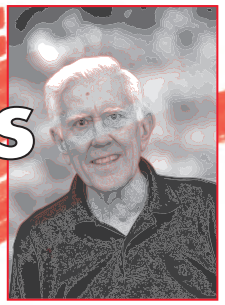
Outside the Lines



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 Brave New World of Designers' Complexity

When was the last time you drove a rental car?

If it was a different make or model than the car you usually drive, did you look for an owner's manual? If you found the manual, did it help you understand the features you were trying to operate? How long did it take you to drive with confidence after you started moving? If there was no owner's manual, what features did you try to decipher? How long did it take you to feel comfortable with them?

Welcome to the brave new world of designers' complexity. This column is about automotive complexity, drivers' habits and system safety. Recent experiences with rental cars and other family members' new cars — and the frustrations we encountered with them — are the *topic de jour*. But these challenges are equally applicable to any increasingly complex system.

Challenges confront drivers when they first operate an unfamiliar car. The 45-year-old has likely been driving for 30 years, the mildly elderly for 50 and the ancient and venerable for three-quarters of a century. The authors have more than 125 years' collective driving experience. We started with three on the floor, a clutch pedal and turn signaling by hand out the driver's window — and even those limited acts were hard to coordinate at first.

Over time, drivers become familiar with the features of the car that they drive regularly. They develop rote responses to task demands that the vehicle imposes on them for safe operation. But when we start to drive a car with which we're unfamiliar and that is configured differently, we confront a learning challenge. How do you adjust the seat, the steering wheel and the mirrors? Where is the headlight switch? How do you start the car? Where are the gauges, and what does each tell you? How do you turn on the overhead light to find the controls you are looking for at night, or dim or brighten the dashboard lights? How do you release the parking brake, or is it automatic? How do you…?

And that's just to get the car moving.

Once on the road, more learning demands confront us. How sensitive are the brakes and steering? Is it front-, rear- or all-wheel drive? How do you sound the horn? Set the speed control? Where is the hazard light switch? How does it work? Where are the air conditioning or heating controls, and how do you change their settings? Where are the windshield and rear window defroster controls?

One way to find the answers to these questions is to read the owner's manual. But where do you find the manual? When was the last time you found an owner's manual in a rental car's glove box? Some new cars only provide manuals online. When you get your hands on a 300-page manual, where is the information you need? Have you read your current car's owner's manual — and the warnings and precautions it contains — from cover to cover?[1] Why not? When is the last time you even looked for the manual for the vehicle you drive regularly?

Car salespeople teach you "what you need to know" by walking you through the procedures in the showroom. But did those instructions provide all you

[1] *Journal of System Safety*, V. 42, No. 2, pp. 8-10, March-April 2006.

needed to know to operate all of your car's features under all driving conditions, or did you have to refer (at least once) to the owner's manual? If you received instruction on the sales floor, how much of it were you able to absorb? How long did it take you to develop rote habits so that operating your car's features didn't demand your conscious attention?

So far, we've addressed only the tasks needed to make the car get us from place to place. But there's more than just driving involved. New car designers compete to provide occupant amenities. How do you open the moon roof in rush hour? What if you want to change your destination or route on the GPS display? Or play a CD? Or change the screen on your dashboard touchscreen display? (We should note that some functions are locked out while cars are in motion, but it's not clear that lockouts are consistent across all vehicles.) If we don't know whether a feature is resisting operation because it's locked out or because we're pushing the wrong switch, we haven't eliminated the distraction from the road while we determine why "the #*&*! thing doesn't work."

Despite our needs as drivers, the most common way to gain know-how about a car is by driving it. Is this the optimum approach to safe vehicle operation? In a recent newspaper column, automotive reviewer Dan Neil, on the instrumentation of the new Ford Focus, wrote:

"The center stack is dominated by the eight-inch touch screen, above a gloss-black panel with the rotary controller for the Sony sound system (there's a smaller LCD between the gauges in the instrument cluster). The leather steering wheel has more buttons than a band uniform, offering triple redundancy for phone and audio. I think. Frankly, it would take more than a day behind the wheel to become fluent in these interfaces."[2]

And that from an experienced auto reviewer.

Cars have become increasingly complex as each new electronic control, technical device or amenity is added. Complexity increases drivers' workloads, distracts from essential operating tasks and can introduce confusion about controls and their use. Each uncertainty extends problem resolution time and, consequently, the length of time drivers' attention must be diverted from essential safe driving tasks: vehicle separation, course and speed adjustments, and interactions with other drivers.

Government regulators, automobile manufacturers and many drivers recognize the increased risks posed by distractions from driving tasks. Unfortunately, most risk-abatement innovations have resulted only in response to an abundance of mishaps that receive attention from the news media. Although manufacturers have provided interlocks[3] or warnings[4] for some common hazards, those that can pose serious risks are frequently ignored. How often have accidents been attributed to "driver error," rather than been examined seriously?

This is where system safety applications should come in. System safety analyses should be applied to evolving automotive designs. Designers should harmonize what dynamic systems *can* do with what human operators *will* do. Interfaces between the machine and its driver's behaviors should not be capable of introducing new risks into the human-machine system. Does unfamiliarity with — or impaired ability to operate — basic systems or accessories of a car affect safety risks? Have designers set up tests with random users to verify their assumptions?

In its analysis of the issues that arose during the Toyota/Lexus "unintended acceleration" issues in 2009, *Car and Driver* magazine revealed information that seems to show that those kinds of tests and analyses were not a common occurrence:

"Unlike vehicles from some other automakers, Toyotas don't kill the throttle when you hit the brakes. This means it's possible to apply both at the same time. Our own instrumented testing determined that you can safely brake a car from highway speed, even with the throttle pegged. But if the accelerator is floored and the car is in gear, repeated stabs at the pedal and modulation of speed with the brake will eventually overheat the brakes and cause them to fail. Pumping the brakes is a bad idea beyond the overheating issue. When the throttle is stuck open, the engine isn't producing sufficient vacuum to enable power assist for the brakes, so press the brake pedal firmly once and don't let up."[5]

How many of you knew that?

Where is the system safety community when we need it?

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[2] *Wall Street Journal*, Feb. 5-6, 2011, p. D10.
[3] E.g., the requirement to depress the brake pedal before shifting the transmission out of "park."
[4] E.g., the alarm notifying that the key is still in the ignition with the driver's door open.
[5] http://blog.caranddriver.com/toyota-recall-scandal-media-circus-and-stupid-drivers-editorial/