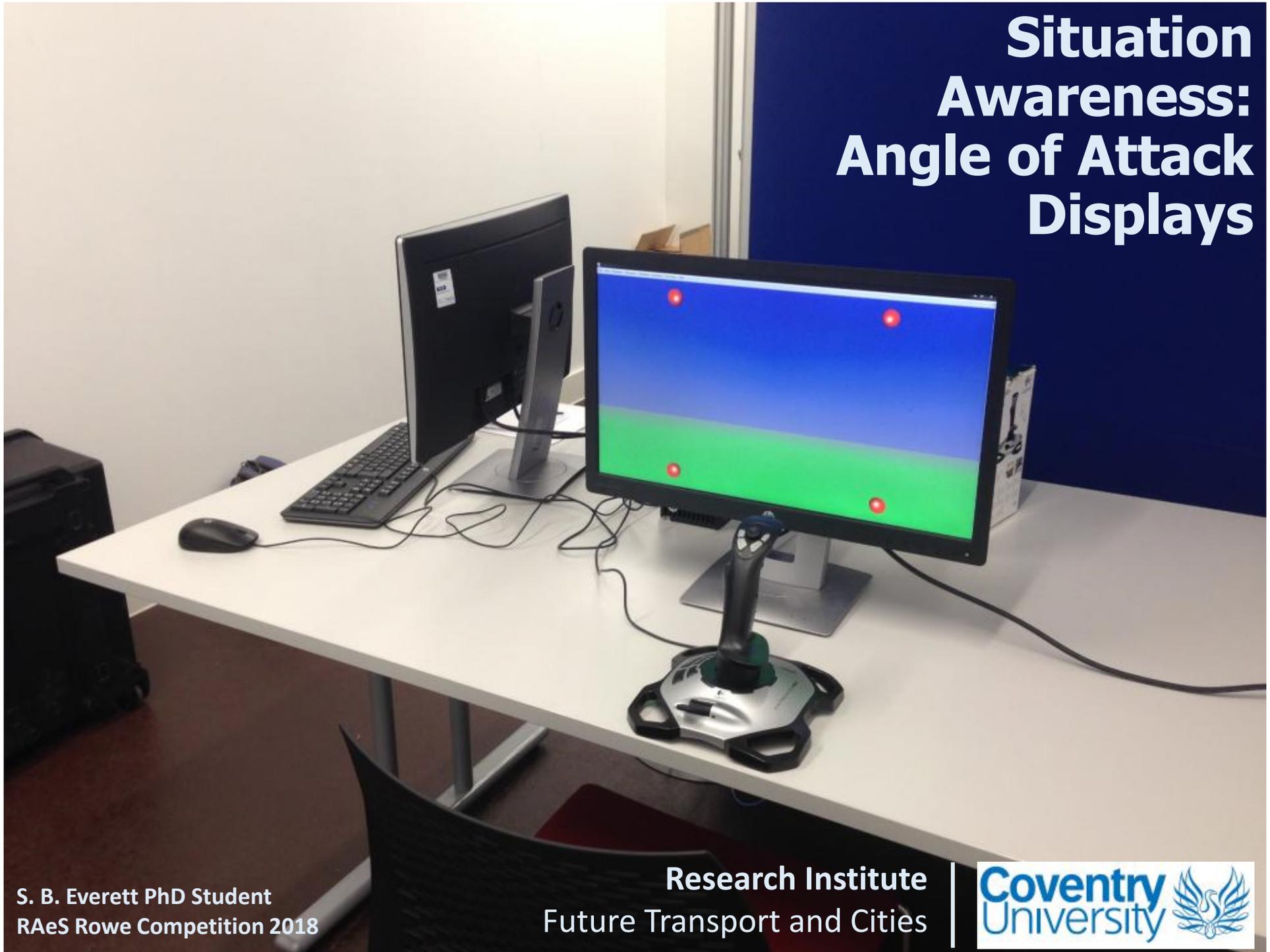


# Situation Awareness: Angle of Attack Displays



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RAeS Rowe Competition 2018

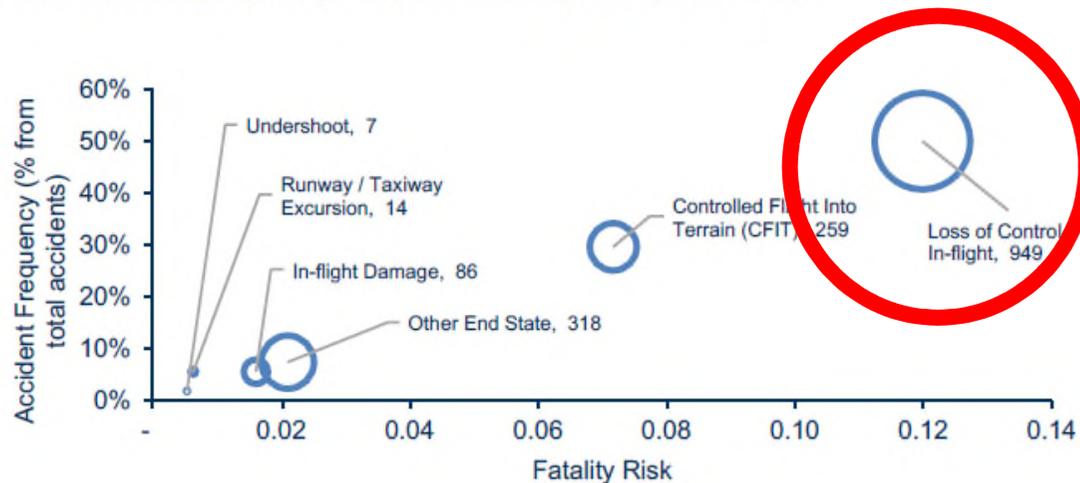
Research Institute  
Future Transport and Cities



# Introduction

The accident category Loss of Control – In Flight (LOC-I) has the largest proportion of fatal accidents across all sectors of aviation.

Accident Category Frequency and Fatality Risk (2012-2016)

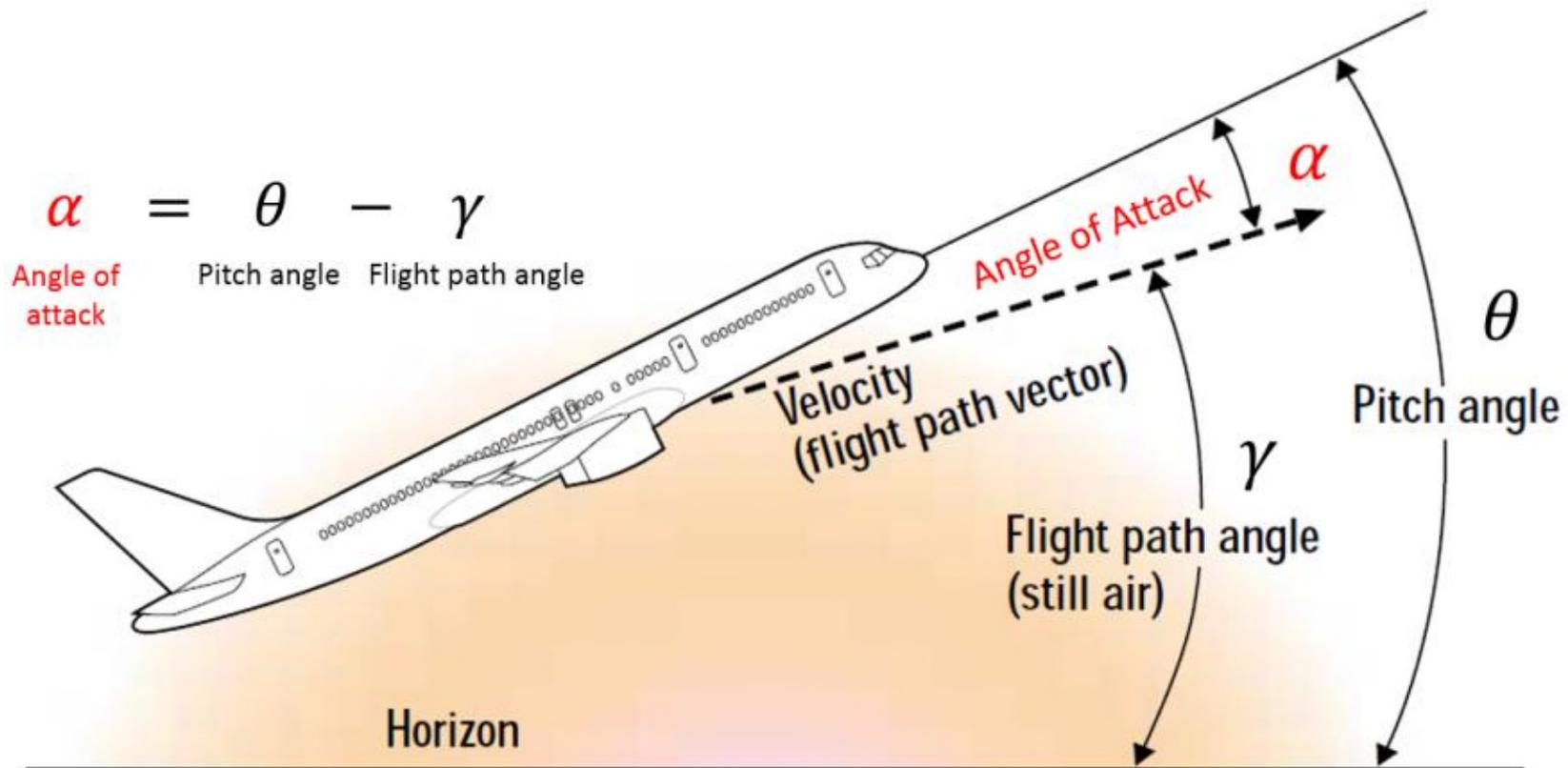


Fatal Accident Category Frequency and Fatality Risk (IATA 2017)

Failure to maintain airspeed leading to a stall is commonly quoted as a primary factor in LoC-I accidents.

But an aircraft can stall at any airspeed, as the stall speed is dependant on many factors such as g-loading, bank angle, and configuration.

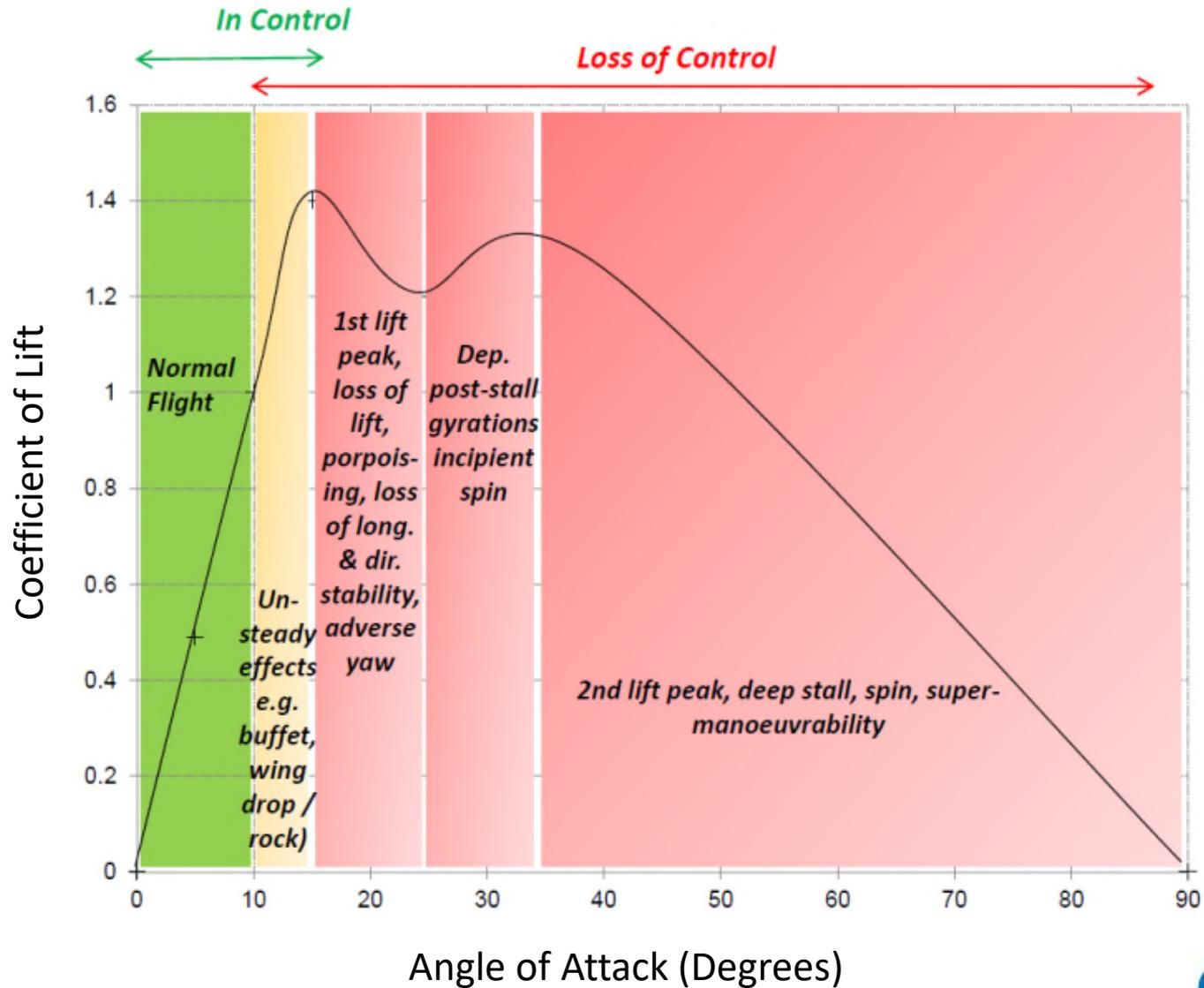
# Introduction



*AoA Definition (Adapted from Boeing)*

The Angle of Attack is the angle between the mean aerodynamic chord of the wing and the on-coming air flow. It is the difference between the pitch angle and the flight path angle.

# Why is AoA Important?



Typical relationship between coefficient of lift and AoA (Bromfield 2017)

# Angle of Attack Display Effectiveness

- AoA presentation solutions from across the aerospace sector (35 total: 8 commercial, 8 military, & 19 general aviation)
- Each display design is being evaluated against a number of visual display principles (Wickens 2014)
- Asking: are they fit for purpose?

| Category: | Index   | Quantitative  | Pictorial   |
|-----------|---|---|---|
| Example:  | <p>Alpha Systems Eagle<br/>Stand alone system</p>  | <p>Teledyne Avionics<br/>Integrated display</p>  | <p>ICON A5<br/>Integrated display</p>  |

# Situation Awareness Assessment Desktop Study

## Aim

Evaluate whether examples from the AoA display categories have any impact on pilot performance and SA.

## Hypotheses

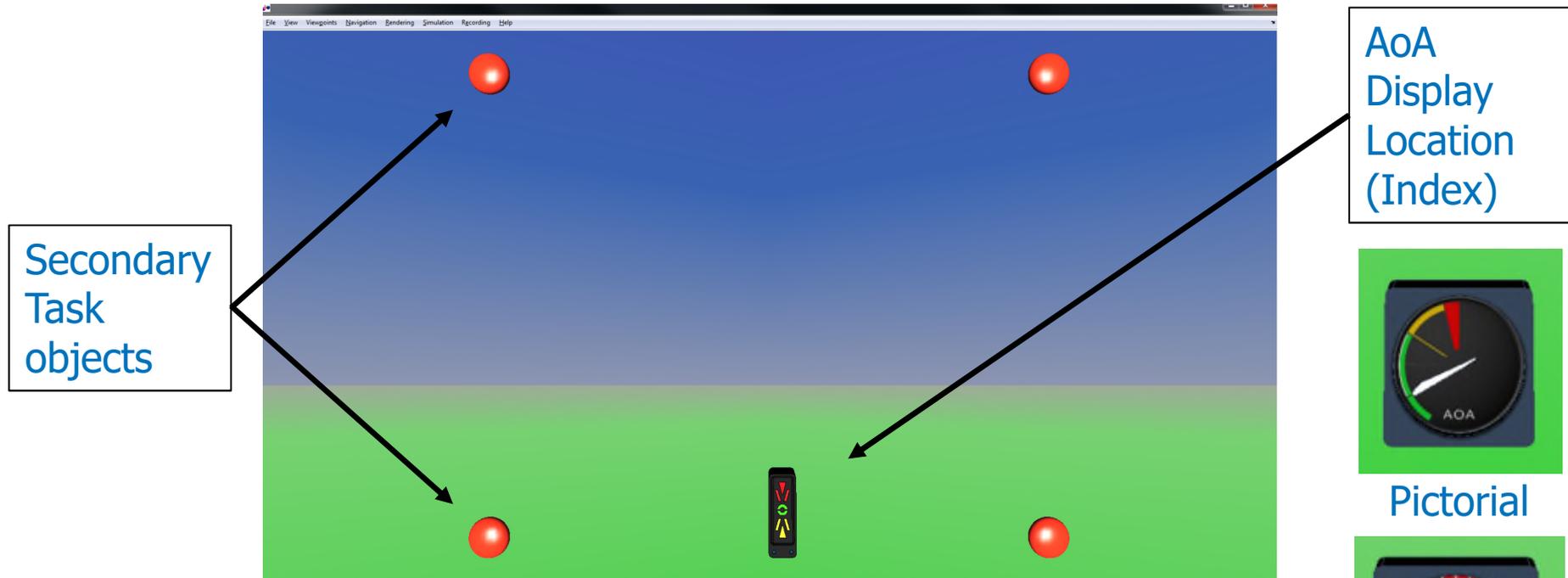
- Participants would perform better at the primary task when assisted by an AoA display compared to no display.
- Increase in performance in the primary task may come at the cost of a reduction in the performance and SA of the secondary task.



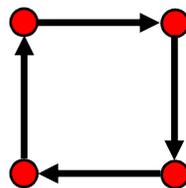
# SA Assessment Desktop Study

- 18 participants, 9 with flying experience (4 with PPL).
- The study included a primary pitch control task and a secondary object tracking task.
- A questionnaire was administered post scenario to gather subjective SA data (SAGAT-style).
- A NASA TLX without pairwise comparisons was used to gather subjective workload data.
- Objective performance data taken directly from the Simulink environment.
- 1 DoF model using Simulink; stability derivatives from a Cirrus SR-20.

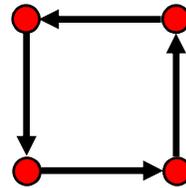
# SA Assessment Desktop Study



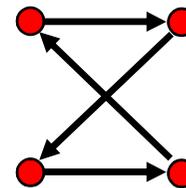
Secondary task sequences:



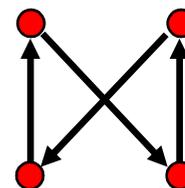
*Pattern 1:  
Clockwise*



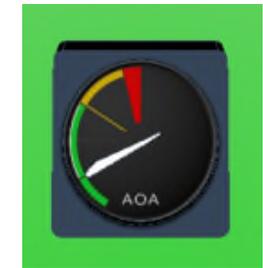
*Pattern 2:  
Anticlockwise*



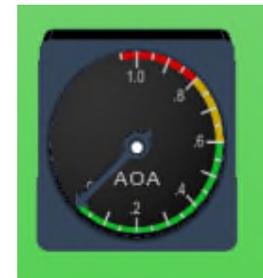
*Pattern 3:  
"Z" shape*



*Pattern 4:  
"N" shape*



Pictorial

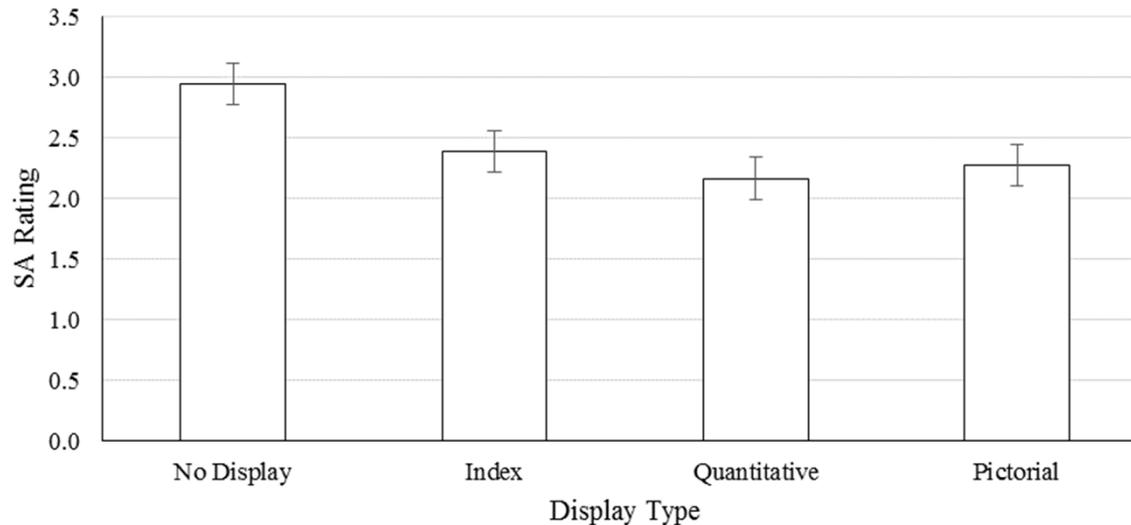


Quantitative

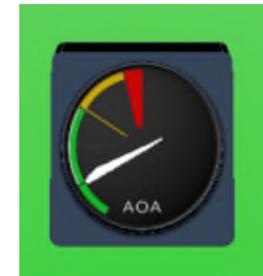
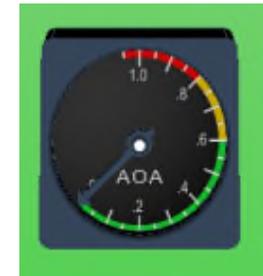
## SAGAT-Style Questions

|   | Questions  | Possible responses   |
|---|--|--|
| 1 | How does your planned attitude compare with your final attitude? | Far above, above, on target, below, far below, don't know.   |
| 2 | How often did you use the display?                               | All the time, very often, often, sometimes, seldom, never, not applicable  |
| 3 | What was the final location of the red object?                   | Top left, top right, bottom left, bottom right   |
| 4 | What would be the next location of the red object?               | Top left, top right, bottom left, bottom right   |
| 5 | Did you notice a pattern in the movement of the red object?      | Yes, no  |
| 6 | If yes, what was the pattern?                                    | Free text field  |
| 7 | In seconds, how long were you flying for?                        | Less than 45 seconds, between 45 and 55 seconds, between 55 and 65 seconds, between 65 and 75 seconds, more than 75 seconds. |

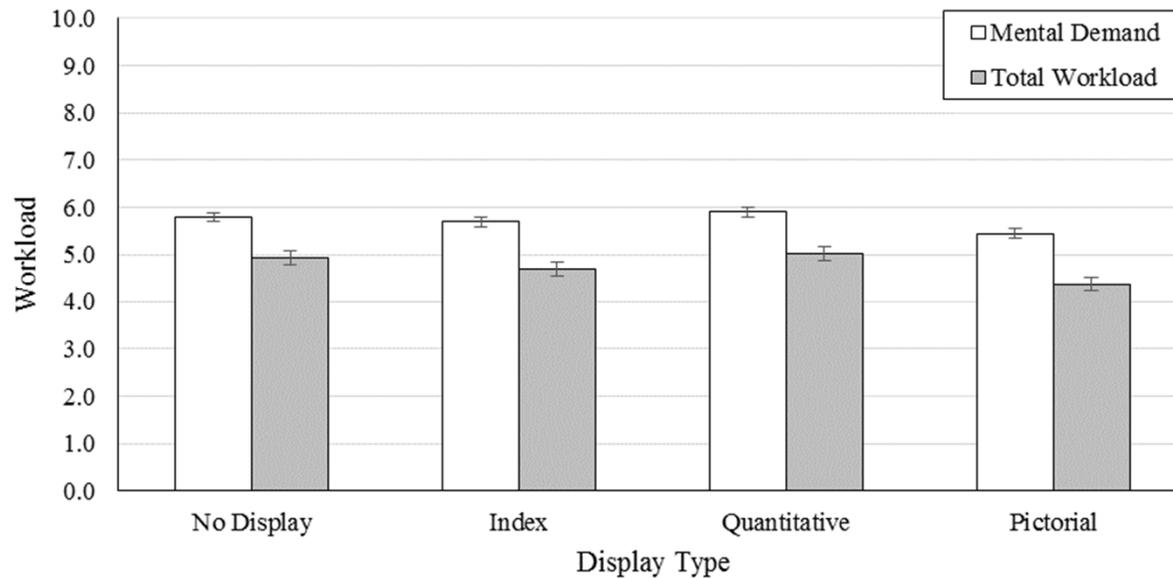
# SA Assessment Desktop Study: Results



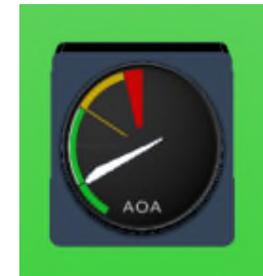
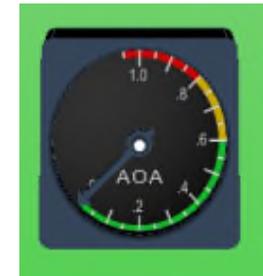
- In all scenarios with displays, the participants on average exhibited some reduction in subjective secondary task SA.
- However there was no significant effect on the SA due to the AoA presentation method, turbulence level, or pilot experience.
- The inclusion of participants without flying experience showed no significant variation in the results.



# SA Assessment Desktop Study: Results



- No significant difference in workload based on the grouping variables display type and pilot experience
- Significant difference in workload based on the turbulence level, as desired from the study design.



# Observations

- There was no roll control. Not all participants noticed.
- All participants attempted to pull the trigger for the last red object – suggesting that none of them were tracking how many appeared.
- Participants correctly identified the amount of time they were flying for in 39 out of 144 scenarios.
  - Two participants got it right for every scenario
  - On average, participants underestimated the amount of time

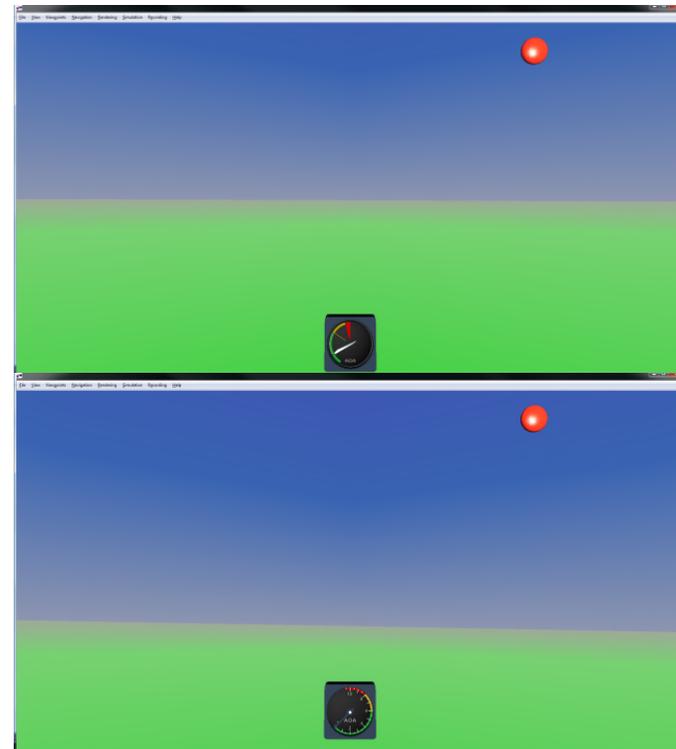
|   |   |  |
|---|---|--|
| 7 | In seconds, how long were you flying for? | Less than 45 seconds,<br>between 45 and 55 seconds,<br>between 55 and 65 seconds,<br>between 65 and 75 seconds,<br>more than 75 seconds. |
|---|---|--|

# Future Work

Civil Aviation focused study using the Coventry Human-in-the-Loop laboratory aerospace module, a configurable engineering flight simulator with touchscreen displays and 220 by 60 degree field of view.



# Questions?



## References

IATA (2017). 'Safety Report 2016. 53<sup>rd</sup> Edition.' Available from <http://www.iata.org/publications/Pages/safety-report.aspx> (accessed Aug 2017)

Bromfield, M.A., (2017). 'Re-defining Loss of Control In Flight.' Proceedings of the EASA European Operators Flight Data Monitoring Conference, Cologne, Germany. June 12-13, 2017.