Written Evidence to the Standing Senate Committee on Transport and Communication

Bill C-49, an Act to amend the Canada Transportation Act and other Acts respecting transportation and to make related and consequential amendments to other Acts (short title: Transportation Modernization Act).

Assoc. Professor Guy Walker
Heriot-Watt University
Edinburgh
[UK]EH14 4AS

Scope of Written Evidence

I wish to thank the Standing Senate Committee on Transport and Communication for inviting me to provide written evidence on Bill C-49 Transportation Modernisation Act. I am Associate Professor Guy Walker from Heriot-Watt University in Edinburgh, Scotland. I am a leading academic in the Ergonomics and Human Factors discipline and have undertaken a considerable amount of research in the rail sector, particularly around the issue of data recording.

My background enables me to comment on the measures proposed for the installation of Locomotive Voice and Video Recorders (LVVR) and the use of data obtained therein. My background is largely based on work undertaken in the UK context and, for full disclosure, my research in this area was funded by the UK Economic and Physical Sciences Research Council (EPSRC) under Grant Reference EPSRC EP/I036222/1. This project explored how data, routinely collected from On-Train Monitoring and Recording devices, could be used in an integrated way as part of a new Rail Data Monitoring (RDM) process. The outputs of this project are publically available (see below).

Summary of Main Points

1. **HUMAN PERFORMANCE IN RAILWAY SYSTEMS**: The International Ergonomics Association (IEA) defines ergonomics (or human factors) as the scientific discipline concerned with the understanding of interactions among humans and technologies. It is about the application of theory, principles, data and methods to design in order to optimize human well-being and overall (in this case railway) system performance.

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1 The terms Ergonomics and Human Factors are used interchangeably. The latter is used in this Evidence
2. **HUMAN VERSUS SYSTEM ERROR:** Bill C-49 is explicit in its aim of enhancing safety. Human error is often diagnosed as a root cause of railway accidents but it is important to highlight that the underlying issues are more complex. Human behaviours, including those categorised as human error, occur within a wider engineering and regulatory context. The engineering and regulatory context in which people are placed can enhance or restrict their safety behaviours, often in ways that are unexpected, unintentional, and both challenging to analyse and predict. Despite the inherent appeal of LVVR technology, the information collected only gains its true value by being coupled to an underlying Human Factors science-base. Experience and ‘common sense’ is not sufficient, on its own, to advance a safety agenda using in-cab voice and video data.

3. **MORE DATA BUT FEWER ACCIDENTS:** The ability to collect data using technologies such as LVVR has never been greater, yet the need to analyse such data in the case of an actual serious accident, has also never been lower. This is because railway safety globally has shown an improving trend for over 50 years.

4. **STRATEGIC SAFETY ISSUES ARE CHANGING:** Progress in railway safety has served to expose a number of challenging issues. Firstly, evidence across a range or rail and wider transport domains shows that safety performance is plateauing. Methods and interventions which have proven effective in the past are in some cases reaching their limits of usefulness. Secondly, there is evidence that while serious accidents and incidents have decreased, underlying indicators have not. Indeed, in some cases they have increased. Thirdly, progress in railway safety has exposed a particular class of accident resistant to conventional analysis and remedial measures; a class of accident with a prominent Human Factors dimension. Many sectors, including rail, have identified Human Factors as a strategic safety priority upon which more progress needs to be made.

5. **DATA COLLECTION AS PART OF AN INTEGRATED RAIL DATA MONITORING PROCESS:** Successful deployment of technologies like LVVR has occurred under the auspices of highly integrated Safety Management Systems. The emphasis in these cases is not on post-accident investigation or punitive measures targeted at drivers. Instead, it is on trend analysis, incident prediction, a confidential and non-punitive safety culture, strong employee buy-in, and a holistic approach to the causes and consequences of individual human behaviours. The civil aviation sector provides an exemplar for how equivalent LVVR technology is integrated within such an approach.

### Supporting Science

**Human Factors and Train Driver Performance**

From a human-performance perspective train driving is a particularly demanding task. It requires high levels of sustained vigilance, in-depth route knowledge, very high levels of so-called ‘feedforward control’ and prediction. The popular view of railway accidents, as evidenced in the wider media, for example, tends to conceal much of this complexity. The cases in which drivers deliberately, malignantly, or negligently caused a train to crash are exceedingly rare. Much more common are cases where the driver, if they survive the accident, does not seek to excuse themselves. Indeed, a feature of many post-accident inquiries is the extent to which drivers are equally perplexed at what caused them to make in many cases, and in hindsight, what could be construed as basic errors.
Placing the blame on drivers for seemingly obvious ‘human errors’ does not just reflect a media preference for simplicity and culpability; it is also an artefact of many accident analysis tools. Many of these have their basis in engineering methods and focus on identifying root causes. As the driver is quite often the last person to have touched the controls (or seemingly failed to touch the controls) it is not surprising they should emerge from so many inquiries as heavily implicated in the cause of a crash. The issue I am keen for the Standing Committee to consider is not whether LVVR technology can be used to detect, sanction, or punish drivers for errors such as these, but to help identify what features of the engineered and regulated railway environment cause certain driver behaviours to emerge. In other words, when placed in a particular set of circumstances, in a given situation and context, could it reasonably be expected that other drivers might behave in similar ways? Human Factors research frequently reveals the answer to be yes.

**KEY ISSUE:** Drivers are placed in regulated, highly engineered environments by their employers and expected to perform in ways that are expected. Those environments do not always evoke the correct behaviour. Simple ‘driver errors’ are often much more complex ‘system errors’. The term ‘system’ encompasses both the regulatory and engineering environment, and the manner in which it interacts with driver behaviour. LVVR policy could support an agenda for addressing complex ‘system errors’ like these in a predictive, non-punitive manner, before a serious accident occurs.

LVVR technology has the potential to provide a window on human behaviour as it occurs in its context. By coupling the science of Human Factors to the information available from LVVR, it becomes possible to identify factors which make certain forms of erroneous behaviour more, or less likely. Indeed, far from an individual driver being unique, blame worthy, or deficient, it is likely the interplay of contextual factors and driver psychology creates additional risks for many other drivers too. These risks lie at the heart of strategic safety plans in transport sectors across the world. In rail these risks include signals passed at danger, over-speed events, wrong-side door activations, and so on. Events such as these often defy easy explanation, recur despite increasing levels of technical intervention, and often require drivers to defeat one or several layers of defence. This happens because of the complex ways in which humans and systems interact.

**KEY ISSUE:** LVVR makes it possible to define driver behaviour in terms of ‘what’ occurred. Understanding ‘why’ those behaviours occurred needs a scientific approach. The complex nature of human behaviour in a railway context mean that drivers present in the actual situation captured by LVVR may not be able to provide the insights needed from LVVR data. Even great operational experience alone may not be sufficient. Insights from LVVR are likely to be founded on a collaborative approach, blending the science-base with all relevant stakeholders. Using LVVR technology collaboratively, blending the science-base with all relevant stakeholders, would be of significant value in tackling strategic risks in an enlightened way.

**Leading and Lagging Safety Indicators**

The retrieval of a crash survivable ‘black box’ is a common trope in the popular media but is far from common in reality. The vast majority of the Canadian railway vehicle fleet has, or will, spend its entire serviceable life of 30 or more years with their data (or indeed LVVR) recorders never being used for their primary purpose of post-accident investigation. This is because the vast majority of rolling stock will, quite simply, never be involved in an accident. This paradox is the reason for a switch in emphasis from so-called lagging to leading safety performance indicators.
Lagging indicators are ‘loss metrics’ which only become apparent after an event has taken place. Lagging indicators are said to be ‘reactive’ because something harmful needs to occur before it can inform learning. For this reason lagging indicators are often viewed as ‘negative performance indicators’.

Leading indicators, on the other hand, are sometimes referred to as ‘positive performance indicators’. Leading indicators are measurable precursors to major events such as an accident. The indication of a precursor ‘leads’, or comes before, the actual event itself. Leading indicators are said to be ‘proactive’ because they enable steps to be taken to avoid seriously adverse consequences before they occur.

**KEY ISSUE:** The data collected from an LVVR post-accident represents a ‘lagging indicator’ (the accident has occurred). Data collected from an LVVR in normal operations could serve as a ‘leading indicator’ (the accident has not occurred, but trends may be evident which could be corrected to prevent it taking place).

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### Integrated Railway Data Monitoring (RDM) Process

#### Definitions

The civil aviation sector has already been on a similar regulatory journey with respect to Flight Data Recorders and Cockpit Voice Recorders. The impetus for the development of both was, like the rail industry, the wish to learn from incidents with the data used as a lagging indicator. Having delivered significant safety improvements in the sector, the relative infrequency of major incidents now limits the insights a traditional ‘learning from disasters’ approach can now offer. To address these limitations, and to capitalise on the opportunities to make better use of data already being collected, the UK civil aviation sector developed Flight Data Monitoring (FDM). This is presented to the Standing Committee as an exemplar of how LVVR technology could be used in a highly integrated way acceptable to all stakeholders.

#### DEFINITION OF FLIGHT/RAIL DATA MONITORING: “A systematic method of accessing, analysing, and acting upon information obtained from digital flight data records of routine flight operations to improve safety. It is the pro-active and timely use of flight data to identify and address operational risks before they can lead to incidents and accidents.”

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### Objectives

It is recommend that FDM or a comparable Rail Data Monitoring process should form part of a feedback loop, preferably as part of a Safety Management System (SMS). It should be constructed with the following objectives, drawn from UK CAA document CAP 739: Flight Data Monitoring. A Guide to Good Practice (available from [http://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=5613](http://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=5613)), in mind:

1. Identify areas of operational risk and quantify current safety margins;
2. Highlight when non-standard, unusual or unsafe circumstances occur;

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2 In North America a conceptually similar approach, developed later, is called Flight Operations Quality Assurance (FOQA).
3. Use the information on the type, frequency, and severity of occurrence(s) to determine which may become unacceptable if the discovered trend continues;

4. Undertake remedial action once an unacceptable risk, either actually present or predicted by trending, has been identified.

5. Following remedial actions, the situation should continue to be monitored to ensure the action was effective in targeting the identified risk and also that it did not transfer the risk to another area of operation.

**In Practice**

How FDM objectives manifest themselves in practice varies but is nonetheless instructive for the Canadian rail sector, and the formation of Bill C049. The process begins with the routine download of ‘normal’ flight data from the aircraft, which in turn is subject to processing by an FDM analyst.

On this point it appears that Bill C-49, under which future LVVRs will fall, makes certain tacit assumptions about what forms these technologies will take. It is therefore useful to say that LVVRs are not necessarily stand-alone data capture devices which can fall neatly within a particular policy purview. Modern train ‘information architectures’ are such that legally mandated data collection devices could be just one of several other, non-mandated devices. All of these devices would be connected to a more pervasive and networked data acquisition infrastructure, which may or may not fall within the provisions of Bill C-49.

**KEY ISSUE:** In civil aviation, data recorded by the crash survivable Flight Data Recorder (FDR) is harvested (in most cases) from the aircraft’s wider electronic architecture. The FDR itself is not accessed. Devices such as Quick Access Recorders (QARs) are used specifically for FDM purposes and often provide more information than that recorded by legal mandate on the FDR. This is mentioned because similar capability is available (or becoming available) on numerous modern train fleets.

Returning to the practice of FDM, once the data is accessed the FDM analyst will assess the findings. Individual operational feedback that needs to be communicated to a specific crew is done so via the Trade Union, and also safety officers at monthly review meetings. This, however, is not the primary objective of FDM. Insights gained from analysis of routine operations are aggregated and combined with those from air safety and other reports, to form a clearer picture of wider safety issues. The outcomes of these meetings will feed into a number of other channels; trend information, for example, will be reported to management and staff; any new safety issues identified will be used to inform flight data investigations and will contribute to improvements to the monitoring software; insights will also be applied to practice via changes to equipment, infrastructure, operating procedures, manuals, crew training and other measures. These changes also impact on the FDM process itself, thus serving to feed a process of continuous improvement. Routine FDM analysis is not used to penalise individual crew members.

**Opportunities for the Canadian Rail Sector**

Where a comparable Rail Data Monitoring process could be strengthened is in the area of Human Factors. Methods exist to accept the information from data recorders and LVVRs and convert them into Human Factors insights. By these means favourable changes to operating conditions could be made so that risks of erroneous behaviours are minimised, and train driver skill and expertise maximised through design, training, procedures and so forth.
KEY ISSUE: There is an opportunity for the rail sector to build on previous experience and lead in the future development of rail data monitoring processes. LVVR, coupled to Human Factors approaches, could play an important role in driving further improvements to railway safety. The key to unlocking this potential is how such technology is implemented and for what purposes. The policy backdrop is an important enabler in ensuring LVVR is used in a collaborative, scientific way in order to deliver substantial benefits for all stakeholders.

Confidentiality and Safety Culture
In highlighting the aviation sector as an exemplar of how LVVR technology could be implemented, it is important to also say it is not immune to industrial relations challenges. The benefit for a transport sector, like rail, which may wish to emulate best-practice from aviation is that these challenges have been confronted over the course of several decades. Specifically in relation to FDM but also in relation to data and voice recording more generally. As it exists today, FDM is part of a broader safety culture in which the flight crew are encouraged to report operational issues, events and potential problems.

KEY ISSUE: In successful Data Monitoring implementations 'crew feel comfortable reporting safety incidents with the knowledge that the information will be used to improve safety rather than punish transgressions.'

Recommendations
The scope of this written evidence permits me to make three broad recommendations for the Standing Senate Committee to consider:

1. A policy backdrop which creates the conditions for a punitive focus on train drivers is, in my view, unlikely to deliver the potential safety benefits of new technology such as LVVR. A holistic view of how train driver behaviour connects to the wider policy, regulatory, and engineering context is needed for genuine progress towards strategic safety goals.

2. The science of Human Factors needs a greater strategic role and LVVR’s could be one of many technological enablers. While many current safety priorities are complex, the promise inherent in complexity is that small, evidence-based Human Factors interventions could have disproportionately beneficial safety impacts. A policy backdrop which creates favourable conditions for this to occur would also be recommended.

3. Equivalent LVVR technology has been implemented in a parallel transport domain with favourable outcomes for all stakeholders. Similarly transformative outcomes are, I believe, available to the rail sector as well. Again, the policy backdrop plays a critical role in setting a positive agenda for the deployment of enabling technology like LVVR.

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Further Sources


Full reports and findings from EPSRC Project EP/I036222/1 entitled: *Flight Data Monitoring, On Train Data Recording, and Human Factors* is available upon request. Please contact Assoc. Professor Guy Walker on: g.h.walker@hw.ac.uk


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