Implications of Autonomous Driving: Could “We” be a Near Term Threat?

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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 very little change in how drivers interface with vehicle.

- What do trends in automation, advanced driver assistance systems and information connectivity tell us about expectations for the next 25 or more years?
A Partial List of Concepts To Consider

In no particular order of significance

- Trust in technology
- The theory of experience
- Lessons from other domains
- Education
- Human capabilities
My Trust in Technology

Windows

A fatal exception 0F has occurred at 0028:C00068F8 in UxD VMM(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

Today  
VMT = VMD 

Tomorrow? 
VMT ≠ VMD 

Vehicle Miles Traveled (VMT) 
Vehicle Miles Driven (VMD)
A Case Study: The FAA

A Comparative Analysis of Flightdecks With Varying Levels of Automation
Federal Aviation Administration Grant 90-G-039

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.
AAR-100

Technical Monitor:
John Zabriskie
Tom McClymer
Elena Edens

SAFO
Safety. Aid for Operators
SAFO 10002
DATE: 11/13/13
Flight Standards Service
Washington, DC

http://www.faa.gov/cybersecurity/industrialline/operations/phase2/safosafe/index.cfm

SAFOs are important safety information and advisory bulletins. Recommended actions in SAFOs should be especially valuable to operators in identifying best practices and procedures to improve the safety and efficiency in their flight operations. Operators should be aware of and take appropriate action to correct any deficiencies or errors that may result from operating their aircraft contrary to the recommendations in this SAFO.

Purpose: This SAFO encourages operators to promote manual flight operations where 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 automatic flight systems (e.g., autopilot or autothrottles sometimes). Unfortunately, continuous use of these systems does not reinforce a pilot’s knowledge and skills in manual flight operations. Automatic flight systems are useful tools for pilots and have improved safety and workload management, and thus enabled more precise operations. However, continuous use of automatic flight systems could lead to degradation of the pilot’s ability to quickly recover the aircraft from an unusual state.

Operators are encouraged to take an integrated approach by incorporating emphasis of manual flight operations into both line operations and training (initial, upgrade, and recurrent). Operational policies should be developed or reviewed to ensure there are appropriate opportunities for pilots to exercise manual flight skills, such as in non-VFR airspace and during low workload conditions. In addition, policies should be developed or reviewed to ensure that pilots understand what to use the automatic systems, such as during high workload conditions or difficult procedures that require use of manual control for precise operations. Improved crew operations may also limit the ability of some pilots 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: Directors of Operations, Program Managers, Directors of Training, Training Center Managers, Check Pilots, Training Pilots, and Flightcrews should be familiar with the content of this SAFO. They should work together to ensure that the content of this SAFO is incorporated into operational policy, provided to pilots during ground training, and reinforced in flight training and proficiency checks.

Contact: Questions or comments regarding this SAFO should be directed to the Air Carrier Training Branch, AFS-210, at (202) 267-4164

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Education

“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)
A Simple Way to Think of Operator Behavior Variability

Drivers

Pilots

Astronauts

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Motivation to Learn and Maintain Focus

Drivers

Pilots

Astronauts
Human Centered Automation
A key to safety?

“The human is seen as an essential element in the system for monitoring the automation, to act as a supervisory controller over the [automation], and to be able to step in when the automation fails.”

“But it has been become evident that the human, when put in the role of monitor, supervisor, and automation backup in the case of failure, may not perform well.”

Sheridan (1995), Human centered automation: oxymoron or common sense?
Workload & Performance

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

![Diagram showing the relationship between workload and performance with the Yerkes-Dodson Law, illustrating optimal range, inattention, active distraction, fatigue, and overload.](image-url)
Workload & Performance

More Information in the Vehicle Tends to Increase Workload

- Fatigue
- Inattention
- Optimal Range
- Active Distraction
- Overload
Automation Tends to Lower Workload

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

Workload & Performance

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Inattention

Optimal Range

Active Distraction

Overload

Workload / Stress

Performance
Physiological Measures

A method for detecting over-arousal and possibly under-arousal (fatigue, inattentiveness)

This can provide:

- Input to workload management
  (reduce low priority information display and minimize automation induced monotony)

- Input to active safety
  (automatic collision response)

- Input to passive safety
  (next generation advanced collision notification)

Our vision of aware vehicles where the driver is an active, not passive, part of the system. (Reimer, Coughlin & Mehler, 2009)
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

- Which measures will prove most sensitive at differentiating levels of demand?

- What minimum set of measures is required to quantify changes in driver state that provide a robust understanding of arousal and attentional focus?

(drawn in part from Mehler et al., 2009)
Heart Rate & Skin Conductance Response to 3 Levels of Added Workload

- Both increase with task difficulty (p < .001)
- Heart rate (HR) changes essentially linear with demand; rapid recovery
- Skin Conductance (SCL) reactivity at low demand suggests emotional component; slower recovery

(Mehler, Reimer & Coughlin, 2012)
Aware Vehicles
Individualized Real-time Feedback for the Driver

- Improve self control
- Increase trust (person as an active vs. passive partner)
- Tailor to individual reactivity profiles and capacity

(Coughlin, Reimer & Mehler, 2011)
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Other Applications of Physiological Monitoring

- **Design assessment and optimization:** minimize cognitive workload and distraction associated with in-vehicle and handheld technology usage – method of classifying overtaxing non-visual demands?

- **Health state detection:** monitoring diabetes or cardiovascular conditions – warning that attention may be compromised?

- **Emergency response data:** store short term EKG prior to crash and provide as supportive information to emergency medical teams – optimize the golden hour?
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
Contact

Bryan Reimer, Ph.D.

Bryan Reimer 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. Dr. Reimer is an author on over 70 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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