



It's all about stability and capability

SPC AND PROCESS CAPABILITY

A photograph of a city street scene. In the foreground, a person wearing a light-colored sweater and dark pants is walking away from the camera on a sidewalk. The street is paved with asphalt and has a white painted line. In the background, there are several cars, including a yellow taxi and a dark SUV, parked or moving. The buildings are multi-story and have various signs and windows. The overall tone of the image is slightly desaturated, giving it a vintage or artistic feel.

Statistical Process Control

Process Capability



Role of Tolerances

The background of the slide is a photograph of a brick wall. The bricks are in shades of red and orange. In the center of the wall, there is a large, faded red heart shape. On the left side of the wall, there are two vertical pipes. The pipe on the far left is dark and has some rust or discoloration. The pipe next to it is silver and appears to be made of metal. Both pipes are secured to the wall with brackets.

It all starts in
design



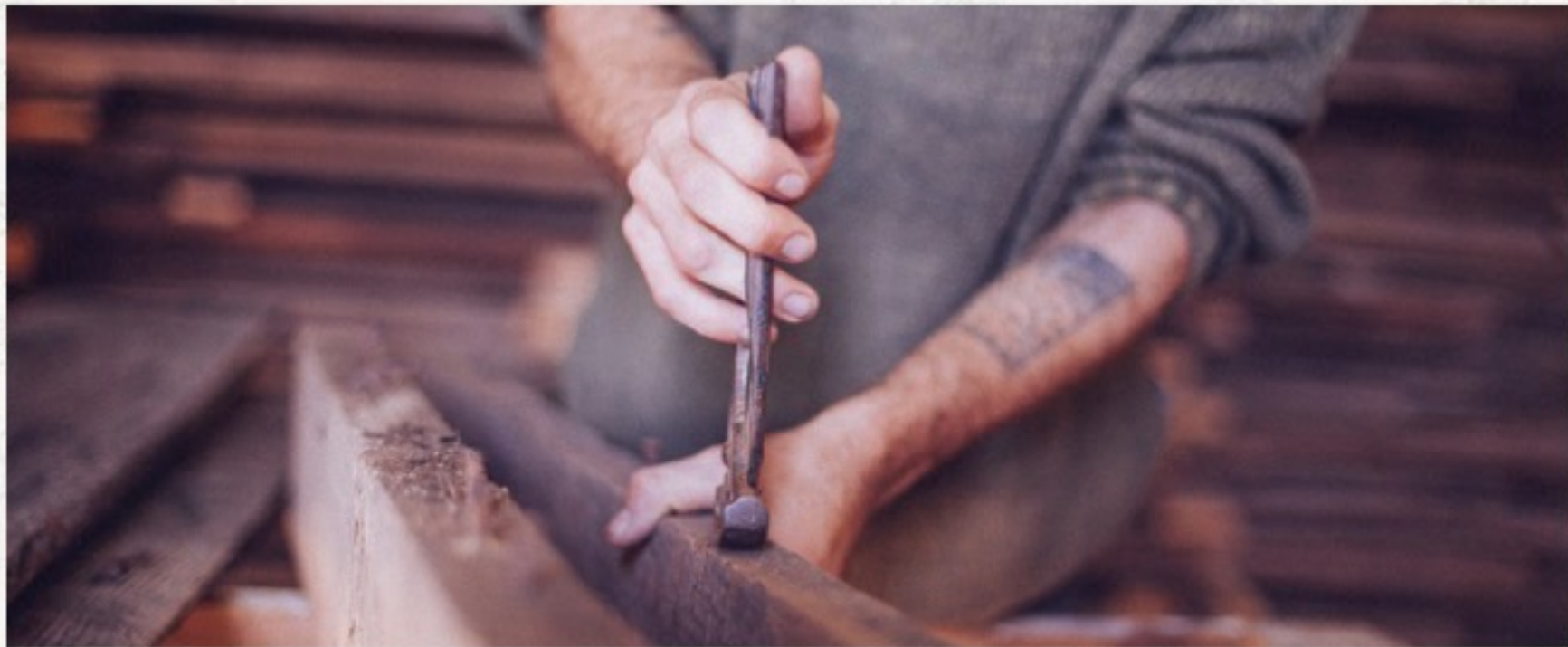
Visual tracking made easy

CONTROL CHARTS

It's The Design's Fault



Variation Happens



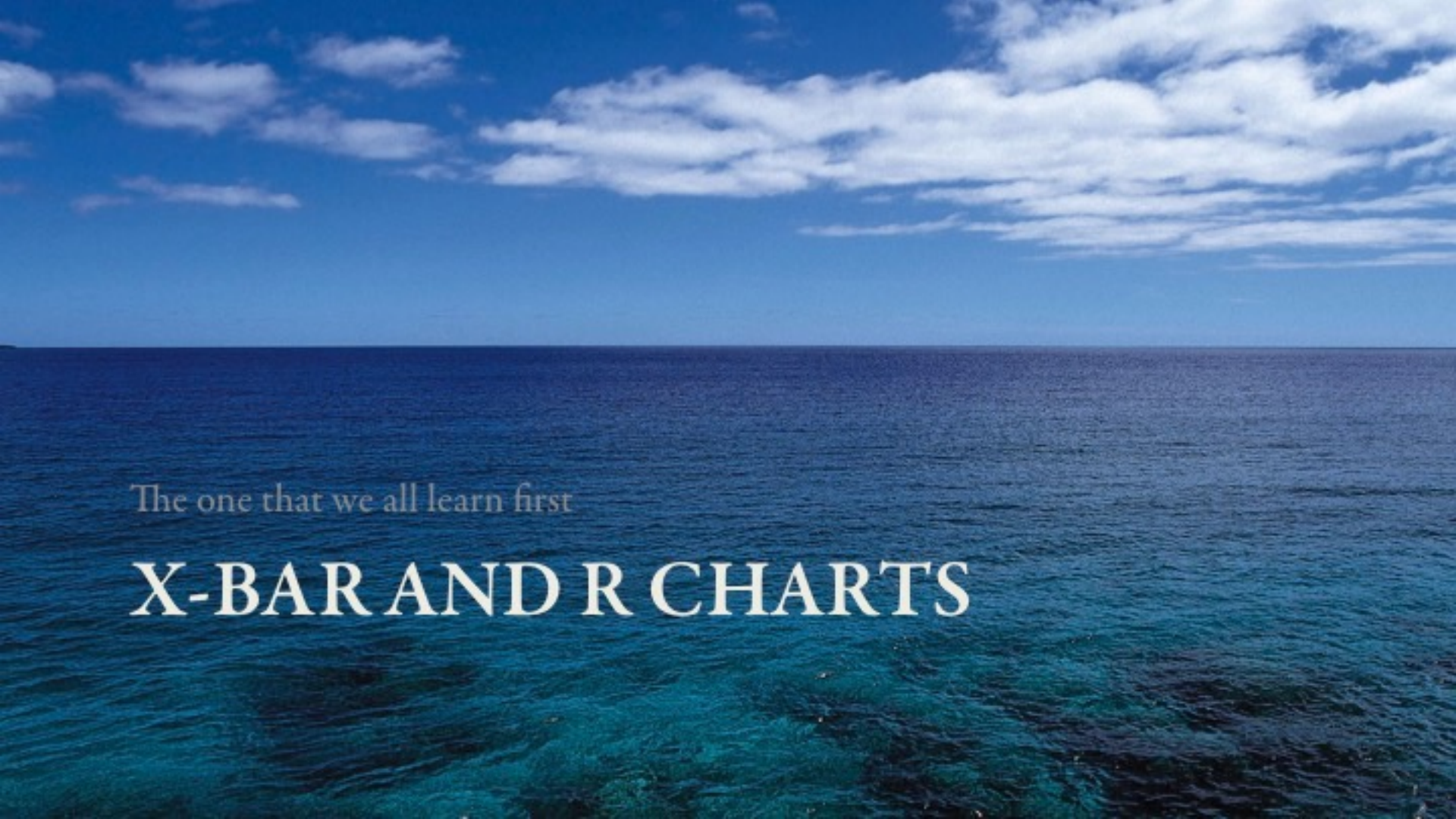
SPC is a Tool to Check Stability



Once Stable, Check Capability



How do you
know if a control
chart is real?



The one that we all learn first

X-BAR AND R CHARTS



Steps to construct $\bar{X}$ & R charts

1. **Determine sample size**
2. **Collect 20 to 25 sets**
3. **Calculate average for each sample**
4. **Calculate range for each sample**
5. **Calculate $\bar{\bar{X}}$**
6. **Calculate $\bar{R}$**
7. **Calculate control limits**
8. **Plot the data and ID out of control signals**

A few factors and formulas

$\bar{X}$ Chart

$$UCL_{\bar{X}} = \bar{\bar{X}} + A_2 \bar{R}$$

$$LCL_{\bar{X}} = \bar{\bar{X}} - A_2 \bar{R}$$

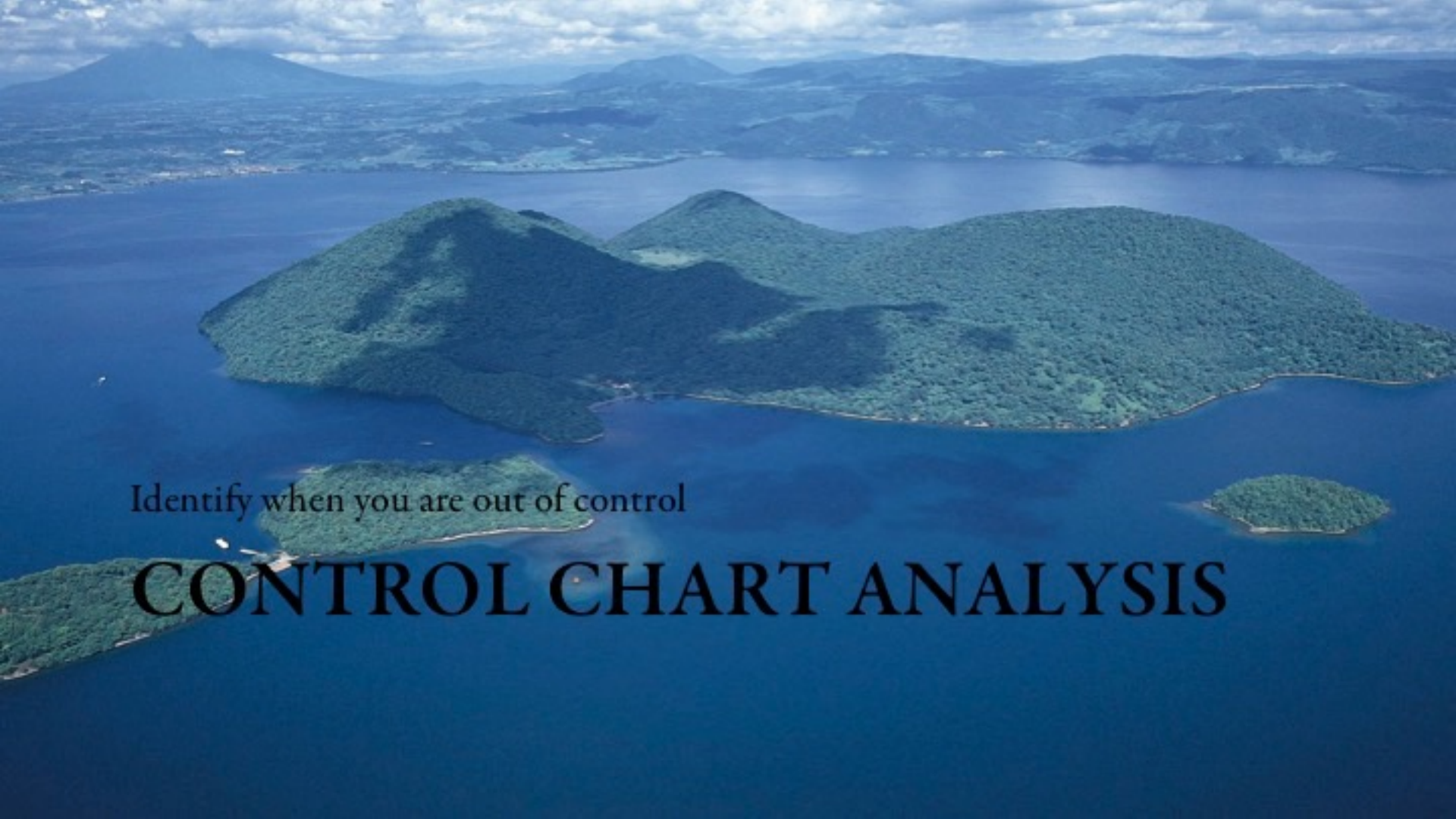
R Chart

$$UCL_R = D_4 \bar{R}$$

$$LCL_R = D_3 \bar{R}$$

n	A2	D3	D4
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00

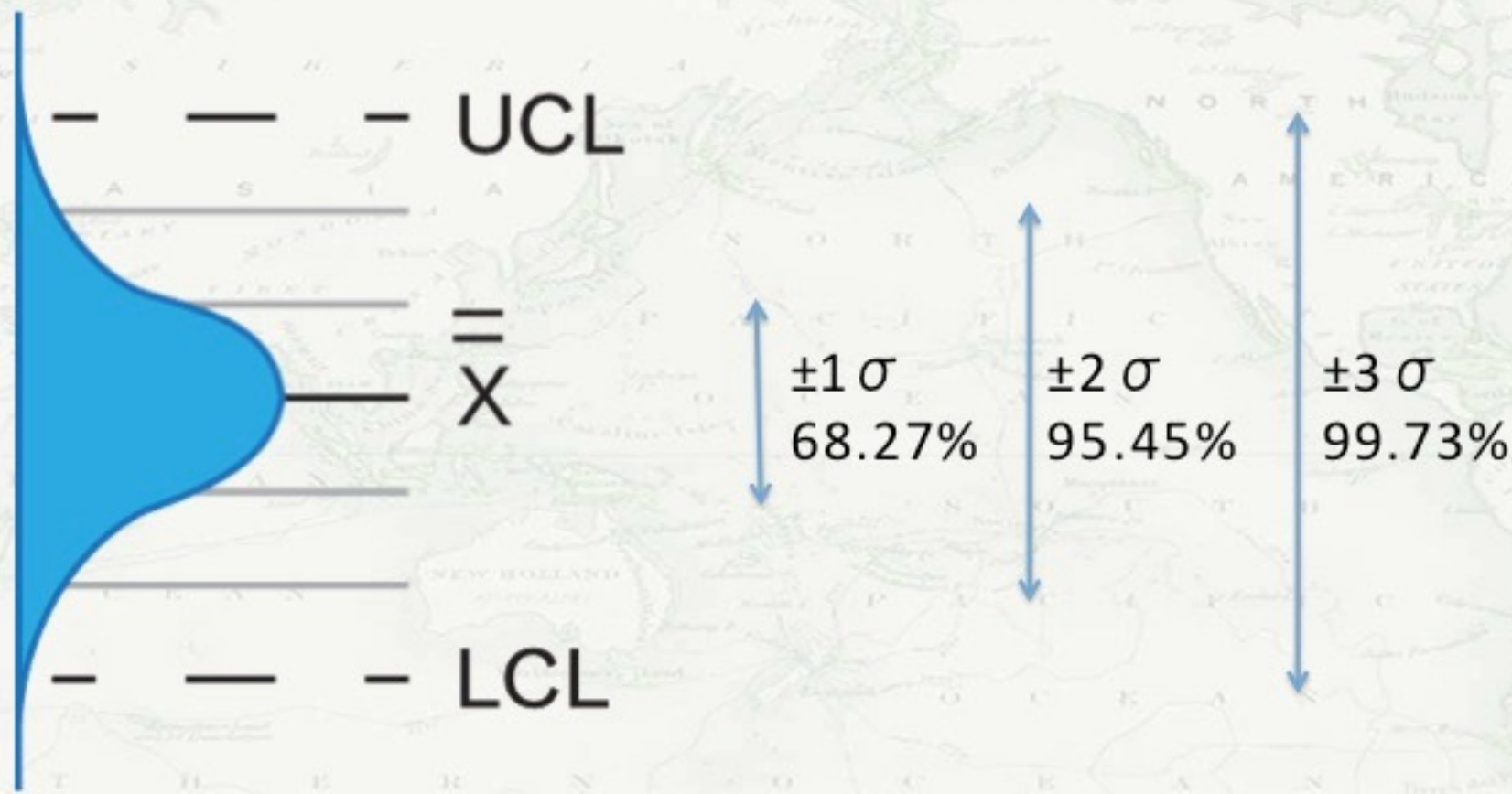
What is the role
of the Central
Limit Theorem?

An aerial photograph of a tropical island. In the foreground, a large, forested island with a prominent volcano dominates the scene. The volcano has a conical shape with a dark, shadowed peak. The island is surrounded by deep blue water. In the background, a large body of water, likely a lake or bay, stretches towards the horizon. Beyond the water, there are more mountains and hills under a cloudy sky. The overall scene is serene and scenic.

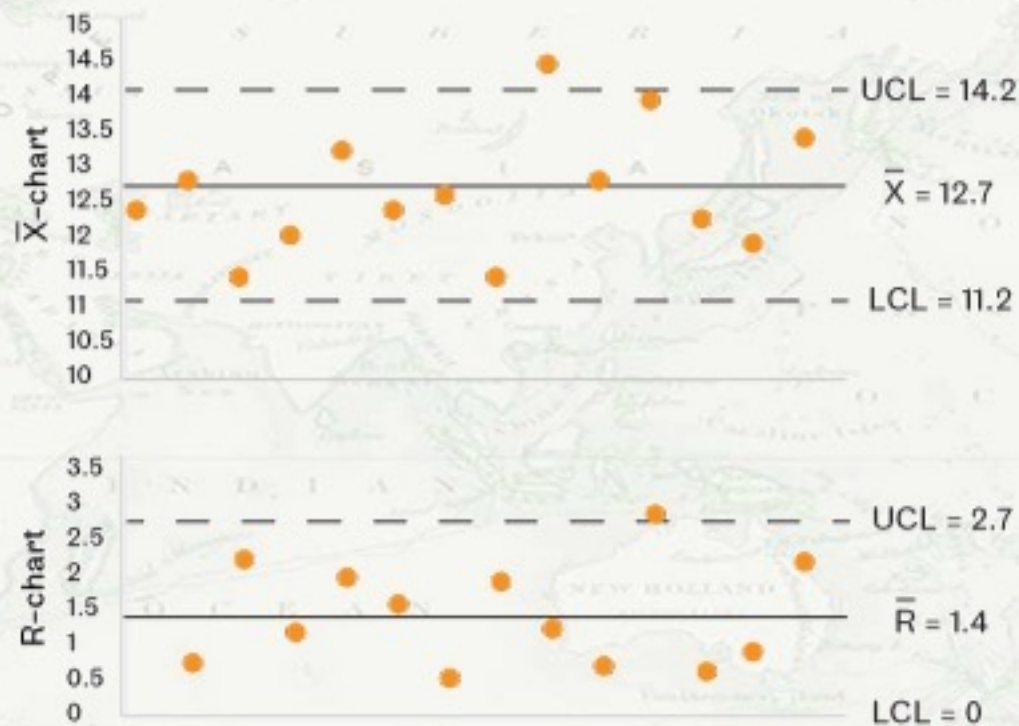
Identify when you are out of control

CONTROL CHART ANALYSIS

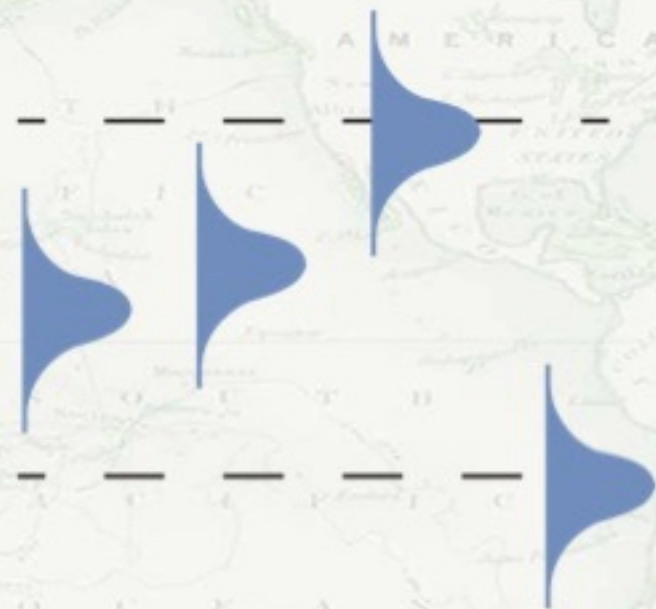
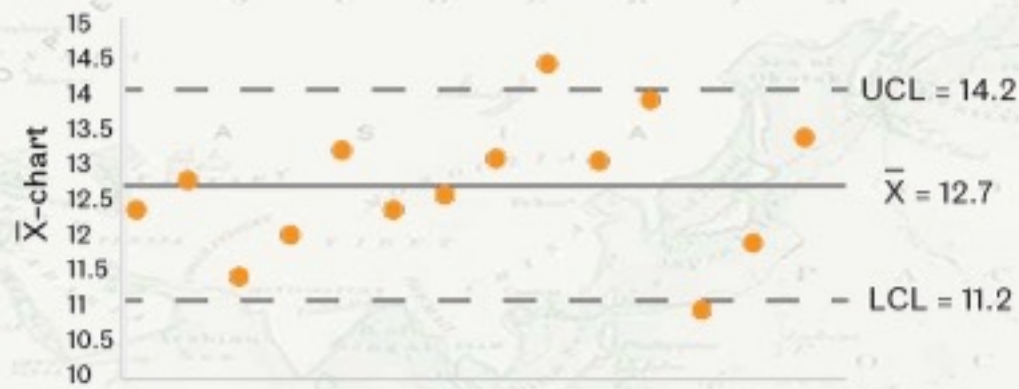
Special Causes indicate out of control



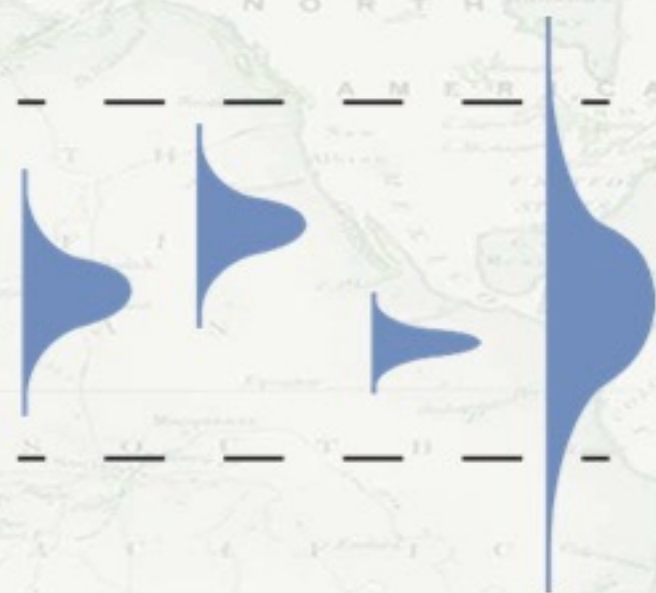
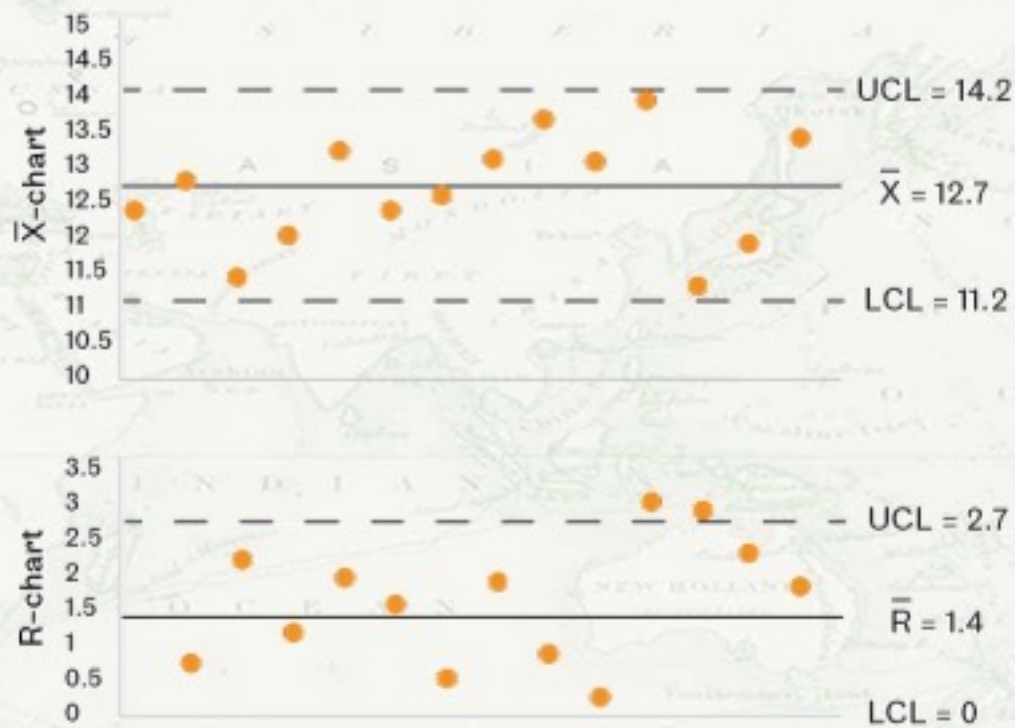
Average & Variation Out of Control



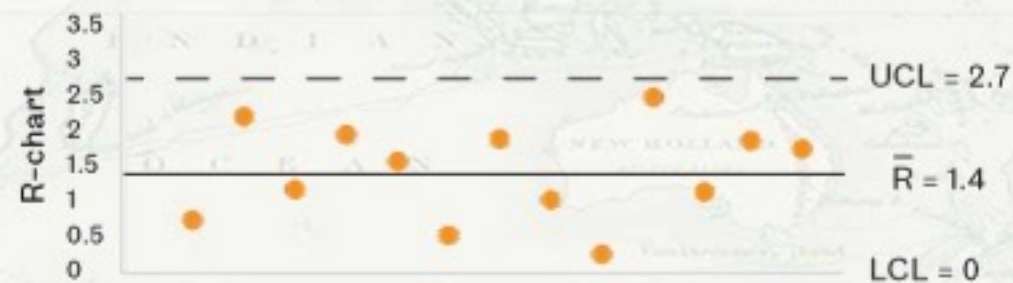
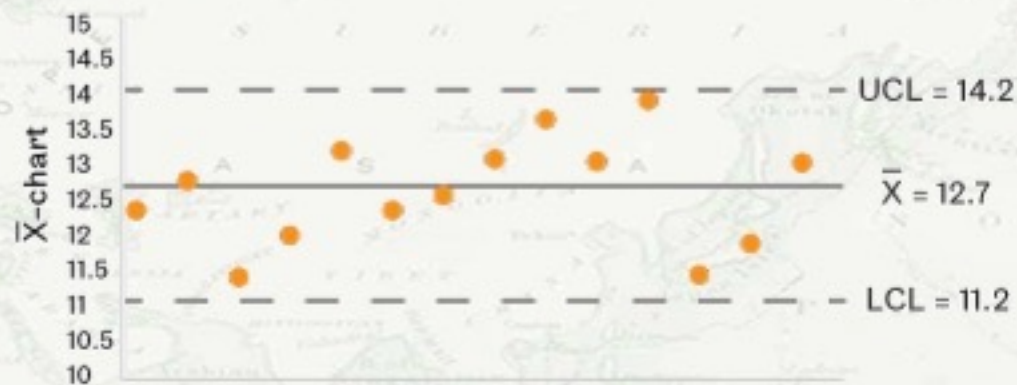
Average Out of Control



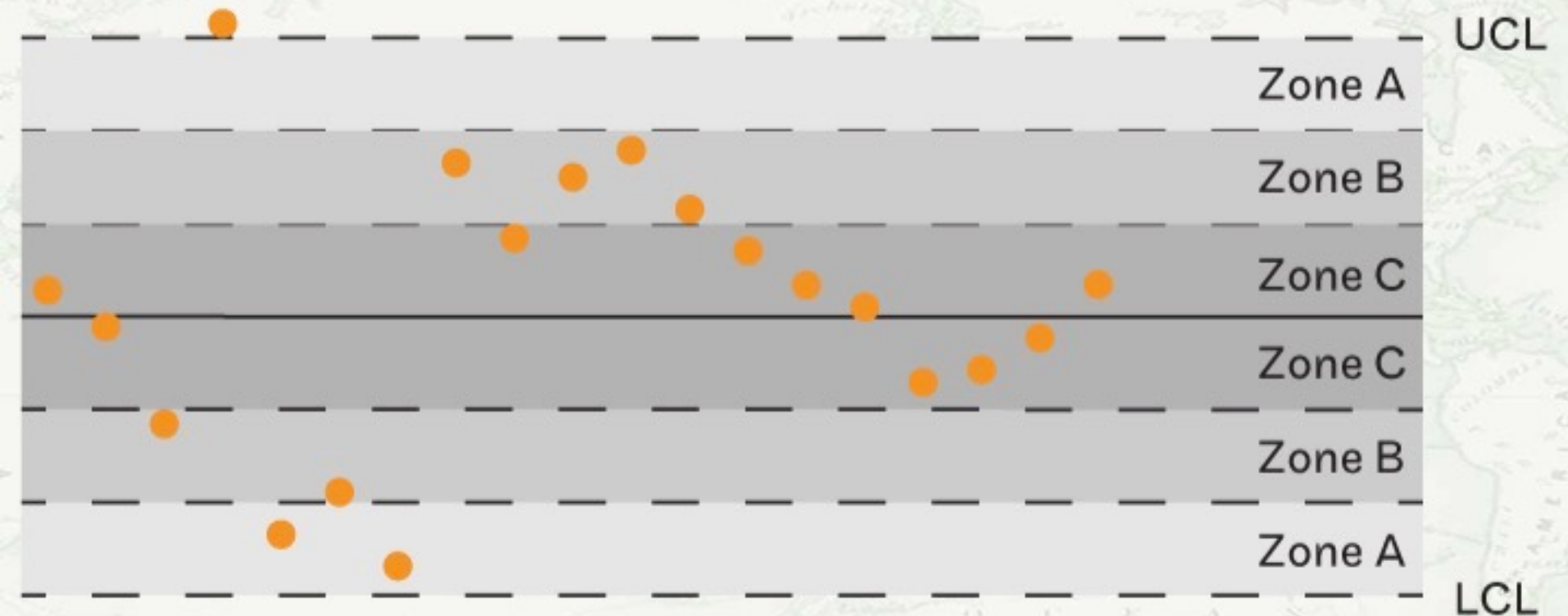
Variation Out of Control



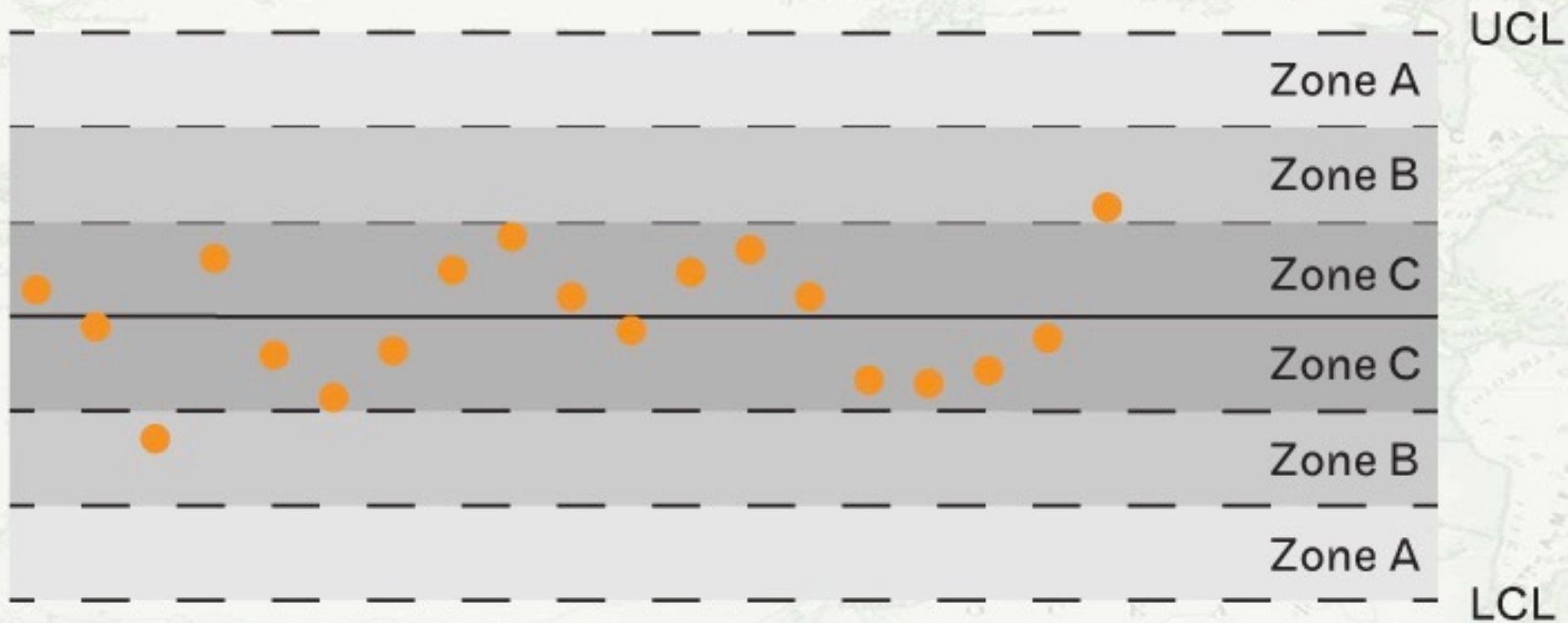
Process In Control



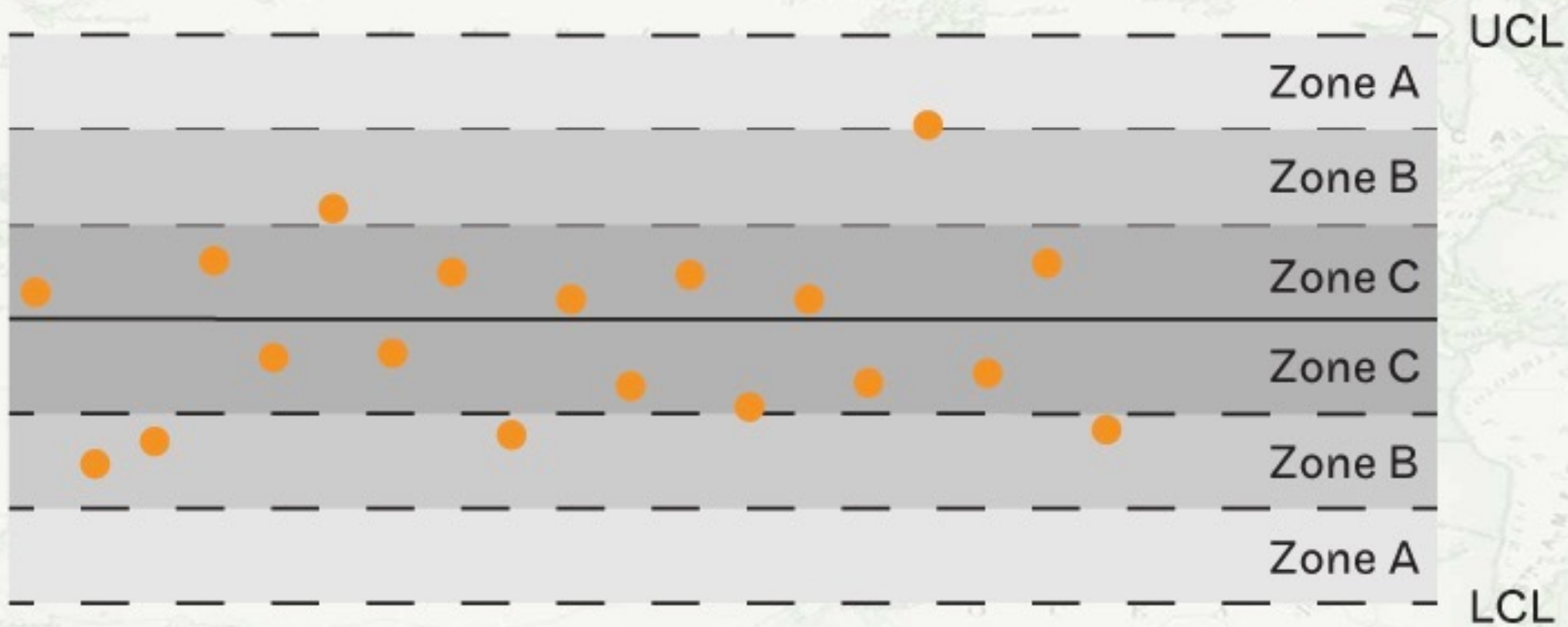
Five Common Rules



Stratification Rule



Mixture or Systematic Variation



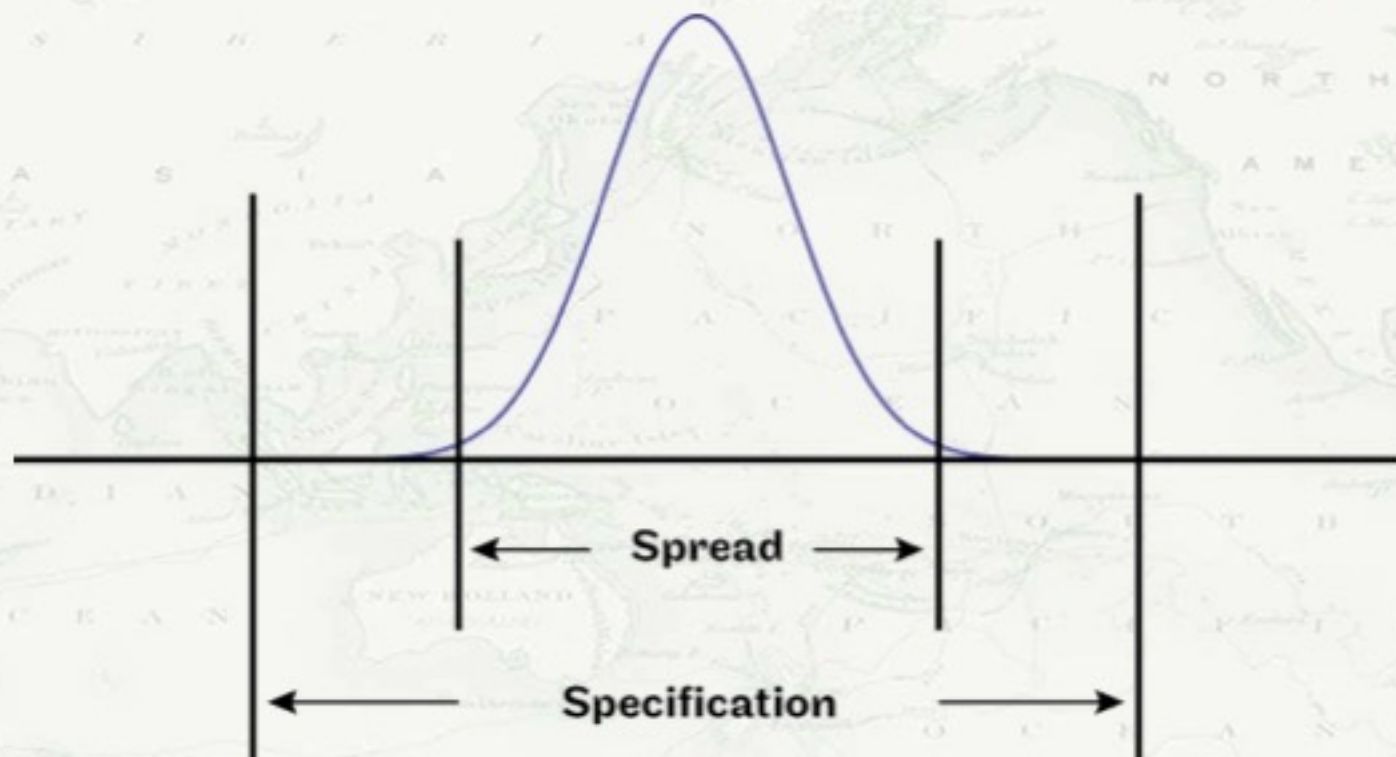
What is the
probability of
each signal?

An aerial photograph of a rugged coastline. The foreground shows dark, rocky cliffs meeting the ocean, with white foam from breaking waves visible. The middle ground features a steep, grassy hillside that slopes down towards a small town or village nestled in a valley. The background shows more distant, hilly terrain under a clear blue sky. The overall scene is dramatic and scenic.

So what, your stable, is that good enough?

PROCESS CAPABILITY INDICES

Spread vs Tolerance



Comparison & Actions

- 1. Do nothing – everything is in spec**
- 2. Change the specifications**
- 3. Center the process**
- 4. Reduce Variability**
- 5. Accept the losses**

C_p

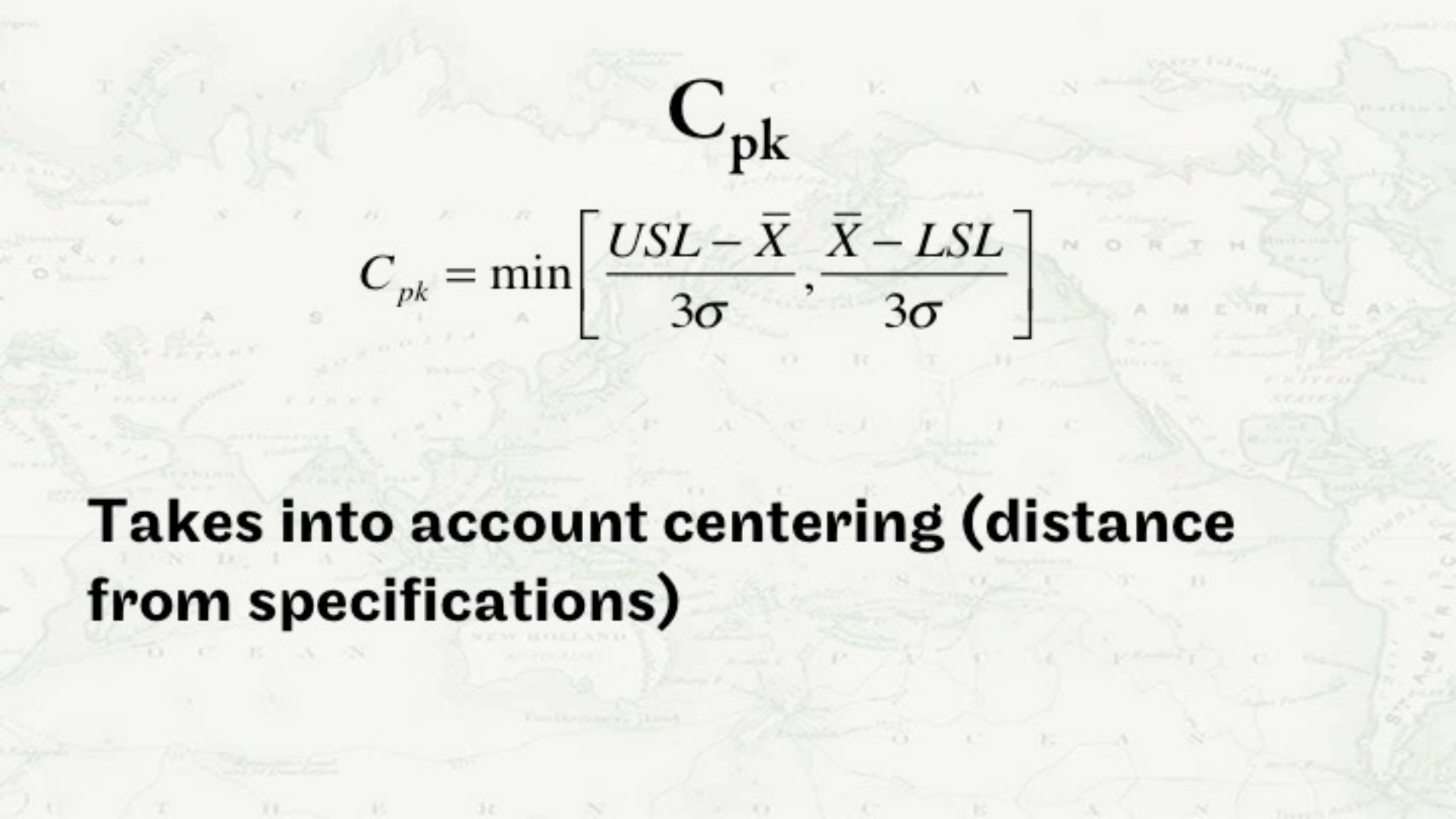
The Capability Index

$$C_p = \frac{USL - LSL}{6\sigma}$$

$C_p > 1.33$ – Capable

$C_p = 1$ to 1.33 – Capable with tight Control

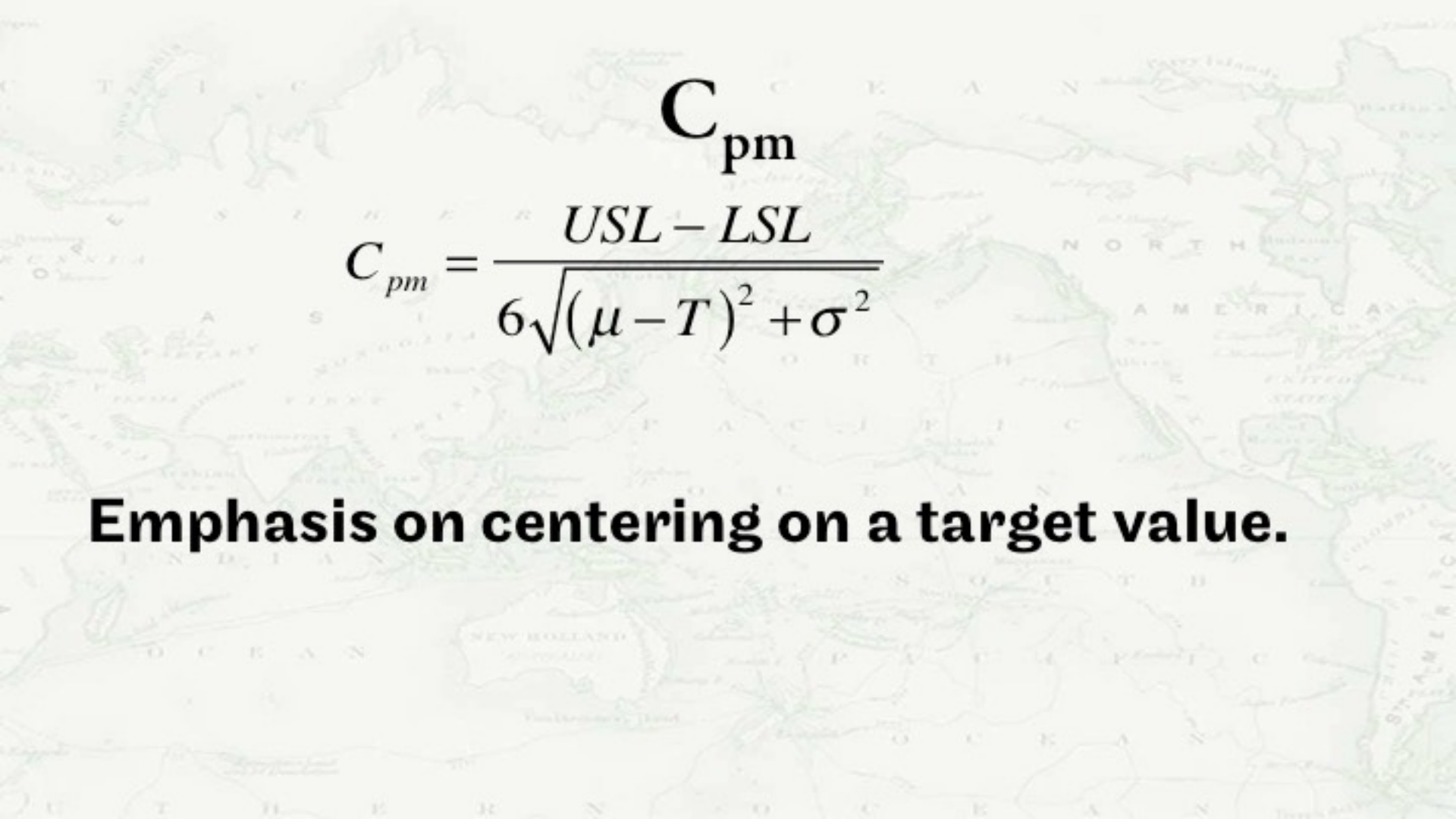
$C_p < 1$ – Incapable



C_{pk}

$$C_{pk} = \min \left[\frac{USL - \bar{X}}{3\sigma}, \frac{\bar{X} - LSL}{3\sigma} \right]$$

Takes into account centering (distance from specifications)



C_{pm}

$$C_{pm} = \frac{USL - LSL}{6\sqrt{(\mu - T)^2 + \sigma^2}}$$

Emphasis on centering on a target value.

Stable and
Capable?