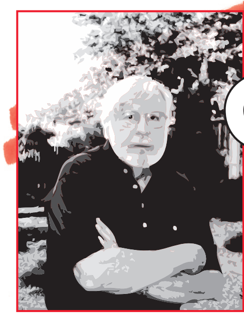

Outside the Lines

"Problems cannot be solved by thinking within the framework in which the problems were created." – Albert Einstein

by Ludwig Benner, Jr. and Ira J. Rimson

The Curse of the Retros

> Retro- : *A prefix from Latin meaning "backward."*
> Retrospection: *Looking backward.*
> Retrogression: *Going backward to an earlier and usually worse condition.*[1]
> Retrocursor: *An event that follows another similar event and demonstrates that the initial event's lesson(s), if any, have yet to be learned and applied.*[2]

On a bright day in May, 2009, the driver of a vehicle northbound on U.S. highway 550 in New Mexico lost control, crossed the median, entered the opposite lanes and collided head-on with a southbound auto. The two occupants of the northbound car and the single occupant of the southbound car were killed instantly.

So, what's the big deal? A thousand persons, more or less, are killed every week on U.S. roads. What makes this accident different?

What's different is that U.S. 550 between Bernalillo and Farmington, New Mexico, was originally New Mexico State Road 44, a 150-mile long, two-lane deathtrap with blind curves and grades, and one of the highest head-on motor vehicle accident rates in the country. In 1999, it was accepted into the U.S. highway system. Funding was allocated to upgrade it to a four-lane divided roadway. The new road is a vast improvement over the original. However, its designers lost sight of one of the primary considerations for upgrading the road: eliminating the old road's hazards.

Knowledge about the hazard of head-on collisions on two-lane highways is probably as old as the automobile. Knowledge about separating opposing roadways on new divided roads is at least 60 years old. Innumerable accident investigations have demonstrated that merely separating the opposing roadways by a few dozen feet is inadequate to ensure that a vehicle leaving one roadway cannot enter the opposite one. We believe that the principal investigation output should be knowledge of how the planned scenario went bad.[3]

The Pennsylvania Turnpike first opened in 1940. Although it was constructed as a four-lane divided roadway, the level-grade median was merely one-lane wide. That design still allowed vehicles to cross into opposing roadways, even at the vehicle energies of the 1940s, and head-on collisions were not appreciably decreased.

When plans were laid for the Ohio Turnpike in 1949, the designers recognized the lesson from the Pennsylvania Turnpike. The designers applied the lesson from those head-on collision behaviors, and pursued a different design. They acquired large swaths of flat land to separate opposing roadways laterally by dozens of feet, by grade where feasible, and by depressing the median to a depth of six to eight feet where it was not. By design, accidental crossovers on the Ohio Turnpike were almost eliminated.

Whoever specified the design of U.S. 550 in New Mexico lost sight of one of the most critical considerations for improving the old state road: reducing the severity of hazards from accidental crossovers. Had the specification for the new road included an opera-

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[1] Definitions from *The Random House Dictionary of the English Language* (1967).

[2] Definition by the authors.

[3] This assumes that investigators can determine that (a) there was a planned scenario; (b) something(s) compelled a change to the scenario; and (c) the changed scenario led to an undesired outcome.

The Pennsylvania Turnpike, Circa 1942.

Library of Congress Photo

tional requirement that accidental crossovers between roadways be eliminated, designers would have found a way to achieve that goal. A retrospective modification is underway now to limit the crossover hazard: installation of cable-barriers between the roadways, to deflect out-of-control vehicles back into their original lane.

We define accidents that replicate the behavior of prior occurrences as "retrocursors": They demonstrate that lessons which could have been learned and applied from prior mishaps have yet to be recognized. Retrocursors occur often enough that they should have captured the attention of system safety practitioners. They acknowledge that all outcomes, good or bad, desired or undesired, derive from human behavior. Inanimate objects are incapable of volitional action.[4]

"Retrocursors occur often enough that they should have captured the attention of system safety practitioners. They acknowledge that all outcomes, good or bad, desired or undesired, derive from human behavior. Inanimate objects are incapable of volitional action."

The 2007 collapse of the I-35 bridge in downtown Minneapolis, Minnesota, represented a common retrocursor. Despite the National Transportation Safety Board's citation of under-designed gussets among the bridge's girders as causative[5], disclosure that the Minnesota Department of Transportation (MNDOT) instituted expansion of the original bridge from four to 10 lanes without robust recalculation of the potential effects of the modification on the original structure is exemplary of losing sight of the behavior that led to the failure.[6] The lesson not learned: Scaling up a design requires reanalysis.

A potentially fertile field for reducing retrocursors is crane safety. Cranes, construction equipment and their usage fall under Title 29 of the Code of Federal Regulations, Section 1926.550, under the purview of the Occupational Safety & Health Administration (OSHA) of the U.S. Department of Labor. OSHA's crane standards have not been changed since 1971, despite both significant operational changes and major technological advancements. Lessons should have been learned from crane accidents. Learning a lesson depends on its being both identified and applied. Behaviors that have led to crane mishaps might have been mitigated were federal regulators to require states to license crane operators, yet they do not. Furthermore, states are free to relegate regulation-mandated annual inspections to OSHA, which is not manned or funded to perform them. The non-exhaustive data found in Figure 1 were report-

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[4] Some may argue that Artificial Intelligence systems are exceptions, but they are restricted to metrics and responses established by human programmers.

[5] NTSB Report Number: HAR-08-03, adopted on 11/14/2008.

[6] Kevin Diaz, "I-35W bridge tragedy may yield new rules," *Minneapolis Star-Telegram*, November 14, 2008, at http://www.startribune.com/politics/state/34454549.html?page=1&c=y.

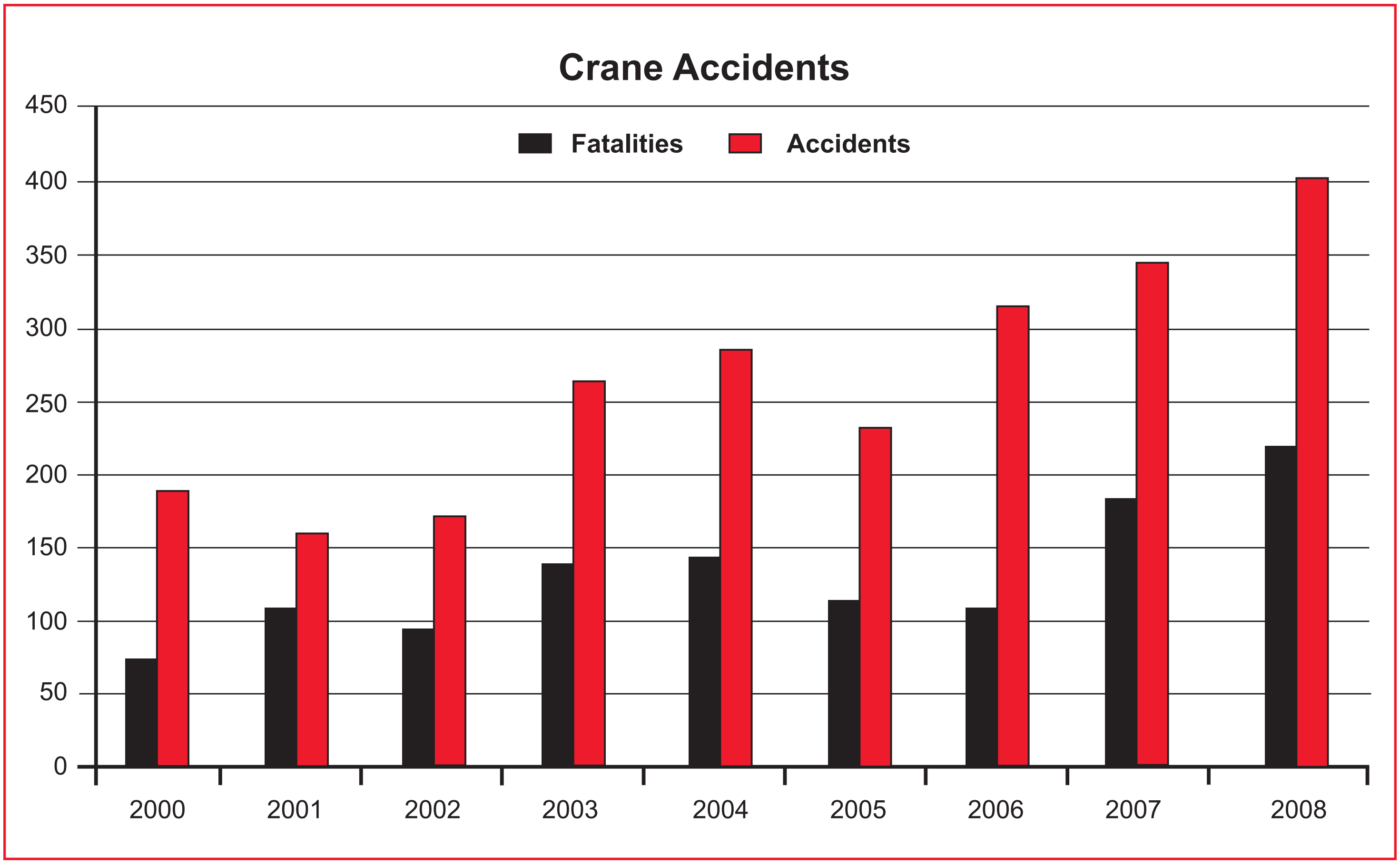

Figure 1 — Crane Accident Data Reported to the Web Site www.craneaccidents.com from 2000 to 2008.

ed to the site www.craneaccidents.com within the past nine years, and provide insight into the scope of crane accident lessons-not-learned.

Why haven't lessons from past mishaps been learned well enough to prevent occurrence of retrocursors? We have observed a number of reasons:

First, of relevance primarily to system safety practitioners, preliminary safety studies performed early in systems' development lack sufficiently robust data relevant to the systems' *dynamic performance*. That information is needed to generate realistic predictions of how hazards can influence behavioral decisions that make planned scenarios go wrong during operations.[7]

Second, accident investigation reports don't identify lessons in forms that can be applied to new systems. Investigators tend to identify behaviors that led to undesired outcomes as "failures" unique to the specific system under investigation. We have observed little "cross-referencing" of either obvious or subtle similarities to identify lessons that could be applied cross-culturally. For example, lessons-learned technology that has been applied for decades to separate trains is now being investigated for use in separating airplanes on the ground, and avoiding accidental runway incursions.

Third, historic investigation data are not documented and reported to facilitate easy retrieval. Investigators, analysts, hazard control managers and operators, who need data to support their applications, find it hard to identify relevant lessons in old accident data. Trends toward categorizing scientific and technical data into "taxonomies" requires those who wish to access historic data to try to guess what "label" was assigned by the person who filed the data. Attempts to fit measurable data into taxonomies are, in most cases, more successful in inhibiting access to the data than in facilitating it. The lesson, simply stated, is:

"Taxonomies purport to map the way you think, so you can find what you want. Unfortunately, you don't think the way I think, and your colleagues won't necessarily think the way you think either."[8]

Fourth, "lessons-to-be-learned" are seldom, if ever, itemized explic-

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[7] See our "Outside the Lines" column, "Hazard Analysis for Dynamic Systems," in *JSS* V. 45, No. 2, p. 4 – 6.

[8] Flank, Sharon. "Why Taxonomies Are Doomed," Data Strategy Consulting white paper, 2004.

itly in investigation reports. If they were, the lessons would provide both a "road map" for improving systems' operational efficiency, and a measure of how well lessons are *really* learned.

"Lessons learned" availability reduces system safety hazard and risk analysts' reliance on ""requisite imagination" and personal experience to identify and analyze hazards. But until system safety analysts demand improved investigation lessons learned quality, dissemination and access from providers, they should recognize that they will continue to be poorly served by the investigation community.

Retrocursors Abound in Recent Aviation Accidents

At the time of this column's writing in mid-June, 2009 has seen at least five fatal aviation accidents that appear to be retrocursors of prior accidents, the lessons of which have not been learned:

2009 Date	Operator/Flight Number	Aircraft Model	Location
Feb. 12	Colgan/Continental 3407	Bombardier Dash 8	Buffalo New York, U.S.
Feb. 25	Turkish A/L 1951	Boeing 737	Amsterdam, The Netherlands
March 23	Federal Express	Boeing MD-11	Narita, Japan
June 1	Air France 447	Airbus A-330	Mid-Atlantic Ocean
June 9	New Mexico State Police	Agusta A109 Helo	Near Santa Fe, New Mexico, U.S.

All the accidents resulted in fatalities, from two in the New Mexico State Police helicopter crash to 228 in the Air France Airbus. Although no formal investigations have yet been completed, enough factual data have emerged from the accidents to establish that none were historically unique. Design-related system safety issues have been cited in both the March 23 and June 1 accidents. In the other three, system safety implications relate to training and operational issues. Despite their differences, each case repeated well-documented behaviors of prior occurrences from which attainable lessons weren't recognized, disseminated or learned.