether the focus should be on monitoring already implemented actions. The What-If panel supports estimation of improvement targets and helps assess whether the defined goal is realistically achievable.

6.3 Scenario 3 – Operational benchmarking at local level

Question: “Which team contributes most to the losses? Are the losses related to human errors?”

Approach: Using drill-through navigation, the analysis can move to the local level on the Team Overview page. KPIs are reviewed in a effectiveness context relative to line-level results. This allows comparison of which teams perform better or worse compared to overall line results by cross-referencing values from tooltips (Team KPI vs Line KPI).

Weekly distributions presented in table structures support benchmarking between teams and shift performance, making it possible to identify whether issues occur only for specific teams (e.g. Teams D and E on Line 3) and whether these patterns are more frequent during night shifts.

The charts at the bottom of the page provide additional context by showing reported organizational downtime and number of shifts, which can be a useful indicator when evaluating weekly performance impact. The table on the right provides a concise summary of shift performance.

Outcome: Clear identification of operational focus areas. The analysis highlights where higher scrap levels may be driven by human performance and where organizational or shift-related factors should be addressed.

These three scenarios can be combined into one extended analytical discussion, but they can also be used independently. Such analyses can be a regular part of management meetings and support structured, repeatable performance reviews.

7. Limitations, Learnings & Future Improvements

7.1 Design Decisions & Trade-offs

This project was intentionally designed with a limited analytical scope in order to balance realism, stability of the data model, and development effort. Several design decisions and trade-offs were made consciously during the implementation phase.

- Performance losses were not analysed explicitly.

Although Performance is part of the OEE framework, a detailed analysis of performance losses would require more granular and realistic input data (e.g. cycle time variability, operator influence, material flow constraints). Simulating such behaviour with synthetic data would introduce a high risk of artificial or overly deterministic patterns. For this reason, Performance analysis was intentionally limited to a derived KPI rather than a dedicated analytical layer.

- Microstops were included in Availability.

Due to the decision not to analyse Performance losses, microstops were included in Availability losses to ensure that their impact on production time is captured within the KPI framework. This approach is mathematically consistent and ensures internal coherence of the model, although it simplifies real manufacturing behaviour where microstops typically affect performance rather than full line stoppage. This trade-off was accepted to preserve KPI consistency and avoid fragmented loss attribution.

- Local KPIs are presented as effectiveness metrics.

At Team and Machine level, KPIs are calculated as effectiveness indicators rather than full OEE values. OEE and its components are non-additive measures, and analysing them at a local level without proper context could lead to misleading interpretations. This approach preserves the reference to line-level performance and supports meaningful benchmarking without overstating precision.

- Limited downtime hierarchy was applied.

Another important simplification is the lack of a deeper, more granular hierarchy of downtime analysis, such as a detailed structure from downtime type to exact stop reason codes. This decision was made consciously in order to maintain a stable and manageable data model with a sufficient level of detail, while avoiding over-engineering and analysis that would typically be performed at an engineering level rather than at a management decision-making level. Increasing the level of detail would not add any proportional analytical value for a management-oriented dashboard.

- Visual and naming simplifications were used deliberately.

KPI names and tooltip content were kept short to ensure dashboard readability. Some metrics may appear ambiguous without context; therefore, their interpretation is explicitly clarified in the documentation rather than through overly complex visual elements.

Overall, these decisions reflect a conscious prioritisation of analytical clarity, model stability, and interpretability over maximum granularity. The chosen scope aligns with the primary use case of the dashboard: management-level performance monitoring and structured root-cause exploration.

7.2 Conclusion

The main limitation of this project is the use of simulated synthetic data. I decided to make several compromises to achieve a reasonably realistic data model, while keeping the dataset limited in size, number of variables, and number of fact tables. As mentioned earlier, the most significant simplifications and rigid assumptions concern the area of performance losses and the production plan with execution logic.

If, in the future, it were possible to work with a similar but real (non-simulated) dataset, I would extend the dashboard with a dedicated analysis of Performance losses. A Performance Overview page would focus on cycle time analysis, comparing ideal (defined) cycle times with actual values, identifying reasons for slow cycles, tracking bottlenecks, and analyzing line saturation. In such a case, microstops currently included in the Availability overview would be moved to the Performance analysis area.

Within the Availability domain, further analyses could focus on repeatable downtime patterns, including, for example, a ranking of the top five longest stops within a selected period. With more realistic and detailed input data, the dashboard could be developed to a higher analytical maturity level.

During the execution of this project, I learned how to independently design and deliver an end-to-end Power BI project, translating a structured analytical approach into a dashboard that is accessible to management users. One of the key learnings was the distinction between additive and non-additive measures, as well as the correct handling of non-additive metrics. This project highlighted that simple mathematical operations applied to non-additive measures can easily lead to misleading results if context and aggregation logic are not carefully considered.

Appendix A

KPI	Level	DAX Formula	Notes
Availability Factory	Factory	VAR Weights = SUMX(VALUES(DimLine[line_id]), [Production Planned]) VAR WeightedSum = SUMX(VALUES(DimLine[line_id]), [Availability (Line level)] * [Production Planned])) RETURN DIVIDE(WeightedSum, Weights)	Operational KPI
Availability (Line level)	Line	DIVIDE ([Total Planned Time (Line level)] - [Total Downtime Time (Line Level)], [Total Planned Time (Line level)], 0)	Operational KPI
Machine Downtime Impact	Machine	DIVIDE(([Total Downtime Time (Machine)]), [Total Planned Time (Line level)], 0)	Operational KPI
YTD Availability	Factory	VAR Weights = TOTALYTD(SUMX(VALUES(DimLine[line_id]), [Production Planned]), DimDate[date]) VAR WeightedSum = TOTALYTD(SUMX(VALUES(DimLine[line_id]), [Availability (Line level)] * [Production Planned]), DimDate[date]) RETURN DIVIDE(WeightedSum, Weights)	Strategic KPI With Line filter this measure give the same results like for Line Level.

PM Factory Availability	Factory	CALCULATE(
		   [Availability Factory],
		   PREVIOUSMONTH(DimDate[date])
		)
			Tooltips for YTD

MoM Availability	Factory	VAR CurrentMonth = CALCULATE([Availability Factory], DimDate[month] = MAX(DimDate[month])) VAR Previous = [PM Factory Availability] VAR MoM = (CurrentMonth - Previous) * 100 VAR MoMv = MoM RETURN FORMAT(MoMv, "+0.##;-0.##;0.##") & " pp"	Tooltips for YTD

7 Days Rolling Availability	Factory Line	CALCULATE(
		   [Availability Factory],
		   DATESINPERIOD(
		      DimDate[date],
		      LASTDATE(DimDate[date]),
		      -7,
		      DAY)
		)
			Tooltips for MTD

Last Day Availability	Factory Line	CALCULATE(
		   [Availability Factory],
		   DimDate[date] = MAX(DimDate[date])
		)
			Tooltips for MTD

Availibility after reduction	Line	DIVIDE(
		   ([Total Planned Time (Line level)]-('Downtime time'[Downtime time after reduction] + [Microstops time (Line Level)])),
		   [Total Planned Time (Line level)]
		)
			What-If
			Strategic KPI

Δ vs Target Availability		Δ Availability = VAR delta = ([Factory Availability after reduction] - [T Availability])*100 VAR diff = delta RETURN FORMAT(diff, "+0.##;-0.##;0.##") & " pp"	Tooltip for What-if