



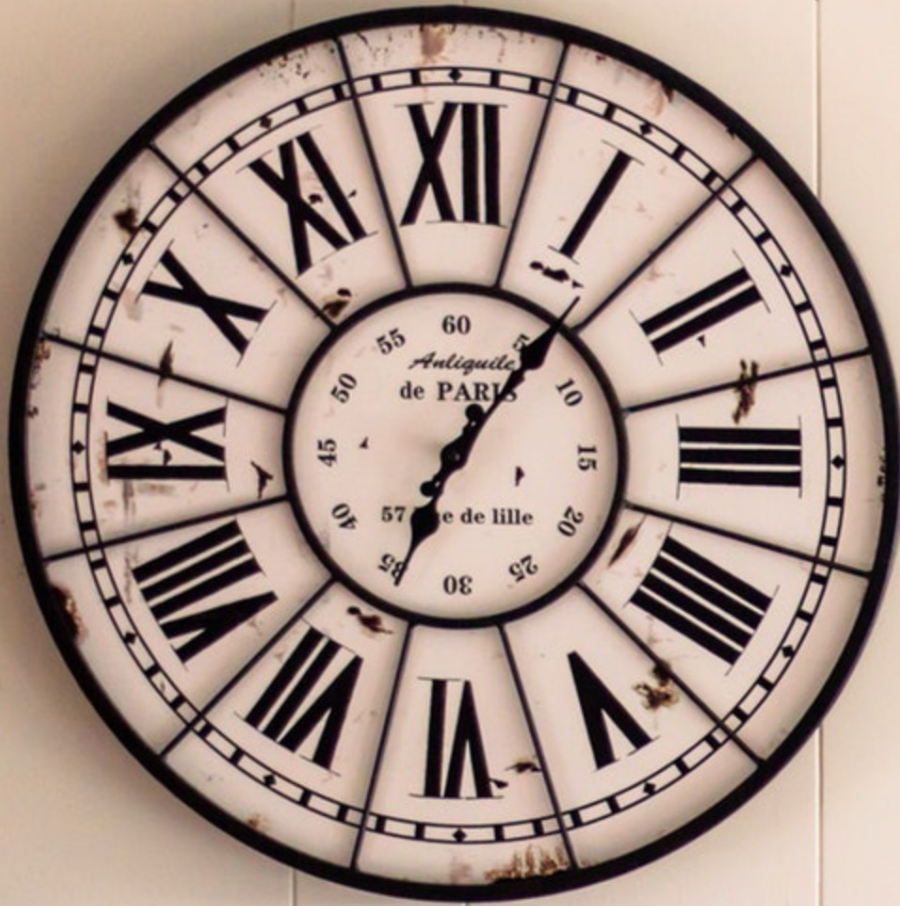
Fundamentals of Measurement System Analysis

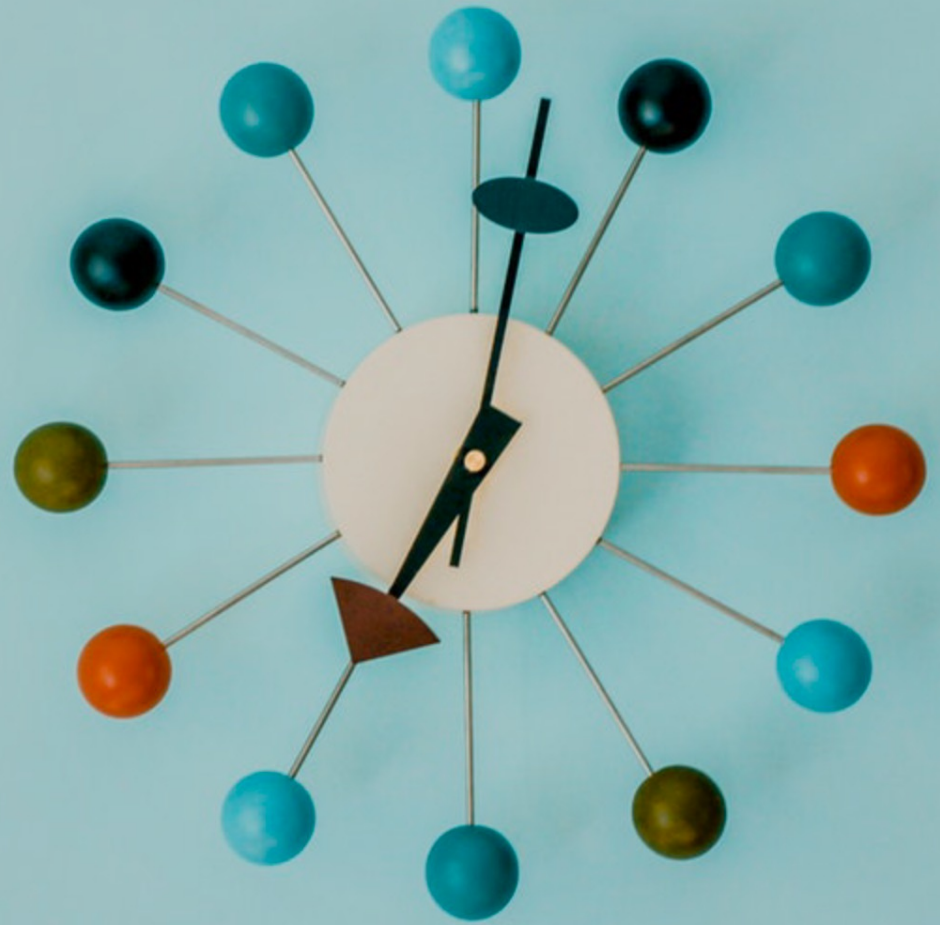
Fred Schenkelberg

Data



Decisions





Unknowable

Measurement System Analysis

Is our measurement
useful or not?

Use of Measurements



Comparisons Monitoring Decisions

Making Comparisons



what is the chance we select
the wrong one?

A v B comparisons

Design of experiments

to specification

to requirements

to standard

to settings

Monitoring Variability



is it just variation or error?

Process control
safety valves
for improvement
for sorting
for characterization

Informing Decisions



Show me the data

Data to support a decision

Data to identify solutions

Data to change a design

Data to determine risk

What are some

of the ways you use
measurements?

Bias



Define



Problem



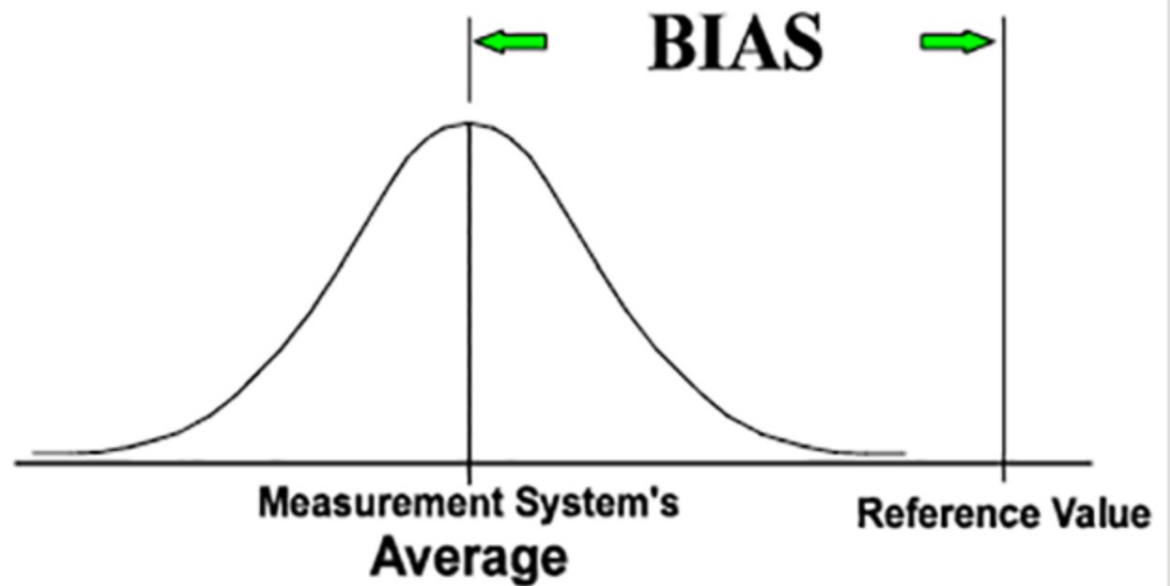
Test

Defining Bias



location variation offset from true

same characteristic, same part



Bias Causes



Bias and accuracy are not the same thing, BTW

need calibration

worn equipment or fixture

wrong gage for application

environmental effects

wrong constants applied

operator fatigue

Testing for Bias



Often accounted for within
a measurement system

reference items or masters
repeated measurements
determine average offset or bias

How else may bias

effect your
measurements?

Repeatability



Define



Problem



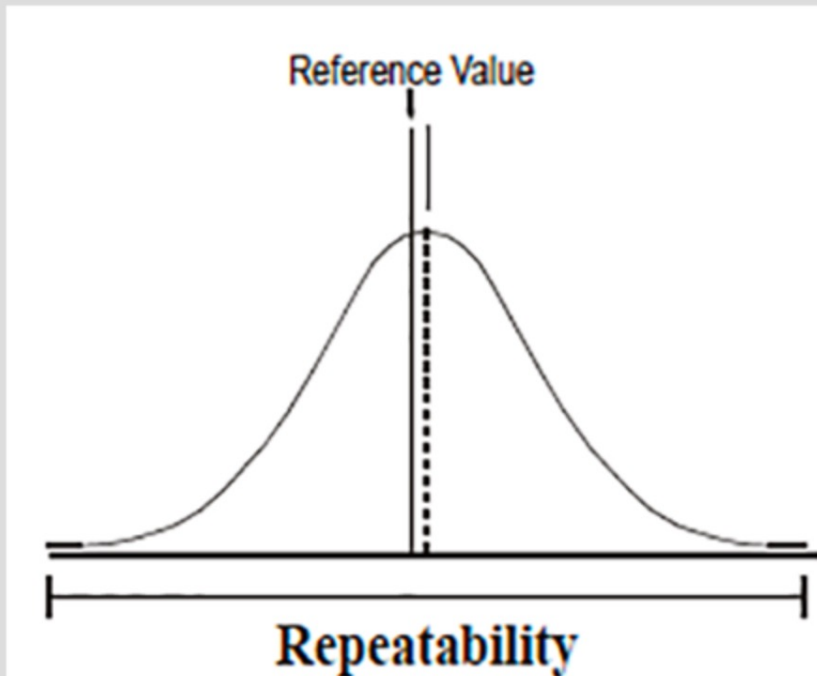
Test

Defining Repeatability



Width error
inherent variation or capability
of the equipment/process

Same instrument, same person, same
sample, same characteristic



Repeatability Problems



'Best available' should
always be defined in detail

sample variability
instrument variability
method variability
appraiser technique variability
environmental variability

Testing for Repeatability



See Gage R&R studies

Same person make repeated measurements on same part using same gage and method

estimate variability

(Note: tricky in practice is the operator knows what value the measurement should actually be)

Can you average you
way out of

repeatability
problems?

Reproducibility



Define



Problem



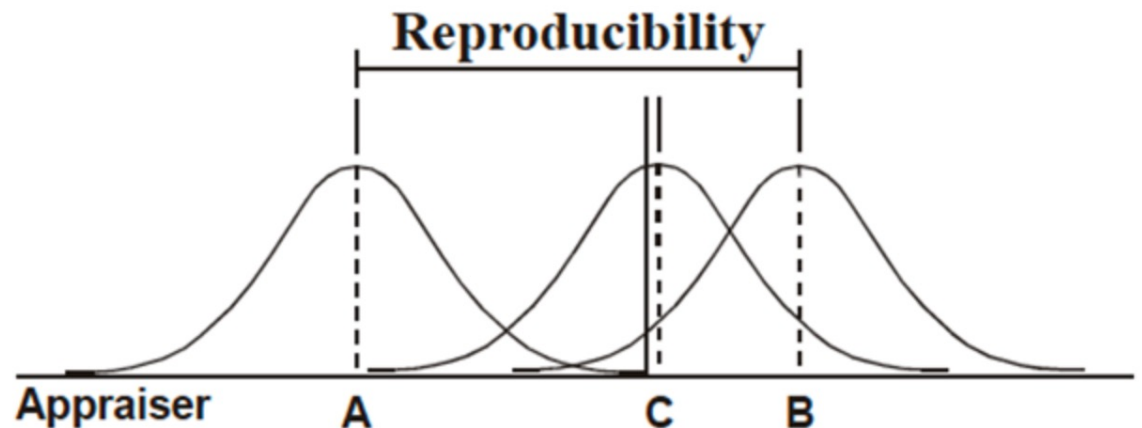
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Defining Reproducibility



Width error
different setup yet get the same
results

same characteristic, same part, yet may
have different gages, labs, appraisers, and
environments



Reproducibility Problems



'Best available' should
always be defined in detail

sample and gage variability

gage differences

method differences

appraiser differences

environmental differences

operator training differences

Testing for Reproducibility



see gage R&R study

like repeatability, yet with different people

Note: again tricky if individuals know what the measurement should be

Is an unreproducible
measurement

useful?

Stability



Define



Problem



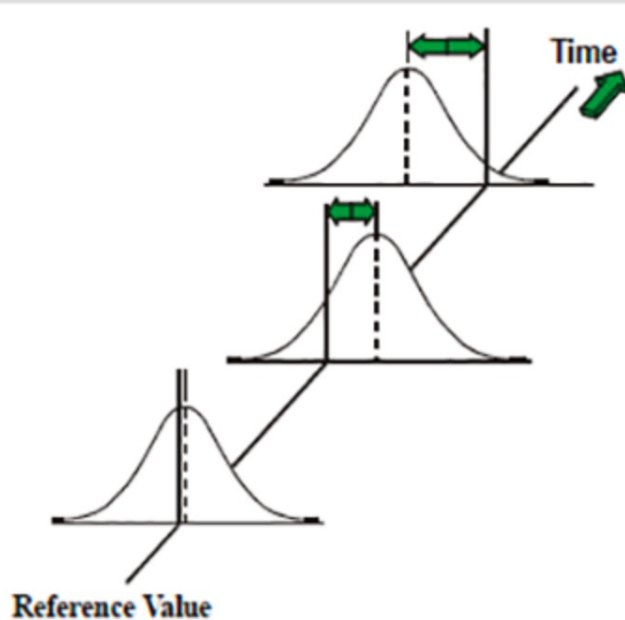
Test

Defining Stability



Location error
also known as drift

same characteristic, same part, over
extended period of time



Stability Problems



it may not be monotonic

worn equipment or fixtures

normal aging

worn or damaged master

change in measurement process

operator fatigue

seasonal environmental effects

Testing for Stability



This one takes time

Repeat Bias or Gage R&R periodically

Hard part is determining duration over which it should be stable, and how stable is stable enough.

Control charting is handy tool here

What if the
manufacturing

process isn't stable?

Linearity



Define

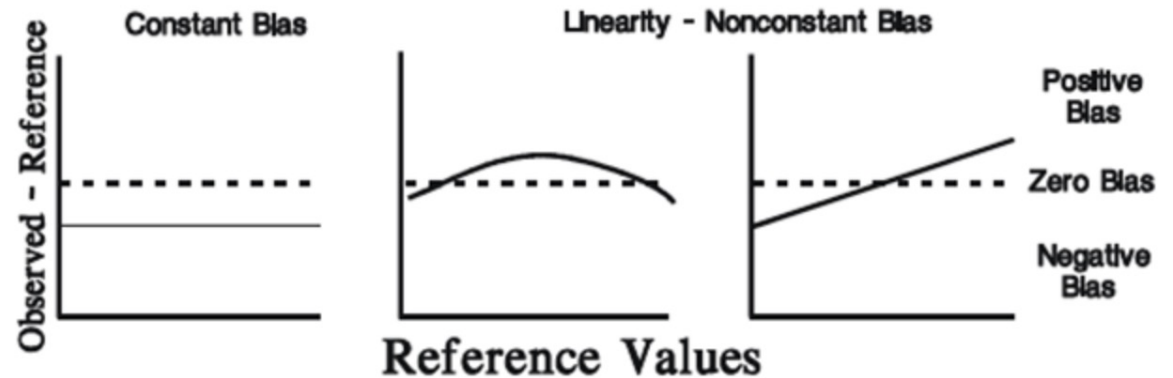
Problem

Test

Defining Linearity



change in bias over measurement range



Linearity Causes



Location error
could be a simple design
trade off, or a poor design

needs calibration
change in master(s)
poor maintenance practices
operator fatigue
environmental effects
worn equipment or fixture

Testing for Linearity



the big and small of a
measurement system

Repeat bias measurement using master samples that cover the range of the expected measurements

How good is

good enough?

In Summary

Gather Data



Clean the Data



Plots and Analysis



Ask Good Questions



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