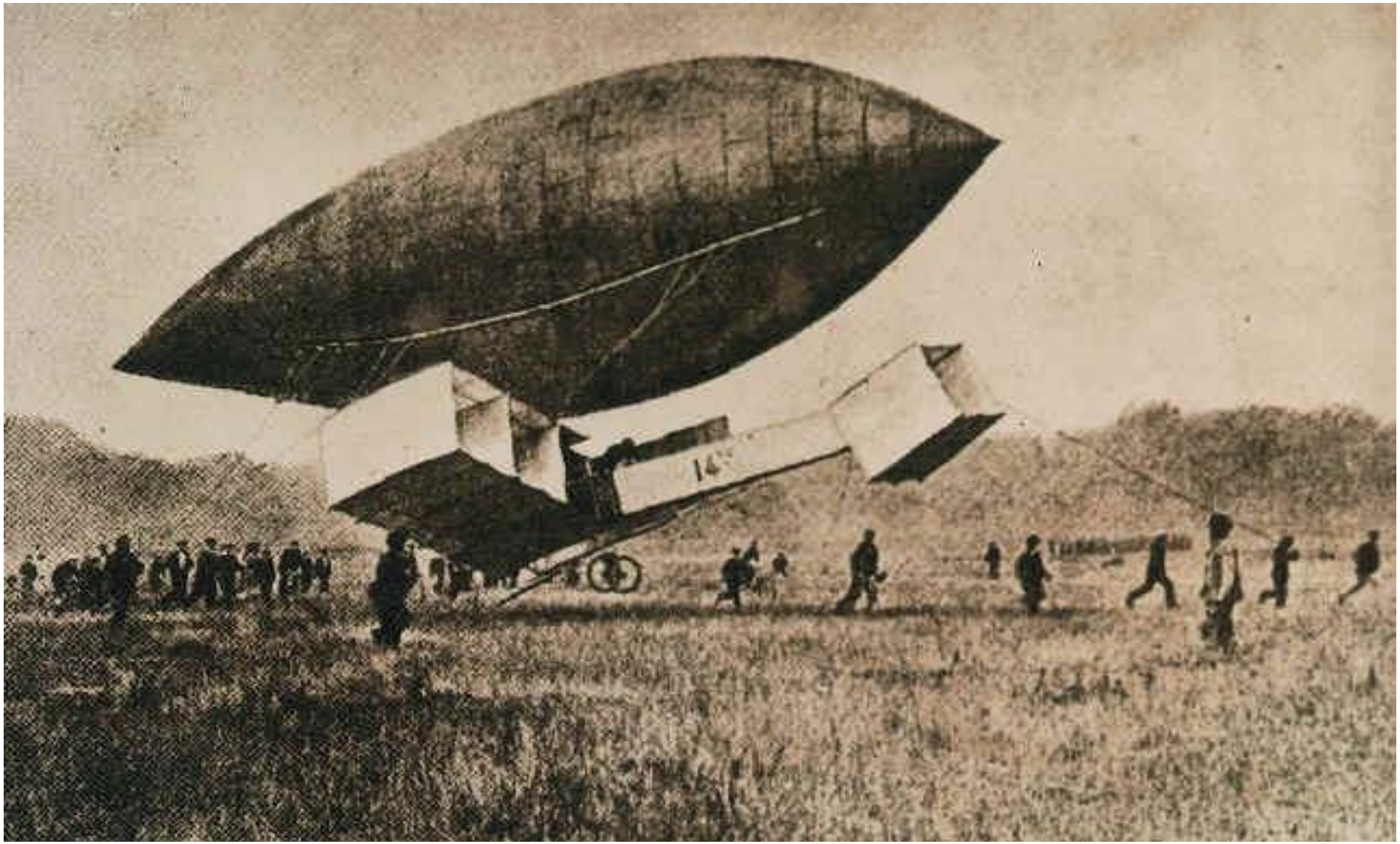
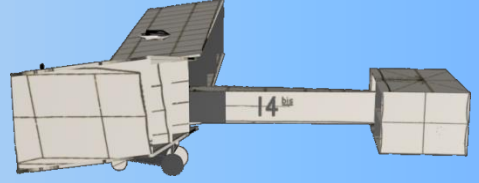

14 bis

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

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



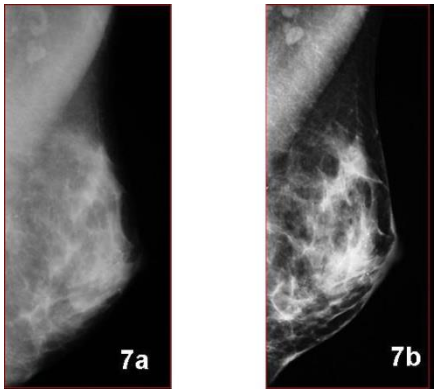
Introduction

- 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

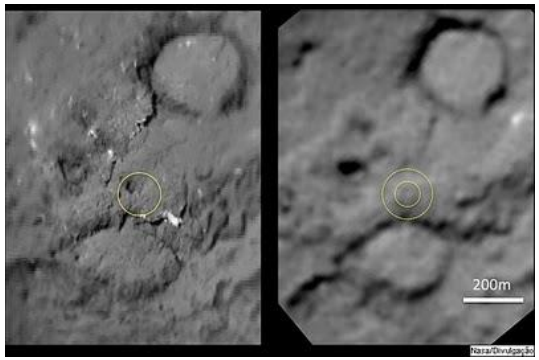
Imaging Processing

- Many applications areas

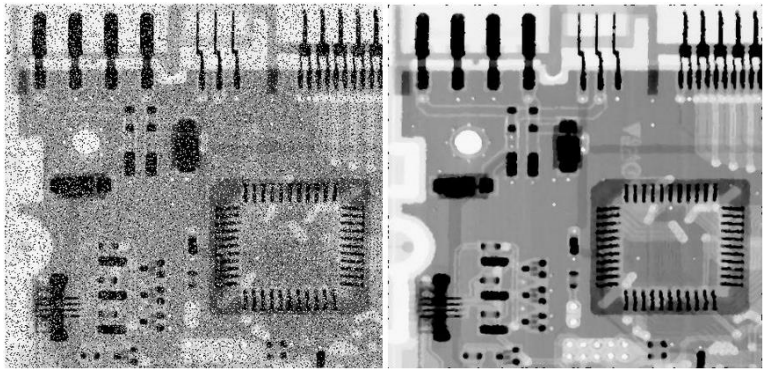
Fingerprint recognition



Digital mammography



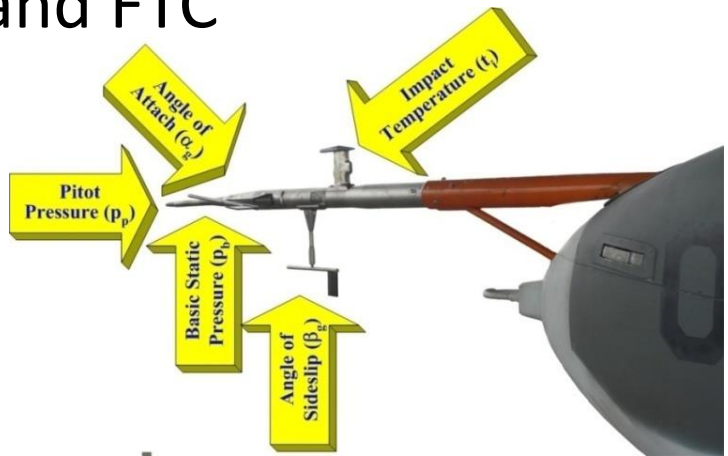
Tempel-1 Comet

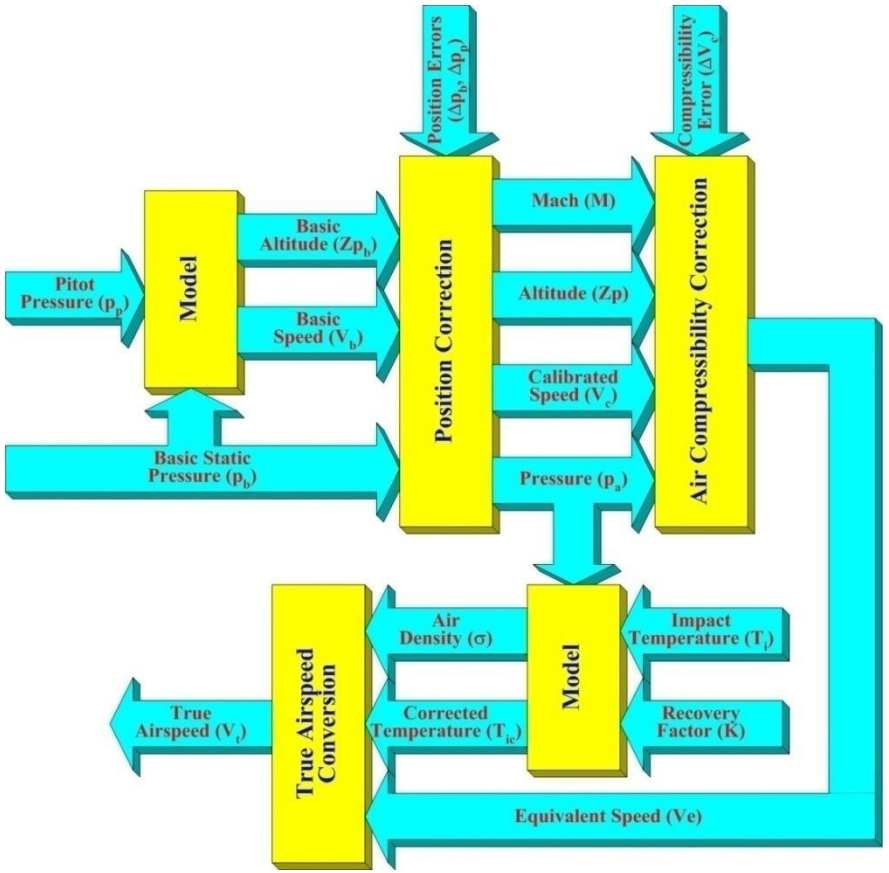


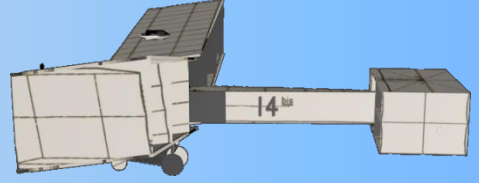
Electronic Circuit

ADS FTC Overview

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



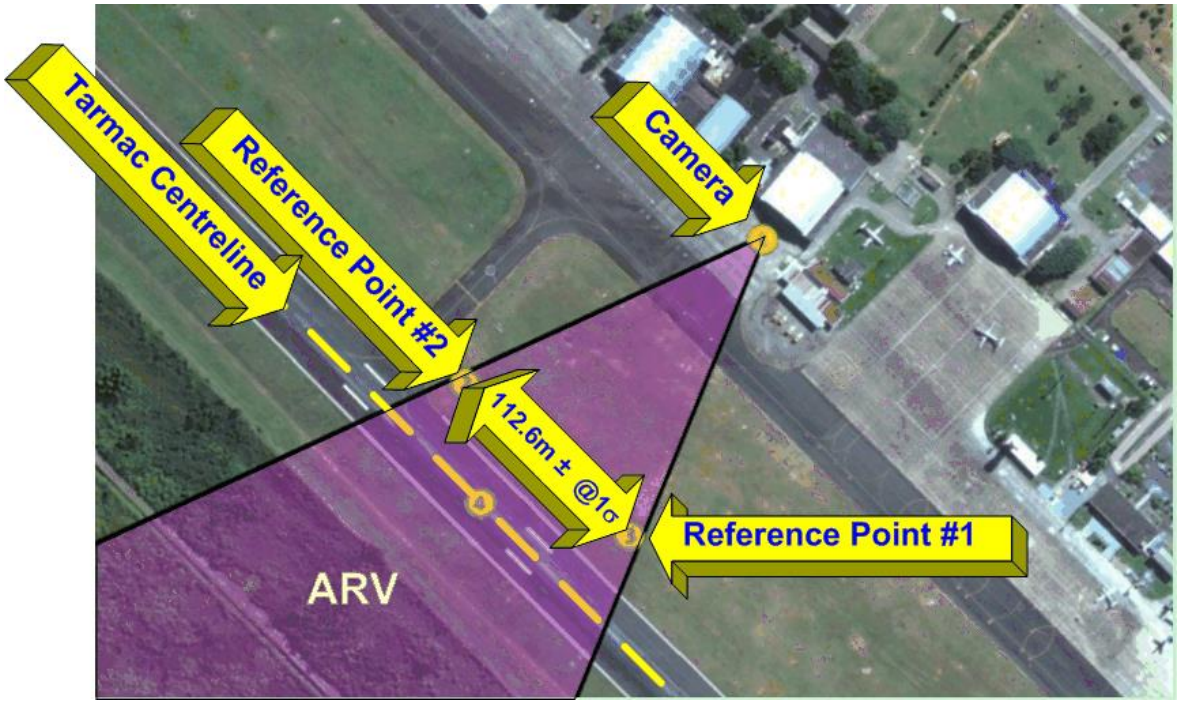




ADS Calibration

- 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



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

ADS Calibration

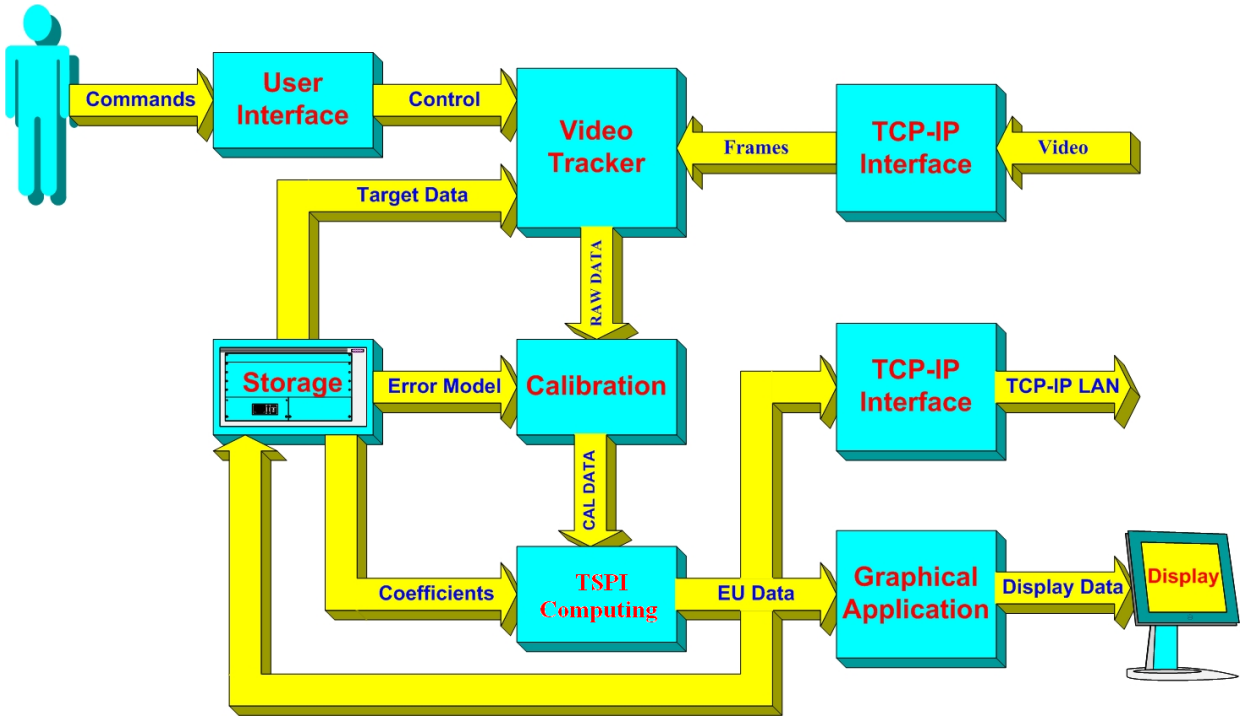
Valid Test Point with H-55 Helicopter

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

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

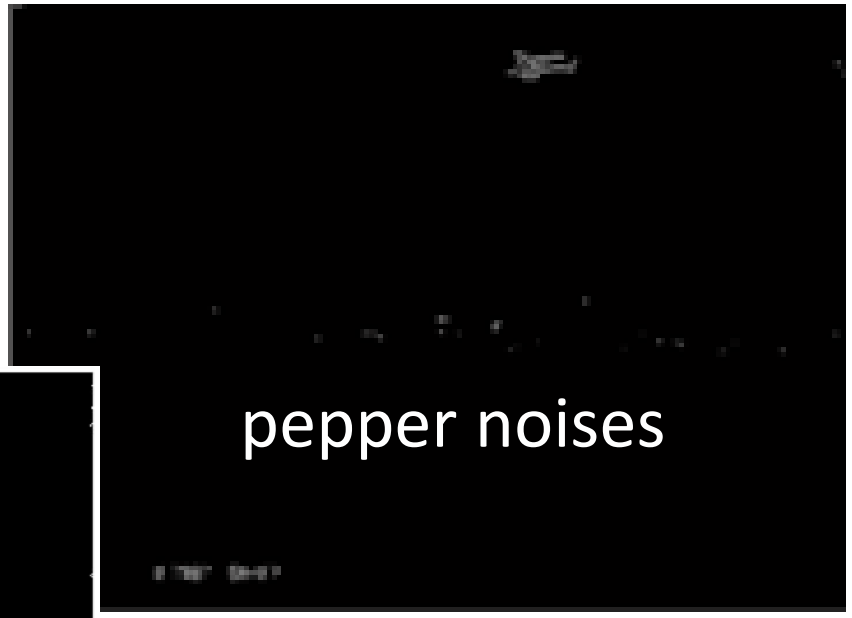
- Algorithms:
  - Reference point detection;
  - Tarmac centreline detection;
  - Aircraft detection;
  - TSPI Computing; and
  - Test Point Validation

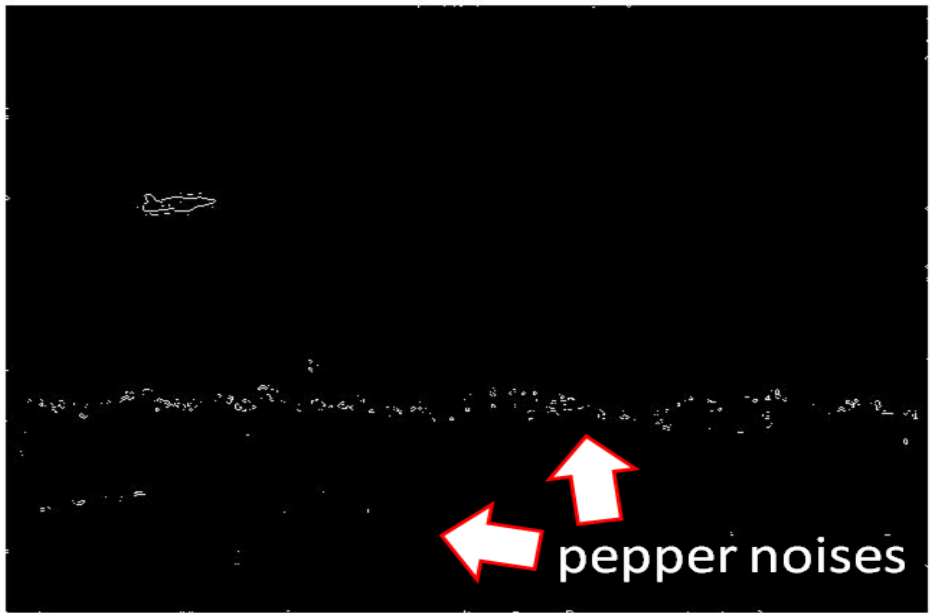
Aircraft Detection

- 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

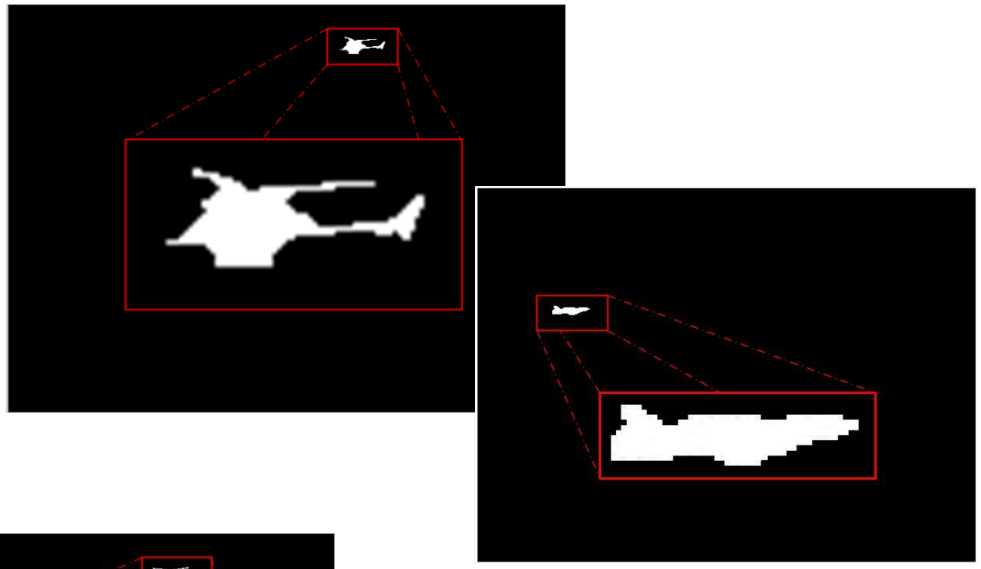
- Next steps:
  - Detect edges
  - Remove pepper noises

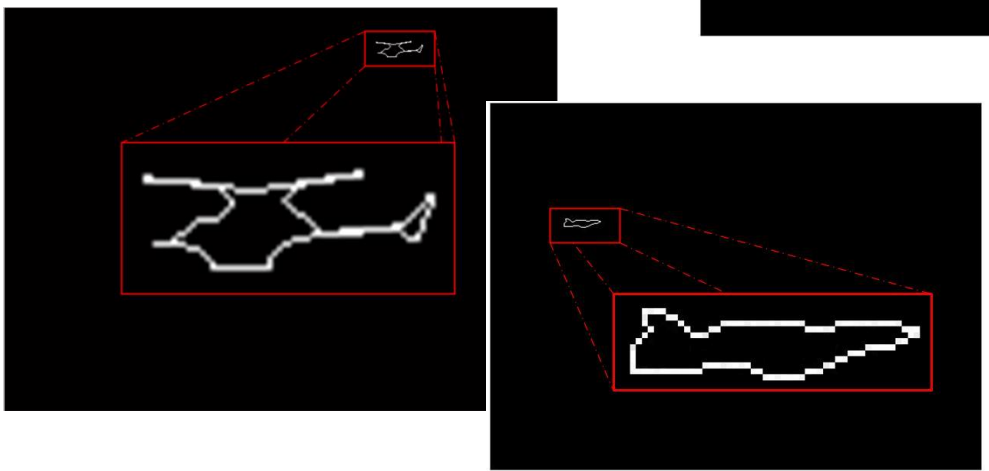




Aircraft Detection

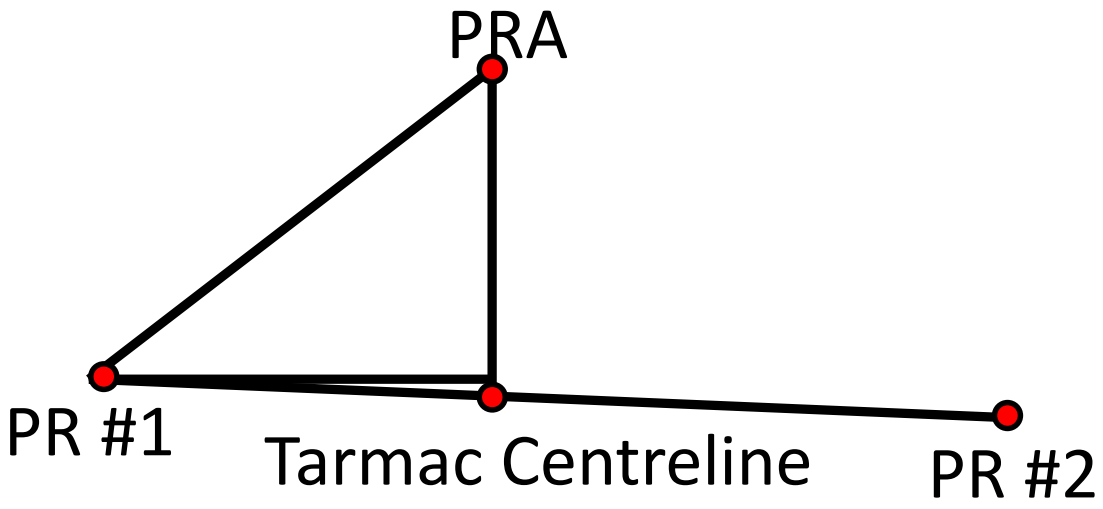
- Next steps:
  - Perform CCL
  - Sort ascending size order (CCL)
  - Biggest CCL contains aircraft
  - Perimeter Pixels





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



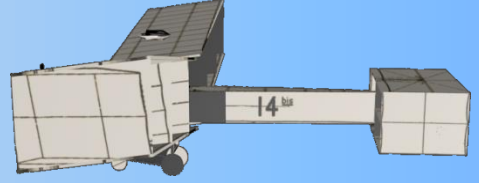
$$V_t = \frac{k\Delta S}{\Delta t} \ (\mathrm{m/s})$$

Tool Evaluation

HELIBRAS Esquilo H55

MacroVis SpeedCam

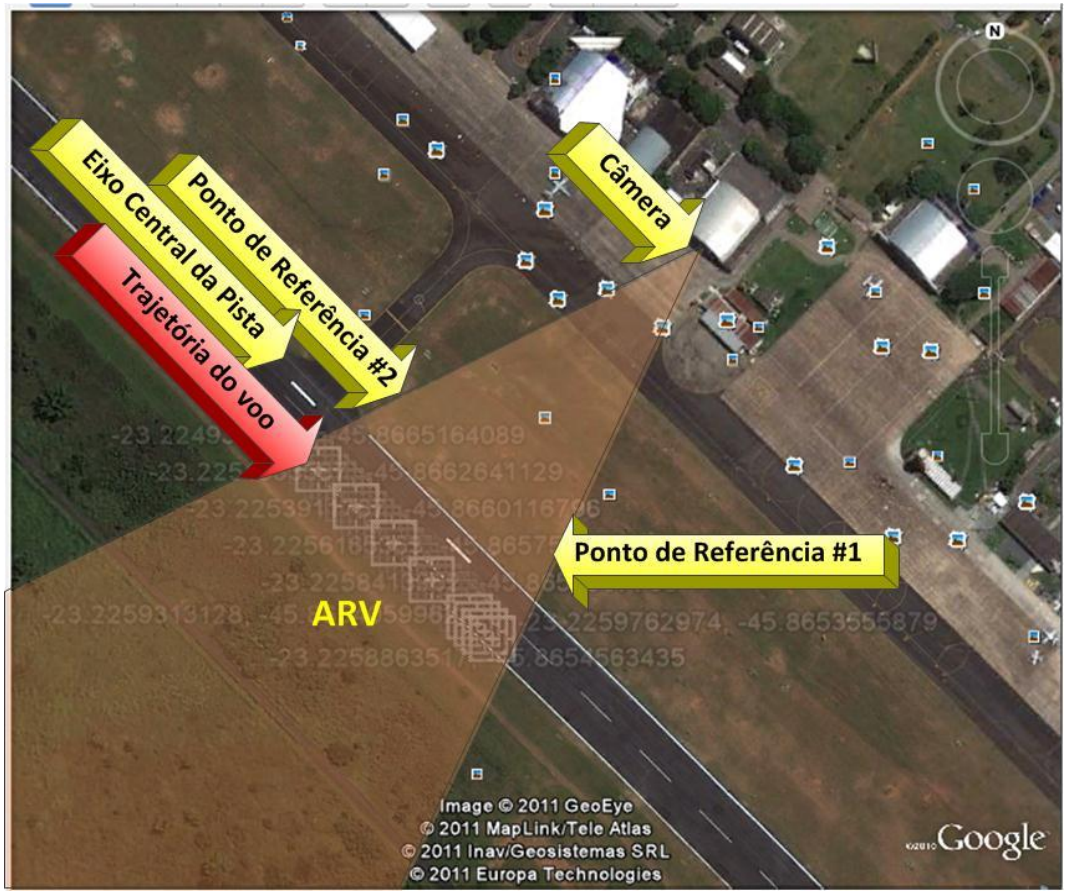
EMBRAER Xavante Jet XAT-26



Tool Evaluation

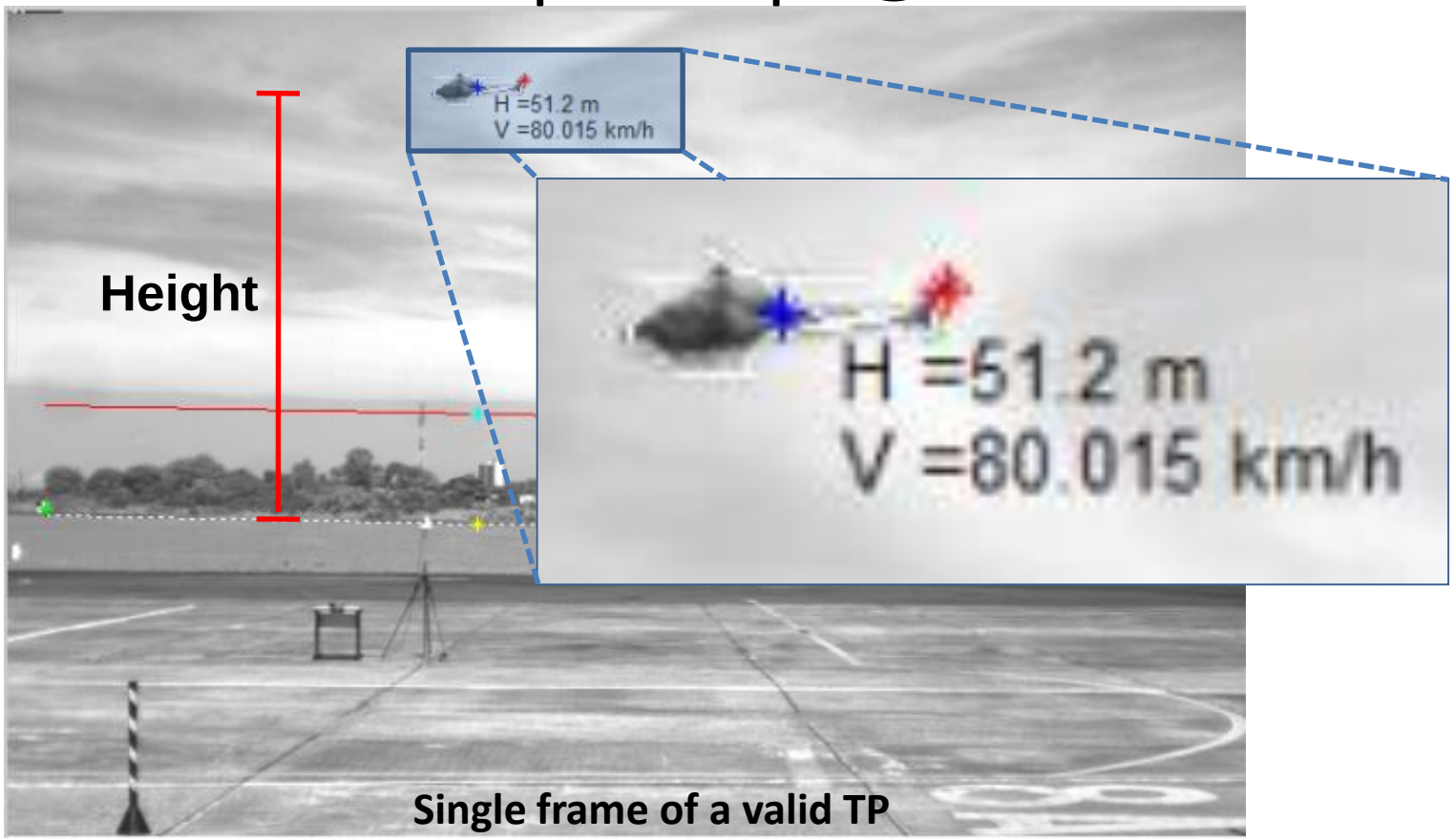
- MatLab® environment
- Intel®Pentium IV Core™ 2 Duo CPU T5800 2.00 GHz notebook, 4 Gb RAM and Microsoft Windows 7 Professional.
- Camera: best configuration was to generate images in grayscale, 400 fps and 720i resolution.

Tool Evaluation



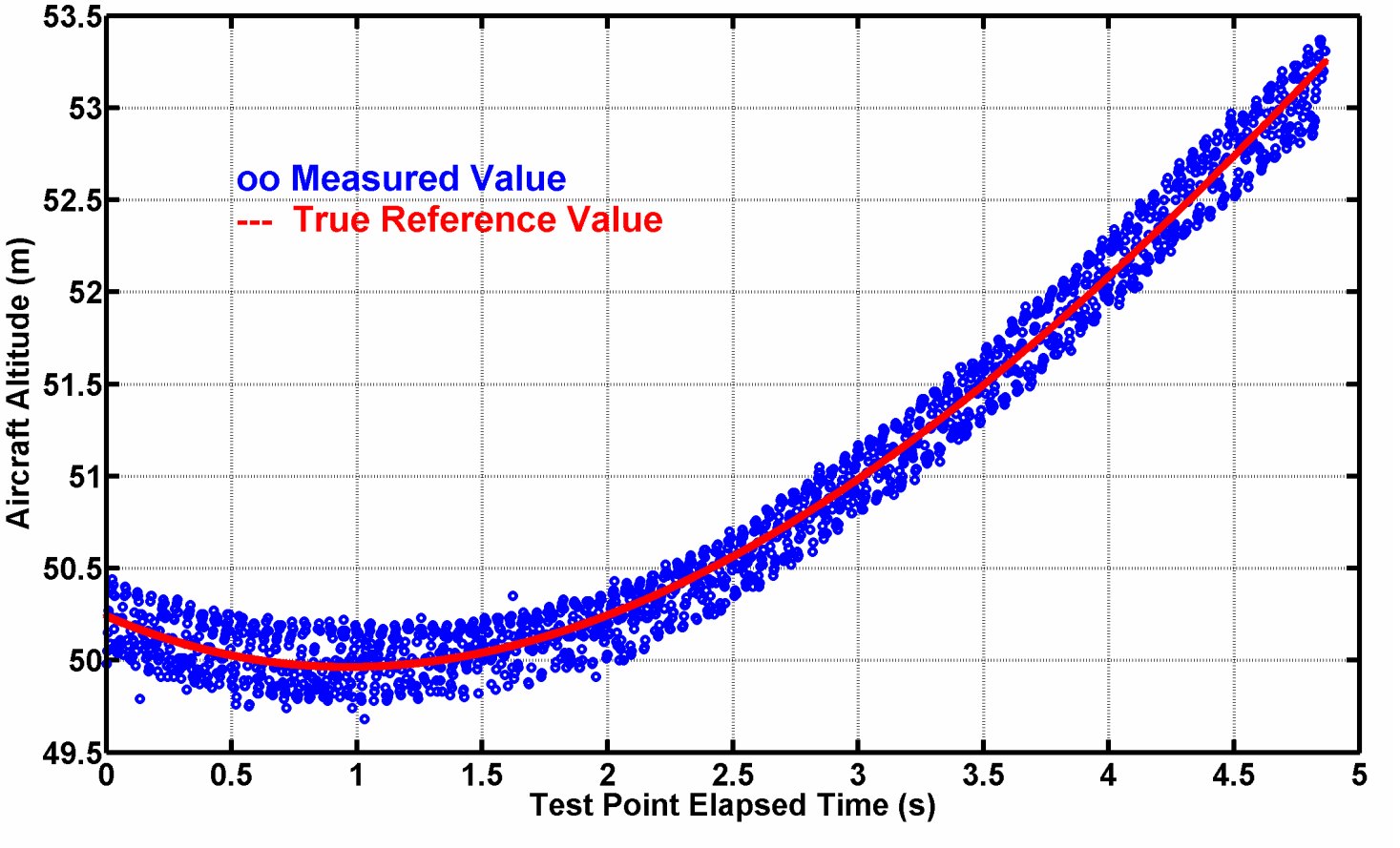
Tool Evaluation

Runs at 52 fps ± 2 fps @1σ



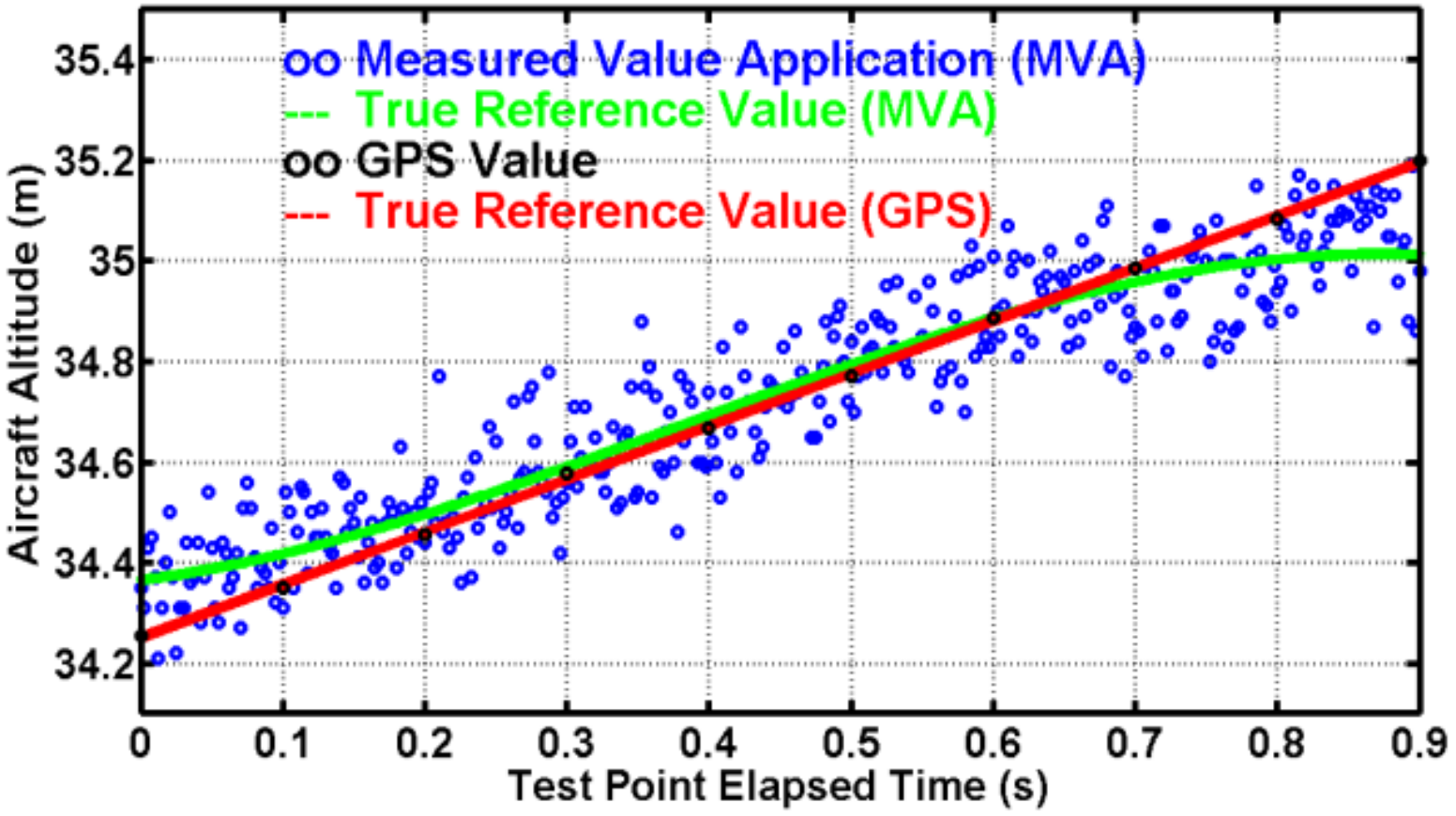
Single frame of a valid TP

Tool Evaluation



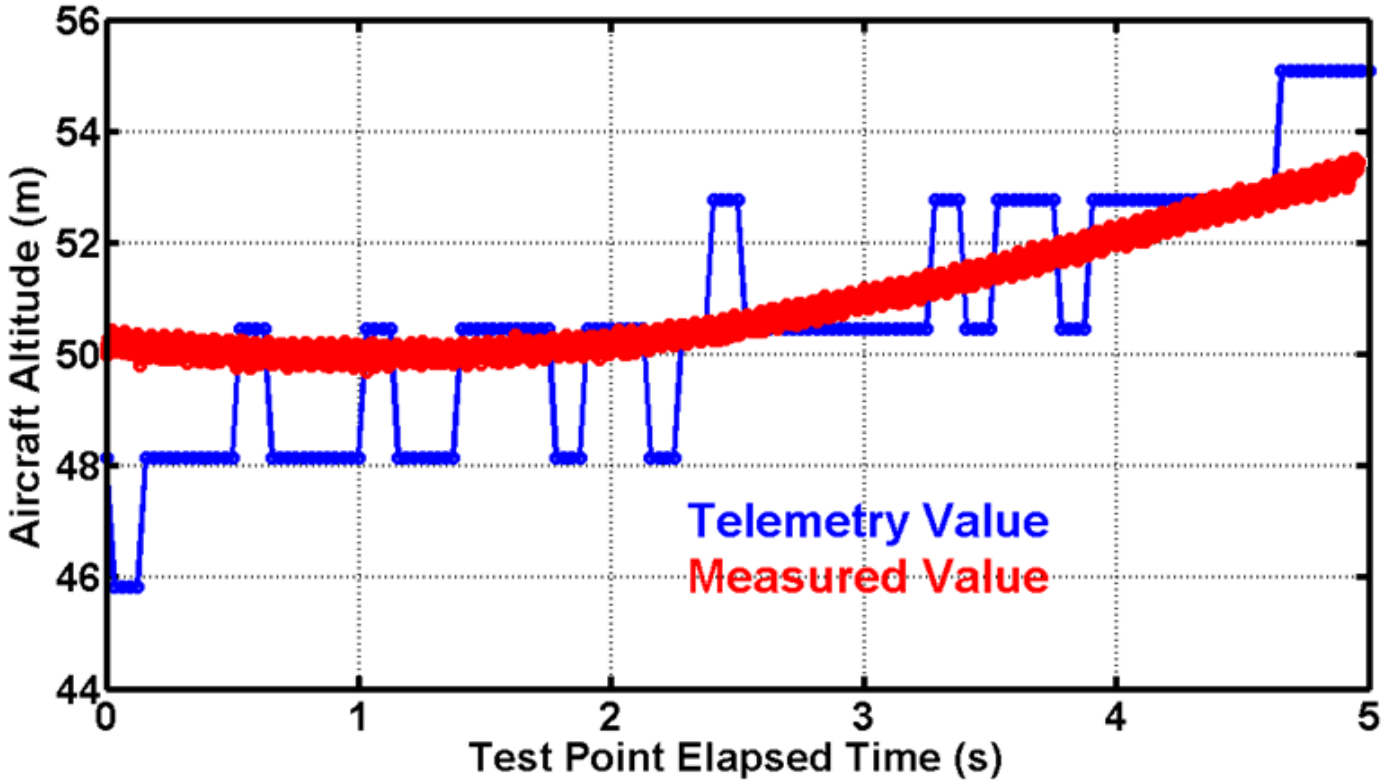
True Reference and Computed Altitude

Tool Evaluation



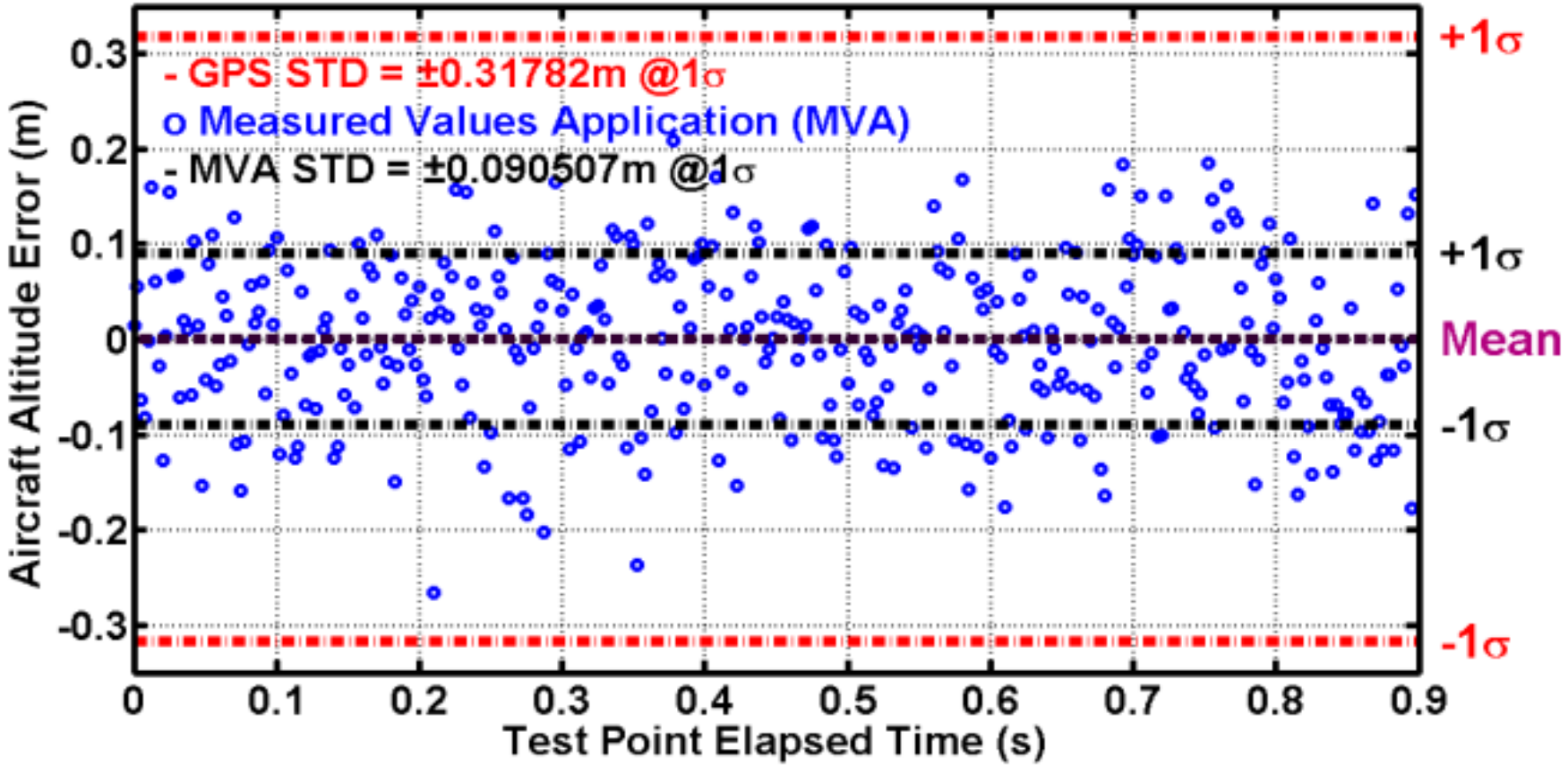
Computed Altitude by the Application and Measured Altitude by the GPS

Tool Evaluation



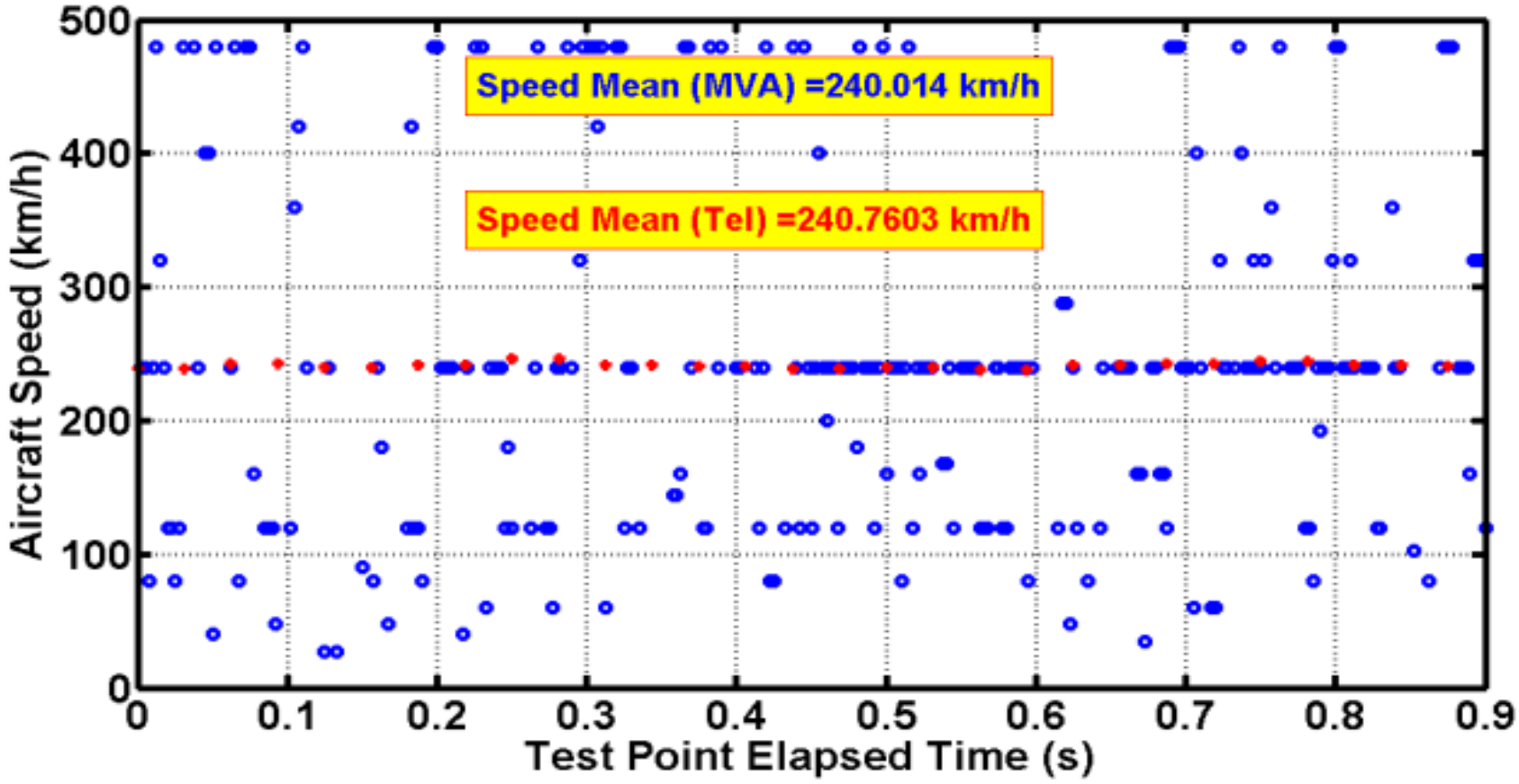
Computed Altitude by the Application and Measured Altitude by the GTS

Tool Evaluation

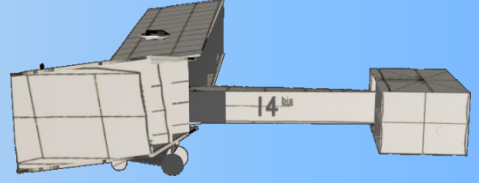


Uncertainty Altitude with XAT-26

Tool Evaluation



Computed Airspeed by the Application and Measured Airspeed by the GTS



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;
  - Develop a tool to integrate this application with GPS and GTS.

Acknowledgement

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