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

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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

**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)
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)
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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
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: relative number of Access to Information Sources for All Tasks (Decision & Support Tasks (clearances, communications etc): 29 (PG), 31 (PL))

Use of Information Sources for Ground (PG) and Tower (PL) Controller for Medium Size Int. Airport

- Radar: 55% ground, 74% tower
- ATC: 21% ground, 21% tower
- IFV: 45% ground, 32% tower
- DEPCOS: 24% ground, 31% tower
- NAV: 0% ground, 35% tower
- IDVS: 10% ground, 34% tower
- Telecommunications: 31% ground, 35% tower
- Airport Information System: 45% ground, 35% tower
- FIDS: 52% ground, 55% tower
- Radio Strips: 55% ground, 55% tower
- Radio (Ground): 45% ground, 36% tower
- Radio (Pilot): 3% ground, 13% tower
Scenario 1:
Remote Control of Small Airport from Local Tower

Local large Airport

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
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Different Possibilities of RTC Work Organization

RTC Microworld Simulation with Colored Petri Nets
Airport Towersimulator with RTO-Console

180° RTO Panorama HMI
- Live Stream
- Live Replay
- Traffic Simulation
- Synthetic Vision with live Data

200° Airport Traffic Simulator
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Augmented Vision Video Panorama System at Braunschweig Airport

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

Height 20 m

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

- GPS Position & Speed
- Transponder (Multilateration)
- Image Processing / Movement Detection
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Validation Experiments: Comparing Real View and Videopanorama

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

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
Video Replay: Deviation from Routine Operation

Replay: 1 TB High Res. Video / Day

PTZ: $Z \approx 20$
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)
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
Flight test 22/05/07
cloudy

Distance to ARP / km

Observation Diff.: Eye - Video / km

Slope $\beta = 0.43 \pm 0.02$:

$$\alpha_{V} = \alpha_{E} \left(1 - \beta_{1}\right)^{-1} = 1.75 \alpha_{E}$$

$$\Delta x(\text{eye - video}) = \left(1 - \alpha_{E}/\alpha_{V}\right)x_{E}$$

A/C visible
Gear down
touchdown
takeoff

Video Resolution / arc min

(R² = 0.994, F = 321, p = 0.003)
**RTO Touch-/Pen Input Interaction Display**

<table>
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<tr>
<th>Mini Panorama &amp; PTZoom positioning</th>
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<td>PTZ Camera &amp; Position Control: Virtual Joystick</td>
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<td>Weather</td>
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- **Communication & RWY / TWY Lights**
- **Electronic Flight Strips**

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### Electronic Flight Strips

- **B738 M TVS401 A1404**
  - FMS
  - LKFR ESSA 009 29

- **B738 M CSA617 A5640**
  - FMS
  - CKKK LKFR 008 29

- **B738 M TVS821 A1403**
  - FMS
  - LKFR LHBP 007 29

- **B762 M KLY523 A5612**
  - FMS
  - LLBG LKFR 006 29

- **A310 M CSA109 A4321**
  - FMS
  - CYUL LKFR 005 29

- **B752 M BCS918 A1410**
  - FMS
  - LKPR EDDF 004 29

- **B752 M BMN584 A2541**
  - FMS
  - EGLL LKFR 003 29

- **A321 M DLH3265 A1405**
  - FMS
  - LKPR EDDF 002 29
Moving Object detection by Static Background Subtraction.
Determination of Traffic Parameters (Position, Speed) and Detection of Debris & Dust