



TriControl

A Multimodal Air Traffic Controller Working Position

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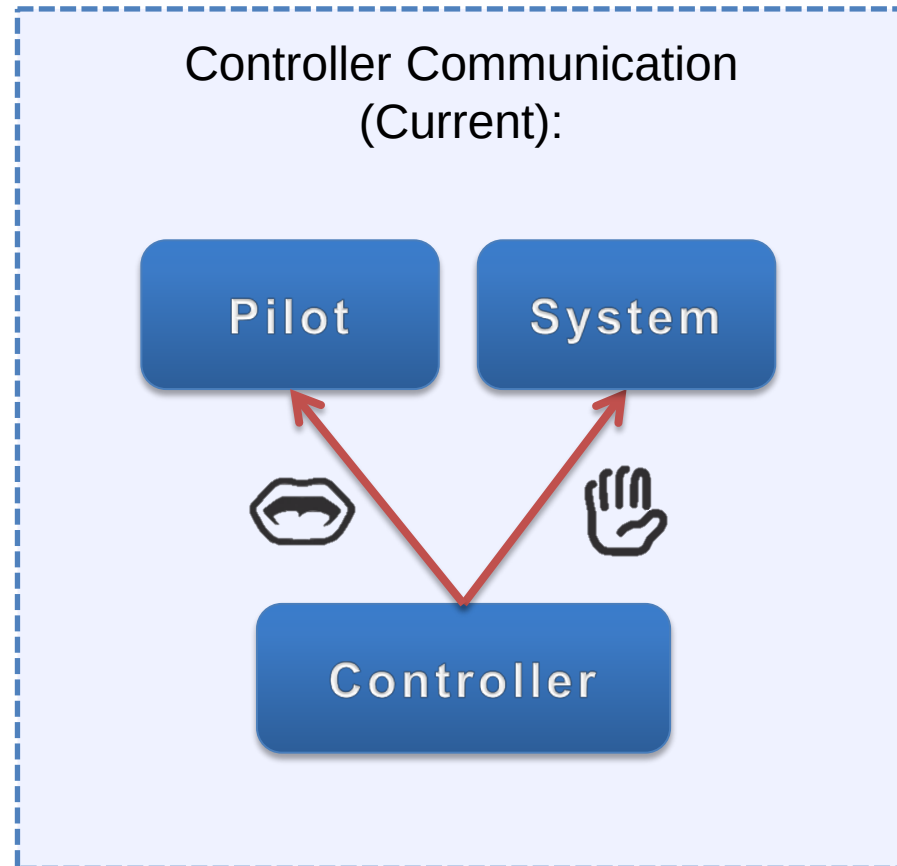


Knowledge for Tomorrow

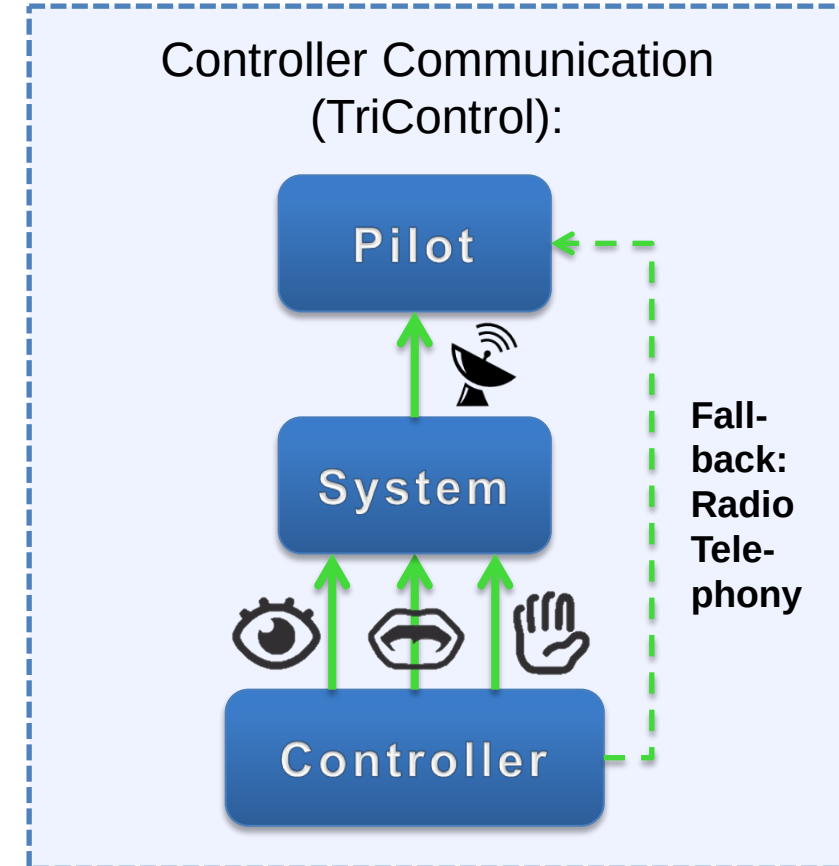




Motivation and Concept



- Potential communication bottleneck
- Suitability of current modalities?



- Principles of inter-human communication
- Goal: **quicker** and more **intuitive interaction**



Previous Work

- Today many different interaction modalities available in various domains
- Investigations (see references in paper)
 - Technology screening (SESAR 10.10.02)
 - Multi-touch (SESAR 10.10.02)
 - Eye tracking (internal)
 - Speech recognition (AcListant® project)
- Development of unimodal prototypes and performance assessment (internal)
 - Mouse
 - Multi-touch
 - Speech recognition





Previous Work – Eye Tracking



Image © Tobii.com; Source:
http://www.tobii.com/imagevault/publishedmedia/oitl02c419sxix444pr3/TobiiTech_EyeX_for_Press_1500x1000_300dpi_08.jpg

- ATC usage possibilities
 - Mental workload and fatigue assessment
 - Input device
 - **Hands-free** interaction (manipulation of radar labels or electronic flight strips)
 - **Fast and natural** (e.g. compared to mouse)
 - Efficient pointing device
- Development of research prototype
 - Eye tracking device (Tobii)
 - Evaluated as suitable for callsign selection





Previous Work – Speech Recognition

- Automatic speech recognition (ASR) of controller-pilot communication
- DLR Development of an Active Listening Assistant in cooperation with Saarland University
- With context knowledge → **Command error rate < 2%**
- Reducing controller workload by automating flight strip management
 - **Flight strips are integrated** into radar labels
 - Controller commands are **automatically inserted**
 - Time reduction for radar label maintenance **by a factor of 3**

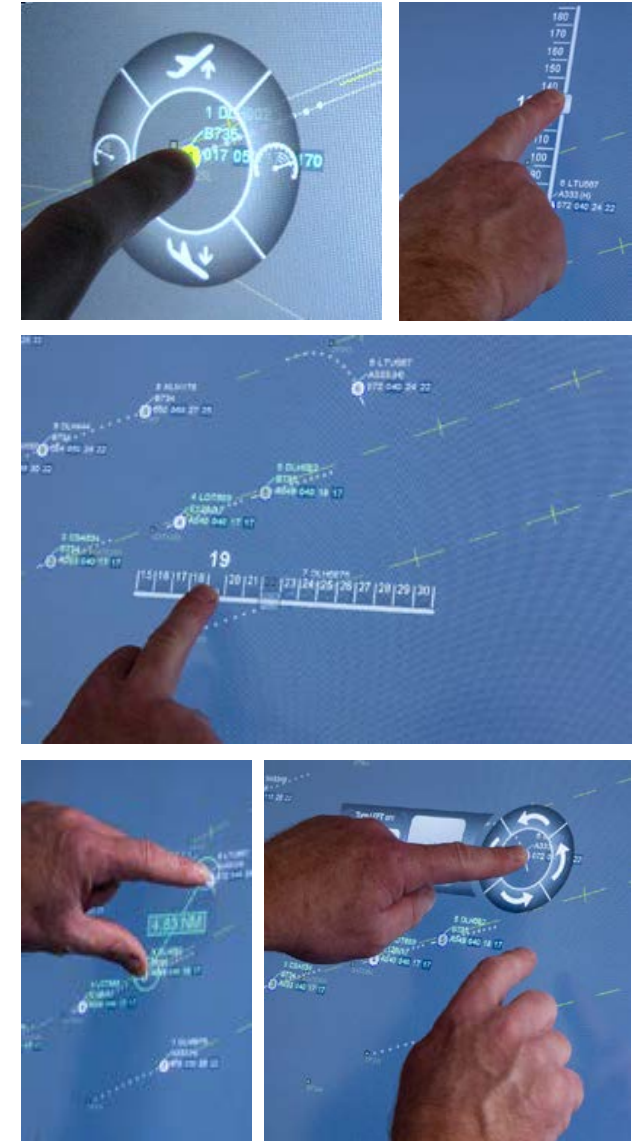
AcListant[®]





Previous Work – Multi-Touch

- Unimodal prototype development in SESAR 10.10.02 (DLR, DFS)
- **Investigation of usability**
- Direct multi-touch manipulation of aircraft on radar screen
- Gestures
 - Altitude (vertical)
 - Speed (horizontal)
 - Headings (rotational)
 - Distance measuring (two fingers)
- Evaluation with 14 air traffic controllers:
 - **Fast and efficient**
 - **Conceivable at CWP**s
 - Error tolerant
 - Not a show-stopper due to safety issues

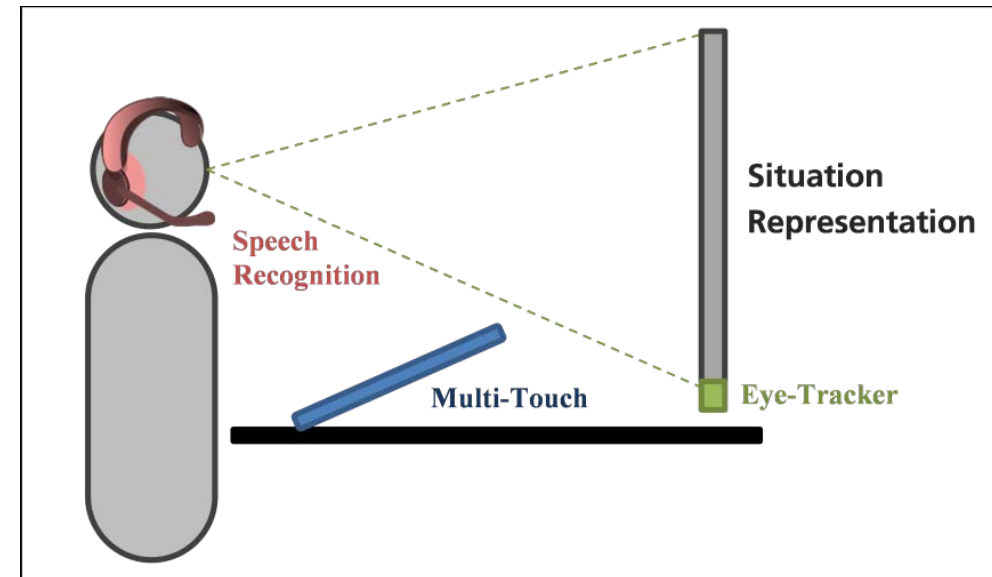




TriControl – Idea

	Aircraft DLH001	Type DESCEND	Value FL 70
	good	poor	poor
	medium	good	medium
	medium	medium	good

- Aircraft identifier selected by eye gaze
- Command type selected via multi-touch gestures

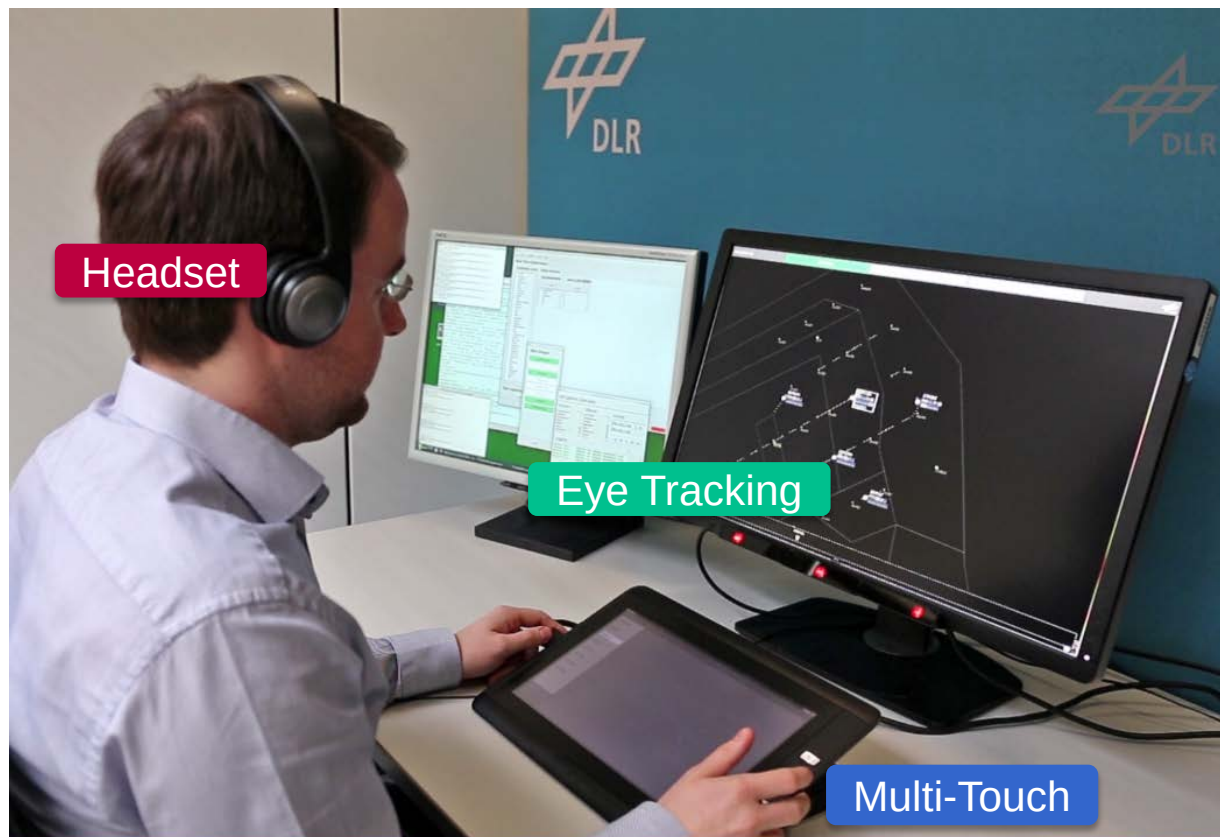


- Command value is spoken
- Insertion of elements consecutively or simultaneously





TriControl – Set-up



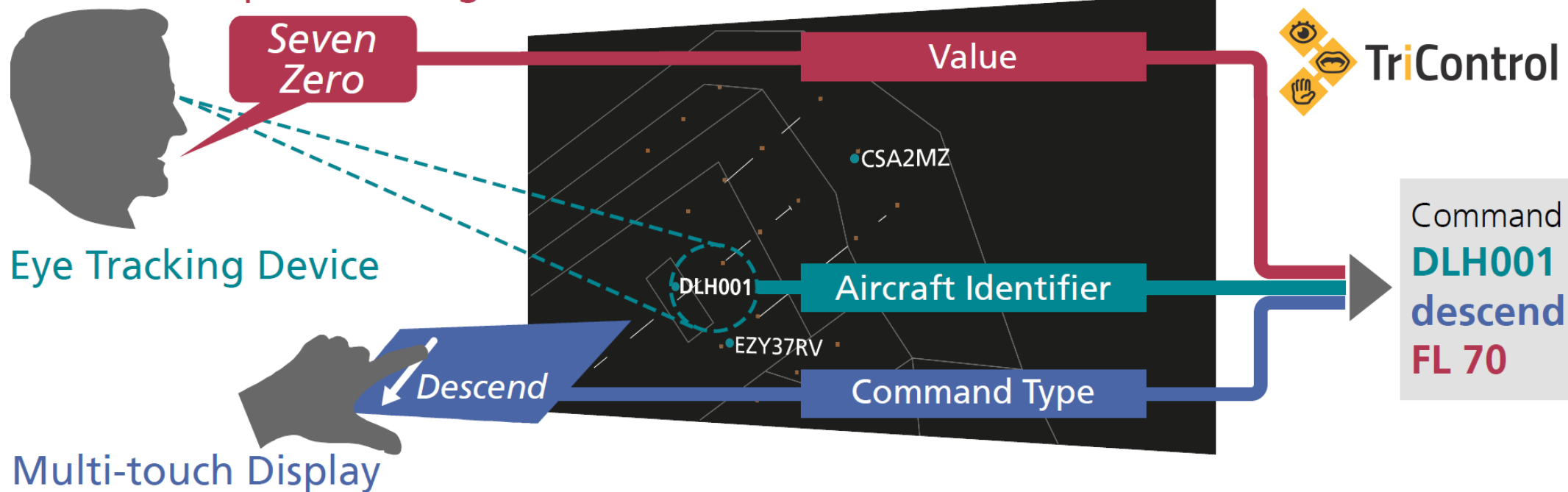
- Standard display for radar and flight strip information
- Headset with “push-to-talk” via foot switch
- Contactless eye-tracking device
- Multi-touch device for gesture input
- No “head-down” time required





TriControl – Workflow

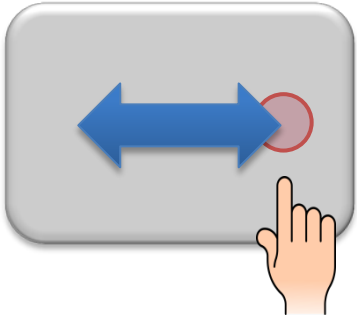
Automatic Speech Recognition



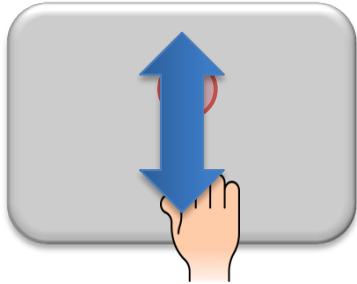


TriControl – Gestures

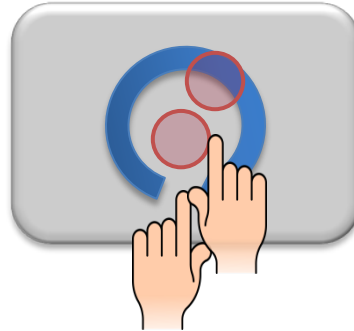
Speed



Altitude

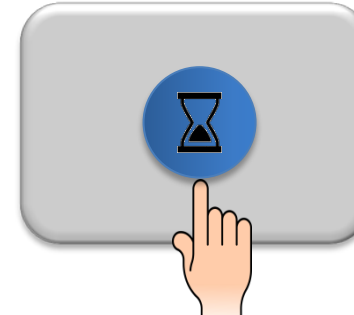


Heading

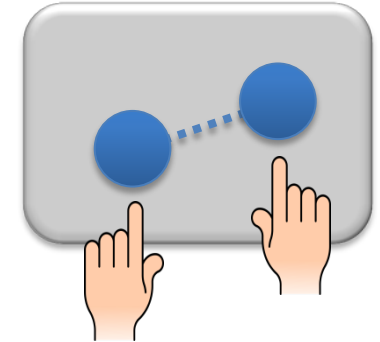


Direct

(+ Cleared ILS, Handover)



Distance Measure



- Operated intuitively and blindly

- Additional gestures for zooming, panning





TriControl – „RadarVision“ Flight Strip Integration

- Five grey cells in label
 - Command types

DLR001 (H)			
FL	Altitude	KT	Speed
Heading / Waypoint	Rate of Descent	Miscellaneous	

- Empty Commands

DLR001 (H)			
F121	---	29	--
-----	-----	-----	





TriControl – „RadarVision“ Flight Strip Integration

- Cancel command with single touch → white old value
- Newly inserted commands → yellow value
- Correction always possible → insert new command
- Acknowledge command with single touch → white new value

DLR001 (H)			
F121	80	29	22
LMA	↓500	ILS	

Command



DLR001 (H)			
F121	70	29	20
LMA	↓500	ILS	

Correction



DLR001 (H)			
F121	70	29	18
LMA	↓500	ILS	

Acknowledge



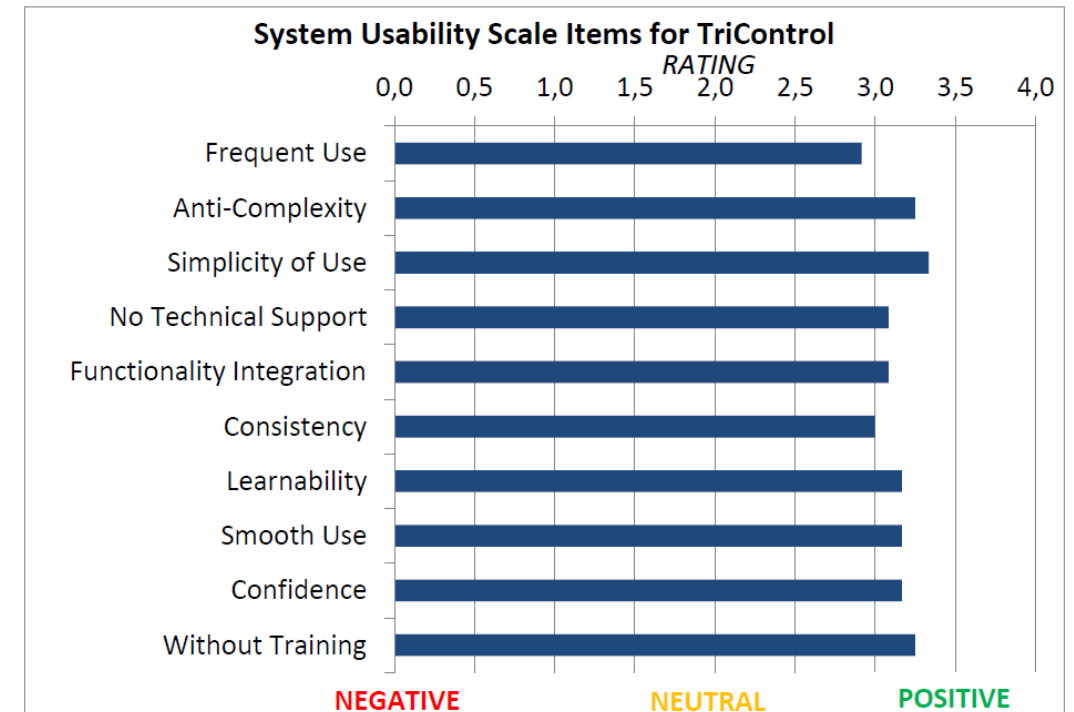
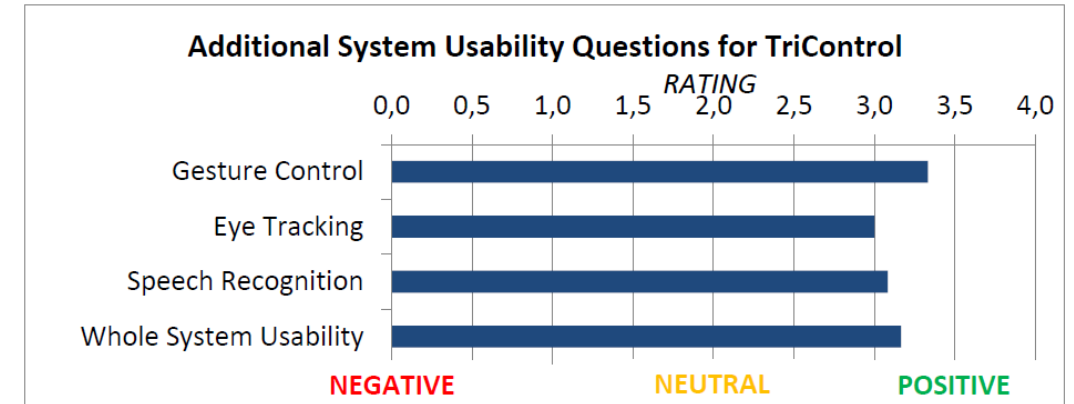
DLR001 (H)			
F121	70	29	18
LMA	↓500	ILS	





Preliminary Evaluation

- Structured feedback (12 people, many ATCOs) at World ATM Congress 2016
- System Usability Scale questionnaire (SUS)
- Average SUS score: 79 → Good usability of whole multimodal CWP
- “Frequent Use” only rated 2.9 → Eye tracking issues (glasses, contact lenses)?
- Simplicity rated best (3.3) → Clarity and intuitiveness of multimodal concept
- All other item ratings between 3.0 and 3.3 → Good usability of different aspects

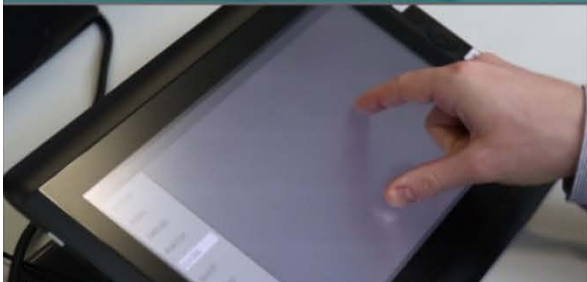




Demonstration



Eye-Tracking



Multi-Touch



Speech Recognition

BER8411

HEADING

200



BER8411
A41 40 20 19
200 -----
180 F100

DLR

BER113G
A16 17 18
H3OV

CSA2MZ
A41 20 19
H3OV

EZY3RV
A40 40 20 19
260 ILS

BER167
A50 50 20 19
260 ILS

DL420, DL421, DL429, DL430, DL428, DL426, DL454, DL409, DL408, DL407, DL406, DL404, DL403, DL482, DL410, DLH6V, F75 50, DL410

4.4 BER113G 8.1 CSA2MZ 6.4 EZY3RV





Conclusion and Future Work

- **TriControl**: first multimodal air traffic CWP prototype with potential benefits:
 - Natural, intuitive, and efficient interaction to reduce mental workload
 - Speed gain through three parallel modalities (comparing conventional systems)
- **Other combinations** of interaction modalities / other devices (to be compared)

	Aircraft	Type	Value
	✓	?	?
	✓	✓	✓
	✓	✓	✓



- User should choose **individually preferred modality**
- Implement contextual correction, automatically correct implausible commands
- Studies on operational feasibility, suitability, user acceptance, usability, operational improvements, capacity, and safety





TriControl

Thank you for your attention!

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