

Ergonomic system design: A user-centred approach for DFS

Basic Principles and Lessons Learned

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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?

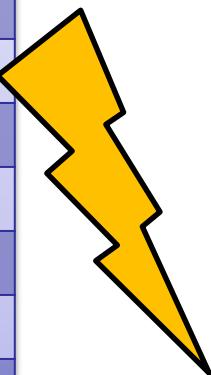
Top 10 cited measures of UCD effectiveness

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)

cf. Leveson et al. (2001)



Demands in Air Traffic Control

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

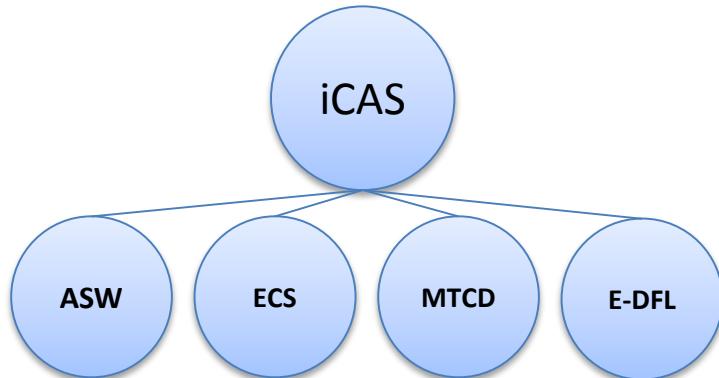
Conservative Systems

Advantages of an User Centered Design in Air Traffic Control

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

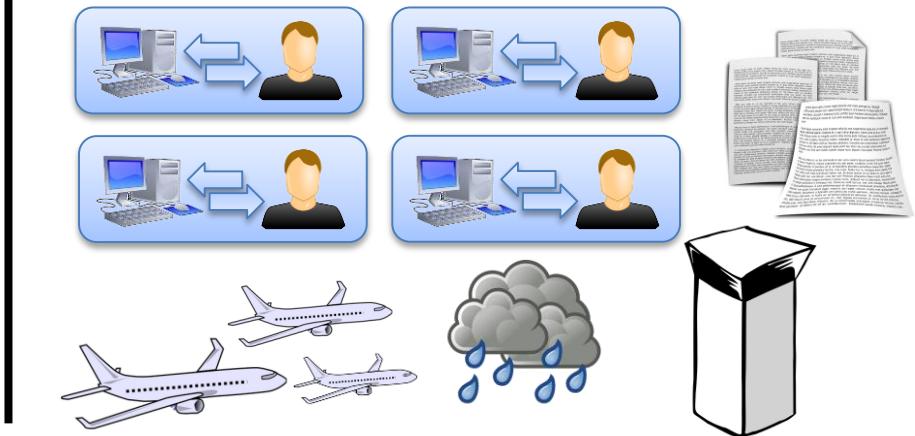
Intrinsic Complexity

... results from system architecture



Extrinsic Complexity

... results from the various interactions



cf. Boy (2013)

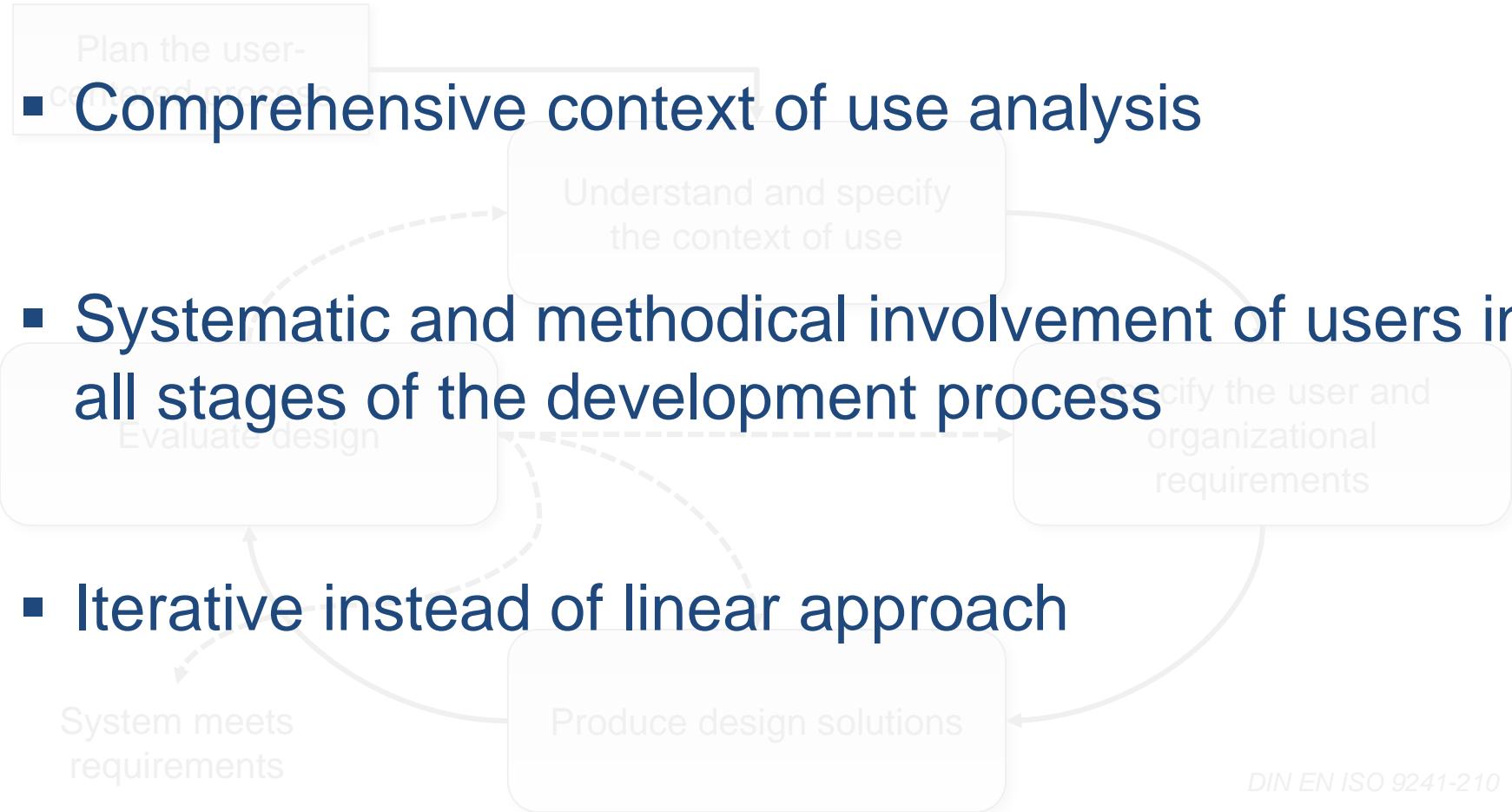
Costs of Ergonomics

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

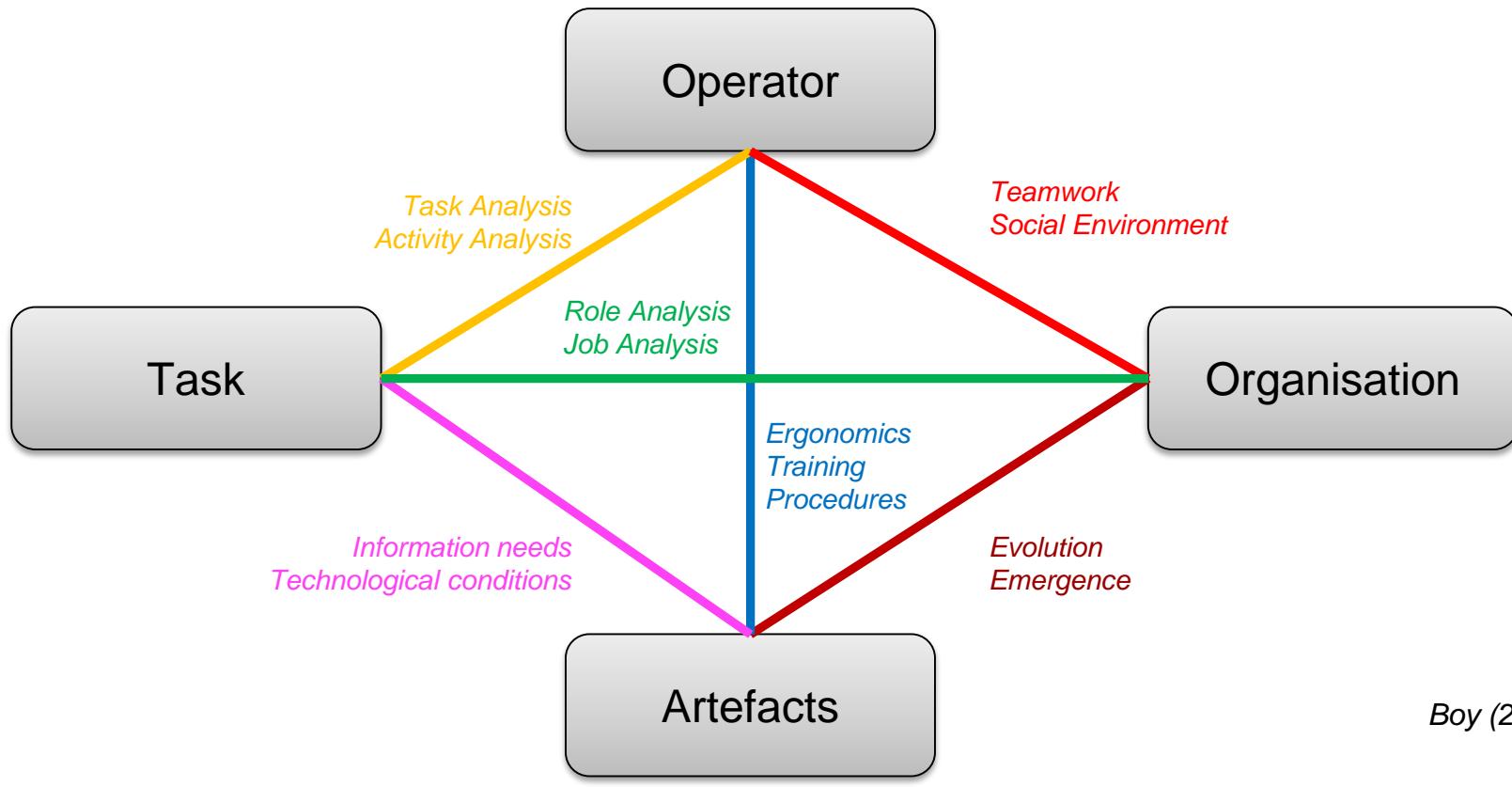
Alexander (1999)

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**



Context of Use Analysis as a Starting Point for further Automation



Boy (2011)

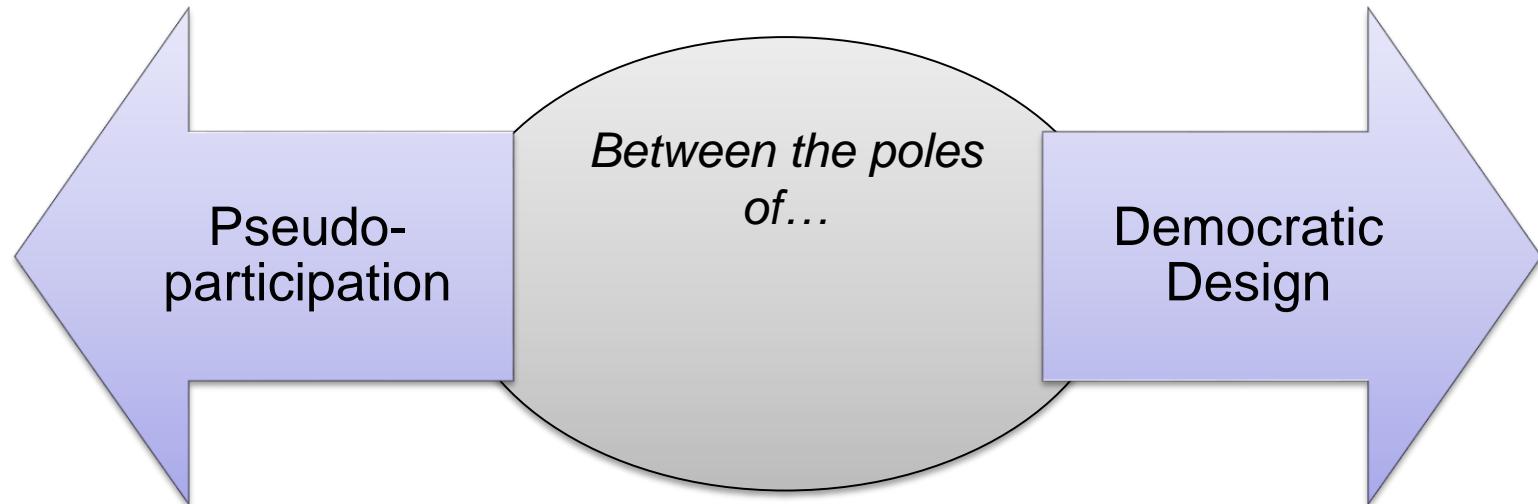
*What problems are we going to solve?
What is a desirable automated target state?
What steps are required to achieve this state?*

**User Centered
Automation Strategy**



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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

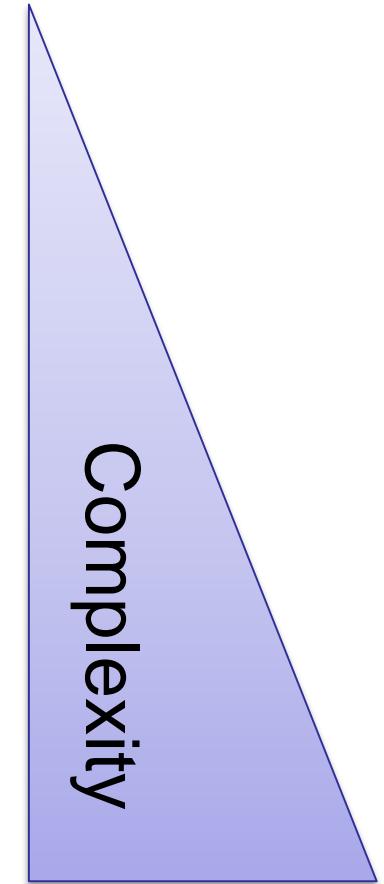
Systematic and methodical involvement of users

- 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



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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