So what do people actually do?

Brown Bag Lunch
August 20th, 2024

Human Systems integration division

Immanuel Barshi, NASA Ames Research Center

A quick thought experiment

- Human error has been implicated in up to 80% of accidents in civil and military aviation[1]

A quick thought experiment

- Human error has been implicated in up to 80% of accidents in civil and military aviation[1]

Attributed to Human Intervention	Not Accident	Accident	
No	?	20%	?
Yes	?	**80%**	?
	?	?	?

Outcome

A quick thought experiment

- Human error has been implicated in up to 80% of accidents in civil and military aviation[1]
- Pilots intervene to manage aircraft malfunctions on 20% of normal flights[2]

Attributed to Human Intervention	Outcome: Not Accident	Outcome: Accident	
No	80%	20%	?
Yes	**20%**	**80%**	?
	?	?	?

A quick thought experiment

- Human error has been implicated in up to 80% of accidents in civil and military aviation[1]
- Pilots intervene to manage aircraft malfunctions on 20% of normal flights[2]
- World-wide jet data from 2007-2016[3]
  - 244 million departures
  - 388 accidents

Attributed to Human Intervention	Outcome: Not Accident	Outcome: Accident	
No	80%	20%	?
Yes	**20%**	**80%**	?
	243,999,612	**388**	**244,000,000**

(1) Weigmann & Shappell, 2003; (2) PARC/CAST, 2013; (3) Boeing, 2017

A quick thought experiment

- Human error has been implicated in up to 80% of accidents in civil and military aviation[1]
- Pilots intervene to manage aircraft malfunctions on 20% of normal flights[2]
- World-wide jet data from 2007-2016[3]
  - 244 million departures
  - 388 accidents

Attributed to Human Intervention	Outcome: Not Accident	Outcome: Accident	
No	195,199,690	78	195,199,768
Yes	48,799,922	310	48,800,232
	243,999,612	388	244,000,000

(1) Weigmann & Shappell, 2003; (2) PARC/CAST, 2013; (3) Boeing, 2017

Pilots *Produce* Safety Far More Often than They *Reduce* It

- Human error has been implicated in up to 80% of accidents in civil and military aviation[1]
- Pilots intervene to manage aircraft malfunctions on 20% of normal flights[2]
- World-wide jet data from 2007-2016[3]
  - 244 million departures
  - 388 accidents

Attributed to Human Intervention	Outcome: Not Accident	Outcome: Accident	
No	195,199,690	78	195,199,768
Yes	48,799,922	310	48,800,232
	243,999,612	388	244,000,000

Frequently Studied

Rarely Recognized

Learn more: Holbrook, J. (2021). Exploring methods to collect and analyze data on human contributions to aviation safety. In *Proceedings of the 2021 International Symposium on Aviation Psychology.* https://aviation-psychology.org/wp-content/uploads/2021/05/ISAP_2021_Proceedings_FINAL.pdf *(1) Weigmann & Shappell, 2003; (2) PARC/CAST, 2013; (3) Boeing, 2017*

Pilots *Produce* Safety Far More Often than They *Reduce* It

- Human … up to 8 … militar…
- Pilots i… malfur… ons o… flights…
- World…
  - 244 n…
  - 388 a…

$$\frac{48{,}799{,}922}{310} = 157{,}419$$

Pilots intervene to keep flights safe from aircraft malfunctions ~157,000 times for every time that human error contributes to an accident!

Frequently Studied

195,199,768
48,800,232
244,000,000

Learn more: Holbrook, J. (2021). Exploring methods to collect and analyze data on human contributions to aviation safety. In *Proceedings of the 2021 International Symposium on Aviation Psychology.* https://aviation-psychology.org/wp-content/uploads/2021/05/ISAP_2021_Proceedings_FINAL.pdf

Revisiting Our Assumptions on Human Performance

- Human error has been implicated in 70% to 80% of accidents in civil and military aviation (Weigmann & Shappell, 2003)

Revisiting Our Assumptions on Human Performance

- Human error has been implicated in 70% to 80% of accidents in civil and military aviation (Weigmann & Shappell, 2003)

Actually, 100% of accidents are due to human limitations!

Revisiting Our Assumptions on Human Performance

- Human error has been implicated in 70% to 80% of accidents in civil and military aviation (Weigmann & Shappell, 2003)

Actually, 100% of accidents are due to human limitations!

And 100% of successful operations are due to human capabilities!

Revisiting Our Assumptions on Human Performance

- Human error has been implicated in 70% to 80% of accidents in civil and military aviation (Weigmann & Shappell, 2003)

Actually, 100% of accidents are due to human limitations!

And 100% of successful operations are due to human capabilities!

- Pilots intervene to manage aircraft malfunctions on 20% of normal flights (PARC/CAST, 2013)

Revisiting Our Assumptions on Human Performance

- Human error has been implicated in 70% to 80% of accidents in civil and military aviation (Weigmann & Shappell, 2003)

Actually, 100% of accidents are due to human limitations!

And 100% of successful operations are due to human capabilities!

- Pilots intervene to manage aircraft malfunctions on 20% of normal flights (PARC/CAST, 2013)

Pilots intervene in various ways on 100% of flights!

Revisiting Our Assumptions on Human Performance

$$\frac{48{,}799{,}922}{310} = 157{,}419$$

Pilots intervene to keep flights safe from aircraft malfunctions ~157,000 times for every time that human error contributes to an accident!

This is a *conservative* estimate!

Revisiting Our Assumptions on Human Performance

$$\frac{48{,}799{,}922}{310} = 157{,}419$$

Pilots intervene to keep flights safe from aircraft malfunctions ~157,000 times for every time that human error contributes to an accident!

(All non-accidents)

$$\frac{243{,}999{,}612}{388} = 628{,}865$$

(All accidents)

Human capabilities keep flights safe more than **628,865** times for every time that a human limitation contributes to an accident!

This is a *conservative* estimate!

This estimate is more indicative of operational realities!

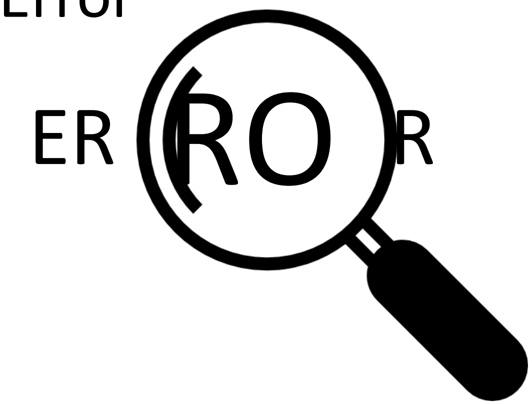
To Err is Human…

- Claybrook & Kildare (*Science*, 2018)
  - "… humans are inherently bad at monitoring semi-autonomous systems and are readily distracted."
  - *Note*: The cited reference (Cunningham & Regan, 2015) doesn't actually speak to this being "*inherent*"…

To Err is Human…

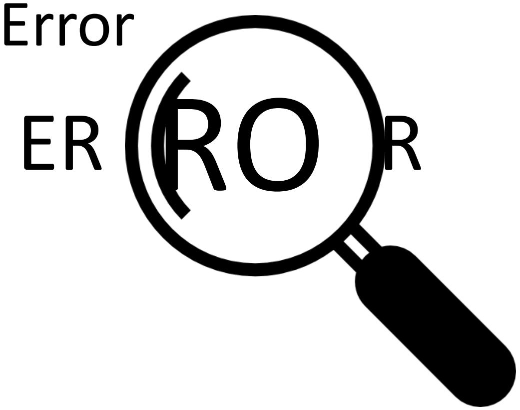
- Claybrook & Kildare (*Science*, 2018)
  - "… humans are inherently bad at monitoring semi-autonomous systems and are readily distracted."
  - *Note*: The cited reference (Cunningham & Regan, 2015) doesn't actually speak to this being "*inherent*"…
- "To fast forward to the safest possible operational state … network operators will be interested in the path that realizes full machine autonomy as quickly as possible." (Uber, 2016)
  - *Note*: Accordingly, it's a *safety imperative* to get those error-prone humans out of the safety loop!

Consequences of Focusing on Human Error



- Designs intended to “protect” the system from “error-prone” humans can design *out* the capability for humans to effectively intervene/adapt, which is a far more common behavior than error.

Consequences of Focusing on Human Error



- Designs intended to “protect” the system from “error-prone” humans can design *out* the capability for humans to effectively intervene/adapt, which is a far more common behavior than error.
- Automation levels are only increasing
  - Until automation designers acknowledge and consider that pilots can intervene to *cause* safety, every increase in automation adds to the risk of
    - Isolating the pilot from the aircraft
    - Limiting the pilot’s adaptive capacity and capability

Consequences for you

- How do you see the focus on human error in your work?

Consequences for you

- How do you see the focus on human error in your work?
- How would you change the narrative about the role of the human in operations?

Consequences for you

- How do you see the focus on human error in your work?
- How would you change the narrative about the role of the human in operations?
- What research projects can you think of that would support that change?

All technical systems fail

- Much of the cost of building and running technical systems goes into figuring out how things can fail, building in defenses, fail-safes, and redundancies.

- Safe organizations invest in failure
  - Procedures and backup plans
  - Practice, simulation, and training
  - Hard work, fortitude, and culture

Failure investment ≠ Failure proof

- All of this investment does not make systems failure proof!
- The goal of this investment should not just be to prevent failures from happening, or problems from occurring.
- The goal should also include preparing for, responding to, and recovering from failures (which <u>will</u> happen).
- That’s what “resilience” is all about.

How do we think about the Operation?

Traditional Thinking ("Safety-I")
Focused on ensuring that "as few things as possible go wrong"
Humans are a source of errors and hazards: Control and correct
Variability is a threat—minimize it
Focus on incident rates
Focus on what we don't want: injuries and incidents
Procedures are complete and correct
Systems are well designed, work as designed, and are well maintained

** See Hollnagel, Wears, & Braithwaite (2015)*

How do we think about the Operation?

Traditional Thinking ("Safety-I")	"Safety-II" Thinking*
Focused on ensuring that "as few things as possible go wrong"	Focused on ensuring that "as many things as possible go right"
Humans are a source of errors and hazards: Control and correct	Humans are a source of flexibility and resilience: Learn and adapt
Variability is a threat—minimize it	Variability is normal—manage it
Focus on incident rates	Focus on learning
Focus on what we don't want: injuries and incidents	Focus on what we do want: how safety is created; how problems are solved
Procedures are complete and correct	Procedures are under-specified and must be interpreted and adapted
Systems are well designed, work as designed, and are well maintained	Systems are complex and will degrade; there will always be flaws and glitches

** See Hollnagel, Wears, & Braithwaite (2015)*

Responding to Mishap Findings

Finding from Mishap Analysis	Traditional Risk Mgmt. Response (Safety-I)	RE/HRO/Safety-II Response
• People had concerns but did not speak up.	• Encourage workers to speak up (e.g., "if you see something, say something").	• Change meeting format: ask open-ended questions, leader speaks last. • Encourage cross-checks and promote cross-role understanding.
• No one noticed the emerging problem.	• Attribute to complacency or loss of situation awareness. • Encourage workers to be careful and pay attention.	• Look for evidence of dismissing problems, prioritizing authority over expertise, simplified root-cause analyses. • Implement structured pre-mission briefs focused on reinforcing awareness of risks and contingencies.
• There was a failure in responding to the unexpected.	• Create rules that specify what the correct response should be.	• Build tangible experience with uncertain and unpredicted events. • Develop drills and simulations to practice noticing subtle cues and responding to surprise.
• Mishap was a recurring anomaly.	• Create more documentation of incidents and lessons learned. • Require workers to review and study them.	• Expand analysis methods and breadth of learning opportunities. • Identify similar events in which things went well, and ask, “what can we learn from our success?”

Our thinking affects our policies and plans

- When policy decisions are based only on failure data, they are based on a very small sample of non-representative data
  - Without understanding the mechanisms by which problems are solved, any estimate or claim about the predicted safety of autonomous machine capabilities is inherently suspect.
  - Removing the human demonstrated reliable source of safety-producing behavior without first understanding the capability being removed introduces unknown risks.

Human Systems integration division

How to "Change the Narrative…"

…that people are the safety problem

IMPLICATIONS

- Designs intended to "protect" the system from "error-prone" humans can design-out the capability for the human to effectively intervene/adapt, which is a far more common behavior.

- Designs intended to replace humans often fail to acknowledge or understand the capabilities that humans routinely contribute to safety, and therefore fail (or don't have the data/knowledge) to design that into the system.

- Designs that leverage a "safety pilot" who will only intervene to "save the day" in rare failure events fail to consider how our cognitive systems work and how they evolved to work. Such designs are setting up the safety pilot to fail.

How to "Change the Narrative…"

…that people are the safety problem

PROPOSED SOLUTION

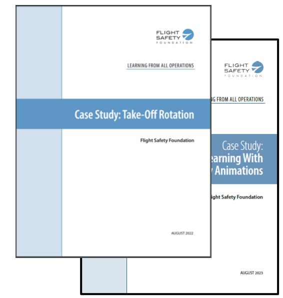
- In today's aerospace industry, *data talks*
- When the only data that are available are about human failure, then data-driven designs only consider that humans fail
- To change the narrative, we need new data and new ways to examine data
  - Specifically, data on how (and the processes by which) humans *contribute* to safety

IMPACTS

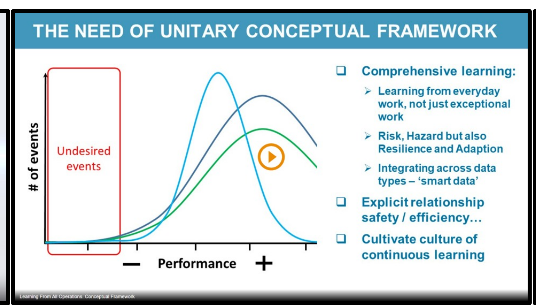
- Safer system designs
- Increased organizational awareness
- Improved operational learning/training
- System safety that is robust and resilient to future changes

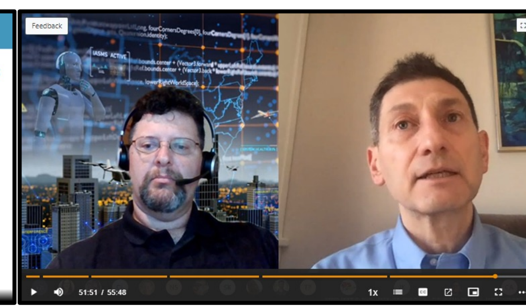
Learning from All Operations: Resources

Publications



https://flightsafety.org/toolkits-resources/learning-from-all-operations/





https://nescacademy.nasa.gov/video/15d835918c84470bbf3177d0c4db65961d

Approaches that Have Been Implemented

- **American Airlines** – Learning & Improvement Team (LIT)
- **Japan Airlines** – Resilience Operation Monitoring (ROM)
- **Southwest Airlines** – Safety & Learning Advancement Team (SLAT)
- **Delta Air Lines** - Integrating Learning From All Operations into the Components of a Safety Management System
- **Cathay Pacific** – Operational Learning Review (OLR)

Consequences for you

- How do you see the focus on human error in your work?
- How would you change the narrative about the role of the human in operations?
- What research projects can you think of that would support that change?
- What data would you suggest collecting to help change the narrative?
- How would you collect and analyze such data?
- What will you do differently now?

Regardless of how much automation or autonomy is built into a system,

**all systems are being built
by people for people.**

People will continue to be at the center.

Make it easy to do the right thing.

Make it difficult to do the wrong thing.

Make it extremely difficult (impossible?) to do the catastrophic thing.

Human Systems integration division

Additional Information:

NASA/TM—2016–219421

Designing Flightdeck Procedures

Immanuel Barshi
NASA Ames Research Center

Robert Mauro
Decision Research
University of Oregon

Asaf Degani
General Motors Advanced Technology Center

Loukia Loukopoulou
San Jose State University Foundation
SWISS International Air Lines

October 2016

NASA/TP—2017–219479

Designing Flightdeck Procedures: Literature Resources

Jolene Feldman
San Jose State University Research Foundation

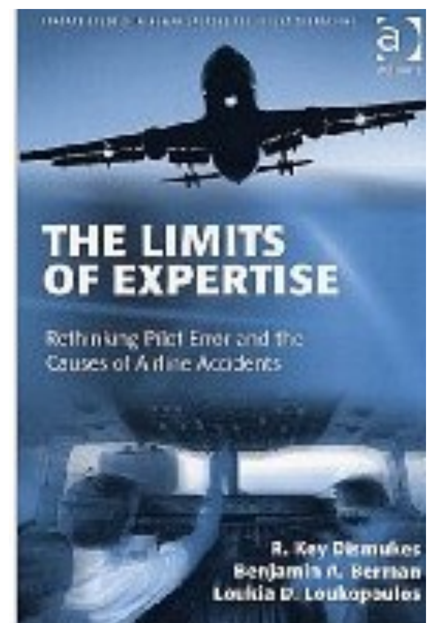
Immanuel Barshi
NASA Ames Research Center

Asaf Degani
General Motors Advanced Technology Center

Loukia Loukopoulou
San Jose State University Research Foundation and the SWISS International Air Lines

Robert Mauro
Decision Research and the University of Oregon

March 2017



Or contact me at: Immanuel.Barshi@nasa.gov

Thank you!

Human Systems integration division

Immanuel.Barshi@nasa.gov