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Making sense of signals

Why it sometimes takes too long to understand a relevant cue – and what we can do about it

Robert Jan de Boer

Human Factors NL - Themabijeenkomst Luchtvaart achter de schermen

Veghel, 14 maart 2019

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- Former professor of Aviation Engineering, HvA
- Professional trainer and consultant
- Education:
  - MSc Aerospace Engineering - TU Delft (1988)
  - PhD Cognitive Systems Engineering - TU Delft (2012)
- Relevant experience
  - Director of Engineering, Fokker Technologies
  - Experience in manufacturing and distribution
  - Industry experience: luxury yachts, aerospace, hi-tech, lighting, infrastructure, pharmaceutical, FMCG
  - Research into collaboration of technical teams
- Robert.deboer@northumbria.ac.uk

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Agenda: making sense of signals

- Introduction
- Laboratory studies
- Sensemaking model
- Summary

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Introduction

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The case of the taxiway take-off

Dutch Safety Board. (2011b). Take-off from Taxiway Amsterdam Airport Schiphol. The Hague, the Netherlands.

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The case of the taxiway take-off

- Aircraft had been de-iced on an apron
- Light snow on taxiways.
- ATC instructed to taxi to the departure runway 36C via taxiway ‘A’
  - Was against prescribed direction of travel
  - There are two parallel taxiways adjacent to runway 36C
- High workload
- During taxi ATC suggested W8 entry and this was accepted.
- Whilst on W8 received ‘line up and wait’ and take off clearances in quick succession.
- Neither green taxiway lighting nor yellow taxi lines nor blue markers visible at turn off although the airport complies to ICAO standards.
- Plane turned right again onto taxiway ‘B’ and began a standing start take off.
- Aircraft was not monitored by ATC between clearance and take-off.
- Air traffic control informed the crew of the incident during climb.

Dutch Safety Board. (2011b). Take-off from Taxiway Amsterdam Airport Schiphol. The Hague, the Netherlands.

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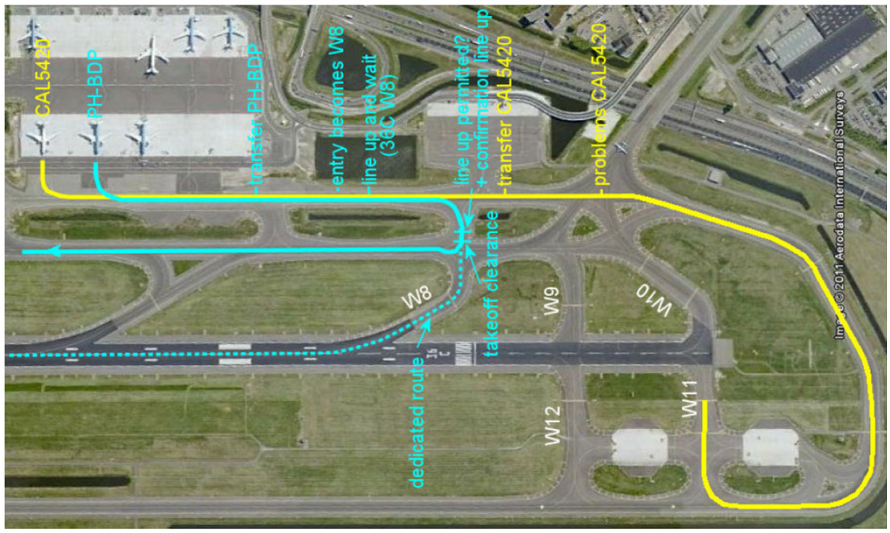
De case of the taxiway take-off



Dutch Safety Board. (2011b). Take-off from Taxiway Amsterdam Airport Schiphol. The Hague, the Netherlands.

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Skybrary summary of the incident

On 10 February 2010 a KLM Boeing 737-300 unintentionally made a night take off from Amsterdam in good visibility from the taxiway parallel to the runway for which take off clearance had been given. Because of the available distance and the absence of obstructions, the take off was otherwise uneventful. The Investigation noted the familiarity of the crew with the airport and identified apparent complacency.

http://www.skybrary.aero/index.php/B733,_Amsterdam_Netherlands,_2010; accessed April 22nd, 2016

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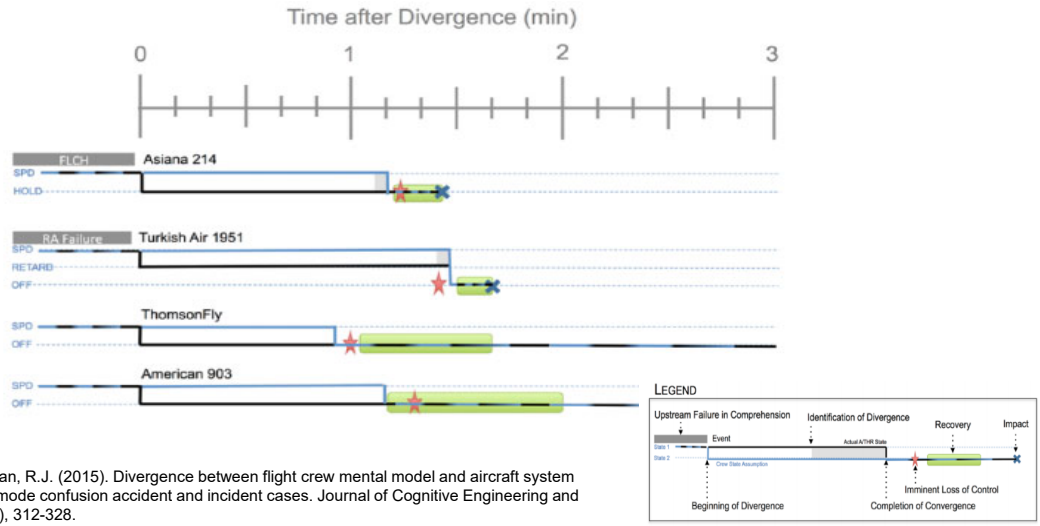
Time needed for recovery versus time to identify a problem



Silva, S.S., & Hansman, R.J. (2015). Divergence between flight crew mental model and aircraft system state in auto-throttle mode confusion accident and incident cases. Journal of Cognitive Engineering and Decision Making, 9(4), 312-328.

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Laboratory studies

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RJ de Boer, W Heems, K Hurts (2014): The Duration of Automation Bias in a Realistic Setting. In: The International Journal of Aviation Psychology 24(4).

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5
10
41.0
N1
%
5
10
88.3
CL
88.5%
5
10
472
EGT
°C
5
10
681
FOB: 4920 KG
63.5
N2
%
96.3
240
F.F
KG/H
2260
SEAT BELTS
RJ de Boer, W Heems, K Hurts (2014): The Duration of Automation Bias in a Realistic Setting. In: The International Journal of Aviation Psychology 24(4).

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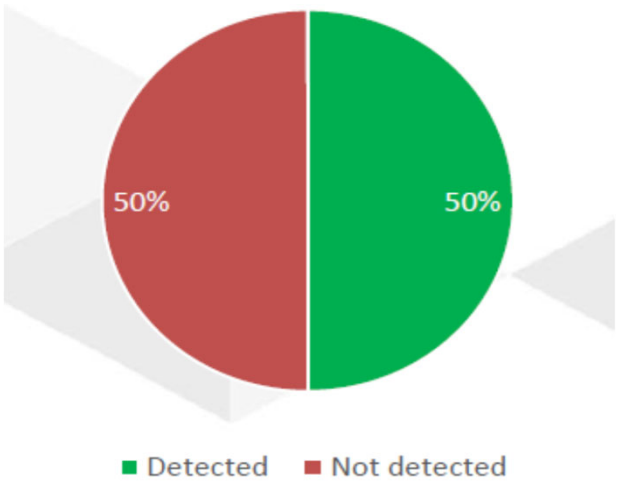
50% of the participants identified the malfunction within 720 seconds



Adapted from: RJ de Boer, W Heems, K Hurts (2014): The Duration of Automation Bias in a Realistic Setting.
In: The International Journal of Aviation Psychology 24(4).

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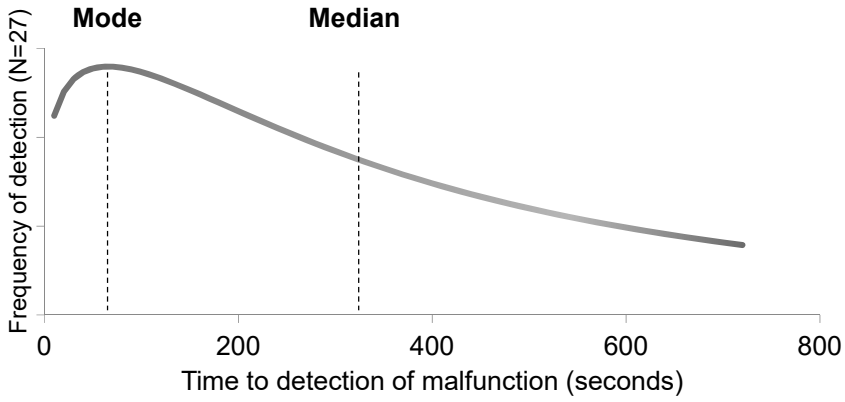
Log-log distribution for the detection of a malfunction



Adapted from: RJ de Boer, W Heems, K Hurts (2014): The Duration of Automation Bias in a Realistic Setting.
In: The International Journal of Aviation Psychology 24(4).

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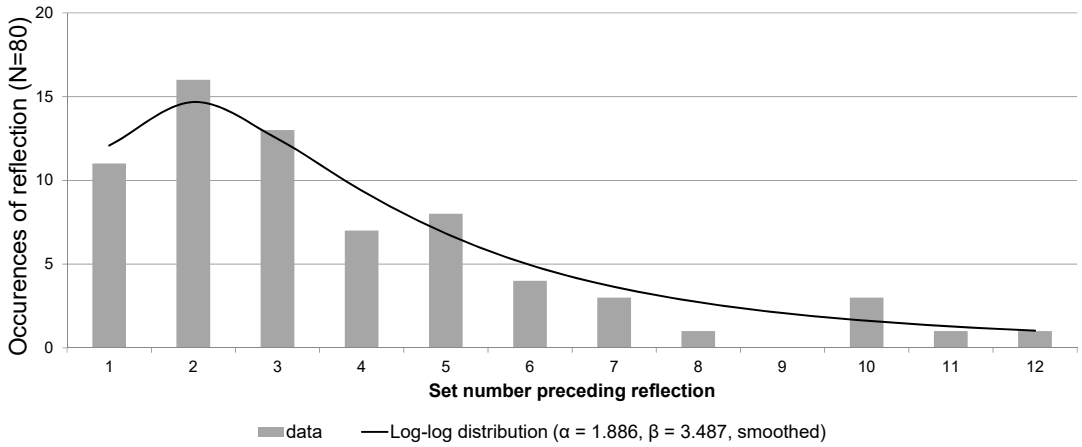
Log-log distribution for the detection of an instruction error



De Boer, R.J. (2012). Seneca's Error: An Affective Model of Cognitive Resistance. Delft, the Netherlands: Delft University of Technology. p.136

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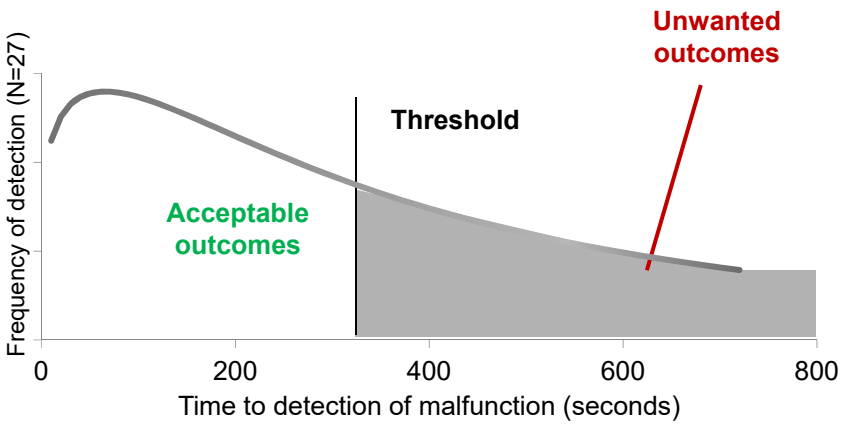
Understanding can be improved* by having more time available



* Improved understanding = lower median; note the higher mode of the distribution
Adapted from: RJ de Boer, W Heems, K Hurts (2014): The Duration of Automation Bias in a Realistic Setting. In: The International Journal of Aviation Psychology 24(4).

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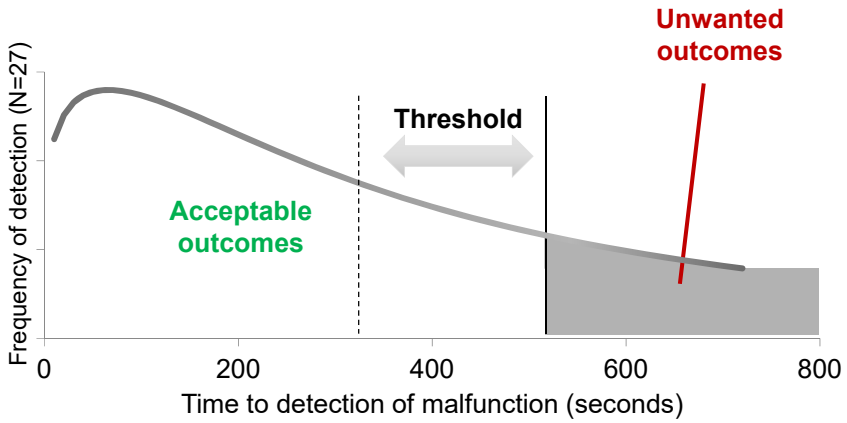
Understanding can be improved* by having more time available



*Improved understanding = higher probability of detection
Adapted from: RJ de Boer, W Heems, K Hurts (2014): The Duration of Automation Bias in a Realistic Setting. In: The International Journal of Aviation Psychology 24(4).

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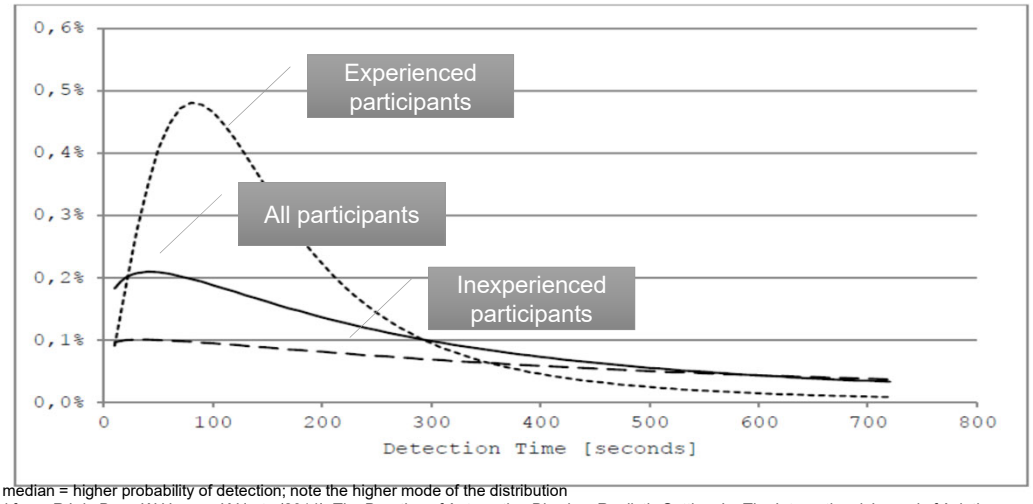
Understanding can be improved* by experience



*Lower median = higher probability of detection; note the higher mode of the distribution
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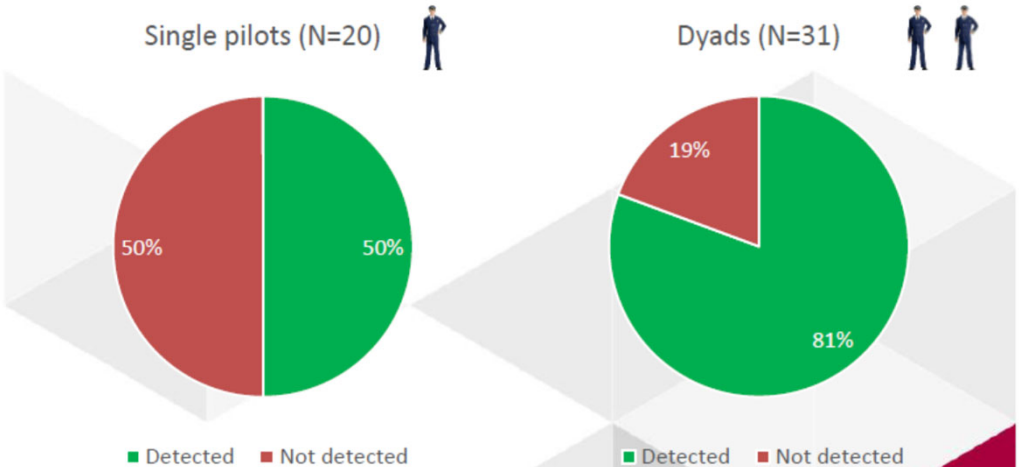
Understanding can be improved by more pairs of eyes



P Soltani & RJ de Boer (2015): Understanding flight crew performance through the lens of honest signals. Presentation at the Human Factors & Ergonomic Society European Chapter Annual Mtg

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Sensemaking model

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Sensemaking model: the crew-aircraft contextual control loop

Rankin, A., Woltjer, R., & Field, J. (2016). Sensemaking following surprise in the cockpit – a re-framing problem. Cognition, Technology & Work, 18(4), 623-642.

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Hypotheses for the sensemaking model

- Trust in the automation is not predicted to be reduced through contradictory feedback
- Re-framing occurs within the individual without external trigger
- Cause is lack of knowledge about the automation in current context

R.J. de Boer & S.W.A. Dekker: Models of Automation Surprise: - Results of a Field Survey in Aviation. In: Safety 2017, 3, 20; doi:10.3390.

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Survey approach

- 200 pilots, predominantly Dutch
  - Websites
  - Briefing room
- 20 questions
  - Respondent demographics and flight experience
  - Specific details about the last AS-experience that can be recalled
  - Experiences with AS in general
- Prompt to describe a recent case of Automation Surprise:

  "For this research, we are specifically interested in the last time you experienced Automation Surprise. The following questions […] are aimed at the last time you exclaimed something like: 'What is it doing now?' or 'How did it get into this mode?'."

R.J. de Boer & S.W.A. Dekker: Models of Automation Surprise: - Results of a Field Survey in Aviation. In: Safety 2017, 3, 20; doi:10.3390.
RJ de Boer & K Hurts: Automation Surprise - Results of a Field Survey of Dutch pilots. In: Aviation Psychology and Applied Human Factors 7(1), 28–41, Hogrefe Publishing, DOI: 10.1027/2192-0923/a000113

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Demographics

- Gender: 96% male, 4% female
- Rank:
  - 54% captain,
  - 42% first officer
  - 2% second officer
- Current aircraft type (in order of frequency):
  - Boeing 737NG,
  - Airbus A330,
  - Boeing 777,
  - Embraer 170/190,
  - Fokker 70/100
- Age: 23 to 58 years (median 38 years).
- Flying experience 750 to 27500 hours (median 7500 hours).
- Number of flights per month: 3 to 43 (28 median)

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RJ de Boer & K Hurts: Automation Surprise - Results of a Field Survey of Dutch pilots. In: Aviation Psychology and Applied Human Factors 7(1), 28–41, Hogrefe Publishing, DOI: 10.1027/2192-0923/a000113

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Occurrences of Automation Surprise

- Introductory question has appropriately triggered AS memory
- Prevalence of AS: three times per year per pilot.
- Severity of AS:
  - Undesired aircraft state not induced: 90%
  - Consequential damage: one case (0.5%)
- Reportable AS event: estimated at once every three years per pilot

RJ de Boer & K Hurts: Automation Surprise - Results of a Field Survey of Dutch pilots. In: Aviation Psychology and Applied Human Factors 7(1), 28–41, Hogrefe Publishing, DOI: 10.1027/2192-0923/a000113

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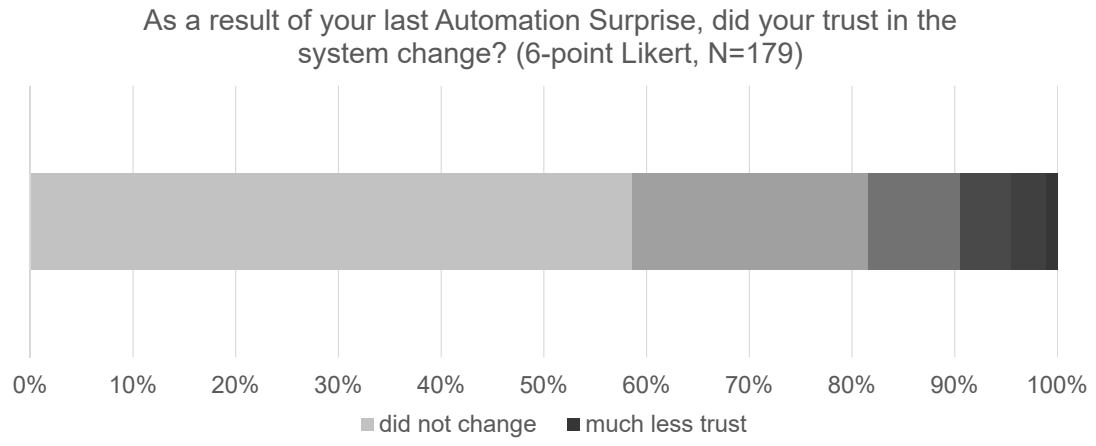
Marker 1: Trust did not change significantly



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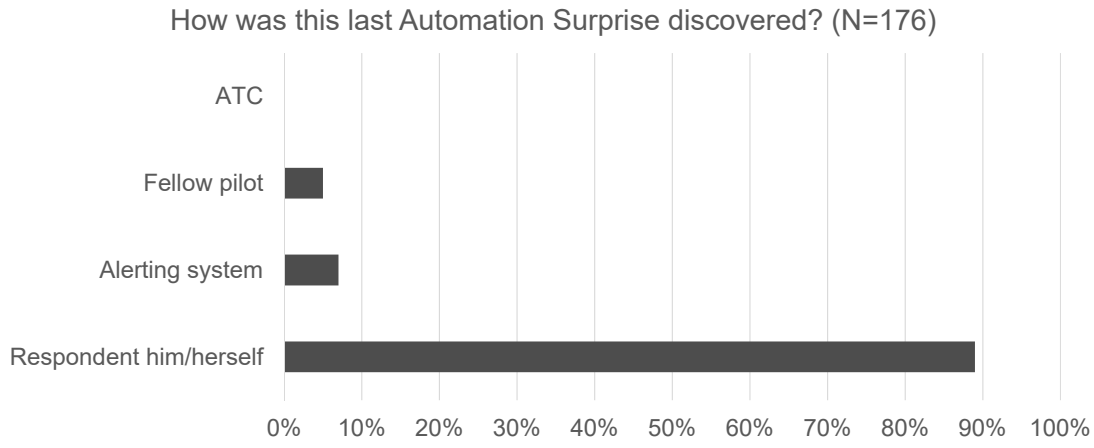
Marker 2: discovery often without external trigger



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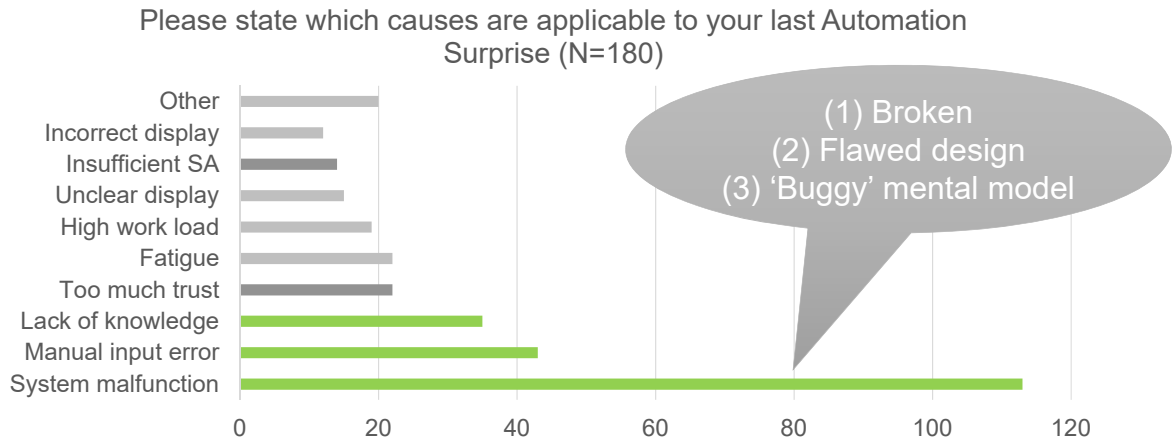
Marker 3: Lack of knowledge often cause of Automation Surprise



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Results support the sensemaking model

- ✓ Trust in the automation is not predicted to be reduced through contradictory feedback
- ✓ Re-framing occurs within the individual without external trigger
- ✓ Cause is lack of knowledge about the automation in current context ("buggy mental model")

R.J. de Boer & S.W.A. Dekker: Models of Automation Surprise: - Results of a Field Survey in Aviation. In: Safety 2017, 3, 20; doi:10.3390.

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The sensemaking model has explanatory power

- Aligns with
  - "New View": Human errors are a symptom of system vulnerability
  - System I and System II model
- Avoids 'useless' terms which only serve to blame the operator
- Rather, sensemaking approach is needed for better understanding of human and automation interaction:
  - taking into account systemic factors
  - the complexity of the operational context
  - rather than focusing on suboptimal human performance.
- Automation Surprise
  - seems to be a manifestation of the system complexity and interface design choices in aviation today,
  - rarely the result of individual under-performance.

R.J. de Boer & S.W.A. Dekker: Models of Automation Surprise: - Results of a Field Survey in Aviation. In: Safety 2017, 3, 20; doi:10.3390.

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Summary

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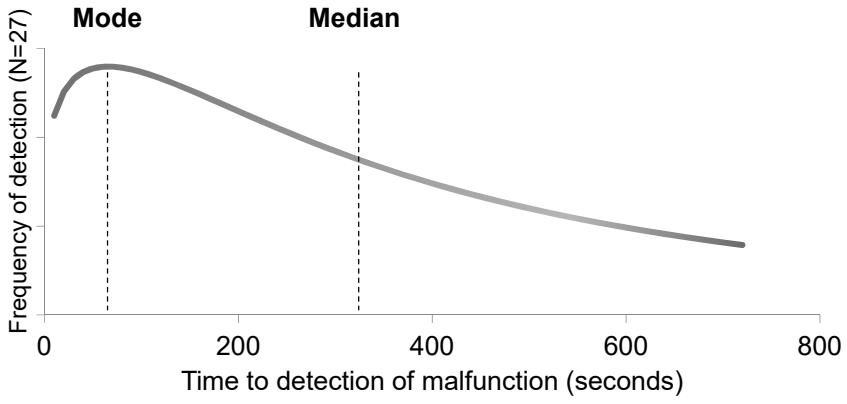
Humans take longer than expected to perceive cues



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Improving understanding

- More time available
- Experience
- More pairs of eyes
- **Human-centric task design & training**

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Thank you for your attention.

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