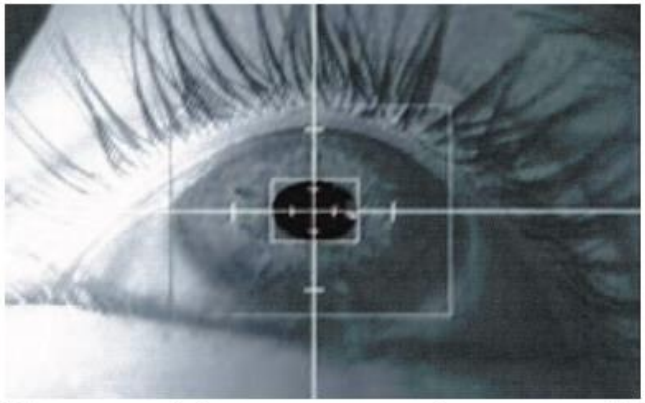
Eye tracking for flight safety

"From laboratory to everyday activity"

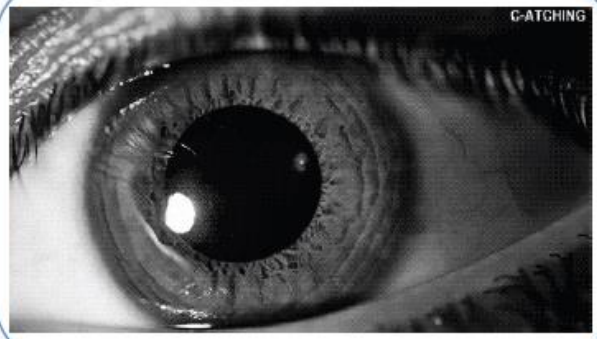
AXA Research Fund
Through Research, Protection

Pr. Frédéric Dehais, Maxime Reynal

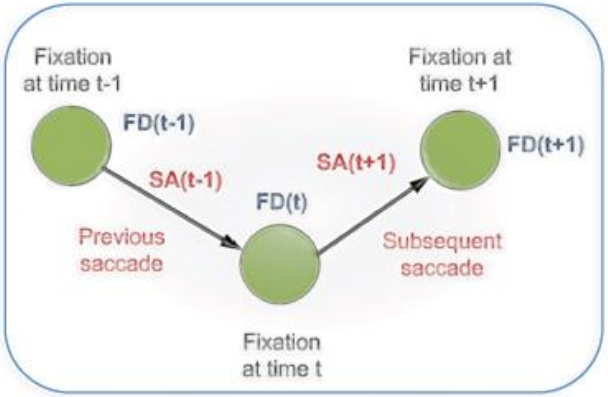
Eye tracking - metrics



Eye tracking – assessing cognitive performance (see [Holmqvist et al, 11])



Pupillometry



Eye movements analysis

AOI-based analysis

PARG Project: Loss of Aircraft trajectory during go-around

- **Why this study:**
  - 1985-2000: 10 accidents/serious accidents
  - 2001-2009: 14 accidents/serious accidents
  - Since 2010: a trend of increasing accidents

    ⟶ CFIT - situation awareness issues!
- **BEA has decided to:**
  - Conduct a deeper analysis all of these events
  - Design an on-line national survey (open/closed questions)
  - Experiment with 2 synchronized eye tracking system

PARG Project: Loss of Aircraft trajectory during go-around

- BEA: project leader
- Airbus: expertise + 330 full flight sim
- Airlines: Air France (expertise777 full flight sim), XL and Corsair
- Dédale (HF company): expertise, debriefing/behavioral analysis
- Jean Pinet (former flight test pilot): expertise, survey analysis
- ISAE Supaéro: Eye tracking

PARG Project: Loss of Aircraft trajectory during go-around

Part 1:

"on line" survey

PARG Project: Survey (700 participants)

- Training issue:
  - Rare event (medium haul flight crew: 1GA/year, long haul flight crew: 1 GA/5 to 10 years)
  - Lack of training in fligh sim (mostly N-1/engine failure)
- CRM issues: lack of assistance/monitoring from PM
- Automation issues: mode transitions issues, AP/ATHR nor properly engaged, authority conflict (eg. Trim, GA below current altitude)
- ATC: "last minute" go around procedure, long clearance, disturbing
- High load/attentional tunneling: eg. VFE, one axis vs the other

PARG Project: Loss of Aircraft trajectory during go-around

Part 2:

Experiment

PARG Project: Scenario(s)

- Go-Around #1 : low energy, low altitude, Manual GA, ATC "surprise"
  - Night 36L ILS Lyon St Exupery approach
  - 200ft : go-around is required with different heading (340 instead of 350) and altitude (2500ft instead of 5000ft)
- Go-Around #2: low energy, low altitude, Manual GA, crew decision
  - Night 31R ILS Marseille approach
  - 15/20 kts gusts of wind (tail-wind) leading crew to go-around
  - ATC requires 2000ft (instead of 3500ft)
- Go-Around #3: AP/go around, First officer is PF
  - Night LOC/DME 13L Marseille
  - Too low visibility leading crew to go-around

PARG Project: Scenario(s)

	Aicraft	GA#1 (ATC decision)	GA#2 (crew decision)	GA#3(crew decision)
Crew 1-6 (1 airliner)	Boeing 777	Captain PF/First officer PM		Captain PM/First officer PF
Crew 7-11 (3 airliners)	Airbus 330	Captain PF/First officer PM		Captain PM/First officer PF

- **Briefing: 15-30'**
- **Flight preparation in the cockpit + eye tracker: 40'**
- **Flight scenario: 2h15**
- **Debriefing: 1h30**

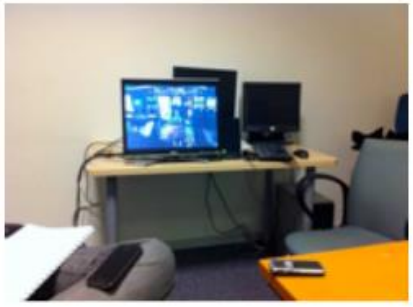
Objective measurements: ***Eye tracking, video recording***

→ ocular activity, crew's action & communication

PARG Project: Loss of Aircraft trajectory during go-around

2 synchronized eye trackers

PARG Project: experimental set up



PARG Project: Behavioral Results

- Training issue:
  - Rare event (medium haul flight crew: 1GA/year, long haul flight crew: 1 GA/5 to 10 years)
  - Lack of training in fligh sim (mostly N-1/engine failure)
- CRM issues: lack of assistance/monitoring from PM
- Automation issues: mode transitions issues, AP/ATHR nor properly engaged, authority conflict (eg. Trim, GA below current altitude)
- ATC: "last minute" go around procedure, long clearance, "noisy"expertise, survey analysis
- High load/attentional tunneling: eg. VFE, one axis vs the other

PARG Project: videos

PARG Project: Behavioral Results

- All flight crews managed to perform the maneuver:
  - Go around mean duration : 1'10" (range 55"-1'42")
  - All PMs but one reported high workload (PF's call out, ATC, actions)
  - ATC instructions:
    - Only 3 crews were able to read back the complete sequence
    - 7 crews : 20-30" to dial ATC instructions
  - Half of the crews experienced lateral or horizontal deviations
  - FMA issues

PARG Project: Area Of Interests (AOIs)

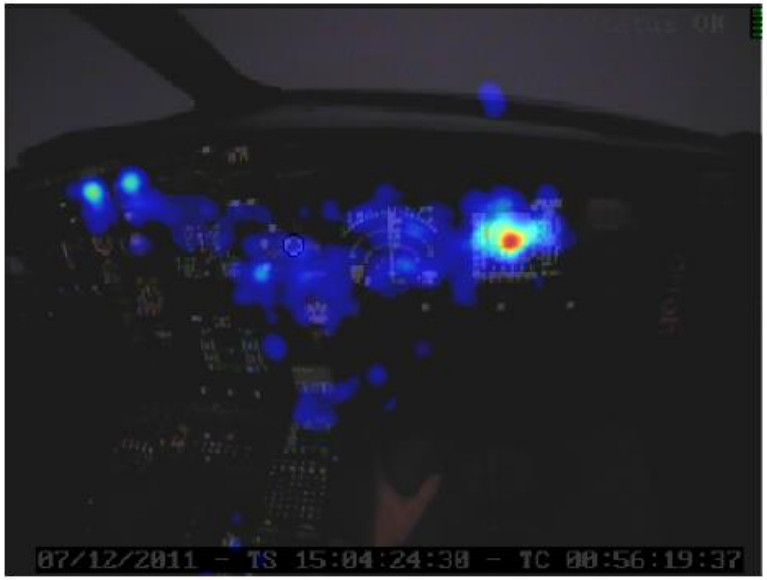
Captain

First Officer

PARG Project: heatmaps

Captain

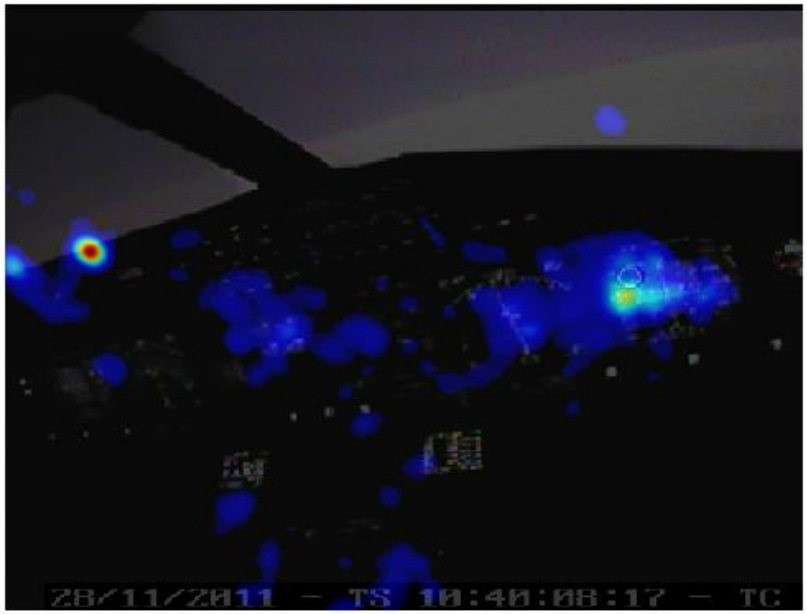
First Officer



PARG Project: Area Of Interests (AOIs)

Captain

First Officer



PARG Project: Eye tracking results

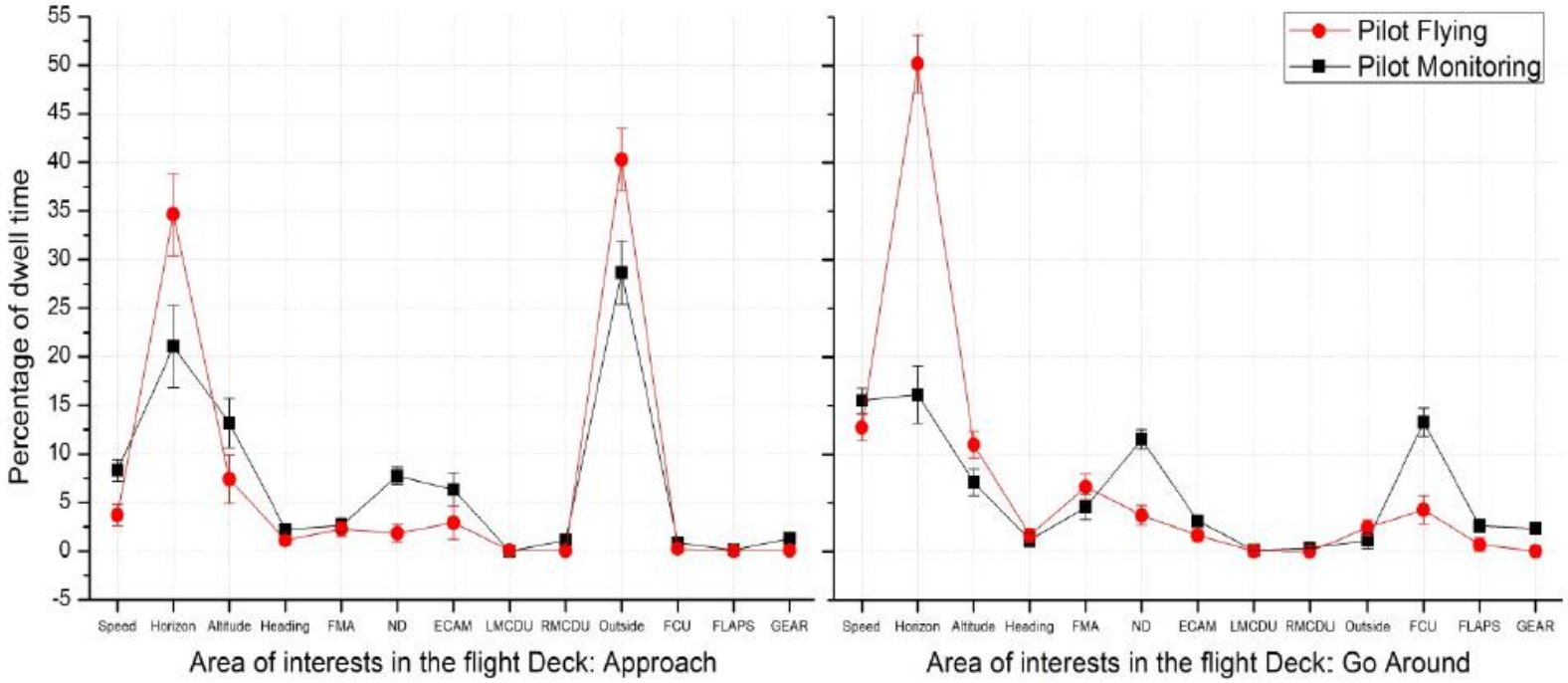
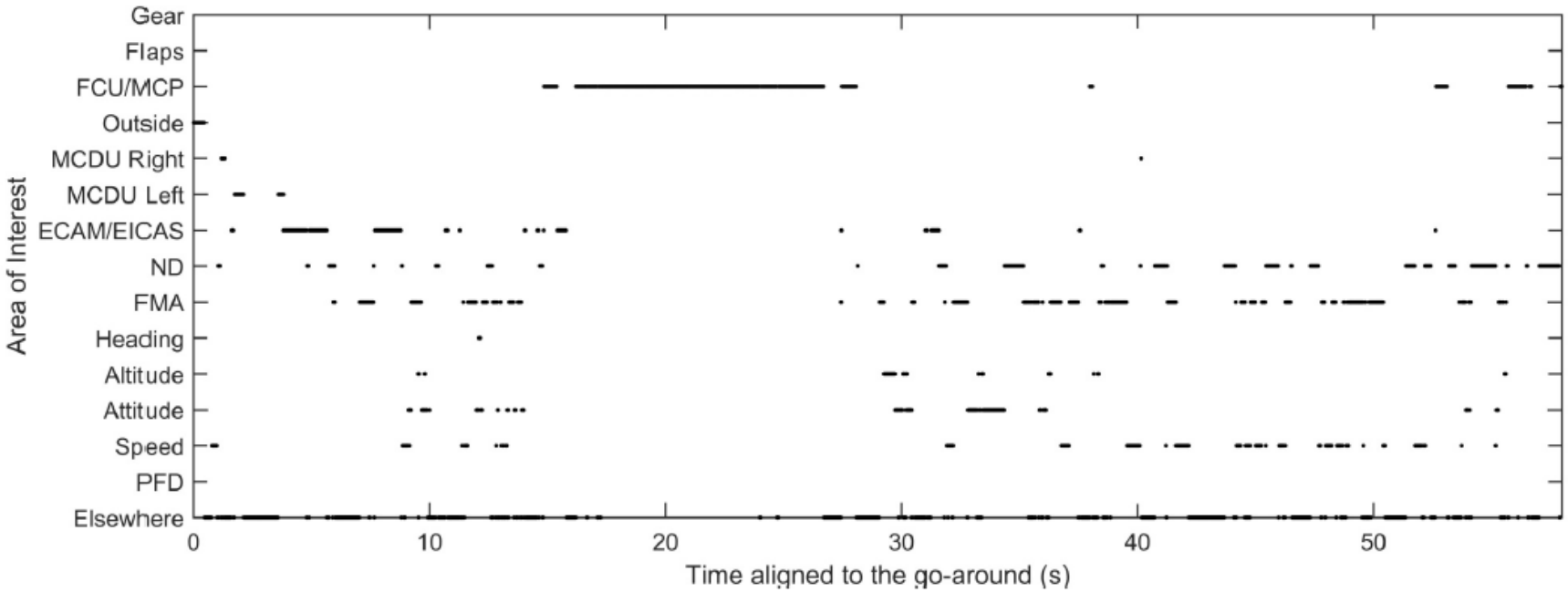


Figure 2. Distribution of the PF's and PM's eye gaze over the different AOIs during final approach (left) and go-around (right)

PARG Project: Eye tracking results



The gaze of the pilot monitoring of the crew n°3 during the go-around phase according different areas of interest.

PARG Project: Eye tracking results

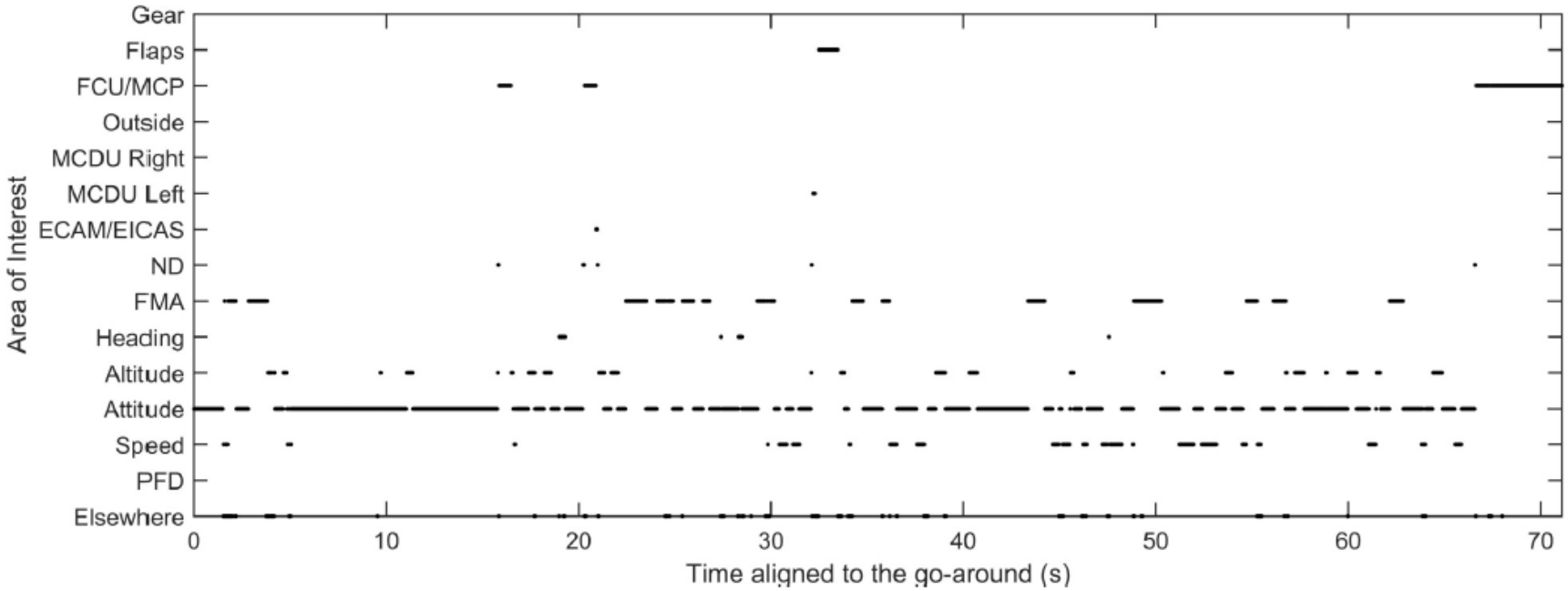


Figure 7. The gaze of the pilot flying of the crew n°8 during the go-around phase according different areas of interest.

PARG Project: Loss of Aircraft trajectory during go-around

DSAC eye tracking project

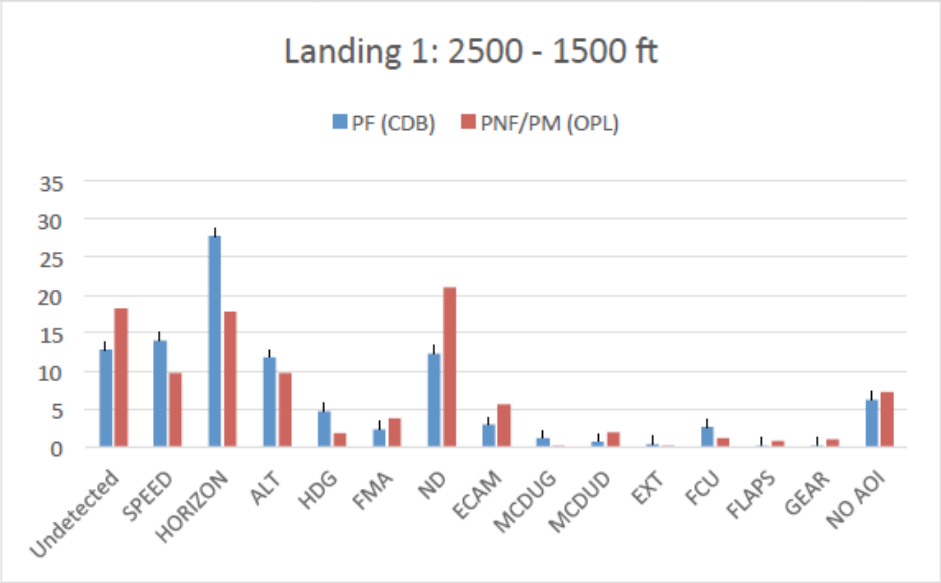
DSAC Project: analyzing pilot's ocular behavior during landing

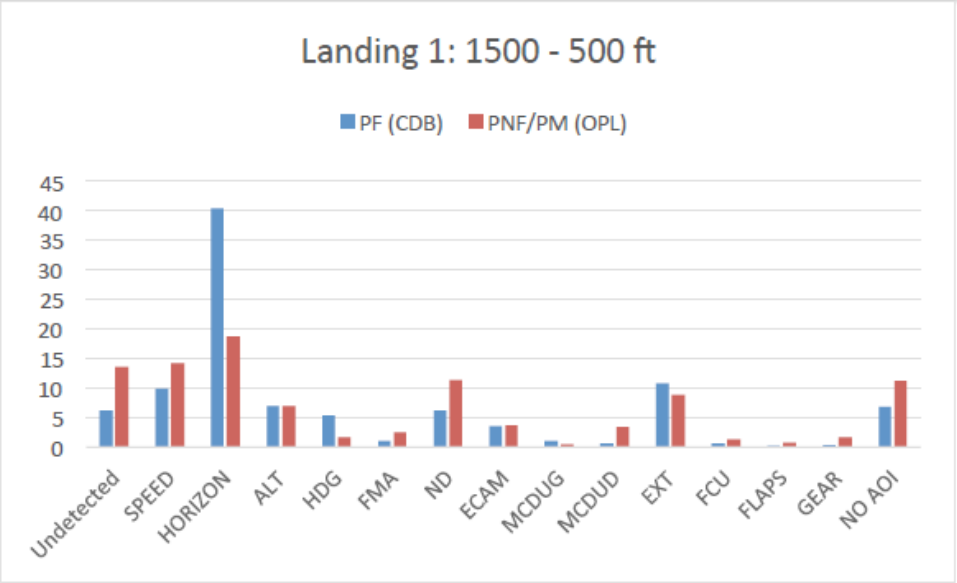
- DSAC motivations:
  - PF and PM's ocular behavior (fix time and scan pattern)
  - Defining standards (eg. min fix. time on speed indicator)
  - Potential of eye tracking for flight safety
- ISAE has collected:
  - 4 landings *12 crews * 12 pilots (B777 & A330) = 96 analyses
  - 4 landings * 28 PF (B737 old and new generation)
  - 2500 – 1500ft; 1500-500ft; 500ft –touch down/GA

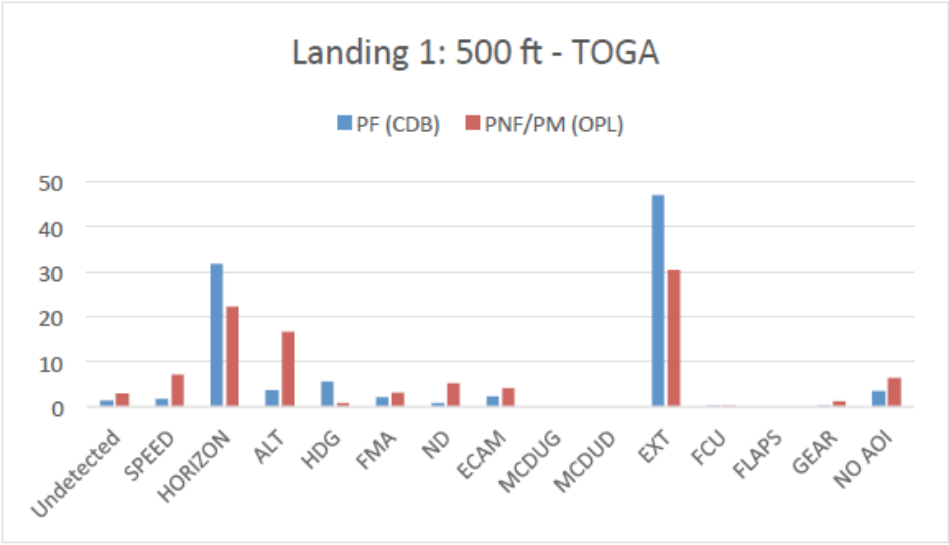
PARG Project: Loss of Aircraft trajectory during go-around

- Landing #1 :
- Night 36L ILS Lyon St Exupery approach
- Manual landing
- Captain = PF ; First officer = PM

DSAC Project: landing 1



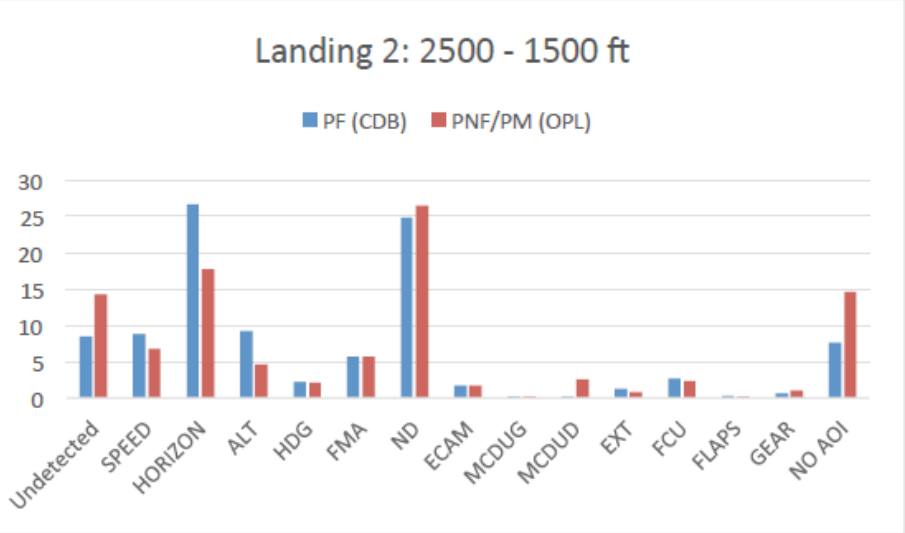


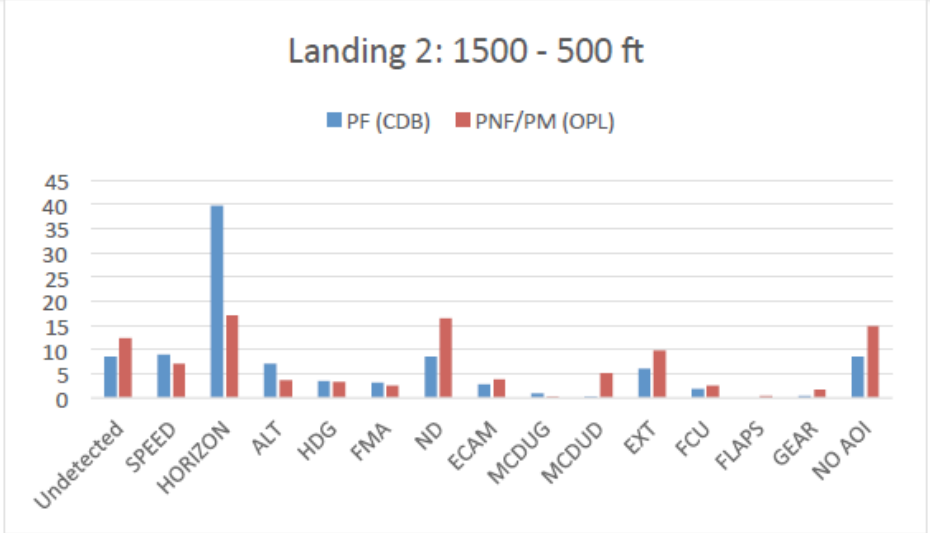


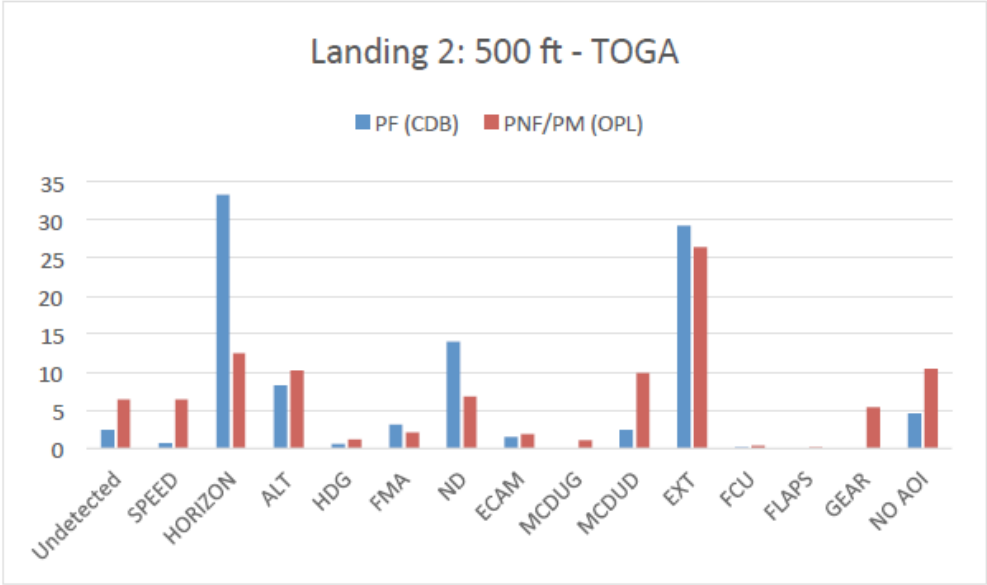
PARG Project: Loss of Aircraft trajectory during go-around

- Landing #2:
  - Night 31R ILS Marseille approach
  - Manual landing
  - Captain = PF ; First officer = PM

DSAC Project: landing 2



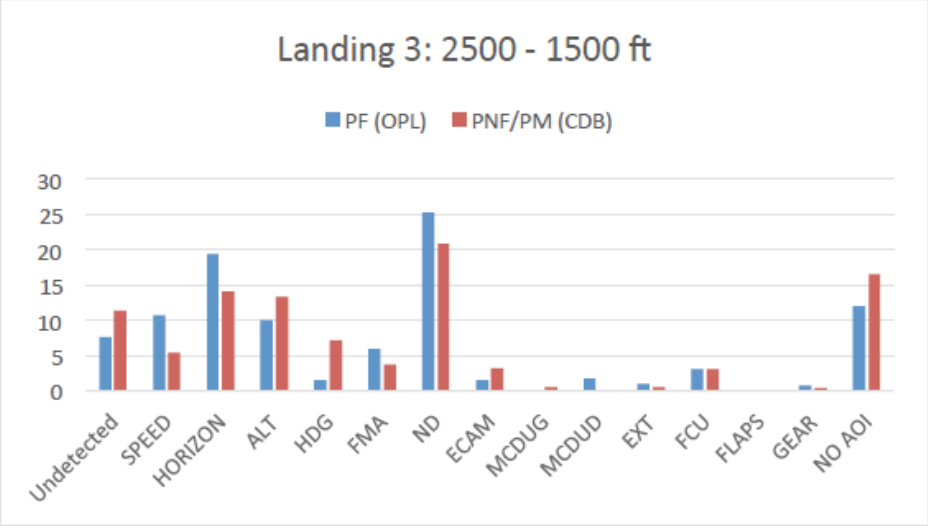


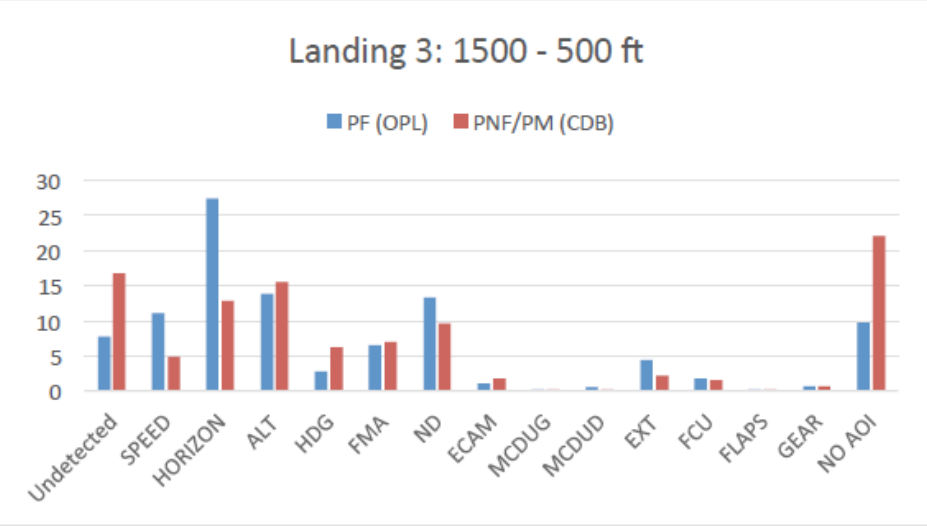


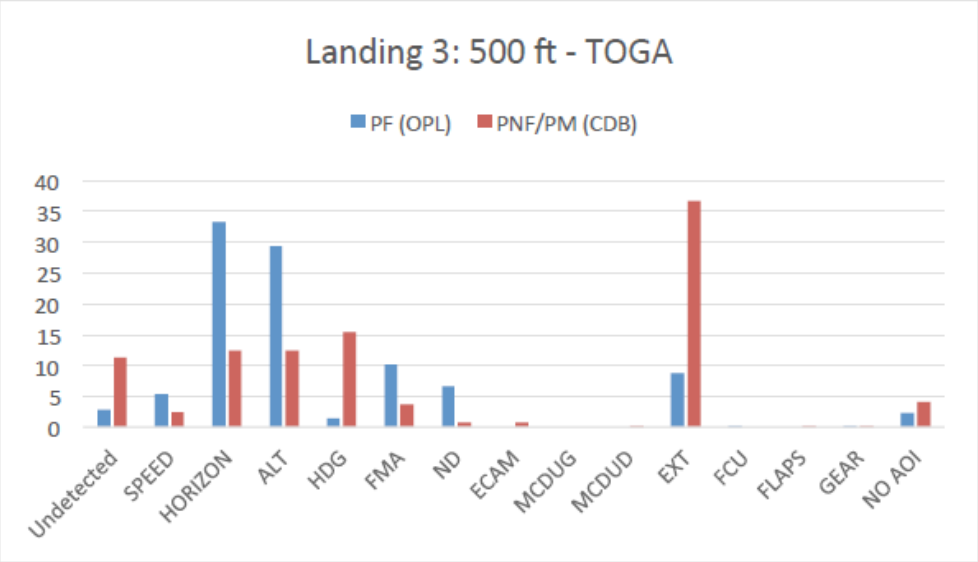
PARG Project: Loss of Aircraft trajectory during go-around

- Landing #2:
  - Night LOC/DME 13L Marseille - IMC
  - Automated landing
  - Captain = PM ; First officer = PF

DSAC Project: landing 3



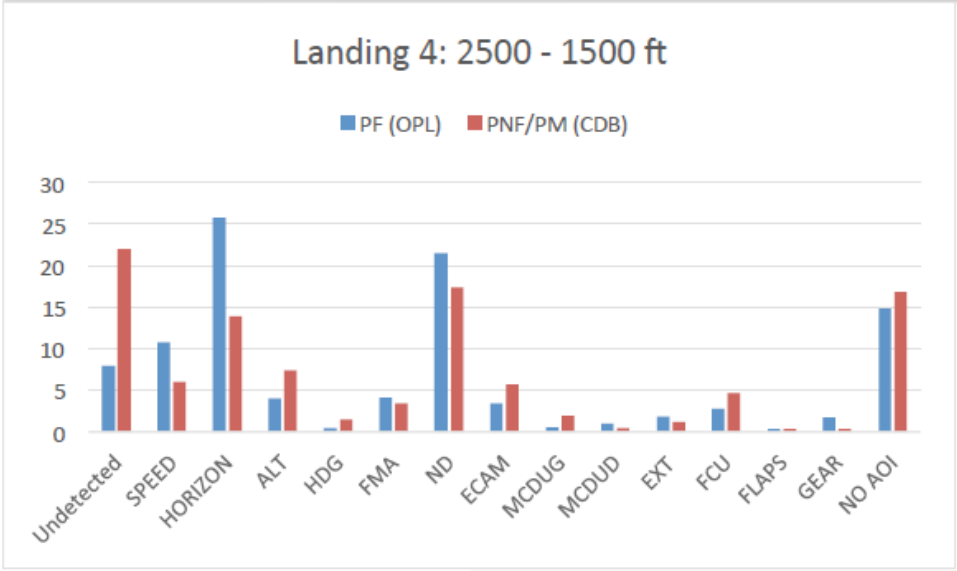


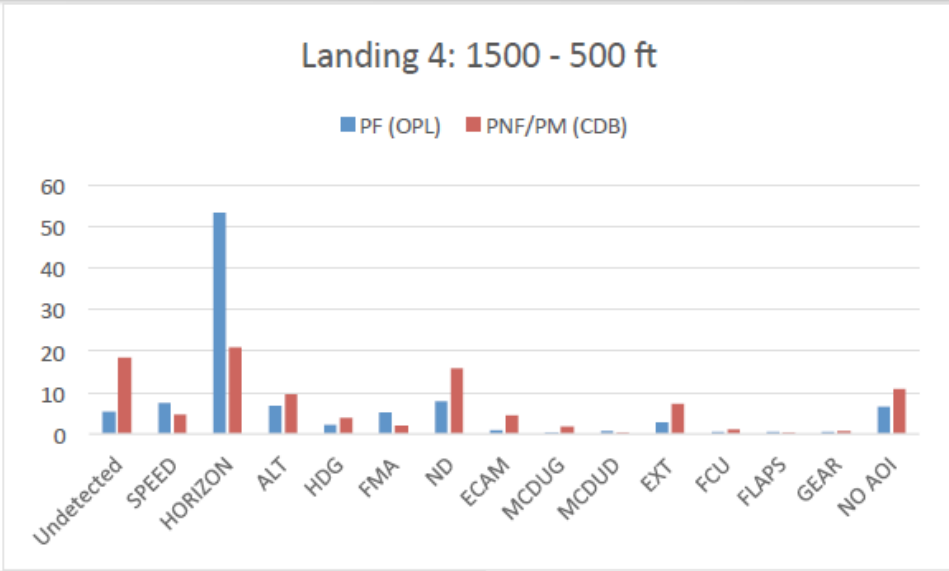


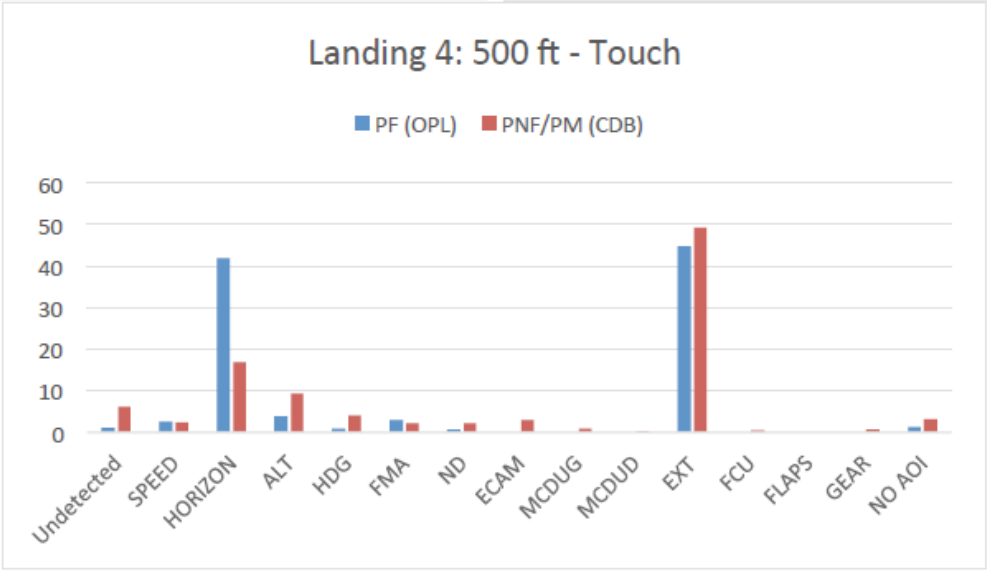
PARG Project: Loss of Aircraft trajectory during go-around

- Landing #4:
  - Night LOC/DME 13L Marseille
  - Manual landing
  - Captain = PM ; First officer = PF

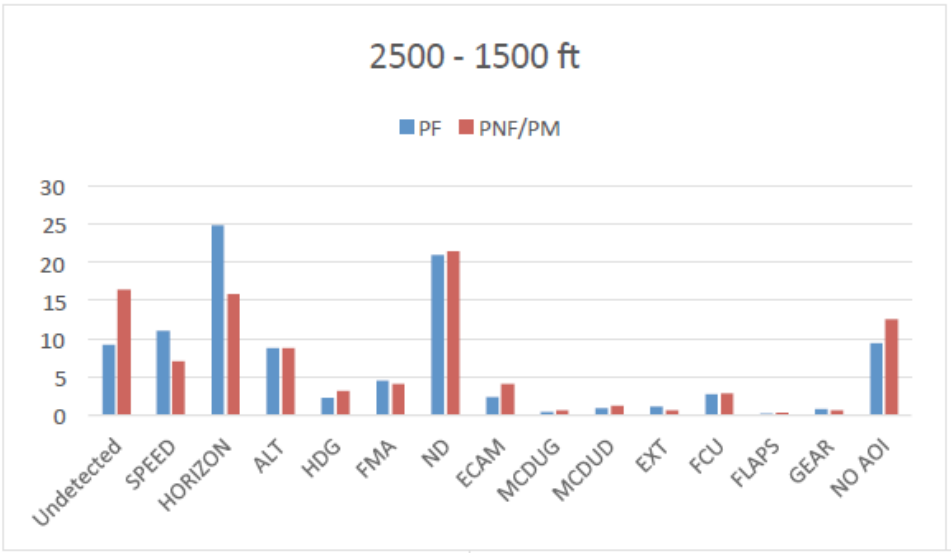
DSAC Project: landing 3

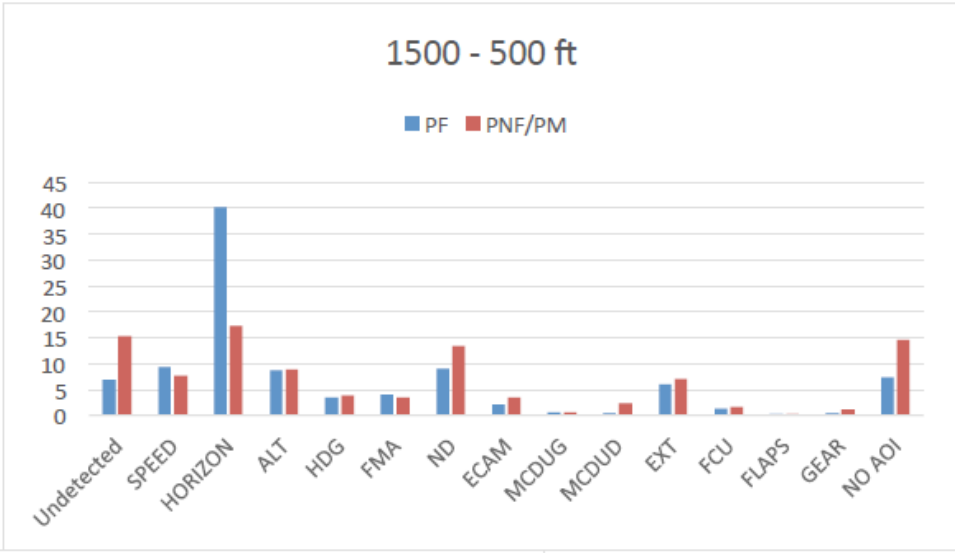


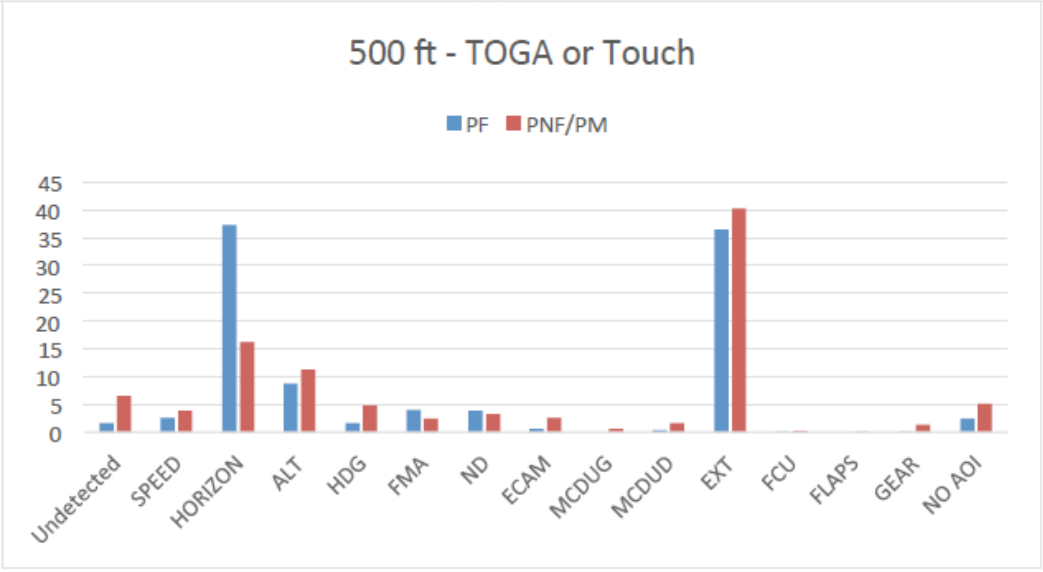




DSAC Project: all landings - mean







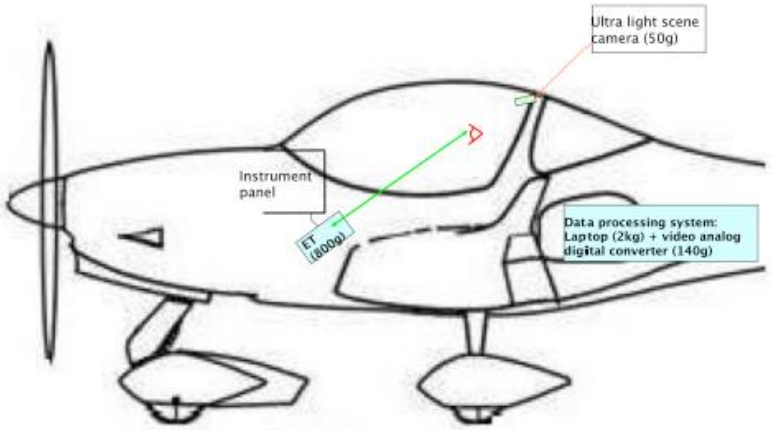
PARG Project: Loss of Aircraft trajectory during go-around

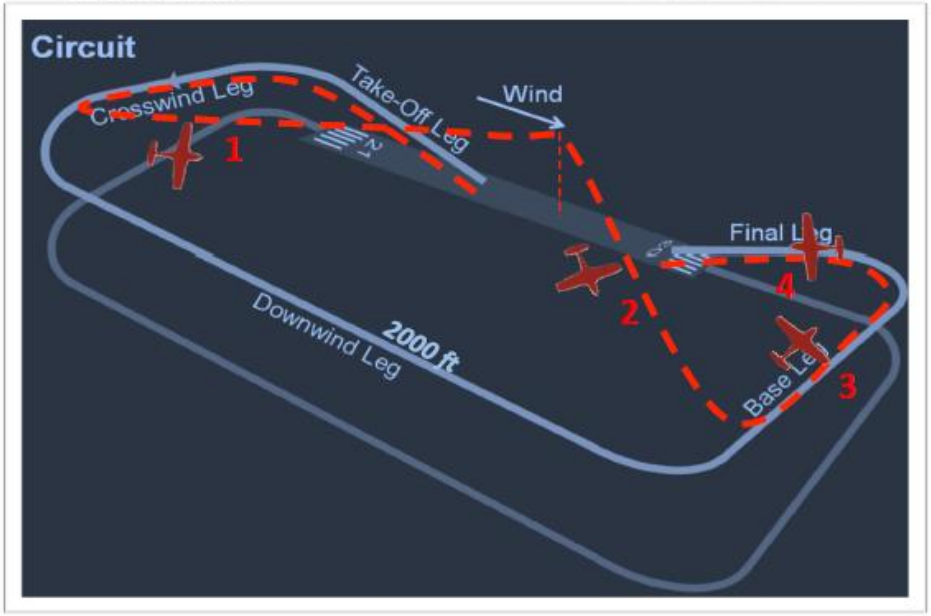
Eye tracking: real flight conditions

1st study: comparing ocular activity during nominal vs. power off approach

Original device: Tobii X50

Embedded device



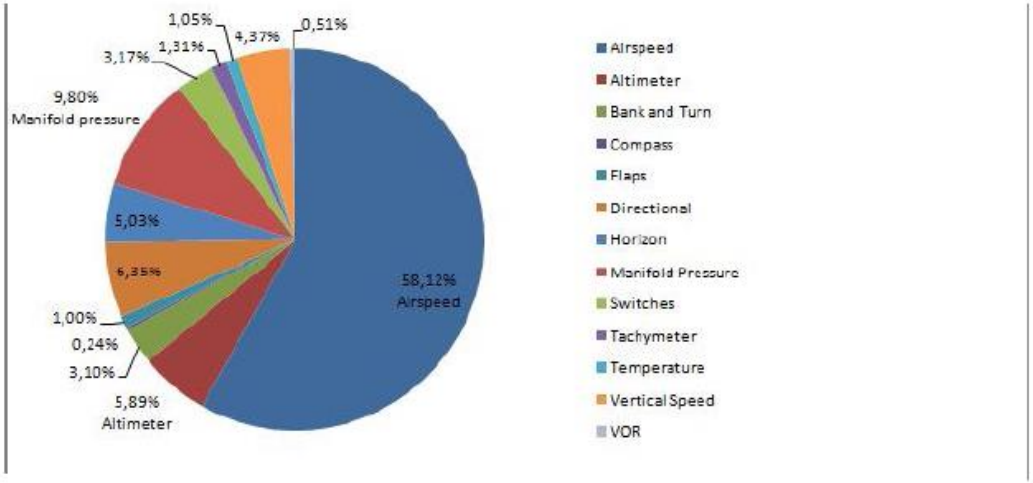


(Permit to fly number 856/2007 – EASA PTF.A07.0232)

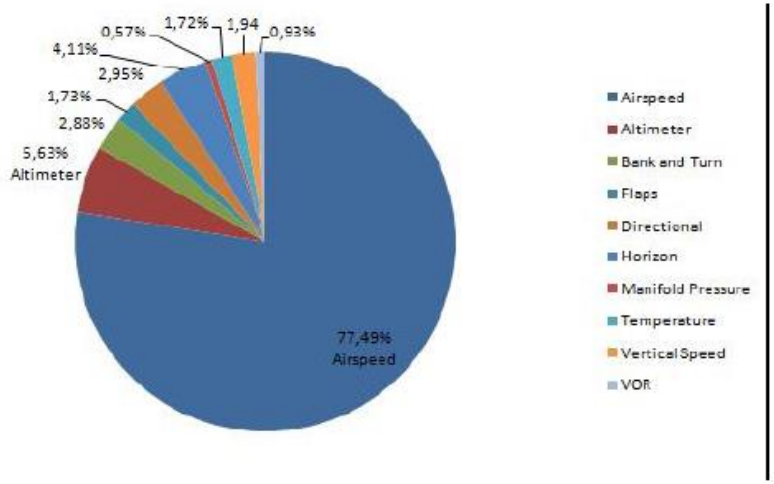
1st study:nominal landing vs power off landing N=6 (5896 flight hours)

14 Areas of Interests (AOIs)

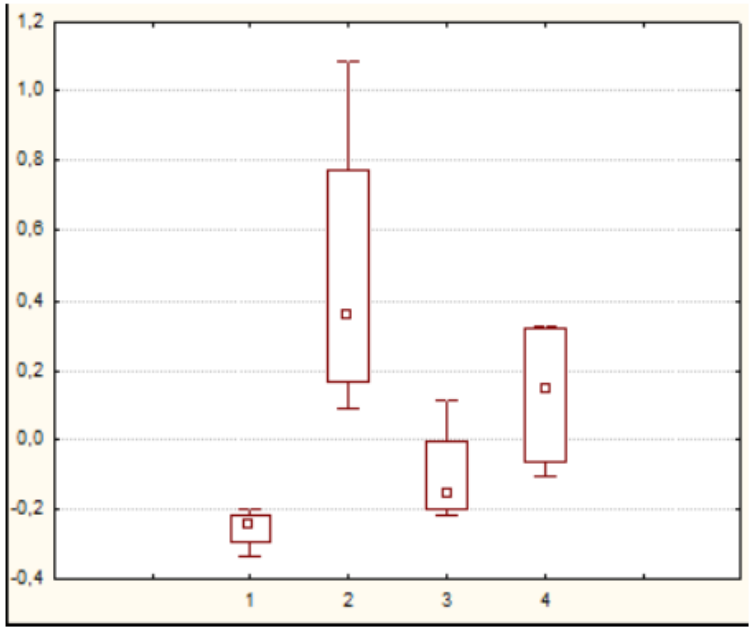
Nominal Landing

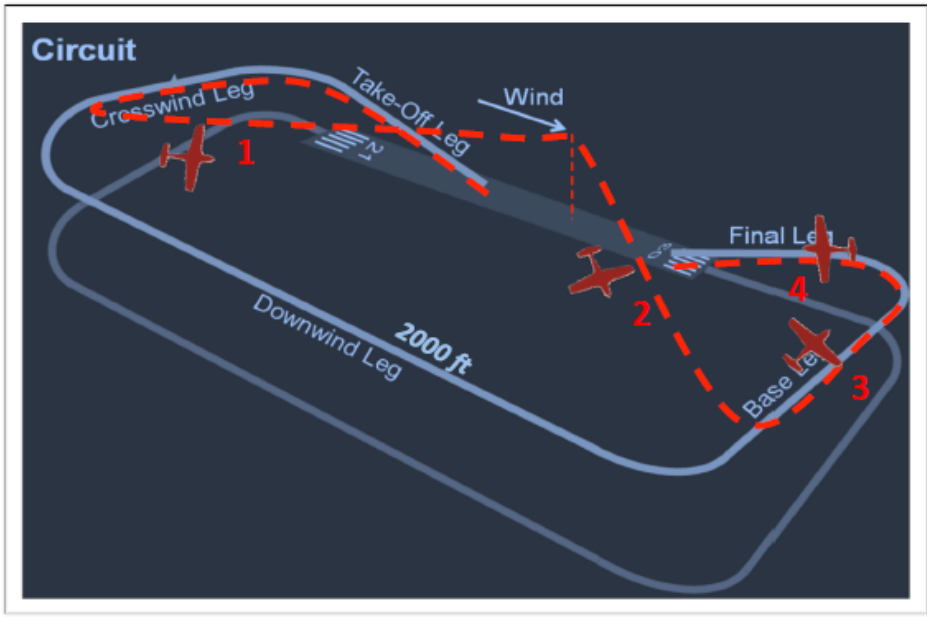


360° power off approach



1st study: pupillometry – 360 power off approach





Gupta et al [00]: pupil size is not affected by illuminance<25Lux

Pupil diameter changes (in mm) during the second flight sequences:

- Before the failure (1), the failure (2), the base leg (3), from the last turn to the final touch (4). (Friedman ANOVA. n=4 ; p=0.001)
- **Strong limitations!!!!: very small sample, 23 factors influence pupil size (vergence, saccades…) [Tryon, 75]**

Dehais, F., Causse, M., & Pastor, J. (2008, March). Embedded eye tracker in a real aircraft: new perspectives on pilot/aircraft interaction monitoring. 3rd ICRAT conference