Where are we?

Define	Measure	Analyse	Improve	Control
✓ Introduction	❑ Measurement & Variation	☐ Root Cause	☐ PDCA	☐ Auditing
✓ Y=(f)x	❑ Data Collection	☐ Regression	☐ Risk Management	☐ Lessons Learnt
✓ SIPOC	❑ Collection Plan	☐ Hypothesis Testing	☐ FMEA	☐ SOPs
✓ Cause & Effect	❑ MSA	☐ t-tests	☐ Value Stream Mapping	
✓ 5 Whys	☐ SPC	☐ ANOVA	☐ Solution Selection Matrix	
✓ Is it? Is it not?	☐ Process Capability	☐ DoE	☐ Five S	
✓ Project Charter	☐ Charting	☐ Cost Benefit Analysis	☐ Benchmarking	
✓ VoC & QFD	☐ Industry 4.0 technologies		☐ Control Plans	
✓ Critical to Quality (CTQ)			☐ Pilot Studies	
✓ Team Working				

Level 5 – Continuous Improvement with Industry 4.0

Measure 1 - Measurement and Variation

Measure Phase

- Identify measurement and variation
- Determine data type
- Develop data collection plan
- Understand Measurement Systems Analysis
- Perform data collection
- Perform capability analysis

- **What are we trying to achieve?**
- **Why measure? What to measure? How to measure?**

- Measurement allows us to;
  - Establish baseline process performance
  - Isolate sources of variation
  - Identify areas where improvements can be made.

Data Collection Plan

Help us ensure successful analysis of the problem by ensuring the data we collect is useful.

Attribute

Pass / Fail, Yes / No or Stop / Go
Hot/Cold (Attribute - Binary data)
Strongly agree/Agree/Disagree
(Attribute - Ordinal data)

Variable

Can be measured? Examples?

Data Collection Plan

1. What data will be collected?
2. Why is it needed?
3. Who is responsible?
4. How will it be collected?
5. When will it be collected?
6. Where will it be collected?

Ask yourself some questions…

- What knowledge is desired about the process?
- What are the potential sources of variation in the process?
- Are there cycles in the process?
- How much time is needed to collect data to capture a true picture?
- Who will be collecting the data?
- How will the measurement system be tested?

Ask yourself some questions…

- **Existing versus New?**
- **Have data or Need more data?**

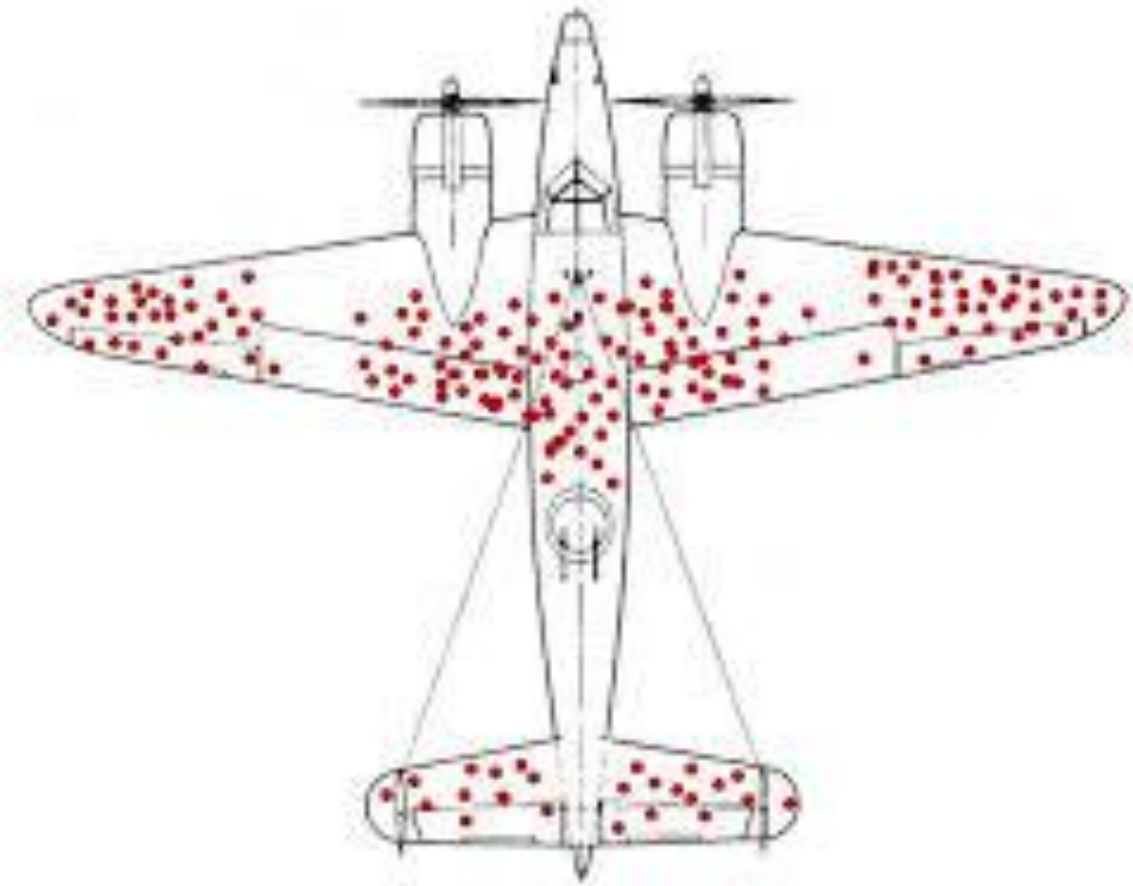
- Perhaps you have data already available? If not, what is the collection plan?

- Are your own organisation's definitions for measurement sufficiently detailed?

- Where could data collection errors occur? How will data collection errors be handled?

- How will the data be displayed?

The Pattern seems clear



Many of the airplanes were riddled with gunfire all over the wings and fuselage.

But they were not being hit in the cockpit or tail.

Syed, Matthew. 2015. Black Box Thinking. New York: Penguin Random House. pp 33-37

How do we know our Measurement System is giving us a true view of what is occurring?

Measurement Systems Analysis (MSA)

- How do we know our Measurement System is giving us a true view of what is occurring?

- We know we have process variation, what about appraiser (measurement device) variation?

Measurement Systems Analysis (MSA) is used to ensure that the information collected is a true representation of what is occurring in the process.

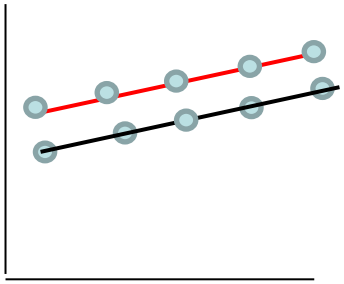
Measurement Systems Analysis (MSA)

- Measurement System Analysis (usually referred to as MSA) is a structured procedure which we use to assess the ability of a measurement system to provide good quality data.

Combination of people, equipment, materials, methods and environment.

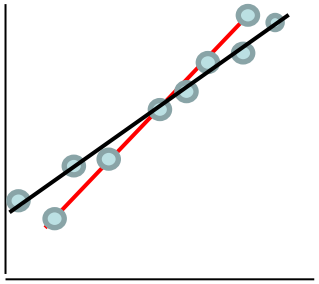
- Is the measurement system capable for this study?
- How big is the measurement error?
- How much uncertainty should be attached to a measurement when interpreting it?
- Are the measurements being made with measurement units that are small enough to properly reflect the variation present?

Measurement Systems Analysis (MSA)



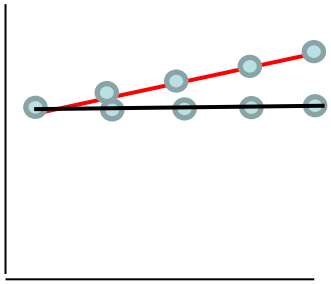
Bias Error – difference between actual and measured consistent e.g. weighing scales out by 10Kg (the offset is constant)

Measurement Systems Analysis (MSA)



Linearity Error – difference between actual and measured changes (the offset changes)

Measurement Systems Analysis (MSA)



Stability Error – differ to the other two as they manifest over time – same part measured but value changes (might be temperature, gauge wear?)

MSA Examples…

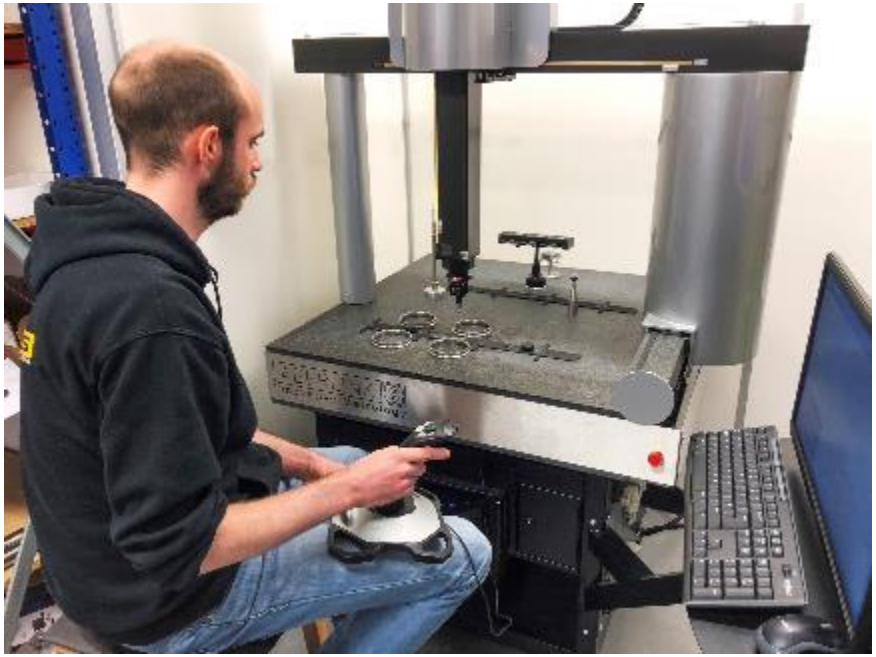
Time taken from receipt of an invoice until payment
Measurement System: a piece of computer software which measures the time from start to finish, or possibly someone measuring the time using a stopwatch or a clock

Dimensions of a machined part
Measurement System: a vernier calliper, a coordinate measurement machine (CMM) or a Go/No Go gauge in combination with the person operating the piece of equipment, the procedures they are following and environmental conditions such as the temperature or vibration level in the working environment.

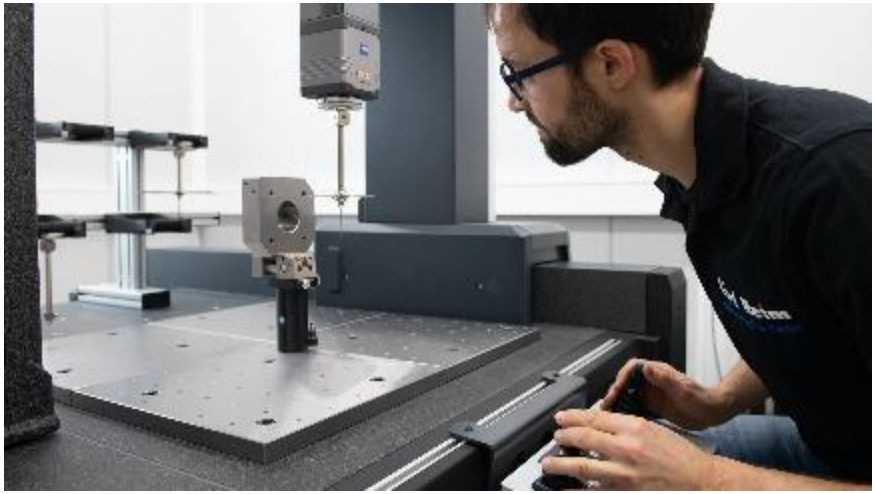
Number of errors on an engineering drawing
Measurement System: a person checking each drawing and counting the number of errors in combination with the assessment standards, procedures being used and environment conditions such as changes in the natural light conditions.

MSA Potential Pitfall

Where the measurement system is a device such as a vernier calliper or CMM and you have multiple devices it is important to recognise that each device is a separate system, and each must separately be analysed.



For example just because one CMM machine is a good or bad system does not mean that other ‘identical’ machines will have the same characteristics.



How does it work?

If the <u>same</u> person or piece of equipment measures the same item over and over again, do we consistently get the same data?

For example if the same person measures the weight of a parcel 3 times would they record the same weight each time?

If a person or a piece of equipment is not able to consistently measure the same item, then clearly this would result in unreliable data.

Repeatability assesses whether each person can measure the same item multiple times with the same measurement device and get the same value when measuring continuous data.

How does it work?

If <u>different</u> people or piece of equipment measures the same item over and over again, do we consistently get the same data?

For example if three different people weighed the same parcel multiple times would they each record the same weight?

Problems such as 'no fault found' parts are often a result of a lack of agreement between two different measurement systems. Any disagreement indicates a problem with the reliability of data collected from such a system

Reproducibility assesses whether different people can measure the same item multiple times with the same measurement device and get the same average value

Repeatability is asking the question 'do the appraisers agree with themselves when asked to do the same assessment a number of times?'

Reproducibility is asking the question 'do the appraisers agree with each other when asked to do the same assessments?'

Measure Phase

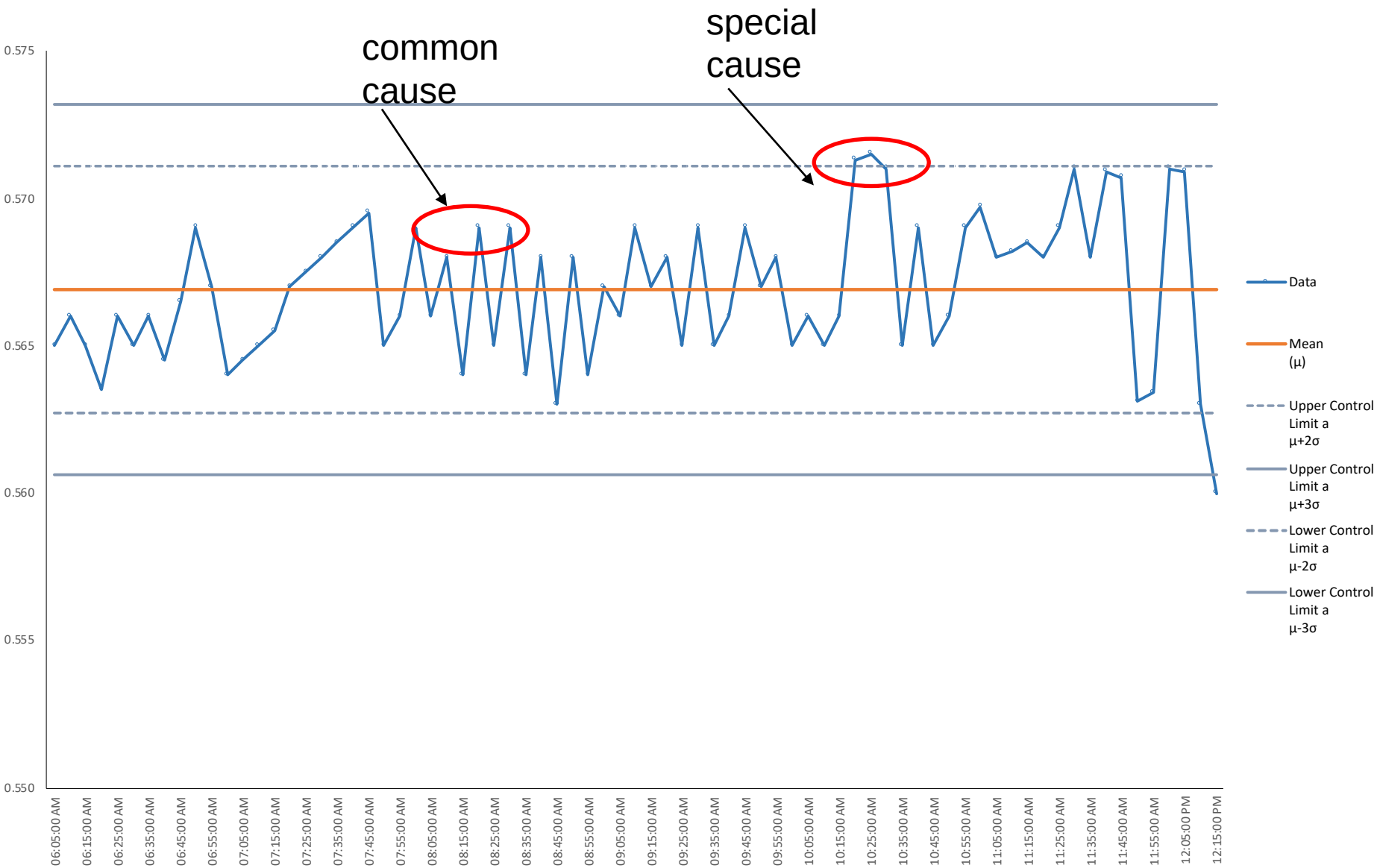
- ☐ Equipment to be used is calibrated
- ☐ Equipment used has sufficient measurement resolution.
- ☐ That the measurement system is suitable for a range of measurements.
- ☐ Equipment used is stable
- ☐ That there are clear operational definitions in place.
- ☐ Observe a few measurements being made.

- **Walter Shewhart, the man whose work laid the foundations for SPC, recognized that variation has two broad causes: common causes and special causes**

- **Common causes of variation** are inherent in the process and can be thought of as the "natural rhythm of the process."

Common causes are evidenced by a stable, repeating pattern of variation. Real quality improvement requires a continual focus on reducing common- cause variation.

Control Chart



Measure Phase

	Definition	Characteristics
Common Cause Random	No undue influence by any of the 6Ms	Expected Predictable Normal
Special Cause Non-Random	Undue influence by at least one of the 6Ms	Unexpected Unpredictable Not normal

- **Special causes of variation** are a signal that something has changed in the process, disruption of the stable, repeating pattern of variation.

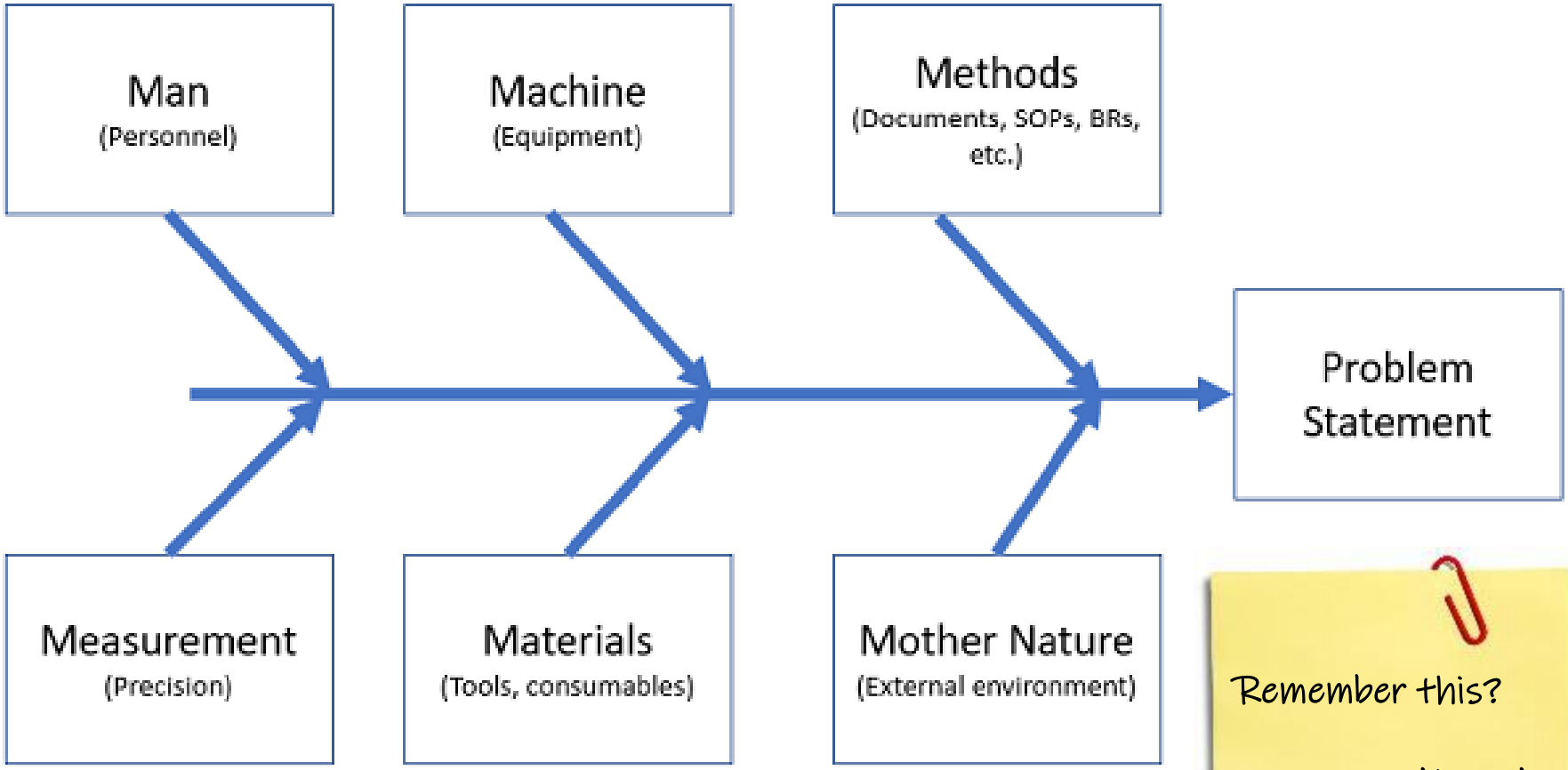
Special causes of variation result in unpredictable process performance and must therefore be identified and removed before taking other steps to improve quality.

- **Why is it important to distinguish between these two types of variation?**

- **Because the remedies are completely different.**

Understanding the difference between the two types of variation helps manufacturers to target quality improvement efforts correctly and thereby avoid wasted effort and expense.

Sources of Variation – 6Ms



Remember this?

We can use it again here in the Measure phase.