Optimized traffic control with benchmarked road weather data

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FUNCTIONALITY OF TRAFFIC CONTROL

critical road weather & surface condition

Data quality?

Detection by stationary sensor systems

Detection of erroneous measurements

Plausibility checks for road weather data [technical bulletin, 2010]

Control algorithms in traffic control centres

Interpretation & reaction to the results

Benchmarking system

Variable Message Signs (VMS): Warnings, Speed limits

⇒ maximized benefit of the plausibility checks
GERMAN TEST SITE FOR ROAD WEATHER STATIONS

www.vt.bv.tum.de/umfelddaten
GERMAN TEST SITE FOR ROAD WEATHER STATIONS
Situated on motorway A92 near Munich Airport

• Evaluation of different sensor systems from various companies under same weather conditions
  → Published in annual reports (http://www.vt bv.tum.de/abschlussbericht )

• Development of plausibility checks for aggregated weather data:
  – Single Measurement checks
  – Logical-physical coherence checks
  – Long-term plausibility checks
  → Published in a technical bulletin (2010) [FGSV, issue 306]

• Integration of plausibility checks into traffic control centres
• Implementation of automatic plausibility analysis for aggregated data
  → Data Distribution Tool
BENCHMARKING CONCEPT

Conventional traffic control set-up according to German Technical Bulletin

Conventional system set-up

- Data acquisition
- Data aggregation
- Data transfer
- Plausibility control
- Data processing
- Control algorithm

Benchmarking Concept

- FMEA*
- Knowledge Base*
- Severity of error
- Substitute Value
- Service-Level
- Appropriate reaction to disturbance
- Information to the operator
  - prompt reaction
  - soon reaction
  - reaction at next service

* prior input from traffic engineer needed
FAILURER MODE AND EFFECTS ANALYSIS (FMEA)
Concept: failure prevention instead of error correction

Analysis of potential failure
which can be incurred:
→ random error
→ systematic error
→ missing data

Preparation and Planning
identify of main measures for traffic control

Risk assessment and evaluation
Occurrence (O)
Severity (S)
Detection (D) of a failure
= Risk Priority Number (RPN)
⇒ RPN = O * S * D

FMEA workflow

Evaluation of FMEA
Feedback from operators
Actualization of Service-Level and disturbance

Improvement of Quality
Development of the detection and
Enhancing the acceptance of VMS

Benchmarking and Selection
Appropriate reaction to disturbance

CHAIR OF TRAFFIC ENGINEERING AND CONTROL
Univ.-Prof. Dr.-Ing. Fritz Busch
**POTENTIAL ERRORS: MEASUREMENT RANGES**

Definition of risk priorities of failure modes:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Occurrence (O)</th>
<th>Severity (S)</th>
<th>Detection (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Very high:</td>
<td>Very critical:</td>
<td>Unlikely:</td>
</tr>
<tr>
<td>9</td>
<td>Frequent failure</td>
<td>Direct influence on traffic control</td>
<td>No plausibility check available</td>
</tr>
<tr>
<td>8</td>
<td>High:</td>
<td>Critical:</td>
<td>Incidental detection</td>
</tr>
<tr>
<td>7</td>
<td>Repeated failure</td>
<td>Indirect influence on traffic control</td>
<td>at service work</td>
</tr>
<tr>
<td>6</td>
<td>Moderate:</td>
<td>Moderate:</td>
<td>Plausibility check or</td>
</tr>
<tr>
<td>5</td>
<td>Occasional failure</td>
<td>Influence on plausibility check</td>
<td>Information from road</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>of a primary measurement</td>
<td>Information from road</td>
</tr>
<tr>
<td>3</td>
<td>Low:</td>
<td>Influence on plausibility check</td>
<td>Few plausibility checks</td>
</tr>
<tr>
<td>2</td>
<td>Relatively few failures</td>
<td>of a secondary measurement</td>
<td>available</td>
</tr>
<tr>
<td>1</td>
<td>Unusual failure</td>
<td>No influence on traffic control</td>
<td>Evident failure</td>
</tr>
</tbody>
</table>

RPN = O * S * D

*high RPN: high importance, high priority
additional check of single highly ranked factors*
PRIORITY AND USAGE OF MEASUREMENT PARAMETERS

- **Visibility**
- Precipitation type
- Precipitation intensity
- Water film thickness
  - For automatic traffic control

- Status of road surface
  - Freezing temperature
  - …
  - For semi-automatic traffic control (winter time)

- Air temperature
  - Air humidity
  - …
  - For plausibility checks

Risk Priority Number (RPN)

- **High**
- **Low**
DETAILED RPN CALCULATION
Detailed analysis of single measurements concerning the possible failure types and plausibility checks

<table>
<thead>
<tr>
<th>measurement unit: visibility</th>
<th>O</th>
<th>S</th>
<th>D*</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>random error / systematic error</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>relevant time period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>measurement value is too high</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>192</td>
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<tr>
<td>measurement value is too low</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>relevant measuring range for traffic control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>measurement value is too high</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>224</td>
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<td>2</td>
<td>5</td>
<td>5</td>
<td>50</td>
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<tr>
<td>not relevant time period</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>not relevant measuring range for traffic control</td>
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<td>160</td>
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<td>measurement value is too low</td>
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<td>3</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>missing data</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>relevant time period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>measurement value is too high</td>
<td>10</td>
<td>1</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>measurement value is too low</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>27</td>
</tr>
</tbody>
</table>

*dynamic adaptation; here the range of most of the failure is shown

Is the measured data..
- within the relevant time period?
- within the range for traffic control?
- too high or too low?

How many plausibility checks identified erroneous data?

- Risk factors are set every minute and a new RPN is calculated
- classification of RPN based on the experiences from the German Test Site
ONLINE QUALITY MONITORING USING SERVICE LEVELS

- Service-Levels are uniform agreements on the desired quality of data and equipment
- Disturbances are identified promptly
- Using Service-Levels helps to detect:
  - failure of equipment
  - low data quality
  - lack of data
- Example: Service-Level on the quality of data:
  **Classification of service levels**
  - Data are completely plausible
  - Data are largely plausible
  - Data are not plausible
  - No information on quality of data
- System “tracks” the “history” of a reported error until successful removal of the cause
CONCLUSION AND OUTLOOK

• Development of benchmarking system to maximize benefits from plausibility checks
• Improvement of interpretations and decisions
• Proposal of appropriate reactions on individual errors and disturbances

• Next steps:
  • Implementation of benchmark system
  • Software implementation of schematic procedures

EXPECTED BENEFIT

• Enhancement of the acceptance of traffic control systems
• Increasing of traffic safety on motorways during adverse weather situations
THANK YOU FOR YOUR ATTENTION

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