Steps Towards the Virtual Tower: Remote Airport Traffic Control Center (RAiCe)

N. Fürstenau, M. Schmidt, M. Rudolph,
C. Möhlenbrink, A. Papenfuß, S. Kaltenhäuser
German Aerospace Center (DLR), Inst. of Flight Guidance
Braunschweig

Overview

- Introduction
- Work Analysis & Scenarios
- Simulation
- Remote Tower Experimental System
- Field Testing
- Outlook and Conclusion

Future Tower Control

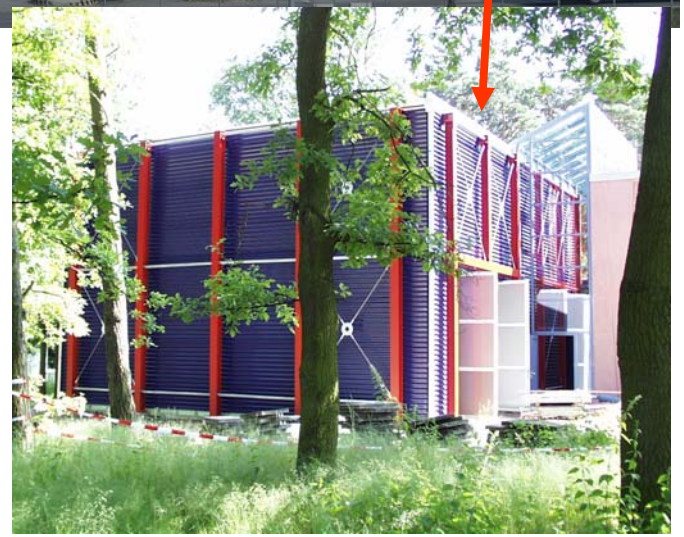
Reduce Cost of Airport Surface Movement Management

Improve Situation Awareness

Increase Safety

Reduce Weather Dependence

Photo: DFS



Solution: "Virtual Tower"
Sensor Based (Windowless) Control Center with **Video Reconstruction of Far View**

Concept Study *ViTo* (2002 – 2004)
Project *RapTOr* (2005 – 2007)
Project *RAiCe* (2008 – 2012)

German Airports

Motivation for RemoteTower Center (RTC) Research:

- meet request of low **cost carriers** by providing cost efficient controlled airspace to **small airports**
- **Capacity increase** of Hubs by Coordinated central control of **RWY Networks**

RAiCe Research Goal:

Methods & Technologies to provide centralized controlled Airspace for Several Airports from a Remote Tower Center (RTC)

Overview

- Introduction
- Work Analysis & Scenarios
- Simulation
- Remote Tower Experimental System
- Field Testing
- Outlook and Conclusion

The Role of Visual Surveillance: Present … Future?

Vision based Ground Traffic Control: **"Controllers most used Tool"** (25 – 70%)

Problems:

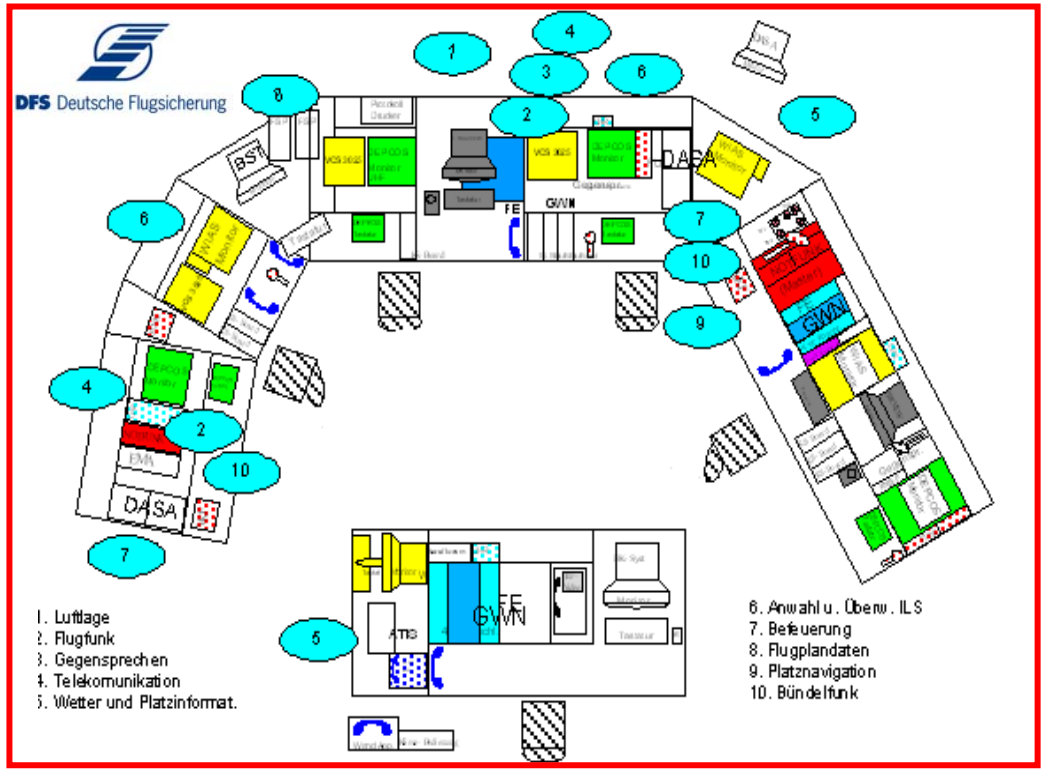
⇒High Cost of Conventional Tower Control

⇒Head Down Times increase with Computer Assistance & with Traffic Load

DFS Tower Layout

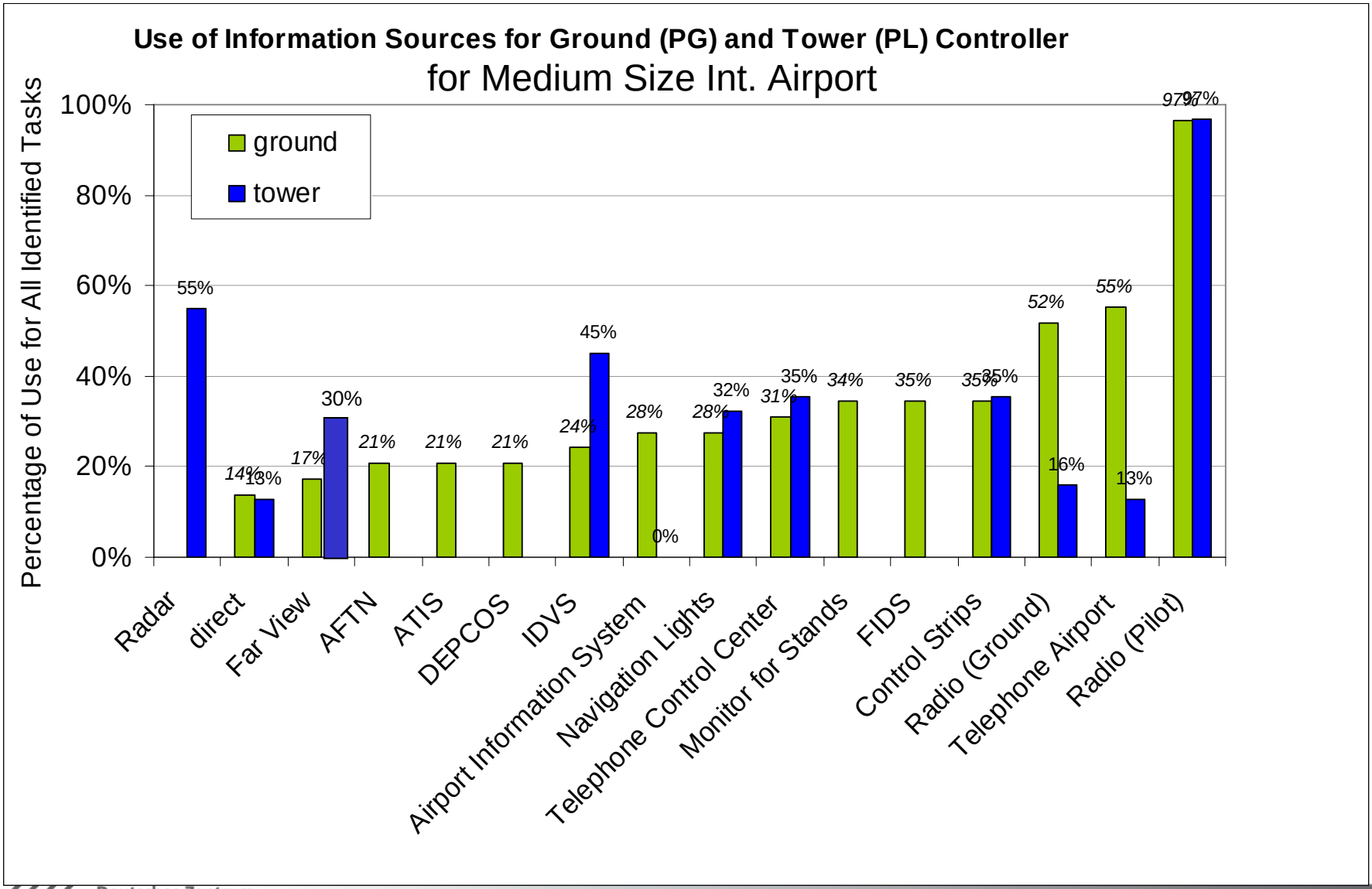
RTC – HMI Design Task:

- Integrate Controller's Information / Interaction Equipment into **High Resolution Video Panorama** HMI
- Reduce Head-Down Time by **Augmented TWR Vision**

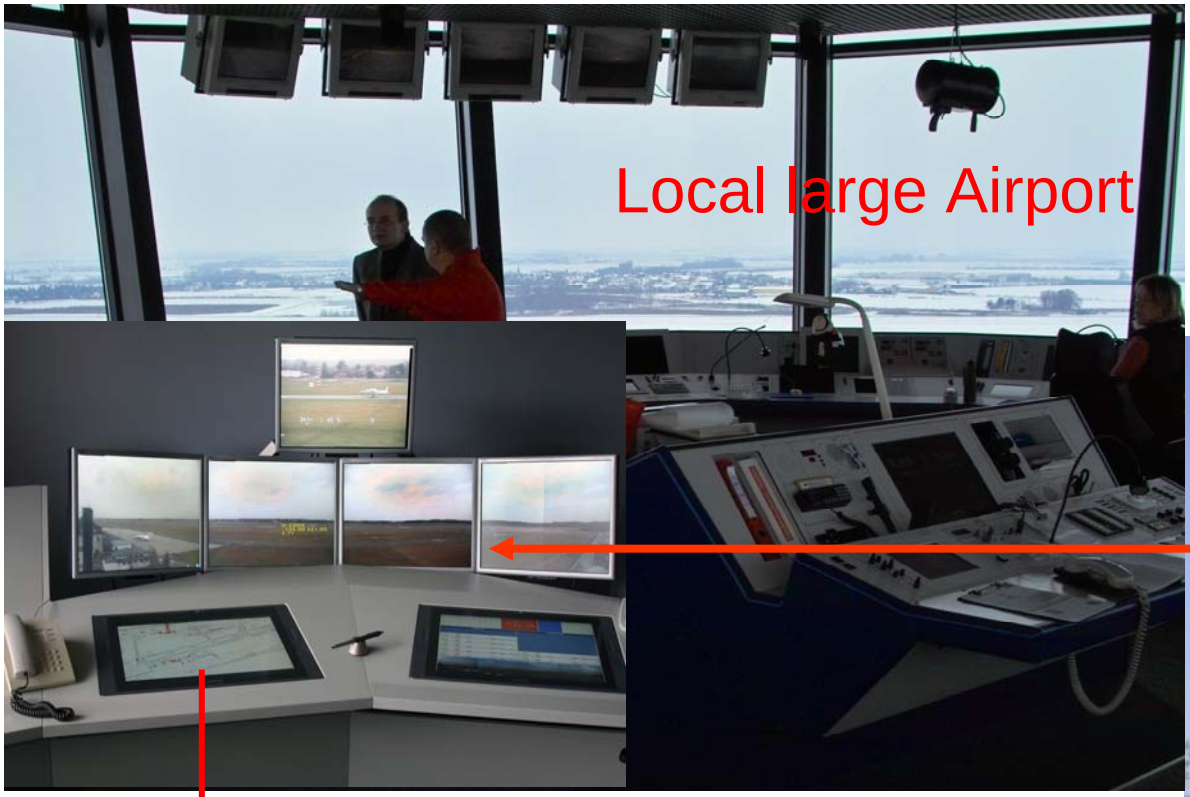


Work Analysis: rel. no. of Access to Information Sources for All Tasks

(Decision & Support Tasks (clearances, communications etc): 29 (PG), 31 (PL))



Scenario 1:
Remote Control of Small Airport from Local Tower



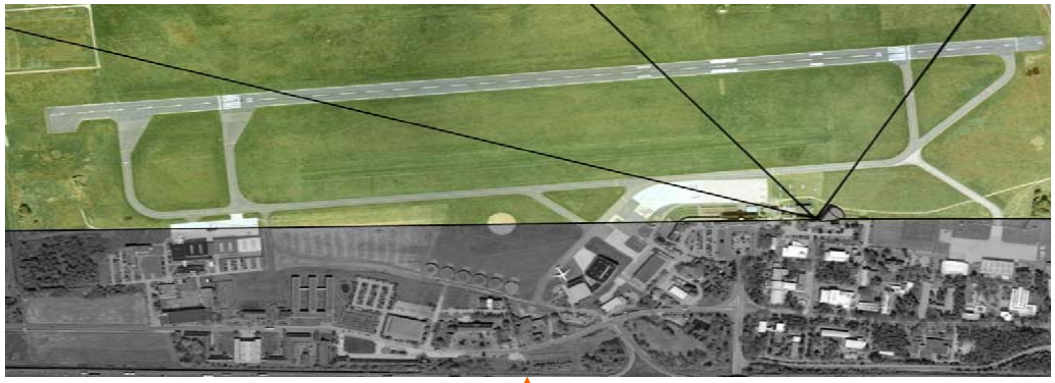
Remote small Airport :
Controlled Airspace

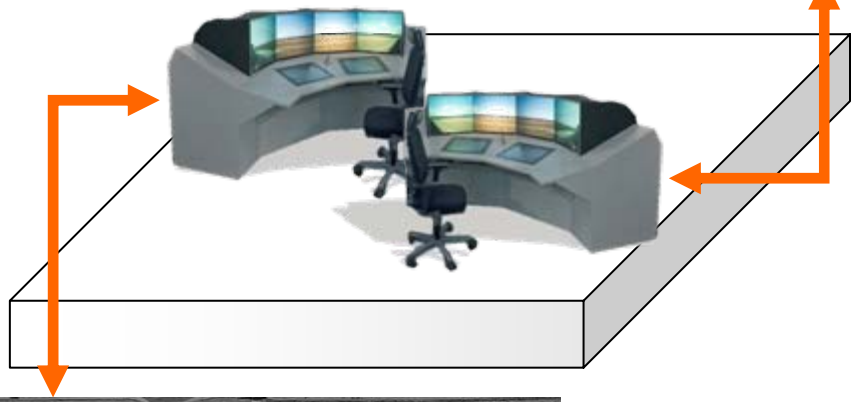
GBit/s
Datalink

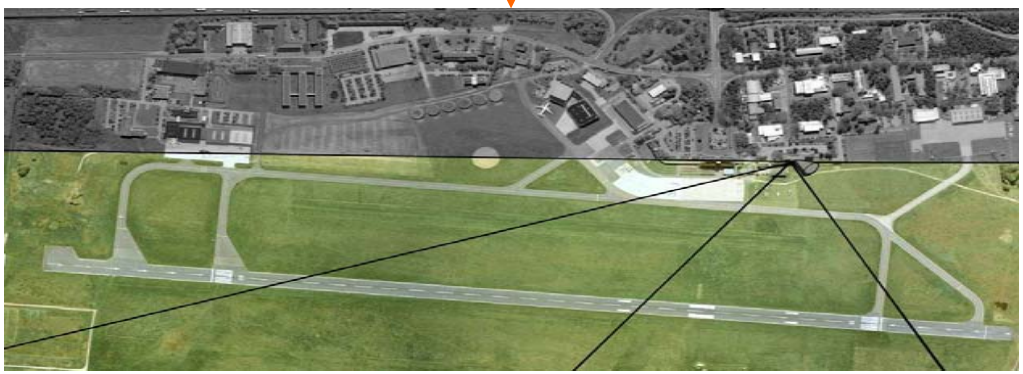
Design of RTO Controller Workplace
within local Airport TWR
or
Remote TWR Center for several small Airports

Szenario 2

RTC for Surveillance of several Small Airports

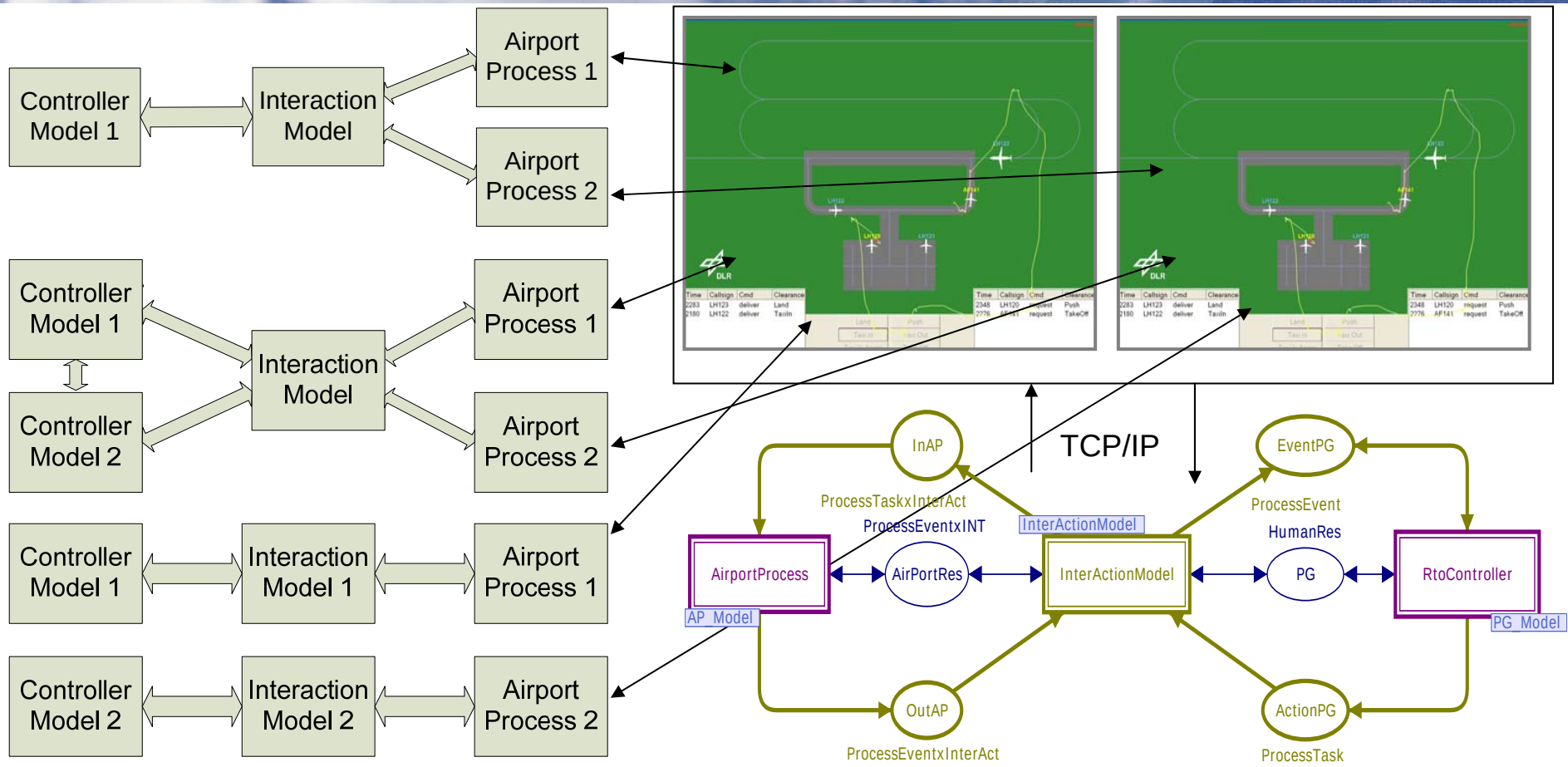






Overview

- Introduction
- Work Analysis
- RTC - Simulation
- RTO Experimental System
- Field Testing
- Outlook and Conclusion



A/P Traffic Model | Interaction Model | Human Model

Different Possibilities of RTC Work Organization

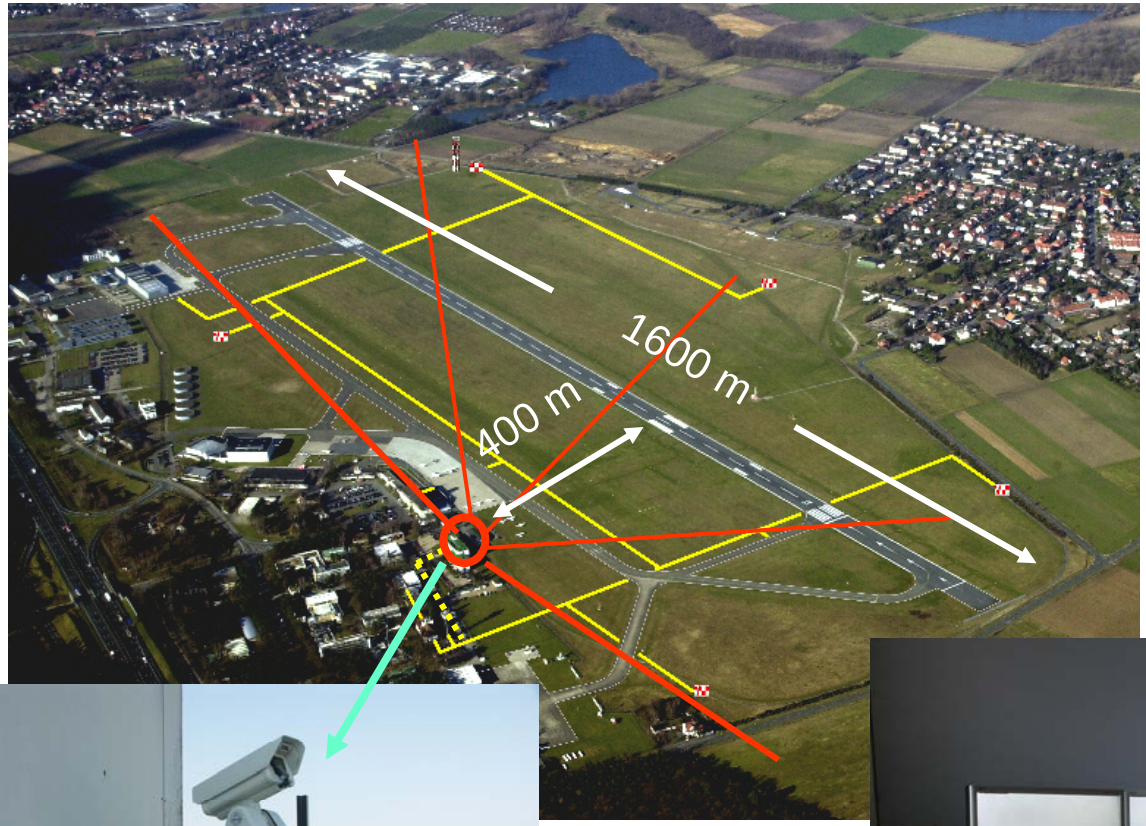
RTC Microworld Simulation with Colored Petri Nets

Airport Towersimulator with RTO-Console

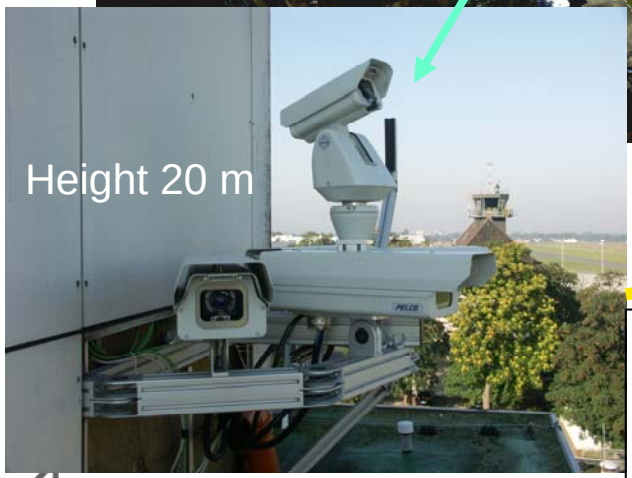
Overview

- Introduction
- Work Analysis
- Simulation
- Remote Tower Experimental System
- Field Testing
- Outlook and Conclusion

Augmented Vision Video Panorama System at Braunschweig Airport



- Video system for panorama and image processing
- Gbit/s - Fibre optic LAN
- Experimental Augmented Vision HMI



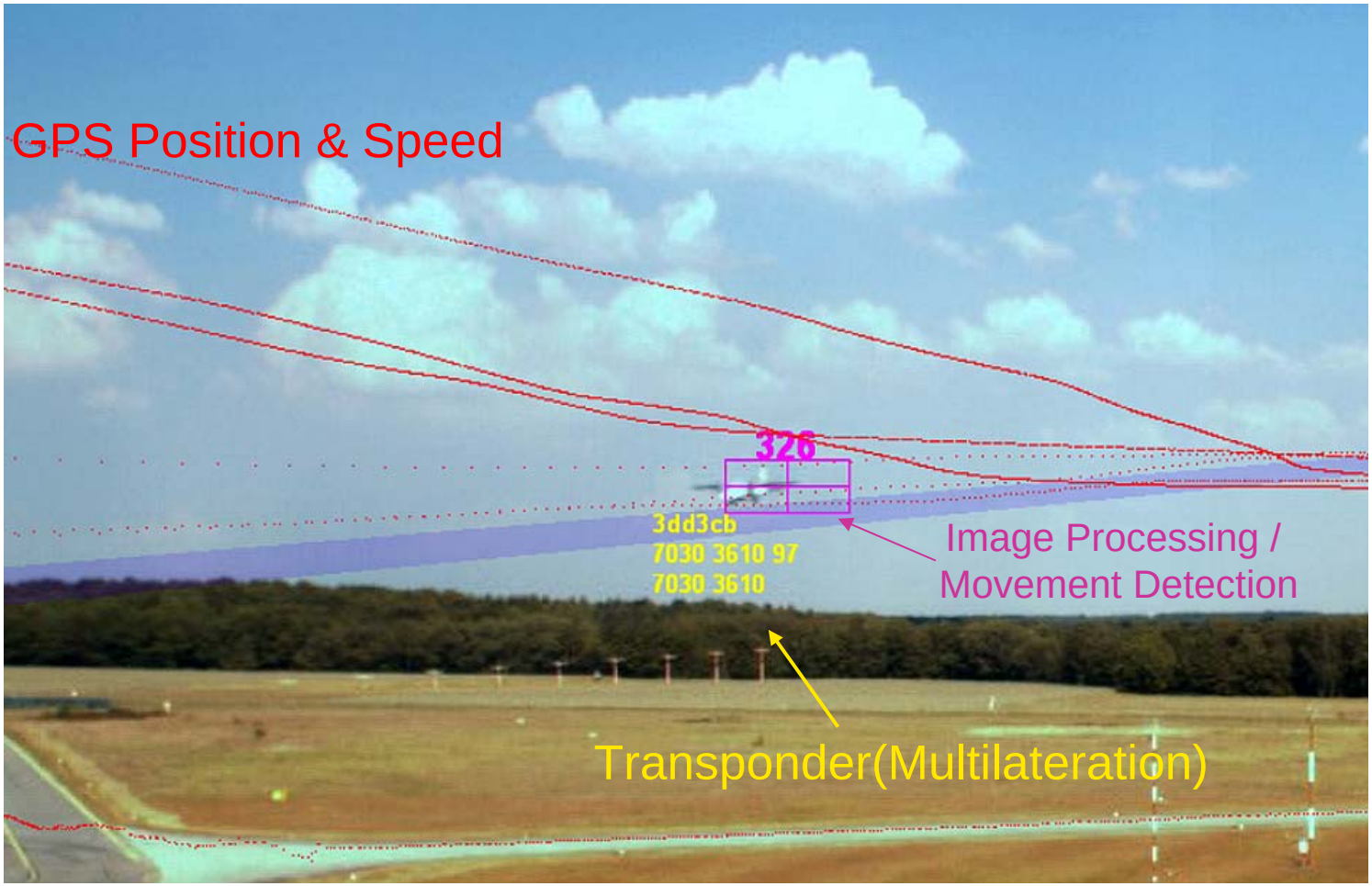
Camera Resolution ca. 2 arcmin

Augmented Vision:
Multilateration Position and A/C-Label / Transponder Code

PT-Zoom camera with manual or automatic object tracking

Pen Touch-Input Interaction Display

180° Augmented Vision Videopanorama RTO-HMI:
Visual Resolution 2 arc min or 0.35 m / 588 m



Augmented Vision

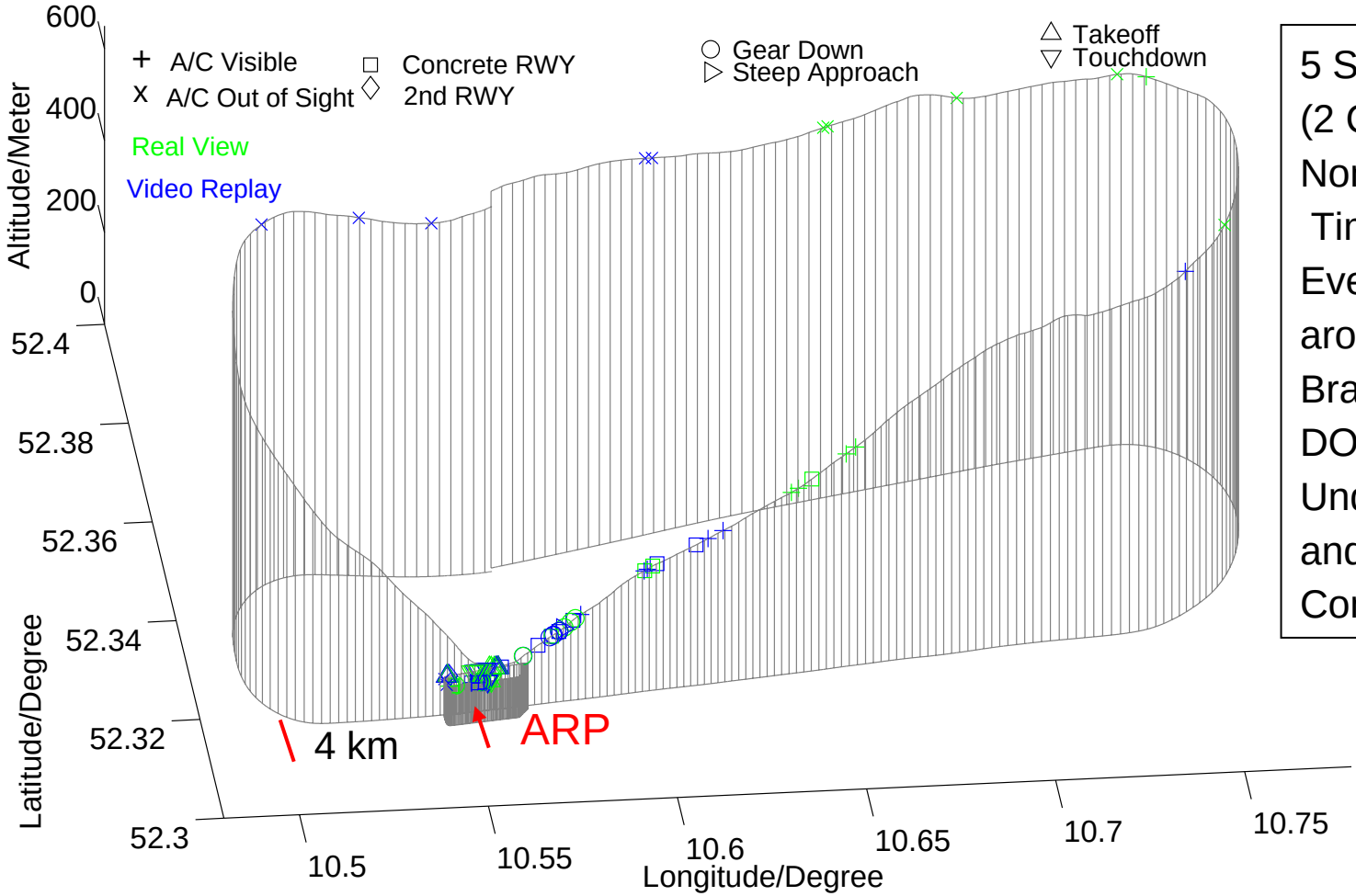
Overview

- Introduction
- Work Analysis & Scenarios
- Simulations
- RTO Experimental System
- Field Testing
- Outlook and Conclusion

3 series of flight tests with pre-defined events during 10 rounds of Aerodrome Circling (12/06 & 5/07)

Validation Experiments: Comparing Real View and Videopanorama

GPS−Trajectory D−CODE 21.05.07: 10th Round (all Participants)



5 Subjects
(2 Controllers, 3 Non-Experts)
Time Stamp 11 Events /10 rounds around Airport Braunschweig with DO-228 (D-CODE) Under Real View and Video Replay Conditions

D-GPS Trajectories with Event Observation Time Stamps

Evaluation of Real View – Video Replay of Event-Time Observation confirms **2 arcmin visual Resolution** for Panorama, 1 arcmin for PTZ (Z = 4)

Video Replay: Deviation from Routine Operation

Replay: 1 TB High Res. Video / Day

Summary / Conclusion

- **Structured Work Analysis** ⇒ Requirement for Visual Surveillance ⇒
  Concept: High Resolution Augmented Vision Videopanorama with PTZ & Tracking
  Scenarios: RTO Console at large Airport TWR; RTC for several small Airports

- **Simulation Environment:** supporting Work Analysis & Designing RTC Work Organisation

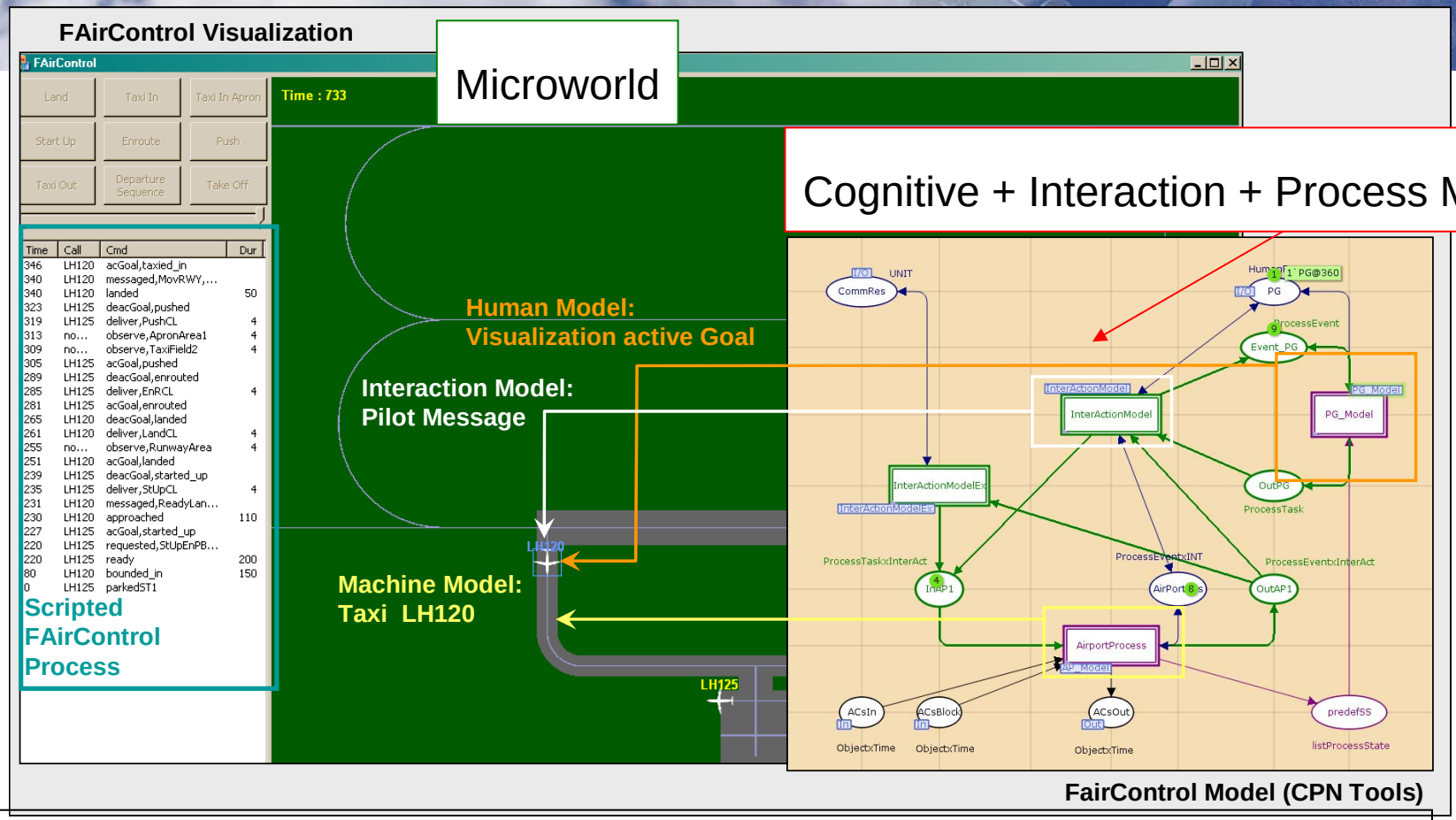
- **Experimental Environment** at Braunschweig Research Airport provides facilities for testing of Vision Based Remote Tower Center Concepts

- **Augmented Vision HMI:** Compact RTC Console & Reduced Head Down Time

- **Initial Field Testing:** Visual Resolution of Videopanorama System meets Specs

- **Perspectives** (Project RAiCe 2008-2012):
  Experimental RTC with 2 Small Airports for Shadow Mode Testing

RAiCe Team (at 2nd RTO Workshop, DLR 04/2008)



Scenario Simulations for Supporting Work Analysis & System Design

Formal Airport Control Model for simulating interaction between Operator, HMI, and Process with Airport Microworld of controlled process. Active goal of Human Model: blue frame (orange arrow). Communication with pilot (white arrow) changes colour of call sign (LH120). [Werther, Möhlenbrink et.al. 2007]

RTO Video Panorama Experimental System: Simplified Block Diagram

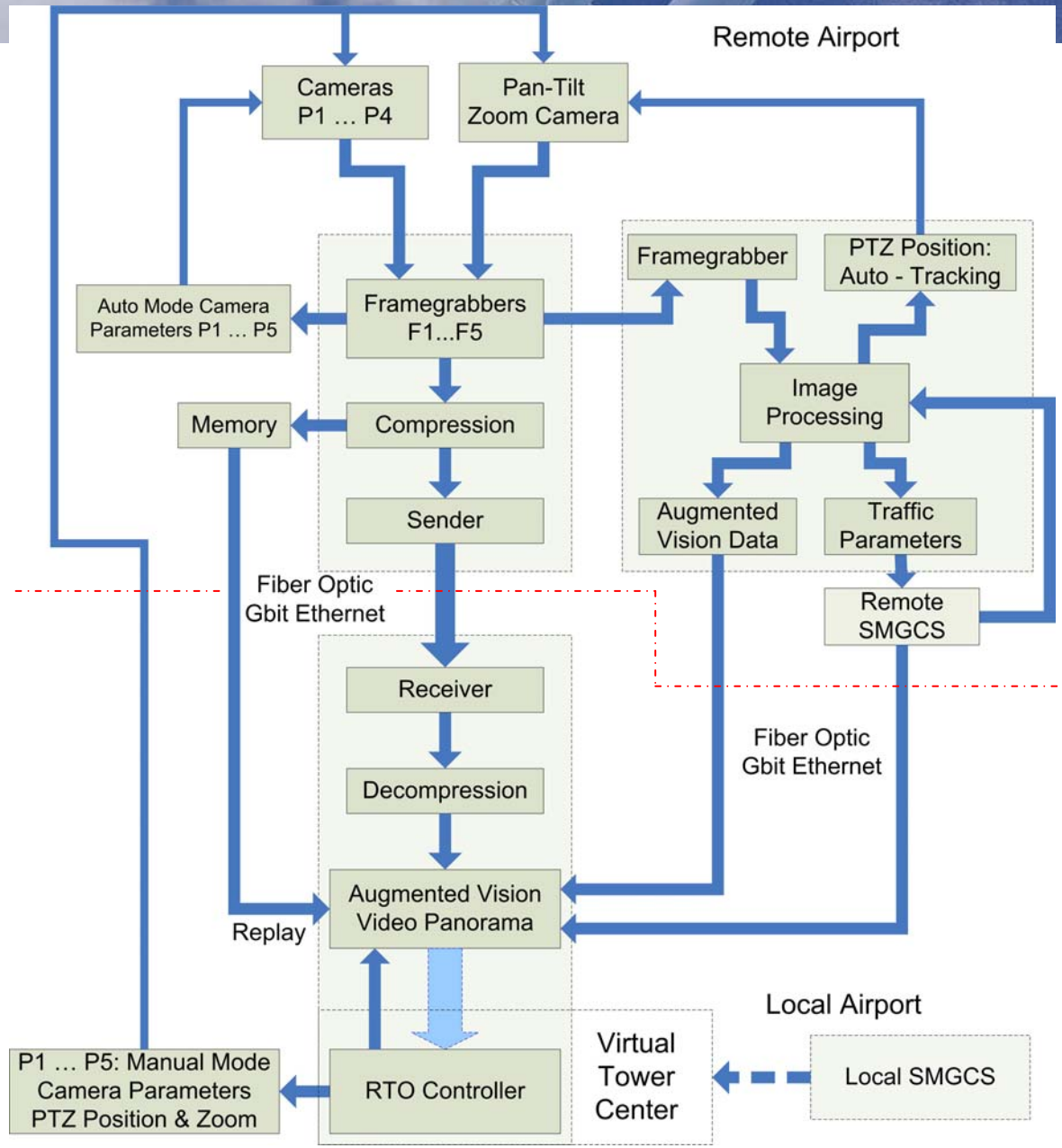
Technical Data

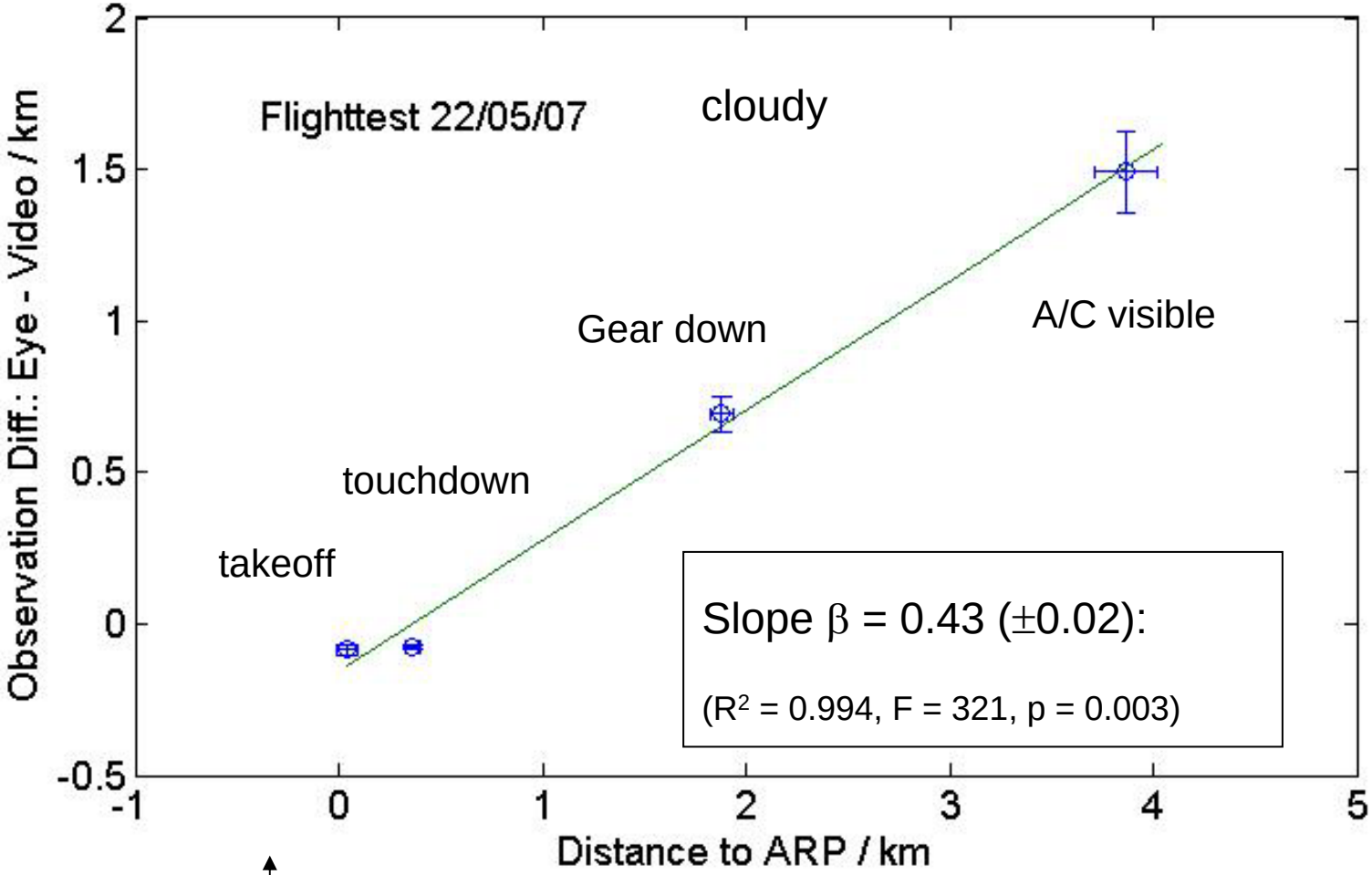
Cameras:
4 x (1600x1200), 25 frames/s
PTZ: f = 3.6 – 82.8 mm, 23 fold

Panorama:
5 UXGA Monitors 1600 x 1200
alternatively:
Wide angle tiled projection with 4x2 SXGA (1280 x 1024)

Data Transfer:
GBit Ethernet, Average 100 MBit/s, MJPEG compressed

Storage Capacity: 5x 500 GB

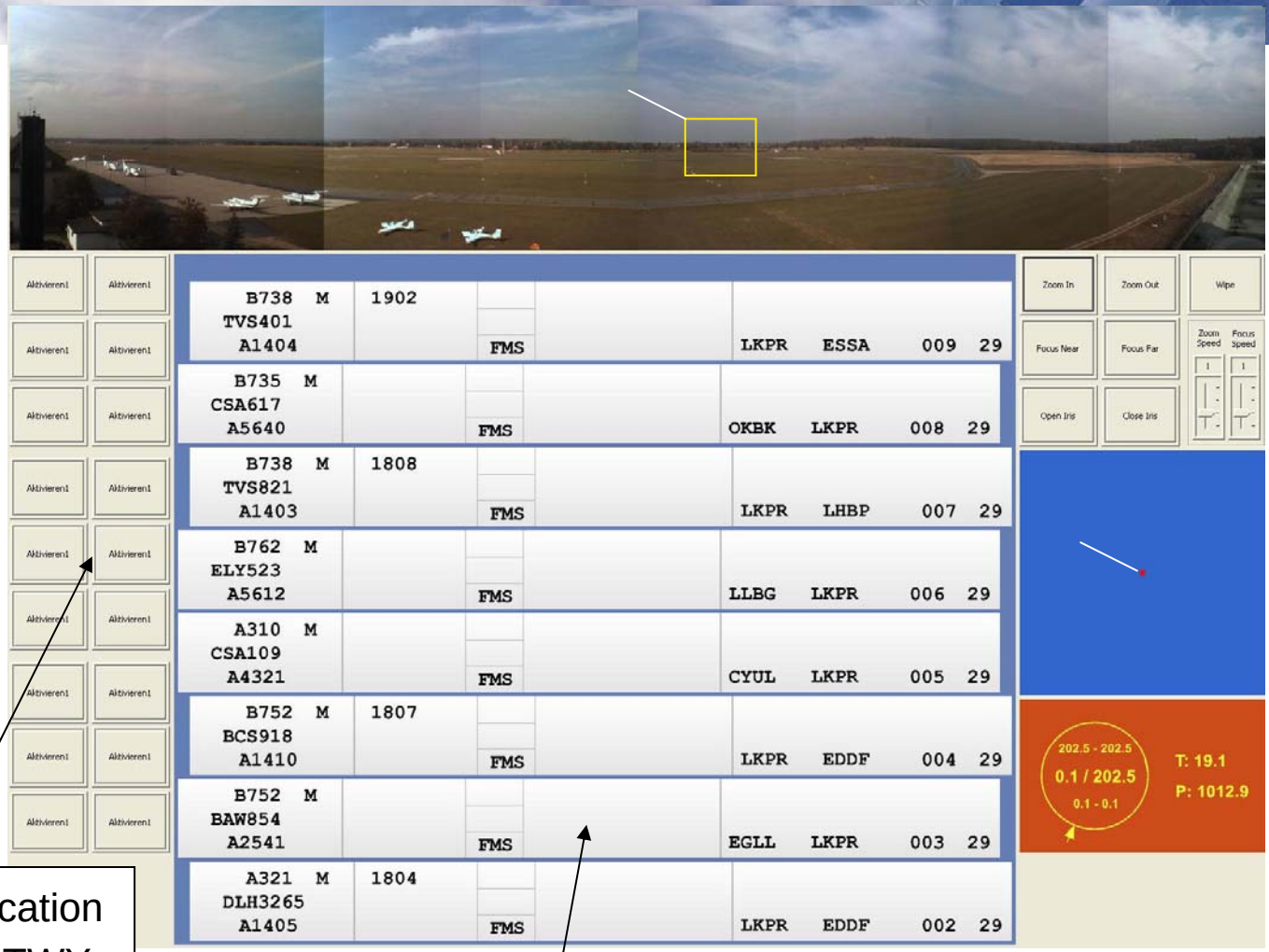




$$\Delta x(\text{eye}-\text{video}) = (1-\alpha_E/\alpha_V)x_E$$

Video Resolution / arc min

$$\alpha_V = \alpha_E(1-\beta_1)^{-1} = 1.75\alpha_E$$



Mini Panorama & PTZoom positioning

PTZ Camera & Position Control: *Virtual Joystick*

Weather

Communication & RWY / TWY Lights

Electronic Flight Strips

RTO Touch-/Pen Input Interaction Display

RTO Image Processing

Moving Object detection by Static Background Subtraction.
Determination of Traffic Parameters (Position, Speed) and Detection of Debris & Dust