Monitoring Driving Behaviour:
Encouraging CMV Safety Through Technology, Behaviour Change, and Safety Culture

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Behaviour Change and Behaviour-Based Safety

- Human Factors R&D in Driver Safety
- Program Evaluation
- Program Development
- Accident Case Analysis
- Safety Climate and Culture
Active vs Passive Safety

Fix the Vehicle & Roadway?

or

Fix the “Nut Holding the Steering Wheel”?

“...our society knows a great deal more about building safer machines than it does about getting people to behave safely”.

Ralph Nader 1967
Fixing the Nut Isn’t Easy
The Driver is a Complex Machine

<table>
<thead>
<tr>
<th>Skills and Capabilities</th>
<th>Motivation</th>
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<tbody>
<tr>
<td>Knowledge</td>
<td>Emotions</td>
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<td>Cognitive processing skills</td>
<td>Confidence</td>
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<td>Attentional skills</td>
<td>Goals and Objectives</td>
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<td>Anticipation skills</td>
<td>Basic drives</td>
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<td>Perceptual skills</td>
<td>Values</td>
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<td>Decision skills</td>
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<td>Psycho-motor skills</td>
<td>Social influences</td>
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<td>Self-control skills</td>
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<td>Beliefs</td>
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<td>Biases and Illusions</td>
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Some aspects of human factors are important and often forgotten:

Channel Capacity

• Human information processing capacities, even in a highly-capable individual under optimal conditions, have fundamental limitations.

Task Demand

• These limitations may be exceeded within the range of predictable operational demands.

Individual Differences

• These basic sensory, mental and psycho-physical capacities vary greatly between individuals and within the same individual at different times.
Behaviour Analysis Perspective

Safety is a continuous fight with human nature, because:

- At risk behaviours often result in quick and certain positive consequences (e.g., comfort, convenience, efficiency)
- At risk behaviours rarely result in quick and certain negative consequences (e.g., injury, discipline)
- Safe behaviour is usually more uncomfortable, inconvenient, and time consuming than at risk behaviour.

(Hickman and Geller, 2003)
The driver's own actions determine the difficulty of his task. Driving is essentially a self-paced activity. Because of this … motivation is at least as important, if not more so, than limitations of perceptual-motor capabilities…” (Ray Fuller, 1984)
**MOTIVATION: A Closer Look**

**Personal Motivators –**

*Internal*
- Values
- Autonomy
- Target risk
- Sensation seeking

*External*
- Incentives
- Disincentives
- Feedback
- Approval

**Biases and Illusions**
- Optimism Bias
- Control Illusion
- Depersonalize Risk

**Social Activators –**
- Responsibility
- Leadership
- Community Values
- Active Caring
Effective Behaviour-Based Safety

- Coordination of influences
- Evidence-based methods
- Technical excellence
- Multi-level commitment
- Continuous evaluation & improvement

Organizational Behaviour Change

Individual Behaviour Change
CMV Safety Management

TRB review of CMV safety management cites key areas:

• Driver hiring practices
• Employee training
• Fatigue management programs
• Driver wellness programs
• BBS methods
• Monitoring driver performance
• Employee retention programs
• Safety equipment and systems
• Vehicle maintenance and inspection

Bergoffen et al., TRB Circular 2007
Monitoring of driver performance can extend more traditional VDR and EDR benefits and support technical excellence, if it:

- Is part of a comprehensive behavioural safety program
- Is developed within a solid safety climate and culture
- Concentrates on feedback and positive coaching
- Is acceptable to drivers and other employees
Potential Benefits

Safety & Cost Savings

• Property damage
• Human life
• User costs/delays
• Environmental liability
• Tort Liability
• Insurance costs
• Loss of mobility/efficiency
• Capital infrastructure costs
• Fuel savings
• Vehicle wear and tear
• Driver retention
PATH Prototype Monitoring Systems

- Cummins C-Clect+ Engine ECU
- Vehicle-to-Vehicle Communication System
- WABCO “Euro” EBS
- Accelerometer and Gyroscope
- Lidar and Radar Sensors
- PC104 Control Computer
- Magnetometer Sensor Array Bar
- Steering Actuator
Behavior-based safety approach to onboard driver-monitoring requires four steps:

• Identify behaviors which may be precursors to increased crash rates.
• Determine cost-effective ways to monitor safe and unsafe behaviors.
• Determine the best way to provide the driver with feedback which rewards safe behavior and discourages unsafe behavior.
• Establish management and driver acceptance to the program.
Monitoring CMV Driving

- Speed Selection – maximum or relative
- Vehicle location & tracking
- Dynamics – lateral, longitudinal
- Lane Tracking – LDWS
- Following – FCWS
- Rollover Risk – RSC
- Alertness, fatigue – PERCLOS
- Attention, distraction – devices, eye position
- Hours of Service – EOBR
# Speed Selection

<table>
<thead>
<tr>
<th>Core Behaviour</th>
<th>Parameters to be Monitored</th>
<th>Required Sensors or Subsystems</th>
<th>Potential Driver Feedback</th>
<th>Potential Driver Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed Selection</td>
<td>Speed versus:</td>
<td>Vehicle J-bus GPS Database of Speed Limits Road Surface Weather Radar or Lidar Accelerometer</td>
<td>Visual feedback of recommended and maximum speed limits</td>
<td>Summary metrics such as the time spent over the speed limits</td>
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<td>- Speed Limit</td>
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<td>- Traffic Flow</td>
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<td>- Curve Speed</td>
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<td>- Road Surface</td>
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<td>- Grade</td>
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Speed Parameters

*Speed limit*
- Wheel speedometer, GPS system, and GIS information

*Safe curve speed*
- Speedometer and rollover stability advisor

*Speed relative to roadway condition*
- Stored regional weather map, wiper usage, and thermometer

*Speed relative to traffic flow*
- Speedometer and Radar/Lidar

*Following distance*
- Stored regional weather map, wiper usage, thermometer, speedometer, and Radar/Lidar
## Following Behaviour

<table>
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<th>Potential Driver Feedback Offline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Following Behavior</td>
<td>Following Distance</td>
<td>Forward-Collision Warning System (FCWS)</td>
<td>Visual feedback of following time-gap shown and approaching too fast</td>
<td>Summary of time spent following too closely, number of warning incidents, video review of warning incidents</td>
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<tr>
<td></td>
<td>Forward-Collision Warnings</td>
<td>Radar or Lidar Video Recording</td>
<td>Auditory alerts for following too closely and approaching too fast</td>
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<td>Driver Response to Cut-ins</td>
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# Attention/Distraction

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</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>Road/Lane Departures</td>
<td>Road Departure Warning System (RDWS or LDWS)</td>
<td>Visual and auditory alerts of lane departures or eyes-off-the-road for too long</td>
<td>Summary metrics such as the frequency of lane departures, hard braking, and hard steering incidents</td>
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<td></td>
<td>Hard Braking Events</td>
<td>Accelerometer</td>
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<td>Hard Steering Events</td>
<td>Steering Angle</td>
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<td>Eye-Off-the-Road</td>
<td>Steering Gyro</td>
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<td>Video Recording</td>
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<td>Eye/Face Tracking</td>
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# Fatigue

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</thead>
<tbody>
<tr>
<td>Fatigue</td>
<td>Road/Lane Departures</td>
<td>RDWS/LDWS</td>
<td>Visual and auditory alerts of lane departures, lane weaving, eye closure, and HOS compliance</td>
<td>Summary metrics such as the frequency of lane departures, hard braking, hard steering incidents, and HOS compliance</td>
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<tr>
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<td>Lane Position</td>
<td>Eye Tracking</td>
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<td>Hard Braking</td>
<td>Accelerometer</td>
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<td>Hard Steering</td>
<td>Steering Angle</td>
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<td>Eye Closure (PERCLOS)</td>
<td>Steering Gyro</td>
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<td>HOS Compliance</td>
<td>Video Recording</td>
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<td>EOBR</td>
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Complex Monitoring System

The PATH prototype OBMS consists of six subsystems:

- Core system
- Sensing equipment
- Data storage devices
- Real-time feedback devices
- Driver input devices
- Offline analysis tools
OBMS Engineering Guidelines

Barr et al. say an effective system must:

• Measure what is intended, operationally (e.g., eye blinks) and conceptually (e.g., alertness).
• Monitor driver behavior in real time.
• Be consistent in its measurement over time and for all drivers.
• Operate in daytime and night-time illumination.
• Produce audible warnings not startling to the user.
• Operate over the range of truck cab temperature, humidity, and vibration.
• Minimize missed events (false negatives) and false alarms (false positives).
• Operate with only normal maintenance and replacement costs.
OBMS Functionality

OBMS operating modes:

• Driver identification

• Monitoring, recording, and as available, real-time feedback during normal driving conditions

• Incident and event recording

• Reporting (generated from system logs)

• Idle mode (when ignition is off)
Vendor Effectiveness Claims

Substantial Crash reductions are reported by system vendors – in this case InThinc
Hickman and Hanowski (2009) found:
• Safety Critical Events down 38-52%
• Coaching added value to feedback

Battelle (2007) reported that systems helped drivers:
• Keep a safe following distance
• Improve reaction time
• Increase awareness when distracted.

But it’s early days as this technology rolls out and expands in scope.

Critical reviews and watching briefs required.
Monitoring Purchase Decision Factors

Purchase decision factors for telematics and on-board driver support systems:

- Price
- Testing, evaluations, reviews, driver feedback
- Ergonomic considerations (readability, simplicity, ease of use)

(CTA Survey, in Thiffault, 2011)
Thiffault’s massive 2010 review concludes:

- There is a clear connection between safety and culture;
- Safety culture is defined by an organization’s norms, attitudes, values and beliefs;
- Top down safety communication/interaction enhances SC;
- Organization subgroups can have their own specific SC;
- Rewarding safe behaviors is an effective component of SC;
Driver experience enhances SC, therefore high turnover rates have a negative impact on SC, and most likely on safety;

SC communication needs to be dynamic and multilevel, given the remote workforce characteristic of the CMV industry;

Policies, procedures, responsibility need to be clear and simple;

Hiring and training are key components of SC;

Monitoring safety performance of drivers and carriers as a whole is key to SC.
Driver perception of safety culture in CMV operations is most strongly influenced by:

- Driver safety training
- Driver autonomy regarding safety
- Opportunities for safety input (driver empowerment)
- Top management commitment toward safety

(Thiffault, 2011)

Strong safety climate and culture =

- Use the best BBS methods
- Use the best available technologies
Incentives

Incentive effects are powerful, but not automatic. Maintaining maximum effect depends on many factors:

- Reward characteristics
- Reward size
- Contingency criteria
- Performance period/frequency
- Group performance
- Organizational levels
- Operating rules & procedures
- Progressive rewards
- Progressive criteria
- Perceived equity
The Virage VS600M is built with real truck components on a three degree of freedom motion /vibration platform and surround sound. Learners have a 180-degree forward field of view plus rear view mirrors and the manual shifter provides realistic force feedback and vibrations.
Simulator training is the other very promising technology, enabling drivers to:

- Experience a wide variety of driving situations in a compressed time period
- Receive precise, accurate, objective feedback on performance, including replays and detailed analyses
- Practice the correct behaviours again and again with random situational variations in order to assure that mastery is achieved

Also, simulators and CBT can train fundamental cognitive and perceptual capabilities, such as attention.
There is No Silver Bullet

We need to maximize the benefits of:

- Passive and active approaches to safety
- Crash prevention and damage mitigation
- Human factors and technology
- Human skills and motivations

- Emerging technologies in monitoring and simulator training, when integrated into effective BBS are pretty close to silver.
Questions?
## General Safety

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<tbody>
<tr>
<td>General Safety</td>
<td>Seat Belt Use</td>
<td>Safety Belt Monitor</td>
<td>Visual and auditory alerts if</td>
<td>Summary metrics such as time spent</td>
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<td></td>
<td>Lane Change Turn Signals</td>
<td>Video Recording</td>
<td>safety belt is not used</td>
<td>using the safety belt and the</td>
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<td></td>
<td>Blind Spot Check Mirror</td>
<td>RDWS/LDWS</td>
<td>Visual feedback on other parameters</td>
<td>other listed parameters</td>
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<td>Adjustment</td>
<td>Eye/Face Tracking</td>
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<td>Fuel Economy</td>
<td>Accelerometer</td>
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<td>Engine speed</td>
<td>Vehicle J-bus Access</td>
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<td>Acceleration</td>
<td>MiscWire Taps</td>
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<td>Deceleration</td>
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<td>Gear selection on grades</td>
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