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The magnitude of risk is far greater than the potential of any condition monitoring system to resolve.

Steven Harrod

Commentary/Analysis

Can artificial intelligence and data analytics keep our railroads safe? Leading executives certainly hope so. In response to February's train wreck and hazardous chemical spill in East Palestine, Ohio, railroad management has made assurances that more automated monitoring will be installed, and that this will resolve the public's safety concerns. Unfortunately, the problem is that the magnitude of risk is far greater than the potential of any condition monitoring system to resolve.

In 1958, a "long train" in North America was 120 train cars. This train had a crew of five, of which three rode in a trailing car called a caboose, from which they monitored the train. Typical car length then was 40 feet and thus train length was 4,800 feet. Today, efficient train length is over 12,000 feet, there is a crew of two, and nobody rides the rear of the train. Modern trains are much improved over trains of 1958. Modern trains have better materials and better technology, yet the laws of mathematics frustrate our safety objectives.

Imagine a railroad car has a certain probability of failure per mile traveled. Independently and identically distributed Poisson is a reasonable assumption. Poisson distribution is a way to express the probability theory in statistics where the probability of a given number of events that would occur in a fixed interval of time and space if these events occur with a known constant mean rate, and independently of the time since the last event The Poisson symbol is – λ.

With this in mind, a train with one car has a failure rate of λ, a train with two cars 2λ, and so on. Today's 12,000-foot-long train needs a failure rate less than half that of 1958 to maintain the same safety factor. However, with more and heavier cars in the train, each failure actually puts at risk about double the amount of cargo as a 1958 train. So, to maintain the same risk exposure of 1958, you really need to have a failure rate of about one-quarter 1958 standards.

But who wants to live with 1958 safety standards? Railroad history is filled with romantic stories of real heroes, such as Casey Jones and Kate Shelley, who had separately sacrificed their lives to prevent horrible accidents in the nick of time.

For much of history, railroad accidents were just an unavoidable cost of doing business. This is no longer acceptable. We don't drive cars without seatbelts, we don't smoke on airplanes, and we don’t want hazardous material trains crashing, well, anywhere, but certainly not in populated areas.

Unfortunately, railroad safety has not improved sufficiently to meet modern expectations and to respond to the increase in risk created by operating efficiency improvements, and it is doubtful that technology alone can resolve this. Railroad monitoring follows one of two strategies: passive and active. In North America, trackside sensors monitor a passing train and report data to both the train crew and to central databases. This has been the standard for easily 50 years, but it means your data is only as good as the last measurement, and since that measurement is taken by a sensor on the ground facing a train moving at 60 miles per hour, there is a limit to how detailed the data can be.

In Europe, trackside sensors are also used, but they don’t play a central role. Trains in Europe are limited to 2,300 feet in length, because the railroad network is older and focused more on passenger trains. Freight trains in Europe run shorter distances at higher speeds, and thus receive more inspections and are held to a higher standard because of the risk exposure to passenger trains. There are aspirational plans in Europe to equip freight trains with onboard sensors and wireless communication on every freight car, and thus achieve a six-sigma level of failure reduction.

Both of these approaches seem to be either insufficient or uneconomic. The European Union (EU) has a sustainability goal of shifting 50% of freight traffic from road to rail by 2050, but rail freight in the EU is not profitable. The many proposed EU technology advances for rail freight will make it even less profitable in the future, raising questions of whether this modal shift will in fact require a government subsidy.

North American railroads have taken an entirely different approach, and as a consequence are immensely profitable. The typical North American railroad has an operating ratio of 60, which means that for each dollar of revenue, 40 cents is profit. This has been achieved by a focus on economies of scale and restrained technology, keeping the sensors on the ground and not on the train, for example. But it has also been achieved by accepting train accidents as a certain cost of doing business. Reported train derailments in the United States have held steady at about 1,200 per year in the last five years. Last year there were 101 reported train-to-train collisions (as opposed to collisions with road vehicles). Of these, 40 were rear collisions and 12 were head-on (train front to train front) collisions. The European Union also has its accidents, although with a much higher traffic density.

The European Union has reported an average of 12 rail accidents per year with release of hazardous materials, over the last decade.

The Association of American Railroads industry group boasts that derailments have been reduced by 30% since 2000. Even if we assume that this rate of progress can be repeated in the next

20 years, is this sufficient to meet public safety expectations, especially in the carriage of hazardous goods? I suspect not, and by making public statements that improved data collection, monitoring and analysis will resolve safety concerns, railroad executives place an unacceptable burden on the field of AI and data analysis to deliver. The data systems become a scapegoat: "Well, we would not have had these accidents if the data collection and analysis had been implemented *correctly*."

Data analysis is not going to prevent these accidents. Data analysis can assist in asserting better control over operations and failure rates of trains, but it cannot resolve the inherent risk factors of freight trains transporting hazardous materials. You can't put wireless sensors on a horse-drawn wagon on a country road and assert that you have solved the problems of runaway horses and broken wagon wheels.

Risk reduction on railroads will require operational as well as technology changes. Train length may need to be limited. Hazardous goods may need to be segregated on shorter, dedicated trains. Crash protection for hazardous goods tank cars may need to be improved. Data collection and tools can help us understand what has happened and what is likely to happen, but it cannot replace management of the physical environment.

Steven Harrod is an associate professor at the Technical University of Denmark. Dr. Harrod is a teacher and researcher in transport, especially railway transport. His current projects

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