Incident Management combined with Traffic Management

Isabel Wilmink, Ben Immers[†], Peter Zwaneveld
TNO Inro, Delft, the Netherlands,
e-mail: isw@inro.tno.nl, bim@inro.tno.nl, pzw@inro.tno.nl.
[†] K.U. Leuven, Department of Civil Engineering, Heverlee, Belgium
Jaime Barceló, Lídia Montero Mercadé
Universitat Politècnica de Catalunya, Facultat d'Informàtica, Barcelona, Spain,
e-mail: barcelo@eio.upc.es, lmontero@eio.upc.es.
Pablo Barceló
TSS-Transport Simulation Systems, e-mail: info@tss-bcn.com

SUMMARY

(10 lines)

COMBINING INCIDENT MANAGEMENT WITH TRAFFIC MANAGEMENT

OBJECTIVES

Incident management (IM) has been implemented in many countries over the past years. It can be seen as the total package of measures geared to optimising traffic safety during the handling of incidents (unexpected events such as accidents, stalled vehicles, spilled loads, etc.), to rapid and efficient handling of incidents and following on from this, to minimal traffic delays. The above definition indicates that IM comprises a variety of measures and that by applying these measures the realisation of several objectives is aimed at. Incident Management can be *curative* and *preventive*.

Curative Incident Management

Curative incident management consists of procedures and technical improvements to speed up incident detection, verification and response. As a result, Police, Ambulances, Fire Brigades, tow trucks and other emergency services arrive at the incident location sooner and clearance time is reduced. Numerous traffic management measures that can help the incident management process can be identified. Most fall in the following categories:

- information dissemination about the incident
- measures to increase the safety and efficiency of emergency services

Information about incidents can be given to road users during the trip and at home or work. Variable message signs or radio messages (RDS-TMC) can be used to warn for incidents and congestion due to incidents. This should result in a reduction of the number of secondary incidents, and less 'rubbernecking' causing congestion in the opposite travel direction. Using a screen to block the drivers' view of the incident can also prevent rubbernecking. At home and on the road information can be provided about alternative routes to avoid congestion due to incidents.

Apart from reducing the incident duration, incident management also aims at increasing the safety and efficiency of emergency services. Monitoring and signalling devices on the freeways commonly used these days can be used to close lanes (via variable message signs) and provide road users with information about incidents. Also, an optimisation procedure for the route choices the emergency services have to make to reach the incident location can be useful (e.g. shortest/fastest routes; allowing emergency services to use the shoulder lane).

Preventive Incident Management

Preventive incident management is based on the assumption that dangerous (accident-prone) situations can be predicted. Roadway geometry characteristics combined with traffic and weather data are used to estimate the incident probability on a roadway segment. Using real-time data, short-term predictions (5-15 minutes ahead) can be provided. Two models which can carry out such real-time predictions were developed in the EU DGXIII project In-Response (In-Response, 1996/97).
Applying traffic management measures might alleviate some of the specific conditions resulting in high incident probabilities. Table 1 gives several traffic management actions that might be taken in case of high incident probabilities. Given the short-term nature of the predictions and the variability of conditions, immediate action is required.

Table 1 Traffic management measures to avoid incidents

Traffic management measure	**Interface**	**Estimated time implementation**
dynamic lowering of speed limit	Variable Message Signs	<= 5 minutes
homogenising of traffic	Variable Message Signs	<= 5 minutes
homogenising of traffic	police cars	> 15 minutes
ramp metering (upstream)	metering devices at e ramps	5-15 minutes
traffic information, warning	Variable Message Signs RDS/TMC	<= 5 minutes
traveller information (before departure)	RDS/TMC	>= 15 minutes

INTEGRATION OF IM WITH TRAFFIC MANAGEMENT

Incident management should not be seen as a solitary process to improve the conditions on the road network. Combining it with traffic management (TM) can be a powerful management strategy to make it even more effective.

To get a clear overview of the traffic management measures that support the application of IM it is necessary to know which objectives can be distinguished and which priorities are being attached to these objectives. In the measures geared to safety improvements the following objectives can be distinguished:

- guaranteeing a safe working environment for the emergency workers involved;
- improvement of the emergency services provided to victims (post-crash safety);
- prevention of secondary accidents, e.g. at the end of the tailback.

In the measures geared to increasing the handling speed of the incident, focus will be on the duration of the incident. The objective of these measures is to reduce the delays for (other) road users, e.g. by bringing down the incident handling time and by removing bottlenecks quickly (opening one or more lanes to the traffic).

Two other objectives that can be distinguished in the Incident Management process are:

- continuous monitoring of the incident characteristics; this objective should enable emergency services to take the most appropriate measures depending on the development of the incident. This objective serves both safety and handling speed;
- safeguarding the traces of evidence, which facilitate research into the question of guilt; this last objective aims at a correct legal completion of the incident procedure.

TRAFFIC MANAGEMENT MEASURES SUPPORTING INCIDENT MANAGEMENT

Table 2 shows a number of traffic management measures that support the above mentioned objectives.

Table 2 Traffic management measures supporting incident management

Objective	**Traffic management measures**
Safe working Environment for emergency workers	• lane signalling (variable lane closures) • cargo identification (in case of hazardous materials) • motorist information (VMS, RDS/TMC, etc.), possibly in combination with ramp metering • availability of various response policies, depending on traffic load, e.g. fast (before peak hour starts) or delayed (until after peak hour, when vehicle is not obstructing the roadway) vehicle removal • *accident investigation sites*
Post-crash safety casualties	• incident access support of emergency services (quick access to incident site by response vehicles, possibly through remote control of emergency-services-only entry points) • *helicopter support (trauma team, traffic surveillance, etc.)*
Prevention of secondary incidents	• motorist information (upstream of the incident site: variable message signs, lane signalling/speed reinforcement signs) • alternative route planning • identification and surveillance of tail of queue • installation of fence to avoid rubbernecking
Reduction of incident handling time, cutting down delays for road-users	• fast and accurate incident detection (via electronic loop detectors and/or video imaging) • unique and fast determination of incident location • incident verification (via video and closed circuit TV, central information processing, etc.) • motorist information • frequent checks on the necessity to keep lanes closed • *efficient incident response (emergency vehicle access, interagency radio communication, etc.)*

	• *efficient incident clearance/site management (central information processing and control, etc.)*
Continuous update of incident characteristics	• *interagency radio communication* • *central information processing and control* • *establishment of command posts at the incident site*
Safeguarding traces of evidence	• *total station surveying equipment* • *interagency radio communication*

Items in italics are typically incident management measures, but important in the case of combined incident and traffic management. Some form explicit requirements for both to work, or support in a major way. Without the use of the traffic management facilities some could not be carried out.

CHOOSING COMBINATIONS OF IM AND TM

The above examples (although not meant to be exhaustive) clearly show the extensive involvement of the Traffic Control Centre (TCC) in defining and executing traffic management measures in the context of IM.

When we look at the different traffic management measures that are implemented in the incident management process we see that one measure can serve several objectives. It is, however, also imaginable that measures have opposing effects. For example, measures aiming at the safety of emergency services and victims, such as variable lane closing, will often result in longer incident duration, as emergency services understandably prefer to work with lanes closed. This frustrates the aim to minimise incident delay.

In order to prioritise the different incident management measures, it is advisable to investigate the relationship between the measure and the priority of the objective to be realised. In the Netherlands, for instance, the safety of everyone involved is considered priority number one and measures aiming to reduce incident duration must sometimes wait a little longer.
In many cases a prioritisation like this will support decisions as to what measure should be applied. However, operators and emergency services should at all times realise that every incident is unique and might require its own (unconventional) approach. The same goes for location or situation specific characteristics of incidents. Clearly, the flexibility needed, combined with the desired speed of action in incident management, requires a great deal of the functionality of the TCC.
Apart from checking the internal consistency of the IM approach, measures taken in that perspective must be co-ordinated with (other) traffic management measures already in operation (like re-routing advice given because of road repair works).

Operators in the control centre and emergency services at the incident location will all strive to do the best they can in the given situation. Finding an optimal solution is important, as an incident already represents a major problem, due to the unavoidable capacity reduction it causes. Wrong assumptions about the effects of measures can have large impacts on the adequacy of the incident handling and the total delay which motorists are faced with.

The question is: in which way can it be guaranteed that in every incident situation, an adequate if not optimal decision can be made? How can the measures, part of the incident response, be implemented timely and properly? Figure 1 gives a first approach. A first priority is information, about incident characteristics, and traffic flow and weather conditions in the network. This results in a set of required IM actions, as well as a set of required traffic management measures to support the IM actions. The same or other traffic management measures might already be in operation because of generally bad traffic conditions. The combined effect of IM and new and current traffic management measures needs to be checked. When satisfactory, the operator can go ahead and implement the optimal set of measures in this incident situation.

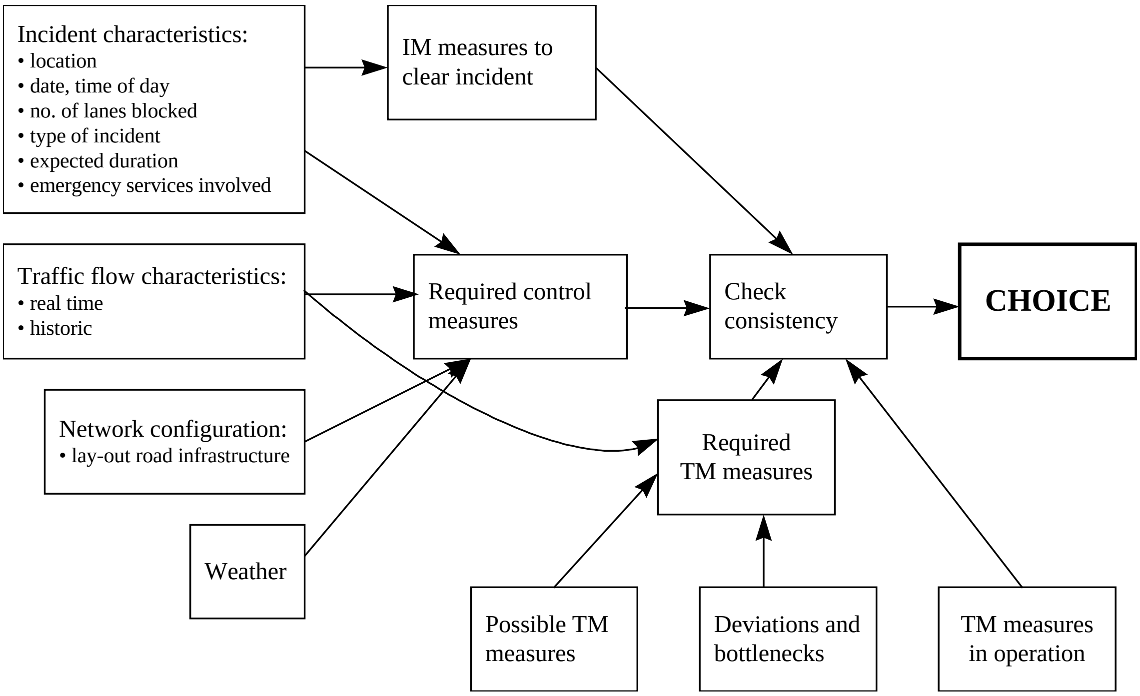

Figure 1 Scheme of the IM and TM consistent approach

To enable operators in a TCC to follow a procedure like this, the following requirements should be met:

- there is a user friendly Graphical User Interface (GUI), supporting the operator;
- simulation is used to gain insight into the effects of a large number of situations. Past experience is incorporated into the model. When effects of measures under various conditions are known beforehand, the operators can get an instant feedback on the consequences of their choices;
- new experiences should be stored in the system and the system should ‘learn’ from them;
- the users of the system (traffic operators) have adequate insight into the incident management process, the characteristics of the road network, the traffic conditions on it and the general effects of traffic management measures;
- there is a continuous dialogue between operator and the emergency services on the site.

The diagram in figure 2 schematises the methodological procedure used for the simulation of incident detection and management. The procedure works in the following way:

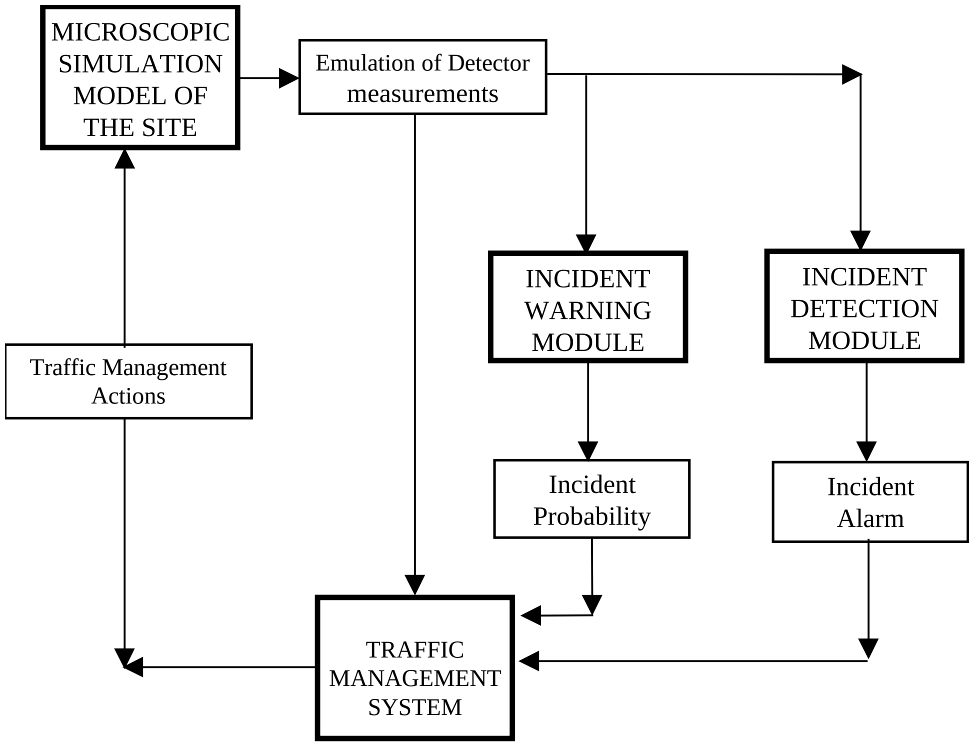

Figure 2. Metodological scheme for the simulation of incidents and incident management

- A microscopic simulation model of a site able of suitably emulating the traffic conditions on the site, after a proper calibration and validation of the model, generates traffic data: flows, occupancies, speeds, (travel times when required), at the sampling rate requested by the incident warning, incident detection and traffic management modules (for example 30 seconds is an standard request for most automatic incident detection algorithms), with the format proper of the technology used at the site.
- These traffic data feed the Incident Warning, Incident Detection and Traffic Management Modules. The simulation model should also be able of either include these modules as in-built parts of the model, or communicate with them though suitable interfaces.
- The Incident Warning applications estimate an incident probability (Wilmink and Immers, 1995) that is sent as a warning to the Traffic Management System that may take it into account.
- Incidents of varied severities can be generated either manuslly or according to probabilistic patterns.
- Once the Incident Detection Module detects an incident, it generates an incident alarm, which is sent to the Traffic Management System. The management decisions are

communicated to the simulation model through the corresponding interface, and the simulator implements them to evaluate their impact.

The microscopic traffic simulation model used in our research has been AIMSUN2 (Barceló, J. and Ferrer, J.L., 1997). AIMSUM2 models in a very detailed and realistic way the road network geometry, the behaviors of individual vehicles by means models of car-following, lane change, gap acceptance, etc., for different types of vehicles, and an exact reproduction of the traffic control strategies for the signalized intersections, ramp metering, etc. Vehicles can have specific origins and destinations and follow time dependent routes selected according to various route choice models Barceló et al. 1995). In the current version AIMSUN2 has an open software architecture that by means of a DLL library of functions can communicate with almost any type of traffic control or management system. AIMSUN2 can in this way simulate real-time adaptive control systems, as SCOOT or SCATS for example, as well as management strategies based on Variable Message Signs, speed control or any other traffic calming policies. AIMSUN2 provides these applications the required information based on an accurate emulation of the detector measurements. Incidents can be generated in AIMSUN2 models either manually, by means of the graphic editors of the GETRAM software environment (Barceló et al. 1994) in which AIMSUN2 is embedded, or interfacing an external incident generation module that could could be a function of a probabilistic generator as in the conceptual diagram in figure 2.

SIMULATION MODEL FOR A SPANISH TEST SITE

An AIMSUN2 prototype model of a Spanish Test Site has been built and calibrated (In-Response 1996/1997). A scheme of the site is displayed in Figure 3. The Valencia site comprises the ring road, the A-7 highway from Castellón to Puzol node, and the other accesses to the city. The Valencia ring road turns around the city linking all its accesses. It acts as a fundamental "by-pass" for the traffic in the North-South direction. The A7 highway has two lanes per way and covers about 54 km. The average traffic flow is 30.000 vehicles/day. Daily congestion is registered in many sections. The By-pass Highway is managed by the DGT from their Traffic Control Centre in the town. There are 58 loops traffic monitoring stations along the ring road and accesses, which measure and register all traffic variables (volume, speed, length, etc.) needed. All the information from the loop detectors is transmitted to the DGT Control Centre. There are 48 mobile cameras for surveillance installed along the ring road and accesses, including Puzol node. Fully video images are transmitted to the DGT Control Centre through optical fibre cable. There are 54 LED's signals with fully graphics and text mode capabilities installed along the ring road and the accesses. Remote control of variable messages is available from the DGT Control Centre Finally, an emergency phone, every 2 km, in each direction is installed along the whole demonstrator site.

SIMULATION EXPERIMENT

The effect of a double incident on a section of the Valencia model has been evaluated, for peak morning demand. The simulation is supposed to start at 8 o´clock a.m., the first incident is generated at 8:25am with a duration of 25 min, after 5 minutes, i.e. at 8:30am, a second incident, with 20 min duration, is generated in the same road section (identifier 949). Figure

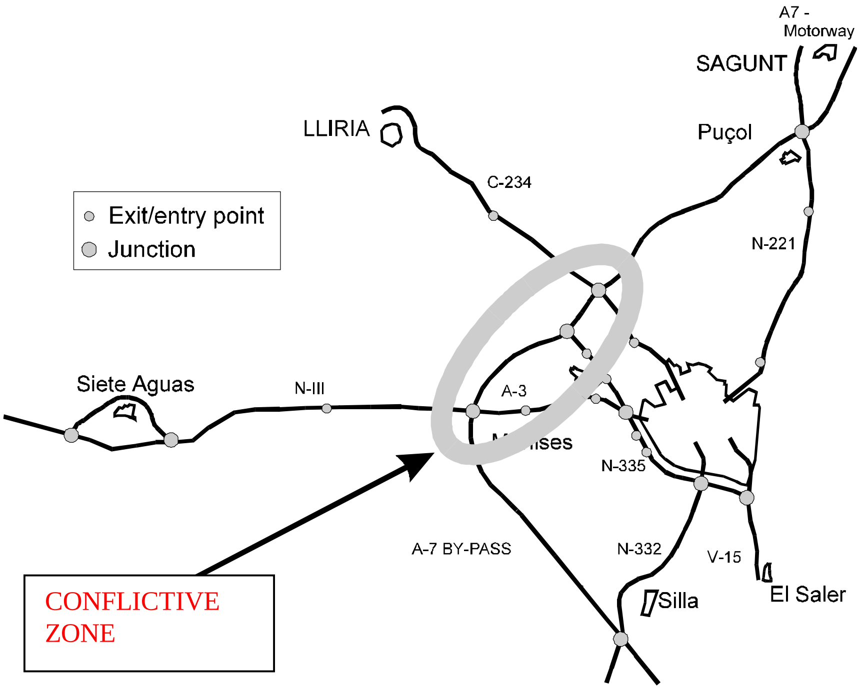

Figure 3. Valencia Test Site for simulation experiments

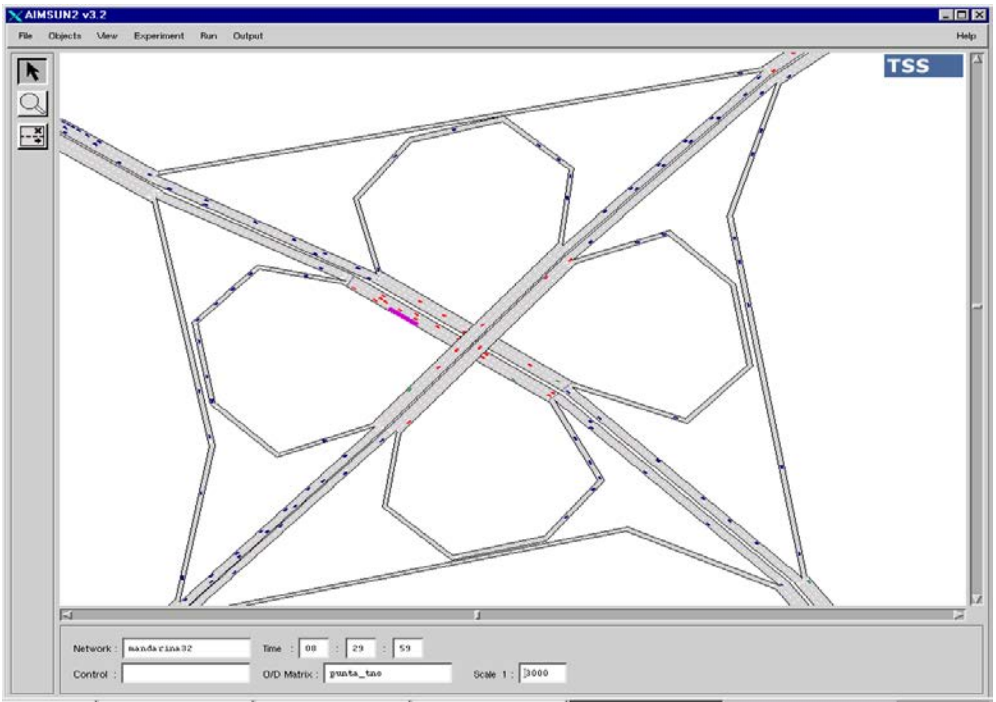

Figure 4. Valencia Test Site after the first incident generation

4 shows the state of the affected section after the first incident generation (after 8:30am). Figure 5 shows congestion effect after both incident are generated and Tables 3a, 3b and 3c present the simulation results for time 8:20 (5 minutes before the first incident), 8:30 (5 minutes after the first incident just when the second incident occurs), and 8:45, five minutes before the end of both incidents. The simulation enables not only to generate the incidents at the time and location of interest for the study (for example to analyse the propagation of

queues and congestion on the neighbour road sections), but also to define some aspects related to the incident severity as the number of lanes blocked, the length of the lane blocked and the duration of the incident.

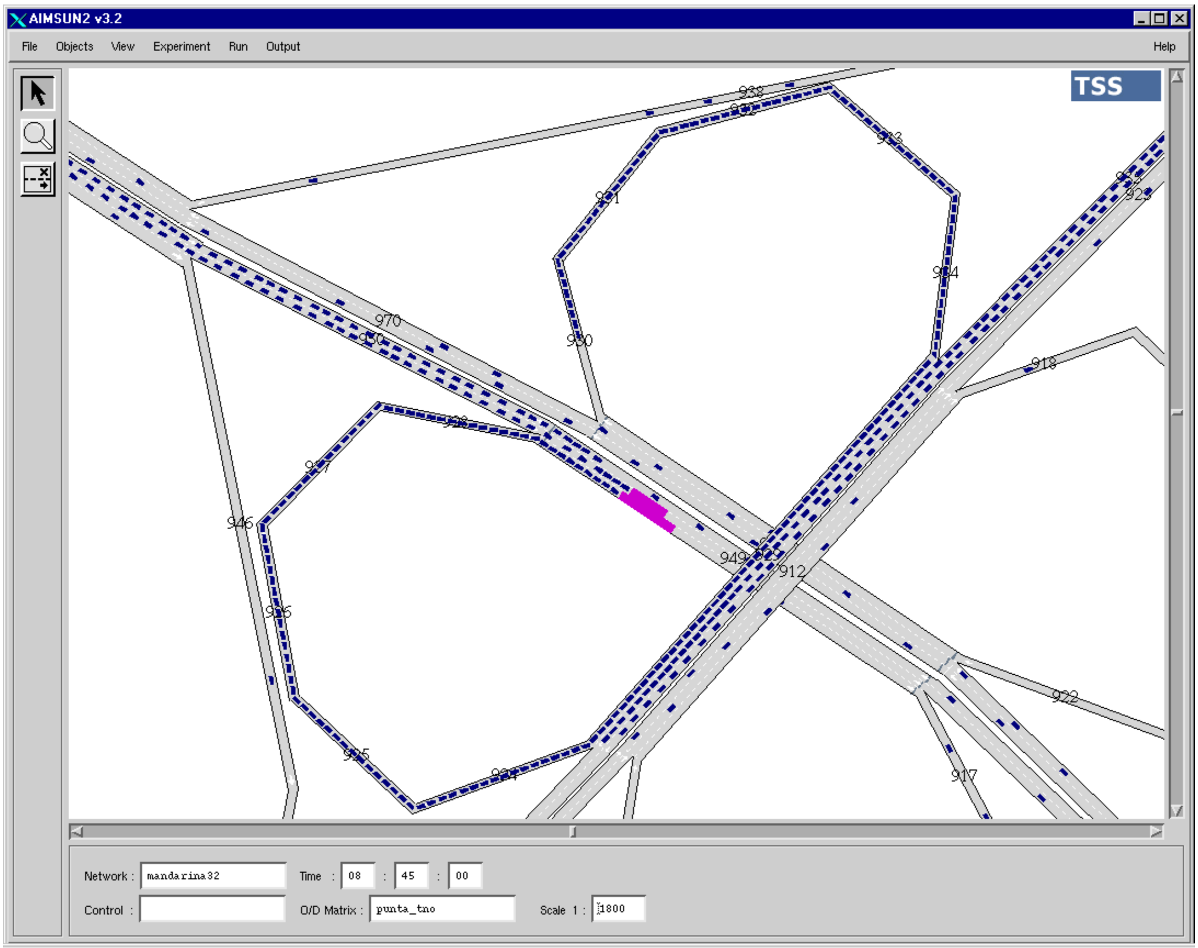

Figure 5. Valencia Test Site after the first and second incident generation (8:41am)

Table 3a: Periodical Statistics of Sections, Time : 08:20:00

	FLOW Veh/h	DENSTY veh/Km	SPEED Km/h	TRAVEL h:mm:ss	DELAY h:mm:ss	STOP h:mm:ss	STOPS #/Veh	QUEUE LENGHT Mean / Max
	------	---------	------	---------	---------	--------	-------	------------
* SECTION 950	1178	6.3	90.0	0:00:07	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 949	2476	10.7	78.8	0:00:10	0:00:01	0:00:00	0.0	0.0 / 0.0
* SECTION 935	3005	17.1	90.6	0:00:09	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 929	3678	15.1	83.3	0:00:10	0:00:01	0:00:00	0.0	0.0 / 0.0
* SECTION 924	1202	20.7	59.9	0:00:05	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 925	1226	23.8	51.9	0:00:05	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 926	1226	24.5	50.5	0:00:05	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 927	1298	25.7	49.6	0:00:05	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 928	1370	25.5	51.8	0:00:05	0:00:02	0:00:00	0.0	0.0 / 0.0
* SECTION 930	673	9.4	71.3	0:00:03	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 931	625	10.5	62.2	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 932	577	10.1	61.5	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0

* SECTION 933	553	9.0	61.3	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 934	601	10.1	56.4	0:00:04	0:00:02	0:00:00	0.0	0.0 / 0.0

Table 3b: Periodical Statistics of Sections,Time : 08:30:00

	FLOW Veh/h	DENSTY veh/Km	SPEED Km/h	TRAVEL h:mm:ss	DELAY h:mm:ss	STOP h:mm:ss	STOPS #/Veh	QUEUE LENGHT Mean / Max
* SECTION 950	1635	11.6	70.6	0:00:09	0:00:02	0:00:00	0.0	0.0 / 1.0
* SECTION 949	3270	27.0	44.4	0:00:20	0:00:11	0:00:03	0.8	0.9 / 6.0
* SECTION 935	3270	17.7	92.8	0:00:09	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 929	4039	16.0	83.9	0:00:10	0:00:01	0:00:00	0.0	0.0 / 0.0
* SECTION 924	1515	27.6	55.8	0:00:05	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 925	1539	30.2	50.0	0:00:05	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 926	1466	42.7	37.6	0:00:08	0:00:02	0:00:00	0.1	0.1 / 3.0
* SECTION 927	1418	81.8	19.1	0:00:15	0:00:10	0:00:02	1.	1.0 / 5.0
* SECTION 928	1466	97.0	15.6	0:00:19	0:00:16	0:00:03	1.2	1.4 / 8.0
* SECTION 930	697	9.6	74.5	0:00:03	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 931	673	10.4	65.1	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 932	649	10.3	64.8	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 933	625	9.7	64.0	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 934	625	11.0	57.7	0:00:04	0:00:02	0:00:00	0.0	0.0 / 0.0

Table 3c: Periodical Statistics of Sections, Time : 08:45:00

	FLOW Veh/h	DENSTY veh/Km	SPEED Km/h	TRAVEL h:mm:ss	DELAY h:mm:ss	STOP h:mm:ss	STOPS #/Veh	QUEUE LENGHT Mean / Max
* SECTION 950	1803	132.7	6.8	0:01:38	0:01:31	0:01:12	15.3	18.1 / 25.0
* SECTION 949	1947	39.4	27.7	0:00:37	0:00:27	0:00:21	2.2	5.9 / 8.0
* SECTION 935	2789	22.2	74.5	0:00:12	0:00:03	0:00:00	0.0	0.0 / 2.5
* SECTION 929	2548	113.8	18.9	0:00:58	0:00:49	0:00:25	3.0	18.2 / 29.0
* SECTION 924	168	190.6	0.9	0:05:54	0:05:48	0:05:52	1.0	16.8 / 18.0
* SECTION 925	168	192.2	0.8	0:05:32	0:05:27	0:05:32	1.0	14.7 / 15.0
* SECTION 926	144	190.5	0.8	0:05:53	0:05:47	0:05:53	1.0	15.8 / 16.0
* SECTION 927	120	195.3	0.8	0:05:43	0:05:37	0:05:43	1.0	15.3 / 16.0
* SECTION 928	120	189.4	0.8	0:05:34	0:05:31	0:05:34	1.0	14.6 / 15.0
* SECTION 930	649	9.3	72.3	0:00:03	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 931	649	10.3	62.6	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 932	649	11.0	62.6	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 933	601	10.1	61.2	0:00:04	0:00:00	0:00:00	0.0	0.0 / 0.0
* SECTION 934	601	11.1	55.1	0:00:05	0:00:02	0:00:00	0.0	0.0 / 0.0

Comparing the values for flows, speeds, queue length, etc. in the tables one can analyze the queuing and congestion building processes over time. This analysis can also be done graphically. Figure 6 displays the evolution of the flows for four selected sections, numbers 949 (incident section), 929, 933 and 926 over one hour simulate time. The first incident at 8:25 has not an appreciable impact on the capacity given that the two remaining lanes are enough to allocate the demand. A severe decrease in the flow rate is observed after the second incident as well as the secondary effects on sections 933 and 926 dropping down to zero the flow around 8:47. The graphic also shows the flow recovery after the incident.

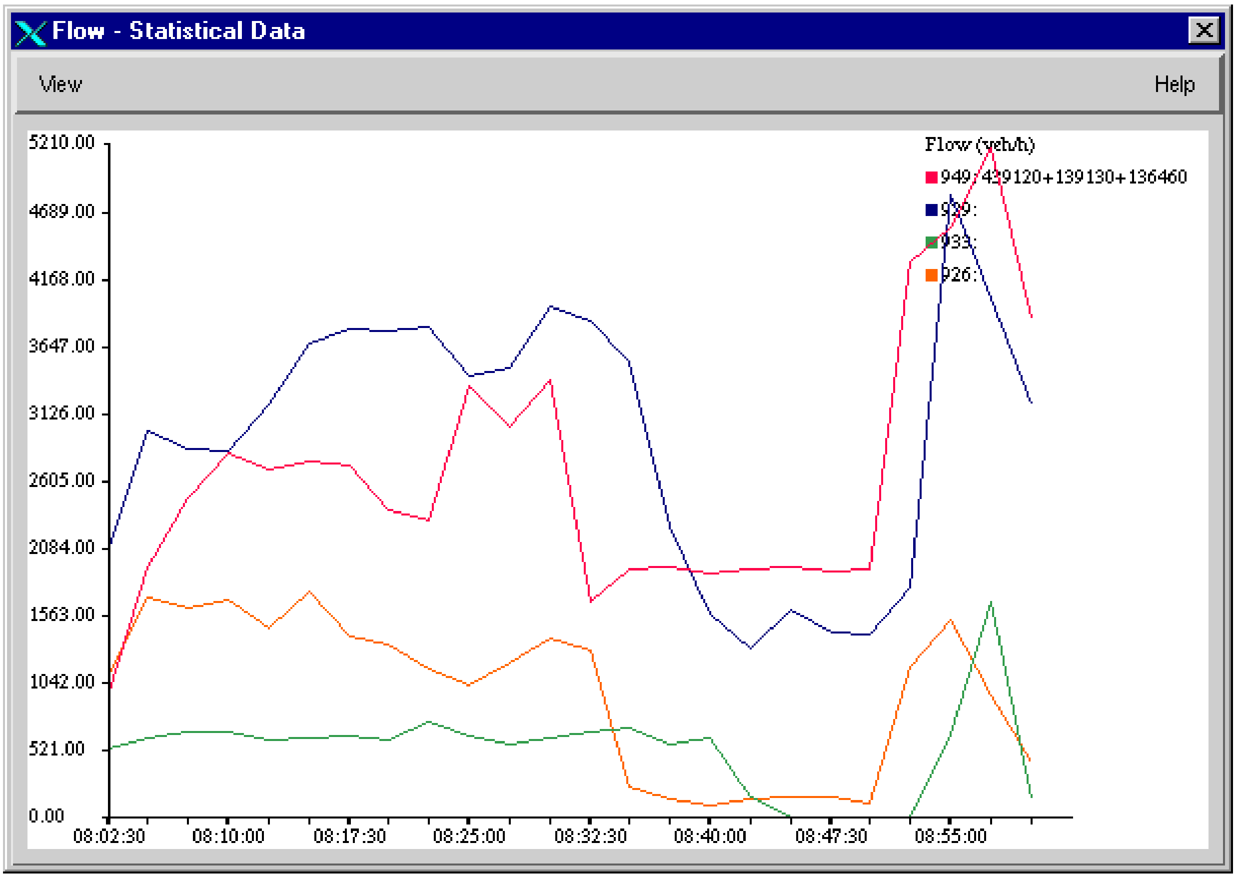

Figure 6: Flow evolution during the simulation

REFERENCES

Barceló, J., J.L. Ferrer (1997). *AIMSUN2: Advanced Interactive Microscopic Simulator for Urban Networks. User´s Manual*. Departamento de Estadística e Investigación Operativa. Facultad de Informática. Universidad Politécnica de Cataluña.

Barceló, J., Ferrer, J.L., Grau, R., Florian, M. and Le Saux, E., (1995), A Route Based Variant of the AIMSUN2 Microsimulation Model. Proceedings of the Second World Congress on Intelligent Transport Systems. Yokohama.

Barceló, J., J.L. Ferrer and R. Grau (1994). *AIMSUN2 and the GETRAM Simulation Environment. Internal Report.* Departamento de Estadística e Investigación Operativa. Facultad de Informática. Universidad Politécnica de Cataluña.

In-Response (1996, 1997) Deliverables 4.3, 5.1, 5.2 and 6.1. In-Response, EU DGXIII, TR1030.

Wilmink, I.R. and Immers, L.H., 1995, Deriving Incident Management Measures using Incident Probability Models and Simulation, TNO Research Report 95/NV/172, The Netherlands.