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# DECISION SUPORT SYSTEM FOR TRANSPORT DEMAND MANGEMENT: OBJECT ORIENTED APPROACH USING KAPPA PC 2.4 EXPERT SYSTEM SHELL

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## ABSTRACT

In view of the fact that supply strategies alone could not solve urban congestion, many cities around the globe have adopted Transport Demand Management (TDM) strategies as part and partial of their congestion mitigation plan. TDM comprises several strategies and policies that aim to modifying travelers' behaviour. TDM comprises strategies and policies that are different in nature which can be divided into several categories according to how they affect travelers' behavior. Selecting and determining suitable TDM strategies for a particular congestion mitigation goal can be a complex task; thus requires expertise. In this regards, the effectiveness of a TDM strategy is primarily depending on whether its selection was appropriately examined prior to its field implementation. This paper presents the development of an expert system shell for TDM. The process of organizing the available knowledge of TDM strategies, as well as the process leading to the selection of one or more strategy advice, is encoded in the knowledge based expert system shell developed for the purpose by using shell expert system Kappa-PC version 2.4 which was adopted object oriented approach and high resolution graphical user interface. The advice given from the working system was evaluated and validated by comparing the output of the system against the recommendations made by transportation professionals. The evaluations indicate favourable results for the system. The expert advisory system can be used as a decision support system as well as a teaching tool for junior transportation engineers, planners, private developers, and government officials.

**Keywords:** transport demand management, decision support system, expert system, Kappa PC.

## 1. INTRODUCTION

As traffic grows around the world, congestion becomes more widespread and occurs significantly longer during weekdays. As such congestion and traffic-related pollution are increasingly becoming major issues in towns and cities world-wide. According to Kuala Lumpur Structure Plan 2020 released by Kuala Lumpur City Council, private cars are rising dramatically. The increasing reliance on private transportation, in particular private cars, has created considerable pressure on the road network which consequently has contributed to the problems of traffic congestion. Providing more road spaces to keep pace with traffic demand is not the answer. It would be far too expensive and socially disruptive, and would exacerbate the long term problem which was initially trying to be tackled. Some people argued that we should let traffic find its own level, thus forcing drivers to find alternative ways of travel, or not to travel at all. However, we believe this would mean abdicating our economic, social and environmental responsibilities. In the meantime, the countryside and urban areas would both suffer significant deterioration. The only realistic option is to seek ways of first controlling, then reversing, the growth in traffic. This needs to be done in the most equitable way, acknowledging that there are sections of society for who travel choices are more limited.

## 2. TRANSPORT DEMAND MANAGEMENT

### TDM as solution

In the last decades, traffic and transport engineers and practitioners had come to the conclusion that traffic problems can be mastered only through the introduction of appropriate Transport Demand Management (TDM) measures rather than through the provision of new highway infrastructure [1]. Demands on traveling increasing with the assumptions that private car is the best or the only solution for mobility. The supply for the infrastructure increases proportional to traffic volume. At one point, supply cannot meet demands due to certain factors such as budget, land or space issue [2]. Allowing traffic to grow to levels at which there is extensive and regular congestion is economically inefficient [3]. Although the construction of additional road capacity can alleviate some of the effects of congestion, the benefits may be counterbalanced unless growth in traffic volumes can be restrained. Therefore, another alternative is by implementing TDM, which is to make sure that people still travel but at the same time reducing the private car usage [2].

### How expert advisory system can help us

The implementation of TDM requires experts' knowledge, skills and experiences; as they are able to undertake a complex scenario analysis and subsequently can provide reliable TDM solutions based on the specific context of the problem (e.g. purpose and location details).

As argued, expert are not always available, nor do they always have the time to consult all possible references, review available data, etc [4]. This will lead towards time consuming on scheduling appointments and interviews, thus delaying one project. There is also a possibility that there might be no more adviser persons left upon death since most of them are at elderly age.

**TDM measurement (Supply and Demand)**

Traditionally, transportation strategies adopt "supply-side" tactic, which addresses the increased demand for transportation facilities by supplying more, in other ways, increasing the capacity of the facilities [5]. Now, it is being realized that this strategy will not be able to meet the long-term goals and objectives of the transport planners and policy makers. The experiences of many large cities of the world have revealed that as capacity is increased, demand also needs to be increased at a similar rate, otherwise, in the long-term, transport users experience no net travel time advantages and society suffers the impacts of costly road bills and environmental degradation [6].

Nowadays, it reiterated in the literature to put more emphasis on transportation demand management strategies rather than the traditional transportation strategies which are based on "supply-side" tactics to solve the problems of transportation systems [7]. In fact, TDM measures were introduced because of the failure of traditional solutions in addressing the huge magnitude of congestion in major metropolitan areas [8] where most of the traditional solutions were either financially or practically infeasible. Furthermore, Broaddus [9] also emphasize that we cannot build our way out of congestion; we need paradigm shift from supply side measures to demand management as shown in Figure-1.

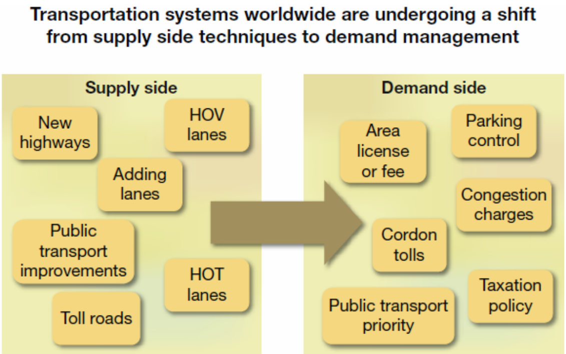


**Figure-1.** Paradigm shift from supply side measures to demand management.

## 3. METHODOLOGY

**Expert system as decision support system tool**

Advisory system is an expert system that provides advice to a user [10]. Advisory systems provide the advices and assist for solving problems that are normally solved by human experts. They can be classified as a type of expert systems [11]. According to Aronson and Turban [12], both advisory systems and expert systems are problem-solving packages that mimic a human expert in a special area. These systems are constructed by eliciting knowledge from human experts and coding it into a form that can be used by a computer in the evaluation of alternative solutions to problems within that domain of expertise. On the other hand, Gregg and Walczak [13] were stated that advisory systems are designed to support decision making in more unstructured situations which have no single correct answer.

Various methods have been applied in knowledge acquisition process in order to collect data from books, encyclopedia, and expert people in transportation, also known as expert domain. There are lots of TDM strategies listed and understanding each of it is very important. Based on the summary provided, the most suitable and appropriate TDM strategies are then identified based on specific objectives and geographical area. The final advices are chosen according to the most appropriate three strategies among very appropriate list determined by expert domain. Suppose there are less than three very appropriate strategies, and then the less appropriate TDM strategies are chosen in order to fill in the advising spaces.

A computer tool used to develop the expert system is by using open source software called Kappa-PC version 2.4. The first step is to create hierarchy from TDM strategies towards specific objectives, main purpose, choice of area and the final three advices respectively as shown in Figure-2. Kappa-PC provides the developer with the flexibility and power required in supporting complex applications [14]. It allows the knowledge engineer to develop prototype using hybrid knowledge representation technique.

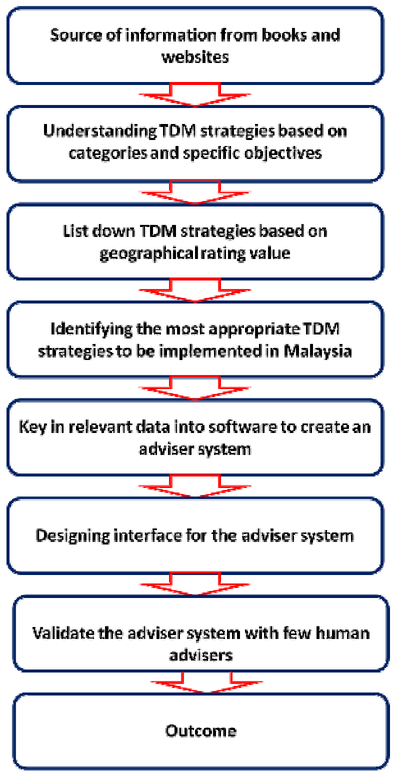


**Figure-2.** Task analysis.

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## 4. RESULTS AND ANALYSIS

### System architecture of expert system shell

The expert system shell was developed for young and inexperienced transport engineers and planners, who are involved in transportation demand management (TDM) strategy planning and implementation. Such system is able to provide them with reliable advices in order to effectively decide TDM strategies during the planning and implementation phases. The object browser window in Figure-3 represents the top-level hierarchical in the object model developed for the expert system domain. The class of expert system represents the overall prototype that is comprised of nine major subclasses.

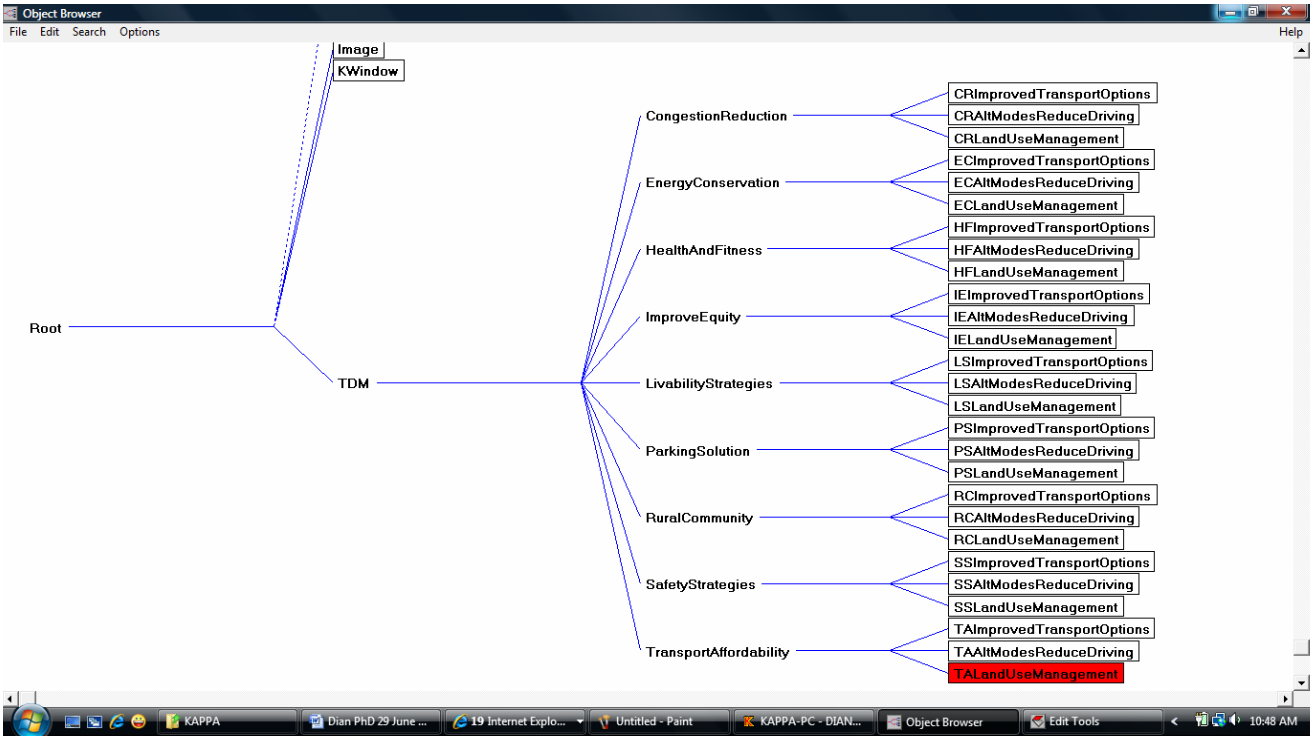


**Figure-3.** Top-level object hierarchy of the E-ASSIST.

The module names in Figure-3 are boxed to indicate that their subclasses are not shown. Example of object hierarchy of subclasses, which are components of different types of major categories of TDM; *improved transport options*, *incentives to use alternative modes* and *reduce driving, and land use management* as shown in Figure-4 for *improved transport options*. Total are 27 hierarchies in subclasses according the main objective of TDM Strategies.

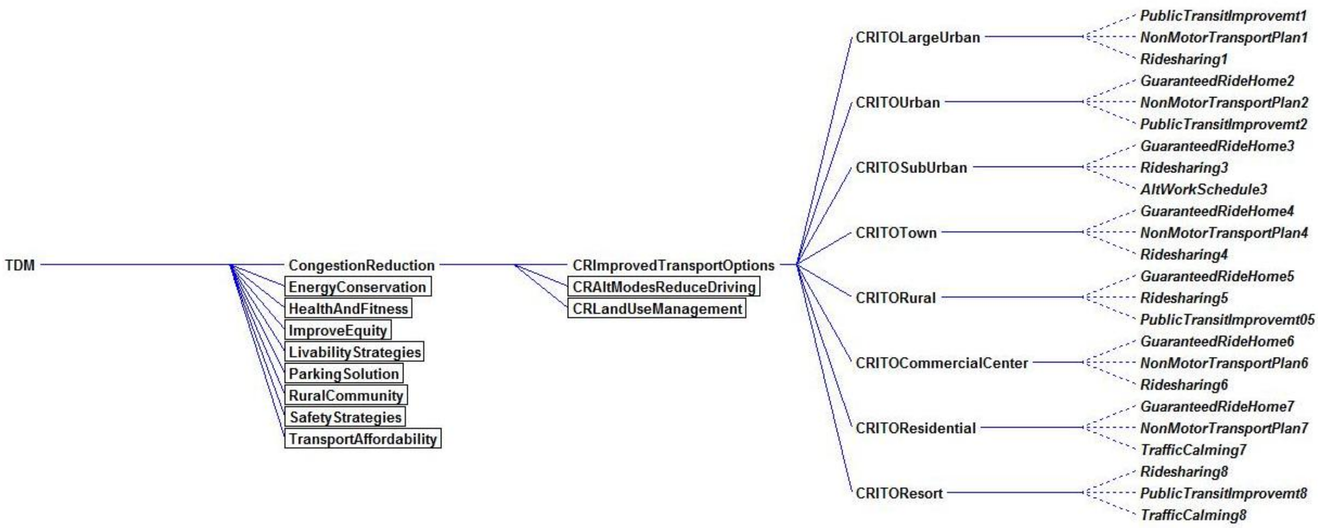


**Figure-4.** Example of hhierarchical architecture of improved transport options for congestion reduction.

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**Object oriented approach of expert system domain**

As an illustration of typical object representation in the expert system domain, the hierarchy of CRimprovedtransportoption class which is a descendant of the Congestion Reduction class is shown in Figure-5.

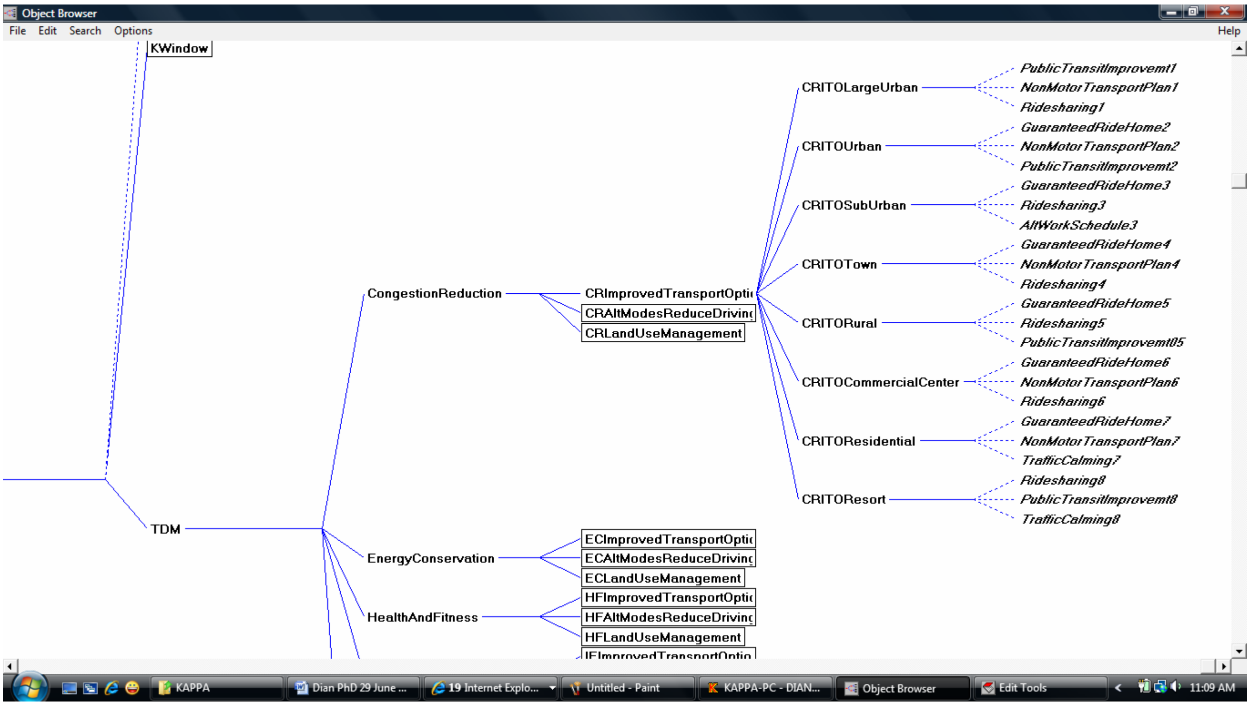

**Figure-5.** Object hierarchy of *CRimprovedtransportoption* class.

*CRITOLarge Urban* class as shown in Figure-5 above is geographical area entity that represents appropriate condition of area need to be implementing TDM strategies. It contains the slots: (i) *PublicTransportImprovement*1, which indicates the strategy on Public Transit (also called Mass-Transit) includes various services using shared vehicles to provide mobility to the public; (ii) *NonMotorTransportPlan1*, which indicates Non-motorized Transportation (also known as *Active Transportation and Human Powered Transportation*) includes walking and bicycling, and variants such as Small-Wheeled Transport (skates, skateboards, push scooters and hand carts) and Wheelchair travel; (iii) *Ridesharing1*, which refers to carpooling and vanpooling (the term is sometimes also applied to public transit, particularly commuter express bus), in which vehicles carry additional passengers. Carpooling uses participants' own automobiles. Vanpooling usually uses rented vans (often supplied by employers, non-profit organizations or government agencies). Most vanpools are self-supporting - operating costs are divided among members. Vanpooling is particularly suitable for longer commutes.

These slots are inherited from the parent class *CRimprovedtransportoption* which is a descendant of the *Congestion Reduction* class.

**Knowledge based model of espert system shell**

The expert system knowledge base is made up of nine class module as mentioned in previous section, each deal with specific strategy of TDM domain.

First, launch the expert system (called as E-ASSIST) by opening the Kappa-PC software and open the E-ASSIST file (.kal) continued by open the *session* to start the expert advisory system. After the program is loaded, the general information interface appears (Figure-6) in the center of the displaying area if the computer has resolution of 1366x768 pixel (32 bits).

**Figure-6.** General information interface.

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By clicking on the *OK* button closes the general information interface and invokes the main E-ASSIST window, as shown in Figure-7. Two way communications between user and E-ASSIST has been started in this interface.

Figure-7 shows the E-ASSIST main menu from which the advisory system for TDM can be accessed with the help of appropriate button. The main menu screen also has *e-library* and *ABOUT* button to give information about all TDM strategies used in this system and the system information in E-ASSIST.

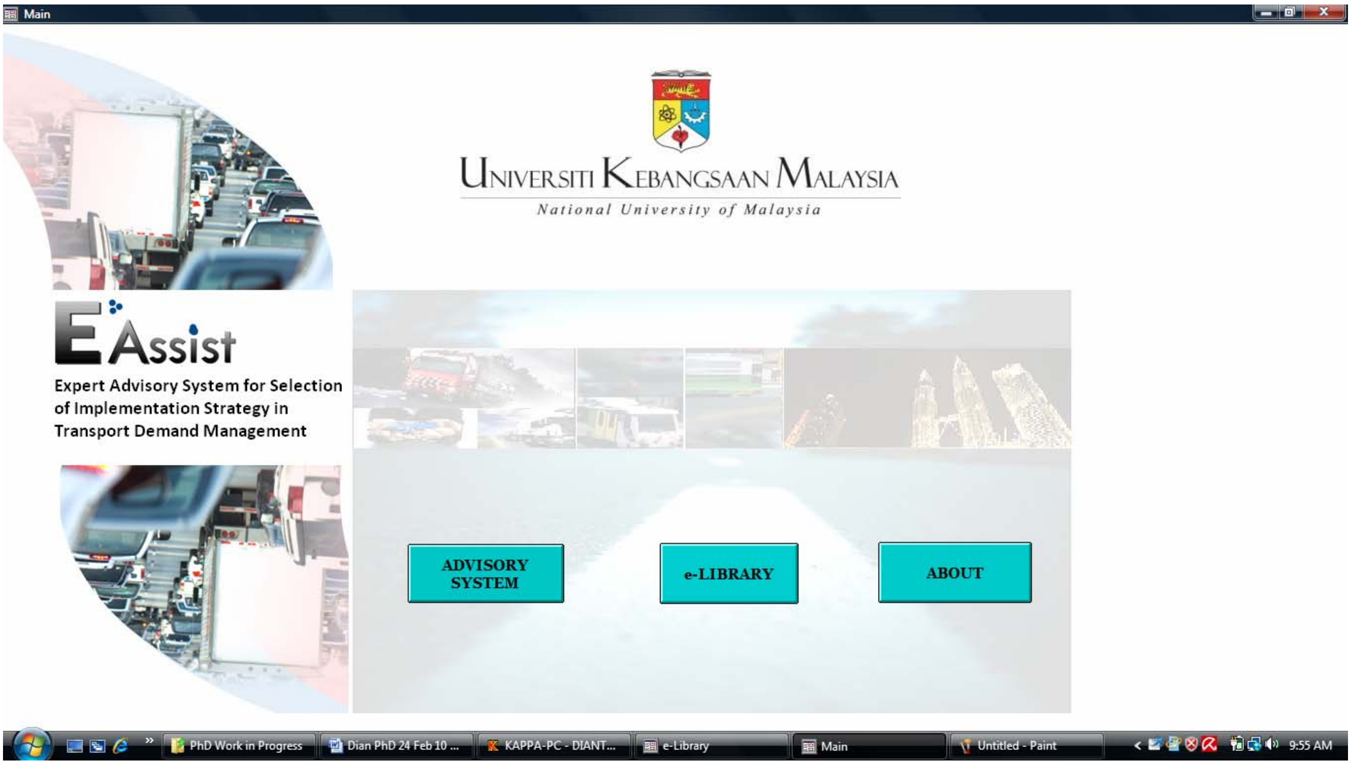


**Figure-7.** Main interface.

**Expert system shell module**

Since the E-ASSIST system used in this project based on the 'objective to implement of TDM' as the input, clicking the on the Advisory System button leads the user to nine main objective of implementing TDM, as shown in Figure-8. There are nine main objectives associated in this interface as inputs define. Select the one that matches the problem the user encountered in current situation in order to see the full description about the objective, in this case Energy Conservation and Emission Reduction has been chosen for system exploration purpose.

Example of this situation is when the new transport planner facing with the "pollution problem" in one area triggered by heavy vehicle such as trucks. To solve this issue, the user needs to select *Energy Conservation and Emission Reduction* as the input in line with the objective of this strategy to reducing vehicle energy consumption and pollution emission. After the selection, the description of this TDM strategy is appeared on the specific box allocated. If user sure and confirmed with the input (correct main objective) then clicking on the *NEXT* button calls up the viewing window that displays the S*pecific Aim to Achieve the Main Objective* interface, as shows in Figure-9.

If the user cannot confirm the description is his/her objective to implement TDM then it is necessary to click BACK button, click on the other main objective as the input, read the TDM main objective description, and do the same step as before, until the actual main objective is found and confirmed. Once interface of *Specific Aim* appeared, clicking on the *bullet* button to see the specific aim description to implement the TDM on how to achieve the main objective as shown in previous step. This dialog window is designed to ensure the user choose appropriate input to avoid wrong advise in appropriate strategy.

In this case, user choose *Incentives to use Alternative Modes and Reducing Driving* as the *Specific Aim* to achieve main objective which is describe on the box it can give commuter's resources and incentives to reduce their automobile trips by providing more efficient alternative modes of travel. Again, if user sure and confirmed with the selection, then clicking on the *NEXT* button calls up the viewing window that displays the *GEOGRAPHICAL AREA* interface as shown in Figure-10.

After selection of specific objective, the size of study area or area that want to be implement are listed on the left of interface window.

The geographical area is become important in this step since all TDM strategies in particularly only can be

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effective in certain area in term of size and population. If the user cannot expect the size of their study area or not sure about the geographical condition in particular area, then they can refer to the description box provided. If the size is identified and selected; for example TOWN, then by click NEXT button cause calls up the viewing window that displays the *ADVISE ON TDM STRATEGIES* as shown in Figure-11.

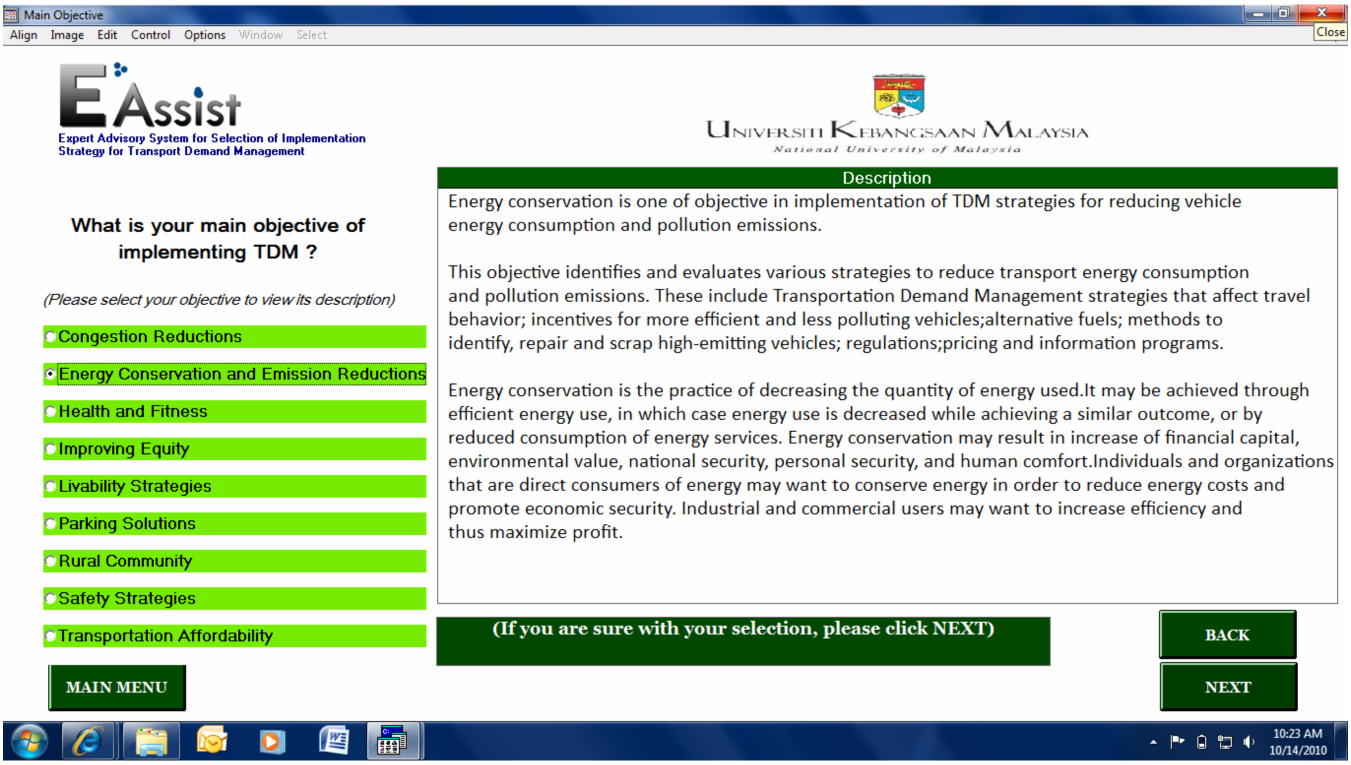


**Figure-8.** TDM main objective interface.

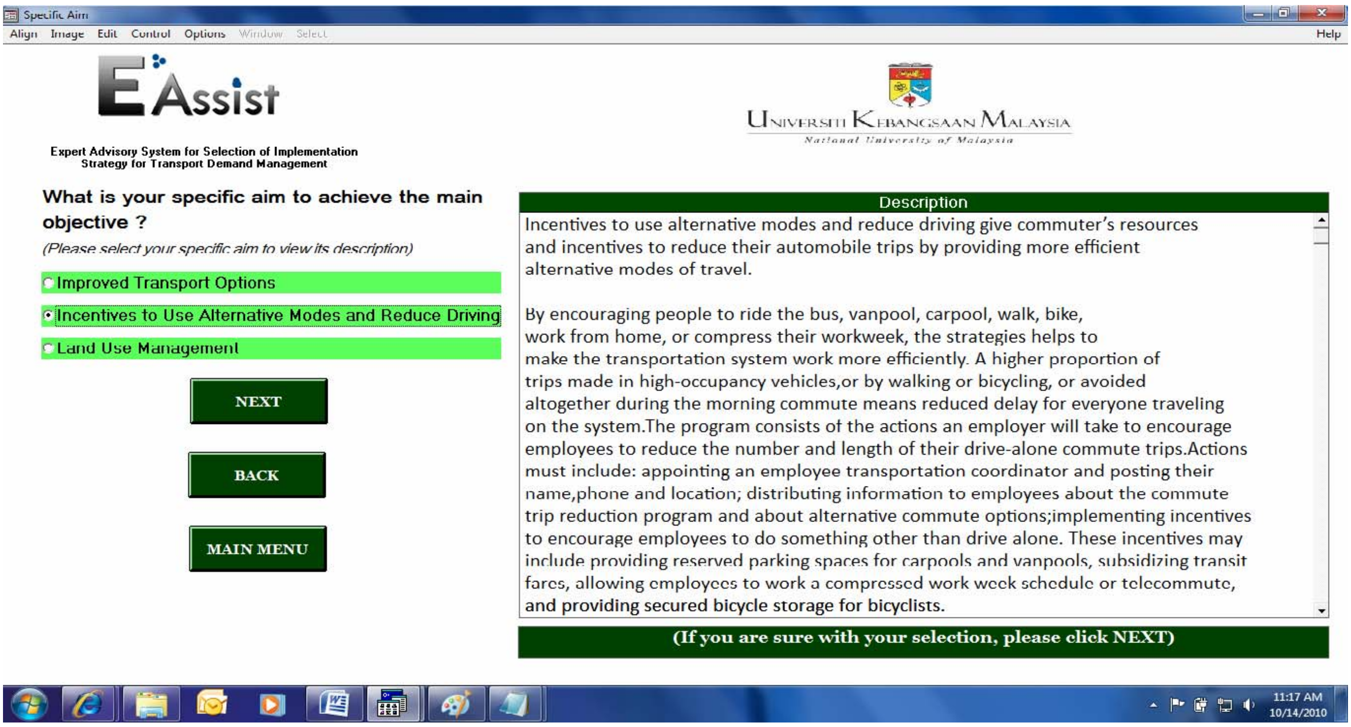


**Figure-9.** TDM specific aim interface.

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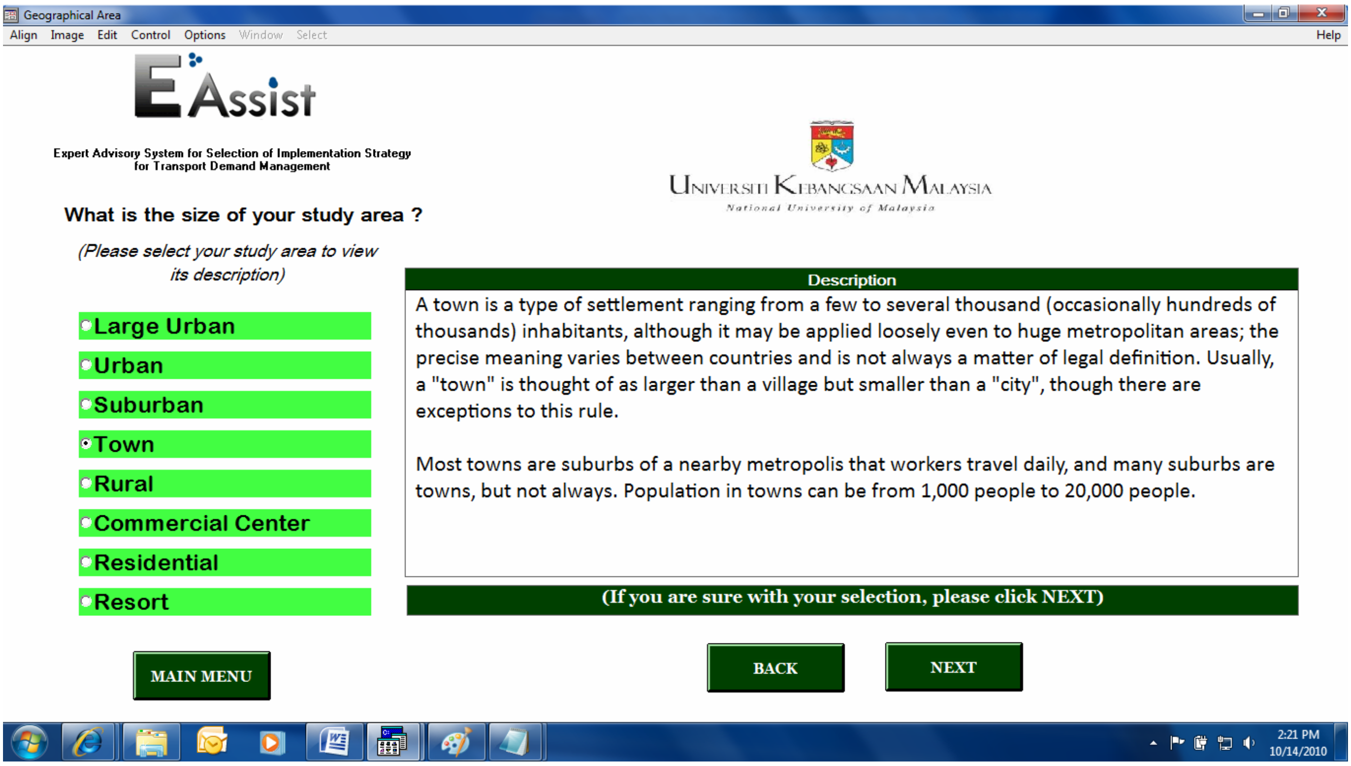


**Figure-10.** Geographical area interface.

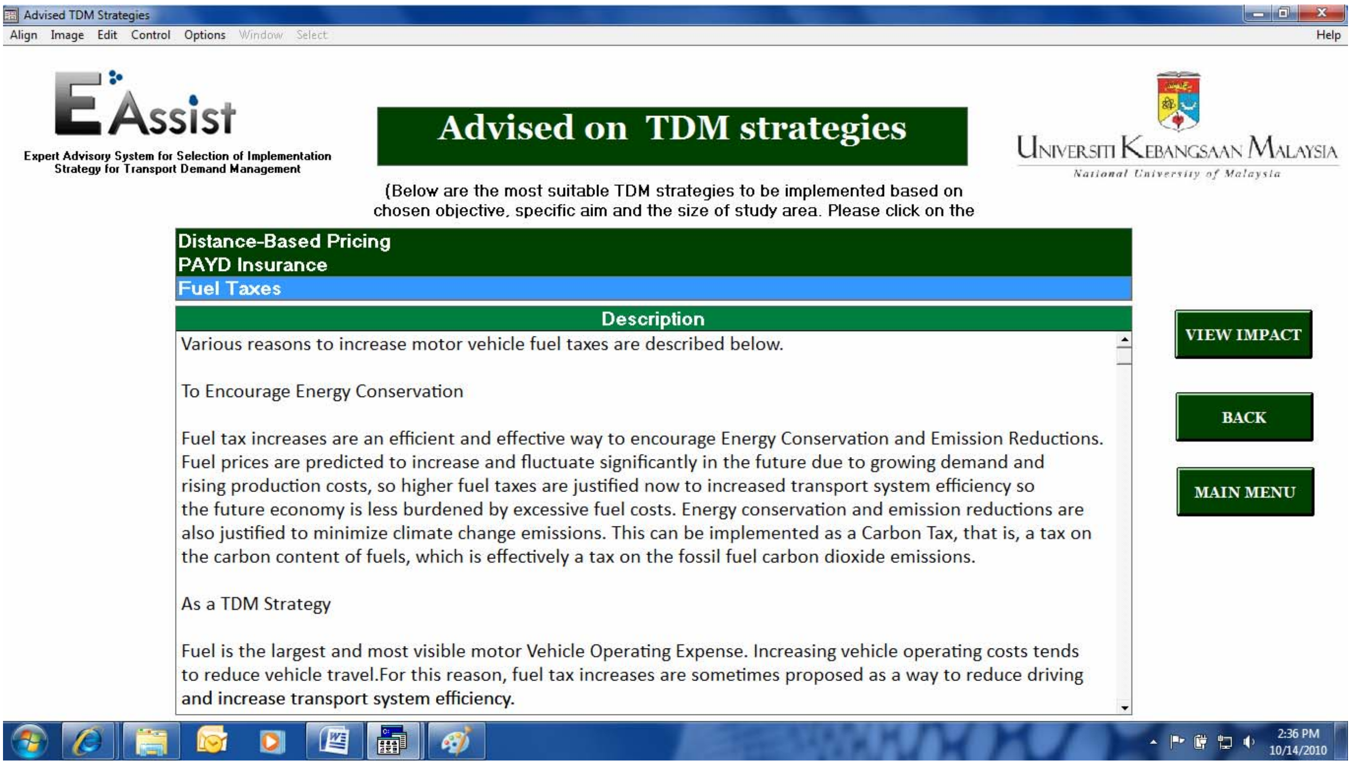


**Figure-11.** Advised TDM strategies result interface.

Figure-11 shows the advice strategy window. It is display three appropriate strategies which is the most suitable TDM strategies to be implemented based on the input selection. The advice system considers three strategies for user to judging and makes decision of suitable TDM strategy.

Description for all three strategies also provided in box dialog to help and guide the user. The user also can click the *VIEW IMPACT* button and *ADVISE STRATEGY*

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*IMPACT SUMMARY* will display on the interface as shown in Figure-12.

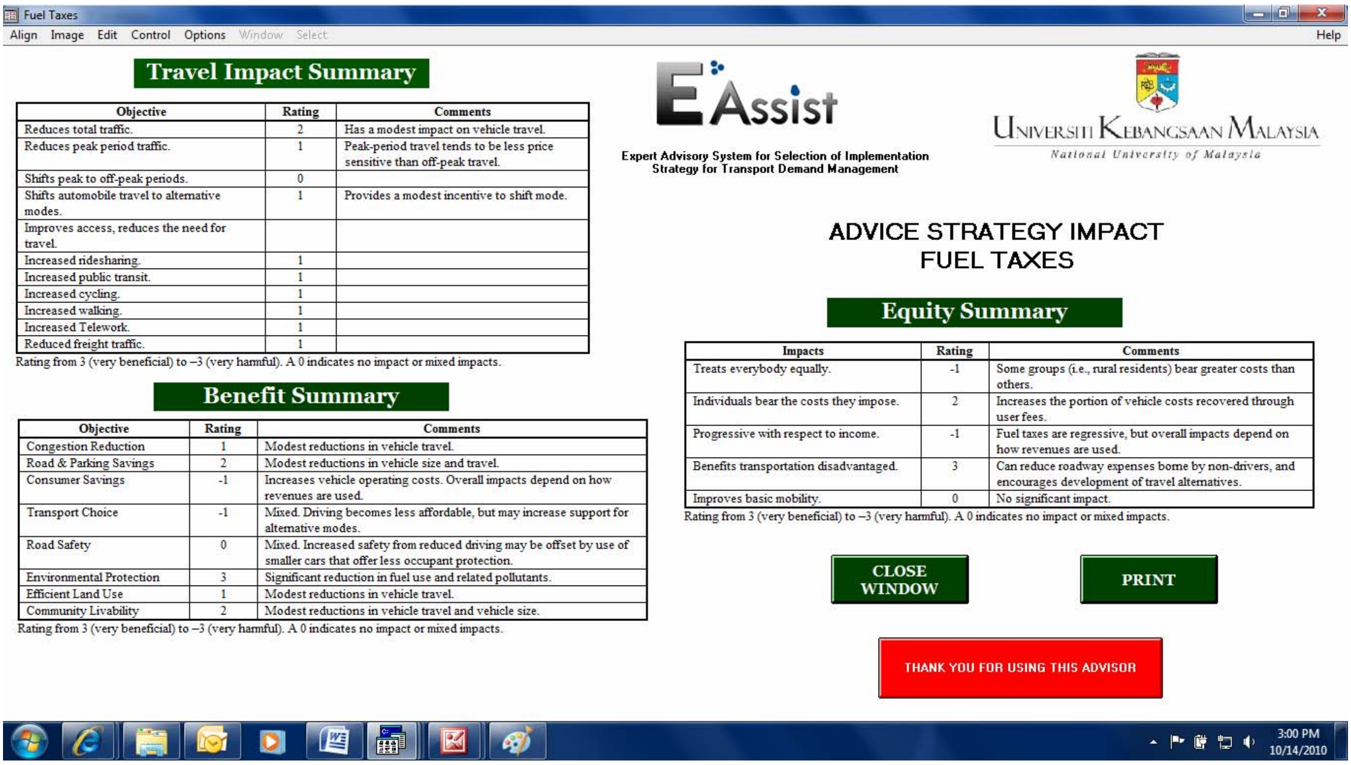


**Figure-12.** Impact summary interfaces.

Figure-12 above shows the advice strategy for "fuel tax" as an example. Result shows that travel impact in term of reducing total traffic significantly as rating "2" was shown (beneficial). On benefit summary, environmental protecting given rating"3" which is significant reduce in fuel use and related pollutants. Advice strategy summary shows the travel impact, benefit and equity if the strategy chosen will be implemented. Based on the travel impact summary, user can easily to identified how effective reduction of trip or total traffic which is stated in the summary using the rating scale; rating from 3 (very beneficial) to -3 (very harmful); 0 indicates no impact or mixed impact on the objective if user implement this strategy. In this case, from the beginning user has been identified the objective was *Energy Efficiency* with specific aim is *Incentives to use Alternative Modes and Reducing Driving*; implementing in *TOWN*. As result mentioned, three advises were given according to the input selected such as *DISTANCE BASED-PRICING, PAYD INSURANCE and FUEL TAX*

If the user can confirm this strategy is the most suitable strategy then it is necessary to clicking *PRINT* button to viewing window spawns a Notepad text editor with analysis result (rating scale). Once finishing the use of E-ASSIST, user can click on the *CLOSE WINDOW* button on the right bottom interface to end the system.

### Validation and evaluation

The prototype testing or validation is the process of evaluating the performance and utility of the program and revising it as necessary. Testing the prototype also involves looking at the ease of handling the user interface and understanding the explanatory text [15]. Generally, the performances of the E-ASSIST were comprehensive and satisfactory to the author's judgment and evaluator who is expert in transportation field. The evaluators are different people (not domain expert) who have same qualification with the domain expert. In this research, evaluation has been verified by Richard Freeman, Senior Lecturer from University of East London, Mr. Badrul Amin, Senior Transport Engineer from Seberang Perai City Council, Penang, Malaysia and Ir. Dr. Olly Norojono, Transport and Infrastructure Specialist from Asian Development Bank, Manila, Philippine.

The evaluation results demonstrated that the expert decision compared well with the E-ASSIST output. This is a positive indication of the accuracy of the knowledge base of the E-ASSIST. The user friendliness of E-ASSIST was the assessed to be satisfactory as a working prototype.

## 5. CONCLUSIONS

The expert system shell developed is user friendly, and it does not require the user to have any programming knowledge to use it. The user can smoothly navigate through nine different input screens before the system outputs its conclusion. Without referring to any TDM expert, the system can help young and inexperienced engineers and planners in their decision making. In addition, such systems are less costly to use and saves time.

Moreover, the successful development of an expert advisory system for implementations of TDM (E-ASSIST) demonstrates that the application of expert system as decision support using object oriented approach in this domain is promising. Frame-based knowledge representation method in conjunction with the power of object-oriented programming enables the knowledge to be abstracted and represented for the computer to manipulate efficiently and for the knowledge engineer to update the knowledge base with great flexibility. Since the knowledge in this domain is dynamically growing, the E-ASSIST is by no means complete at this stage.

## ACKNOWLEDGMENTS

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