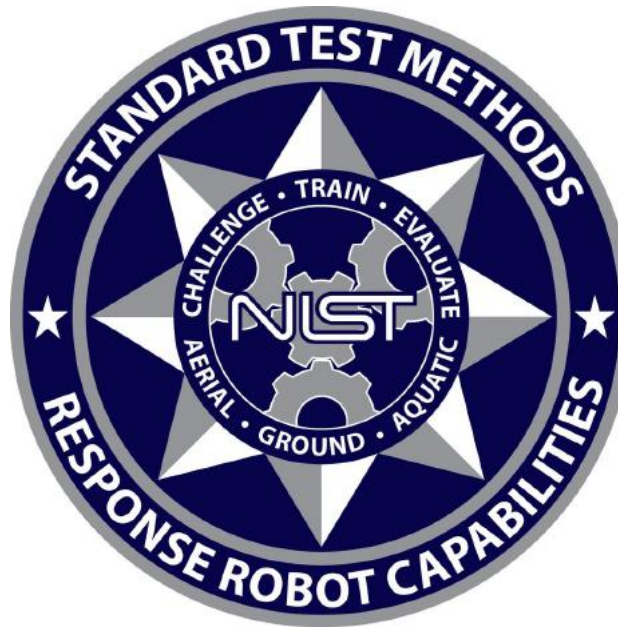


# Aerial Drone Tests and Scorable Scenarios for Evaluating System Capabilities and Remote Pilot Proficiency in Level 3 Open, Level 4 Obstructed, and Level 5 Confined Environments

*Developed by the National Institute of Standards and Technology*



*Test Director*

**Adam Jacoff**

Intelligent Systems Division  
National Institute of Standards and Technology  
U.S. Department of Commerce

*Sponsor:*

Systems Engineering & Standards Division  
Science and Technology Directorate  
U.S. Department of Homeland Security

Internet  
[RobotTestMethods.nist.gov](http://RobotTestMethods.nist.gov)



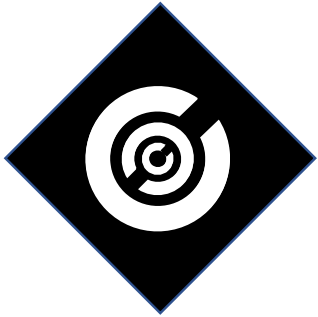
Email  
[RobotTestMethods@nist.gov](mailto:RobotTestMethods@nist.gov)



# Level 5 Confined Environments

LEVEL

**5**



## **CONFINED Test Lane**

### **Payload Functionality Trials**

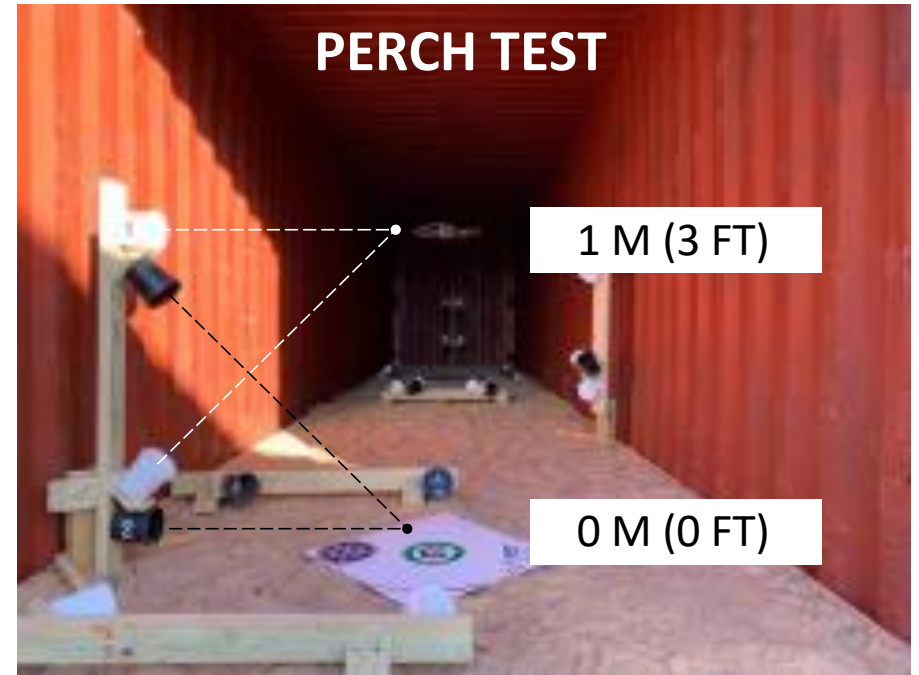
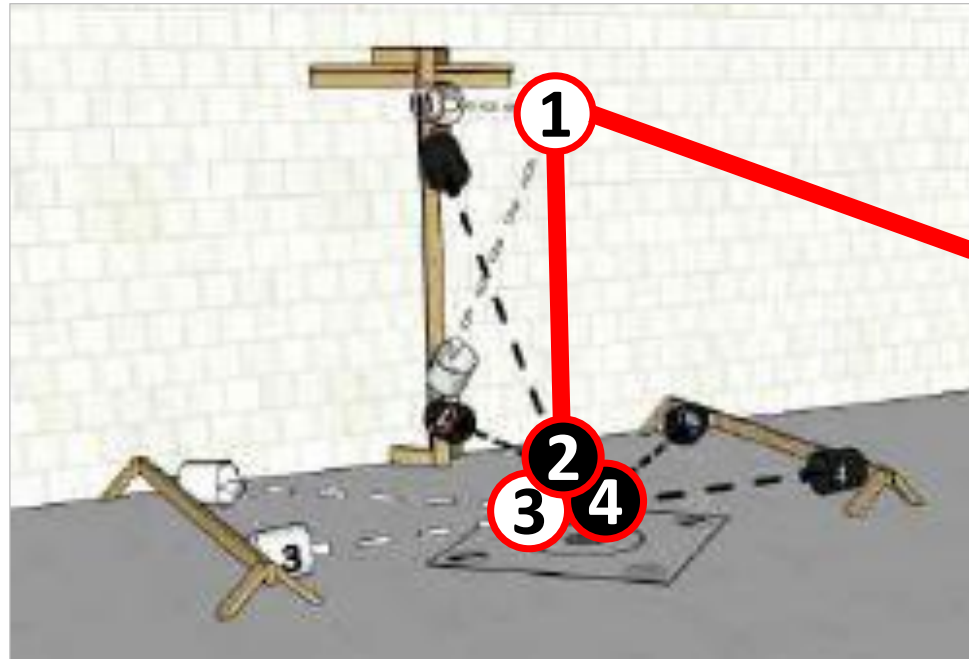
**Evaluate maneuvering in tight spaces,  
dealing with the drone's own turbulent  
air, while controlling zoom and exposure.**

- *25 minutes (5 minutes each)*
- *50 Alignment & 50 Acuity Points*

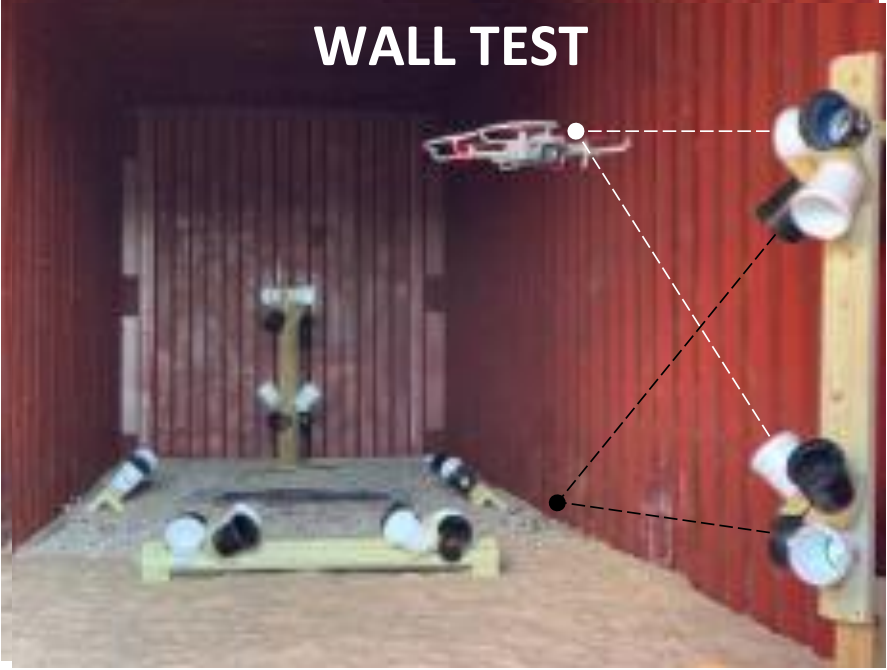
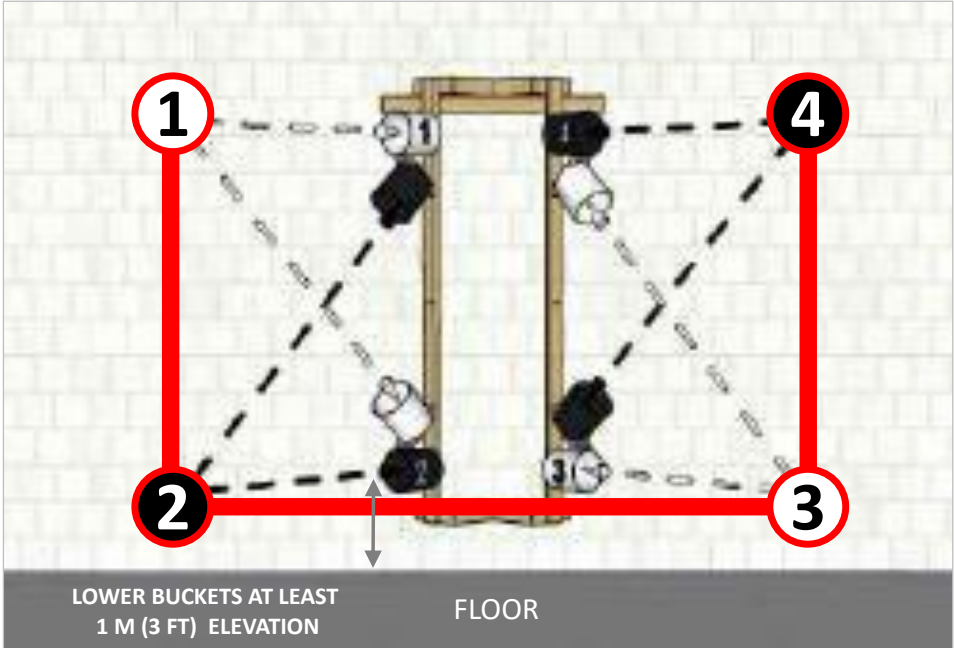


# PERCH

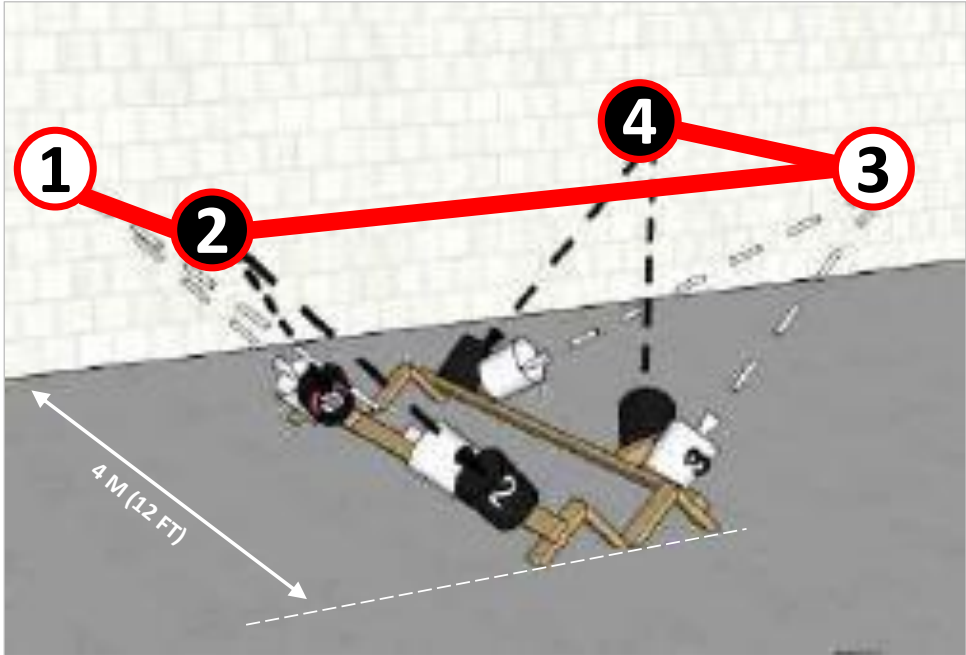
PAY 6



# WALL PAY 7

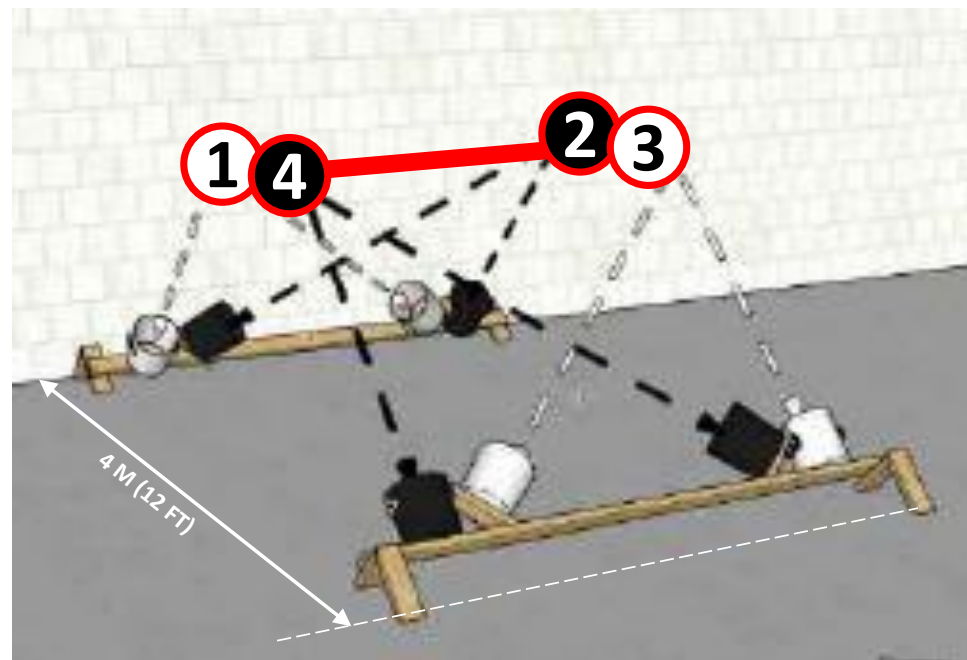


# GROUND PAY 8

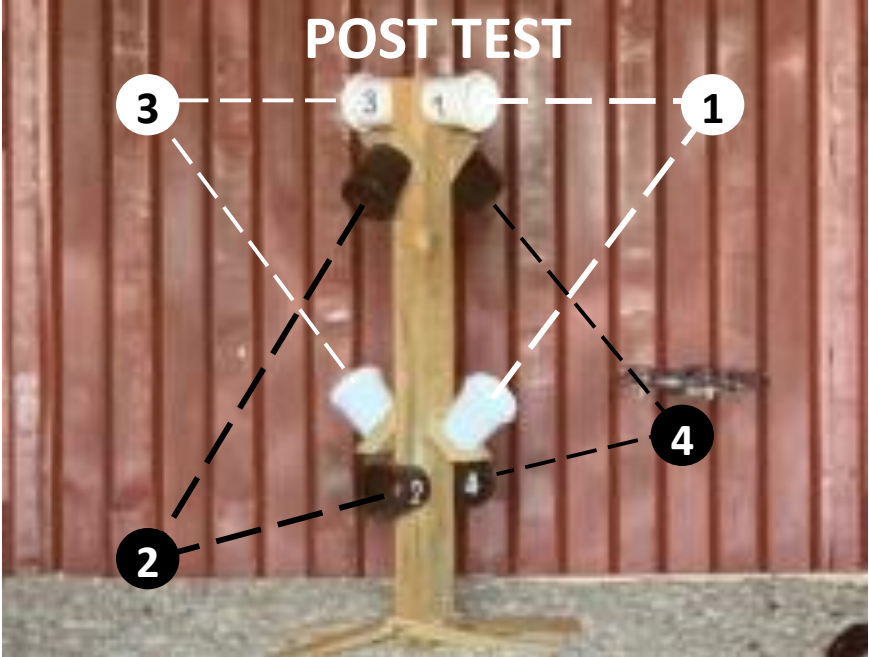
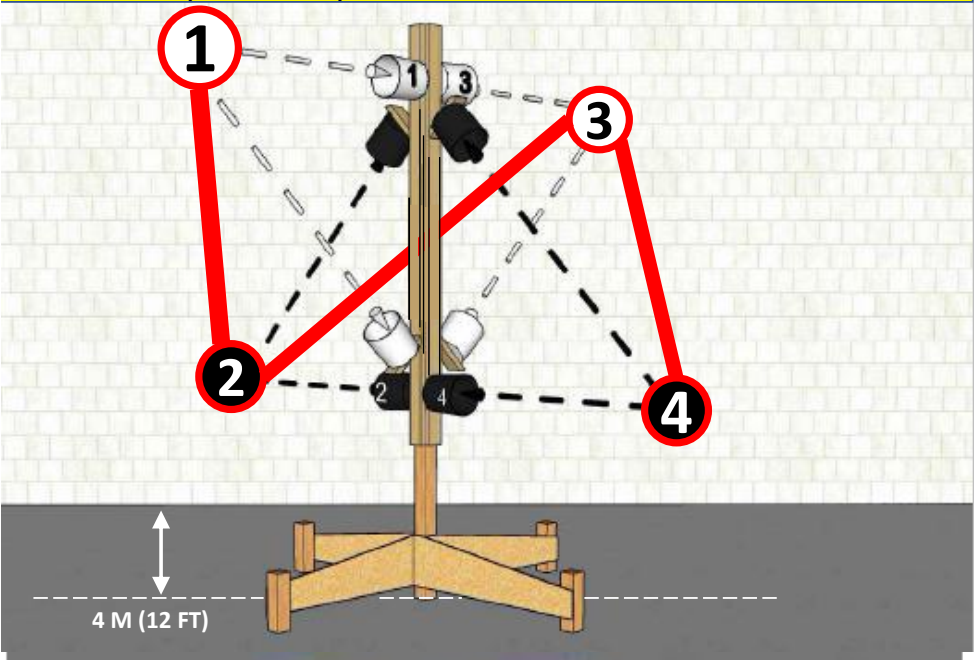


# ALLEY

PAY 9



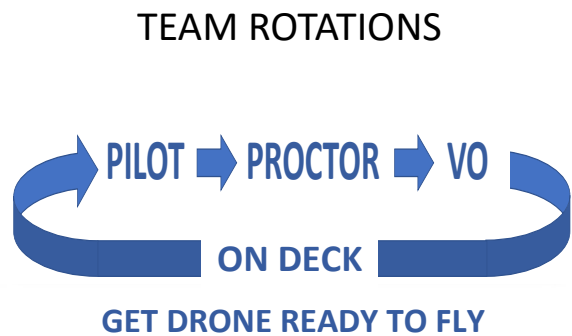
# POST PAY 10





## Teams Rotate Through Each Role

Each Pilot flies a 5-minute trial with help from other team members.  
A 3-4 person team completes all 5 tests in 2 hours.



Four person teams always have one person getting their aircraft ready to launch right after the previous lands.

Three person teams work too, but require some time between each rotation to prepare the next aircraft.

### PILOT

- Maintain control of the aircraft.
- Call out each intention of movement before doing so.
- Call out each bucket alignment and acuity target gap.

### PROCTOR

- Fill in the form header.
- Read the test procedures to the Pilot.
- Confirm, record, and attest to scoring after the trial.

### VISUAL OBSERVER (VO)

- Maintain sight with the aircraft and surroundings.
- Repeat the Pilot's intention of movement to confirm.
- Call out corrections and warnings as necessary.



# Level 5 Confined Lane Proctoring

## Scoring Alignment Points

Capture images of alignment rings to verify

### ALIGN WITH BUCKETS AND LAND ACURATELY

10 ALIGNMENT RINGS TOTAL 50 POINTS



CAPTURE IMAGES OF THE INSCRIBED RINGS AND LAND ACCURATELY.

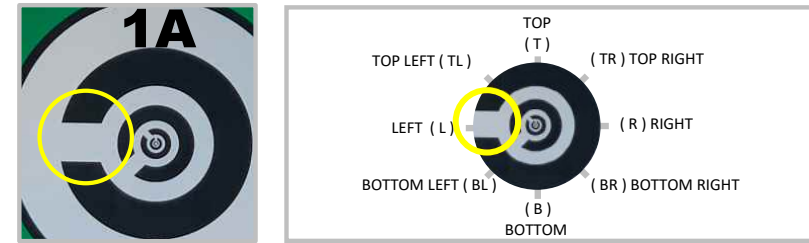
- First align with each PERPENDICULAR BUCKET to capture a SINGLE ALIGNMENT IMAGE of the inscribed ring.
- Score captured images with
  - UNBROKEN RINGS (5 points)
  - BROKEN RINGS (1 point)
  - NO RINGS (0 points, strike through line)
- Accurate landings are not scored.
- Verification of captured alignment images can be during the trial when obvious or after the trial to eliminate discussions during the trial. Images can also be stored for documentation.

## Scoring Acuity Points

Identify increasingly small visual acuity targets

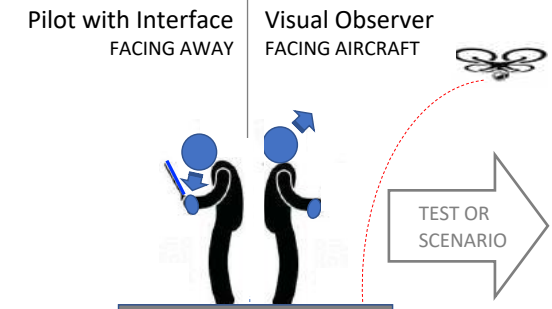
### ALIGN THEN CONTROL ZOOM AND EXPOSURE

10 ACUITY TARGETS TOTAL 50 POINTS



REPORT GAP DIRECTIONS RELATIVE TO THE BUCKET NUMBER (TOP)

- Then align with each ANGLED BUCKET to IDENTIFY ACUITY TARGETS using camera zoom and exposure controls.
- Call out as many of the Concentric C gap directions as possible (1 pt each).
- Fly facing away from the test lane or scenario with a Visual Observer to evaluate flying interface only as if beyond visual line of sight.



# Level 5 Confined Lane

## Payload Functionality Trials



Test Methods for Evaluating Aerial Drones  
*Safety | Capabilities | Proficiency*  
 RobotTestMethods.nist.gov



VERSION 2023A



Pilot LAST Name \_\_\_\_\_

Pilot FIRST Name \_\_\_\_\_

Pilot Organization \_\_\_\_\_

Drone Make \_\_\_\_\_

Drone Model \_\_\_\_\_

Facility Location \_\_\_\_\_

Date (YYYY/MM/DD) \_\_\_\_\_ Team #: \_\_\_\_\_

**PROCTOR NAME** \_\_\_\_\_

BUCKET DIAMETER		VISIBILITY			WIND		PILOT VIEW		TIME LIMIT		
2 IN (5 CM)	4 IN (10 CM)	LIGHTED 300+ LUX	DIM 1-300 LUX	DARK < 1 LUX	AVERAGE _____ MPH	GUSTS _____ MPH	LINE OF SIGHT FACINE LANE OPTIONAL V.O.	INTERFACE ONLY BACK TO LANE MANDATORY V.O.	5 MIN	10 MIN	_____ MIN
(CIRCLE ONE)		(CIRCLE ONE)			(FILL IN)		(CIRCLE ONE)		(CIRCLE ONE or FILL IN)		

- Fill in the header information completely!
- **PROCTOR ATTESTATION**  
(The Proctor's printed name)
- Bucket Size
- Lighting
- Wind
- Pilot view
- Time limit

# Level 5 Confined Lane Payload Functionality Trials

Brief reminders.

White and black bucket shading.

SCORE WHILE PERCHED.

Circle alignment points when declared by the pilot with verification of images during or after the trial.

Separate totals for ALIGNMENT and ACUITY points (50 points each).

Any organization can select their own passing score.

**ALIGNMENT SCORE:** Circle points for images with UNBROKEN RINGS (5 pts), BROKEN RINGS (1 pt), Draw a line through all incomplete.  
**ACUITY SCORE:** Circle correctly identified GAP DIRECTIONS in the answer key (1 pt each).

PERCH (PAY 6)			WALL (PAY 7)			GROUND (PAY 8)			ALLEY (PAY 9)			POST (PAY 10)		
21 IMAGES TO CAPTURE			21 IMAGES TO CAPTURE			21 IMAGES TO CAPTURE			21 IMAGES TO CAPTURE			21 IMAGES TO CAPTURE		
• 1 PRE-LAUNCH			• 1 PRE-LAUNCH			• 1 PRE-LAUNCH			• 1 PRE-LAUNCH			• 1 PRE-LAUNCH		
• 20 ALIGNMENTS			• 20 ALIGNMENTS			• 20 ALIGNMENTS			• 20 ALIGNMENTS			• 20 ALIGNMENTS		
• WHILE PERCHED														
ALIGNMENT	ACUITY		ALIGNMENT	ACUITY		ALIGNMENT	ACUITY		ALIGNMENT	ACUITY		ALIGNMENT	ACUITY	
BUCKET SEQUENCE	IMAGE POINTS	CIRCLE CORRECT GAPS (1 POINT EACH)	BUCKET SEQUENCE	IMAGE POINTS	CIRCLE CORRECT GAPS (1 POINT EACH)	BUCKET SEQUENCE	IMAGE POINTS	CIRCLE CORRECT GAPS (1 POINT EACH)	BUCKET SEQUENCE	IMAGE POINTS	CIRCLE CORRECT GAPS (1 POINT EACH)	BUCKET SEQUENCE	IMAGE POINTS	CIRCLE CORRECT GAPS (1 POINT EACH)
1	5	1	1	5	1	1	5	1	1	5	1	1	5	1
1A		TR B TR L BR	1A		TR B TR L BR	1A		TR B TR L BR	1A		TR B TR L BR	1A		TR B TR L BR
2	5	1	2	5	1	2	5	1	2	5	1	2	5	1
2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R
3	5	1	3	5	1	3	5	1	3	5	1	3	5	1
3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL
4	5	1	4	5	1	4	5	1	4	5	1	4	5	1
4A		T BL B TR L	4A		T BL B TR L	4A		T BL B TR L	4A		T BL B TR L	4A		T BL B TR L
3	5	1	3	5	1	3	5	1	3	5	1	3	5	1
3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL
2	5	1	2	5	1	2	5	1	2	5	1	2	5	1
2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R
1	5	1	1	5	1	1	5	1	1	5	1	1	5	1
1A		TR B TR L BR	1A		TR B TR L BR	1A		TR B TR L BR	1A		TR B TR L BR	1A		TR B TR L BR
2	5	1	2	5	1	2	5	1	2	5	1	2	5	1
2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R	2A		L BR T TL R
3	5	1	3	5	1	3	5	1	3	5	1	3	5	1
3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL	3A		BR T TL R BL
4	5	1	4	5	1	4	5	1	4	5	1	4	5	1
4A		T BL B TR L	4A		T BL B TR L	4A		T BL B TR L	4A		T BL B TR L	4A		T BL B TR L
SCORE	SCORE		SCORE	SCORE		SCORE	SCORE		SCORE	SCORE		SCORE	SCORE	
	/50			/50			/50			/50			/50	
ELAPSED TIME (MM : SS)			ELAPSED TIME (MM : SS)			ELAPSED TIME (MM : SS)			ELAPSED TIME (MM : SS)			ELAPSED TIME (MM : SS)		
PASS	CIRCLE ONE	FAIL	PASS	CIRCLE ONE	FAIL	PASS	CIRCLE ONE	FAIL	PASS	CIRCLE ONE	FAIL	PASS	CIRCLE ONE	FAIL



# Confined Vehicle Inspection Scenarios

Day and Night Trials

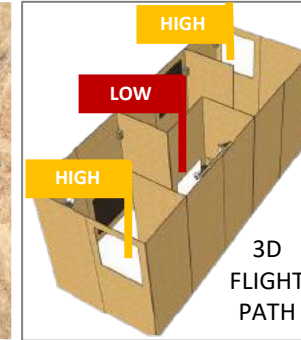
USE SETS OF 5 "INLINE" DUAL BUCKET RAILS  
DISTRIBUTED THROUGHOUT THE SCENARIO



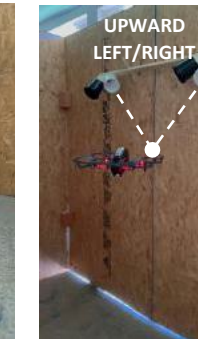
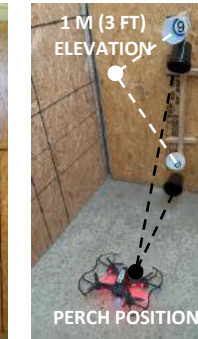
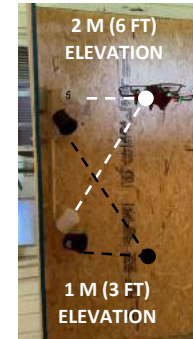
# Confined Room-to-Room Labyrinth

Search tasks with 1 m (3ft) minimum clearances

USE SETS OF 5 "INLINE" DUAL BUCKET RAILS  
HORIZONTALS FOR LEFTWARD/RIGHTWARD INSPECTIONS



VERTICALS FOR UPWARD/DOWNWARD INSPECTIONS



- Fabricated room-to-room search scenario with inspect tasks that can be replicated to track and compare scores.
- Self-standing plywood corner walls define 1.2m (4 ft) switchback hallways with a blackout tarp ceiling over top at 2.4m (8ft). Fits inside a 6m (20ft) shipping container.
- Square access "windows" measuring 1m (3ft) square provide entry/exit and interior high/low pass throughs.

VERSION 2023A

# LEVEL 5 | CONFINED SCORABLE SCENARIOS



Pilot LAST Name \_\_\_\_\_  
 Pilot FIRST Name \_\_\_\_\_  
 Pilot Organization \_\_\_\_\_  
 Drone Make \_\_\_\_\_  
 Drone Model \_\_\_\_\_  
 Facility Location \_\_\_\_\_  
 Date (YYYY/MM/DD) \_\_\_\_\_ Team #: \_\_\_\_\_

PROCTOR NAME \_\_\_\_\_

<b>BUCKET DIAMETER</b> 2 IN (5 CM) (CIRCLE ONE)    4 IN (10 CM) (CIRCLE ONE)		<b>VISIBILITY</b> LIGHTED 300+ LUX (CIRCLE ONE)    DIM 1-300 LUX (CIRCLE ONE)    DARK < 1 LUX (CIRCLE ONE)		<b>WIND</b> AVERAGE _____ MPH (FILL IN)    GUSTS _____ MPH (FILL IN)		<b>PILOT VIEW</b> LINE OF SIGHT FACINE LANE OPTIONAL V.O. (CIRCLE ONE)    INTERFACE ONLY BACK TO LANE MANDATORY V.O. (CIRCLE ONE)		<b>TIME LIMIT</b> 5 MIN    10 MIN    _____ MIN (CIRCLE ONE or FILL IN)	
---	--	---	--	---	--	--	--	---	--

**ALIGNMENT SCORE:** Circle points for images with UNBROKEN RINGS (5 pts), BROKEN RINGS (1 pt), Draw a line through all incomplete.  
**ACUITY SCORE:** Circle correctly identified GAP DIRECTIONS in the answer key (1 pt each).

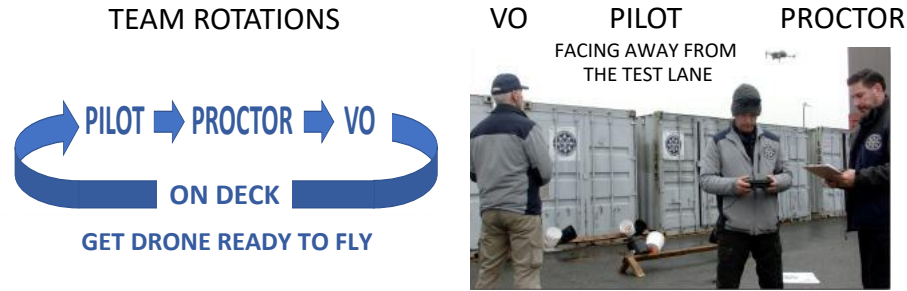
	BUCKETS	ALIGNMENT	ACUITY
START TIMER (CAPTURE CLOCK IMAGE) : :	NUMBER	IMAGE POINTS (5 OR 1 POINT)	CIRCLE GAPS (1 POINT EACH)
1 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	1	5 1 0	
2 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	1A		TR B TR L BR
3 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	2	5 1 0	
4 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	2A		L BR T TL R
5 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	3	5 1 0	
6 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	3A		BR T TL R BL
7 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	4	5 1 0	
8 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	4A		T BL B TR L
9 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	5	5 1 0	
10 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	5A		BL R TL L BL
11 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	6	5 1 0	
12 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	6A		TR B TR L BR
13 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	7	5 1 0	
14 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	7A		L BR T TL R
15 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	8	5 1 0	
16 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	8A		BR T TL R BL
17 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	9	5 1 0	
18 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	9A		T BL B TR L
19 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	10	5 1 0	WHILE PERCHED
20 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	10A		BL R TL L BL
STOP TIMER. RECORD SCORES AND ELAPSED TIME.		/50	/50
ELAPSED TIME (MM:SS)			

	BUCKETS	ALIGNMENT	ACUITY
START TIMER (CAPTURE CLOCK IMAGE) : :	NUMBER	IMAGE POINTS (5 OR 1 POINT)	CIRCLE GAPS (1 POINT EACH)
1 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	1	5 1 0	
2 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	1A		TR B TR L BR
3 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	2	5 1 0	
4 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	2A		L BR T TL R
5 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	3	5 1 0	
6 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	3A		BR T TL R BL
7 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	4	5 1 0	
8 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	4A		T BL B TR L
9 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	5	5 1 0	
10 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	5A		BL R TL L BL
11 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	6	5 1 0	
12 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	6A		TR B TR L BR
13 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	7	5 1 0	
14 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	7A		L BR T TL R
15 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	8	5 1 0	
16 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	8A		BR T TL R BL
17 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	9	5 1 0	
18 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	9A		T BL B TR L
19 PERPENDICULAR BUCKET: ALIGN AND CAPTURE IMAGE	10	5 1 0	WHILE PERCHED
20 ANGLED BUCKET: CALL OUT ACUITY GAP DIRECTIONS	10A		BL R TL L BL
STOP TIMER. RECORD SCORES AND ELAPSED TIME.		/50	/50
ELAPSED TIME (MM:SS)			



## Teams Rotate Through Each Role

Each Pilot flies a 5-minute trial with help from others.  
A 3-4 person team completes all 5 tests in 2 hours.



Four person teams always have one person getting their aircraft ready to launch right after the previous lands.

Three person teams work too, but require some time between each rotation to prepare the next aircraft.

### PILOT

- Maintain control of the aircraft.
- Call out each intention of movement before doing so.
- Call out each bucket alignment and acuity target gap.

### PROCTOR

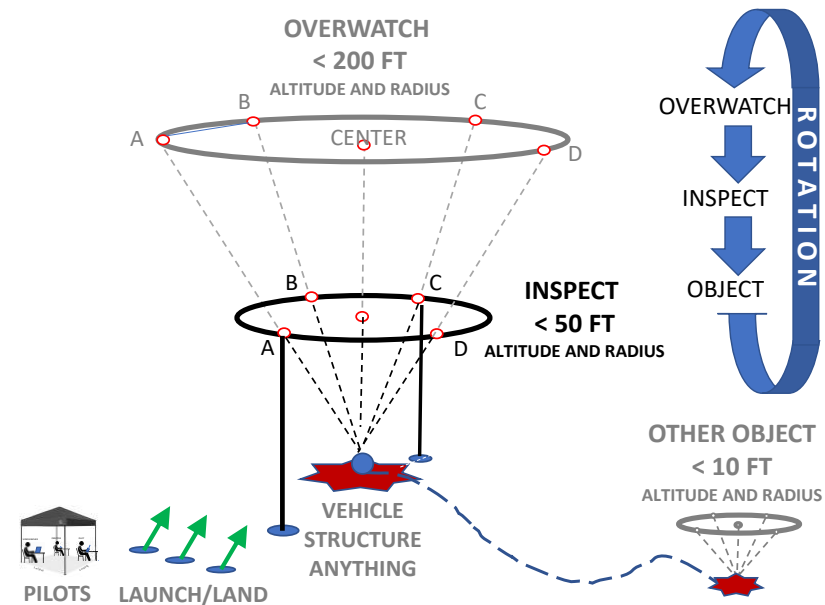
- Fill in the form header.
- Read the test procedures to the Pilot.
- Confirm, record, and attest to scoring after the trial.

### VISUAL OBSERVER (VO)

- Maintain sight with the aircraft and surroundings.
- Repeat the Pilot's intention of movement to confirm.
- Call out corrections and warnings as necessary.

## Teams Sequence Through Scenarios

Each Pilot flies a 15-minute scenario, sequencing through 3 objectives for 5 minutes each.



- This scenario mechanization enables embedded bucket scoring tasks to be performed similarly by all participating Pilots. So the results are comparable within the same scenario layout. Additional tactics can be overlaid onto these scenarios at your facility.
- Up to 3 teams concurrently fly different scenario objectives from safe distances and altitudes apart.
- Teams move as necessary to maintain sight lines with their aircraft and communications with other teams. The overwatch team leads communications.
- Scenarios restart every 20 minutes with a different rotation of Pilot, Proctor, and VO.



# Level 5 Review

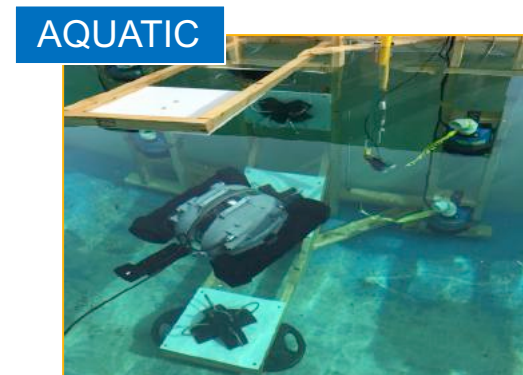
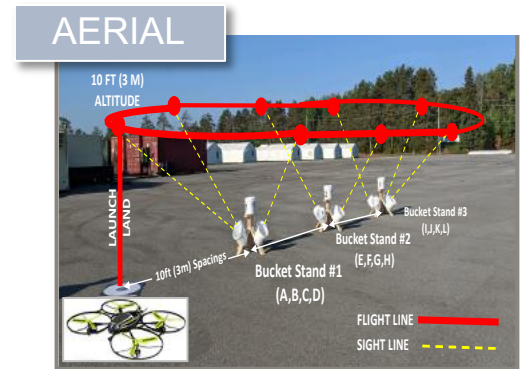
# Standards Enable Credentialing of Proctors and Remote Pilots

Safety | Capabilities | Proficiency

## NIST Develops and Validates Test Methods

- **Apparatus** that can be reproducible by others.
- **Procedures** that are repeatable to conduct test trials.
- **Performance Metrics** that are quantitative and can be compared over time, across locations and internationally
- **Evaluate Systems** using expert pilots conducting complete trials
- **Operator proficiency** is compared with similar systems on the same lane spacing in similar environmental conditions with either complete or time limited trials

Compare time limited trials that are incomplete by total points for similar elapsed times or calculate and compare the scoring rate as points per minute for different elapsed times

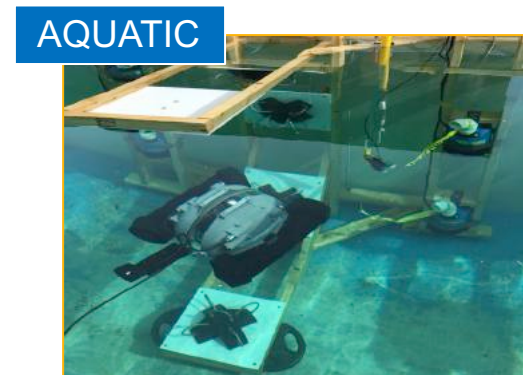
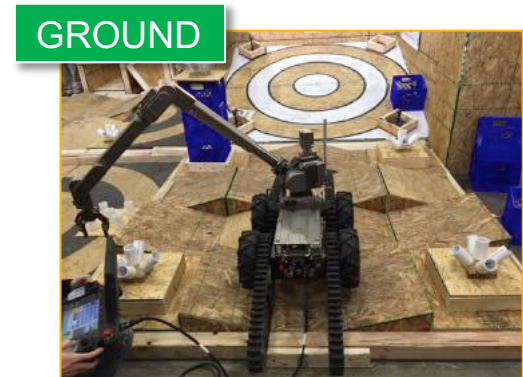
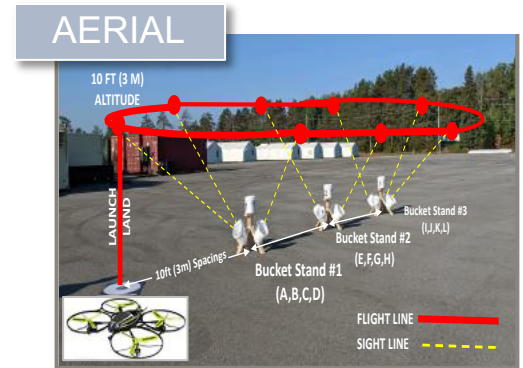


# Standards Enable Credentialing of Proctors and Remote Pilots

Safety | Capabilities | Proficiency

When conducting evaluations with these Test Methods the results should only be compared to similar environmental conditions.

Night or dark trials can be conducted with white or red headlamps illuminating the white buckets or only using the lights and sensors onboard the drone.

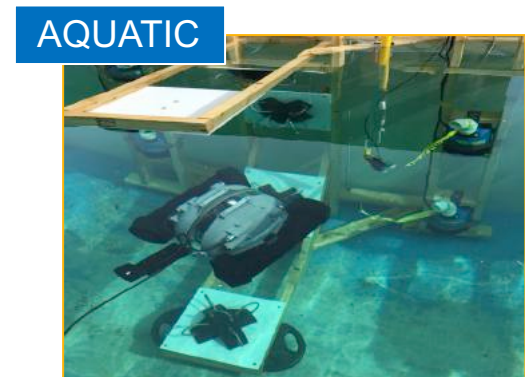
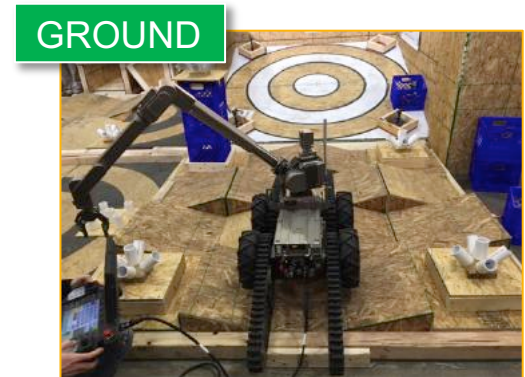
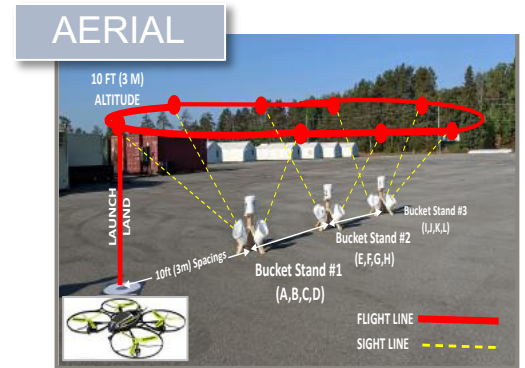


# Standards Enable Credentialing of Proctors and Remote Pilots

Safety | Capabilities | Proficiency

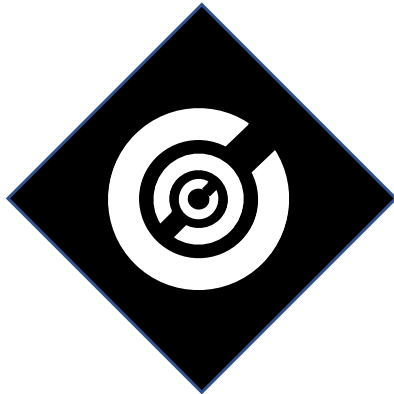
*When Credentialing operators an organization can;*

- Set their own pass/fail scoring threshold
- Adopt a pass/fail scoring threshold set by a regional or national association with which the organization collaborates
- Adopt a pass/fail scoring threshold set by a similar organization



**LEVEL**

**5**



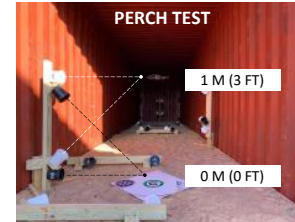
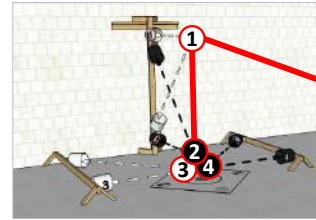
## **CONFINED Test Lane**

### **Payload Functionality Trials**

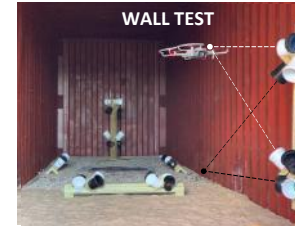
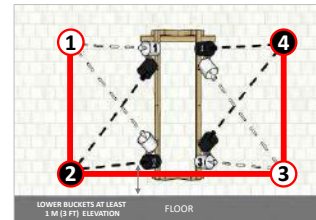
**Evaluate maneuvering in tight spaces, dealing with the drone's own turbulent air, while controlling zoom and exposure.**

- ***25 minutes (5 minutes each)***
- ***50 Alignment & 50 Acuity Points***

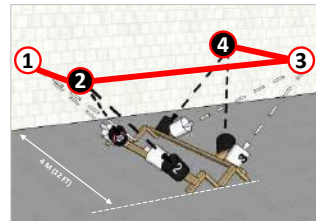
**PERCH**  
PAY 6



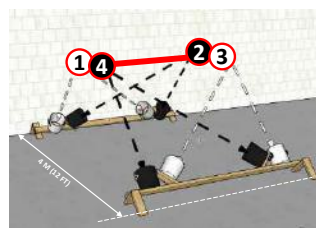
**WALL**  
PAY 7



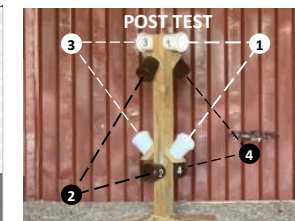
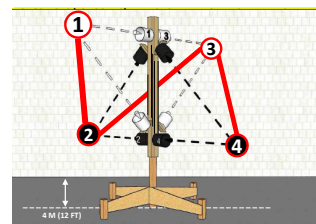
**GROUND**  
PAY 8



**ALLEY**  
PAY 9



**POST**  
PAY 10



## Scoring Alignment Points

Capture images of alignment rings to verify

### ALIGN WITH BUCKETS AND LAND ACURATELY

10 ALIGNMENT RINGS TOTAL 50 POINTS



CAPTURE IMAGES OF THE INSCRIBED RINGS AND LAND ACCURATELY.

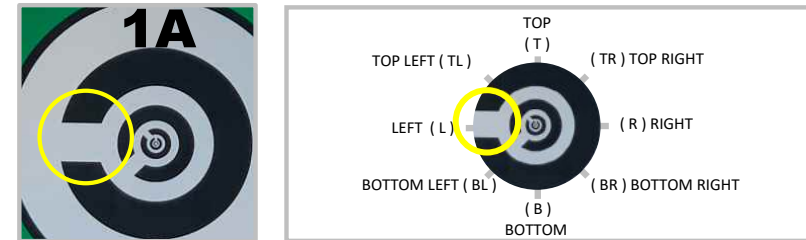
- First align with each PERPENDICULAR BUCKET to capture a SINGLE ALIGNMENT IMAGE of the inscribed ring.
- Score captured images with
  - UNBROKEN RINGS (5 points)
  - BROKEN RINGS (1 point)
  - NO RINGS (0 points, strike through line)
- Accurate landings are not scored.
- Verification of captured alignment images can be during the trial when obvious or after the trial to eliminate discussions during the trial. Images can also be stored for documentation.

## Scoring Acuity Points

Identify increasingly small visual acuity targets

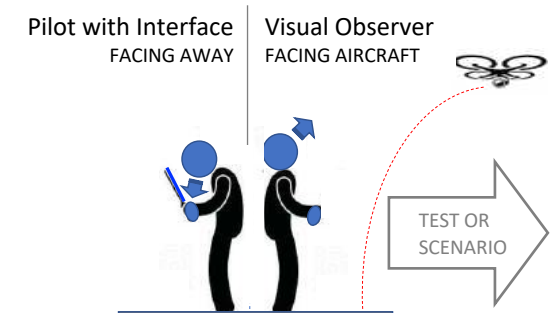
### ALIGN THEN CONTROL ZOOM AND EXPOSURE

10 ACUITY TARGETS TOTAL 50 POINTS



REPORT GAP DIRECTIONS RELATIVE TO THE BUCKET NUMBER (TOP)

- Then align with each ANGLED BUCKET to IDENTIFY ACUITY TARGETS using camera zoom and exposure controls.
- Call out as many of the Concentric C gap directions as possible (1 pt each).
- Fly facing away from the test lane or scenario with a Visual Observer to evaluate flying interface only as if beyond visual line of sight.





# Aerial Drone Tests and Scorable Scenarios for Evaluating System Capabilities and Remote Pilot Proficiency in Level 3 Open, Level 4 Obstructed, and Level 5 Confined Environments

*Developed by the National Institute of Standards and Technology*



*Test Director*

**Adam Jacoff**

Intelligent Systems Division  
National Institute of Standards and Technology  
U.S. Department of Commerce

*Sponsor:*

Systems Engineering & Standards Division  
Science and Technology Directorate  
U.S. Department of Homeland Security

Internet  
RobotTestMethods.nist.gov



Email  
RobotTestMethods@nist.gov