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

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Enhanced User Needs & Scenario Planning

Summary Report

VERSION 2.0

Enhanced User Needs and Scenario Planning

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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 3.1 (Enhanced User Needs & Scenario Planning) is to:

- Identify the PRIME 'enhanced user needs'
- Identify the PRIME test scenarios to be undertaken
- Define the techniques and assessment methods to be used for each scenario

The key results found from the PRIME 'Enhanced User Needs' Questionnaire were:

- No systems were currently in use to estimate the probability of incidents on key parts of a traffic network.

- Respondents stated that they found the concept of incident prediction interesting but few felt committed to developing incident probability estimation models themselves. They believed that such a system would be hard to develop in practise.

- Respondents were not satisfied with current incident detection or verification systems. There was a need for fast and reliable detection, reducing false alarms and increasing detector coverage over the network. Verification time needed to be reduced, and verification needed to include integration of information from different sources.

- Integrated incident management was seen as being in its infancy at most sites. To enable its faster development improved communication and exchange of data between and within management centres was needed as well as decision support mechanisms.

The following off-line scenarios will be tested in PRIME:
- **Estimation of Incident Probability** (using a probability model to be developed by TNO and UPC).
- **Incident Detection** (using hardware (360^0 camera) and software (Persaud and other algorithms) to be tested by UPC, FORTH and KION).
- **Integrated Incident Management** (using the simulation models RGCONTRAM, FLOWSIM and AIMSUN II to assess the effects of various integrated incident management strategies. To be developed by UPC and TRG).

The following on-line scenarios will be tested in PRIME:
- **Incident Detection** (using U06 SCOOT messages to estimate speed and journey time. To be developed by TRG).
- **Automated Incident Verification** (using IVR/CTI technologies to be developed by ITEL and KION)
- **Incident Management through Integrated Traffic Management Strategies** (to be developed by TRG and FORTH).

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1. Introduction

The objective of **Deliverable 3.1** (Enhanced User Needs & Scenario Planning) is to:

- Identify the PRIME 'enhanced user needs'
- Identify the PRIME test scenarios to be undertaken
- Define the techniques and assessment methods to be used for each scenario

Deliverable 3.1 consists of these sections:

- Summary Report
- Annex 1: Introduction to PRIME
- Annex 2: Results from user needs analysis
- Annex 3: Scenario Planning
- Annex 4 (APPENDIX): PRIME Questionnaire
- Annex 5 (APPENDIX): KAREN user needs overview

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

2. PRIME Enhanced User Needs

The framework for identifying user needs in PRIME was based on the established CODE guidelines. Previous user needs obtained from the related projects IN-RESPONSE, EUROSCOPE and KAREN were used in conjunction with a specific PRIME User Needs Questionnaire (Annex 4).

From the CODE guidelines the following specific objectives were identified for User Need Analysis within PRIME:

- Identify user characteristics and special needs. Users include three groups from the PRIME test sites at Southampton, Munich and Thessaloniki and two groups from the secondary sites of Barcelona and Athens.
- Identify the present service use patterns for the modules which make up an incident management system, (prediction, detection, verification and response).
- Determine the effects of service use patterns on user behaviour, attitudes, and preferences.
- Identify problems encountered by users and integrate suggestions for service improvements.
- Summarise user activities

The following summary of key PRIME Enhanced User Needs is derived from the Enhanced User Needs that were identified in Annex 2:

2.1 Estimating Incident Probability (EIP) User Needs

Users: Emergency services, Logistics/Freight companies, Traffic Control Centres, Motoring Organisations
KAREN Terminator: Driver, Emergency Systems, External Service Provider, Law Enforcement Agency, Maintenance Organisation.

Summary No.	Annex 2 No.	User Need Description
SP1	EIP7 EIP11	The system shall help in the prevention of incidents by giving warnings on dangerous road sections to enhance overall traffic safety.
SP2	EIP8 EIP11	The system shall provide real-time estimates of incident probability on individual links in the network.
SP3	EIP10	The system shall provide a graphical representation of network incident probability to the traffic operator and other relevant users (police, emergency services).
SP4	EIP12	The system should be capable of warning drivers about high incident risk situations.
SP5	EIP13	The system shall support the operator in the implementation of risk mitigating countermeasures in situations with high incident risk.
SP6	EIP14	The system shall be capable of automatically implementing pre-planned

		strategies incorporating risk mitigating countermeasures in situations where the probability of incidents is high.
SP7	EIP15	The system shall minimise the time between the detection of situations with a high incident probability and the deployment of risk mitigating countermeasures.

2.2 Incident Detection (ID) User Needs

Users: Emergency services, Logistics/Freight companies, Traffic Control Centres, Motoring Organisations, Media
Appropriate KAREN Terminator categories: Driver, Emergency Systems, External Service Provider, Law Enforcement Agency, Maintenance Organisation.

Summary No.	**Annex No.**	**User Need Description**
SD1	ID16 ID17 ID18 ID19	The system shall quickly detect the occurrence of incidents with a high detection rate and low false alarm rate
SD2	ID20	The system shall automatically trigger an alarm when an incident is detected
SD3	ID21	The system should be capable of automatically triggering follow up actions when an incident is detected (e.g. incident verification actions)

2.3 Incident Verification (IV) User Needs

Users: Emergency services, Traffic Control Centres, Motoring Organisations, Media
Appropriate KAREN Terminator categories: Driver, Emergency Systems, External Service Provider, Law Enforcement Agency, Maintenance Organisation.

Summary No.	**Annex No.**	**User Need Description**
SV1	IV22 IV26	The system shall verify that an incident has occurred and provide relevant information to help operators organise an appropriate incident response (e.g. location, type, severity, number and type of vehicles involved, need for rescue vehicles, level traffic disruption.)
SV2	IV23	The system shall collect, filter and integrate emergency calls from different sources to provide all relevant information for incident verification (e.g. video, cellular phones, service providers at the incident site.)
SV3	IV24	The system shall support communication between all parties involved in incident verification (e.g. road users, police, fire brigade, traffic management centres, and service providers.)

SV4	IV25	The system shall minimise the time between the point the incident was detected and the time it was independently verified.
SV5	IV27	The system should be capable of receiving and acting on incident verification updates to enable a reassessment of the incident response needs.
SV6	IV28	The system shall enable the collection and storage of verified incident data for evaluation purposes.

2.4 Integrated Motorway and Non-Motorway Incident-Related Traffic Management (IRTM) User Needs

Users: Police, Traffic Control Centres, Motoring Organisations, Media
Appropriate KAREN Terminator categories: Driver, Emergency Systems, External Service Provider, Law Enforcement Agency, Maintenance Organisation.

Summary No.	**Annex No.**	**User Need Description**
SI1	IM29	The system shall be able to minimise the consequences of an incident on the road network for those travellers who are not directly involved.
SI2	IM30 IM31	The system shall provide necessary information on each incident to Traffic Information Centres for onward transmission to travellers.
SI3	IM32	The system shall implement measures that improve safety at the incident location to reduce the risk of secondary incidents.
SI4	IM34	The system shall guarantee consistency in the implementation of incident related integrated motorway and non-motorway traffic management strategies at different participating control centres.
SI5	IM33 IM35	The system shall support users to select and implement incident related integrated motorway and non-motorway traffic management strategies
SI6	IM36	The system shall be able to run (pre-)defined incident mitigation traffic strategies automatically
SI7	IM37	The system shall establish an appropriate and clear organisational architecture for integrated motorway and non-motorway traffic management
SI8	IM39	The system shall enable a Traffic Control Centre operator to improve control of traffic responsive infrastructure elements for incident-related traffic control (e.g. variable message signs, intersection control, ramp metering, etc.) in both motorways and non-motorway networks
SI9	IM40	The system shall collect and store all relevant data for post incident evaluation of incident related integrated motorway and non-motorway traffic management strategies (e.g. traffic conditions before, during and after the incident and the implementation of measures.)

The following conclusions were drawn from the PRIME User Questionnaire:

Estimation of incident probability

- The responses suggested that no systems were currently in use to estimate the probability of incidents on key parts of a traffic network.

- Respondents stated that they found the concept interesting and that their current management systems that would act in anticipation of incident conditions need improvement.

- Few respondents felt committed to developing incident probability estimation models themselves. (Site representatives believed that the concept of estimating the likelihood of incidents was valid but that such a system would be hard to develop).

Incident detection

- Respondents were not satisfied with current incident detection systems. There was a need for fast and reliable detection. Where possible the detection of incidents should be automated, with a special attention being given to:

  ⇒ Increasing detection rates
  ⇒ Lowering false alarm rates
  ⇒ Extending the size of the network under automated detection
  ⇒ Maximising cost effectiveness

Incident verification

- Respondents were not satisfied with current incident verification systems. (Current systems often took a long time before all information needed to organise an appropriate response had been confirmed). Subjective judgement was felt to play a large part in current system operation.

- The key areas that needed improvement were:

  ⇒ Reliability of the information coming from different verification sources
  ⇒ The time before an incident is officially verified must be reduced
  ⇒ Automation of the verification process.

Integrated incident-related traffic management

- The results suggest that integrated management is in the early stages of development at most sites. Improvements that could contribute to better integration of incident management strategies on motorways and non-motorway networks were:

  ⇒ Better organisation and delegation of responsibilities
  ⇒ Better communication and exchange of data between and within management centres
  ⇒ Development of common integrated management strategies
  ⇒ Provision of improved decision support to select and implement common integrated traffic management strategies.

3. Scenario Planning

The following off-line and on-line scenarios will be tested within PRIME.

3.1 Off-Line Scenarios

3.1.1 Estimation of Incident Probability

Objective:

- According to the prevailing traffic/environmental conditions, estimate the probability of reduced vehicle throughput and speed and increased congestion and/or
- Estimate the probability of incidents occurring as a result of these conditions.

Developer:
TNO, UPC

Test Site:
Thessaloniki, Barcelona

Methodology:
The sites will provide the necessary data to enable satisfactory testing of the incident probability models developed by TNO and UPC.

The data requirements for the model will be **incident data** (location, severity, start time, end time, duration, type), **link specific data** (geometric characteristics of the road, gradients, curvatures), **traffic data** (flow, occupancy, speed), **environmental data** (wind speeds/directions, rain precipitation, temperature, level of light, degree of visibility) and **other parameters** (proportions of HGVs, towing vehicles, dangerous cargoes)

The sites will provide these data to the developer in the format specified by the developer.

The model will give estimates of the probability of incidents occurring from the data supplied.

Evaluation:
Where recorded data include an actual incident, the incident probability model will be evaluated according to its success in estimating whether this event was likely to occur.

The simulation model AIMSUN II will be used to simulate localised effects of management strategies designed to remove traffic onto neighbouring links when the likelihood of incidents increases.

3.1.2 Incident Detection

Objective:

- Trial a new compact machine vision system incorporating a 360^0 lens camera for detecting incidents using the AUTOSCOPE software.
- Test the accuracy of the Persaud and Hall incident detection algorithm (and any new algorithms) using data from the PRIME test sites.

Developer:
UPC, FORTH, KION

Test Site:
Thessaloniki, Barcelona, Munich, Athens, Southampton

Methodology:

- The AUTOSCOPE automatic incident detection software will be tested using a 360^0 camera which is being provided through FORTH. The likely test site for this will be Athens. The software will be installed into the existing system architecture in place at the site and real-time pre-recorded images from the camera assessed. A qualitative and quantitative evaluation of the suitability of the camera for operation with the AUTOSCOPE software will be made.

- All the sites will be asked to collect data for testing the Peraud and Hall (and new) incident detection algorithms. The data requirements for the model will be **incident data** (location, severity, start time, end time, duration, type), **link specific data** (geometric characteristics of the road, gradients, curvatures), **traffic data** (flow, occupancy, speed), **environmental data** (wind speeds/directions, rain precipitation, temperature, level of light, degree of visibility) and **other parameters** (proportions of HGVs, towing vehicles, dangerous cargoes)

Use the AIMSUN II microscopic traffic simulator to:

- Replicate conflicting traffic situations for which incidents have been recorded in a historical database.
- Use a subset of these replications to calibrate thresholds and parameters for the algorithms. Three alternatives are being considered:

  ⇒ Investigate the performance of algorithms based on Catastrophe Theory to distinguish between incident congestion and recurrent congestion.

  ⇒ Use a related algorithm for comparison. (A local implementation of DELOS is being considered as it has already been tested as part of IN-RESPONSE).

  ⇒ Use a machine vision system (AUTOSCOPE) on a section of the site to gather comparative data.

• Use the remaining subset of the data to evaluate the performance of the subsystem (false alarm rate, detection rate, time to detection)
Evaluation: Where recorded data include an actual incident, the algorithm will be evaluated according to its success in detecting the incident. Other performance indicators will be false alarm rate, detection rate, time to detection (in relation to the actual time of the incident) and incident duration. The performance of the AIMSUN2 simulation model will not be evaluated explicitly.

3.1.3 Integrated Incident Management

Objective:
In *Southampton*, evaluate the potential benefits of integrated incident management policies incorporating Variable Message Signs (VMS) using simulation techniques.

In *Barcelona*, evaluate and assess the potential impacts and benefits from alternative incident management strategies using the AIMSUN II simulation model.

Developer:
UPC, TRG

Test Site:
Southampton, Barcelona

Methodology:

Southampton
At the Southampton site the RGCONTRAM (Route Guidance CONtinuous TRaffic Assignment Model) model will be used to:

- Simulate VMS and potential/real-life driver response to potential incident scenarios, providing quantitative estimate of network benefits.

- Explore the benefits of potential improved incident detection. (For instance, parameters within the model include the start and end time of the incident, and the start and end time of the VMS message). These can be varied to assess the potential effects of improved incident detection time and hence earlier setting of VMS messages and, therefore, diversions. There is potential to incorporate real-life findings from incident detection trials.

FLOWSIM (Fuzzy LOgic motorWay SImulation Model) is a microscopic model, which was originally developed to investigate driver behaviour on motorways, but has recently been adapted for use on non-motorway roads as well. It will be used to:

- Investigate the localised effects of potential incidents occurring on a single link, in particular, a motorway. This could include recovery time and queue propagation along the link.
- Where appropriate, results from other scenarios (particularly the incident detection modules) could be externally assessed for localised situations using FLOWSIM.

Barcelona
Various combinations of three incident management strategies will be assessed:

- Information and route recommendations using VMS
- Speed control using Variable Speed Signs
- Access control based on ramp metering strategies at the equipped entry ramps

The scenarios will be assessed for the traffic conditions used to calibrate the basic simulation model. The main objective of the simulation experiments are:

- Estimate the potential benefits of the single factors and the combination of factors with

respect to the do-nothing scenario.

- Estimate the effects of a timely identification of incidents in combination with the design factors.
- Derive rules for establishing management strategies.

The results of the simulation analysis and assessment of scenarios will be the basis for a decision making process which could lead to a real-life implementation of the defined management strategies.

Evaluation:
This scenario will focus on assessing the effects of incident detection and incident-related traffic management applications. The performance of the RGCONTRAM, FLOWSIM and AIMSUN II simulation models will not be explicitly evaluated.

3.2 On-Line Scenarios

3.2.1 Incident Detection (through journey time estimation)

Objective:

- Use the 250-ms binary data provided by SCOOT type single inductive loops to provide journey time estimates every 30-seconds. This will be done using two estimation techniques (a mechanistic approach and a neural network model). Use these estimates for identifying possible traffic incidents.

- Use the ALOTPV (average loop-occupancy time per vehicle) and AHTBV (average headway time between vehicles) algorithms to determine when incidents and periods of abnormal congestion have occurred over single inductive loops.

Developer:
TRG, STCL

Test Site:
A33 Southampton

Methodology:

- Peak-period (07:00 – 09:15) M24, U06 and U07 data will be collected through the ROMANSE central processor for the detectors on the Southbound section of the A33. These data are used to estimate journey times using two models (a mechanistic journey time estimator written in Fortran77 'M24' and a neural network journey time estimator) developed under an EPSRC 'LINK' project. Measured journey times will be collected through registration plate recognition.

- Potential incidents on the A33 which affect traffic flow and increase journey times include scheduled bus stops (the A33 has 4 bus stops Southbound), pedestrian crossings and illegally stopped or right turning vehicles.

- Such events will be identified in the U06/U07 data which provides speed, flow, percentage occupancy of the detector, ALOTPV and AHTBV data every 30-seconds from all the loop detectors on the link. The ALOTPV data are used to estimate journey time in the two techniques mentioned. An assessment will be made of the relevant merits of each parameter for identifying incidents.

- The U06/U07 data will be collected on a daily basis for 8-12 months along with video footage from the two cameras for verifying incidents when they occur.

- The most effective parameter for identifying incidents/congestion will be used in the development of a graphical interface to be incorporated into the existing control room infrastructure. This will provide enhanced decision support to aid network management.

Evaluation:
The performance of the loops in identifying incidents will be assessed according to the false alarm and detection rates determined by the CCTV cameras. The system incident detection time and the total duration of the incident will be compared to reality. A range of incident types will be covered (stopped vehicles, pedestrian activity, and vehicle-on-vehicle accidents) and an additional performance index assigned to each event.

3.2.2 Automated Incident Verification by IVR/CTI Systems

Objective:

- Test the potential for IVR/CTI and GPS/GSM for incident verification in comparison to regular GSM.
- Improve the quality of incident verification data

Developer:
ITEL, KION

Test Site:
Athens

Methodology:
A system will be designed to allow mobile phone users to enter details of road incidents directly into a control centre database using Interactive Voice Response/Computer Telephony Integration (IVR/CTI). The concept involves a user providing specific incident details described by a recorded voice, giving option responses by pressing appropriate numbers on the mobile phone handset.

A second system involving combined GPS/GSM will be tested to see if accurate incident location can be derived from this technology.

Evaluation:
Likely performance indicators would be the percentage of incorrect information supplied by the systems, the ease and speed of information transfer by users.

3.2.3 Incident Management through Integrated Incident-Related Traffic Management Strategies

Objective:

- Improve traffic flow and reduce congestion during incidents.
- Reduce the likelihood of secondary incidents and reduce the negative impact of an incident.

Developer:
TRG, FORTH

Test Site:
Southampton. Munich, Thessaloniki, Athens

Methodology:

- According to the incident information produced by the various PRIME scenarios (incident probability, detection and verification), the sites will develop decision support systems enabling a more structured response to overall incident management.
- As part of the decision support system the sites will design a framework of the most appropriate incident control strategies using the traffic control technologies already in place at the site (e.g. VMS, speed control and ramp metering).
- Where situations allow, the network control centres at each site will trial these strategies under real-life conditions and evaluate their effectiveness. (In the case of Southampton, it is planned to gather O-D data for specific junctions on the M27 feeding the inner city and determine the likely effectiveness of various incident diversion strategies in these areas using RGCONTRAM.)

Evaluation:
Where possible the effectiveness of these strategies will be assessed using simulation (AIMSUN II and RGCONTRAM) to determine the reduction in network delay over a 'do-nothing' scenario.