



TECHNISCHE  
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WIEN

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Dissertation am IMW, TU Wien  
unter Univ.-Prof. Dr. S. Köszegi

Working Title: *“Cockpit Automation and Human  
Performance in the Aviation Domain”*

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1. Motivation and Relevance
2. S-O-A, Research Gap, Problem
3. Solutions, Contribution S-O-A
4. Methods
5. Literature

## Relevance of Problem

- Aviation domain is in a shift towards heightened automation levels: cockpit HF and HCI
- Multi-crew → Dual-crew → Single pilot → Highly automated → Human in the loop → Human on the loop → ...autonomous
- Tech innovations (avionics, computing power, ML), enabling automation and autonomy
- Market shifts (pilot shortages/surplus cycles; fleet retirement), efficiency demands, fast-paced implementation of automation

### Automation: Opportunities and Strengths

Enhanced safety, economic benefits, efficiency boosts, decreased environmental impacts, increased comfort, heightened transparency, data and resource optimization,...

### Threats and Risks

Ethical considerations, short and long term impacts on human cognitive function, impact on society, development of learned helplessness, increased dependency, modification of human behavior, unlearning and fading of skills, decreased affordability, increased complexity of failure modes (FMEA), in-transparency, complex certification paths...

## Landscape

FAA cert. Autoland system in an integrated flight deck; emergency control and land the aircraft without human intervention. (M600, Cirrus Vision Jet, Daher TBM 940) (Garmin)



Joby S4, DEP & unified flight control system to reduce pilot workload ... technology foundation for autonomous human-on-the-loop flight. (Joby)



TTTech TTP and deterministic ethernet offers embedded flight control systems and data communication platforms; B787: fault-tolerance, safety and availability (TTTech, Boeing)



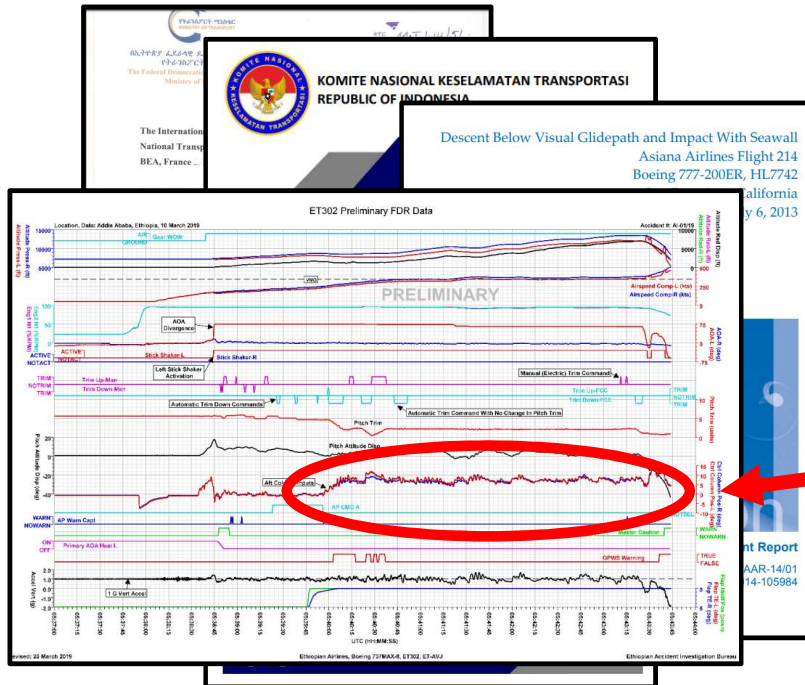
2020 EASA cert. Universal Avionics Systems ClearVision enhanced flight vision system (EFVS) with SkyLens head-wearable display. (UAS)

Airbus: Autonomous Taxi, Take-Off and Landing (ATTOL) project, fully automatic vision-based take-offs and landings, controlled using on-board image recognition technology



## Cockpit Automations *dark side*

Accident reports: Asiana 214, Ethiopian ET-AVJ, LionAir PK-LQP



Recorded (aft-wards) control column input



Boeing 737 MAX cockpit (Photo: NYTimes, 2018)

## Automation – Framework and Roadmaps

- **Bainbridge: Ironies of automation** (the designer who tries to eliminate the operator, leaves them to do those tasks that are left over: often arbitrary, without support, and yet critical to safe operations) (Bainbridge, 1983)
- **Billings: ‘Clumsy’, poorly-designed automation** can decrease safety by increasing risk: reduction in pilot attentiveness during long periods of inactivity, insufficient monitoring and control or procedural errors in complex automation systems. (Billings, 1997)
- EC’s AI Ethics Guidelines, FAA NextGen
- EASA AI roadmap, human-centric approach to AI in aviation, outlines possible certification paths
- **TU Wien IMW, Labor Science and Organisation/Trust robots.** *How do we distribute work among humans and machine agents? How do we design trustworthy intelligent technology around people, control AI technology? How do we rely on the benevolent intentions and security of autonomous technology?*

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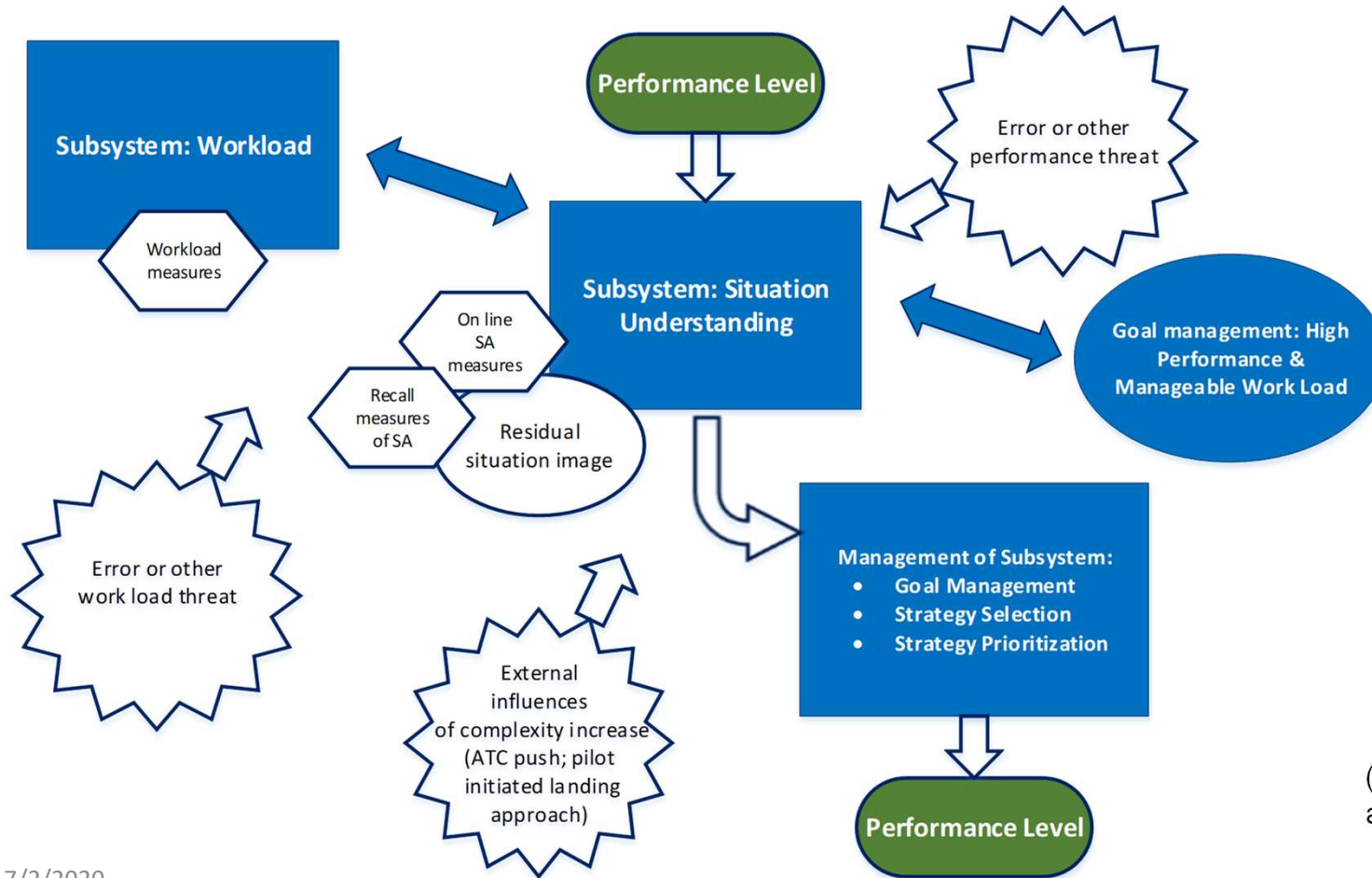
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## Relationship of WL and Situation Understanding



(after Wickens et al., and Durso et al. (2007))

- **Automation:** compute, plan and solve; relieve human
- **Work load models** (mental resources demanded by a task and those resources supplied by the human operator). (Parasuraman, Sheridan, Wickens, 2008; Durso and Manning, 2008; Kantowitz and Casper, 1988)
- **WL Measurement** (cardiovascular, ocular, respiratory, endocrine, central nervous system, such as event-related brain potentials) (Durso et al., 2008)
- **Situational awareness models** (extract information, integrate with knowledge, create mental picture, direct perceptual exploration, anticipate future) (Endsley, 1998; Dominguez et al., 1994)
- **Performance management and organizational theory within cockpit** environments (Durso and Gronlund, 1999; Durso, Rawson, and Giroto, 2007; Standon, Salmon, Walker, Baber, and Jenkins, 2005; Tenney and Pew, 2006)
- Deskillling, un-learning, agency, sensemaking, attribution ('it' → 'George is flying'),

## Research gap & proposed contribution to body of knowledge

- Gaps in scientific model-based approach to how technology is actually impacting pilot performance and risk.
- Anecdotal evidence (Air Asia, 737MAX MCAS) allows postulations on gap between research basis and operational world (industry and certification authorities)
- Understudied domain of performance of human operators in cockpit and impact of today's deployed technology on their performance (or break down thereof)

## Practical Problem

- *Cockpit Automation and Human Performance in the Aviation Domain: Analysis of incidents and failures within an existing database*
- *“Do high levels of automation in cockpit environments have latent unintended consequences in terms of WL, SA, and performance degradation, what kind and to what degree?”*
- Goal is to study abnormal occurrences, issues and failures, in an attempt to better qualify and quantify the relationship of WL, SA, performance with level, type and complexity of such automation

## Methodological Approach

- Explorative research and analysis of the NASA Aviation Safety Reporting System (ASRS) database.
- Extract, categorize (phenotypes and genotypes) and analyze failures and incidences.
- Evaluate based on key words, dimensions, categories, while adapting and adding as needed: generate a narrative of numbers to substantiate the developed theories.
- Weave into narrative the concepts of attribution, agency and expectations
- Necessity to carefully manage limitations and biases, coding taxonomy.

Background: ASRS, voluntarily submitted incident reports from pilots and others. Unsafe occurrences and hazardous situations, and focus is on quality of human performance. Altitude and heading deviation most frequently reported problems.

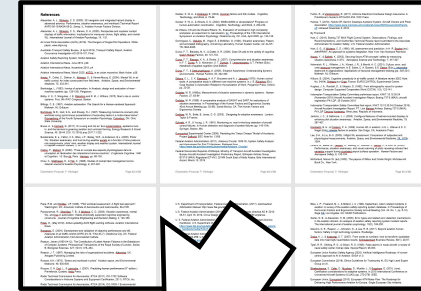
| No. | Category   |
|-----|--|
| 1   | Keyboard errors made by flight crew in inputting data                            |
| 2   | Logic errors made by flight crew in inputting data                               |
| 3   | System performance errors - attributed to hardware errors/failures               |
| 4   | System performance errors - attributed to software mistakes/design problems      |
| 5   | Errors of expectation/interpretation by the flight crew - ATC logic related      |
| 6   | Errors of expectation/interpretation by the flight crew - FMS logic related      |
| 7   | Errors due to ATC/crew high workload - above 10,000 ft.                          |
| 8   | Errors due to ATC/crew high workload - below 10,000 ft.                          |
| 9   | Mode control panel (MCP)/automation control selection errors made by flight crew |
| 10  | FMS/MCP interaction errors   |
| 11  | Errors related to pre-stored database/company routes                             |
| 12  | Training/flight crew proficiency related errors/performance problems             |
| ... | ...  |

Descriptive Categories used in ASRS study by Eldredge et al. (1992)



## Expected Solutions, Scientific Contribution to State-of-the-Art

- Generate new **scholarship** connected to existing and developing theories
- Contribute an improved and updated **understanding of impacts** of advanced automation on WL, SA, and performance of pilots.
- Qualitative and quantitative **assessment** based on categories for reported problems
- Use this structured assessment to **guide future human factors related trends** in advanced avionics deployment, automation, and AI in cockpits and interconnected domains.
- **Benefit** to technology and organizational researchers, avionics designers and pilot users.



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**Q&A**

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