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
INTRODUCTION
• 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
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
OUR ACTIVITIES

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

RESEARCH
- Safety
- Composites
- Capacity
- Maintenance

PEER NETWORKING
- Network events
- Workshops and lectures
- Round table sessions
- Conferences
QANTAS FLIGHT QF 32
4 NOVEMBER 2010

www.hva.nl/techniek
QF 32
4 NOVEMBER 2010
TIME LINE QF32

- Engine failure
- problem analysis
- flight performance
- wait
- disembarking

HOURS

0:00 0:30 1:00 1:30 2:00 2:30 3:00
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)
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
TIMELINE

0:00:00
ATC

0:01:00

0:02:00

0:03:00

0:04:00

birdstrike

US 1549

Other pilot

splashdown

TIMELINE

US 1549

Other pilot

splashdown
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?

ATC

US 1549

birdstrike

Other pilot

splashdown

WHAT ABOUT ATC?
SENSEMAKING DELAYS
PERCEIVE & BELIEVE

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

THE CREW-AIRCRAFT CONTEXTUAL CONTROL LOOP

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

Progress of WARP trials - example

Duration per trial [sec]

Trial [sequence number]

Learned model
Pattern model
Target
LOG-LOG DISTRIBUTION OF SENSEMAKING (N=81)

FLIGHT SIMULATION EXPERIMENTS

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

SO HOW TO IMPROVE RESILIENCE?
1. ENABLE TRAINING

Duration until detection for single pilots

De Boer, Heems & Hurts (2014)
2. IMPROVE KNOWLEDGE BASE

Please state which causes are applicable to your last Automation Surprise (N=180, multiple answers possible)

- Other
- Incorrect display
- Insufficient SA
- Unclear display
- High work load
- Fatigue
- Too much trust
- Lack of knowledge
- Manual input error
- System malfunction

De Boer (2016)
3. WORK TOGETHER (1)

- Single pilots (N=20):
  - Detected: 50%
  - Not detected: 50%

- Dyads (N=31):
  - Detected: 81%
  - Not detected: 19%

De Boer, Heems & Hurts (2014); De Boer & Soltani (2014)
3. WORK TOGETHER (2)

Average time until detection [seconds]

- Dyads (N=25) 136
- Single pilots (N=10) 364

De Boer, Heems & Hurts (2014); De Boer & Soltani (2014)
4. DESIGN FOR SENSEMAKING DELAYS

- Asiana 214
  - July 6 2013
  - 27 seconds

- TK 1951
  - 25 February 2009
  - 39 seconds

- KLM B737
  - 10 February 2010
  - 27 – 49 seconds

Probability of reflection vs. Time available to avert an accident or incident

NTSB 2014, OVV 2009, OVV 2010
5. ENSURE REPORTING & ACTING

CONTACT

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