

# Ergonomic system design: A user-centred approach for DFS

Basic Principles and Lessons Learned

*Dr. André Perott*



**DFS** Deutsche Flugsicherung

# Outline

- **Introduction**
- **User Centered Design**
- **Implications & Lessons Learned**
- **Conclusion**

# Technology Centered Design vs. User Centered Design



**From Technology to Design**

**From Context to Design**

# Why pursuing an User Centered Design?

## Top 10 cited measures of UCD effectiveness

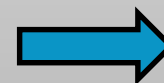
Measures	#
External (customer) satisfaction	33
Enhanced ease of use	20
Impact on sales	19
Reduced help desk calls	18
Prerelease user testing/feedback	16
External (customer) critical feedback	15
Error/success rate in user testing	14
Users' ability to complete required tasks	10
Internal (company) critical feedback	6
Savings in development time/costs	5
No effectiveness measures in place	15
Uninterpretable response	20

*n* = 103

Mao et al. (2005)

## Demands in Air Traffic Control

- Professionalized work equipment handling
- Redundancy
- Mutual checking components
- Loose coupling of systems
- Large error margins



**Conservative Systems**

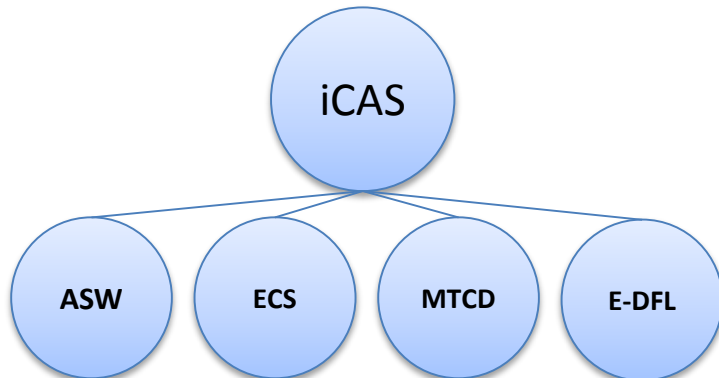
*cf. Leveson et al. (2001)*

# Advantages of an User Centered Design in Air Traffic Control

User Centered Design helps to manage complexity in safety critical systems.

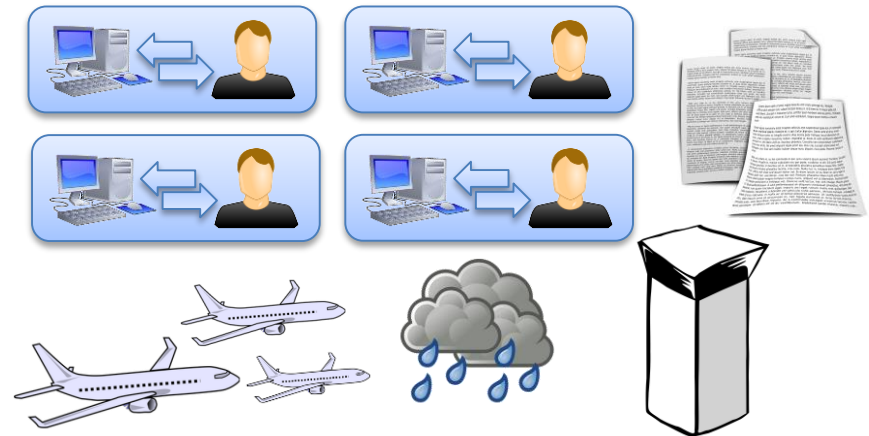
## Intrinsic Complexity

*... results from system architecture*



## Extrinsic Complexity

*... results from the various interactions*



*cf. Boy (2013)*

# Costs of Ergonomics

<b>Phase of development</b>	<b>Share of the total budget for development (%)</b>
<b>Development of a concept</b>	1 - 2.5
<b>Draft phase</b>	1 - 3
<b>Construction</b>	2 - 6.5
<b>Commissioning</b>	4 - 10.5
<b>Normal operations</b>	5 - 12+

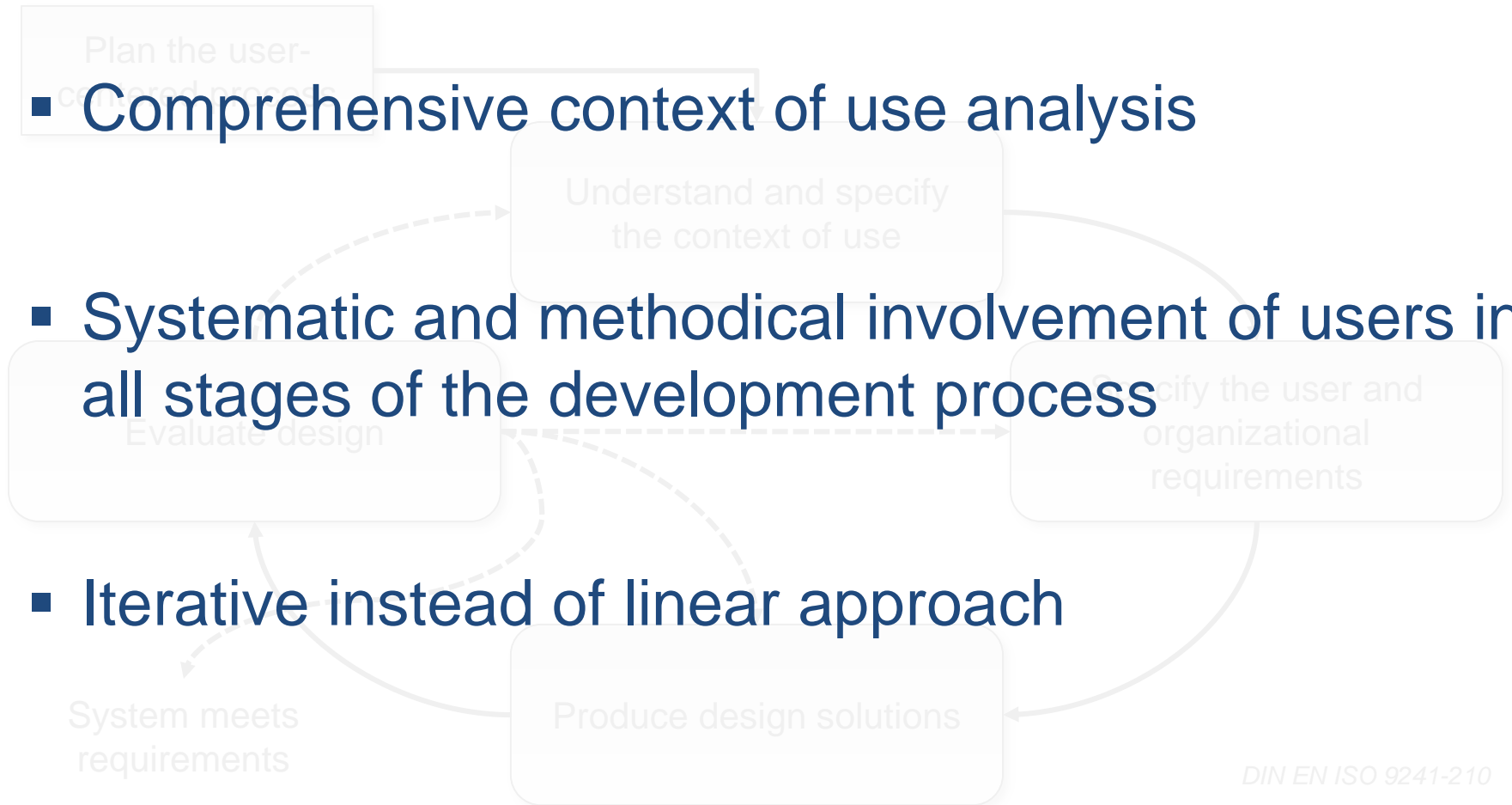
*Alexander (1999)*

# Characteristics of the User Centered Design Process

- Comprehensive context of use analysis

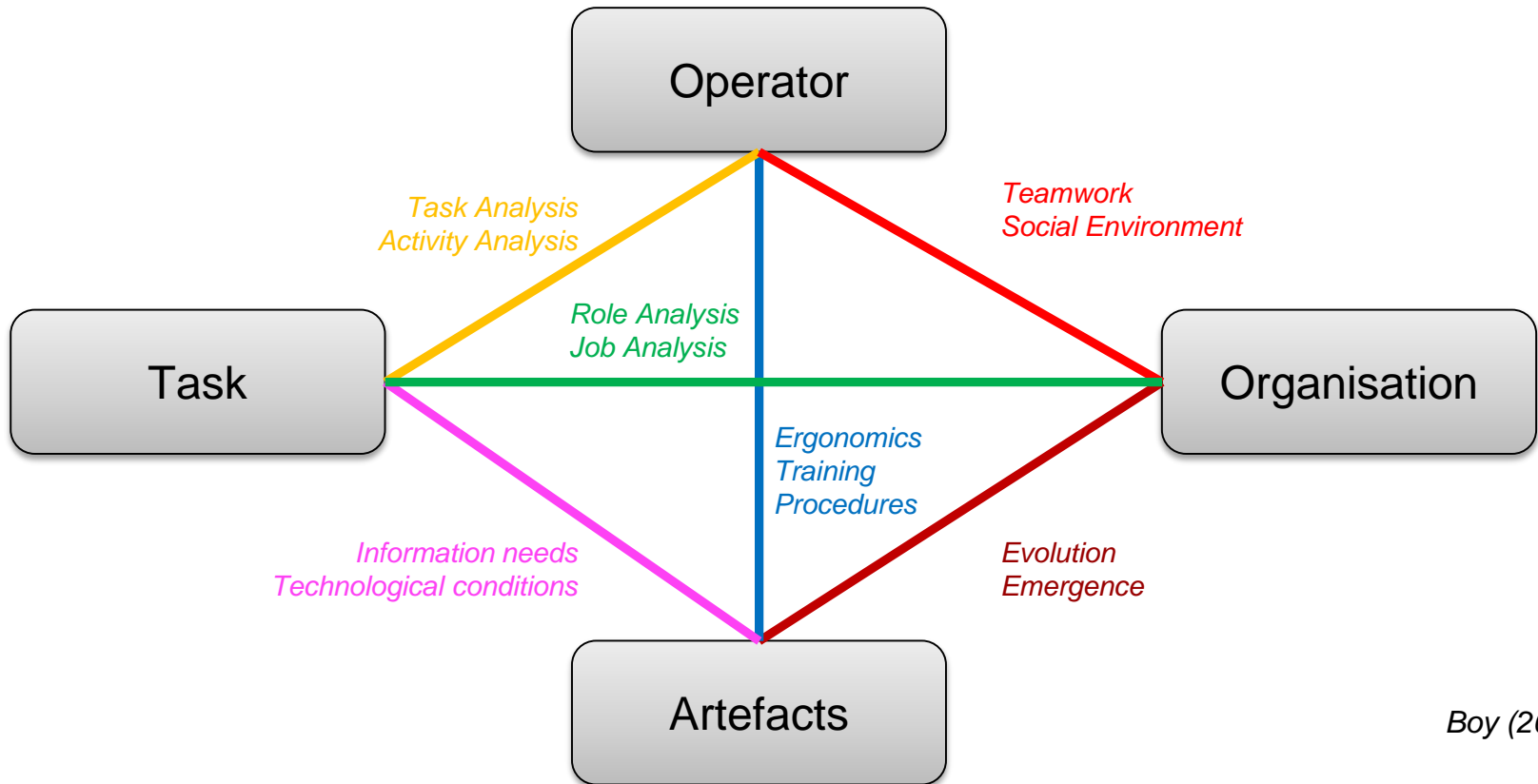
- Systematic and methodical involvement of users in all stages of the development process

- Iterative instead of linear approach



DIN EN ISO 9241-210

# Context of Use Analysis as a Starting Point for further Automation

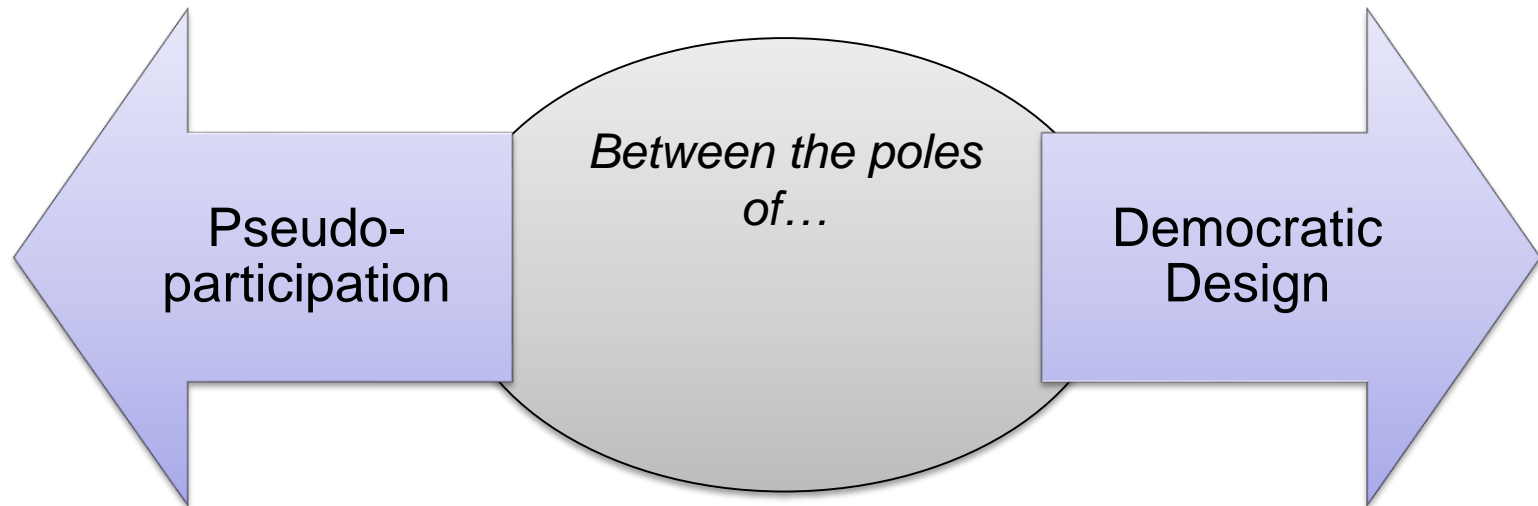


*What problems are we going to solve?*  
*What is a desirable automated target state?*  
*What steps are required to achieve this state?*

**User Centered  
Automation Strategy**



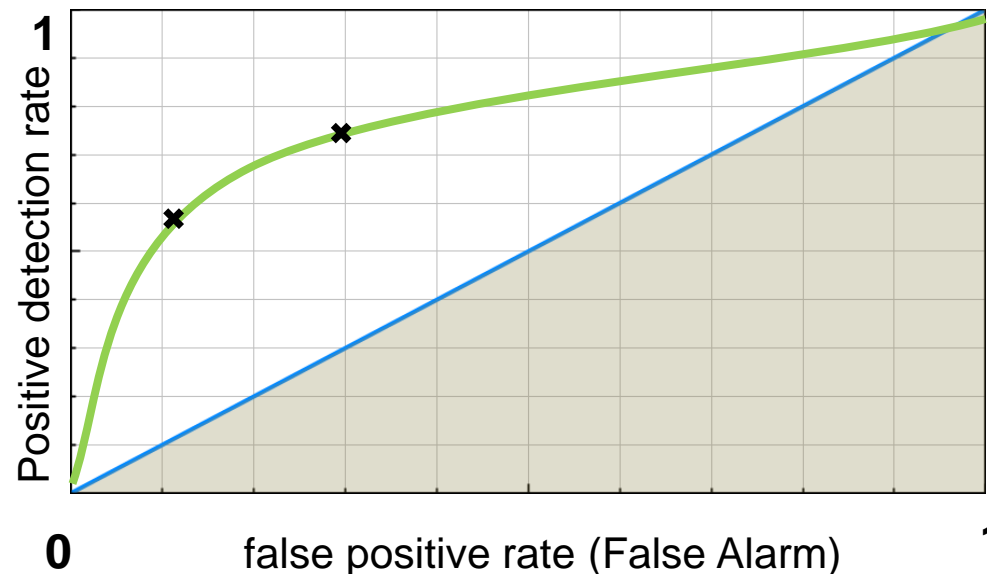
# Systematic and methodical involvement of users



- Decisions are made in the forefront
- Selected users are asked to acknowledge these decisions afterwards
- For that, designers use their specific information advantage about the product
- Risk increases, that important requirements from the context of use remain unconsidered
- Responsibility is virtually transferred to the users
- The design with the majority of votes is implemented
- Risk increases, that only marginal changes are considered
- User opinions may be volatile

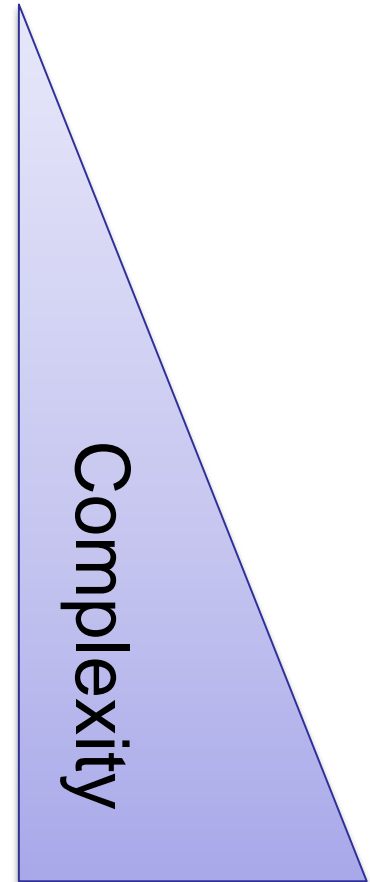
# Systematic and methodical involvement of users

- Adequate methods and concepts are needed to guide an User Centered Design and to separate valid and meaningful user requirements from spontaneous and minor opinions.
- For example, the Receiver Operating Characteristic (ROC) curve might be appropriate to find a trade-off between false-positive (nuisance) and false-negative (missing) alerts.



# Evaluating as early as possible with the help of prototypes

- > **Design Prototype** : Early sketches and drafts to show the overall concept and the most important use cases.
- > **Laboratory Prototype**: Analysis of specific issues under controlled conditions.
- > **Functional Prototype**: Most features are already implemented and can be evaluated by the users (Alpha-Version)
- > **Pilot System**: Almost identical with the final version (Beta-Version)



# Evaluating automation in day to day operations as well as in critical situations

## Normal operation

- Normal amount of traffic
- Standard procedures apply
- All systems are working properly
- All positions are manned

## Abnormal Operation / Degraded Mode

- Working under extreme (high or low) workload
- Emergencies and exceptional situations
- Failure of primary and secondary systems
- Working under production pressure and short-staffed situations

# Conclusion

- User Centered Design is a promising methodology for future automated systems.
- The purpose of automation is based on the context of use and not on available technologies.
- An User Centered Design is characterized by
  - a comprehensive context of use analysis
  - a systematic and methodical involvement of users in all stages of the development process
  - an iterative approach
- More design methods and concepts are needed to derive valid and meaningful user requirements.

# THANK YOU



**DFS** Deutsche Flugsicherung

# References

Alexander: The cost justification process. Presented at the Department of Defence Annual Ergonomics Conference, Fairfax, VA. 1999

Boy: Orchestrating Human-Centered Design. Springer, 2013

Boy: A Human-Centred Design Approach. In: Handbook of Human-Machine Interaction (Ed. Boy), 2011, 1-20

ISO 9241:-210: Ergonomics of human-system interaction - Part 210: Human-centred design for interactive system. Beuth, 2010

Leveson, de Villepin, Srinivasan, Daouk, Neogi, Bachelder, Bellingham: A Safety and Human-Centred Approach to Developing New Air Traffic Management Tools. Fourth USA/Europe Air Traffic Management R&D Seminar, 2001

Mao, Vredenburg, Smith, Carey: The state of User-Centered Design Practice. In: Communications of the ACM, 48 (3), 2005, 105-109