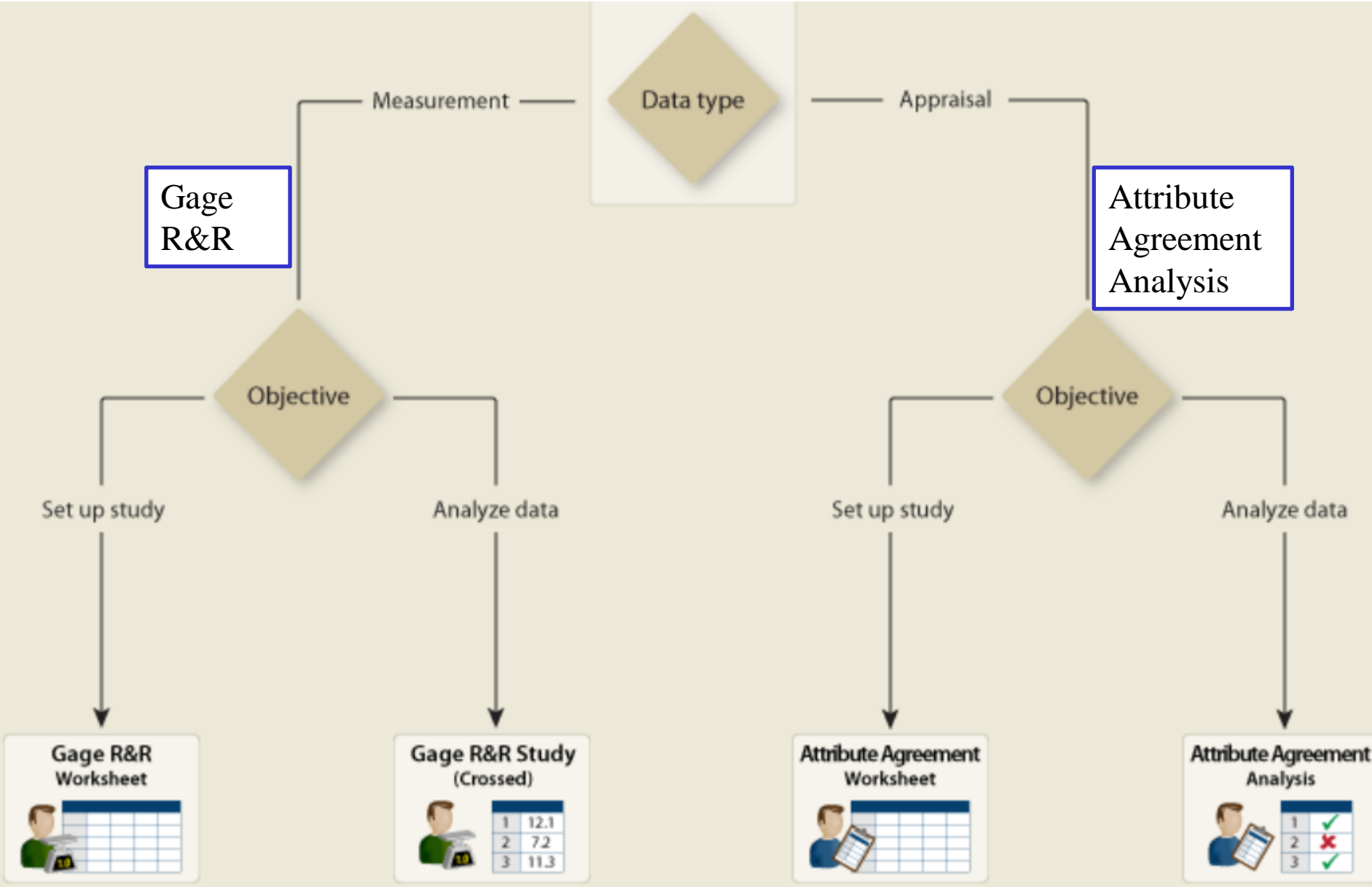


**GAGE R&R**  
**Long's Anthropometric Corporation**  
Green Belt's Training | May 2021

# Two Types of Measurement System Analysis



# Minitab Key Features for MSA

The screenshot shows the Minitab software interface with the following elements:

- Menu Path:** Stat > Quality Tools > Gage Study
- Highlighted Items:**
  - Stat menu (marked with a red star)
  - Quality Tools menu (marked with a red star)
  - Gage Study menu item (marked with a yellow star)
  - Attribute Agreement Analysis... menu item (marked with a yellow star)
  - Type 1 Gage Study... menu item (marked with a yellow star)
  - Create Gage R&R Study Worksheet... menu item (marked with a yellow star)
  - Gage R&R Study (Crossed)... menu item (marked with a yellow star)
- Worksheet:** Worksheet 1 \*\*\* with columns C1, C2, C3, C4 and rows 1-6.

# LAC - Long's Anthropometry Corporation

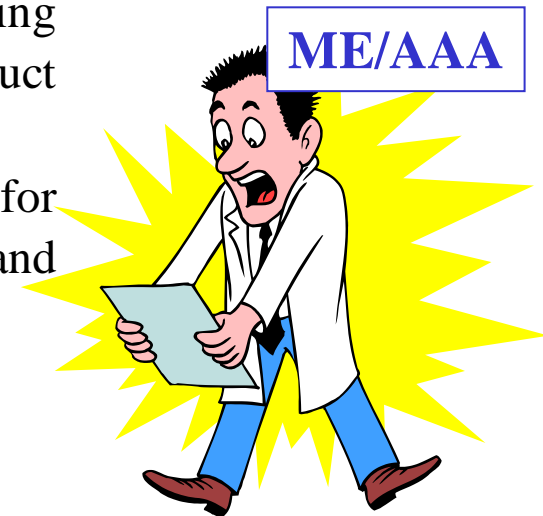
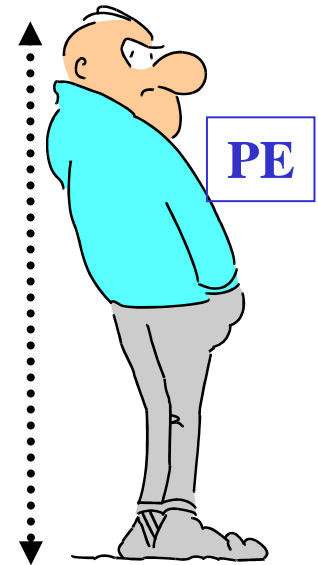


LAC was once a “well-established” company certified by the rigorous Federal Agency of Anthropometry (FAA). The company offers a “full range of services” related to the **measurement of height**, width, distance, extension, altitude, elevation, length, size, etc. Their competition now says that they are too specialized and that they just sell one service. Moreover, FAA recently sent a letter to LAC saying that the company could lose its license due to several clients’ complaints. One such complaint is that LAC was unable to perform reliable measurements on the width and height of several parts of one specific product. If its license is revoked, LAC will go belly up.

As a last resort, the company decides to **perform a study of its own measurement system team**. Mr. Long, the president of the company, suggests that the whole team must be considered a part of the measurement system.

In order to perform a Gage R&R on his team, Mr. Long, the CEO of Long's Anthropometry Corporation, offers himself as a training coordinator. The first thing he does is to randomly select **groups of at least eight people** among his employees. He also randomly divides them into **three categories** according to the following elements:

- The **Part-Element (PE)** represents a part height to be measured. A small sample of **five or more PEs** is recommended to each group and should represent, in the best possible way, the process variation. Mr. Long will inform them that PEs are guinea pigs per se and are supposed to act like a part, i.e., they must remain straight, emit no sound, and above all, must demonstrate absolute control over their own bodily functions.
- The **Measurer-Element (ME)** is the person responsible for taking the measurements. They are the operators or appraisers. To conduct this study, **at least two MEs** per group are necessary.
- The **Odd Jobs Technician (The Boss)** is the person responsible for writing down the PEs height's readings taken by the MEs and generally getting in the way .



Each LAC team should contain 2 MEs, a Boss and at least 5 PEs;

Both PEs and MEs should be labeled;

Each team must save its spreadsheet data;

Each ME shall measure a PE 3 times alternately;

The measuring tape can not touch the PE;

Results should be in centimeters (eg 178 cm);

The MEs must make 3 rounds of measurement of the PEs;

At each round the PEs will change their positions randomly;

The MEs should not communicate their results to each other;

The Boss can not communicate the results to the other MEs.

# Minitab Worksheet

## Create Gage R&R Study Worksheet

Number of parts:

Number of operators:

Part	Part Name
1	Part 1
2	Part 2
3	Part 3
4	Part 4
5	Part 5

Operato	Operator Nam
1	Operator A
2	Operator B

**For 5 PEs and 2 MEs. Each ME measure each PE for 3 times**

Number of replicates:

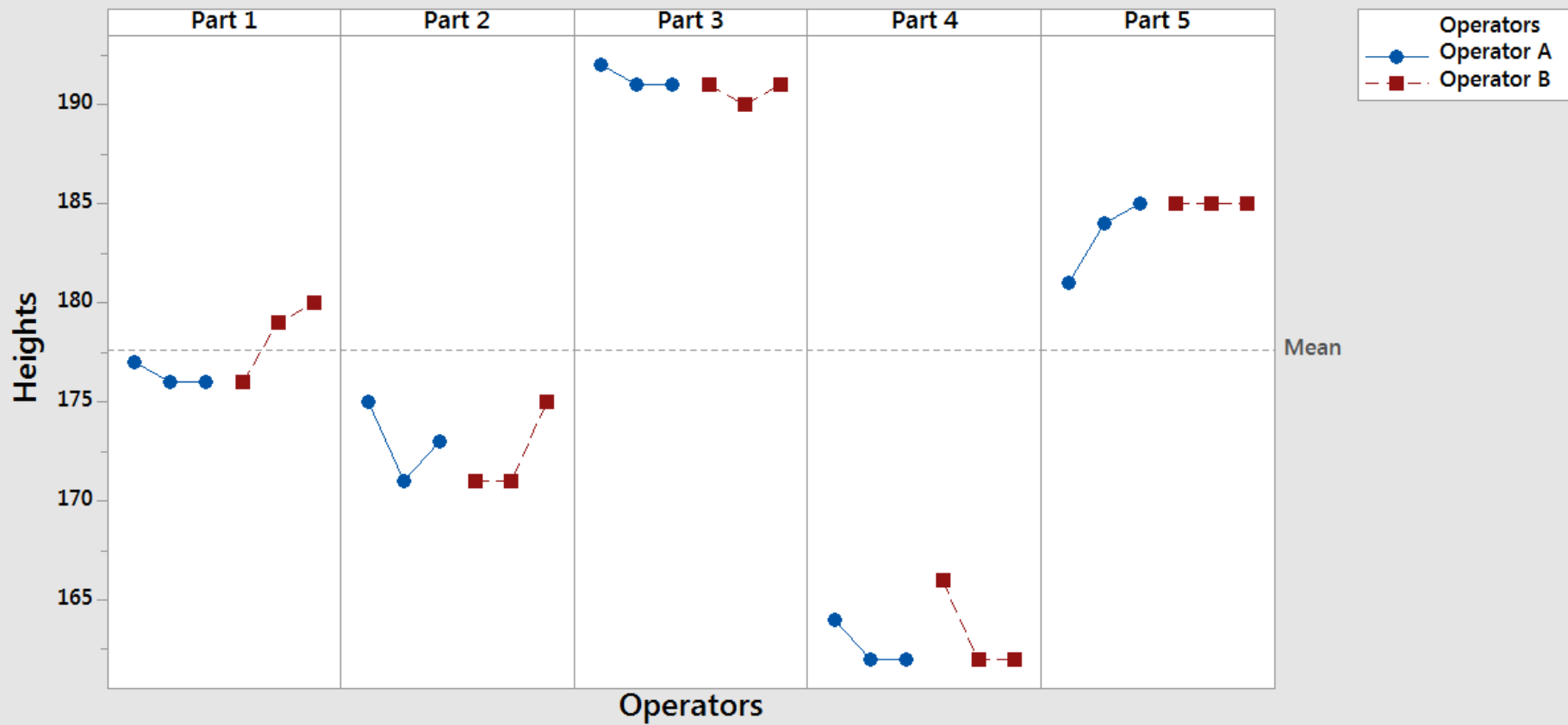
RunOrder	Parts	Operators	Height
1	Part 3	Operator A	
2	Part 2	Operator A	
3	Part 1	Operator A	
4	Part 5	Operator A	
5	Part 4	Operator A	
6	Part 2	Operator B	
7	Part 3	Operator A	
8	Part 4	Operator A	
9	Part 5	Operator A	
10	Part 1	Operator A	
11	Part 1	Operator A	
12	Part 3	Operator A	
13	Part 4	Operator A	
14	Part 5	Operator A	
15	Part 2	Operator A	
16	Part 4	Operator B	
17	Part 2	Operator B	
18	Part 5	Operator B	

Input Column of height measurements.

<Stat><Quality Tools> <Gage Study> <Create Gage R&R Study Worksheet>

ME	PE	Measure (cm)	ME	PE	Measure (cm)	ME	PE	Measure (cm)
Operator A	Part 1	177	Operator A	Part 1	176	Operator A	Part 1	176
Operator A	Part 2	175	Operator A	Part 2	171	Operator A	Part 2	173
Operator A	Part 3	192	Operator A	Part 3	191	Operator A	Part 3	191
Operator A	Part 4	164	Operator A	Part 4	162	Operator A	Part 4	162
Operator A	Part 5	181	Operator A	Part 5	184	Operator A	Part 5	185
Operator B	Part 1	176	Operator B	Part 1	179	Operator B	Part 1	180
Operator B	Part 2	171	Operator B	Part 2	171	Operator B	Part 2	175
Operator B	Part 3	191	Operator B	Part 3	190	Operator B	Part 3	191
Operator B	Part 4	166	Operator B	Part 4	162	Operator B	Part 4	162
Operator B	Part 5	185	Operator B	Part 5	185	Operator B	Part 5	185



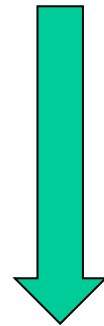


## Two-Way ANOVA Table **With** Interaction

Source	DF	SS	MS	F	P
Parts	4	2761,47	690,367	291,704	0,000
Operators	1	2,70	2,700	1,141	0,346
<b>Parts * Operators</b>	<b>4</b>	<b>9,47</b>	<b>2,367</b>	<b>0,922</b>	<b>0,471</b>
Repeatability	20	51,33	2,567		
Total	29	2824,97			

No  
Interaction

When  
 $P > 0,25$  the  
interaction  
term is  
removed



$\alpha$  to remove interaction term = 0,05

## Two-Way ANOVA Table **Without** Interaction

Source	DF	SS	MS	F	P
<b>Parts</b>	<b>4</b>	<b>2761,47</b>	<b>690,367</b>	<b>272,513</b>	<b>0,000</b>
Operators	1	2,70	2,700	1,066	0,312
Repeatability	24	60,80	2,533		
Total	29	2824,97			

Parts are different  
Operators are equals

<1%	<10%	Acceptable
De 1% a 9%	De 10% a 30%	Acceptable depending on application
> 9%	> 30%	Not acceptable
(1) VarComp	(2) %Study Var	

## Gage R&R

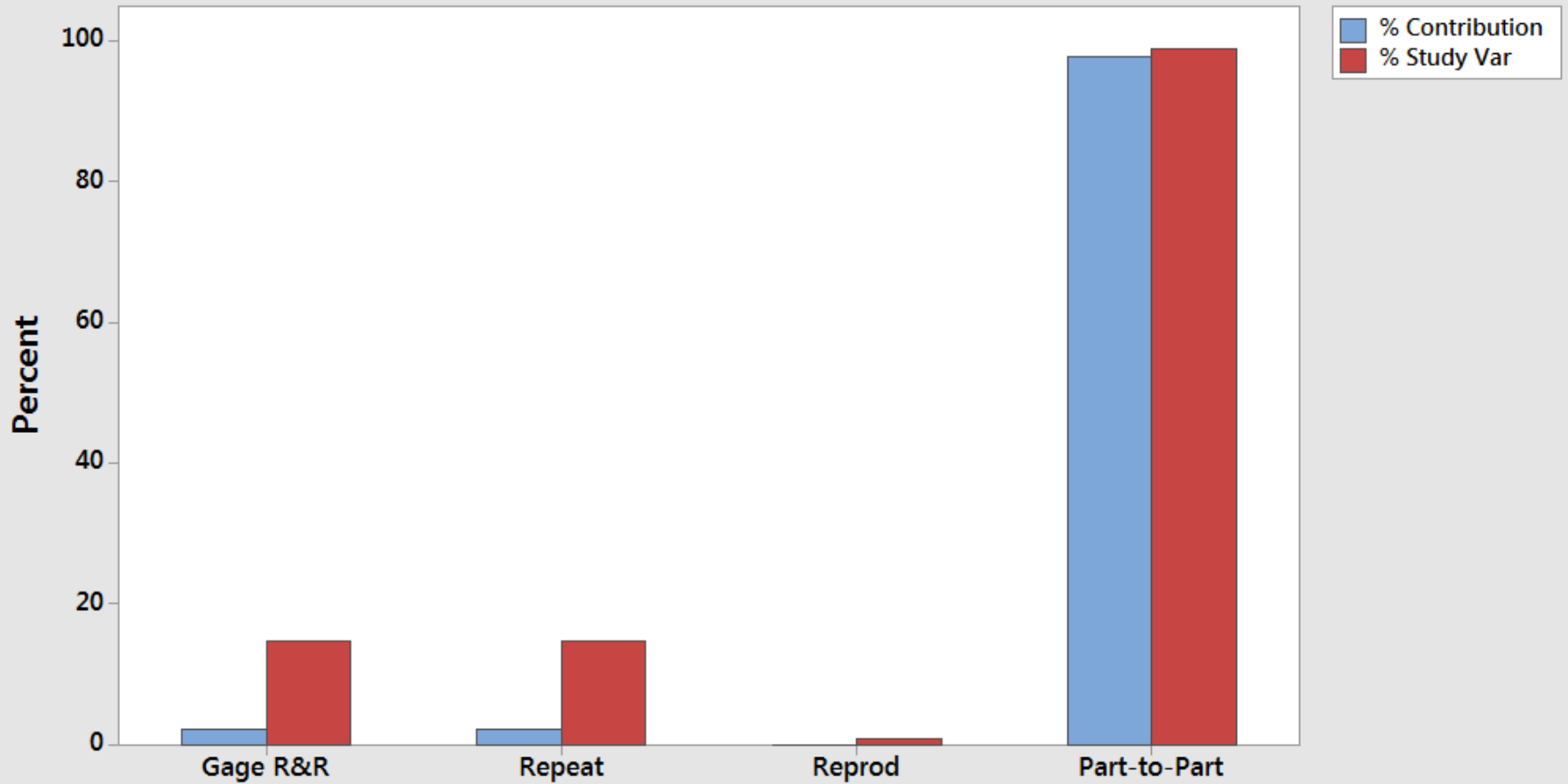
Source	VarComp	%Contribution (of VarComp)	
Total Gage R&R	2,544	2,17	(1)
Repeatability	2,533	2,16	
Reproducibility	0,011	0,01	
Operators	0,011	0,01	
Part-To-Part	114,639	97,83	
Total Variation	117,183	100,00	

Acceptable  
depending  
on  
application

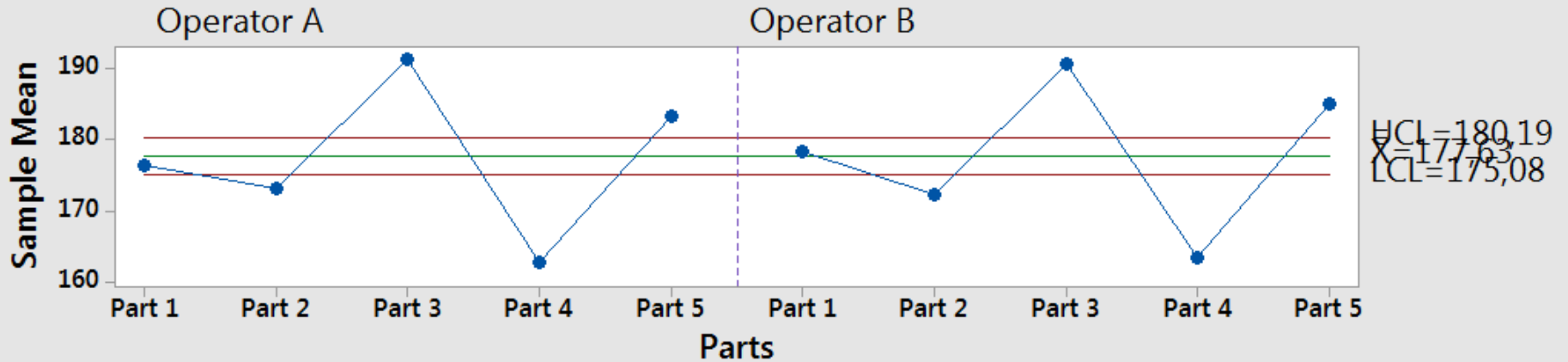
Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)	
Total Gage R&R	1,5951	9,5708	14,74	(2)
Repeatability	1,5916	9,5499	14,70	
Reproducibility	0,1054	0,6325	0,97	
Operators	0,1054	0,6325	0,97	
Part-To-Part	10,7070	64,2417	98,91	
Total Variation	10,8251	64,9508	100,00	

Number of Distinct Categories = 9

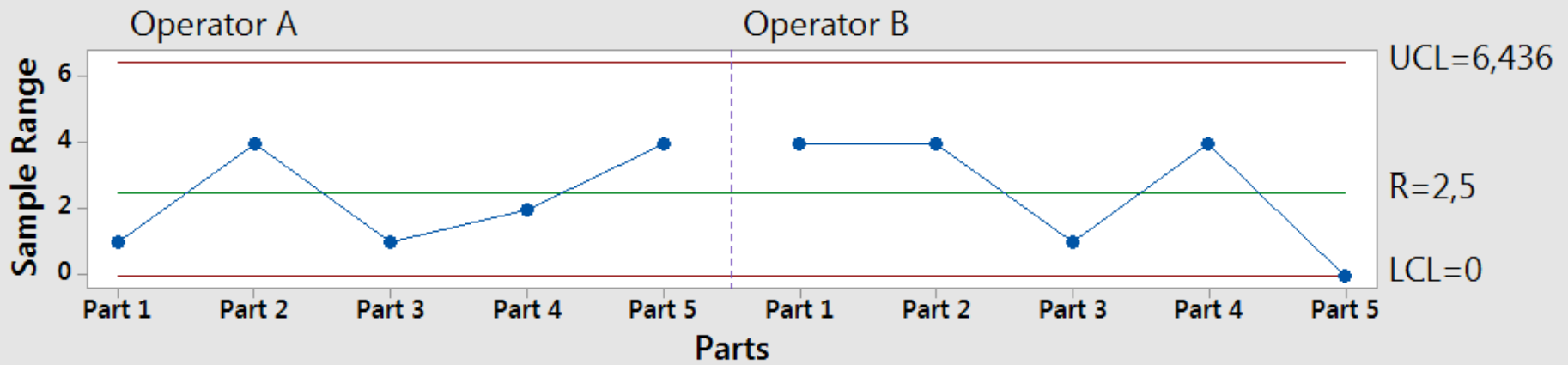
## Components of Variation



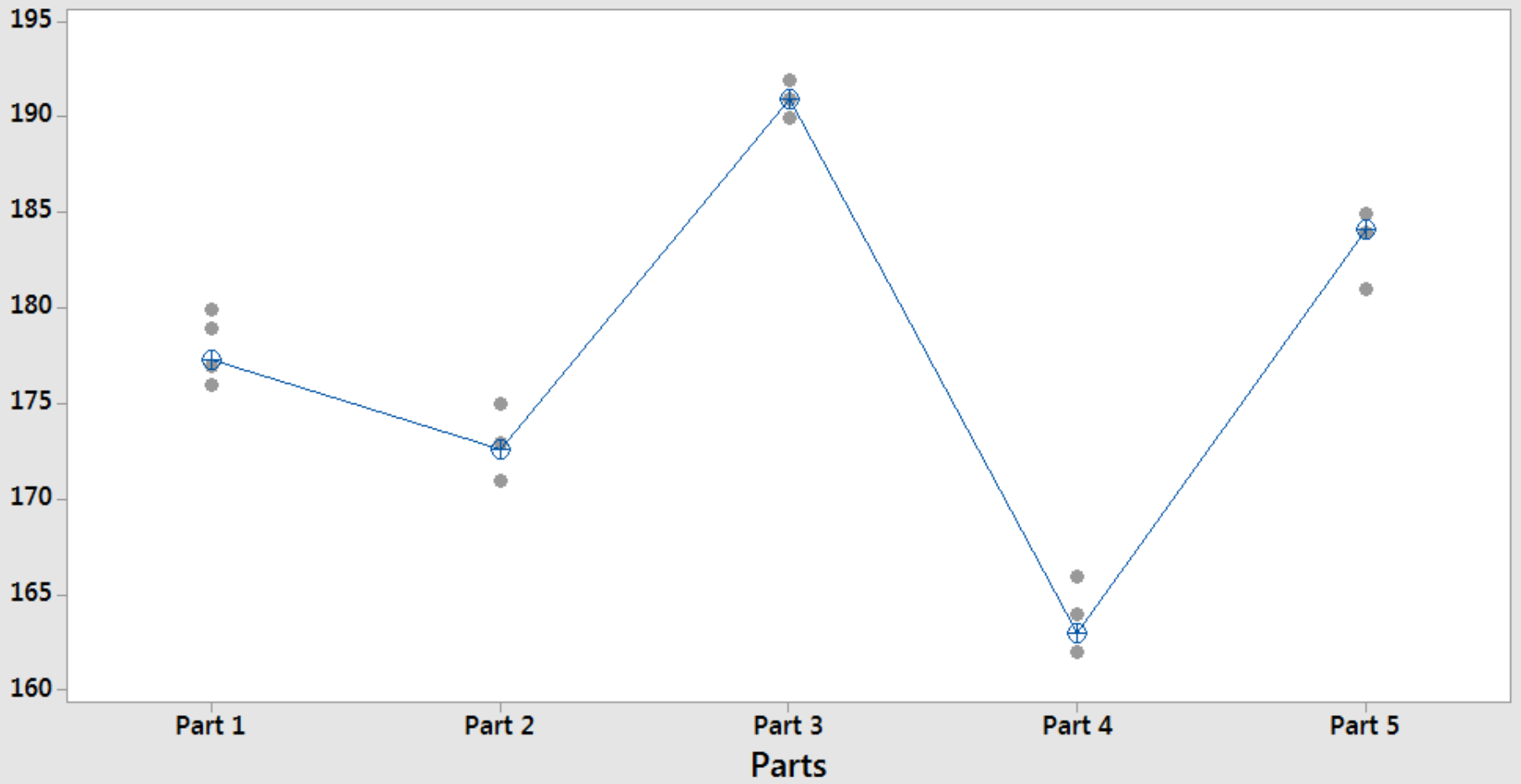
### Xbar Chart by Operators



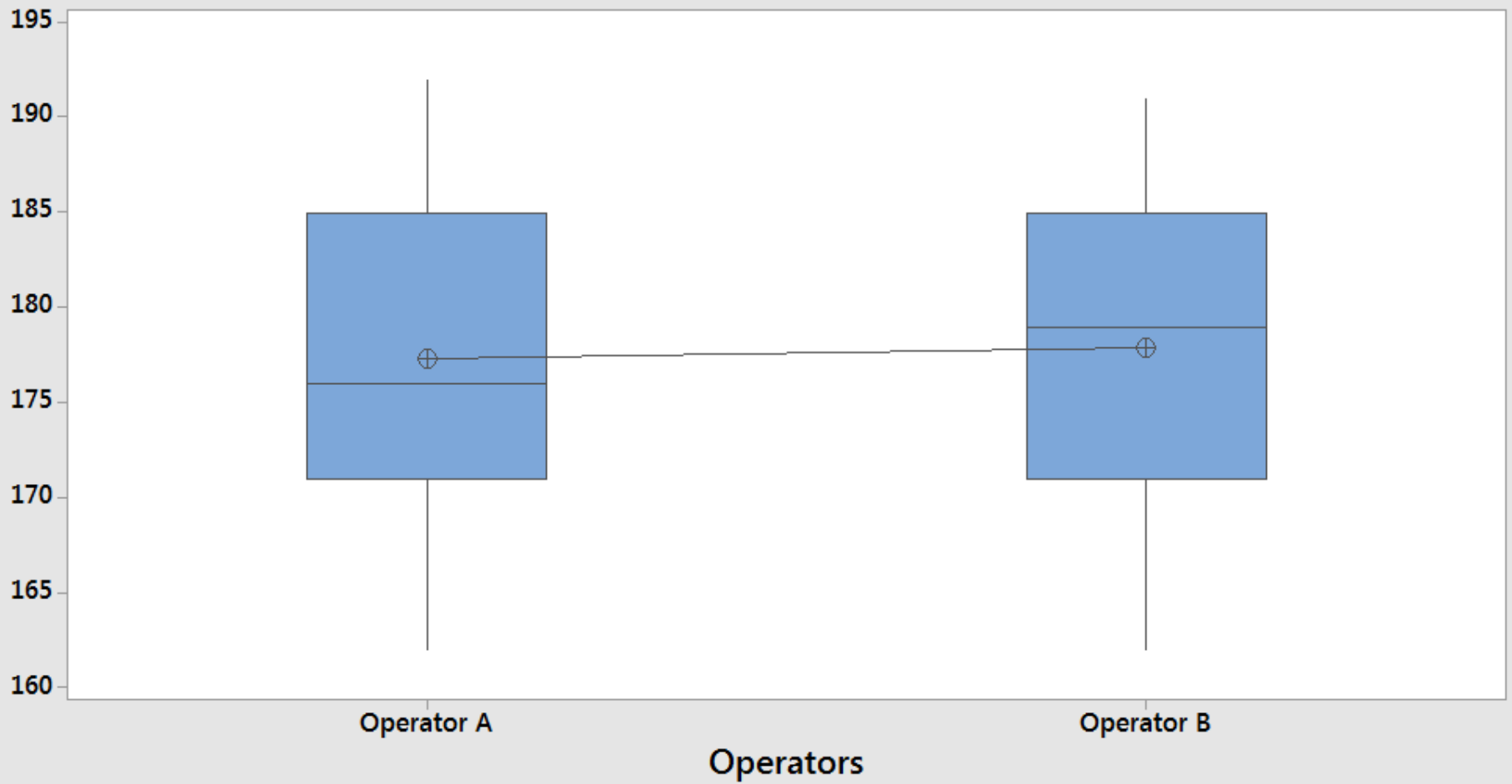
### R Chart by Operators



## Heights by Parts



## Heights by Operators



## Parts \* Operators Interaction

