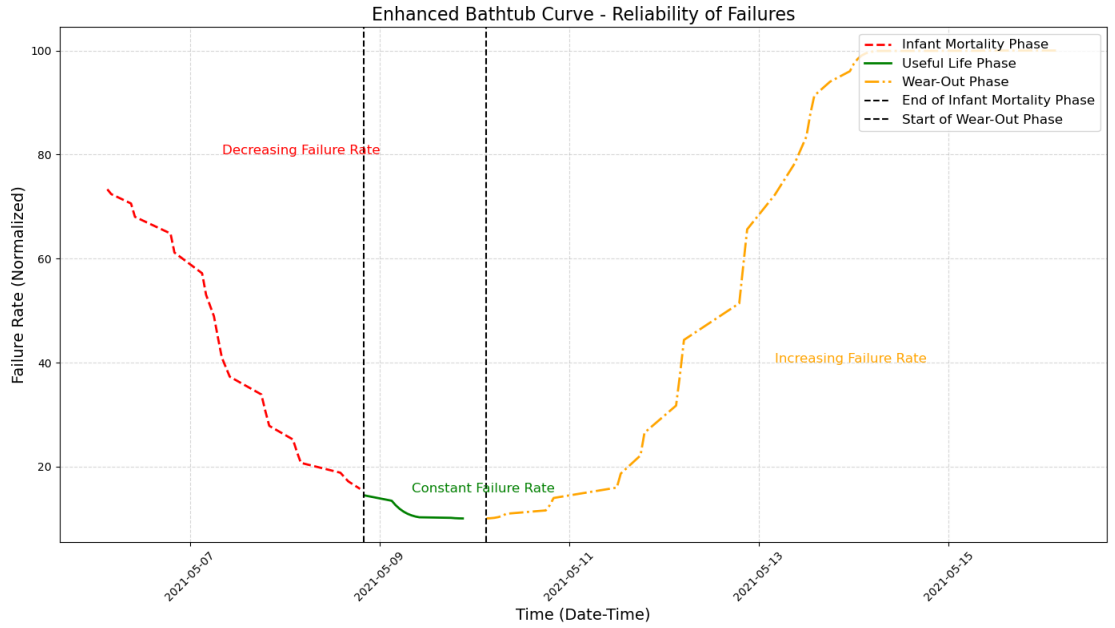
PREDICTIVE MAINTENANCE SOLUTION

OBJECTIVE

- Develop a **Predictive Maintenance Solution Model** to anticipate system failures and minimize downtime.
- Analyze trends in sensor data to identify early failure indicators.
- Map alarms and source readings for a comprehensive failure prediction strategy.

LIFECYCLE OF SYSTEM RELIABILITY: THE BATHTUB CURVE



- The Enhanced Bathtub Curve illustrates system reliability and failure rates over its lifecycle:
- **Infant Mortality Phase:**
  - High failure rate initially
  - Failures decrease as issues are resolved.
- **Useful Life Phase:**
  - Stable operation with random, constant failure rates.
- **Wear-Out Phase:**
  - Failures increase due to aging and component wear.
  - Preventive maintenance is critical here.
- **Transition Points:**
  - End of Infant Mortality Phase.
  - Start of Wear-Out Phase.

MODEL FOR PREDICTIVE MAINTENANCE

- **Analysis:** Captures trends, seasonality, and noise in sensor readings over time.
- **Exogenous Variables (X):** Incorporates external factors to improve prediction accuracy.
- **Seasonality Support:** Effectively models recurring patterns in sensor data, crucial for periodic maintenance needs.
- **Implementation:**

1. Data Preprocessing:
   - Cleaned and aggregated data from sensor readings and alarms.
   - Addressed missing values and ensured data stationarity.
2. Model Design:
   - Selected parameters based on trend, seasonality, and residual analysis.
   - Included relevant exogenous factors like pressure and temperature etc.
3. Training and Evaluation:
   - Trained the model on historical data for compressors.
   - Validated predictions using actual failure and alarm events.

TARGET PREDICTIONS

Focus on Failure Prediction:

- Historical trends and sensor data were analyzed to accurately anticipate potential failures, enabling proactive maintenance.

Next 7 days FailureStartTime forecast:

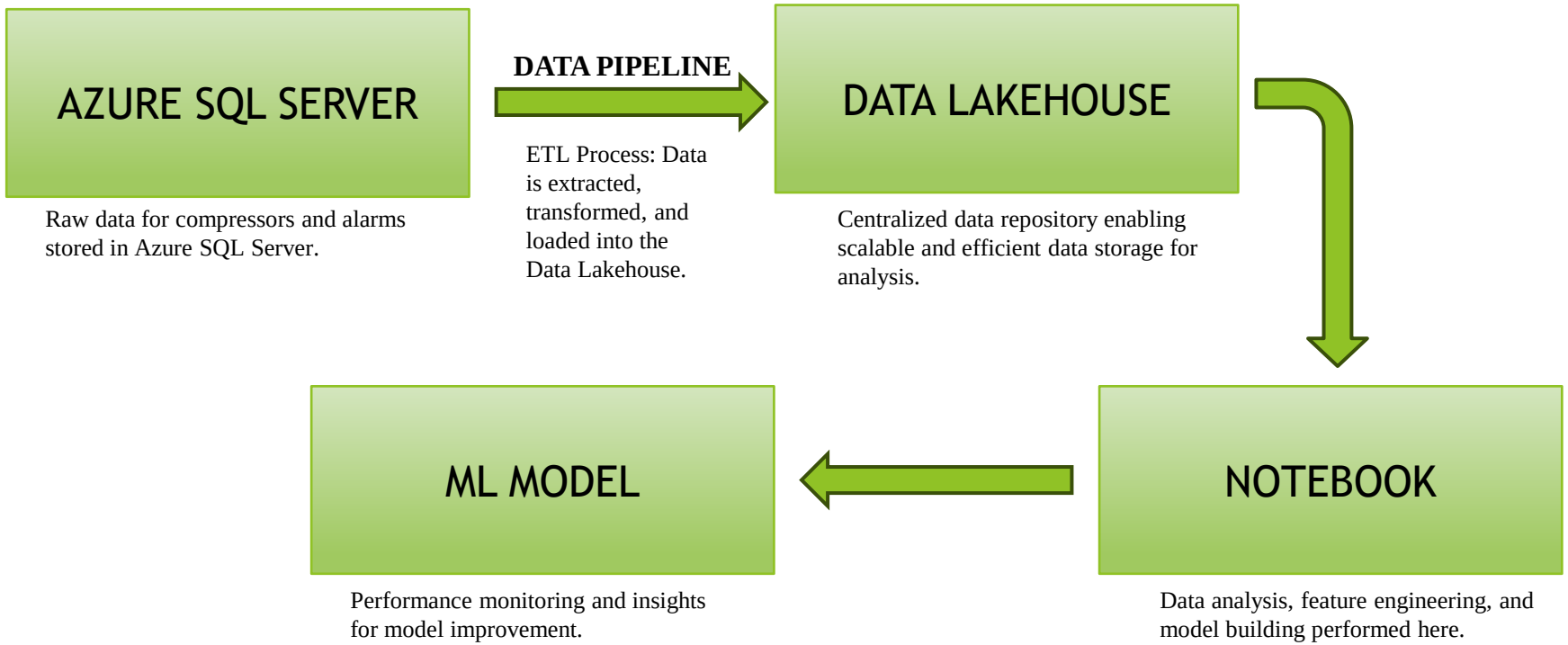
FailureStartTime	mean	mean_se	mean_ci_lower	mean_ci_upper
2021-08-31 17:00:00	0.0	0.000010	-0.000020	0.000020
2021-09-01 17:00:00	0.0	0.000014	-0.000028	0.000028
2021-09-02 17:00:00	0.0	0.000017	-0.000034	0.000034
2021-09-03 17:00:00	0.0	0.000020	-0.000039	0.000039
2021-09-04 17:00:00	0.0	0.000022	-0.000044	0.000044
2021-09-05 17:00:00	0.0	0.000024	-0.000048	0.000048
2021-09-06 17:00:00	0.0	0.000026	-0.000052	0.000052

Approach for Alarms Prediction:

- Model was utilized to predict alarms and their corresponding indications.
- Alarms serve as early warning signals, helping operators take preventive actions to avoid downtime and reduce risks.

MachineId	ClassName	Name	Timestamp	Confidence
Comp_A	Oil Temperature	Fault Low	2024-10-20 00:00:00	75.51829701
Comp_A	Oil Pressure Alarm	Warning Low	2024-10-20 00:30:00	96.30872277
Comp_A	Oil Pressure Alarm	Warning Low	2024-10-20 01:00:00	13.53501756
Comp_A	Inlet Temperature	Warning Low	2024-10-20 01:30:00	36.82704076
Comp_A	Control Gas Pressure	Fault Low	2024-10-20 02:00:00	67.16496258
Comp_A	Inlet Pressure	Warning Low	2024-10-20 02:30:00	41.875202
Comp_B	Control Gas Pressure	Fault Low	2024-10-20 00:00:00	95.26575289
Comp_B	Control Gas Pressure	Warning Low	2024-10-20 00:30:00	59.13587304
Comp_B	Inlet Pressure	Fault Low	2024-10-20 01:00:00	33.60762302
Comp_B	Inlet Pressure	Fault High	2024-10-20 01:30:00	14.55694853
Comp_B	Inlet Pressure	Fault Low	2024-10-20 02:00:00	21.00937759
Comp_B	Control Gas Pressure	Fault Low	2024-10-20 02:30:00	57.83793756
Comp_C	Oil Pressure Alarm	Warning Low	2024-10-20 00:00:00	94.90801093
Comp_C	Oil Pressure Alarm	Fault Low	2024-10-20 00:30:00	16.74480042
Comp_C	Inlet Pressure	Fault High	2024-10-20 01:00:00	31.31773213
Comp_C	Inlet Pressure	Warning High	2024-10-20 01:30:00	17.58302935

WORKFLOW



Raw data for compressors and alarms stored in Azure SQL Server.

ETL Process: Data is extracted, transformed, and loaded into the Data Lakehouse.

Centralized data repository enabling scalable and efficient data storage for analysis.

Data analysis, feature engineering, and model building performed here.

Performance monitoring and insights for model improvement.