

The background features a dark blue gradient. At the top, there is a silhouette of an industrial skyline with various buildings and chimneys. Below this, the lower half of the image is filled with numerous semi-transparent gears of different sizes, creating a mechanical theme.

KPI Analytics of Mobile Assets

■ Data type

Basic attributes: Date, Model, operation status and respective times (such as Operating delay, Standby)

Maintenance-related attributes: Downtime, MTBS, MTBF, MTTR, Availability, Utilization, UofA...



6 shovel types, 8 truck types

Available KPIs

Unscheduled Downtime

Scheduled Downtime

TotalDown

Availability

Utilization = OperatingTime/TotalHrs

Utilization of Availability = Utilization/Availability

MTBF = (OperatingTime + OperatingDelay)/# of failures

MTTR = Unscheduled downtime/# of failures

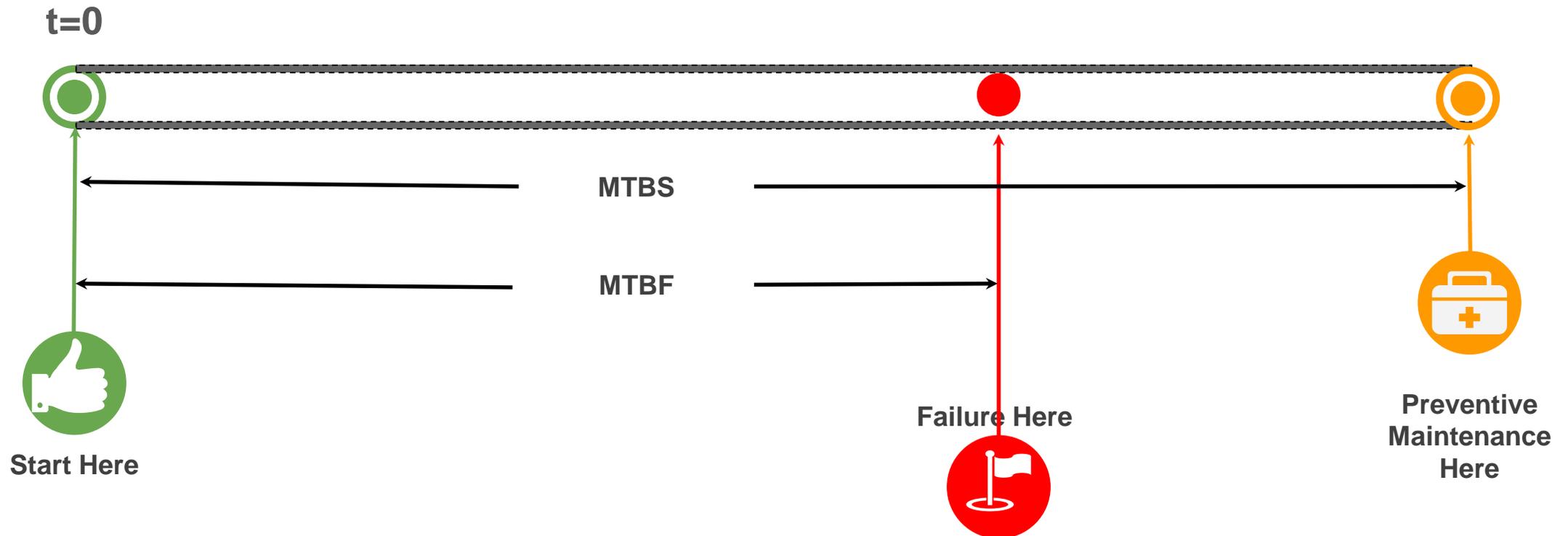
MTTR scheduled = Scheduled downtime/# of PMs

MTBS = OperatingTime/# of PMs

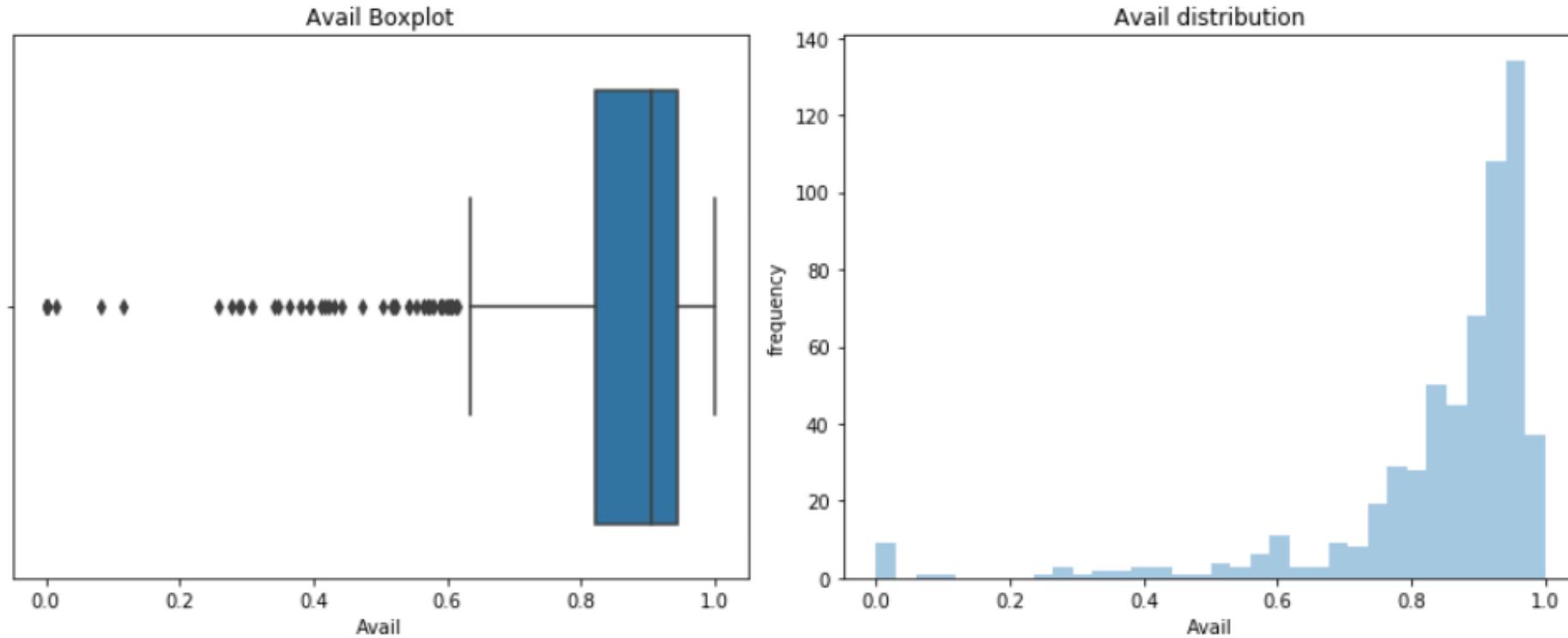
■ Key Objectives

- Find statistical properties between target KPIs (e.g., Availability, UofA, utilization)
- Find correlation pattern between influencing KPIs (e.g., downtime, MTBF, MTBS)
- Estimate lifetime parameter and reliability of assets

Optimize PM interval to increase availability



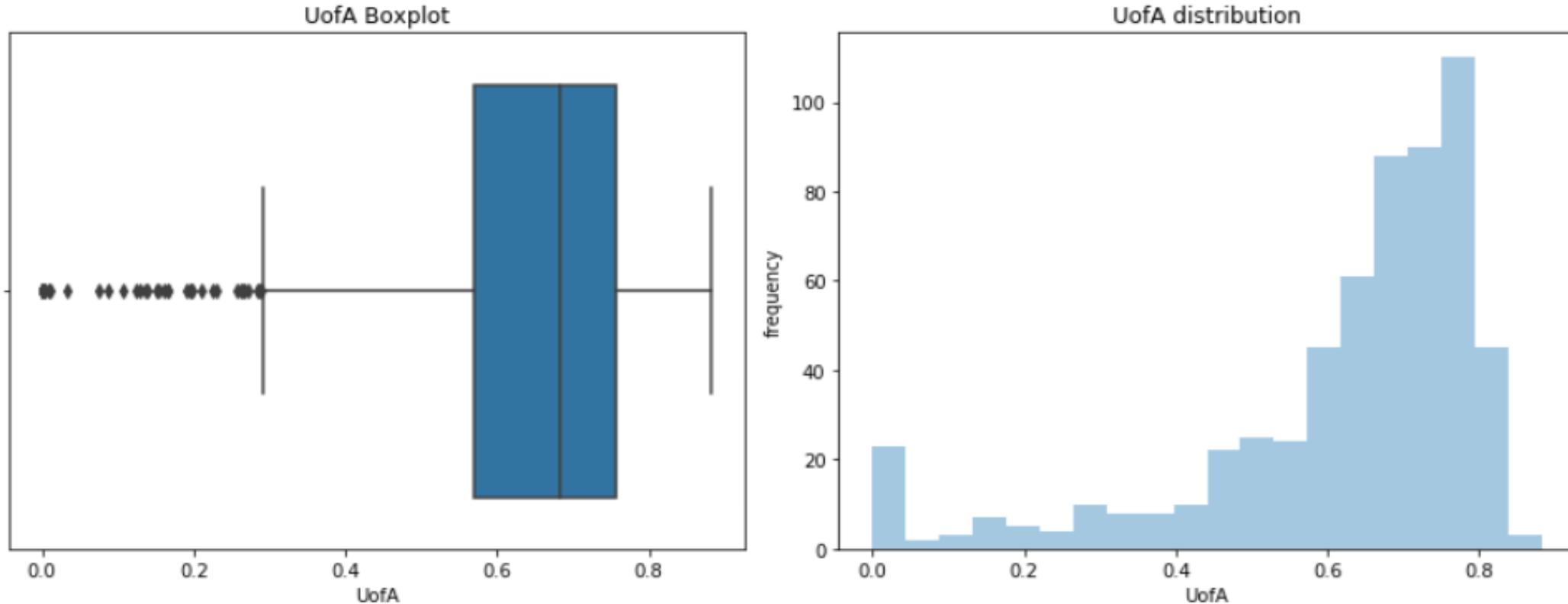
- **Frequency Analysis (for vehicle model 1)**



Frequency of asset availability (left: boxplot; right: histogram)

- The asset availability fluctuate mainly from 0.85 to 0.95 (relatively steady)

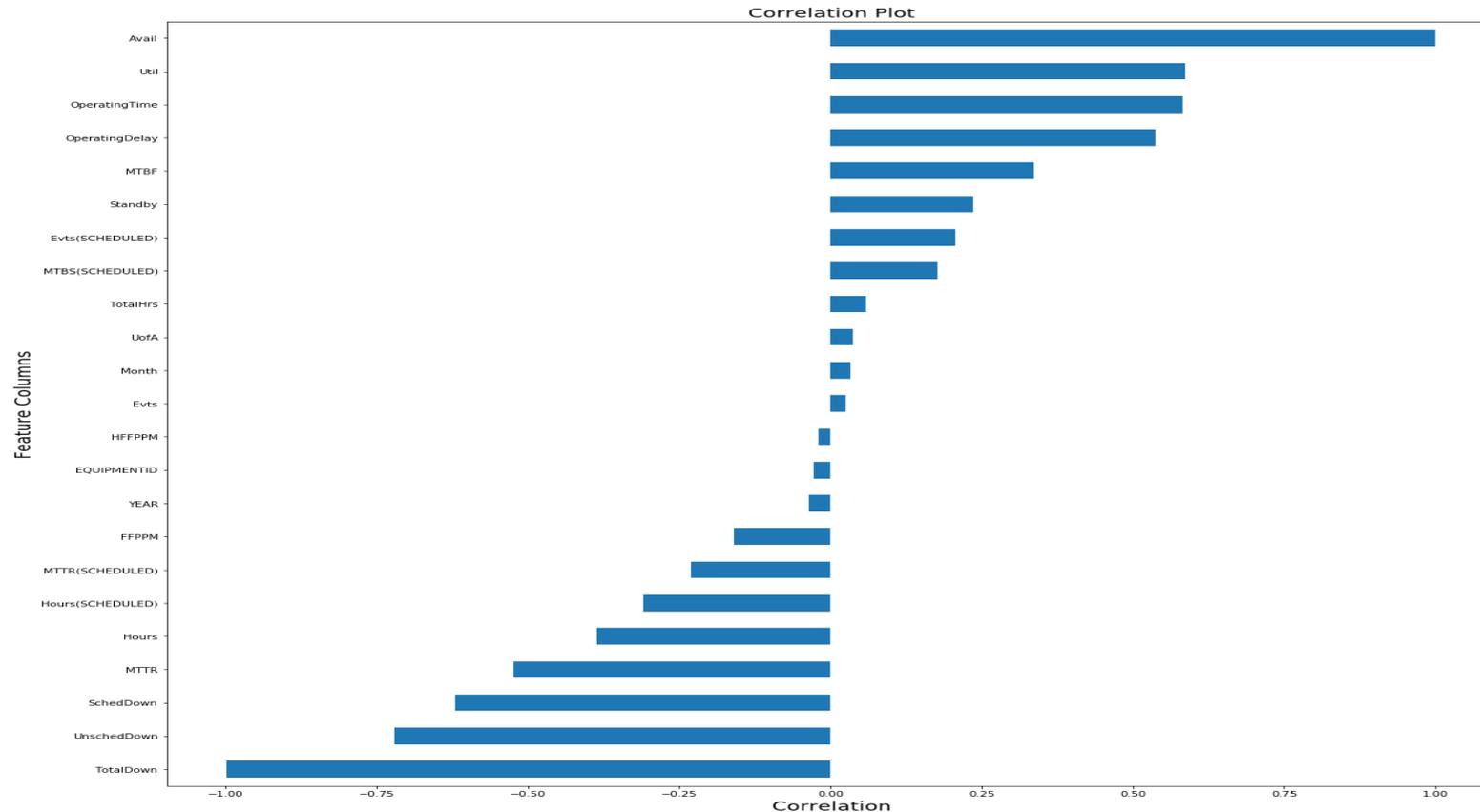
- **Frequency Analysis (for vehicle model 1)**



Frequency of Utilization/availability (left: boxplot; right: histogram)

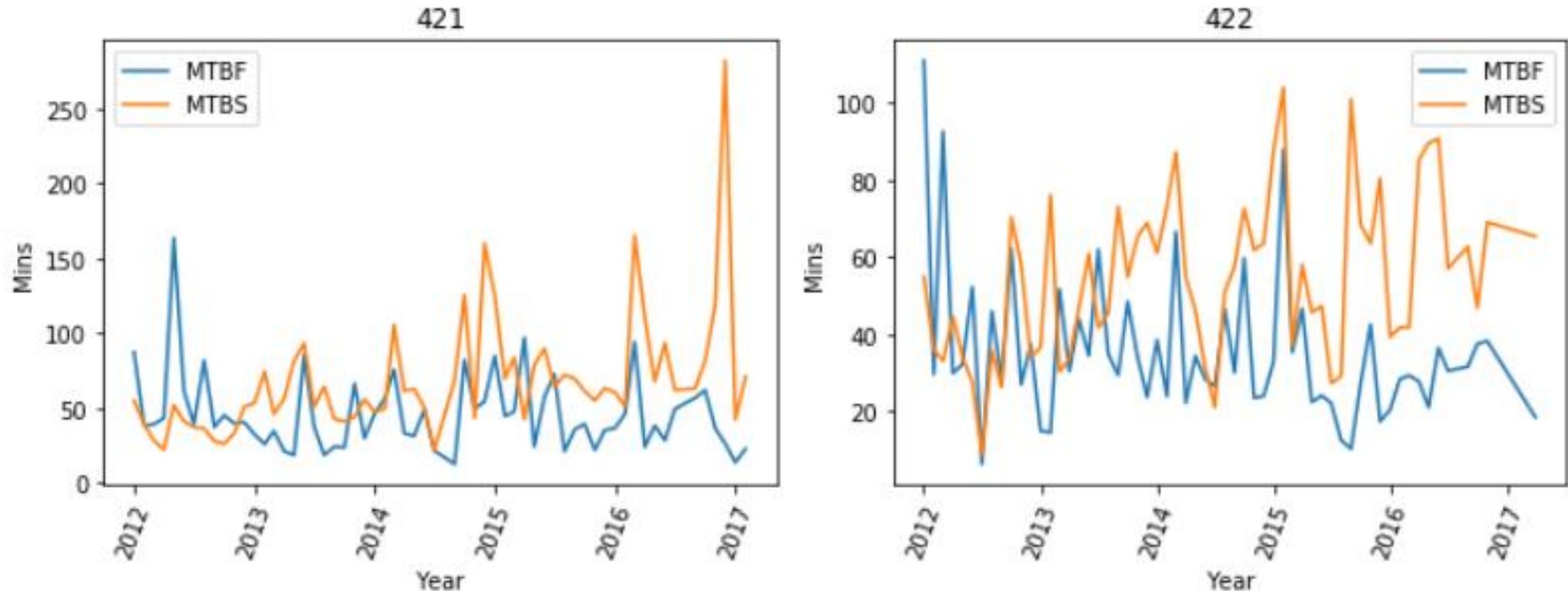
- The value of UofA seldomly exceeds 0.8 (mainly from 0.4 to 0.8)
- Idle time due to operations delays and standby significantly affects utilization rate

- **Correlation Analysis**



- Availability of vehicle model 1 is chosen for correlation analysis.
- Availability is most related to maintenance downtime, while year and month has the least impact

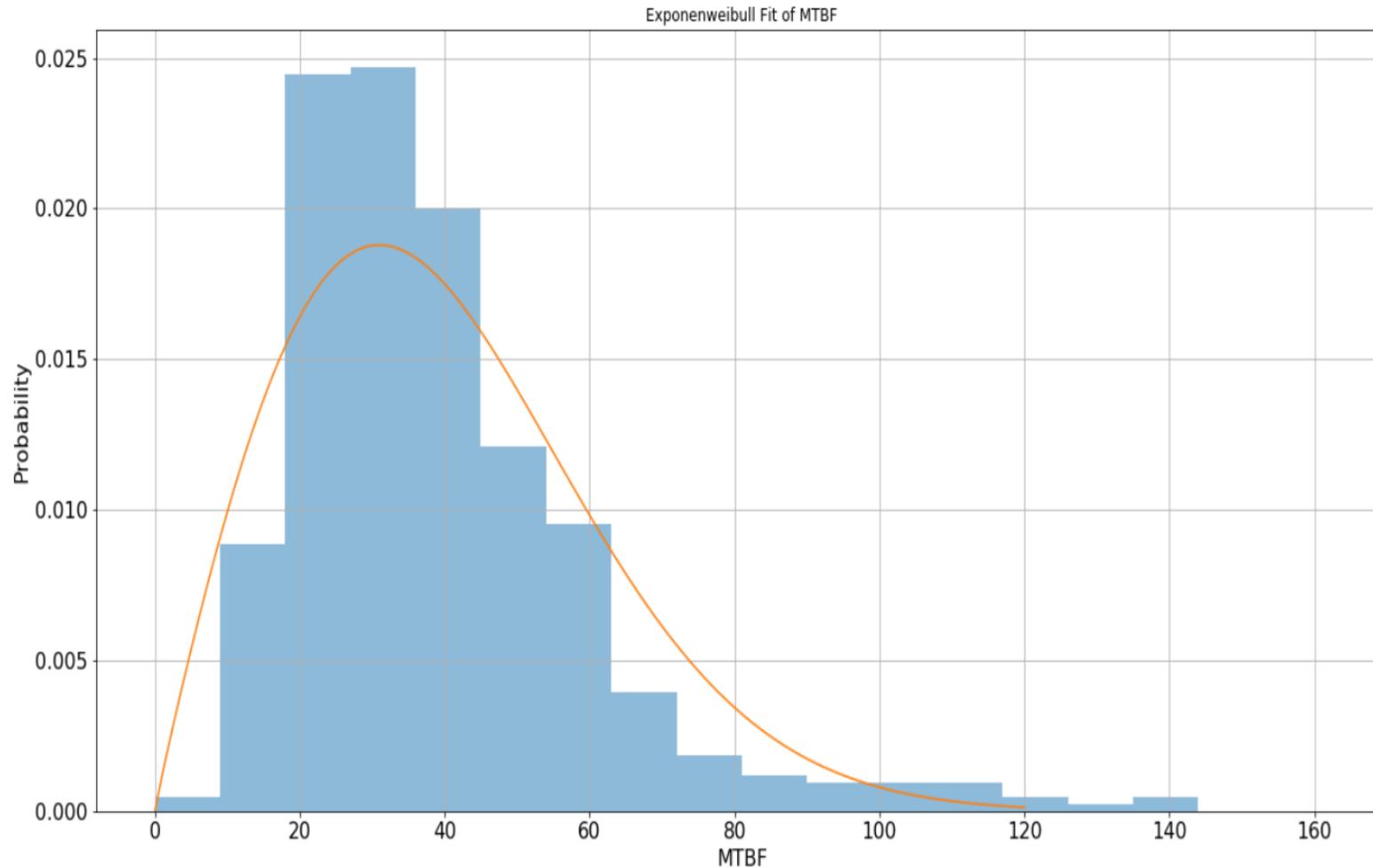
■ Comparison between critical KPIs



- Observation:**
1. In most cases, MTBF is larger than MTBS, particularly from Year 2014 to Year 2017
 2. MTBF shows a decrease trend, indicating a accumulated age impact; MTBS, however, shows a increasing trend.

Suggestion: Preventive maintenance can be scheduled more frequently in recent years.

■ Lifetime distribution fitness



Availability in terms of MTBF (fitted by Weibull)

■ Data source: MTBF

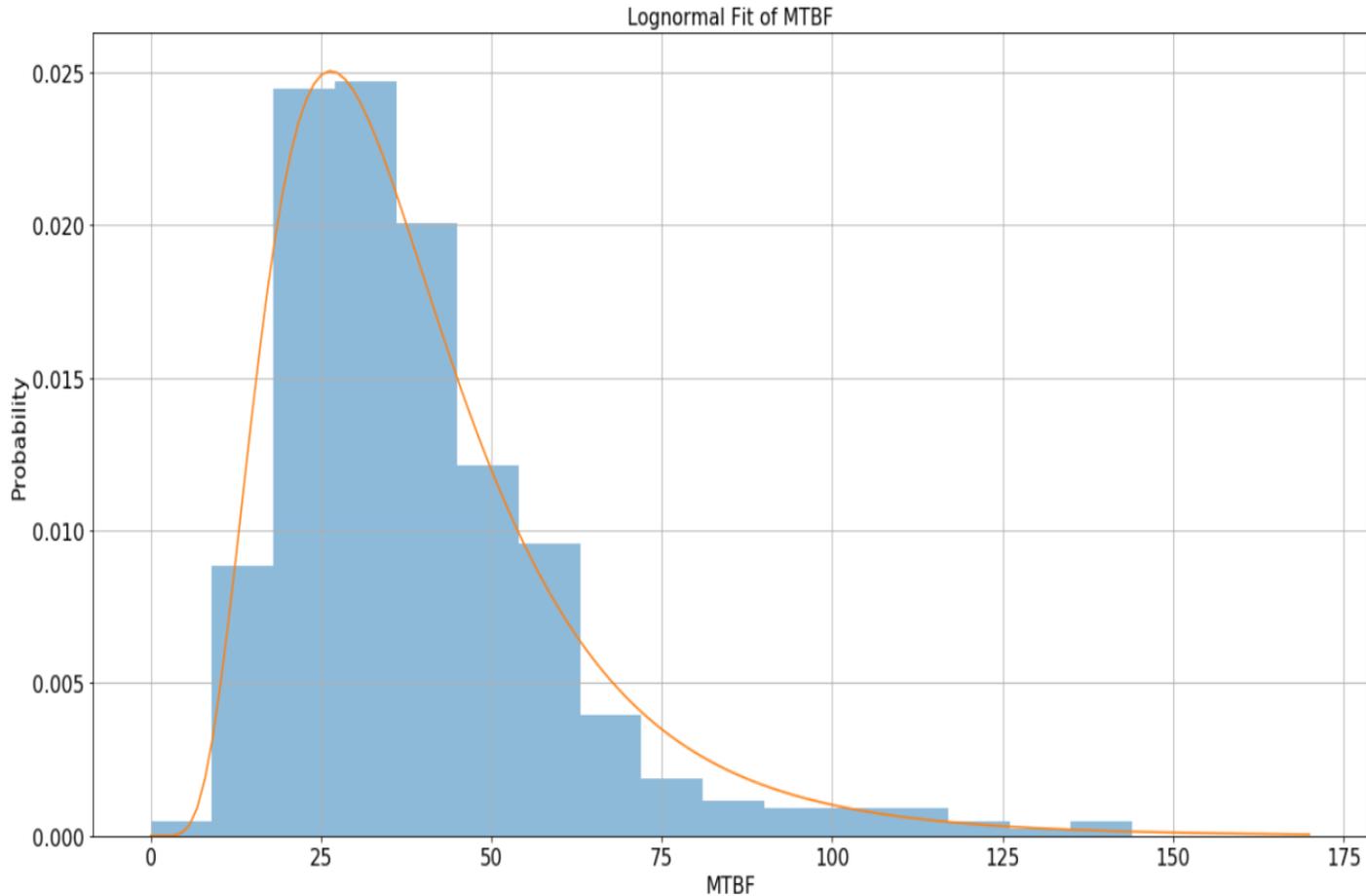
■ Distribution: Weibull

■ Estimated Parameter

- Scale: 47.96 (h)

- Shape: 3.77

■ Lifetime distribution fitness



■ Data source: MTBF

■ Distribution: log-normal

■ Parameter

- mean: 3.59
- Standard deviation: 0.59

Availability in terms of MTBF (fitted by log-normal)

Observation: Log-normal outperforms Weibull in statistical fitting of MTTF.

■ Lifetime distribution fitness

Asset	Shape Factor	Scale Factor	Approximate Months till 100% Failure
Shovel Fleet model	4.88	33.54	45
1	3.34	35.75	60
2	9.01	28.80	35
3	4.69	58.43	80
4	5.76	50.07	65
5	2.97	24.70	41
6	5.72	36.45	50
7	5.03	26.31	36
8	2.06	28.86	61

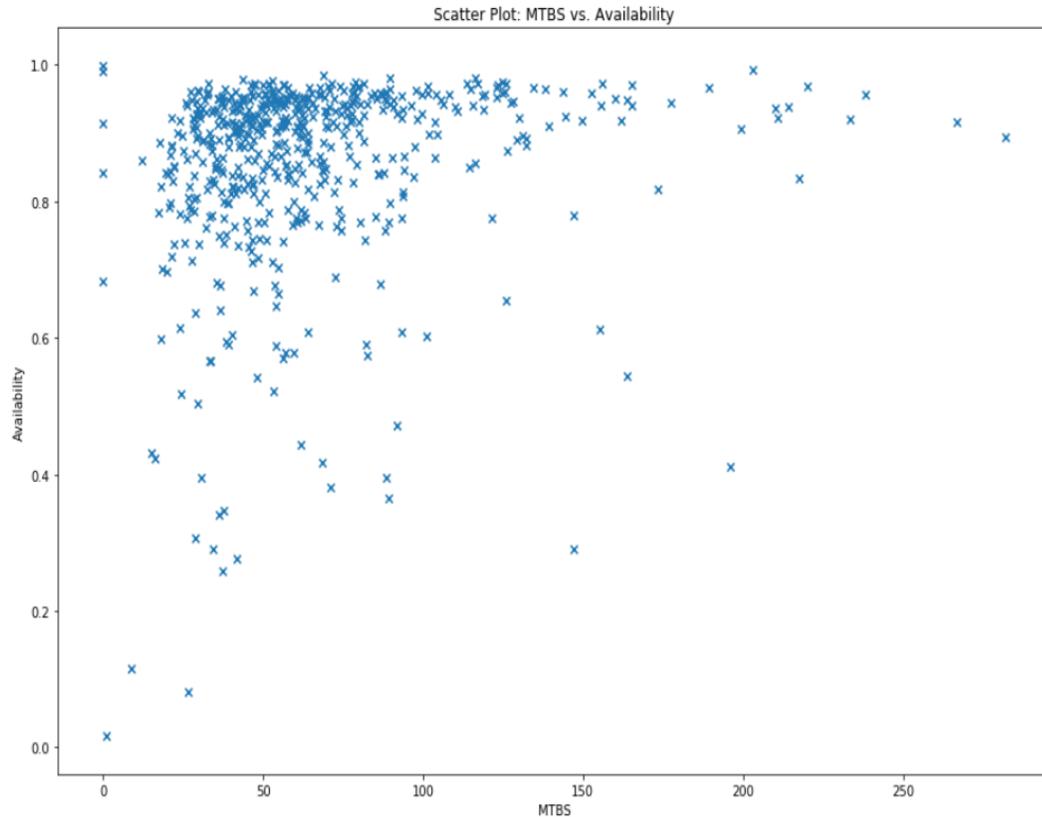
Fitting results for all shoves

Asset	Shape Factor	Scale Factor	Approximate Months till 100% Failure
Truck Fleet model	6.9	35.097	44
1	3.77	47.89	48
2	15.59	24.14	27
3	6.15	60.018	79
4	2.8	45.79	80
5	-33.07	32.131	0
6	3.77	38.28	59

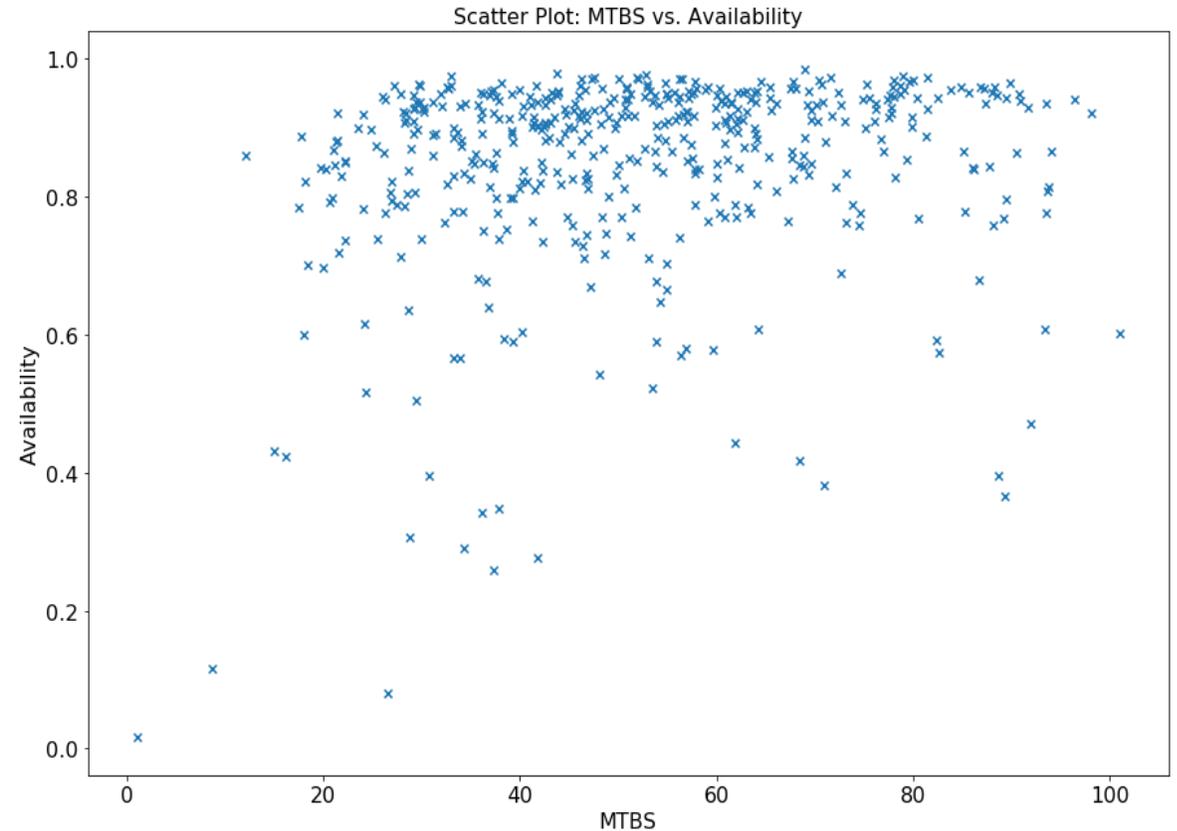
Fitting results for all trucks

Observation: Significant difference between reliability level and variation trend of different assets .

■ Pattern Analysis (for a specific model)



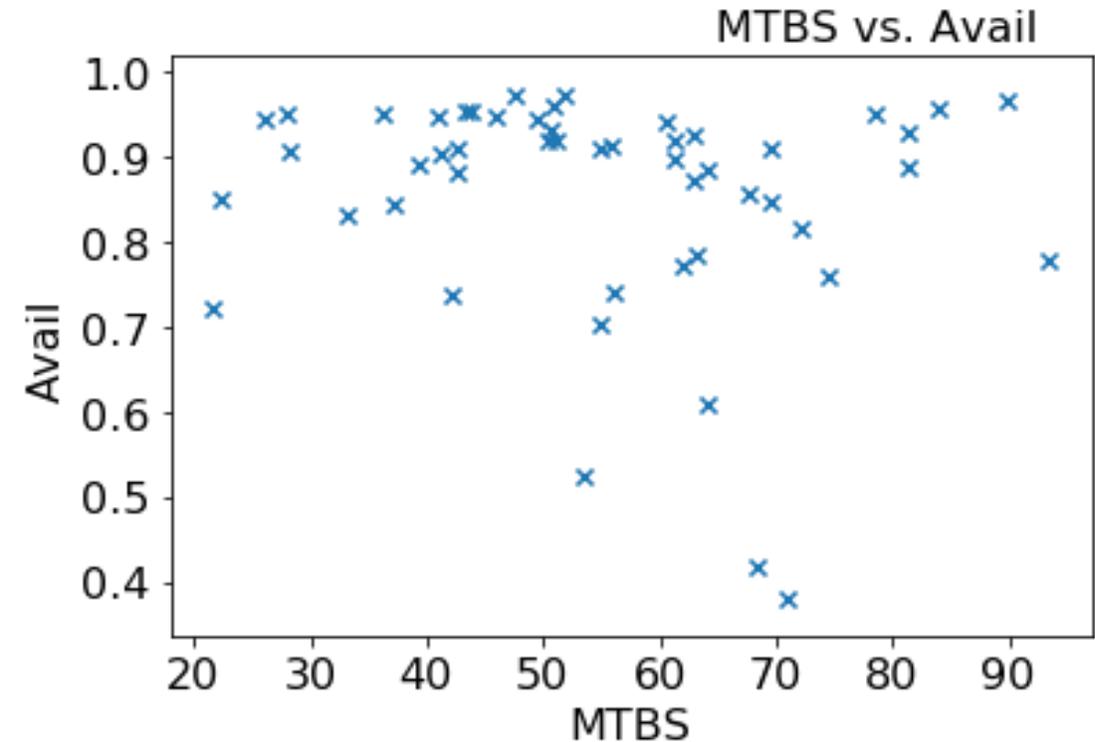
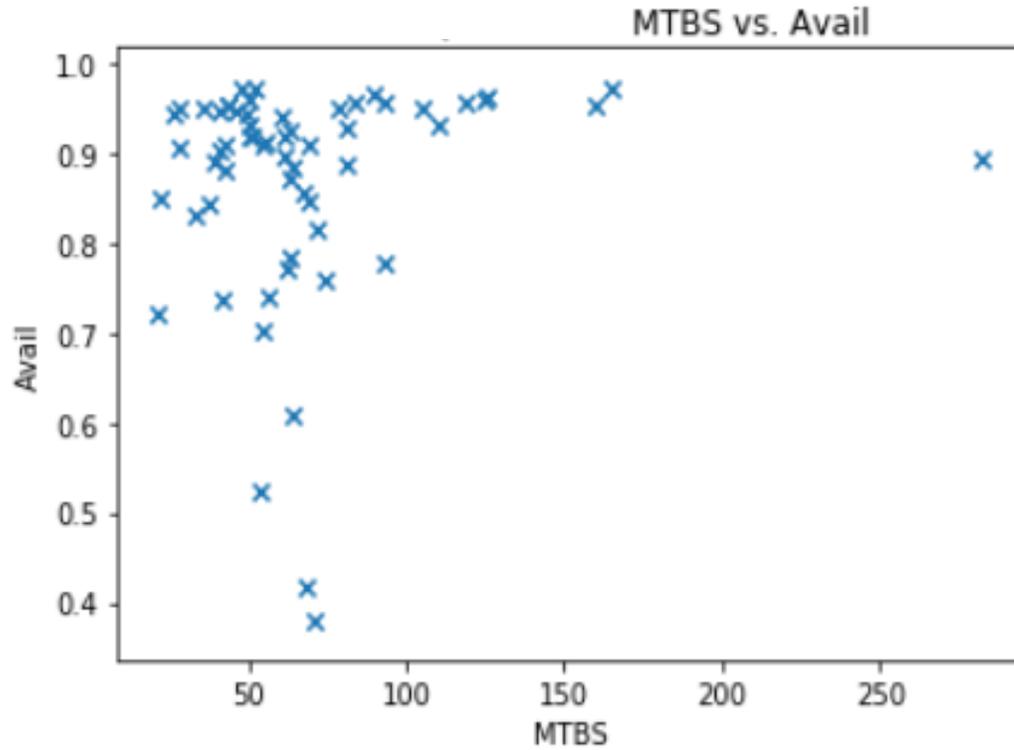
Availability vs MTBS (before removing outliers)



Availability vs MTBS (after removing outliers)

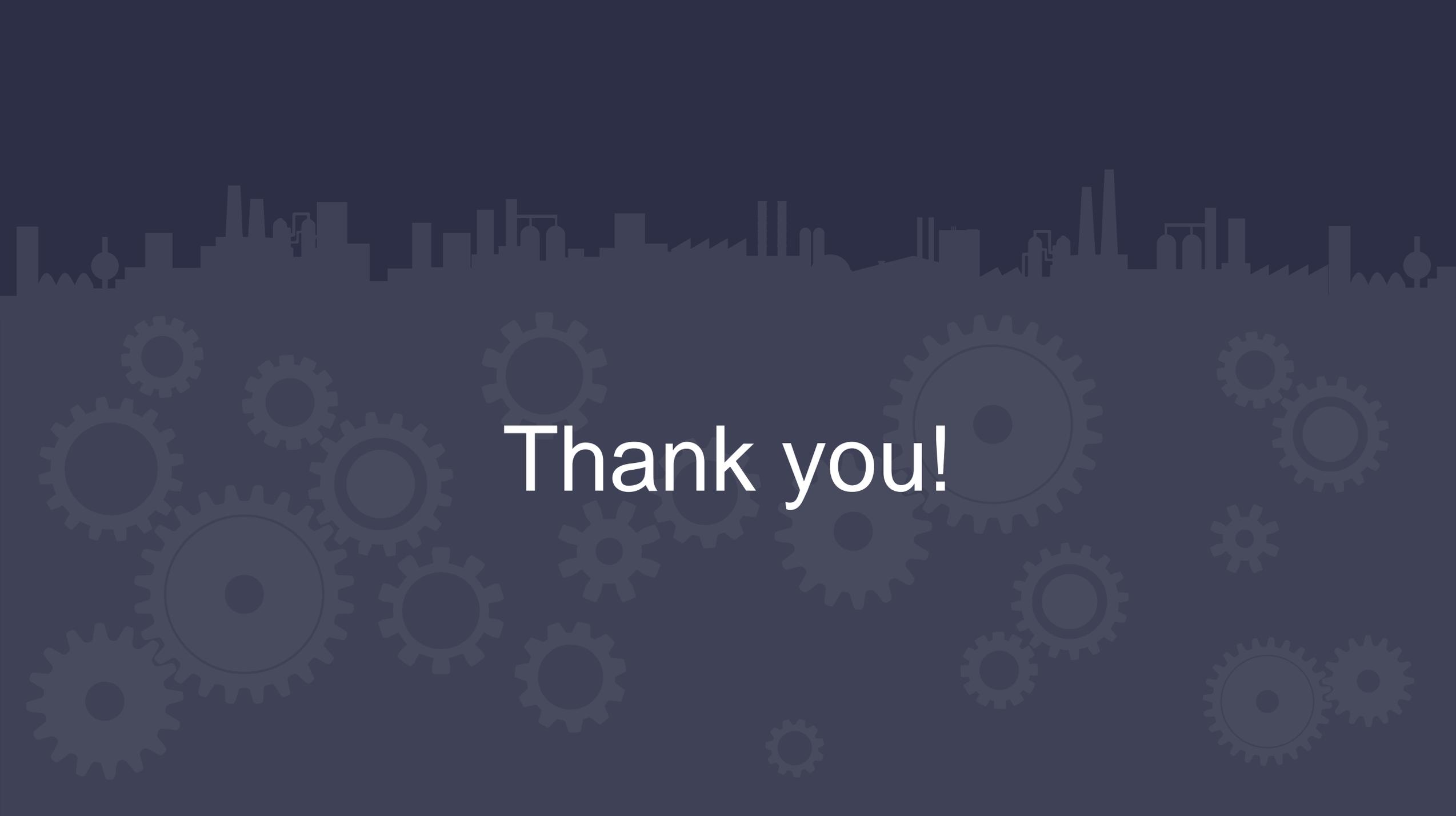
- Variation pattern of selected asset model throughout 5 years
- The impact of MTBS on asset availability is limited when MTBS falls in [20,100]
- Too large or small PM intervals significantly reduces availability

■ Pattern Analysis (for a specific asset)



- Variation pattern of selected asset (Model 1 truck 1) throughout 5 years
- More randomness incurred due to reduce of sampling size
- No trending pattern found between [20,90]

- Test **comprehensive** effect of several KPIs (e.g., MTBF+MTBS) on availability/utilization;
- formulate maintenance models with different **repair effect** (spare part replacement, minimal repair or imperfect repair);
- Optimize maintenance **intervals/frequencies** such that system **availability** can be enhanced and system **downtime** can be reduced.

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Thank you!