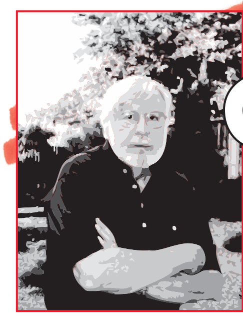


Outside the Lines

"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

Old Habits Die Hard

"As a matter of fact, yeah, they were foolproof. The problem is that you don't have to protect yourself against fools. You have to protect yourself against people like me."
— Jeffrey Deaver, *The Blue Nowhere*

On Aug. 28, 2009, a Lexus ES350 "loaner" car from a San Diego dealership crashed after careening through traffic at speeds estimated up to 120 mph.[1] A 19-year veteran of the California Highway Patrol was at the wheel. Initial conjecture, and the manufacturer's arguments about the mechanism of the unintended and uncontrollable acceleration, pointed to floor mats that could slip out of position and jam the accelerator pedal. But the question remained: How could that have prevented a police officer, experienced in coping with emergencies, from bringing the car under control?

Recently, unexpected and seemingly uncontrollable events requiring choices of responses have confronted system operators with increasing frequency: Ambiguous data confronted train controllers involved in a 2009 Washington, D.C. Metrorail crash[2]; unexpected loss of control confronted operators of unmanned aeronautical systems (UASs)[3]; the crew of USAir Flight 1549[4] faced sudden loss of power in both engines after bird strikes, and while they dealt with that successfully, the crew of CO Flight 3407 wasn't as fortunate when confronted by their aircraft's stalling on approach to Buffalo.[5] Unexpected wake turbulence confronted Air Canada Flight 190's crew[6]; unexpected accelerations have confronted drivers of Toyotas[7]; and a sudden loss of automatic controls in a storm confronted pilots of Air France Flight 447's Airbus-330 over the Atlantic Ocean.[8] These diverse occurrences suggest unrecognized aspects of safety risks involving newly encountered or deteriorating operational situations that lack precedent in the operators' experiences. Each case required operators to recognize and respond to challenges differently from ways with which they had been familiar. To cope, they often reverted to intuitive responses reflecting behaviors learned in the past. Some were successful; others were not.

It is now known that the rig's operators noted deteriorating conditions prior to the recent BP oil well blowout in the Gulf of Mexico. It appears at this writing that some management and operators reacted to successively deteriorating well behavioral data by

---

[1] http://articles.latimes.com/2009/oct/18/business/fi-toyota-recall18, *inter alia*.

[2] http://www.washingtonpost.com/wp-srv/special/metro/red-line-crash/, *inter alia*.

[3] "The Sky Isn't Falling – Or Is It? Part 1". *Journal of System Safety*, V. 44, No. 2, March-April, 2008, pp. 4-7.

[4] http://en.wikipedia.org/wiki/US_Airways_Flight_1549, *inter alia*.

[5] http://en.wikipedia.org/wiki/Colgan_Air_Flight_3407, *inter alia*.

[6] Transportation Safety Board of Canada (TSB) June 1, 2010 final investigation report (A08W0007) into the Jan. 10, 2008 encounter with wake turbulence involving the Air Canada Airbus A319 operating as flight ACA190.

[7] http://www.autoblog.com/2010/05/25/nhtsa-claims-toyota-unintended-acceleration-may-have-claimed-89/, *inter alia*.

[8] http://en.wikipedia.org/wiki/Air_France_Flight_447, *inter alia*.

reverting to an established and accepted habit pattern: deviating from established risk mitigation procedures in favor of more highly valued priorities. In hindsight, those reactions likely deterred additional risk controls that might have prevented the ultimate failures. It remains to be seen whether investigations into this accident will delve into the sufficiency of both management's and operators' ability to evaluate accurately the increased risks resulting from the unexpected behaviors signalled by the data, and the extent to which reversion to previously successful habit patterns influenced their reactions.

> "However, we know of no training designed specifically to prevent reversion to old habits under stress in novel or deteriorating situations. Nor can any trainer state with confidence that his training reliably produces the desired new habituated behaviors in all likely situations, if indeed they have been anticipated at all."

Humans acquire behavioral habit patterns over time. Habituated behaviors carry over to the operation of new or modified systems until they are changed. Unexpected or novel challenges posed by new or modified systems, and particularly controls, may require behaviors that are counterintuitive to operators' habituated response patterns. When challenges arise, what happens when operators revert to their old habits? To the best of our knowledge, neither system safety nor reliability analysts address those considerations, either in their literature or their practices.

Habituated behaviors can be changed through experience. Unfortunately, acquisition of new habits that way requires surviving the experience. Much of the time that may happen; often, it doesn't. Pulling one's hand away from an open flame after being burned is an example of experiential habit formation.

Training operators on new or modified systems is a common way to attempt to instill new behavior patterns. Training intensity is generally proportional to the complexity of the new or revised systems. Operators may be tested to demonstrate that they are thoroughly familiar with new operational requirements, and have achieved the necessary new behaviors with an acceptable level of skill.

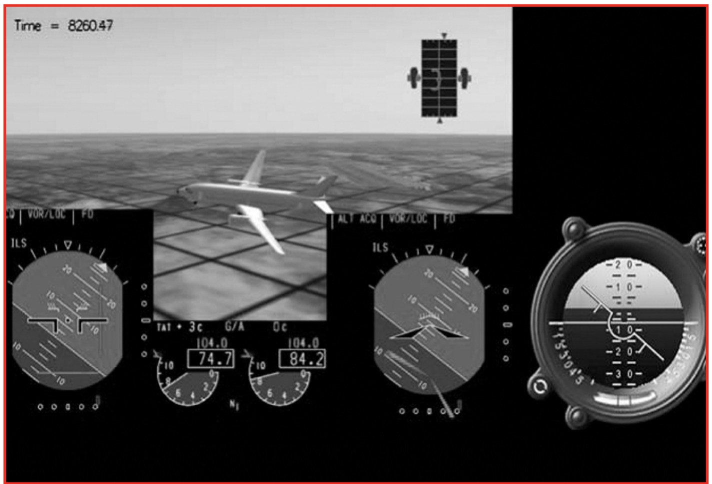
However, we know of no training designed specifically to prevent reversion to old habits under stress in novel or deteriorating situations. Nor can any trainer state with confidence that its training reliably produces the desired new habituated behaviors in all likely situations, if indeed they have been anticipated at all. Furthermore, we don't know of any metric that can evaluate whether previous habits that should be avoided in new systems or operations have been eliminated by training. (This is not a new problem; it was identified more than 100 years ago in a slightly different social context.[9]) It can result in subtle consequences. For example, when complex technical innovations in electronic control systems migrate into common usage, the initial comprehensive training mandated for corporate operators may not descend to the public that will use the consumer products. The progression of "glass cockpits" from military and commercial use to general aviation illustrates this point.

The NTSB recently released a safety study comparing accident records of aircraft equipped with "glass cockpit" avionics displays vs. those equipped with older analog "steam gauges."[10] The new displays "…integrate aircraft control, autopilot, communication, navigation and aircraft system monitoring functions, applying technology previously available only in transport category aircraft. The enhanced function and information capabilities of glass cockpits represent a significant change *and potential improvement in the way general aviation pilots monitor information needed to control their aircraft*."[11] (emphasis added)

If the premise of enhanced control information availability were valid, the NTSB should have found corroborating data that demonstrates improved aircraft control. The NTSB chose to examine as a metric the incidence of fatal and nonfatal accidents in glass-cockpit

---

[9] McMein, M., and J. F. Washburn. "The Effect of Mental Type on the Interference of Motor Habits," *The American Journal of Psychology*, V. 20, No. 2, April 1909, pp. 282-284.
[10] NTSB/SS-10/01, PB2010-917001: "Introduction of Glass Cockpit Avionics into Light Aircraft," Adopted March 9, 2010; available at http://www.ntsb.gov/publictn/2010/SS1001.pdf .
[11] Id., p. vii.



"Among its conclusions, the NTSB '…found that pilots' experiences and training in conventional cockpits do not prepare them to safely operate the complex and varied glass cockpit systems being installed in light aircraft today. Further, the lack of information provided to pilots about glass cockpit systems may lead them to misunderstand or misinterpret system failures.'"

("g-c") and conventionally instrumented aircraft. Of 266 accidents from 2002 through 2008, the non-fatal conventional aircraft accident rate (84%) exceeded the g-c rate (69%), yet the fatal conventional rate (16%) was only slightly more than half of the fatal g-c rate (31%).[12] Furthermore, although the percentage of g-c aircraft in the study remained constant at 62% from 2006 through 2008, the g-c proportion of fatal accidents increased from 78% to 84% in the period.[13]

Among its conclusions, the NTSB "…found that pilots' experiences and training in conventional cockpits do not prepare them to safely operate the complex and varied glass cockpit systems being installed in light aircraft today. Further, the lack of information provided to pilots about glass cockpit systems may lead them to misunderstand or misinterpret system failures."[14]

Another common approach to behavior change is to provide emergency procedures guidance in manuals, checklists, warnings or other source documents. The USAir 1549 case demonstrated that the speed with which human systems' operators must cope with novel or deteriorating circumstances can overwhelm the time available to locate data, interpret them, and act. In such cases, operators may revert to old behavioral habits and memorized knowledge bases, with unintentional success.

The risk associated with this approach was clearly illustrated by the actions of the crew of USAir 1549 after the aircraft lost power in both engines following bird strikes. Captain Chesley "Sully" Sullenberger reported in an *Air & Space Magazine* interview:

> ***Air & Space***: So your first officer would have found that procedure and had a checklist to go through for the ditching procedure?
>
> **Sullenberger:** Not in this case. Time would not allow it. The higher priority procedure to follow was for the loss of both engines. The ditching would have been far secondary to that. Not only did we not have time to go through a ditching checklist, we didn't have time to even finish the checklist for loss of thrust in both engines. That was a three-page checklist, and we didn't even have time to finish the first page. That's how time-compressed this was.[15]

From a safety or reliability analyst's perspective, there are discrete, interacting considerations involved:

- What habituated operator actions can reasonably be expected during day-to-day operation of new or modified systems?
- What habituated operator reactions *can happen*, even unreasonably, during unexpected or deteriorating operations or sudden emergencies?[16]

Both situations should be identified during hazard analyses. Analysts should identify current habituated behaviors, and analyze whether reversion to those behaviors could be detrimental to novel or rapidly deteriorating operational situations of the new or modified system. If so, safe outcomes require that systems be designed to accommodate habituated behavior reversion in situations that would lead to major damage, injury, destruction or death.

We'll delve more deeply into the topic of behavior transference in a coming column.

---

[12] Id., p. 22. (Significant at p=0.004)
[13] Id., Fig. 8.
[14] Id., p. viii.
[15] http://www.airspacemag.com/flight-today/Sullys-Tale.html.
[16] C.O. Miller often remarked, "If an action can happen, it will."