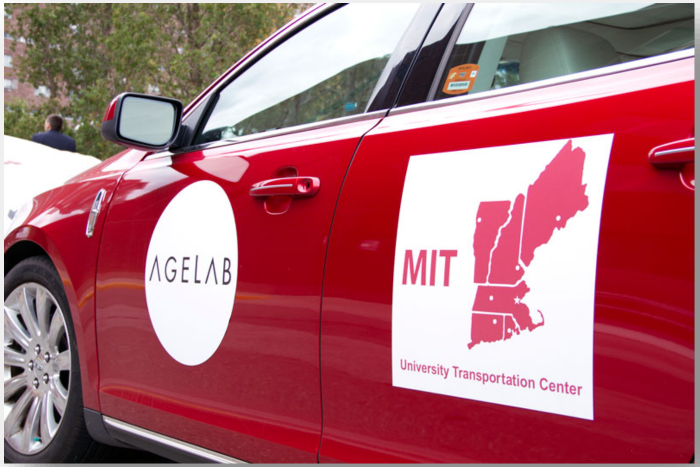
Human Centered Considerations: Future Vehicles & The Aging Operator

Bryan Reimer, Ph.D.
MIT AgeLab & New England University Transportation Center

Vermont Highway Safety Alliance Annual Meeting
Killington, VT

October 14, 2014



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

Projected Population of People 70+

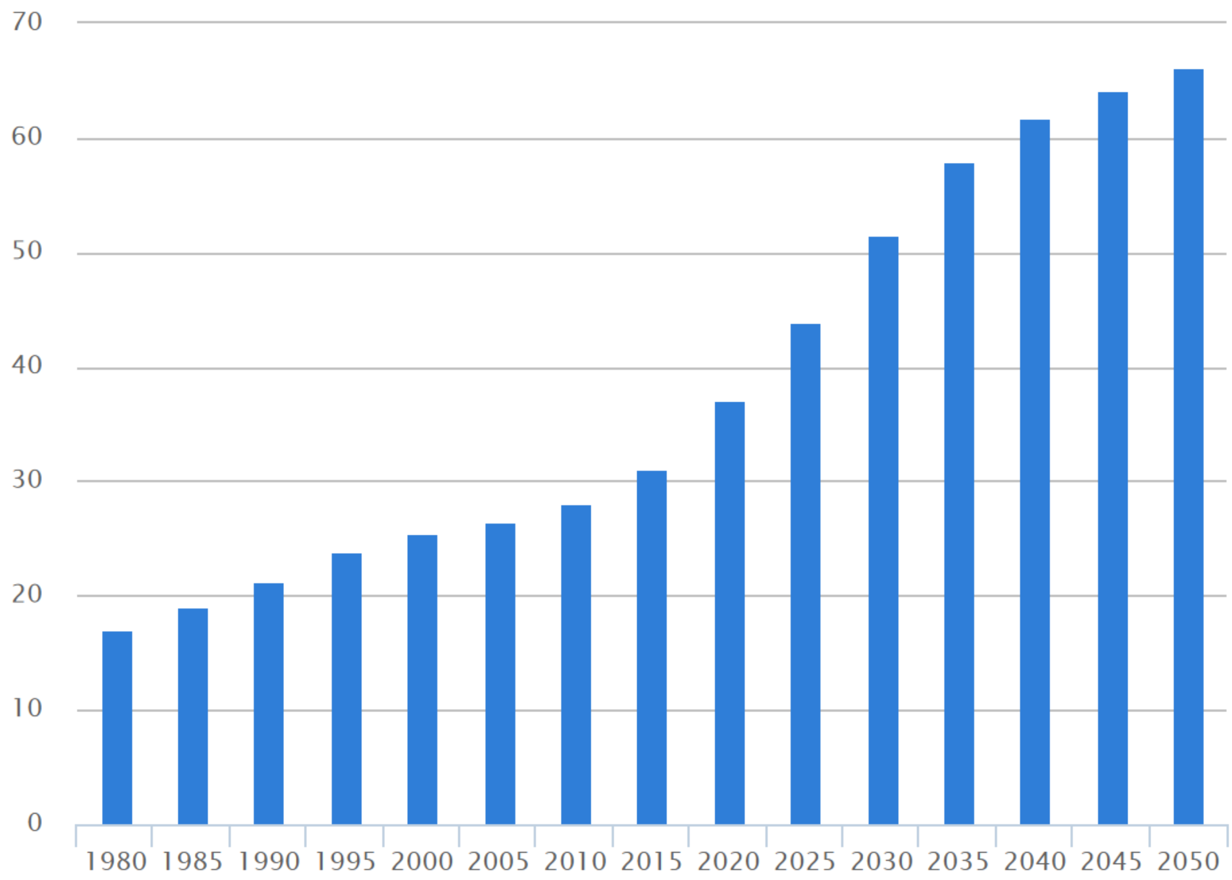
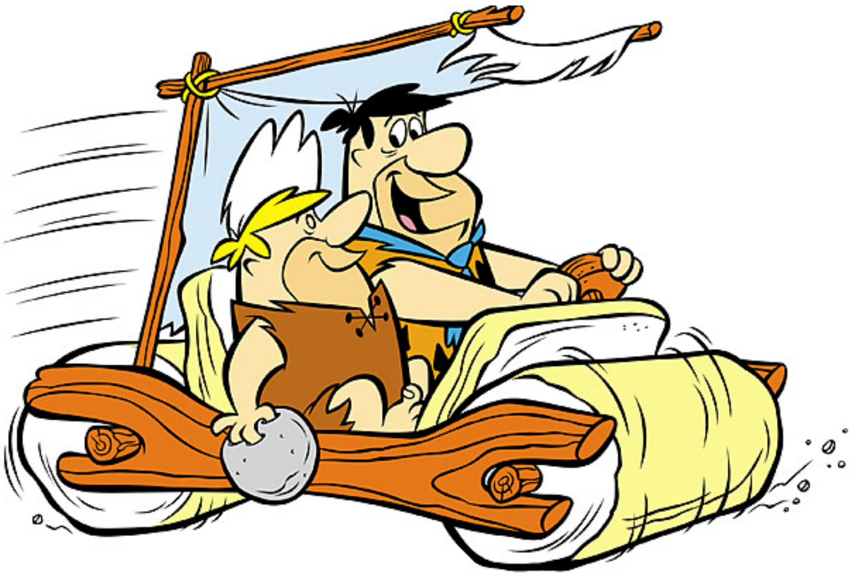


Figure drawn from IIHS Status Report (2014) Vol. 49, No. 1

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT

Evolution

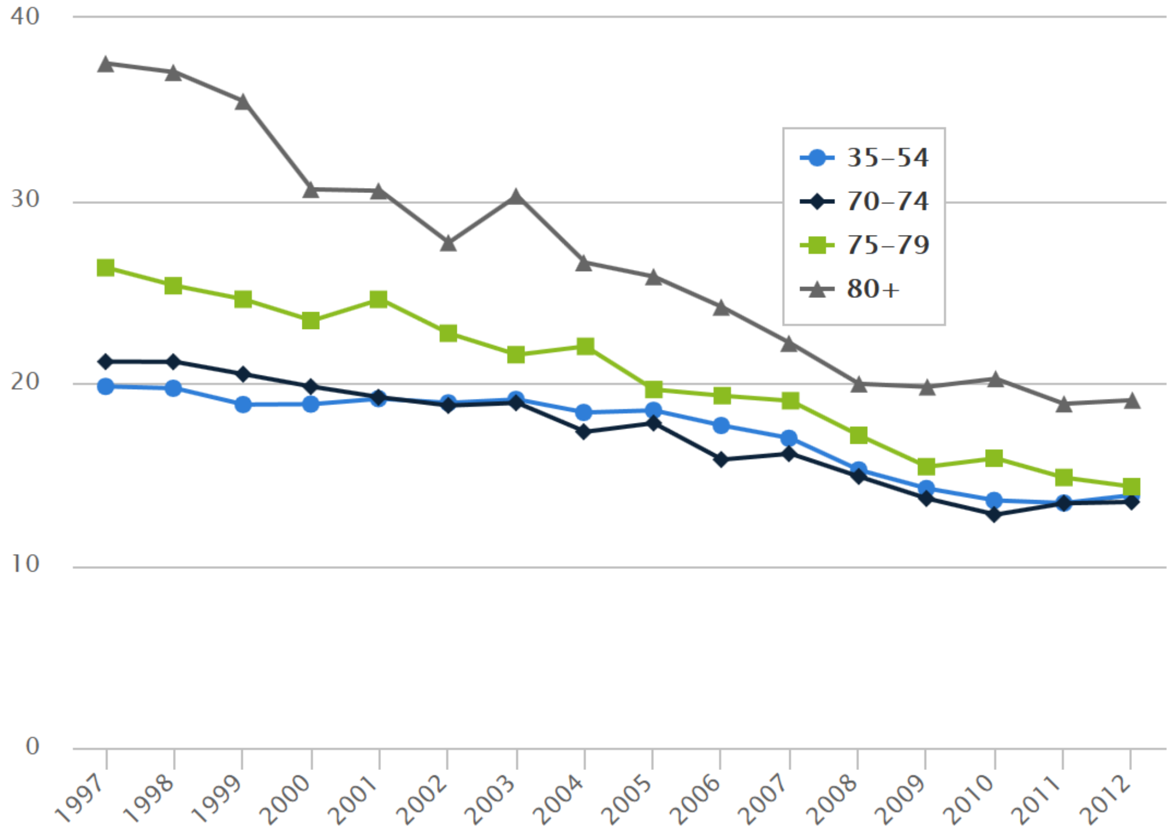


- Drivers are "outdated … with stone age characteristics and performance controlling a fast, heavy machine in an environment packed with unnatural, artificial signs and signals." (Dewar, 1988)
- Faber (1993) expands on this by noting that our ancestors were daytime hunters used to monitoring animals running at speeds of no more than 25 MPH

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu
© 2014 MIT AGELAB MIT

Crash Rates are Decreasing for Older Adults

US fatal passenger vehicle driver crash involvements per 100,000 licensed drivers by age



Older drivers are looking more like middle-aged drivers

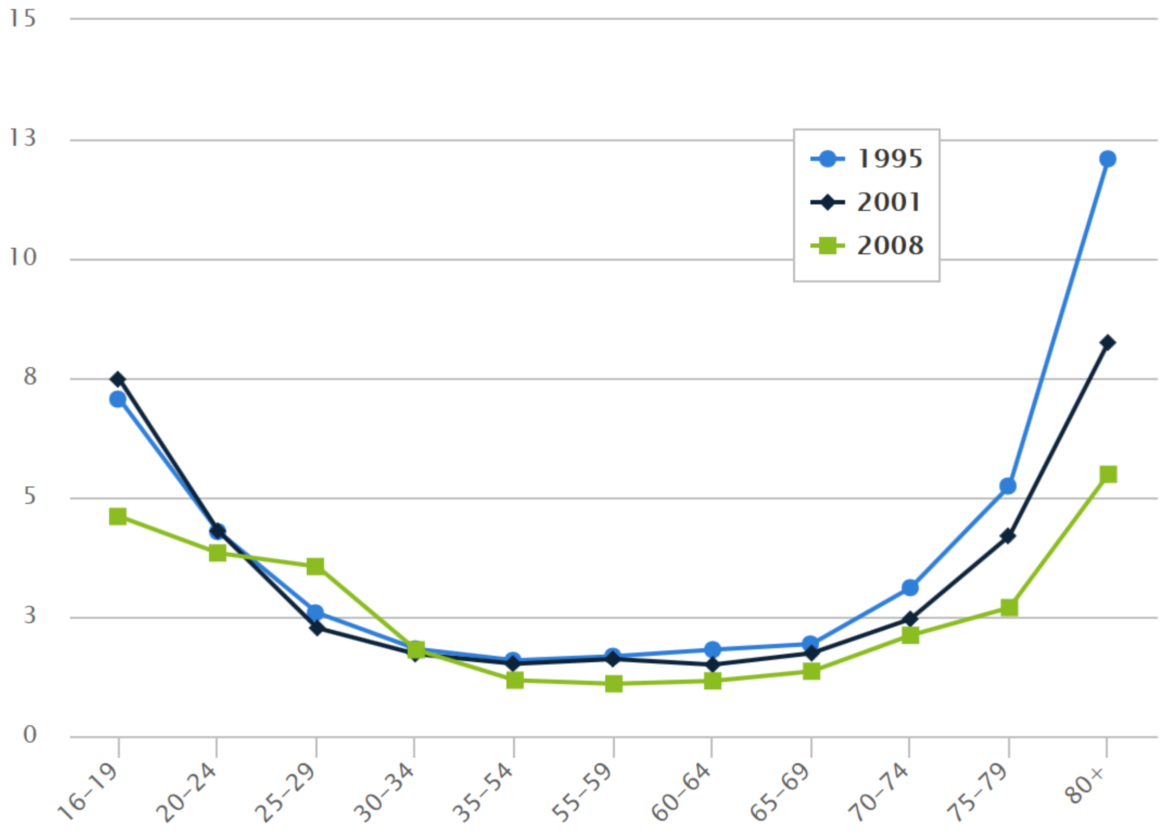
Figure drawn from IIHS Status Report (2014) Vol. 49, No. 1

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB

Crash Rates are Decreasing for Older Adults

US fatal passenger vehicle driver crash involvements per 100 million miles traveled



The bathtub curve is changing shape

Figure drawn from IIHS Status Report (2014) Vol. 49, No. 1

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB

The Importance of Driving to Older Adults

- Responses from MIT AgeLab focus group research:
  - "If it came to eating soup every day to keep my car or steak every day to give up the car...... I would eat soup".
    Older Female Respondent, Chicago
  - "You can always get another wife, but you can only get one driver's license".
    Older Male Respondent, Boston

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

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?

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014

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

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB

Technological Advances

Will lead to driverless vehicles but challenges remain

- Sensor technology
- Computational power
- Algorithm development
- Connectivity

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

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

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

Levels of Control

"Partially Autonomous Driving" is the focus of todays 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 (Levels 2 and 3)

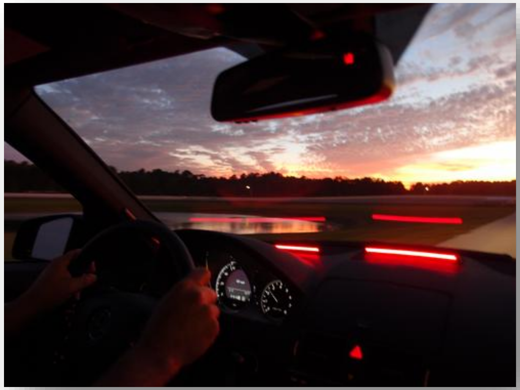
Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

Advanced Driver Assistance Systems

Independently implemented level 0 – 1 automation

- Low speed maneuvering
  - Backup cameras
  - Forward and reverse sensing
  - Cross traffic warning
  - Parallel parking assistance
  - Pedestrian detection
- High speed travel
  - Adaptive cruise control
  - Forward collision warning
  - Automatic emergency braking
  - Blind spot detection or warning
  - Lane departure warning
  - Lane departure mitigation



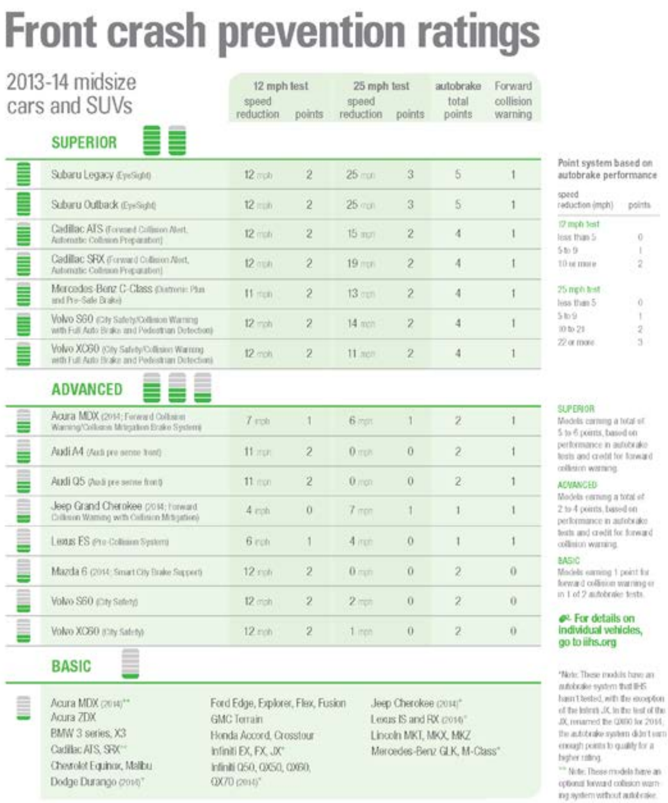
Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

The Benefits of ADAS

Autonomous Emergency Braking (AEB) – a key technology for enhancing older adult safety?

Projected benefits



Front crash prevention ratings

2013-14 midsize cars and SUVs

	12 mph test speed reduction	12 mph test points	25 mph test speed reduction	25 mph test points	autobrake total points	Forward collision warning
SUPERIOR						
Subaru Legacy (EyeSight)	12 mph	2	25 mph	3	5	1
Subaru Outback (EyeSight)	12 mph	2	25 mph	3	5	1
Cadillac ATS (Forward Collision Alert, Automatic Collision Preparation)	12 mph	2	15 mph	2	4	1
Cadillac SRX (Forward Collision Alert, Automatic Collision Preparation)	12 mph	2	19 mph	2	4	1
Mercedes-Benz C-Class (Distronic Plus and Pre-Safe Brake)	11 mph	2	13 mph	2	4	1
Volvo S60 (City Safety/Collision Warning with Full Auto Brake and Pedestrian Detection)	12 mph	2	14 mph	2	4	1
Volvo XC60 (City Safety/Collision Warning with Full Auto Brake and Pedestrian Detection)	12 mph	2	11 mph	2	4	1
ADVANCED						
Acura MDX (2014; Forward Collision Warning/Collision Mitigation Brake System)	7 mph	1	6 mph	1	2	1
Audi A4 (Audi pre sense front)	11 mph	2	0 mph	0	2	1
Audi Q5 (Audi pre sense front)	11 mph	2	0 mph	0	2	1
Jeep Grand Cherokee (2014; Forward Collision Warning with Collision Mitigation)	4 mph	0	7 mph	1	1	1
Lexus ES (Pre-Collision System)	6 mph	1	4 mph	0	1	1
Mazda 6 (2014; Smart City Brake Support)	12 mph	2	0 mph	0	2	0
Volvo S60 (City Safety)	12 mph	2	2 mph	0	2	0
Volvo XC60 (City Safety)	12 mph	2	1 mph	0	2	0

BASIC

Acura MDX (2014)**
Acura ZDX
BMW 3 series, X3
Cadillac ATS, SRX**
Chevrolet Equinox, Malibu
Dodge Durango (2014)*
Ford Edge, Explorer, Flex, Fusion
GMC Terrain
Honda Accord, Crosstour
Infiniti EX, FX, JX*
Infiniti Q50, QX50, QX60, QX70 (2014)*
Jeep Cherokee (2014)*
Lexus IS and RX (2014)*
Lincoln MKT, MKX, MKZ
Mercedes-Benz GLK, M-Class*

Point system based on autobrake performance

speed reduction (mph)	points
12 mph test	
less than 5	0
5 to 9	1
10 or more	2
25 mph test	
less than 5	0
5 to 9	1
10 to 21	2
22 or more	3

SUPERIOR
Models earning a total of 5 to 6 points, based on performance in autobrake tests and credit for forward collision warning.

ADVANCED
Models earning a total of 2 to 4 points, based on performance in autobrake tests and credit for forward collision warning.

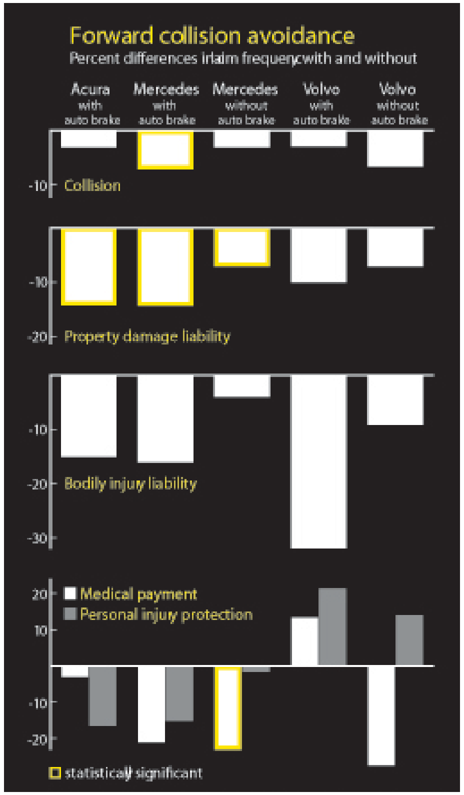
BASIC
Models earning 1 point for forward collision warning or in 1 of 2 autobrake tests.

For details on individual vehicles, go to iihs.org

*Note: These models have an autobrake system that IIHS hasn't tested, with the exception of the Infiniti JX. In the test of the JX, renamed the QX60 for 2014, the autobrake system didn't earn enough points to qualify for a higher rating.
** Note: These models have an optional forward collision warning system without autobrake.

IIHS Crash Avoidance Ratings 2013

Real-world benefits



IIHS, Status Report 2012

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB

Human Factors for Automated Vehicles

A sample of questions "I" keep getting asked about

- How do we ensure a smooth transition from highly automated driving back to "manual" control?
- How can we develop an interface that can provide a "driver" with a clear understanding of the status of the automation?
- How do we ensure that the "operator" remains attentive and capable of resuming control if the automation fails?
- Do we need to keep the driver "in the loop"?

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu
© 2014 MIT AGELAB MIT University Transportation Center

Human Centered Considerations

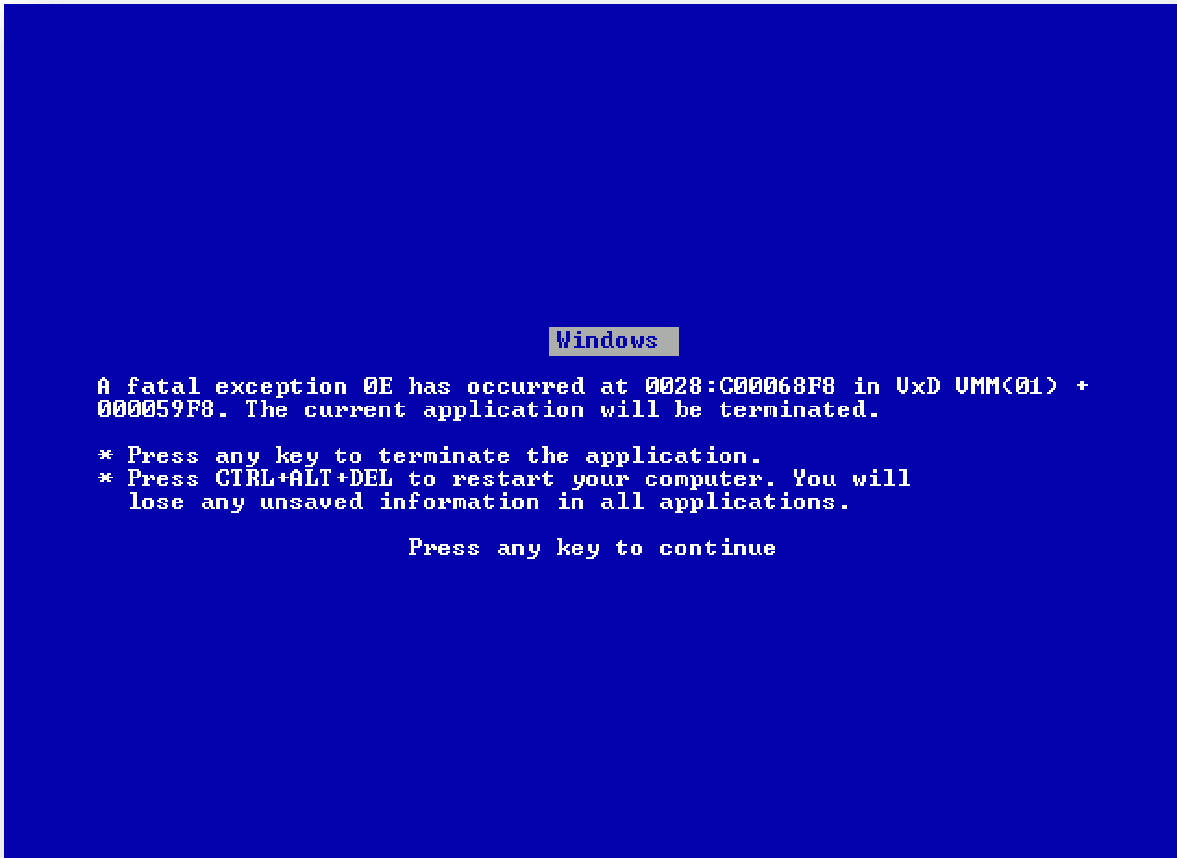
A partial list in no particular order of significance

- Trust in technology
- The theory of experience
- Education
- Workload

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

My Trust in Technology

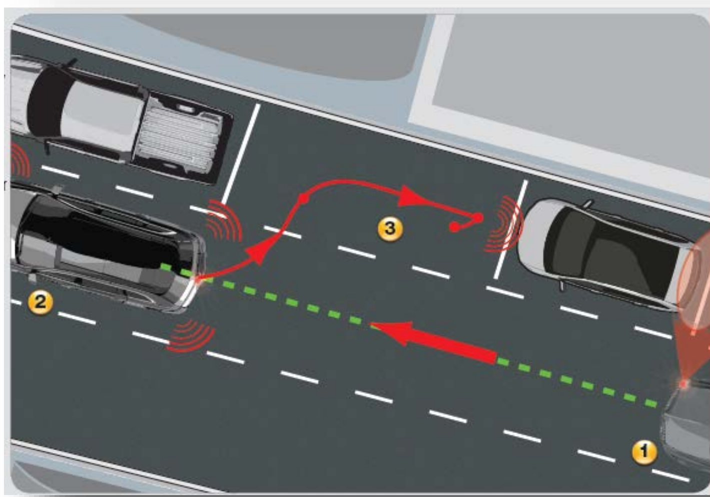


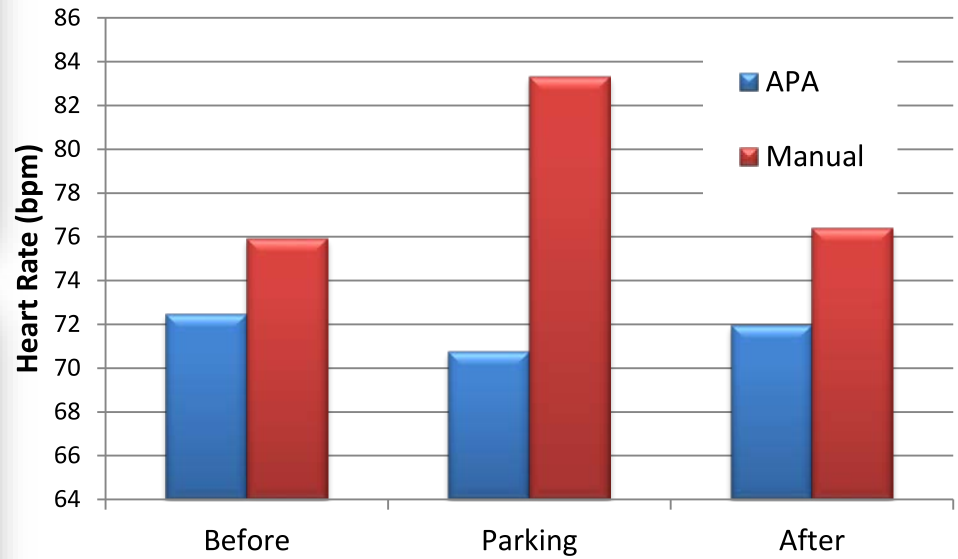
Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT

Ford Active Park Assist

Trust can be trained





(Reimer, Mehler & Coughlin, 2010)

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT

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?
- In what way will automation impact self-regulation?
- Experiential learning does not yet exist.

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

Experience

Vehicle Miles Traveled (VMT)

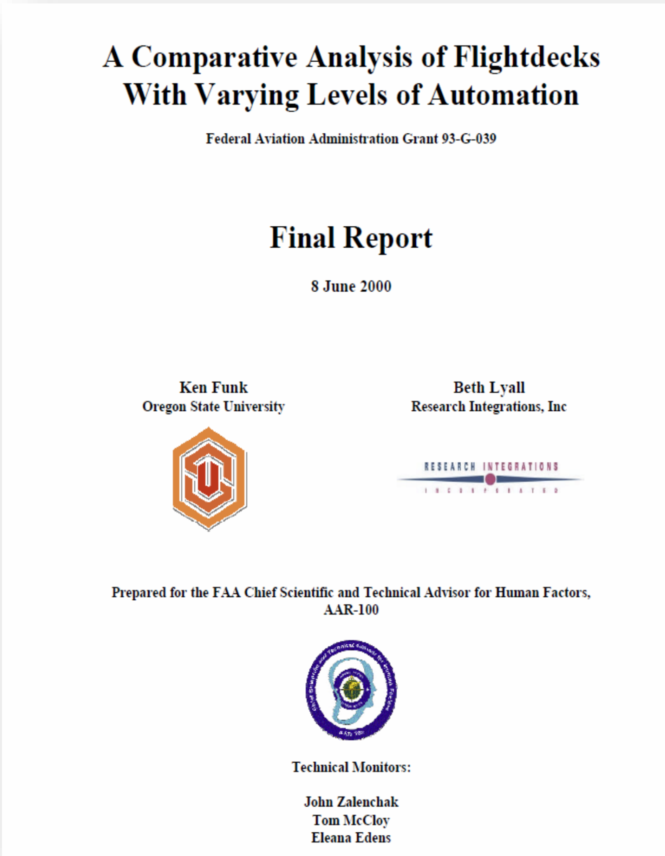
Vehicle Miles Driven (VMD)

Today	Tomorrow?
VMT = VMD	VMT ≠ VMD

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014

A Case Study: The FAA



A Comparative Analysis of Flightdecks With Varying Levels of Automation

Federal Aviation Administration Grant 93-G-039

Final Report

8 June 2000

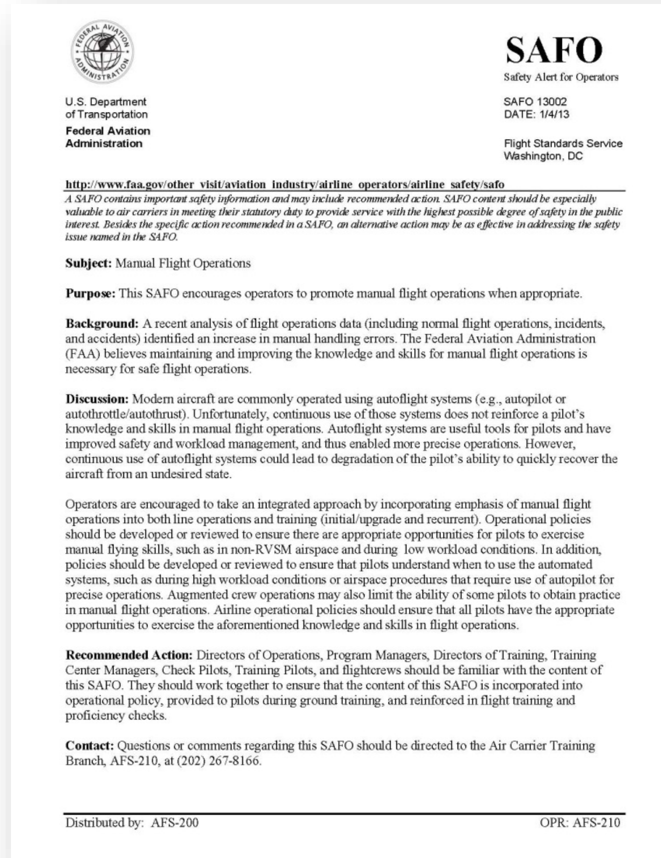
Ken Funk
Oregon State University

Beth Lyall
Research Integrations, Inc

Prepared for the FAA Chief Scientific and Technical Advisor for Human Factors, AAR-100

Technical Monitors:

John Zalenchak
Tom McCloy
Eleana Edens



SAFO
Safety Alert for Operators

U.S. Department of Transportation
Federal Aviation Administration

SAFO 13002
DATE: 1/4/13

Flight Standards Service
Washington, DC

http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo

A SAFO contains important safety information and may include recommended action. SAFO content should be especially valuable to air carriers in meeting their statutory duty to provide service with the highest possible degree of safety in the public interest. Besides the specific action recommended in a SAFO, an alternative action may be as effective in addressing the safety issue named in the SAFO.

Subject: Manual Flight Operations

Purpose: This SAFO encourages operators to promote manual flight operations when 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 autoflight systems (e.g., autopilot or autothrottle/autothrust). Unfortunately, continuous use of those systems does not reinforce a pilot's knowledge and skills in manual flight operations. Autoflight systems are useful tools for pilots and have improved safety and workload management, and thus enabled more precise operations. However, continuous use of autoflight 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 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 flying skills, such as in non-RVSM airspace and during low workload conditions. In addition, policies should be developed or reviewed to ensure that pilots understand when to use the automated systems, such as during high workload conditions or airspace procedures that require use of autopilot for precise operations. Augmented crew operations may also limit the ability of some pilots to obtain practice in manual flight operations. Airline operational policies should ensure that all pilots have the appropriate opportunities to exercise the aforementioned knowledge and skills in flight operations.

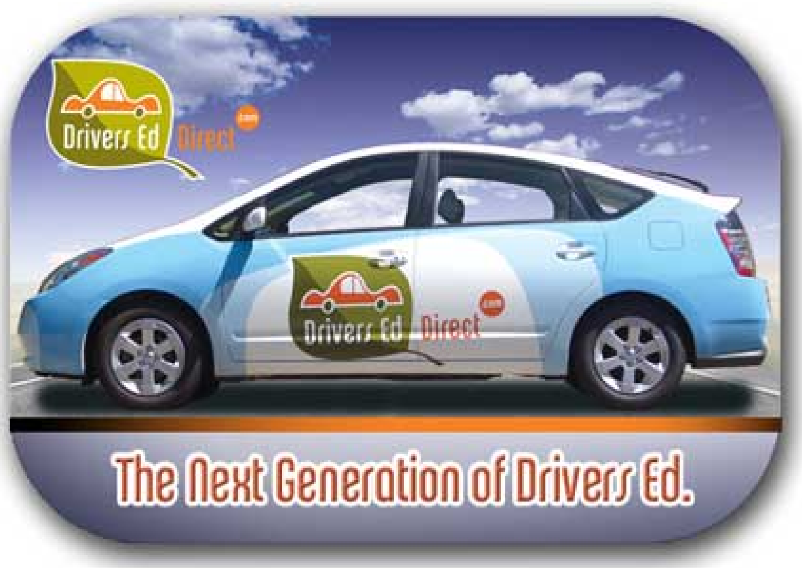
Recommended Action: Directors of Operations, Program Managers, Directors of Training, Training Center Managers, Check Pilots, Training Pilots, and flightcrews should be familiar with the content of this SAFO. They should work together to ensure that the content of this SAFO is incorporated into operational 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) 267-8166.

Distributed by: AFS-200 | OPR: AFS-210

© 2014 MIT AGELAB MIT University Transportation Center

Education

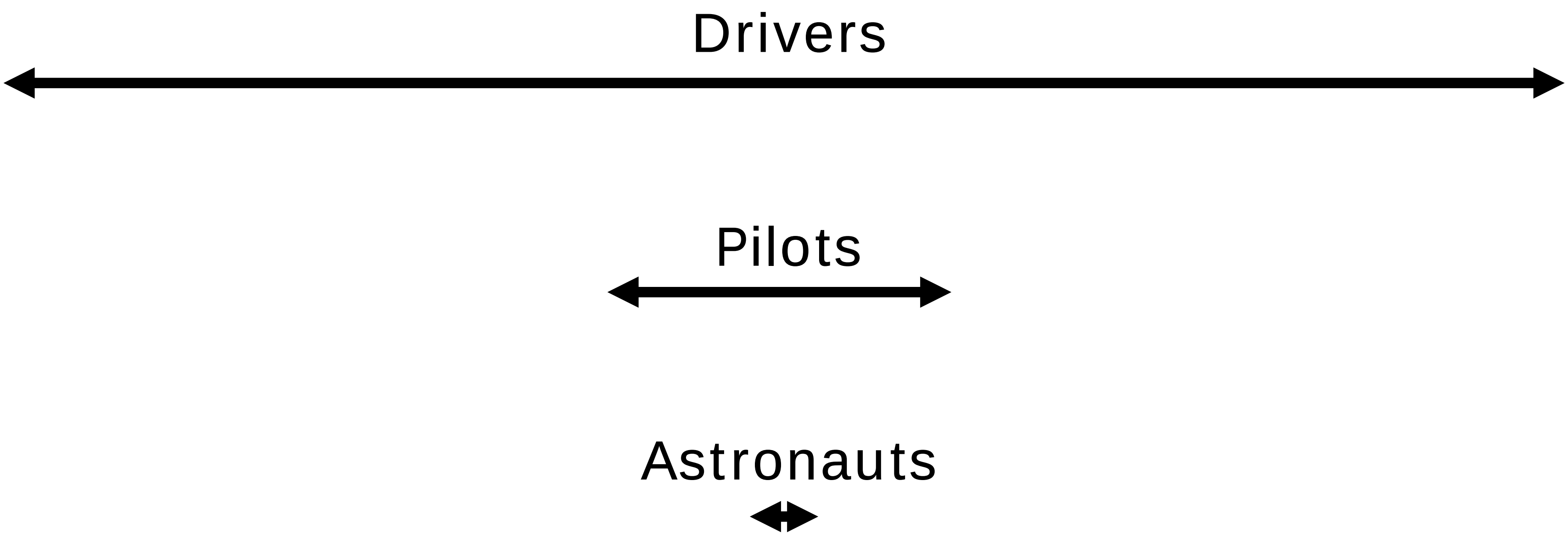


"One of the myths about the impact of automation on human performance is as investment in automation increases, less investment is needed in human expertise"

David Woods as quoted by Robert Sumwalt, 2012

© 2014 MIT AGELAB MIT

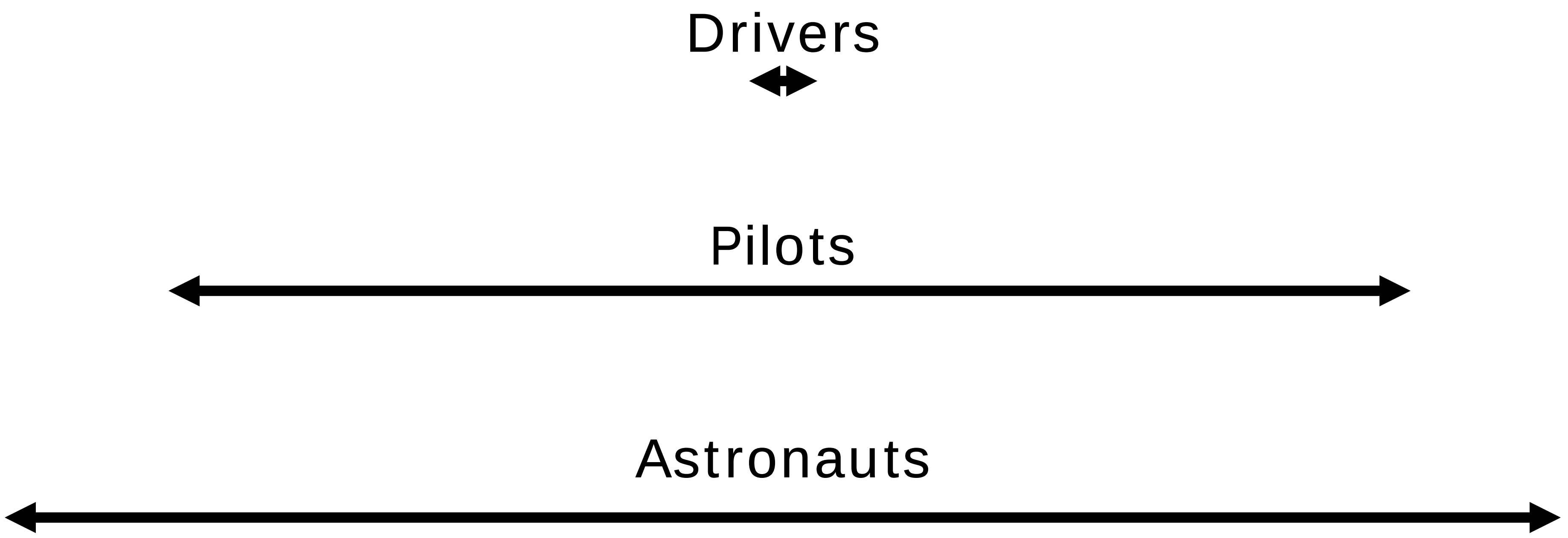
A Simple Way to Think of Operator Behavior Variability



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

Motivation to Learn and Maintain Focus

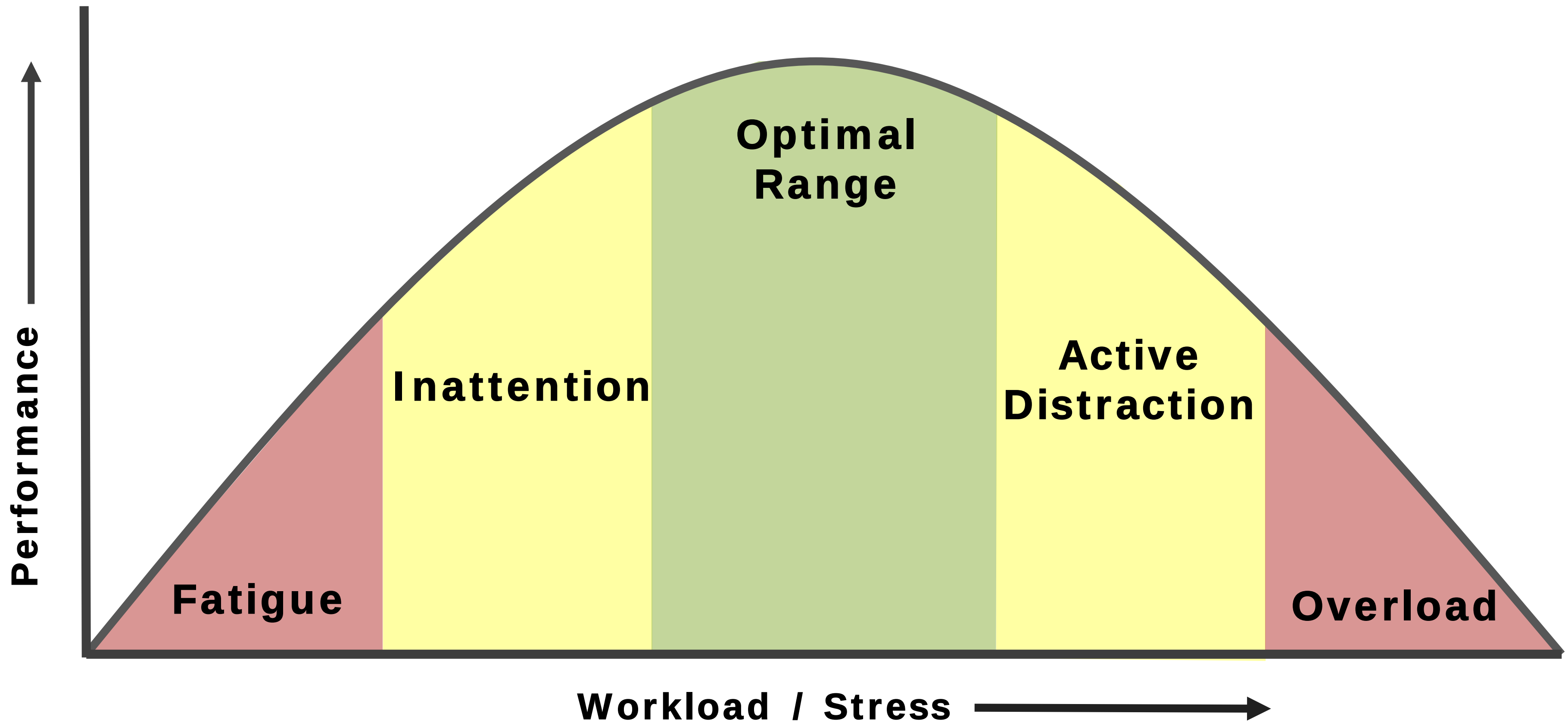


Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014

Workload & Performance

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

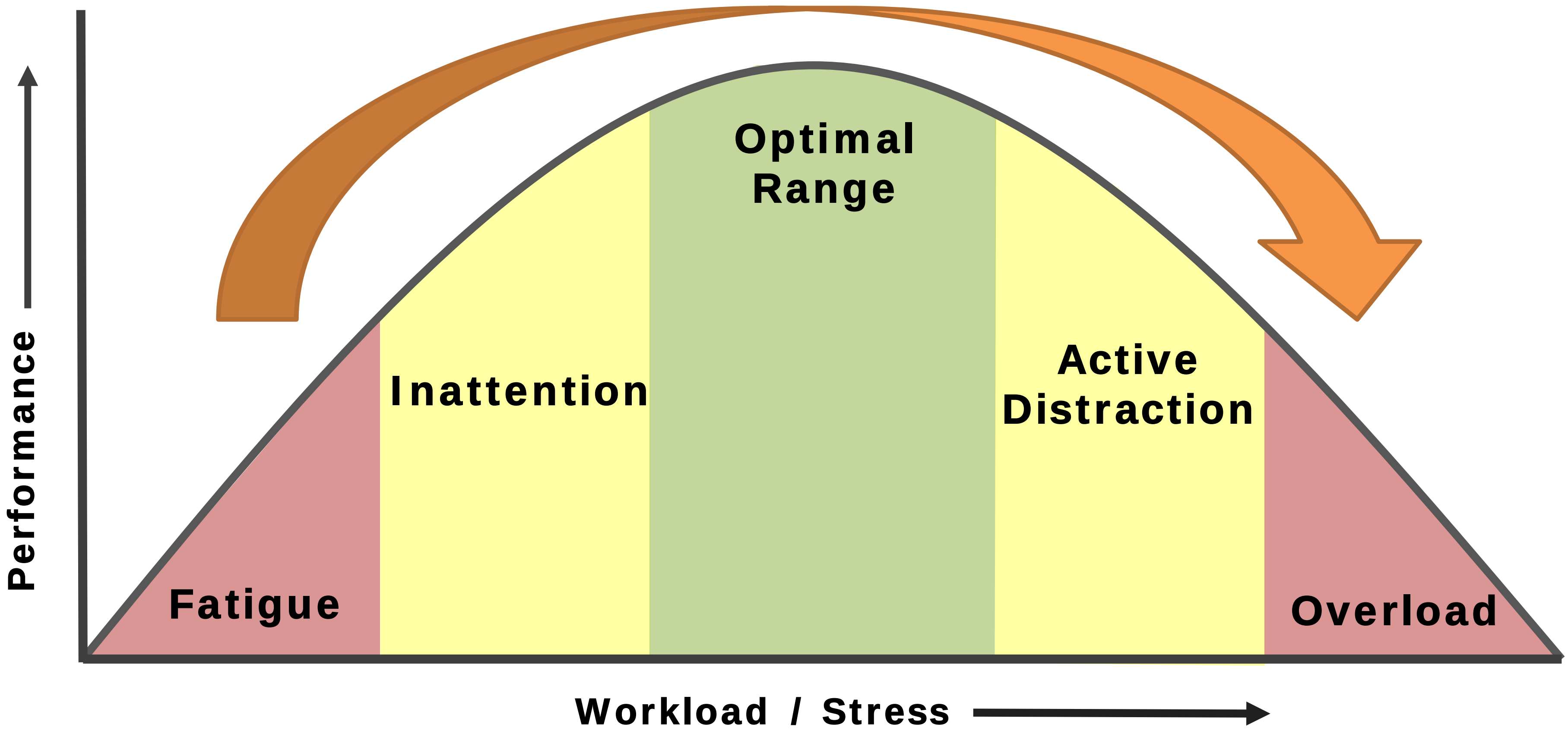


Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT

Workload & Performance

More Information in the Vehicle Tends to Increase Workload

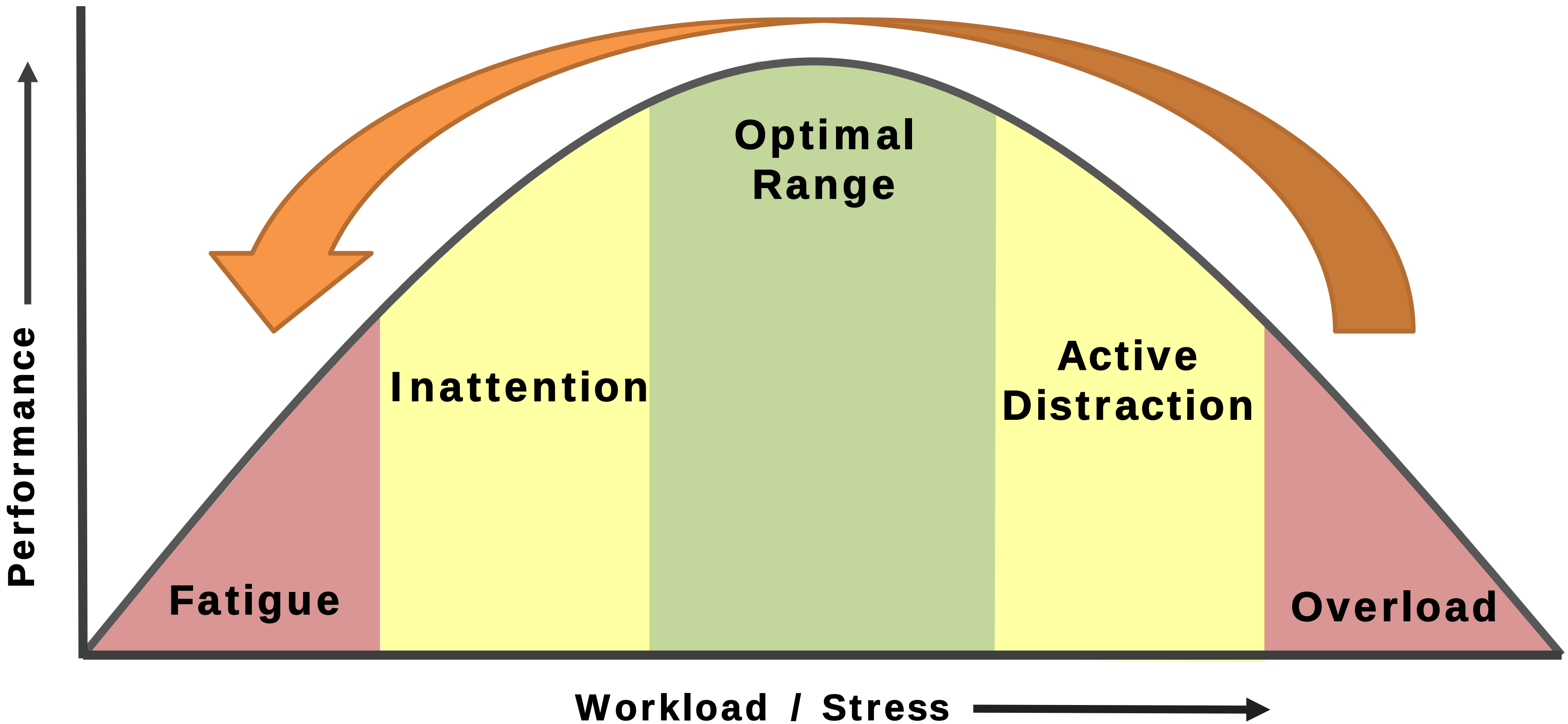


Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT

Workload & Performance

Automation Tends to Lower Workload



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014

Failures in Automation

Required reading

IEEE SPECTRUM

Follow on:

Topics Reports Blogs Multimedia Magazine

Computing | Software | Feature

Automated to Death

As software pilots more of our vehicles, humans can pay the ultimate price. Robert N. Charette investigates the causes and consequences of the automation paradox

By Robert N. Charette
Posted 15 Dec 2009 | 5:00 GMT

Share | Email | Print

"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"

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

Liability

No system is “truly perfect”

“The first time that a driverless vehicle swerves to avoid a shopping cart and hits a stroller, someone’s going to write, ‘robot car kills baby to save groceries,’ ” he said. “It’s those kinds of reasons you want to make sure this stuff is fully tested.”

(Ryan Calo, a law professor at the University of Washington who co-founded the Legal Aspects of Autonomous Driving Center at Stanford, 2013)

© 2014 MIT AGELAB MIT University Transportation Center

What is Defective?

Is it the technology or the operator?

NHTSA Office of Defects Investigation (ODI) “received two complaints of false application of emergency braking in model year 2013 Infiniti JX35 vehicles. In both complaints, the **consumers allege that the intelligent brake assist system inappropriately activated emergency braking autonomously** bringing the vehicle to an immediate and complete stop.” – **Nissan’s resolution was a software update**

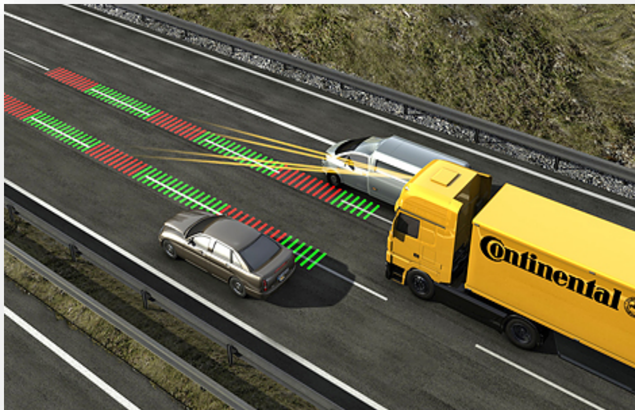
An investigation is currently active looking at a similar ODI complaint against the **2014 Chevy Impala.**

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB
MIT University Transportation Center

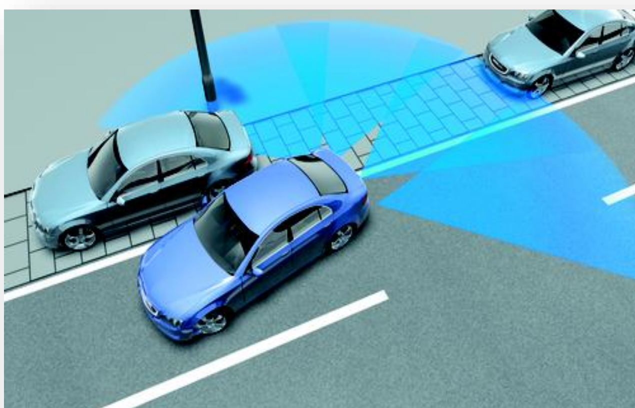
Looking at Technology Learning

Where the rubber meets the road!



?

- The manual
- DVD's & the web
- Sales staff
- Friends
- Trial and error



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT

Voice Interfaces

strative results drawn from: Reimer, B. & Mehler, B. (2013). The Effects of a Production Level “Voice-Command” Interface on Driver Behavior: mmary Findings on Reported Workload, Physiology, Visual Attention, and Driving Performance. MIT AgeLab White Paper No. 2013-18A. ssachusetts Institute of Technology, Cambridge, MA.

Interface Tasks

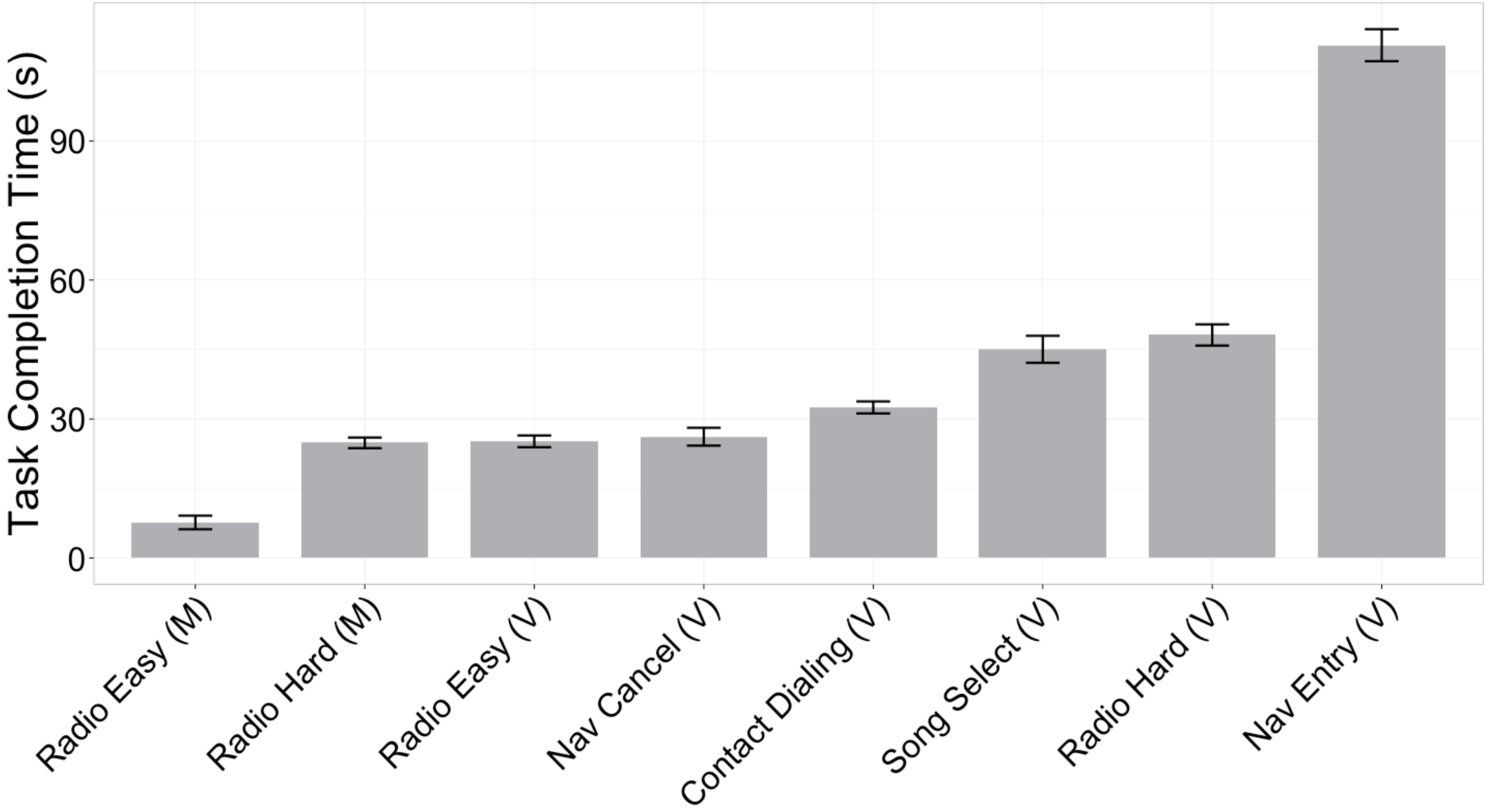
Extensive parking lot training and driving evaluation (x2)

- Visual-manual task (radio tuning)
  - Single press preset selection – Radio Easy (M)
  - Manual radio tuning to a specified station (i.e. FM 98.5) – Radio Hard (M)
- Voice interface tasks
  - Preset selection (manual preset selection equivalent) – Radio Easy (V)
  - Tuning to a station (manual radio tuning equivalent) – Radio Hard (V)
  - Full address destination entry – Nav Entry (V)
  - Cancel navigation – Nav Cancel (V)
  - Simple Pre-set phone contact dialing – Contact Dialing (V)
  - Song selection – Song Select (V)
  - Song selection failure (1 experience) – Song Fail (V)

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu
© 2014 MIT AGELAB MIT University Transportation Center

Time on Task

The Voice-based Navigation Entry task took much longer to complete than any other task ($p < .001$)



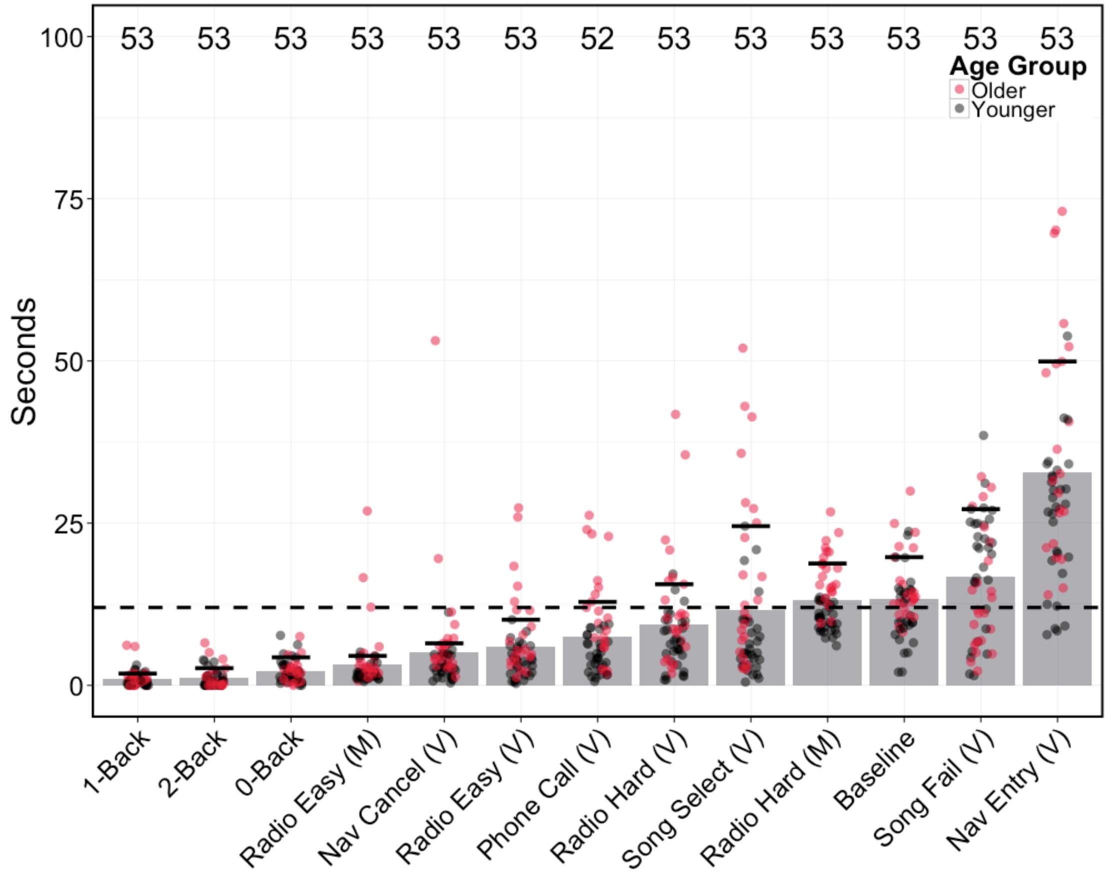
Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

Total Off-Road Glance Time

Longest for Voice Navigation Entry

Voice Radio Hard was lower than Manual Radio Hard



12 second threshold shown as a dashed line. The longer individual line above each bar represents the 85% point in the sample distribution for each task.

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB

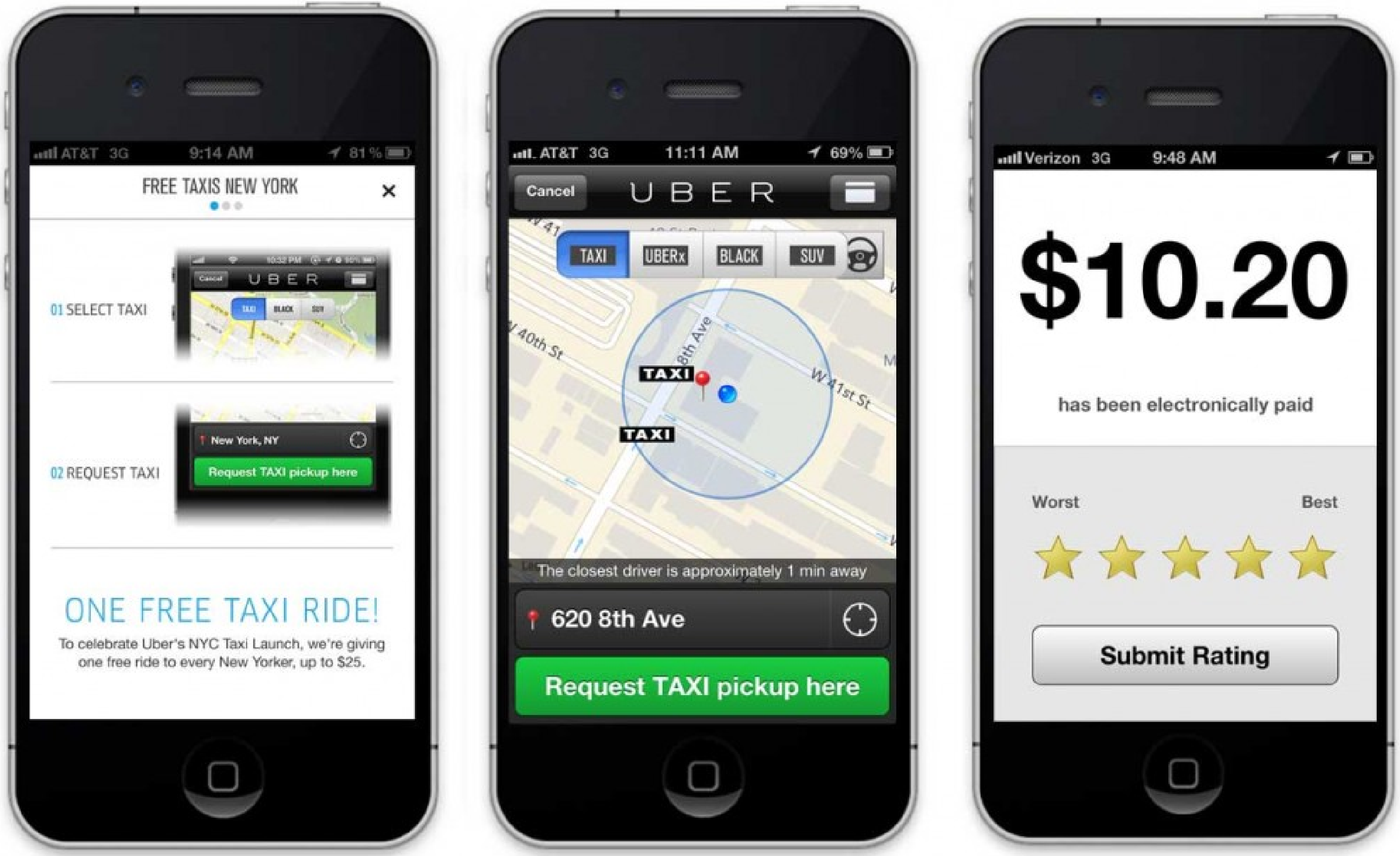
Some General Conclusions

- The voice-command interface showed advantages in lower workload and visual engagement in some activates (e.g. radio tuning)
- **Cognitive load** for the voice-command tasks studied was **generally lower than expected** (based on self-report, physiology, driving performance)
- **Visual demand** for some voice-command tasks was **higher than might be expected**
- Voice recognition was higher than expected with only a select number subjects being “dropped” for issues
- Reducing the amount of audio content listening time required and confirmatory responses (expert mode) shortened task time but did not appreciably reduce visual demand

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center

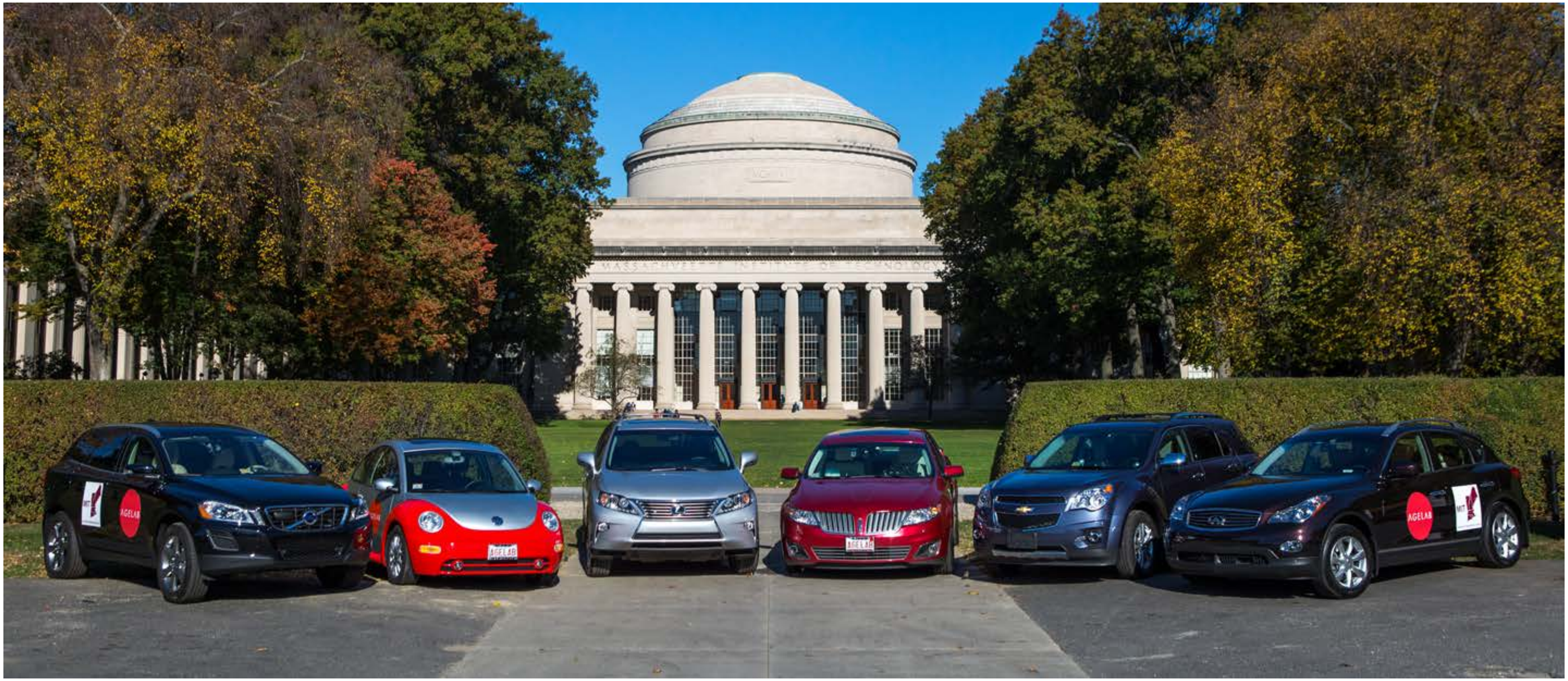
UBER - The Ultimate Automated Vehicle for the Older Driver?



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB

Questions



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

© 2014 MIT AGELAB MIT University Transportation Center