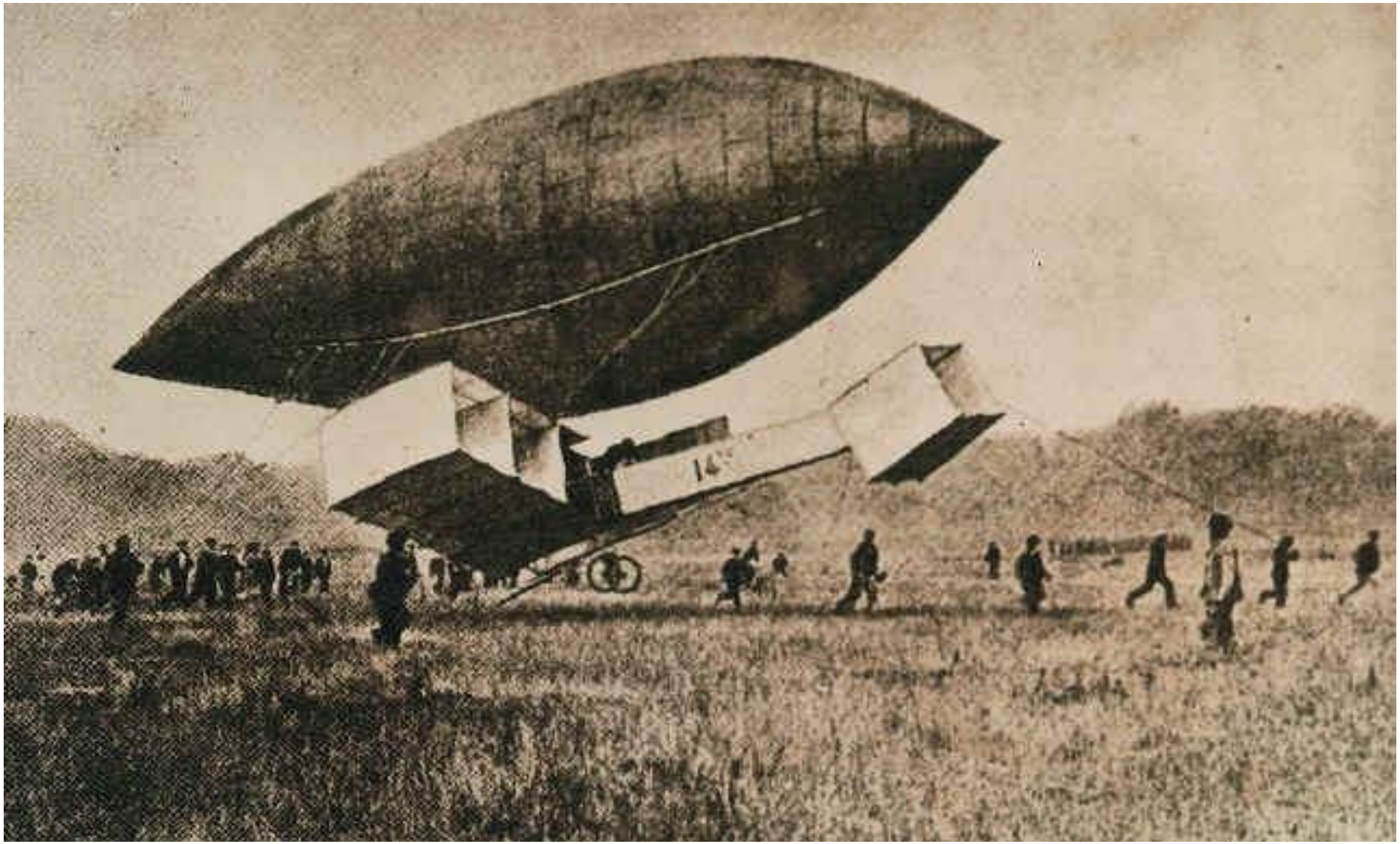
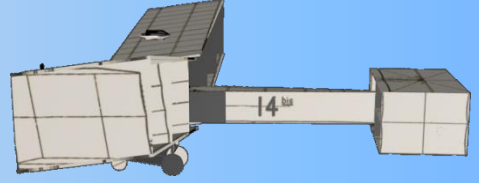

14 bis

Development of a Hi-Speed Near Real-Time 720i Image Processing Application for Flight Test

Luiz Eduardo Guarino de Vasconcelos
Nelson Paiva Oliveira Leite, PhD
Carlos Alberto Murari Pinheiro, PhD
Otávio Augusto Salgado Carpinteiro, PhD

- Test Point
- Goal: Altitude and Airspeed
- Reference Points



Introduction

- Images frames are used as information source to clearly pinpoint the aircraft behaviour at the FTC.
- Air Data System (ADS) Calibration FTC using the **tower-fly-by method** requires the knowledge of the exact aircraft reference altitude.
- The IPEV uses an off-line video processing application that computes the aircraft altitude from a snap-shot picture.
  - **Main disadvantage**: measurement accuracy is jeopardized.
- **Solution**: application to process 720i video frames at up to 400 fps to be used for ADS calibration FTC

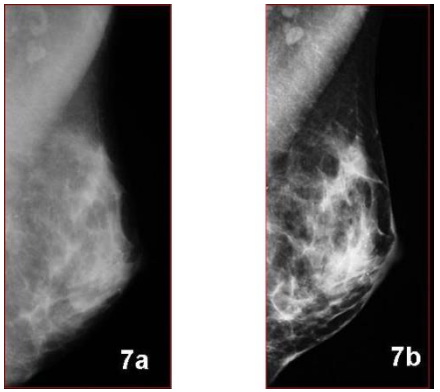
Imaging Processing

Brightness +143% and Contrast + 79%

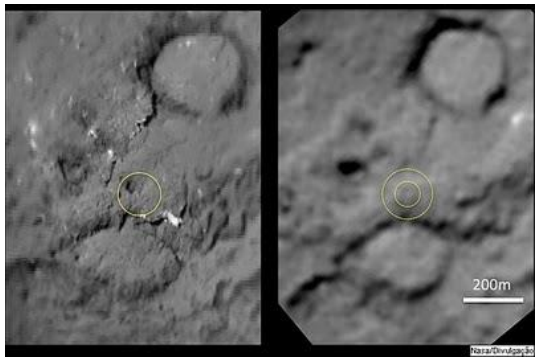
Imaging Processing

- Many applications areas

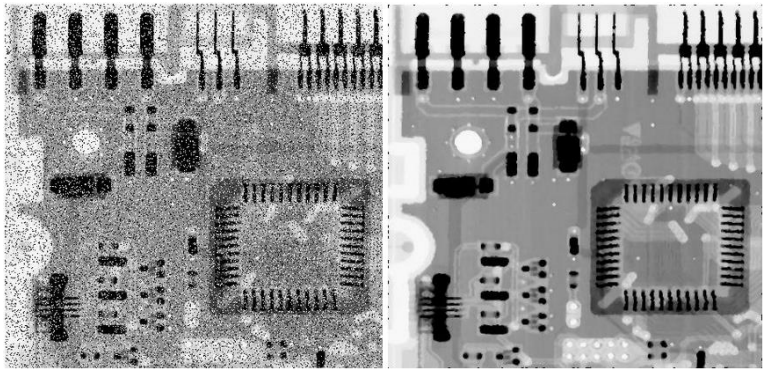
Fingerprint recognition



Digital mammography



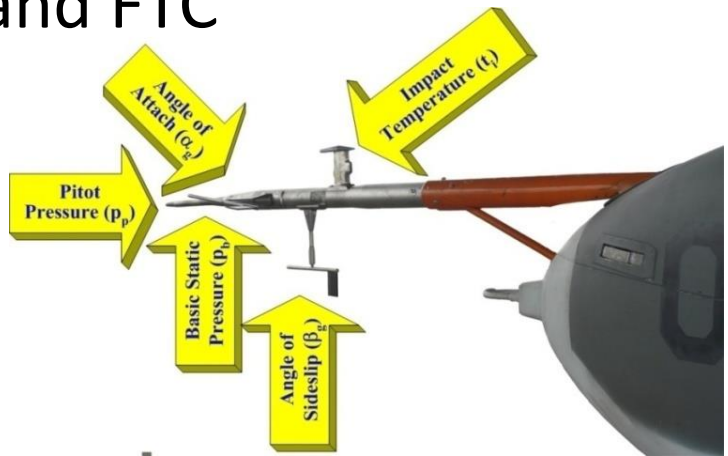
Tempel-1 Comet

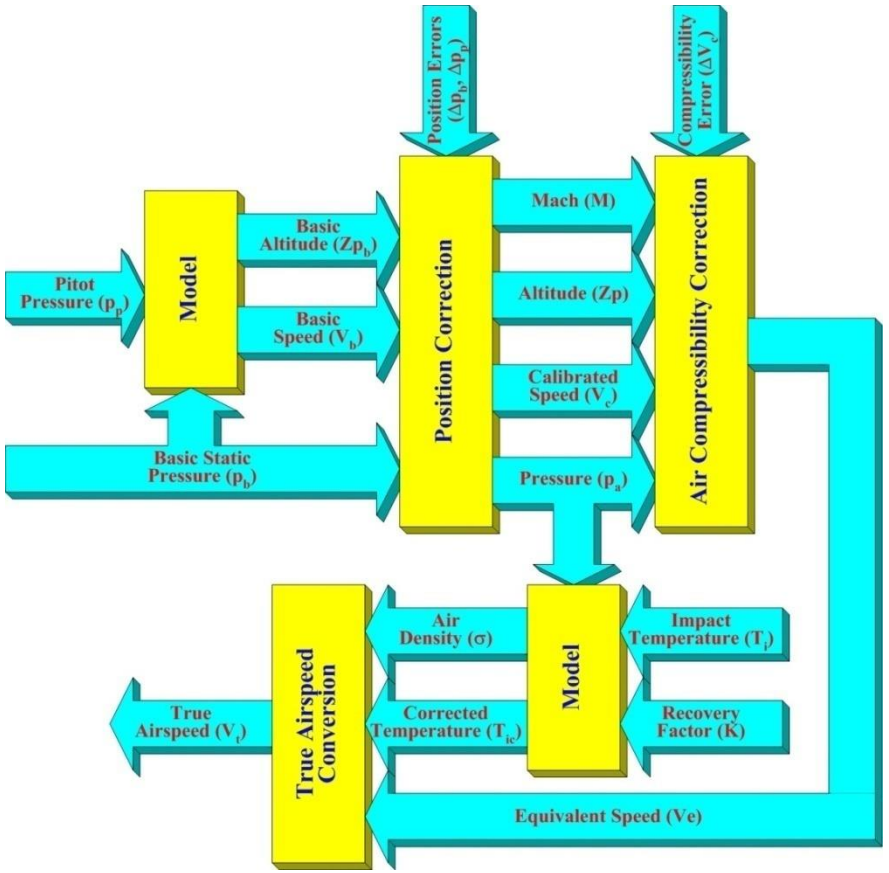


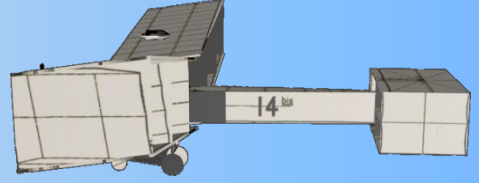
Electronic Circuit

ADS FTC Overview

- Essential to Flight Safety
- Derived from Dynamic and Static Pressures
- Computation requires Calibration in Laboratory and FTC







ADS Calibration

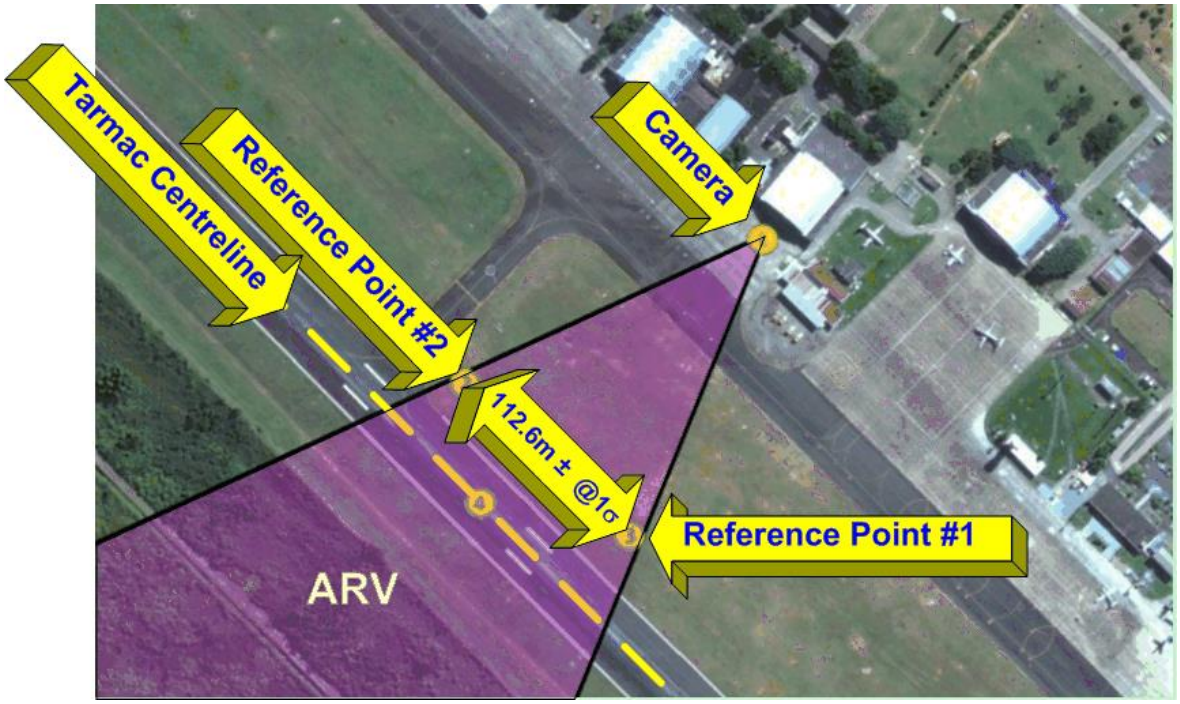
- Consists n TP: 1.2 Stall Speed to VH
- Requirements for Valid Test Point:
  - Z_{pb} and V_b should be stabilized
  - $\overline{Vb}_i \leq Vt_i \pm 5kts$
  - $\Delta Zpb_i \leq \pm 20\ ft$
  - $\Delta Vb_i \leq \pm 2kts$
- Where:
  - ΔVb_i maximum deviation of basic speed at the i^{th} (kts);
  - ΔZpb_i maximum deviation of the aircraft altitude at the i^{th} (ft);
  - $\overline{Vb}_i$ mean basic speed at the i^{th} test point (kts)
  - Vt_i scheduled basic speed for the i^{th} test point (kts);

ADS Calibration

Valid Test Point with H-55 Helicopter

- Requirements are considered within the valid area (ARV)
- Reference Points in the lower corners

ADS Calibration

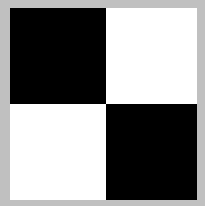


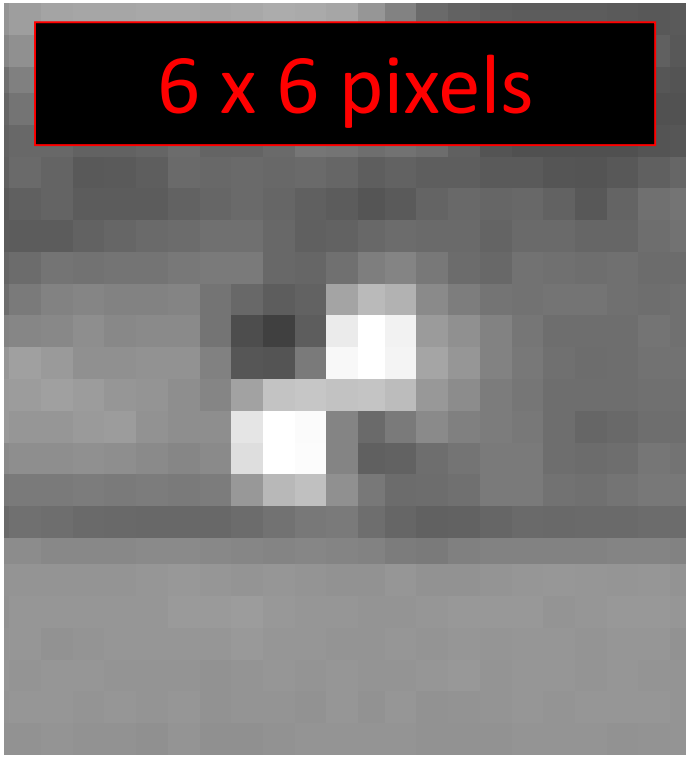
- Test Site ADS
- Mantain Trajectory
- Camera and RP are static and known position

Challenges

Automatic detection

1m±0.04m @1σ

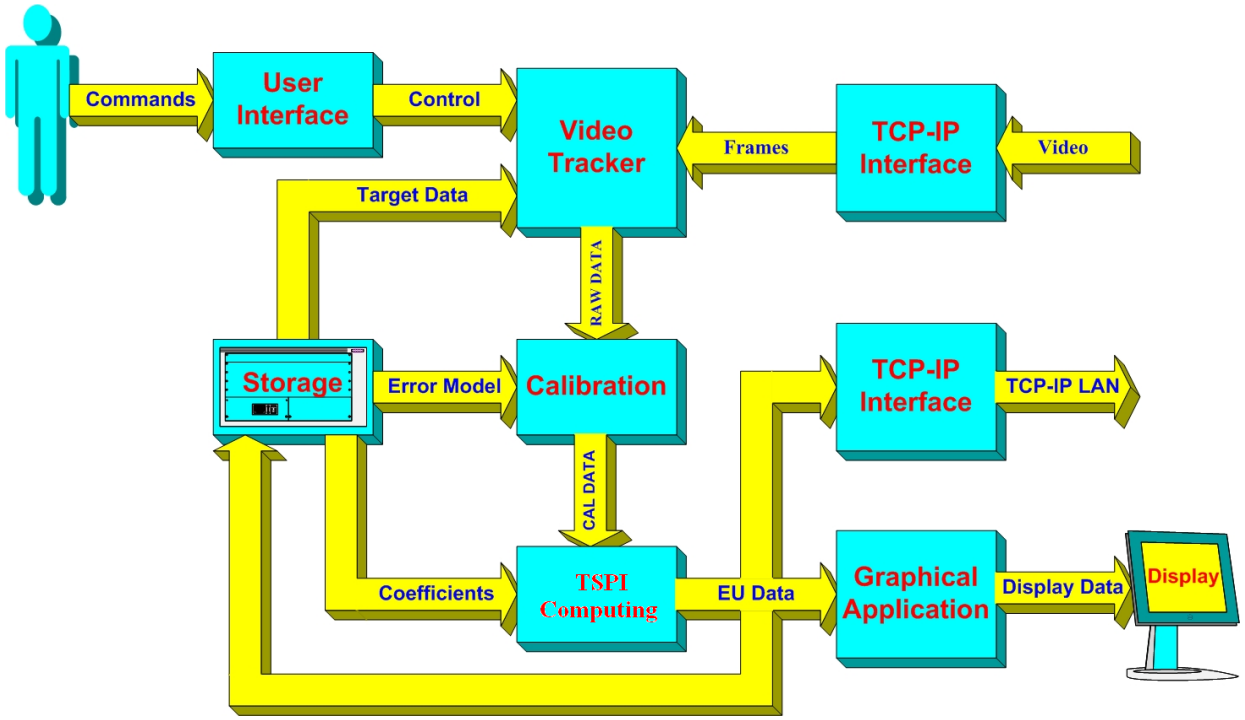




Challenges

Weather Conditions

Tool Development



- User makes application setup
- Video frames transmitted
- Extraction of target coordinates
- Correction to minimize errors lens distortion
- Computes TSPI
- Results

Tool Development

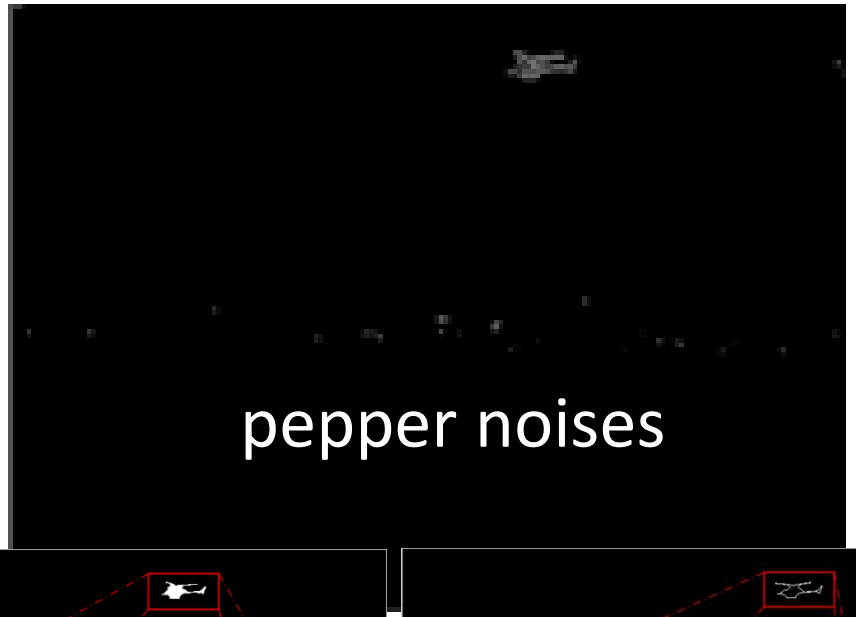
- Algorithms:
  - Reference point detection;
  - Tarmac centreline detection;
  - Aircraft detection;
  - TSPI Computing; and
  - Test Point Validation

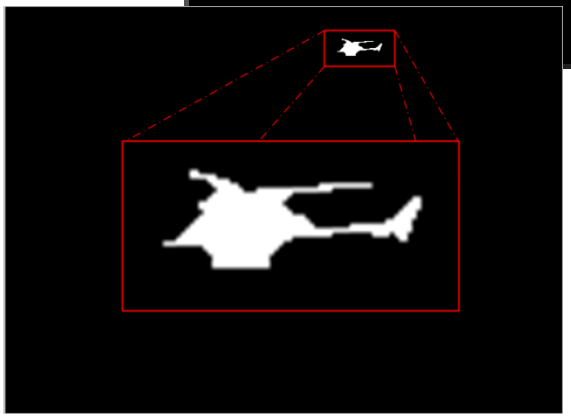
Aircraft Detection

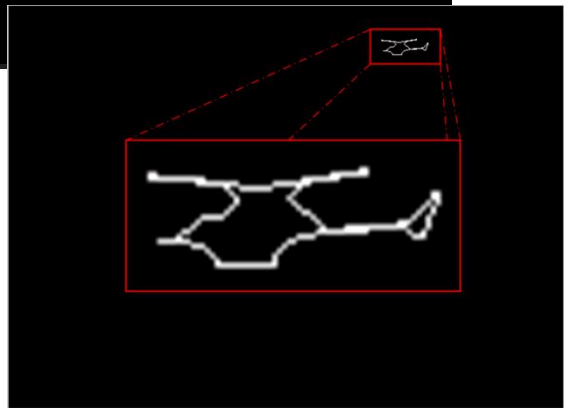
- Segmentation
- First Frame TP is Reference Background Image
- $Irt_{x_i y_j} = It_{x_i y_j} - IB_{x_i y_j}$, must have aircraft and pepper noises

Aircraft Detection

- Next steps:
  - Detect edges
  - Perform CCL
  - Remove pepper noises
  - Sort ascending size order (CCL)
  - Biggest CCL contains aircraft
  - Perimeter Pixels

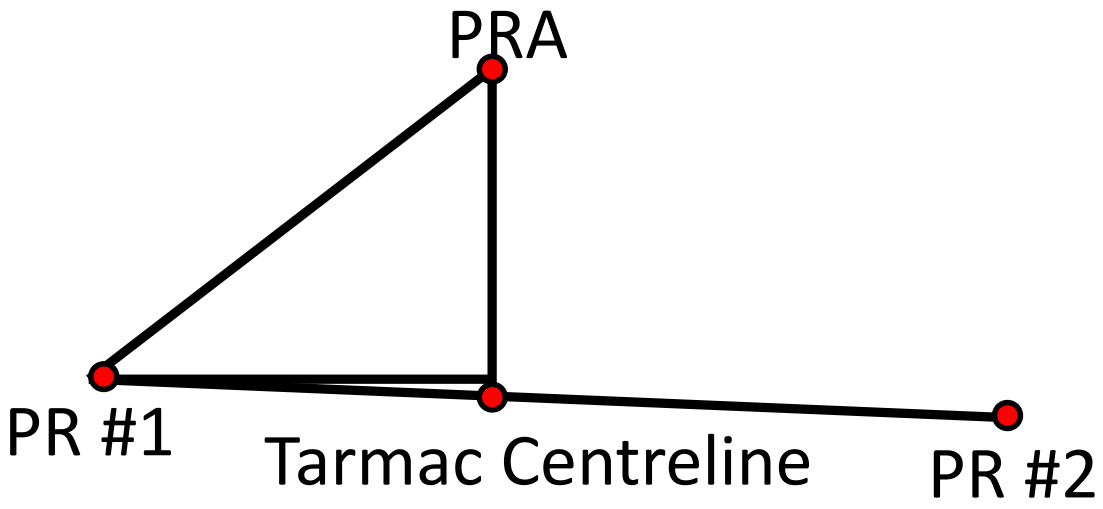






TSPI Computing

- Now, requirement is find a fixed reference point on the aircraft (RPA) for measure altitude and airspeed
  - Centroid, Front, Rear and Bottom Edge detection
- After several tests, the Rear is the better
- Found PRA, computes altitude and airspeed



$$V_t = \frac{k\Delta S}{\Delta t} \ (\mathrm{m/s})$$

Tool Evaluation

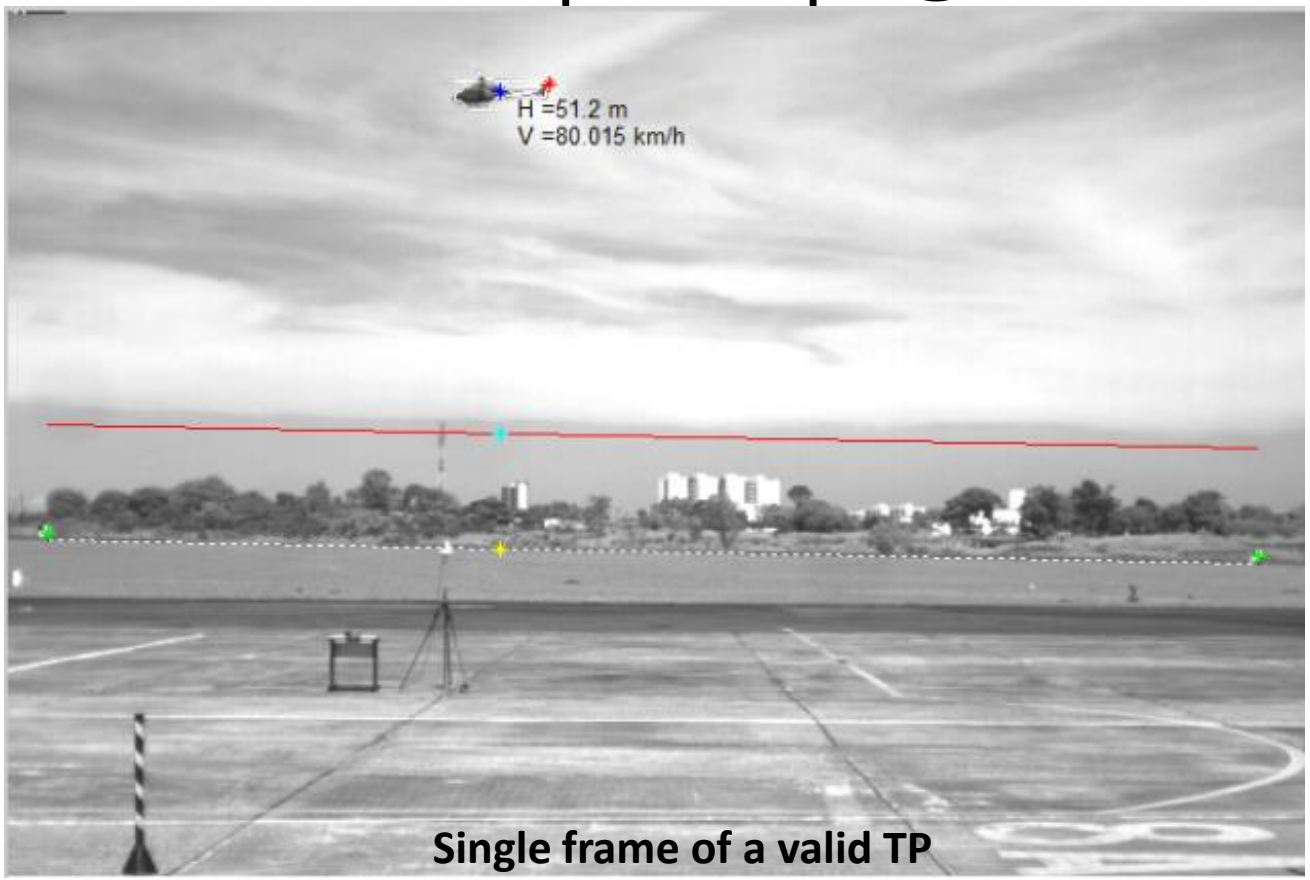
HELIBRAS Esquilo H55

MacroVis SpeedCam

- MatLab® environment
- Intel®Pentium IV Core™ 2 Duo CPU T5800 2.00 GHz notebook, 4 Gb RAM and Microsoft Windows 7 Professional.
- Camera: best configuration was to generate images in grayscale, 400 fps and 720i resolution.

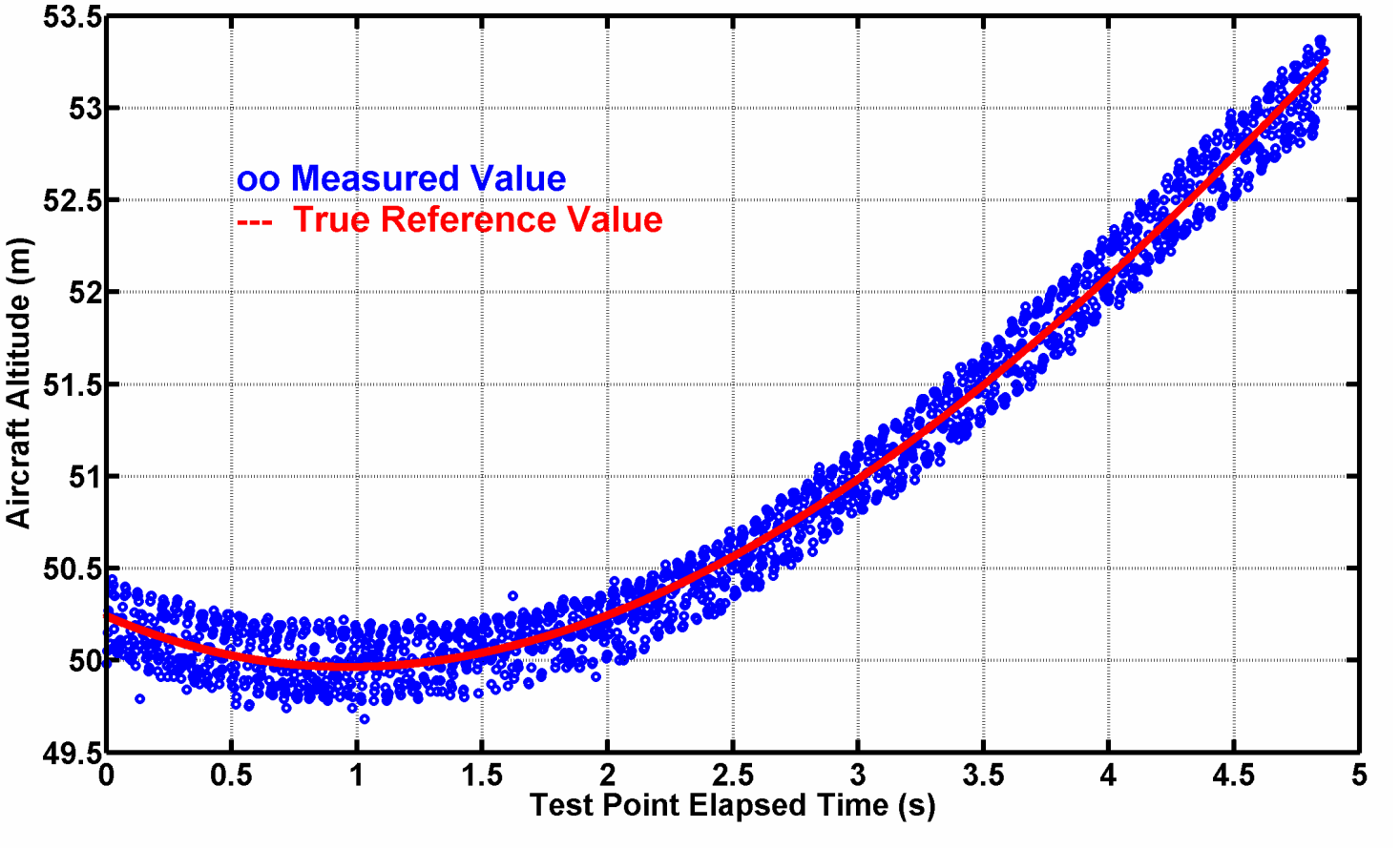
Tool Evaluation

Runs at 48 fps ± 2 fps @1σ



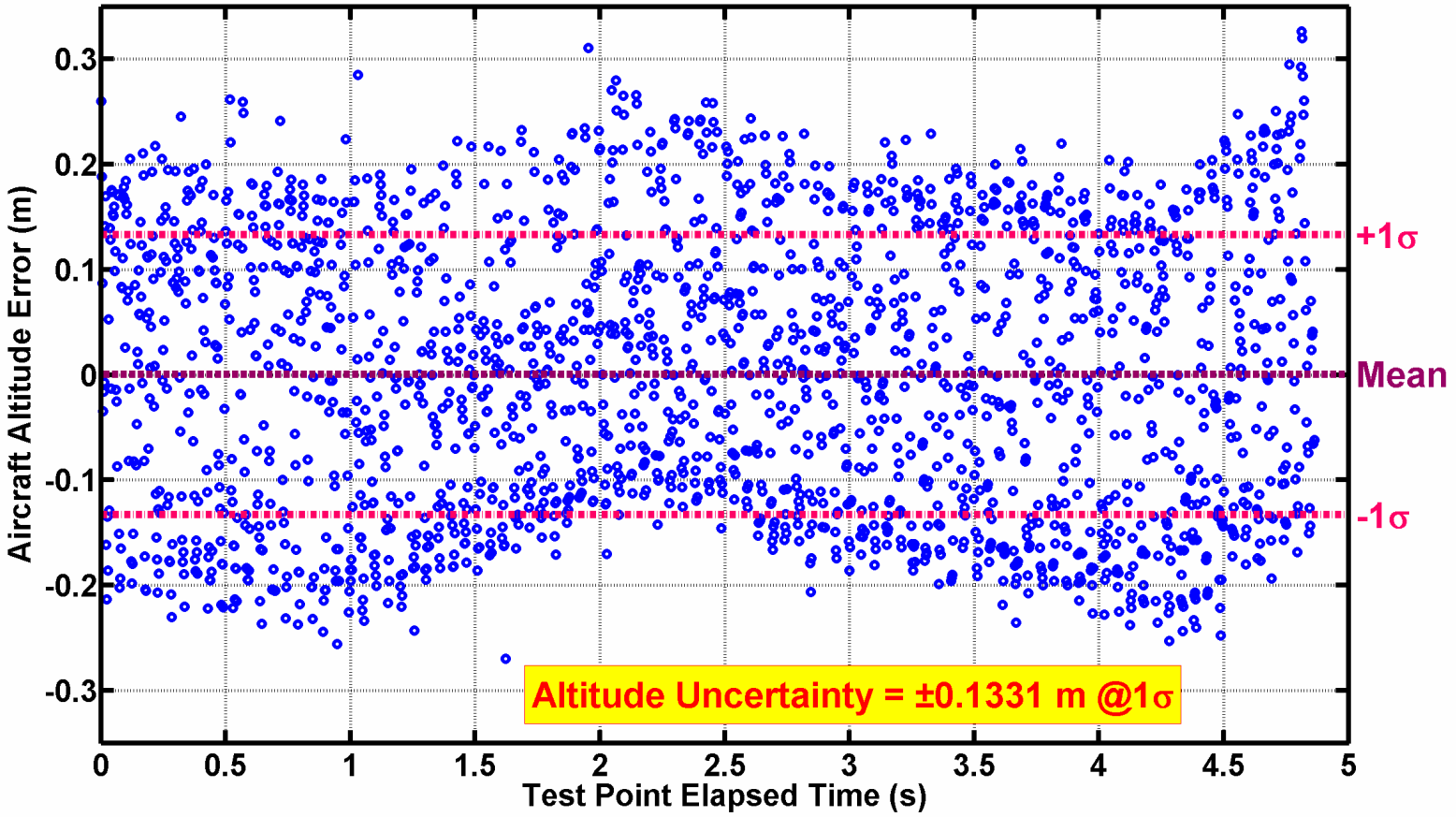
Single frame of a valid TP

Tool Evaluation

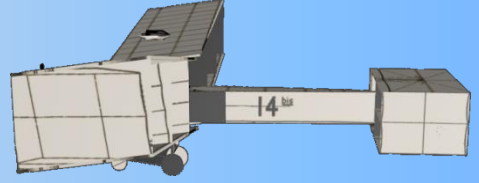


True Reference and Computed Altitude

Tool Evaluation

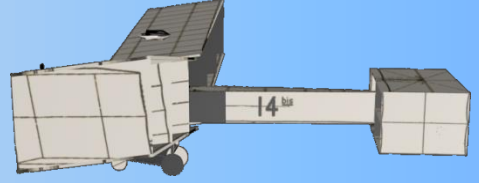


Altitude Uncertainty



Summary

- The development and evaluation of a Hi-Speed near Real-Time 720i Image Processing Application for Flight Test **was successfully executed**.
- This application integrates several simple yet efficient vision tools, which are easy to implement.
- The system can be customized for several aircrafts. As a result the system is very flexible and reliable and it can be used in wide range applications.



Summary

- The next steps are:
  - Evaluate the tool with other aircrafts;
  - Improve system performance using:
    - Parallel processing techniques; and
    - Graphics Processor Unit (GPU) cards;
  - Retrieve images directly from the buffer of high-speed camera; and
  - Develop a tool to integrate this application with GPS and GTS.

Acknowledgement

- We wish to thank the partial support given by the Flight Test Research Institute, specially the Flight Test Course Students, for supporting the measurement and the ADS calibration flight tests campaigns.
- Also we like to thank **FINEP** under agreement 01.07.0663.00 that funded the development of this tool and the presentation trip.