INFORMATION SOCIETY TECHNOLOGIES (IST) PROGRAMME

PRIME

Prediction Of Congestion And Incidents In **R**eal Time, For **I**ntelligent Incident **M**anagement And **E**mergency Traffic Management

Project reference: IST 13036

Deliverable No: D3.2

Technology Assessment and Expected Targets

Summary Report

VERSION 2.0

Technology Assessment and Expected Targets

Dissemination: Public

Submission Due Date: 30/04/00

AUTHORS

UPC: Jaime Barcelo
TRG: Andy Richards, Tom Cherrett, Mike McDonald
FORTH: Yorgos Stephanedes
TNO: Isabel Wilmink, Chris Tampere
SCC: Ray Morris
HCC: Ken Laughlin
SSP: Hanno Schellenberg
TRD: Teti Nathanail

ADMINISTRATIVE COORDINATOR:

Prof. Mike McDonald
Transportation Research Group,
Dept of Civil & Environmental Engineering,
University of Southampton,
Southampton, UK
Tel: + 44 23 8059 2192
Fax: + 44 23 8059 3152
Email: mm7@soton.ac.uk

TECHNICAL MANAGER AND TECHNICAL CO-ORDINATOR:

Prof. Yorgos Stephanedes
Institute for Computer Science
Foundation for Research & Technology Hellas,
Vassilika Vouton,
GR 711 10 Heraklion,
Crete, Greece
Tel: +30 944 444685
Fax: +30 81 391601
Email: prime@ics.forth.gr

PARTNERS

Transportation Research Group (TRG)	UK
Foundation for Research & Technology Hellas (FORTH)	Greece
Southampton City Council (SCC)	UK
Hampshire County Council (HCC)	UK
Siemens Traffic Control Ltd (STCL)	UK
ATTIKI ODOS	Greece
Kion Meletitki Ltd (KION)	Greece
Transport Research & Development (TRD)	Greece
Informatics and Telematics Ltd (ITEL)	Greece
Universitat Politecnica de Catalunya (UPC)	Spain
Transport Simulation Systems (TSS)	Spain
Ajuntament de Barcelona (AB)	Spain
SSP Consult (SSP)	Germany
TNO Inro (TNO)	Netherlands

Executive Summary

The objectives of PRIME (Prediction of Congestion and Incidents in Real Time, for Intelligent Incident Management and Emergency Traffic Management) are to:

- Develop methods for **estimating incident probability** in real-time
- Develop improved systems and algorithms for **detecting incidents**
- Improve and integrate **incident verification** techniques
- Integrate motorway and non-motorway **incident management** strategies to increase their effectiveness.

The objective of deliverable 3.2 is to:

- Review current practises in incident detection, probability estimation, verification and management.
- Identify the expected targets to be achieved in PRIME
- Describe the PRIME test sites and relevant technologies

The literature suggests that few practical applications of dynamic incident prediction algorithms have been undertaken. The evaluation of incident management strategies has also been largely simulation based. Incident detection algorithms have been well documented but their proper calibration and identification of transferability properties have suffered from a lack of effective practical testing using real incident data under common protocols. There appears to be a need to further assess the role incident prediction and detection models could play as part of an integrated network management strategy. PRIME aims to address this through the long-term collection of data at multiple sites.

The expected PRIME targets are:

Improved Sensing and Automatic Incident Detection (AID)

- Development of improved machine vision based system
- Developing and testing incident detection algorithms
- Incident detection through on-line journey time estimation

Improved Integration of Incident Verification and Dynamic Databases

- Improved integration of incident verification messages
- On-line entry of incident data to PRIME database via IVR/CTI and GPS/GSM

Models to Estimate Incident Probability

- Continue the research started under IN-RESPONSE and further develop the Multinomial Poisson and Logit Probability models.
- Design a new data collection process to operate throughout the project lifespan.
- Use AIMSUN II/RGCONTRAM to simulate and evaluate traffic management measures implemented in response to detected/predicted incidents.

Integration of Motorway and Non-Motorway Incident Management Strategies

- Develop methodologies for integrating urban and motorway based incident management strategies.
- Assess technical and institutional barriers to such integration.
- Support control centres in selecting and applying the best incident management strategy.

The PRIME test sites are key freeways and urban arterials in the sites of Southampton, Barcelona, Athens, Thessaloniki and Munich. All have CCTV, AID, VMS and vehicle detector technologies.

Table of Contents

1 Introduction

The objective of **Deliverable 3.2** (Technology Assessment and Expected Targets) is to review the current practices in incident detection, verification, integrated motorway/non-motorway management and in the estimation of incident probability. It reports on the findings from previous projects, identifies the expected targets and data available in PRIME, describes the PRIME test sites and provides guidelines for specifications. Deliverable 3.2 consists of four sections:

- Summary Report;
- Annex 1: Introduction to PRIME;
- Annex 2: Literature Review;
- Annex 3: Sites, Available Technology, Data Requirements and Targets.

This report provides a summary of the key findings from the deliverable.

2 Achievements from FP4 projects related to PRIME

A review of 4th Framework (FP4) projects related to PRIME was undertaken. The projects considered were those which participated in the 'Network and Traffic Management' Concertation area of the Telematics Application Programme (TAP). The objectives of each project, their relevance to PRIME and the key findings are shown in Table 1.

Project	Objectives	Relevance to PRIME	Key Findings/Products
KAREN	Framework design for the deployment of working ITS products up to 2010	Description of user needs for incident management systems	User needs requirements and recommendations for architecture structure
IN-RESPONSE	Develop and demonstrate tools for incident detection, prediction, verification and emergency response	1) Testing incident detection algorithms (California, Algorithms 7, 8 and Delos) using various loop detector and machine vision systems 2) Development of an incident prediction model (multiproportional Poisson model)	Incident detection algorithms were tested at 6 sites. Detection Rate reached DR=90% and False Alarm Rate reached FAR=0.1% but the two could not be achieved together and not consistently. Performance depended on the extent to which the algorithm used had been calibrated for the site.
COSMOS	To develop, verify and demonstrate new procedures for reducing and avoiding congestion in urban areas	Automatic incident and congestion detection (ACID), traffic signal control and re-routing	1) Development of strategic plans for UTC control under congested conditions 2) Urban incident and congestion detection strategies involving re-routing
EUROSCOPE	To implement and validate transport telematic systems in Hampshire/Southampton, Cologne, Piraeus, Rotterdam, Strasbourg, Hamburg, Genoa and Cork	Work Area 3: included Incident Management. AID systems trialled (BEATRICS, ARTEMIS, INGRID), Incident modelling using RGCONTRAM	1) Potential network benefits from using VMS for re-routing in incident situations 2) Incident detection possible using loop and machine vision systems
HANNIBAL	To develop and test telematic applications for improved traffic management.	Testing of different video image analysis software	Comparison testing of different machine vision software prior to purchase
ENTERPRICE	To develop EU-wide mobility and traffic information centres (MOTICs)	Using traffic information as part of an overall network management strategy	GSM based information provision to user terminals
DACCORD	Develop a dynamic traffic management system for	Short-term forecasts of flows, speeds and travel	

	inter-urban motorway corridors	times	

Project	Objectives	Relevance to PRIME	Key Findings/Products
AUSIAS	Demonstrate the benefits of integration and standardisation of different traffic control and information system technologies in Valencia	Incident management and pattern matching	Procedures for incident identification
QUARTET PLUS	Developing an Integrated Road Transport Environment (co-operative network monitoring)	Traffic management strategies	Reductions in journey times by 13% for car trips
TABASCO	The validation of multi-modal information and control systems	Traffic management and motorway incident warning systems	Slip road control, VMS control strategies.
CLEOPATRA	Field evaluation of techniques and algorithms to support guidance and information systems	Demonstration of new path flow estimator developed in MARGOT, short-term journey time prediction, prediction of incident effects using RGCONTRAM, VMS strategies	Potential savings in overall network journey times from VMS (2-4%)
ESCORT	To develop a standard interface (SIM/IPS) for connecting signal controllers to new telematic applications	AID using the INDIA4 video processing system	AID using machine vision
CAPITALS	To develop a common traffic information service platform for public and private service providers	AID using TRAFICON trialled in Brussels using PAYNE 2 algorithm	Poor system performance (Detection Rate DR=4.8%, 99% false alarm rate)
VERA	Approaches for enforcing traffic laws using video technology	Object recognition from CCTV footage	99% recognition accuracy over 24-hour period
CONCERT	Smart demand management tools for promoting public transport over the private car	(Not related to incident detection or prediction) Technologies at the Barcelona and Thessaloniki sites were used	
INFOTEN	Interconnect regional traffic information centres for the dissemination of multi-modal traffic information	(Not related to incident detection or prediction) Systems and infrastructure necessary for the dissemination of travel information	
VADE MECUM	Design study identifying user needs in network management, information provision and freight operations	User needs in network management	

Table 1: Summary of Review of FP4 Projects Related to PRIME

The review shows that several projects have addressed the subjects of incident detection and overall incident management as part of an overall network control strategy. Only the IN-RESPONSE project attempted to design and trial algorithms to estimate the probability of incidents using traffic and environmental data.

The IN-RESPONSE, COSMOS, EUROSCOPE, AUSIAS, ESCORT and CAPITALS projects all trialled incident detection systems and/or separate algorithms designed to detect abnormalities in traffic flow using data from surface mounted or machine vision detectors.

For the requirements of emergency services (IN RESPONSE), indicator thresholds for the performance of incident detection systems were defined as follows:

- accuracy in location 300 m
- detection rate 95% or better
- false alarm rate 0.1% or less
- time to detect less than 2 mins
- system unavailability less than 5%.

Detection Accuracy of 300 m was achieved at certain sites as this is a function of the location of the detectors. When detectors are spaced as per project specification, this accuracy can be achieved.

Detection Rate (DR) of 95% was not achieved. Machine vision could achieve DR=90% over long periods (Paris site). Algorithm DELOS could achieve DR=79%, and #8 DR=77% (Paris site), both at a high FAR.

False Alarm Rate (FAR) of 0.1% = 0.05 false alarms/hour was achieved by both DELOS and ALG 8 but at a low DR of 25%. Machine vision achieved 0.4 false alarms/camera/day.

Time To Detect (TTD) of 2 min. was achieved by machine vision. Owing to filtering, certain tested algorithms could not achieve better than 4 min.

System Unavailability (No failure) of 5% was achieved by certain systems.

From the above IN-RESPONSE findings, a performance of DR=95% together with FAR=0.1% at TTD=2 min, which is the performance desired by the users, has not been achieved and is still a challenge for PRIME.

The literature suggests that few practical applications of incident prediction algorithms have been undertaken. The evaluation of incident management strategies has also been largely simulation based. There appears to be a need to further assess the role incident prediction and detection models could play as part of an integrated network management strategy.

3 Additional Literature Review Material

In addition, different sources outside the FP4 projects were studied. The findings are summarised below for each of the four PRIME modules:

- Incident detection;
- Estimation of incident probability;
- Incident verification;
- Integrated motorway/non-motorway incident management.

3.1 Incident Detection Algorithms

Automatic Incident Detection (AID) involves two major elements, a traffic detection system that provides the traffic information necessary for detection, and an incident detection algorithm that interprets the information and ascertains the presence or absence of a capacity-reducing incident. The Incident Detection review describes the key algorithms that have been developed to estimate the likelihood of incident occurrence using data from a range of detectors.

Most AID algorithms have been developed based on loop detector data. Detection has typically been based on models that determine the expected traffic state under normal traffic conditions and during incidents. Comparative (or pattern recognition) algorithms establish predetermined incident patterns in traffic measurements and attempt to identify these patterns by comparing detector output against preselected thresholds. One of these involves separating the flow-occupancy diagram into areas corresponding to different states of traffic conditions (e.g., congested and not congested) and detecting incidents after observing short-term changes of the traffic state. These algorithms operate on detector output of 30-60 sec occupancy and volume data.

Time series and statistical algorithms employ simple statistical indicators or time series models to describe normal traffic conditions and detect incidents when measurements deviate significantly from model output.

A third class includes algorithms that involve macroscopic traffic flow modeling to describe the evolution of traffic variables; the diversity of incident patterns requires development of a large number of pattern-specific models and this has limited the potential of these algorithms for practical applications.

Other methods include detection of stationary or slow-moving vehicles; filtering to reduce the undesired effects of traffic disturbances; application of fuzzy sets; Transform analysis, and neural networks to take advantage of learning processes.

Recent work addressed the vehicle reidentification problem, lexicographic optimisation, and derivation of section-related measures of traffic system performance using current inductive loops that provide vehicle waveforms. Another promising recent work performs real-time detection and characterisation of motorway incidents using a three-step process, i.e., symptom identification of anomalous changes in traffic characteristics, signal processing for stochastic estimation of incident-related lane traffic characteristics, and pattern recognition.

In Europe, algorithms tested with data from loops are of the comparative type (e.g., HERMES I, German I, II and IV, Dutch MCSS), time series (GERDIEN), or the type employing filtering (HERMES II). They use typical aggregate data (speed, volume, occupancy), and aim to detect congestion, slow moving or stopped vehicles. Other AID techniques extract traffic data from radar, such as the Millimetric Radar System (MMW) and German III. Using machine vision, AID systems serve as loop detector emulators (CCATS VIP, IRB), qualitative traffic state detectors (IMPACTS) or vehicle tracking detectors (TRISTAR, CCIDS). FP4 results were summarised earlier in this Annex.

Despite substantial research, algorithm implementation has been hampered by limited performance reliability, substantial implementation needs, and strong data requirements. Several problems require the attention of developers:

False Alarm Rate (FAR). The *high number of false alarms* has discouraged traffic engineers from integrating these algorithms in automated traffic operations. Algorithm alarms typically trigger the operator's attention; *the operator verifies the validity of the alarm using closed circuit TV* cameras and decides on the appropriate incident response. In most cases, incident response is initiated only after an incident has been reported by the police or motorists.

Calibration. The need for algorithm calibration has not been extensively assessed, and lack of adequate calibration often leads to significantly deteriorated algorithm performance. Calibration by optimisation of a set of different algorithms on the same field dataset is the most reliable way for comparative evaluation across algorithms.

Evaluation. The major method adopted for comparatively evaluating the performance of AID algorithms is that of the operating characteristic curves. Performance tests have shown that:

U.S.
a. Time-series algorithms performed worse than comparative ones. b. DELOS, an algorithm based on filtering, produced at least 50% fewer false alarms than comparative algorithms, e.g., California-type. c. The time-series algorithm by Persaud et al. produced good detection rate but too many false alarms to be practical.
France
a. Comparative algorithms produced at least 30% fewer false alarms than single-variable time series algorithms (Standard Normal Deviate, Double Exponential, ARIMA), at all detection levels. b. DELOS performed better than the time-series algorithm developed by Persaud et al.
IN-RESPONSE
a. DELOS and Algorithm #8 were evaluated against machine vision methods and the results showed each to have its strengths under given conditions.
Canada
a. The time-series algorithm by Persaud et al. produced fewer false alarms than the California algorithm and was adopted as its replacement.

Transferability. Some understanding of algorithm transferability potential has been achieved, mainly in the IN-RESPONSE, HERMES, MARGOT-LLAMD and EUROCOR projects, and in a comparative evaluation in Minnesota and California (analysis of 213 incidents over 1660 hours, 24hrs/d).

Traffic Management Objectives. While most U.S. efforts seek to remove the incident and achieve smooth traffic flow, work in Europe focuses on warning drivers of congestion even if no incident has occurred, and assisting stopped vehicles. Work in rural areas has focused on achieving AID with sparse instrumentation. The latter two objectives can often best be addressed by AID systems that are based on machine vision. Such systems have achieved performance equivalent to that of loop detectors. However, the additional advantage of the new systems is that they can detect incidents that do not influence traffic substantially or that cannot be detected by loop-based systems but are still a risk to the motorist.

Addressing the need for determining improved performance of incident detection methods under varying conditions PRIME will test incident detection algorithms that have not been extensively tested in Europe, and more-advanced sensing hardware. Increased cost-effectiveness will be the focus of the hardware testing. Algorithm testing will seek to improve on the earlier performance as users have determined it with respect to the standard performance indicators of Detection Rate and False Alarm Rate on the Performance Characteristic Curves. From experience in IN-RESPONSE, the Persaud *et al.* (1990) algorithm will be given exposure in PRIME and will be compared against other algorithms as time and resources allow.

3.2 Estimation of Incident Probability

The real-time estimation of incident probability appears to be sparsely documented in the literature.

Within IN-RESPONSE a prototype of an 'incident prediction module' was developed. The core of this module consisted of a mathematical model for estimating incident probability that identified and quantified the impact of road geometry, traffic, and weather characteristics on incident probabilities. This model was used to feed an incident probability based Decision Support System (DSS) which was designed for use in traffic control centres as one of the modules of the integral control system.

The core of the DSS was the incident probability estimation model. This was a binary logit model quantifying the contribution of several exogenous variables (rain, fog, traffic volume, speeds) to the probability of an incident (the endogenous variable).

From IN-RESPONSE it was concluded that the incident probability estimation model was a promising way of linking real-time 1-minute traffic and weather data to static data on road geometry for estimating incident probability.

- The incident probability estimation model could not be properly evaluated because of a shortage of incident data and the inaccuracy of incident time stamps.

The same lack of incident data was reported by Hughes & Council (1999), (refer to Annex 2 for references). The authors present several empirical methods for analysing incident data. They used dynamic 20-second data on prevailing traffic conditions to establish relationships between those conditions and an increased likelihood of incidents.

- Similar problems were found in trying to decipher the precise time an incident occurred. A key issue raised was whether an accident was responsible for the measured variability in traffic conditions or whether these conditions were caused by the accident.

The problem of data availability was not reported by Madanat & Liu who used a similar model to that in IN-RESPONSE (binary logit) to establish relationships between incident likelihood and explanatory variables like weather and traffic conditions. The authors had over 800 incident records recorded over a period of 8.5 months.

Madanat & Liu found intuitively plausible relations confirming the expected influence of explanatory variables (temperature on overheating incidents and bad visibility on car crashes).

No other practical applications of the model have been found in the literature to reinforce these findings. The authors stated that the model was to be implemented it in a pro-active corridor-wide traffic control system for initiating control strategies to reduce the incident probability.

- The literature suggests that the current incident estimation models have suffered a lack of rigorous testing through sparse data resources. Their true performance can only be gauged through the collaborative collection of incident data from several sites as proposed in PRIME.

- A method of overcoming this shortage of incident data is to simulate incident situations. PRIME proposes to use AIMSUN II and RGCONTRAM to assess the affects of incidents at microscopic and macroscopic levels respectively. Simulation modelling incorporating simulated detector output could be a useful tool in providing a large number of incident situations for testing the incident probability models described.

3.3 Incident Verification

Incident Verification (IV) aims to accumulate evidence and information about possible detected incidents, and use this additional information to drop false alarms, merge repeated alarms and provide complete incident reports in case of real incidents.

Most countries with an operational traffic management system are using one or more incident verification methods, primarily CCTV and patrol vehicles. Realizing the potential of using cellular telephones as an incident management tool, many highway agencies have formed partnership with the cellular telephone carriers to implement programs that encourage drivers to report randomly occurring motorway incidents.

However, information obtained from cellular phones varies in the detail and quality, and the incident may be reported after considerable time has elapsed. Therefore, the feasibility of motorway surveillance systems utilizing cellular phones needs to be carefully evaluated. A survey of 42 Traffic Management Centers (TMC's) in the U.S. found that 75% use cellular detection. However, in most states, as in Texas, video cameras are deployed for verification.

Weaknesses of cellular phones include a very low rate of detecting small incidents, the highest rate of false alarms, and limited information on the incident severity. Also, cellular phone messages need further *verification* and cannot tell when the incident is cleared. Incidents reported by cellular phones show greater incident duration by 14 minutes on the average than similar incidents reported by the CHP/MSP. This extra delay is due to the incident verification process by dispatching an officer.

Cellular-phone false alarms fall in two categories: (1) reporting incorrect or incomplete information regarding the location of the incident and its severity; (2) erroneous calls including fake or prank calls. On the other hand, wireless phone users can report incidents that traditional methods cannot capture, such as debris, flooding, or wandering animals.

In the U.S., the Federal Communications Commission (FCC) adopted in 1996 a Report & Order which requires the identification of a wireless caller's phone number and physical location when dialing emergency services. Under Phase II of E911 implementation, wireless communications carriers must be able to locate 911 callers within a 125 meter radius in 67% of all cases. This requirement must be met by October 1, 2001.

Incident management requirements for incident verification within Advanced Transport Telematics (ATT) systems cannot rely solely on cellular phones. Cellular phone reports may contribute significantly to the incident detection in combination with other sources, and may be used in the verification of incidents, including those detected by other methods. This would require proper fusion of cellular phone data with information from other sources and use of appropriate technologies, such as video surveillance.

In this project, analysis of the direct interviews with representatives of the sites, and of the user needs questionnaire, concluded that:

- More-reliable incident verification is needed, paying particular attention to the location of the incident.
- There is a need for rapid assessment of the incident severity.

When all sites use the same automated and reliable procedure, consistent information about the incidents will be collected. Information that could be retrieved to verify an incident in this way can include one or more incident attributes, e.g.:

- Location (Road number, Travel direction, Km point, Lane).
- Type and severity (injuries, fire, trapped injuries, hazardous goods).
- Identity of source.
- Type of assistance needed (Mechanical, Police, Emergency).
- Certainty.

3.4 Integrated Motorway/Non-Motorway Incident Management

This review addressed the current state of world-wide non-motorway/motorway incident management systems and technologies.

EU research has concentrated largely on the role VMS can play in affecting management strategies through the re-routing of vehicles to avoid an incident. Macroscopic modelling techniques such as RGCONTRAM and SATURN have been used to determine network benefits (reductions in overall network delay) that would result if certain proportions of vehicles diverted in response to certain VMS messages.

In the case of RGCONTRAM, it was found that significant diversions at VMS could potentially produce substantial network savings in Southampton. It was concluded that a small number of well handled incidents using VMS would pay back the initial capital cost of the equipment.

In a similar test of diversion rates, the SATURN Heathrow Road Traffic Model showed that optimal numbers of diversions ranged from 2% to 62% depending on the incident severity and the network loading at the time. The SIRIUS trial in Paris showed that between 5 and 10% of motorists changed their route as a result of VMS information.

VMS appear to have potential for aiding incident management strategies. There is still a shortage of quantitative results regarding their true effect on route choice. Their effectiveness is also critical on the time lag between the incident occurrence, verification and the VMS strategy implementation.

4 Technology Review

Vehicle detection can be achieved using many different technologies. This review has covered the more traditional types (inductance loops, microwave radar, piezo cables, capacitance strips, passive infra-red, magnetometers, ultrasound) and the new emerging ‘machine vision’ technologies automatically analysing live CCTV footage.

Key detection devices to be used in PRIME are single inductive loop detectors. These are well established and are commonly used in UTC systems throughout Europe. In the case of SCOOT they provide a vehicle presence output every 250-ms. From this digital output, accurate estimates of flow, occupancy, queue intensity and headway can be derived. Accurate estimates of vehicle speed can also be deduced if the detectors have been correctly calibrated. Inductive loops have the advantage of being relatively cheap to install and maintain.

Within PRIME the AUTOSCOPE and ARTEMIS machine vision systems will also be used. These use trip wire sensing algorithms to sense pixel changes on the video footage. Vehicle presence over simulated inductance loops can be mirrored and individual vehicle speeds can also be derived. The software used in both systems can detect the presence of stationary vehicles in the field of view. The systems are beneficial in that an operator can set ‘trigger lines’ on critical areas of the road as seen through the CCTV (e.g. to detect broken down vehicles in the hard shoulder). The cost-effectiveness of such systems can improve with the incorporation of alternative camera types.

5 Expected Targets within PRIME

The following targets will be addressed during the PRIME project:

5.1 Improved Sensing and Automatic Incident Detection (AID)

- Development of improved machine vision based system;
- Developing and testing incident detection algorithms;
- Incident detection through on-line journey time estimation.

In particular, AID algorithms have been expected to reach specific targets, such as the target values that the users proposed for performance indicators in project IN-RESPONSE:

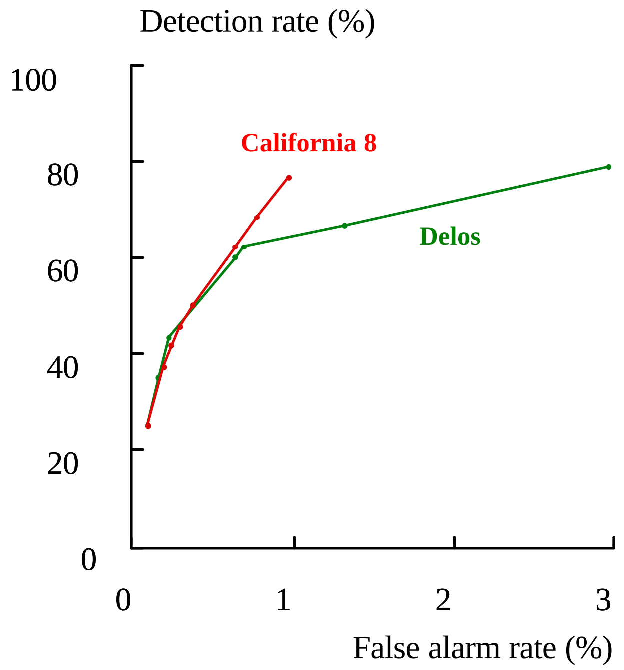
IN-RESPONSE Incident Detection Target Values of Performance

Indicator	Target values IN-RESPONSE
Detection accuracy, DA	300 m
Detection Rate, DR	95%
False Alarm Rate, FAR	0.1%
Time to Detection, TTD	2 min
System Unavailability, SU	5%

These target values proved hard to achieve individually, and impossible as a package. For example, in Paris the following performance was achieved in the project:

	SIER NETWORK				**BOULEVARD PERIPHERIQUE**	
	DELOS		**ALG 8**		**DELOS**	**Machine Vision**
DR	44%	67%	38%	77%	42%	57%
FAR	0.2%	1%	0.2%	1%	0.85%=0.4 fa/hr	4.8 false alarms/cam/day
TTD					6 min	100 sec
DA					500 m	15 m

The characteristic curves of the two main algorithms tested in IN-RESPONSE Paris site, DELOS and ALG 8, are reported in the figure below.



Performance Characteristic of incident detection algorithms at Paris site.

From the IN-RESPONSE results, it is concluded that:

Detection Accuracy of 300 m was achieved only at certain sites as this is a function of the location of the detectors. When detectors are spaced as per project specification, this accuracy can be achieved.

Detection Rate (DR) of 95% was not achieved. Only machine vision could achieve DR of 90% over long periods (Paris site). Algorithm DELOS could achieve DR of 79%, and #8 DR of 77% (Paris site), both at a high FAR (see Performance Characteristic above).

False Alarm Rate (FAR) of 0.1% = 0.05 false alarms/hour was achieved by both DELOS and ALG 8 but at a low DR of 25% (see Performance Characteristic above). Machine vision achieved 0.4 false alarms/camera/day.

Time To Detect (TTD) of 2 min. was achieved by machine vision systems. Owing to their filtering, the tested algorithms could not achieve better than 4 min.

System Unavailability (No failure) of 5% was achieved by certain systems.

From the above, a performance of DR=95% together with FAR=0.1% at TTD=2 min, which is the performance desired by the users, has not been achieved but may be impossible. A realistic target performance set for PRIME is:

PRIME Incident Detection Target Values of Performance

Indicator	Target values PRIME
Detection accuracy, DA	300 m
Detection Rate, DR	95%
False Alarm Rate, FAR	0.1%
DR and FAR	60% and 0.2%
Time to Detection, TTD	2 min
System Unavailability, SU	5%

Achievement of this target can be well established using the performance characteristic curves shown above. Improved performance curves always lie above-left of the existing.

5.2 Improved Integration of Incident Verification and Dynamic Databases

- Improved integration of incident verification messages;
- On-line entry of incident data to PRIME database via IVR/CTI and GPS/GSM.

The target of improved Incident Verification system is to retrieve information that could verify an incident:

PRIME Incident Verification Target Information

- Location (Road number, Travel direction, Km point, Lane).
- Type and severity (injuries, fire, trapped injuries, hazardous goods).
- Identity of source.
- Type of assistance needed (Mechanical, Police, Emergency).
- Certainty.

An example incident type classification, from in IN-RESPONSE, remains the target:

- Incidents that are due to vehicle breakdown.
- Accidents with material damage.
- Accidents with (fatal) injuries.
- Accidents with trapped injuries.
- Accidents with fire.
- Accidents with tilted trucks.
- Accidents with hazardous materials.
- Other incidents (too high vehicles in tunnels, fire at verge of the road, etc.).

5.3 Models to Estimate Incident Probability

- Continue the research started under IN-RESPONSE and further develop the Multinomial Poisson and Logit Probability models;
- Design a new data collection process to operate throughout the project life-span;
- Use AIMSUN II/RGCONTRAM to simulate and evaluate traffic management measures implemented in response to detected/predicted incidents.

5.4 Integration of Motorway and Non-Motorway Network Incident Management Strategies

- Develop methodologies for integrating urban and motorway based incident management strategies;
- Technical and institutional barriers to such integration will be identified;
- Support control centres to select and apply the best incident management strategy.

6 Data Requirements within PRIME

6.1 Incident Detection

Incident Detection algorithms require data on occupancy (almost all), volume (some), and speed (few). The time interval over which the control variable is averaged is in the range of 20-300 seconds and the cycle is updated every 20-60 seconds except for a few algorithms that require an update every 1-5 seconds. Detection stations are located every 500-750 meters. All algorithms require ground truth as presented in section 3.4.3 of D3.2, Annex 3.

6.2 Estimating Incident Probability

The anticipated data required for this model are:

Traffic data (per direction, and, when available, per lane):

- mean speed of all vehicles per minute, per direction and lane
- mean volume per minute
- truck percentage per minute
- mean speed difference between cars and trucks
- density
- volume / capacity ratio
- standard deviation of the mean speed

Road geometry and surface data:

- number of lanes
- change in number of lanes
- presence of on/off ramp
- presence of weaving section
- width of the right (and left) shoulder
- presence of an emergency phone
- presence of a viaduct
- presence of a baffle board / other type of visible barriers close to roadway
- pavement condition

Weather data:

- weather conditions (visibility, precipitation, wind)
- condition of the road surface (dry, wet or black ice/snow)

Incident data:

- location and direction of traffic of where the incident occurred
- date and time of the incident (preferably the exact minute)
- severity/nature of the incident

Congestion data

- time and place of occurrence
- length of queue (each time unit)
- cause of congestion

Other data:
- road works
- events

6.3 Simulation Modelling

The simulation models to be used in PRIME have the following data requirements:

AIMSUN II:

- Road geometry data (from AUTOCAD or GIS)
- Traffic control data (signal timings, turning movements, flows, speeds)
- Vehicle attribute data (length, desired speed, acceleration/deceleration, minimum headway/gap acceptance, emissions)

RGCONTRAM:

- Road geometry data (link capacities, origin-destination matrix, type of link (controlled, give-way, signalised), link length, storage capacity, saturation flow)
- Traffic control data (signal timings, turning movements, flows, speeds)
- Driver behaviour characteristics (proportion of familiar drivers who will divert on seeing a VMS message)

FLOWSIM:

- Dynamic car-following and lane-changing data (relative speed and separation to the leading and following vehicles)
- Road geometry data (link capacities, link length, storage capacity, saturation flow)

7 Site Descriptions and Available Technology

The test sites to be used in PRIME and their relevant technologies are described in Table 3.

Site Name	Site Description	Technologies
Southampton	A33 Bassett Avenue, 4-lane unsegregated dual carriageway	250-ms single inductive loops (22), ARTEMIS AID system, 2 CCTV, 1 VMS, SCOOT network, INGRID AID system
Munich	The A94 highway in the Neu Riem district of Munich	60 double inductive loops, 5 CCTV
Thessaloniki	The ERMIS system (Emergency Response and Management Information System) on the Thessaloniki freeway	CCTV, AUTOSCOPE AID system
Barcelona	The ring road which links the Ronda de Dalt, crossing the upper part of the city from the El Tibidabo hills to the Ronda Litoral running parallel to the Mediterranean shore.	12 CCTV, 18 Local Controllers, 12 Detection Stations, 10 VMS, 13 Variable Speed Signals.
Athens	A 5 km section linking the Elefsina-Stavros-Spata Airport Motorway to the Western Peripheral (ESS-IWP) Motorway	CCTV, VMS (for planned installation)

Table 3: The test sites to be used in PRIME