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Thesis Summary of

Computerized Multiple Criteria Decision Making Model for Projects Planning and Implementation

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Abstract

Projects are initiated and implemented to promote investment and maintain the competitiveness of the company. In order for projects to be successful, the company management must come up with the best decisions during the planning and implementation phases of these projects.

This paper addresses a computerized multi-criteria decision making model based on the Analytic Hierarchy Process (AHP) which has been developed to assist in decision making for projects. This will avoid inadequate decisions, lack of consistency and failure to consider all relevant criteria.

This process incorporates the quantitative and qualitative aspects of the decision making problem and provides a measure for determining the consistency of the decision maker. Additionally a survey has been conducted to gather information about the criteria that influence the decisions for ranking and evaluating telecommunications projects alternatives. To demonstrate the usefulness and application of the model, it has been applied on a telecommunications project for a major industrial company using the criteria that resulted from the questionnaires.

1. Introduction

The success of the project is related to choosing the best project alternative during the preliminary engineering study. The decision making process involves many objectives which need to be satisfied. Therefore, there is a great need to determine the order of preference of those objectives for the available project alternatives. Although the project goals are defined, it is usually not clear how they can be achieved. There is an array of possible alternative solutions to any project design problem. Deciding on which alternative is difficult.

Traditionally, owners compare only the cost of alternatives to their projects; however, projects involve as well environmental and political factors that cannot be measured in momentary units. The decision making process might encounter certain problems such as complexity of the decision, inconsistency of the decision maker, political favors and hidden agenda by the decision maker, overlooking the objective of the project, conflict between individuals, and variation of perception from one individual to another. To avoid these problems and improve the process, a structured computerized multi-criteria decision making model based on the analytical hierarchy process (AHP) that assists in selecting the best project alternative is presented in this research. This model will help in focusing the decision-maker's attention on the project's main objective. To demonstrate its usefulness, it has been applied to a case study, telecommunications projects. The factors that influence the decision making are obtained from literature review, survey, and previous telecommunications projects documentation.

2. Previous Studies

Previous studies were found in the literature addressing methods of selecting project alternatives. Such methods have been used in Value Engineering where alternatives are compared by using weighted evaluation in the selection of the best alternative. Many factors other than cost can be considered in the evaluation. The method consists of two processes, the Paired Comparison Criteria Weighting Process and the Evaluation Matrix.

Under the Paired Comparison Criteria Weighting Process, criteria that influence the decision making for selecting an alternative are listed. Each criterion is assigned a letter of the alphabet and its importance to the decision-maker is determined. Once the criteria elements and their weighs have been established, they are entered in an evaluation Matrix. Then each criterion is ranked against each alternative. Afterwards, each alternative with the weight of criterion is multiplied and the result is entered in the matrix. The total score is summed up for each alternative and ranked for selection. The alternative with the highest score is the one to be selected.

A value engineering study was conducted for Saudi aramco for the fiber optic system at Riyadh-Pump Station No. 3. the purpose of the study was to select the best alternative for the fiber optic project based on the weighted evaluation method. Here few criteria such as Initial Cost, Operation and Maintenance Cost, Technological Life, System Compatibility, Field Proven, Saudi Aramco Ownership & Control & Replacement. This method can handle only a limited number of decision criteria and it is difficult to use. Also, it has a limitation on its scale (using only a 5-point scale in making judgement.)

Other studies used the Fuzzy Multi-Criteria Concept for comparing projects. Generally, the practical application of fuzzy set theory can be difficult because of coding the relationships and the quantification of membership sets. The more fuzzy logic you have, the more difficult it is to implement. Additionally, it requires that the decision-makers express their choices in precise quantitative terms that most decision makers are not ready for.

Other methods such as multi-attribute utility function were used. In construction, the analytic hierarchy process (AHP) was applied in the areas of project assessment and bidding decisions. This method is the basis of this thesis.

3. The Analytic Hierarchy Process (AHP)

3.1 Introduction

The decision making approaches that have been discussed have their own shortcomings that can be alleviated by the AHP. For instance, it is difficult to assign and estimate the weights of each attribute and sometimes the decision making is based on subjective criteria, which can not be quantified. To overcome the shortcomings of the various decision making approaches, the AHP is recommended as a viable decision making tool. It will be presented as such and used in this study.

3.2 The AHP Steps

The AHP involves four steps. These are:

1. Constructing a decision hierarchy by breaking down the decision problem.
2. Performing pairwise comparisons of the decision elements.
3. Estimating the weights of the decision elements.
4. Aggregating the relative weights of the decision elements to provide a set of ratings for the decision alternatives.

Nodes in the hierarchy represent main criteria that may have sub-criteria or decision alternatives in the immediate lower level to be prioritized. Each relationship is weighted according to the strength of influence an alternative or criterion at the same level. The more general, risky and uncertain the decision elements, the higher the levels are. The elements in each level are influenced or controlled by the elements in the level immediately above. Influence is distributed downwards from the top, which is the main objective. The main objective has the greatest influence with a value of one. This value is divided among the decision elements of the second level and the values of each level down below down to the level of alternatives, the last level in the hierarchy. The degree of influence is measured on a nine-point scale and the final solution results in the assignment of weights to the alternatives located at the lowest hierarchical level. The 1 to 9 scales is used as follows:

One (1) for equal importance of the two evaluated elements.

Three (3) for moderate importance of one element over the other.

Five (5) for strong importance of one element over the other.

Seven (7) for very strong importance of one element over the other.

Nine (9) for extreme importance of one element over the other.

2, 4, 6, 8 for compromise.

Reciprocals for the inverse comparison.

The second step involves the pairwise comparison of the decision elements. The comparison is done in pairs and place in a matrix. Pair wise comparisons are fundamental building blocks of the AHP.

In the 3rd step the eigen value method is used to estimate the relative weights of the decision elements.

In the last step of the AHP, the relative weights of various levels are aggregated. The results produce a vector of composite weights, which will serve as a ranking of the decision alternatives.

The author supported his description of the AHP method by providing a full mathematical explanation of the method. In addition, he addressed using equations the consistency, prioritization, the decomposition and aggregation, and the calculation steps of the AHP Method.

4. Decision Criteria for the Selection of Projects Alternatives

4.1 Intoduction

The following criteria were obtained from the literature review, documentation of previously implemented telecommunications projects, a survey and informal interviews with the people who are responsible for conducting telecommunications projects. There are other criteria that can be included, which are system specific. However, these criteria are common for every telecommunications system.

4.1.1 Cost

These costs will be broken down as follows: Initial Cost, Operating and Maintenance Cost, Replacement Cost, System Upgrading Costs, Leasing Cost, and Decommissioning Cost. The cost criteria include all the costs associated with system installation, replacement, operation and maintenance. Initial cost is the cost associated with engineering, acquisition, and installation, commissioning and operation of the system. Operation cost includes the costs associated with the system operation, power consumption and HVAC usage. Maintenance costs are the cost involved in maintaining the system including the preventive maintenance and repair cost. Replacement cost is the cost associated with replacement of the components of the system and supporting systems. System upgrading cost includes the costs that are required for upgrading the system for increasing the system capacity or upgrading the hardware of the system. Leasing cost involves the cost of leasing system components or space for housing the system equipment. Decommissioning cost is the cost that is incurred when the system is removed from service at the end of its life.

4.1.2 Life

The sub-factors are as follows: Technological Life, Working Life, and Economical Life. The life of the implemented system includes the working, economical and technological life. Technological life is dependent on the life expectancy of a communication system based on anticipated vendor support. Some vendors discontinue manufacturing certain products after a limited number of years due either to bankruptcy or the introduction of a new product that meets the demands at that time. The newer the technology is the greater the life expectancy and vice versa. Economical life is the period of time during which the system provides benefits. It relates time and benefits. Working life is the period of time during which the system is in operation. Some times a company may shut down a communications system installed to support a specific operation for a limited time.

4.1.3 Ownership and Control

The criterion considers the importance to ownership of the system and control. The company may decide to lease the service from other entity. The problem associated with this choice is the lack of system by the company. If an outage happens somewhere in the system at certain time, repair might not take place immediately because the leasing entity has assigned it a low priority rating. As a result of this, the company may incur a great deal of loss of revenue due to the lack of production of oil and gas.

4.1.4 Technology

Technology compares new systems with little operational history background to older system with known established operational characteristics. It may include sub-factors such as Filed Proven technology, technology under research and development, and new technology that is still not yet used on a large scale.

4.1.5 System Features

The system features include: Mandatory Features, and Optional Features.

Each communications system offers a unique variety of features because of the characteristics of each system. Mandatory features include the features that are essential for successful operation of the system. Operational features are redundant, not part of the customer requirements. The vendor usually offers these features in the proposed systems.

4.1.6. Ease of Migration

This is a measure of system flexibility which provides the ability to transfer from one frequency band to other, or the ability to transfer to future system developments without the need of replacing the system. Stated differently, it is the responsiveness of the system to future changing needs. It includes system capacity, conformance to new standards and protocols and the upgrading of the system. Sub-criteria may include system modularity or system software upgrade. System modularity is the addition of the system modules or subsystem when an expansion or modification is required without the need for changing the existing system components. Software upgrade is the addition to the system software to upgrade the system to meet the future demands or changes which may be incorporated without changing or altering the system components.

4.1.7 Protection during failures

The ability of the system to recover from failure. It basically includes the provisioning of the critical system components with automatic switchover in the event of failure.

4.1.8 Compatibility

The compatibility is the ability of the system to interface with the existing system and future systems. This includes the compliance of the system with internationally known standards and protocols to avoid problems when interfacing with other systems that comply with these standards and protocols.

4.1.9 Reliability

The reliability of the system includes the Mean Time Between Failures (MTBF) and Mean Time to Repair (MTTR). MTBF is the time it takes the system to recover from failure. MTTR is the time to repair the system after failure. The less the MTTR or the MTBF is, the more reliable the system is.

4.1.10 Availability

It is the time it takes the system to operate continuously without breakout or it is the percentage of time the system meets performance requirements; unavailability is the percentage of time the system does not meet the requirements.

4.1.11 System Security

The security of the system includes the security of the system files and the security of the transmitted voice or data. How secure the system is? Can it be accessed by unauthorized personnel? Does it have Password Protection?

4.1.12 Equipment Dimension

Dimension of the system equipment includes height, width and depth. Equipment might not fit in the provided space available at certain sites.

4.1.13 Equipment Weight

It is the nominal weight of the system equipment. The lighter the weight of the equipment the more desirable it is.

4.1.14 Physical configuration and Appearance

This criterion considers whether the equipment is designed for indoor installation such as desktop or rack-mounted or outdoor installation for post installation such as Remote Terminal Units (RTU). The appearance of equipment is concerned basically with color of the equipment so that it matches the color of the existing equipment on site.

4.1.15 Climatic and Environmental Requirements

The ambient temperature and relative humidity are respectively the temperature and humidity the system can operate under without affecting its performance.

4.1.16 Power Requirements

The system should operate at a specified power either – 48 VDC (Nominal) or 120 VAC, 60 Hz or as specified. The system should be able to switch automatically to the backup power in the event of the main power failure. Sometimes solar energy is required instead of the conventional power.

4.1.17 Heat Dissipation

A measure for the equipment heat dissipation is BTU per Hours. The less heat the equipment dissipates the lower the requirements for HVAC to cool the equipment.

4.1.18 Acceptance of the Project with Proposed System

It includes satisfaction or acceptance of the proposed system by: Owner (Operating Organization), Project Management Team (PMT), End-User, Public, Government. Quite often, the end user or the operating organization may require a different system than the proposed system, due to certain constraints that the proposed one could not meet. These constraints may include political, budget or schedule factors.

4.1.19 Permits

The permits include: Equipments import Permits, Land Use Permit.

The equipment must be granted an import permit by the government before the user can use it. The import permits are difficult to get sometimes due the limitation imposed on the company. Often these permits are delayed which lead to delays in the delivery and installation of the equipment, especially wireless communications equipment. The land use permits are required when the system is installed in areas that do not belong to Saudi Aramco. This requires leasing, buying the land from others or applying for a land use permit. If these permits cannot be granted the project cannot be implemented or if they get delayed, then the project will be delayed.

4.1.20 Waivers

Occasionally, users have unique requirements that cannot be satisfied within Saudi Aramco Standards. In such a case, the user organization applies to the Consulting Services Department for a waiver. If such waivers are not approved, the project can not be implemented.

4.1.21 Vendor Support

This criterion includes: the vendor’s experience and reputation; the vendor’s capability to support its products through warranties, on site maintenance, hot-line support, user training, consulting, and documentation, and the product pricing structure.

4.1.22 Time to Implement

The time required to place the system in operation. The time might be affected by delays in approvals of waivers, import permits, land use permits or the completion of the construction of the supporting facilities.

4.1.23 Equipment Safety

This criterion is associated with the safety of the equipment. The evaluator needs to find out if the equipment is intrinsically safe. When it is confirmed that the equipment is intrinsically safe, it means that the equipment is approved to operate in areas in which hazardous concentrations of flammable gasses exist.

4.1.24 Compliance

This constitutes compliance of the system to the owner's standards as well as internationally known standards.

4.1.25 Project Location

This criterion specifies the location of the project. Generally, the project location could have considerable impact on the economic growth of the area where the site will be located. For one reason or another, the owner or the operator of such a site would not agree on a particular location due to its remoteness or it was not considered to be a strategic location.

5. Survey and Data Analysis

A survey was conducted to determine the criteria that influence the decisions for telecommunication projects. To achieve this, (30) questionnaires were distributed to selected professionals who play a major role in the decision making process for telecommunication projects. The purpose of the questionnaire was to collect data to identify the decision factors and to determine their overall importance in the decision making process. Appendix A in the thesis includes information pertaining to the survey and the collected data.

The participants constitute a mixture of the engineers who deal with all aspects of communication systems, such as fiber optic system, mobile radio systems, telephone and switching, satellite and microwave systems. They represent project management, communications and computer engineering and communication and computer services.

Table 5.1 – Participants List

Organization	No. Of Quest.	No. Of Replies
Consulting Service Department / Computer & Communications Group	2	0
Computer and Communications Engineering Division	5	3
Communications and Computer Services Division	5	3
Communications Projects Division	18	17
Total	30	23

The number of questionnaire that was sent to each organization was determined by the degree of involvement of each organization in the decision-making process. Only twenty-three (23) replied. This number of respondents constitutes about 77% of the questionnaires distributed.

The questionnaire started by asking the position of the participant and the extent of his involvement in the recommendation and decision making for selecting and/or recommending telecommunications projects or technologies.

Then each participant was asked to review the list of criteria and determine if the list was complete or if there was any criterion that needed to be added or deleted from the list. Each participant is asked to determine the influence of each factor on the overall decision by assigning a number that represented the influence of each factor on the overall decision by assigning a number that represented the influence on a scale of 1 to 9. The next tables show the mean influence and the variance of the decision criteria that were resulted from the survey.

Table 5.2 – Criteria and sub – criteria list with mean influence

Decision Criteria	Total	Mean Influence	Variance	Standard Deviation
1. Cost				
Initial Cost	163	7.1	2.9	1.7
Operating And Maintenance Cost	149	6.5	4.1	2.0
Alteration And Replacement Costs	121	5.3	2.8	1.7
Leasing Cost	107	4.7	4.3	2.1
Decommissioning Cost	73	3.2	4.4	2.1
System upgrade cost	119	5.2	3.4	1.8
Composite Values - Cost		5.3	3.6	2.5
2. Project Location	122	5.3	6.3	2.5
3. Ownership and control	158	7.0	2.4	1.5
4. Life				
Technological Life	163	7.1	1.2	1.1
Working Life	155	6.7	1.7	1.3
Economical Life	164	7.1	1.5	1.2
Composite Values --Life		7.0	1.5	1.2
5. Technology	162	7.04	3.3	1.8
6. Ease of Migration	141	6.1	3.4	1.8
7. System Features				
Mandatory Features	173	7.5	3.8	3.8
Optional Features	92	4	3.6	2.0
Composite Values --Features		5.8	3.7	2.9
8. Ease of Protection During Failure	154	6.7	3.6	1.9
9. compatibility	171	7.4	3	1.7
10. Reliability	159	6.9	1.6	1.3
11. Availability	166	7.2	2.7	1.6
12. System Security	130	5.6	3.4	1.8
13. Equipment Dimension	87	3.8	3.4	1.8
14. Equipment Weight	75	3.3	3.5	1.9

15. Physical Configuration	75	3.3	2.7	1.6
16. Climatic and Environment Req.	123	5.3	4.5	2.1
17. Power Requirements	110	4.8	3.0	1.7
18. Heat Dissipation	111	4.8	4.4	2.1
19. Acceptance				
By Owner (Operating Organization)	176	7.7	1.8	1.3
By Project Manag. Team (PMT)	153	6.7	2.0	1.4
By End User	142	6.2	5.5	2.3
By Government	133	5.8	8.5	2.9
By Public	99	4.3	6.3	2.5
Composite Values---Acceptance		6.1	4.8	2.1
20. Permits				
Equip. Importation Permits	131	5.7	6.2	2.5
Land Use Permit	137	6.0	8.7	3.0
Composite values – Permits		5.8	7.5	2.8
21. Vendor Support				
Warranties	147	6.4	3.6	1.9
On-Site Maintenance	137	6.0	6.1	2.5
Consulting	120	5.2	4.1	2.0
Documentation	149	6.5	4.1	2.0
Hot-Line Support	100	4.3	3.5	1.9
User Training	147	6.4	4.7	2.2
Composition Values---Vendor Support		5.8	4.4	2.1
22. Waivers	140	6.1	2.2	1.5
23. time to implement	150	6.5	2.3	1.5
24. Intrinsic Safety	170	7.4	2.3	1.5
25. Compliance				
Owner Standards	160	7.0	2.4	1.5
International Standards	152	6.6	2.8	1.7
ITU	162	7.0	2.7	1.6
Composite Values---Compliance		6.9	2.6	1.6

Table 5.3 – Main Criteria Influence

	Decision Criteria	Mean Influence	Variance	Standard Deviation
1	Cost	5.3	3.6	1.6
2	Project	5.3	6.3	2.5
3	Ownership and Control	7.0	2.4	1.5
4	Life	7.0	1.5	1.2
5	Technology	7.0	3.3	1.8

6	Ease of Migration	6.1	3.4	1.8
7	System Features	5.8	3.7	2.9
8	Ease of Protection During Failure	6.7	3.6	1.9
9	Compatibility	7.4	3	1.7
10	Reliability	6.9	1.6	1.3
11	Availability	7.2	2.7	1.6
12	System Security	5.6	3.4	1.8
13	Equipment Dimension	3.8	3.4	1.8
14	Equipment Weight	3.3	3.5	1.9
15	Physical Configuration	3.3	2.7	1.6
16	Climatic & Environment Requirement	5.3	4.5	2.1
17	Power Requirement	4.8	3.0	1.7
18	Heat Dissipation	4.8	4.4	2.1
19	Acceptance	6.1	4.8	2.1
20	Permit	5.8	7.5	2.8
21	Vendor Support	5.8	4.4	2.1
22	Waivers	6.1	2.2	1.5
23	Time to Implement	6.5	2.3	1.5
24	Intrinsic Safety	7.4	2.3	1.5
25	Compliance	6.9	2.6	1.6

The next table present the ranking of the criteria mean influence along with variance and standard deviation from highest to lowest. From the analysis, we find that the range of the mean is between 3 and 7. We find that none of the criteria is at the values of 8, 9, 1 or 2.

Table 5.4 – Main Criteria Influence Ranked from Highest to Lowest

Decision	Mean Influence	Variance	Standard Deviation
9. Compatibility	7.4	3	1.7
24. Intrinsic Safety	7.4	2.3	1.5
11. Availability	7.2	2.7	1.6
10. Reliability	6.9	1.6	1.3
5. Technology	7.0	3.3	1.8
4. Life	7.0	1.5	1.2
3. Owner & Control	6.9	2.4	1.5
25. Compliance	6.9	2.6	1.6
8. Ease of Protection During Failure	6.7	3.6	1.9
7. System Features	6.5	3.7	2.9
23. Time to emplement	6.5	2.3	1.5
6. Ease of Migration	6.1	3.4	1.8
22. Waivers	6.1	2.2	1.5
19. Acceptance	6.1	4.8	2.1
21. Vendor Support	5.8	4.4	2.1
20. Permits	5.8	7.5	2.8
12. System Security	5.6	3.4	1.8
1. Cost	5.3	3.6	1.6
16. Climatic and Environment	5.3	4.5	2.1

Requirements			
2. Project Location	5.3	6.3	2.5
18. Heat Dissipation	4.8	4.4	2.1
17. Power Requirements	4.8	3.0	1.7
13. Equipment Dimension	3.8	3.4	1.8
15. Physical Configuration	3.3	2.7	1.6
14. Equipment Weight	3.3	3.5	1.9

Although, some of the participants evaluated some of the criteria at 8, 9 or 1, the majority evaluated the criteria at a range of 3 to 7. This resulted in the overall result in the neighborhood of seven (7) at one extreme and three (3) at the other extreme. This shows a tendency of most of the participants to use a five point scale disregarding the upper or lower limits. This may represent the fact that scales for any evaluation do not exceed five points.

Additionally, the analysis shows that cost did not receive a high rating. This reflects the fact that, in Saudi ARAMCO, cost is not as important as other factors when implementing telecommunications projects because communications projects constitute a small portion of any oil gas project. The emphasis of the company appears to be on the major carrying-cost items related to the oil and gas facility. For example the author of this thesis has been assigned a telecommunications project that is part of a Gas & Oil Separation (GOSP) Project, where the estimated cost of the communication portion was only about 4 % of the total cost of the plant.

Therefore, the management effort to save money will be concentrated on the major items that incur most of the cost. The communications system is essential to running the daily oil and gas production. In this kind of environment, communications can not be compromised, as far as the rapid advances and evolution of the electronics are concerned. On the other hand, advances in oil and gas related equipment is slow when compared to development in communications systems.

Also, it can be noted that the first six factors that were evaluated to be very strongly important with rating ranging from 7 to 7.4, carry with them hidden costs. The first factor is compatibility. If the system is not compatible then the company will have to replace the existing system in order for both systems to interface without any problem. Replacing the existing system will incur additional costs for buying the new system and for decommissioning the old system. Additionally, the life of the old system will be cut short, where it will not provide the benefits it was intended to provide. The second factor, intrinsic safety, with a rating of 7.4, is as important as the compatibility. Safety is always first in our daily life. Safety cannot be compromised, especially when dealing with end user communications equipment in a plant area. This equipment should be safe to operate in areas with a high concentration of flammable gasses, where a small spark from a battery of equipment might cause major damage to the plant, thereby incurring large repair or replacement costs. Availability and reliability come next in order with a 7.2 and 7.0 rating respectively. Availability is essential to insure the continuity of service. If it is jeopardized by the poor performance of the system, it will force the oil and gas production to lie idle, because every thing depends on communications. If the system is not reliable, it will affect availability and efficiency, thereby adversely affecting daily business. All of these effects will result in big loss of revenue, so this is a cost impact in the long run. System life and technology come next in line with a rating of 7.0. If the company buys a system with a technology that is emerging or under research and development, then this technology will bring with it schedule risks and the possibility that it may not work as expected. This may result in additional cost due to delay if the system does not work or arrives on the market after the expected date.

The next set of factors was evaluated with a rating ranging from, 6.1 to 6.9. The first two factors were ownership, control, and compliance. The factor is related to cost. If the communications system is owned by some other entity whether it is a government or private agency, the system will not be on the priority list. This in turn incurs a big loss revenue. On the other hand, if the company owns and controls the system, it will receive the required attention immediately.

The other factors in this range include ease of migration, system features, time, migration, waivers and acceptance. The acceptance factor includes sub-factors, one of which is the acceptance by government. If the government does not accept the project, the company can not implement the project.

Vendor support, permits, cost, climatic and environment requirements and project location with ratings ranging from 5.3 to 5.8 are next. If permits cannot be granted then the company cannot implement the project. If the vendor support is discontinued, the system needs to be replaced, which will result in additional cost for buying new system.

Heat dissipation and power requirements factors got 4.8 points, between strongly and weakly important. The last three factors are the lowest in the ranking and they can be dropped from the analysis.

The list of criteria can be broken into three groups. Project related factors, system related factors and vendor/manufacturer related factors.

After the data analysis had been done, another review of the factors was conducted with some of the participants and it was agreed that vendor criteria should be modified as shown below:

Vendor Reputation (Availability of technical literature; Responsiveness to customers; Consultation.)

Vendor Support During Implementation (Availability of technical expertise; Quality of engineering work; On site support for installation and commissioning)

Vendor Support After Commissioning (Warranty; On site maintenance; Documentation; Hot line support; User training)

The next tables show the final grouping of criteria for each group.

Table 5.5 – Project Related Criteria

Project Related Factors
Cost
Time to Implement
Ownership and Control
Project Location

Acceptance
Permits

Table 5.6 – Project Related Criteria

Vendor –Related Factors
Vendor Reputation
Vendor Support During Implementation
Vendor Support After Commissioning

Table 5.7 – System Related Criteria

System Related Factors
Operability
Mechanical Characteristics
Compliance
Life & Technology

6. Computerized Decision Making Model

6.1 Introduction

The computerized decision making model was created in visual basic. The program consists of six modules. These are:

1. Start Module (should be clicked first to start the program)
2. Initial Data Module
3. Criteria Pairwise Comparison Module
4. Initial Alternatives Data Module
5. Alternative Pairwise Comparison Module
6. Synthesis Module

All the input data and output data are saved automatically in a Microsoft Access file called Alirezam.mbd. The output data is plotted immediately after performing the pairwise comparison and obtaining the weights for the criteria. The consistency check is done every time the pairwise comparison is performed. The data must be entered in the initial data module and in the alternative initial data module and not in the Access files.

The program has the capability to retrieve the files from database via the pop-up menu. The print command prints the image of the sheet only.

6.2 Program Limitations

The program is limited to decision problems that have:

- Hierarchies of five (5) levels or less.
- Criteria groups with ten (10) sub-criteria or less.

There is no restriction on the number of alternatives, but it is recommended that the number of alternatives should not exceed more than ten (10) alternatives.

6.3 Flow Chart of the Program (Step by Step Calculation)

The next figures show the step by step instructions. The program has mainly 12 steps. Once the program is loaded it initializes the output data files and then proceeds with the calculations after the user has input the data. The next section explains this process in full detail.

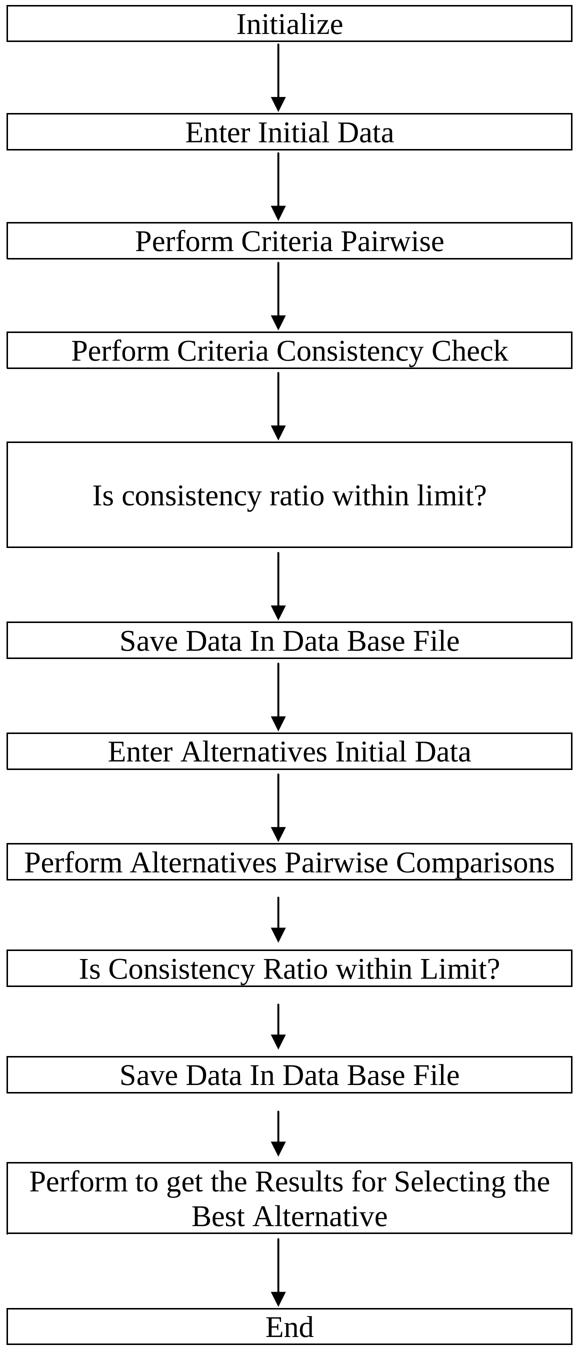

Figure 6.1 – The Program Steps

6.4 Program step by step calculations:

In this section the author has explained the six modules and give lot of details about the computer program and the way the user has to interact with. The section was illustrated with figures.

6.5 Program Description:

The program was created in Visual Basic (VB)which is based on the concept of object-oriented programming. Each object has an event such as click, double click, key press, change and mouse move by which it can be activated. These events were described.

This section addresses the program subroutines by listing them and showing the corresponding event and action. The author of the thesis included all the program codes listing in Appendix B of the thesis. The following table shows the number of subroutines for each module:

Serial Number	Module	No. of Subroutines
1	Start Module	2
2	Initial Data Module	17
3	Criteria Pairwise Comparison Module	8
4	Initial Alternatives Data Module	3
5	Alternative Pairwise Comparison Module	8
6	Synthesis Module	1
7	Total	39

7. Project Alternatives Evaluation Problem: (Case Study)

7.1 Scope

A major industrial company has decided to replace its current mobile radio communications system, infrastructure and end user equipment with a new state of the art mobile radio system. The model is applied here to rank project alternatives, however this model can be applied to all aspects of the project.

7.2 Alternatives

Three mobile radiosystem alternatives were investigated. These are to replace the old system with:

1) an analog system which has been tried, field proven, and used by other entities
2) open system architecture. This might end up in potential cost and schedule risks.
3) Proprietary system architecture. It might carry with it discontinued vendor future support due to using non-standard equipment.

7.3 Methodology Applications and Discussion

The decision problem is first formulated in a hierarchical structure. At the top lies the most important objective, selection of most appropriate telecommunications project. In the second level, the main criteria are listed. In the third level, project criterion is broken down into sub-criteria. The decision maker has to judge if any of these criteria has more influence or importance than other criteria. Each of those sub-criteria is broken further into more sub-criteria.

7.4 Criteria Pairwise Comparison

The pairwise comparison was performed for all the criteria. Results were shown in 15 tables.

7.5 Alternatives with Respect to Criteria Pairwise Comparisons

The author showed the alternatives with respect to criteria pairwise comparisons in 49 tables. Then he explained the step by step instructions for entering the data and performing the criteria and alternatives pairwise comparisons calculation along with a consistency check. The last step involves the aggregation of results, the synthesis. It was determined that alternative no. 3 is the most appropriate for the company to decide on.

8. Summary, Conclusion, & Recommendation

8.1 Summary

Conducting the initial feasibility studies usually requires the determination or selection of the best alternative for any investment project. This can be accomplished by the use of multi-criteria decision making approach that considers the tangible and intangible decision criteria.

In this research a Computerized Multiple Criteria Decision Making Model based on the AHP Methodology was developed. It was applied to rank telecommunications project alternatives for a major oil and gas company in the region. The mode was programmed in visual basic and the data files are automatically saved in Microsoft Access. The program is user friendly and provides the user with the ability to change the evaluation scale. Also, the user has the freedom to list any factors appropriate to any decision making situation.

8.2 Conclusion

The developed computerized model gives the user a structured and systematic decision making approach for evaluating and selecting project alternatives. Additionally, this model can be used throughout the phases of the project from preliminary engineering phase to contract development and bidding phase to evaluation phase of the value engineering phase.

The application and the use of thisdecision making approach is straightforward. However, the difficulty lies in the construction of the decision hierarchy which depends mainly on the decision maker's experience.

8.3 Recommendations for future research

Additional research on the developed Computerized Multiple Criteria Decision- making Model should be conducted. It is recommended that this computerized model should be developed further to be part of an expert system that includes all the criteria that influence the various decisions for all aspects of the project. It is recommended that future research incorporate uncertainties and not be based on a deterministic approach to decision making.

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