How will Pilots and Future Systems Interact? Automation, Autonomy, and AI

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Disclaimer

The views presented are those of the authors and **do not necessarily represent** the views of the U.S. Federal Aviation Administration or Thales

We Will Discuss

- **Enablers and capabilities**
- **Learning from other domains**
- **Challenges**
- **Lessons**
- **Approaches to human-machine cooperation**

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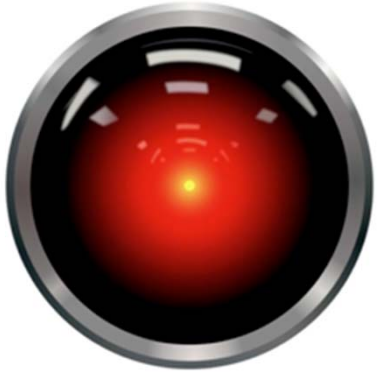
What is AI? There is no single accepted definition. Examples:

- Machine Learning
- Deep Learning
- Artificial Neural Networks
- Machines that reason/behave like humans
- Computational techniques for solving certain kinds of problems
- Knowledge ← ”understanding” → Magic

What can and can't AI do?

- **Weak versus strong AI**
- **Weak AI has limitations…**



Sorry Dave I can't do that…

Why Watson and Siri Are Not Real AI

Douglas Hofstadter is a cognitive scientist at Indiana University and the Pulitzer Prize-winning author of *Gödel, Escher, Bach: An Eternal Golden Braid*. While the face of the artificial intelligence field today is IBM's Watson or Apple's Siri, Hofstadter says these have nothing to do with thinking machines.

Hey Siri…

Also see:
https://www.technologyreview.com/s/609048/the-seven-deadly-sins-of-ai-predictions/

Automation and Resurgence in Artificial Intelligence (AI): Enablers

- **Increased computing capability**
- **Accessible big data**
- **Reduced cost of storing data**
- **Improvements in sensors and processing**

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Statistics

- **Self-driving cars: 1 critical disengage per 40,000 miles (2017)**
- **Humans Drivers: 1 injury accident per 1,000,000 m**
- **Time from software hand-back to human control ~ 1min**

Courtesy Alonso Vera, NASA Ames

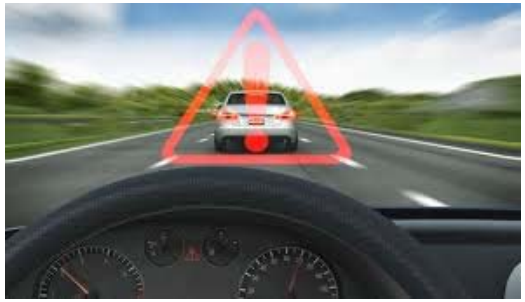
Forward collision warning systems for automobiles fail dramatically to detect motorcycles,

Providing inadequate results in 41 percent of tested cases, against only 3.6 percent for passenger cars.

https://www.ifz.de/wordpress/wp-content/uploads/2016/10/John-Lenkeit.pdf

Car as Guardian: Assisted Driving

- Lane keeping (Tight or loose?)
- Blind-spot monitoring
- Adaptive cruise control (speed & spacing)
- Automated Emergency Braking
- Forward Collision Warning



Car as Chauffeur: Self-Driving

- Autosteering (Tesla); DrivePilot (MB)

Courtesy Alonso Vera, NASA Ames

Autonomy Issues

- Trust issues (none or too much)
- Understandability Issues
- Training issues

The Autonomy Paradox

(Blackhurst, Gresham & Stone, 2011)

- Why ‘unmanned systems’ don’t shrink manpower needs
- Autonomy doesn’t get rid of humans, it changes their roles

As machine intelligence advances,
*the **need for better human interfaces** increases*

Autonomy as a path to crew reduction?

US Littoral Combat Ship

Initially **120**

- **++ Workload and fatigue**
- **Expensive retrofit**

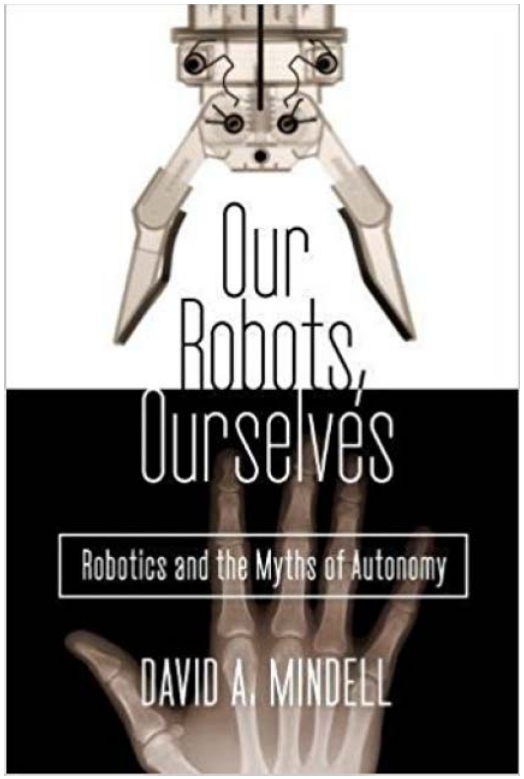
  To accommodate additional personnel
- **Training**

  Negative transfer of training from one system to the other

  Systems require different training pipelines → E5 and above

Three Myths of Autonomy

- **Myth of replacement**
- **Myth of linear progress**
- **Myth that autonomy** is the highest level of technology.



The highest expression of the technologies are the ones that work most deeply, fluidly, ***with*** *human beings.*

Automated Systems Technology

Requires testing of complex software

Current modern large transports can have

– Highly complex and integrated systems

– 10's of millions of lines of code

"It's relatively easy to stage a demonstration that looks impressive but to get to the point where a system is ready for public use is vastly more complicated and challenging"

Steve Shladover, UC Berkeley.

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Challenges

- Variable expectations of safety for different segments of aviation
- Liability/responsibility/authority – who?
- Cybersecurity
- Infrastructure
- Over-expectation
- Need to learn lessons from past experience

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Lessons – Automated Systems

- **Automated systems have contributed significantly to safety, effectiveness and efficiency**
- **Appropriate integration of humans and automated systems is necessary for success**
- **Our view of automated systems has matured**

Automated Systems

Old View	New View
Automation	Automated systems
Give the human operator what s/he does best, give the automation what it does best	Human-system integration to enable the human operator
Automation causes degradation of basic skills	Lack of practice causes degradation of basic skills
Automation should be another “crewmember”	Automated systems are tools to help the responsible human
More automation reduces training	More automation can increase training
More automation reduces risk	More automation introduces different risks

Lesson: Pilots and controllers mitigate risk on a regular and ongoing basis

Safety Snapshot: Split-second Decision Saved the Day (and more) in Perth

by John Croft in Things With Wings — Mar 16, 2015
RSS

TWEET — COMMENTS 1

EASA	EMERGENCY AIRWORTHINESS DIRECTIVE
	AD No.: 2014-0266-E Date: 09 December 2014 Note: This Emergency Airworthiness Directive (AD) is issued by EASA, acting in accordance with Regulation (EC) No 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation.

This AD is issued in accordance with EU 748/2012, Part 21.A.3B. In accordance with EC 2042/2003 Annex I, Part M.A.301, the continuing airworthiness of an aircraft shall be ensured by accomplishing any applicable ADs. Consequently, no person may operate an aircraft to which an AD applies, except in accordance with the requirements of that AD, unless otherwise specified by the Agency [EC

Questions for Consideration

- **What operations?**
- **What level(s) of safety?**
- **Who is responsible for the safety of flight?**
  - If it is the pilot, then pilot must have the knowledge and skills, and the system design must enable the pilot to intervene as needed
  - If not the pilot, then who? How does that affect the design requirements from a safety perspective?
- **If we don't know all the ways pilots bring safety to the operation, how can we automate it?**
- **What model(s) of human-machine interaction should be used?**

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Examples of design strategies

2 - 1 = 1

“Downsizing”

1 = 0 + 1

“Elevator”

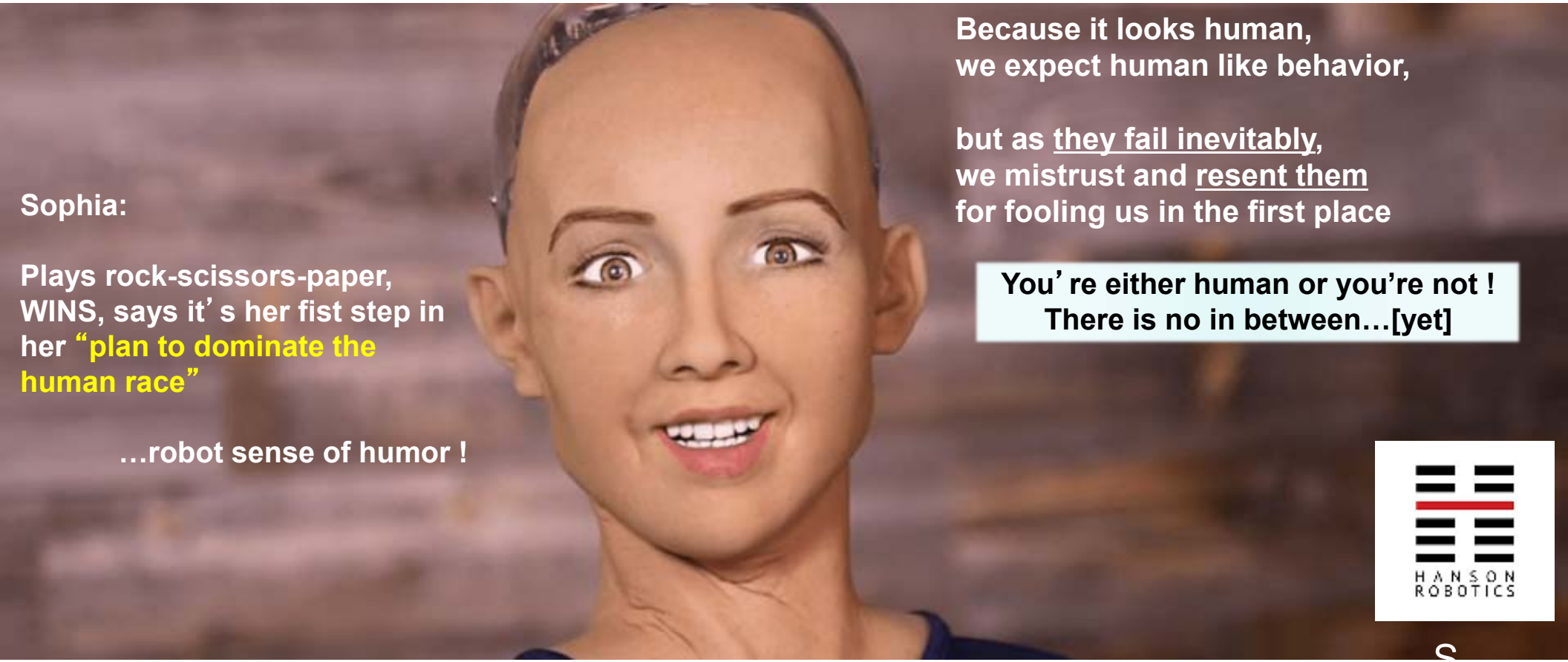
Who is Responsible? Who is Liable?

Shift of responsibility/liability

Pilot responsibility/liability

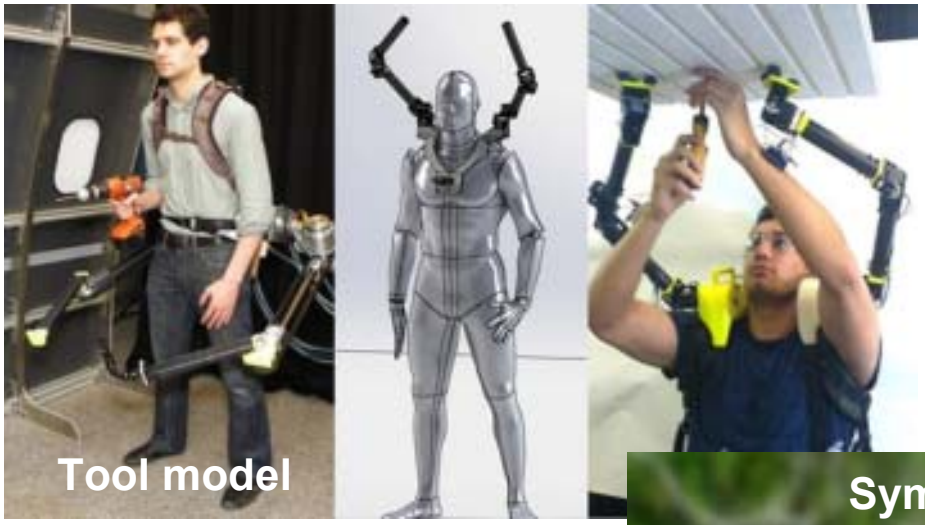
Product liability

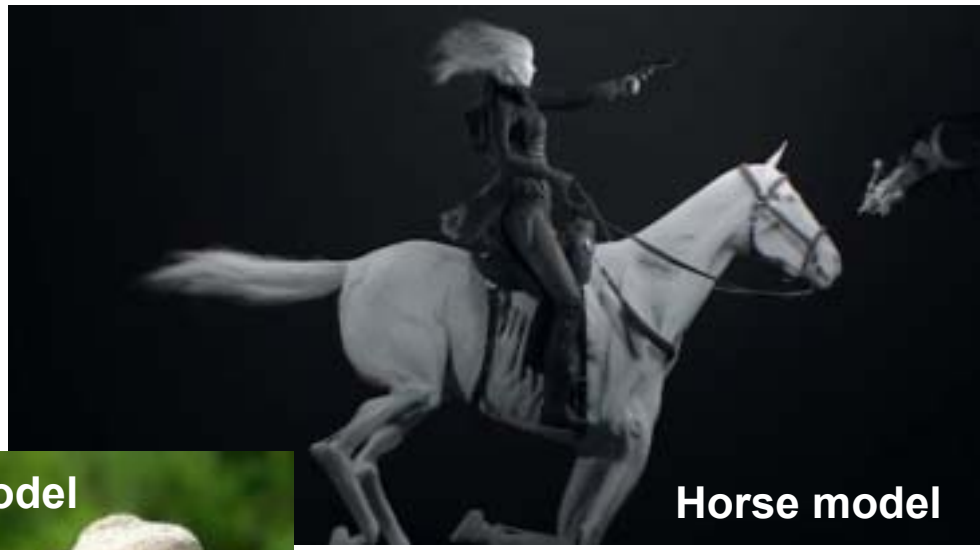
What model(s) of human-machine interaction should be used?

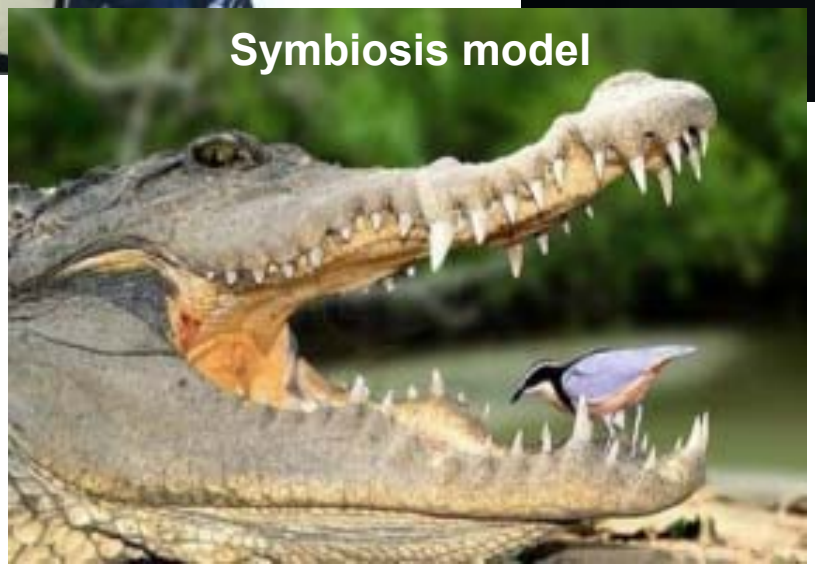


The one we have been after for years, without success…

Other cooperation models







Concluding Thoughts

- We can expect amazing improvements
- Use of automation/autonomy is intended to reduce cost and staffing and improve safety – but when does it?
- Moving from demonstration to real world is challenging
- One size does not fit all
- Human operators bring more safety than is often acknowledged
- Humans will continue to be part of the system – in a combination of roles
- Effective human-system integration is critical

Questions?