Real Time Image Recognition for Remote Airport Tower Operation ("RapTOr„)

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Outline

- Goal of the Project

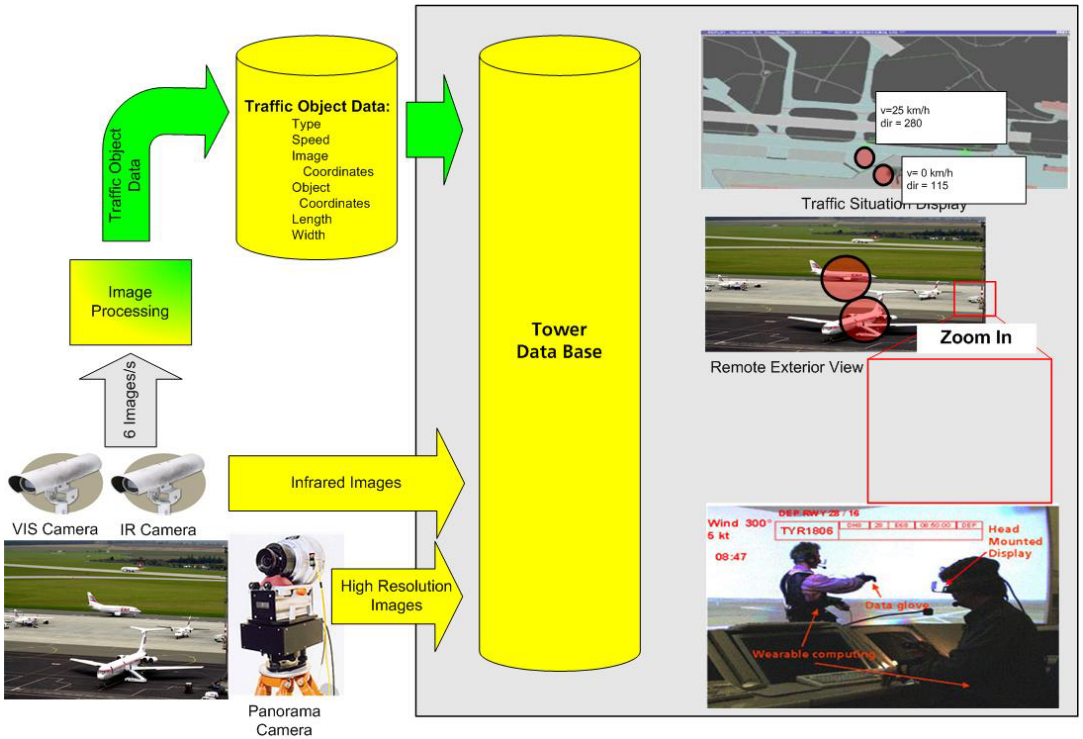
- Test facility: Research Airport Braunschweig

- Image Processing system
  - Tasks
  - Principles of image processing
  - FPGA Hardware platform

Conclusions / Next steps

Goal of the Projekt

Remote Tower Operation (RTO) describes the goal of surface movement management of small airports from a remotely located control center without direct far view to the airport surface



Research Topics:

- Human Machine Interface (HMI)

by structured tower work analysis cognitive and traffic process models

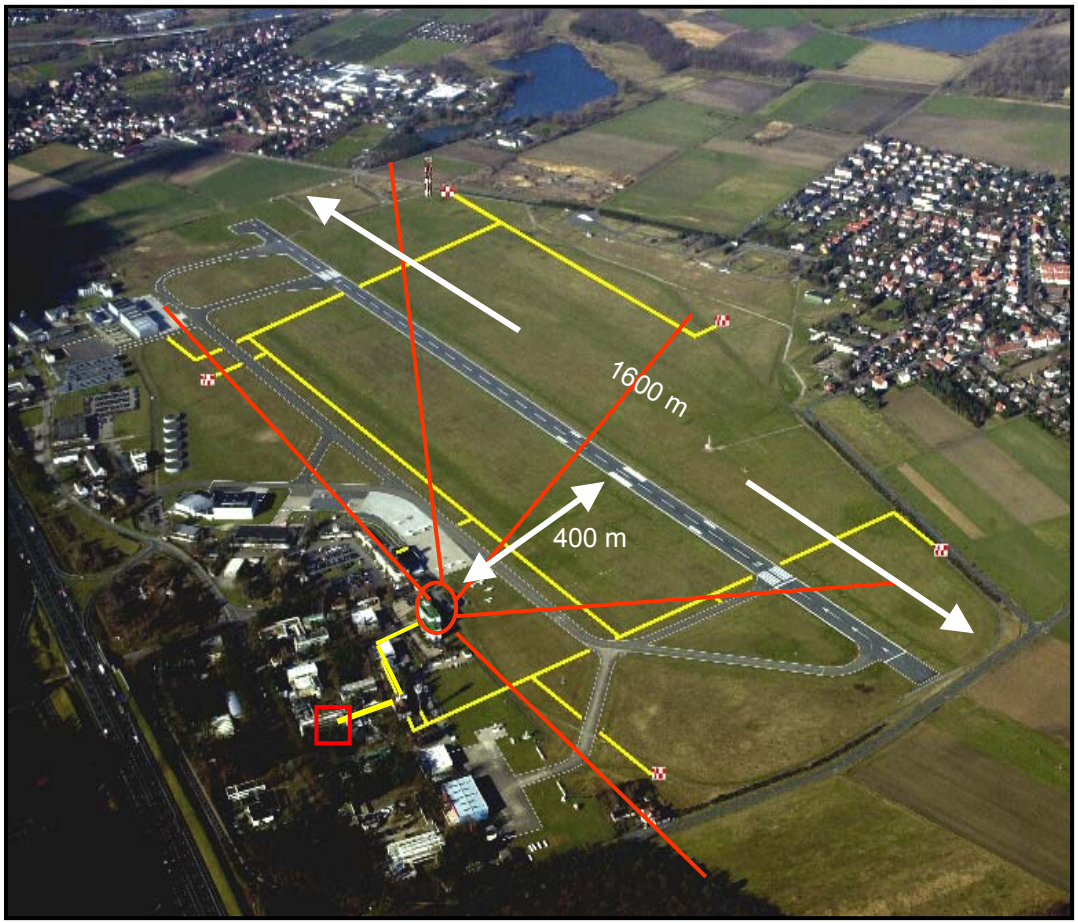
- Augmented vision videopanorama

Based on a high resolution panorama camera system

- Real Time Image Processing:

- Recognition of moved objects
- Visualisation (Highliting) of Objekts

Test Facility: Research Airport Braunschweig



- Red lines: indicate camera segments of 180° video panorama system;

- Red circle: camera location;

- Red square: visualisation system;

- Yellow lines: fiber-optic high speed data network with thick line indicating Gbit link for panorama video transmission.

Camera system

- Four remotely controlled high resolution panorama cameras

  14 bit CCD PCO 1600

  1280 * 1024 Pixel

- Pan-tilt zoom (PTZ) camera with automatic tracking function. Braunschweig control tower in the background.

Back

Video panorama with integrate real-time aircraft position information

Back

Tasks of the Image-Processing System

With Image-Processing attention of air controller will be focused to:

- Starts and Landing of aircrafts
- Persons, moved objects and vehicles (Gangway, busse, Cargo-Transporter,…)
- Parked planes and vehicles
- Prob. leaved objects on the runway

Displaced or hidden of non traffic objects :

- buildings, lamp posts,
- grassland,
- trees and bushes
- fixed blinking airport lights

Image processing work flow

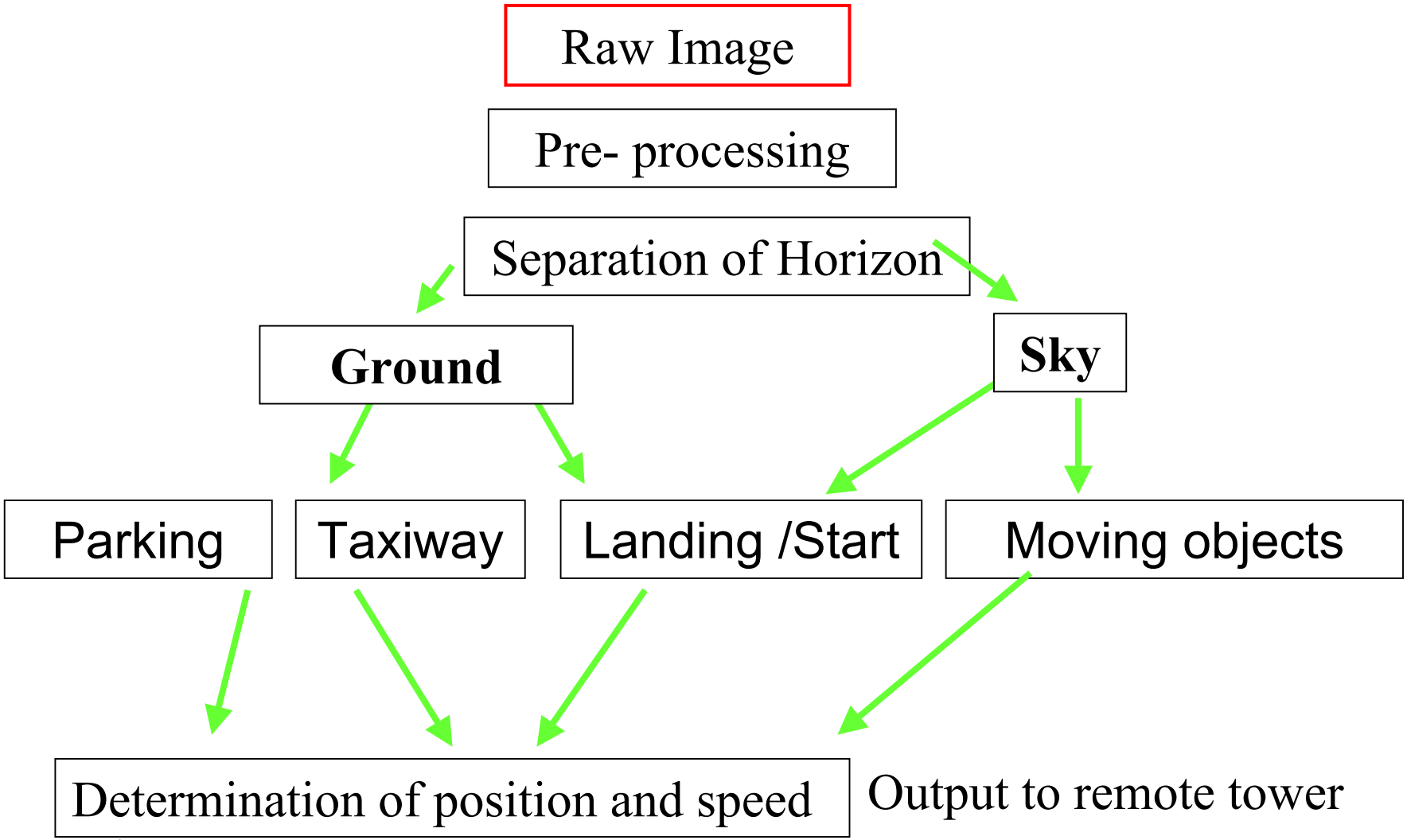


Image pre- processing I

Separation ground and sky by horizon determination

Non continuity in texture und brightness for horizon determination

- Used gradient operators and texture filters
- offline process is done before image recognition algorithms

Image pre- processing II

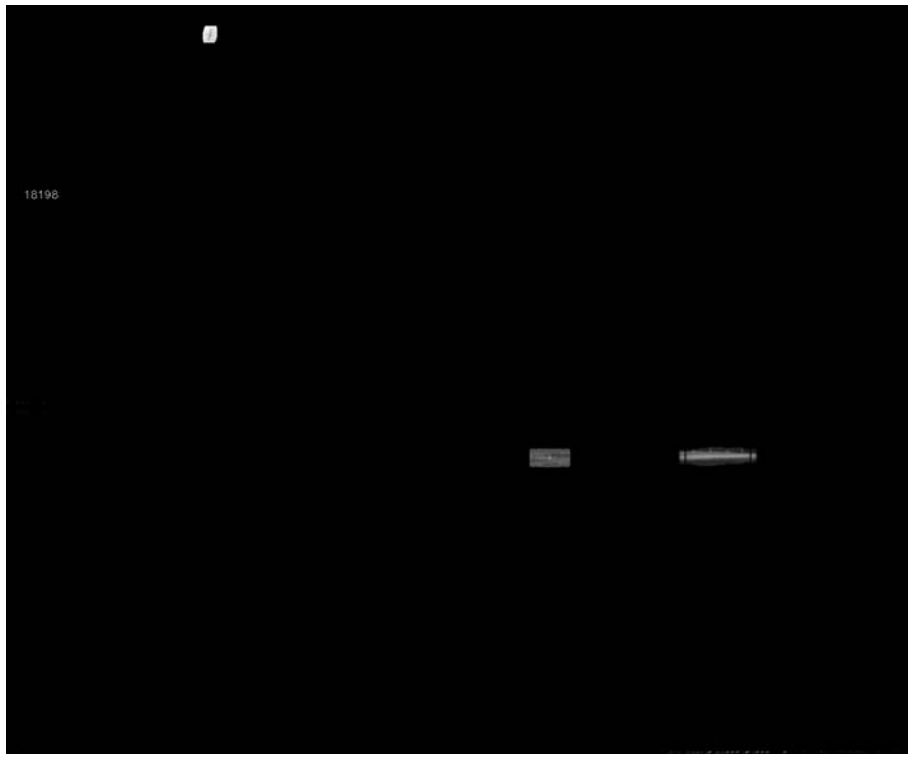
Analysis of "non traffic area"

- **Masking trees and bushes with texture analysis**

Detection of planes in the sky

Principle: - Movement of aircrafts faster than movement of clouds
- Aircrafts have different texture than clouds
- Detection by combination of different features

Glider in moved clouds



Original- Image

Detection of moved objects

Detection of moving planes and objects on ground

Principe:

- Feature of image differences (with time shift)
- Separation of vehicles and planes by contour and texture analysis and segmentation
- possibility by determination of „plane-active-areas“ in long time analysis (in general aircrafts move in pre-defined areas)

Moving fire brigade

Moving aircraft

Detection starting planes

Principle:

- Feature of image differences (with time shift)
- Texture analysis of detected clusters
- Combination of different features

Further challenges

-**Blinking lights elimination**

-successive calculation of background estimation and selection of changed areas.

- If mean value of the surrounding is stable than decision for „Blinking lights”

- Memory of detected locations

- **Elimination of cloud shadows**

Image-Processing Integration in the Test System

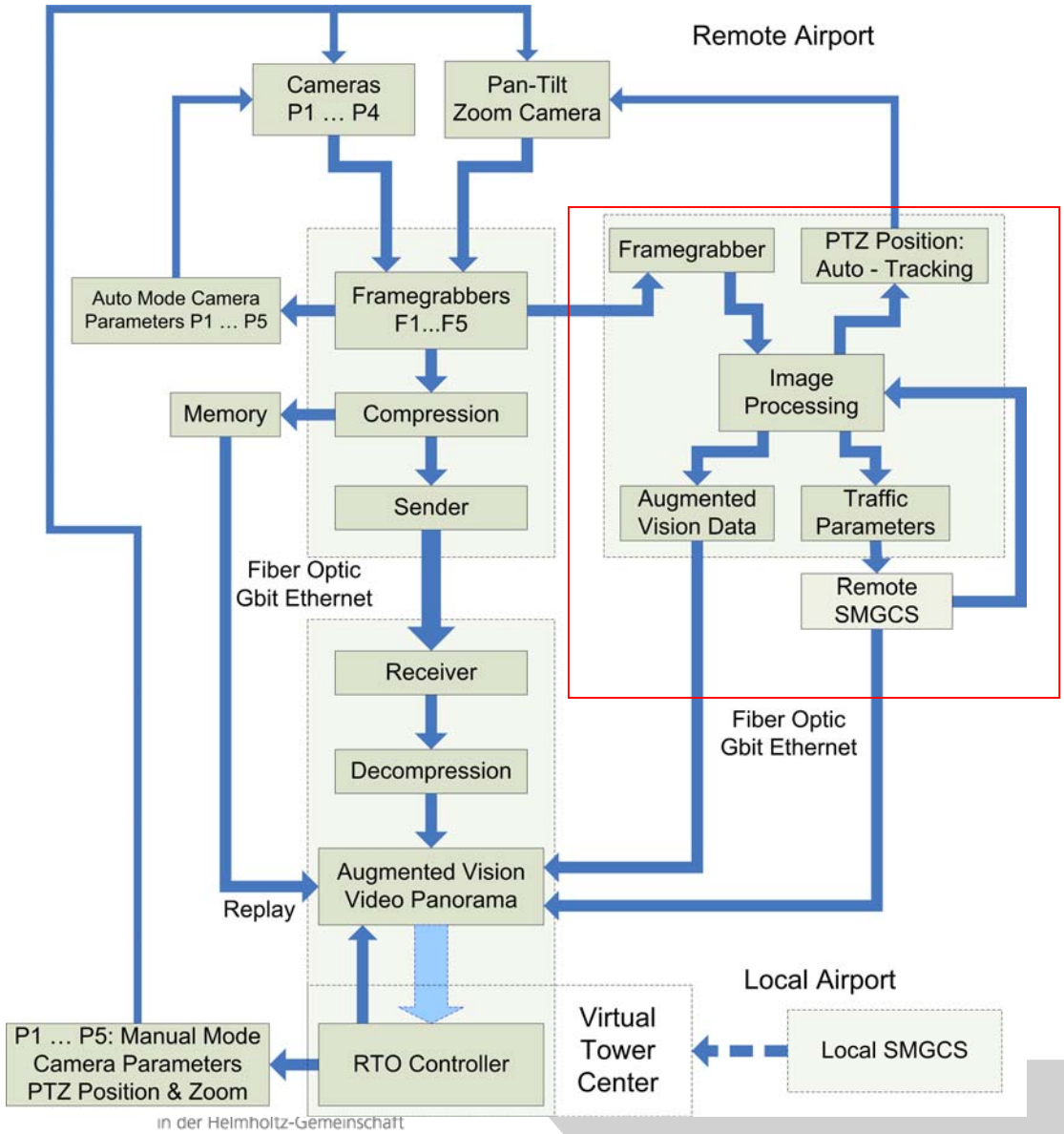


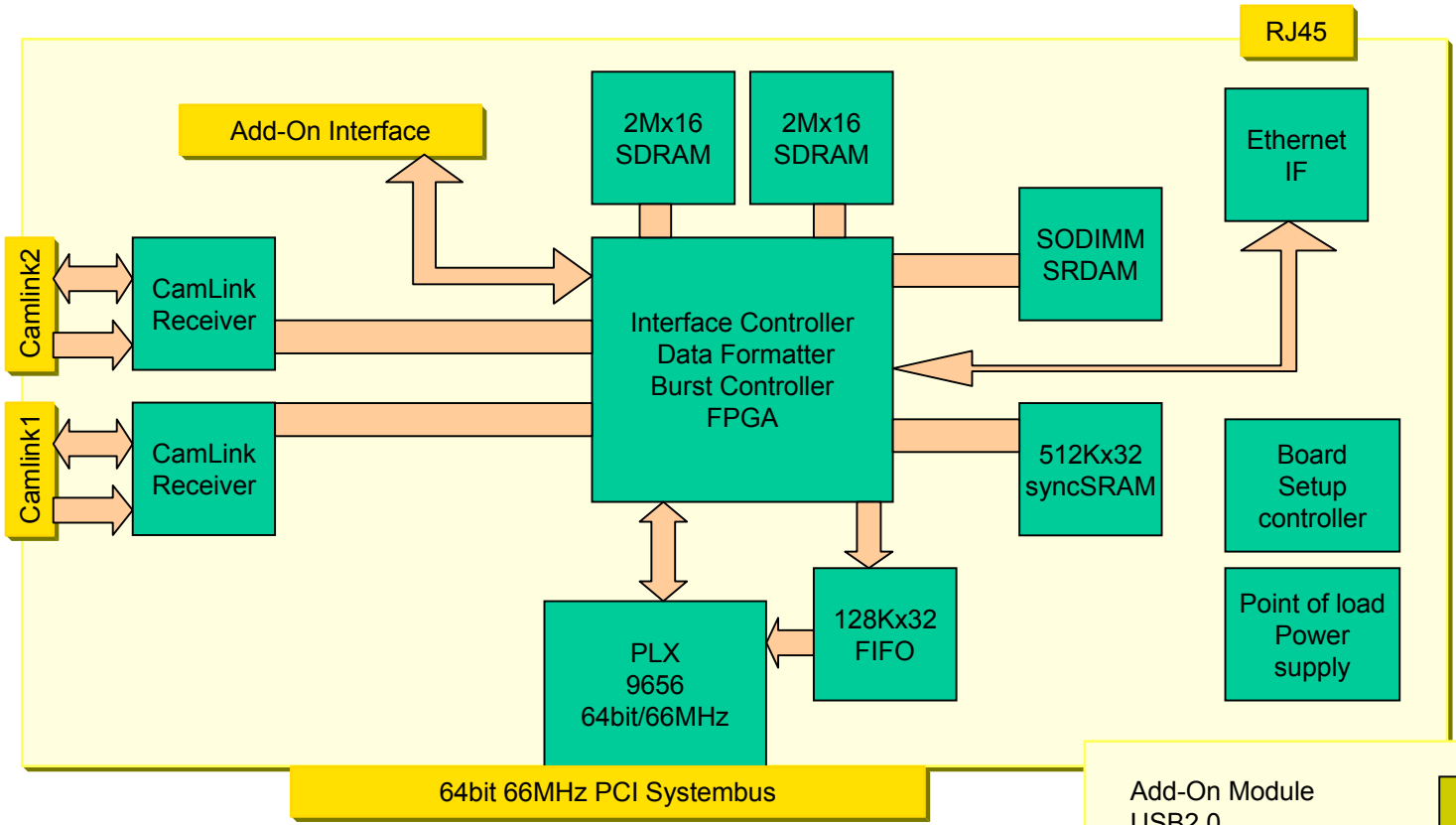
Image processing queue:

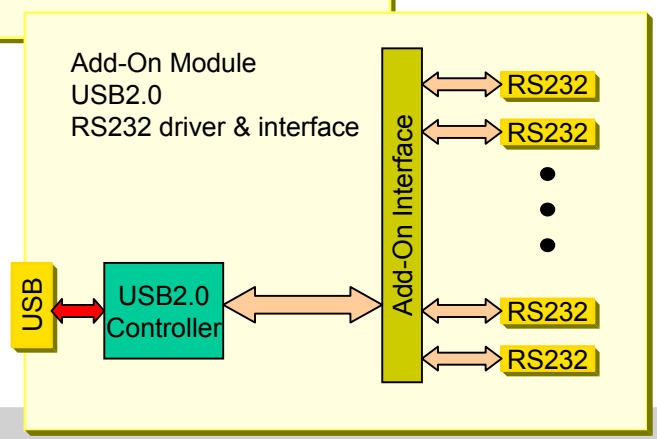
Input of raw data via direct data connector (Cam-Link) to FPGA

Image Algorithms implemented in VHDL and IDL (Interactive Data Language)

Output of coordinates to:
-SMGCS Airport Ground System
- Image Auto-Tracking-System

Implementation into FPGA Hardware





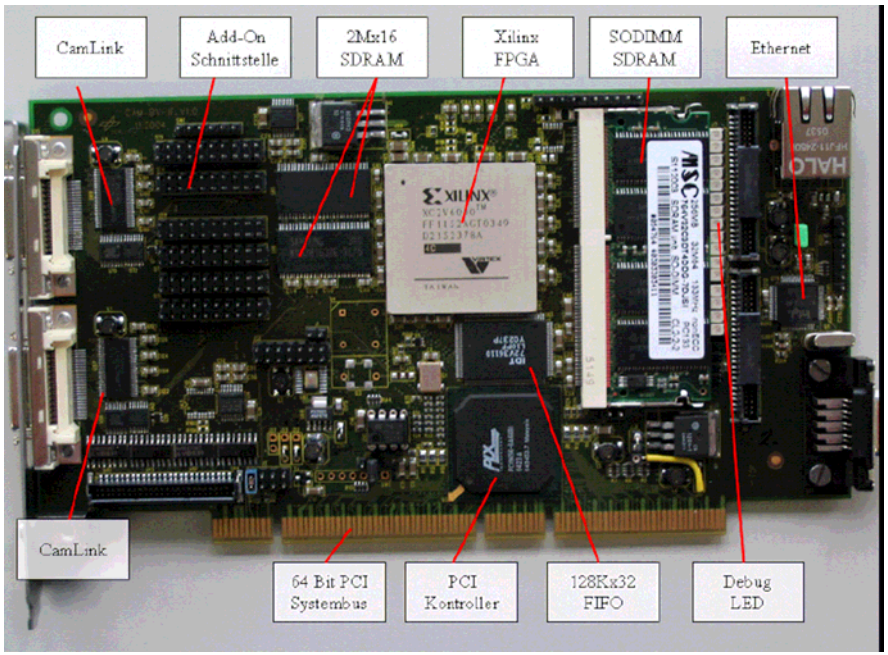
3 Versions possible:

1.) USB -stand lone board;

2.) PCI-bus-board;

3.) Compact PCI-BUS

Implementation into Test Hardware



Main features of the FPGA cart:

- Xilinx-Virtex2-FPGA (1000, 3000, 4000, 6000)
-Configuration Boot-Rom or from PC via PCI /USB

Connection to Host

- 32/64 Bit PCI Bridge; or PCI-Out Burst Interface
- Ethernet PHY
-Communication Mailbox Register or DMA Channels
-Interrupt generation from PCI Controller or FPGA
-Tasks possible
-PLX-PCI-Controller with 128 K x 32 Bit FIFO as communications puffer

On-Board RAM

-RAM for Image Processing (DSDIM/ with Burst Buffer),
-RAM for intermediate data
• 256 MByte SDRAM
• two 16 MByte SDRAM
• 4 MByte synchronous SRAM

Initial Field Trials and Evaluation

Goal:

1.) Evaluation of the comparability of the video-panorama with the real view out of the tower windows (with experts and non-experts)

2.) Comparison of the image recognition system with the real view.

-> Flight tests of two hour duration with the DLR DO-228 (D-CODE) test aircraft “approach, landing or touch-and-go” 21. / 22. Mai 2007

Day 2: 22.05.2007	**Position Graspiste/ Landebahn**	**Anflugwinkel**	**Time approach, landing or touch-and-go**			
Path				real view	video-panorama	image recognitin
1	**Landebahn**	**Standard Glideslope ± 0°**	**Touch and Go**	…	…	…
2	**Graspiste**	**Standard**	**Durchstarten 14:09**	…	…	…

Initial Field Trials and Evaluation

Visualization of traffic object parameter in post- processing

-> Image processing results has a delay between 4 and 10 frames …

Conclusion

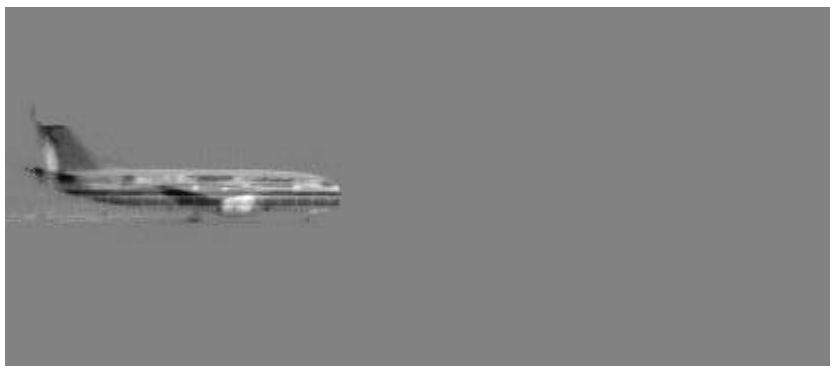
- **Development robust image algorithms suitable for the detection of**
  - Starts and landing of planes
  - Persons, moved objects and vehicles (Gangway, buses, Cargo-Transporter,…)
  - Parked planes and vehicles

- **Development of a FPGA Hardware**
  - Cam-Link Frame-Grabber
  - Xilinx-Virtex2-FPGA for image pre-processing system

- **Implementation of algorithms to *VHDL* and *IDL***
  -> up to 4 Hz image processing was reached
  Next Step: Pipeline processing of the algorithm must be done
- **Direct link to SMGCS airport system**
  - Output of coordinates und speed of detected objects
  - Augmented vision at video panorama system
  -> First Field Trials with in complete system

Next steps I

Detection of dust (or bigger particles) at take-off or detection of wakes



Next steps II

Infrared Analysis