




Section: Case Study

Topic: Background

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| Enabling Objective | Demonstrate the ability to apply an MSA to a case study example |
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| Storyboard#: 02010200 | | Building Block #: BB 50 GraphicLFT TextRT | |
| Back/Previous Page: 01060800 | Next Page: 02010400 | Page Number: 1 | |
| Screen Title: Background | | | |
|  | | <p>Have you ever stepped on an airplane and wondered how “accurate” the plane’s navigation system is? Probably not, because we all assume (and hope!) it is accurate.</p> <p>Although pilots have multiple ways to check their aviation gages (altimeters), the airline industry and regulatory agencies hold airplane gage manufacturers to very high standards.</p> <p>Click Next to continue.</p> | |
| Programming Notes: N/A | | Graphic/Media Notes: Filename: mbb_02010200 Alt text = women on airplane //Size: 280x280 Default ext = gif <input checked="" type="checkbox"/> Use image: 020724_1624_0011_dacs (AbleStock) <input type="checkbox"/> Create new or modify image: Description: | |
| <End-> | | | |

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| Storyboard#: 02010400 | | Building Block #: BB 50 TextLFT GraphicRT | |
| Back/Previous Page: 02010200 | Next Page: 02010600 | Page Number: 2 | |
| Screen Title: Background (continued) | | | |
| <p>Typical vertical separation between planes is 1000 ft. When the altimeter (height gage) reads 2000 feet, the pilot assumes he is really at 2000 feet. Imagine the consequences if the plane was actually at 1000 feet—especially if there were other airplanes in the area!</p> <p>Can a pilot safely assume his altimeter is reliable? Yes, he can and here's why: Before the plane's first flight using that altimeter, a team of Black Belts (BBs) at the manufacturing plant performed an MSA to ensure the altimeter and its method of use were acceptable.</p> <p>Click Next to continue.</p> | |  | |
| Programming Notes: | | Graphic/Media Notes: | |
| N/A | | Filename: mbb_02010400 Alt text = cockpit of airplane //Size: 280x280 Default ext = gif <input checked="" type="checkbox"/> Use image: 616016 <input type="checkbox"/> Create new or modify image: Description: | |
| <End-> | | | |

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| Storyboard#: 02010600 | | Building Block #: BB 50 GraphicLFT TextRT | |
| Back/Previous Page: 02010400 | Next Page: 02020200 | Page Number: 3 | |
| Screen Title: Background (continued) | | | |
|  | | <p>When the BB team set up the study, they decided to test the altimeter at altitudes ranging from 2000 vertical feet to 2400 vertical feet. The team also knew that altimeters discriminate or indicate altitude in 20-foot intervals. The team hoped to find no more than a 100-foot variation in either direction, up or down.</p> <p>Because many measurements needed to be taken and the cost of multiple flights would be prohibitive, the team chose to use a flight simulator with the same altimeter as the plane to conduct the MSA. The pilot and co-pilot, in turn, sat in the cockpit in front of a simulated instrument panel. When a radio signal sounded, each of the operators read the altimeter just as they would in a real cockpit and recorded the altimeter reading on a separate form.</p> <p>Click Next to continue.</p> | |
| <p>Programming Notes:</p> <p>operators should be a small popup window with this text:</p> <p>“Operator is the term used for the person who is measuring or collecting the data. This person may or may not be the operator of the process.”</p> | | <p>Graphic/Media Notes:</p> <p>Filename: mbb_02010600</p> <p>Alt text = altimeter</p> <p>//Size: 280x280 Default ext = gif</p> <p><input checked="" type="checkbox"/> Use image: altimeter.jpg</p> <p><input type="checkbox"/> Create new or modify image:</p> <p>Description: Taken and provided by instructional designer</p> | |
| <-End-> | | | |

Topic: Sources of Variation

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| Enabling Objective | Demonstrate the ability to apply an MSA to a case study example |
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| Storyboard#: 02020200 | | Building Block #: BB 30A > Sequence It | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|---|--|---------------------------|-----------|-----------|-------|--------|-----------|-------|----------|--|--|---------------------|--|--|---|---|--|-----------------|---|--|--|---|--|----------|---|--|---|---|--|---------------------------|---|--|---|---|--|-----------|---|--|--|---|--|-----------|---|--|
| Back/Previous Page: 02010600 | | Next Page: 02030200 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Page Number: 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Screen Title: Knowledge Check | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>For the first phase of the MSA, the BB team needed to think about the possible sources of variation. The team considered the types of questions it might ask about each possible source of variation before designing the study. Based on what you know about the sources of variation, match the question with the type of variation it addresses.</p> <p>Drag each question to the source of variation that it best represents. When you've arranged all the questions, click Submit.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Programming Notes:</p> <pre>//Correct answers noted in table //text of positive feedback pos_fb = "Great job. All your answers are correct." //text of first negative feedback neg_fb1 = "Please try again. Hint: You might refer to the glossary for help." //text of partially correct feedback p_neg_fb1 = "Some, but not all, of your answers are correct. Try again. Hint: You might refer to the glossary for help and then try again." //text of second negative feedback neg_fb2 = "Incorrect. The right answers are shown here. Please review the terms in the glossary."</pre> | <p>Graphic/Media Notes:</p> <p>Interaction is created as a Flash object Size: 600x340 Default ext = swf Description: Information in table</p> <table border="1" style="width: 100%; border-collapse: collapse; background-color: #e0e0e0;"> <thead> <tr> <th style="width: 50%;">Items</th> <th style="width: 15%;">Initial #</th> <th style="width: 20%;">Order</th> <th style="width: 15%;">Labels</th> <th style="width: 10%;">Correct #</th> <th style="width: 10%;">Order</th> </tr> </thead> <tbody> <tr> <td>Question</td> <td></td> <td></td> <td>Source of Variation</td> <td></td> <td></td> </tr> <tr> <td>When the gage is at 1,500 feet, does it read 1,500 feet? We would need to test the gage against an altitude standard.</td> <td>1</td> <td></td> <td>Reproducibility</td> <td>4</td> <td></td> </tr> <tr> <td>Does the gage read as accurately at 1,000 feet as it does at 5,000 feet?</td> <td>2</td> <td></td> <td>Accuracy</td> <td>1</td> <td></td> </tr> <tr> <td>Over time, if we measure the same altitude, would the gage read 1,500 feet each time?</td> <td>3</td> <td></td> <td>Precision (Repeatability)</td> <td>5</td> <td></td> </tr> <tr> <td>If both the pilot and co-pilot are reading the gage, do they get the same result?</td> <td>4</td> <td></td> <td>Stability</td> <td>3</td> <td></td> </tr> <tr> <td>If one person, using the same gage, measures the same altitude repeatedly, does he or she get the same result each time?</td> <td>5</td> <td></td> <td>Linearity</td> <td>2</td> <td></td> </tr> </tbody> </table> | | | Items | Initial # | Order | Labels | Correct # | Order | Question | | | Source of Variation | | | When the gage is at 1,500 feet, does it read 1,500 feet? We would need to test the gage against an altitude standard. | 1 | | Reproducibility | 4 | | Does the gage read as accurately at 1,000 feet as it does at 5,000 feet? | 2 | | Accuracy | 1 | | Over time, if we measure the same altitude, would the gage read 1,500 feet each time? | 3 | | Precision (Repeatability) | 5 | | If both the pilot and co-pilot are reading the gage, do they get the same result? | 4 | | Stability | 3 | | If one person, using the same gage, measures the same altitude repeatedly, does he or she get the same result each time? | 5 | | Linearity | 2 | |
| Items | Initial # | Order | Labels | Correct # | Order | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Question | | | Source of Variation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| When the gage is at 1,500 feet, does it read 1,500 feet? We would need to test the gage against an altitude standard. | 1 | | Reproducibility | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Does the gage read as accurately at 1,000 feet as it does at 5,000 feet? | 2 | | Accuracy | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Over time, if we measure the same altitude, would the gage read 1,500 feet each time? | 3 | | Precision (Repeatability) | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| If both the pilot and co-pilot are reading the gage, do they get the same result? | 4 | | Stability | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| If one person, using the same gage, measures the same altitude repeatedly, does he or she get the same result each time? | 5 | | Linearity | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <-End-> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Topic: Terminology

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| Enabling Objective | Define the terms specification limits, target, and tolerance Explain the part tolerance plays in the evaluation of an MSA |
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| Storyboard#: 02030200 | | Building Block #: BB 50 TextLFT GraphicRT | |
| Back/Previous Page: 02020200 | Next Page: 02030400 | Page Number: 1 | |
| Screen Title: Terminology | | | |
| <p>Before we go any further, let's stop and define some of the basic terms used in MSA:</p> <ul style="list-style-type: none"> - Defect - Specification limits - Tolerance - Target value <p>Click Next to continue.</p> | | | |
| Programming Notes: | | Graphic/Media Notes: | |
| N/A | | <p>Filename: mbb_02030200</p> <p>Alt text = MBB David Spaulding speaking with colleague</p> <p>//Size: 280x280 Default ext = gif</p> <p><input checked="" type="checkbox"/> Use image:</p> <p><input type="checkbox"/> Create new or modify image:</p> <p>Description:</p> <p>Need image of Expert 1 with colleagues</p> | |
| <-End-> | | | |

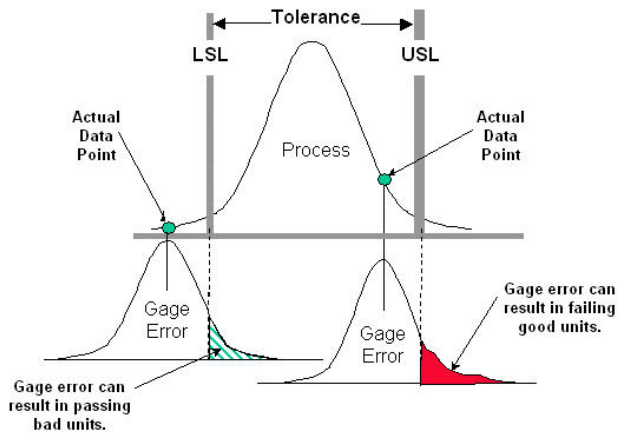
| | | | |
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| Storyboard#: 02030400 | | Building Block #: BB 50 GraphicLFT TextRT | |
| Back/Previous Page: 02030200 | Next Page: 02030600 | Page Number: 2 | |
| Screen Title: Defect | | | |
| Cannot find suitable picture that client likes | | A defect is an output that fails to meet specification and is unacceptable to the customer. Click Next to continue. | |
| Programming Notes: N/A | | Graphic/Media Notes: Filename: mbb_02030400 Alt text = //Size: 280x280 Default ext = gif <input checked="" type="checkbox"/> Use image: <input type="checkbox"/> Create new or modify image: Description: | |
| <-End-> | | | |

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| Storyboard#: 02030600 | | Building Block #: BB 50 TextLFT GraphicRT | |
| Back/Previous Page: 02030400 | Next Page: 02030800 | Page Number: 3 | |
| Screen Title: Specification Limits | | | |
| <p>Specification limits indicate how much deviation from the target value the customer is willing to accept or “tolerate” in the product or process.</p> <ul style="list-style-type: none"> - USL = Upper specification limit = The maximum the customer will accept. - LSL = Lower specification limit = The minimum the customer will accept. <p>You usually have one of three cases: 1) more is better, 2) less is better, or 3) a specific range is better. For example, suppose you are a professional athlete. You might:</p> <ul style="list-style-type: none"> - Need to maintain a certain weight or greater – For example, you must be more than 140 pounds without a maximum value (LSL=140). - Have a maximum weight to maintain – For example, you must be less than 160 pounds without a minimum value (USL=160). - Need to be within a particular range – For example, you must be between 140 and 160 pounds (LSL=140 and USL=160). | |  | |
| Click Next to continue. | | | |
| Programming Notes: | | Graphic/Media Notes: | |
| N/A | | <p>Filename: mbb_02030600</p> <p>Alt text = person on a scale</p> <p>//Size: 280x280 Default ext = gif</p> <p><u>X</u> Use image: 000801_0202_0010 or <u>0202h0010.jpg</u> (AbleStock)</p> <p>__ Create new or modify image:</p> <p>Description:</p> | |
| <-End-> | | | |

Storyboard#: 02030800 Building Block #: BB 50 GraphicLFT | TextRT

Back/Previous Page: 02030600 Next Page: 02031000 Page Number: 4

Screen Title: Tolerance



Tolerance is the total amount of variation that is acceptable in either direction from the target value. In other words, tolerance is the difference between the USL and the LSL.

Tolerance = USL – LSL

For example, if your target value is to get to work in 35 minutes +/- 5 minutes (or from 30 to 40 minutes), your tolerance is 10 minutes.

In the graph shown here, about 50% of tolerance is used up by variability in the measurement system itself. This leaves only 50% for the process variability! When you perform an MSA, you want the measurement system to use less than 10% of the tolerance.

Click Next to continue.

Programming Notes:

N/A

Graphic/Media Notes:

Filename: mbb_02030800

Alt text = tolerance diagram


//Size: 280x280 Default ext = gif


Use image: _____

Create new or modify image: tolerance.jpg

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| Storyboard#: 02031000 | | Building Block #: BB 50 GraphicLFT TextRT | |
| Back/Previous Page: 02030800 | Next Page: 02031200 | Page Number: 5 | |
| Screen Title: Target Value | | | |
|  | | <p>The target value is where we will “aim” our product/process. Given the variation in the process, where do we want the process to be centered and still produce non-defective units? The target value is the goal we hope to reach.</p> <p>Click Next to continue.</p> | |
| Programming Notes: N/A | | Graphic/Media Notes: Filename: mbb_02031000 Alt text = dart in board //Size: 280x280 Default ext = gif <u>X</u> Use image: 011218_1234_0023 (AbleStock) or 1234h0023 __ Create new or modify image: Description: | |
| <End> | | | |

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| Storyboard#: 02031200 | | Building Block #: BB 50 TextLFT GraphicRT | |
| Back/Previous Page: 02031000 | Next Page: 02031400 | Page Number: 6 | |
| Screen Title: Example | | | |
| <p>Consider this example: You run a pizza delivery business. Your goal is to deliver hot pizza to each customer's door. Your target value is 160 ° F, with an LSL of 150 ° F and a USL of 170 ° F. Any pizza whose temperature upon delivery is outside this range will be considered a defect. Therefore, your tolerance is 20 degrees (150 ° F–170 ° F).</p> <p>Let's say our goal is to reduce the variation in temperature in our pizza delivery process. In Measure Step 3, we would need to validate our measurement system prior to analyzing any data.</p> <p>Target value = 160 ° F LSL = 150 ° F USL = 170 ° F Defect = < 150 ° F or > 170 ° F Tolerance = 20 ° F</p> <p>Click Next to continue.</p> | |  | |
| Programming Notes: | | Graphic/Media Notes: | |
| | | Filename: mbb_02031200 Alt text = pizza //Size: 240x180 Default ext = jpg <input checked="" type="checkbox"/> Use image: 020522_1519_0032_lacs or 1519h0032 (AbleStock) <input type="checkbox"/> Create new or modify image: Description: | |
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| Storyboard#: 02031400 | | Building Block #: BB 55 > Single Multiple Choice | |
| Back/Previous Page: 02031200 | Next Page: 02040200 | Page Number: 7 | |
| Screen Title: Knowledge Check | | | |
| <p>Ideally, the mail on my street is supposed to be delivered at 1 p.m. give or take a half hour. What is my upper specification limit and what is the tolerance? Choose the correct answer, then click submit.</p> | | | |
| <input type="radio"/> | USL = 1:30 p.m. and tolerance = ½ hour | | |
| <input type="radio"/> | USL = 12:30 p.m. and tolerance = 1 hour | | |
| <input type="radio"/> | USL = 12:30 p.m. and tolerance = ½ hour | | |
| <input type="radio"/> | USL = 1:30 p.m. and tolerance = 1 hour | | |
| Programming Notes: | | Graphic/Media Notes: | |
| <pre>//correct answer, could be 1~4 Correct answer = "4" //text of positive pos_fb = "Correct. With an LSL of 12:30 and an USL of 1:30, the tolerance is 1 hour." //text of first negative feedback neg_fb1 = " Please try again. Hint: The LSL is 12:30. " //text of second negative feedback neg_fb2 = "Incorrect. Tolerance is the difference between the USL and the LSL, which in this case is the difference between 1:30 p.m. and 12:30 p.m., or one hour." //number of distracters (typically 4)</pre> | | N/A | |

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| question_number= 4; | |
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| <-End-> | |
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Topic: How To

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| Enabling Objective | List the five types of MSA tools and the distinguishing factors for each Choose the correct MSA tool type based on the type of data being used |
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| Storyboard#: 02040200 | Building Block #: BB 50 TextLFT GraphicRT |
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| Back/Previous Page: 02031400 | Next Page: 02040400 | Page Number: 1 |
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Screen Title: MSA Checklist

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| <p>Here at GE, we've developed a checklist to guide us through the MSA process. You can view and download the checklist in its entirety by clicking the following link.</p> <div style="background-color: #ffff00; padding: 10px; margin: 10px 0;">  Click MSA Checklist to download the MSA checklist. </div> <p>Click Next to continue.</p> | <div style="border: 1px solid black; padding: 10px;"> <p style="text-align: center;">MSA Checklist</p> <p>Questions to ask as you plan your MSA Study:</p> <ol style="list-style-type: none"> 1. What are you measuring? _____ 2. Who is measuring? _____ 3. Is there a measurement procedure used? How are you measuring (Standard Operating Procedure)? What standards apply? Are they used? _____ 4. If applicable, what does the gage supplier state is the device's: <ul style="list-style-type: none"> • Discrimination (Resolution)? _____ • Accuracy (Bias)? _____ • Precision (Measurement error)? _____ 5. Do you have results of a: <ul style="list-style-type: none"> • Test-Retest Study? _____ • Gage R&R Study? _____ 6. Is the resolution of your measurement system? Is it acceptable? _____ 7. What is the precision (measurement error) of the system? How was it determined? Is it acceptable? _____ 8. What is the accuracy (bias) of your measurement system? How has the accuracy been determined? Is it acceptable? _____ 9. Which of the following (if any) are you concerned about: <ul style="list-style-type: none"> • Reproducibility _____ • Accuracy _____ • Precision (Repeatability) _____ • Stability _____ • Linearity _____ 10. Are different measurement systems (gages, scales, etc.) used to gather the same data? Identify which data comes from which device. _____ </div> |
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| <p>Programming Notes:</p> <p>MSA Checklist = /resources/msa_checklist_blank.pdf</p> | <p>Graphic/Media Notes:</p> <p>Filename: mbb_02040200</p> <p>Alt text = MSA checklist</p> <p>//Size: 280x280 Default ext = gif</p> <p><u>X</u> Use image: msachecklist_blank.gif</p> |
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Description:

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| Storyboard#: 02040400 | | Building Block #: 56 Table Explore | |
| Back/Previous Page: 02040200 | Next Page: 02040600 | Page Number: 2 | |
| Screen Title: MSA Checklist Questions | | | |
| <p>Let's take a look at how the BB team working on the altimeter project filled in the first four questions on the MSA Checklist. Before we show it to you, see whether you know the answer to each question.</p> <p>Click each question to view its answer.</p> | | | |
| Question | | Answer | |
| 1. What are you measuring? | | We are measuring the altitude of a plane in flight. In this case, the part is the flight and the characteristic is the height. | |
| 2. Who is measuring? | | Pilot and co-pilot are taking and recording the measurements. | |
| 3. Is there a measurement procedure used? How are you measuring (Standard Operating Procedure)? What standards apply? Are they used? | | Once a signal sounds, the operators (pilot and co-pilot) simultaneously read the altimeter (analog gage) while sitting in the flight simulator. This measurement procedure is the exact same procedure used in-flight. There is a standard gage that is used to calibrate the altimeter. The altimeter has been calibrated prior to the study. | |
| 4. If applicable, what does the gage supplier state is the device's: <ul style="list-style-type: none"> - Discrimination (measurable increments)? - Accuracy? - Precision? | | Discrimination = 20 feet Accuracy = Not specified Precision = Not specified Note: Discrimination is also know as the 'scale of scrutiny.' It denotes the resolution of the gage; in other words, it is the smallest marking on the gage. | |
| Programming Notes: | | Graphic/Media Notes: | |
| " | | N/A | |
| <-End-> | | | |

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| Storyboard#: 02040600 | | Building Block #: BB 50 TextTOP GraphicBTM | |
| Back/Previous Page: 02040400 | Next Page: 02050200 | Page Number: 3 | |
| Screen Title: Partially Completed MSA Checklist | | | |
| <p>So here's what the first part of the MSA checklist looked like after the BB team filled it in.</p> <p>Click Next to continue.</p> <div style="border: 1px solid black; padding: 10px;"> <ol style="list-style-type: none"> 1. What are you measuring? Altitude of a plane in flight 2. Who is measuring? Pilot and co-pilot 3. Is there a measurement procedure used? How are you measuring (Standard Operating Procedure)? What standards apply? Are they used? Once a signal sounds, the operators (pilot and co-pilot) simultaneously read the altimeter (analog gage) while sitting in the flight simulator. This measurement procedure is the exact same procedure used in-flight. There is a standard gage that is used to calibrate the altimeter. The altimeter has been calibrated prior to the study. 4. If applicable, what does the gage supplier state is the device's: <ul style="list-style-type: none"> • Discrimination (Resolution)? 20 feet • Accuracy (Bias)? Not specified • Precision (Measurement error)? Not specified </div> | | | |
| Programming Notes: | | Graphic/Media Notes: | |
| | | Filename: mbb_02040600 Alt text = partially completed MSA Checklist //Size: 280x280 Default ext = gif <input type="checkbox"/> Use image: _____ <input checked="" type="checkbox"/> Create new or modify image: msachecklist_1-4.gif Description: | |

Topic: Output

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| Enabling Objective | List the five types of MSA tools and the distinguishing factors for each Choose the correct MSA tool type based on the type of data being used |
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| Storyboard#: 02050200 | | Building Block #: BB 15 Slideshow base | |
| Back/Previous Page: 02040600 | Next Page: 02050400 | Page Number: 1 | |
| Screen Title: Types of Studies | | | |
| <p>There are five types of MSA studies we use at GE. Click each slide link to view the slide show. Test/Retest Short Form ANOVA Attribute Destructive/Temporal</p> | | | |
| Programming Notes: Initial Slide = 02050210 Slide 1 = 02050215 Slide 2 = 02050225 Slide 3 = 02050235 Slide 4 = 02050245 Slide 5 = 02050255 | | Graphic/Media Notes: N/A | |
| <-End-> | | | |

Storyboard#: 02050210 **Building Block #: BB 15 > Slide**

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Destructive Gage R&R (Nested Design)
Each Operator Consumes Different (But Identical) Samples

Descriptive Statistics
Variable: Altitude

| Statistic | Value |
|------------------------------------|-------------------|
| Anderson-Darling Normality Test | 1.539 |
| P-Value | 0.000 |
| Mean | 1980.00 |
| SDStdev | 18.44 |
| Variance | 340.08 |
| Skewness | -7.3E-02 |
| Kurtosis | 0.193112 |
| N | 30 |
| Minimum | 1960.00 |
| 1st Quartile | 1980.00 |
| Median | 2000.00 |
| 3rd Quartile | 2000.00 |
| Maximum | 2040.00 |
| 95% Confidence Interval for Mu | 1981.11 - 2004.89 |
| 95% Confidence Interval for Sigma | 14.70 - 24.81 |
| 95% Confidence Interval for Median | 2000.00 - 2000.00 |

Programming Notes:
 //Initial layer displayed when page opens.

Graphic/Media Notes:
 Filename: mbb_02050210
 Alt text = collage of MSA study results
 //Size: 240x180 Default ext = jpg
 X Use image: msastudiescollage.gif
 __ Create new or modify image:
 Description:

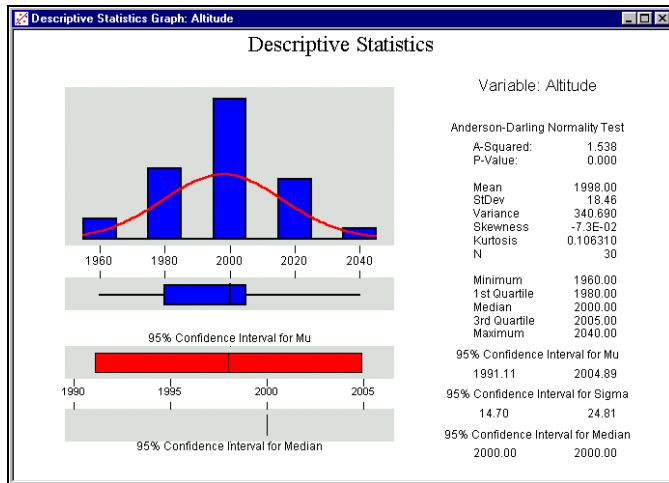
<-End->

Storyboard#: 02050215

Building Block #: BB 15 > Slide

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Test/Retest Study

This first step on your MSA journey (also called a calibration study) gives you a quick indication of your measurement system's reliability. If you measure a known standard unit, you can also look at accuracy. Obviously, if your measurement system fails here, there is no point in doing a more detailed study.

A Test/Retest study measures precision (repeatability) and accuracy. The study involves having the same operator repeatedly measure the same characteristics on the same unit under the same conditions. Performing 20 or more measurements is usually considered an adequate sample.

Programming Notes:

// Slide 1 shown when Slide 1 link is clicked

Graphic/Media Notes:

Filename: mbb_02050215

Alt text = results of Test/Retest study

//Size: 240x180 Default ext = jpg

__x__ Use image: __ Step5 desc statistics window.jpg

__ Create new or modify image:

Description: Test/Retest Step 5: Calculate Statistics image (Step5 desc statistics window.jpg)

<-End->

Storyboard#: 02050225 **Building Block #: BB 15 > Slide**

Back/Previous Page: # **Next Page: #**

| Part | Operator A | Operator B | Range (A-B) |
|------|------------|---------------|-------------|
| 1 | 1 | 4 | 2 |
| 2 | 2 | 3 | 1 |
| 3 | 3 | 6 | 7 |
| 4 | 4 | 5 | 7 |
| 5 | 5 | 9 | 8 |
| 6 | 6 | | |
| 7 | 7 | | |
| 8 | 8 | | |
| 9 | 9 | | |
| 10 | 10 | | |
| 11 | | | |
| 12 | | | |
| 13 | | Sum of Ranges | 7 |
| 14 | | Average Range | 1.4 |
| 15 | | | |
| 16 | | | |
| 17 | | | |

Short Form Analysis

A Short Form Analysis is used when you cannot have the same person independently measure the same part repeatedly, but you can have a second person measure the same part. Short Form evaluates reproducibility only.

In some cases, if you have limited time, money, parts and/or resources, you may be “forced” to conduct only a Short Form Analysis, even though you do meet the conditions for running a full ANOVA Gage R&R Study (discussed next).

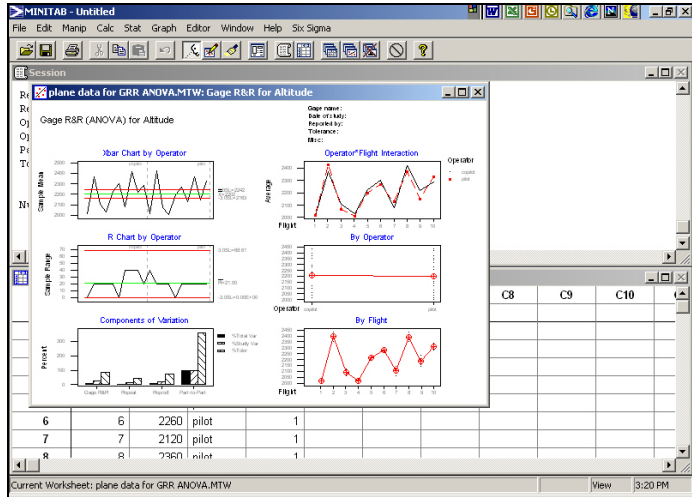
Programming Notes:
 // Slide 2 shown when Slide 2 link is clicked

Graphic/Media Notes:
 Filename: mbb_02050225
 Alt text = data from Short Form Analysis
 //Size: 240x180 Default ext = jpg
 ___ Use image: _____
 ___ Create new or modify image:
 Description: Image from Module 3 Storyboard. This image has not been provided yet. This image will have to wait until images for Module 03 are captured.

<-End->

Storyboard#: 02050235 **Building Block #: BB 15 > Slide**

Back/Previous Page: # **Next Page: #**



ANOVA Gage R&R Study

An ANOVA Gage R&R Study is our most comprehensive MSA study that looks at repeatability, reproducibility, and interactions between the parts and operators. The ANOVA Gage R&R examines all three of these characteristics separately, unlike the Test/Retest Study and Short Form Analysis. An ANOVA Gage R&R Study can give you a very detailed picture of what's going on in your measurement system.

An ANOVA Gage R&R Study involves having multiple operators measure the same characteristic on multiple parts under the same conditions multiple times.

Programming Notes:

// Slide 3 shown when Slide 3 link is clicked

Graphic/Media Notes:

Filename: mbb_02050235

Alt text = ANOVA Gage R&R Study

//Size: 240x180 Default ext = jpg

Use image: MBB_Module4_8_Outputs_a.jpg

Create new or modify image:

Description:

<-End->

Storyboard#: 02050245

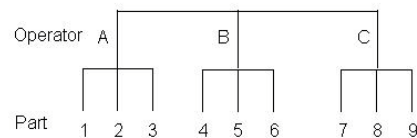
Building Block #: BB 15 > Slide

Back/Previous Page: #

Next Page: #

Destructive Gage R&R (Nested Design)

Each Operator Consumes Different (But Identical) Samples



Destructive/Temporal Study

In many cases, events are “destructive” or “temporal” because they happen a certain way only once and cannot be measured a second time by the same or another person. In these cases, it is sometimes possible to conduct a Destructive/Temporal Study by substituting homogeneous (very similar, almost identical) parts.

When it appears that we cannot get a second measurement, we can sometimes be creative and overcome the situation. For example, documenting, recording, or videotaping may allow us to have the same another person measure the same part. Or, we might be able to get simultaneous measurements from several people at the same event, thus allowing us to run one of the studies we have already reviewed.

For example, you might study the reliability of Olympic judging by recording several events and showing them repeatedly to multiple officials. **Note:** This type of study will not be covered in this module, but it will be covered in greater detail in your class sessions.

Programming Notes:

// Slide 5 shown when Slide 5 link is clicked

Graphic/Media Notes:

Filename: mbb_02050245

Alt text = destructive study design

//Size: 240x180 Default ext = jpg

X Use image: destructive.jpg

__ Create new or modify image:

Description: Copied from L5 Destruct Temporal.ppt

<-End->

Storyboard#: 02050255

Building Block #: BB 15 > Slide

Back/Previous Page: #

Next Page: #

| Sample | Operator 1 | | | | Operator 2 | | | | Operator 3 | | | | | |
|------------|------------|-----|-----|--------|------------|-----|-----|--------|------------|------------|-----|--------|--|-------|
| | Tr1 | Tr2 | Tr3 | Match? | Tr1 | Tr2 | Tr3 | Match? | Tr1 | Tr2 | Tr3 | Match? | | |
| 1 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 2 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 3 | N | N | N | Y | N | N | N | Y | D | N | N | N | | |
| 4 | D | D | D | Y | D | D | D | Y | D | D | D | Y | | |
| 5 | D | D | D | Y | D | D | D | Y | D | N | D | N | | |
| 6 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 7 | N | D | N | N | D | D | D | Y | D | D | D | Y | | |
| 8 | N | N | N | Y | D | N | D | N | N | N | N | Y | | |
| 9 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 10 | N | N | N | Y | N | N | N | Y | D | N | D | N | | |
| 11 | D | D | D | Y | D | D | D | Y | D | D | D | Y | | |
| 12 | N | N | N | Y | D | D | D | Y | D | D | D | Y | | |
| 13 | D | D | D | Y | D | D | D | Y | D | D | D | Y | | |
| 14 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 15 | D | D | D | Y | D | D | D | Y | D | D | D | Y | | |
| 16 | D | D | D | Y | N | N | N | Y | N | N | N | Y | | |
| 17 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 18 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 19 | N | N | N | Y | D | D | D | Y | N | N | N | Y | | |
| 20 | N | N | N | Y | N | N | N | Y | D | D | N | N | | |
| 21 | D | D | D | Y | D | D | D | Y | D | D | N | N | | |
| 22 | N | N | N | Y | D | D | D | Y | N | N | N | Y | | |
| 23 | N | N | N | Y | D | D | D | Y | N | N | N | Y | | |
| 24 | N | N | N | Y | N | N | N | Y | D | D | D | Y | | |
| 25 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 26 | D | D | D | Y | D | D | D | Y | D | D | D | Y | | |
| 27 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 28 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 29 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 30 | N | D | N | N | D | D | D | Y | D | D | D | Y | | |
| 31 | D | D | D | Y | D | D | D | Y | D | D | D | Y | | |
| 32 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 33 | D | N | N | N | D | D | N | N | N | N | N | Y | | |
| 34 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 35 | N | N | N | Y | N | N | N | Y | N | D | N | N | | |
| 36 | D | D | D | Y | D | D | D | Y | D | D | D | Y | | |
| 37 | N | N | N | Y | N | N | N | Y | D | N | N | N | | |
| 38 | N | N | N | Y | N | N | N | Y | N | N | D | N | | |
| 39 | N | N | N | Y | N | N | N | Y | N | N | N | Y | | |
| 40 | N | N | N | Y | D | D | D | Y | N | N | N | Y | | |
| Operator 1 | | | | 0.925 | Operator 2 | | | | 0.950 | Operator 3 | | | | 0.800 |

Attribute R&R Study

If you have discrete data rather than continuous data, you will perform an Attribute R&R Study instead of the other types of MSA studies discussed here.

Note: This type of study will not be covered in this module, but it will be covered in greater detail in your class sessions.

Programming Notes:

// Slide 4 shown when Slide 4 link is clicked

Graphic/Media Notes:

Filename: mbb_02050255

Alt text = Attribute R&R Study

//Size: 240x180 Default ext = jpg

Use image: attributedata.gif

Create new or modify image:

| | |
|--|--|
| | Description: Copied from L4 Attribute Gage.ppt |
|--|--|


<-End->

| | | | |
|--|--------------------------------------|---|---|
| Storyboard#: 02050400 | | Building Block #: BB 14b > Graphic Rollover | |
| Back/Previous Page: 02050200 | Next Page: 02050600 | Page Number: 2 | |
| Screen Title: MSA Summary | | | |
| <p>Here is a summary of the three types of MSA studies we will discuss in this course. An “X” indicates what you will learn from each study. Mover your cursor over each items to learn more about it.</p> | | | |
| Study | Type of Measurement Variation | | |
| | Reproducibility | Accuracy/Bias (Need a standard) | Precision/Repeatability (Pure Error) |
| Test/Retest | | X | X |
| Short Form | X | | |
| ANOVA Gage R&R | X | | X |
| AIAG* Reference page | 53–54 | 49–50 | 52–53 |
| * AIAG Measurement Systems Analysis, MSA, 3 rd edition | | | |
| Programming Notes: | | Graphic/Media Notes: | |
| (-hotspot1-) = 02050415 (-hotspot2-) = 02050425 (-hotspot3-) = 02050435 | | Filename: mbb_02050400 Alt text = MSA studies and what they tell you //Size: 526 x 280 or set screen grab size Default ext = gif X Create new or modify image: msastudieschart.gif Description: | |
| <-End-> | | | |

| Storyboard#: 02050415 | | Building Block #: BB 14b > Layer | | | | | | | | | | | | | | | | | | | | | | | | |
|---|-------------------------------|---|---|-------|-------------------------------|--|--|-----------------|------------------------------------|---|-------------|--|---|---|------------|---|--|--|----------------|---|--|---|----------------------|-------|-------|-------|
| Back/Previous Page: # | Next Page: # | | | | | | | | | | | | | | | | | | | | | | | | | |
| <div style="border: 1px solid black; background-color: yellow; padding: 5px; width: fit-content; margin: 0 auto;">Variation due to operator</div> <table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <thead> <tr> <th rowspan="2" style="padding: 5px;">Study</th> <th colspan="3" style="padding: 5px;">Type of Measurement Variation</th> </tr> <tr style="background-color: yellow;"> <th style="padding: 5px;">Reproducibility</th> <th style="padding: 5px;">Accuracy/Bias (Need a standard)</th> <th style="padding: 5px;">Precision/Repeatability (Pure Error)</th> </tr> </thead> <tbody> <tr> <td style="padding: 5px;">Test/Retest</td> <td></td> <td style="text-align: center; padding: 5px;">X</td> <td style="text-align: center; padding: 5px;">X</td> </tr> <tr> <td style="padding: 5px;">Short Form</td> <td style="text-align: center; padding: 5px;">X</td> <td></td> <td></td> </tr> <tr> <td style="padding: 5px;">ANOVA Gage R&R</td> <td style="text-align: center; padding: 5px;">X</td> <td></td> <td style="text-align: center; padding: 5px;">X</td> </tr> <tr> <td style="padding: 5px;">AIAG* Reference page</td> <td style="text-align: center; padding: 5px;">53–54</td> <td style="text-align: center; padding: 5px;">49–50</td> <td style="text-align: center; padding: 5px;">52–53</td> </tr> </tbody> </table> <p style="font-size: small; margin-top: 10px;">* AIAG Measurement Systems Analysis, MSA, 3rd edition</p> | | | | Study | Type of Measurement Variation | | | Reproducibility | Accuracy/Bias (Need a standard) | Precision/Repeatability (Pure Error) | Test/Retest | | X | X | Short Form | X | | | ANOVA Gage R&R | X | | X | AIAG* Reference page | 53–54 | 49–50 | 52–53 |
| Study | Type of Measurement Variation | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Reproducibility | Accuracy/Bias (Need a standard) | Precision/Repeatability (Pure Error) | | | | | | | | | | | | | | | | | | | | | | | |
| Test/Retest | | X | X | | | | | | | | | | | | | | | | | | | | | | | |
| Short Form | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| ANOVA Gage R&R | X | | X | | | | | | | | | | | | | | | | | | | | | | | |
| AIAG* Reference page | 53–54 | 49–50 | 52–53 | | | | | | | | | | | | | | | | | | | | | | | |
| Programming Notes: | | Graphic/Media Notes: | | | | | | | | | | | | | | | | | | | | | | | | |
| //The small layer of text should be placed over the image as shown above | | //No graphic in the layer. Image is shown for text placement only | | | | | | | | | | | | | | | | | | | | | | | | |
| <End> | | | | | | | | | | | | | | | | | | | | | | | | | | |

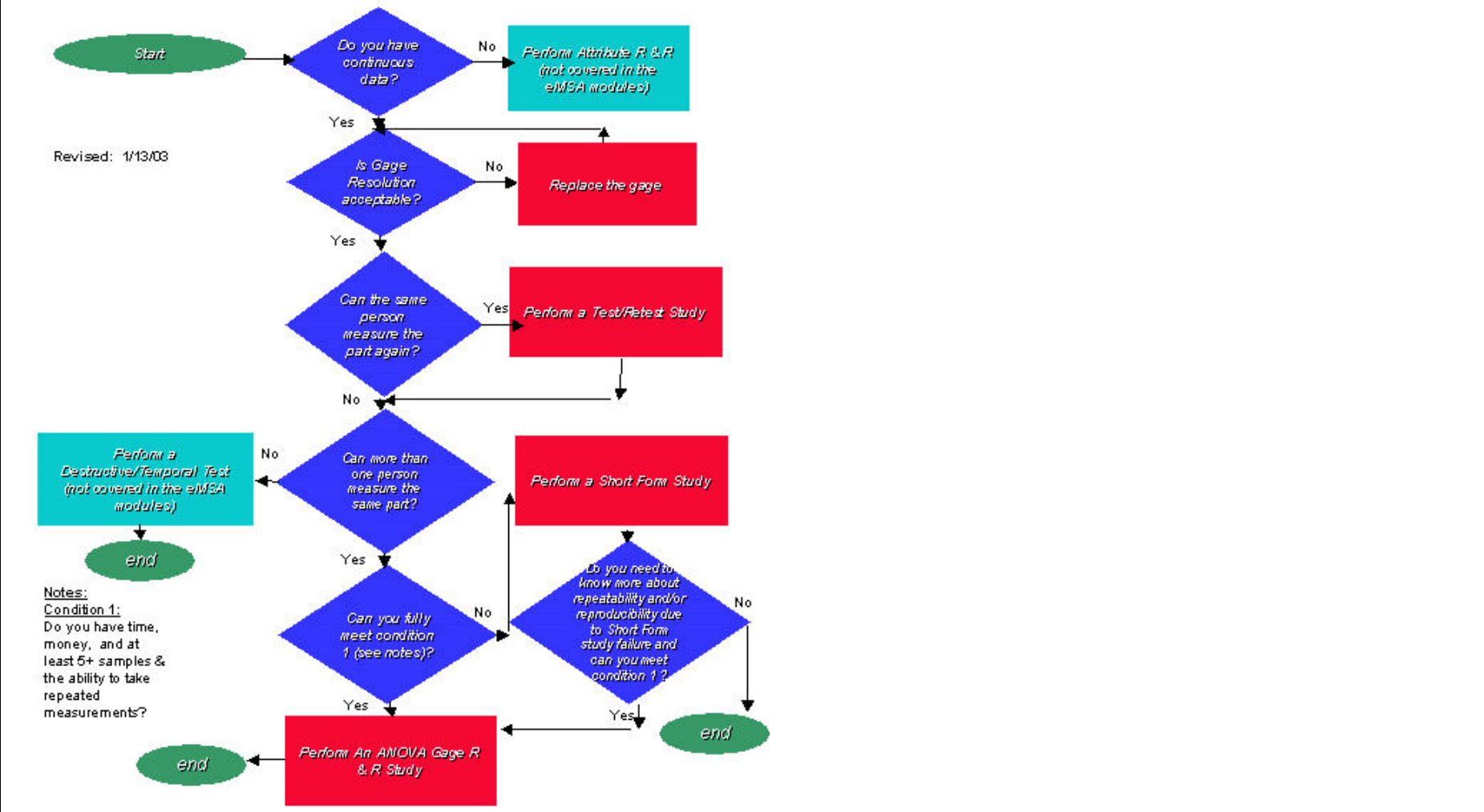
| | | | |
|--|--------------------------------------|---|---|
| Storyboard#: 02050425 | | Building Block #: BB 14b > Layer | |
| Back/Previous Page: # | Next Page: # | | |
| <div style="border: 1px solid black; display: inline-block; padding: 5px 20px; background-color: #ffff00;">Variation due to gage</div> | | | |
| Study | Type of Measurement Variation | | |
| | Reproducibility | Accuracy/Bias (Need a standard) | Precision/Repeatability (Pure Error) |
| Test/Retest | | X | X |
| Short Form | X | | |
| ANOVA Gage R&R | X | | X |
| AIAG* Reference page | 53–54 | 49–50 | 52–53 |
| <p><small>* AIAG Measurement Systems Analysis, MSA, 3rd edition</small></p> | | | |
| Programming Notes: | | Graphic/Media Notes: | |
| //The small layer of text should be placed over the image as shown above | | //No graphic in the layer. Image is shown for text placement only | |
| <End> | | | |

| Storyboard#: 02050435 | | Building Block #: BB 14b > Layer | | | | | | | | | | | | | | | | | | | | | | | | |
|--|-------------------------------|---|---|-------|-------------------------------|--|--|-----------------|------------------------------------|---|-------------|--|---|---|------------|---|--|--|----------------|---|--|---|----------------------|-------|-------|-------|
| Back/Previous Page: # | Next Page: # | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2" style="width: 20%;">Study</th> <th colspan="3" style="background-color: #ffffcc;">Type of Measurement Variation</th> </tr> <tr> <th style="background-color: #c6efce;">Reproducibility</th> <th style="background-color: #ffffcc;">Accuracy/Bias (Need a standard)</th> <th style="background-color: #ffffcc;">Precision/Repeatability (Pure Error)</th> </tr> </thead> <tbody> <tr> <td>Test/Retest</td> <td></td> <td style="text-align: center;">X</td> <td style="text-align: center;">X</td> </tr> <tr> <td>Short Form</td> <td style="border: 2px solid yellow; text-align: center;">X</td> <td></td> <td></td> </tr> <tr> <td>ANOVA Gage R&R</td> <td style="text-align: center;">X</td> <td></td> <td style="text-align: center;">X</td> </tr> <tr> <td>AIAG* Reference page</td> <td style="text-align: center;">53–54</td> <td style="text-align: center;">49–50</td> <td style="text-align: center;">52–53</td> </tr> </tbody> </table> <div style="border: 1px solid black; padding: 5px; margin-top: 10px; width: fit-content;"> Provides no information on repeatability </div> <p style="font-size: small; margin-top: 10px;">* AIAG <i>Measurement Systems Analysis</i>, MSA, 3rd edition</p> | | | | Study | Type of Measurement Variation | | | Reproducibility | Accuracy/Bias (Need a standard) | Precision/Repeatability (Pure Error) | Test/Retest | | X | X | Short Form | X | | | ANOVA Gage R&R | X | | X | AIAG* Reference page | 53–54 | 49–50 | 52–53 |
| Study | Type of Measurement Variation | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Reproducibility | Accuracy/Bias (Need a standard) | Precision/Repeatability (Pure Error) | | | | | | | | | | | | | | | | | | | | | | | |
| Test/Retest | | X | X | | | | | | | | | | | | | | | | | | | | | | | |
| Short Form | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| ANOVA Gage R&R | X | | X | | | | | | | | | | | | | | | | | | | | | | | |
| AIAG* Reference page | 53–54 | 49–50 | 52–53 | | | | | | | | | | | | | | | | | | | | | | | |
| Programming Notes: | | Graphic/Media Notes: | | | | | | | | | | | | | | | | | | | | | | | | |
| //The small layer of text should be placed over the image as shown above | | //No graphic in the layer. Image is shown for text placement only | | | | | | | | | | | | | | | | | | | | | | | | |
| <-End-> | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | |
|--|----------------------------|---|--|
| Storyboard#: 02050600 | | Building Block #: BB 50 TextTOP GraphicBTM | |
| Back/Previous Page: 02050400 | Next Page: 02050800 | Page Number: 3 | |
| Screen Title: Determining Which Type of Study to Do | | | |
| <p>Now that you know the different types of MSA studies, how do you decide which one is appropriate for a given situation? Here at GE, we have developed the MSA flowchart to guide you through the decision making process.</p> <p>You can explore the MSA flowchart on the next page. You can download a copy of the flowchart by clicking the link below.</p> <p>Click Next to continue.</p> | | | |
|  Click MSA Flowchart to view and download the MSA flowchart. | | | |
| Programming Notes: MSA Flowchart = /resources/msaflowchart.pdf | | Graphic/Media Notes: | |
| <-End-> | | | |

Screen Title: MSA Flowchart

Mover your cursor over each item in the flowchart to learn more about it.



Programming Notes:

Each shape should have a rollover that shows an enlargement of it. The goal is to let the learner read the text in all the shapes. Each item will be active and a larger, readable version of each block will be shown when the cursor is over it.

Graphic/Media Notes:

Filename: mbb_02050800

Alt text = MSA Flowchart

//Size: 526 x 280 or set screen grab size Default ext = gif

X Create new or modify image: msa_flowchart.jpg Description: Redo to make more attractive and readable. See Module 1 Art, part 2, slide 4. Each item will be active and a larger, readable version of each block will be shown when the cursor is over it.

<-End->

| | | | |
|--|----------------------------|--|--|
| Storyboard#: 02051000 | | Building Block #: BB 55 > Multiple Multiple Choice | |
| Back/Previous Page: 02050800 | Next Page: 02051200 | Page Number: 5 | |
| Screen Title: Knowledge Check | | | |
| Which of the following study types can tell you about repeatability? Click the button next to all the correct responses, then click submit. | | | |
| <input type="radio"/> | Test/Retest Study | | |
| <input type="radio"/> | Short Form Analysis | | |
| <input type="radio"/> | ANOVA Gage R&R Study | | |
| <input type="radio"/> | Attribute R&R Study | | |
| Programming Notes: | | Graphic/Media Notes: | |
| <pre>//correct answers, must be a string Ex "2,4" Correct answer = "1,3" //text of positive feedback pos_fb = "Correct. Test/Retest, ANOVA Gage R&R, and Attribute studies all examine repeatability." //text of first negative feedback neg_fb1 = "Try again. Hint: Short Form Analysis only examines reproducibility." //text of partially correct feedback p_neg_fb1 = "Some, but not all, of your answers are correct. Hint: Short</pre> | | N/A | |

Form Analysis only examines reproducibility. Please try again."

//text of second negative feedback

neg_fb2 = "Incorrect. Test/Retest, ANOVA Gage R&R, and Attribute studies all examine repeatability."

//number of distracters (typically 4)

question_number= 4;

<-End->

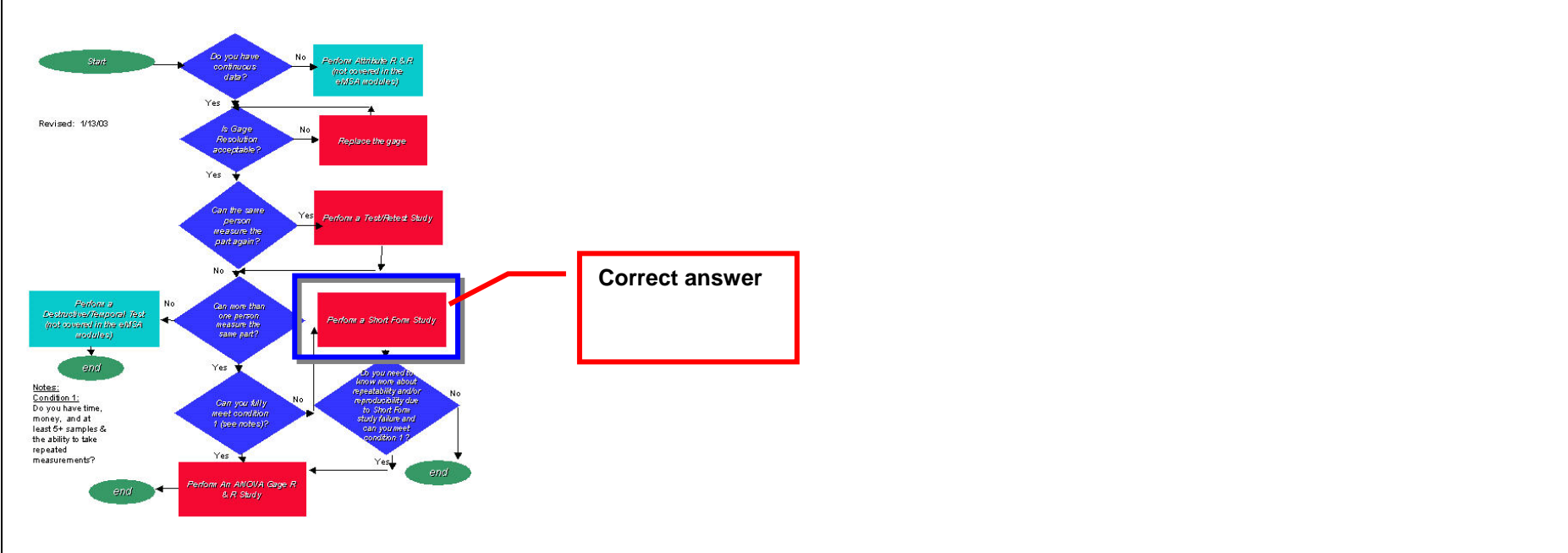
Storyboard#: 02051200 Building Block #: BB 63 > Identification

Back/Previous Page: 02051000 Next Page: 02051400 Page Number: 6

Screen Title: Knowledge Check

Suppose you have already done a Test/Retest Study and the results were satisfactory. More than one person can measure the same part, you cannot get repeated measurements. What's your next step in the MSA flowchart?

Click the correct area in the flowchart.



Each shape should have a rollover that shows an enlargement of it.

| | |
|---|---|
| <p>Programming Notes:</p> <pre>//correct answer is one area only as shown above. Next button is active //text of positive pos_fb = "Correct. Performing a Short Form Analysis would be indicated." //text of first negative feedback __ = "Please try again. Remember, the ability to perform repeated measurements is one of the criteria used in Condition 1."</pre> | <p>Graphic/Media Notes:</p> <p>Filename: mbb_02051200</p> <p>Alt text = Alt tags need to be created for each block, so if the user rolls the cursor over the block – alt tag of the text for that block will be displayed.</p> <p>//Size: 526 x 280 or set screen grab size Default ext = gif</p> <p>__ Use image:</p> <p>__X_ Create new or modify image: msa_flowchart.jpg</p> |
|---|---|

| | |
|---|--|
| <p>//text of second negative feedback</p> <p>neg_fb2 = "Incorrect. Performing a Short Form Analysis would be indicated when you cannot measure the same part multiple times."</p> <p>Alt tags need to be created for each block, so if the user rolls the cursor over the block – alt tag of the text for that block will be displayed.</p> | <p>Description: Redo to make more attractive and readable. See Module 1 Art, part 2, slide 4.</p> <p>//Neg_fb2 image has the correct answer highlighted</p> <p>//Add "b" to matching filename of base image</p> <p>Neg_fb2 Filename: mbb_02051200b</p> |
| <p><-End-></p> | |

| | | | |
|--|--------------------------------|--|--|
| Storyboard#: 02051400 | | Building Block #: BB 55 > Single Multiple Choice | |
| Back/Previous Page: 02051200 | Next Page: (-nextpage-) | Page Number: 7 | |
| Screen Title: Knowledge Check | | | |
| Of the following types of MSA studies, which is the most informative? Choose the correct answer, then click submit. | | | |
| <input type="radio"/> | Test/Retest Study | | |
| <input type="radio"/> | Short Form Analysis | | |
| <input type="radio"/> | ANOVA Gage R&R Study | | |
| <input type="radio"/> | Destructive/Temporal Study | | |
| Programming Notes: //correct answer, could be 1-4 Correct answer = "3" //text of positive pos_fb = "Correct. An ANOVA Gage R&R Study examines repeatability, reproducibility, and the interactions between them." //text of first negative feedback neg_fb1 = "Please try again. Remember, Test/Retest looks at repeatability only, while Short Form looks at reproducibility only." //text of second negative feedback neg_fb2 = "Incorrect. An ANOVA Gage R&R Study is the most informative because it examines repeatability, reproducibility, and the interactions between them." | | Graphic/Media Notes: N/A | |