Real Time Delivery Trend Performance

Purdue Student Labs

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Agenda

1. **Business Problem & Objectives**
2. **Analytical Problem Framing**
3. **Data Snapshot**
4. **Approach to Solution**
5. **Impact**
6. **Dashboard**

Business Problem & Objectives

Stakeholder Profile

Our client was a leading welding equipment manufacturer produces a low volume, high mix of machines. They have pioneered with 125 years of excellence and also deal with cutting, retail, training equipment, guns and torches. Their solution covers automative/transportation, shipbuilding, pipeline, structural, fabrication, process, power generation, repair and pipe mill domain. The current supply chain for welding machines supports:

800 Suppliers

13,000 unique parts

Product Line:

Welding Equipment

Cutting Equipment

Guns and Torches

Retail Equipment

Training Equipment

Business Problem

The Problem: The commodity managers manually review the quarterly reports, taking a reactive approach to address supplier performance issues

- The static manual scorecards review about 75 suppliers, leading to potential gaps in covering 800 supplier base.
- Quarterly data is outdated and can misrepresent a supplier's current delivery trends.
- The current scorecards capture suppliers score on delivery performance and is not reflective of other areas such as production planning or stockout risk analysis.

Business Objectives

Key Metrics Comparison

Supplier Delivery Performance
(Full shipment)

- Gauge monthly delivery performance & aging view at a Supplier, Material, Commodity and Plant levels
- Compare and analyze documented lead times to actual delivery dates
- Identify top 10 Suppliers, Materials Commodities and Plants by # late deliveries and days overdue

Risk Rating

Supplier Stockout Risk
(Scorecard using Key Metrics)

- Calculate a stockout risk rating by supplier for commodity managers
- Stockout prediction for contingency planning

Recommend

Alerts and ROP
(Threshold on Supplier Score < 3)

- Send real-time alerts to commodity managers based on threshold metric
- Generate recommended ROP and safety stock levels based off delivery performance
- Increase in delivery efficacy and production by 40%

Real Time Reporting

Tracking delivery trend
(Reduce report latency by 100%)

- Allow commodity managers to investigate historical delivery performance by supplier or material
- Replace quarterly scorecards with real time BI dashboard

Target Audience

This project is focused on creating value for two primary user groups:

Executives

(concerned with managing the broad portfolio of products and the impact to financials)

- **Real-Time Performance Insights:** Delivers instant snapshots of supplier timeliness for actionable insights.
- **Customizable Data Views:** Allows detailed data selection at various levels—Supplier, Material, Commodity, Plant—to suit specific analytical needs.
- **Data-Driven Decision Making:** Enables managers to make informed choices and effectively communicate with suppliers using data-supported insights.

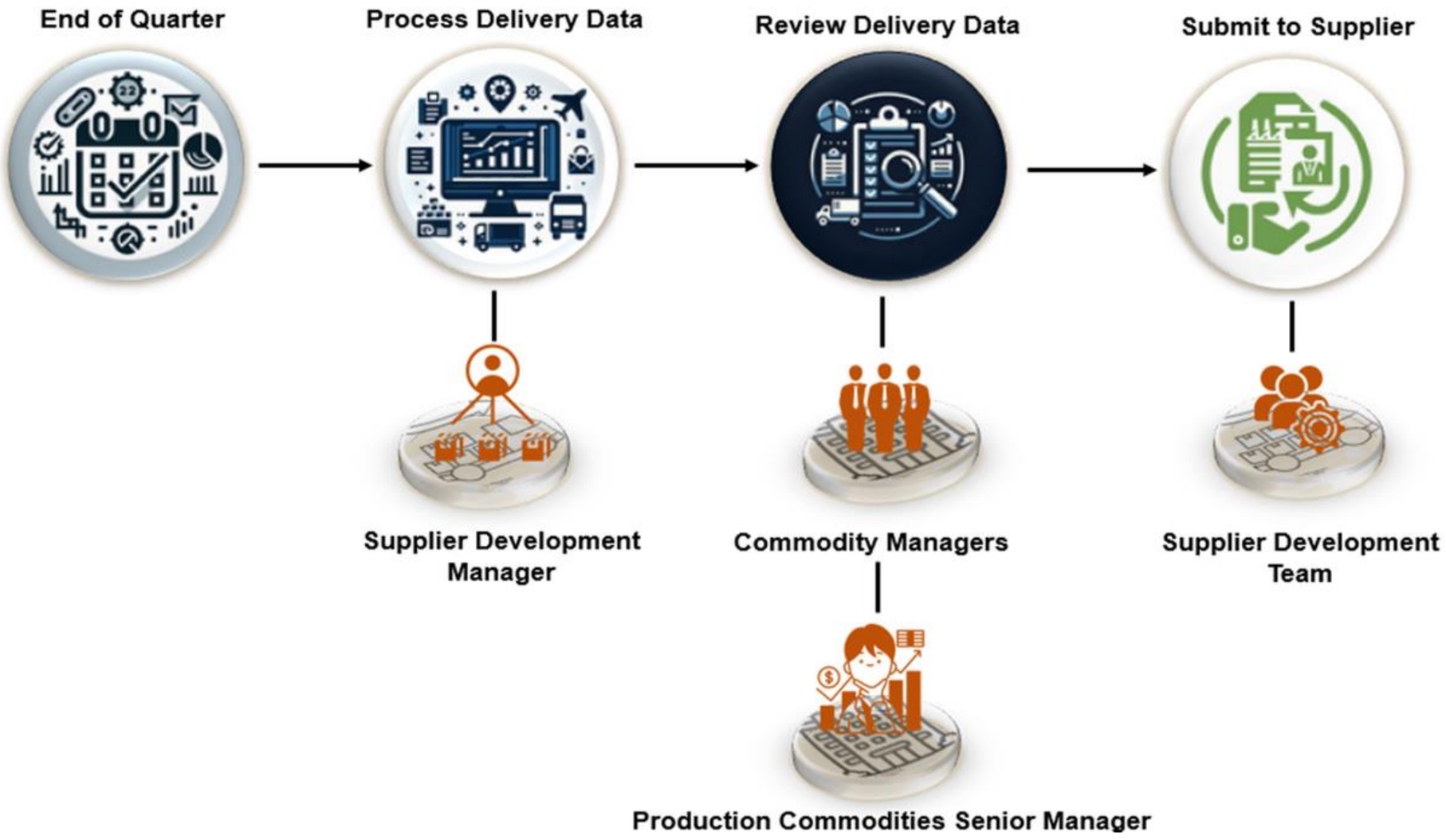
Commodity Managers

(concerned with managing supplier risks and long-term relationships and personal portfolio performance)

- **Personalized Oversight:** Allows Commodity Managers to use personal filters for monitoring specific supply chain performance, across all levels.
- **Quantitative Performance Metrics:** Provides stockout scores to quantify supplier timeliness and performance.
- **Proactive Alert System:** Sends email alerts for significant performance breaches, aiding swift contingency planning.

Analytical Problem Framing

Current State



Transition to Future State

	Current State	Ideal Future State
Reporting Frequency	Quarterly	Real-time
Data Reporting	Manual	Automated system (Dashboard)
Scope of Monitoring	Limited to around 75 suppliers	All 800+ suppliers and 13,000 materials
Analysis Approach	Reactive, with static manual scorecards to review of delivery trends	Proactive, with automated dashboards, KPI based alerts to pre-emptively address issues
Metrics	Only the Delivery performance (supplier scorecard) which is not applied stockout risk analysis	Comprehensive analysis including delivery performance, supplier performance and stockout risk analysis
Impact	Limited scope of monitoring leads to minimal impact on overall supply chain efficiency.	Maximized scope of monitoring leads to increased financial savings, no report latency, optimized production efficiency.

Data Snapshot

Data Summary

Data Sources | Data Preprocessing | Data Relationships

1.Delivery Data

Records = 188,464
Columns = 20

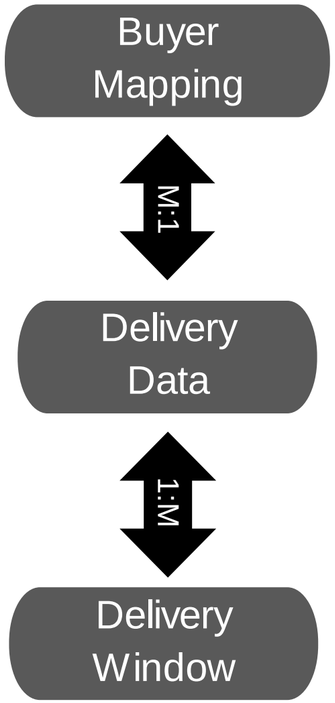
2.Delivery Window

Records = 10,424
Columns = 2

3.Buyer Mapping

Records = 452
Columns = 3

- Aggregated the values for full shipment
- Created primary keys based on Purchase order, Item ID and Statistical Delivery date
- Wrangled supplier name
- Updated document date, days early/late & days to receipt based on credit given



Assumptions:

- On time shipment is based on set delivery window for suppliers
- Full shipments are measured against purchase orders for on-time delivery and complete purchase order delivery.

Approach

Methodology

Ingested the modified data Excel files

File Ingestion

BI Analytical Engine

Wrangles data and establishes relationships.

Reports KPI's for full shipments for Executives & Commodity Managers. Infers stockout risks for suppliers & materials

Real-time Dashboarding

Delivery Performance

Stockout Risk Rating

Alerts

Supplier Risk Score

Identify Metric

- Calculating Total Deliveries based on Early, On-time, Late and In progress shipments
- Considered two metrics: Frequency of Late deliveries (FLD) and Average Late Days (ALD)

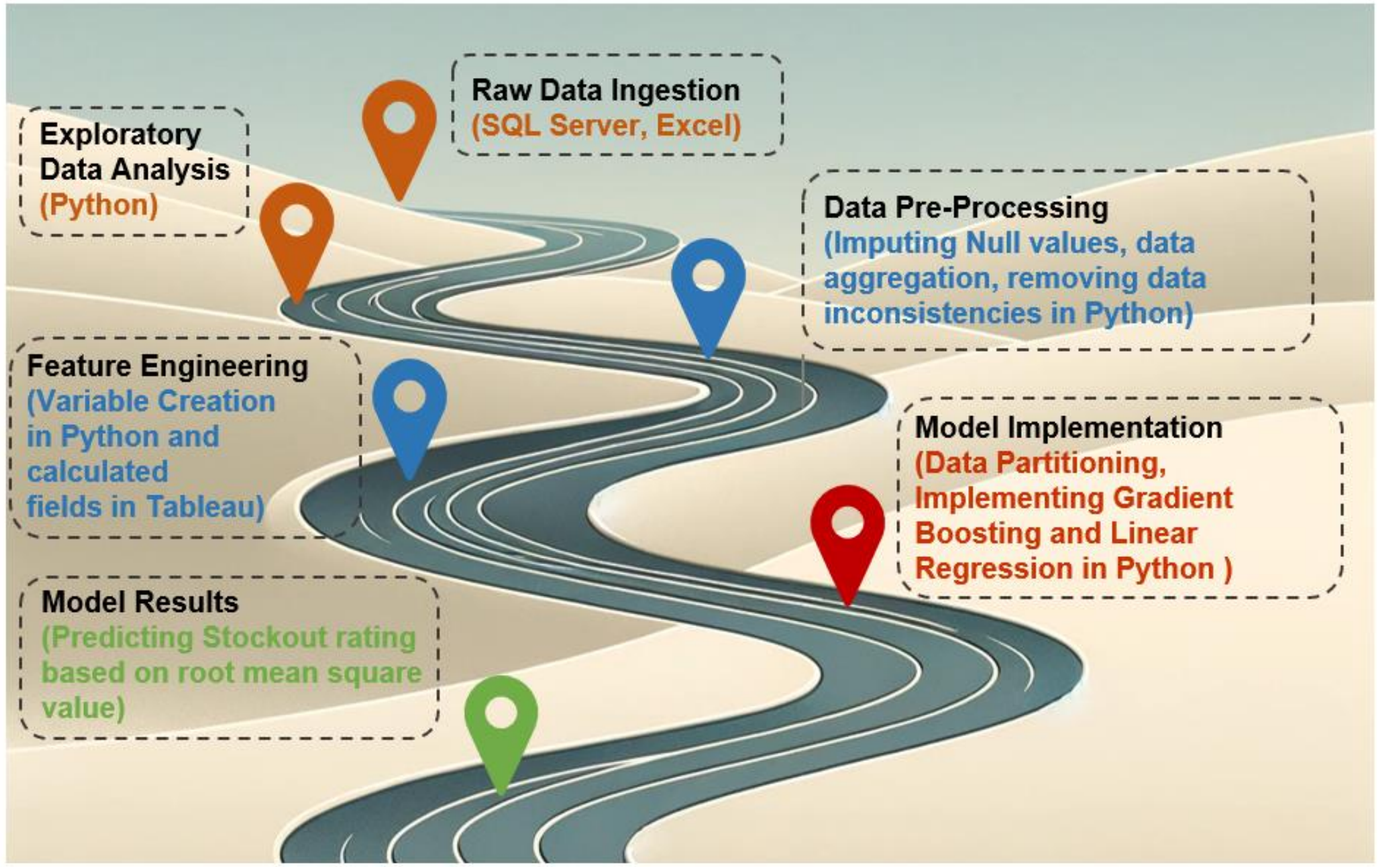
Normalize

- Normalized FLD and ALD at 0-100 scale.
- Post analysis – we considered 0.5 for FLD and 42 for ALD as base maximum.

Assign Risk Score

- Assigned weights for FLD: 0.25 and ALD: 0.75.
- Calculated Risk Rating on a scale of 0-10 as below:
  - 0 to 3 – High Risk
  - 4 to 6 – Medium Risk
  - 7 to 10 – Low Risk

Risk Modeling



Stockout Risk Model

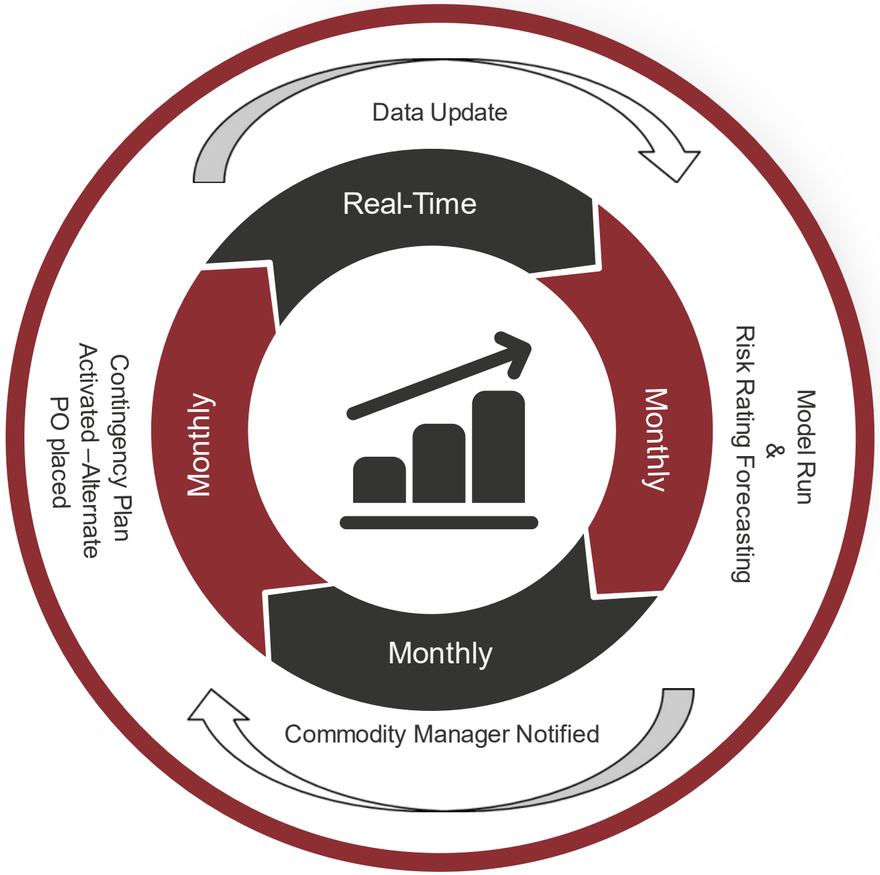
- We used XG Boost Regression model with multi-class probabilities 1500 trees.
- Hyperparameters tunings resulted in model with best result having max depth of 7 and learning rate of 0.1
- Grid search with 3-fold cross-validation to rigorously evaluate the model's performance

Model Performance

- Model selection based on lowest RMSE & highest R Square gave following result:
  - **Model RMSE : 0.36**
  - **Model MAE: 0.2**
  - **Model R Square : 98.7%**

Risk Forecasting Maintenance & Frequency

Activity	Frequency
Data Update	Real-time
Risk Rating Forecasting	Monthly
Model Execution	Monthly
Notifications to Commodity Manager	Monthly



Impact

Impact

Delivery Tracking:

From quarterly to daily updates, eliminating report latency by 100%

Supplier Delivery Rate

Every Supplier has been rated on a scale of 0 -10. Giving data driven knowledge to commodity managers for contingency plans

Alerts & ROP:

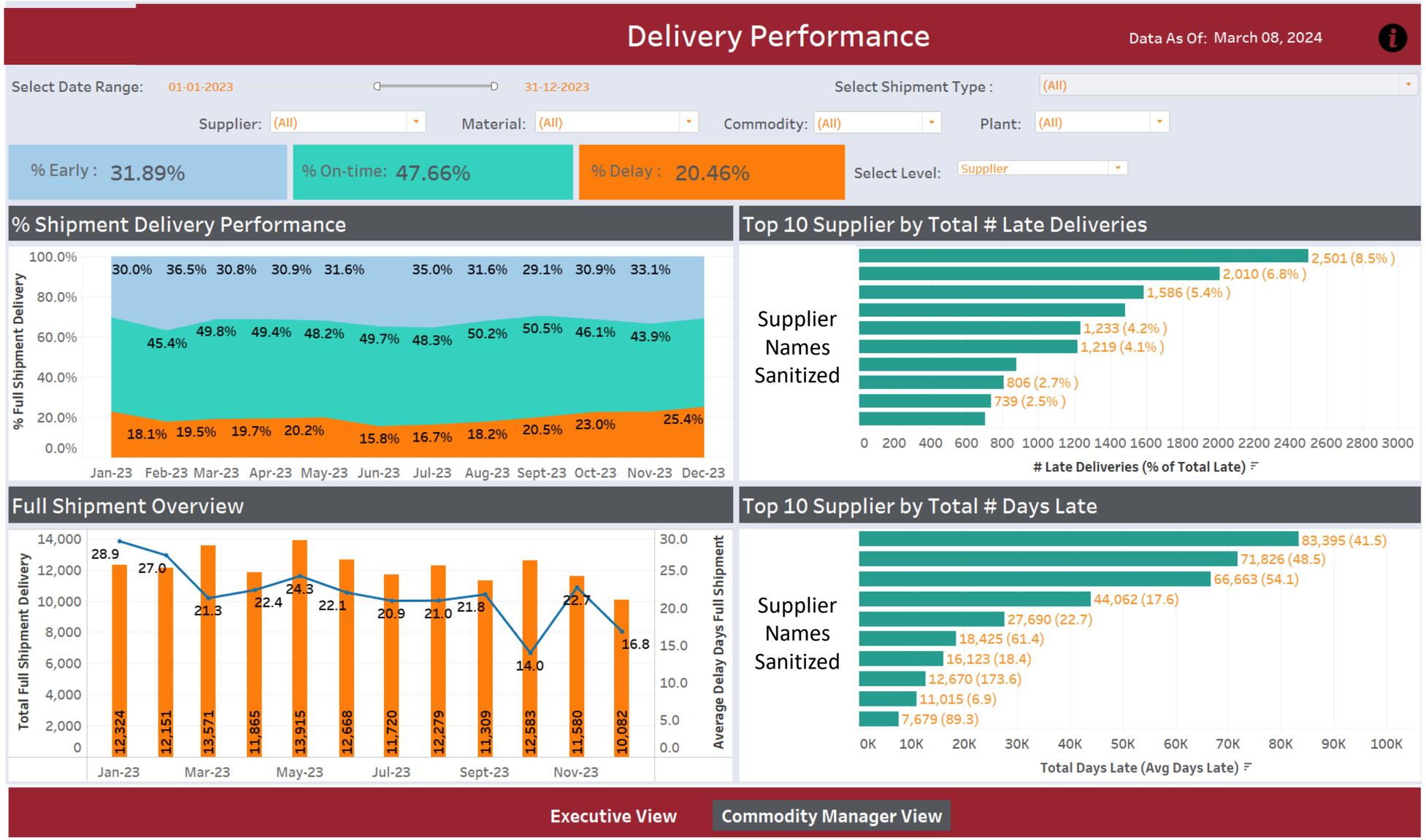
Optimal stock, aiming for full delivery efficacy and increase in production.

Forecasting:

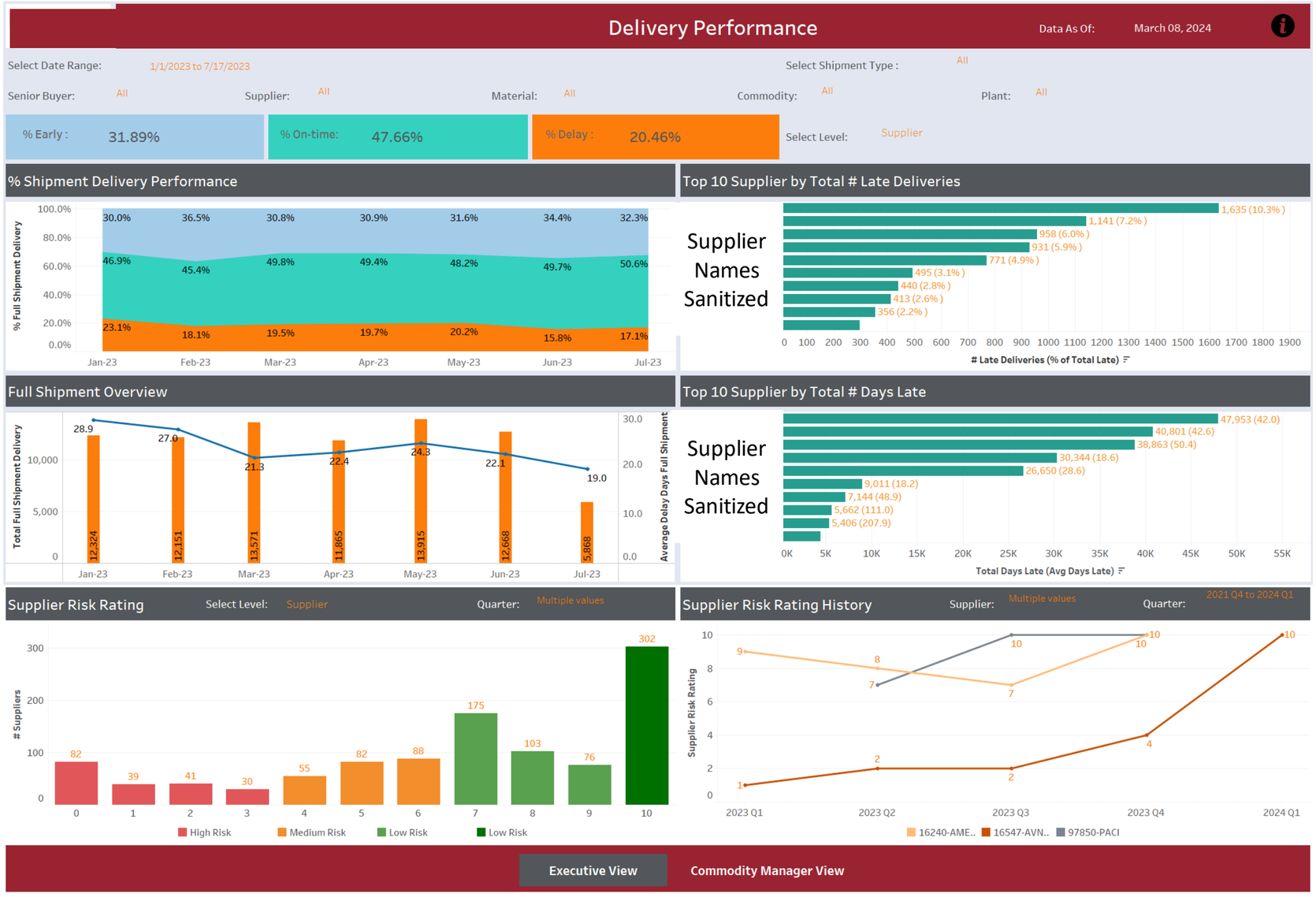
Stockout prediction for contingency planning and alternative sourcing with RMSE 0.3

Demo

Executive View

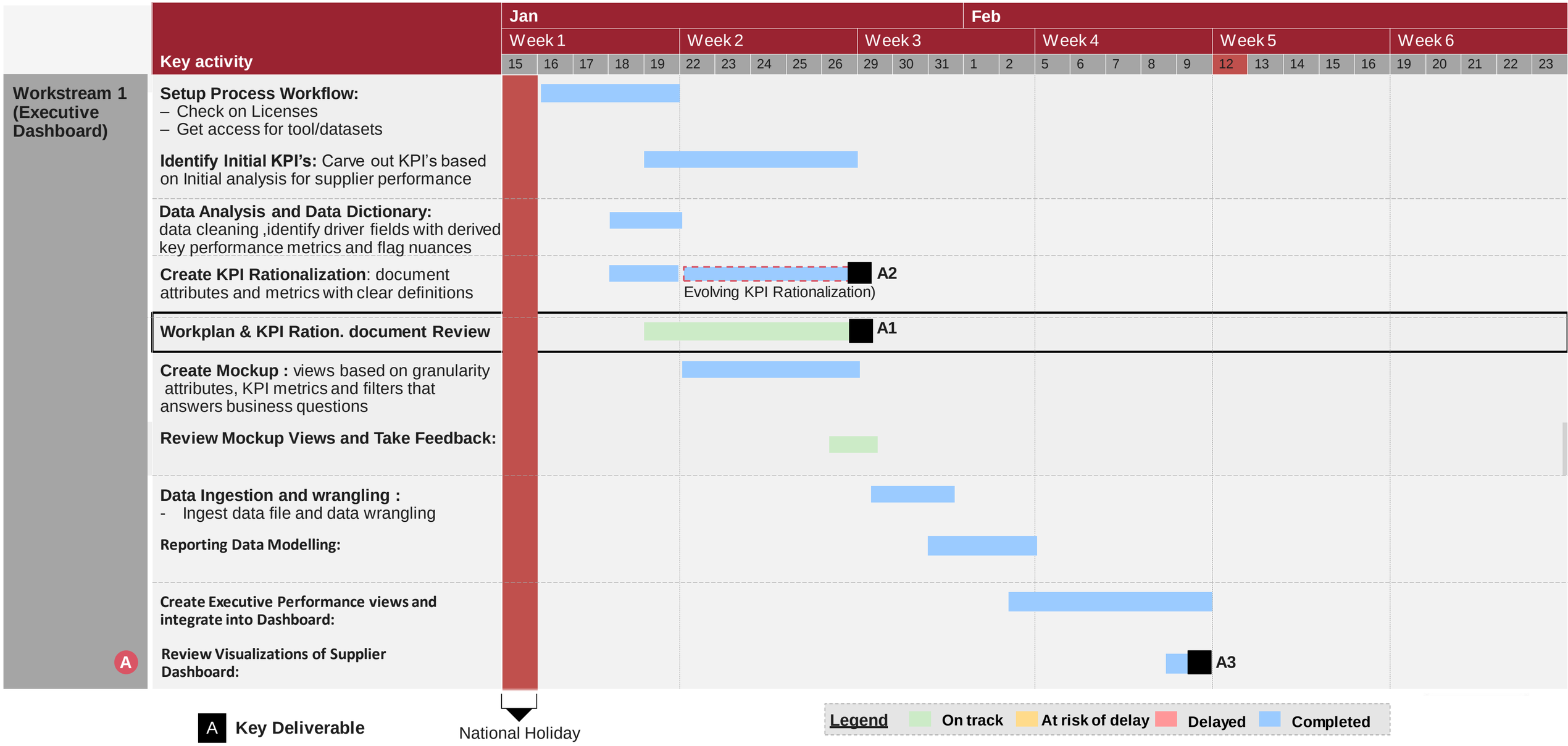


Commodity Manager View



Thank You

Project Workplan & Detailed Activities | 14 weeks collaborative plan to review workstream key activities and milestones



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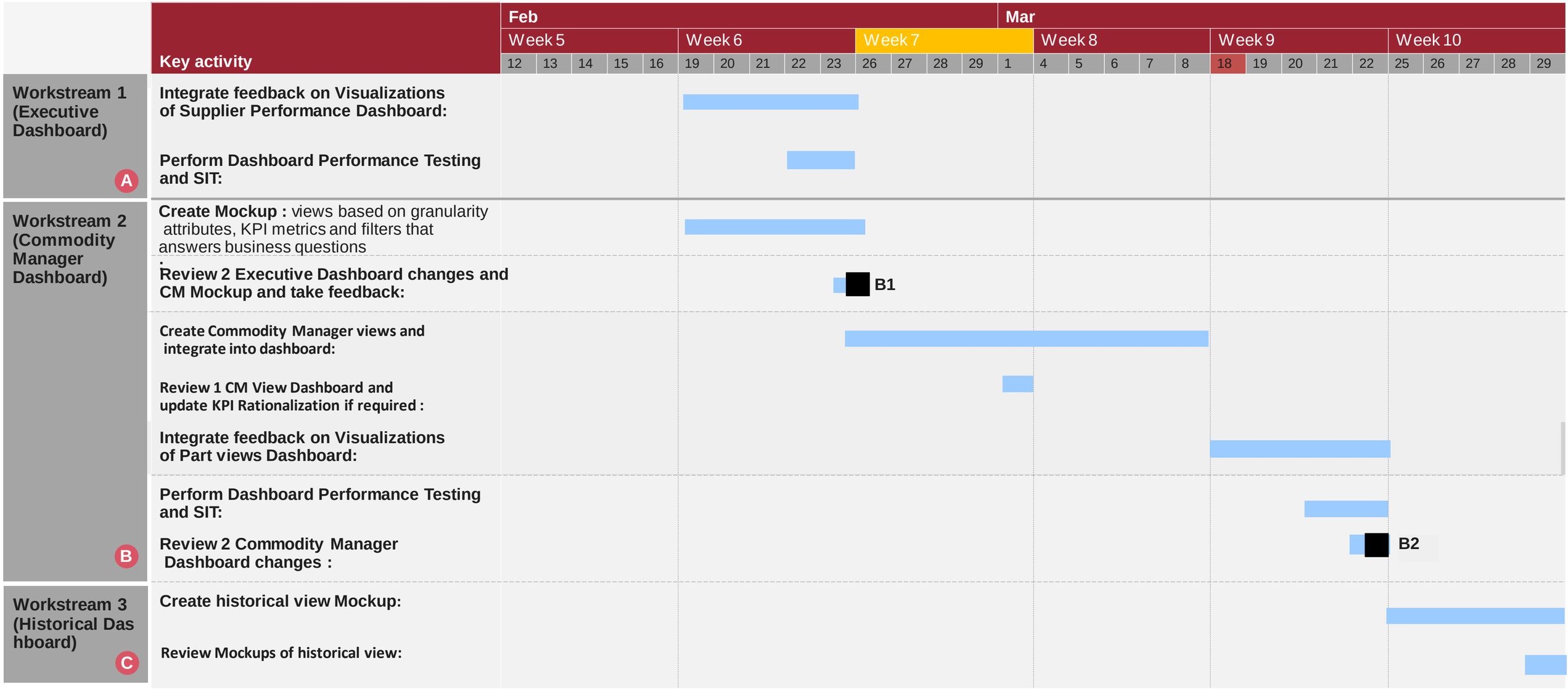

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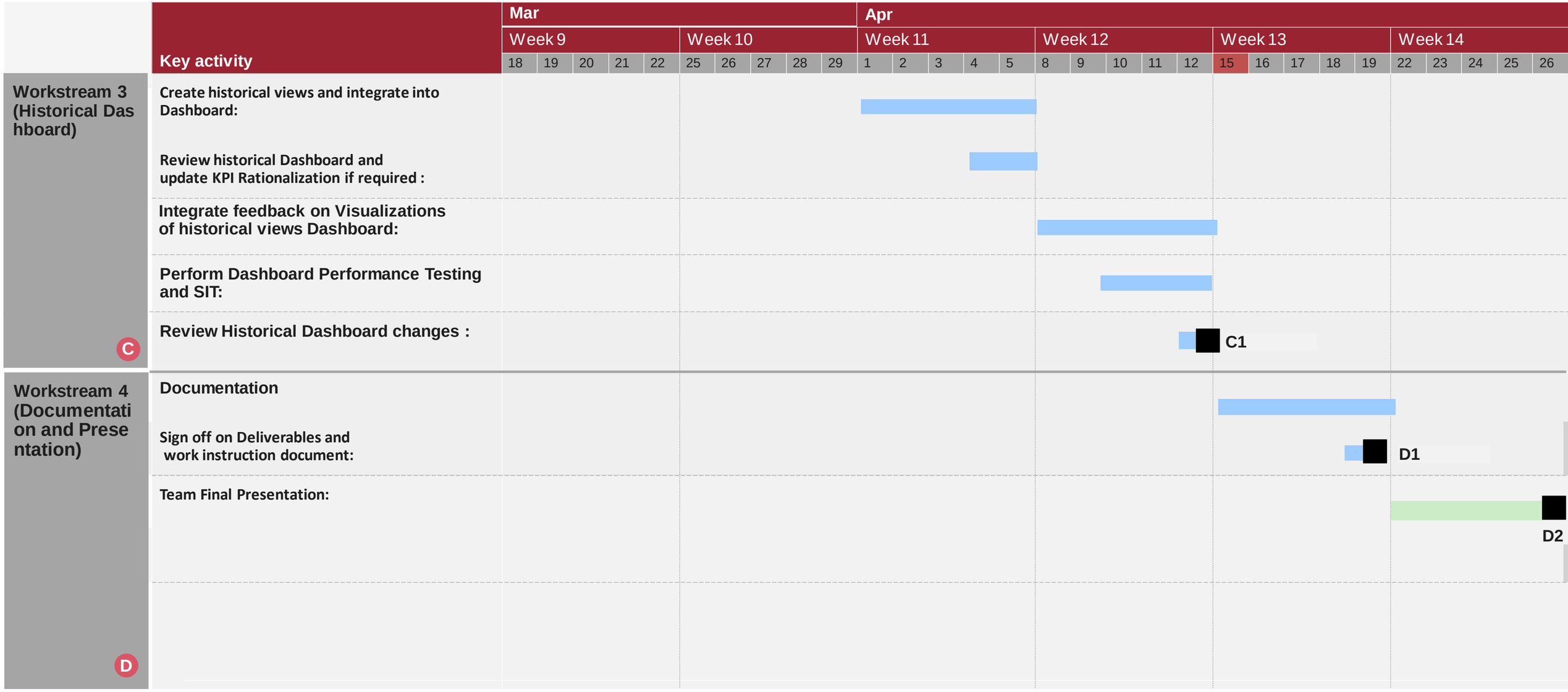

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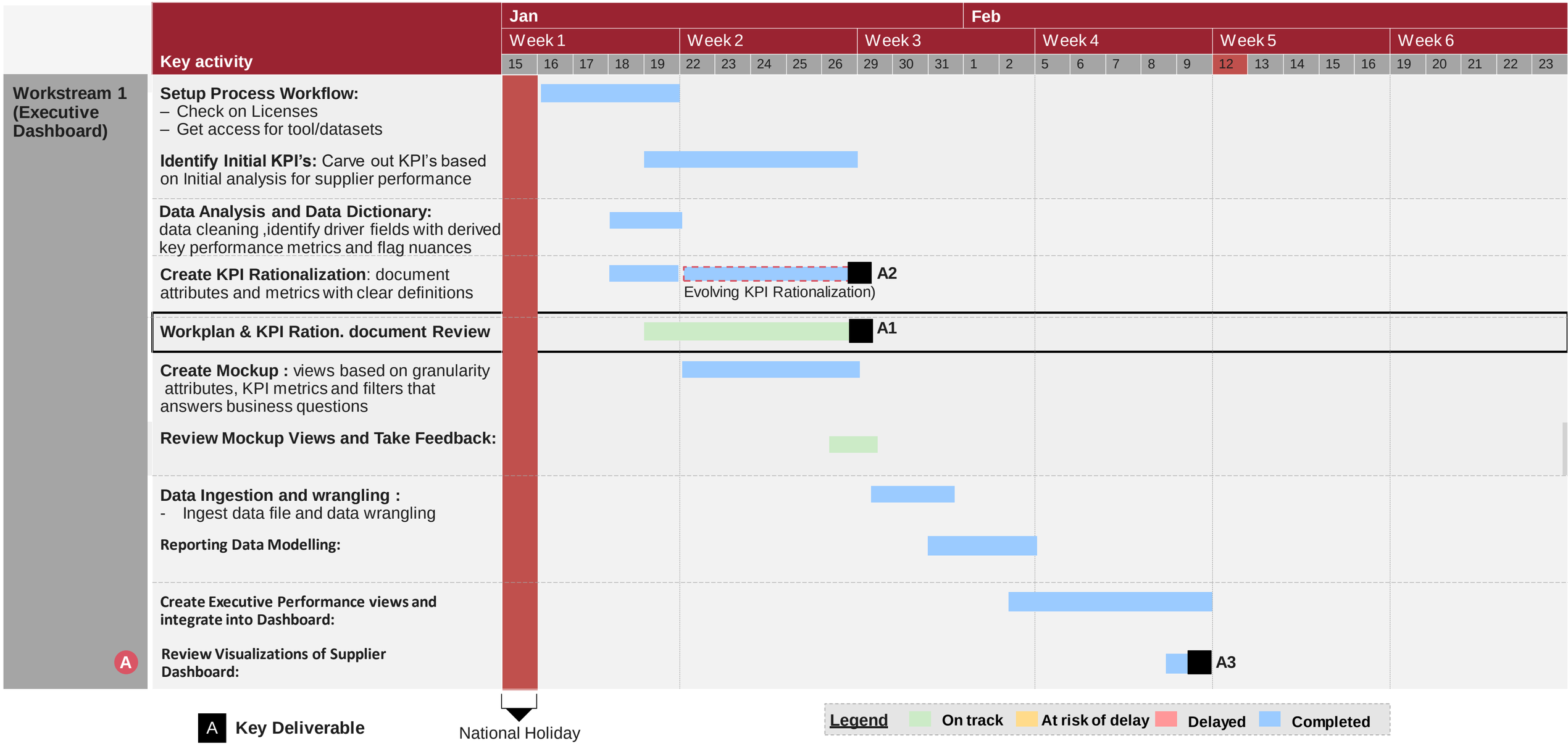

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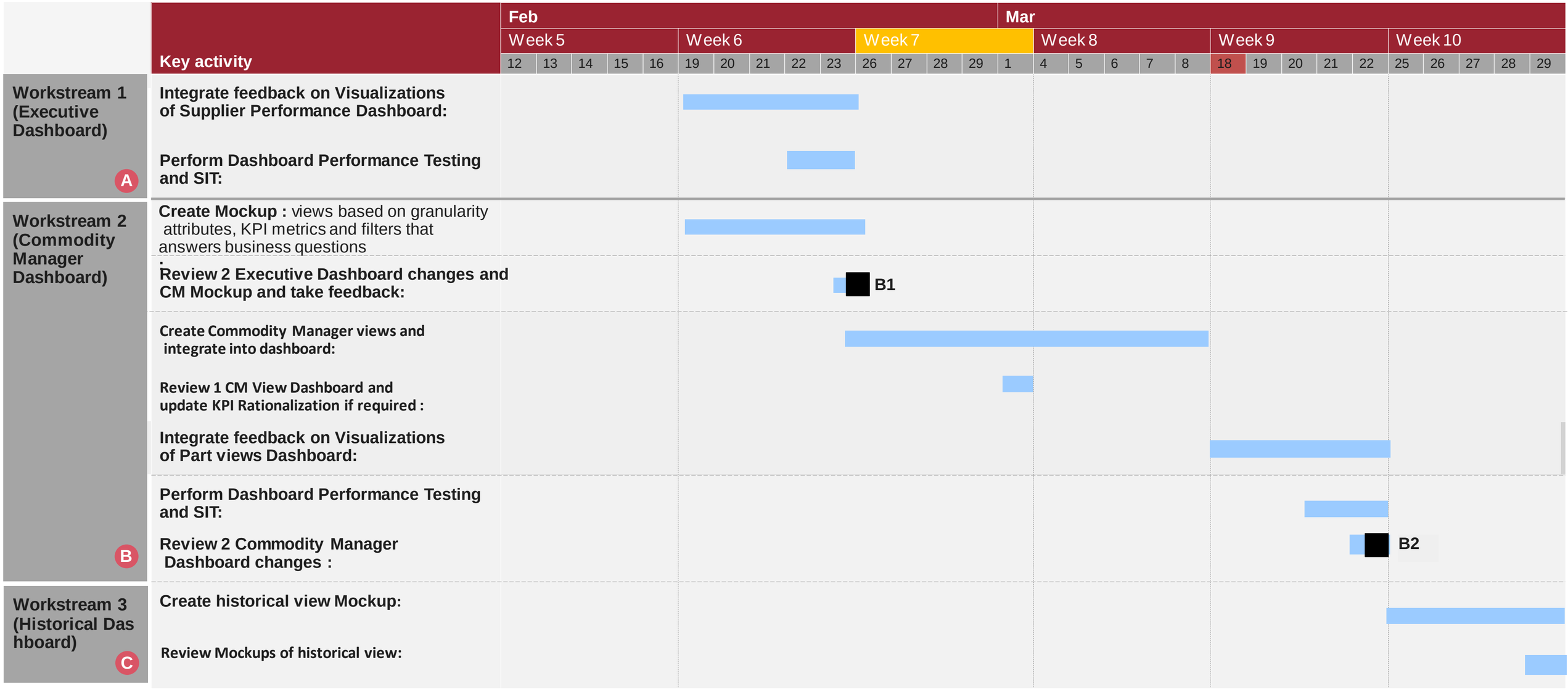

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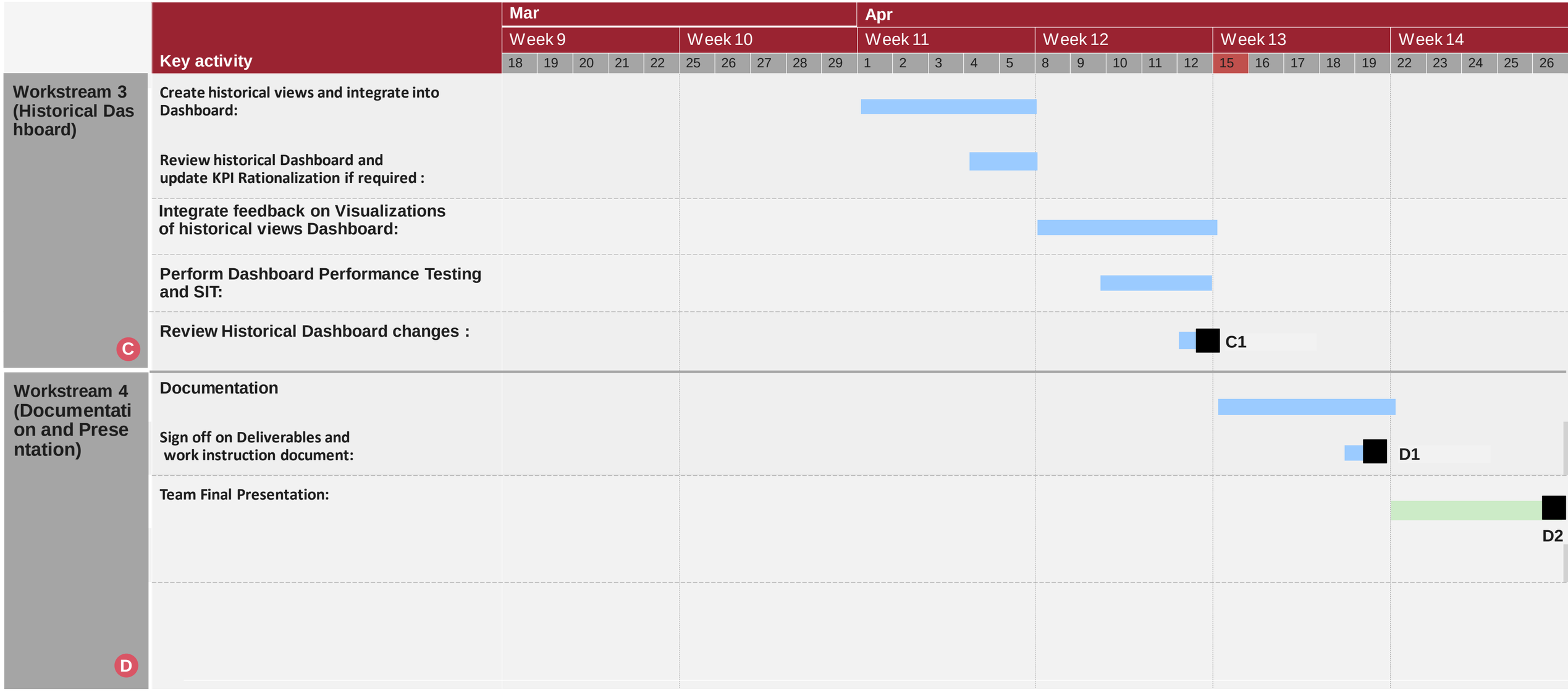

Steps to Calculate Risk Rating

Step 1: Calculating Total Deliveries and segregate it based on Early, Ontime, Late and Delivery in Progress.

Supplier ID	Total Deliveries	Late Deliveries	Sum of Late Days	Early Deliveries	Sum of Early Days	Delivery in Progress Deliveries	On Time Deliveries
10283	8	3	38	2	13	0	3

Step 2: Frequency of Late Deliveries (FLD)

For each supplier, calculate FLD as:

FLD = Num of Late Deliveries for the Supplier/ Total Num of Deliveries for the Supplier

Total Deliveries	Late Deliveries	Sum of Late Days	Early Deliveries	Sum of Early Days	Delivery in Progress Deliveries	On Time Deliveries	FLD (Frequency of Late Deliveries)
8	3	38	2	13	0	3	=D4/C4

Step 3: Average Late Days (ALD)

For each supplier, calculate ALD as:

ALD = Sum of Late Days for the Late Deliveries / Num of late deliveries of the supplier

Late Deliveries	Sum of Late Days	Early Deliveries	Sum of Early Days	Delivery in Progress Deliveries	On Time Deliveries	FLD (Frequency of Late Deliveries)	FED (Frequency of Early Deliveries)	ALD (Avg Late Days)
3	38	2	13	0	3	0.375	0.25	=E4/D4

Steps to Calculate Risk Rating

Step 4: Normalizing FLD and ALD at 0-100 Scale

For each supplier normalize FLD and ALD values based on the maximum and minimum value of their respective columns. As requested, we have considered the base maximum values to be considered for FLD as 0.5 and ALD as 42.

*Norm FLD = IF (FLD>0.5, 100, ((FLD – Min(FLD)) * 100) / (0.5 - Min(FLD)))*

*Norm ALD = IF(ALD>42, 100, ((ALD - Min(ALD)) * 100) / (42 - Min(ALD)))*

Normalized Rating (0-100)	
Norm FLD (Frequency of Late Deliveries)	Norm ALD (Avg Late Days)
75.00	30.16

Step 5: Combined Risk Score (CRS)

Determine weights for FLD and ALD based on importance *(W1 + W2 = 1)*. As requested, we considered that to be W1 = 0.25, W2 = 0.75

*CRS = W1 * Norm FLD + W2 * Norm ALD*

Normalized Rating (0-100)				
Norm FLD (Frequency of Late Deliveries)	Norm ALD (Avg Late Days)	CRS (Combined Risk Score)	Raw Risk Rating	Risk Rating (0 to 10)
75.00	30.16	=K4*R3+L4*R4	58.63	6.00

Weights	
Norm FLD (Frequency of Late Deliveries)	0.25
Norm ALD (Avg Late Days)	0.75

Steps to Calculate Risk Rating

Step 6: Raw Risk Rating (0 - 100) and Risk Rating (0 – 10) Scale

First, finding the maximum and minimum CRS across all suppliers to use as a reference. Then normalize or rate each supplier's CRS to a 0 - 100 scale for Raw risk rating, considering 0 (poor) and 100 (excellent):

$$\textit{Raw Risk Rating} = 100 - ((\textit{CRS} - \textit{Min CRS}) * 100) / (\textit{Max CRS} - \textit{Min CRS}))$$

Then, final Risk Rating will be rounded between 0 to 10 based on Raw risk rating:

$$\textit{Risk Rating} = \textit{Round}\ (\textit{Raw Risk Rating} / 10, 0)$$

CRS (Combined Risk Score)	Raw Risk Rating	Risk Rating (0 to 10)
41.37	58.63	6.00

Model Snippet

```
# Split the data into train and test sets
X_train, X_test, X_id_train, X_id_test, y_train, y_test = train_test_split(X, X_id, y, test_size=0.2, random_state=42)

# Create an XGBoost regressor
model = XGBRegressor(random_state=42, n_estimators=1500)

# Train the model
model.fit(X_train, y_train)

# Make predictions on the train and test sets
y_train_pred = model.predict(X_train)
y_test_pred = model.predict(X_test)

# Calculate RMSE for train and test sets
train_rmse = mean_squared_error(y_train, y_train_pred, squared=False)
test_rmse = mean_squared_error(y_test, y_test_pred, squared=False)

# Calculate MAE for train and test sets
train_mae = mean_absolute_error(y_train, y_train_pred)
test_mae = mean_absolute_error(y_test, y_test_pred)

# Calculate R² (coefficient of determination) for train and test sets
train_r2 = r2_score(y_train, y_train_pred)
test_r2 = r2_score(y_test, y_test_pred)
```

Project Documentation

1	KPI Rationalization
2	Alerts/Triggers Suggestions and how to enable
3	Work Instruction document
4	Project Plan deck
5	Info excel
6	Risk Rating Steps
7	Model (Executable File)