

Appendix D Safety Validation Report for AVOID Dataset using the CuneiForm method

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Safety Validation Report for AVOID Dataset using the CuneiForm method

Dataset Safety Report
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The output of AVOIDDS Case Study



Part of PhD project Supervised by
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Definitions

Concept	Definition
ALARP	As Low As Reasonably Practicable
ArcUC	Architect Epistemic Uncertainty Curve for a given dataset
PHI	Pictorial Visible Horizon Attitude Indicator
TOI	Target Object of Interest

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Introduction

- **Objective:** Assess the **trustworthiness** of AVOIDDS for **AI-based mid-air collision avoidance systems**.
- **Validation Methodology:** Applied **CuneiForm analysis** to evaluate dataset completeness, bias, and epistemic uncertainty. Access the paper [here](#).
- **Key Dimensions Analyzed:**
 - **Time-of-day coverage** (bias in night/midday instances).
 - **Cloud coverage distribution** (imbalanced across scenarios).
 - **Pictorial distance & object positioning** (lack of dangerously close TOIs).
 - **Horizon attitude coverage** (limited diversity in aircraft perspectives).

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Purpose of the Report

The purpose of this report is to assess the AVOID dataset's **suitability for training AI-based mid-air collision avoidance perception models** by evaluating its **epistemic uncertainty** and **dataset bias** across CuneiForm epistemic training classes. Specifically, this report aims to:

- **Validate dataset completeness** using the **CuneiForm method**, ensuring that training samples cover diverse operational conditions.
- **Identify dataset biases** that may introduce epistemic uncertainty, leading to unreliable model performance in critical scenarios.
- **Evaluate dataset suitability** for **Black Swan** scenarios, determining whether the dataset supports robust AI decision-making in unpredictable or rare events.
- **Assess the trustworthiness** of AVOIDDS for **real-world safety-critical applications**, particularly for aviation-based detect-and-avoid systems.
- **Provide mitigation strategies** to improve dataset robustness, ensuring compliance with ALARP uncertainty coverage standards.

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Findings

Dataset lacks coverage for **critical Black Swan scenarios**.

High **uncertainty in detecting close, and atypically oriented aircraft**.

Potential risks in real-world applications for mid-air collision avoidance.

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Satisfying ALARP Requirements

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AVOIDDS does not pass the ALARP criteria for the coverage of times of day training classes.

AVOIDDS does not satisfactorily fulfil the ALARP requirement for pictorial distance training classes coverage.

AVOIDDS does not satisfactorily fulfil the ALARP requirement for TOI's positioning training classes coverage.

AVOIDDS does not satisfactorily fulfil the ALARP requirement for pictorial horizon attitudes training classes coverage.

Recommendations

Improve

Improve dataset balance across CuneiForm Training Classes to meet the ALARP Requirement to reduce uncertainty.

Expand

Expand training instances to cover Black Swan Scenarios to meet the ALARP Requirement to reduce uncertainty.

Enhance

Enhance operational domain epistemic coverage to meet the ALARP Requirement to reduce uncertainty (Traceability to clearly articulated Safety Concept).

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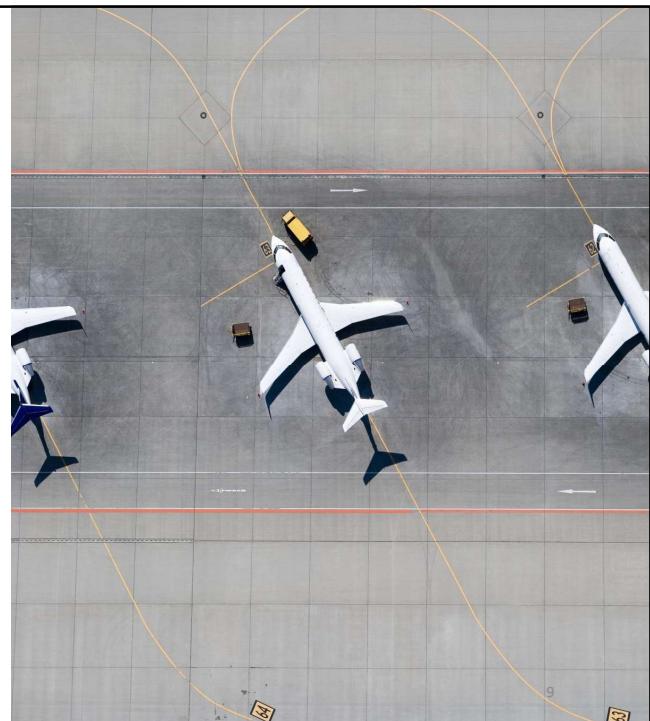
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Conclusion

AVOIDDS is **useful as a benchmark** but requires **further improvements** to support real-world **safety-critical aviation AI models**.

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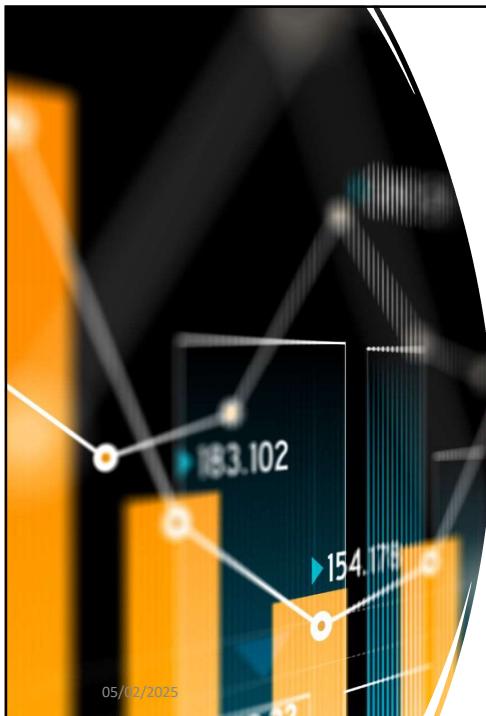
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AVOID Dataset description

This repository contains datasets, models, and simulators for the AVOIDDS (Aircraft Vision-based Intruder Detection Dataset and Simulator) benchmark, which centres around the vision-based aircraft detect-and-avoid (DAA) problem. The full AVOIDDS dataset, which includes 72,000 labelled images, is available here: purl.stanford.edu/hj293cv5980.

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Assumptions

- The sample_small folder of training and validation datasets is statistically representative of AVOIDDS dataset.
 - 30 images, training sample.
 - 30 images validation sample.
- Time of day, Clouds types, file names all taken directly from the provided state_data.xlsx in the repository.
- The CuneiForm coverage results on the representative sample are accepted as a quality assessment of the entire AVOIDDS dataset.

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Definition of ALARP

Our ODD classification for time of day

Category	Time Range
Early Morning (Dawn)	4:00 AM - 6:00 AM
Morning	6:00 AM - 9:00 AM
Mid-Morning	9:00 AM - 11:00 AM
Midday (Noon)	11:00 AM - 1:00 PM
Afternoon	1:00 PM - 4:00 PM
Evening	4:00 PM - 6:00 PM
Evening (Dusk)	6:00 PM - 8:00 PM
Night	8:00 PM - 4:00 AM

To reduce the risk of perception failure due to insufficient development dataset coverage, statistically sound samples should demonstrate the following coverage criteria:

- Note: the following criteria in the blue table are directly taken from AVOIDDS documentation associated with their datasets.
- Their classification of timing did not make sense, so we used our time of day classification.

ODD Dimension	Training class spec
Weather Conditions	clear, high cirrus, scattered clouds, broken clouds, overcast, stratus
Time of Day	morning, midday, afternoon, and late afternoon.

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Definition of ALARP: TOI's 3D orientation coverage to achieve ALARP requirement

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To reduce the risk of epistemic uncertainty that can lead to perception failure due to insufficient development dataset coverage, statistically sound samples should demonstrate the following training classes coverage criteria:

Front up left	Front up center	Front up right	Rear down right	Rear down center	Rear down left
Left	Front	Top	Bottom	Rear	Right
Front down left	Front down center	Front down right	Rear up left	Rear up center	Rear up right

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Definition of ALARP: Pictorial distance categories

To reduce the risk of perception failure due to insufficient development dataset coverage, statistically sound samples should demonstrate the following coverage criteria:

To define the pictorial distance units, we define the following system:

- 1 Nindan = the TOI pictorial size, covers the size of the picture frame.
- 1 Nuviadan = 9 Nindans further away = 1/9 frame area
- 1 Centiadan = 81 Nindans further away = 1/81 frame area
- 1 Miliadan = 81 * 9 = 729 Nindans further away = 1/729 frame area

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1 Nindan = the TOI pictorial size, covers the size of the picture frame.

- 1 Nuviadan = 9 Nindans further away = 1/9 frame area
- 1 Centiadan = 81 Nindans further away = 1/81 frame area
- 1 Miliadan = 81 * 9 = 729 Nindans further away = 1/729 frame area

Category (wrt human verifier)	Pictorial Distance (Dx) Range	Example
Extremely Unrecognisable TOI Distance	Dx > 1600 nindans	
Moderately Recognisable TOI Distance	729 > Dx <= 1600 nindans	
Recognisable TOI Distance	300 > Dx <= 729 nindans	
Clear Close TOI Distance	40 > Dx <= 300 nindans	
Dangerously Close TOI Distance	Dx <= 40 nindans	

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Definition of ALARP: Pictorial distance categories

To compute the pictorial distance, we used a Python script that calculated the bounding box number of pixels (as specified by the training dataset sample) and the total number of pixels for the whole image area. Then we matched a particular categorical system to define whether a TOI is within a specific range. Below is a sample of the Python script output

Category (wrt human verifier)	Pictorial Distance (Dx) Range	Example
Extremely Unrecognisable TOI Distance	$Dx > 1600$	
Moderately Recognisable TOI Distance	$729 > Dx \leq 1600$	
Recognisable TOI Distance	$300 > Dx \leq 729$	
Clear Close TOI Distance	$40 > Dx \leq 300$	
Dangerously Close TOI Distance	$Dx \leq 40$	

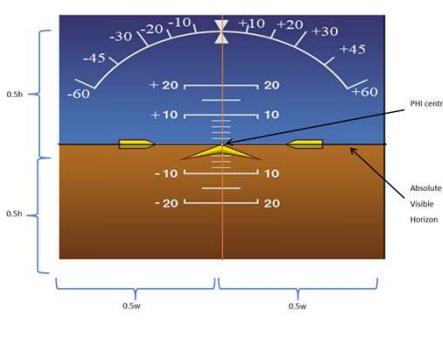
Image	X1	Y1	X2	Y2	Bounding B	Total Pixels	Pictorial Distanc	Training Class
0.jpg	2518	1851	2584	1876	1627	5621280	3454.996927	Extremely Unrecognisable TOI Distance
1.jpg	2245	1541	2398	1599	8801	5621280	638.7092376	Recognisable TOI Distance
2.jpg	1958	879	2073	922	4969	5621280	1131.269873	Moderately Recognisable TOI Distance
3.jpg	2610	1279	2657	1296	815	5621280	6897.276074	Extremely Unrecognisable TOI Distance

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Definition of ALARP: Horizon attitude categories to achieve ALARP requirements

To reduce the risk of perception failure due to insufficient development dataset coverage, statistically sound samples should demonstrate the following coverage criteria:



Horizon attitude category	Roll Range	Pitch Range
Level Horizon	$-1 \leq ROLL \leq 1$	$-1 \leq PITCH \leq 1$
Positively Tilted Level Horizon	$1 < ROLL \leq 90$	$-1 \leq PITCH \leq 1$
Negatively Tilted Level Horizon	$-90 \leq ROLL < -1$	$-1 \leq PITCH \leq 1$
Elevated Level Horizon	$-1 < ROLL \leq 1$	$1 < PITCH \leq 45$
Positively Tilted Elevated Horizon	$1 < ROLL \leq 90$	$1 < PITCH \leq 45$
Negatively Tilted Elevated Horizon	$-90 \leq ROLL < -1$	$1 < PITCH \leq 45$
Acute Angled Bird's Eye Ground View	$-90 \leq ROLL \leq 90$	$45 < PITCH \leq 80$
Bird's Eye Ground View	$-90 \leq ROLL \leq 90$	$80 < PITCH \leq 90$
Lowered Level Horizon	$-1 \leq ROLL \leq 1$	$-45 \leq PITCH \leq -1$
Positively Tilted Lowered Horizon	$1 < ROLL \leq 90$	$-45 \leq PITCH \leq -1$
Negatively Tilted Lowered Horizon	$-90 \leq ROLL < -1$	$-45 \leq PITCH \leq -1$
Acute Angled Rocket Sky View	$-90 \leq ROLL \leq 90$	$-80 \leq PITCH \leq -45$
Ascending Rocket Sky View	$-90 \leq ROLL \leq 90$	$-90 \leq PITCH \leq -80$

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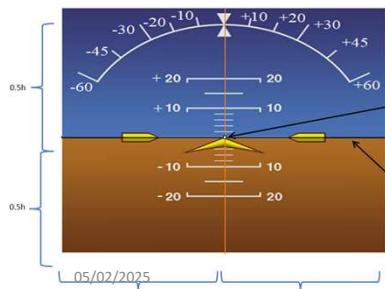
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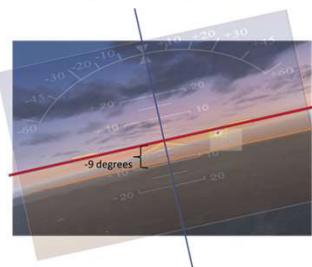
Definition of ALARP: Horizon attitude categories to achieve ALARP requirements

To reduce the risk of perception failure due to insufficient development dataset coverage, statistically sound samples should demonstrate the following coverage criteria:

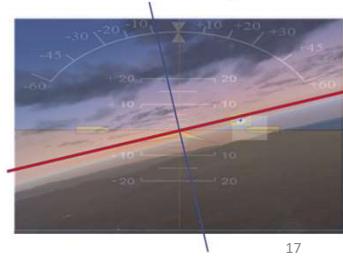
Horizon attitude category	Roll Range	Pitch Range
Level Horizon	-1<ROLL<1	-1< PITCH <1
Positively Tilted Level Horizon	1<ROLL<90	-1< PITCH <1
Negatively Tilted Level Horizon	-90<ROLL<-1	-1< PITCH <1
Elevated Level Horizon	-1<ROLL<1	1< PITCH <45
Positively Tilted Elevated Horizon	1<ROLL<90	1< PITCH <45
Negatively Tilted Elevated Horizon	-90<ROLL<-1	1< PITCH <45
Acute Angled Bird's Eye Ground View	-90<ROLL<90	45< PITCH <80
Bird's Eye Ground View	-90<ROLL<90	80< PITCH <90
Lowered Level Horizon	-1<ROLL<1	-45< PITCH <-1
Positively Tilted Lowered Horizon	1<ROLL<90	-45< PITCH <-1
Negatively Tilted Lowered Horizon	-90<ROLL<-1	-45< PITCH <-1
Acute Angled Rocket Sky View	-90<ROLL<90	-80< PITCH <-45
Ascending Rocket Sky View	-90<ROLL<90	-90< PITCH <-80



PHI pitch angle



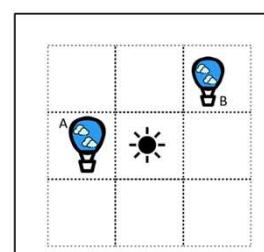
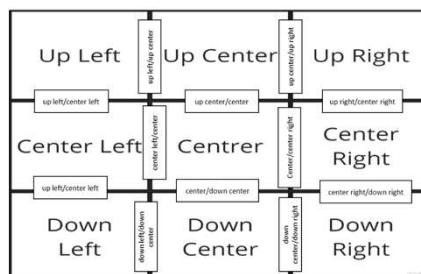
PHI roll angle



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To reduce the risk of perception failure due to insufficient development dataset coverage, statistically sound samples should demonstrate the following training class coverage criteria:

down right	center right	up right
down center	center	up center
down left	center left	up left
up left/center left	center left/center	center/down center
up left/center left	down left/down center	up center/up right
up left/up center	up center/center	Center/center right
down center/down right	up right/center right	center right/down right

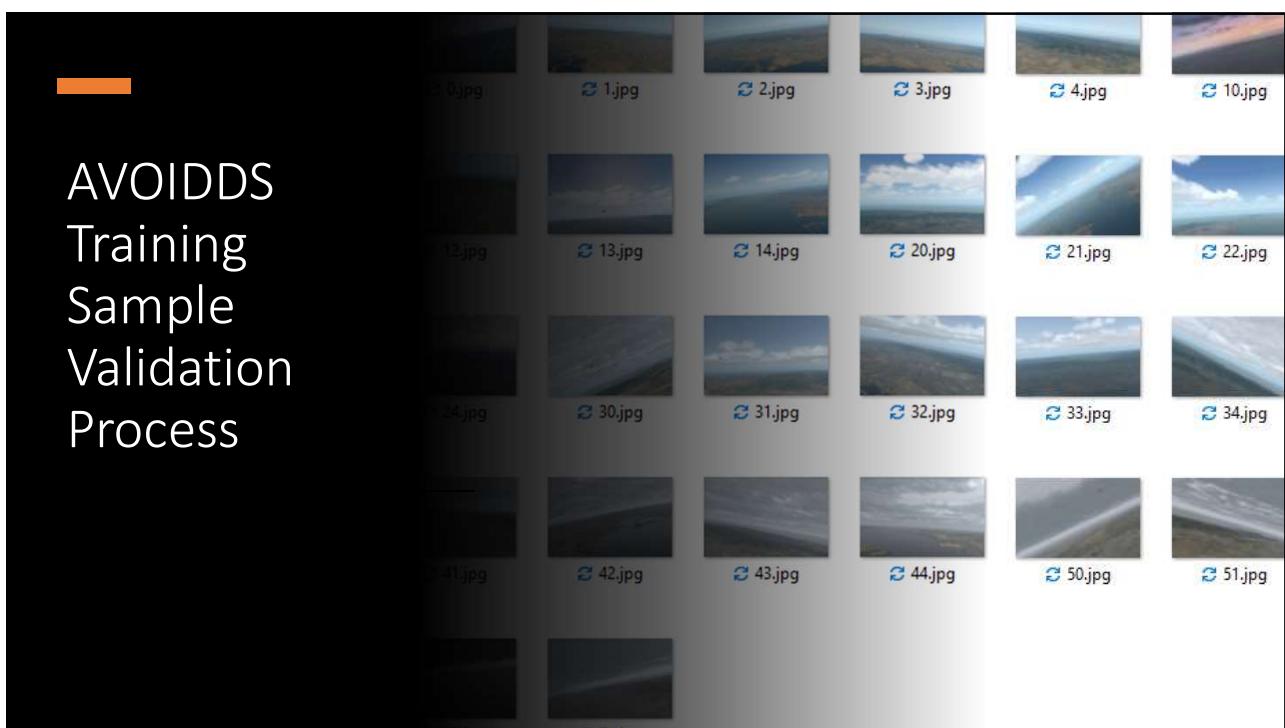


Definition of ALARP: TOI's positioning Training classes to achieve ALARP requirements

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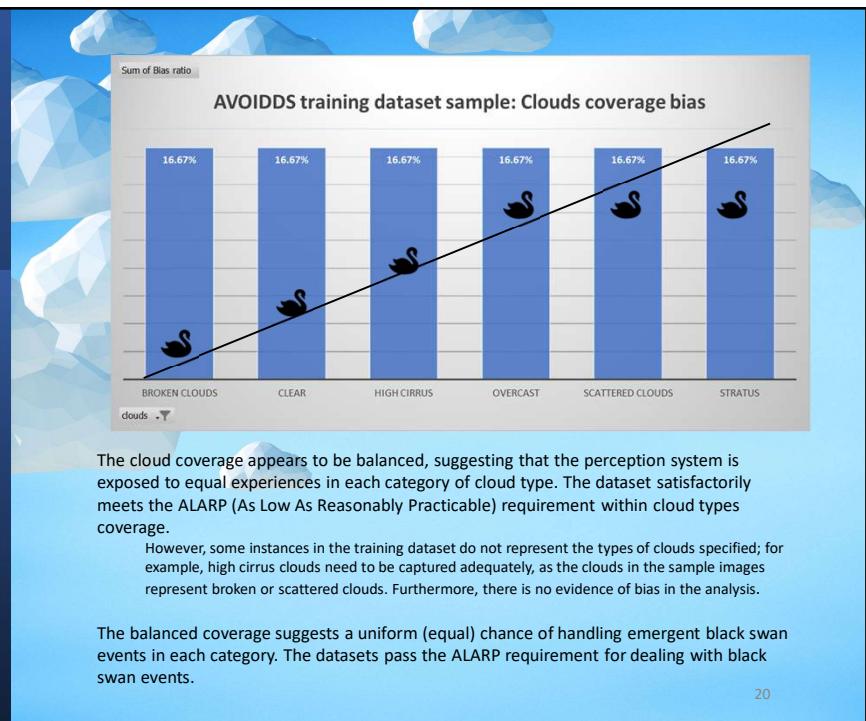
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Examining AVIDDS Training Strategy in Covering Clouds type

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Missing Training and Black Swan Scenarios



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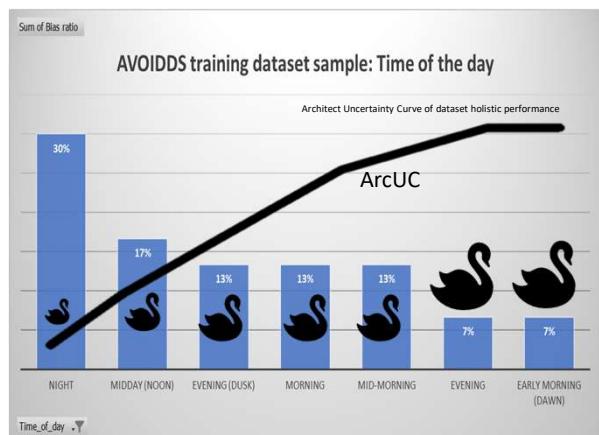
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Examining AVOIDDS Training Strategy in Covering Time-of-Day Training Classes

There exists an imbalance in coverage, with 47% of instances recorded at night or at midday (noon), demonstrating strong bias.

The lack of balanced exposure constitutes a potential for an exponentially unpredictable high-risk emergent black swan behaviour the perception performs. The dataset does not satisfactorily meet the ALARP requirement.

This dataset does not pass the ALARP criteria for the coverage of times of day categories. The unbalanced coverage leads to hazardous uncertainty in the intelligent system's behaviour during Black Swan scenarios in a respective category.



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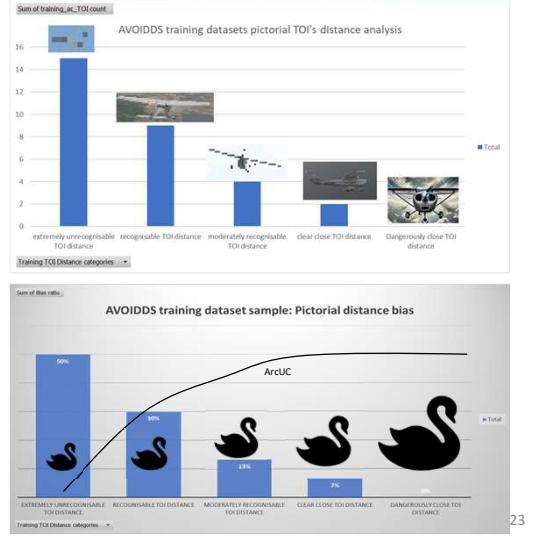
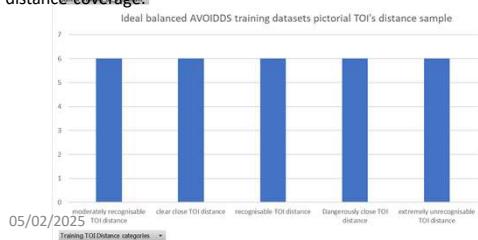
Examining AVOIDDS Training Strategy in Covering Pictorial Distance Training Classes:

The dataset exhibits significant imbalance, with 50% of instances in 20% of required coverage. Categorized as occurring at “extremely unrecognizable distance”. Notably, there is a complete absence of instances classified as :

1. dangerously close distances

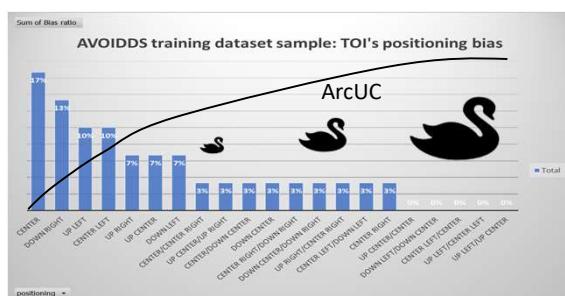
The lack of exposure constitutes a potential for an exponentially unpredictable high-risk emergent black swan behaviour performed by the perception. Unbalanced coverage leads to a hyperbolic uncertainty profile in the intelligent system's behaviour. [An example incident of a Mid-air collision due to a close but unnoticed approach.](#)

Consequently, the dataset does not satisfactorily fulfil the ALARP requirement for pictorial distance coverage.



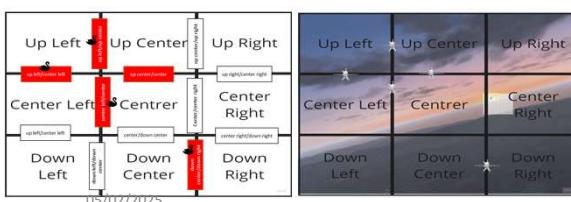
23

Examining AVOIDDS Training Strategy in Covering TOI's Positioning Training Classes:



The dataset exhibits significant imbalance, with 60% of perception experiencing TOIs only 20% of the possible positioning quadrants. Notably, there is a complete absence experience in the following possible positions:

1. up center/center
2. up left/center left
3. center left/center
4. up left/up center
5. down left/down center



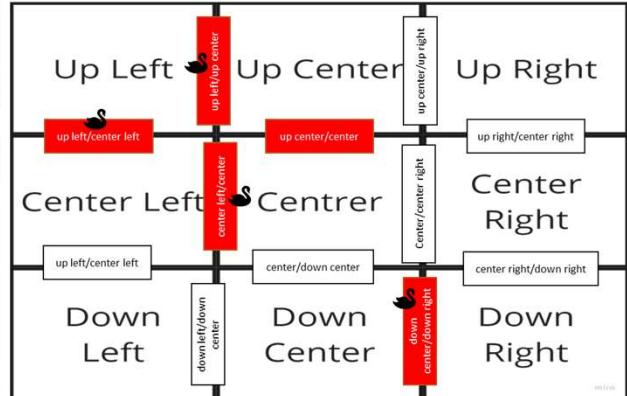
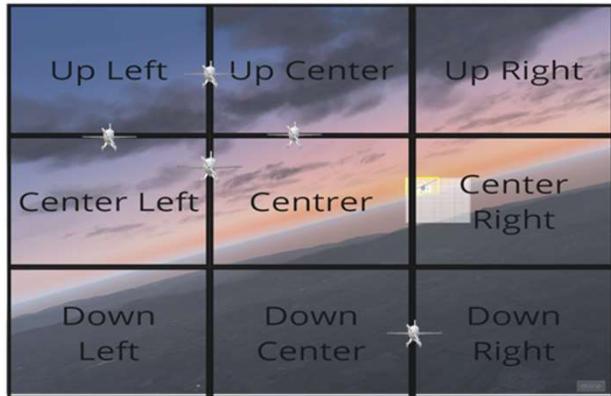
The lack of exposure constitutes a potential for an exponentially unpredictable high-risk emergent black swan behaviour performed by the perception.

Consequently, the dataset does not satisfactorily fulfil the ALARP (As Low As Reasonably Practicable) requirement for TOI's positioning coverage.

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Examining AVOIDDS Training Strategy in Covering TOI's Positioning Training Classes:

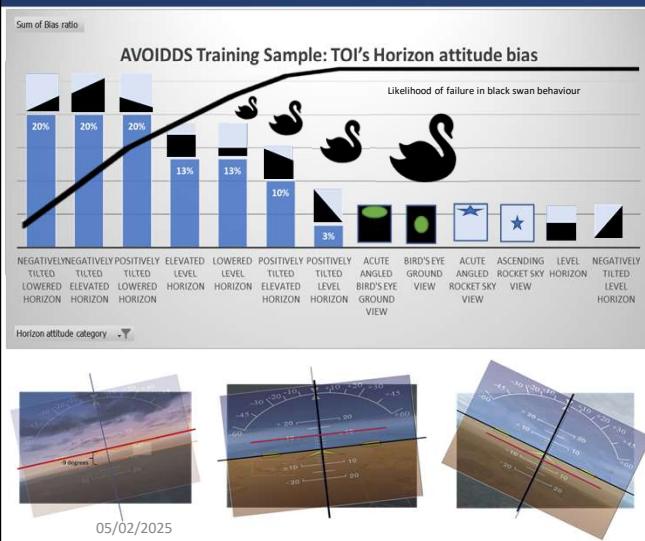


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AVOIDDS Training Sample TOI's Horizon attitude analysis



The dataset exhibits significant imbalance, with 60% of perception experiencing TOIs in only 23% of the possible horizon attitudes. Notably, there is a complete absence of experience in the following possible horizon attitudes:

1. Level Horizon
2. Negatively Tilted Elevated Horizon
3. Acute Angled Bird's Eye Ground View
4. Bird's Eye Ground View
5. Ascending Rocket Sky View
6. Negatively Tilted level Horizon
7. Acute Angled Rocket Sky View

The lack of exposure constitutes a potential for an exponentially unpredictable high-risk emergent black swan behaviour performed by the perception.

Consequently, the dataset needs to satisfactorily fulfil the ALARP (As Low As Reasonably Practicable) requirement in terms of horizon attitude coverage.

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AI Training Cuneiforms

We retrospectively produced Cuneiforms for the training to illustrate how the Cuneiform can be designed.

We grouped the training images according to Clouds type.

For determining the pictorial distances of TOIs, we used a Python script to compute the area of the bounding boxes relative to the area of an image.

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AI Training Cuneiform 0

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Abstract CuneiForm Characteristics (dimensions)	Abstract CuneiForm Characteristics definitions
TOIs definition and their aesthetic complexity	Single-engine propeller aeroplane {1}
TOI Motion and Dynamic optical states	Motion trajectory: Linear motion captured in consecutive images where the aeroplane appears to move in a straight line at a constant speed (no acceleration) {1,2}. Dynamic optical state: captured without optical blur {1,3}.
Background Objects associated with TOIs	Clear sky{2} green-terrain {3} water surface{4}
Background Objects Motion and Dynamic optical states	Motion trajectory: is static {2,1,3,1,4,1} Dynamic optical state: no motion blur{2,2,3,2,4,2}
Visible horizon attitude	Negatively Tilted Lowered Horizon{5} Positively Tilted Lowered Horizon{6} Elevated Level Horizon{7} Negatively Tilted Elevated Horizon{8} Positively Tilted Elevated Horizon{9}
TOI's Pictorial Positioning	up center{1,4} Down right{1,5} center left{1,6}
TOI's Pictorial Distance	recognisable TOI distance{1,8}, moderately recognisable TOI distance{1,9}, extremely unrecognisable TOI distance{1,10}.
TOI's 3D Orientation	front down right{1,11} rear down right{1,12} right{1,13} Unknown{?}

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AI Training CuneiForm 0

Training TOIs

{1,2,3,6,10,13} {1,2,3,6,10,12}

(a) (b)

Right Rear down right

{1,2,3,5,9,10} {1,2,3,5,8,11}

(c) (d)

Front down right Front down right

{1,2,3,5,10?} {3D To be confirmed}

(e)

Front down right

Instantiated Image cessna_ac_training0 cessna_ac_training1 cessna_ac_training2 cessna_ac_training3 cessna_ac_training4

Time of Day Evening (Dusk) Midday (Noon) Morning Night

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AI Training CuneiForm 0

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

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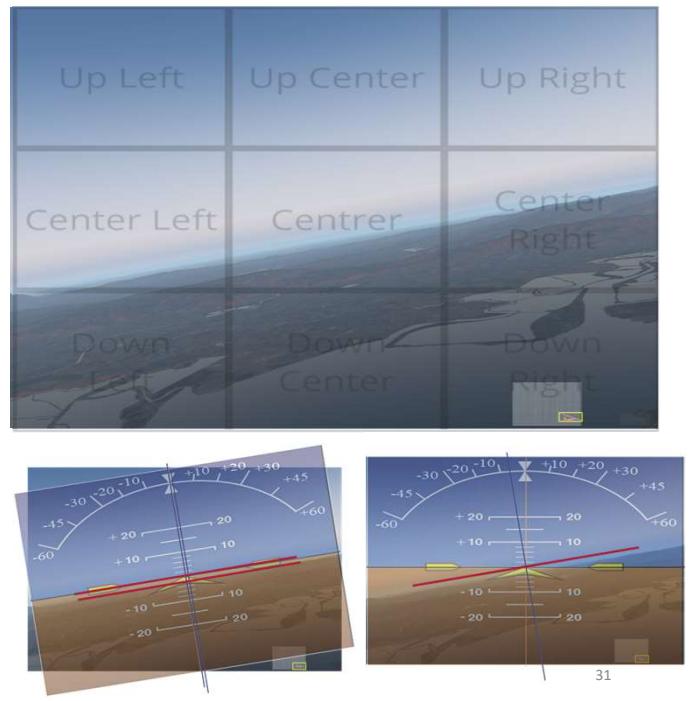
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0.jpg

ODD Dimension	Training class spec
Weather Conditions	clear
Time of Day	Evening (Dusk). 18:15:31

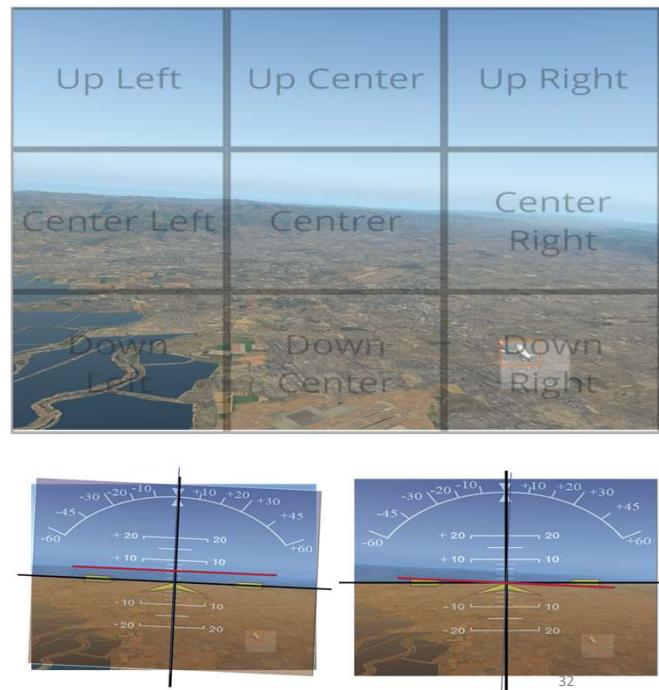
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (3455)
TOI's Pictorial positioning	Down right
TOI's 3D orientation	front down right
Horizon attitude	Roll: -5, Pitch: -2



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1.jpg

ODD Dimension	Training class spec
Weather Conditions	clear
Time of Day	late afternoon, 19:20:53
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Recognisable TOI Distance (639)
TOI's Pictorial positioning	down right
TOI's 3D orientation	front down right
Horizon attitude	Roll: 1, Pitch: 7



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2.jpg

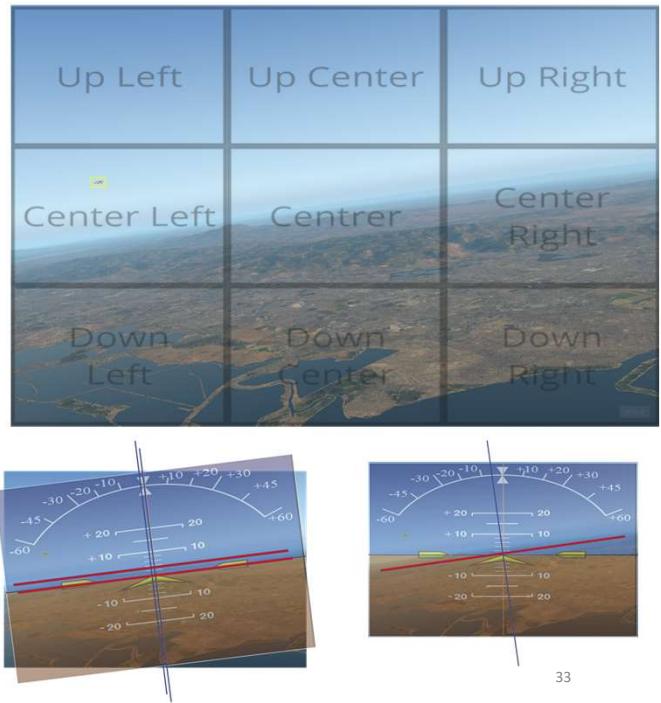
ODD Dimension	Training class spec
Weather Conditions	clear
Time of Day	Midday (Noon), 11:16:17
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Moderately Recognisable TOI Distance (1131)
TOI's Pictorial positioning	center left
TOI's 3D orientation	right
Horizon attitude	Roll: -5, Pitch: 3



Right



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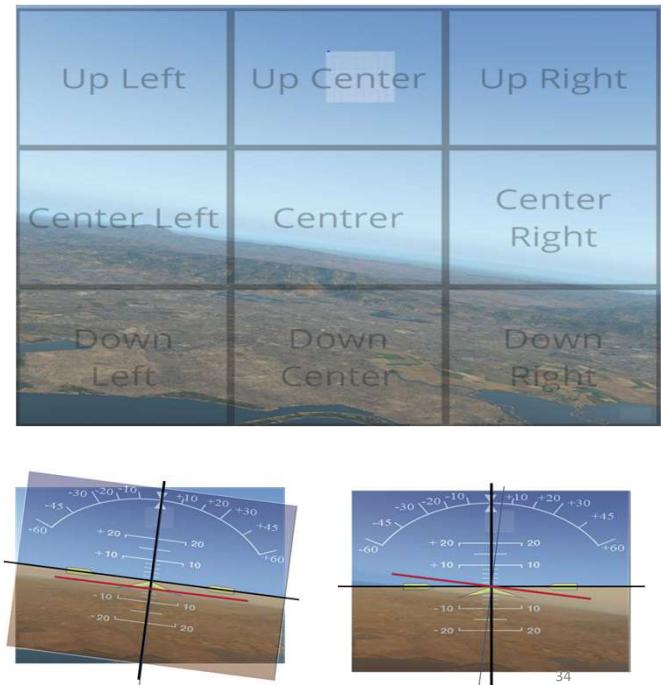
3.jpg

ODD Dimension	Training class spec
Weather Conditions	clear
Time of Day	morning, 08:29:51
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (6897)
TOI's Pictorial positioning	up center
TOI's 3D orientation	Unknown
Horizon attitude	Roll: 5, Pitch: -4

?



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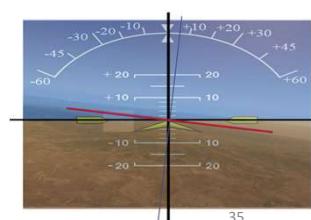
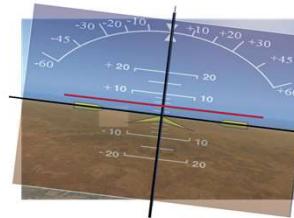
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4.jpg

ODD Dimension	Training class spec
Weather Conditions	clear
Time of Day	Morning, 01:44:03
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Moderately Recognisable TOI Distance (868)
TOI's Pictorial positioning	center left
TOI's 3D orientation	rear down right
Horizon attitude	Roll: 5, Pitch: 4



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AI Training
CuneiForm 1



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Abstract CuneiForm Characteristics (dimensions)	Abstract CuneiForm Characteristics definitions
TOIs definition and their aesthetic complexity	Single-engine propeller aeroplane {1}
TOI Motion and Dynamic optical states	Motion trajectory: Linear motion captured in consecutive images where the aeroplane appears to move in a straight line at a constant speed (no acceleration) {1.2}. Dynamic optical state: captured without optical blur {1.3}.
Background Objects associated with TOIs	high cirrus clouds{2} green-terrain {3} water surface{4}
Background Objects Motion and Dynamic optical states	Motion trajectory: is static {2.1,3.1,4.1} Dynamic optical state: no motion blur{2.2,3.2,4.2}
Visible horizon attitude	Negatively Tilted Lowered Horizon{5} Lowered Level Horizon{6} Elevated Level Horizon{7} Negatively Tilted Elevated Horizon{8} Positively Tilted Level Horizon{9}
TOI's Pictorial Positioning	Center{1.4} center right{1.5} center right/down right{1.6} down center{1.7} up right/center right{1.8}
TOI's Pictorial Distance	recognisable TOI distance{1.9}, extremely unrecognisable TOI distance{1.10}.
TOI's 3D Orientation	Front{1.11} front down right{1.12} rear{1.13} right{1.14}

AI Training CuneiForm 1

Training TOIs
{1,2,3,5,9,11} {1,2,3,4,9,12}
(a) (b)
Front Front down right
{1,2,3,6,10,12} {1,2,3,8,9,13}
(c) (d)
Front down right Rear
{1,2,3,7,10,14} {e}
Front Right

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AI Training CuneiForm 1								
The clouds in AVOIDS training do not validate the cuneiform.								
Up Left	Up Center	Up Right	Center Left	Center	Up Right	Up Left	Up Center	Up Right
Center Left	Center	Center Right	Down Left	Down Center	Down Right	Center Left	Center	Center Right
Down Left	Down Center	Down Right	Down Left	Down Center	Down Right	Down Left	Down Center	Down Right

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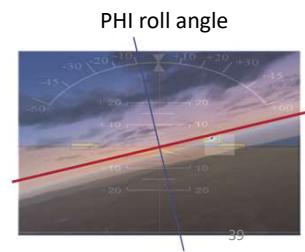
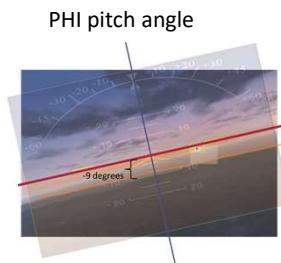
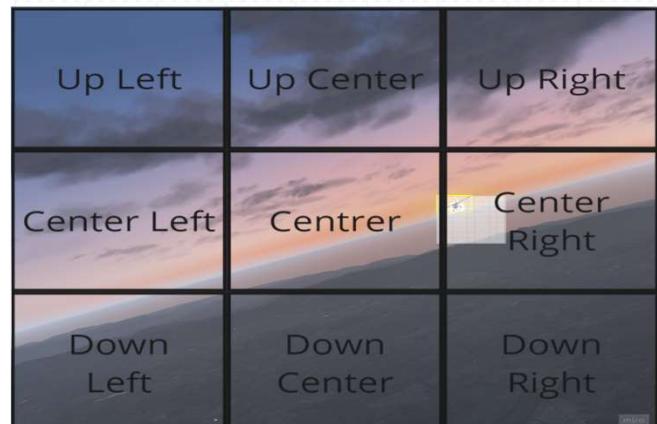
38

AVOIDDS Sample Training: 10.jpg

ODD Dimension	Training class spec
Weather Conditions	high cirrus
Time of Day	Evening (Dusk) 18:11:31
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Moderately Recognisable TOI Distance (1352)
TOI's Pictorial positioning	center right
TOI's 3D orientation	Front
Horizon attitude	Roll: -10, Pitch: -9



Front



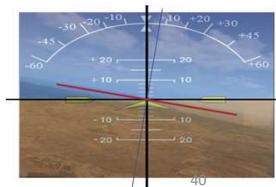
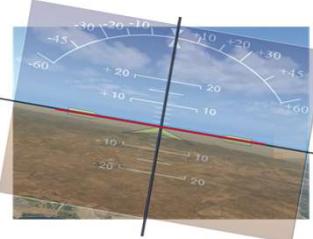
39

11.jpg

ODD Dimension	Training class spec
Weather Conditions	high cirrus
Time of Day	morning, 03:58:23
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Recognisable TOI Distance (694)
TOI's Pictorial positioning	center right/down right
TOI's 3D orientation	front down right
Horizon attitude	Roll: 5, Pitch: 0



Front down right



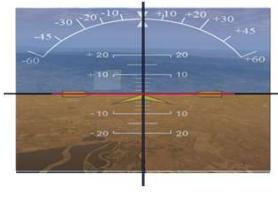
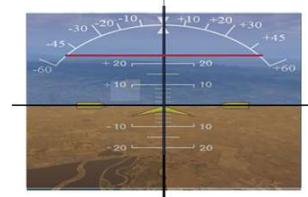
40

12.jpg

ODD Dimension	Training class spec
Weather Conditions	high cirrus
Time of Day	late afternoon
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (7515)
TOI's Pictorial positioning	center
TOI's 3D orientation	front down right
Horizon attitude	Roll: 0, Pitch: 25



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41

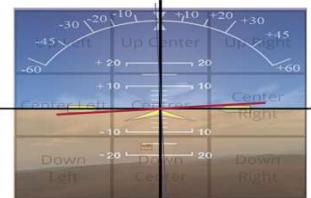
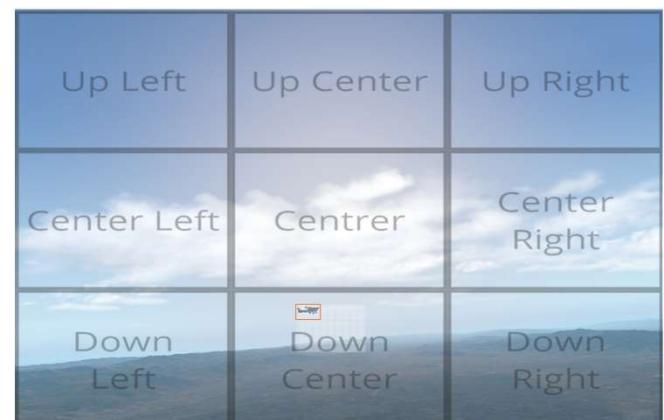
41

13.jpg

ODD Dimension	Training class spec
Weather Conditions	high cirrus
Time of Day	afternoon,
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (13949)
TOI's Pictorial positioning	down center
TOI's 3D orientation	right
Horizon attitude	Roll: -1, Pitch: -22



Right



42

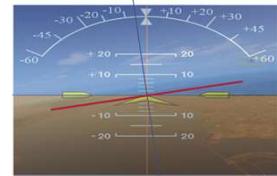
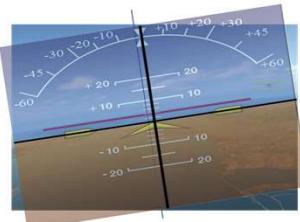
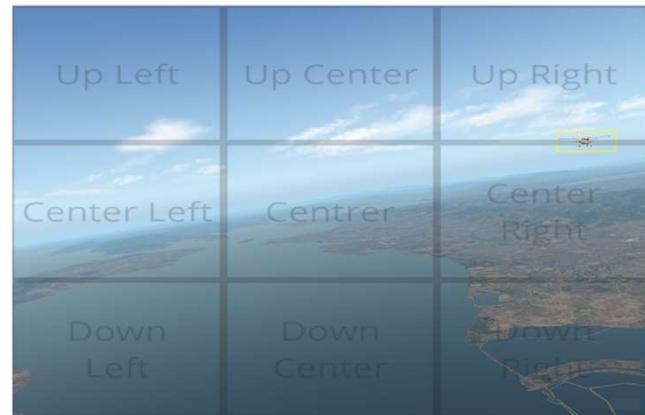
42

14.jpg

ODD Dimension	Training class spec
Weather Conditions	high cirrus
Time of Day	Evening (Dusk), 19:42:11
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (13811)
TOI's Pictorial positioning	up right/center right
TOI's 3D orientation	rear
Horizon attitude	Roll: -5, Pitch: 4



Rear



43

43

AI Training CuneiForm 2



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44

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Abstract CuneiForm Characteristics (dimensions)	Abstract CuneiForm Characteristics definitions
TOIs definition and their aesthetic complexity	Single-engine propeller aeroplane {1}
TOI Motion and Dynamic optical states	Motion trajectory: Linear motion captured in consecutive images where the aeroplane appears to move in a straight line at a constant speed (no acceleration) {1.2}. Dynamic optical state: captured without optical blur {1.3}.
Background Objects associated with TOIs	Scattered Clouds{2} green-terrain {3} water surface{4}
Background Objects Motion and Dynamic optical states	Motion trajectory: is static {2.1,3.1,4.1} Dynamic optical state: no motion blur{2.2,3.2,4.2}
Visible horizon attitude	Negatively Tilted Lowered Horizon{5} Lowered Level Horizon{6} Elevated Level Horizon{7} Positively Tilted Elevated Horizon{8}
TOI's Pictorial Positioning	center{1.4} Up left{1.5} up right{1.6}
TOI's Pictorial Distance	Moderately recognisable TOI distance{1.7}, extremely unrecognisable TOI distance{1.8},
TOI's 3D Orientation	Left{1.9} Rear{1.10} Rear up left{1.11} rear up right{1.12} Unknown{?}
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AI Training CuneiForm 2

Training TOIs

(1,2,3,5,8,12) {1,2,3,4,8,9}

(a) Rear up right (b) Left

(1,2,3,6,7,10) {1,2,3,5,8,11}

(c) Rear (d) Rear up left

(1,2,3,7,10,14) {e} 3D To be confirmed Left

Instantiated Image: cessna_ac_training20, cessna_ac_training21, cessna_ac_training22, cessna_ac_training23, cessna_ac_training24

Time of Day: Evening (Dusk), Midday (Noon), Morning, Night

Scattered clouds: 45

45

AI Training CuneiForm 2

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

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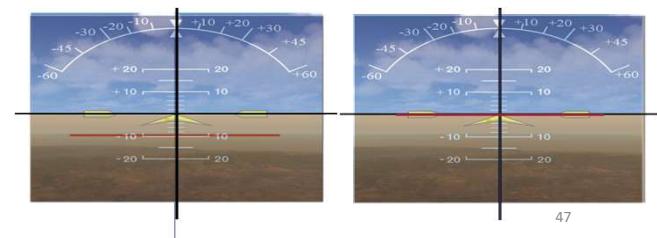
46

20.jpg

ODD Dimension	Training class spec
Weather Conditions	scattered clouds
Time of Day	morning, 08:12:49
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (16436)
TOI's Pictorial positioning	center
TOI's 3D orientation	left
Horizon attitude	Roll: 0, Pitch: -10



Left
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47

47

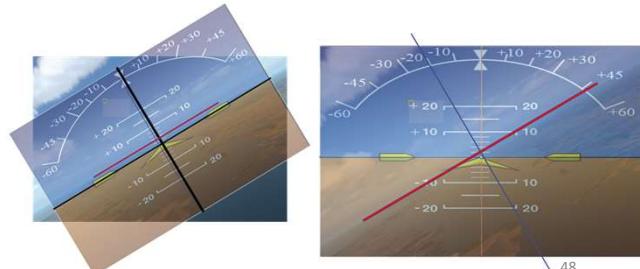
AVOIDDS Sample Training:

21.jpg

ODD Dimension	Training class spec
Weather Conditions	scattered clouds
Time of Day	Morning 06:56:32
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (5369)
TOI's Pictorial positioning	Up left
TOI's 3D orientation	Rear up left
Horizon attitude	Roll: -11, Pitch: +3



Rear up left
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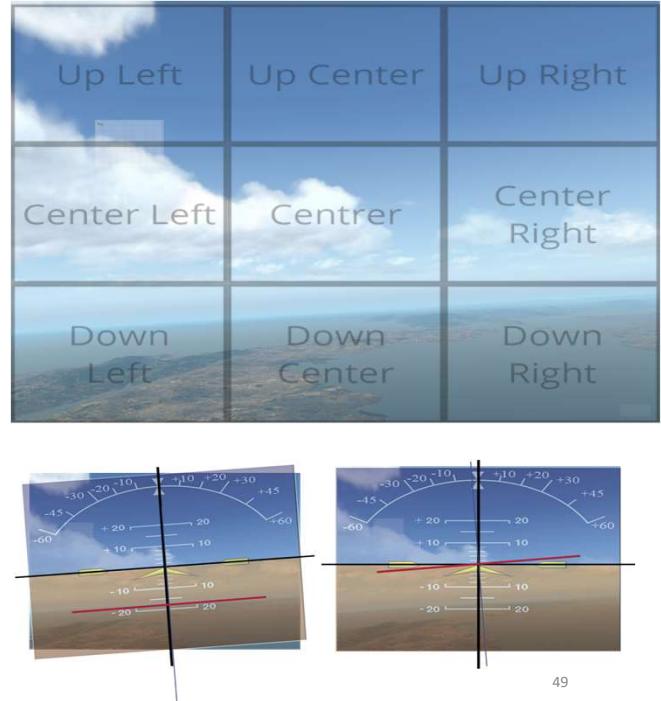


48

48

22.jpg

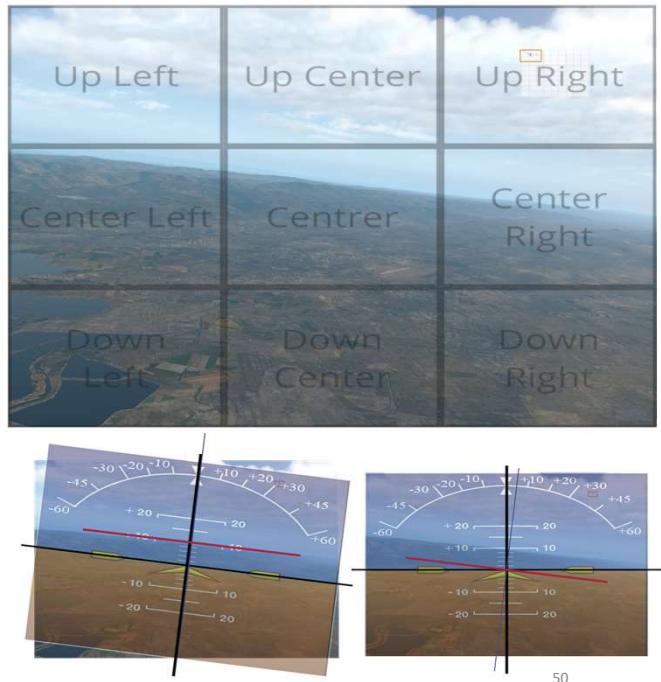
ODD Dimension	Training class spec
Weather Conditions	scattered clouds
Time of Day	morning, 01:14:22
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (34486)
TOI's Pictorial positioning	Up left
TOI's 3D orientation	rear up right
Horizon attitude	Roll: -2, Pitch: -18
	 
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23.jpg

ODD Dimension	Training class spec
Weather Conditions	scattered clouds
Time of Day	late afternoon, 20:41:29
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (130727)
TOI's Pictorial positioning	up right
TOI's 3D orientation	rear
Horizon attitude	Roll: 5, Pitch: 10
	 
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50

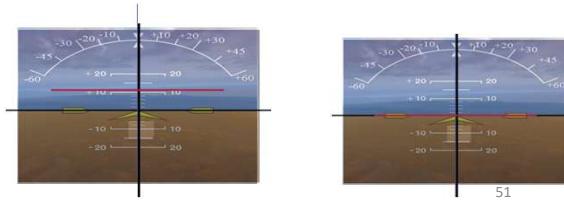
24.jpg

ODD Dimension	Training class spec
Weather Conditions	scattered clouds
Time of Day	midday, 12:14:28
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Moderately Recognisable TOI Distance (1454)
TOI's Pictorial positioning	center
TOI's 3D orientation	Unknown
Horizon attitude	Roll: 0, Pitch: 11

3D?

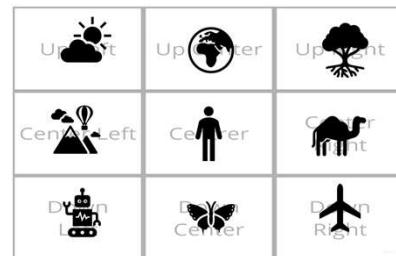


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AI Training
CuneiForm 3



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Abstract CuneiForm Characteristics (dimensions)	Abstract CuneiForm Characteristics definitions
TOIs definition and their aesthetic complexity	Single-engine propeller aeroplane (1)
TOI Motion and Dynamic optical states	Motion trajectory: Linear motion captured in consecutive images where the aeroplane appears to move in a straight line at a constant speed (no acceleration) {1.2}. Dynamic optical state: captured without optical blur {1.3}.
Background Objects associated with TOIs	Broken Clouds{2} green-terrain {3} water surface{4}
Background Objects Motion and Dynamic optical states	Background objects' motion trajectory is static {2.1,3.1,4.1} Dynamic optical state: no motion blur{2.2,3.2,4.2}
Visible horizon attitude	Negatively Tilted Lowered Horizon{5} Positively Tilted Lowered Horizon{6} Lowered Level Horizon{7} Negatively Tilted Elevated Horizon{8} Positively Tilted Elevated Horizon{9}
TOI's Pictorial Positioning	Center{1.4} Down right{1.5} center left{1.6} center/center right{1.7}
TOI's Pictorial Distance	recognisable TOI distance{1.8}, moderately recognisable TOI distance{1.9}, extremely unrecognisable TOI distance{1.10}
TOI's 3D Orientation	Rear up left{1.11} front up right{1.12} Right{1.13} front down left{1.14}
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AI Training CuneiForm 3

Training TOIs

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AI Training CuneiForm 3

This instantiation looks more like scattered clouds than broken

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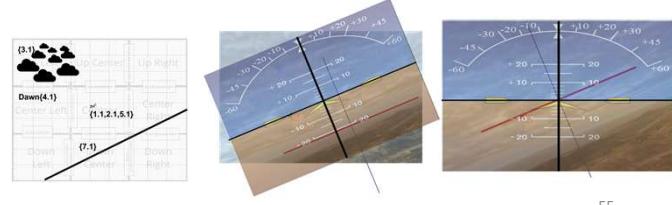
54

30.jpg

ODD Dimension	Training class spec
Weather Conditions	broken clouds
Time of Day	Early Morning (Dawn), 05:26:23
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Moderately Recognisable TOI Distance (1555)
TOI's Pictorial positioning	center
TOI's 3D orientation	rear up left
Horizon attitude	Roll: -15, Pitch: -20



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55

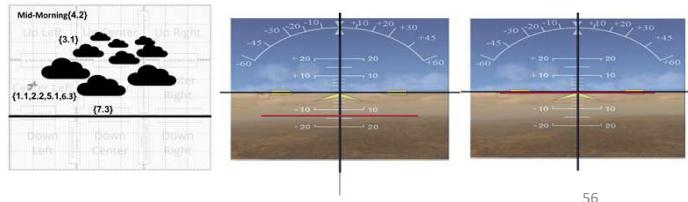
55

31.jpg

ODD Dimension	Training class spec
Weather Conditions	broken clouds
Time of Day	Mid-Morning, 10:20:18
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (8353)
TOI's Pictorial positioning	center left
TOI's 3D orientation	front up right
Horizon attitude	Roll: 0, Pitch: -14



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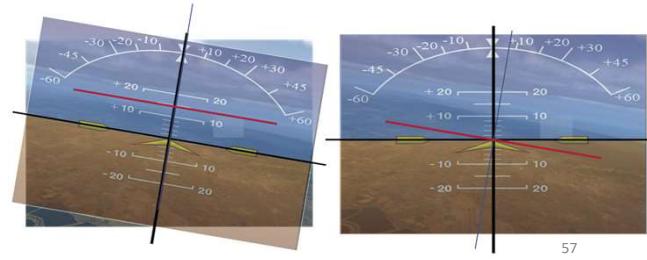
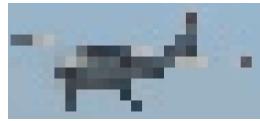


56

56

32.jpg

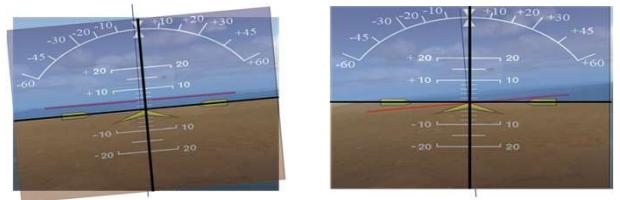
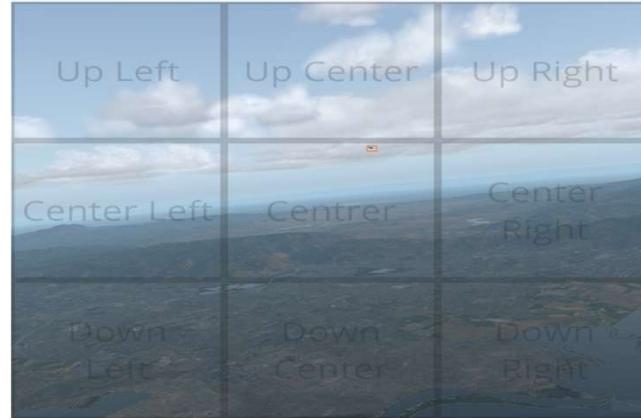
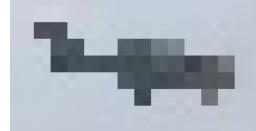
ODD Dimension	Training class spec
Weather Conditions	broken clouds
Time of Day	night, 03:40:13
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (18675)
TOI's Pictorial positioning	center/center right
TOI's 3D orientation	front down left
Horizon attitude	Roll: 7, Pitch: 15



57

33.jpg

ODD Dimension	Training class spec
Weather Conditions	broken clouds
Time of Day	Night, 23:26:59
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (43241)
TOI's Pictorial positioning	center
TOI's 3D orientation	right
Horizon attitude	Roll: -3, Pitch: 4



58

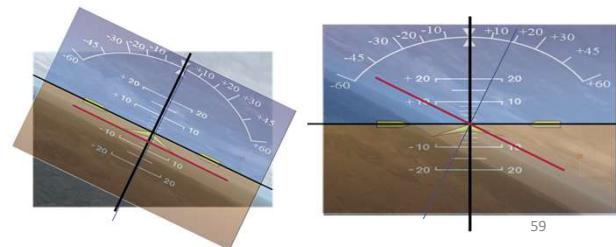
34.jpg

ODD Dimension	Training class spec
Weather Conditions	broken clouds
Time of Day	Early Morning (Dawn), 04:03:13
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (8428)
TOI's Pictorial positioning	down right
TOI's 3D orientation	Unknown
Horizon attitude	Roll: 18, Pitch: -6

?

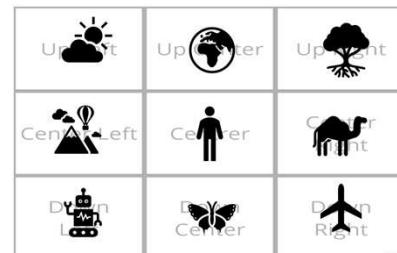


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AI Training
CuneiForm 4



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Abstract CuneiForm Characteristics (dimensions)	Abstract CuneiForm Characteristics definitions
TOIs definition and their aesthetic complexity	Single-engine propeller aeroplane {1}
TOI Motion and Dynamic optical states	Motion trajectory: Linear motion captured in consecutive images where the aeroplane appears to move in a straight line at a constant speed (no acceleration) {1.2}. Dynamic optical state: captured without optical blur {1.3}.
Background Objects associated with TOIs	Overcast Clouds{2} green-terrain {3} water surface{4}
Background Objects Motion and Dynamic optical states	Background objects' motion trajectory is static {2.1,3.1,4.1} Dynamic optical state: no motion blur {2.2,3.2,4.2}
Visible horizon attitude	Lowered Level Horizon {5} Positively Tilted Lowered Horizon {6} Elevated Level Horizon {7} Negatively Tilted Elevated Horizon {8}
TOI's Pictorial Positioning	down center/down right{1.4} Down right{1.5} up center{1.6} Up left{1.7} up right{1.8}
TOI's Pictorial Distance	recognisable TOI distance{1.9}, moderately recognisable TOI distance{1.10}, extremely unrecognisable TOI distance{1.11}
TOI's 3D Orientation	Unknown{1.12} rear down right{1.13} rear up center{1.14} right{1.15}
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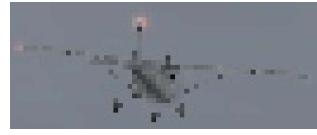
AI Training CuneiForm 4

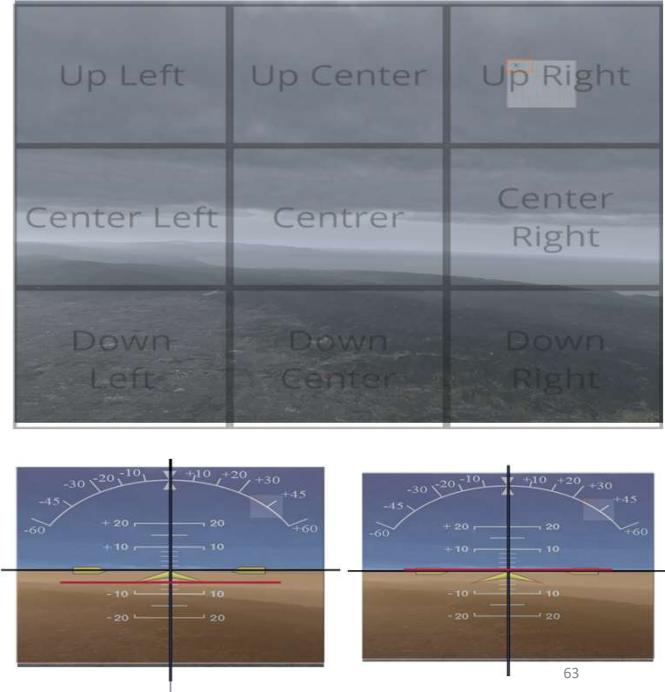
61

AI Training CuneiForm 4

62

40.jpg

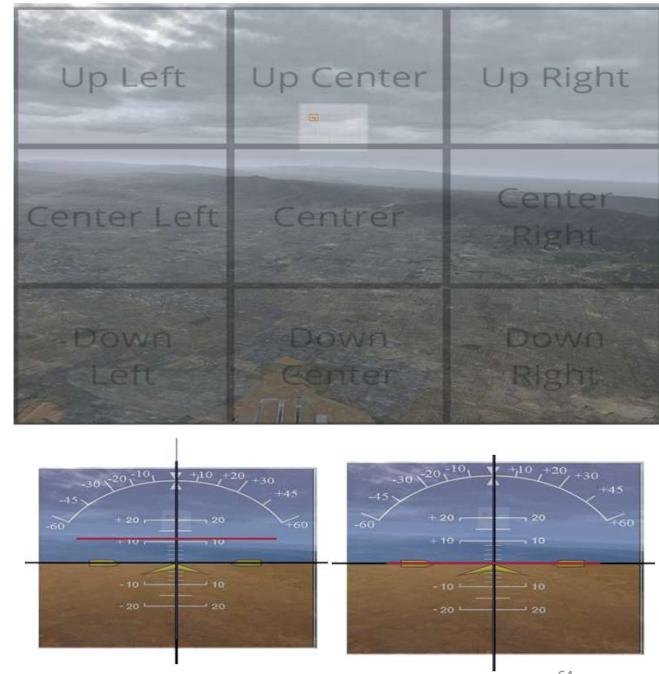
ODD Dimension	Training class spec
Weather Conditions	overcast,
Time of Day	morning, 03:52:05
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (2324)
TOI's Pictorial positioning	up right
TOI's 3D orientation	rear up center
Horizon attitude	Roll: 0, Pitch: -6
	 Rear up center
	
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41.jpg

ODD Dimension	Training class spec
Weather Conditions	overcast,
Time of Day	midday, 12:19:34
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (22131)
TOI's Pictorial positioning	up center
TOI's 3D orientation	right
Horizon attitude	Roll: 0, Pitch: 11
	
	
	Right
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42.jpg

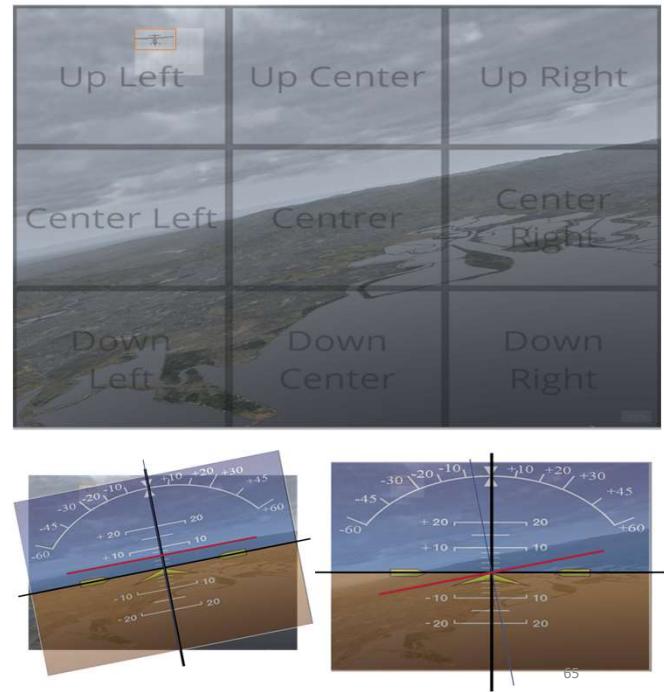
ODD Dimension	Training class spec
Weather Conditions	overcast
Time of Day	midday, 12:58:14
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Moderately Recognisable TOI Distance (1164)
TOI's Pictorial positioning	Up left
TOI's 3D orientation	Rear up center
Horizon attitude	Roll: -8, Pitch: 6



Rear up center



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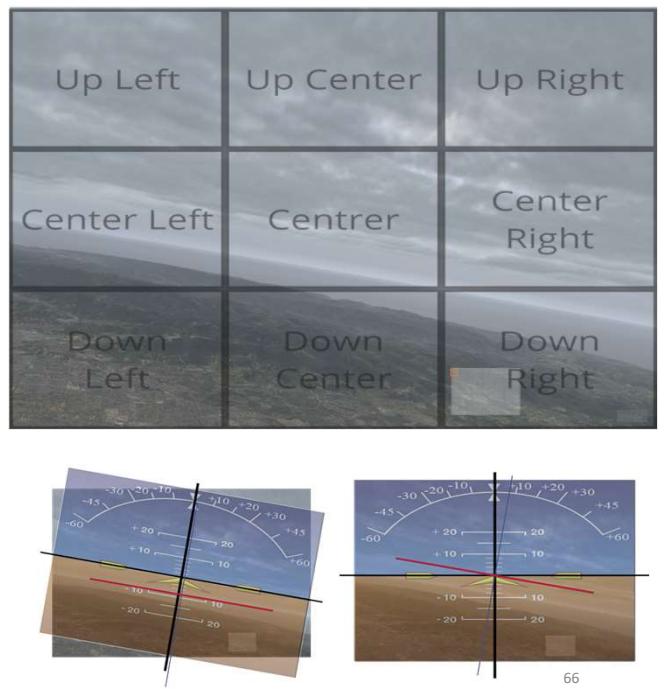
43.jpg

ODD Dimension	Training class spec
Weather Conditions	overcast,
Time of Day	morning, 10:36:00
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (62459)
TOI's Pictorial positioning	down right
TOI's 3D orientation	Unknown
Horizon attitude	Roll: 8, Pitch: -9

?



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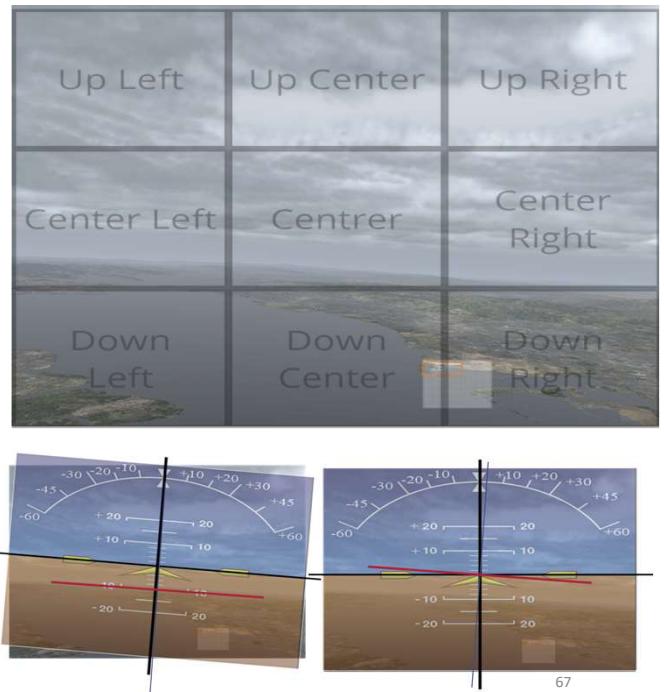
66

44.jpg

ODD Dimension	Training class spec
Weather Conditions	overcast
Time of Day	morning, 17:59:44
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Moderately Recognisable TOI Distance (1038)
TOI's Pictorial positioning	down center/down right
TOI's 3D orientation	rear down right
Horizon attitude	Roll: 2, Pitch: -10



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AI Training CuneiForm 5



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Abstract CuneiForm Characteristics (dimensions)	Abstract CuneiForm Characteristics definitions
TOIs definition and their aesthetic complexity	Single-engine propeller aeroplane {1}
TOI Motion and Dynamic optical states	Motion trajectory: Linear motion captured in consecutive images where the aeroplane appears to move in a straight line at a constant speed (no acceleration) {1.2}. Dynamic optical state: captured without optical blur {1.3}.
Background Objects associated with TOIs	Stratus Clouds{2} green-terrain {3} water surface{4}
Background Objects Motion and Dynamic optical states	Background objects' motion trajectory is static {2.1,3.1,4.1} Dynamic optical state: no motion blur{2.2,3.2,4.2}
Visible horizon attitude	Negatively Tilted Lowered Horizon{5} Positively Tilted Lowered Horizon{6} Negatively Tilted Elevated Horizon{7}
TOI's Pictorial Positioning	center/left/down left{1.4} center/down center{1.5} down left{1.6} up center/up right{1.7}
TOI's Pictorial Distance	recognisable TOI distance{1.9}, clear close TOI distance{1.10}, extremely unrecognisable TOI distance{1.11},
TOI's 3D Orientation	Front{1.12} rear down right{1.13} Right{1.14} Unknown{1.15}

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AI Training CuneiForm 5

Training TOIs

{1,2,3,7,10,12} {1,2,3,6,11,12} {1,2,3,6,9,13} {1,2,3,4,10,14} {1,2,3,5,9,12}

(a) (b) (c) (d) (e)

3D To be confirmed

Front

Rear down right

Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Front

Up Right

Center Right

Down Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Instantiated Image

Time of Day

cessna_ac_training50
cessna_ac_training51
cessna_ac_training52
cessna_ac_training53
cessna_ac_training54

stratus clouds

69

69

AI Training CuneiForm 5

53.jpg

52.jpg

51.jpg

50.jpg

54.jpg

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Front

Up Right

Center Right

Down Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Up Left Up Center Up Right

Center Left Center Center Right

Down Left Down Center Down Right

Instantiated Image

Time of Day

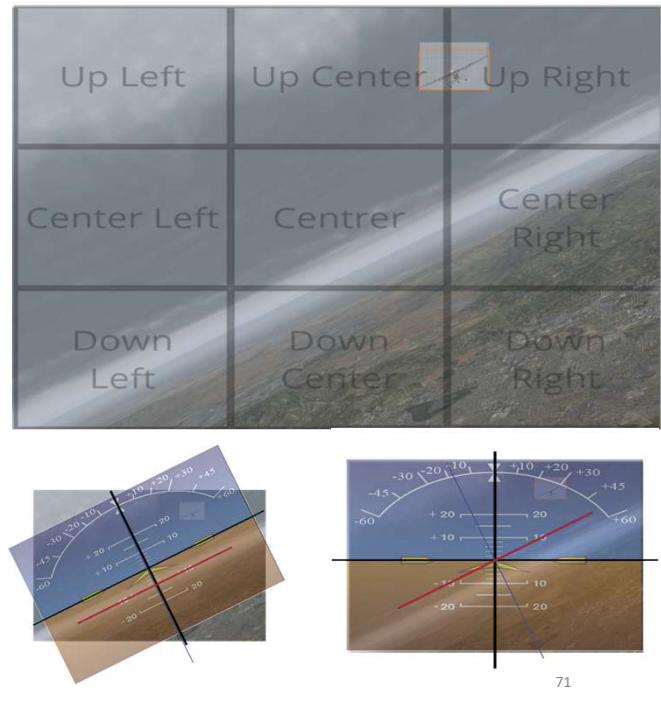
cessna_ac_training50
cessna_ac_training51
cessna_ac_training52
cessna_ac_training53
cessna_ac_training54

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50.jpg

ODD Dimension	Training class spec
Weather Conditions	stratus
Time of Day	Mid-Morning, 10:07:30
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Recognisable TOI Distance (303)
TOI's Pictorial positioning	up center/up right
TOI's 3D orientation	Front
Horizon attitude	Roll: -18, Pitch: -10

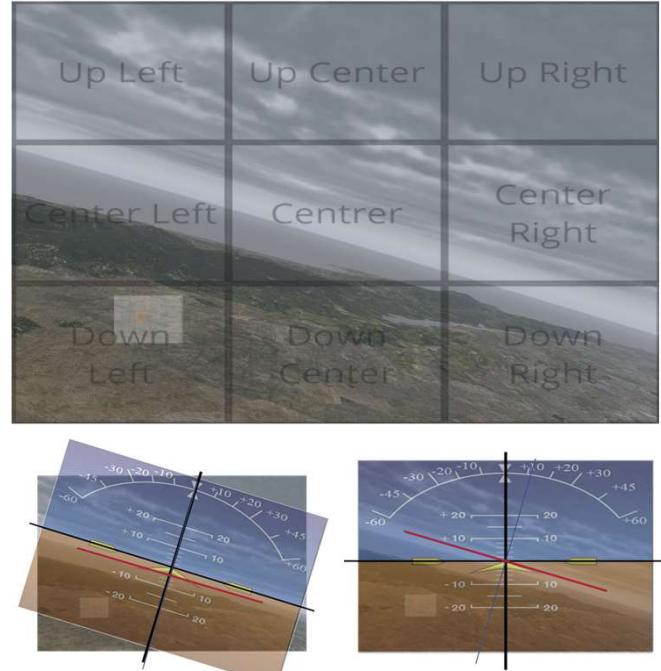


71

51.jpg

ODD Dimension	Training class spec
Weather Conditions	stratus
Time of Day	late afternoon, 20:50:56
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Extremely Unrecognisable TOI Distance (61101)
TOI's Pictorial positioning	down left
TOI's 3D orientation	unknown
Horizon attitude	Roll: 12, Pitch: -4

?



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52.jpg

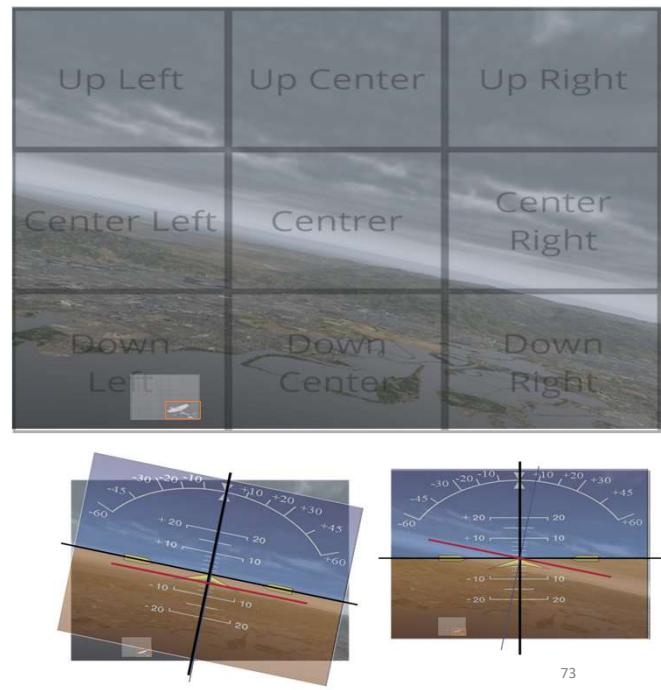
ODD Dimension	Training class spec
Weather Conditions	stratus
Time of Day	morning, 06:10:03
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Moderately Recognisable TOI Distance (979)
TOI's Pictorial positioning	down left
TOI's 3D orientation	rear down right
Horizon attitude	Roll: 8, Pitch: -4



Rear down right



05/02/2025



73

53.jpg

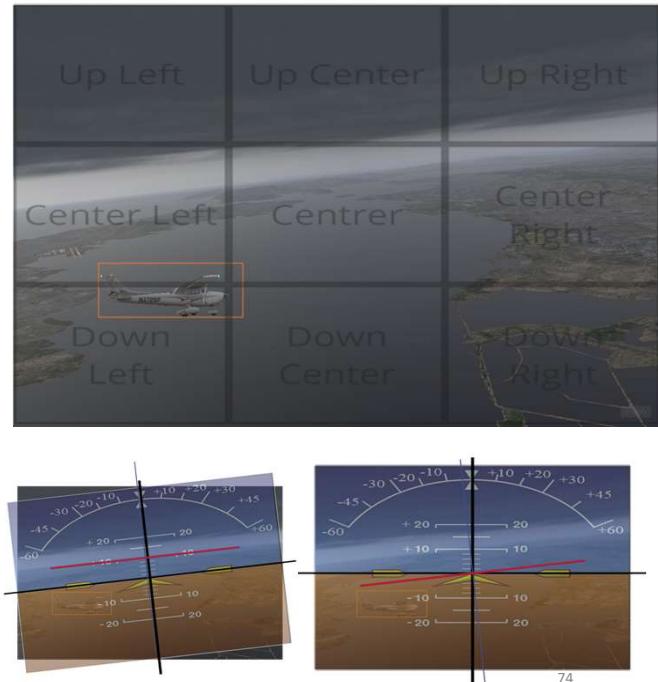
ODD Dimension	Training class spec
Weather Conditions	stratus
Time of Day	morning
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Clear Close TOI Distance (58)
TOI's Pictorial positioning	center left/down left
TOI's 3D orientation	right
Horizon attitude	Roll: -3, Pitch: 10



Right



05/02/2025



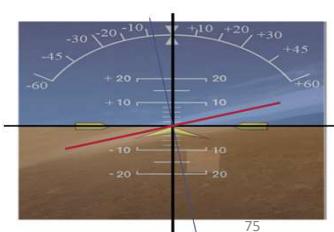
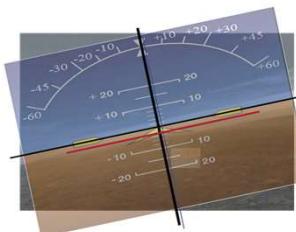
74

54.jpg

ODD Dimension	Training class spec
Weather Conditions	stratus
Time of Day	midday, 12:10:28
CuneiForm Dimension	Training class spec
TOI's pictorial distance (nindans)	Recognisable TOI Distance (673)
TOI's Pictorial positioning	center/down center
TOI's 3D orientation	right
Horizon attitude	Roll: -8, Pitch: -3

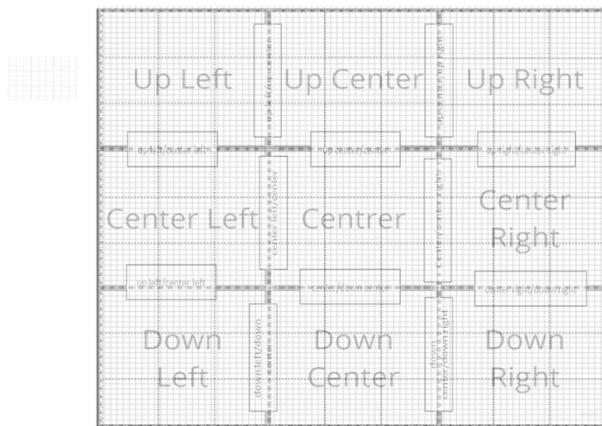


Right
05/02/2025



75

CuneiForm Canvas



05/02/2025

76

76