

Sesar Innovation Days 2014

Usability Evaluation of Multi-Touch-Displays for TMA Controller Working Positions

DLR German Aerospace Center, DFS German Air Navigation Services

Maria Uebbing-Rumke, DLR

Hejar Gürlük, DLR

Malte-Levin Jauer, DLR

Konrad Hagemann, DFS

Andreas Udovic, DFS

Knowledge for Tomorrow



Contents

Motivation

Concept

Research Prototypes

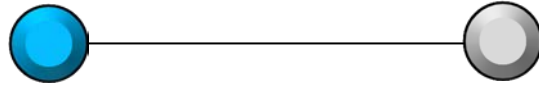
Methods

Results

Conclusion



MOTIVATION



Concept

Background

State of the Art

Research
Prototypes

Experiment

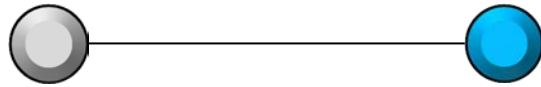
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- SESAR WP 10.10.02 “CWP Human Factors Design”
- Task “Innovation Analysis Report 2013”,
 - Focus on interaction technologies:
 - Multi-Touch
 - Eye Tracker
 - Handwriting Recognition
- Our investigation subject
 - Compare multi-touch with mouse interaction



MOTIVATION



Background

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Advantages of multi-touch

- Reduced selection time, direct-touch of object
- Bi-manual gestures enable faster trigger of actions
- Hedonistic user experience
- No intermediate device
- Easy and fail-safe
- Possibility for intuitive design
- Potential for collaborative use at big screens

Disadvantages of multi-touch

- Lack of preciseness
- On large displays reachability may be bad
- Target objects may be hidden by hand
- Visual and haptic feedback is missing



CONCEPT



Questions



Research Hypotheses

Research
Prototypes

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Mouse HMI is used as reference

- Is multi-touch really faster than mouse?
- Is it more intuitive?
- Is multi-touch suitable for the feeder controller working position?
- Do controllers appreciate direct manipulation of aircraft objects?



CONCEPT



Questions



Research Hypotheses

Multi-Touch HMI compared to mouse HMI:

1. Mental workload will be lower
2. Physical workload will be higher
3. General usability will be higher
4. User experience will be higher
5. Controller performance will be higher

Research
Prototypes

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RESEARCH PROTOTYPES

Methods

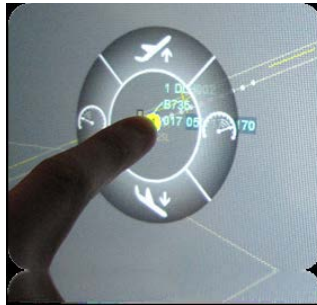
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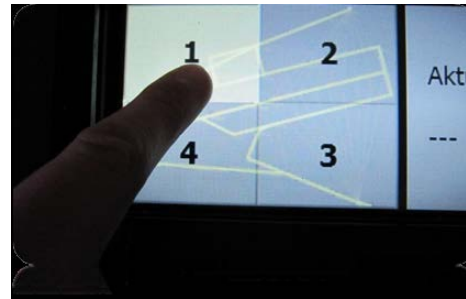


Multi-Touch

Mouse



Option
Wheel



Area
Selection



Reduce
Command



Descend
Command



RESEARCH PROTOTYPES

Methods

Results

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Multi-Touch

Mouse



Turn-to-Base
Command



Handover Button



One Hand
Distance
Measuring



Two Hands
Distance
Measuring



RESEARCH PROTOTYPES



RESEARCH PROTOTYPES

Methods

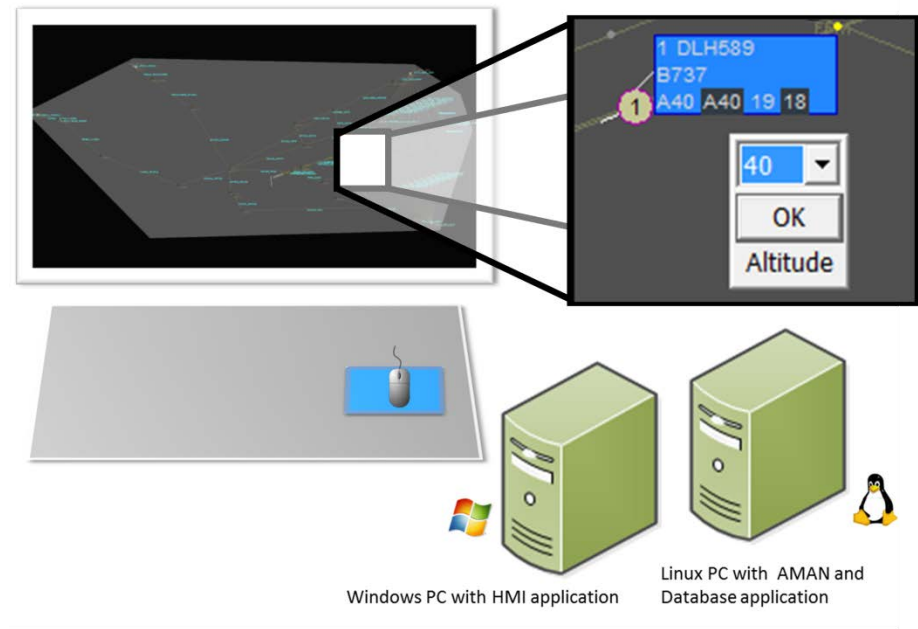
Results

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Same selection of commands and functions, interaction by:

- left click,
- right click,
- mouse wheel,
- menus



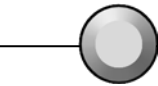
METHODS

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Experimental Setup



Scenarios &
Simulation Runs



Metrics



Execution

Display for

- traffic situation overview
- AMAN sequence/runway allocation advisory

Multi-touch interaction device for

- section of traffic situation
- AMAN sequence/runway allocation advisory

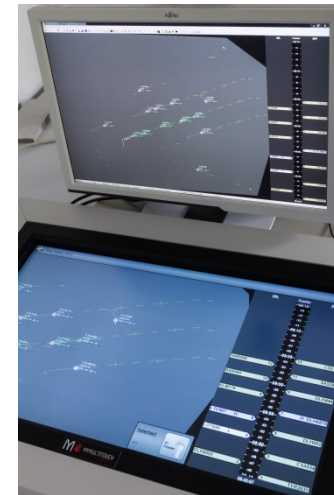
Working position is standing upright

Display for

- traffic situation overview
- AMAN sequence/runway allocation advisory

Mouse interaction device

Working position is seated



Multi-touch
CWP



Mouse
CWP



METHODS

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Experimental
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Scenarios & Simulation Runs



Metrics



Execution

Simulation of Frankfurt Approach:

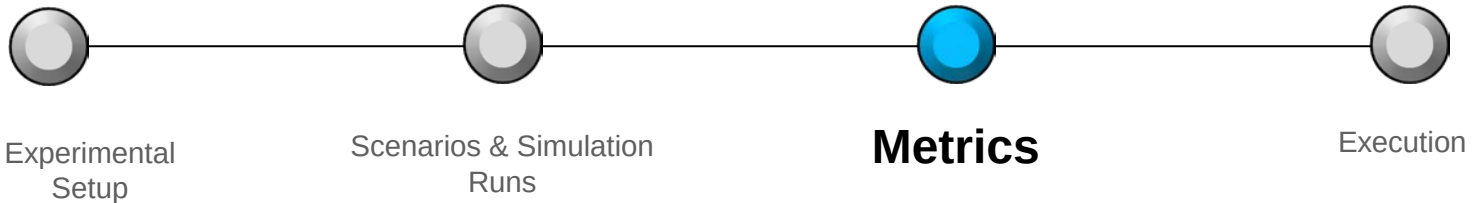
- Airspace structure 2010, 2 parallel dependent runways
- Realistic traffic with medium task load
- Data link communication assumed
- Simulated ideal pilots reacting without delay
- Same scenario for simulation runs with different input devices
- Controller task required:
 - Compact sequence on centerline
 - Compliance to separation rules
- Limitations:
 - Small amount of possible commands
 - No corrections in final phase by tower controller possible



METHODS

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Conclusion



Parameter	Determination
Workload	NASA-TLX
User Experience	User Experience Questionnaire
Usability	System Usability Scale, SUS General Usability Questionnaire Specific Usability Questionnaire for CWP Functions
Controller Performance	Overall indicator composed by: • Separation accuracy • Number of landings during trial • Separation violations



METHODS

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Metrics



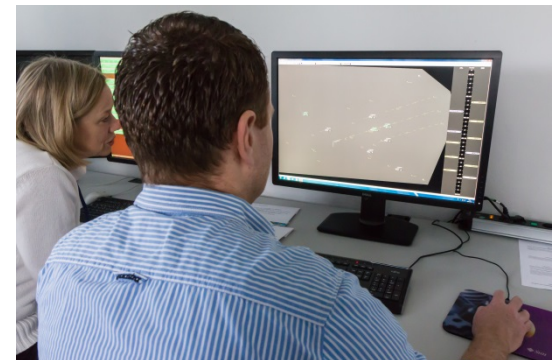
Execution

Investigation Setup:

- 7 days of trials
- Participants: 14 controllers from DFS,
- 7 TMA, 7 en-route controllers,
- 2 female, 12 male
- 2 participants on every day, one starting with multi-touch, the other with mouse to avoid sequence effects

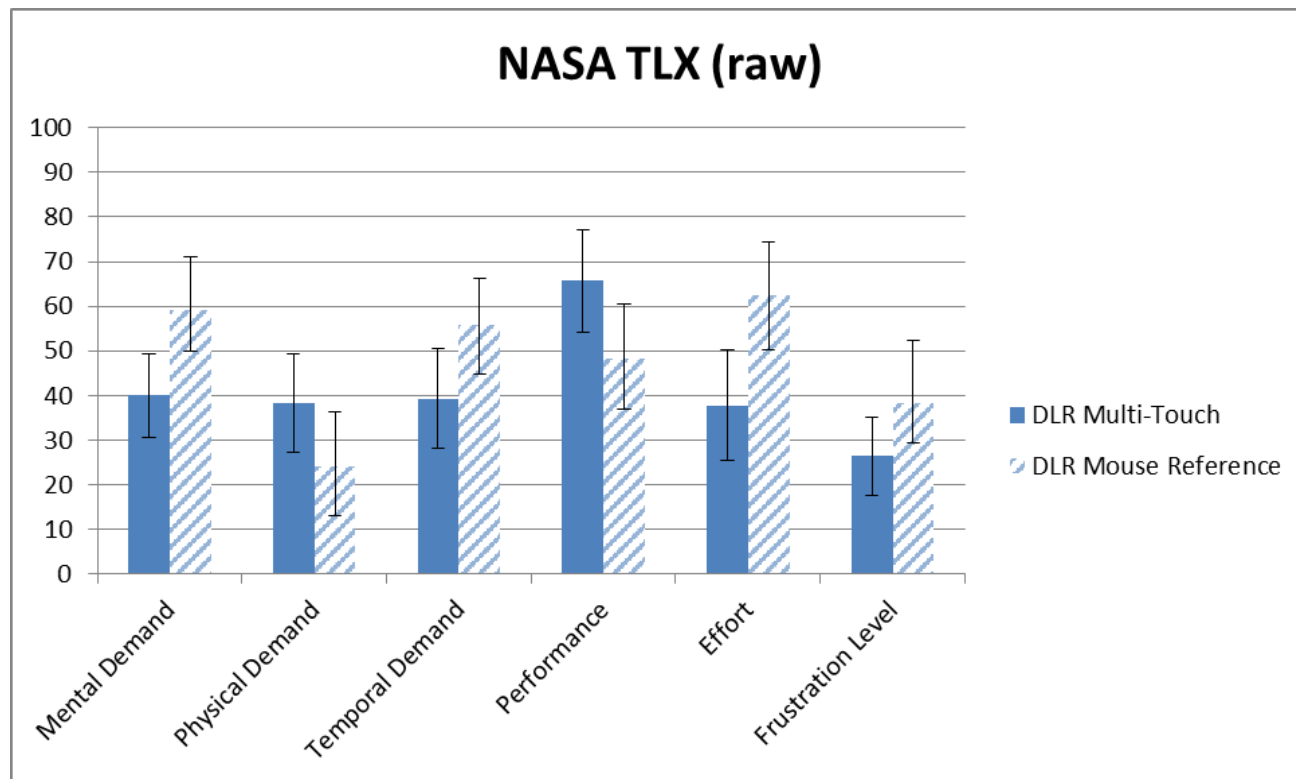
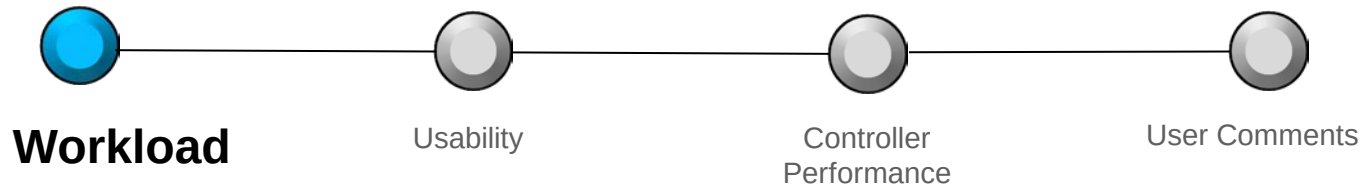
Time schedule test run for each device:

- 10 min. training session
- 25 min. trial session
- Debriefing



RESULTS

Conclusion

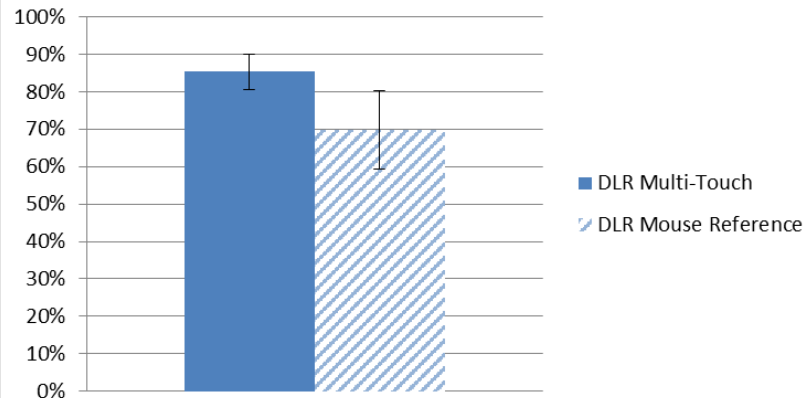


RESULTS

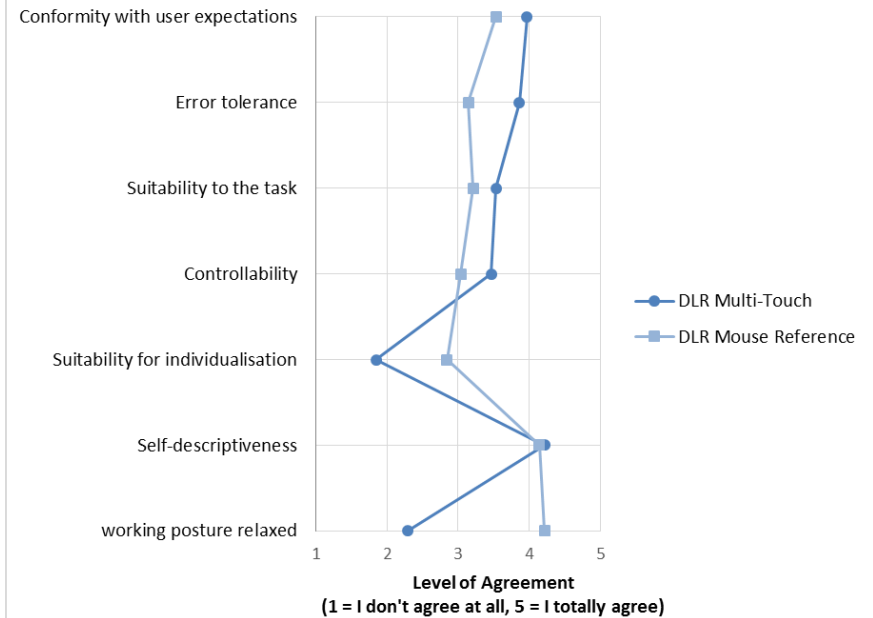
Conclusion



System Usability Scale

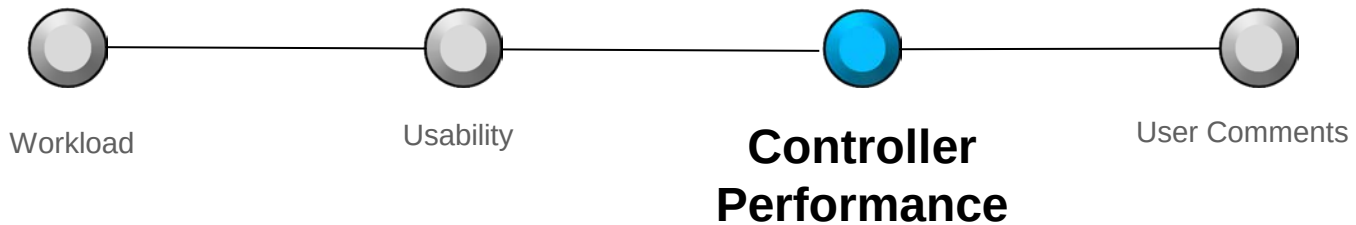


Usability Questionnaire

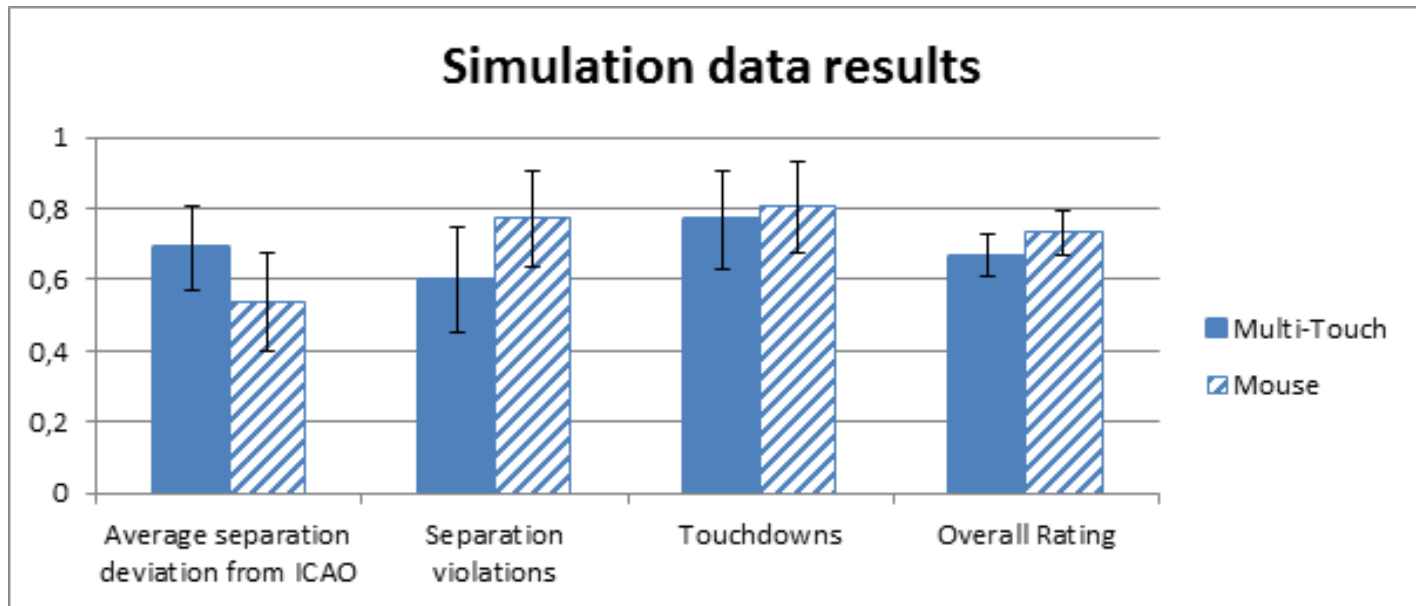


RESULTS

Conclusion

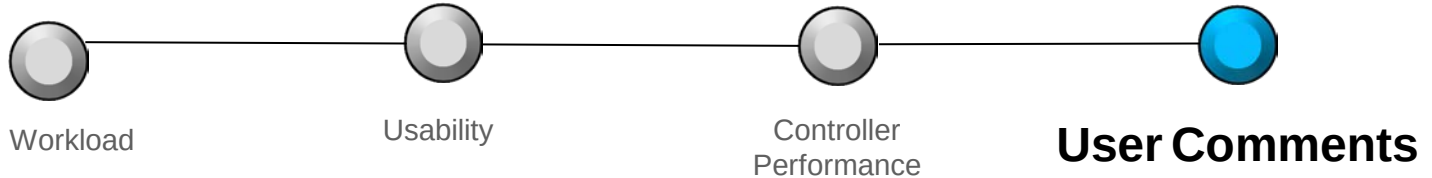


Simulation Data Conclusion for Controller Performance



RESULTS

Conclusion



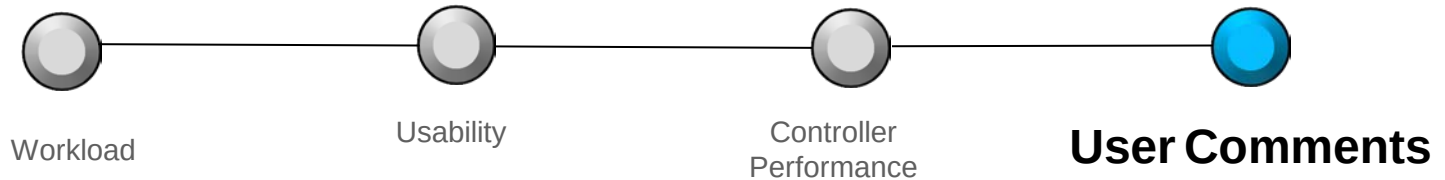
Cons:

- Touch accuracy is sometimes a problem when selecting moving objects
- Information on screen was sometimes covered by menus, too big icons, or by hands
- Some controllers did not like a two display concept
- Infra-red based multi-touch sometimes produced unwanted ghost touches
- Ergonomic problems, e.g. arms fatigue, could arise when working for a longer period of time



RESULTS

Conclusion



Pros:

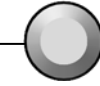
- Gestures are innovative and intuitive
- Analogies used for the implementation of commands are more easily understood and memorized
- The infrared technology allows comfortable and smooth input with the fingers
- The abortion of an action and restart of a new action was very fast
- Not many unintended actions occurred
- Direct touch philosophy is easy to apply
- Multi-touch is safer because of being easier to use



CONCLUSION



Hypotheses Assessment



Benefits



Outlook



Highlights

1. Mental workload will be lower

- Mental workload and effort rated lower in NASA-TLX



2. Physical workload will be higher

- Upright position leads to higher physical workload



3. General usability will be rated higher

- Investigated multi-touch implementation is well-accepted
- Rated as excellent because of intuitive and fast gestures
- Individualization is rated as poor



4. User experience will be rated higher

- No clear difference can be extracted



5. Controller performance will be higher

- Choice of interaction technology does not influence controller performance significantly



CONCLUSION



Multi-touch implementation in the experiment is found to be:

- no show-stopper due to safety issues
- imaginable at the working position
- error tolerant
- quick
- efficient
- hardly influencing performance of the controller, even at this early stage



CONCLUSION



Hypotheses Assessment



Benefits



Outlook



Highlights

Recommended extensions of the multi-touch operations:

- Implementation of complex commands (command chains)
- Design of intuitive gestures for complex commands
- Integration of MT device in ergonomically designed furniture
- Use of navigation gestures known from consumer devices for zooming and panning



CONCLUSION



Hypotheses Assessment



Benefits



Outlook



Highlights

- **First study** investigating a gesture language for CWP functionality
- Developed **innovative and intuitive gesture interaction concept** for approach control
- **Usability** of multi-touch **rated significantly higher** than mouse
- Controllers' feedback:
Multi-touch interaction technology ready for use at daily work



Thank you for your attention

Contact:

Maria Uebbing-Rumke
DLR, Institute of Flight Guidance
Lilienthalplatz 7
D-38108 Braunschweig
phone: +49 531 295-2798
email: maria.uebbing@dlr.de

