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Challenges of improving safety in very safe transport systems

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ABSTRACT

This paper discusses some challenges that may arise when trying to improve safety in systems that are already very safe. Railways in Norway are used as a case of a very safe transport system. The following challenges in improving safety are discussed: (1) A low number of accidents per unit of time makes it difficult to estimate both the current level of accident risk and changes over time in the level of accident risk. (2) Partly as a result of the low number of accidents, incident reporting has been introduced; however it is not always clear how to interpret changes in the number of incidents reported. One reason for this is that some incidents have a low potential for developing into accidents, because multiple safety barriers (defences-in-depth) stop incidents from escalating. (3) Knowledge of the effectiveness of safety barriers combined with a good safety record may lead to excessive reliance on the safety barriers and behavioural adaptation to them. The existence of these challenges is illustrated by means of data from Norwegian railways. It is discussed whether attaining a very high level of safety may lead to loss of information and loss of motivation that may slow down further progress in improving safety.

1. Introduction

As knowledge about risk factors associated with accidents and how to control the hazards generated by these factors has improved, ambitions for improving safety have increased in all sectors of society. Norway has officially adopted Vision Zero as the long-term ideal for transport safety. Vision Zero states that the ultimate goal is a transport system in which nobody is killed or permanently injured. In Norway, Vision Zero applies to all modes of transport (Samferdselsdepartementet, 2009).

The risks associated with travel in Norway are very similar to those found in most rich countries. Road travel typically accounts for more than 90% of all transport-related fatalities. Compared to road travel, aviation, railways and maritime travel are quite safe modes of transport. In Norway, it is not uncommon that there are zero passenger fatalities in aviation, rail and maritime travel. What happens when a transport system becomes very safe? Does the system reach a limit, beyond which the lack of information regarding safety prevents further progress from being made? Do transport operators and managers lose interest in trying to improve safety? This paper will explore these questions, using railways in Norway as an example of a very safe transport system. The paper is inspired by the points raised by Amalberti (2001) in his discussion of the paradoxes of almost totally safe transport systems.

The basic argument made in the paper is as follows: When a system becomes very safe, there will be few accidents and these accidents will have little in common and limited potential for learning. As a result of this, other indicators of safety will be created, such as incident reporting. Incidents are events or states that have the potential for developing into accidents. However, the relationship between incidents and accidents may be complex, as some incidents do not have the potential for developing into major accidents, because safety barriers have been introduced to prevent unwanted events from developing into accidents. If safety barriers are known to be highly reliable, an un-intended behavioural adaptation to the barriers may occur and this may reduce safety margins. The challenge is to prevent safety barriers from leading to behavioural adaptation.

2. A very safe transport system: Railways in Norway

Railways in Norway are very safe. Fig. 1 compares fatalities per billion kilometres of travel for railway passengers in Norway to corresponding fatality rates for travel by road. Nearly 90% of all kilometres of travel in Norway are by road (Vågane and Rideng, 2011). Railways include mainline railways only, not trams and underground.

The risk involved in travelling by rail is given for two periods: 1992–2011 and 2002–2011. It is seen that the risk was substantially lower in the 2002–2011 period than in the 1992–2011 period. The difference is almost entirely attributable to a major accident in 2000, in which 16 passengers and 3 train staff were killed. In the past ten years, travel by train in Norway has been extremely safe, considerably safer than travel by bus, which is the safest means of travel by road. There were only two railway

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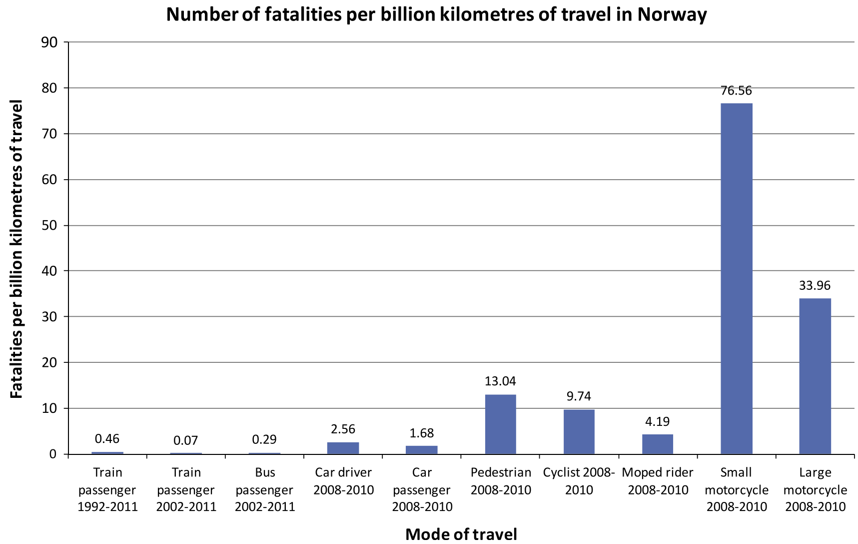

Fig. 1. Number of fatalities per billion kilometres of travel in Norway.

passenger fatalities in Norway between 2002 and 2011. The total number of fatalities in railway accidents has been less than 10 every year since 1994, except for the year 2000. Driving a car, by far the most common means of travel in Norway, involves a fatality risk which is 5–35 times higher than being a passenger in a train, depending on whether the risk to train passengers refers to the 2002–2011 period or the 1992–2011 period. Train trips are not normally door-to-door, but contain a share of walking, driving a car or otherwise accessing the station at either end of the train trip. These access and egress parts of a journey add to the risk, but using the train for most of the distance covered is still likely to have the lowest overall risk compared to any means of road transport.

3. The challenge of estimating the current level of risk and trends in risk

The fact that a single major accident may exert a large influence on the estimate of the risk involved in travelling by train illustrates one of the problems in reliably estimating the fatality risk associated with a very safe transport system. Major accidents are rare and unpredictable. The data collected for this paper cover a period of fifty years (1962–2011). During this period there were only two major accidents: one in 1975 (27 fatalities) and one in 2000 (19 fatalities). If one selects a shorter period as a basis for estimating risk, such as ten years, it is largely a matter of chance whether such a period will contain a major accident or not. In fact, the most frequently occurring number of train passenger fatalities in Norway between 1962 and 2001 was zero. Fig. 2 shows the number of years with a given number of train passenger fatalities during the period 1962–2011. There were zero fatalities in 19 years, one fatality in 15 years, and more than five fatalities in just two years.

Published accident statistics do not specify the number of fatal accidents involving 1, 2, 3, etc. fatalities. However, by combining information from several sources of data (statistics, annual reports of train operators, newspaper archives), an attempt has been made to reconstruct the number of fatal train accidents during the period 1962–2011. Train accidents include train collisions, derailments and trains striking fixed objects. While there remains a little uncertainty about the count of fatal train accidents, the best estimate was that during the period covered by the study, there were 23 fatal train accidents with a total of 81 fatalities. There were 14 accidents with 1 fatality, 4 with 2 fatalities, 1 with 3 fatalities, 2 with 5 fatalities, 1 with 19 fatalities and 1 with 27 fatalities.

Evans (2003, 2007) argues that estimates of risk based on long-term trends should be preferred to estimates of risk based on recent accident history in transport systems that are characterised by clear long-term trends in risk and a low annual count of accidents. He illustrates this approach using data for train accidents in Great Britain. The long-term trend in the risk of fatal accident (fatal accidents per billion train kilometres) was estimated according to the following function:

$$\lambda(t) = \alpha k_t \cdot \exp^{\beta t} \quad (1)$$

$\lambda(t)$ is the predicted number of accidents in period t (the period could be a single year or several years), k_t is train kilometres in period t, α is a scaling constant (consistent with the assumption that the number of accidents is proportional to train kilometres) and the exponential function (exp) is intended to capture the long-term trend in the rate of accidents per train kilometre. The parameter β of the exponential function is the rate of change per unit of time in the accident rate (accidents per million train kilometres). Evans (2003, 2007) estimated the coefficients α and β by means of Poisson-regression or negative binomial regression, the results of which did not differ much. This method for estimating risk has been applied in a number of papers (Evans, 2007, 2010, 2011).

A similar approach has been applied in this paper in order to estimate current risk and changes over time in risk. For this purpose, a distinction is made between the following types of railway accident:

1. Train collisions: A train collision is a collision between trains in regular traffic or between shunting movements in shunting yards.
2. Trains striking fixed objects: These accidents include trains running into landslides or hitting buffers at the end of a track.
3. Derailments: This includes derailments both on track and in shunting yards.
4. Grade crossing accidents: These are collisions between a train and a road user or vehicle.
5. Other accidents: This category includes all accidents not classified as one of the above four types; most of these accidents involve trespassers struck by trains. Incidents judged to be suicides are not counted as accidents and are removed from statistics.

The total number of accidents is the sum of the five types listed above. Table 1 presents the number of accidents, the number of