THE OPERATIONAL RESEARCH SOCIETY

Using Multi-Criteria Decision Making for Selecting Maintenance Strategy

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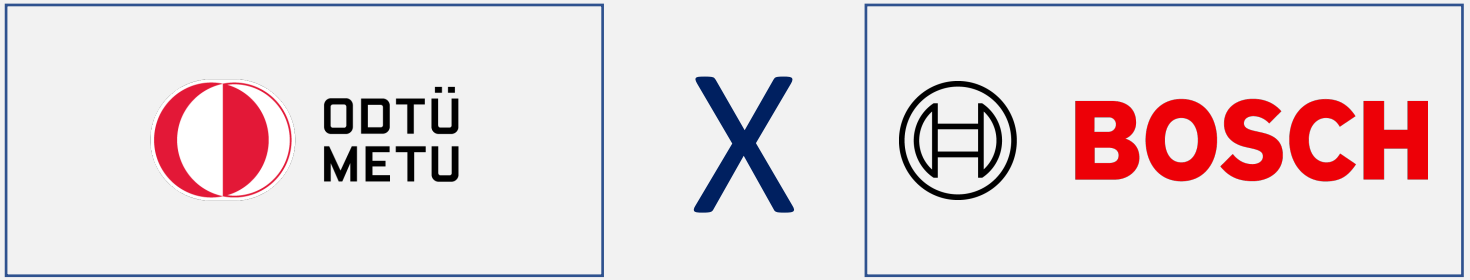
Outline

- Introduction
- Analysis
- Approach
- Results



Middle East Technical University Industrial Engineering Deparment undergraduate students had started transformation journey with BOSCH Bursa Facility for senior year project.

What is maintenance and multi criteria decision making (MCDM) ?

Maintenance

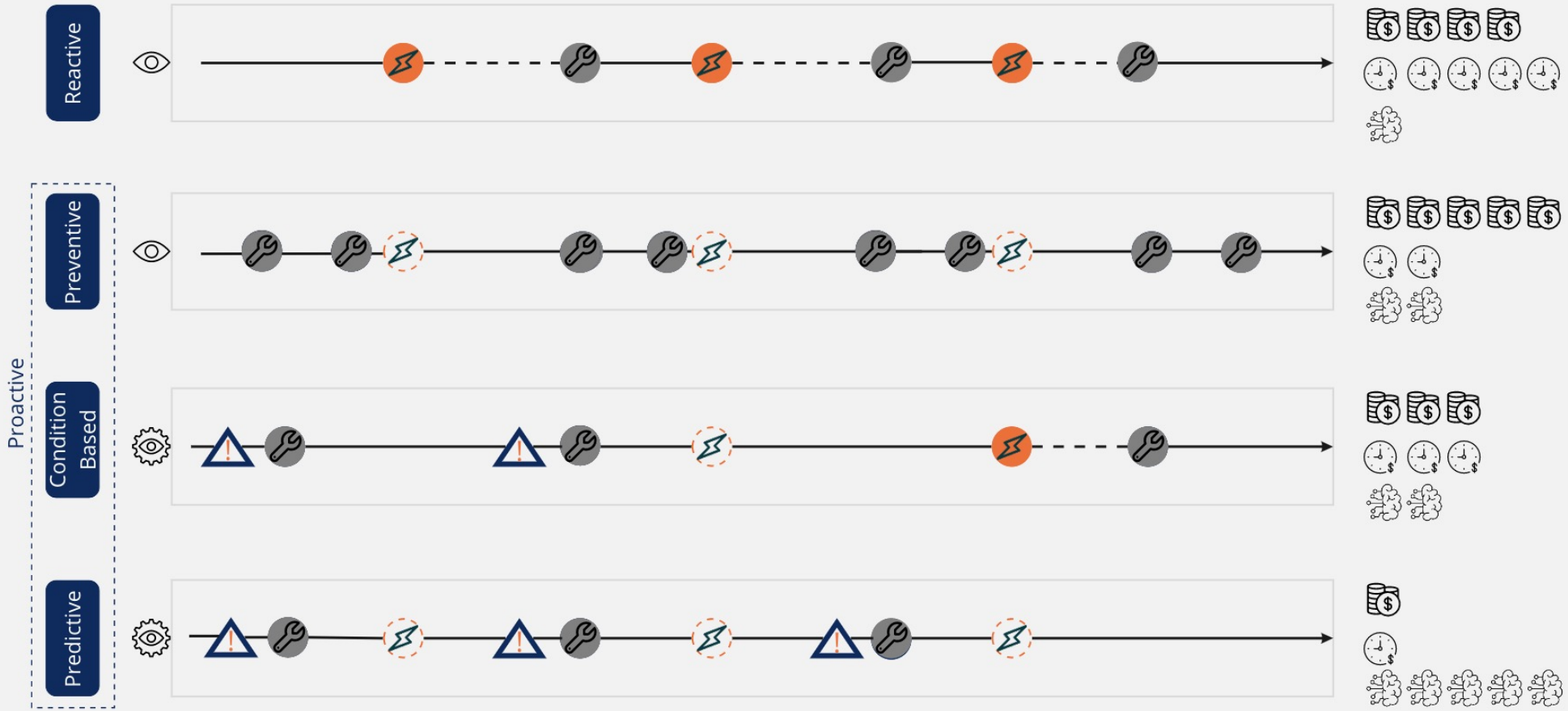
"The act of keeping something in good condition by checking or repairing it **regularly**." [1]

MCDM

"It is a branch of a general class of Operations Research (or OR) models which deal with decision problems under the presence of a number of decision criteria."[2]

[1]Oxford Dict.
[2]Triantaphyllou,1998

There are two main maintenance approaches which includes several maintenance strategy.



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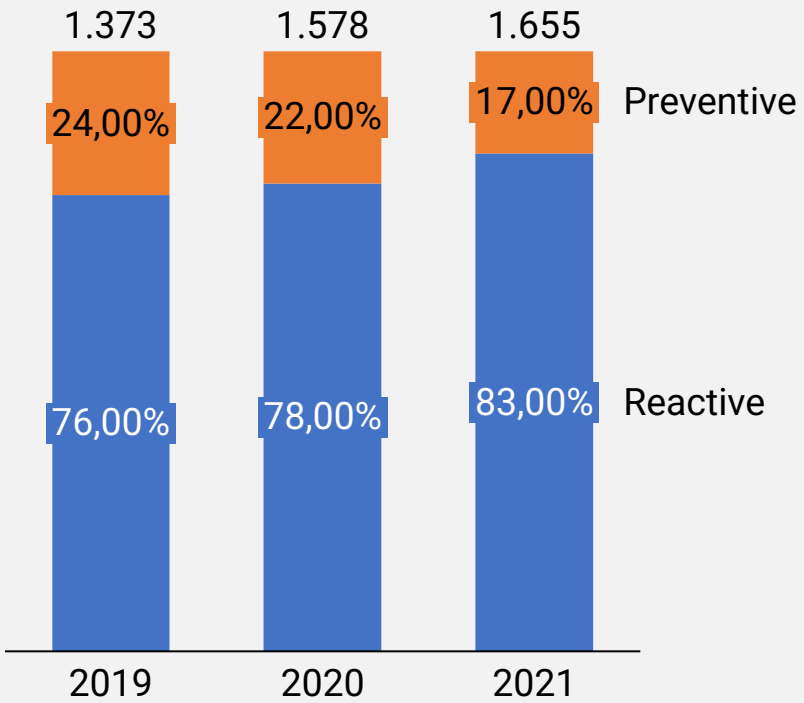
How we use MCDM ?

- Which maintenance strategy is appropriate for which machines?

- Which fitness criterion should be used to select maintenance strategy for machines?

- Which MCDM method is suitable for current situation?

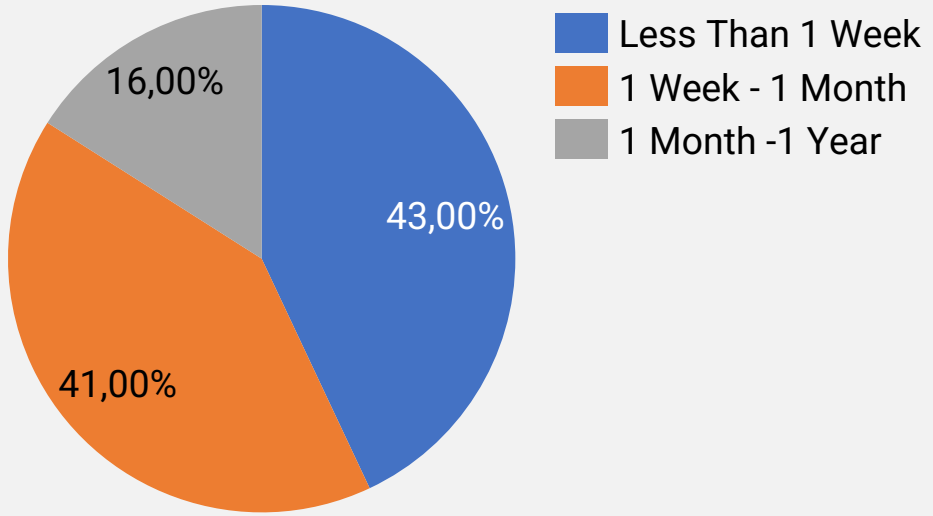
We have analysed the maintenance records of Bosch. We realised that there are two different applied maintenance strategies



Maintenance records for maintenance strategies from years

According to last 3 years records, approximately 80% of the maintenance activities can be identified as reactive maintenance and the remaining are pro-active preventive maintenance .

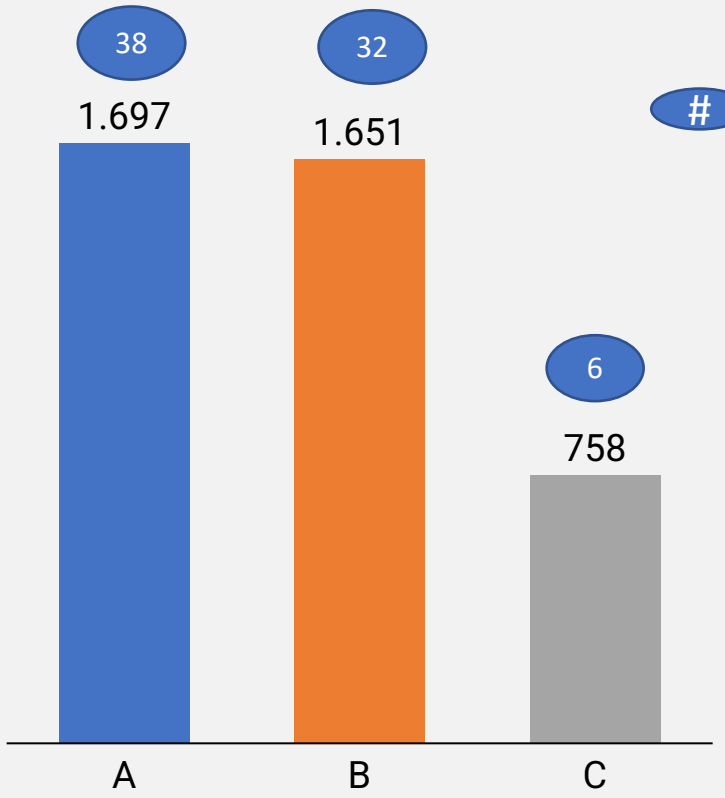
To analyse the effectiveness of the maintenance we have control the first breakdown after applying the preventive maintenance.



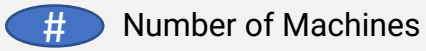
First occurrence of breakdown after applying preventive maintenance

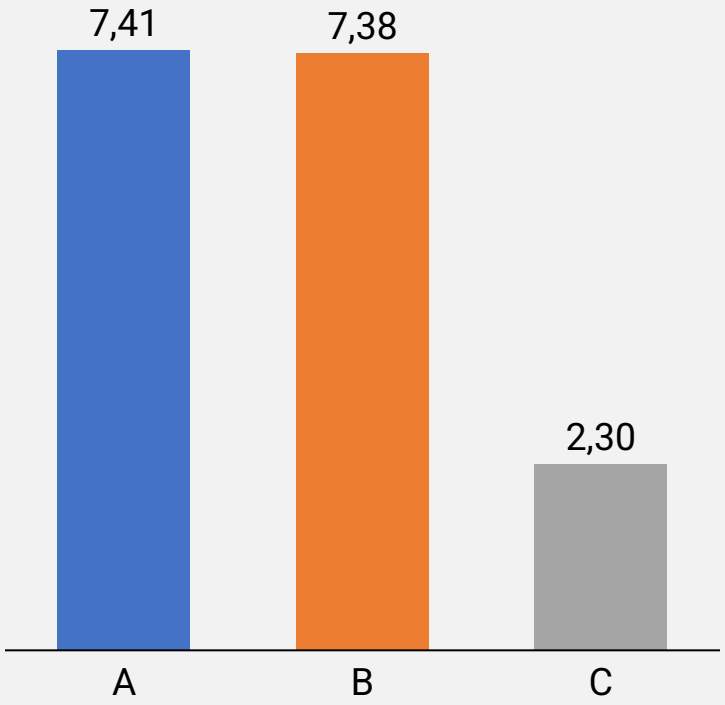
Since the 84% of the time passed until failure after preventive maintenance is shorter than a month, effectiveness of application of preventive maintenance can be identified as low.

We have analysed maintenance records of Bosch and realised that there are significant downtimes due to unexpected machine breakdowns.



Number of breakdowns for top 3 important machine groups last year

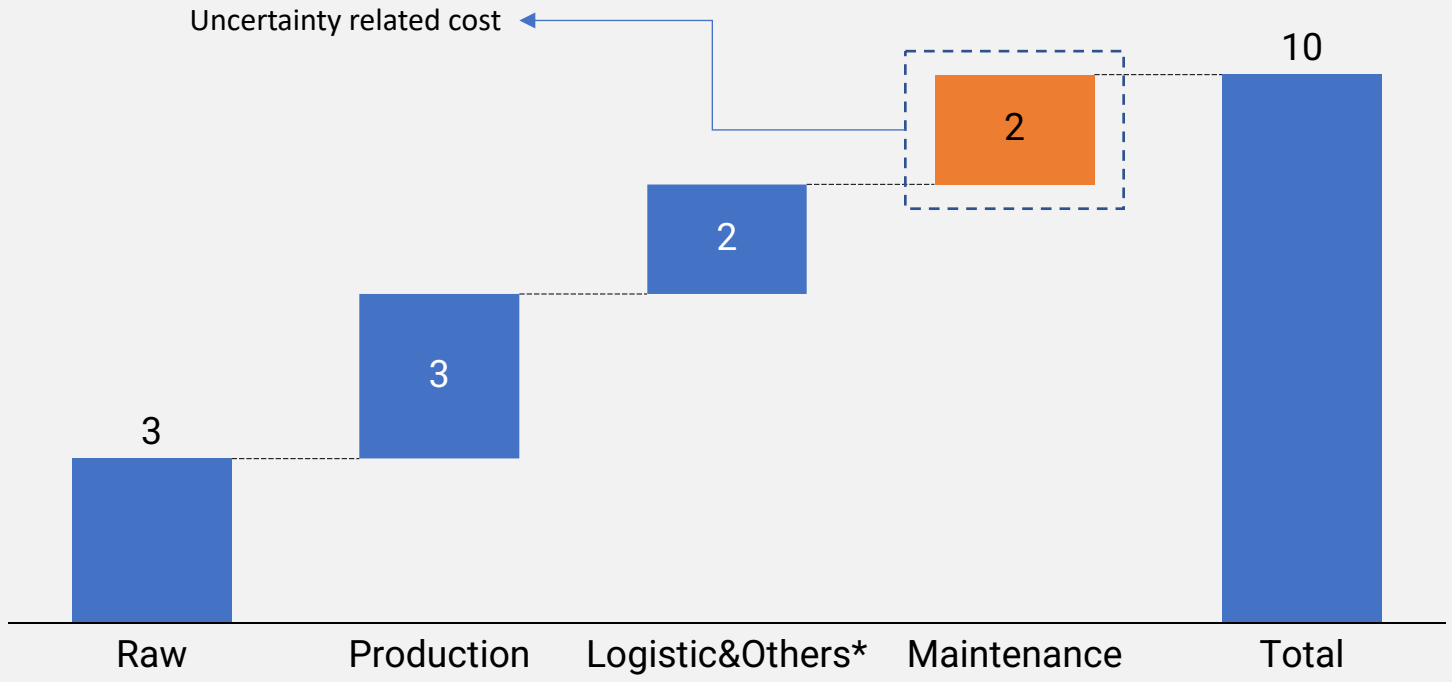




Monthly Average Downtime of A,B,C machine group in hours

A,B,C is the machine groups in company

There are several cost items for producing one unit. The most uncertain cost is maintenance cost. The unexpected breakdowns interrupts the production process and increase this cost.



Cost components of average product.

To avoid these uncertainties, sufficient predictions could have positive impact on maintenance cost and the seamless production.

Predictive maintenance is one of the effective ways to handle with consequences of unanticipated breakdowns.

To analyse the appropriateness of predictive maintenance to machines, several criterion which indicate cost and uncertainty are considered.

1-Cost Related Features

- Total cost of failure
- Total number of failure

2-Time Related Features

- Mean time to repair
- Mean time between failure

3-Uncertainty Related Features

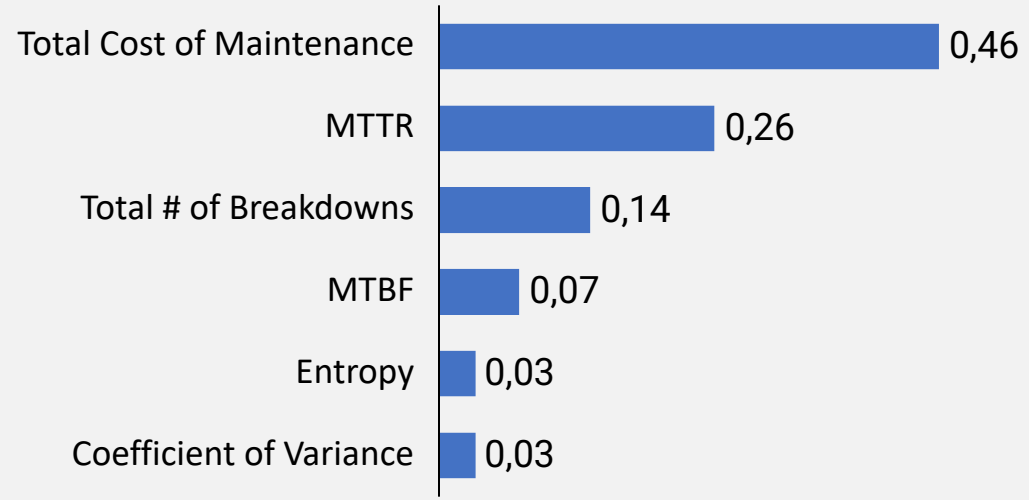
- Entropy
- Coefficient of Variation

After deciding the criterion, relative importance are evaluated by using Analytic Hierarchical Process [1] applied with the help of Bosch engineers & executives

Evaluate the importance criteria

Preference Scales	
Scale	**Description**
1	Equally Important
3	Moderately Important
5	Strongly Important
7	Very Strongly Important
9	Extremely Important
2,4,6,8	Intermediate Values

After applying AHP, we checked the consistency of our calculations.



Consistency Ratio
R=0.045 < 0.1

[1]Saaty(1988)

After importance factors are evaluated by using AHP, positive and negative ideal points for fitness to predictive maintenance strategy are identified for TOPSIS analysis.

- \+ Total cost of failure
- \+ Total number of failure
- − Mean time to repair
- \+ Mean time between failure
- \+ Entropy
- \+ Coefficient of Variation

TOPSIS

Ranking of TOPSIS
Type_A_m1
Type_A_m2
Type_A_m3
Type_B_m1
Type_B_m2
Type_A_m4
Type_A_m5
...
Type_C_m7

Proposing the list of the appropriateness of machines, Bosch chose the top 5 machines due to their budget limit.

Ranking of TOPSIS
Type_A_m1
Type_A_m2
Type_A_m3
Type_B_m1
Type_B_m2
Type_A_m4
Type_A_m5
…
Type_C_m7

Investment for each machine are mutually compatible. The cost of sensors are considered for selected number of machines.

Conclusions

- Strategy selection for maintenance is an multi dimensional project.

- When considering maintenance strategy, features that show uncertainty has an important impact.

- Correct maintenance strategy selection can increase the observing affect of maintenance.

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Thank you for your listening.

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