Are Your Data Reliable?
Thinking Creatively to Develop Quality Control Checks

Craig J. Palmer, Ph.D.
QA Specialist, GDIT

Brick M. Fevold
Research Scientist Advisor, GDIT

Adam Bucher¹, Molly M. Amos¹, Louis Blume²

¹ GDIT, Alexandria, Virginia
² U.S. Environmental Protection Agency, Chicago, IL

Disclaimer: The views expressed in this presentation are those of the author(s) and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.
Great Lakes Restoration Initiative

- Initiated in 2010
- 16 federal agencies
- $2.56 billion FY 2010-2017
- Five focus areas
  1. Toxic Substances and Areas of Concern
  2. Invasive Species
  3. Nonpoint Source Pollution Impacts on Nearshore Health
  4. Habitats and Species
  5. Foundations for Future Restoration Actions
Interagency Ecological Restoration Quality Committee

Guidance Document

Chapter 5:
Quality Control During Field Activities
Quality Control

Field ‘measurements’ require different QC approaches...

... than those used in the laboratory.
Observer-Determined Measurements

Definition:
Measurements determined using human judgment, interpretation or observation reliant on senses (visual, auditory, tactile, olfactory)

Examples:
- species identifications and gender
- counts and abundance
- condition classes
- cover (e.g., % or class)
- weather (e.g., beaufort scale)
- interpretation of analog instruments (e.g., densitometer, Secchi disk)
Quality Assurance and Quality Control

<table>
<thead>
<tr>
<th>Quality Assurance</th>
<th>Quality Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Process oriented</td>
<td>• Product oriented</td>
</tr>
<tr>
<td>• Focuses on preventing deviations from project objectives and requirements (proactive)</td>
<td>• Focuses on identifying deviations from project objectives and requirements (reactive)</td>
</tr>
</tbody>
</table>
Quality Assurance and Quality Control

**QA Examples**

- Identifying training, certifications, equipment, etc. that are needed to ensure the data collected will support project objectives
- Identifying recommendations for improving process controls and criteria based on results of process audits and analysis of data quality

**QC Examples**

- Reviewing field and laboratory records to verify that data reflect the required locations, procedures, calculations and frequencies
- Verifying that staff have the required experience and training, as well as access to necessary information and equipment before allowing them to collect data
The Goal of QA/QC is...

“to ensure that all research data collected, synthesized, and utilized ... are scientifically sound, of known quality and thoroughly documented.”

Project Lifecycle with Key QA Components

**Plan**
- Project Goals & Objectives
  - Sampling Objectives
- Data Quality Indicators
- Acceptance Criteria

**Prepare**
- Standard Operating Procedures (SOPs)
- Training and Certification

**Collect**
- Quality Control Checks
  - (hot, precision, cold, blind, calibration)

**Review**
- Data Verification
- Data Validation

**Evaluate**
- Data Quality & Usability
- Corrective Actions
Goal of Conducting Quality Control

1. Determine if data are being collected according to SOPs
2. Evaluate if whether data quality meets acceptance criteria
3. Ensure data collection is complete
4. Identify opportunities for improving data quality
5. Document data quality assessment
Quality Control

Challenges posed by observational measurements

Examples:
- species identifications
- individual counts
- condition classes
- cover classes
- gender determination
- reproductive status
- color, texture, etc.
Error in Environmental Monitoring

Total Study Error (Total Variability)

Sampling Error (Sampling Variability)
- Inherent
- Sampling Design

Measurement/Observation Error (Measurement Variability)
- Sample/Data Collection
- Sample Handling
- Sample Analysis

project planning

project implementation
Precision, Bias, and Accuracy

- **Low Precision**
  - High (+) Bias
  - Low Accuracy

- **High Precision**
  - High (-) Bias
  - Low Accuracy (for replicates)

- **Low Precision**
  - No Bias
  - Low Accuracy

- **High Precision**
  - No Bias
  - High Accuracy

Stem Density

**true value**

**mean**

Crew 1: Replicates
Crew 2: Replicates
Crew 3: Replicates
Crew 4: Replicates
1. What can we do to minimize measurement error and improve the reliability of project data?

2. And, in particular, data produced from judgement-based evaluation?
   - Visual and auditory assessment (e.g., bird survey)
   - Counts, color, texture, odor
Quality Control Planning

Begins at Office
Conducted in Field
And at Office

Data Recorded on Hardcopy or Electronic Data Form → Sample Documented and Handled Following Protocol → Data Recorded From/By Calibrated Electronic Instrument

Recorded Data Reviewed by Crew Leader for Legibility, Accuracy and Completeness Prior to Departing Sample Unit Location → Lab QA Manager Review

Crew Leader Submits Data Package* to QA Manager (collected samples are shipped to laboratory for analysis)

Data Package Returned to Crew Leader for Corrections

Data Package Reviewed by QA Manager for Legibility, Accuracy and Completeness

Electronic Data Transferred from Device → Hardcopy Data Transcribed Into Electronic Format → Single- or Double-Entry Reconciliation → Electronic Data Records Reviewed by QA Manager for Accuracy, Consistency and Completeness (DOCUMENT REVIEW OUTCOMES IN METADATA)

Electronic Data Records Submitted for Database Integration and Additional QA/QC Data Review for Data Quality Documentation and Certification
Crew Training and Certification

• Develop training/certification program
  – SOP implementation & data form completion
  – Taxonomic identification (keys, photos, audio recordings)
  – List of ‘expected’ and ‘possible’ species
  – List of cryptic and similar-appearing or sounding species
  – Instrument use and calibration protocols
  – Interpretation of environmental conditions required for sampling
  – Management of raw data and physical samples

➢ Classroom (or Lab) and ‘On-line’ Training

➢ Field Training!!

McCune et al. (1997)
Trained crew member assigned to lichen collection replaced by untrained person. Measurement error was inflated and impaired the data analyst’s ability to detect significant differences between plots. Bryologist 100: 40-46.
Precision, Bias, and Accuracy

- Low Precision
  - High (+) Bias
  - Low Accuracy
- High Precision
  - High (-) Bias
  - Low Accuracy
  (for replicates)
- Low Precision
  - No Bias
  - Low Accuracy
- High Precision
  - No Bias
  - High Accuracy

True Value = best estimate ± 2

Compliance Rate

- CREW 1: 21%
- CREW 2: 0%
- CREW 3: 41%
- CREW 4: 100%

Replicates
Data Quality Assessment

- True Value = Best Estimate ± Uncertainty
- Specific approaches for estimating uncertainty for different measurement types:
  - Field samples – Duplicate/matrix spike/blank samples
  - Field instruments – Calibration standards, duplicate measurements
  - Field observer-determined?
Data Quality Assessment

• Re-measurements:
  ▫ Within crews
  ▫ Between crews
  ▫ Expert crews or QA crews

• Where:
  ▫ Training plots
  ▫ Routine plots
  ▫ Calibration plots

➢ *Transitory vs. Stable Variables*
Quality Control Checks (QC Checks)

Approaches to assess precision, bias, and accuracy

<table>
<thead>
<tr>
<th>Laboratory (inorganic/organic)</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Measurements</td>
<td>Measurements &amp; Observations</td>
</tr>
<tr>
<td>Lab duplicates, field duplicates, procedural blanks, matrix spikes, standard reference materials</td>
<td>Hot-checks, cold-checks, blind-checks, precision-checks, and calibration-checks</td>
</tr>
</tbody>
</table>
Five Kinds of QC Checks

1. **Calibration-Check** – routine crew conduct one or more measurements against a ‘true’ or ‘accepted’ value determined by QA crew

2. **Precision-Check** – routine crew re-measure plots previously measured by the same or a different routine crew

3. **Hot-Check** – QA crew (or expert) shadows routine crew during plot measurements

4. **Cold-Check** – QA crew re-measure plots previously measured by a routine data collection crew

5. **Blind-Check** – QA crew (or different routine crew) re-measure plots without knowledge of results from the prior crew assessment
# Routine Crew vs. QA Crew

<table>
<thead>
<tr>
<th>Routine Data Collection Crew</th>
<th>QA Crew (expert)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Data Collection Staff</td>
<td>Designated Experts</td>
</tr>
<tr>
<td>Regular or seasonal staff trained to conduct ‘routine’ data collection activities (primary data)</td>
<td>Trained in QA/QC procedures Considered ‘Expert’ in conducting measurements and implementing SOPs</td>
</tr>
<tr>
<td>Analogous to an instrument requiring ‘calibration’</td>
<td>May provide SOP training and certification to routine crews</td>
</tr>
<tr>
<td>Considered vested in the project outcome</td>
<td>May or may not be vested in the project outcome</td>
</tr>
</tbody>
</table>
# QC Field Check – Summary Matrix

<table>
<thead>
<tr>
<th>QC Field Check</th>
<th>Conducted by:</th>
<th>Can Assess:</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration Check</td>
<td>Routine Crew</td>
<td>✔ ✔ ✔</td>
<td>Provide Training &amp; Recalibration</td>
</tr>
<tr>
<td>Precision Check</td>
<td></td>
<td>✔ ✔ ✔</td>
<td>Assess Repeatability</td>
</tr>
<tr>
<td>Hot Check</td>
<td>QA Crew or Expert</td>
<td>✔ ✔ ✔</td>
<td>Provide Real-time Feedback</td>
</tr>
<tr>
<td>Cold Check</td>
<td></td>
<td>✔ ✔ ✔</td>
<td>Produce Empirical QC Data</td>
</tr>
<tr>
<td>Blind Check</td>
<td></td>
<td>✔ ✔ ✔</td>
<td>Produce Empirical QC Data (Unbiased)</td>
</tr>
</tbody>
</table>
Questions?
Vegetation Quadrat Sampling

Cover Classes
1 = less than 1% cover
2 = 1-5% cover
3 = 5-25% cover
4 = 25-50% cover
5 = 50-75% cover
6 = >75% cover

1-m² Quadrat

Cover Classes
0% - 100% (1% increments)
Exercise 1: Calibration Checks (training)

Measurement or observation conducted by a routine crew on one or more variables with a known (true or accepted) value as determined by a QA crew or expert.

<table>
<thead>
<tr>
<th>Calibration-Check Purpose:</th>
<th>Outcome:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Provide simple approach to maintain measurement accuracy and precision</td>
<td>• Improved accuracy and data quality</td>
</tr>
<tr>
<td>• To ‘re-calibrate’ (re-train) routine crews</td>
<td>• Empirical data to re-evaluate acceptance criteria</td>
</tr>
</tbody>
</table>

Data Quality Indicator(s) Addressed:

• Precision, Bias, and Accuracy

➢ comparability, representativeness, sensitivity (detectability), and completeness
Calibration Checks (Training)

Data Quality Acceptance Criteria:
Measurement Error Tolerance = ± 3%
Frequency of Compliance = 80%

1-m² Quadrat  1 cell = 5% cover

Data Recording Form

<table>
<thead>
<tr>
<th>Obs</th>
<th>Class</th>
<th>Solid %</th>
<th>Checked %</th>
<th>True %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hexagon</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Circle</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Triangle</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Square</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>W Space</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5</td>
<td><strong>100</strong></td>
<td></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Standard Operating Procedure

1. Compare checked shapes to solid shapes to calibrate assessment of % cover
2. Determine ‘Checked %’ value for each Class starting with Obs 1 (calculate Obs 5)
3. Record on form in integer values
4. Total must = 100 %
**Calibration Checks** (Certification)

1-m² Quadrat 1 cell = 5% cover

Data Recording Form

<table>
<thead>
<tr>
<th>Obs</th>
<th>Class</th>
<th>Crew %</th>
<th>True %</th>
<th>Diff Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hexagon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Circle</td>
<td></td>
<td></td>
<td>Values Masked</td>
</tr>
<tr>
<td>3</td>
<td>Triangle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Square</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>W Space</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Data Quality Acceptance Criteria:**
Measurement Error Tolerance = ± 3%
Frequency of Compliance = 80%

**Standard Operating Procedure**
1. Determine % cover for each class starting with Obs 1 (calculate Obs 5)
2. Record on form in integer values
3. Adjust estimates of Obs 1-5 using best professional judgement so total = 100%
4. Use calibration tool to aid assessment
Calibration Checks

**Logistical Considerations:**

- **Site Selection:**
  Calibration checks should be conducted in locations independent of the project sampling design, and can include staged and natural settings.

- **Timing:**
  Incorporate calibration checks systematically across the sampling period and at times representative of effects due to circadian and seasonal patterns. Calibration checks conducted at end of sampling period can be used to document that field crews have maintained their quality standards in data collection.

- **Crew Management:**
  Calibration measurements conducted by one routine field crew should not be witnessed by a different crew.

- **Data Management:**
  Each crew’s dataset (or set of measurements) represents a QC sample used solely for evaluating crew performance against pre-established quality objectives.
### Exercise 2: Precision Checks

Repeated measurement or observation conducted by the same (within) or different (between) routine crew on a previously measured plot or set of variables.

<table>
<thead>
<tr>
<th>Precision-Check Purpose:</th>
<th>Outcome:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Provide simple approach to assess measurement precision (repeatability)</td>
<td>• Quantify measurement precision within- and between- routine crews</td>
</tr>
<tr>
<td>• Evaluate whether data collected meet specified acceptance criteria for precision</td>
<td></td>
</tr>
</tbody>
</table>

#### Data Quality Indicator(s) Addressed:

- Precision
  - comparability, representativeness, sensitivity (detectability), and completeness
1-m² Quadrat  1 cell = 5% cover

<table>
<thead>
<tr>
<th>Obs</th>
<th>Class</th>
<th>Cr-A %</th>
<th>Cr-B %</th>
<th>Diff Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hexagon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Circle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Triangle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Square</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>W Space</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Data Quality Acceptance Criteria:**
Measurement Error Tolerance = ± 3%
Frequency of Compliance = 80%

**Standard Operating Procedure** (for each crew)
1. Determine % cover for each class starting with Obs 1 (calculate Obs 5)
2. Record on form in integer values
3. Adjust estimates of Obs 1-5 using best professional judgement so total = 100%
4. Use calibration tool to aid assessment

**Precision Checks**
Logistical Considerations:

- **Site Selection:**
  
  Use random selection methods to select sampling units so they can be considered representative of typical conditions within and across all treatments (or sites).

- **Timing:**
  
  Dates and times need to be coordinated to ensure that crews collect re-measurement data under similar conditions and that are representative of phenological change.

- **Crew Management:**
  
  For between-crew assessments, data collection efforts conducted by the routine field crew should not be witnessed by the crew conducting the precision check.

- **Data Management:**
  
  The first crew’s dataset should be treated as the routine sample in the process of data compilation. The second crew’s dataset represents a QC sample used solely for evaluating crew performance against pre-established quality objectives.
Exercise 3: Hot Checks

QA crew (or expert) shadows, in real-time, the performance of a routine crew during plot measurements.

<table>
<thead>
<tr>
<th>Hot-Check Purpose:</th>
<th>Outcome:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Identify and correct improper measurements and observations in real time</td>
<td>• Improved data quality</td>
</tr>
<tr>
<td>• Clarify SOPs, data form completion, and technical implementation</td>
<td>• Improved consistency in implementing SOP</td>
</tr>
</tbody>
</table>

**Data Quality Indicator(s) Addressed:**

• Precision, Bias, and Accuracy

➢ comparability, representativeness, sensitivity (detectability), and completeness
Hot Checks

1-m² Quadrat  1 cell = 5% cover

Data Recording Form

<table>
<thead>
<tr>
<th>Obs</th>
<th>Class</th>
<th>Crew %</th>
<th>QA Exp %</th>
<th>Diff Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hexagon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Circle</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Triangle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Square</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>W Space</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard Operating Procedure
1. Determine % cover for each class starting with Obs 1 (calculate Obs 5)
2. Record on form in integer values
3. Adjust estimates of Obs 1-5 using best professional judgement so total = 100%
4. Use calibration tool to aid assessment

Data Quality Acceptance Criteria:
Measurement Error Tolerance = ± 3%
Frequency of Compliance = 80%
Hot Checks

Logistical Considerations:

- **Site Selection:**
  Select sites considered both representative of typical conditions and that can accommodate additional staff with minimal site impacts. Can be conducted at sites used for calibration checks.

- **Timing:**
  Conduct hot checks systematically throughout the project sampling period. (For example, early, mid, and late or monthly)

- **Crew Management:**
  Prioritize inexperienced or problematic crews, newly certified crew members, or individuals who experienced problems during field training.

- **Data Management:**
  Data collected by crew under assessment can be considered as routine sample or as QC sample pending objectives. Data should be corrected onsite as issues are identified, and related problems should be documented and later evaluated to determine the cause.
Exercise 4: Cold Checks and Blind Checks

QA crew re-measure plots with (Cold Check) or without (Blind Check) prior knowledge of results from the prior crew assessment.

<table>
<thead>
<tr>
<th>Cold-Check Purpose:</th>
<th>Outcome:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Develop empirical data to assess crew measurement accuracy</td>
<td>• Document data quality</td>
</tr>
<tr>
<td>• Provide objective assessment on the usability of routine crew results</td>
<td>• Identify needs for corrective actions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blind-Check Purpose:</th>
<th>Outcome:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Provide ‘unbiased’ assessment of data quality – typically by ‘non-vested’ crew</td>
<td>• Unbiased assessment of data quality</td>
</tr>
<tr>
<td>• Provide objective assessment on the usability of routine crew results</td>
<td></td>
</tr>
</tbody>
</table>

Data Quality Indicator(s) Addressed:

• Precision, Bias, and Accuracy
  ➢ comparability, representativeness, sensitivity (detectability), and completeness
Cold Checks

1-m² Quadrat  1 cell = 5% cover

Data Recording Form

<table>
<thead>
<tr>
<th>Obs</th>
<th>Class</th>
<th>Crew %</th>
<th>Expert %</th>
<th>Diff Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hexagon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Circle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Triangle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Square</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>W Space</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard Operating Procedure
1. Determine % cover for each class starting with Obs 1 (calculate Obs 5)
2. Record on form in integer values
3. Adjust estimates of Obs 1-5 using best professional judgement so total = 100%
4. Use calibration tool to aid assessment

Data Quality Acceptance Criteria:
Measurement Error Tolerance = ± 3%
Frequency of Compliance = 80%
Cold Checks and Blind Checks

Logistical Considerations:

- **Site Selection:**
  Use random selection methods to select sampling units so they can be considered representative of typical conditions within and across all treatments (or sites).

- **Timing:**
  Dates and times need to be coordinated to ensure that crews collect re-measurement data under similar conditions and that are representative of phenological change.

- **Crew Management:**
  Performed by a QA crew or expert. Data collection efforts should take place soon after the routine sampling has been completed.

- **Data Management.**
  QA crew dataset represents a QC sample used solely for evaluating crew performance (data quality for blind checks) against pre-established quality objectives. For independence, the QA crew should remain ‘blind’ to routine sample results until the completion of their re-sampling effort.
Amphibian Point Count Sampling

Observer must determine distance (bag #) the call is coming from
Before - Calibration

Observer must determine distance (bag #) the call is coming from

<table>
<thead>
<tr>
<th>Observer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Before Calibration</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew Estimate of Distance (bag #)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True Distance (bag #)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference: Crew - True Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine Crew Error Tolerance</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td></td>
</tr>
<tr>
<td>Routine Crew Compliance Rate</td>
<td>Error Tolerance = ± 1 Compl Rate ≥ 65 %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>

TRIAL - A

Speaker
Before - Calibration

Observer must determine distance (bag #) the call is coming from

Observer

1 2 3 4 5

Speaker

Distance (bag #)

Before Calibration

<table>
<thead>
<tr>
<th></th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew Estimate of Distance (bag #)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True Distance (bag #)</td>
<td>5</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference: Crew - True Distance</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>Routine Crew Error Tolerance</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>Routine Crew Compliance Rate</td>
<td>Error Tolerance = ± 1 Compl Rate ≥ 65 %</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
</tbody>
</table>
### Before Calibration

**Trial - C**

Observer must determine distance (bag #) the call is coming from

<table>
<thead>
<tr>
<th>Observer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (bag #)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Trial</strong></td>
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<td>Trial B</td>
</tr>
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<td><strong>Crew Estimate of Distance (bag #)</strong></td>
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</table>

**Speaker**

TRIAL - C

*Observer must determine distance (bag #) the call is coming from.*
### After - Calibration

**TRIAL - A**

Observer must determine distance (bag #) the call is coming from

**Speaker (2)**

1. **Distance (bag #)**

---

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## QC Field Check – Summary Matrix

<table>
<thead>
<tr>
<th>QC Field Check</th>
<th>Conducted by:</th>
<th>Can Assess:</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Precision</td>
<td>Bias</td>
</tr>
<tr>
<td>Calibration Check</td>
<td>Routine Crew</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Precision Check</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Hot Check</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cold Check</td>
<td>QA Crew or Expert</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Blind Check</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
We Conduct QC Checks to...

- Evaluate and document whether measurements meet specified acceptance criteria
- Collect empirical data to evaluate measurement precision, bias, and accuracy
- Provide information on data quality to make real-time corrective actions
- Serve as training and recalibration tools
- Improve SOPs
- IMPROVE DATA RELIABILITY!
Thank You!
Final Questions?

Craig J. Palmer – Craig.J.Palmer@gdit.com

Brick M. Fevold – Brick.Fevold@gdit.com