TWO MESSAGES

- In this presentation I explain some important new safety principles and how the research of the Aviation Academy has contributed to this thinking.
- I present and justify two main paradigms:
  - The label “human error” is not very useful to understand what is going wrong (or right).
  - Rather than focusing on errors, safety performance can be improved by focusing on the difference between how work is actually executed and how it is prescribed in rules and procedures.
INCIDENTS & ACCIDENTS ARE ONLY A SMALL PERCENTAGE OF ALL OUTCOMES

All outcomes (mostly acceptable)

Planned Outcome

Positive Surprises

Unwanted outcomes

Incidents & accidents

Adapted from Art of Work 2018 / Hollnagel 2014
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
• Maximum 720 seconds

LOG-LOG DISTRIBUTION OF HUMAN PERFORMANCE

Threshold

Acceptable outcomes

Unwanted outcomes

Time to detection of malfunction (seconds)

Frequency of detection (N=27)

‘Cause of NAM gas-condensate leakage is combination of human and technical error’
AUTOMATION SURPRISES REFLECT THE VARIABLE THRESHOLD OF “ERRORS”

Cases of Automation Surprise (N=178)

- NONE
- DEGRADATION IN AUTOMATION
- AUTOMATION RESELECTED AFTER CORRECTION
- DEVIATION FMS PROCEDURE
- MANUAL TAKEOVER/CORRECTION
- DIVERSION
- GO AROUND
- VECTORS/HELP ATC
- SIGNIFICANT INCREASE IN WORKLOAD
- SIGNIFICANT DEVIATION IN SPEED
- SIGNIFICANT DEVIATION ROUTE/PATH
- SIGNIFICANT DEVIATION IN ALTITUDE
- SAFETY REPORT SUBMITTED/TECH LOG
- UNSTABLE FLIGHT
- DAMAGED AIRCRAFT

Severity Index


UNDERSTANDING CAN BE IMPROVED BY SALIENCE OF CUES

With additional warning

No additional warning

Frequency of detection

Time to detection of malfunction (seconds)
UNDERSTANDING CAN BE IMPROVED BY EXPERIENCE

Time to detection of malfunction

- Experienced participants
- Inexperienced participants
- All participants


UNDERSTANDING CAN BE IMPROVED BY MORE PAIRS OF EYES...

Average time until detection [seconds]

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

UNDERSTANDING CAN BE IMPROVED BY EYES THAT ARE EQUALLY DOMINANT


UNDERSTANDING CAN BE IMPROVED BY HUMAN-CENTRIC TASK DESIGN & TRAINING

Please state which causes are applicable to your last Automation Surprise (N=315 for 180 cases of AS)

(1) Broken
(2) Flawed design
(3) ‘Buggy’ mental model

UNDERSTANDING CAN BE IMPROVED BY COMBINING DIFFERENT VIEWPOINTS

SUMMARY SO FAR: “HUMAN ERROR” SAYS MORE ABOUT THRESHOLDS THAN ABOUT PERFORMANCE

- The label “human error” is not very useful to understand what is going wrong (or right).
- Acceptable outcomes can be improved by:
  - More time available
  - More salient cues
  - Experience
  - More pairs of eyes …. that are equally dominant
  - Human-centric task design & training
  - Combining different viewpoints
INCIDENTS & ACCIDENTS ARE ONLY A SMALL PERCENTAGE OF ALL OUTCOMES

Adapted from Art of Work 2018 / Hollnagel 2014
As intended by management and regulators taking into account known risks

As executed by front-line employees taking into account day-to-day reality including production pressures

Adapted from Hollnagel 2014
WAD DIFFERS FROM WAI BECAUSE OF CONFLICTING GOALS

WAD DIFFERS FROM WAI BECAUSE WAI IS FOR COMPLIANCE ONLY
WAD DIFFERS FROM WAI BECAUSE CIRCUMSTANCES CHANGE

WAD DIFFERS FROM WAI DUE TO LACK OF TRAINING
WAD DIFFERS FROM WAI DUE TO LACK OF SUPERVISION

M Pappot, RJ de Boer (2015): The integration of drones in today's society. In the proceedings of the 3rd European STAMP Workshop, Procedia Engineering 128
Leveson (2011): Engineering a Safer World

[Diagram of drone operation and supervision]

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[Image of a drone operator and drone]
Work-as-Imagined

Successful outcome
A SMALLER GAP BETWEEN WAD AND WAI IS BETTER FOR (SAFETY) PERFORMANCE

• Work as Imagined is important for five reasons:
  • Memory aid for steps, especially in emergency situations
  • To co-ordinate between multiple actors
  • As a basis for training
  • As organisational memory
  • To enable the monitoring and checking of behavior
• A large gap means that these purposes are not fulfilled
  • Gap needs to be identified, understood, closed and preserved
WORK AS IMAGINED IS NOT ALWAYS SAFER THAN WORK AS DONE

Boelhouwer (2016): Het uitbreiden van STAMP met Work-as-Done, BSc thesis
IDENTIFY THE GAP BETWEEN WAD AND WAI: NEW SAFETY METRICS REQUIRED

- A four year project sponsored by SIA investigates
  - SMS assessment
  - Safety culture prerequisites
  - Risk control effectiveness
  - Resource gaps
  - Work-as-imagined vs work-as-done at the task level


IDENTIFY THE GAP BETWEEN WAD AND WAI: SAFETY MANAGEMENT SYSTEM MAPPING

IDENTIFY THE GAP BETWEEN WAD AND WAI:
PROCESS MAPPING USING STAMP

Boelhouwer (2016): Het uitbreiden van STAMP met Work-as-Done, BSc thesis
Leveson (2011): Engineering a Safer World

IDENTIFY THE GAP BETWEEN WAD AND WAI:
DATA MINING

- Data mining is the process of collecting, searching through, and analyzing data in databases, as to discover useful, possibly unexpected, patterns and relationships in data
- In the industry data mining is used e.g. to optimize processes, reduce costs and increase revenues

De Boer, Broodbakker & Pelt (2016): Data mining in MRO. Presentation to the NVvL.
UNDERSTAND WORK AS DONE: COLLECTING NARRATIVES

Events + Experiences + Emotions + Perspectives = Narrative

Kurtz (2014): Working with Stories in Your Community or Organization - Participatory Narrative Inquiry

THE NARRATIVES REFLECT THE “CAN-DO” MENTALITY OF THE DUTCH MILITARY

Can-do Resilient
Failing Bureaucratic

Achieved results vs plan: high low
Alignment between WaD and WaI: high low

R.J. de Boer (2017): Using narratives to identify safety issues in helicopter maintenance. Presentation at the 2nd ICSC
THE NARRATIVES REFLECT THE “CAN-DO” MENTALITY OF THE DUTCH MILITARY

Achieved results vs plan

Alignment between WaD and Wal

High

Military MRO organisation

Resilient (N=4)

Bureaucratic (N=0.5)

Can-do (N=33.5)

Failing (N = 7)

MAKE THE GAP AS SMALL AS AUDITABLE: LEAN PROCESS (RE)DESIGN

Aviation MRO organisations

R.J. de Boer (2017): Using narratives to identify safety issues in helicopter maintenance. Presentation at the 2nd ICSC.

LEAN PROCESS REDESIGN RESULTS IN LESS DEFECTS

![Graph showing trend in acceptable deferred defects from May 2014 to November 2014.](image)

Koen Brinkman (2015): Verification of SME MRO Process Improvements. BSc

MAKE THE GAP AS SMALL AS AUDITABLE: MICRO-EXPERIMENTS

- Small initiatives to try out improvements, suitable for complex systems
- Safe-to-fail
  - process risks
  - personal safety
  - reputational damage
- Means to amplify (expand) or dampen (discontinue)
- Based on bottom-up ideas of front-line employees
- Requires coaching and facilitation

MAKE PEOPLE ACCOUNTABLE FOR GAP: IMPROVE THE SAFETY CULTURE

- Aviation Academy Safety Culture Prerequisites (AVAC-SCP) tool
  - Actionable measures, therefore distinct from culture
  - Necessary but not sufficient for a beneficial safety culture
  - Full set
    - Based on Reason’s (1998) five safety subcultures (just, flexible, reporting, informative and learning cultures)
    - Supplemented with general organizational prerequisites from other sources
  - Web-based tool focused on
    - Which prerequisites are currently present?
    - Which prerequisites are operationalised?
  - Identified in the course of contract research for a nuclear power plant

N Karanikas, P Soltani, RJ de Boer, A Roelen, S Dekker (2015): Company X Phase 2 Project Report, Aviation Academy, Company Confidential


REPORTING NEEDS TO BE IMPROVED TO ENHANCE THE SAFETY CULTURE

Example: Asian airline

- Learning
- Information
- Reporting
- Flexible
- Just
- General

Number of markers per dimension (Total = 57)

Below average  At average  Above average compared to database (N=16)

SUMMARY SO FAR:

- Work-as-Done differs from Work-as-Imagined
  - Conflicting goals
  - Compliance
  - Changing circumstances
  - Training and supervision
- Important to minimize the gap for (safety) performance
- Close gap:
  - Identify the gap between WaI and WaD
  - Understand why work is done like WaD
  - Let people make the gap so small as to be auditable
  - Make people accountable for getting their job done properly

SAFETY WITHOUT HUMAN ERROR

- “Human Error” says more about thresholds than about performance
- Acceptable outcomes can be improved
- Work-as-Done differs from Work-as-Imagined
- Important to minimize the gap between WaD and WaI for safety
Fokke & Sukke
Make a virtue out of it

We have just taken on the position of Director...

...to never ever have to develop our personal skills again

Translated from Reid, Geleijnse & Van Tol (2018): Fokke & Sukke aan de leiding

THANK YOU FOR YOUR ATTENTION AND SUPPORT