Introduction

Aerial Test Methods

Version 2021A

WEBSITE POINTER:
DOWNLOAD STICKER FILES, FORMS AND PRACTICE SCORING VIDEOS

WEBSITE POINTER:
WATCH FABRICATION VIDEOS AND FLIGHT PATH ANIMATIONS

Online Only Meeting
February 3, 2021
10:00am – 2:00pm EST

Sub Committee Chair:
Adam Jacoff
Intelligent Systems Division
National Institute of Standards and Technology
U.S. Department of Commerce

Committee Chair:
Phil Mattson
Science and Technology Directorate
U.S. Department of Homeland Security

Internet
RobotTestMethods.nist.gov

Email
RobotTestMethods@nist.gov

Call To Order

Committee Meeting

- Reminder that electronic recording of ASTM meetings is prohibited.
- This meeting will run in accordance with the ASTM Antitrust Statement (see minutes).

Antitrust Statement

ASTM International is a not-for-profit organization and developer of voluntary consensus standards. ASTM's leadership in international standards development is driven by the contributions of its members: more than 30,000 technical experts and business professionals representing 135 countries.

The purpose of antitrust laws is to preserve economic competition in the marketplace by prohibiting, among other things, unreasonable restraints of trade. In ASTM activities, it is important to recognize that participants often represent competitive interests. Antitrust laws require that all competition be open and unrestricted.

It is ASTM's policy, and the policy of each of its committees and subcommittees, to conduct all business and activity in full compliance with international, federal and state antitrust and competition laws. The ASTM Board of Directors has adopted an antitrust policy which is found in Section 19 of ASTM Regulations Governing Technical Committees. All members need to be aware of and compliant with this policy. The Regulations are accessible on the ASTM website (http://www.astm.org/COMMIT/Regs.pdf) and copies of the antitrust policy are available at the registration desk. ***For a complete list of standards, see:*** *http://www.astm.org/COMMIT/SUBCOMMIT/E5409.htm*

Agenda

Committee Meeting

.

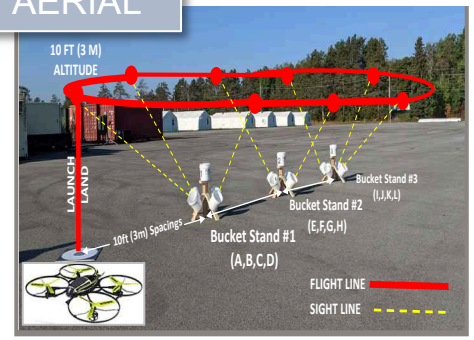
10:00 am EST Introduction to Open Test Lane

10:30 am EST Use Case Examples

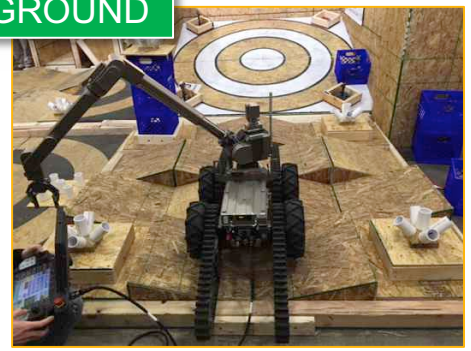
12:00 pm EST Advanced Test Lanes and Embedded Scenarios
- Obstructed Test Lane
- Confined Test Lane
- Sensors and Radio Comms
- Others

2:00 pm EST Open Discussion

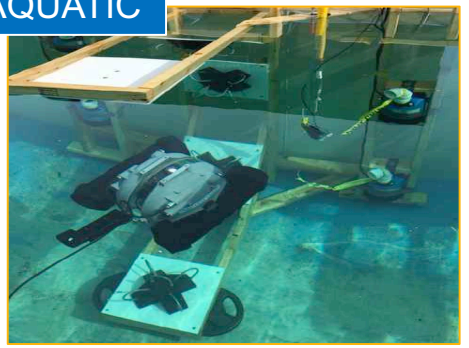
AERIAL



GROUND



AQUATIC



Acknowledgements

Acknowledgements

This work was sponsored by the Department of Homeland Security, Science and Technology Directorate, through an interagency agreement with the National Institute of Standards and Technology (NIST).

The NIST Team includes:
Adam Jacoff, Raymond Sheh, Kamel Saidi,
Kenny Kimble, and Ann Virts.

Dozens more people have contributed to the development and validation of these test methods. They include FEMA urban search and rescue task force teams, firefighters, law enforcement, collaborating test facilities, other civilian and military organizations, and commercial manufacturers. There are far too many to mention, but some of the ongoing (non-commercial) collaborators are listed below, roughly in order of their involvement:

Disclaimer

Commercial equipment shown in this document are for illustrative purposes only. This does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the products identified are necessarily the best available for the purpose.

Measurement Units

The International System of Units (a.k.a. SI Units) and U.S. Customary Units (a.k.a. Imperial Units) are used throughout this document. Approximate equivalents in each system of units enable use of readily available materials in different countries. This avoids excessive purchasing and fabrication costs. The differences between the stated unit dimensions are insignificant for comparison of test method results, so each set of units are considered standard for the purposes of these test methods.

Collaborators

Tom Haus, Los Angeles Fire Dept. & CA-TF1, CA

Parry Boogard, Valley Regional Fire Authority & WA-TF1, WA

Clint Arnett, TEEX/Disaster City & TX-TF1, TX

George Hough, Fire Dept. of New York City & NY-TF1, NY

Jim Ingledue, Virginia Beach Fire Dept. & VA-TF2, VA

Mark Hundley, Virginia Beach Fire Dept. & VA-TF2, WA

Michael O'Shea, FAA UAS Integration Office (formerly U.S. DOJ)

Martin Hutchings, Sacramento Sheriff & IAB, CA

John Delaney, Arlington County Fire, Dept., & IAB, VA

Mike Marino, Prince George's County Fire Dept. & IAB, MD

Coitt Kessler, Austin Fire Dept., TX

Chris Sadler, York County Fire Dept., VA

Andy Moore, Southwest Research Institute, San Antonio, TX

Al Frazier, Grand Forks County Sheriff's Dept., ND

Ben Miller, CDPS COE for Aerial Technology Fire Fighting, CO

Mark Blanks, Virginia Tech University, VA

Daniele Nardi, Sapienza Universita di Roma, Italy

Max Delo, ESF-13, U.S. Marshals Service, DOJ

Bryan Gillespy, ESF-13, U.S. Marshals Service, DOJ

Gabriele Ferri, NATO CMRE, Italy

Howie Stockhowe, Virginia Beach Fire Dept, Virginia Beach, VA

Tony Galladora, Montgomery County Police, MD

Satoshi Tadokoro, Tohoku University, Sendai, Japan

Tetsuya Kimura, Nagoaka Univ. of Technology, Nagoaka, Japan

Bob Gann, CDPS COE for Aerial Technology Fire Fighting, CO

Andy Olesen, Canadian Explosives Technicians Assoc., Canada

Tom Prentice, Reveille Peak Ranch, Burnet, TX

Michael Leo, Fire Department of New York City, NY

Luke Bergan, New South Whales Police Dept., Sydney, Australia

Katie Thielmeyer, Woodlawn Fire Dept. OH

Oliver Huke, RACE Test Facility, UKAEA, Oxfordshire, United Kingdom

Example Spectrum of sUAS (”Drones”)

Safety | Capabilities | Proficiency

Small Unmanned Aircraft Systems (sUAS)
Weigh Less Than 25 kg (55 lbs)











Initial focus is VTOL, but some tests apply to forward flying aircraft when scaled up to the appropriate orbit radius.

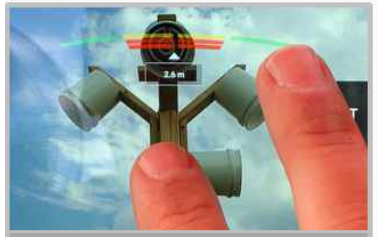
Reproducible Tests for Maneuvering and Payload Functionality

Safety | Capabilities | Proficiency

MEASURE & COMPARE


SMALL SYSTEMS


LARGE SYSTEMS

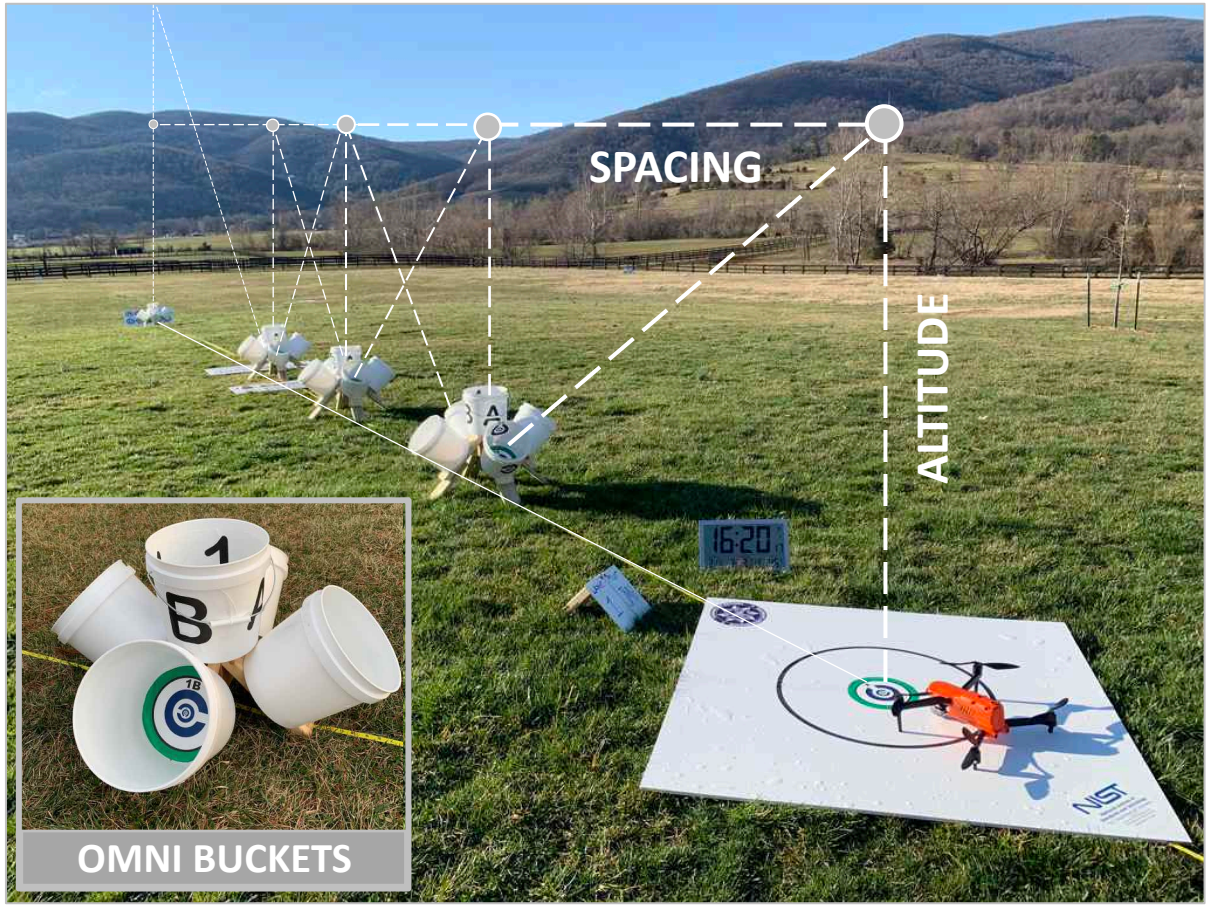

INTERFACES


PROCEDURES

SENSORS


MANEUVERING

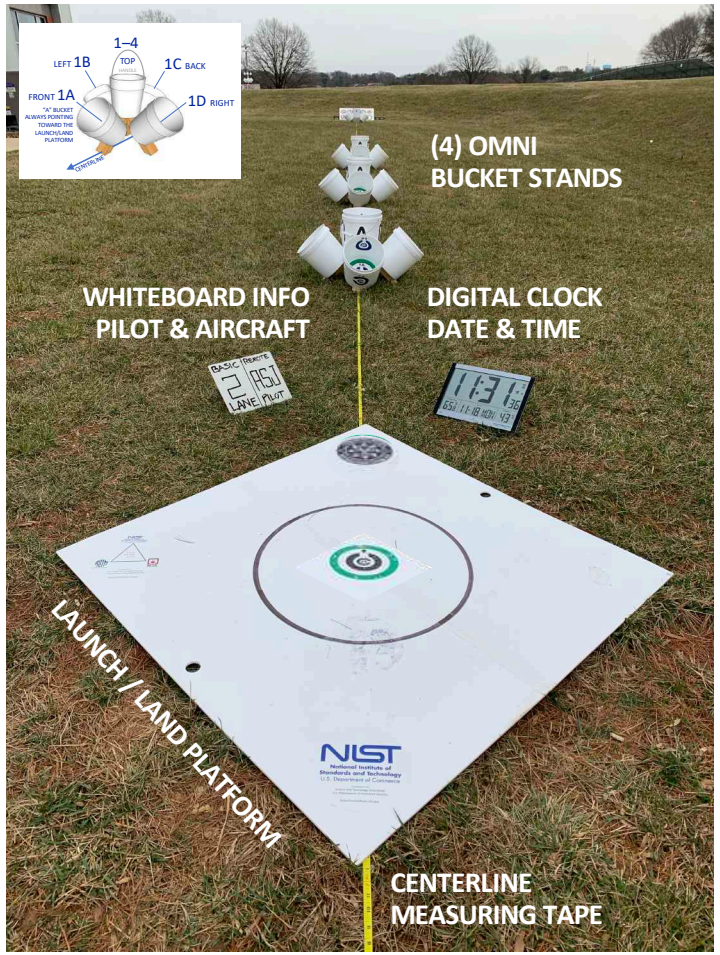
SCALABLE TEST LANES (ALTITUDE = SPACING)



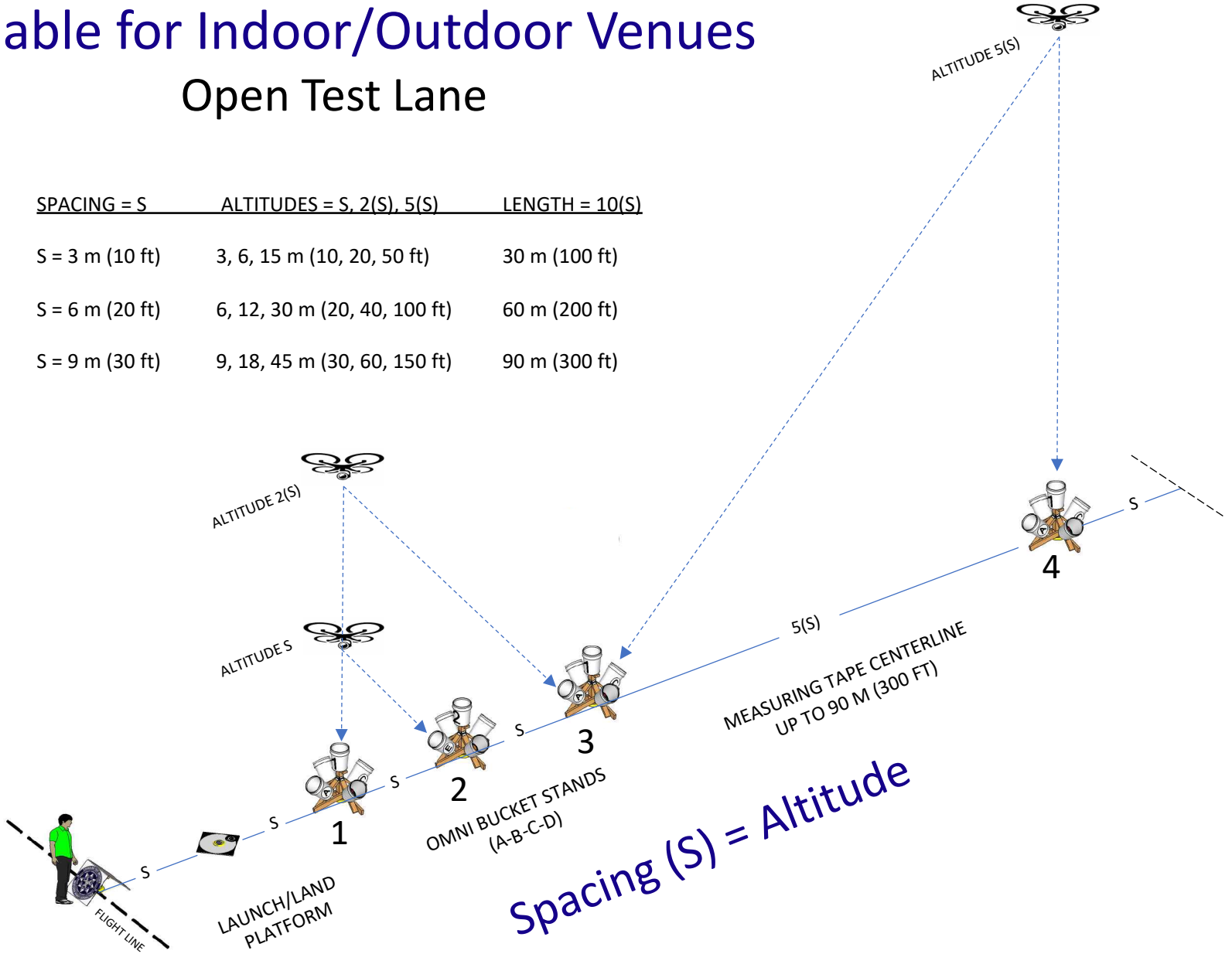
OMNI BUCKETS

Scalable for Indoor/Outdoor Venues

Open Test Lane



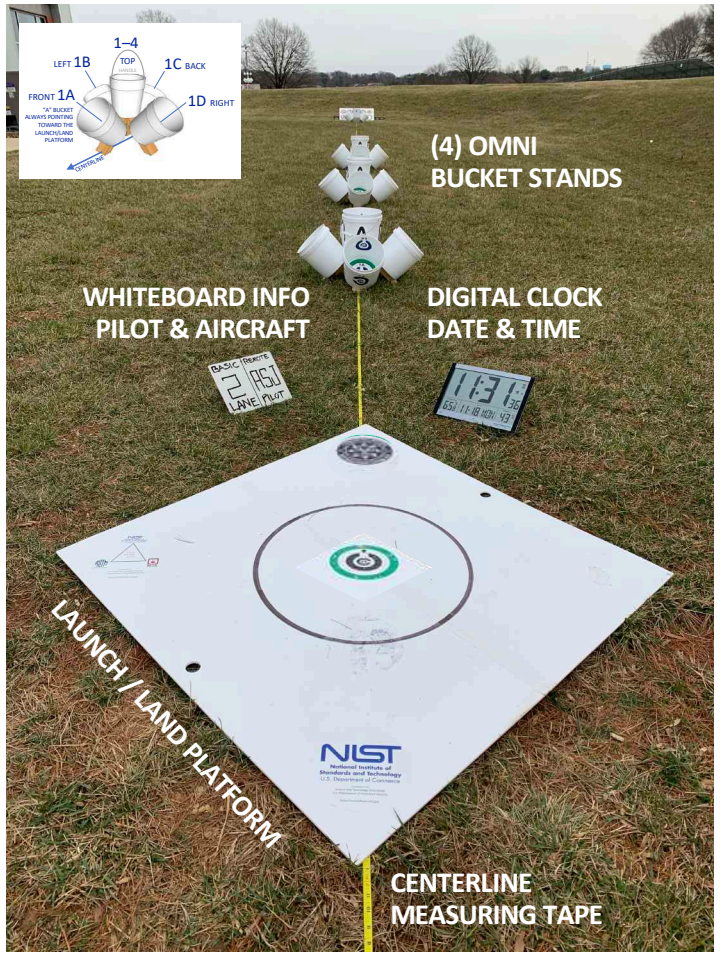
SPACING = S	ALTITUDES = S, 2(S), 5(S)	LENGTH = 10(S)
S = 3 m (10 ft)	3, 6, 15 m (10, 20, 50 ft)	30 m (100 ft)
S = 6 m (20 ft)	6, 12, 30 m (20, 40, 100 ft)	60 m (200 ft)
S = 9 m (30 ft)	9, 18, 45 m (30, 60, 150 ft)	90 m (300 ft)

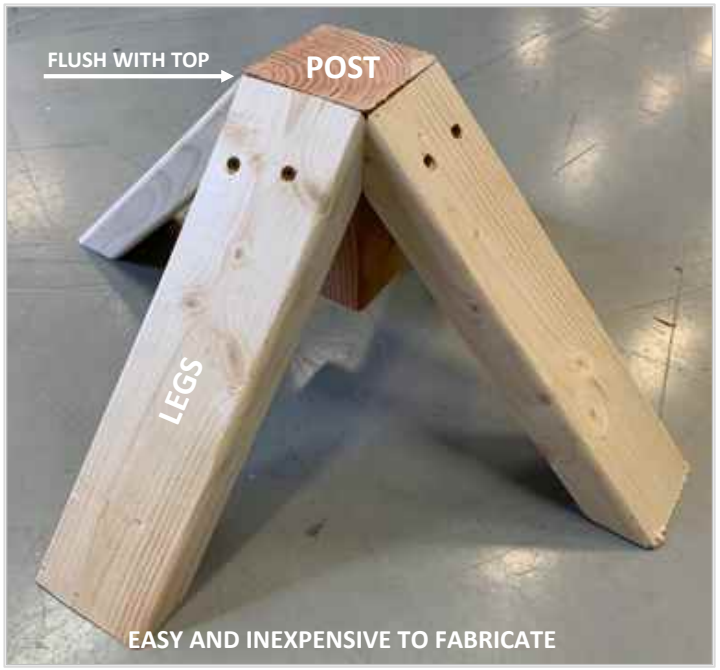


Easy Fabrication and Stowing

Open Test Lane

2 Gallon Buckets – Printed Stickers – Transportable



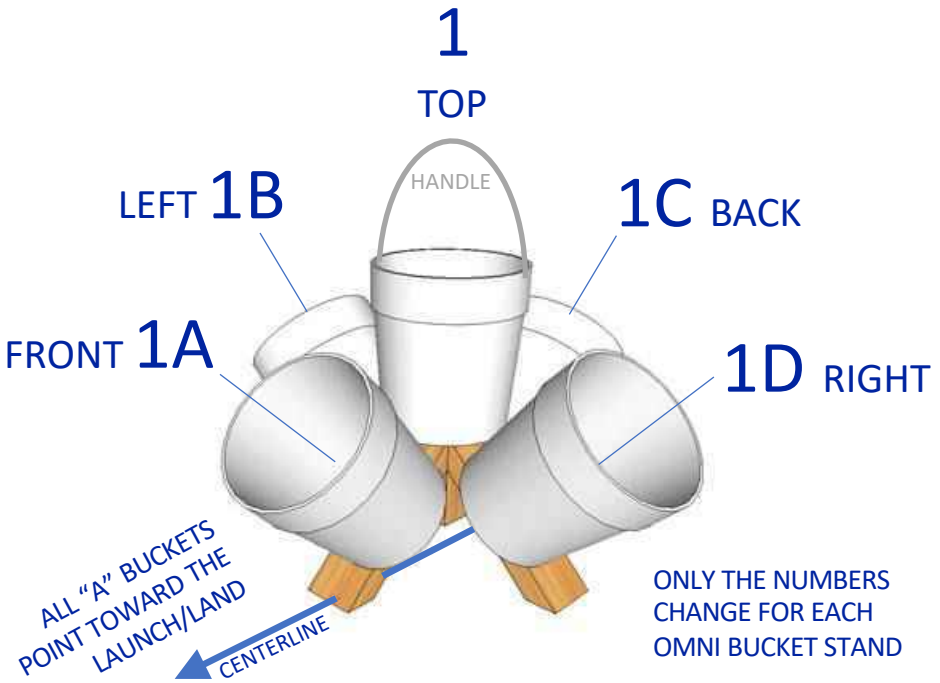


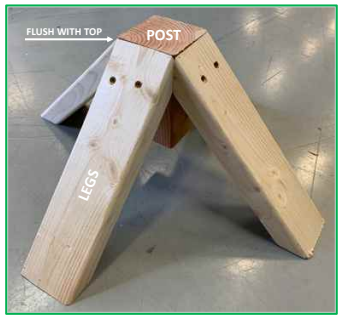
Omni Bucket Stands

Open Test Lane

WHITE BUCKETS & GREEN RINGS IN STANDARD TEST LANES

SHOWN NOT ALIGNED





BLACK BUCKETS & COLOR RINGS EMBEDDED INTO SCENARIOS

SHOWN ALIGNED

Conduct Tests Two Ways

Open Test Lane

Basic Maneuvering (MAN)

ALIGN WITH BUCKETS AND LAND ACCURATELY

Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** showing the green ring inside the bucket. Score 5 points for a continuous green ring or 1 point for a partial. Similar scoring for accurate or partial landings.

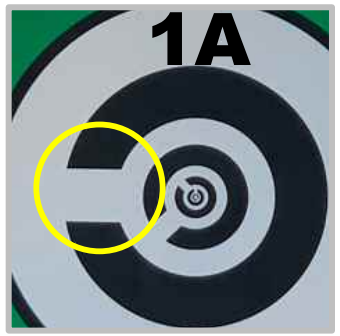
20 ALIGNMENTS TOTAL UP TO 100 POINTS

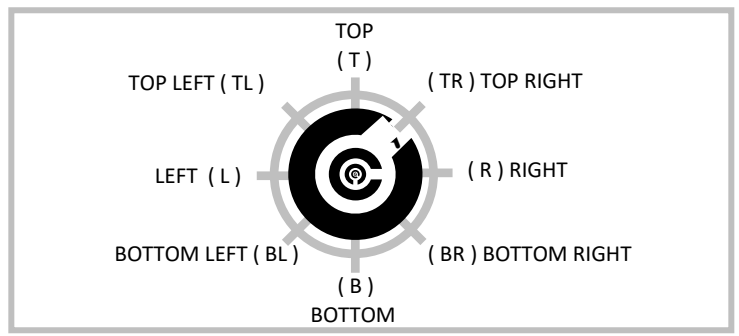
Payload Functionality (PAY)

ALIGN AND IDENTIFY ACUITY TARGETS

Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** AND a **single acuity image of each target (MAX ZOOM)**. Score 1 point for each correct identification of the 5 increasingly small Concentric C gap directions.

20 TARGETS TOTAL UP TO 100 POINTS





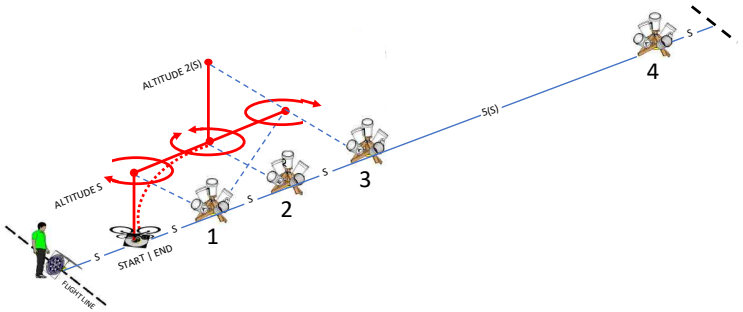
Positive Aircraft Control (Part 107 Skills Test?)

Open Test Lane

Position

MAN/PAY 1

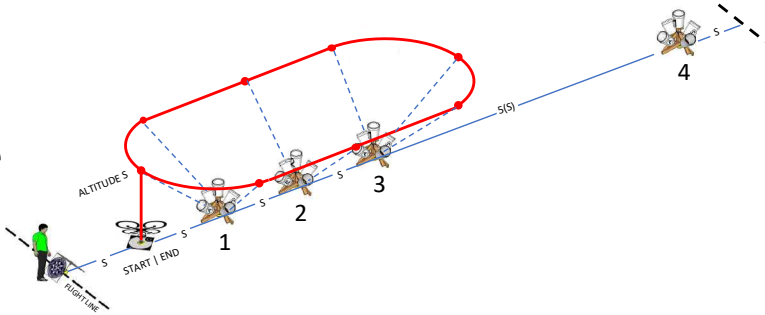
- Hover stably
- Basic maneuvers
- Land accurately
- 20 Buckets in 1 lap



Traverse

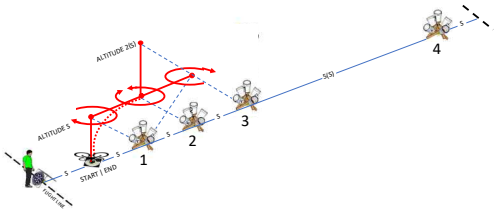
MAN/PAY 2

- Fly sideways along a line
- Left and right directions
- Land accurately
- 20 Buckets in 2 laps

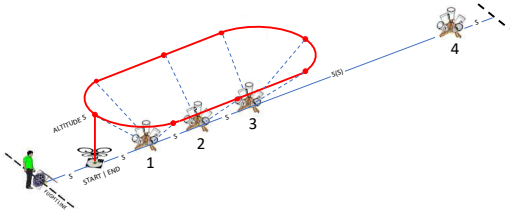


5 Different Tests – Simulated and Physical

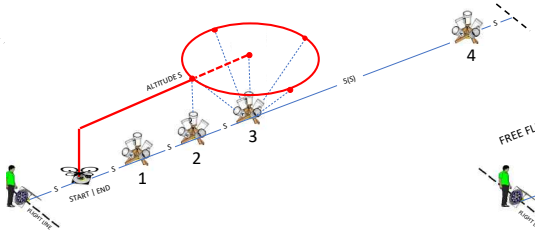
Open Test Lane



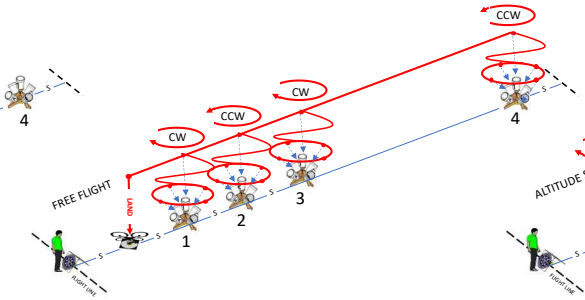
Position
MAN/PAY 1



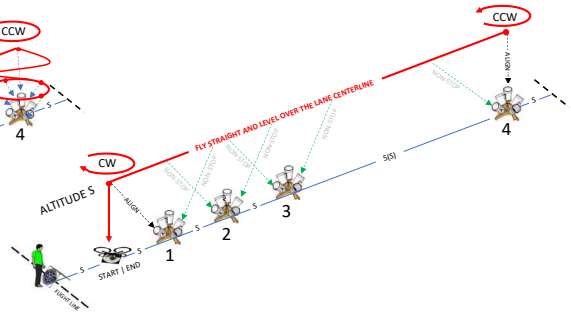
Traverse
MAN/PAY 2



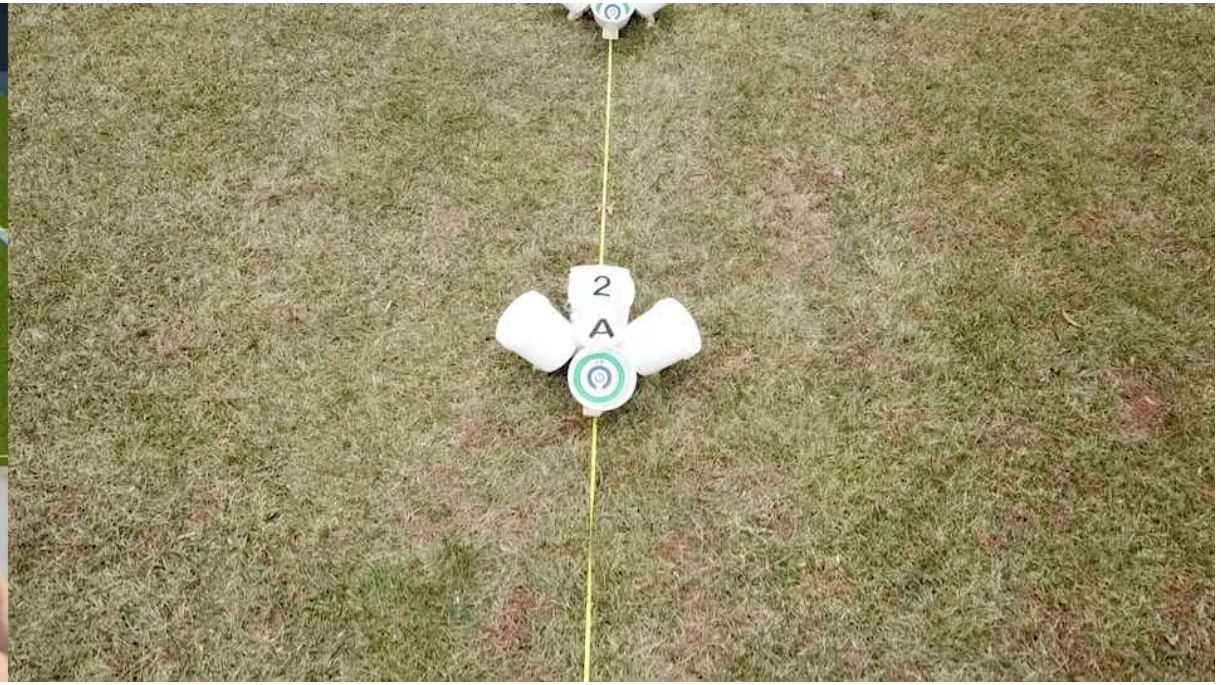
Orbit
MAN/PAY 3



Spiral
MAN/PAY 4



Recon
MAN/PAY 5



Open Test Lane: Position Test

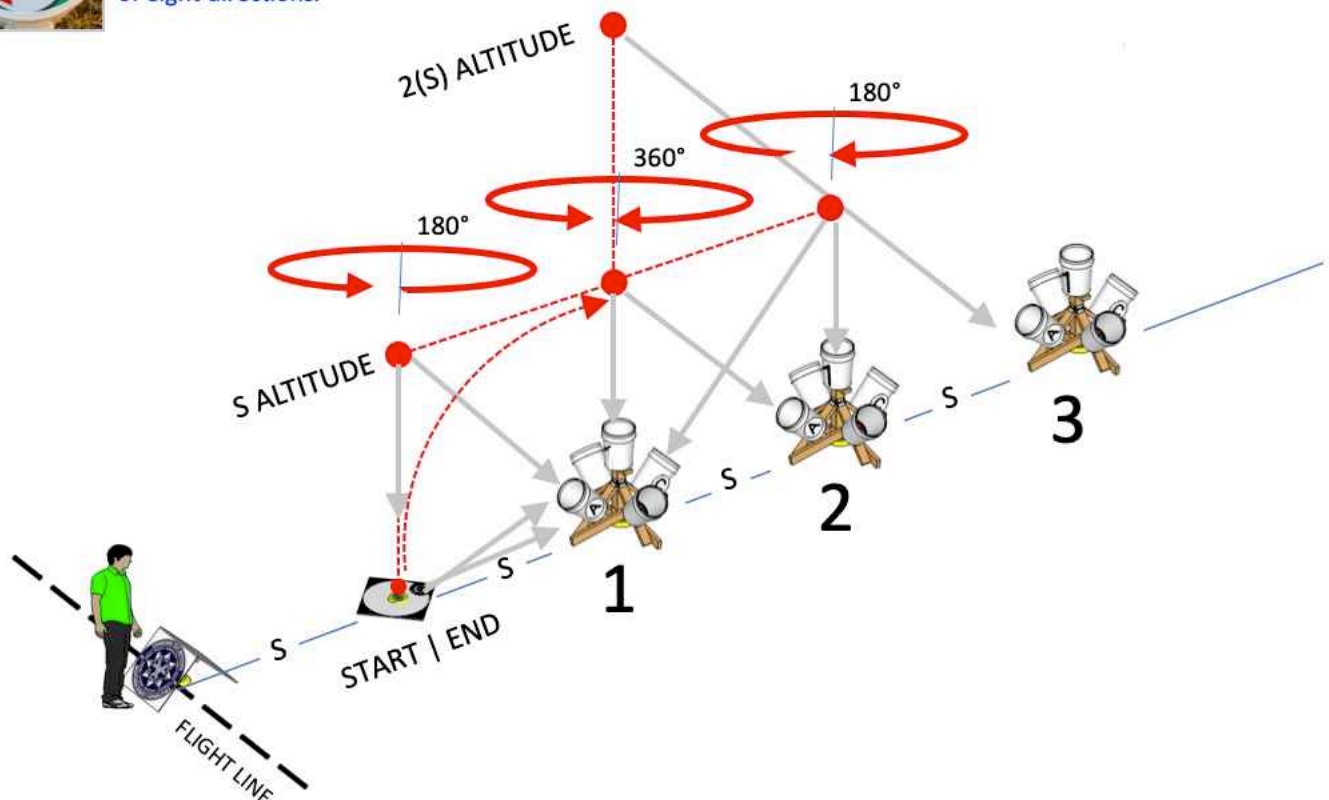
MAN 1 | PAY 1

MAN 1-5 ALIGN WITH BUCKETS

See the entire inscribed ring inside the buckets to evaluate successful alignments. The letters are bucket identifiers.

PAY 1-5 VISUAL ACUITY TARGETS

Align and identify the visual acuity targets with increasingly small concentric C gaps in one of eight directions.



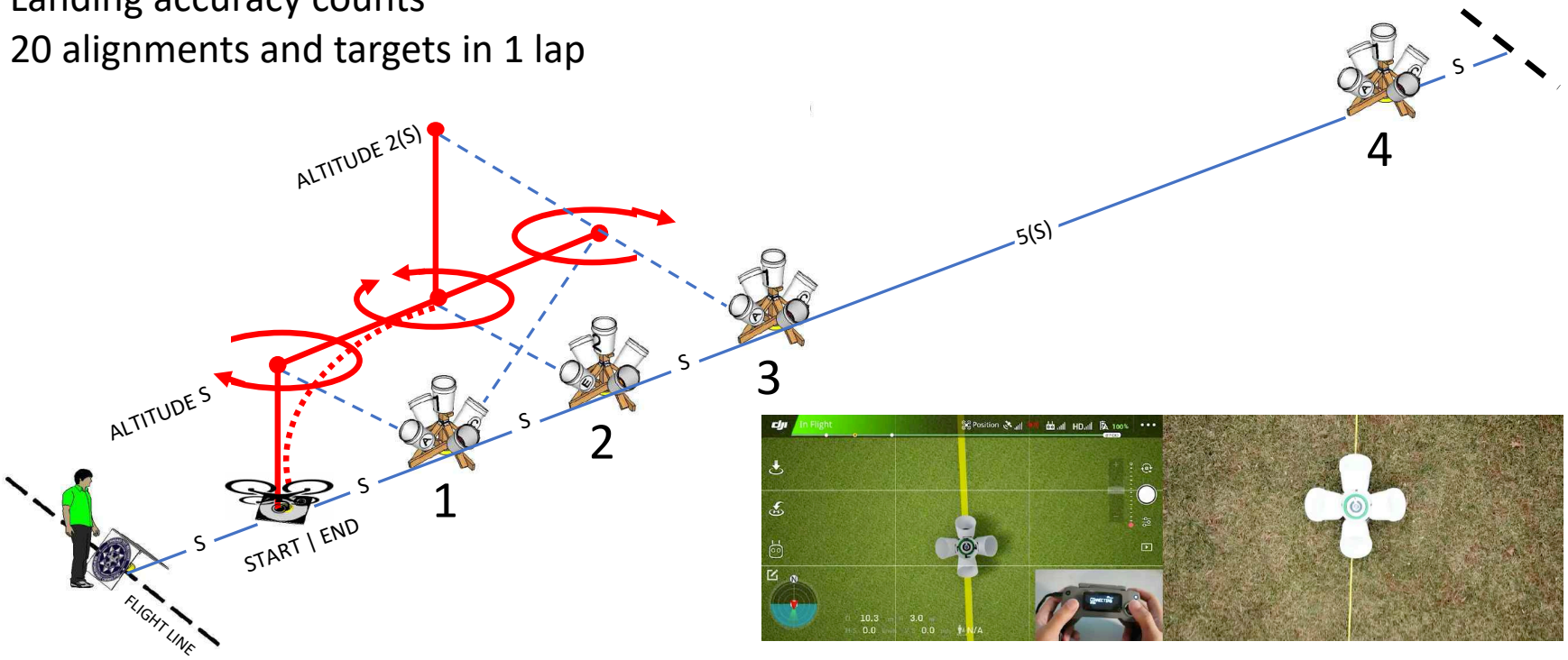
PROCEDURE | POSITION		FORMS ANSWER KEY VERSION 2020B					
CAPTURE IMAGE OF CLOCK -- LAUNCH FROM PLATFORM		CIRCLE WHEN ALIGNED	CIRCLE GAP DIRECTION WHEN CORRECT				
1	**HOVER AT ALTITUDE (S) OVER STAND 1**	1	T	BL	R	BR	L
2	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	2A	L	BR	T	TL	R
3	**YAW LEFT 360°**	1	T	BL	R	BR	L
4	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	2A	L	BR	T	TL	R
5	**YAW RIGHT 360°**	1	T	BL	R	BR	L
6	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	2A	L	BR	T	TL	R
7	**CLIMB TO ALTITUDE 2(S)**	1	T	BL	R	BR	L
8	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	3A	BR	T	TL	R	BL
9	**DESCEND TO ALTITUDE (S)**	1	T	BL	R	BR	L
10	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	2A	L	BR	T	TL	R
11	**FORWARD OVER STAND 2**	2	BL	T	BR	R	TL
12	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	3A	BR	T	TL	R	BL
13	**BACKWARD OVER STAND 1**	1	T	BL	R	BR	L
14	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	2A	L	BR	T	TL	R
15	**FORWARD OVER STAND 2 AND YAW RIGHT 180°**	UPSIDE 2 DOWN	TR	B	TL	L	BR
			UNDERLINE MEANS YOU'RE READING THE TARGET UPSIDE DOWN				
16	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	1C	BR	R	TL	L	BR
17	**FORWARD OVER LANDING AND YAW LEFT 180°**	L	B	TR	L	BL	T
18	ALIGN/IMAGE DOWNWARD THEN FORWARD IN ORDER	1A	TR	B	TR	L	BR
19	**LAND CENTERED FACING STANDS** (WORTH 2 POINTS)	CENTERED | PERCH 1	BL	R	TL	L	BL
20	IMAGE FORWARD PERCH TARGETS P1/P2 IN ORDER	CENTERED | PERCH 2	L	BR	T	TL	B
LAND CENTERED FACING DOWN RANGE -- CAPTURE IMAGE OF CLOCK -- END OF TRIAL							
IF A FAULT OCCURS, STRIKE THROUGH THE ENTIRE TRIAL AND CIRCLE THE REASON:			APPARATUS	GROUND	BOUNDARY	SAFETY	

*If your training aircraft has only a fixed camera, or limited range of motion, align with as many buckets as possible. Performance is never compared across aircraft anyway.

Position Test (MAN/PAY 1)

Open Test Lane

- Hover stably in designated positions and orientations
- Align with two buckets simultaneously at each position
- Basic maneuvers between positions
- Altitude S and 2(S)
- Landing accuracy counts
- 20 alignments and targets in 1 lap



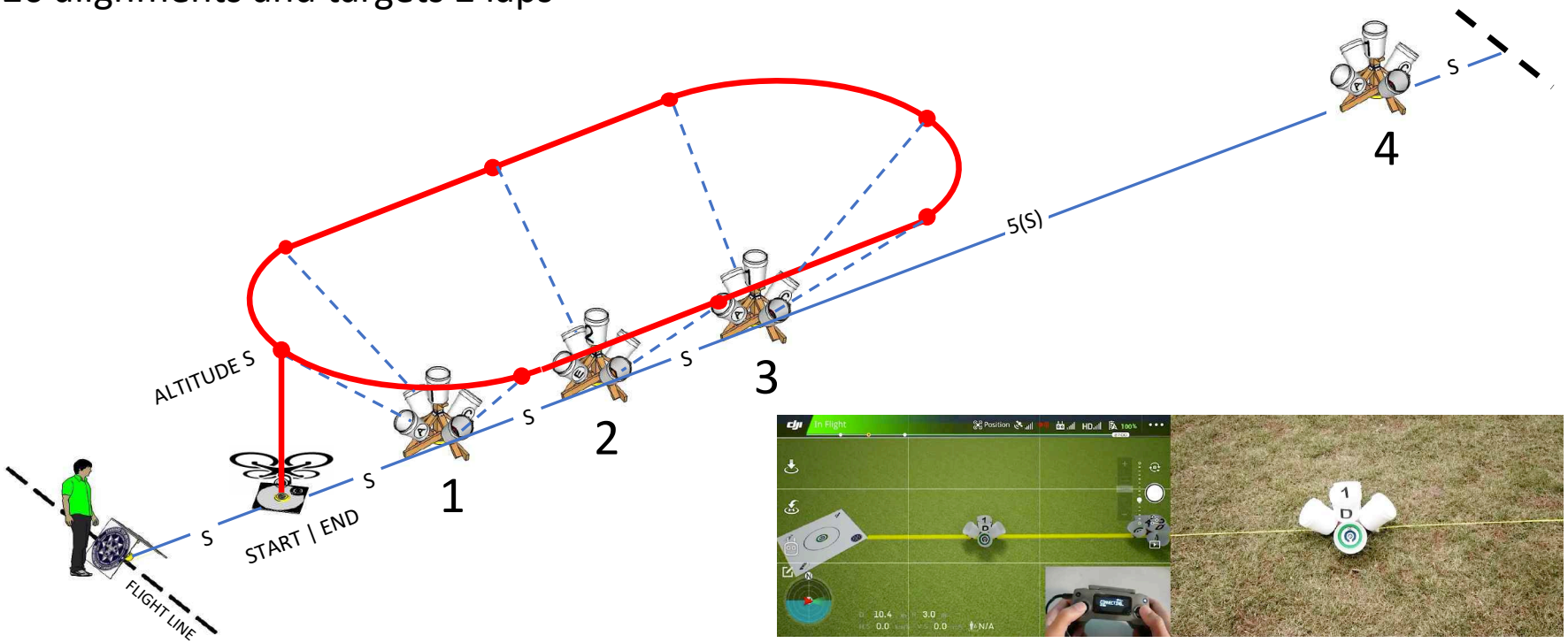
MAN 1-5 BASIC MANEUVERING
ALIGN WITH BUCKETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** showing the green ring inside the bucket. Score 5 points for a continuous green ring or 1 point for a partial. Similar scoring for accurate or partial landings

PAY 1-5 PAYLOAD FUNCTIONALITY
IDENTIFY VISUAL ACUITY TARGETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** AND a **single acuity image of each target (MAX ZOOM)**. Score 1 point for each correct identification of the 5 increasingly small Concentric C gap directions.

Traverse Test (MAN/PAY 2)

Open Test Lane

- Fly sideways along a line or object
- Leftward and rightward directions to align with angled buckets
- Altitude S throughout
- Landing accuracy counts
- 20 alignments and targets 2 laps



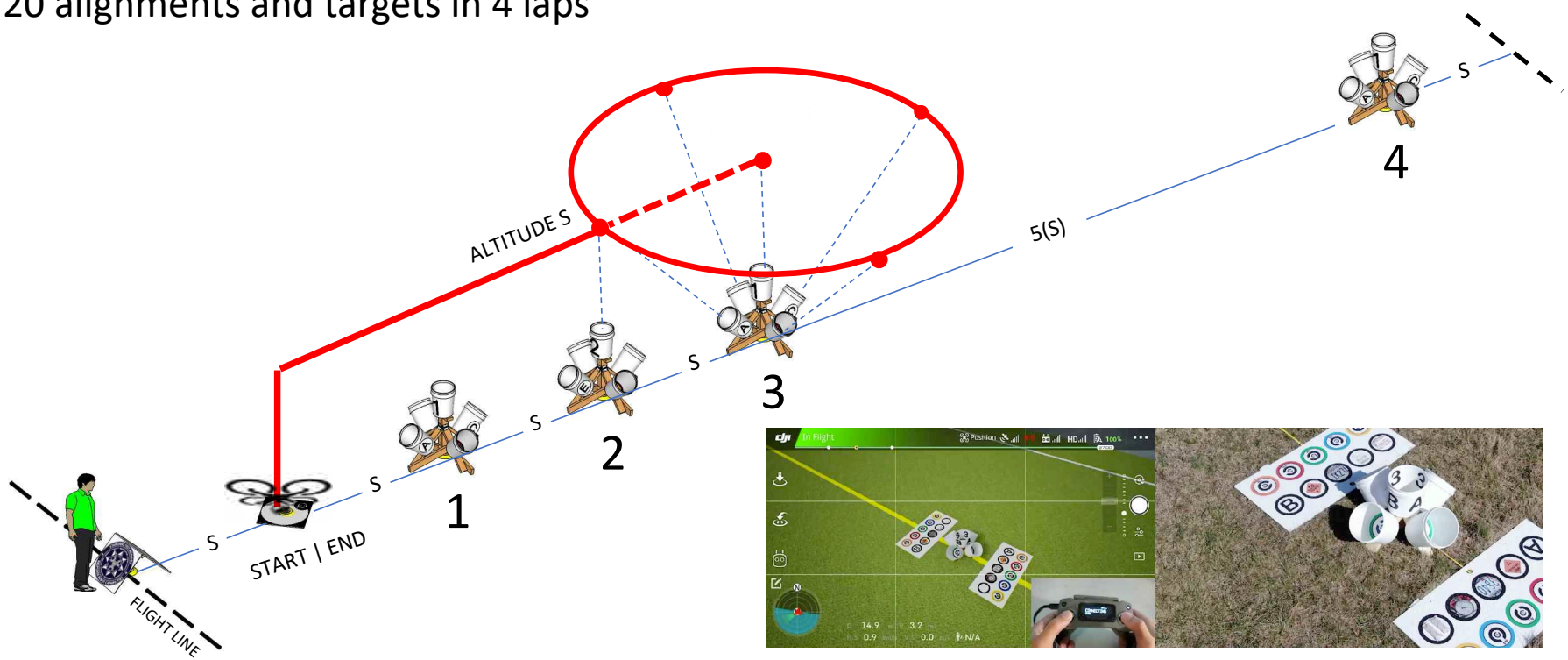
MAN 1-5 BASIC MANEUVERING
ALIGN WITH BUCKETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** showing the green ring inside the bucket. Score 5 points for a continuous green ring or 1 point for a partial. Similar scoring for accurate or partial landings

PAY 1-5 PAYLOAD FUNCTIONALITY
IDENTIFY VISUAL ACUITY TARGETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** AND a **single acuity image of each target (MAX ZOOM)**. Score 1 point for each correct identification of the 5 increasingly small Concentric C gap directions.

Orbit Test (MAN/PAY 3)

MAN/PAY 3

- Orbit around a designated point
- Leftward and rightward directions to align with angled buckets
- Downward radius checks at start of each orbit
- Altitude S throughout
- 20 alignments and targets in 4 laps



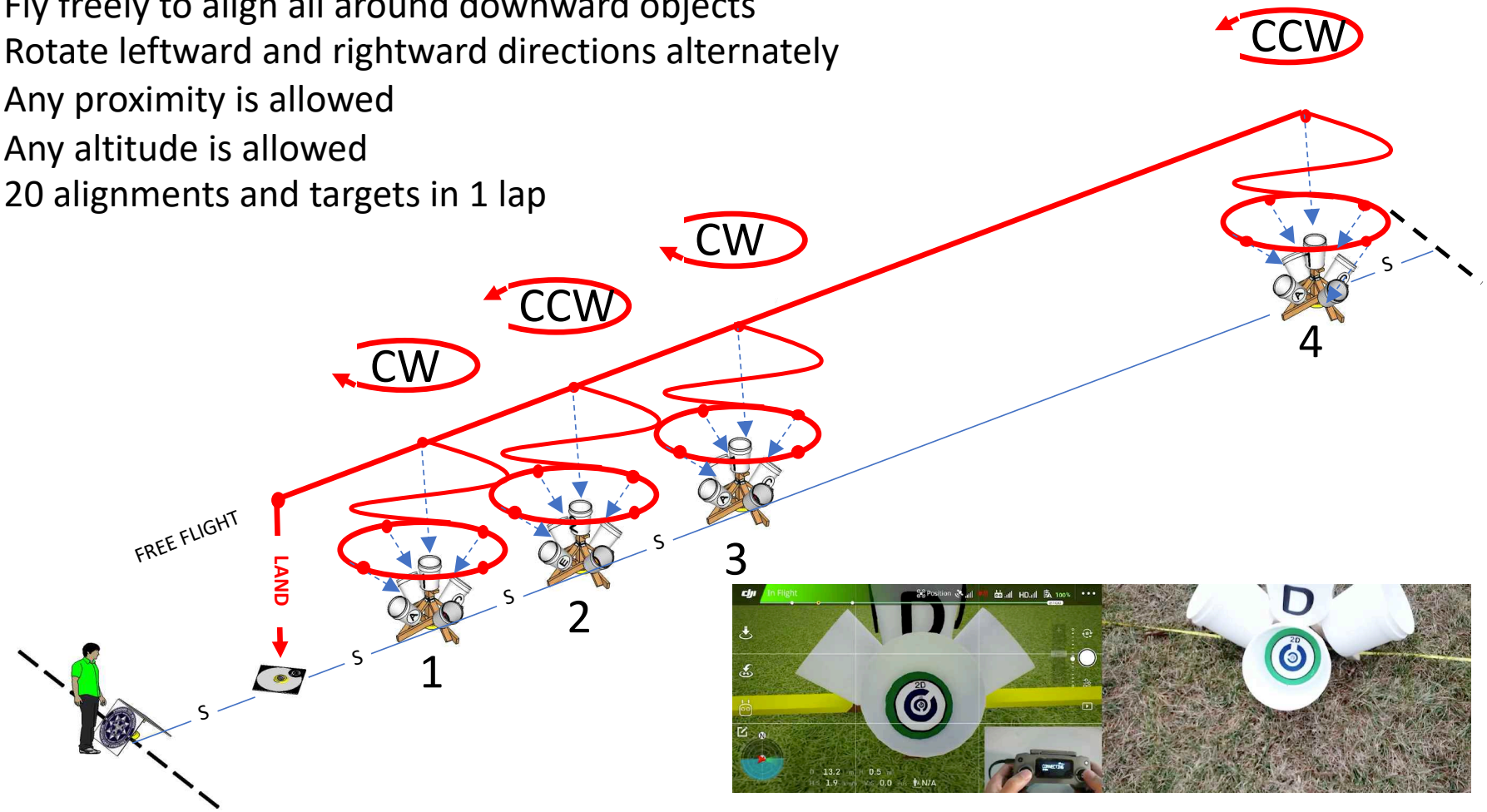
MAN 1-5 BASIC MANEUVERING
ALIGN WITH BUCKETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** showing the green ring inside the bucket. Score 5 points for a continuous green ring or 1 point for a partial. Similar scoring for accurate or partial landings

PAY 1-5 PAYLOAD FUNCTIONALITY
IDENTIFY VISUAL ACUITY TARGETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** AND a **single acuity image of each target (MAX ZOOM)**. Score 1 point for each correct identification of the 5 increasingly small Concentric C gap directions.

Spiral Test (MAN/PAY 4)

Open Test Lane

- Fly freely to align all around downward objects
- Rotate leftward and rightward directions alternately
- Any proximity is allowed
- Any altitude is allowed
- 20 alignments and targets in 1 lap



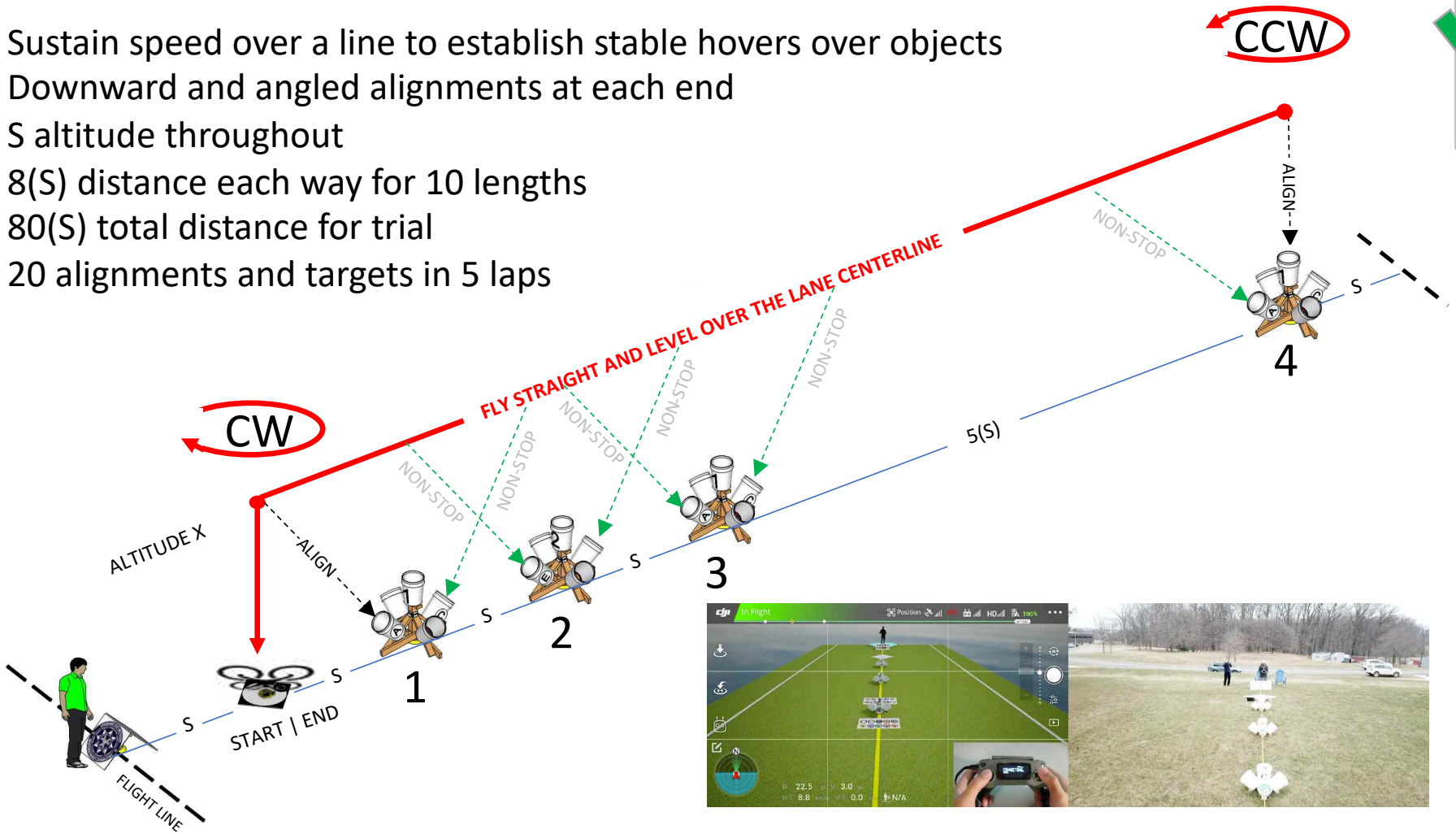
MAN 1-5 BASIC MANEUVERING
ALIGN WITH BUCKETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** showing the green ring inside the bucket. Score 5 points for a continuous green ring or 1 point for a partial. Similar scoring for accurate or partial landings

PAY 1-5 PAYLOAD FUNCTIONALITY
IDENTIFY VISUAL ACUITY TARGETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** AND a **single acuity image of each target (MAX ZOOM)**. Score 1 point for each correct identification of the 5 increasingly small Concentric C gap directions.

Recon Test (MAN/PAY 5)

Open Test Lane

- Sustain speed over a line to establish stable hovers over objects
- Downward and angled alignments at each end
- S altitude throughout
- 8(S) distance each way for 10 lengths
- 80(S) total distance for trial
- 20 alignments and targets in 5 laps



MAN 1-5 BASIC MANEUVERING
ALIGN WITH BUCKETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** showing the green ring inside the bucket. Score 5 points for a continuous green ring or 1 point for a partial. Similar scoring for accurate or partial landings

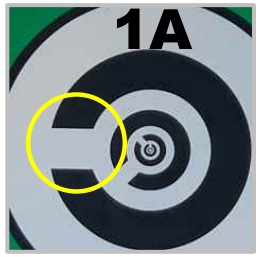
PAY 1-5 PAYLOAD FUNCTIONALITY
IDENTIFY VISUAL ACUITY TARGETS
Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** AND a **single acuity image of each target (MAX ZOOM)**. Score 1 point for each correct identification of the 5 increasingly small Concentric C gap directions.

Circuit Training with Scores

Open Test Lane

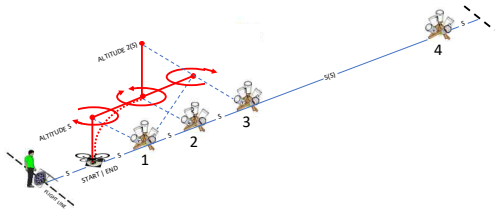
BASIC MANEUVERING
ALIGN WITH BUCKETS

Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** showing the green ring inside the bucket. Score 5 points for a continuous green ring or 1 point for a partial. Similar scoring for accurate or partial landings



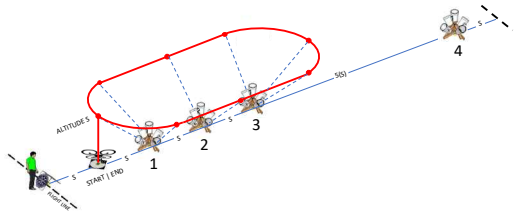
PAYLOAD FUNCTIONALITY
IDENTIFY ACUITY TARGETS

Align with each bucket long enough to capture a **single alignment image (NO ZOOM)** AND a **single acuity image of each target (MAX ZOOM)**. Score 1 point for each correct identification of the 5 increasingly small Concentric C gap directions.



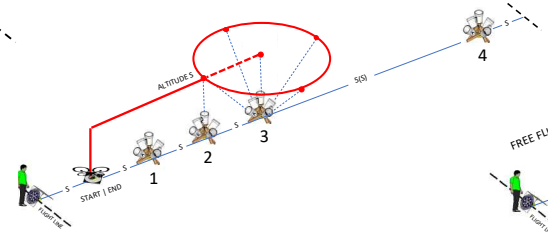
Position
MAN/PAY 1

- Hover stably
- Basic maneuvers
- Landing accuracy
- 20 alignments in 1 lap



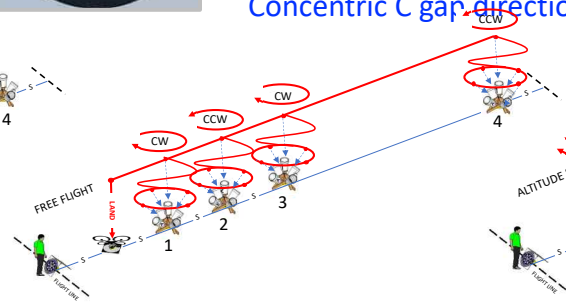
Traverse
MAN/PAY 2

- Fly sideways along a line
- Left and right directions
- Landing accuracy
- 20 alignments in 2 laps



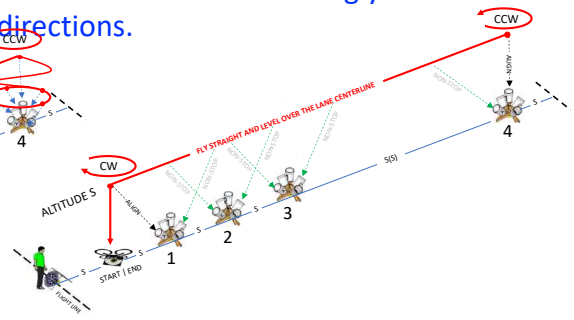
Orbit
MAN/PAY 3

- Orbit to identify objects
- Left and right directions
- S altitude
- 20 alignments in 4 laps



Spiral
MAN/PAY 4

- Fly freely to inspect objects
- Any proximity (use zooms)
- Any altitude
- 20 alignments in 1 lap



Recon
MAN/PAY 5

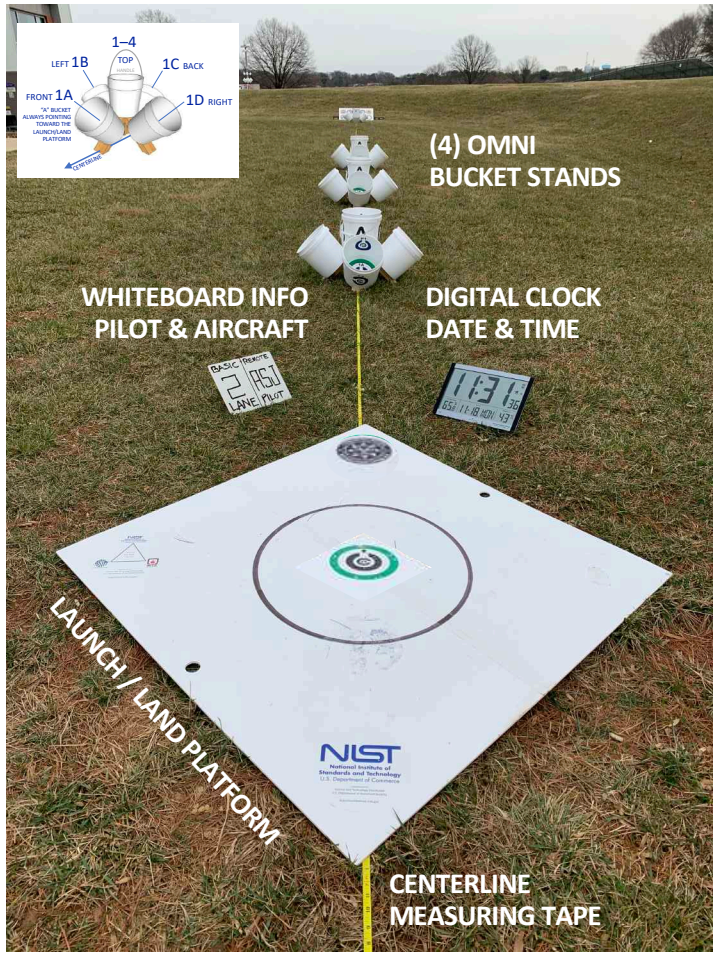
- Sustain speed over a line
- Establish hovers over objects
- S altitude, 160(S) distance
- 20 alignments in 5 laps

MAN: Align only 5 minutes / 100 points	MAN: Align only 5 minutes / 100 points max	MAN: Align only 5 minutes /100 points	MAN: Align only 5 minutes / 100 points	MAN: Align only 5 minutes / 100 points	500 PTS
PAY: Align and Identify 10 minutes / 100 points	PAY: Align and Identify 10 minutes / 100 points	PAY: Align and Identify 10 minutes / 100 points	PAY: Align and Identify 10 minutes / 100 points	PAY: Align and Identify 10 minutes / 100 points	500 PTS

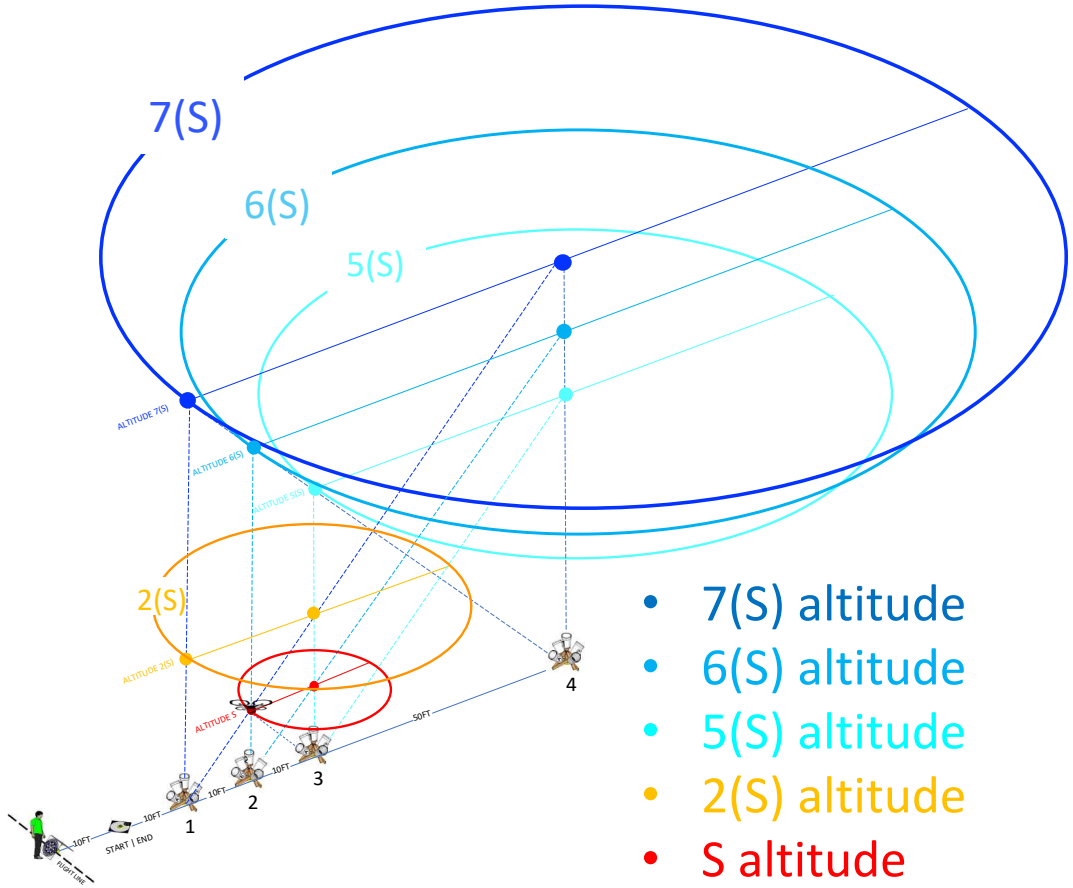
*If your training aircraft has only a fixed camera, or limited range of motion, align with as many buckets as possible. Proficiency is compared using similar aircraft.

Same Lane Supports Other Flight Paths

Open Test Lane

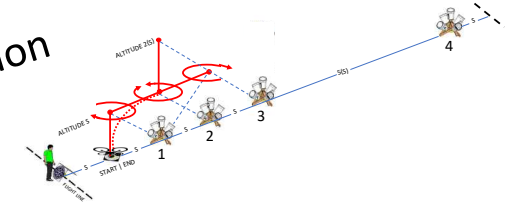


5 Different Orbits in Every Lane Spacing
(S) = 10ft, 20ft, 30ft, or other

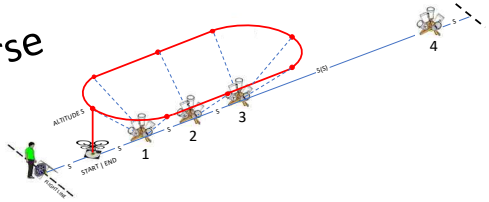


- 7(S) altitude
- 6(S) altitude
- 5(S) altitude
- 2(S) altitude
- S altitude

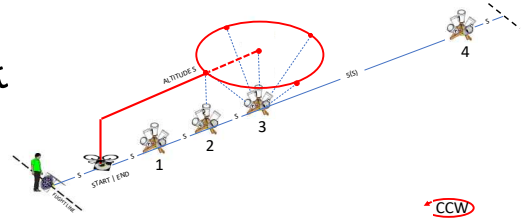
Position



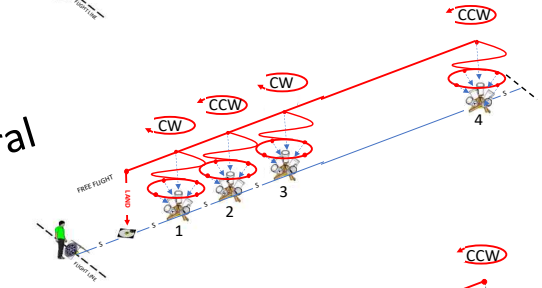
Traverse



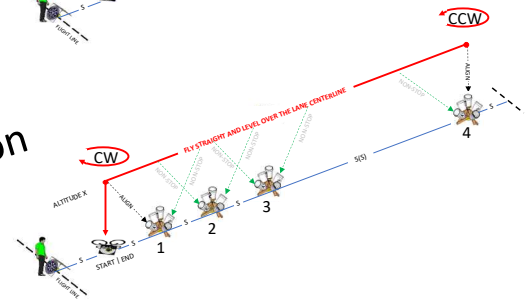
Orbit



Spiral



Recon



Scoring Metrics for Test Trials

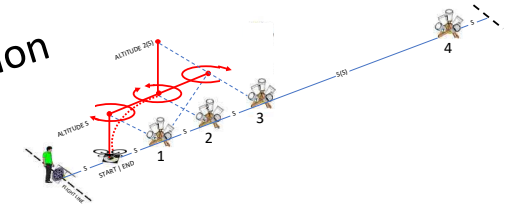
Open Test Lane

1. **Completeness (Primary)**
   If you can't finish a trial without faults, just keep track of how far into the trial sequence you get until you're reliably finishing the trials.

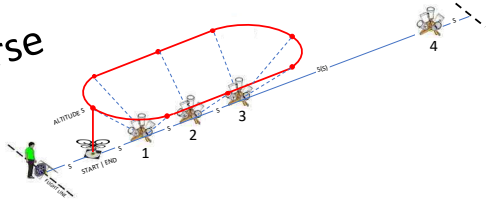
2. **Score (Secondary)**
   For complete trials, you can start tracking your scores over time to find the average of the most recent five trials. That's a good indication of your proficiency that can be compared to others using similar systems in similar test lanes.

3. **Efficiency (Optional)**
   If two systems or pilots are consistently completing trials, and their average scores are perfect, then the average elapsed time of the last 5 trials can help identify the most efficient systems or pilots exhibiting the most effective techniques.

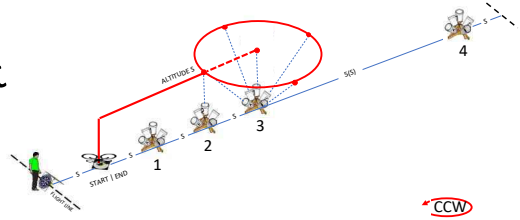
Position



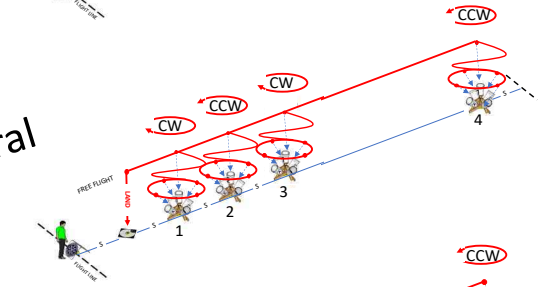
Traverse



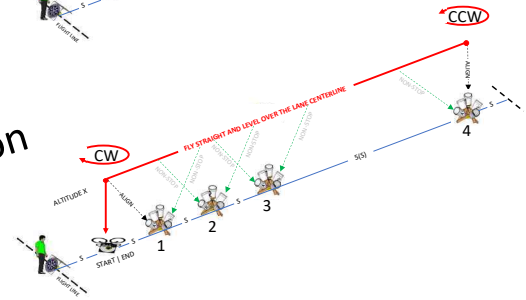
Orbit



Spiral



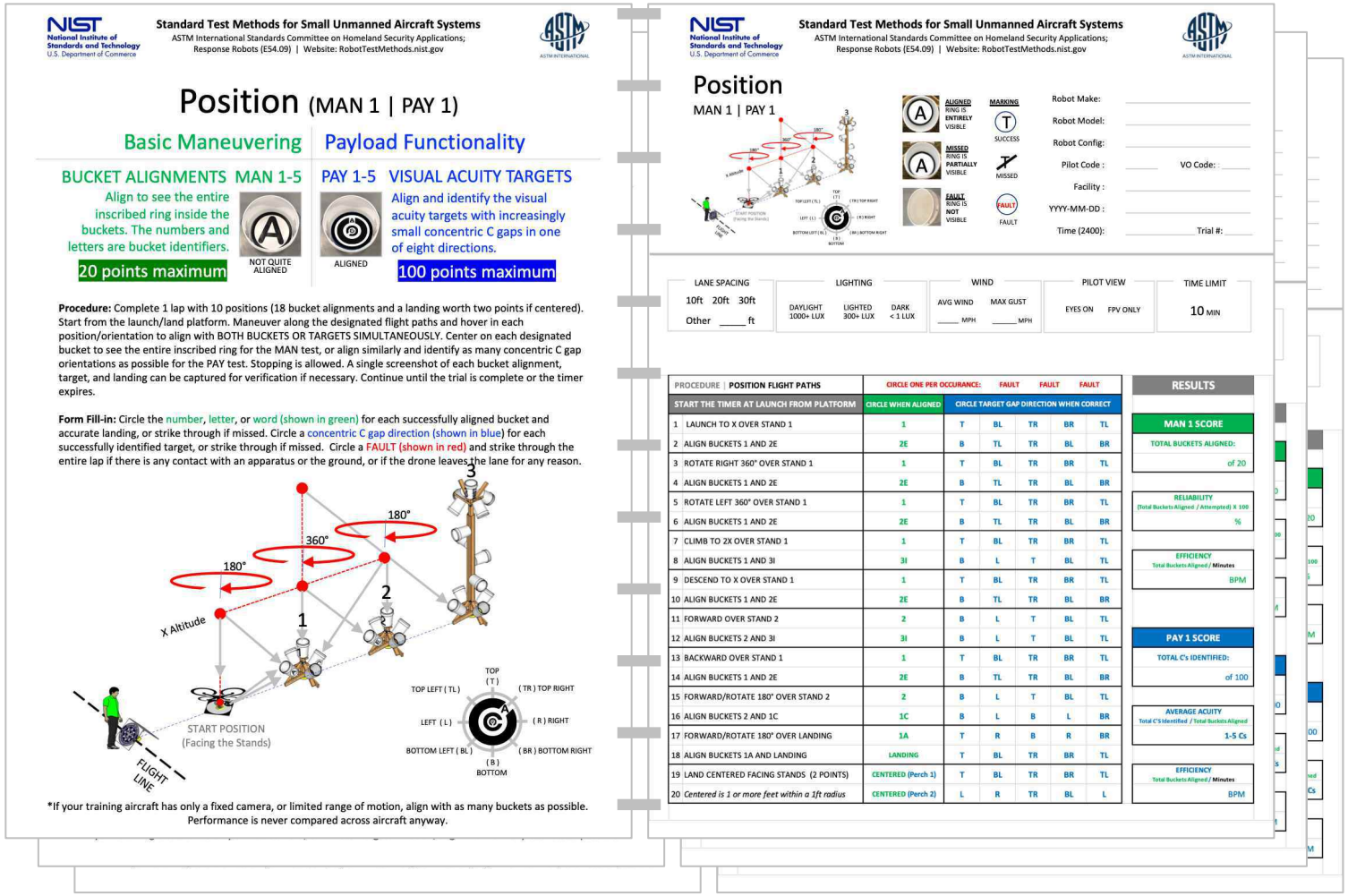
Recon



Track Scores Over Time

Open Test Lane

[Download Forms Books Here]



Standard Test Methods for Small Unmanned Aircraft Systems
ASTM International Standards Committee on Homeland Security Applications;
Response Robots (E54.09) | Website: RobotTestMethods.nist.gov

Position (MAN 1 | PAY 1)

Basic Maneuvering | Payload Functionality

BUCKET ALIGNMENTS MAN 1-5
Align to see the entire inscribed ring inside the buckets. The numbers and letters are bucket identifiers.
20 points maximum

NOT QUITE ALIGNED | ALIGNED

PAY 1-5 VISUAL ACUITY TARGETS
Align and identify the visual acuity targets with increasingly small concentric C gaps in one of eight directions.
100 points maximum

Procedure: Complete 1 lap with 10 positions (18 bucket alignments and a landing worth two points if centered). Start from the launch/land platform. Maneuver along the designated flight paths and hover in each position/orientation to align with BOTH BUCKETS OR TARGETS SIMULTANEOUSLY. Center on each designated bucket to see the entire inscribed ring for the MAN test, or align similarly and identify as many concentric C gap orientations as possible for the PAY test. Stopping is allowed. A single screenshot of each bucket alignment, target, and landing can be captured for verification if necessary. Continue until the trial is complete or the timer expires.

Form Fill-in: Circle the number, letter, or word (shown in green) for each successfully aligned bucket and accurate landing, or strike through if missed. Circle a concentric C gap direction (shown in blue) for each successfully identified target, or strike through if missed. Circle a FAULT (shown in red) and strike through the entire lap if there is any contact with an apparatus or the ground, or if the drone leaves the lane for any reason.

*If your training aircraft has only a fixed camera, or limited range of motion, align with as many buckets as possible. Performance is never compared across aircraft anyway.

Standard Test Methods for Small Unmanned Aircraft Systems
ASTM International Standards Committee on Homeland Security Applications;
Response Robots (E54.09) | Website: RobotTestMethods.nist.gov

Position
MAN 1 | PAY 1

ALIGNED — RING IS ENTIRELY VISIBLE — MARKING: SUCCESS
MISSED — RING IS PARTIALLY VISIBLE — MISSED
FAULT — RING IS NOT VISIBLE — FAULT

Robot Make:
Robot Model:
Robot Config:
Pilot Code : VO Code:
Facility :
YYYY-MM-DD :
Time (2400): Trial #:

LANE SPACING: 10ft 20ft 30ft; Other ____ ft
LIGHTING: DAYLIGHT 1000+ LUX; LIGHTED 300+ LUX; DARK < 1 LUX
WIND: AVG WIND ____ MPH; MAX GUST ____ MPH
PILOT VIEW: EYES ON; FPV ONLY
TIME LIMIT: 10 MIN

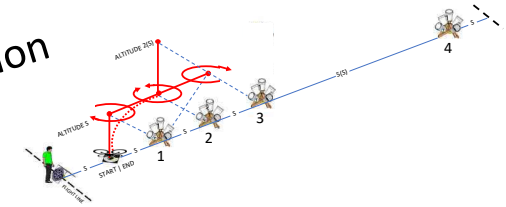
PROCEDURE | POSITION FLIGHT PATHS	CIRCLE ONE PER OCCURANCE:	FAULT	FAULT	FAULT		
START THE TIMER AT LAUNCH FROM PLATFORM	CIRCLE WHEN ALIGNED	CIRCLE TARGET GAP DIRECTION WHEN CORRECT				
1 LAUNCH TO X OVER STAND 1	1	T	BL	TR	BR	TL
2 ALIGN BUCKETS 1 AND 2E	2E	B	TL	TR	BL	BR
3 ROTATE RIGHT 360° OVER STAND 1	1	T	BL	TR	BR	TL
4 ALIGN BUCKETS 1 AND 2E	2E	B	TL	TR	BL	BR
5 ROTATE LEFT 360° OVER STAND 1	1	T	BL	TR	BR	TL
6 ALIGN BUCKETS 1 AND 2E	2E	B	TL	TR	BL	BR
7 CLIMB TO 2X OVER STAND 1	1	T	BL	TR	BR	TL
8 ALIGN BUCKETS 1 AND 3I	3I	B	L	T	BL	TL
9 DESCEND TO X OVER STAND 1	1	T	BL	TR	BR	TL
10 ALIGN BUCKETS 1 AND 2E	2E	B	TL	TR	BL	BR
11 FORWARD OVER STAND 2	2	B	L	T	BL	TL
12 ALIGN BUCKETS 2 AND 3I	3I	B	L	T	BL	TL
13 BACKWARD OVER STAND 1	1	T	BL	TR	BR	TL
14 ALIGN BUCKETS 1 AND 2E	2E	B	TL	TR	BL	BR
15 FORWARD/ROTATE 180° OVER STAND 2	2	B	L	T	BL	TL
16 ALIGN BUCKETS 2 AND 1C	1C	B	L	B	L	BR
17 FORWARD/ROTATE 180° OVER LANDING	1A	T	R	B	R	BR
18 ALIGN BUCKETS 1A AND LANDING	LANDING	T	BL	TR	BR	TL
19 LAND CENTERED FACING STANDS (2 POINTS)	CENTERED (Perch 1)	T	BL	TR	BR	TL
20 *Centered is 1 or more feet within a 1ft radius*	CENTERED (Perch 2)	L	R	TR	BL	L

RESULTS

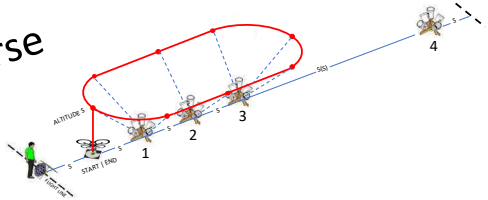
MAN 1 SCORE
TOTAL BUCKETS ALIGNED: of 20
RELIABILITY (Total Buckets Aligned / Attempted) X 100 %
EFFICIENCY Total Buckets Aligned / Minutes BPM

PAY 1 SCORE
TOTAL C's IDENTIFIED: of 100
AVERAGE ACUITY Total C's Identified / Total Buckets Aligned 1-5 Cs
EFFICIENCY Total Buckets Aligned / Minutes BPM

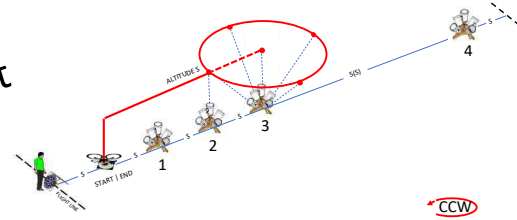
Position



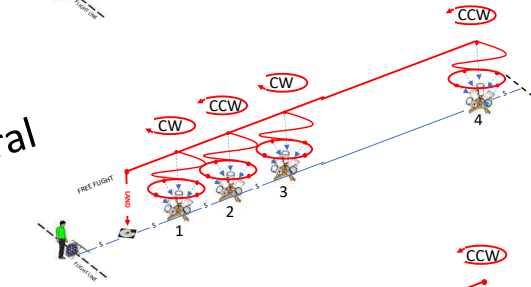
Traverse



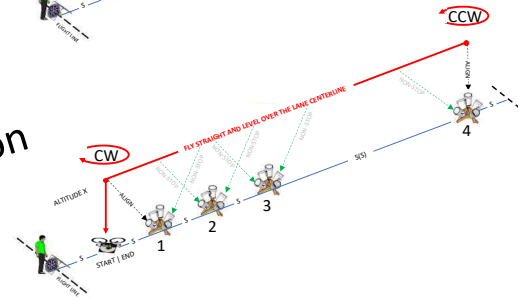
Orbit



Spiral



Recon



Standard Lanes and Repeatable Scenario Scores

Open Test Lane

REMOTE PILOT TRAINING – CANADIAN POLICE COLLEGE, ONTARIO, CANADA

20 OMNI TARGETS = 100 PTS

WIDE AREA SEARCH

20 EXTERIOR/INTEROR = 100 PTS

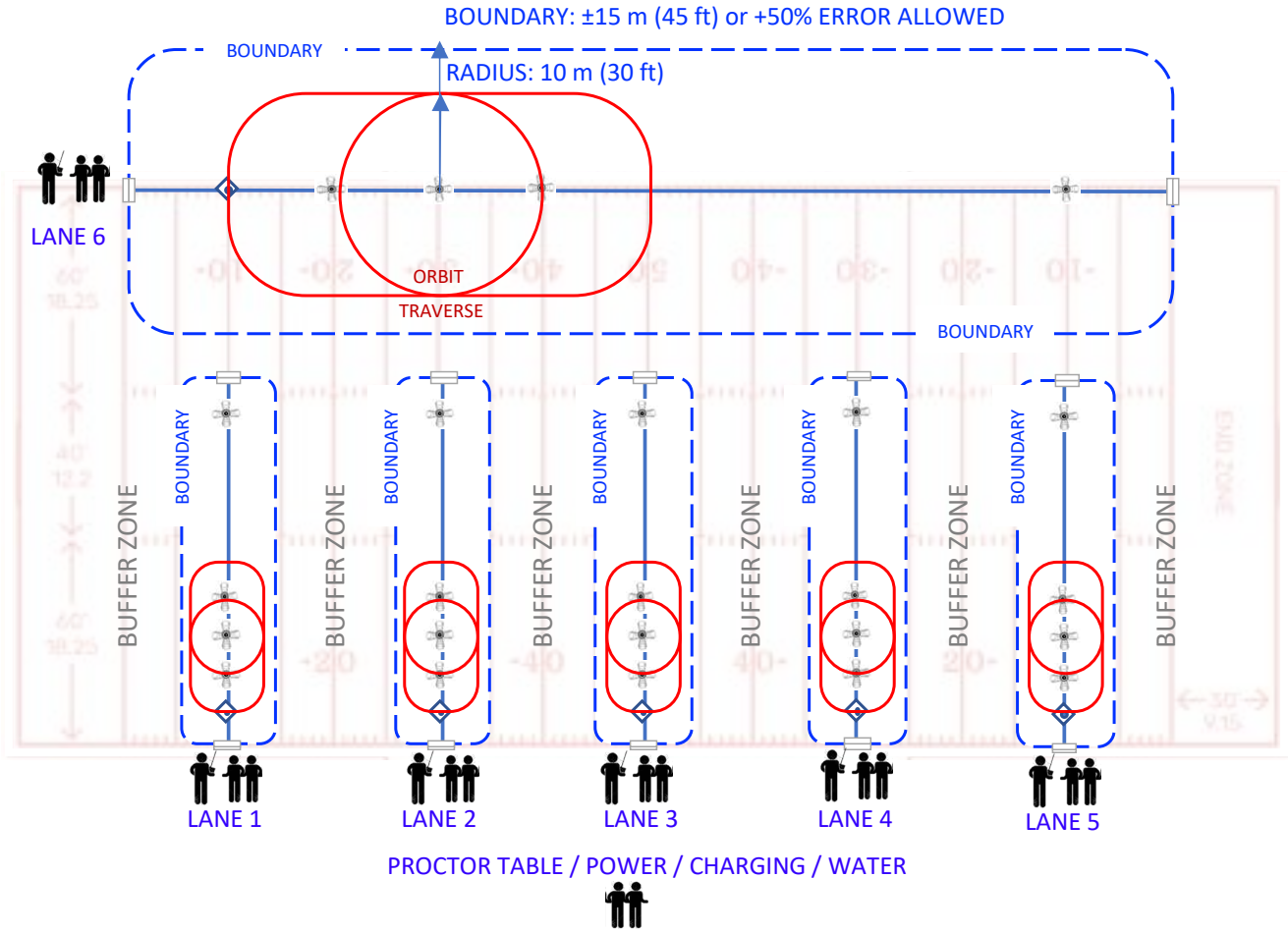
VEHICLE INSPECTION

20 DOWNWARD | 20 FORWARD

BUILDING EXTERIOR SEARCH

Football Field Layout

Open Test Lane



LANE SPACING
10 m (30 ft)

BOUNDARY (+50%)
± 15 m (45 ft)

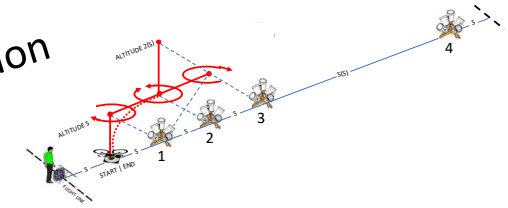
LANE LENGTH
100 m (300 ft)

LANE SPACING
3 m (10 ft)

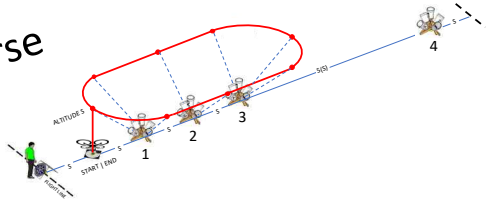
BOUDARY (+50%)
±5 m (15 ft)

LANE LENGTH
30 m (100 ft)

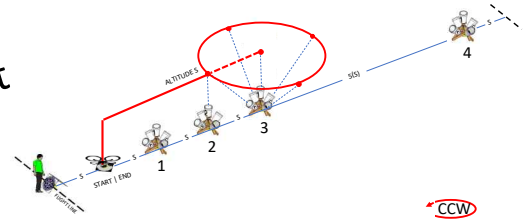
Position



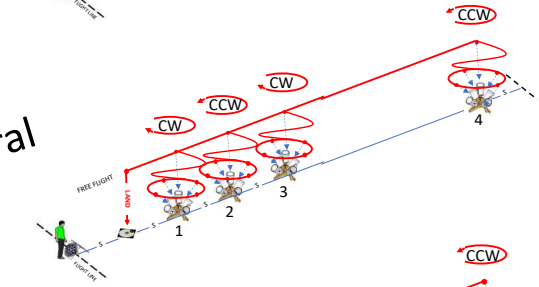
Traverse



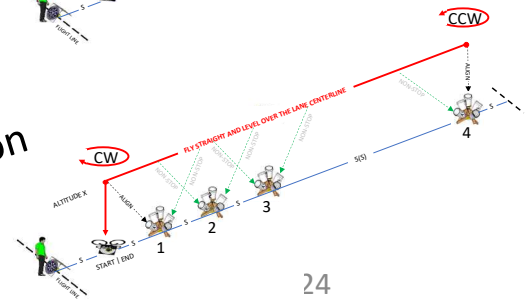
Orbit



Spiral



Recon



SENSOR PANELS & FLIGHT LINES

LAUNCH/LAND PLATFORM

OMNI BUCKET STANDS #1, #2, #3, #4

ORBIT PATH AND TRAVERSE PATH

PILOT, VISUAL OBSERVER, AND FORM FILLER

Quantifying Practical Skills Requirements

Focus Training and Evaluate Proficiency for Credentialing

"ASTM F38 Standard Guide for Training for Remote Pilot in Command of UAS Endorsement"

<u>Qualitative Task Performance Levels:</u>

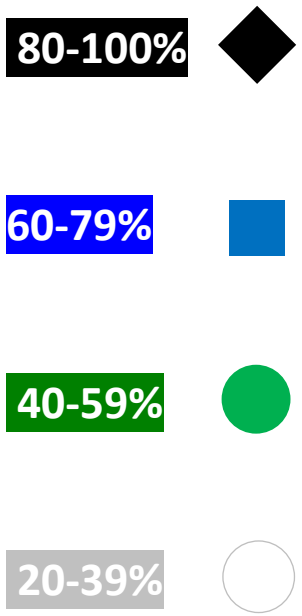
4) PROFICIENT
- Can do the complete task quickly and accurately.
- Can tell or show others how to do the task.

3) COMPETENT
- Can do all parts of the task.
- Needs only a spot check of completed work.

2) PARTIALLY PROFICIENT
- Can do most parts of the task.
- Needs only help on hardest parts.

1) LIMITED
- Can do simple parts of task.
- Needs to be told or shown how to do most of task.

<u>Quantitative Measures</u>
Example Thresholds



<u>Thresholds Set By Any Organization</u>
Based on Airspace, Mission, Environment

Organization "A" Pass/Fail
Maybe populated, obstructed area, windy, night, etc.

Organization "B" Pass/Fail
Maybe populated, open area, windy, daytime, etc.

Organization "C" Pass/Fail
Maybe rural, open area, calm, daytime, etc.

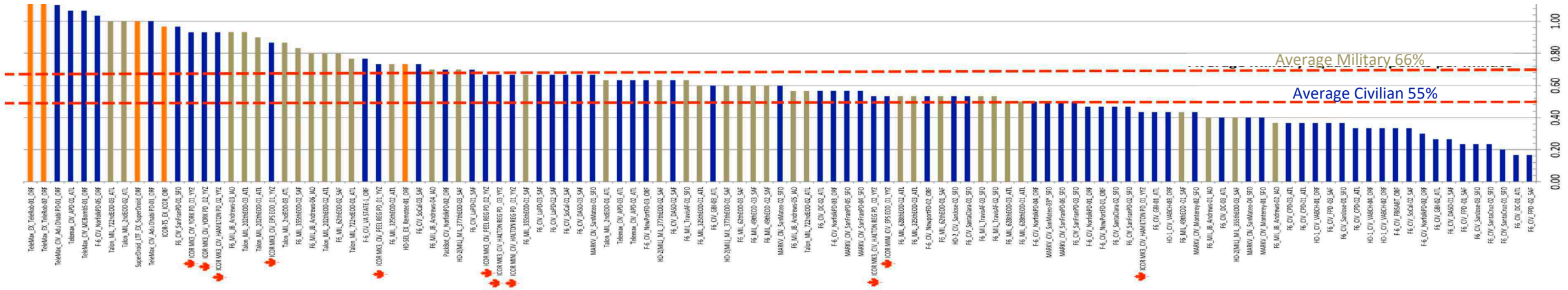
Set Your Minimum Thresholds for Pass/Fail

Focus Training and Evaluate Proficiency for Credentialing

- Organizations can set their own threshold for pass/fail in these tests based on their tolerance for reliability and/or efficiency. Complete trials are assumed.

- Measure everybody repeatedly over time and graph the results to help people understand their strengths and weaknesses. Then set minimum thresholds relative to the average or “expert” scores. Or adopt other organization’s thresholds as a central credentialing reference.

- At deployment time, each organization needs to consider their airspace restrictions, environmental variables, and mission complexity (night ops, BVLOS, etc.) to select a pilot and aircraft that’s likely to succeed.



Example proficiency data shown from bomb squads in ground robot tests

Select Trial Settings for Different Flight Credentials

Focus Training and Evaluate Proficiency for Credentialing

DAYLIGHT / LOS

1) Select the test lane and scenarios based on the intended environment and aircraft:
   – **Open, Obstructed, or Indoor**

2) Select the test procedure and time limit based on the intended mission:
   – **MAN (5 min. each) or PAY (10 min. each)**

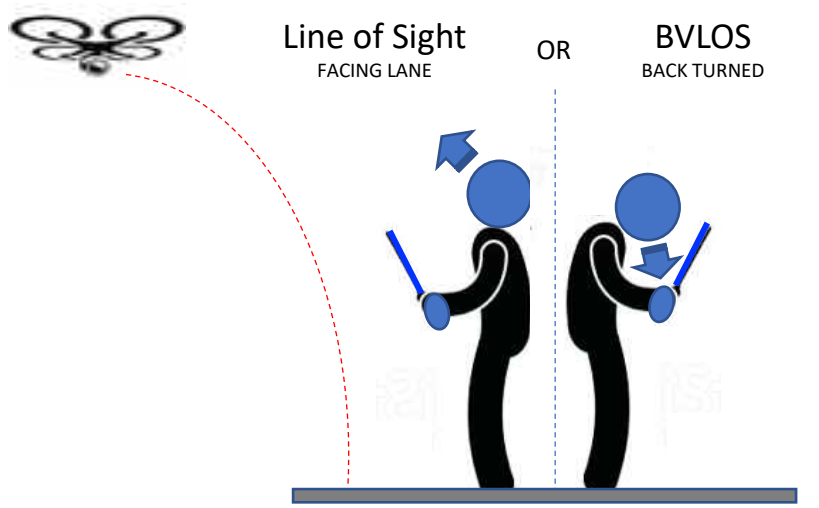
3) Select the minimum proficiency based on average or "expert" scores in the same trials:
   – **Example: 40%, 60%, 80% of "expert"**

ADDITIONAL

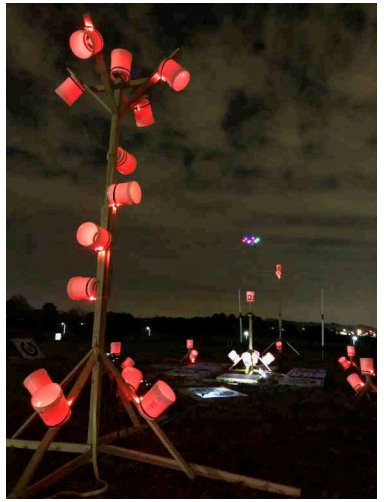
4) Select pilot view:
   – **Line of Sight or BVLOS**

5) Select lighting (indoor or outdoor) for daylight or night credentials:
   – **Lighted/Daylight or Dark**

CREDENTIALS	Daylight/LOS	BVLOS	Night Ops
Standard Lane (Indoor or Outdoor)	Pilot's Eyes On (Available)	Pilot's Back Turned (Interface Only)	Lights Out, Buckets Lit
Embedded Scenario (Indoor or Outdoor)	Pilot's Eyes On (Available)	Pilot's Back Turned (Interface Only)	Lights Out, Buckets Lit



THE PILOT'S BACK TURNED TO THE LANE FORCES RELIANCE ON THE INTERFACE (VISUAL OBSERVER REQUIRED)



ILLUMINATED BUCKETS PROVIDE POSITIONING AIDS LIKE STRUCTURE WINDOWS OR STREET LIGHTS

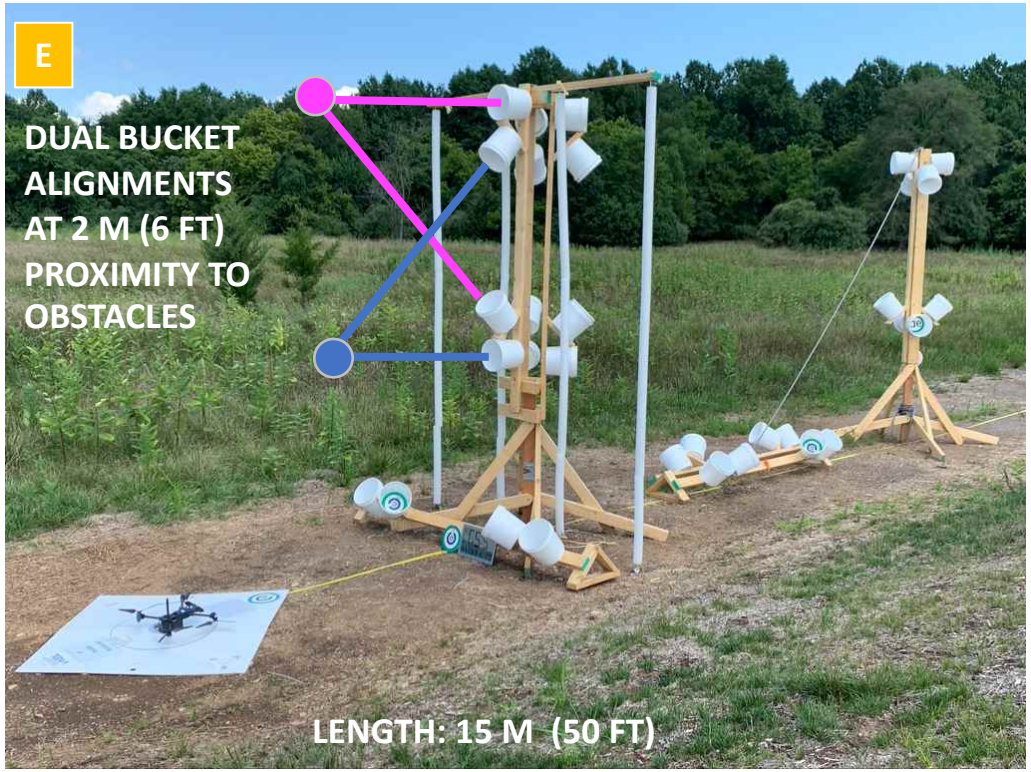
Montgomery County Police Drone Training & Evaluation Facility

Safety | Capabilities | Proficiency

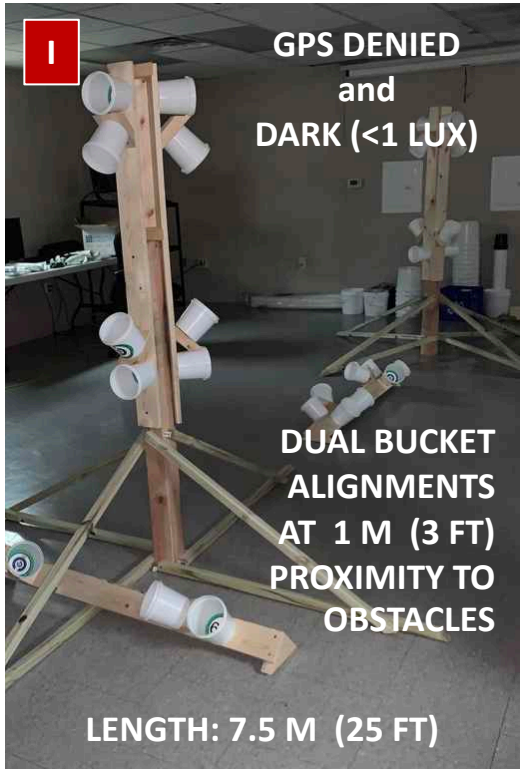
DOJ/DHS National Unmanned Aircraft Systems Program Evaluation, August 2020

OPEN TEST LANE

OBSTRUCTED TEST LANE



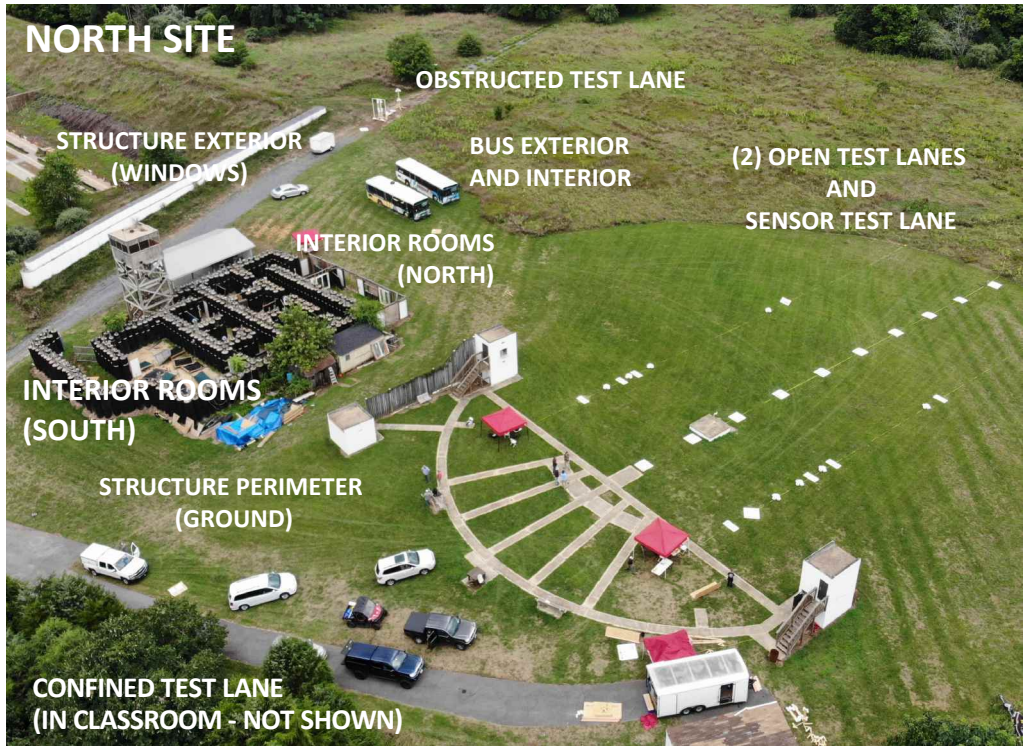
CONFINED TEST LANE

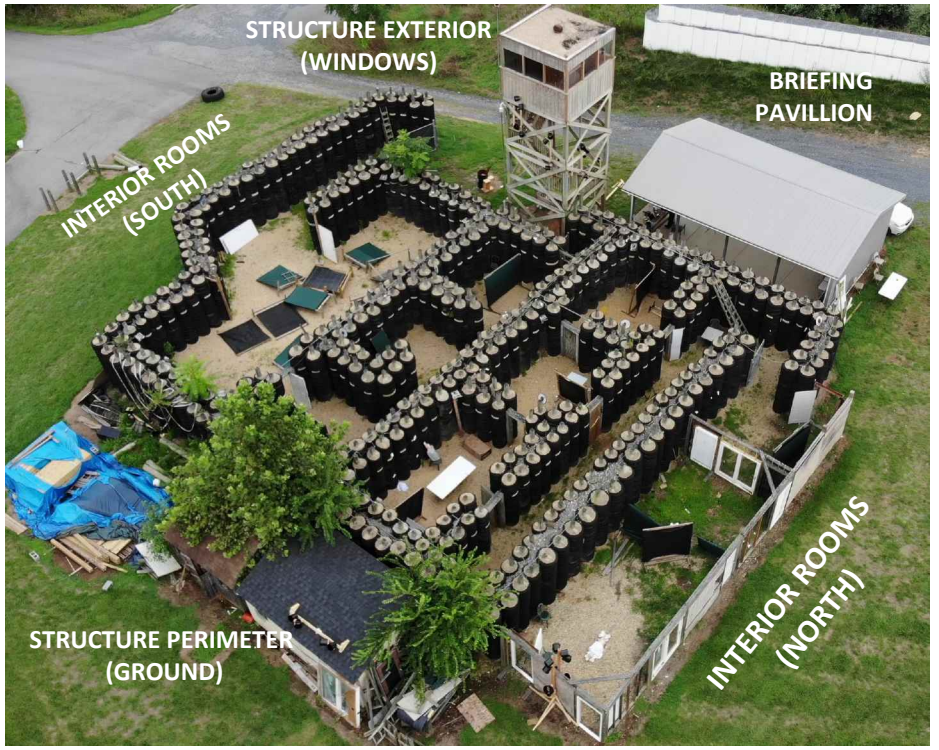


Montgomery County Police Drone Training & Evaluation Facility

Safety | Capabilities | Proficiency

DOJ/DHS National Unmanned Aircraft Systems Program Evaluation, August 2020





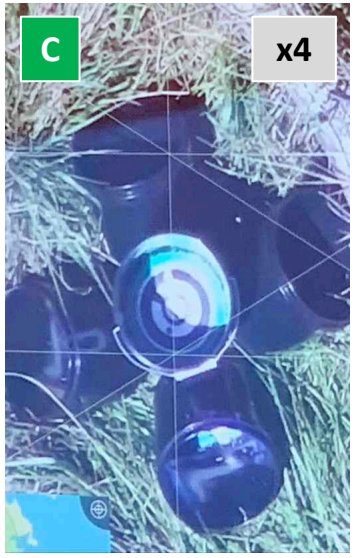
Montgomery County Police Drone Training & Evaluation Facility

Safety | Capabilities | Proficiency

DOJ/DHS National Unmanned Aircraft Systems Program Evaluation, August 2020

Operational Scenarios with Embedded Scoring
(Each with 20 buckets/targets, 100 points maximum)

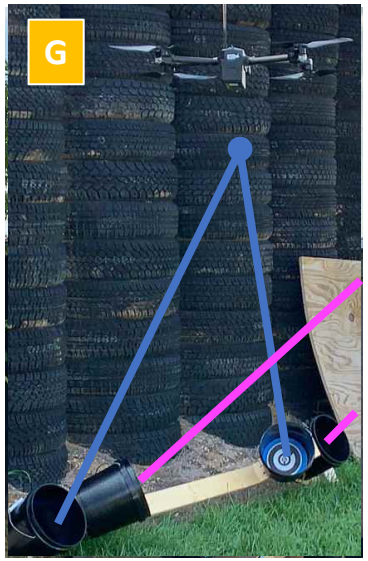
WIDE AREA MAPPING



EXTERIOR BUS

EXTERIOR WINDOWS

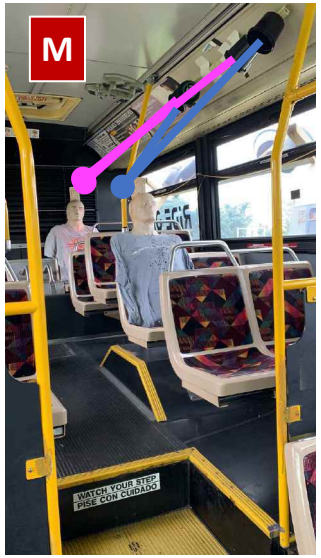
EXTERIOR GROUND



INTERIOR ROOMS

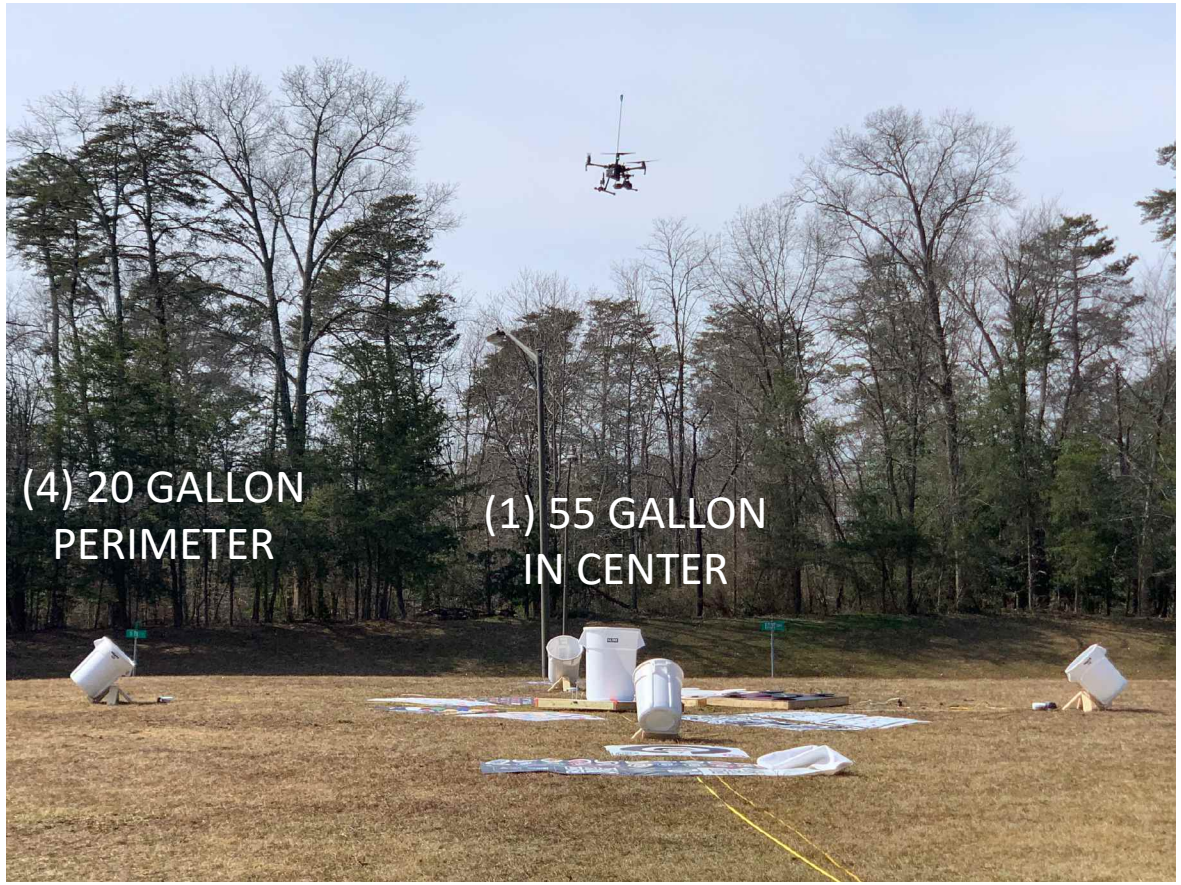
INTERIOR STAIRS

INTERIOR BUS



High Hover Tests with Larger Buckets

High Hover Tests (100-300 ft)



Hover Stability Test

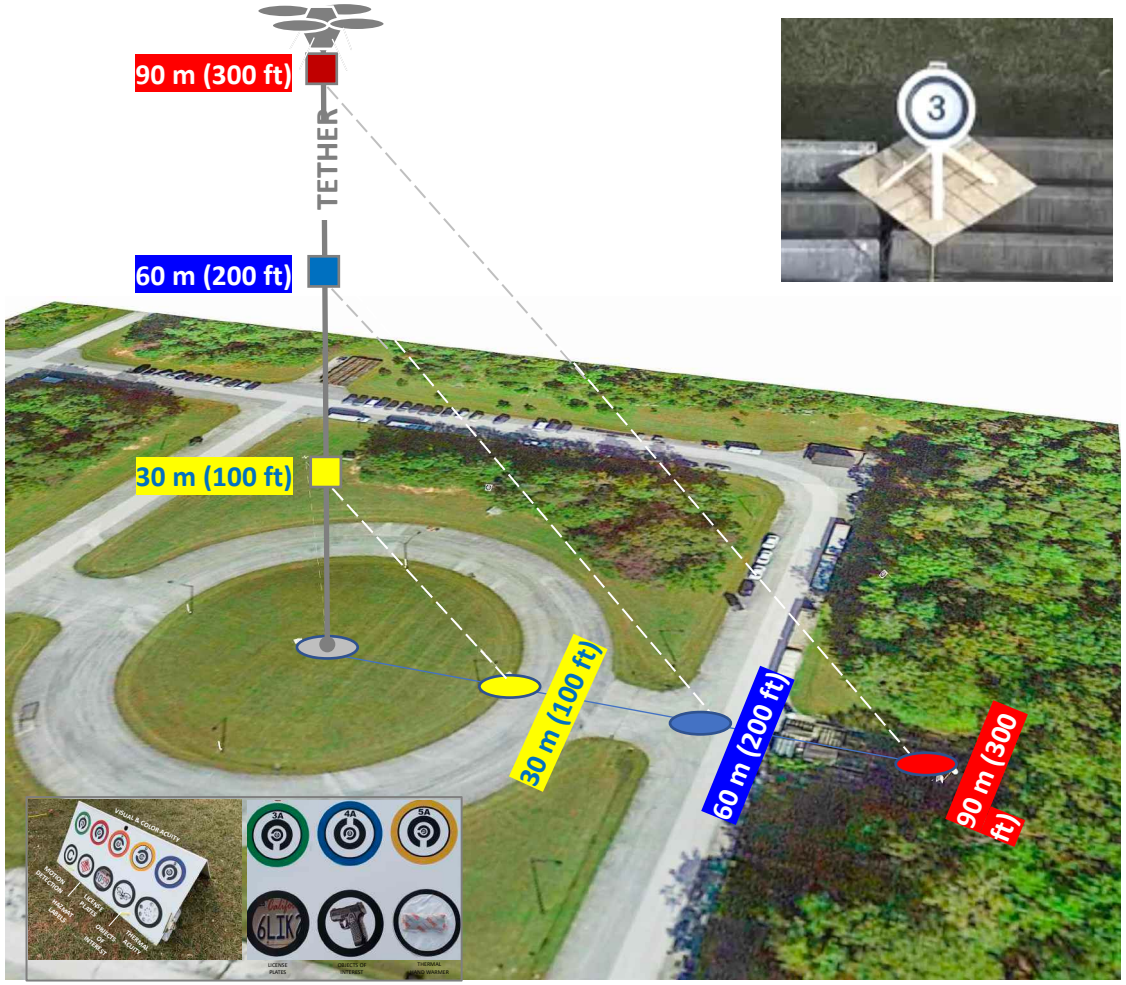
High Hover Test (100-300 ft)

Purpose:
This test evaluates remotely piloted aircraft hover stability at different altitudes using dual bucket alignments at fixed distances from a designated hover position.

This test can be used to evaluate free-flying or tethered aircraft system capabilities. This test can also be used as a repeatable training task to practice operation of the system interface and evaluate remote pilot proficiency.

Summary of Test:

- Altitudes are 30 m (100 ft), 60 m (200 ft), 90 m (300 ft).
- Dual bucket alignments are performed at each altitude using buckets with an appropriate diameter to be seen clearly from the intended altitudes located straight down (90°) and along the centerline at an equal distance to the intended altitude (45°).
- At each altitude, separately timed alignment intervals are conducted alternating between the downward and angled alignment buckets (30 seconds per alignment, 60 seconds per complete repetition).

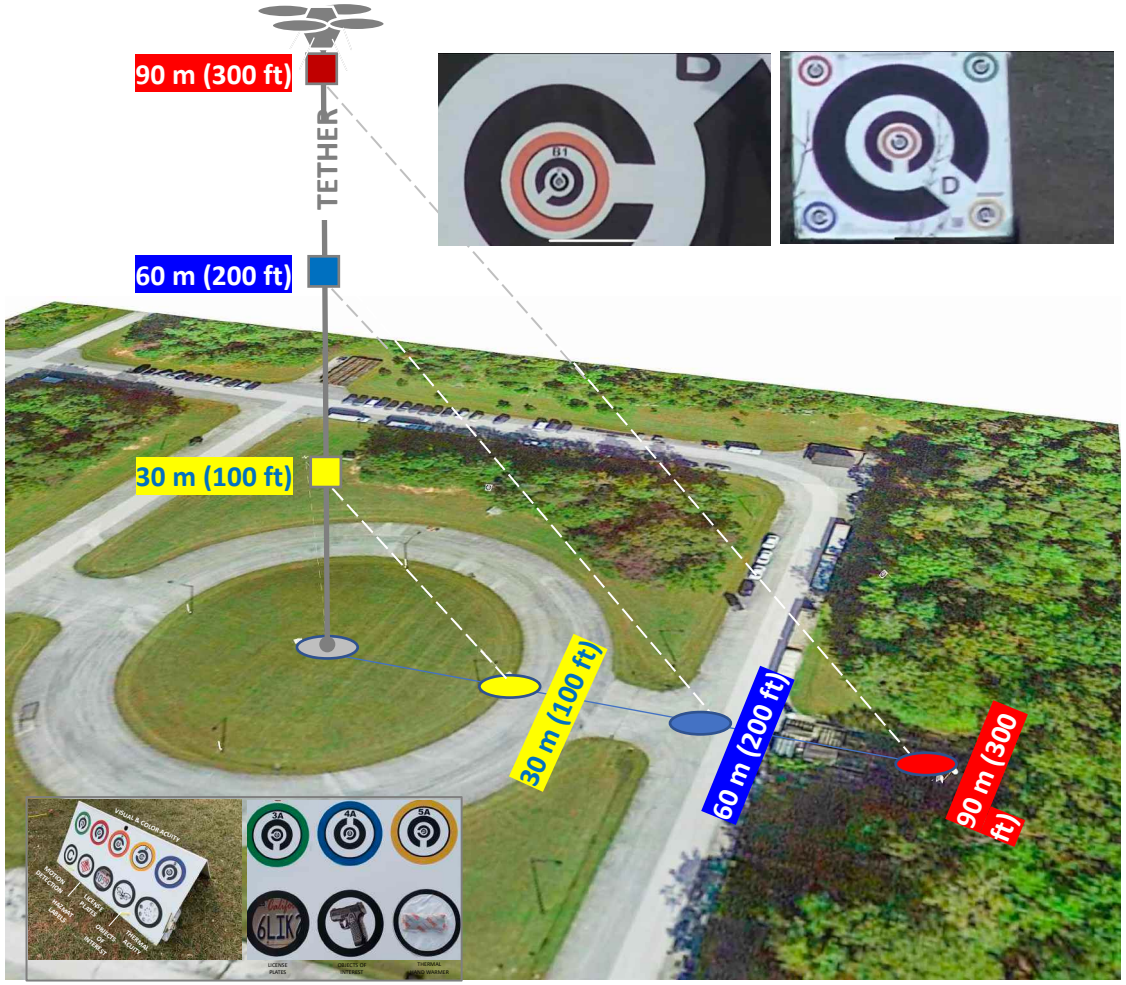


Pan-Tilt-Zoom Cameras Test

High Hover Tests (100-300 ft)

Purpose:

This test evaluates remotely piloted aircraft camera pointing and zooming capabilities using sensor targets at various distances from a designated hover position and altitude. This test can be used to measure aircraft sensors including visual acuity, color acuity, thermal acuity, motion detection, hazmat label identification, etc. This test can also be used as a repeatable training task to practice the system interface and evaluate remote pilot proficiency for credentialing.



Features:

- Altitude checks defined by a center vertical bucket with angled buckets at equal distance to altitudes.
- Altitudes can be 30 m (100 ft), 60 m (200 ft), 90 m (300 ft)

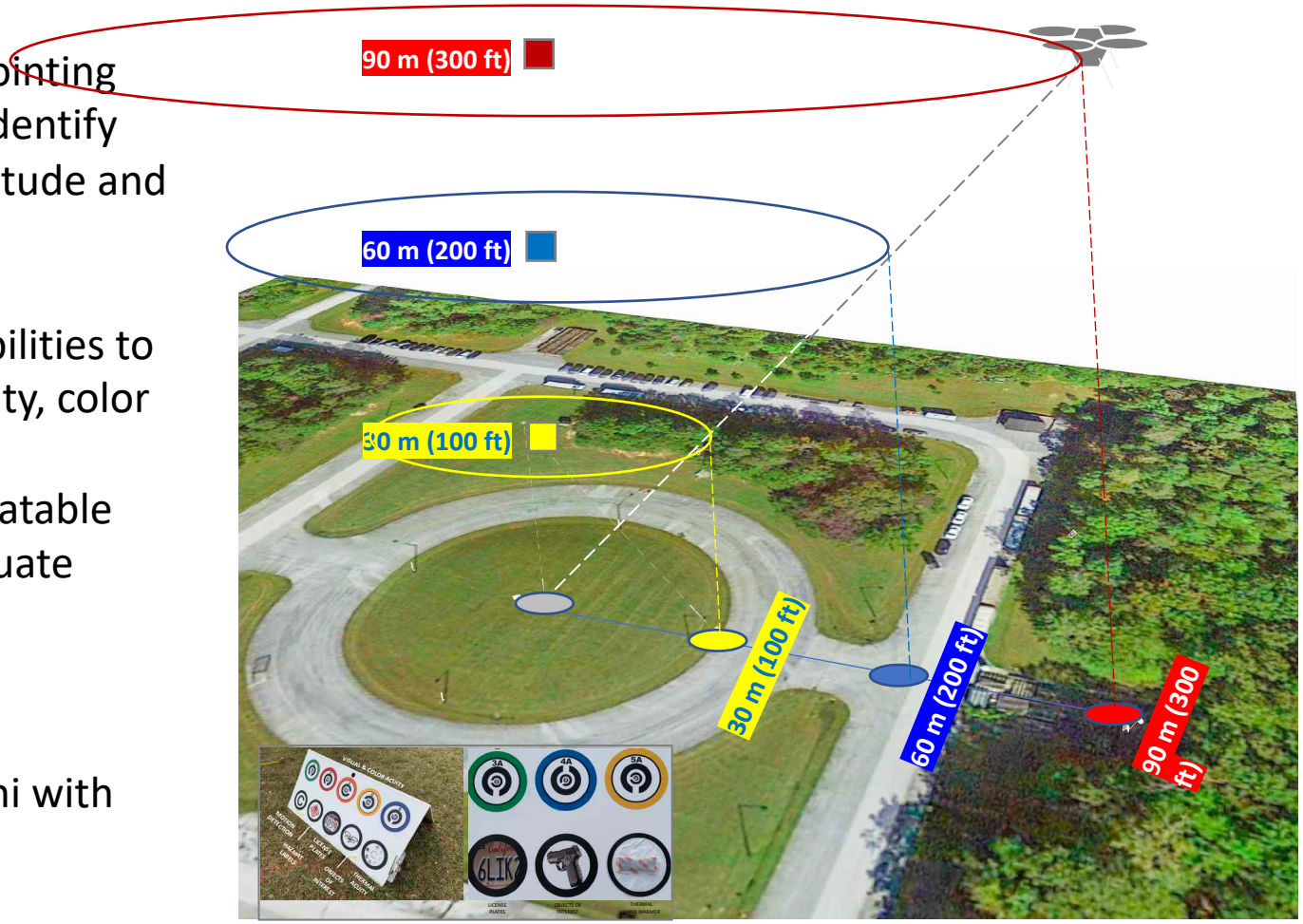
Orbit Test

High Hover Tests (100-300 ft)

Purpose:

This test evaluates remotely piloted aircraft camera pointing and zooming capabilities during high hover orbits to identify four different sides of an object from a designated altitude and radius.

This test can be used to measure aircraft sensor capabilities to identify objects of interest using targets for visual acuity, color acuity, thermal acuity, motion detection, hazmat label identification, etc. This test can also be used as a repeatable training task to practice the system interface and evaluate remote pilot proficiency for credentialing.

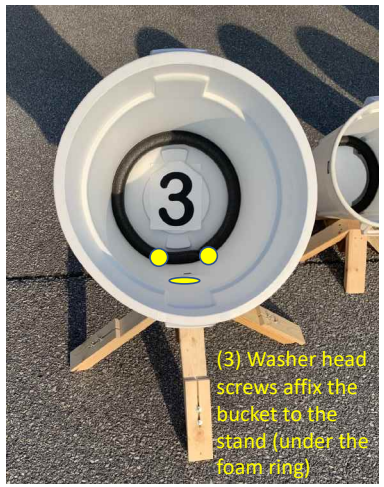


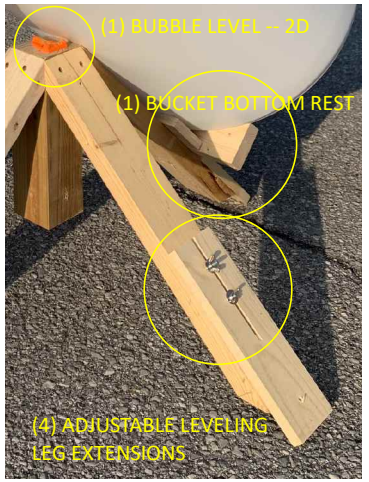
Features:

- Altitude and radius checks defined by a center omni with angled buckets and perimeter vertical buckets.
- Targets at the center with the omni bucket stand.

Large Bucket Apparatuses

High Hover Tests (100-300 ft)





(9) 20-gallon white buckets with 18in diameter.
https://www.uline.com/Product/Detail/H-1854W/Brute-Trash-Cans-and-Accessories/Rubbermaid-Brute-Trash-Can-20-Gallon-White

(9) Foam pipe insulation (2-3in diameter x 6ft long) cut to form the inscribed ring.
https://www.homedepot.com/p/Everbilt-3-4-in-x-6-ft-Foam-Semi-Slit-Polyethylene-Pipe-Insulation-ORP07812/204760801

(9) Center labels to identify each bucket (full page size or 8in)

(1) Omni directional stand with (5) 20-gallon buckets attached to it placed top center of the fuselage with straps and rope extensions to cinch tightly around the aircraft belly.

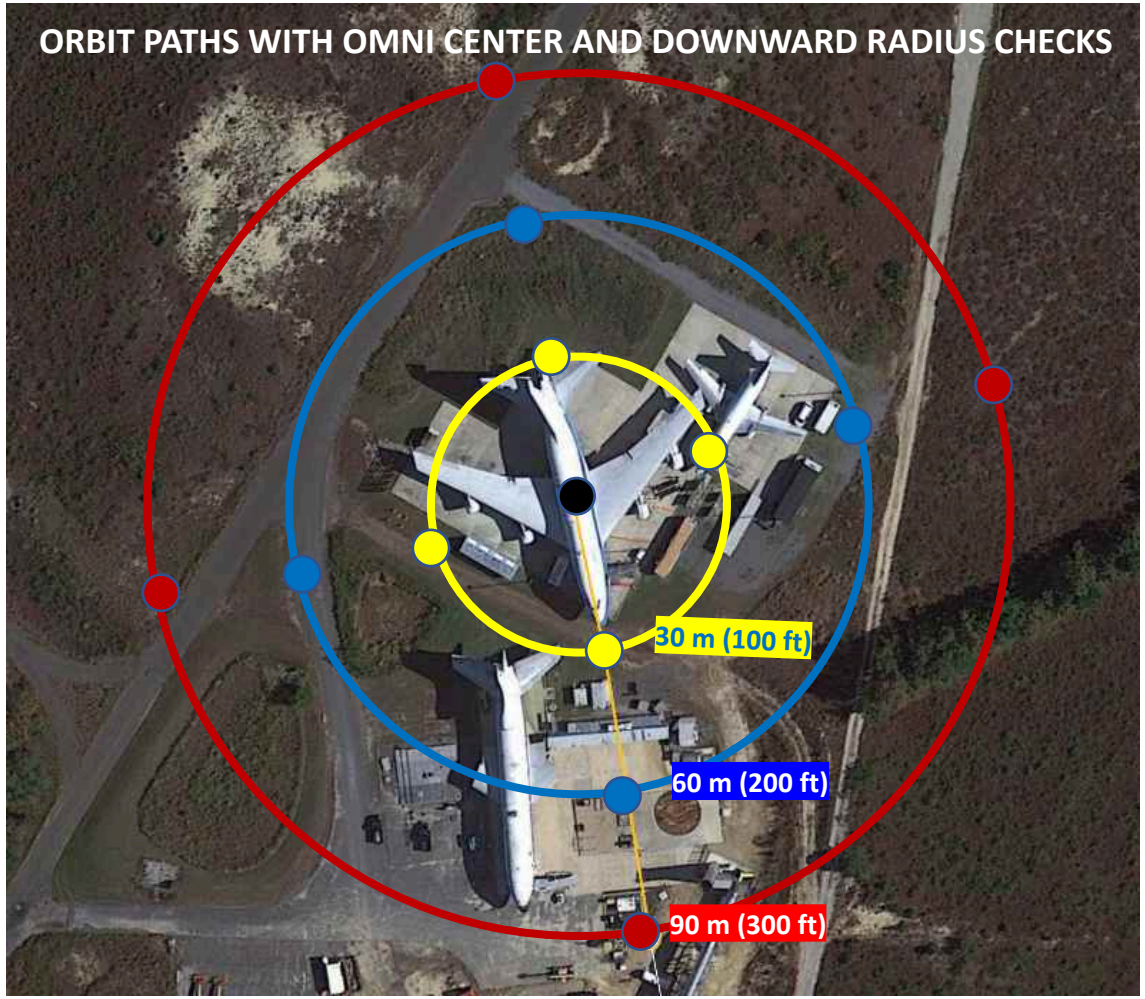
(4) Surrounding vertical bucket leveling stands if not on pavement (weight or stake the buckets to not move in wind)

(1) 300ft measuring tape and chalk paint and wand to mark measured locations.

(1) 45-degree angle level that spans the bucket top.

Embedding into Larger Scenarios

High Hover Tests (100-300 ft)



(9) 20-gallon white buckets with 18in diameter.
https://www.uline.com/Product/Detail/H-1854W/Brute-Trash-Cans-and-Accessories/Rubbermaid-Brute-Trash-Can-20-Gallon-White

(9) Foam pipe insulation (2-3in diameter x 6ft long) cut to form the inscribed ring.
https://www.homedepot.com/p/Everbilt-3-4-in-x-6-ft-Foam-Semi-Slit-Polyethylene-Pipe-Insulation-ORP07812/204760801

(9) Center labels to identify each bucket (full page size or 8in)

(1) Omni directional stand with (5) 20-gallon buckets attached to it placed in the center of the scenario.

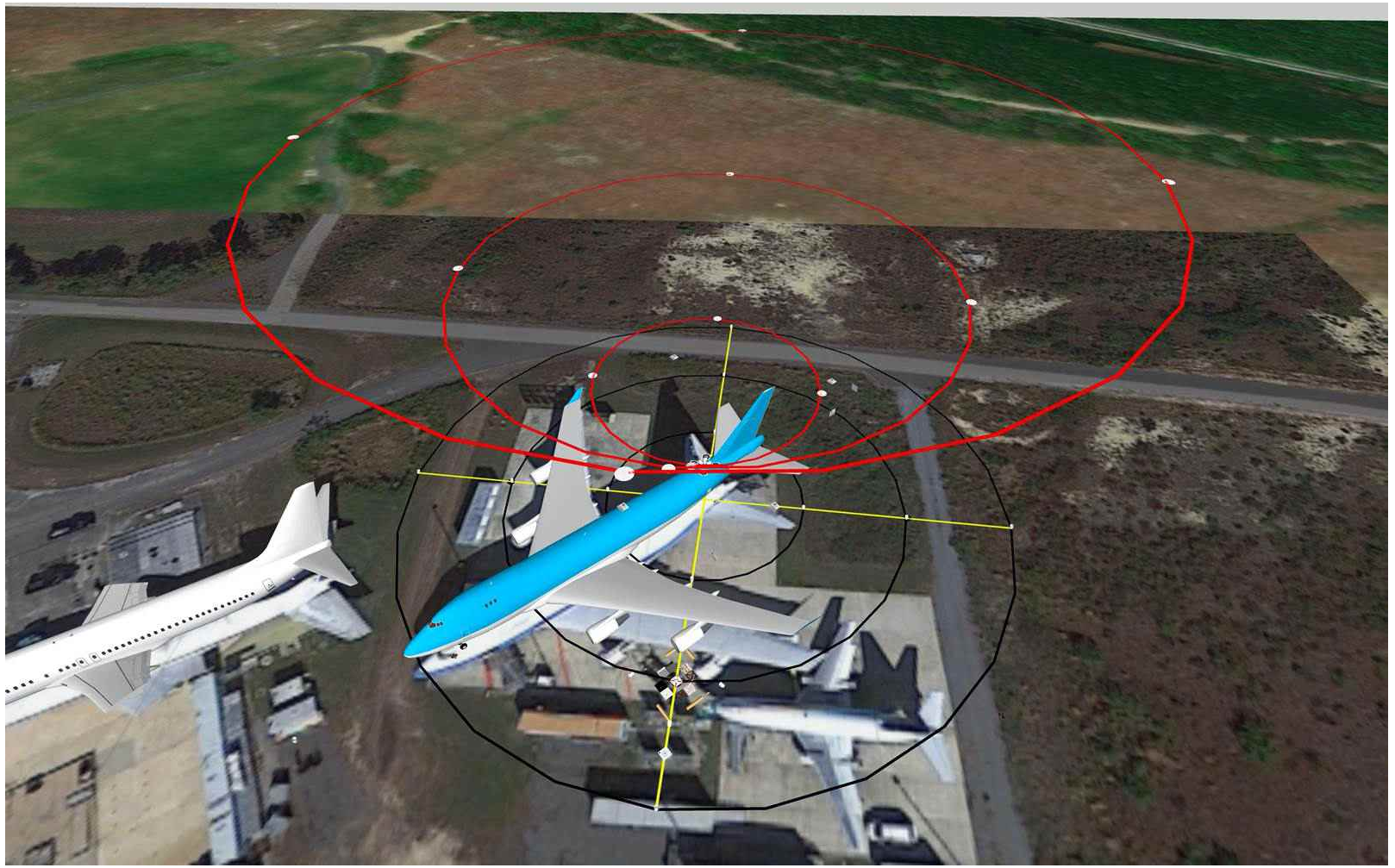
(4) Surrounding vertical bucket leveling stands if not on pavement (weight or stake the buckets to not move in wind)

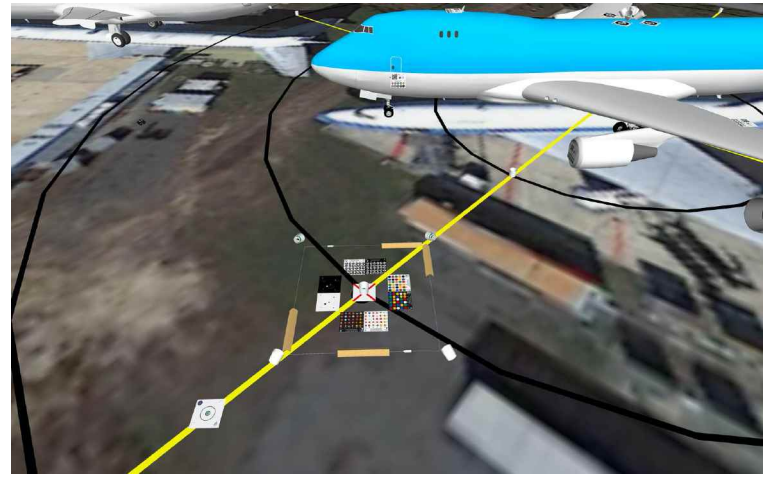
(2) 300ft measuring tapes and chalk paint and wand to mark measured bucket locations.

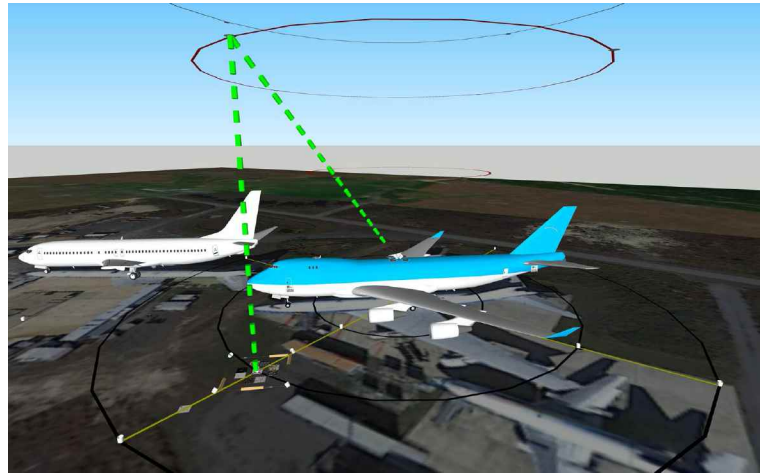
(1) 45-degree angle level that spans the bucket top.

Embedding into Larger Scenarios

High Hover Tests (100-300 ft)







WEBSITE POINTER:
WATCH FABRICATION VIDEOS
AND FLIGHT PATH ANIMATIONS

WEBSITE POINTER:
DOWNLOAD STICKER FILES, FORMS AND
PRACTICE SCORING VIDEOS

Internet
RobotTestMethods.nist.gov

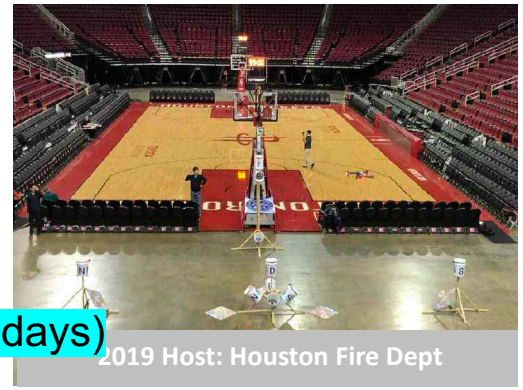
Email
RobotTestMethods@nist.gov

Validation Exercises

Committee Business

Color Key: Ground Aerial Aquatic Multiple Standards

- 2020.08 DHS/DOJ sUAS Procurement Testing ($35M), Montgomery County Police Facility, MD (1 days)
- 2020.10 Air Force Large Ground Robot Procurement ($70M), Tyndall AFB, FL (Weeks)
- 2020.08 DHS/DOJ sUAS Procurement Testing ($35M), Montgomery County Police Facility, MD (5 days)
- ~~2020.09 Canadian Fire Training Facility Opening Exercise, Toronto Airport, Ontario, Canada (4 days)~~
- ~~2020.08 World Robot Summit Disaster Response Championship, Fukushima, Japan (4 days)~~
- ~~2020.06 RoboCupRescue International Championship, Bordeaux, France (5 days)~~
- ~~2020.05 AUVSI Exponential Conference (netted aviary), Boston, MA (3 days)~~
- ~~2020.04 Fire Dept. International Conference (FDIC) Hands-On Training, Indianapolis, IN (3 days)~~
- ~~2020.03 UTAC UAS Conference, Guardian Center, Perry, GA (4 days)~~
- 2020.03 Public Safety UAS Conference Validation Exercise, Crozet, VA (5 days)



2019 Host: Houston Fire Dept

2018 Host: San Diego Fire Dept

2017 Host: Canadian CETA

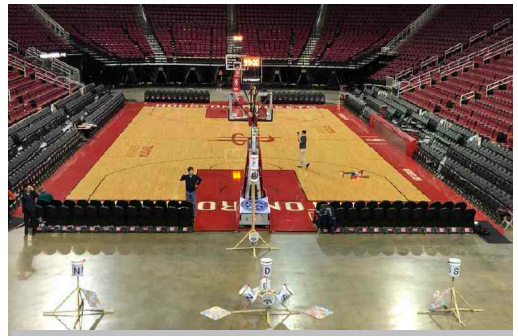
Validation Exercises

Committee Business

Color Key: Ground Aerial Aquatic Multiple Standards

2020.02 ASTM E54.09 Response Robots Meeting and Exercise, Atlanta, CO (3 days)

- 2020.01 Ohio Fire Training Facility Opening, Ohio (2 days)
- 2020.01 FDIC Fire/Rescue East, Daytona, FL (2 days)
- 2020.01 Los Angeles Fire Dept. Training, Los Angeles, CA (3 days)
- 2019.12 FAA Requirements Workshop for Fire Depts and Emergency Services, NIST (1 day)
- 2019.11 Atlantic Future Forum, UK HMS Queen Elizabeth, Annapolis, MD (2 days)
- 2019.11 DHS Familiarization Exercise, Army Camp Shelby, MS (5 days)
- 2019.10 World Robot Summit, Fukushima, Japan (5 days)
- 2019.09 NATO Aerial and Ground Exercise, Base Borden, Ontario, Canada (3 days)
- 2019.07 Aerial Validation Exercise at NIST (3 days)
- 2019.06 RoboCupRescue International Championship, Sydney, Australia (5 days)



2019 Host: Houston Fire Dept

2018 Host: San Diego Fire Dept

2017 Host: Canadian CETA

Validation Exercises

Committee Business

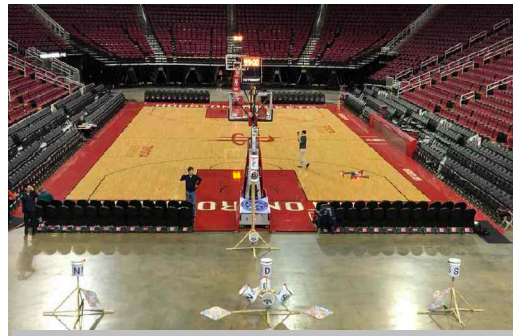
Color Key: Ground Aerial Aquatic Multiple Standards

2019.06 ASTM E54.09 Response Robots Meeting and Exercise, Denver, CO (5 days)

- 2019.05 Western Regional Robot Rodeo, Sandia/Kirtland, Albuquerque, NM (5 days)
- 2019.05 Canadian Police College Training Exercise, London, ON Canada (7 days)
- 2019.04 Thermite RS2 firefighting robot capabilities evaluation (1 day)
- 2019.04 Army Tank Automotive Research and Development facility fabrication (remote)
- 2019.04 Fire Dept Training Conference (FDIC), Indianapolis, IN (3 days)
- 2019.04 Guardian Center Training, Perry, GA (2 days remote)
- 2019.04 Reveille Ranch Calibration, Texas Dept of Public Safety, Burnet, TX (2 days)
- 2019.04 InstantEye UAS capabilities evaluation, NIST (3 days)

2019.03 ASTM F38 standard balloted referencing 6 of our aerial test methods

- 2019.03 Navy Explosive Ordinance Disposal Tech Division facility fabrication (remote)
- 2019.03 Virginia UAS Summit on Public Safety, Crozet, VA (3 days)



2019 Host: Houston Fire Dept

2018 Host: San Diego Fire Dept

2017 Host: Canadian CETA

XXXXXXXXXXXXXXXXXXX

Safety | Capabilities | Proficiency

SLIDE TEMPLATE