

Use of eye-tracking for air traffic controllers

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- > Cooperation between:
 - Institute of Ergonomics, Technical University Darmstadt
 - Institute with 40 members
 - from all backgrounds (engineering, medicine, psychology) and countries
 - Analysis of the interaction of machines and humans
 - Deutsche Flugsicherung Langen (DFS)
 - German Air Traffic Control Center, 5.200 staff members
 - Training and employment of all air traffic controllers
 - Langen: Europe's largest radar control centre

- > Air traffic management in Germany
 - Current situations
 - New work systems (ECPC and MSP)

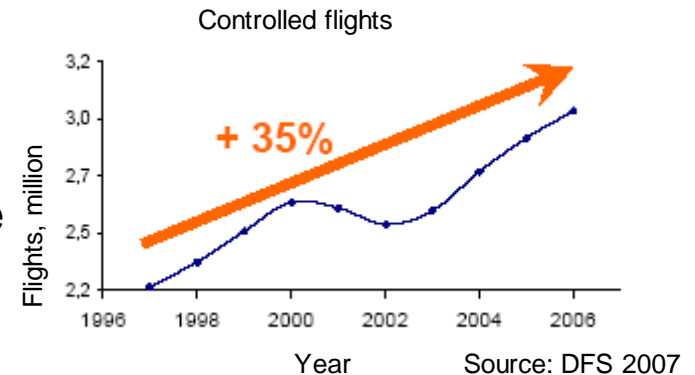
- > Eye-tracking as a new method
 - Visual attention
 - Technical system
 - Interpretation of the data
 - Advantages and disadvantages

- > Results of a study
 - Test design and hypothesis
 - Exemplary results

- > Conclusion

> Deutsche Flugsicherung (DFS)

- Air traffic control for Germany
- German air space as the busiest worldwide
- 9000 flights controlled per day



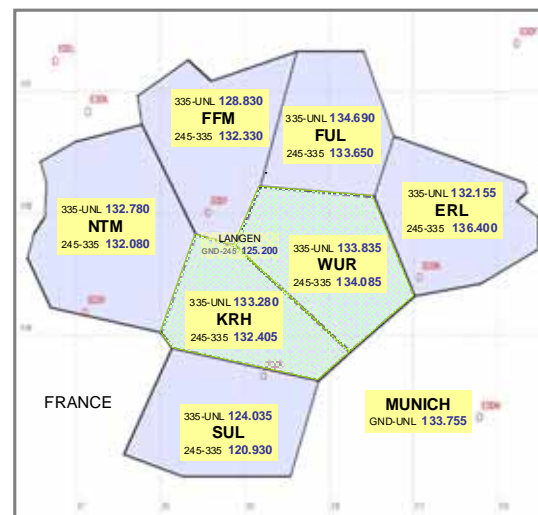
> Challenges in air traffic control

- Rise of 35% in the last 10 years
- Continued rise of air traffic control is predicted [Eurocontrol, 1999]

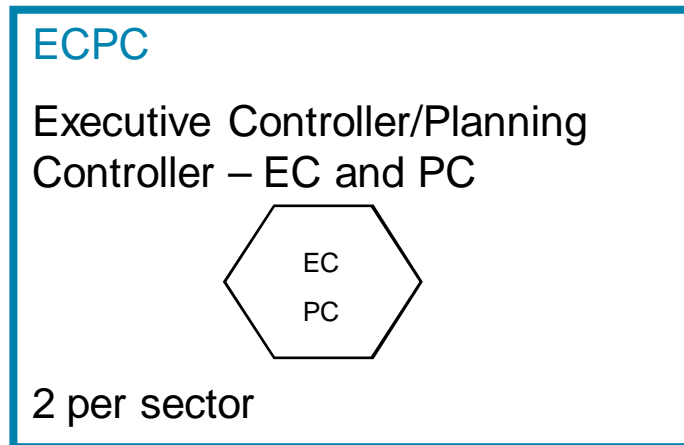
> Consequences

- New concepts for the future organization of the work system of air traffic control are necessary
- Apart from new softwares especially new work systems with new compositions of controllers are discussed

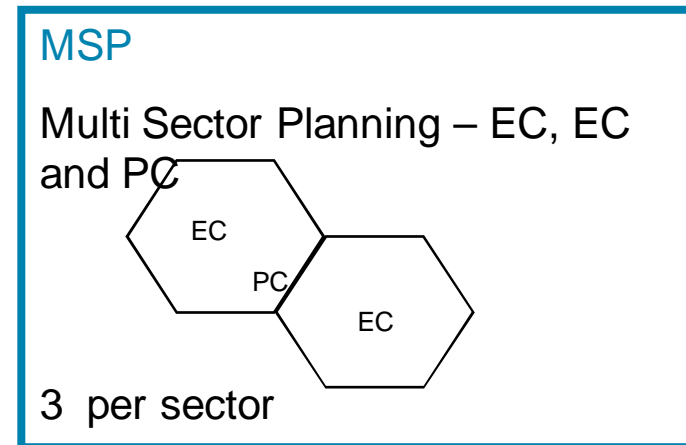
- > Horizontally and vertically distinguished airspaces → sectors
- > Roles with different duties
 - **Executive Controller (EC)**: control of the own sector, main task is the communication with the pilot
 - **Planning Controller (PC)**: Monitoring of the future traffic (coming from other sectors), to avoid conflicts, which will occur in the sector



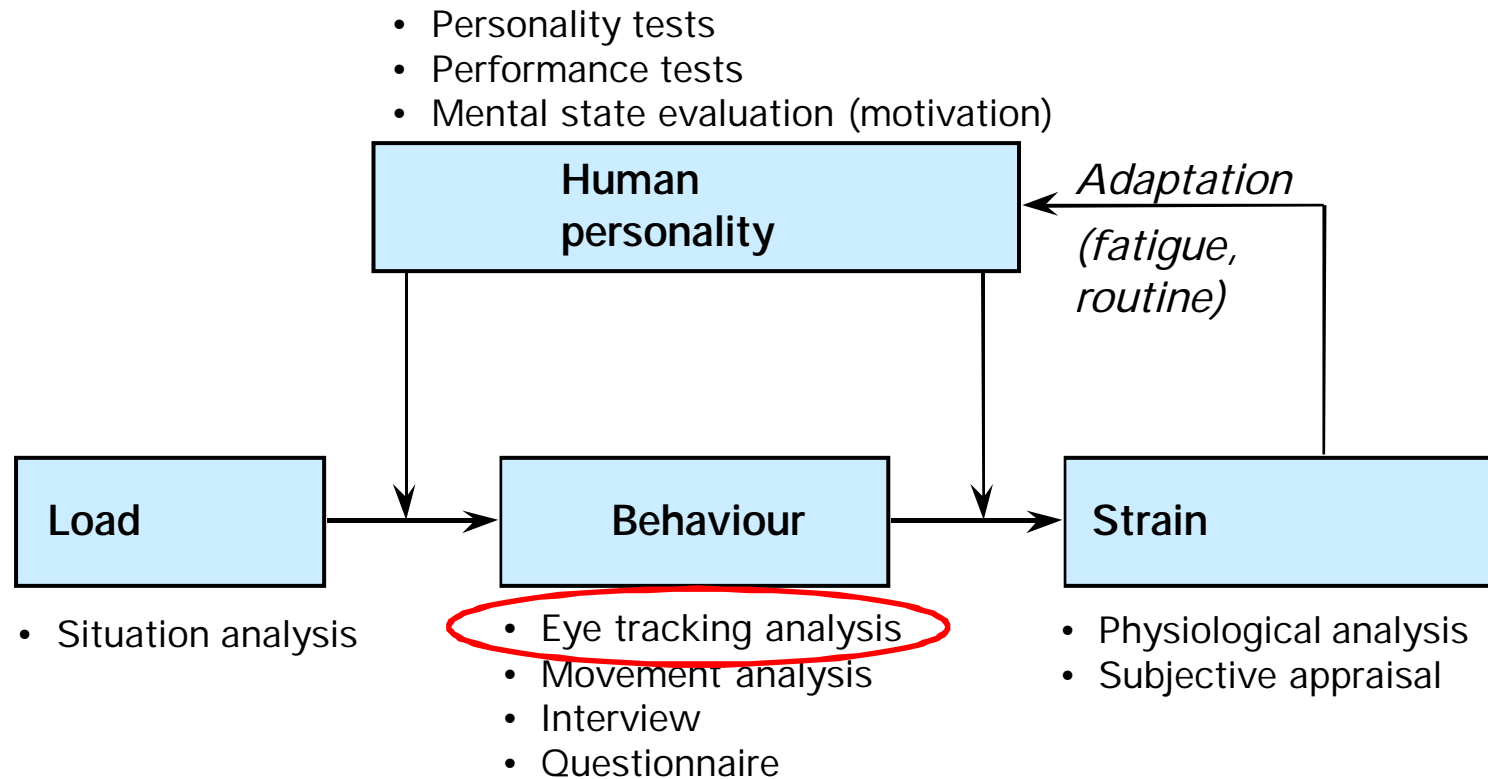
Conventional work system



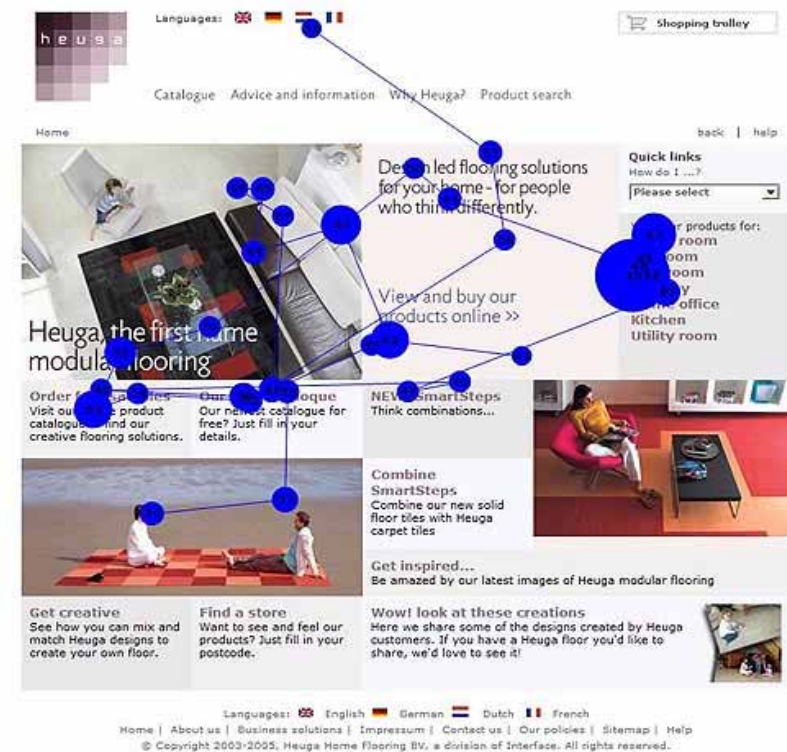
New work system



- > Which impact has the new work system MSP on the air traffic controllers?
- > Which changes will occur in their information processing ?
- > Which changes occur with a higher traffic load?

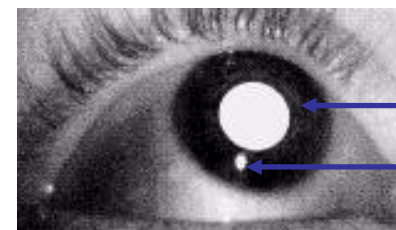


- > Application
 - Reading behavior, advertising psychology
- > Aim
 - To relate to the visible eye-movement internal, subjective operations
 - Analysis of the design
 - Analysis of search processes
 - Explication, measurement and forecast of the length of information reception and information processing



- > Functionality:
 - Projection of a infrared-light beam
 - Reflection on the Cornea (Corneal Reflection).
 - Distance between Cornea Reflex and the centre of the Pupil is calculated

- > Calibration: Fixation of 5 or 9 points with known location

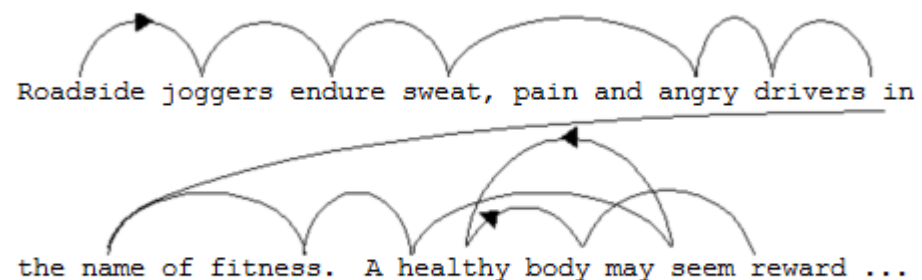


Pupile

Corneal reflection

- > **Fixation:** Points of Fixation on an „Area of Interest“ (always slight tremor). Position (x- and y-value in coordinate plane) and duration can be measured
- > **Saccade:** Jump from one fixation to another. Very quick eye-movement, during which no optical information can be processed
- > Eye-movements are a sequence of fixations and saccades, during fixations information is transmitted to the brain which is processed (also during saccades)

Some numbers (during reading):
Fixation: 200-250 ms
Saccade: 20-35 ms
10-15% backwards



- > Consciousness of something
 - Is an object being registered?

- > Points of fixation
 - Which objects are fixated?
- > Duration of fixation
 - How long is somebody looking at an object?
- > Frequency of fixation
 - How often is an object looked at?
- > Order of fixation
 - In which order do people look at the different objects?

- > Frequency of saccades
 - How many saccades are necessary for the completion of the task?

- > Recording without interruption of the occupation
- > Social desirability and test supervisor effects are minimal
- > Inference to unconscious and very quick processes
- > Possibility to gain objective (independent of the test supervisor) "hard facts"
- > Not measurable if and what a subject really perceived
- > No certainty if the user didn't see something (no measurement of the peripheral field of vision)
- > Partially error-prone due to errors in measurement – relatively save for this work place

Suitability for the analysis of air traffic controllers:
Good practicability for the continued recording during the simulation

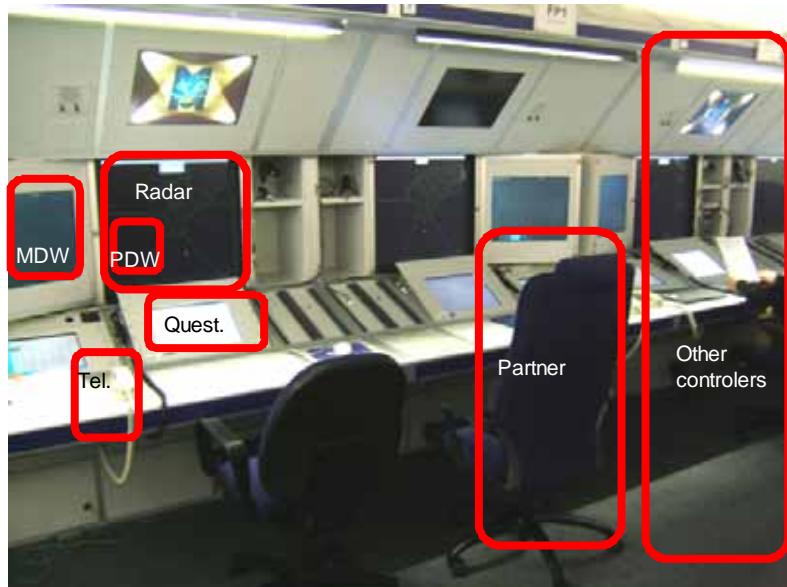
- > Participation of the IAD during 24 simulations runs at the Deutsche Flugsicherung (Langen, Germany)
- > Planning Controller
 - 8 from ECPC-constellation
 - 8 from MSP-constellation
- > Workload
 - 8 times scenarios with current workload
 - 8 times scenarios with future workload (+20%)



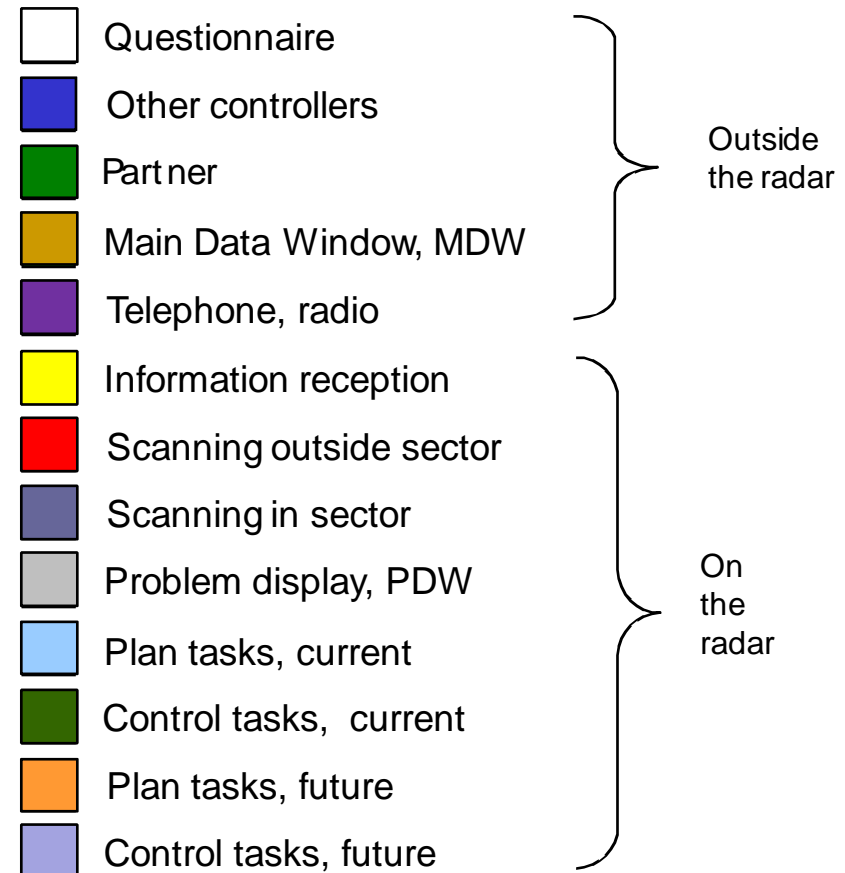
		Work system	
		 ECPC	 MSP
Traffic load	current	4	4
	future, (+ 20%)	4	4

Example: Video of eye-movements



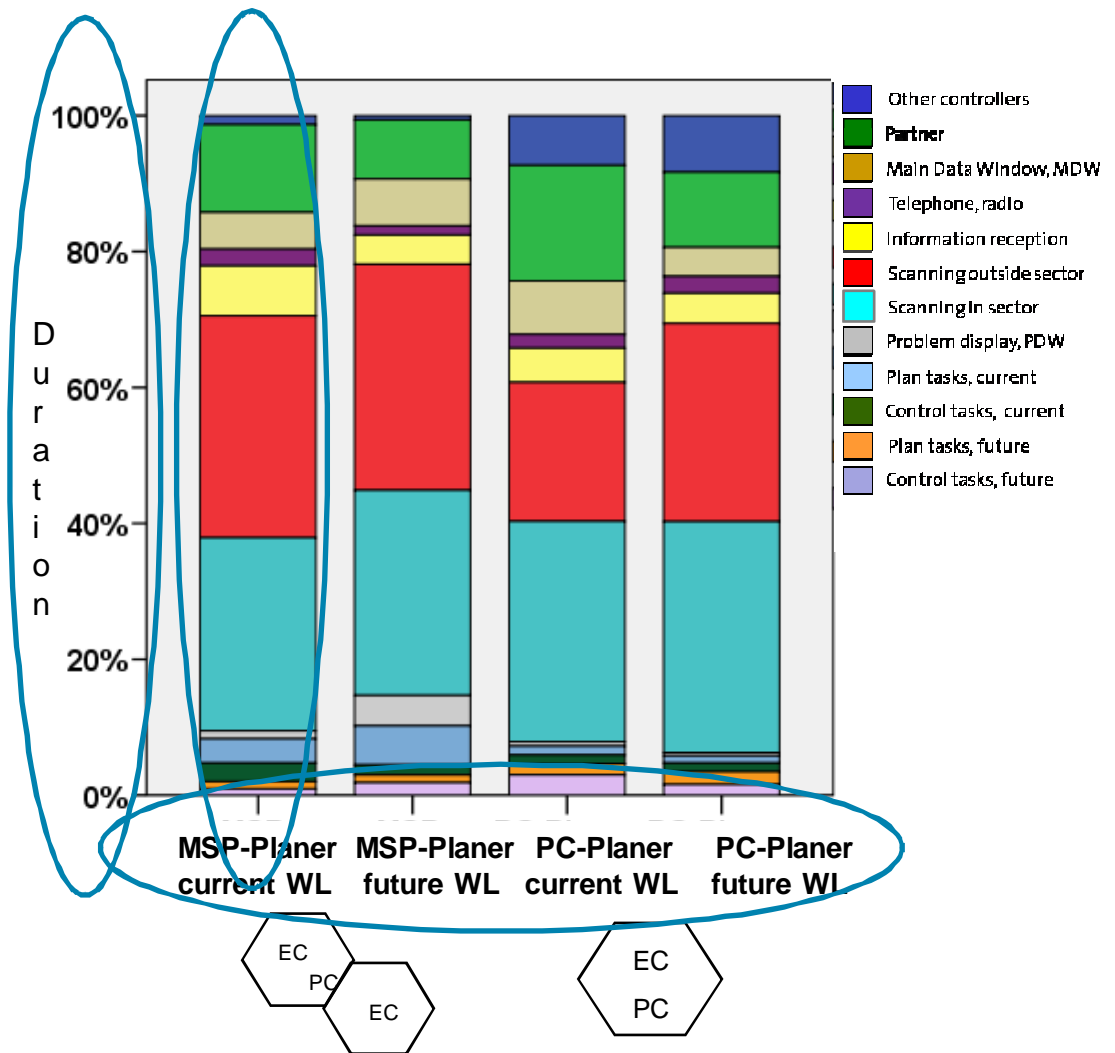


- > 13 different Areas of Interest (AOI)
 - Fixations outside of the radar
 - Fixations on the radar
 - Control relevant tasks: active intervention
 - Plan relevant tasks: Example: Distance in the future (MinSep)



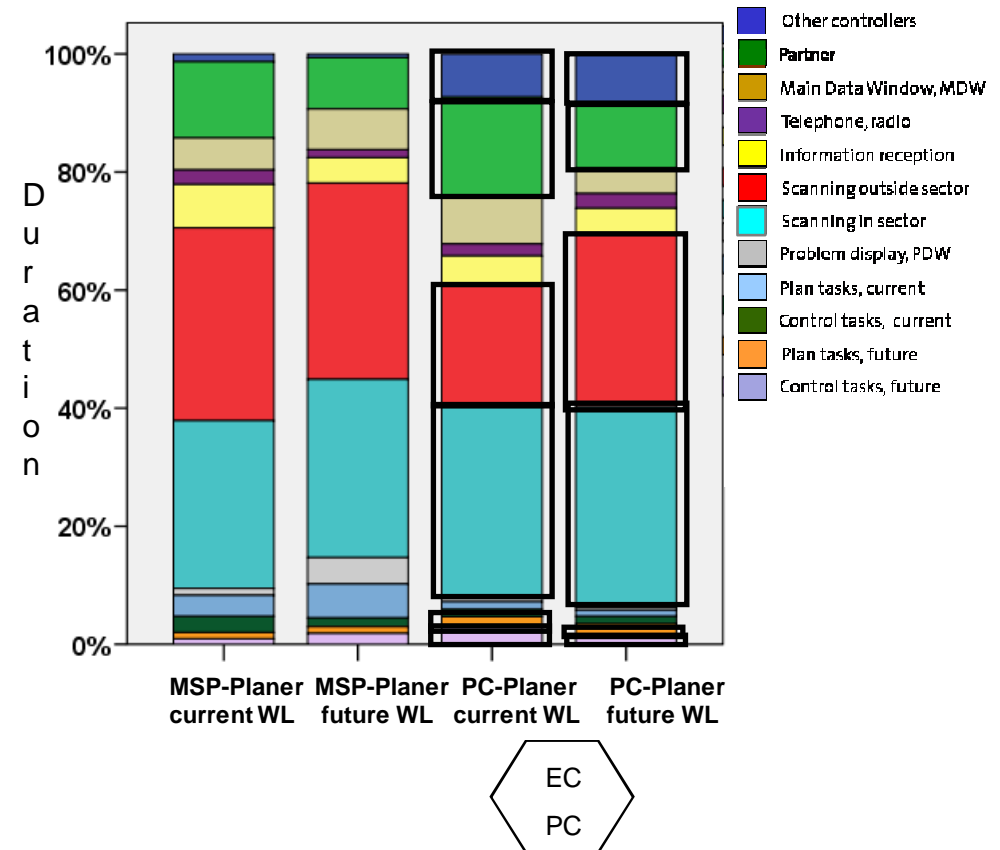
Example: Graphical Visualisation

- > **Y-Axis:** Duration of fixation on the different AOT, scaled to 100% (due to the different lengths of the simulation runs)
- > **X-Axis:** Work system (MSP and ECPC) & traffic work load WL (current and future)
- > **Bar:** Colours stand for the Areas of Interest (duration accumulated for all the traffic controllers for the constellation)



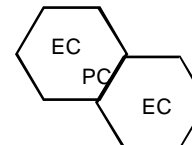
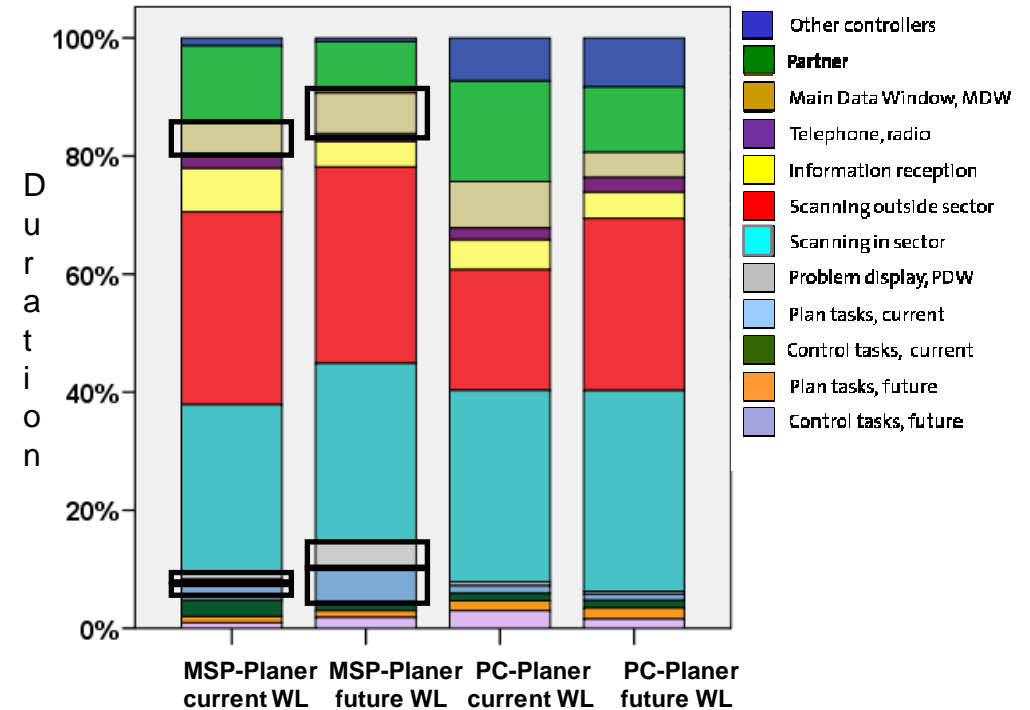
> ECPC-Planning Controller

- More contact
 - with other controllers
 - with the partner in the current work load situation
- Scanning:
 - Fewer scanning outside the sector, rising when more work load
 - More scanning in the sector
- More current planning und controlling tasks



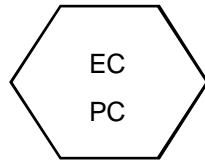
> MSP-Planning Controller

- MDW and PDW
 - Longer use of the two help tools „Problem Data Window“ (PDW, shows conflicts) and „Main Data Window“ (MDW, overview for all flights)
- More and longer planning tasks



ECPC

Executive Controller/Planning
Controller – EC and PC

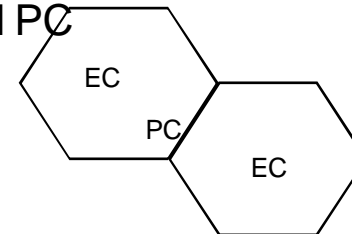


2 per sector

- > The ECPC-Planning Controller has more contact with other controllers, focuses fuer outside the sector, and takes over a lot of current tasks from the Executive Controller

MSP

Multi Sector Planning – EC, EC
und PC



3 per 2 sectors

- > The MSP-Planning Controller, guarding two sectors, focuses more on his main task and uses more the PDW and the MDW

- > Little insight into the air traffic control in Germany
 - Current Problems and developments
 - New work systems

- > Description of eye-tracking
 - Functionality
 - Advantages and disadvantages

- > Presentation of current study
 - Insight into information processing and the work of air traffic controllers which would never be possible without this method

Conclusion

Differences between the work teams get visible

Strong differences in use of systems and work behavior registered

Thank you for your attention!

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Run #	Position	APOS1	CWP1	CWP2	CWP3	CWP4	CWP5	CWP6	CWP7	CWP8	APOS2
	1A_VERT2_neu_ECPC	ADJ1	ZE1	ZP1	ZE2	ZP2	KE1	KP1	KE2	KP2	ADJ2
1	TR1_ECPC	09	03	04	01	02	08	07	06	05	10
2	TR2_ECPC	09	02	01	04	03	07	06	05	08	10
3	100A_ECPC	09	01	02	03	04	08	07	06	05	10
4	100B_ECPC	09	02	03	04	01	05	08	07	06	10
5	120A_ECPC	09	03	04	01	02	06	05	08	07	10
6	120B_ECPC	09	04	01	02	03	07	06	05	08	10
	1A_VERT2_neu_MSP		ADJ1	ZE1	MSPZZ	ZE2	KE1	MSPKK	KE2	ADJ2	
7	TR3_MSP		03	04	01	02	06	05	08	07	
8	TR4_MSP		02	01	04	03	05	08	07	06	
9	100A_MSP		03	04	01	02	06	05	08	07	
10	100B_MSP		04	01	02	03	07	06	05	08	
11	120A_MSP		01	02	03	04	08	07	06	05	
12	120B_MSP		02	03	04	01	05	08	07	06	
	1A_VERT2_neu_ECPC_DL	ADJ1	ZE1	ZP1	ZE2	ZP2	KE1	KP1	KE2	KP2	ADJ2
13	TR5_ECPC_DL	09	02	03	04	01	07	06	05	08	10
14	TR6_ECPC_DL	09	01	04	03	02	08	07	06	05	10
15	100A_ECPC_DL	09	04	01	02	03	07	06	05	08	10
16	100B_ECPC_DL	11	01	02	03	04	08	07	06	05	12
17	120A_ECPC_DL	11	02	03	04	01	05	08	07	06	12
18	120B_ECPC_DL	11	03	04	01	02	06	05	08	07	12
	1A_VERT2_neu_MSP_DL		ADJ1	ZE1	MSPZZ	ZE2	KE1	MSPKK	KE2	ADJ2	
19	TR7_MSP_DL		02	03	04	01	05	08	07	06	
20	TR8_MSP_DL		01	04	03	02	06	05	08	07	
21	100A_MSP_DL		04	01	02	03	07	06	05	08	
22	100B_MSP_DL		01	02	03	04	08	07	06	05	
23	120A_MSP_DL		02	03	04	01	05	08	07	06	
24	120B_MSP_DL		03	04	01	02	06	05	08	07	

> Floor-mounted (remote) eye-tracker

- + no helmet
- + easy coding
- not mobile
- low accuracy



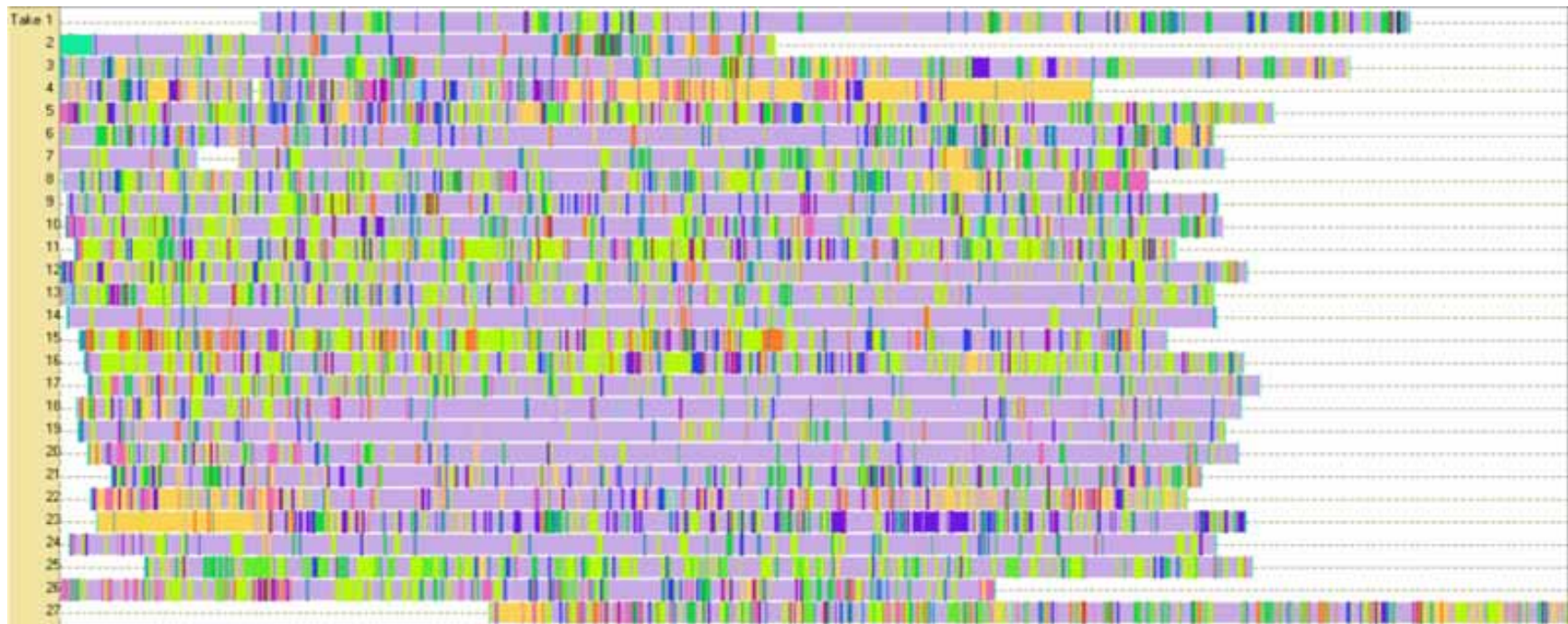
www.interactive-minds.de

> Head-mounted Eye-tracker

- + Mobile use
- + high accuracy
- No long term use possible



- > Coding minute by minute in „Interact“
- > Result is converted to Excel or SPSS (statistical analysis tool)



Interact-Table of coded videos