The pathway to self-driving vehicles: Disconnects between human capabilities and advanced vehicle systems?

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The Ever Changing Vehicle

- Over the past 100 or so years, while the outward appearance of vehicles has changed, we have seen little change in how drivers interface with the vehicle.

- What do trends in advanced driver assistance systems, automation and information connectivity tell us about expectations for the next 100 years?
Benefits of Vehicle Automation

“Autonomous cars may seem like a gimmick, he begins, but when you consider all the **time** that people won’t be devoting to their rear view mirrors, and all the **efficiencies** that come from cars that could be zipping between errands rather than idling in parking lots, the world looks like a very different place. Car ownership would be unnecessary, because your car (maybe **shared** with your neighbors) will act like a taxi that’s summoned when needed. The **elderly** and the **blind** could be thoroughly integrated into society. **Traffic deaths could be eradicated.** Every person could gain lost hours back for working, reading, talking, or searching the Internet.”

Google co-founder Sergey Brin as reported by Brad Stone of Bloomberg Business Week – May 22, 2013
Technological Advances
Will lead to driverless vehicles but challenges remain

- Sensor technology
- Computational power
- Algorithm development
- Connectivity
Vehicle Automation
National Highway Traffic Safety Administration

- Level 0 – No Automation
- Level 1 – Function Specific Automation
- Level 2 – Combined Function
- Level 3 – Limited Self-Driving Automation
- Level 4 – Full Self-Driving Automation
Levels of Control

“Partially Autonomous Driving” is the focus of today’s talk

- Level 0 – No Automation
- Level 1 – Function Specific Automation
- Level 2 – Combined Function
- Level 3 – Limited Self-Driving Automation
- Level 4 – Full Self-Driving Automation

Key area of focus
Human Centered Considerations
A partial list in no particular order of significance

- Trust in technology
- The theory of experience
- Education
- Failures in automation
- Social / political expectations
- Workload
My Trust in Technology

Windows

A fatal exception 0E has occurred at 0028:C00068F8 in UxDo VM(01) + 000059F8. The current application will be terminated.

* Press any key to terminate the application.
* Press CTRL+ALT+DEL to restart your computer. You will lose any unsaved information in all applications.

Press any key to continue
Automation and the Big Red Button

To Trust or Not?

• In many situations automation will outperform human operation, but will the driver trust it?

• How will one choose when to or when not to provide / accept autopilot control?

• Experiential learning does not yet exist.
Experience

Vehicle Miles Traveled (VMT)
Vehicle Miles Driven (VMD)

Today
VMT = VMD

Tomorrow?
VMT ≠ VMD
A Case Study: The FAA

A Comparative Analysis of Flightdecks With Varying Levels of Automation
Federal Aviation Administration Grant 93-G-038

Final Report
8 June 2000

Ken Funk
Oregon State University

Beth Lyall
Research Integrations, Inc

Prepared for the FAA Chief Scientific and Technical Advisor for Human Factors, AER-10

Technical Monitor:
John Zderic
Tom McCler
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SAFO
Safety, Alert for Operations
Federal Aviation Administration

ighted by the Safer Flight Operations (SAFO) program, this final report is a comprehensive analysis of flight deck automation and its impact on pilot performance.

Subject: Manual Flight Operations

Purpose: This SAFO encourages operators to promote manual flight operations whenever appropriate.

Background: A recent analysis of flight operations data (including normal flight operations, incidents, and accidents) identified an increase in manual handling errors. The Federal Aviation Administration (FAA) believes maintaining and improving the knowledge and skills for manual flight operations is necessary for safe flight operations.

Discussion: Modern aircraft are commonly operated using autopilot systems (e.g., autotrust or autotopilot systems). Unfortunately, continuous use of these systems does not reinforce a pilot's knowledge and skills in manual flight operations. Autopilot systems are useful tools for pilots and have improved safety and workload management, and thus enabled more precise operations. However, continuous use of autopilot systems could lead to degradation of the pilot's ability to quickly recover the aircraft from an undesired state.

Operators are encouraged to take an integrated approach by incorporating emphasis of manual flight operations into both pilot training and operation (initial, upgrade, and recurrent). Operational policies should be developed or reviewed to identify the appropriate opportunities for pilots to exercise manual flying skills, such as in novel VOR approaches and during low workload conditions. In addition, policies should be developed or reviewed to ensure that pilots understand and use the aeroshell systems, such as during high workload conditions or unusual procedures that require use of an alternate flight assistance systems (AFS). Manual crew operations may also be used to obtain practice in manual flight operations. Additional operational policies should ensure that all pilots have the appropriate opportunities to exercise the aforementioned knowledge and skills in flight operations.

Recommended Action: AFS-206

Contact: Questions or comments regarding this SAFO should be directed to the Air Carrier Training Branch, AFS-210, at (85) 267-4144

Distributed by: AFS-206 OFR AFS-210
A Simple Way to Think of Operator Behavior Variability

Drivers

Pilots

Astronauts
Motivation to Learn and Maintain Focus

Drivers

Pilots

Astronauts
“One of the myths about the impact of automation on human performance is as investment in automation increases, less investment is needed in human expertise”  
(David Woods as quoted by Robert Sumwalt, 2012)
“There will always be a set of circumstances that was not expected, that the automation either was not designed to handle or other things that just cannot be predicted,” explains (Raja) Parasuraman. So as system reliability approaches—but doesn’t quite reach—100 percent, “the more difficult it is to detect the error and recover from it”
Social / Political Forces Worry Me!

Flying robots with and without missiles worry many

Aviation is safer than driving but we frequently feel less secure
Workload & Performance

Yerkes-Dodson Law
The relationship between performance and physiological or mental arousal

![Graph showing the relationship between workload/stress and performance, with four stages: Fatigue, Inattention, Optimal Range, and Active Distraction/Overload. The graph illustrates how performance decreases as workload/stress increases, with a peak at the Optimal Range.](image-url)
More Information in the Vehicle Tends to Increase Workload

- Fatigue
- Inattention
- Optimal Range
- Active Distraction
- Overload

Workload & Performance
Workload & Performance

Automation Tends to Lower Workload

- Fatigue
- Inattention
- Active Distraction
- Overload
Physiological Arousal
What Can We Study in the Car?
Part of a larger project evaluating various methods of detecting driver state

Measures initially considered:

- Heart Rate
- Heart Rate Variability
- Pulse height (peripheral blood flow)
- Skin Temperature
- Skin Conductance
- Skin Conductance Response
- Respiration Rate
- Pupil diameter
- Muscle Tension
- EEG (brain waves)
- Stress Hormones
- fNIRS (brain blood flow)

(drawn in part from Mehler et al., 2009)
Driver State Detection
Classification of Driver Workload / Arousal

- At the **group level**, changes in demand are clearly evident across several features
- Can machine learning be used for detection at the **individual level**?
  - Apply sliding window to generate a feature set
  - Use classic approaches such as support vector machines (SVN), neural networks or nearest neighbor to classify state
Unanticipated Consequences
Failure is not an option

1. Driverless car accident that results in loss of life
2. Major media coverage
3. Public outcry and fear of automation limits use of active safety (level 1) systems
4. Push for expedited regulation that may result in inefficient standards
5. Setbacks in auto safety could last for years
6. Benefits of Level 4 autonomy delayed
In Summary, I Believe We Need To:

- Continue exploring technologies for autonomous vehicles
- Make parallel investments in developing our understanding of how to optimize the human’s connection with autonomous systems
- Clarify the benefits and consequences of system use and misuse
- Learn from complementary domains
- Stop assuming that autonomy alone will solve our nation’s transportation problems
Bryan Reimer, Ph.D.

Bryan Reimer, Ph.D., is a Research Engineer in the Massachusetts Institute of Technology AgeLab and the Associate Director of the New England University Transportation Center. His research seeks to develop new models and methodologies to measure and understand human behavior in dynamic environments utilizing physiological signals, visual behavior monitoring, and overall performance measures. Dr. Reimer leads a multidisciplinary team of researchers and students focused on understanding how drivers respond to the increasing complexity of the operating environment and on finding solutions to the next generation of human factors challenges associated with distracted driving, automation and other in-vehicle technologies. He directs work focused on how drivers across the lifespan are affected by in-vehicle interfaces, safety systems, portable technologies, different types and levels of cognitive load. This research also assesses the impact of medical impairments such as diabetes, cardiovascular disease, ADHD and autism. Dr. Reimer is an author on over 80 peer reviewed journal and conference papers in transportation. Dr. Reimer is a graduate of the University of Rhode Island with a Ph.D. in Industrial and Manufacturing Engineering.

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