AN INITIAL STUDY FOR A PROPOSAL FOR HANDLING TRAFFIC FLOW IN IFRANE DURING TOURIST SEASON

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Capstone Final Report

Approved by the Supervisor

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Abstract

This capstone project is an initiation to a bigger project that Dr Sheikh is supervising. The goal is to achieve a comprehensive study of the seasonal traffic congestion in Ifrane, and to find an adequate and a feasible solution to this problem. This capstone project can be considered as a guideline to future projects, and specifically to the next step which is the analysis of the seasonal traffic congestion. My contribution will be to gather all necessary tools such as traffic data collection methods, and background regarding the parameter of traffic flow in order to perform an analysis about the congested traffic. In addition, a first contact with the authorities will be made in order to understand their perspective regarding the problem. The result of the capstone project is the capstone report itself since the desired outcome from this initial step is providing guidelines. Recommendations are embedded in every chapter of this capstone report, since all the chapters of this report will be related to the context of Ifrane, especially in the components of possible solutions and the localization of the congestion source. Finally, the background established in the first four chapters will serve as templates for identifying components of possible solutions on which subsequent projects can build on.
Introduction

The main objective of this capstone is to accomplish an initial study for proposal of a feasible solution regarding traffic flow in Ifrane during the peak of the touristic season. Aiming for presenting this proposal to the local authorities we keep in mind that the solution should be flexible since the traffic flow is congested in touristic seasons only. Flexible in this context means that the solution can be of use in other situations when the traffic is not blocked.

In order to successfully design a proposal for a feasible solution planning must be defined and put in the context of Ifrane. In addition, the limitations found in the investigation might be the subject of projects to come. The importance of the literature review resides in identifying the major component of our study, and establishing a solid background since the field of transportation engineering is new to me.

A project of this nature has many dimensions: economic, engineering, social, ethical, political. Given this wide scope, it is important to state that this project is an initiation of a realizable plan which might need few semesters, and a combination of many fields. A successful initiation of this project will be measured by how accurate our guidelines would be, and to what degree future projects can rely on this work.

Ifrane is a small touristic town, the authorities strive to sustain the neat and eco-friendly aspect of the city, especially since it has been rated one of the cleanest cities in the world. Traffic congestion is major problem that paralyses the tourism in the city, which is the main activity in Ifrane. Hence, traffic jam has many negative repercussions, and a solution to this problem is mandatory.
Methodology

The methodology hinges on three main steps: first, establishing a solid background; second, identifying the problem; third, indicating the components of possible solutions. Establishing a solid background requires literature review and related sources to transportation and traffic engineering. The first step in establishing the background will be defining planning and its requirements, and providing a guideline of planning process. The second step in establishing the background would be identifying traffic stream parameters on which the data collection methods will be based on. Explaining the relationship between the parameters of traffic stream will facilitate collecting the data. All the data collection methods will be manual techniques that hinge on the manipulation of traffic stream parameters. An adaptation of data collection methods to the context of Ifrane will be provided. Identifying the source of congestion, and clarifying the authorities’ perspective will guide us to form the components of possible solutions. The source of traffic congestion is composed of three road intersections, thus underlying the conflicts in each road intersections will guide the analysis to find the conflicts that are directly responsible for traffic congestion.
1. Planning

Planning is the procedure of determining what needs to be done and how it needs to be done. Occurring at different levels, planning can be made by simple individuals or families as it can be made by businesses and higher government officials that have greater impact on society. Planning places is modifying them to a large or a reduced extent based on the ideas that dictates what the place should serve or become.

1.1 Planning requirements

Effective planning embeds the values, needs and preferences of those whom the plan serves in the planning decisions. In addition to that, effective planning should be a chance for community development and building, in the case of seasonal traffic congestion in Ifrane planning procedure should establish trust between officials and residents by creating a framework for solving on going resident’s worries. A complete community transportation planning procedure should include moderate land use strategies, traffic safety policies, pedestrian management facilities and roadway projects which deal with traffic problems along with enhancing the community [1].

Effective planning will always favor the solutions that resolve the main problem along with other problems that might arise in the future. Hence, any plan of solving seasonal traffic congestion should consider other problems such as the transit of non-drivers, parking crowding, and pollution. The result of a plan is highly controlled by the involvement, communication and interaction of the stakeholders given the fact that stakeholders have different perspectives regarding the same planning process.
List of stakeholders:

- Users
- Taxpayers
- Businesses
- Authorities / public officials
- Affected interest group (in our case tourists).

Planners should have a long-term, global and strategic image of the desired outcomes. Many towns plan for expected increase in traffic by road enlargement – such one-dimensional approach is not in line with the most comprehensive definition of planning. It is true that it’s hard to deal with uncertainty and change in the factors that affect the traffic growth, for instance tourist preferences, demographic and economic changes, or differences in trip generation growth rates. However, there are some tools to hedge against this uncertainty namely, using probabilities and ranges in describing forecasts. Moreover, planning process can include contingencies that respond to specific circumstances, and would be implemented only if the demand meets a certain level that would threaten the safety of the stakeholders.

1.2 Tourism traffic planning

Our aim for this project is to propose a solution that would make the experience of tourism in Ifrane more enjoyable for tourists and profitable for businesses. Identification of the main attraction for the tourists in our context will lead us to a better understanding of the traffic congestion and will facilitate forecasts regarding the location of tourists.

Tourist attraction planning is directly related to tourism traffic planning, in other words comprehending the tourism destination expansion will allow an adequate guiding of the flow of tourists in all the city of Ifrane. One way to do so is to disperse the attractions along the
transportation network or building new connection in the traffic network so as to get a circular network that reaches all the desired sites. The main purpose of such strategy is to release the pressure on the main touristic sites and dissolve traffic congestion [2].

Tourism planning can reduce the pressure on the main touristic sites by developing it in the indirect support area; this strategy is called dispersal by Bosselman, Peterson and McCarthy. According to these researchers the dispersal strategy is better used when the secondary sites share the same characteristics as the main site.[3] In our case tourists are attracted by the landscape in Ifrane: what makes the difference between the primary tourist site and secondary tourist site is accessibility or the awareness of the tourists of its existence. However, the authors pointed out the high financial risk of this strategy because it does not ensure stable revenue for the townships.

1.3 Accessibility concept

Accessibility can be defined as the capacity to reach targeted goods, activities, destination and a service. Those accessibility components are called opportunities, in the context of this project the main opportunity is destination. There are four main factors that affect accessibility:

1. **Mobility, availability, speed and quality of travel.** It takes into consideration many means: automobiles, cycling, walking, taxi, public transportation etc.

2. **Connectivity of transportation system:** it denotes the density of connection in a network and its directness (simplicity).

3. **Land use:** stands for the geographic distribution of actions and endpoints.
4. **Mobility alternatives:** for instance delivery service and telecommunication that will provide access to information.[4]

Traditional traffic planning tends to consider only mobility, especially vehicle mobility ignoring other aspects of accessibility. For instance if we consider only mobility in our project that will lead us to think of a road expansion in order to improve automobile accessibility. However, the fact that the solution to traffic congestion ignored the negative impact on nonmotorized accessibility it will reduce transit accessibility as a whole given the fact that Ifrane is a touristic town where walking is highly contributing to the mobility of tourists.

An effective planning to the problem should be multi-modal, in other words it should have a balanced transport system that allows the consumers to choose from various options (ridesharing, public transportation, cycling, walking, etc.), and guidelines to use them for what it is best suited for. Thus, transportation objectives should be defined in terms of accessibility within the optimal magnitude of change [4].

### 1.4 Guideline of planning process

1. Establish the development framework: scope, schedule, identification of stakeholders.
2. Share ideas with the stakeholders, and create a problem statement.
3. Develop a shortlist of possible solutions.
4. Prioritize and assess the solutions from best to poorest.
5. Identify constraints and opportunities, and evaluation standards of each solution.
6. Collect baseline data.
7. Elaborate a plan that answers who does what, when and how. The plan has high chances of including contingency options regulated by future conditions.
8. Perform policies and programs.
9. Evaluate the program.

10. Review master plan and add any necessary modifications from the evaluation.

2. Traffic stream parameters

Like any other type of flow, traffic flow has many parameters that are related to it. The aim of providing traffic flow parameters is to allow those who will do the analysis to understand driver and vehicle behavior in addition to identifying variations in the traffic flow. Since the traffic stream is an arrangement of vehicle and driver behavior it is considered as a non-uniform stream. The main factors that contribute to the non-uniformity of traffic stream are the human behavior, and the interactions of all the stream parameters with each other. [5] It is safe to assume that these parameters are predictable within a range that is set by traffic regulators, for instance speed limit regulations.

Parameters of traffic stream can be classified as macroscopic that describes the traffic as a whole including quantitative parameters (density, flow) and qualitative parameters (speed) or microscopic that describes the conduct of a vehicle and its impact on the stream. [5]

2.1 Macroscopic parameters

2.1.1 Speed

Speed is defined as the distance per unit of time; speed \( v \) is given by the equation:

\[
v = \frac{d}{t} \text{ unit : m/s} \tag{1}
\]

There are many variations of the speed that are known as running speed, time mean speed, spot speed and journey speed.
1. **Spot speed**: is the immediate speed of a vehicle at a defined spot, it is used in road maintenance, congestion measuring and accident analysis. Spot speed is generally measured by an enoscope, radar and timing procedures.

2. **Running speed**: the average speed that a vehicle maintained over a section, which means we divide the distance over the duration of the vehicle’s motion, delays are omitted in calculating the running speed.

3. **Journey speed**: it is the effective velocity of a vehicle between two points; this measurement includes any stoppage time. When the journey speed is less than the running speed it shows non-uniformity in the stream.

4. **Time and space mean speed**: time mean speed is the average of the velocities of all the vehicles that are passing at a defined point over a given time interval. While the space mean speed is the average velocities of all the vehicles that are occupying a defined section.

### 2.1.2 Flow

Flow is the number of vehicles that pass a defined spot within a time interval, the flow \( q \) is given by the equation: "\( nt \)" is number of vehicles passing the study spot, and \( t \) is time interval

\[
q = \frac{nt}{t} \text{ unit: vehicles/hour} \tag{2}
\]

Since the traffic congestion in Ifrane happens only in touristic season and it is specific to time intervals when the tourists leave the town or enter it, then the most significant variations of the flow will occur from hour to hour. We might draw some conclusions regarding driver’s behavior if hour to hour patterns are compared over the touristic season.

### 2.1.3 Density

Density is the number of vehicles filling a given distance. The formula of the density \( k \) is:

where \( nx \) is the number of vehicles and \( x \) is the distance.
Density measures the closeness of vehicles which is directly linked to traffic demand, and it is also a parameter of safety since it tightens the driving maneuvers.

\[ k = \frac{nx}{x} \quad \text{unit: vehicle/km.} \quad (3) \]

2.2 Microscopic parameters

2.2.1 Time headway

Time headway is the time difference between two consecutive vehicles; time is measured between the rear bumper of the leading vehicle to the rear bumper of the next vehicle. Adding all the headways \( h_i \) will form the time \( t \) required to move along the section in question.

\[ \sum_{1}^{nx} h_i = t \]

Recalling the equation of flow \( (q) \), and substituting the time \( (t) \) with the sum of time headways we get:

\[ q = \frac{nx}{t} = \left( \frac{n_t}{\sum_{1}^{nx} h_i} \right) = \frac{1}{h_{avg}} \quad (4) \]

Average time headway is denoted by \( h_{avg} \). Then, the flow is the inverse of \( h_{avg} \).
2.2.2 Distance headway

Distance headway is the distance between two consecutive vehicles; generally it is measured between the rear bumper of the leading vehicle to the rear bumper of the next vehicle. Adding all the space headways $s_i$ will form the distance $x$ of the section in study. Hence:

$$\sum_{i=1}^{n} s_i = x$$

Recalling the equation of density ($k$), and substituting the distance ($x$) with the sum of space headways we get:

$$k = \frac{n_x}{x} = \left(\frac{n_x}{\sum_{i=1}^{n} s_i}\right) = \frac{1}{S_{avg}} \cdot (5)$$

$S_{avg}$ stands for the average distance headway. Then the density is the inverse of $S_{avg}$.

2.3 Time-space diagram

The importance of time-space diagram lies in its ability to plot the trajectory of vehicles. It facilitates retrieval of traffic stream parameters, and it provides a comprehensive summary of the vehicle’s motion in a plan $(x,t)$.

2.3.1 Single vehicle analysis

![Different cases of time-space diagram for a single vehicle.][5]
The trajectory is the graphical representation of the distance $x$ as a function of time $t$, $x(t)$, in representation (a) the trajectory shows that the vehicle moves with a constant slope since the distance ($x$) is increasing with time ($t$). In representation (b) we can see that at first the vehicle moves with a constant velocity, and it reversed its direction after reaching a point. In representation (c) we can denote that the vehicle has maintained the same position in a time interval, which will mostly be the case in all the vehicles during traffic congestion.

**2.3.2 Multiple vehicles**

From the space diagram above we can retrieve the fundamental stream parameters such as density and flow, it can provide the microscopic parameters such as spacing and time headway. Since the density is the number of vehicles in a distance then according to the space-diagram above we get the density ($k$) to be:

$$k = \frac{4 \text{ vehicles}}{x_2 - x_1}$$

Recalling the definition of the flow as being the number of vehicles calculated in a time interval then according to the space-diagram above we get the flow ($q$) to be:
The vertical separation between two trajectories is corresponding to the spacing since by definition space headway (spacing) is the difference of distance between two consecutive vehicles. The horizontal gap between two trajectories represents the time headway, by definition time headway is the difference of time between two consecutive vehicles crossing the study spot.

2.4 Fundamental relation of traffic flow

In this part we will discuss time mean speed, space mean speed and how to retrieve fundamental parameters discussed earlier.

2.4.1 Time mean speed

Time mean speed is the sum of all velocities of the vehicles over the number of the vehicles. The formula of time mean speed \( v_t \) is:

\[
v_t = \frac{1}{n} \sum_{i=1}^{n} v_i \quad (6)
\]

\( v_i \) is the speed of the each vehicle in study.

2.4.2 Space mean speed

Space mean speed is the average of the vehicles velocities with respect to space and not time, it is derived from the average travel time \( t_s = \frac{1}{n} \sum_{i=1}^{n} 1/v_i \), since \( v_s \) the space mean speed is \( 1/t_s \) :

\[
v_s = \frac{n}{\left( \sum_{i=1}^{n} \frac{1}{v_i} \right)} \quad (7)
\]
2.4.3 Fundamental relations between traffic flow parameters

The standard deviation of the velocities over the space mean speed plus space mean speed equals time mean speed.

\[ v_t = v_s + \frac{\sigma^2}{v_s} \] (8)

Since the standard deviation of the spot speed can never be negative then time mean speed will always be greater that space mean speed. In the case of traffic congestion the vehicles will have the same spot speed then the time mean speed will be equal to space mean speed.

In a congested traffic flow we will assume that all the vehicles are going at relatively same low speed then the relation between flow \( q \) and the density \( k \) is:

The number of vehicles \( n_1 \) counted in one hour is the flow \( q \):

\[ n_1 = q. \]

Likewise \( n_2 \) is the number of vehicles on a distance.

\[ n_2 = k \times x. \]

⇒ Since all the vehicles in a congested traffic flow will have the same speed then the number of vehicles in an identified distance, and the number of vehicles counted in one hour will be equal hence: \( n_2 = n_1 \)

\[ q = k \times v_s. \] (9)
To conclude the main parameters of traffic stream are flow, density and speed, spacing and time headway are derivatives of the main parameters. This chapter shows how we can extract microscopic parameters from macroscopic parameters, in addition to the use of time-space diagram.

### 3 Data collection

The first part of this chapter will cover features of data collection, mainly, survey design, data analysis and household data. The second part of this chapter will cover traffic data collection methods.

#### 3.1 Data collection features

**3.1.1 Survey design**

The purpose of a survey is to gather data and the aim of this section is to narrow the scope of data collection to the rudimentary requirements from any data collection survey. The intention of the surveys should be directed towards determine the study area, isolating the area into zones, and transport network features.

**Information needed**

The four categories of information needed from data collection are:

1. **Socio-economic data**: important information of socio-economic data are vehicle property, family size, and income.
2. **Travel surveys**: cost of travel, direction of the trip, next destination, and the origin of travel
3. **Land use inventory**: it is generally comprises data on the housing concentration at some specific zones where there is enough trip generation; however, we will adapt the survey to the land use in touristic sites.
4. **Network data:** it includes information about traffic signage, junctions, and road network in general, but we will concentrate on the roads that are subject to traffic congestion. This type of data is useful in traffic assignment models. [6]

**Zoning**

Once the area understudy is determined, it should be divided into small traffic analysis zones with the purpose of easing the spatial analysis of land use and contributing economic factors. In addition to that this division into zones will help in geographically connecting the propagation of the traffic congestion to the touristic sites.

- Zones should have homogenous land use.
- Physical and natural barriers form suitable zone borders such as rives and canals.

**Transport Network**

Transport network is generally composed of junctions, roads, bus stops railways etc… railways and bus stops will be omitted in our case, then the surveys will focus on the road network and the junctions.

Surveys about road network should identify the values of following attributes for each road in the network:

- Starting node/ ending node.
- Road length.
- Authorized speed.
- Capacity.
- Number of lanes / road width.
Surveys about junctions should identify the values of following attributes for each junction in the network:

- Node number.
- Type of intersection (round, uncontrolled or signalized)
- Number of roads joined by the junction

### 3.2.2 Questionnaire design

The design of questionnaire is more of the art of extracting data from the subjects; however, it should respect the guideline below:

*Tourist characteristics:* relevant questions are: where they live, what is their main attraction in Ifrane, do they feel like traffic congestion in Ifrane is a problem, how long are they staying in Ifrane etc.

*Personal characteristics:* This part is not as relevant as the other parts, but it will provide us information about the type of tourists that are interested in Ifrane. Relevant questions to this topic: age and gender, profession, possession of driving license.

*Trip data:* it aims at characterizing trips made by tourists, surveys should include these variables: destination, origin, purpose, start and ending times, walking distance, and the used mode of transportation.

### 3.2 Data collection methods

The study of traffic parameters cannot be performed in a laboratory. Although, we can estimate some parameters like density by taking the density as being the maximum capacity of a given road which is highly probable in traffic congestion, but it is difficult to simulate
drivers’ behavior. The most important parameters to be extracted from the study field are density, flow, speed and travel time, while microscopic parameters can be derived.

3.2.1 Measurements at a point
Measurement at a point is very useful in counting vehicle volume. Since data will be collected manually, the observer will stand at the point of congestion and record the vehicles that are passing. The measurement at a point is done at short time intervals that range from 5 to 15 min.

⇒ Data retrieved from this method is flow data and then time headway can be derived.

3.2.2 Measurements over short section
Measurement over short section recovers the spot speed; it is generally applied in segments of that range from 30-90 meters. This method might not be very useful in traffic congestion since all the vehicles are stationary or going with the same speed. Manual methods used in short section measurements use an enoscope which consists of an open container with a mirror that is attached to a tripod. Placing the enoscope at one end and standing on the other end the observer could measure the time that takes a vehicle to cross the section.

⇒ This method is better suited to measure the speed at which vehicles are passing, so it is better used at the exit of the town.
3.2.3 Moving observer method

Since the relation between parameters of traffic flow is \( q = k \times v_s \), knowing two parameters is enough to calculate the third one. The moving observer method stands as the most used method since it provides the space mean speed \( v_s \) and the flow \( q \).

In a stream of vehicles there are two cases of vehicles’ motion with respect to the observer. In the first case the observer is stationary and the stream is moving, in the second case the observer moves and the stream is stationary, and in the third case the observer is moving within the stream either with it or against it.

**Case 1: observer is stationary.**

If we take \( n_0 \) to be the number of vehicles passing the observer in time \( t \), then:

\[
no = q \times t \quad (10).
\]

**Case 2: observer is moving.**

Taking \( n_p \) to be the number of vehicles that the observer has passed over a distance \( l \), then:

\[
\text{Figure 4: Sketch of enoscope method. [7]}
\]
Substituting \( l \) with \( v_0 \cdot t \). where \( v_0 \) is the velocity of the observer get:

\[
np = k \cdot v_0 \cdot t.
\]

**Case 3: observer moving within the stream.**

The equations that accounts for the number of vehicles overtaken by the observer \( n_0 \) and the number of vehicles that pass the observer \( n_p \) is:

\[
m = n_0 - n_p.
\]

Since we can get \( v_0 \) and \( t \) from the test, we are left with \( q \) and \( k \) that are unknowns. Taking the test twice with and against traffic stream will generate another equation that will match the number of equations to the number of unknowns.

\[
m_w = q \cdot t_w + k \cdot v_w \cdot t_w \quad (13)
\]

\[
m_a = q \cdot t_a - k \cdot v_a \cdot t_a \quad (14)
\]

Where subscripts (a and w) stands fro against or with traffic stream. The negative sign on the equation (14) is due to the fact that the observer is going against the stream, which implies a negative velocity of the vehicles. Since the fundamental equation of the traffic flow is \( q = k \cdot v_s \) we can derive the parameters from equations (13) and (14).

**Flow:**

\[
q = \frac{m_w + m_a}{t_w + t_a} \quad (15)
\]

**Space mean speed:**
Since our study deals with the traffic congestion, this method is better suited to our case because the vehicles are expected to move at low speed and it will allow the observer to accurately count how many vehicles he passed. The limitation with this strategy is that it requires an observer for each jammed way; in addition to that each observer has to take two samples for each way he watches.

It is better to have in each way two observers, in addition to increasing the accuracy of the collected data and reducing the time of the collection process by half it will allow us to fluently pass the surveys to the subjects under study without disturbing the flow.

**Figure 5: Illustration of the moving observer method.**

\[
v_s = \frac{l}{t_w - \frac{m_w}{q}} \quad (16)
\]

**Density:**

\[
k = \frac{q}{v_s}
\]
4. Identification of traffic congestion in Ifrane

4.1 Location of traffic congestion

The traffic congestion in Ifrane is seasonal and positively related to the number of tourists. The map below shows the road network of Ifrane.

As shown in the map, Ifrane is in the middle of the junction of two main roads namely, RN8 and RR707 where RN stands for national road, and RR stands for regional road. The RN8 leads to Azrou from Fes through Ifrane, and RR 707 leads to Michlifen ski station from Meknes through Ifrane. The source of congestion happens where RR707 joins RN8.

Figure 6: Road network of Ifrane.[11]
4.2 Reasons of traffic congestion

The main cause of the seasonal traffic congestion is that there are no alternatives for vehicles to reach their destination without going through the congestion source. Neither the origin of the trip nor the destination matter, if a vehicle is going through Ifrane it will have to pass through the source of traffic congestion. The second factor that contributes to traffic jam is the location of the bottleneck. The bottleneck is near the downtown, restaurants, banks, and the one of the main touristic attractions which is Parc La Prairie. The third factor is the low parking spots to vehicle ratio. Although, tourists have reached their destination, they keep contributing to traffic jam since there aren’t enough parking spots.

4.3 Authorities perspective regarding traffic congestion

A meeting was held with the head of the local communes Mr Mohammed Garissi. According to him, traffic congestion in Ifrane is an issue that should be dealt with, but allocating an adequate budget requires solid justifications especially if the solution to the problem involves big projects such as building new roads or enlarging existing roads.

From the perspective of the authorities traffic congestion is an issue since it harms the image of Ifrane as a touristic destination, and consequently it reflects a poor administration from the governor. Moreover, the authorities are highly concerned about the safety of the tourists, and the city as a whole. According to Mr Garissi, the two main factors that threaten safety are accidents and wildfires, both of which are affected by traffic jam since it handicaps the authorities’ intervention.

Concerning the possible solution to traffic jam, there has been no involvement from the governorate except mobilizing policemen and traffic regulators. The authorities are not willing to allocate a great budget for traffic congestion; however, they believe that
cooperation of the tourists and signage are key to relieving traffic jam. Furthermore, they believe that any solution should consider vehicle parking and traffic evacuation.
5 Traffic intersections

As we have seen in the previous chapter, the source of traffic congestion is at three intersections. The role of traffic intersections is regulating vehicles pathways. The complexity of traffic intersection increases when vehicles from different lines and pedestrians want to occupy the same space in the same time.

5.1 Conflicts at an intersection

Some of these conflicts might vary depending on the country whether it is left-driving or right driving. Here are six main types of conflicts in an intersection, namely, [8]:

- Pedestrian
- Diverging
- Merging
- Left Turn-Through
- Left Turn
- Through traffic.

5.1.1 Computing conflicts in the first intersection

The first intersection is four-legged type. Diverging traffic generates 3 conflicts, while converging traffic generates 5 conflicts. Through traffic conflicts are 2, left turn traffic conflicts are 3, and left turn through traffic are 4. Pedestrian conflicts are 8. The total number of conflicts in the first intersection is 25.
5.1.2 Computing conflicts in the second intersection

The second intersection is three-legged type. Diverging traffic generates 4 conflicts, while converging traffic generates 2 conflicts. There are no through traffic conflicts, and no left turn traffic conflicts. Left turn through traffic conflicts are 2. Pedestrian conflicts are 6. The total number of conflicts in the first intersection is 14.
5.1.3 Computing conflicts in the third intersection

The third intersection is three-legged type. Diverging traffic generates 3 conflicts, while converging traffic generates 3 conflicts. There are no through traffic conflicts. There is only one left turn conflict, and 2 left turn through traffic conflicts. Pedestrian conflicts are 6. The total number of conflicts in the first intersection is 15.
Figure 11: Conflicts of the third intersection

Figure 12: Position of the third intersection. [11]
6 Components of possible solutions

This chapter deals with the components of possible solutions; at this first stage of the project we cannot design operative solutions to the seasonal congestion of traffic since no analysis has been made. However, it possible to extract a general idea about the possible solutions from the background formed throughout this capstone project. Based on the identification of traffic congestion, and the authorities’ perspective regarding our subject two possible solutions arise namely, enlarging existing parking slots or building new ones, and providing signage.

6.1 Parking spots

The low parking spots to vehicle ratio are of the main reasons that contribute to traffic congestion. In addition to that the authorities are considering parking as a possible solution.

6.1.1 Expanding existing parking spots

Compared to building new parking spots, this solution can be done on a low budget, and in a short period of time. This solution might also include redesigning existing parking in order to maximize the capacity. The components of this solution are as such:

- Identifying existing parking spots
- Classify existing parking spots based on expansion necessity
- Calculating the cost of one m² of expansion
- Estimating the parking index after expansion, and compare it to the actual parking index. The parking index is given by: \( \text{Parking index} = \frac{\text{parking load}}{\text{parking capacity}} \times 100 \) [9].

6.1.2 Building new parking spots

Building new parking spots is very delicate to achieve given the magnitude of required budget, and the difficulty of find an adequate space since Ifrane’s governorate is keen to
preserve its lands. However, this approach stands as a long-term and a valuable asset at the hands of the authorities. Components of this solution are as such:

- Determining the threshold of traffic required in order to build a parking spot
- Localizing potential parking sites
- Calculating the cost of building one m²
- Identifying site constraints namely, site slope, and soil capacity.
- Seek and adhere to municipal ordinances.

Site constraints are directly affecting the creating cost, for instance if the soil has a low bearing index, the cost for soil reinforcement will raise the final cost. Municipal ordinances clarify the legal framework, and standardize the parameters of the project such as, acceptable area for a parking site etc.

6.2 Signage

6.2.1 Advantages, drawbacks, and components

The main objective of signage as a solution to traffic congestion is to alert and guide the users of alternative routes, since most of the tourists are not familiar with Ifrane’s road network. Signage is one of the traffic regulation tools, in this project signage will be mainly used with the intention of facilitating traffic evacuation from Ifrane. According to the head of the communes Mr Garissi, traffic congestion reaches its peak when all the vehicles want to leave the city at the same moment, which is generally at the end of the day. Compared to previous approaches, signage stands as the most economical and feasible approach.

The components of this solution are:

- Identifying alternative routes to the main roads.
- Identifying secondary paths that will lead the vehicles from the source of congestion to the alternative roads.
- Destination panels should be meaningful for tourists unfamiliar with the area.
- Local sites shouldn’t be used as a destination, for instance a panel indicating alternative route to Meknes shouldn’t be mentioning Vitel water source.
- Counting number of intersections without a sign in the alternative roads.

This approach has a draw back since it is hard to compete with drivers’ behaviors in general, especially car-following behavior. Car-following behavior stands against this strategy -- studies have shown that in short times headways between vehicles drivers tend to focus more on the task of following the car in front of them which exacerbates car-following behavior [10].

6.2.2 Possible solution

The authorities are concerned in traffic evacuation, and according to them the peak of traffic congestion occurs at the end of the day. Keeping this in mind, this proposed solution identifies an alternative route that will relieve the stress over the national road RN8. The goal of this solution is to lead the traffic stream to take the alternative route without going through the city of Ifrane. It is true that this solution stands against tourism, since it does not pass through any touristic sites, but the focus is on evacuating traffic rather than having a circular traffic network that goes through all the touristic sites. Traffic signage will play an important role in regulating traffic flow by guiding the stream to the alternative road. In our case guiding panels are mandatory as well as a traffic regulator that should be assigned by the authorities. The figure below shows the alternative route.
The main advantage of choosing the alternative route (P7048, P7225) is its proximity to the congestion source. In addition to that the intersection in question is linking Ifrane’s road network to the alternative road, and thus it can be reached from many places as long as signage is well structured. The figure below shows the main intersection that will play a key role in traffic evacuation.
7. STEEPLE analysis:

**Social factors:** social factors such as population growth or life style change might not be of a huge impact since the traffic flow jam occurs seasonally; however, the rise in the urban traffic and the urban development in major cities is directly affecting our study.

**Technical factors:** all the technical factors will help us improve the implementation of the solution for instance the use of new methods in data collection such as the use of pressure contact tubes, inductive loop detector that involves the principles of magnetic inductance. These technologies come in convenient to our study; their implementation might be a great subject of future project.

**Ethical:** the range of social values that must be respected in our project, deals with introducing the concept of social responsibility in order to make it easier for people to accept the strategies that needs people cooperation and law enforcement, especially in traffic limitation strategies.

**Economical:** weighing the value of the solution in the touristic season might overestimate its worth since there is a positive relation between its value and its use. Hence the need of future projects concerning an economic design and a sustainable solution that can be used in other fields when there is no traffic jam.

**Political:** The political factor can be reflected on the opposition of the government towards the change that our solution would bring.

**Legal:** the legal factors are of a huge importance to the study, since there is a strict policy concerning the land use in Ifrane city. The challenge remains in convincing the authorities with our proposal. In addition to that, safety regulations should be taken into considerations since the safety of tourists comes first.

**Environmental:** environmental impact is directly related to the land transformation, for instance if we are to build parking lots, we need to recover the trees and the nature destroyed.
8. Conclusion

This capstone project was an opportunity to improve my self-learning skills; especially that transportation engineering is new field for me. In addition to that, this new capstone approach gives an additional value to my work since future capstone project are going to be based on this initial study.

This capstone project has achieved an initial study that provided background and adapted the findings to the context of Ifrane. The main adaptations were applied to planning concerning tourism traffic planning, in data collection features concerning survey design, and in data collection method concerning the moving observer method. Meeting with the authorities has been beneficial at a personal level, since interviewing the head of the communes requires some professional behavior. Moreover, backing up the initial study with the perspective of the authorities has guided this project to narrow down the scope of the solutions.

Given the nature of this project, it can’t be qualified as a comprehensive study, but the backbone of the full project has been set.
References


