National Transportation Safety Board

What Accident Investigation Has Taught Us (And Continues to Teach Us) About Human Factors in Automated Transportation

Jana Price, PhD
Humans in Modern Transport Systems – Who Is In Control?
May 7-8, 2019, Oslo, Norway

1

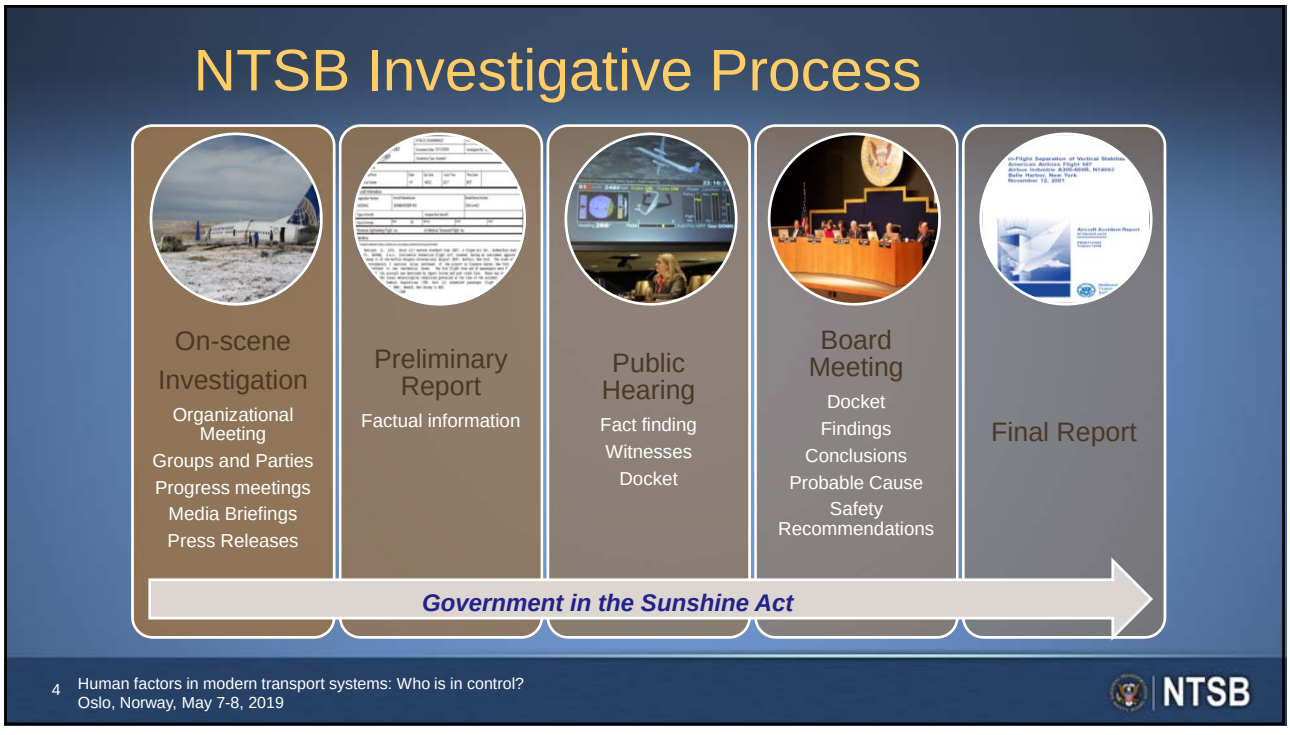
What is the NTSB?

We investigate transportation events and recommend changes to improve safety

2


Multi Modal
THE RESOURCE
3
Human factors in modern transport systems: Who is in control?
Oslo, Norway, May 7-8, 2019
NTSB

3


NTSB Investigative Process
On-scene Investigation
Organizational Meeting
Groups and Parties
Progress meetings
Media Briefings
Press Releases
Preliminary Report
Factual information
Public Hearing
Fact finding
Witnesses
Docket
Board Meeting
Docket
Findings
Conclusions
Probable Cause
Safety Recommendations
Final Report
Government in the Sunshine Act
4
Human factors in modern transport systems: Who is in control?
Oslo, Norway, May 7-8, 2019
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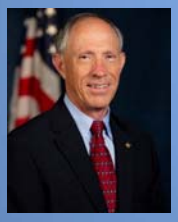
4

What is the NTSB?

- Independent accident investigation agency
- 5 appointed board members


Chairman Robert L. Sumwalt


Vice Chairman Bruce Landsberg


Member Jennifer Homendy


Member Earl F. Weener, PhD

5

NTSB 2019–2020

MOST WANTED LIST

OF TRANSPORTATION SAFETY IMPROVEMENTS

- End Alcohol and Other Drug Impairment
- Eliminate Distractions
- Ensure the Safe Shipment of Hazardous Materials
- Require Medical Fitness-Screen and Treat Obstructive Sleep Apnea
- Implement a Comprehensive Strategy to Reduce Speeding-Related Crashes
- Increase Implementation of Collision Avoidance Systems in All New Highway Vehicles
- Improve the Safety of Part 135 Aircraft Flight Operations
- Reduce Fatigue-Related Accidents
- Strengthen Occupant Protection
- Fully Implement Positive Train Control

6

2018 World Health Organization Global Status Report on Road Safety

135	Number of traffic deaths in 2016	35,092
2.7	Death rate per 100,000 population	12.4
4	Rank among 175 Countries	68

7

NTSB Highway Investigations Involving Automated Vehicle Control

8

May 7, 2016, Williston Florida Fatal Tesla Crash

- 2014 Truck-tractor combination vehicle
- 2015 Tesla, Model S
  - Level 2 automation
- Daytime, dry roadway, no sun glare

9

Vehicle Damage

Courtesy of Florida Highway Patrol

10

Investigation

- Road design/sight distance
- Driver training/experience
- Medical issues
- Substance impairment
- Fatigue
- Distraction/inattention
- Mechanical vehicle factors
- Automated system design
- Overreliance on automation

11

Investigation

- Road design/sight distance?
- ~~Driver training/experience~~
- ~~Medical issues~~
- Substance impairment?
- ~~Fatigue~~
- Distraction/inattention?
- ~~Mechanical vehicle factors~~
- Automated system design?
- Overreliance on automation?

12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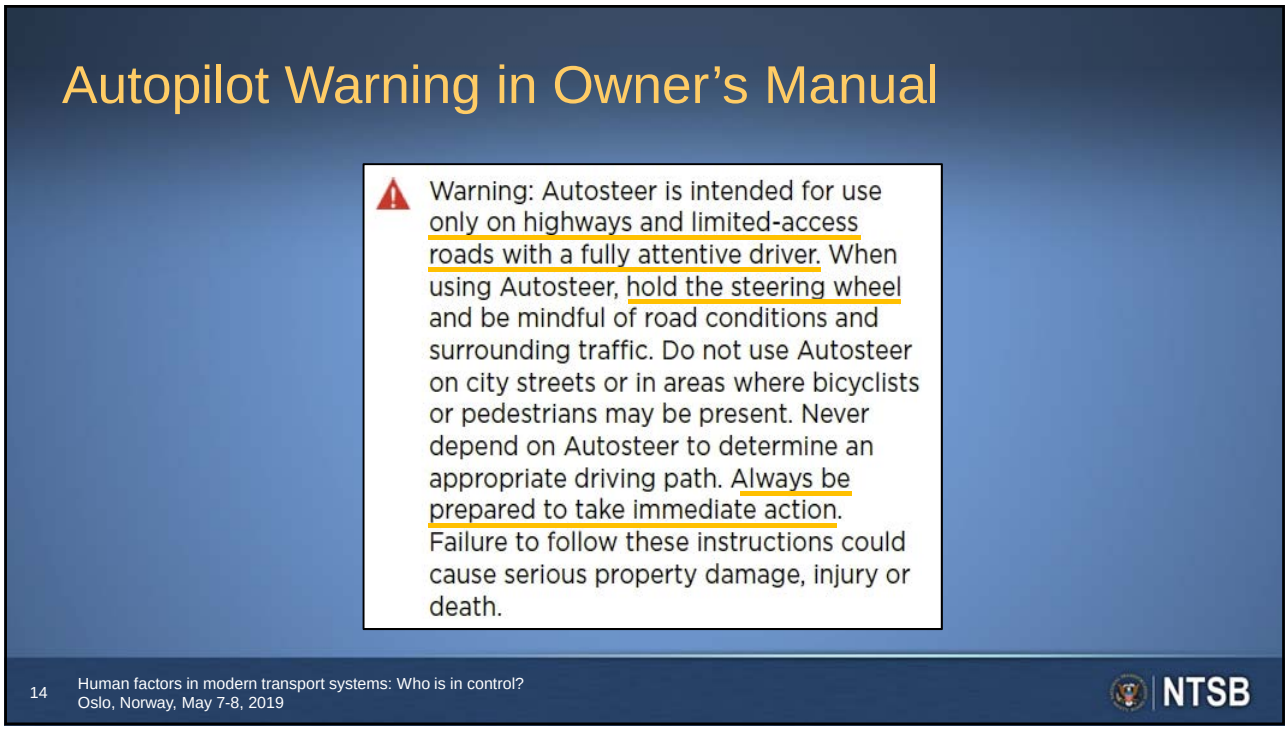
Collision Between a Car Operating With Automated Vehicle Control Systems and a Tractor-Semitrailer Truck
Near Williston, Florida
May 7, 2016
HWY16FH018
13
NTSB
Making Transportation Safer
YESTERDAY ★ TODAY ★ TOMORROW

13


Autopilot Warning in Owner's Manual
Warning: Autosteer is intended for use only on highways and limited-access roads with a fully attentive driver. When using Autosteer, hold the steering wheel and be mindful of road conditions and surrounding traffic. Do not use Autosteer on city streets or in areas where bicyclists or pedestrians may be present. Never depend on Autosteer to determine an appropriate driving path. Always be prepared to take immediate action. Failure to follow these instructions could cause serious property damage, injury or death.
14
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Oslo, Norway, May 7-8, 2019
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14

Operational Domain: US-27A

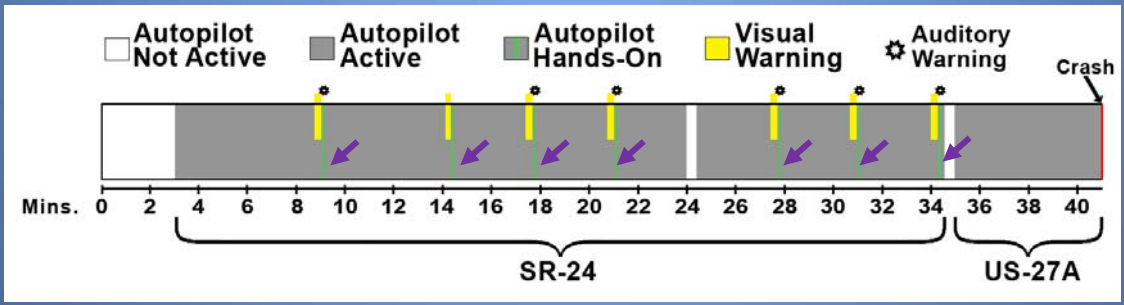
- 4-lane roadway
- With central median divider
- Not limited access
- Cruise speed limited to 145 km/h

Operational Domain: SR-24

- 2-lane roadway
- No central median divider
- Not limited access
- Cruise speed limited to 8 km/h over the speed limit

Driver Engagement During the Crash Trip

- Crash trip lasted 41 minutes
  - Autopilot was engaged for 37 minutes
  - Hands on the steering wheel for 25 seconds



17

Probable Cause

The truck driver's failure to yield the right of way to the car, combined with the car driver's inattention due to overreliance on vehicle automation, which resulted in the car driver's lack of reaction to the presence of the truck. Contributing to the car driver's overreliance on the vehicle automation was its operational design, which permitted his prolonged disengagement from the driving task and his use of the automation in ways inconsistent with guidance and warnings from the manufacturer.

18

Williston Recommendations

- Limit automated vehicle use to conditions for which they are designed
- More effective systems to track driver engagement
- Vehicle-to-vehicle (V2V) safety systems
- Improve data capture and reporting

19

Are there automation lessons to be learned from our history in other modes?

20

Aviation – Eastern Airlines Flight 401, 1972

- Crew preoccupied with nose gear
- Autopilot inadvertently disengaged
- Crew did not detect aircraft descent into ground

- Recommend: altitude and ground proximity warnings

21

Aviation – Scandinavian Airlines Flight 901, 1984

- Autothrottle speed control malfunction
- Crew did not detect problem, leading to runway overrun

- Recommendations: Modify procedures and training to monitor autothrottle system performance and fly manually as needed

22

Aviation – Asiana Airlines Flight 214, 2013

- Unintended deactivation of automatic airspeed control (related to training and documentation complexity)
- Poor monitoring due to expectancy, workload, fatigue, and automation reliance

Recommendations:
- Reduced design complexity
- Enhanced training on autoflight

23

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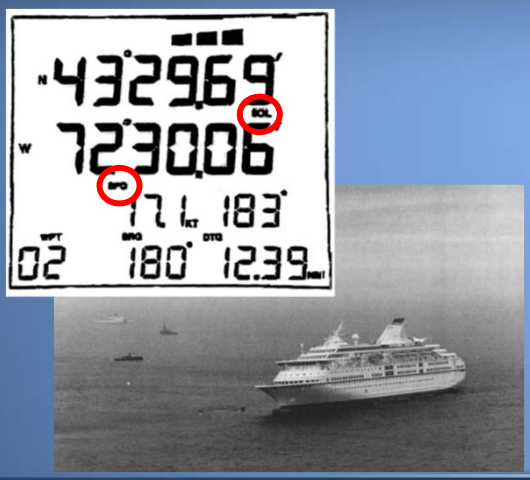
Descent Below Visual Glidepath and Impact with Seawall

Asiana Airlines Flight 214
Boeing 777-200ER, HL7742
San Francisco, California
July 6, 2013
DCA13MA120

24

Marine – Royal Majesty Grounding, 1995



- Integrated bridge system problem not noticed by crew
- External buoy markers not identified (overreliance)

Recommendations:
- Improve system human factors to alert users of system state
- Provide training on system

25

Railroad –Subway T-111 1996

- Automated speed setting led to overruns in snowy weather
- Attempt to reduce automated system speed resulted in default to highest speed

Recommendations:
- Procedures for when automation fails
- Maintain manual proficiency
- Default to safest mode

26

Lessons from Other Modes - Summary

Accident Factors

- Disengagement or malfunction of automated system
- Highly trained crews, yet…
  - Didn't detect problem, or
  - Couldn't handle problem once detected

Recommendations

- System design
  - Monitor system state and provide feedback to users
  - Provide alerts of dangerous conditions
  - Backup/failsafe systems
- Users
  - Training on automated system
  - Maintain manual proficiency

27

Modal Differences

	Aviation	Highway
Operating Environment	Less Variable	More Variable
Time for User Takeover	Longer	Shorter
User Groups	More Trained	Less Trained
Regulatory Environment	More Regulated	Less Regulated
Crash Frequency/Scrutiny	Low/High	High/Low
Postcrash Evidence	Rich, Available	Less Rich, Less Available

28

Operating Environment Time for User Takeover

Aviation

Highway

29 Human factors in modern transport systems: Who is in control?
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29

User Groups

Aviation

- Private
  - 35+ hours flight/training
  - Medical every 2-5 years
  - Knowledge/flight test
  - Proficiency checks every 2 years
- Airline
  - >1,500 hours flight/training
  - Multiple tests/certifications
  - Medical every 6-12 months
  - Proficiency checks every 6 months

Highway

- Private
  - 0-50 practice hours
  - Vision check
  - Knowledge/driving test
  - No proficiency checks
- Commercial driver
  - Written test
  - Driving test
  - Medical every 2 years
  - Training required beginning 2020 (no minimum hours)

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30

Regulatory Environment

- Aviation – 1 regulator, more oversight
  - Vehicle standards – FAA
  - Airports – FAA
  - Air traffic – FAA
  - Pilot training rules – FAA
  - Airline operating rules - FAA
- Highway – Many regulators, less oversight
  - Vehicle standards – NHTSA and OEM certification
  - Interstate road standards – FHWA
  - State road standards – states
  - Traffic laws – states and cities
  - Driver training rules – States
  - Commercial operations - FMCSA

31

Crash Frequency/Scrutiny Postcrash Evidence

- Aviation
  - Total accidents – 1,335
  - Fatal accidents – 221
  - Reporting to NTSB required
  - NTSB required to lead investigation
  - Required data parameters on flight data recorders
  - International data reporting requirements
- Highway
  - Total accidents – 7,277,000
  - Fatal accidents 37,435
  - Reporting requirements and practices vary by state
  - NTSB coordinates with local authorities
  - Limited data requirements and standardization
    - Data parameters required **if** equipped with EDR

32

Go! Flight 1002, 2008

- 24 minutes into flight, crew stopped responding to ATC
- Airplane continued flight, consistent with autopilot
- 42 minutes into flight, 26 miles past destination, crew responded and returned to destination
- Captain and first officer fell asleep during cruise flight

Automation Recommendations

Other Modes Summary

- System design
  - Monitor system state and provide feedback to users
  - Provide alerts of dangerous conditions
  - Backup/failsafe systems
- Users
  - Training on automated system
  - Maintain manual proficiency

Highway (Williston investigation)

- System design
  - Limit vehicles to conditions for which they are designed
  - V2V safety systems
  - Systems to track driver engagement
- Users
  - (No user recommendations to date)
- Data
  - Improve data capture and reporting

NTSB Highway Investigations Involving Automated Vehicle Control

3/18/18, 9:58 p.m.

Uber test vehicle

Volvo XC90 safety functions disabled

Speed limit 72 km/h

Pedestrian walking bicycle

ADS Detection at -6s

ADS Identification at -1.3s

Driver action at <1s

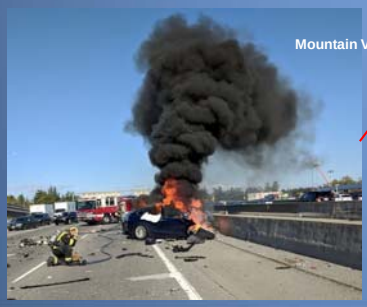
35

NTSB Highway Investigations Involving Automated Vehicle Control

3/23/18, 9:27 a.m.

Tesla Model X

Entered gore and struck damaged crash attenuator



Speed limit 104 km/h

Actual speed 114 km/h

Seconds before crash, Tesla stopped following lead vehicle, steered left and accelerated

36

NTSB Highway Investigations Involving Automated Vehicle Control

11/8/17

Navya shuttle on fixed route

City street, low speed

Combination vehicle struck shuttle while backing into alley

37

Summary

- Event investigations provide insights to improve safety
- Some lessons from other modes are transferable
  - System design recommendations broadly applicable
  - User-training recommendations most applicable to modes with highly trained users and more regulatory oversight
- Understanding overall benefits/costs of automated systems can only be achieved with better data

38

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39

References

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- Eastern Airlines Flight 401: https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR7314.pdf
- Scandinavian Airlines Flight 901: https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR8415.pdf
- Asiana Airlines Flight 214: https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR1401.pdf
- Royal Majesty: https://www.ntsb.gov/investigations/AccidentReports/Reports/MAR9701.pdf
- Subway Train T-111: https://www.ntsb.gov/investigations/AccidentReports/Reports/RAR9604.pdf

40

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  https://www.ntsb.gov/investigations/AccidentReports/Reports/HWY18MH010-prelim.pdf
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