Realising Advanced Incident Detection on European Roads

http://www.fehrl.org/raider

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Realising Advanced Incident Detection on European Roads

Toon Beeks - Project Coordinator

Deliverables:

• User Needs and Requirements
  – Stakeholder Workshop
  – Public report D2.1

• Generic Specifications for Incident Detection Systems
  – Public report D4.1
  – Stakeholder Webinar

• Summary Report with final results and recommendations
  – Public report D5.1

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Outline

• Project Objectives and Results
• Methodology and Tools
• Conclusions and Recommendations on innovative technologies
• Example - Use Case to assess technologies
Improve quality of Incident Detection

- Improve detection performance
  - Detection Rate (DR)
  - Detection Accuracy, including Location Accuracy (LA)
  - Detection Time (DT)
  - False Alarm Rate (FAR)

- 3 types of incidents
  - Accidents (major and minor accidents)
  - Broken down vehicles
  - Extraordinary congestion (including Automatic Incident Detection AID)

- Innovative technologies for the near future - 2020
  - Road side systems (video, radar, laser, BT, ...)
  - In-vehicle systems (Cooperative Systems with G5, 3G)
  - Nomadic devices (3G)
System concepts for incorporating innovative technologies

- Generic Specifications of system concepts
  Specification the performance and costs
  in generic terms of the system configuration

- Examples Use Cases for the decision process of NRAs

<table>
<thead>
<tr>
<th>Road Network</th>
<th>Traffic Volume</th>
<th>Existing Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorway without hard shoulder</td>
<td>High</td>
<td>Inductive loops @ 500m</td>
</tr>
<tr>
<td>Motorway with hard shoulder</td>
<td>High</td>
<td>Electronic Tolling system</td>
</tr>
<tr>
<td>Motorway with hard shoulder</td>
<td>Low</td>
<td>-</td>
</tr>
<tr>
<td>Secondary road</td>
<td>High</td>
<td>-</td>
</tr>
<tr>
<td>Secondary road</td>
<td>Low</td>
<td>-</td>
</tr>
</tbody>
</table>
How to derive integrated innovative technologies in detection systems?
How to define Generic Specifications of the performance and costs?

System Configuration
- Defines the main components and their composition
- Defines the technology, configuration choices and main parameters
  - Penetration rate of equipped vehicles (PEV)
  - Spacing or density of road side detectors (DENS)

Needed:
- Models to estimate detection performance in terms of the configuration
- Models to estimate costs in terms of the configuration

Approach:
- Qualitative models for performance and costs
- Guestimates can be updated for specific situation and products
System Configuration

Data Source -> Data Fusion Algorithm -> Incident Detection Algorithm -> Detection alarm
**System Configuration**

Data Sources:
- Sensor, event detector or traffic detector
- Technology

Data Types:
- Vehicle Incidents
- Vehicle tracking
- Traffic Data (point measurements)
- Travel Time

Incident Detection Algorithms:
- Accident detection
  - Incident event
- Tracking anomaly
- Breakdown detection
- Extraordinary Congestion

Flowchart:
- Data Source → Data Fusion Algorithm → Incident Detection Algorithm → Detection alarm
System Configuration

**Data Sources**
- eCall
- Cooperative Systems
- Nomadic Devices
- Scanning Radar
- Video Tracking
- Inductive Loops
- Tolling Systems
- ANPR
- Bluetooth Scanners

**Data Types**
- Vehicle Incidents
- Vehicle tracking
  - Cooperative Systems
  - Service Providers
  - Road side tracking
- Traffic Data (point measurements)
  - Service providers
  - Road side detectors
- Travel Time

**Incident Detection Algorithms**
- Accident detection
  - eCall
  - Cooperative Systems
  - Nomadic Devices
  - RS Vehicle Tracking
- Breakdown detection
  - Cooperative Systems
  - Nomadic Devices
  - RS Vehicle Tracking
- Extraordinary Congestion
  - Vehicle Tracking
  - Traffic Flow
  - Travel Time
### Cooperative Systems

<table>
<thead>
<tr>
<th>Performance criterion for accident or breakdown detection</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DENS&lt;sub&gt;RIS&lt;/sub&gt;</strong></td>
<td>Density of RIS</td>
</tr>
<tr>
<td><strong>DR&lt;sub&gt;A&lt;/sub&gt;, DR&lt;sub&gt;B&lt;/sub&gt;</strong></td>
<td>Detection Rate</td>
</tr>
<tr>
<td><strong>DT&lt;sub&gt;A&lt;/sub&gt;, DT&lt;sub&gt;B&lt;/sub&gt;</strong></td>
<td>Detection Time with G5 V2I communication to a RIS (configuration option 1)</td>
</tr>
<tr>
<td><strong>DT&lt;sub&gt;A&lt;/sub&gt;, DT&lt;sub&gt;B&lt;/sub&gt;</strong></td>
<td>Detection Time with cellular network communication to a service provider (configuration option 2)</td>
</tr>
<tr>
<td><strong>FAR&lt;sub&gt;A&lt;/sub&gt;</strong></td>
<td>False Alarm Rate for accidents</td>
</tr>
<tr>
<td><strong>FAR&lt;sub&gt;B&lt;/sub&gt;</strong></td>
<td>False Alarm Rate for breakdowns</td>
</tr>
<tr>
<td><strong>LA&lt;sub&gt;A&lt;/sub&gt;, LA&lt;sub&gt;B&lt;/sub&gt;</strong></td>
<td>Location accuracy of on-board positioning</td>
</tr>
<tr>
<td><strong>VC</strong></td>
<td>Vehicle class</td>
</tr>
<tr>
<td><strong>DG</strong></td>
<td>Dangerous goods</td>
</tr>
</tbody>
</table>

*IR* = Incident Rate for Accidents (A) or Breakdowns (B)
### Qualifications

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection Rate (DR)</td>
<td>&lt;= 50%</td>
<td>&gt; 50%</td>
<td>&gt; 80%</td>
<td>&gt; 99%</td>
</tr>
<tr>
<td>Detection Time (DT)</td>
<td>&gt;= 5 min</td>
<td>&lt; 5 min</td>
<td>&lt; 1 min</td>
<td>Low</td>
</tr>
<tr>
<td>Location Accuracy (LA)</td>
<td>&gt;= 100 m</td>
<td>&lt; 100 m</td>
<td>&lt; 10 m</td>
<td>&lt; 1 m</td>
</tr>
<tr>
<td>False Alarm Rate (FAR)</td>
<td>&gt;= 25</td>
<td>&lt; 25</td>
<td>&lt; 2.5</td>
<td>&lt; 0.25</td>
</tr>
<tr>
<td>Suitability</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td></td>
<td>(Does not satisfy all high priority requirements)</td>
<td>(Satisfies all high priority minimum requirements)</td>
<td>(Satisfies all minimum performance requirements)</td>
<td>(Satisfies all performance requirements)</td>
</tr>
<tr>
<td>Costs</td>
<td>€€€€</td>
<td>€€€</td>
<td>€€</td>
<td>€</td>
</tr>
</tbody>
</table>

## Performance Assessment

### Accident Detection (by 2020)

<table>
<thead>
<tr>
<th>Technology</th>
<th>DR</th>
<th>DT</th>
<th>FAR</th>
<th>LA</th>
<th>Vehicle Class &amp; Dangerous Goods</th>
<th>Suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>eCall</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Both</td>
<td>Low</td>
</tr>
<tr>
<td>Cooperative Systems configuration 1 (ITS G5 + RIS)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Very High</td>
<td>Both</td>
<td>Low</td>
</tr>
<tr>
<td>Cooperative Systems configuration 2 (3G)</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Very High</td>
<td>Both</td>
<td>Low</td>
</tr>
<tr>
<td>Nomadic Devices</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>Scanning Radar</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Very High</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>Video Tracking</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Very High</td>
<td>Both*</td>
<td>High</td>
</tr>
</tbody>
</table>

### (by 2030)

<table>
<thead>
<tr>
<th>Technology</th>
<th>DR</th>
<th>DT</th>
<th>FAR</th>
<th>LA</th>
<th>Vehicle Class &amp; Dangerous Goods</th>
<th>Suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>eCall</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Both</td>
<td>Medium</td>
</tr>
<tr>
<td>Cooperative Systems configuration 1 (ITS G5 + RIS)</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Very High</td>
<td>Both</td>
<td>Very High</td>
</tr>
</tbody>
</table>
Conclusions & Recommendations

- eCall
- Cooperative Systems
- Nomadic Devices
- Road side tracking systems
Reliable detections of major accident on entire road network

+ Low False Alarm Rate and high Location Accuracy
+ At minimum costs for the NRA
± Detection Time depends on communication via PSAP
- Low-medium Detection Rate as it only supports major accidents
- Low penetration rate $\text{PEV}_{\text{eCall}} = 10\%$ by 2020 is likely to increase
- Additional provisions needed by NRA to receive information from PSAP

Recommended as reliable source for major accident detections on entire network
  – Included as an option for all Use Cases
Best detection performance on entire network after 2030 when penetration rate is sufficiently high

+ Most reliable detections for all incidents considered

Two configurations:

1. NRA installs road side units and ITS G5 communication on critical network locations
   + Very high detection performance (> eCall, Nomadic Devices, ...)

2. NRA uses cellular network communication or service providers
   + Full network coverage
   + Low costs for the NRA

Recommended as replacement and deployment strategy for incident detection beyond 2020

+ Penetration rate is likely to increase significantly to high Detection Rates
Nomadic Devices

Medium detection performance for all incidents on entire network by 2020 at low setup and maintenance costs for the NRA

- Reliability of accident and breakdown detections is variable due to differences in devices, sensors, vehicle mounting, etc., resulting in higher False Alarm Rates and additional operations costs for incident verification

- Low Detection Rates due to low penetration rate of service users \( (\text{PEV}_{\text{ND}} = 10\%) \) in the scattered market of applications and services

\[\pm\] Detection Time depends on service provider and cellular network communication

Recommended as a low cost solution with medium detection performance in all Use Cases

+ Detection rates increases significantly when the market of applications and services can be harmonised
Video Tracking and Scanning Radar provide high quality detection of accidents and breakdowns by 2020

Preference for Video Tracking (VT) or Scanning Radar (SR) is Use Case specific

Recommended for high quality accident and breakdown detection on critical locations of the road network
Example

How to use the Generic Specifications to assess innovative technologies

1. Use Case of existing situation
2. Requirements for desired situation
3. Options for incident detection systems
4. Assessment of system configurations
1. Use Case

- Motorway with hard shoulder running
- High traffic volume
- Existing systems
  - Inductive Loops @ 500m on every lane
  - CCTV for hard shoulder monitoring
2. Requirements

Priorities

1. Accidents and breakdowns
   1. Very high Detection Rate: DR > 90% (80%)
   2. Low Detection Time: DT < 10 sec (1 min)
   3. Medium False Alarm Rate: FAR
   4. High Location Accuracy: LA = lane level (< 1 m)
   5. Vehicle class (HGV) and dangerous goods

2. Extraordinary Congestion
   If additional detection is required then for minimal costs
## 3. Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Technology</th>
<th>Suitability</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Accidents</td>
<td>Breakdowns</td>
</tr>
<tr>
<td>1</td>
<td>Inductive Loop Detectors</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Upgrade for tracking</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fusion of ILD and RS tracking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>eCall</td>
<td>Low¹)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>2020 (PEV = 10%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>Medium¹)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Nomadic Devices</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>events</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RS vehicle tracking of nomadic devices</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traffic Data, FCD, Travel time data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Cooperative systems</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Configuration 1 (ITS G5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2020 (PEV = 5%)</td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Configuration 2 (3G)</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>5</td>
<td>Video Tracking</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>(upgrading CCTV system)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Scanning Radar</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
3 System Configurations for 2020 and beyond:

A. Nomadic Devices
   + Minimum setup and maintenance costs for NRA
   - High operational costs for incident verification
   - Medium detection performance (< Reqs)
     ➢ Increase penetration rate of service users

B. Cooperative Systems
   + Very high detection performance in 2030 (>= Reqs)
   - Low detection rate by 2020 (< Reqs)
     ➢ Replacement strategy for existing infrastructure

C. Road side tracking systems
   + High detection performance in 2020 (= Reqs)
   - High setup costs
     ➢ Video tracking as upgrade of CCTV is more cost-effective option over scanning radar
RAIDER delivered a methodology and tools to support an NRA in the specification of incident detection systems

- Objective assessment of alternative innovative technologies on the basis of performance and cost criteria.
- Scaling of performance and costs for system configuration parameters
- Technology Library with fact sheets for innovative technologies
Thank you for your attention

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