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A decision making model for maintenance strategy: A combined approach analytic hierarchy process (AHP) and fuzzy logic

Mohammad Moghaddaszadeh Kermani , Dr. Moray W. Kidd

Introduction

The poster aims to compare two tools for decision makers that intend to support decision for the selection of most appropriate maintenance strategy in oil and gas plants. The analytic hierarchy process (AHP) decision making model proposed based on case study that investigate implementation of an integrated condition based maintenance strategy for a plant in oil and gas industry. Moreover fuzzy set theory employed for reducing the vagueness associated with manager preferences elicited via pairwise comparisons.

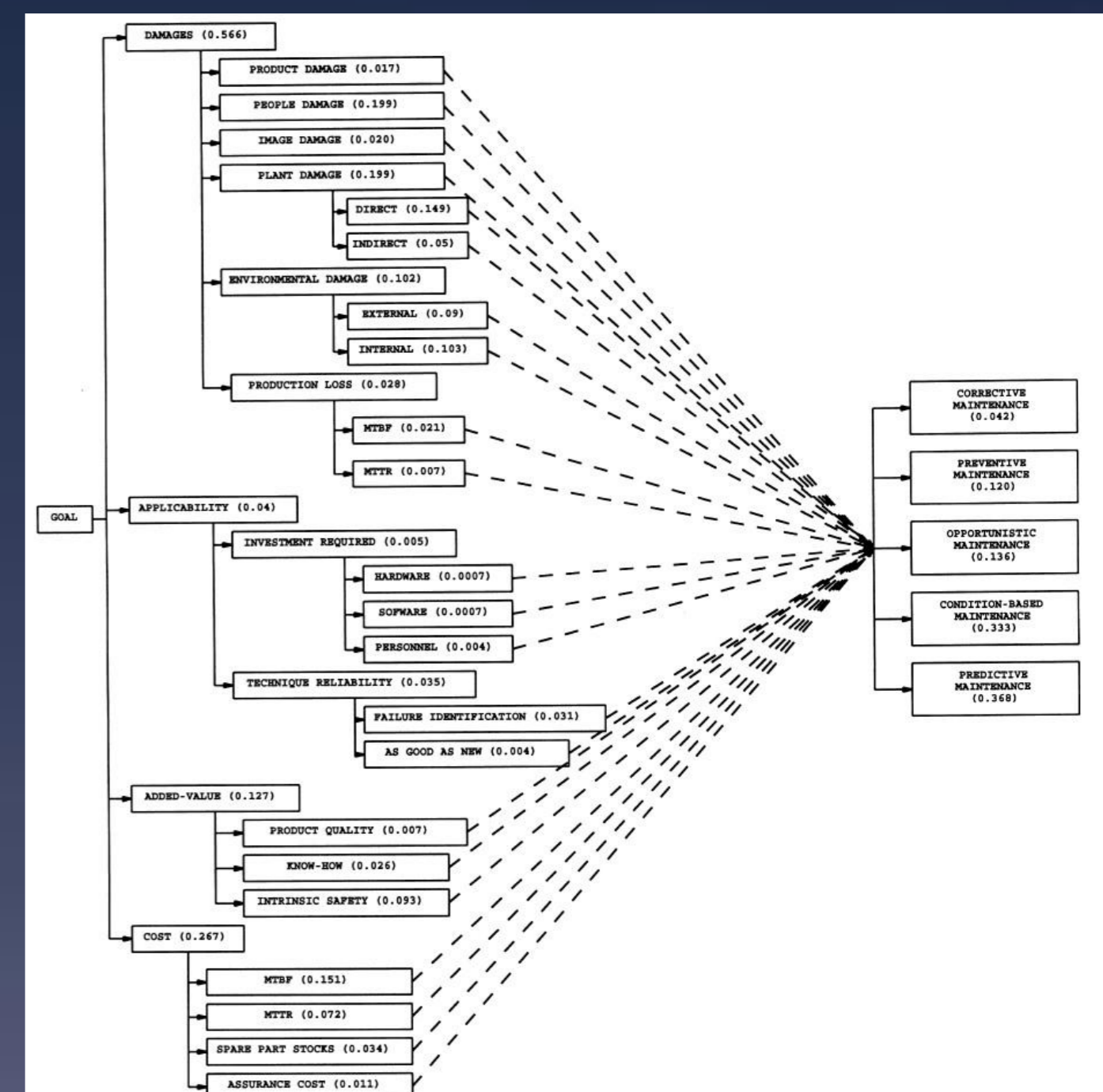
The oilfield developed by British Petroleum(BP) and was brought on stream in June 1990 with the production of 95000 barrels of stabilised crude oil. 670 tonnes of LPG and 16 million standard cubic feet of sales gas in which the associate gas is then fractionated, the methane and ethane are exported as sales gas directly into the grid, while the propane and butane are liquefied and transported by rail tanker. Since operations began, the traditional cost benefit analysis were considered to evaluate the appropriateness of condition based monitoring strategy for rotating equipments.

Existing theories and Gaps in Research

1-The original method for the selection of maintenance strategies for Italian oil refinery was given by (Bevilacqua and Braglia, 2000), but a crisp decision-making method as the traditional AHP is not appropriate because many of the maintenance goals taken as criteria are non-monetary and difficult to be quantified.

2-Al-Najjar and Alsyouf(2003), Sharma et al. (2005) assessed the most popular maintenance strategies using the fuzzy inference theory and fuzzy multiple criteria decision-making (MCDM) evaluation methodology. The application of the fuzzy theory for this problem is a good solution. However, only a few failure causes were considered as the criteria in their Studies.

3- Mechefske and Wang (2003), proposed fuzzy methodology to evaluate and select the optimum maintenance strategy and condition monitoring technique which is based on qualitative verbal assessment inputs is more practical than the formers, because many of the overall maintenance objectives of the organization are intangible. However, the method of Mechefske and Wang (2003) is very subjective to directly assess the importance of each maintenance goal and the capability of each strategy to achieve each maintenance goal.

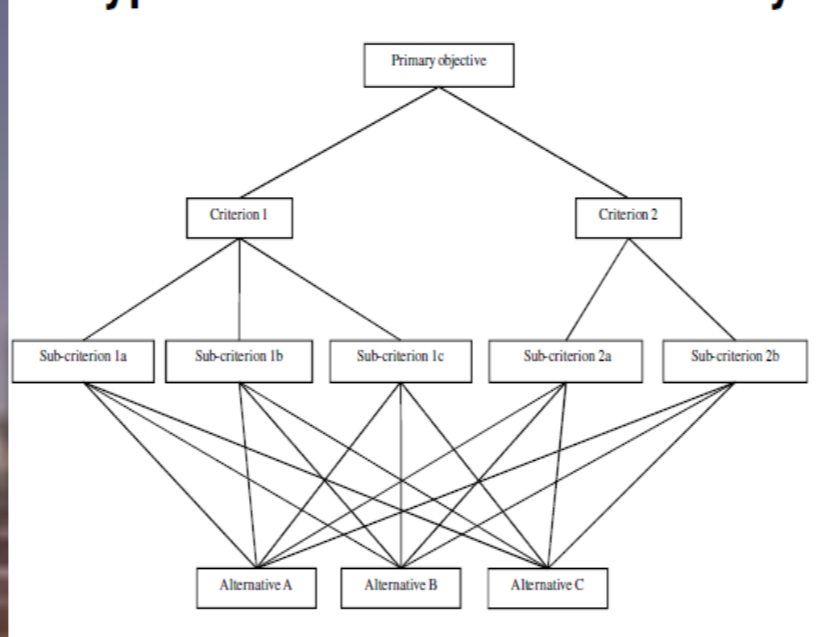


The Proposed AHP Model and Findings

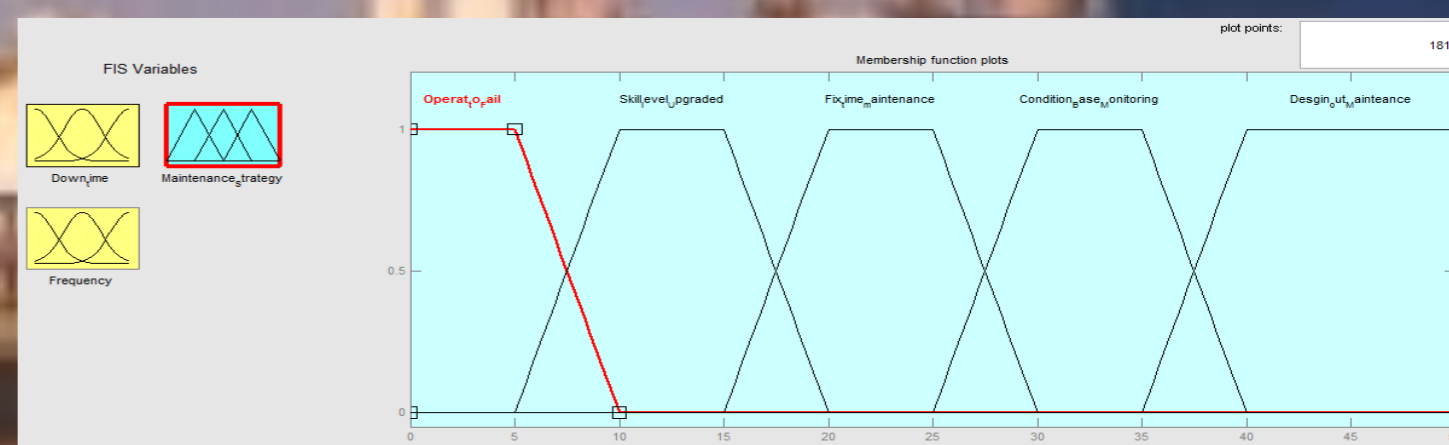
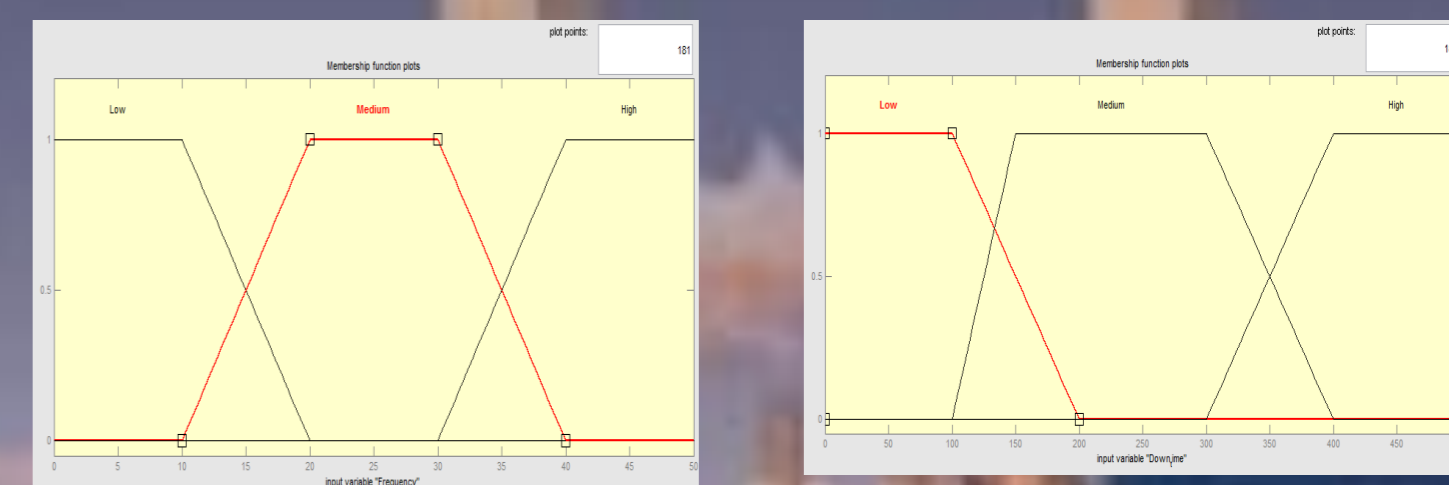
Considering the shortcomings of the existing methods above, it is necessary to develop a new evaluation scheme for maintenance strategies. This scheme should include different aspects of maintenance goals, be able to model uncertainty and imprecise judgments of decision makers (i.e. maintenance managers and engineers), and be easy to use.

- Goal: Selecting Maintenance Strategy**
- Cost (L: .057)
 - Maintenance Cost (L: .239)
 - Production Loss Cost (L: .761)
 - Safety (L: .059)
 - Conseqnc of Failure (L: .682)
 - Operation Condition (L: .318)
 - Sapre (L: .139)
 - Spare Part Availibility (L: .500)
 - Spare Machine Availibility (L: .500)
 - Criticality of item (L: .240)
 - Access Difficulty (L: .166)
 - Bottleneck (L: .834)
 - Failure Frequency (L: .082)
 - Downtime (L: .286)
 - Market demand (L: .137)

A typical AHP decision hierarchy



Implemented Fuzzy interface theory



1. If (Down_time is Low) and (Frequency is Low) then (Maintenance_Strategy is Operate_to_Fail) (1)

2. If (Down_time is Low) and (Frequency is Medium) then (Maintenance_Strategy is Fix_time_maintenance) (1)

3. If (Down_time is Low) and (Frequency is High) then (Maintenance_Strategy is Skill_level_Upgraded) (1)

4. If (Down_time is Medium) and (Frequency is Low) then (Maintenance_Strategy is Fix_time_maintenance) (1)

5. If (Down_time is Medium) and (Frequency is Medium) then (Maintenance_Strategy is Fix_time_maintenance) (1)

6. If (Down_time is Medium) and (Frequency is High) then (Maintenance_Strategy is Fix_time_maintenance) (1)

7. If (Down_time is High) and (Frequency is Low) then (Maintenance_Strategy is Condition_Base_Monitoring) (1)

8. If (Down_time is High) and (Frequency is Medium) then (Maintenance_Strategy is Fix_time_maintenance) (1)

9. If (Down_time is High) and (Frequency is High) then (Maintenance_Strategy is Design_out_Maintenance) (1)

If Down_time is Low and Frequency is High then Maintenance_Strate is Operate_to_Fail

If Down_time is Medium and Frequency is High then Maintenance_Strate is Fix_time_maintenance

If Down_time is High and Frequency is Low then Maintenance_Strate is Condition_Base_Monitoring

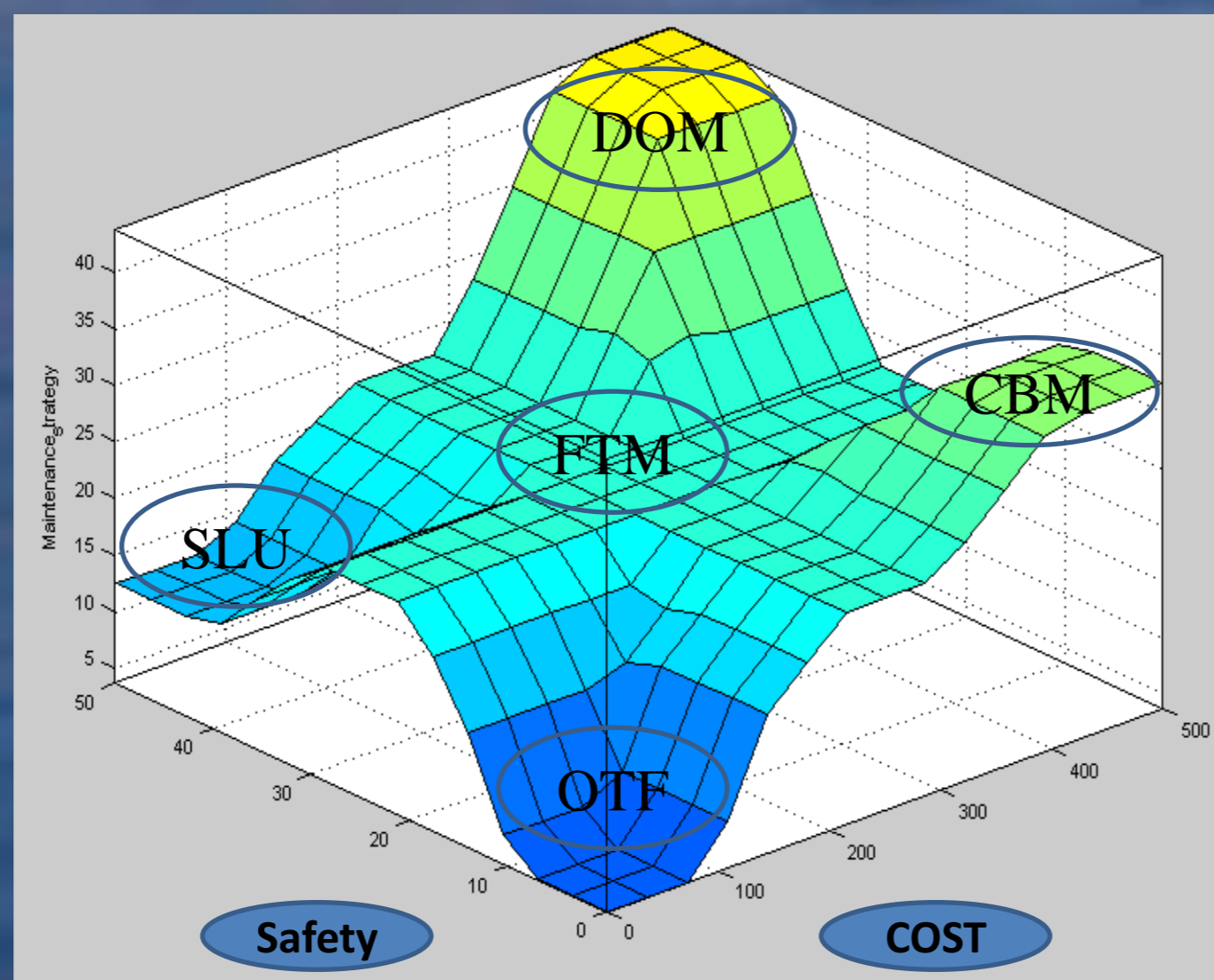
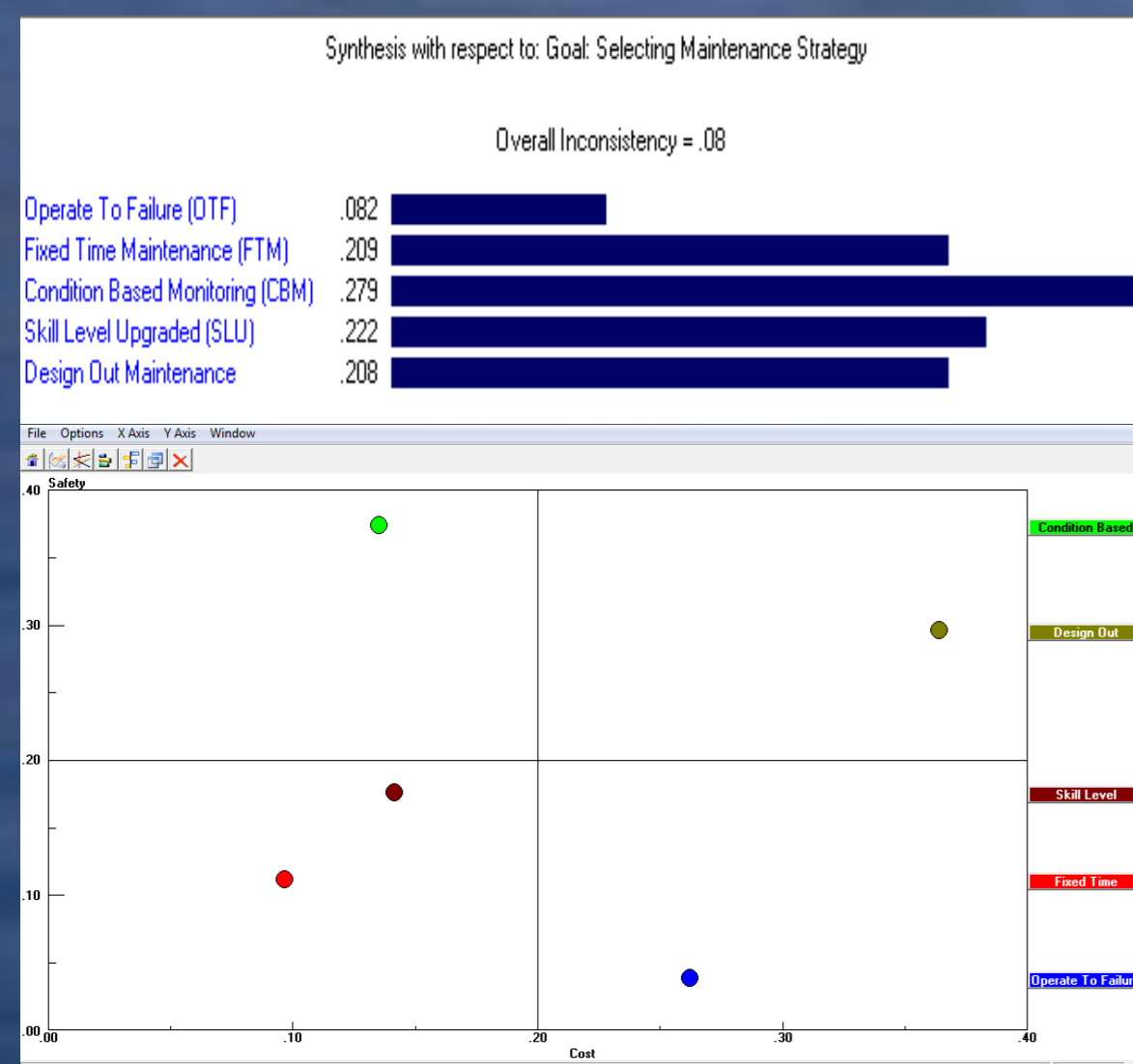
If Down_time is High and Frequency is Medium then Maintenance_Strate is Fix_time_maintenance

If Down_time is High and Frequency is High then Maintenance_Strate is Design_out_Maintenance

Connection: or, and, Weight: 1

FIS Name: Maintenance Strategies

Combined Fuzzy AHP Results



Conclusion

- a) An optimal maintenance strategy obtained for the BP process plant which can effectively improve availability and reliability levels of plants equipment, and reduce unnecessary investment in condition maintenance techniques.
- b) The fuzzy AHP models deal with the uncertainty related to imprecise judgments of decision makers and experts by quantifying the qualitative data obtained through AHP questioners to fuzzy interface model.
- c) The results illustrated that CBM is not necessarily improves the safety of plant whereas investment in upgrading the skill of operators could effectively improves the level of safety in the process plant .

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Updated from (W.Labib, 2004)

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