Information, Warning and Intervention strategies – an overview of the Human Factors work done in interactIVe

Emma Johansson, Volvo Group Trucks Technology

interactIVe Final Event

20th-21st November 2013
Outline

• Work process

• Information, Warning and Intervention (IWI) strategies

• Testing (lab, test tracks)
Work process

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Information, Warning and Intervention (IWI) strategies

- **IWI** strategies should:
  - define the actual function from a driver’s perspective
  - explain how, when and where information, warnings and interventions should be activated
  - specify the appropriate type of interaction
    - Information and Warnings, which can be visual, acoustic or haptic
    - Interventions via active steering, braking or accelerating
Information, Warning and Intervention (IWI) strategies

**Perception Platform**
- Vehicle Filter/State
- Enhanced Vehicle Positioning
- Frontal Object Perception
- Road Edge Detection
- Assignment of Objects to lanes
- Relative Position to the Road of the Ego vehicle
- Moving Object classification
- Environment
- ADASIS Horizon

**Application Platform**
- Target Selection
- Threat Assessment
- Trajectory Planning/Control
- Vehicle Control

**IWI Controllers**
- Steering Actuator
- Brake Actuator
- External Lights

**Driving strategy**
- Sound, visual, haptic
- Steering, braking

**IWI manager**
- Sound, visual, haptic
- Steering, braking
- ...
Information, Warning and Intervention (IWI) strategies

• General IWI strategies → Design Handbook with Human Factors related requirements

  • Main issues and Research questions

  • Findings in literature and expert opinion

• Strategies

  • IWI strategies applied to demonstrators → Functional Requirements
Information, Warning and Intervention (IWI) strategies – design categories

- Sequence of interaction
- Arbitration
- State, Modes and Mode Transitions
- Prioritisation and Scheduling
- Layer of driving tasks
- Level of Assistance & Automation

- Communication channel
- Communicate System Status
- Adaptivity and Adapability
- Trust, Mental workload, Situation Awareness, Driver mental model
Information, Warning and Intervention (IWI) strategies – examples

• **Range of Operation and Availability:**
  - 'Indicate system availability status' [ROA02]

• **Communication channel**
  - 'Use the output channel that should be used for performing the wanted action by either the driver or the system' [CC25]

• **States, Modes and Mode Transitions**
  - 'Single assistance functions and their states are grouped into one concept' [SMT05]
  - Use interlocked transitions [SMT08]
<table>
<thead>
<tr>
<th>ID</th>
<th>General strategy</th>
<th>Explanation with references</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC x</td>
<td>Locate auditory warning signals so that they appear to come from in front of the operator if this is where the hazard is. Locate the warnings close to head height.</td>
<td>Directional warnings have shown to decrease response times ([Ho et al. (2005)]).</td>
</tr>
<tr>
<td>CC y</td>
<td>Position visual display/labels/warnings to ensure proper association</td>
<td>Drivers will assume a relationship between objects based on their spatial proximity ([Salvendy (1997)]). “The law of proximity”: We tend to group things together that are close to each other. If a button is marked TC and is placed near the climate panel, it might as well be Temperature Control.</td>
</tr>
<tr>
<td>CC z</td>
<td>Keep consistency in semantics for all functions indicating same thing. Distinct signals for distinct meaning.</td>
<td>In order to harmonise interfaces and to save physical space, if for example a vibration is used to indicate “danger”, then it should not be used in another context such as an indication or a question [Kelsch (2011)]. Another example is audio or haptic vibration and/or force in steering wheel for lateral support ([ISO17361 (2007)]). Visual information close to or in frontal windshield along with auditory information for longitudinal support. Or make use of distinct output and input channels E.g. lateral problems by haptic information on steering wheel, longitudinal problems by haptic information on pedals. Different beeps for lateral/longitudinal. Make the same functions use the same output/input devices, e.g. forward collision warning the same for different systems e.g. CMW (warning part) and RECA.</td>
</tr>
<tr>
<td>CC n</td>
<td>Do not use one master alarm for all warnings, nor too many different warnings.</td>
<td>Results from a study [Green et al. (2008)] ruled out the use of four individual warnings (one each for LDW, CSW, FCW, and LCM). An analysis that led up to the experiment discouraged the use of a single warning to represent all subsystem warnings collectively. Solution: using two warnings, one for longitudinal and one for lateral threats.</td>
</tr>
</tbody>
</table>
Testing IWI strategies

- 10 simulator and test track experiments +
- Experiments in collaboration with demonstrator owners
Testing IWI strategies: **Steering avoidance**

**Research questions**

- Does drivers accept a *sudden* steering avoidance maneuver?
- Can drivers be *convinced* of system initiated steering maneuver by *prompts/directed warnings* before intervention (directed double tics in steering wheel, acoustic warning)
- Can drivers be *de-coupled* for a short period in order not to counteract the system intervention?
- **Controllability** issues?
Testing IWI strategies: **Steering avoidance**
Testing IWI strategies: **Steering avoidance**

% of drivers w collisions

Baseline no intervention

Steering intervention

<table>
<thead>
<tr>
<th>Exp. 1</th>
<th>Exp. 2</th>
<th>Exp. 3</th>
<th>Exp. 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>62.5%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Exp. 1 (driver coupled) 47%

Exp. 2 (driver coupled) 50%

Exp. 3 (driver decoupled) 7%

Exp. 4 (driver decoupled) 7%

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Testing IWI strategies: **warning modalities in single and multiple threat events**

**Research questions**

- **What warning modalities** are effective in different use cases and **compatible** with drivers’ reaction?

- **How many modalities** are useful for each function and in **multi-event** scenarios?

- Are there different **warning modalities** suitable for **early** and **late** warning stages?
Testing IWI strategies: **warning modalities in Single-Event scenarios**

- Rear End Collision
- Dangerous Curve
- Blind Spot
Testing IWI strategies: *warning modalities in Single-Event scenarios*

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Performance data</th>
<th>Subjective data</th>
<th>Final Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear-end Collision</td>
<td>- Visual &amp; Haptic</td>
<td>- Visual</td>
<td><img src="image" alt="Rear-end Collision" /></td>
</tr>
<tr>
<td></td>
<td>- Pedal</td>
<td>- Pedal or Acoustic</td>
<td></td>
</tr>
<tr>
<td>Dangerous curve</td>
<td>- Visual &amp; Pedal</td>
<td>- Visual</td>
<td><img src="image" alt="Dangerous curve" /></td>
</tr>
<tr>
<td></td>
<td>- Pedal</td>
<td>- Pedal or Acoustic</td>
<td></td>
</tr>
<tr>
<td>Blind spot</td>
<td>- Visual &amp; Acoustic</td>
<td>- Visual</td>
<td><img src="image" alt="Blind spot" /></td>
</tr>
<tr>
<td></td>
<td>- Acoustic</td>
<td>- Wheel or Acoustic</td>
<td></td>
</tr>
</tbody>
</table>

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Testing IWI strategies: **warning modalities in Multiple-Event scenarios**

Rear End Collision and Blind Spot
Testing IWI strategies: **warning modalities in Multiple-Event scenarios**

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<th>Scenario</th>
<th>Performance data</th>
<th>Subjective data</th>
<th>Final Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late “Red” warning Rear End and Blind Spot</td>
<td>- Visual &amp; Haptic pedal</td>
<td>- Visual &amp; Haptic pedal</td>
<td>- Soft Haptic Pedal only when fatigued</td>
</tr>
<tr>
<td>Early “Yellow” warning Rear-end</td>
<td>- Visual &amp; Haptic Pedal</td>
<td>- Visual &amp; Haptic Pedal</td>
<td>- Visual &amp; Haptic Pedal only when fatigued</td>
</tr>
</tbody>
</table>
Testing IWI strategies: **Haptic Pedal Warnings**

- Driver reaction in a **Curve Speed Warning** scenario
  - with or without additional **acoustic** and **visual** feedback
- **Haptic signal** at the **accelerator pedal** either:
  - **Double Tic**,  
  - **Vibration**, or  
  - **Counterforce**
- \( V = 120 \text{km/h} > V_{\text{max(curve)}} \)
- **Pedal Warning**
  - issued 2 seconds before
Testing IWI strategies: Haptic Pedal Warnings

<table>
<thead>
<tr>
<th>Counterforce (C)</th>
<th>Vibration (V)</th>
<th>Doubletick (DT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.27</td>
<td>2.12</td>
<td>2.17</td>
</tr>
<tr>
<td>0.00</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>1.50</td>
<td>2.00</td>
<td>2.50</td>
</tr>
<tr>
<td>3.00</td>
<td>STD ERROR (+/-1)</td>
<td></td>
</tr>
</tbody>
</table>

STD ERROR (++/-1)

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<tr>
<th>Counterforce (C)</th>
<th>Vibration (V)</th>
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<tbody>
<tr>
<td>1.31</td>
<td>1.32</td>
<td>1.27</td>
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<tr>
<td>0.00</td>
<td>0.50</td>
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<tr>
<td>1.50</td>
<td>2.00</td>
<td>2.50</td>
</tr>
<tr>
<td>3.00</td>
<td>STD ERROR (+/-1)</td>
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STD ERROR (++/-1)
Common design elements: challenge!

interactIVe functions

Integrated design concept
Visual design elements
Haptic design elements
Auditory design elements

- Common **auditory** elements for information, warnings and interventions
  - Function status sounds (e.g. functions activated/de-activated, transition refused)
  - Warning sounds
    - Lateral:
      - E.g. Run-off road (RORP), Blind spot (SIA)
    - Longitudinal:
      - E.g. Rear-end collision (RECA), oncoming vehicle collision (OVCA)
Testing: wrap up

- 10 experiments (9 in simulators, 1 on test track) + a range of tests in collaboration with the demonstrator owners
- 400+ test participants at 10 test sites

Research topics:

- Steering Intervention
  - in lateral threat situations
  - in rear end collision or intersection scenarios
    - with coupled & de-coupled drivers
- Acceptance and effectiveness
  - Multiple warning events,
  - Pre-warnings and Warnings
- Haptic pedal signals for longitudinal warning scenarios
- Evaluation of Visual Concepts
  - Comprehensibility & Mode Confusion