Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)
Quick Start Guide
Acknowledgements

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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.
Standard Test Methods for Small Unmanned Aircraft Systems

ASTM International Standards Committee on Homeland Security Applications; Response Robots (E54.09) | Website: RobotTestMethods.nist.gov

Scalable Test Lane
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

- Omni Bucket Leveling Stand
- Spiral Bucket Leveling Post
- Launch/Land Platform
- Lane Marker

FLY SMALL SYSTEMS
FLY LARGE SYSTEMS
WORK THE INTERFACES
PRACTICE PROCEDURES
EVALUATE SENSORS
COMPARE PAYLOADS
Scalable Test Lane

Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

Inside each bucket is an inscribed ring to evaluate alignment. LEFT is aligned, RIGHT is not quite. Center targets can be letters, visual/color/thermal acuity charts, hazmat labels, or other items.
Test Lane Layout

Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

- Pilot flight line with lane marker (A-frame)
- Centerline (long measuring tape or flat cones)
- 1X spacing (10ft, 20ft, 30ft or other)
- 4X overall length (40ft, 80ft, 120ft or other)
- The flight altitudes are always 1X and 2X

Inside each bucket is an inscribed ring to evaluate alignment. LEFT is aligned, RIGHT is not quite. Center targets can be letters, visual/color/thermal acuity charts, hazmat labels, or other items.
Bucket Details – Align and Identify Visual Acuity Targets
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

3 NUMBERED BUCKETS (1-3)
Top Vertical

20 LETTERED BUCKETS (A-T)
Angled 45° and Horizontal

START TOWARD LANDING WITH A VOWEL AND WRAP AROUND RIGHTWARD

Align to see the entire inscribed ring inside each bucket. The letters are bucket identifiers.

Align and identify the acuity target inside each bucket with increasingly small concentric C gaps in one of eight directions.
Bucket Details – Numbering and Lettering
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

3 NUMBERED BUCKETS (1-3)
Top Vertical

20 LETTERED BUCKETS (A-T)
Angled 45° and Horizontal

START TOWARD LANDING WITH A VOWEL AND WRAP AROUND RIGHTWARD

Numbers and letters inside the buckets help guide the pilot.

Perch acuity from the Launch/Land Platform benefit from accurate landings to apply full zoom capabilities.
Bucket Details - 2 Gallon (8in Diam) Sticker Files
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

Waterproof polyester stickers are preferred because they are easy to insert and adjust initially. They also survive the elements. Stickers can contain more than just numbers, letters, and acuity targets. More operationally significant or just random targets work too.

All Basic Lane Buckets
https://drive.google.com/open?id=1NGrHY3UH89FlEuXXyfnnQxt6-h5ewoewqU

Letters - INSERT DISCS FOR MAN
https://drive.google.com/open?id=1FoQvoKkQu5jUC4bJNM7TiLcWVs-C3

Concentric Cs Black - SENSOR PANELS
https://drive.google.com/open?id=1YxY1_26dn1KB0FHfleU4Xna_gxHzw9oL

Concentric Cs Color - SCENARIOS
https://drive.google.com/open?id=19b8RrTmB4TkvZvHcAPuXRWd5SMTuai

Misc Hazmats, Directions, Plates, Images
https://drive.google.com/open?id=1nuHvZS9ARZ6kFVzv2Kh06qwEoUuKM

Xtra Bucket Stands for Scenarios
https://drive.google.com/open?id=1RklQazk4rBZyUPxadJLnpYyf2ZNRcN
Bucket Details – 5 Gallon (10in Diam) Inscribed Rings

Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

• 2 gallon and 5 gallon buckets with inscribed rings and targets inside are essentially interchangeable. The larger bucket has only a slighter bigger diameter but at 20+ ft altitude this is negligible.

• 5 gallon white buckets with 10 in diameter inside bottoms require an inscribed ring plus a sticker.

• Use an extra large black marker to make a 5/8in inscribed ring.

• Tip: Press down using the thickest dimension of the marker tip and pull toward you in the bottom corner of the bucket. Then ROTATE THE BUCKET two revolutions.
Choosing An Appropriate Lane Spacing
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

An appropriate lane spacing is when a 2X hover allows reading at least the outer ring of a concentric C target two stands away.

**FLIGHT LINE**

**NOT QUITE 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.

**MAN 1-5 LETTER IDENTIFIERS**
Align to see the entire inscribed ring inside the buckets. The letters are bucket identifiers.

---

THIS SHOWS THE ANGLED BUCKETS ARE TOO FAR AWAY FOR THE OPTICS ON THIS AIRCRAFT ---- MOVE TO A SHORTER LANE SPACING ----

THIS IS JUST BARELY CLOSE ENOUGH TO BE CERTAIN OF A COMPLETELY INScribed RING (ROUGHLY 1 / 10 OF THE DISPLAY OR LARGER)
Position Test Procedure
Maneuvering (MAN 1) and Payload Functionality (PAY 1)

START THE TIMER when the drone launches from the platform

1. HOVER at X over Bucket 1

2. ROTATE RIGHT 360°

3. ROTATE LEFT 360°

4. CLIMB to 2X

5. DESCEND to X

6. FORWARD over Bucket 2

7. BACKWARD over Bucket 1

8. FORWARD/ROTATE 180° over Bucket 2

9. FORWARD/ROTATE 180° over Landing

10. LAND CENTERED facing stands

---

**MAN: 20 points, 10 Positions, 18 Alignments and a Landing (2pts)**

**PAY: 100 points, 10 Positions, 18 Bucket Targets and 2 Perch Targets**

*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.
MAN 1-5 LETTER IDENTIFIERS
Align to see the entire inscribed ring inside the buckets to. 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.

FLIGHT LINE
X Altitude
360°
180°
180°
360°

FORM FOR TRACKING YOUR PERFORMANCE OVER TIME

<table>
<thead>
<tr>
<th>PROCEEDURE</th>
<th>FLIGHT PATHS</th>
<th>Aligned</th>
<th>C's</th>
<th>Aligned</th>
<th>C's</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HHOVER at X over Bucket 1</td>
<td>Bucket E</td>
<td>Bucket 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ROTATE RIGHT 360°</td>
<td>Bucket E</td>
<td>Bucket 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. ROTATE LEFT 360°</td>
<td>Bucket E</td>
<td>Bucket 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. CLIMB to 2X</td>
<td>Bucket I</td>
<td>Bucket 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. DESCEND to 1X</td>
<td>Bucket E</td>
<td>Bucket 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. FORWARD over Bucket 2</td>
<td>Bucket E</td>
<td>Bucket 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. BACKWARD over Bucket 1</td>
<td>Bucket E</td>
<td>Bucket 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. FORWARD/ROTATE 180° over Bucket 2</td>
<td>Bucket C</td>
<td>Bucket 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. FORWARD/ROTATE 180° over Landing</td>
<td>Bucket A</td>
<td>Landing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. LAND ACCURATELY FACING STANDS</td>
<td>Centered</td>
<td>Perch 1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MAN and PAY TEST
Check mark the buckets when aligned for both MAN and PAY

PAY TEST ONLY
Write the number of C’s correctly identified

RESULTS
• Total aligned buckets
• Total C’s identified
• Faults
• Elapsed time of trial

METRICS (in order)
1. Score
2. Reliability/Acuity
3. Efficiency
Comprehensive Flight Paths in a Single Lane
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

Position
MAN 1 / PAY 1
- Hover position stability
- Basic maneuvers
- Landing accuracy
- 20 tasks in 1 lap

MAN: Align only
PAY: Align and Identify

Traverse
MAN 2 / PAY 2
- Sideways along a line
- Left and right directions
- Landing accuracy
- 20 tasks in 2 laps

MAN: Align only
PAY: Align and Identify

Orbit
MAN 3 / PAY 3
- Orbit identifications
- Left and right directions
- X and 2X altitudes
- 20 tasks in 4 laps

MAN: Align only
PAY: Align and Identify

Spiral
MAN 4 / PAY 4
- Free flight inspections
- Any proximity
- Any altitude
- 20 tasks in 1 lap

MAN: Align only
PAY: Align and Identify

Sustain Speed/Deliver Accurately
MAN 5 / PAY 5
- Max speed following a line
- 5X distance
- X altitude
- 20X distance per lap

MAN: Follow paths
PAY: Deliver Payload Accurately
Evaluate System Capabilities or Pilot Proficiency
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

Position (Version D)
MAN 1 / PAY 1

START POSITION

MANEUVERING 1 (MAN 1)
- 10 positions in 1 lap
- 18 bucket alignments and 1 landing (2pts)
- 1 point each
- 20 points maximum

PAYLOAD FUNCTIONALITY 1 (PAY 1)
- 10 positions in 1 lap
- 18 bucket targets and 2 perch targets
- 5 concentric Cs per target
- 100 points maximum per lap
Evaluate System Capabilities or Pilot Proficiency
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

**Traverse**

**MAN 2 / PAY 2**

**START POSITION**

**MANEUVERING 2 (MAN 2)**
- 20 alignments in 2 laps (rightward/leftward)
- 18 bucket alignments and 2 landings
- 1 point each
- **20 points maximum**

**PAYLOAD FUNCTIONALITY 2 (PAY 2)**
- 20 targets in 2 laps (rightward/leftward)
- 18 bucket targets and 2 perch targets
- 5 concentric Cs per target
- **100 points maximum**
Evaluate System Capabilities or Pilot Proficiency
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

Orbit
MAN 3 / PAY 3

START POSITION

MANEUVERING 3 (MAN 3)
- 20 alignments in 4 orbits (rightward & leftward, 1X & 2X)
- Each orbit has 4 buckets toward center and 1 downward radius
- 1 point each
- 20 points maximum

PAYLOAD FUNCTIONALITY 3 (PAY 3)
- 20 targets in 4 orbits (rightward & leftward, 1X & 2X)
- Each orbit has 4 buckets toward center and 1 downward radius
- 5 concentric Cs per target
- 100 points maximum
Evaluate System Capabilities or Pilot Proficiency
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

Spiral
MAN 4 / PAY 4

START POSITION

MANEUVERING 4 (MAN 4)
• 20 bucket alignments in 1 lap
• 1 Point Each
• 20 Points Maximum

PAYLOAD FUNCTIONALITY 4 (PAY 4)
• 20 targets in 1 lap
• 5 concentric Cs per target
• 100 Points Maximum
Evaluate System Capabilities or Pilot Proficiency
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

Sustain Speed / Deliver Accurately
MAN 5 / PAY 5

**MANEUVERING 5 (MAN 5)**
- 5 laps
- 4 flight path (2 horizontal, 2 vertical)
- 1 Point Each
- **20 Points Maximum**

**PAYLOAD FUNCTIONALITY 5 (PAY 5)**
- 5 placements or drop from 2X altitude
- 20 points for diameters from 4-20ft
- **100 Points Maximum** (max weight object)
Evaluate System Capabilities or Pilot Proficiency
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

Sustain Speed / Deliver Accurately
MAN 5 / PAY 5

5X Altitude
2X Altitude
X Altitude

Overshoot Limit

WEIGHTED PAYLOAD
LAND or DROP

BUCKET AT CENTER OF DROP ZONE
PLACE
PLACE (DETAIL)
Circuit Training with Scores
Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

- **Position (MAN 1 / PAY 1)**
  - Hover position stability
  - Basic maneuvers
  - Landing accuracy
  - 20 tasks in 1 lap

- **Traverse (MAN 2 / PAY 2)**
  - Sideways along a line
  - Left and right directions
  - Landing accuracy
  - 20 tasks in 2 laps

- **Orbit (MAN 3 / PAY 3)**
  - Orbit to identify objects
  - Left and right directions
  - X and 2X altitudes
  - 20 tasks in 4 laps

- **Spiral (MAN 4 / PAY 4)**
  - Free flight to inspect objects
  - Any proximity (use zooms)
  - Any altitude
  - 20 tasks in 1 lap

- **Sustain Speed / Deliver Accurately (MAN 5 / PAY 5)**
  - Max speed following a line
  - 5X distance
  - X altitude
  - 20X distance per lap
## Circuit Training with Scores

Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)

### Position
**MAN 1 / PAY 1**
- Hover position stability
- Basic maneuvers
- Landing accuracy
- 20 tasks in 1 lap

### Traverse
**MAN 2 / PAY 2**
- Sideways along a line
- Left and right directions
- Landing accuracy
- 20 tasks in 2 laps

### Orbit
**MAN 3 / PAY 3**
- Orbit to identify objects
- Left and right directions
- X and 2X altitudes
- 20 tasks in 4 laps

### Spiral
**MAN 4 / PAY 4**
- Free flight to inspect objects
- Any proximity (use zooms)
- Any altitude
- 20 tasks in 1 lap

### Sustain Speed / Deliver Accurately
**MAN 5 / PAY 5**
- Max speed following a line
- 5X distance
- X altitude
- 20X distance per lap

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

### MAN 1-5
**PAY 1-5**

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

### Payoff Grid

<table>
<thead>
<tr>
<th>Position (MAN 1 / PAY 1)</th>
<th>Traverse (MAN 2 / PAY 2)</th>
<th>Orbit (MAN 3 / PAY 3)</th>
<th>Spiral (MAN 4 / PAY 4)</th>
<th>Sustain Speed / Deliver Accurately (MAN 5 / PAY 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAN:</strong> Align only</td>
<td><strong>MAN:</strong> Align only</td>
<td><strong>MAN:</strong> Align only</td>
<td><strong>MAN:</strong> Align only</td>
<td><strong>MAN:</strong> Follow the flight paths</td>
</tr>
<tr>
<td>20 points max</td>
<td>20 points max</td>
<td>20 points max</td>
<td>20 points max</td>
<td>20 points max</td>
</tr>
<tr>
<td><strong>PAY:</strong> Align and Identify</td>
<td><strong>PAY:</strong> Align and Identify</td>
<td><strong>PAY:</strong> Align and Identify</td>
<td><strong>PAY:</strong> Align and Identify</td>
<td><strong>PAY:</strong> Deliver accurately</td>
</tr>
<tr>
<td>100 points max</td>
<td>100 points max</td>
<td>100 points max</td>
<td>100 points max</td>
<td>100 points max</td>
</tr>
</tbody>
</table>

20 points per test

100 points total

100 points per test

500 points total
Training and Embedding into Scenarios
Maneuvering (MAN 1) and Payload Functionality (PAY 1)
Using Standard Test Methods
Safety | Capabilities | Proficiency

**Elemental Testing**
- Repeat to measure *individual capabilities*.
- Identify and fix weaknesses.
- Practice and evaluate task proficiency with quantitative scores in timed trials.

**Combine and Sequence**
- Repeat to measure *system trade-offs*.
- Increase complexity in stepwise ways.
- Practice and evaluate mission proficiency with quantitative scores in timed trials.

**Embed into Scenarios**
- Repeat to measure *degradation and tempo*.
- Involve uncontrolled variables.
- Practice and evaluate operational readiness with quantitative scores in timed trials.
Concurrent Test Lanes
Training and Evaluation

Ceiling height determines maximum safe hover altitude (2X)

Canadian Police College, London, Ontario, Canada
Headlamps wrapped around the buckets pointed inward!

Night Operations
Training and Evaluation

Position guidance for range to target using lighted buckets (red or white)

Inspect objects of interest using lighted buckets (red or white)

Identify objects lighted from the aircraft

Measure additional sensor capabilities

NIST and Reveille Peak Ranch, Burnet, TX
Thermal Targets
Training and Evaluation

NIST and Reveille Peak Ranch, Burnet, TX
## Embed 20 Targets into ANY Scenario

### Training and Evaluation

20 Visual/Color Acuity Targets x 5 Concentric Cs = 100 Points

Download the Bin Round Sticker File

[https://drive.google.com/file/d/15G1Nuarr1_vOdf_1gYgJellA8HuqI9ngT/view?usp=sharing](https://drive.google.com/file/d/15G1Nuarr1_vOdf_1gYgJellA8HuqI9ngT/view?usp=sharing)

### Target Locations

<table>
<thead>
<tr>
<th>#</th>
<th>Target Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ROOF STAND – ANGLED BUCKET Front of the vehicle</td>
</tr>
<tr>
<td>B</td>
<td>ROOF STAND – ANGLED BUCKET Driver side</td>
</tr>
<tr>
<td>C</td>
<td>ROOF STAND – ANGLED BUCKET Rear</td>
</tr>
<tr>
<td>D</td>
<td>ROOF STAND – ANGLED BUCKET Passenger side</td>
</tr>
<tr>
<td>E</td>
<td>FRONT License plate</td>
</tr>
<tr>
<td>F</td>
<td>FRONT Vehicle ID number</td>
</tr>
<tr>
<td>G</td>
<td>DRIVER SIDE Window profile of driver</td>
</tr>
<tr>
<td>H</td>
<td>DRIVER SIDE Other location of interest</td>
</tr>
<tr>
<td>I</td>
<td>DRIVER SIDE Other location of interest</td>
</tr>
<tr>
<td>J</td>
<td>DRIVER SIDE Other location of interest</td>
</tr>
<tr>
<td>K</td>
<td>REAR License plate</td>
</tr>
<tr>
<td>L</td>
<td>REAR Other location of interest</td>
</tr>
<tr>
<td>M</td>
<td>PASSENGER SIDE Other location of interest</td>
</tr>
<tr>
<td>N</td>
<td>PASSENGER SIDE Other location of interest</td>
</tr>
<tr>
<td>O</td>
<td>PASSENGER SIDE Other location of interest</td>
</tr>
<tr>
<td>P</td>
<td>PASSENGER SIDE Window profile of passenger</td>
</tr>
<tr>
<td>Q</td>
<td>CAB INTERIOR Passenger headrest face view</td>
</tr>
<tr>
<td>R</td>
<td>CAB INTERIOR Passenger seat with object</td>
</tr>
<tr>
<td>S</td>
<td>CAB INTERIOR Driver seat with object</td>
</tr>
<tr>
<td>T</td>
<td>CAB INTERIOR Driver headrest face view</td>
</tr>
</tbody>
</table>

### Instructions

1. **Download the Bin Round Sticker File**
2. **Embed 20 Targets**
3. **Create any scenario**
4. **Train and evaluate**

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*Note: Examples of target locations are shown in the images.*
Establish hover directly over top and orbit to identify all buckets on the roof stand (#, A, B, C, D).

Determine if further inspection is warranted (could be 20 vehicles).

Spiral inspect all sides and interior.

Perch to identify underbody targets (and maintain view if necessary for ground robots coming down range).
Establish hover directly over top and orbit to identify all buckets on the roof stand (#, A, B, C, D).

Determine if further inspection is warranted (could be 20 vehicles).

Spiral inspect all sides and interior.

Perch to identity underbody targets (and maintain view if necessary for ground robots coming down range).
Fuel Truck / Rail Car Inspection
Training and Evaluation

Establish hover directly over top and orbit to identify all buckets on the roof stand (#, A, B, C, D).

Determine if further inspection is warranted (could be 20 vehicles).

Spiral inspect all sides and interior.

Perch to identify underbody targets (and maintain view if necessary for ground robots coming down range).
Wide Area Search
Training and Evaluation
Indoor Search
Training and Evaluation

Standard Disaster Response Robot Challenge and Plant Disaster Prevention Challenge, World Robot Summit, Japan
Roles for Standards Organizations and Others

Select standard tests that define readiness for mission tasks.

Set thresholds or adopt averages

Develop standard test methods and collect robot capability and reliability data with “expert” operators

Technical Improvement
Best-In-Class System with Expert Operators (Orange)

Conventional Systems with Expert Operator (Orange)

Example
Ground Robot Operator Proficiency Scores for Bomb Technicians in Standard Maneuvering and Dexterity Test Methods
100+ Trials Across USA and Canada (Tasks per Minute)

Military Average (Brown)
Civilian Average (Blue)

Top 6 of the top 10 responder operators using the best-in-class system (Ease of Use Indicator)
Supporting NFPA 2400 Job Performance Requirements
Safety | Capabilities | Proficiency

Chapter 5 excerpts:
• “Perform aerial maneuvers.... so that the pilot demonstrates positive aircraft control....”

• “Perform payload functionality... so that the sUAS is maneuvered in a manner that avoids obstacles and demonstrates payload drop, payload application, or data acquisition at targeted locations...”

Appendix A:

**Maneuvering Test Methods**
- Maintain Position and Rotate
- Fly Straight and Level
- Move and Rotate
- Avoid Obstacles
- Land Accurately

**Payload Functionality Test Methods**
- Point and Zoom Cameras
- Identify Objects
- Inspect Objects
- Map Wide Areas
- Drop Accurately
Supporting ASTM F38 Practical Skills Requirement
Safety | Capabilities | Proficiency


Qualitative Task Performance Levels:

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.

Quantitative Thresholds
(Examples, You May Set Your Own)

Scores captured in standard tests.

Benefits

Relative to the “expert” provided by the manufacturer (or best score of all).

Same description applies, but thresholds can be chosen based on measured data.

Provides clear thresholds for self-evaluation.
APPARATUS

FABRICATION
The advantage of this bucket leveling stand design is that they can be used WITHOUT THE OUTRIGGERS (shown here as either 2x2s or 2x4s) on flat surfaces indoors and in parking lots. The outriggers allow some leveling capacity in grass or elsewhere. This is best done by resting the center post on a block of wood. This lifts all four legs off the ground at the same time so the center post can be leaned to vertical in any direction while all four legs pivot on one screw to touch the ground before being secured with a second screw. The block can remain there or be removed.
Short Bucket Leveling Stand Fabrication
Optional Hinges for Stowing/Transportation
Tall Bucket Leveling Stand Fabrication
Three Piece Assembly for Stowing/Transportation

Online Apparatus Set Up Videos

NIST-ASTM-NFPA 2400 Test Methods for sUAS: Deploying a 2ft Bucket Leveling Stand for Flat Terrain. 
https://vimeo.com/325054438

NIST-ASTM-NFPA 2400 Test Methods for sUAS: Stowing a 2ft Bucket Leveling Stand for Flat Terrain. 
https://vimeo.com/325052953

NIST-ASTM-NFPA 2400 Test Methods for sUAS: Deploying a 4ft Bucket Leveling Stand for Uneven Terrain. 
https://vimeo.com/320053684

NIST-ASTM-NFPA 2400 Test Methods for sUAS: Deploying a 10ft Spiral Inspect Post (stowable/transportable in three pieces). 
https://vimeo.com/327968250

Tall Bucket Leveling Stand Fabrication
Three Piece Assembly for Stowing/Transportation

Online Apparatus Set Up Videos

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Maneuvering (MAN 1-5) and Payload Functionality (PAY 1-5)
Comprehensive Flight Paths in a Single Lane

- Position (MAN 1 / PAY 1)
- Traverse (MAN 2 / PAY 2)
- Orbit (MAN 3 / PAY 3)
- Spiral (MAN 4 / PAY 4)
- Sustain Speed / Deliver Accurately (MAN 5 / PAY 5)
Test Method Procedures and Flight Paths
Maneuvering (MAN 1) and Payload Functionality (PAY 1)

WATCH THE VIDEO VERSION WITH TEST METHOD FLY THROUGHS
https://vimeo.com/354145833