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RESILIENCE ENGINEERING AND THE RELATION TO THE TORC APPROACH

Dr. Robert J. de Boer, *lector* of Aviation Engineering
Final industrial workshop for the TORC project
Utrecht, Netherlands, Dec 1st 2016

CREATING TOMORROW

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INTRODUCTION

AMSTERDAM UNIVERSITY OF APPLIED SCIENCES

- Some facts:
  - a total of 47,000 students
  - a total of 80 bachelor and master programmes
  - seven schools

- At the moment making the transition from educational institution to research and educational institution

- Aviation Academy is part of the School of Technology.
  - 500 new students each year
  - A total of 1300 students

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OUR ACTIVITIES

EDUCATION	RESEARCH	PEER NETWORKING
Masterclasses and courses	Maintenance	Network events
Professional Masters	Safety	Workshops and lectures
Honours programs for our top students	Composites	Round table sessions
B.Eng. Aviation (Operations & Engineering)	Capacity	Conferences

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OUR ACTIVITIES

EDUCATION

- Masterclasses and courses
- Professional Masters
- Honours programs for our top students
- B.Eng. Aviation (Operations & Engineering)

RESEARCH

- Maintenance
- Safety
- Composites
- Capacity

PEER NETWORKING

- Network events
- Workshops and lectures
- Round table sessions
- Conferences


185A

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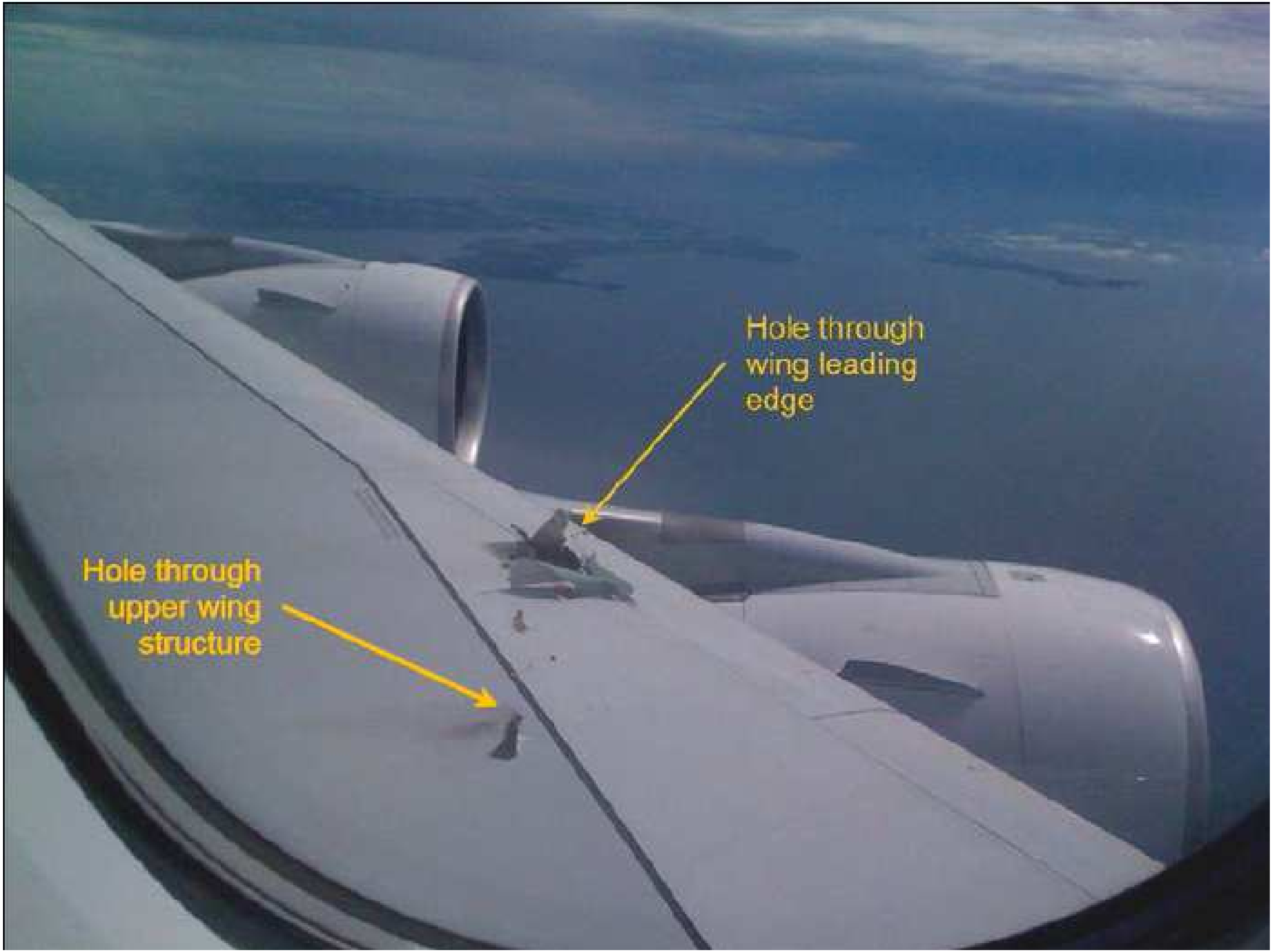
QANTAS FLIGHT QF 32
4 NOVEMBER 2010

www.hva.nl/techniek


Hole through
wing leading
edge
Hole through
upper wing
structure

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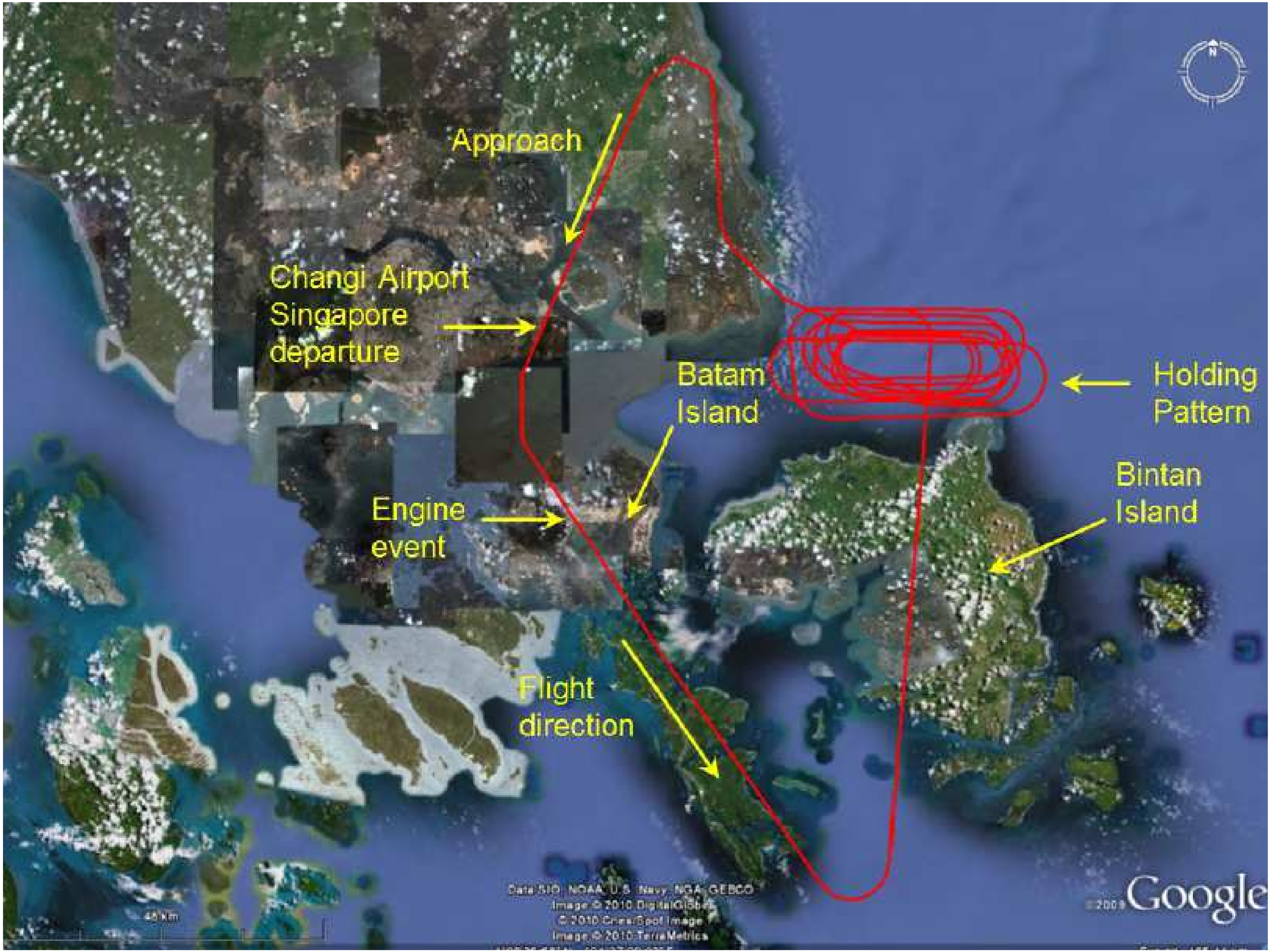
QF 32
4 NOVEMBER 2010


Approach
Changi Airport
Singapore
departure
Batam
Island
Holding
Pattern
Bintan
Island
Engine
event
Flight
direction
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2010 DigitalGlobe
© 2010 Cnes/Spot Image
Image © 2010 TerraMetrics
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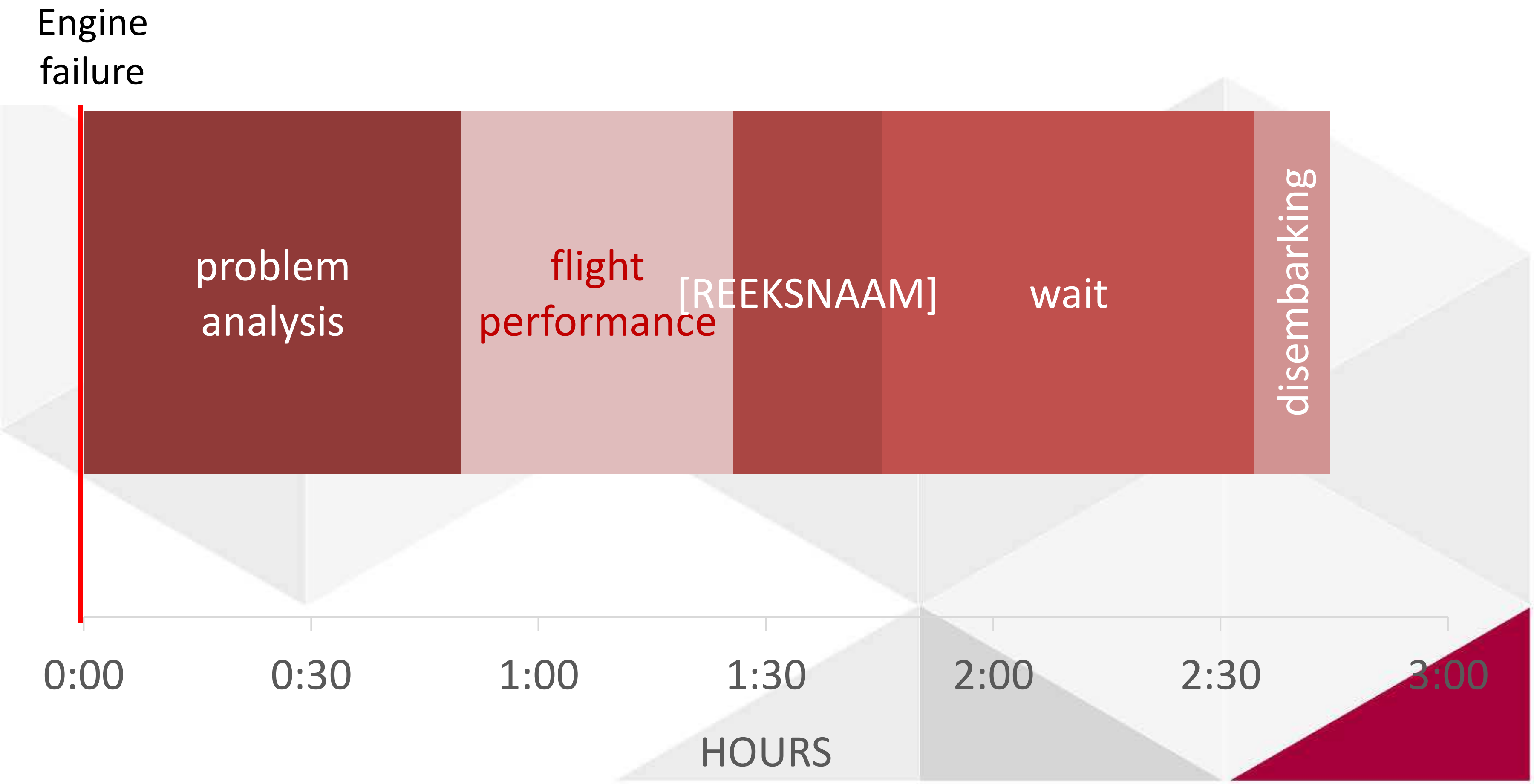
TIME LINE QF32




SWITCHING
ATT HDG
AIR DATA
AUTO BRK
A-SKID

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ANALYSIS ACCORDING TO TORC RESILIENCE FRAMEWORK (IN THE AIR)

- Situation Awareness
  - “Boom … Boom”
  - Altitude hold selected
  - Stable
- Sensemaking (problem analysis 50 minutes)
  - Defined Hazard & Accident Scenario ➔ Emergency training
    - ECAM messages
    - Not consistently followed by crew
  - Therefore unexpected situation ➔ Compliance must be "found" on the spot
- Anticipating (flight performance check 36 minutes)
  - Flight performance analysis for landing
- Deciding & acting: (approach & landing 19 minutes)
- (Monitoring effects decision)


QANTAS
Nancy-Bird Walton
QA
Airport Emergency Service
10

ANALYSIS ACCORDING TO TORC RESILIENCE FRAMEWORK (GROUND)

- Situation Awareness
  - Fuel leaks
  - Very hot brakes
  - No stopping engine number 1
  - No flames
- Sensemaking
  - Danger of disembarking by slides
  - Danger of pax near engine
  - No A/C, grumbling pax
- Anticipating
  - Stopping number 1 engine
  - Need stairs, busses
- Deciding & acting
  - Engine #1 still runs (3:39)
  - Disembark right-hand side only
- Monitoring
  - Everyone safe
  - Gives telephone number
  - (Fails route check)

On ground waiting time: 50 minutes

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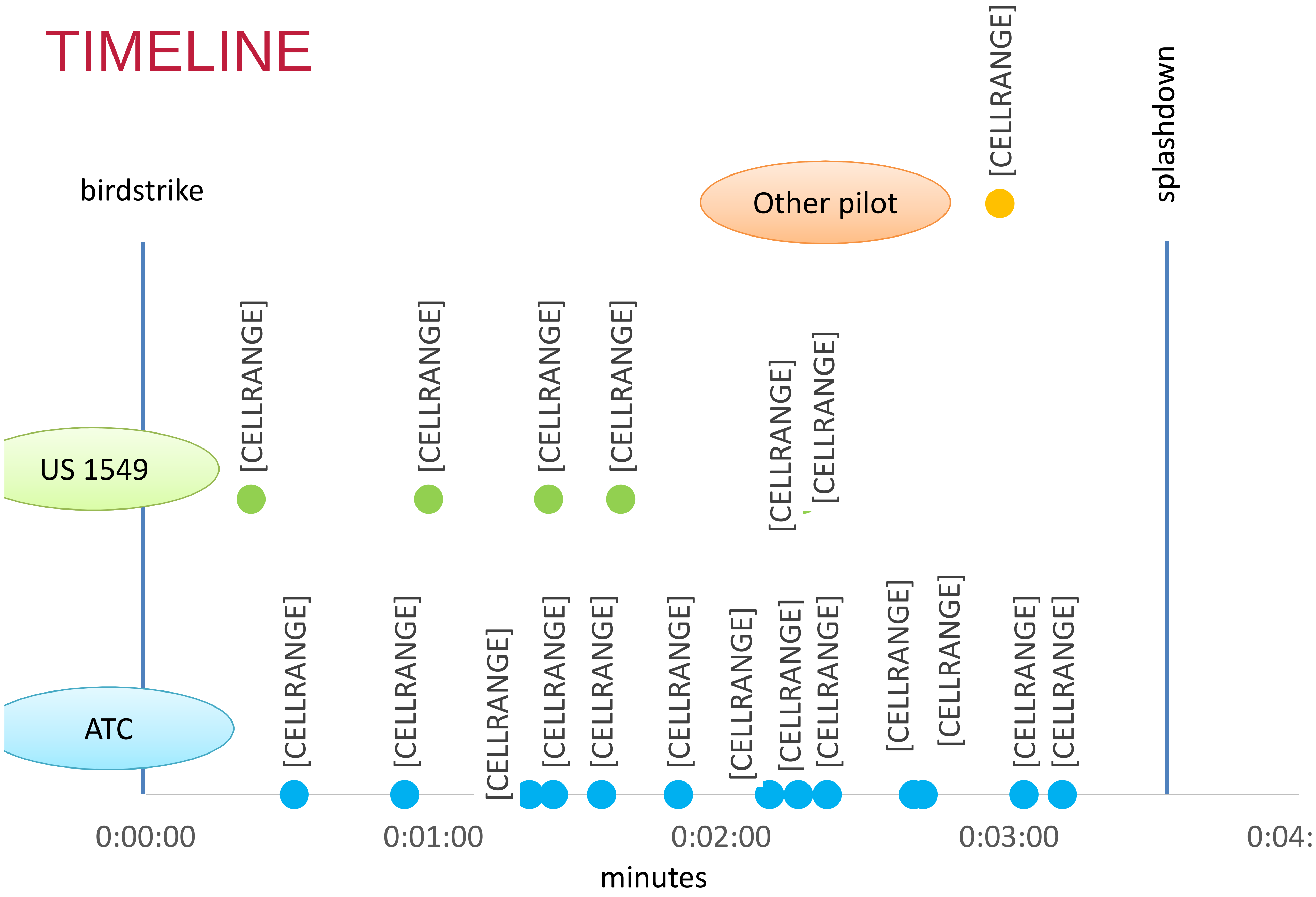
US AIRWAYS FLIGHT 1549
JANUARY 15, 2009


Bird Strike
Area
Hudson River
Airplane touchdown
LGA Airport

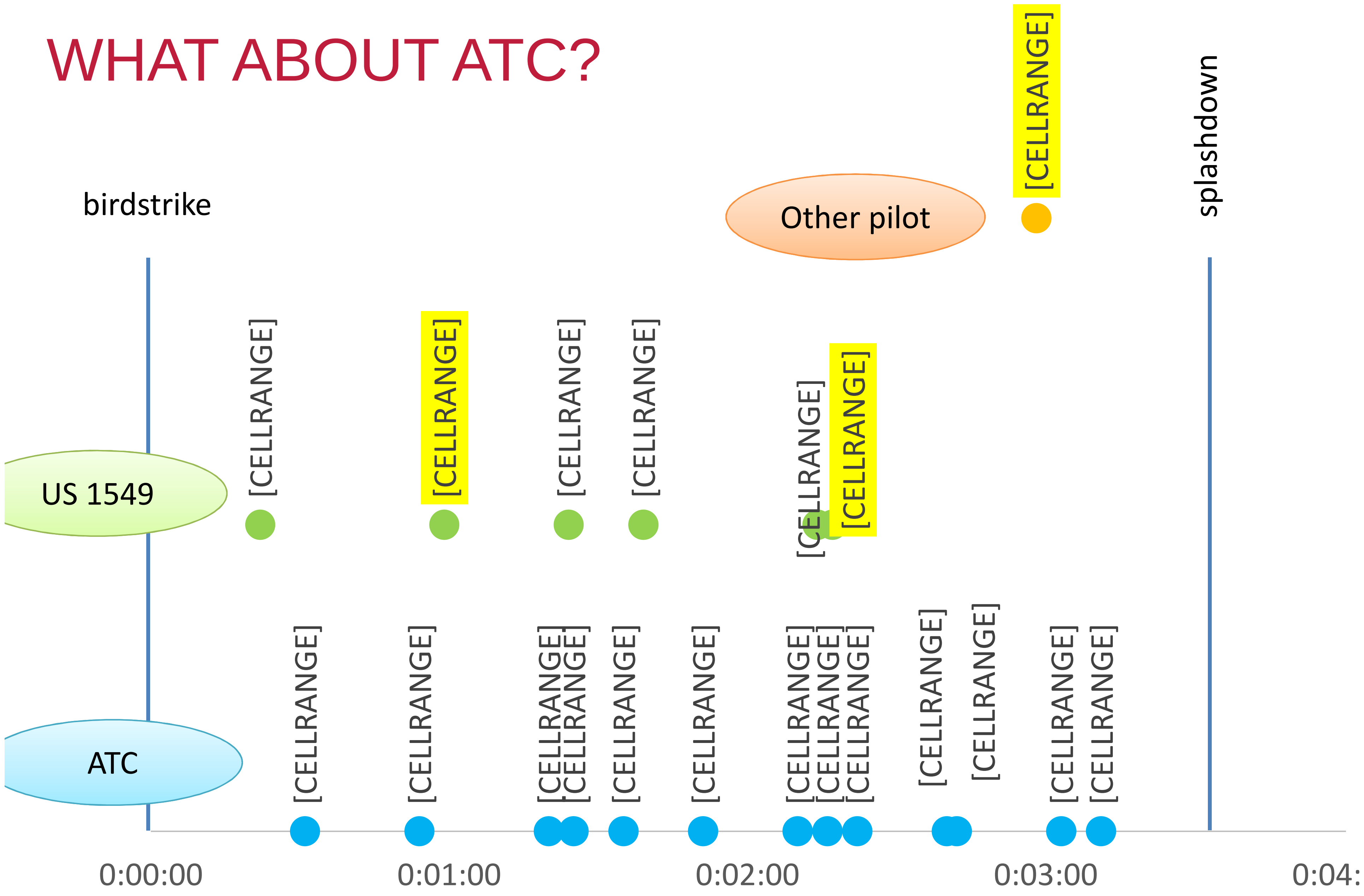
TIMELINE


birdstrike
splashdown
Other pilot
US 1549
ATC
[CELLRANGE]
0:00:00
0:01:00
0:02:00
0:03:00
0:04:
minutes

ANALYSIS ACCORDING TO TORC RESILIENCE FRAMEWORK

- Situation Awareness
  - “Birds”
  - “Both of 'em rolling back”
- Sensemaking
  - Defined Hazard & Accident Scenario ➔ Emergency training
    - Quick Reference Handbook Engine Dual Failure [but valid > 20 000 foot..]
    - Quick Reference Handbook Ditching [but valid with at least one engine..]
    - Time too short, not recognized by crew
  - Therefore unexpected situation ➔ Compliance to be "found" on the spot
- Anticipating & deciding
  - “We may end up in the Hudson”
- (Monitoring effects decision)

WHAT ABOUT ATC?



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SENSEMAKING DELAYS

www.hva.nl/techniek

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Not Noah!

PERCEIVE & BELIEVE

- How many of each animal did Mozes take along in the Arc?

Kahneman, D. (2011). *Thinking, fast and slow* (1st ed.).

THE CREW-AIRCRAFT CONTEXTUAL CONTROL LOOP

(Rankin, Woltjer, Field, & Wood, 2013)

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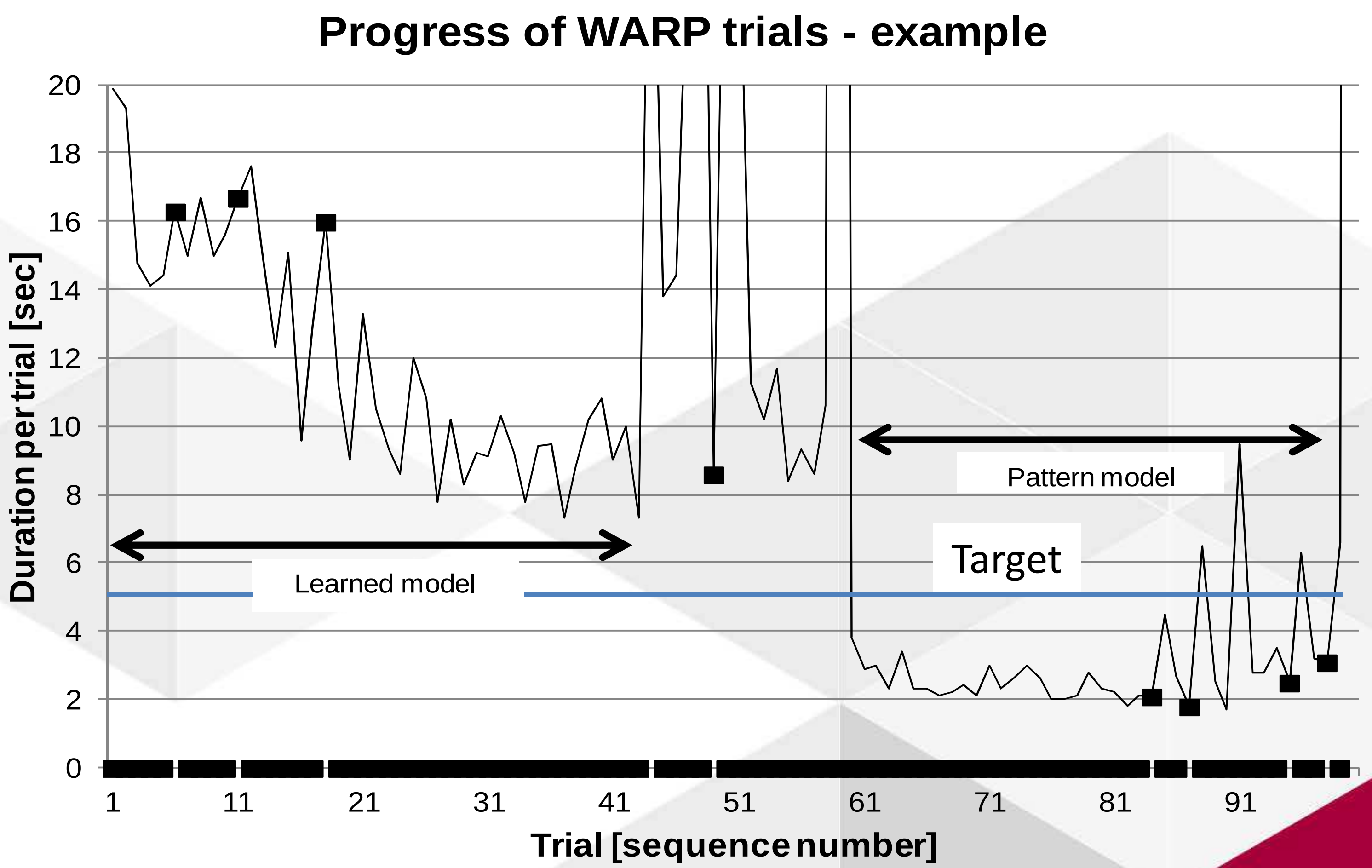
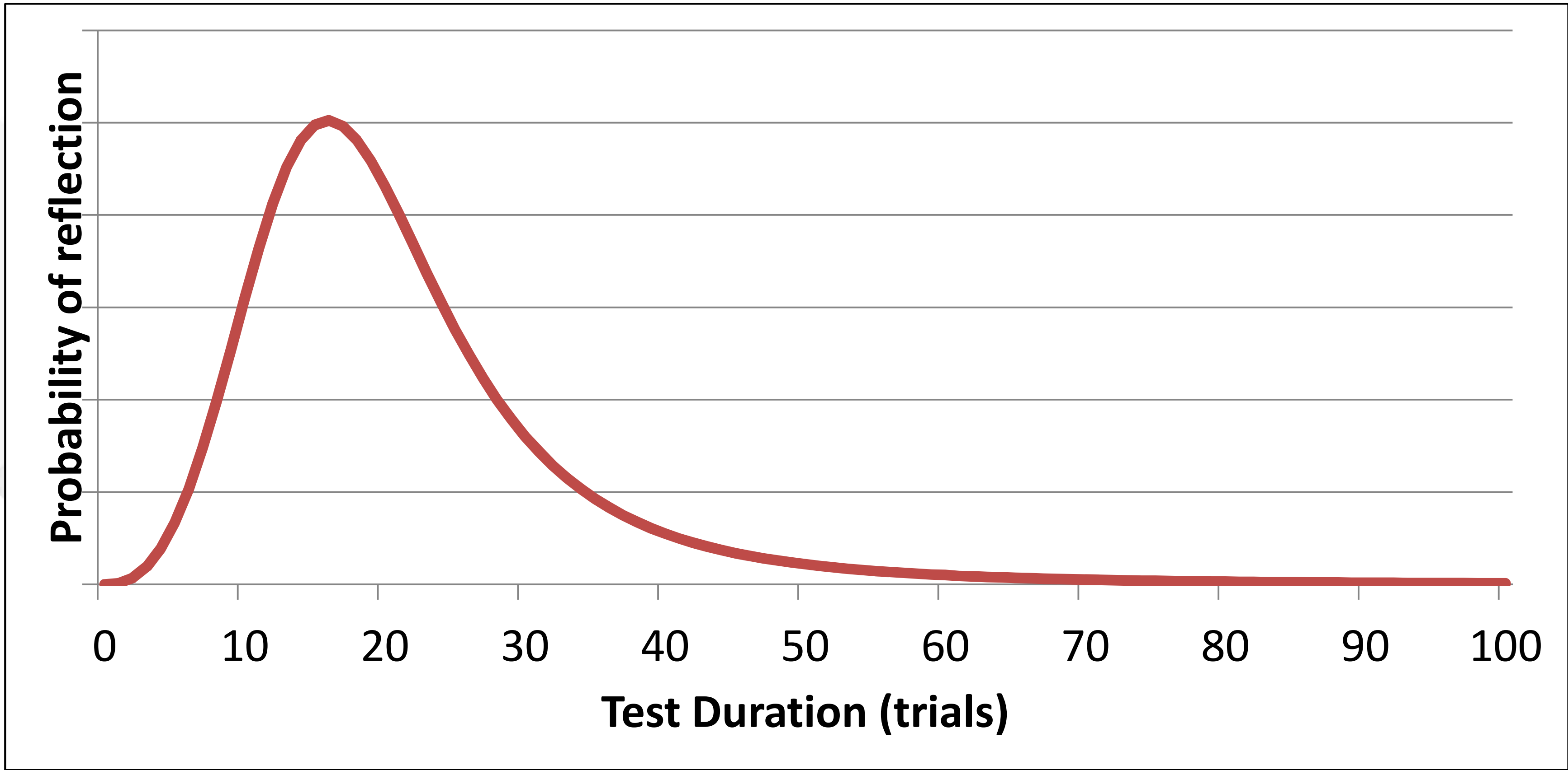
SENSEMAKING TEST



LOG-LOG DISTRIBUTION OF SENSEMAKING (N=81)



De Boer, R.J. (2012). Seneca's Error: An Affective Model of Cognitive Resistance

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FLIGHT SIMULATION EXPERIMENTS

- 31 graduated, inexperienced, dyads
- PF / PM configuration
- A320 Touch Screen Trainer simulator
- Amsterdam Schiphol – London Heathrow

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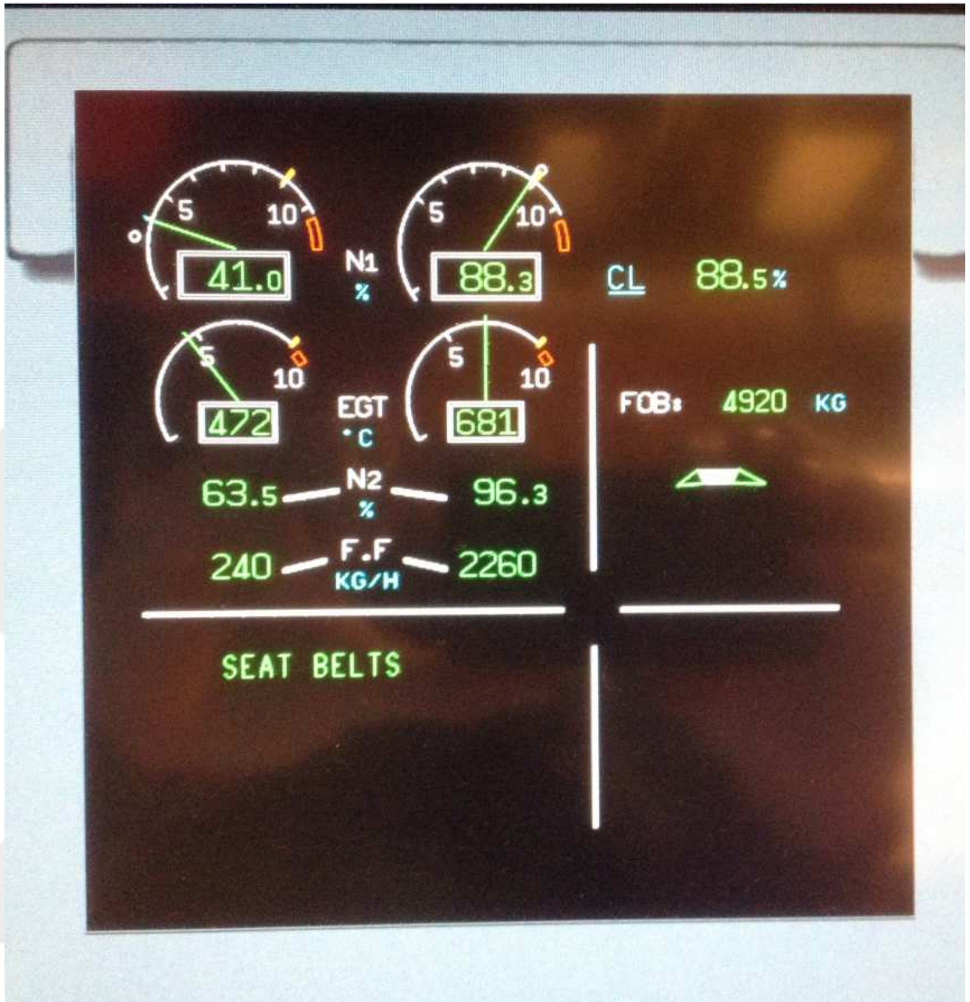
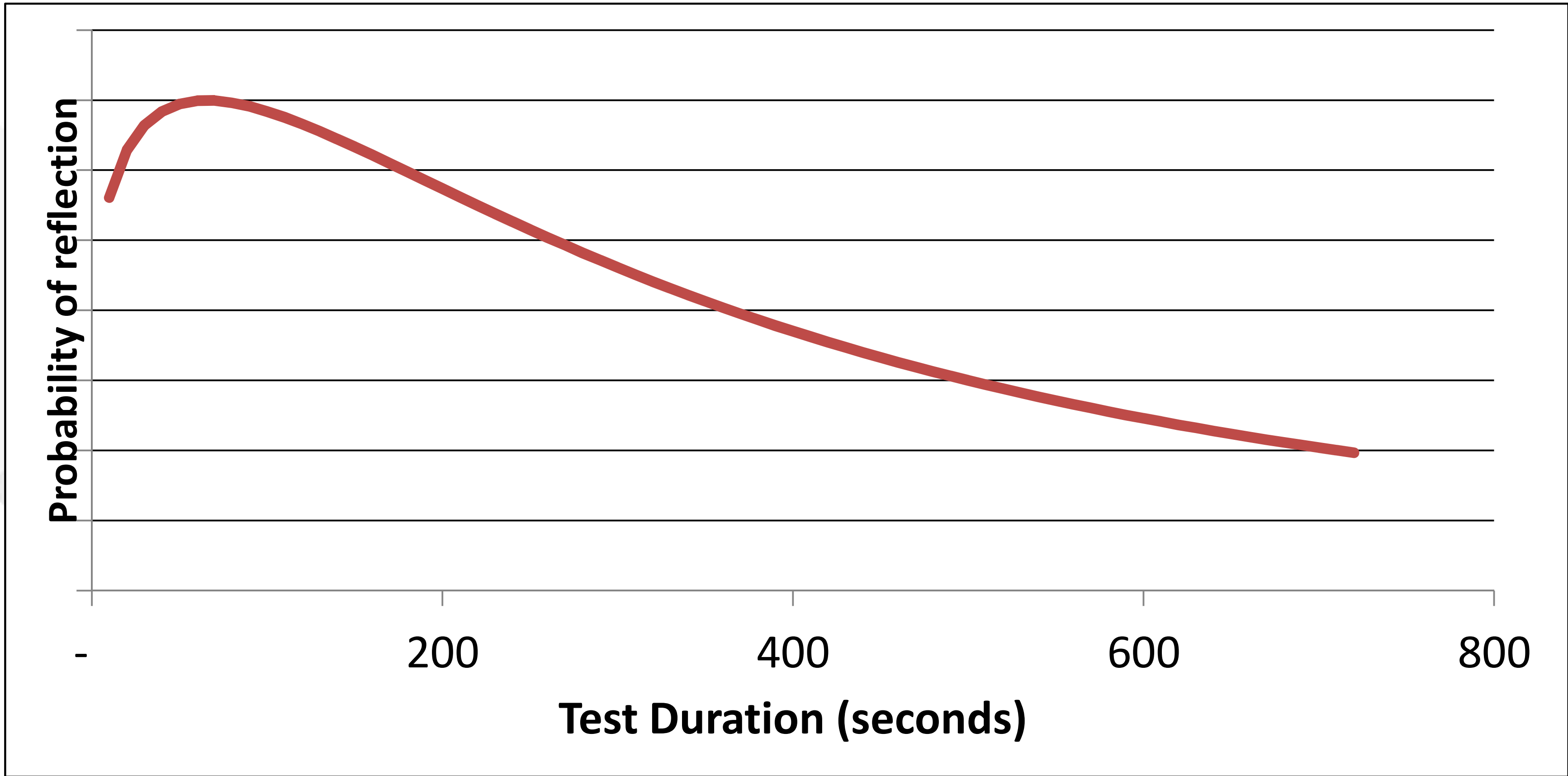
FLIGHT SIMULATION EXPERIMENTS

- Manipulation: Engine #1 stuck in idle mode
  - Discrepancy ENG 1 / 2 in:
    - N1 / N2 speeds
    - Exhaust Gas Temperature
    - Fuel Flow
  - Rudder deflection
  - No cautions on ECAM
- Dependent variable: Detection time



LOG-LOG DISTRIBUTION OF SENSEMAKING (N=27)



Adapted from: Heems, W.J.H. ; A. Speet, R.S. Stam (2012): Automation Surprise.

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SO HOW TO IMPROVE RESILIENCE?

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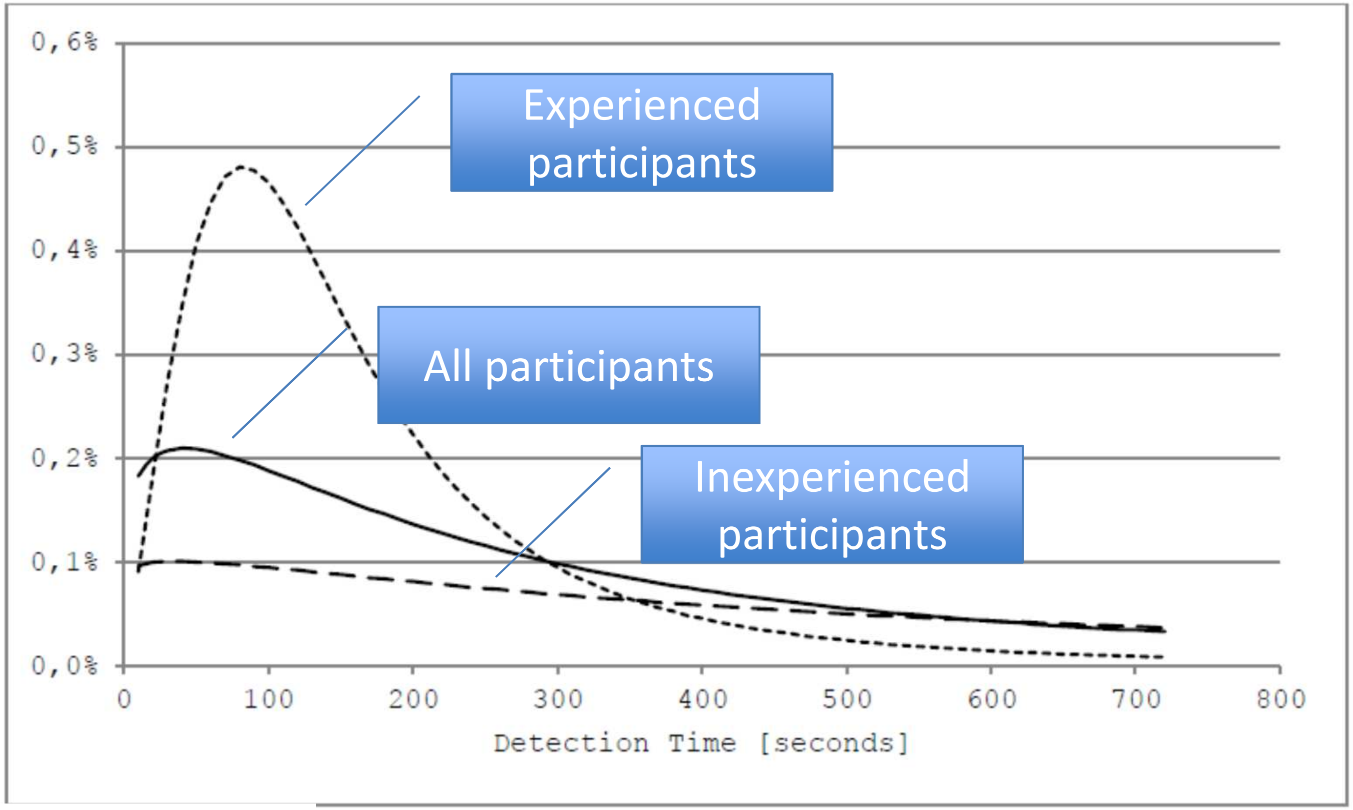
1. ENABLE TRAINING

Duration until detection for single pilots



De Boer, Heems & Hurts (2014)

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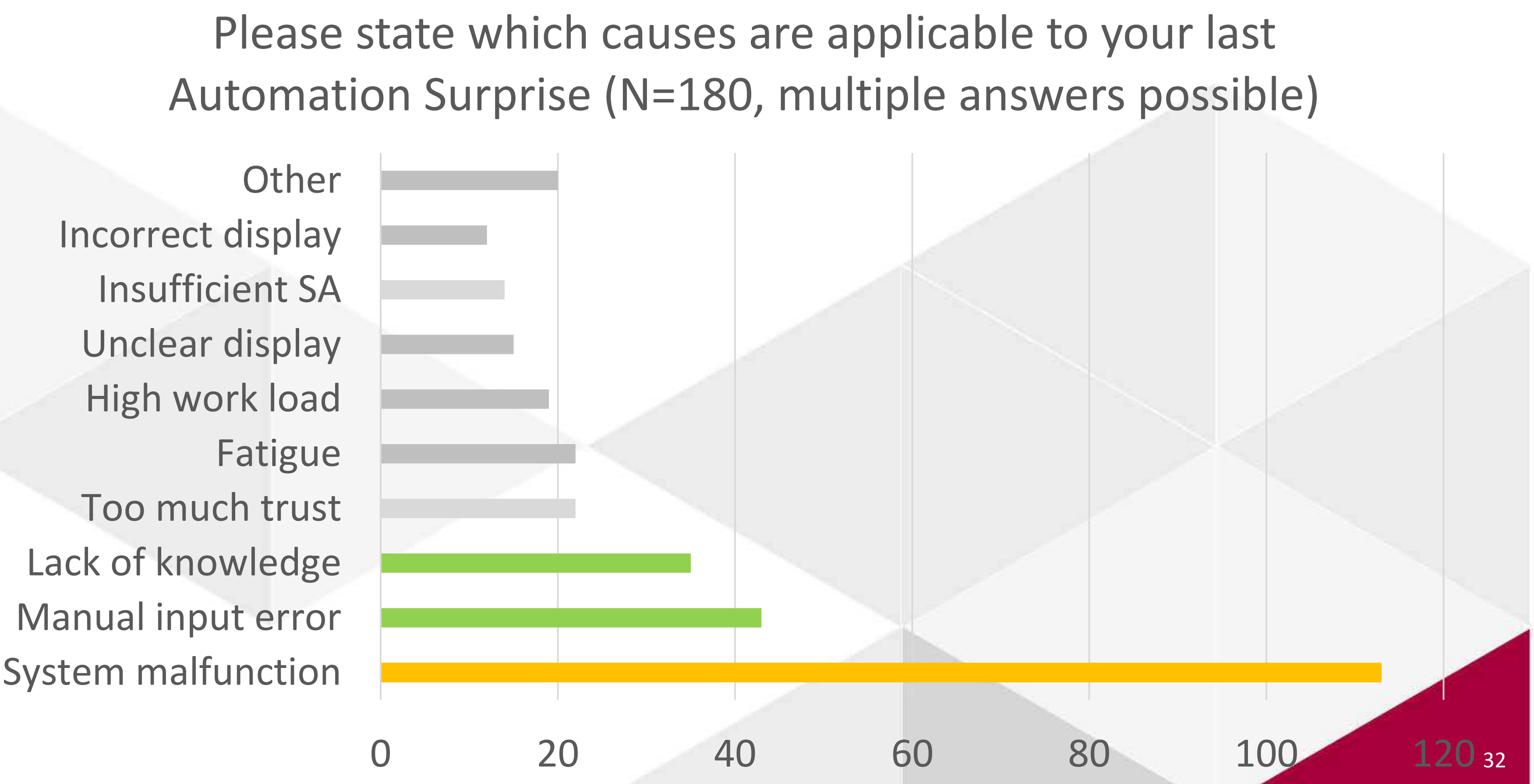
2. IMPROVE KNOWLEDGE BASE



De Boer (2016)

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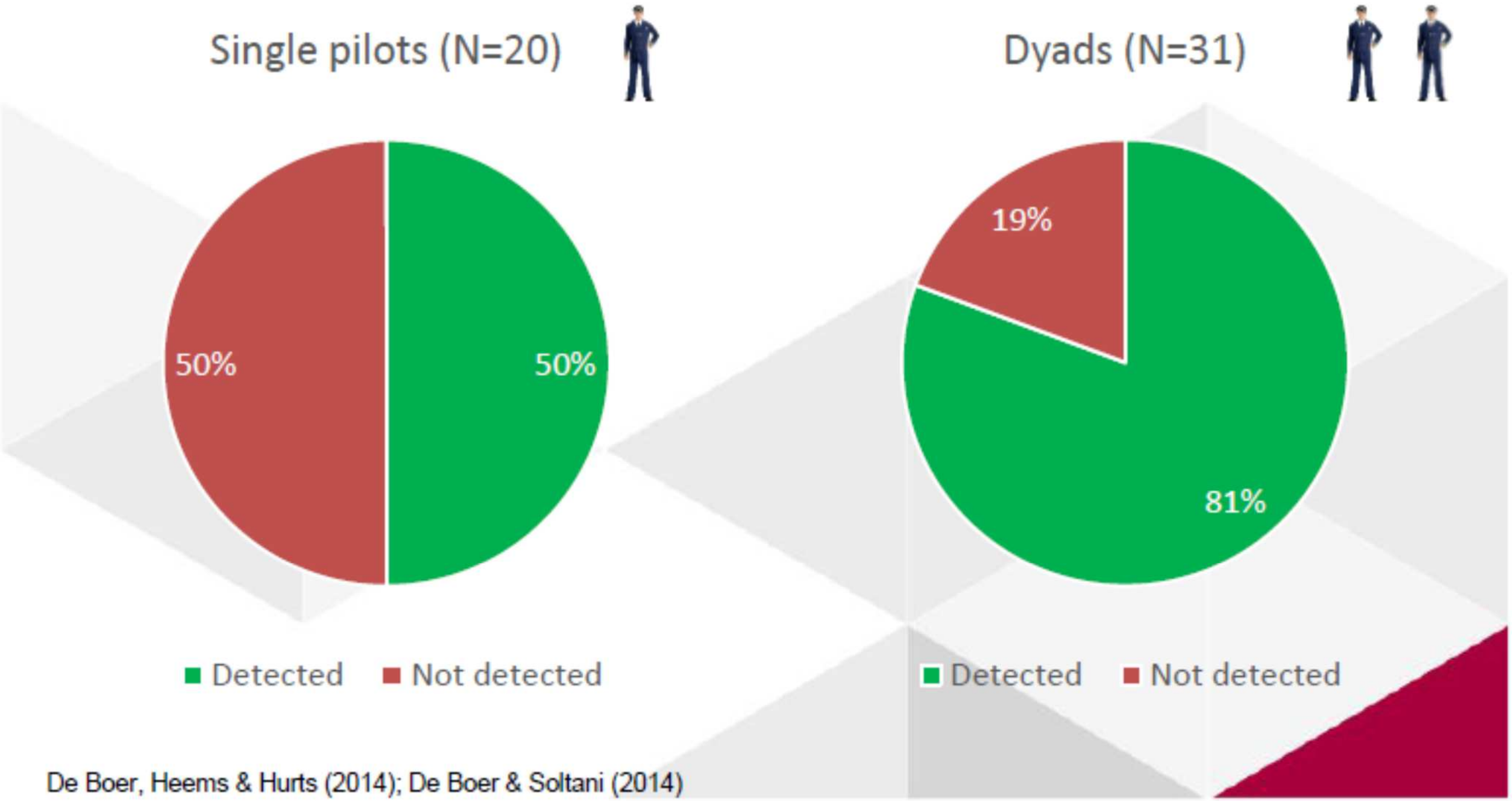
3. WORK TOGETHER (1)



De Boer, Heems & Hurts (2014); De Boer & Soltani (2014)

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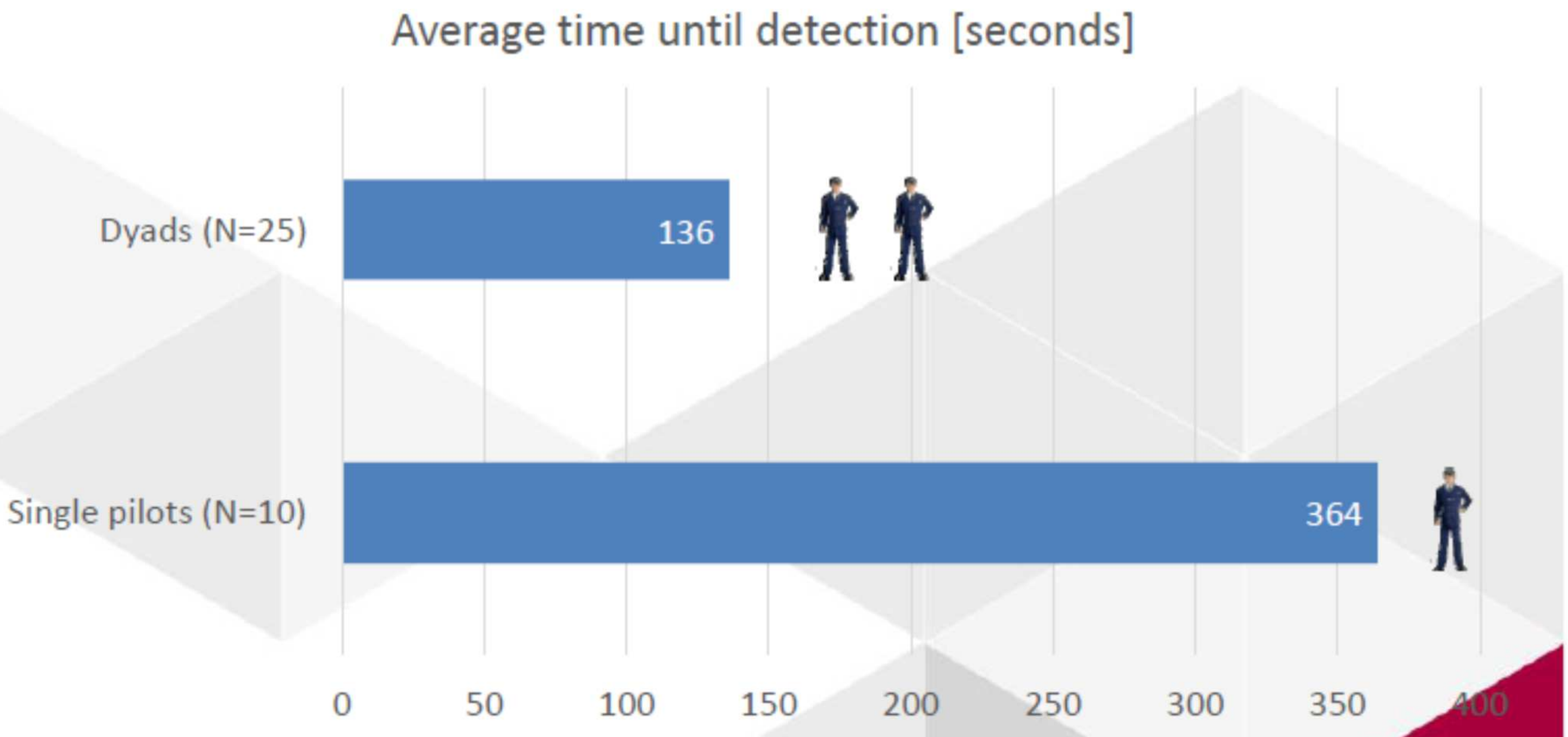
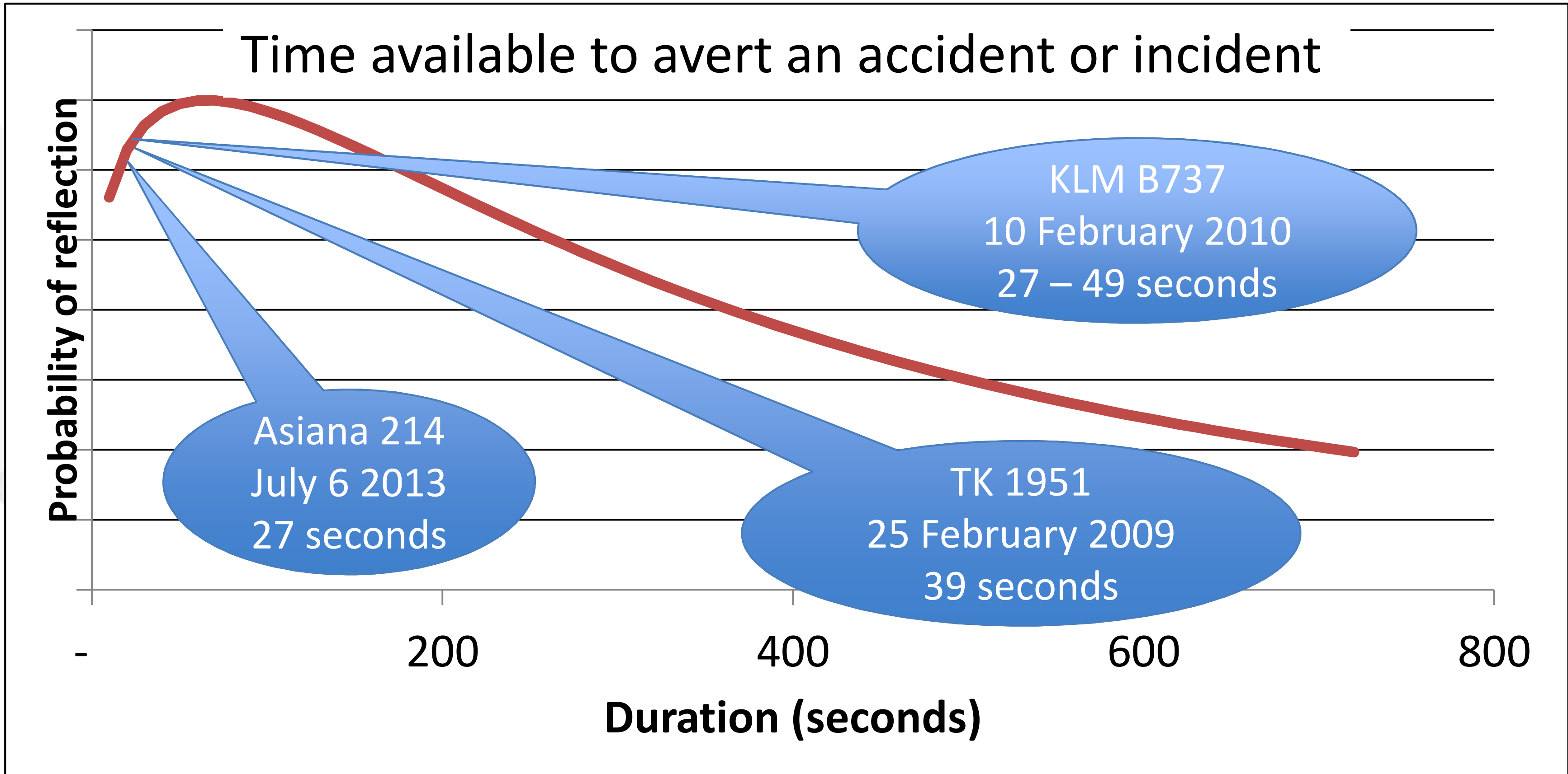
3. WORK TOGETHER (2)



De Boer, Heems & Hurts (2014); De Boer & Soltani (2014)

4. DESIGN FOR SENSEMAKING DELAYS



NTSB 2014, OVV 2009, OVV 2010

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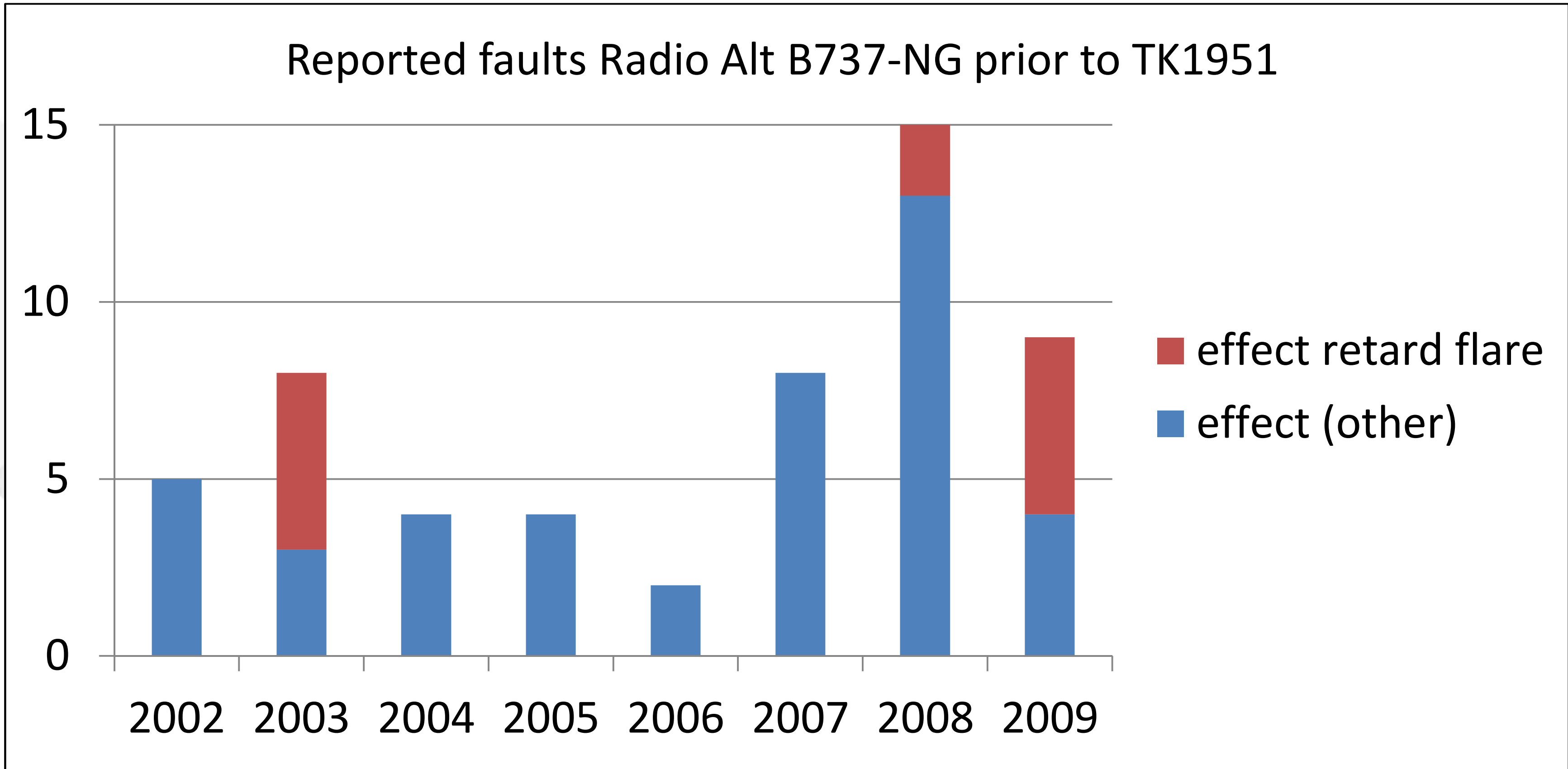
5. ENSURE REPORTING & ACTING



The Dutch Safety Board. (2009).

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CONTACT

- *Lector* of Aviation Engineering: Robert J. de Boer, rj.de.boer@hva.nl
- Website: http://www.hva.nl/aviation