Back to Basic Statistics

Challenging the Status Quo in Statistical Process Control

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Head
Quality Statistics

Phantom
Phone Booths, Inc.

10,000+ units in service

10,000 issues per month

10 years of historical data

CEO
Phantom

Head
Quality Statistics

What is the data telling us?
When do we need to take action?
Can we improve the quality of our products?

What have you been doing so far?

We monitor all our calls on a monthly basis. We use:

- *DPMO (Defects Per Million Opportunities)*
- *Normalization based on # of phone calls*
- ***Statistical Process Control***
- *12-month rolling averages*

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Defects Per Million Opportunities

$$DPMO = \frac{1,000,000 \times \text{number of defects}}{\text{number of units} \times \text{number of opportunities per unit}}$$

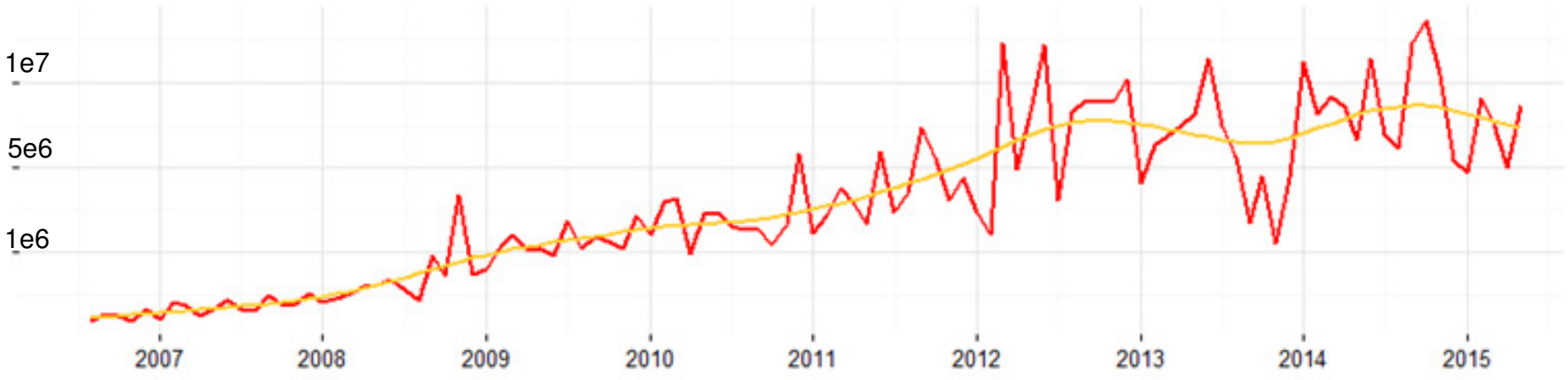
As an example:

The #1 issue last month was on “Dropped call”, which we received 3,000 issues.
We had 10,000 active phone booths and 10,000,000 phone calls last month.

This comes out to 300 DPMO.

Normalization

We get # of calls from our database. Unfortunately we don't get any data for Europe or Australia. Also, some of the data is self-reported so it isn't 100% reliable.



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Statistical Process Control

Walter A. Shewhart, Bell Laboratories, 1924
a.k.a. Shewhart Chart, Control Chart

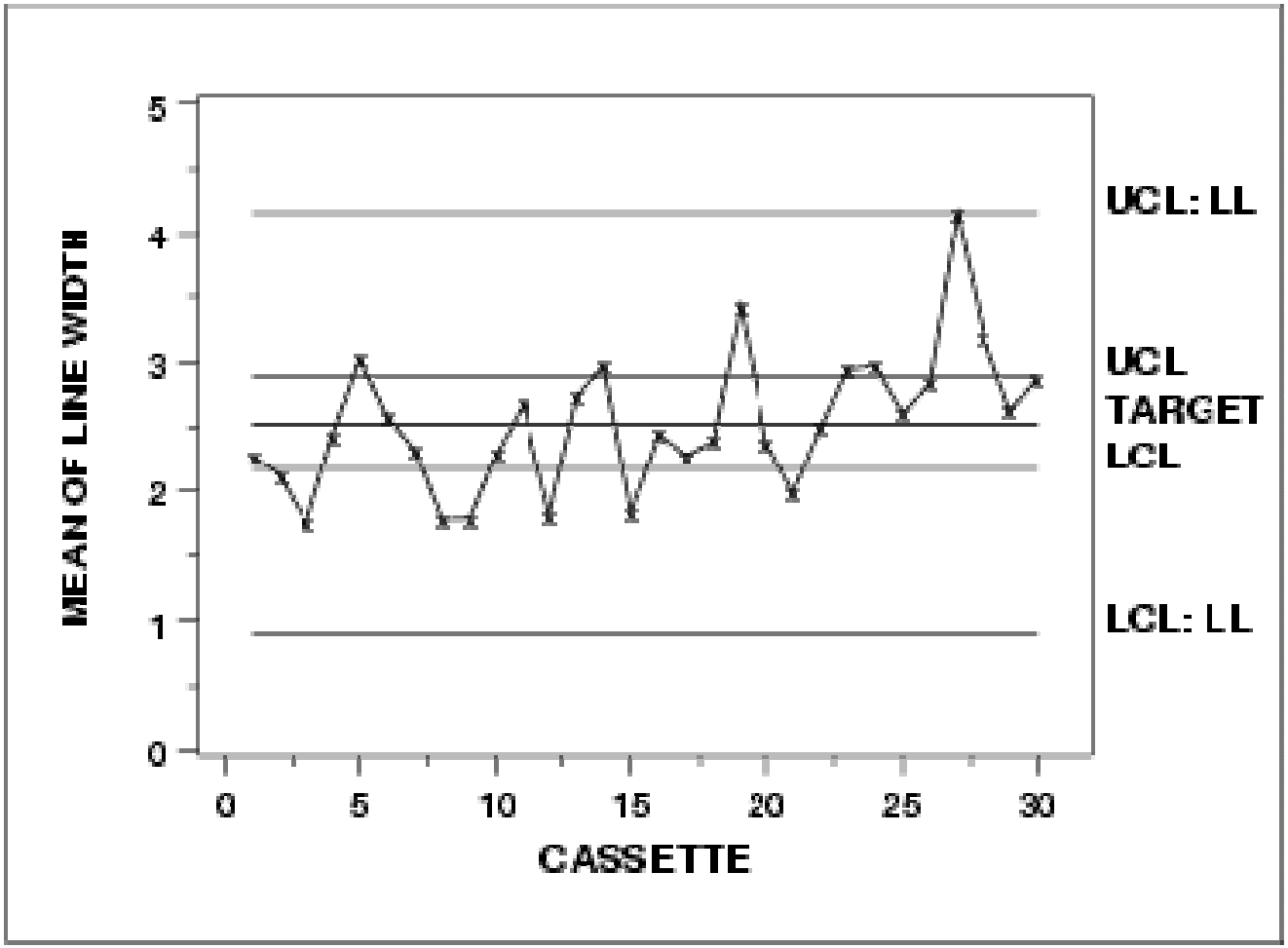
Purpose:

- To monitor and reduce variation in a manufacturing process.
- To minimize waste and failures in the field.

Pioneering use:

Amplifiers manufactured for use in telephony transmission systems.

Statistical Process Control



12-Month Rolling Averages

Purpose:
To help establish the Upper Control Limit (UCL).

$$UCL \cong \bar{x} + 3\delta$$

Where $\bar{x}$ is the average DPMO of the last 12 months.

$$UCL = \overline{x_{12}} + \frac{3\overline{MR}}{1.128}^{*}$$

* Montgomery, Douglas (2005). Introduction to Statistical Quality Control. Hoboken, New Jersey: John Wiley & Sons, Inc. ISBN 978-0-471-65631-9. OCLC 56729567.

What problems have you had with SPC?

Well, you see, both our inspectors and we realize the following shortcomings…

1. *If the DPMO is increasing gradually over many months, we will never exceed the UCL.*
2. *If we always had a lot of issues, our UCL will be very high.*
3. *Many issue types are rare (0 to 2 per month). For these types, 1 received issue becomes flagged by the UCL.*

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I use statistics like a drunken man uses lampposts – for support rather than illumination.

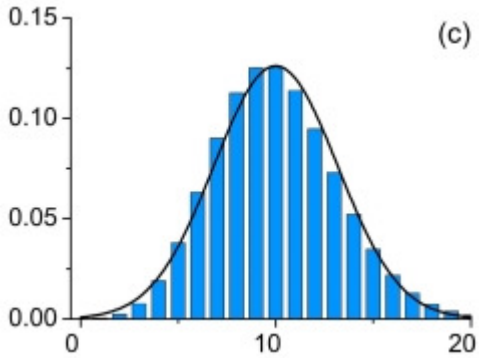
- Andrew Lang 1910

What would you do?

The Data Are Different

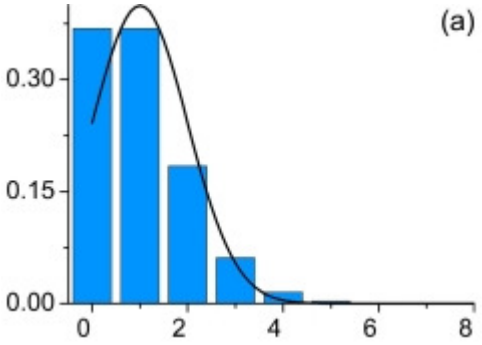
SPC Data

- Samples from a lot
- Sequence of data not as important
- Normal distribution



Issue Data

- Events in the field
- Time is a critical variable
- Poisson distribution



(especially rare events)

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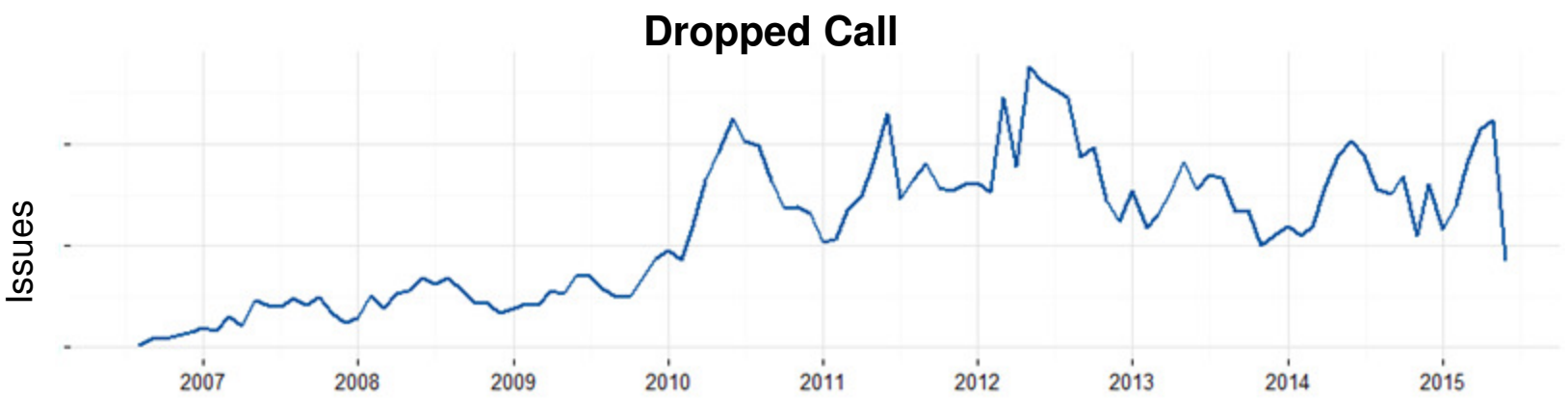
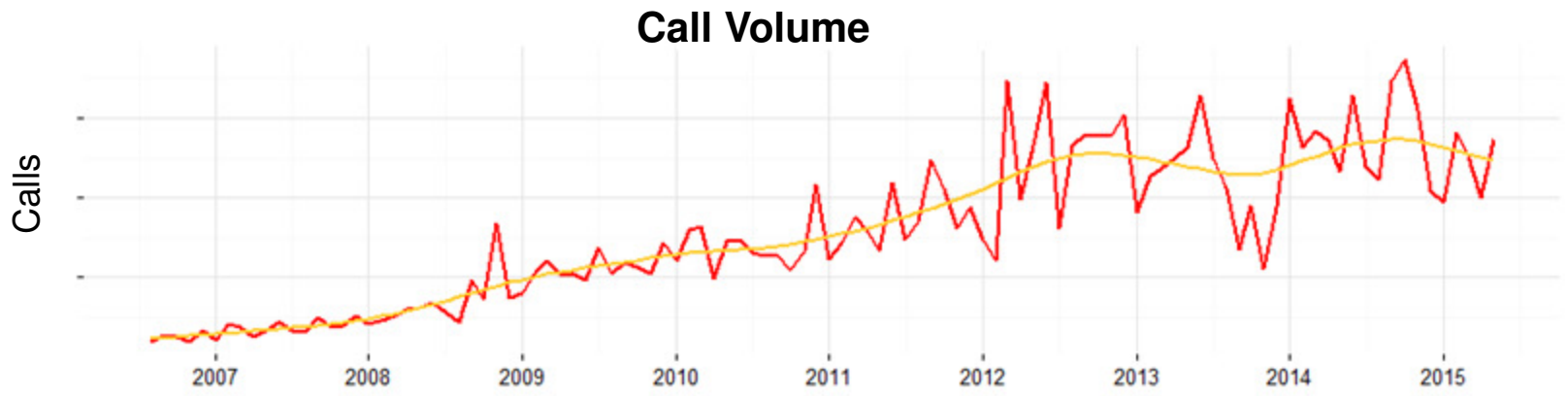
#1: Get Source Data





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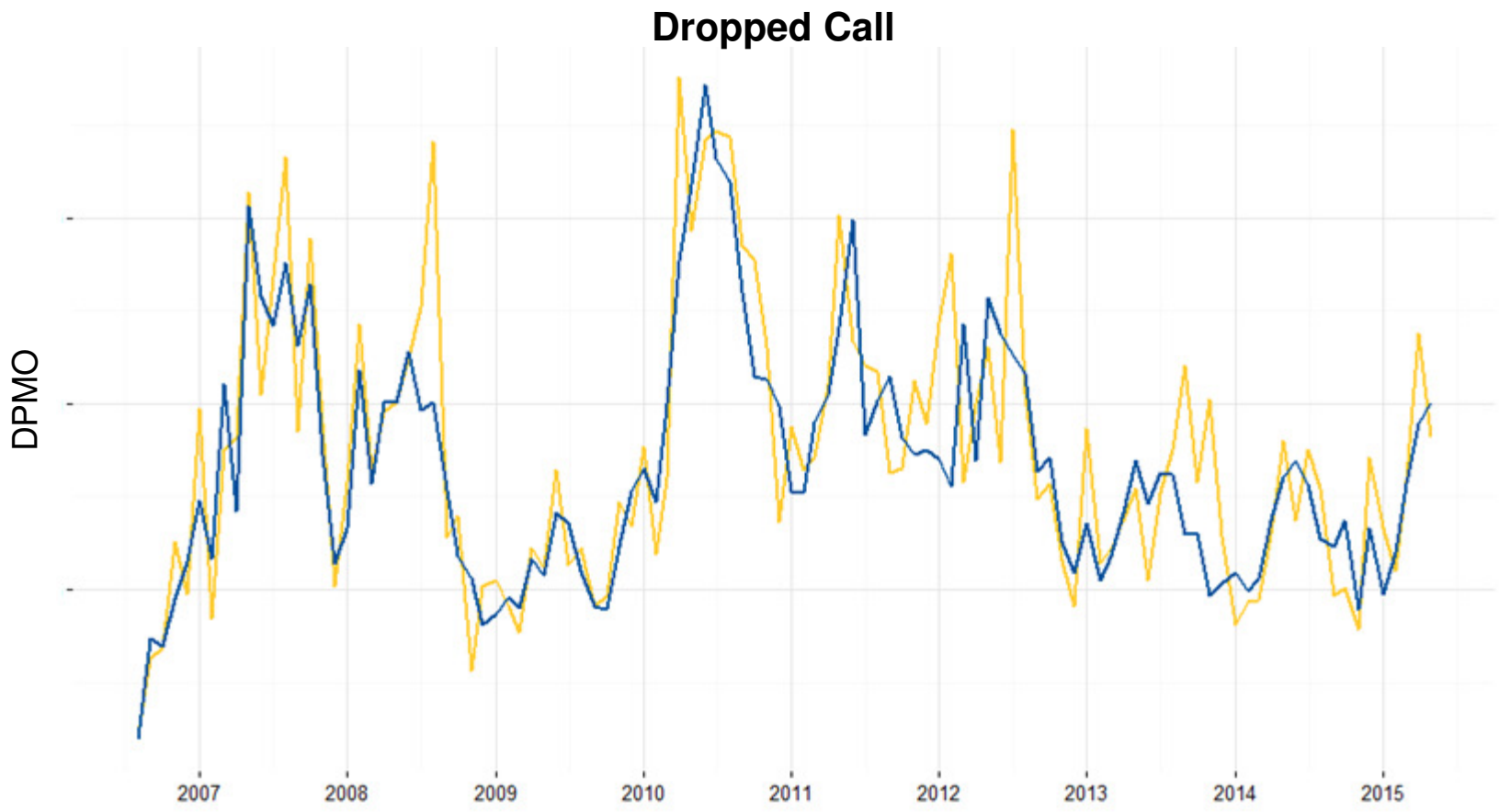
#2: Calculate DPMO



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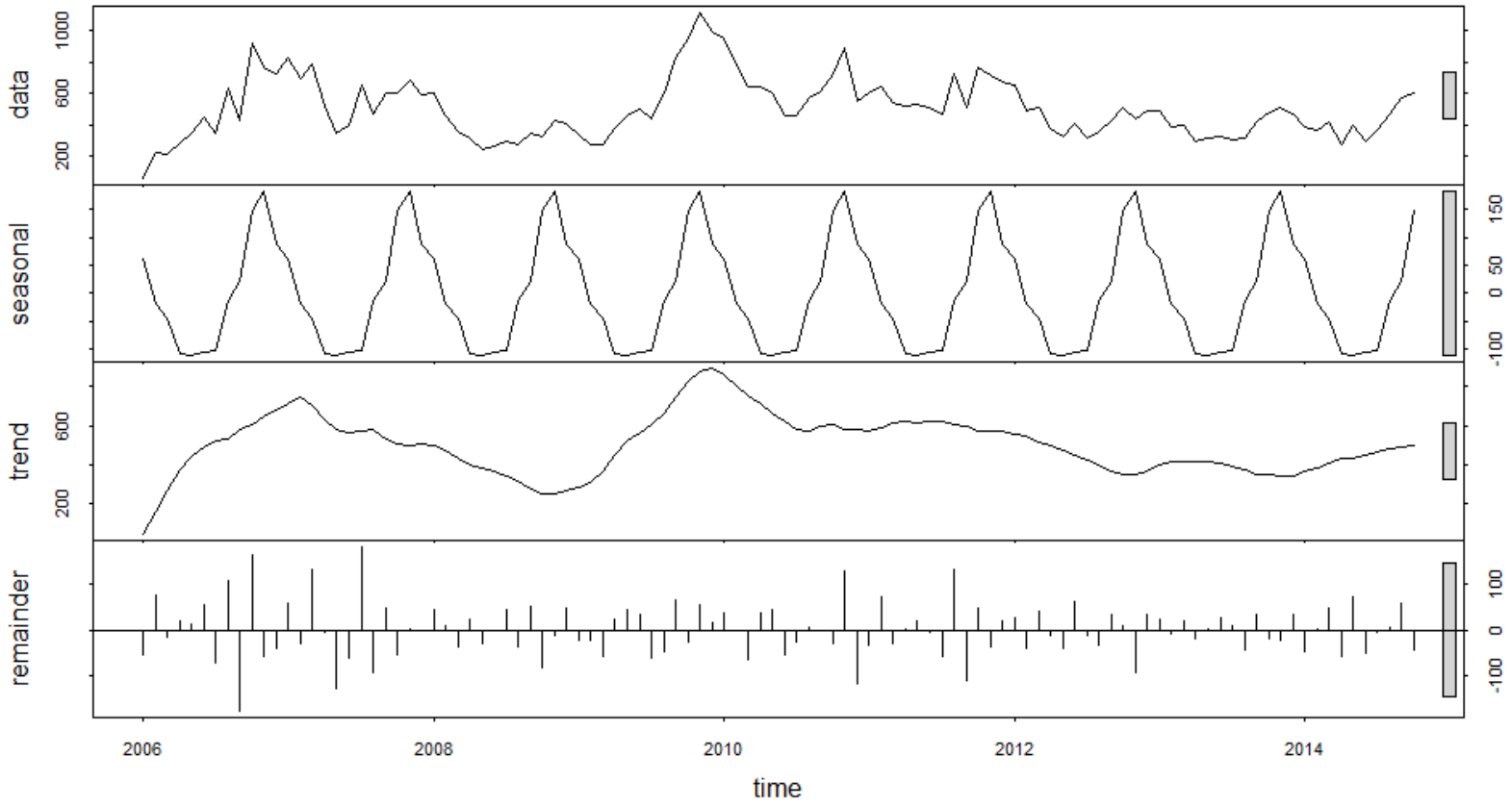
#3: Seasonal Trend Decomposition Using LOESS



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How does this work?

Once the decomposition is done, we look at the following:

- **O**ver – Is the actual DPMO too high?
- **R**epeated – Does the DPMO exhibit periodic behavior?
- **D**irectional – Is the a steadily increasing trend?
- **U**nusual – Is the DPMO unexpectedly higher than normal?

O Six Sigma methodology of minimizing complaints
R Seasonal or cyclic component in a time-series model
D Non-stationary behavior in a time-series model
U Above the UCL of a Shewhart control chart, typically 3σ

} Seasonal Trend Decomposition (STL) Cleveland et al., 1990

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How long does it take to detect a signal?

Assuming a monthly trending process:

- **O**ver – 1 month
- **R**epeated – 7-18 months
- **D**irectional – 3-7 months
- **U**nusual – 1 month

[R] Standard lag of 12, or annual seasonality, with an assumption of 1.5 periods to signal detection, equals 18 months. Lag of 3, or quarterly seasonality, is limited by resolution to a minimum of 7 months per (3).
[D] Current STL LOESS smoother is set to a lag of 7 as a compromise between time to detection and false signal rate from a small smoothing window.

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