RISK MITIGATION BY TRAFFIC MANAGEMENT PLAN – EDUCATIONAL APPLICATION TO THE ITALIAN HIGHWAY A21

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Abstract - Transportation planning is crucial in establishing cities, enabling economic activity, fostering community connection, and improving quality of life. Additionally, it is also essential to guarantee safe access for everyone in different ranges based on civil and environmental factors. Although it is needed to ensure safe access, sometimes there is a risk of a happening crisis on the roads, and following this, other alternative routes should be taken based on the calculated scenarios. In this study, taking into account several parameters, especially rush hour, vehicle type, speed, distance, platoon volume, redundancy level, travel time, traffic patterns, structural reliability of network components, and road capacity, the conditions for introducing alternative options were provided to identify and prioritize transportation network management and planning projects. A traffic management planning (TMP) system has been developed in this research to network assignment modeling for Macro and Micro Alternative Routes to mitigate the effect of the crisis and preventing from a huge volume of traffic. This system analyzes the state of the transportation system, taking into account several key conditions at various times of the day. The results obtained in this study were developed based on an educational course at the Polytechnic of Milan University with the aim of learning one of the applications to manage traffic in the different scenarios on Highway 21 in Italy.The results of the survey onthe Broni-Castel San Giovanni highway in Italy include five possibilities that have been critically modeled so that, in the scenario where one transportation option has a problem, the next best option will be chosen following the criteria. The deployment of this approach brought about a high level of crisis management capability in the transportation sector. By modeling the optimal route selection in this manner, it is possible to reduce the impact of risks on the one hand while preventing any conflict in the transportation system on the other.

Keywords - Crisis conditions, CUBE software, Modeling Transportation, Traffic Management plan, Civil and Environment

I. INTRODUCTION

Individually and collectively, the resilience of robust, large-scale, interdependent civil infrastructure networks, such as transportation systems, utilities, telecommunication facilities, and social networks, has a significant role in defining a community's resilience as a whole.The operation of transportation networks, in particular, is crucial since the restoration of almost all other facilities and lifelines in a community is dependent on people and equipment being able to go to the sites where the crisis has occurred [1], [2]. The ability of a system to withstand or adapt to external shocks and recover effectively and efficiently from such shocks is referred to as its resilience. Controlling a crisis through meticulous planning is an essential skill in civil and environmental management[3].

An Information Decision Support System has been created to assist in crisis management. This system must assure the agility of the crisis response by detecting and anticipating future events. Given the various weather and traffic projections, the system may be able to anticipate future conditions in order to provide a meaningful and proactive response [4]. Before implementing such a system, it is crucial to comprehend the current conditions in communication channels and the impact of these variables when a crisis occurs, which can only be accomplished through the use of accurate modeling and planning systems for crisis management [5].Even if modeling systems and thorough planning have occasionally been demonstrated in some studies, an integrated collecting system and multi-dimensional analysis of circumstances with the use of relevant software are considered a gap in earlier studies.

There are numerous approaches to crisis management, which can be divided into two categories: prevention and recovery. The term "prevention" refers to taking actions to ensure or reduce the likelihood of a crisis developing. However, crises are unavoidable at times, and we must guarantee that a proper, systematic disaster recovery plan is in place to respond swiftly and efficiently in order to control the situation and limit the damage. This type of simulation has many benefits and disadvantages. The pros include controlling the platoon of cars, preventing heavy traffic, and being Straightforward, intuitive, and easily accessible. The cons include data accessibility, the effect of weather conditions, and having no feedback on the driver's actions [6],[7].Traffic congestion is getting increasingly severe and costly in many urban road networks as the global car stock grows. Modeling and optimization of road networks are critical techniques for anticipating traffic flow and decreasing network congestion [8],[9].

The program's major function as part of a crisis management plan is to estimate the time required for a full traffic evacuation upon the occurrence of an emergency, and it also allows users to determine the shortest path [10] for their journey in the event of a roadblock at various points [11].This, of course, minimizes the number of accidents, optimizes travel time, and saves money and energy. The ability to make quick decisions is a crucial characteristic missing in this modeling, which is compensated by providing more online data on changes in roadways based on crisis management to enable real-time decision-making [12], [13].Following that, in crisis situations, decisions are made based on the thresholds established in the implementation scenarios.

It is important that the results obtained in this study were developed based on an educational course at the Polytechnic of Milan University with the aim of learning one of the applications to manage traffic in the different scenarios on Highway 21 in Italy. In this framework, also the data used for the study are the results of hypothesis, assumptions, and statistical estimation.The findings of the studies also provide information as to whether the policy choice would improve energy dependency while boosting the safety of motor vehicle travel,lowering the carbon dioxide level,and preventing unintended consequences such as environmental issues [15],[16].The main goal of this article is to achieve network assignment modeling for Macro and Micro Alternative Routes in order to lessen the impact of a large amount of traffic during a crisis [17], [18], [19]. When a crisis occurs, it is possible to provide calculated alternate routes by using various analytical methodologies.

II. MATERIALS AND METHODS

A Traffic Management Plan (TMP) is described as all of the instructions and actions taken to plan and coordinate traffic management and information efforts in the event of a major event affecting road conditions [20]. They strive to decrease the impact of the events on traffic, ensuring transportation efficiency and user safety.The TMP is a Decision Support System (DSS) for affected users and competent authorities, and it allows effective management in critical situations that may occur on a road network[3], [14], [15].

A.CUBE Software Introduction

CUBE is a versatile and efficient modeling software that may be used to assess the implications of new projects and regulations on a city's transportation network, land use, and population. CUBE 6.5 CE is a desktop interface that connects the model, data, and Geographic Information System (GIS) in a single click, making model development and implementation simple[21].To examine the condition of a highway and suggest alternate routes based on risk mitigation, first considered the target location and the routes to it, as well as the influence of key vehicle volume charging places (centroids). All analysis of the highway and the elements affecting it should be done in CUBE software to maximize accuracy and reduce the number of mistakes in estimates. As an outcome, after discussing the main traffic ideas relevant to this study, the phases of analysis in CUBE software have begun.

B. Area of Interest

The main study area is defined between the cities of Broni and Castel San Giovanni on Highway A21 in the East-West direction, where an interruption occurred on Thursday at 12:00, resulting in a total suspension of the traffic flow moving West from East in a distinctive scenario.Figure 1 depicts the precise region of investigation on Highway A21, demonstrating the probability of the event with the red flag.

C.Network Assignment

Critical structure identification and their relationships were noteworthy after acquiring data at the city, region, and province levels [22], [23], [24]. Figure 2 displays all network assignment options for the A21 highway in the CUBE program. Network Assignment Using CUBE is divided into three parts: 1- All-or-nothing assignment, 2- Choose link assignment, and 3- Exclude group assignment.

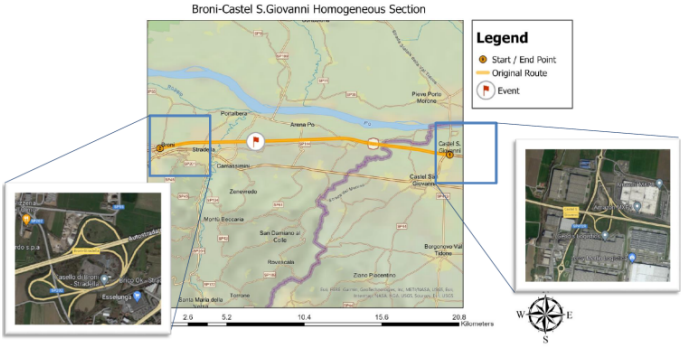


Figure 1: Main study area between the cities of Broni and Castel San Giovanni on Highway A21

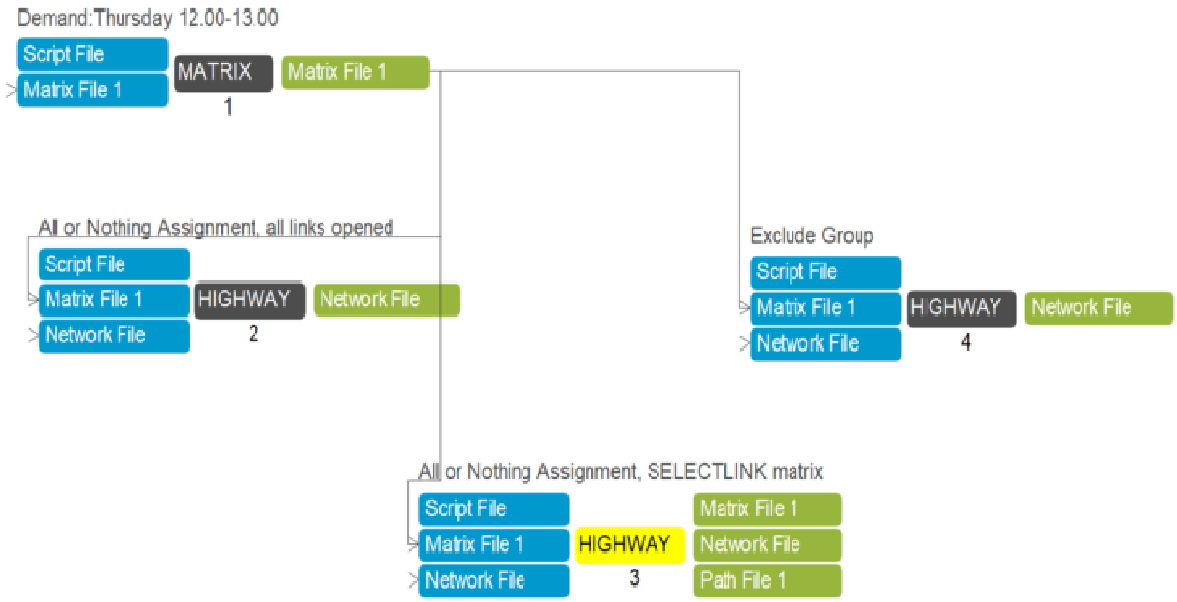


Figure 2:All types of the network assignment for the A21 highway in the CUBE software

1) All-or-Nothing Assignment

The All or Nothing assignment ignores congestion and only considers the network in a normal state, which is the existence of background flow. This assignment is sometimes known as a "basic assignment":

A network file comprising a simplified and linearized representation of all Italian roadways was used to execute the analysis.A matrix (.mat file) was created by converting the national demand (.csv file) using the Matrix Conversion tool. The demand was adjusted to account for the fraction of annual traffic due to the event's day and hour. The All or Nothing (deterministic without considering congestion) assignment was first conducted without respect to the link closure. The displayed graph depicts the basic flow V_1.

2) Select-link Assignment

Only the volumes involving travel via the obstructed link 1172-861 (East to West) were loaded and displayed using the Select Link function.It was possible to generate an output matrix that contained only the portion of the demand that used this link. This process is useful not only for understanding the flows influenced by the obstacle, but also for identifying the zones that may be affected by the event.

3) Exclude group assignment

The ultimate goal of running CUBE software is to determine the network repercussions of completely blocking the specified link. In order to do such an analysis, the national matrix had to be assigned twice in the same roadway program.

It is important that V-1 (volume in the time 0) saves traffic volumes in normal situations.V-2 stores the volumes in the event that the 1172-861 link is completely blocked. In the links that are not affected by the incident, V2_1 (volume after running the software) equals V1_1. On the contrary, the links affected by the obstruction have a V2_1 that is greater or less than V1_1.In order to be implemented, it needs to be modified by a script programming component of the CUBE software, and this step requires knowledge of programming and coding in this software.An example of programming codes in the Macro-Alternatives Excluding Group assignmentexhibits in Figure 3.

```
;;<<Process Template>>><<HIGHWAY>>><<Demand Model>>><<Assignment>>><<Highway>>><<Static>>;;
;{Title,note,12,"Burrell Assignment using a Cost Function"}>>>
;{note2,note,10,"Input / Output Specification"}>>>
;Input Highway Network: {neti,filename,"Input Highway Network File",x,"","Network File (*.net)|*.net"}
;Input OD Matrix: {mati,filename,"Input OD Matrix File",x,"","Matrix File (*.mat)|*.mat"}
;Output Highway Network: {neto,filename,"Output Highway Network File",x,"","Network File (*.net)|*.net"}
;Output Path File: {patho,filename,"Output Path File",x,"","Path File (*.pth)|*.pth"}
;{note3,note,10,"Cost Function and parameters"} Highway Assignment>>>
;Cost function:{cost_fun,editbox,"Cost Function e.g. TIME*1+LI.DISTANCE*0.3",T,"TIME*1"}
;Number of paths:{NPATH,editbox,"Number of paths to be generated",N,"1"}
;Spread coefficient:{SPREAD,editbox,"Spread Coefficient",N,"0.1"}
;;<<End Parameters>>;;

RUN PGM=HIGHWAY

FILEI NETI = {NETI.Q}
FILEI MATI[1] = {MATI.Q}
FILEO NETO = {NETO.Q}
FILEO PAT  1 of 4  [FILEO > NETO]: APPEND DEC EXCLUDE INCLUDE (HIGHWAY / AVENUE)


;   ----- SET CAPACITY and group links
x=RANDSEED(123)  ; makes results repeatable

PROCESS PHASE=LINKREAD
  C = LI.CAP
  T0=li.distance*60/li.speed
; Set Burrell spread factor

W={spread}
if (iteration=0)
  lw.scost=T0  ; stochastic link cost for the first iteration is set to freeflow time
endif
```

Figure 3: Example of programming codes in the Excluding Group assignment for Macro-Alternatives

D. Assessment of the Alternative Routes

The five steps of the alternative route include micro survey,macro itinerary maps [25], real-time travel [12], delay computation, activation threshold, and activation scenarios.

1) Alternative survey at the micro and macro levels

According to a review of prior papers, categorizing approaches into macro and micro scales had been offered [26], but not with the cooperation of the CUBE software. Macro and micro evaluations are connected to the degree of specificity and scope of surveys that are conducted in a region. To be clear, the micro level comprises more details in a limited and focused area, but it cannot be applied to a larger area due to the volume and complexity of the data. In this essay, both of these evaluations are applied.

2) Micro and Macro alternative

To achieve macro-alternatives, we analyze only the large-scale general components and the criteria for two different flows in the assignment [27]. As a result, for each link, the difference between the flows of the two assignments was computed by using (1) and (2).

VOL3=VOL1-VOL2 (1)
VOL4=VOL2-VOL1 (2)

These matrices will only hold the flow increment or decrement for the links whose volumes are affected by the A21 highway obstruction. The blue links show a drop in flow, while the red links show an increase in flow, indicating possible macro-alternative routes to be developed.

The links forming each route were identified in order to determine the trip time corresponding to each of the specified macro-alternatives. The following speed formula was used to calculate the trip time by (3) along each of these links:

$$v = v_f - \alpha \left(\frac{q}{L_u.n}\right)^2 \qquad (3)$$

v = SectionSpeed[km/h]
v_f = Free Flow Speed (FFS) [km/h]
α = Model Parameter
L_u = Working Width of Lane [m]
n = Number of lanes
q = Traffic Flow on the Section (Background flow + Diverted flow) [Vehicle/h]

The same approach was used to determine the travel time of the respective original routes. It should be noted that the original route was identified as the route that originated and ended in the same zones as the relevant macro-route.

After analyzing and monitoring road conditions at the macro level, it is important to explore road conditions at the micro level in greater depth, and this step is slightly more complicated with a bigger volume of data than the macro stage.ArcGIS' Network Analysis tool was used to detect the micro-itinerary. The following changes were made to the Network Dataset:

1. Roads with Functional Road Classes (FRCs) greater than 4 were not considered[28], [29],
2. The obstructed link's complete redirected flow was added to the background flow of all links.
3. The travel time for each link was calculated using the same velocity algorithm as described for the Macro-Alternatives. The computed trip time was used as the impedance when doing the Route analysis.

3) Real Travel Time

Due to the complete closure of our homogeneous section (Castle S.Giovanni - Broni), the background flow that was supposed to pass through this link must be diverted over other network links, necessitating the calculation of new travel times for each link to account for congestion in the analysis. Equation (1) is used to calculate the true velocity of each link.

4) Delay computation

Meeting delay limits is critical for real-time sensor network applications where events must be reported in real-time [12], [30].The Input-Output diagram was utilized to determine the obstruction time duration required for the activation of each of the appropriate alternative routes (Table I). Regardless of the simulated duration of the disruption, the average delay was calculated only for vehicles arriving two hours after the interruption began. To evaluate the flow in the following time band 13:00-14:00, a simplified percentage consideration was used by taking into account the distribution of traffic flow on Thursday.

starting time	11.0									
flow	see manual	(vehic/h)	(h)	Time band	from	to	flow (veh/h)	starting cumulative flow (veh/h)	final cumulative flow (veh)	headway (min)
capacity (q_{MAX})	7050	(vehic/h)		1	11	12	2,900	-	2,900	0.0207
k_j	405	(vehic/km)		2	12	13	2,700	2,900	5,600	0.0222
V_f	115	(km/h)		3	13	14	2,500	5,600	8,100	0.0240
k_c	61	(vehic/km)		4	14	15	3,000	8,100	11,100	0.0200
headway	see manual			5	15	16	1,500	11,100	12,600	0.0400
V_{m1}	4.5	(km/h)	(h)	6	16	17	2,000	12,600	14,600	0.0300
V_{m2}	115.0	(km/h)		7	17	18	2,500	14,600	17,100	0.0240
d	10.0	(km)		8	18	19	3,000	17,100	20,100	0.0200
t_f	0.09	(h)								
m1	1500	(vehic/h)	(vehic/min)	--->	until time (t_{reopen}/t_{change})	12.00		n. hours of delay calculation		2
m2	7050	(vehic/h)	(vehic/min)	--->	from time	12.0		average delay		8.3

Table I - Example of Input-output calculation

The time difference between each alternate route and its corresponding original path was set as the average delay, and the needed time duration of the blockage was calculated accordingly.

E. Micro and Macro Itinerary Maps

To obtain Travel Time under multiple hypotheses, the conditions governing the alternative routes on the map should be split into two groups, micro, and macro.

The Itinerary Map for both micro and macro alternative routes should be developed with careful consideration of travel time [17], volume, speed limit, direction, and road condition based on the information collected from the micro and macro alternative routes.

F. Heavy transport management

A number of preconditions have been calculated and presented, which should be taken into account in the calculations. Considering the current conditions on the A 21 highway, in addition to passenger automobiles, the issue of heavy vehicle traffic and stocking space should be considered inthe assessment (Figure 4).

Logical data assumed for the development of Heavy transport scenarios:

- Identification of the possible available areas taking into consideration: the position of the route to reach it, capacity, maneuvering areas, and presence of basic services.
- 15% is the assumed percentage of vehicles that would arrive at the exit of Castel S. Giovanni
- 20% of the flow is the assumed percentage of heavy vehicles.
- The private parking near Castel S. Giovanni was chosen for its capacity and accessibility.
- The stocking area individuated is private, therefore its activation is regulated by a contract between the managing body of the highway and the private company.

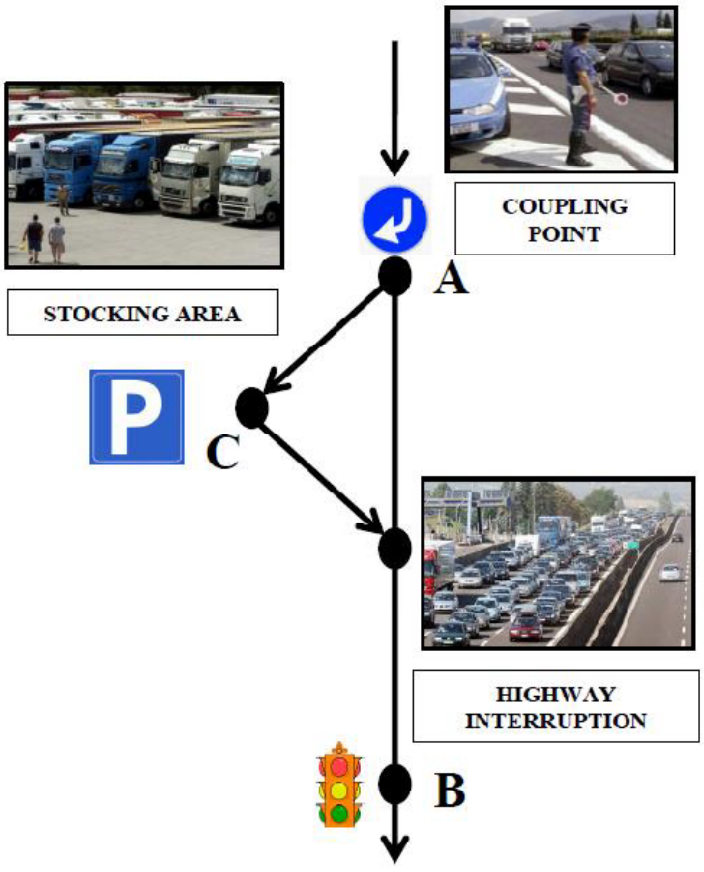


Figure 4: Demonstration of stocking area and parking

G. Activation Threshold

To determine which circumstance the measure must be triggered, different random estimated durations of time were placed into the input-output diagram to acquire the average delay. TABLEIIdefines the criterion for the measure's activation and the formulas for calculation. For Basic conditions for the activation of a stocking area, all of the characteristics in TABLEIIIare to be utilized to check the satisfaction of four conditions; if all four conditions are met simultaneously, the measure Stoking of heavy vehicles (HVs) can be engaged. At the end of the method, several scenarios based on delay were achieved based on the predicted time of the event, causing separate phases to active distinct alternatives. In other words, previously decided alternative routes

are activated based on a computed duration of time (phase) to select the best option over a crisis circumstance [1],[4].

Many studies and articles have been presented in the field of examining methods and providing the best option, but none of them have paid attention to the details of choosing the path during and after the crisis by risk mitigation modeling like [1], [3], [4], [7], [11], [20]. The results are based on the use of all techniques and phases recommended for the best route selection in the road communication network for the Broni Highway study region in Italy.

Parameter	Description	Time	unit
T [m]	Estimated duration of the event	120	min
TAC [m]	Travelling time between coupling point and stocking area	6	min
TCB [m]	Travel time between stocking area and road interruption	10,5	min
Tab [m]	Travel time between coupling point and road interruptions	2	min
Tatt [m]	Actual time needed to activate the stocking area	60	min
Tman [m]	Manoeuvring time for the stocking operations	15	min
Ts [m]	Stocking time (T-(Tac+Tcb+Tman))	88,5	min
P [min]	Time loss (Tac+Tcb+Tman)-Tab	29,5	min
Ta [m]	Residence time on the highway before the traffic is restored	118	min
Heavy vehicle [n°]		54	u
Cap [n°]	Stocking area capacity	90	u
p/Ts	the relation between time loss and stocking	33%	min
Tmax-a [m]	Maximum acceptable residence time on the highway	100	min
Tmin-s [m]	The minimum acceptable residence time within the stocking areas	60	min
(p/Ts)max	Maximum acceptable relation between the time loss and stocking	33%	min

TABLE II - Parameters of threshold activation

T ≥ Tatt	YES
Ta ≥ T_max_a	YES
Ts ≥ T_min_s	YES
(P/Ts) ≤ (P/Ts)max	YES

Table III - Four conditionscheck the satisfaction

H. Activation Scenarios

III. RESULTS AND DISCUSSION

A review of past articles on the application of cube software to assess the status of the roads revealed that none of them especially [18], [21], [32] assessed the conditions of the roads from all three angles: All-or-nothing, select-link, and exclude-group are examples of assignment types. They didn't consider other traffic load circumstances, movement patterns, or vehicle types; they simply considered the straightforward path or the probability of an accident. The results ofthe All-or-Nothing Assignment would imply that the number of cars is large in the middle and northern areas of Italy (Figure 5). Broni Highway study area will demonstrate the most desired section for users to use as a corridor due to the high rate of automobile traffic volume in this part by adopting the Select-link Assignment (Figure 6).

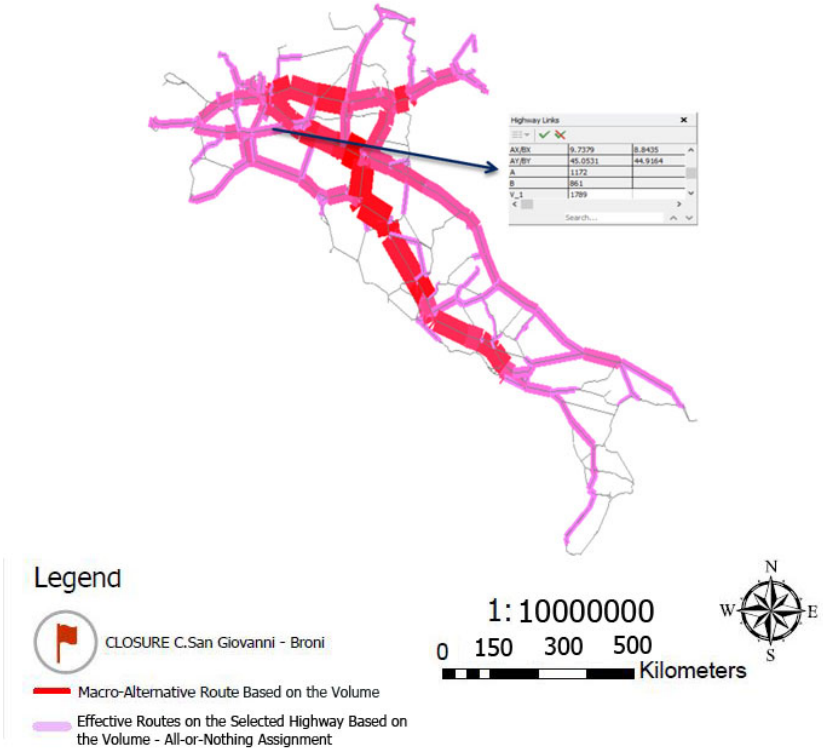


Figure 5: Network volume condition in the part of the All-or-Nothing Assignment

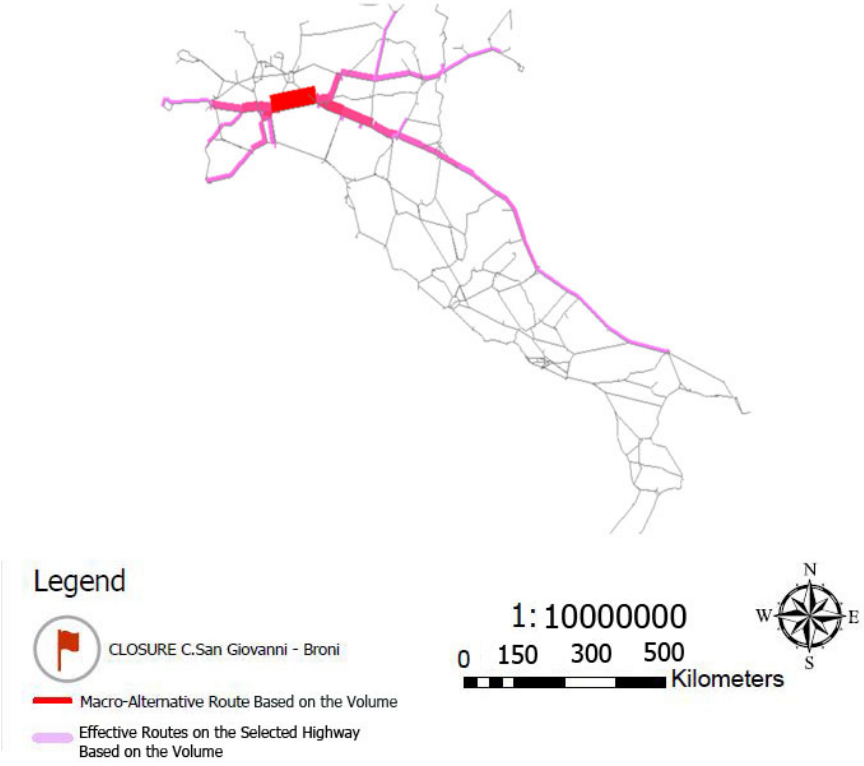


Figure 6:Network volume condition in the part of the Select-link Assignment (1172-861) from East to West

Exclude group Assignment for macro alternatives displays some macro alternatives that can be used to reach destinations in the study area in a practical manner (Figure 7). Based on this, the Original-route timing and Macro-route timing - Zone 2 tables are obtained to determine the exact amount of time

required to reach the locations.Following the volume of automobiles and the period of access to the destination, the optimum priority road to be applicable when a crisis occurs on the Broni Highway is option 1, followed by options 2 and 3.

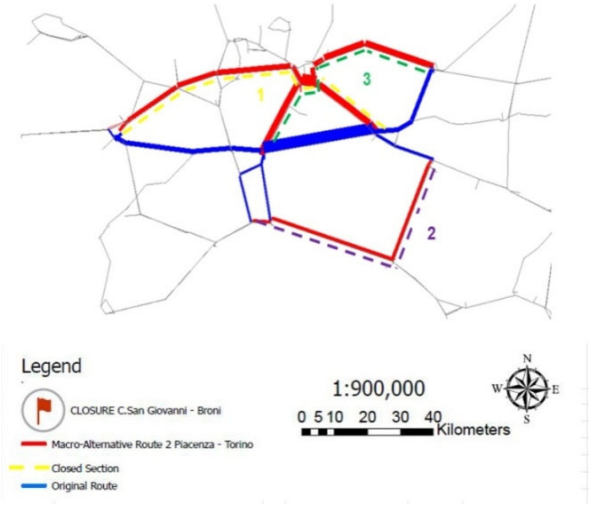


Figure 7: Obtained Macro-alternative routes by Exclude group assignment

Similarly, to other articles like [10], [34], the system's outputs in this article have been focused on documents indicating the effects of functional parameter deterioration on roads that are useful in decision-making regarding the optimal alternative route, and supporting mechanisms in reducing potential hazards.

Additionally, using the CUBE software results in an estimate that is extremely similar to the real world. Due to four options and a stoke area option, it is easy to control traffic in the research area and prevent placing an excessive strain on a road. The outcomes of Original-route timing and Macro-route timing into account can be seen in the Figures. 8 -9based on the three assignments previously mentioned.

Although some articles present a decision methodology to select the best options among potential new construction alternatives to improve the resilience of the network by altering its current topology in the article [1], none of the research ever focuses on the load of terrific in the different hours and different alternatives of the roads.

Most articles like [3] use modeling with GIS software to determine the optimal route, but this software is only suitable for providing possible options, and GIS software is not capable of including traffic parameters, scheduling vehicle movement, and providing practical scenarios.Using the ArcGIS Network Analysis tool, micro-level maps are built by focusing on greater details of road connections and effective elements in this modeling. Following an investigation and survey of the many possible routes, only one Micro-alternative route was discovered to mitigate the risk of using the Broni-Castel San Giovanni highway.

Original Route								
	Links		Flow	KPH	Lanes	Speed	Distance	Time
1	1162	1164	1183	120	2	117.512	1128.6	0.576247
2	1164	1167	1454	120	2	116.2416	772.1	0.398532
3	1167	1172	1033	120	2	118.103	952	0.483646
4	1172	861	1789	120	2	114.3102	76718.4	40.26854
5	861	859	882	120	2	118.617	1389	0.702597
6	859	600	1171	120	2	117.5622	20862.4	10.6475
7	600	598	1128	120	2	117.738	240.2	0.122407
8	598	595	1128	120	2	117.738	443	0.225756
9	595	591	1234	120	2	117.2929	692	0.353986
10	591	560	2291	120	2	110.669	24934.1	13.5182
11	560	562	1424	120	2	116.3951	189.6	0.097736
12	562	427	1584	120	2	115.5395	45027.9	23.38313
13	427	431	1584	120	3	118.0175	222	0.112865
14	431	432	1685	120	3	117.7567	279.2	0.142259
15	432	433	1685	120	3	117.7567	178	0.090696
16	433	441	1685	120	3	117.7567	10233.1	5.214023
17	441	450	1276	120	3	118.7135	597.5	0.301987
18	450	456	1310	120	3	118.6441	442.3	0.223677
19	456	457	1310	120	3	118.6441	207.3	0.104835
								96.96862

Figure 8: Example of Original-route timing- zone 2

Macroroute 2								
	Links		V2	KPH	Lanes	Speed	Distance	Time
1	1162	1166	4252	120	3	105.715	658.9	0.373968
2	1166	4273	4634	120	3	103.0329	8591.1	5.002925
3	4273	4271	4634	120	3	103.0329	11045.7	6.432332
4	4271	1013	4634	120	3	103.0329	4909.2	2.858814
5	1013	1014	4688	120	3	102.6352	28003.9	16.37094
6	1014	1016	4430	120	3	104.4939	1473.5	0.846078
7	1016	877	5414	120	3	96.84038	9603.2	5.949915
8	877	891	1595	120	3	117.9899	930.3	0.473074
9	891	898	1816	120	3	117.3943	14979.5	7.655994
10	898	900	1816	120	3	117.3943	321.4	0.164267
11	900	902	1816	120	3	117.3943	429.1	0.219312
12	902	913	1909	120	3	117.1206	300.1	0.153739
13	913	907	733	120	3	119.5755	343	0.172109
14	907	575	2742	120	3	114.0594	47801.6	25.14563
15	575	570	2210	120	3	116.141	1349.4	0.697118
16	570	633	2515	120	3	115.0023	27586	14.39241
17	633	631	2465	120	3	115.199	250.5	0.13047
18	631	622	2325	120	3	115.7289	288.9	0.149781
19	622	490	2236	120	3	116.0496	271.5	0.140371
20	490	478	2296	120	3	115.8348	41091.9	21.28475
21	478	468	1895	120	3	117.1626	691.6	0.354174
22	468	459	1915	120	3	117.1024	1632.7	0.83655
			Destination Zone 2					109.8047

Figure 9: Example of Macro-route timing - zone 2

Additionally, in some articles, only micro-zone conditions were taken into account, and the impact of macro-zone conditions was not explored especially in [18]; in other cases, when both micro- and macro-zone conditions were taken into account the same article [17], proper cube usage was not taken into account when determining the best course of action.Sometimes macro alternatives are asserted only in a description without any mapping to visualize the condition similar to the article [27].

After completing all of the assignments for the existing alternatives, four proposed options were chosen, with Macro-Route 2 having the lowest delay between Alternative Route and Original Route, and Micro-Route having the highest amount of delay (table IV), which reduces the priority of using it.

	Alternative Route(km)	Original Route(km)	Delay (min)
Micro-Route	92.62	7.62	85
Macro-Route 1	109,80	96.97	12.83
Macro-Route 2	109.54	104.47	5.07
Macro-Route 3	96.28	79.47	16.76

Table IV - Delay in alternative and original routes

In order to Table IV, all the Macro Itinerary maps are obtained which are demonstrated in Figures.10 -12. Macro Itinerary 1 is the route between Parma and Genova, Macro Itinerary 2 includes the way from Piacenza to Torino, and Macro Itinerary 3 is the road from Brescia to Alessandria.

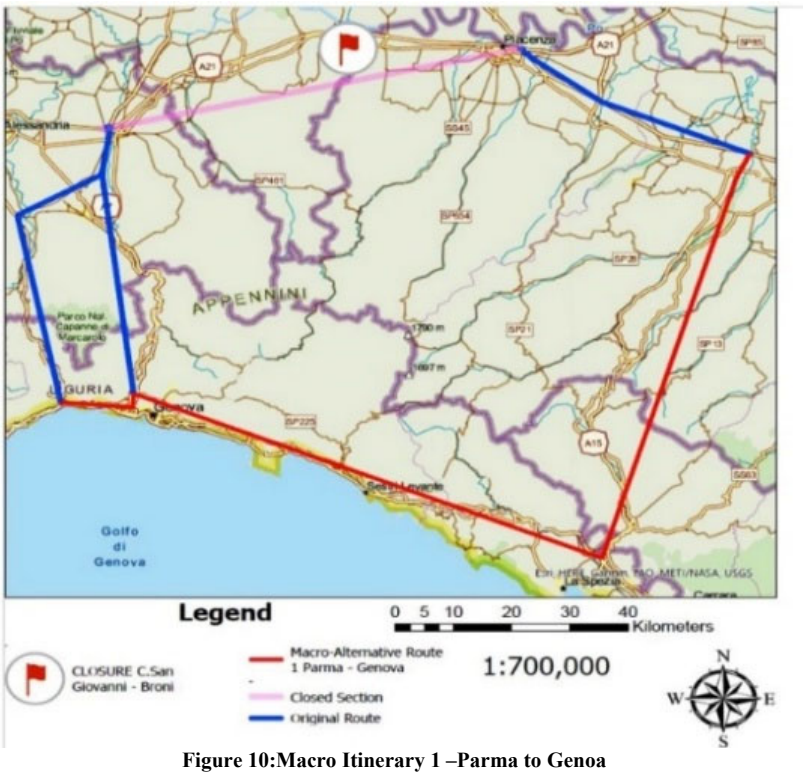


Figure 10:Macro Itinerary 1 –Parma to Genoa

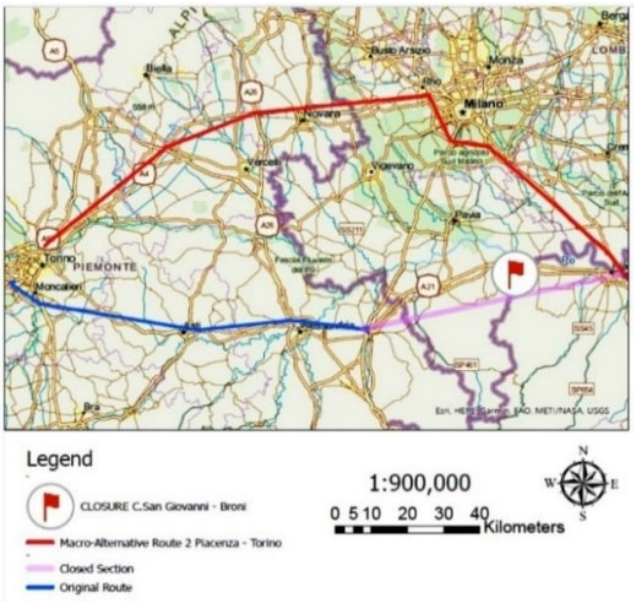


Figure 11: Macro Itinerary 2 –Piacenza to Torino

IV. MICRO ITINERARY MAP –SENSITIVITY ANALYSIS

Sensitivity analysis establishes the impact of various independent variable values on a specific dependent variable under a particular set of assumptions. In other words, sensitivity analyses look at how different types of uncertainty in a mathematical model affect the overall level of uncertainty in the model which has been done in most of the valid articles very similar to the articles [17], [31], [32], [33]. The sensitivity analysis demonstrated that the model provided in our study was nearly reliable and stable (Figure 13), with only the top and second priorities being replaced in priority levels when the weight values of criteria were changed the same as in the article [30].This method is applied within predetermined bounds that hinge on one or more input variables.

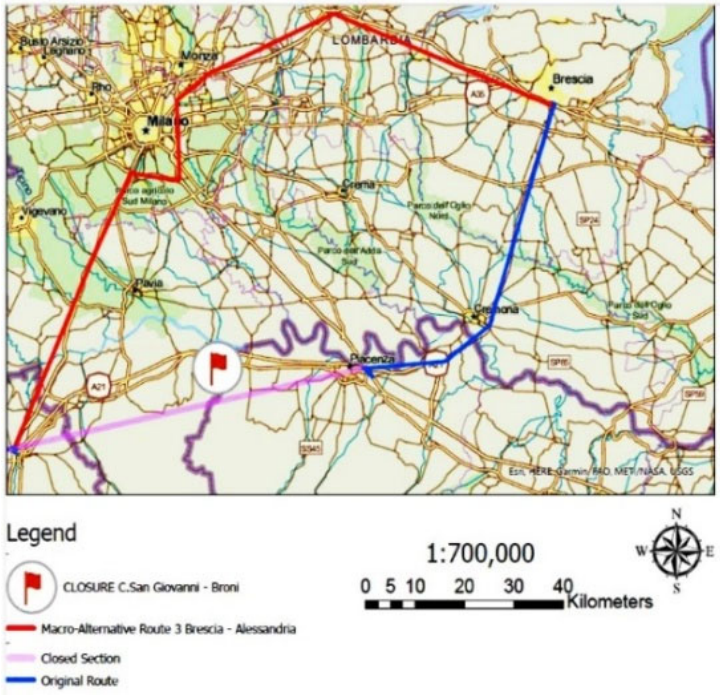


Figure 12:Macro Itinerary 3 –Brescia to Alessandria

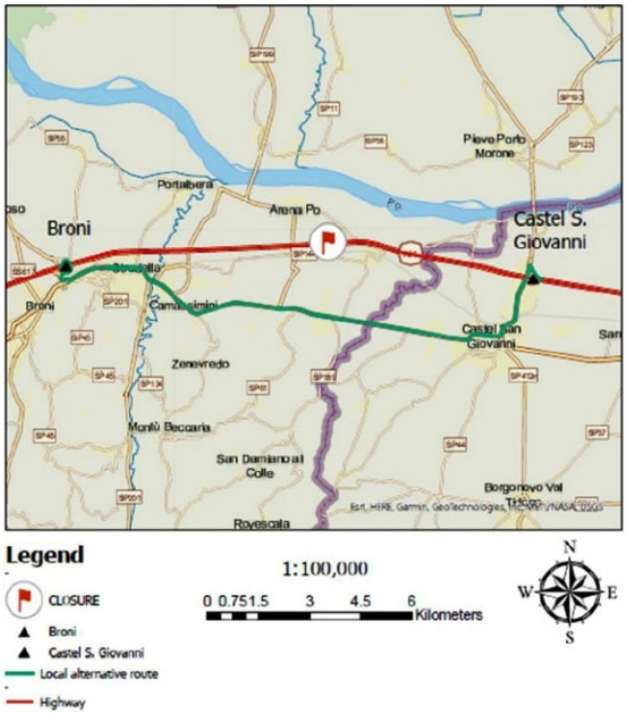


Figure 13: Micro-Itinerary map of Broni - Castel San Giovanni

Table V shows micro-alternatives of travel time. Given that the entire flow is channeled through the micro route. It shows how much real-time is required for various Diverted flows based on the percentages of contribution. As a result, when the entire Contribution is considered, the real-time comes to 214 minutes.

Contribution [%]	Diverted flow [Veic/h]	Real-Time [min]
0.3DV	696	22
0.6DV	1393	39
0.8DV	1857	113
DV	2321	214

Table V - Micro-Alternative Travel Time under the different hypothesis

V. SENSITIVITY ANALYSIS OF THE MICRO ALTERNATIVE (VELOCITY AND VOLUME PARAMETERS)

By doing a Sensitivity analysis on the Micro alternative, it is clear that when the Diverted flow is fully utilized, the average velocity increased as a result of the decreased number of car packets (Figure 14); therefore, the compatible volume of cars is around 700 vehicles per hour. It happens because the large number of cars makes it difficult to maneuver and makes traffic heavier than in the past. Furthermore, as the number of vehicles on the road increases, so does the real arrival time, demonstrating that the optimum volume is up to 1500 vehicles per hour (Figure 15), and anything farther than this causes more delay and traffic congestion. As a result of both figures, the optimum number of cars in the Micro alternative should be between 700 to 1500 vehicles per hour.

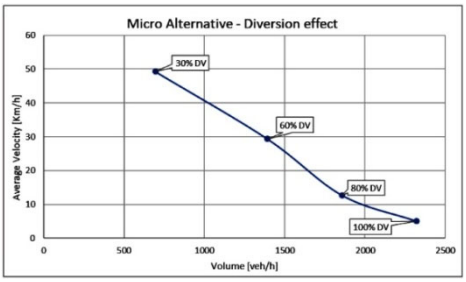


Figure 14: Sensitivity analysis of the Micro alternative (velocity and volume parameters)

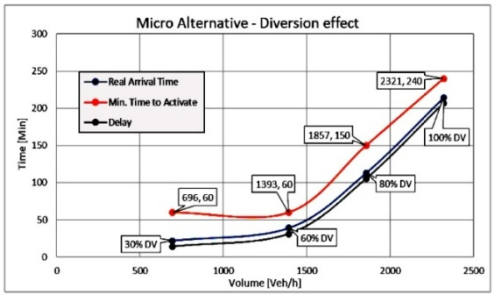


Figure 15:Sensitivity analysis of the Micro alternative (time and volume parameters)

VI. ACTIVATION THRESHOLD

As previously observed, multiple random estimated durations of time were added to the input-output diagram to obtain the average delay in order to identify which condition the measure must be activated. The findings of this calculation, which are shown in Table VI, were used to arrive at the Scenarios throughout various time periods, but in some articles like [13], [14], only the economic and fatality loss threshold is highlighted without any sensitivity analysis.

VII. ACTIVATION SCENARIOS

The conditions for determining Activation intervals are provided for all steps of optimal selection of the access road in the area of Broni and Castel San Giovanni on Highway A21 in Italy for risk mitigation during a crisis, in order to achieve the activation time of each alternative in order to use it, with the help of the threshold activation step.

T Event	15	30	45	60	75	90	105	120
Tac	2	2	2	2	2	2	2	2
Tman	30	30	30	30	30	30	30	30
Tcb	6	6	6	6	6	6	6	6
Ts	-23	-8	7	22	37	52	67	82
Tab	4	4	4	4	4	4	4	4
Ta	11	26	41	56	71	86	101	116
P	34	34	34	34	34	34	34	34
Tatt	38	38	38	38	38	38	38	38
Cap	300	300	300	300	300	300	300	300
Tmax-a	90	90	90	90	90	90	90	90
Tmin-s	60	60	60	60	60	60	60	60
P/Ts(Max)	57	57	57	57	57	57	57	57
P/Ts	-148	-425	486	155	92	65	51	41

Table VI - Parameters` results of threshold activation

The set of phases supplied is about 5 phases, depending on the difference in activation time (Table VII); the fifth phase in extreme crisis conditions which are mentioned in the articles [1], [4], [35] necessitates a stocking place for heavy vehicles to minimize traffic congestion. Table VIII shows a homogeneous segment of the entire pathbetween the cities of Broni and Castel San Giovanni in the East-West direction that is exactly between two specified places inthe research area.

	S 1	S 2	S 3	S 4	S 5
	T<25 min	25 min <=t<45 min	45 min<=t<90 min	90 min<=t<105 min	105 min<=t
Micro-Alternative					
Macro-Alternative 1					
Macro-Alternative 2					
Macro-Alternative 3					
Stocking of HVs					

TABLE VII - Obtained threshold time for different alternatives (Scenarios)

Road traffic is sometimes modeled using the Vehicular Ad Hoc Network (VANET) method similar to [7], [36], but the Cube software's step-by-step methodology not only shows the scenario but also the traffic conditions for different transit loads over day and night scenarios. It has provided a variety of routes for automobiles, and from a visual sense, roundabouts and traffic signals can be utilized to symbolize automobile movement over different scenarios. In line with other studies and research,the proposed scenarios provide priority routes, save money like [20] and [25], time, and energy, and avoid queues and interference with other routes caused by long queues.There is no need forany roundabout or traffic light in this study's alternatives regarding speed limits and roadway quality.

A 21	Phase 1			
	Event and homogenous sections identification			
	Event type		Event code	
	Total closure of the carriageway		E 1	
	Reopening of the carriageway		E 2	
No.	Tollgate name	Progressive (Km)	E1	E2
1	Santena- Villanova	0.0-10.8	E1-T1	E2-T1
2	Villanova-Asti West	10.8-32.5	E1-T2	E2-T2
3	Asti West- Asti East	32.5-38.5	E1-T3	E2-T3
4	Asti East- Falizzano	38.5- 51.6	E1-T4	E2-T4
5	Falizzano- Graft A26	51.6- 65	E1-T5	E2-T5
6	Graft A26- Alessandria West	65- 66	E1-T6	E2-T6
7	Alessandria West- Alessandria East	66- 76	E1-T7	E2-T7
8	Alessandria East- Graft A7	76- 87.4	E1-T8	E2-T8
9	Graft A7- Voghera	87.4-101.3	E1-T9	E2-T9
10	Voghera-CasteggioCasatisma	101.3-114.9	E1-T10	E2-T10
11	CasteggioCasatisma-BroniStradella	114.9-126.9	E1-T11	E2-T11
12	Broni Stradella-Castel S.Giovanni	126.9-140.9	E1-T12	E2-T12
13	Castel S.Giovanni- Piacenza	140.9-157.4	E1-T13	E2-T13
14	Piacenza- Castel S.Giovanni	157.4- 141	E1-T14	E2-T14
15	Castel S.Giovanni- Broni Stradella	141- 127	E1-T15	E2-T15
16	Broni Stradella-Casteggio	127-114.9	E1-T16	E2-T16
17	Casteggio-Voghera	114.9- 101.3	E1-T17	E2-T17
18	Voghera- Graft A7	101.3- 87.4	E1-T18	E2-T18
19	Graft A7- Alessandria East	87.4- 76	E1-T19	E2-T19
20	Alessandria East- Alessandria West	76- 65.8	E1-T20	E2-T20
21	Alessandria West- Graft A26	65.8-65	E1-T21	E2-T21
22	Graft A26- Falizzano	65-51.6	E1-T22	E2-T22
23	Falizzano- Asti East	51.6- 38.5	E1-T23	E2-T23
24	Asti East- Asti West	38.5- 32.5	E1-T24	E2-T24
25	Asti West- Villanova	32.5- 10.8	E1-T25	E2-T25
26	Villanova- Santena	10.8-0.0	E1-T26	E2-T26

TABLE VIII - Identifying the homogenous section

The Traffic Management Plan demonstrates how to run safe traffic and ensure access in times of crisis. Only with the involvement of both locals and the relevant authorities can an effective traffic management plan based on civil and environmental concerns emphasized in the articles of [14], [15], [22] which are in line with the main idea of this research.

VIII. CONCLUSION

Finally, in comparison to other similar studies, the entire process of modeling the roads in crisis condition by CUBE software demonstrates a suitable performance to mitigate the risks that occur on small roads, medium streets, and big highways in Italy. This traffic management modeling would also allow for decreased fuel consumption, less time wasted, and cost and energy savings by taking into account civil and environmental considerations.Furthermore, the achieved five alternative scenarios had the highest compatibility with the study area based on the existing scenarios to be chosen as a priority of the crisis where one transportation option has a problem due to the unprecedented event, the next best option will be chosen following the criteria. A traffic management plan should take into account issues that may become major needs in the near future. It is proposed that future research investigate the effect of driver behavior, cultural factors, and the type and quality of vehicles utilized to travel the routes.

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