

# Causal Loop Diagrams in Quality

24 APRIL 2024

**A. E. (Andy) Moysenko**

**ADVYSE**

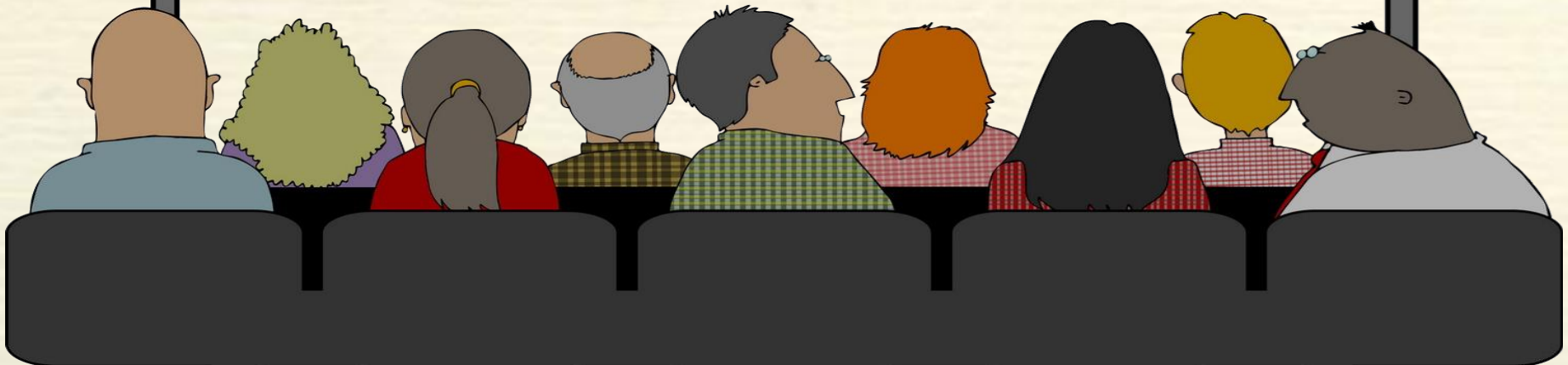
+1-978-427-3838

Andrew\_moysenko@uml.edu

www.advvyse.com



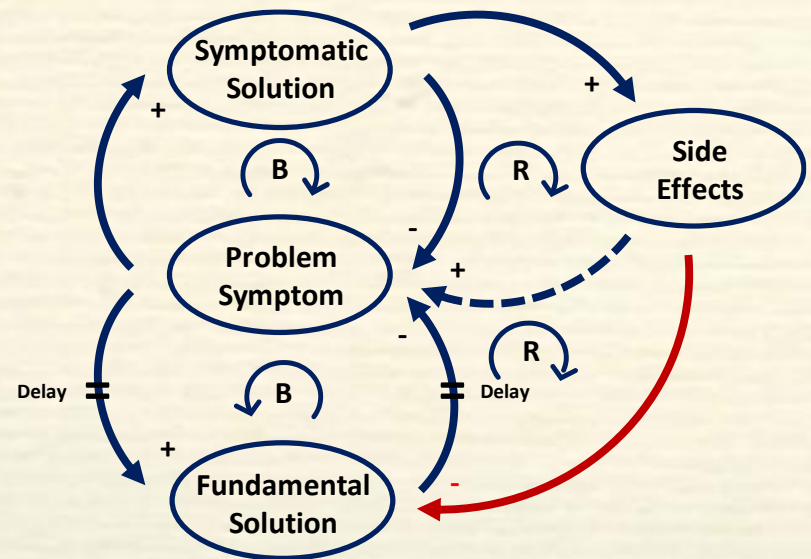
# Greetings and Introduction



# Not Casual Loops:



# CAUSAL Loops:



# Overview

## GOAL:

**Introduce Causal Loop Diagrams as Quality Tools**

## TOPICS:

- **Process Characteristics & Descriptions**
- **Causal Loop Diagram Basics**
- **Causal Loop Diagram Examples**
- **Causal Loop Diagrams & Other Quality Tools**
- **Systems Archetypes**

# Learning Objectives

- **Learn how to construct Causal Loop Diagrams for simple processes**
- **Better understand the advantages of Systems Thinking for managing complex issues**
- **See how to avoid common “unintended consequences” in dynamic systems**

# PROCESS DYNAMICS

# Process Mentality

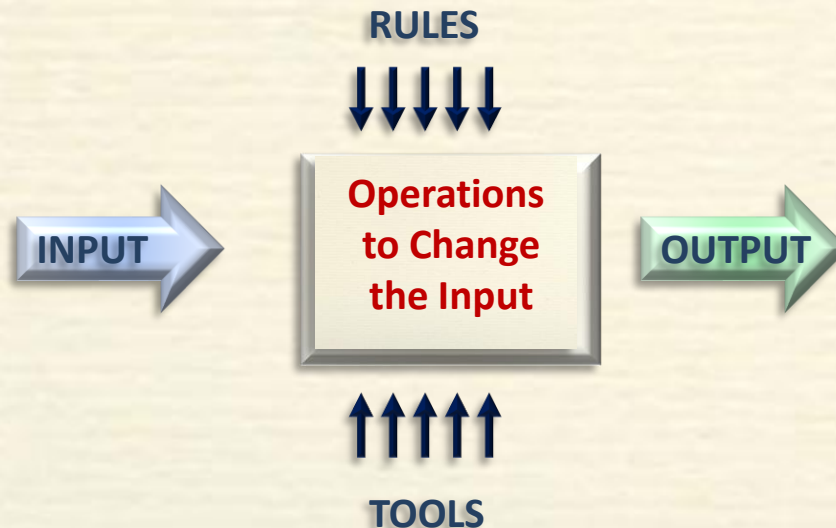
**A “Process Mentality” is essential to Enterprise Effectiveness**

- **ISO 9001**
- **Six Sigma**
- **Lean Manufacturing**
- **Project Management**
- **Business Management**

# Processes

## Just what is a process ??

- A process basically consists of:
  - Inputs and Outputs / Vendors and Customers
  - Rules and Tools
  - Measures of Performance

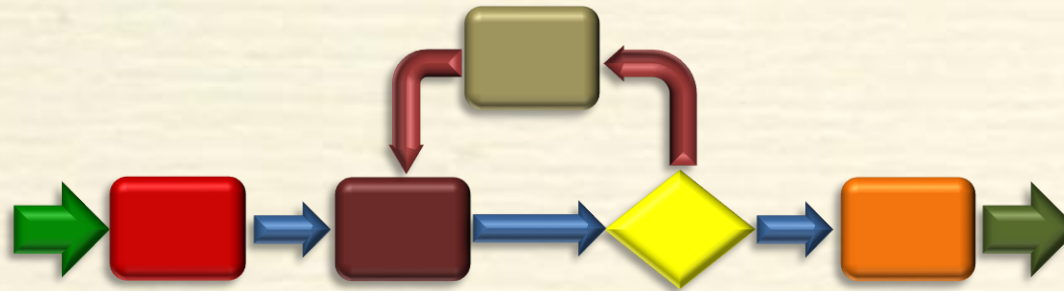


- Transformation of “something” by transitioning through a series of interrelated activities over a period of time.



# Process Description & Analysis

- Process Flow Charts



- Procedures
  - PFMEA's
  - Root Cause Analysis
- Yield/Efficiency Models & Metrics
  - Stories...

# Real World Processes

- **Process Design is generally Product/Service-Centric:**
  - Single-Pass Perspective
  - Product/Service-Specific Activity & Event Focus
  - Metrics relate performance to process features
- **Real World Processes are ongoing and pervasive:**
  - Repeated / Continuous Operation
  - Enterprise processes are interconnected/intertwined
- **Things are complex and get complicated quickly in ‘The Big Picture’:**
  - Leads to narrow focus and sub-optimization
  - Difficult to interconnect processes analytically
  - ‘Unanticipated Consequences’

**A “Systems Mentality” is necessary for multiple processes**

# SYSTEM DYNAMICS

# What is a System?

It's not just a collection of parts and components...



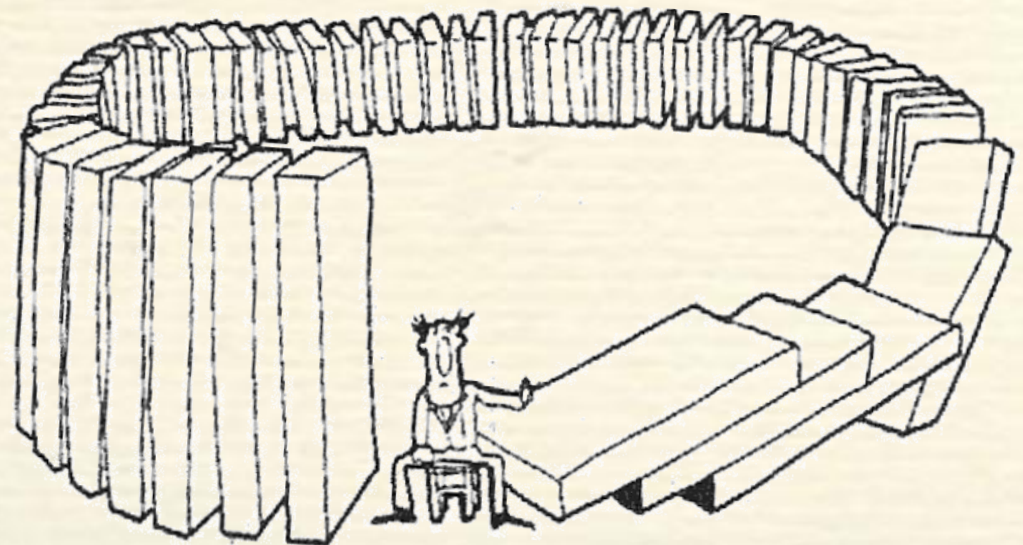
A System is a group of interacting, interrelated, and interdependent components that form a complex and unified whole.

# Characteristics of Systems

- Systems may be complex but not intractable
- System performance is more dependent upon the relationship of its parts than the performance of the individual parts
- The System component functional relationships of System components are frequently indirect (hidden)
- Systems are bounded
- Systems are part of other systems
- There are usually time delays between stimuli and responses
- “Unintended Consequences”

# Real World Process Dynamics

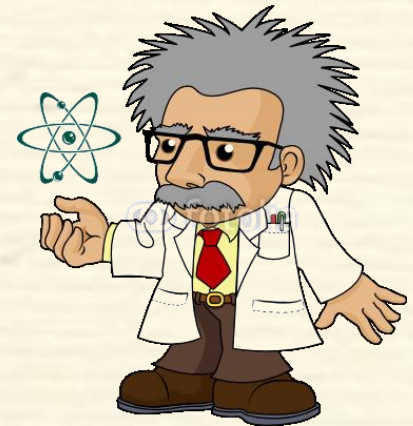
- **Information Paths**
  - Information Feedback travels outside of a process
  - Instructions/Directives have surprising sources
- **Time Delays**
  - Information flow
  - Decision-making
  - Systemic



# Philosophers, Physicists, and Engineers



- Existing Systems
- Qualitative Models
- General Behavior

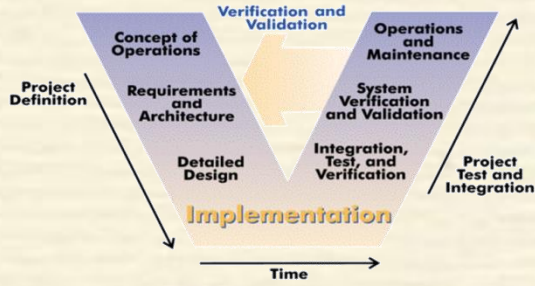


- Existing Systems
- Quantitative Predictions
- Detailed Behavior



- Quantitative Requirements
- Puts Systems Together
- Takes Systems Apart
- Keeps Systems Running (or running better)

# Systems Thinking, Dynamics, & Engineering

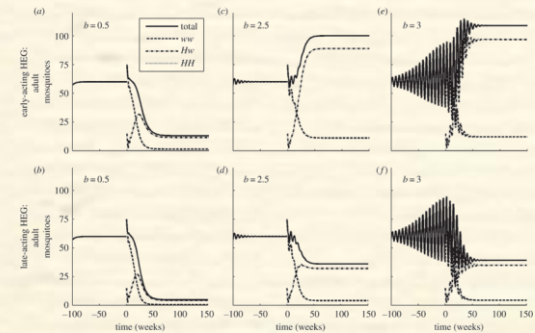
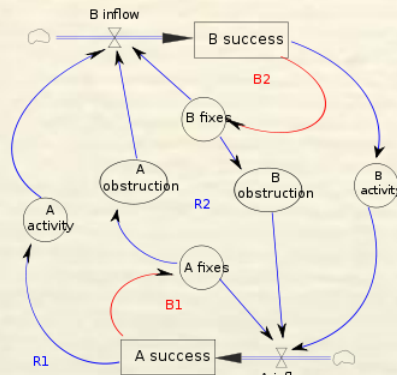


## SYSTEMS ENGINEERING

- Quantitative Requirements
- Puts Systems Together
- Takes Systems Apart
- Keeps Systems Running (or running better)

## SYSTEM DYNAMICS

- Existing Systems
- Quantitative Predictions
- Detailed Behavior



## SYSTEMS THINKING

- Existing Systems
- Qualitative Models
- General Behavior



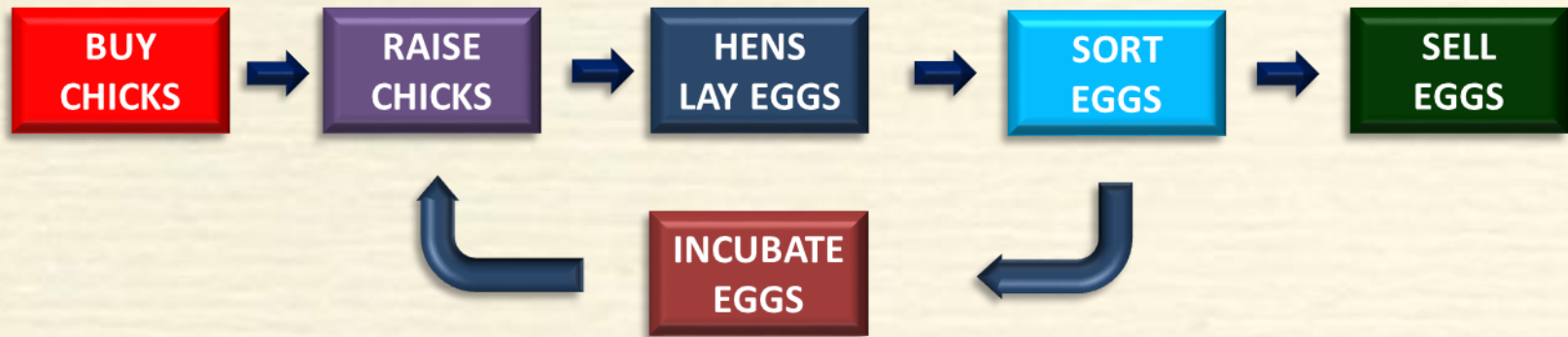
# CAUSAL LOOP DIAGRAMS

# Causal Loop Diagrams (CLD's)

**Graphical representation of the dynamic interrelationships among system components.**

- **Visualize interactions among system parts:**
  - Different Locations
  - Different Times
  - Different Functions
  - Different and seemingly unrelated processes
- **Explore hidden cause-and-effect relationships**
- **Develop models for system dynamic behavior**
- **Foundational tool of Systems Thinking**

# Chicken Farming – The Process



- **Straightforward process → The chickens do the “heavy lifting”**
- **Operating metrics are simple**

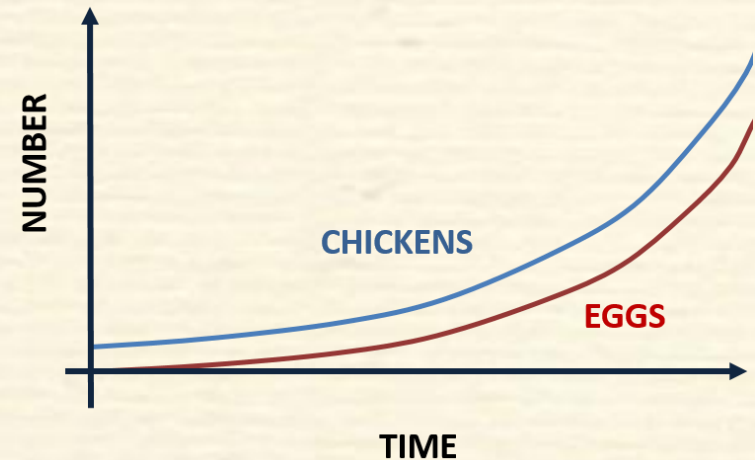
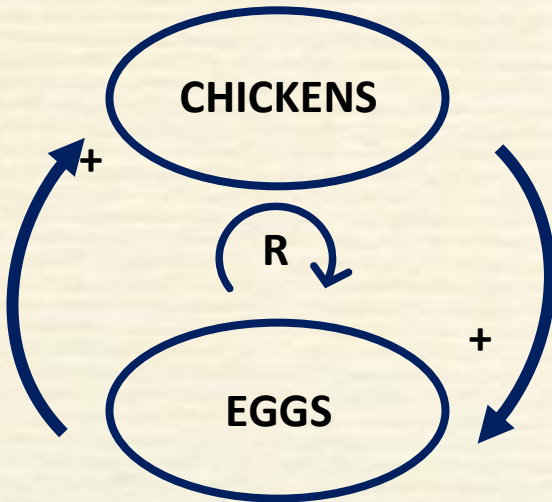
# Chickens & Eggs & CLD's

## The Story:

A farmer buys a number of chickens.

There are no limitations on food, water, or space...for the foreseeable future.

What can we expect for the behavior of the population of the flock??



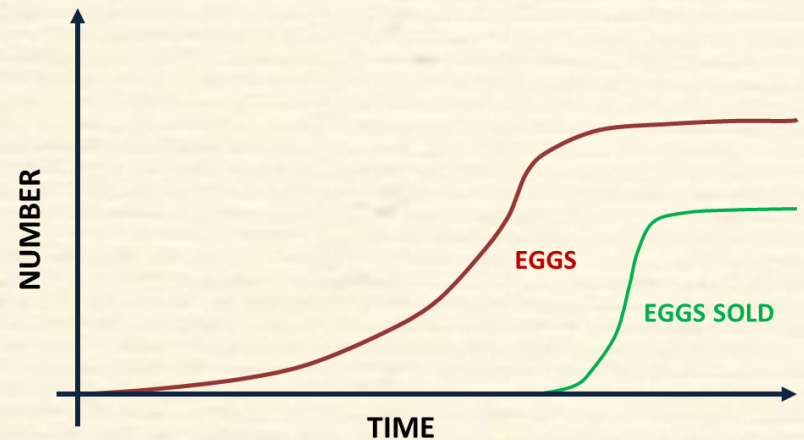
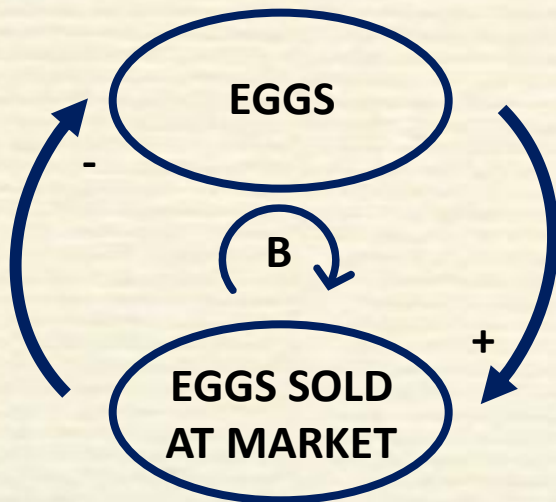
***Reinforcing Loop – Growth (or Decay) Processes***

# Chickens & Eggs & CLD's (cont.)

## The Story (continued):

The farmer decides to start selling eggs and maintain his egg “inventory” at a certain level.

What can we now expect for the behavior of the egg count??



**Balancing Loop - “Goal Seeking” Processes**

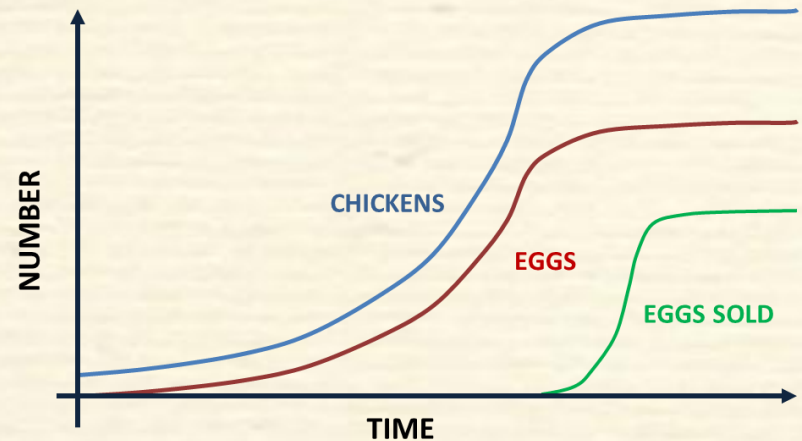
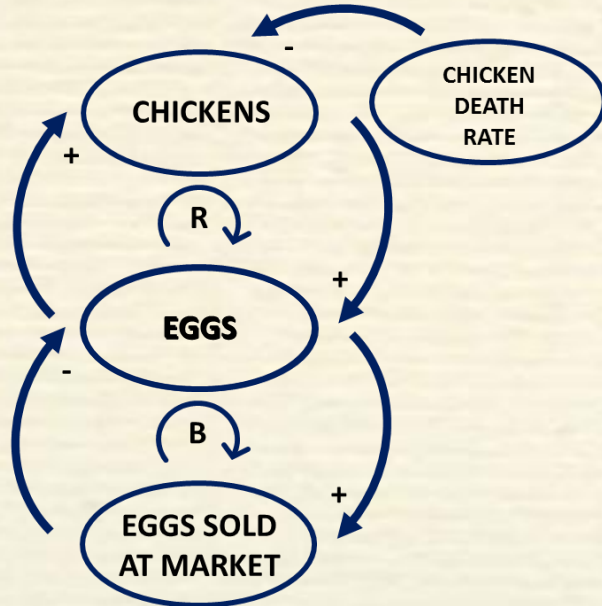
# Chickens & Eggs & CLD's (*cont.*)

## The Story (continued):

The number of eggs on hand affects the number of chickens, and the marketing scheme will similarly affect the chicken population.

And, chickens do not live forever.

What is the expected behavior of the flock population???



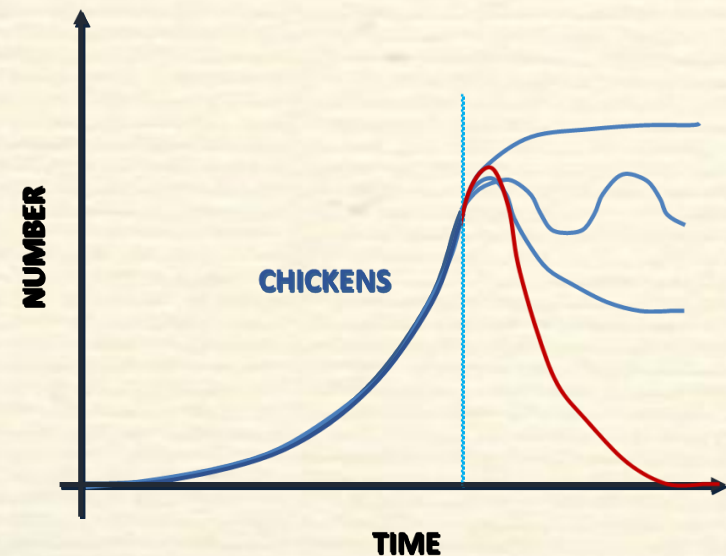
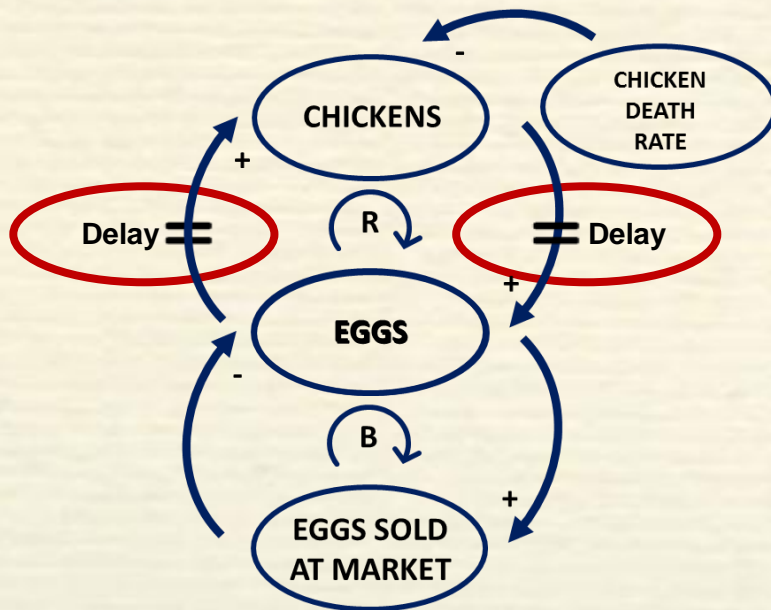
*Things look fine --- Or are they ???*

# Chickens & Eggs & CLD's (cont.)

## The Story (continued):

It turns out that it takes about 21 days for eggs to hatch and about 6 months for chickens to begin laying.

How do these delays affect the flock population??



# Chickens & Eggs & CLD's

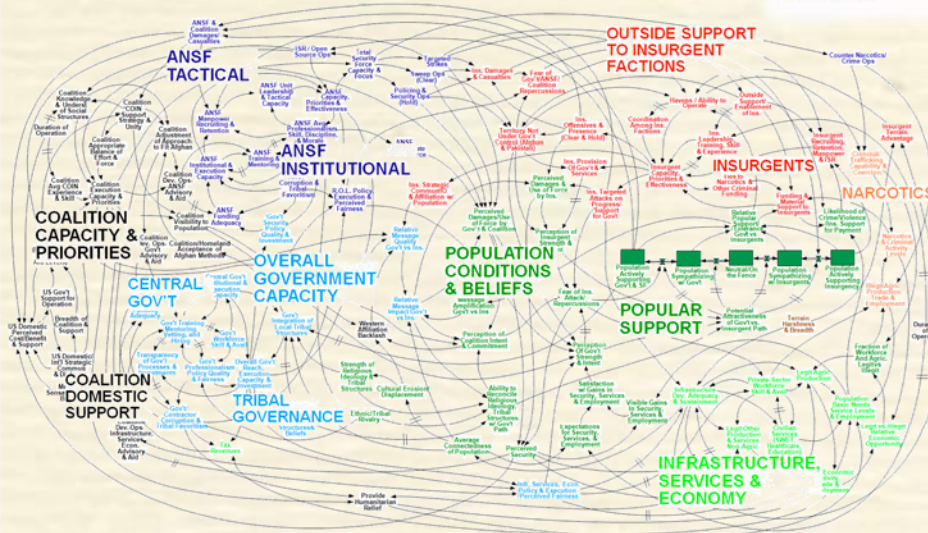
## Summary:

- Provides a different view of the process
- Demonstrates how systemic delays can generate “unintended consequences” of actions
- Reveals hidden complexities in operational dynamics
- Reveals the systemic nature of even simple operations
- Effective CLD's require some discipline



# CLD Practices to Avoid

TMI – There is such a thing as *Too Much Information !!!*



Spaghetti Diagram

Trying to 'Boil the Ocean'...

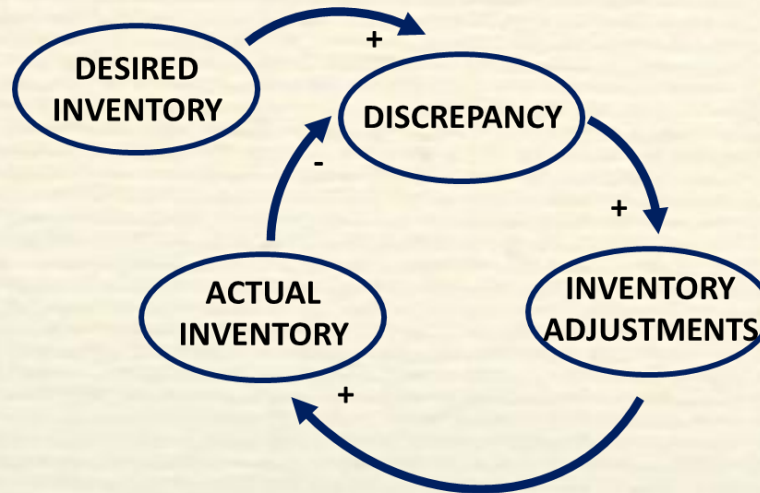
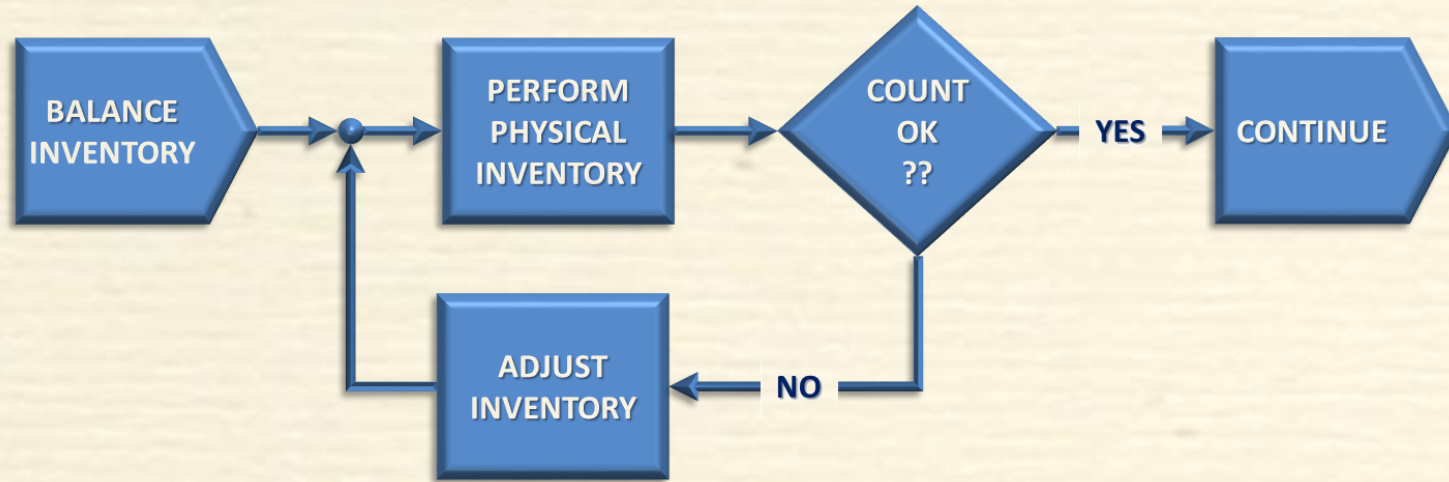


# Building CLD's

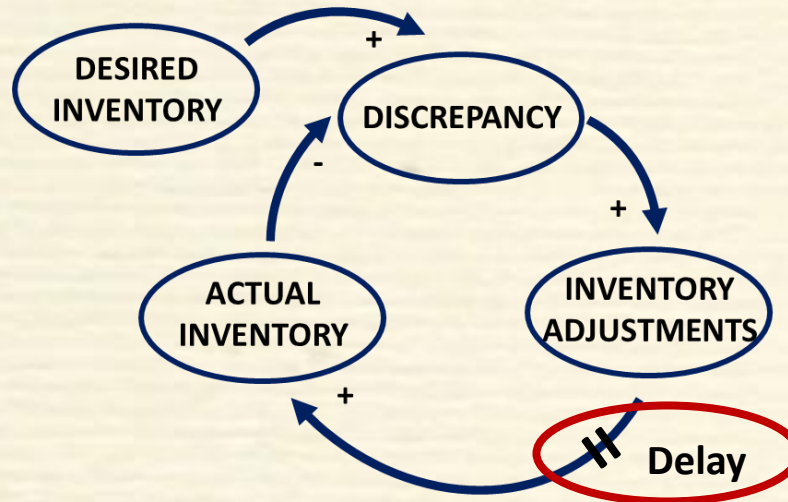
1. **Formulate the core problem:**  
**What is the issue to be better understood?**  
**What is the period of observation?**
2. **Tell the story of the problem behavior:**  
**What is the scope of the system to be understood?**  
**What is the necessary level of detail for the diagram?**
3. **Choose the key variables to work with.**
4. **Name the variables precisely – Use:**
  - Nouns or noun phrases.
  - **Neutral or positive terms where possible.**
5. **Graph the variables' behavior over time.**
6. **Illustrate variable interrelationships with Causal Loops -**  
**What links have significant delays?**
7. **TEST Causal Loop Hypotheses against observed behavior.**

# CLD BUSINESS EXAMPLES

# Inventory Balancing Process



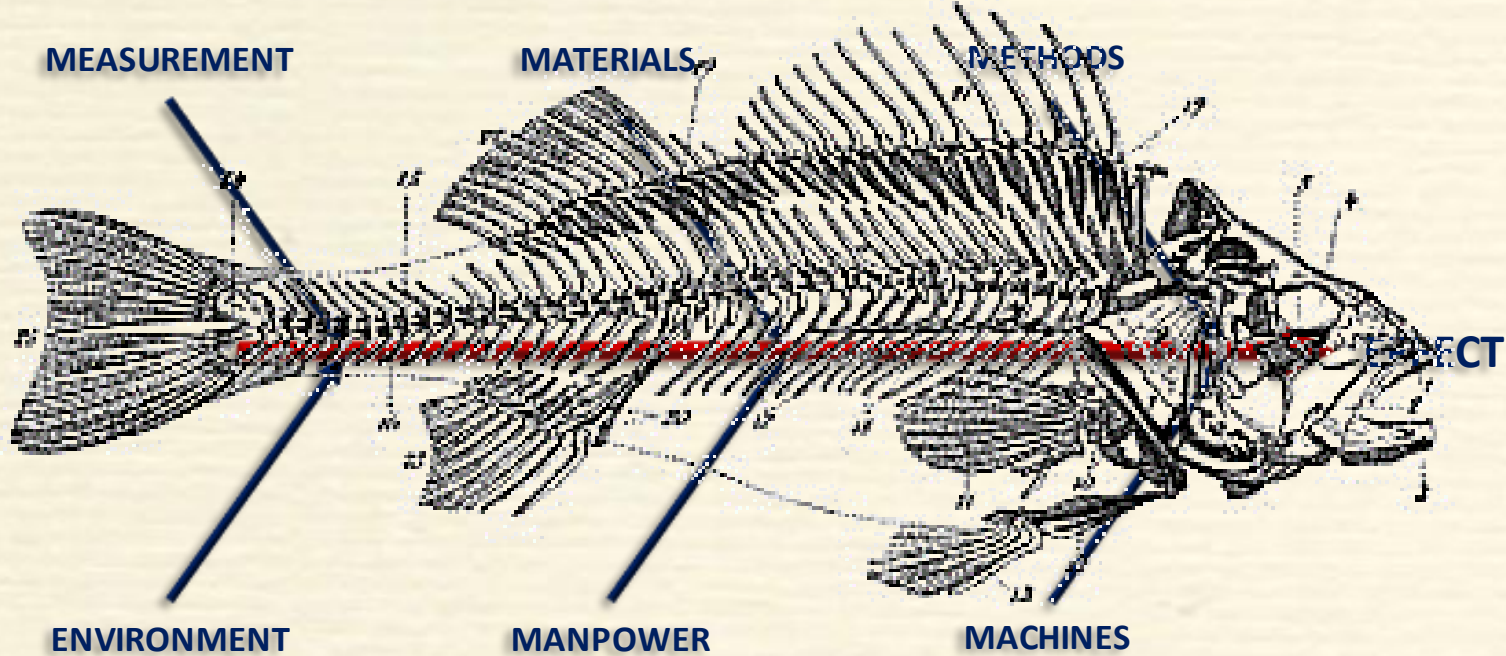
# Delays and Inventory Balancing



- **What is the effect of a delay on Actual Inventory Numbers???**
  - Undershoot / Overshoot
  - Oscillation
- **What are the Business Impacts???**
  - Cash Flow impact
  - Production capability reduced

# CAUSAL LOOP DIAGRAMS & OTHER QUALITY TOOLS

# Cause & Effect Analysis



- Things start off fairly simple, then...
- Reality strikes !!!
- And things get complex quickly

# Causal Loops and Cause & Effect

- **Identify Causes with the Highest Impact (Leverage)**
  - Move ‘Upstream’ in a Causal Chain
  - Is More Data Required?
  - Are there Reinforcing or Balancing Feedback Loops?
  - Which Causes Have the Most ‘Outgoing’ Arrows?
- **Identify Causes Creating “Unanticipated Consequences”**
  - Does a particular Cause Drive more than one Effect?
  - Are there Delays in the Causal Paths?
  - Are there Reinforcing or Balancing Feedback Loops?
  - Are there Delays in the Feedback Loops?





# Six Sigma and Systems Thinking

## Six Sigma Project Selection:

1. Persistent Issue
2. Significant Business Impact
3. Cross Functional
4. Process Based
5. Keeps you awake at night...

## Causal Loop Diagrams Bring:

1. Selection by degree of leverage
2. Reduced sub-optimization
3. Fewer “unexpected consequences”
4. Broader system understanding

# SYSTEMS ARCHETYPES

# The Systems Archetypes

**Common “Stories” that recur in different settings:**

- Same System Structure revealed by characteristic CLD
- Proven resolution strategies are documented:

**1. Limits to Success**

**2. Success to the Successful**

**3. Tragedy of the Commons**

**4. Growth and Underinvestment**

**5. Fixes that Fail**

**6. Shifting the Burden**

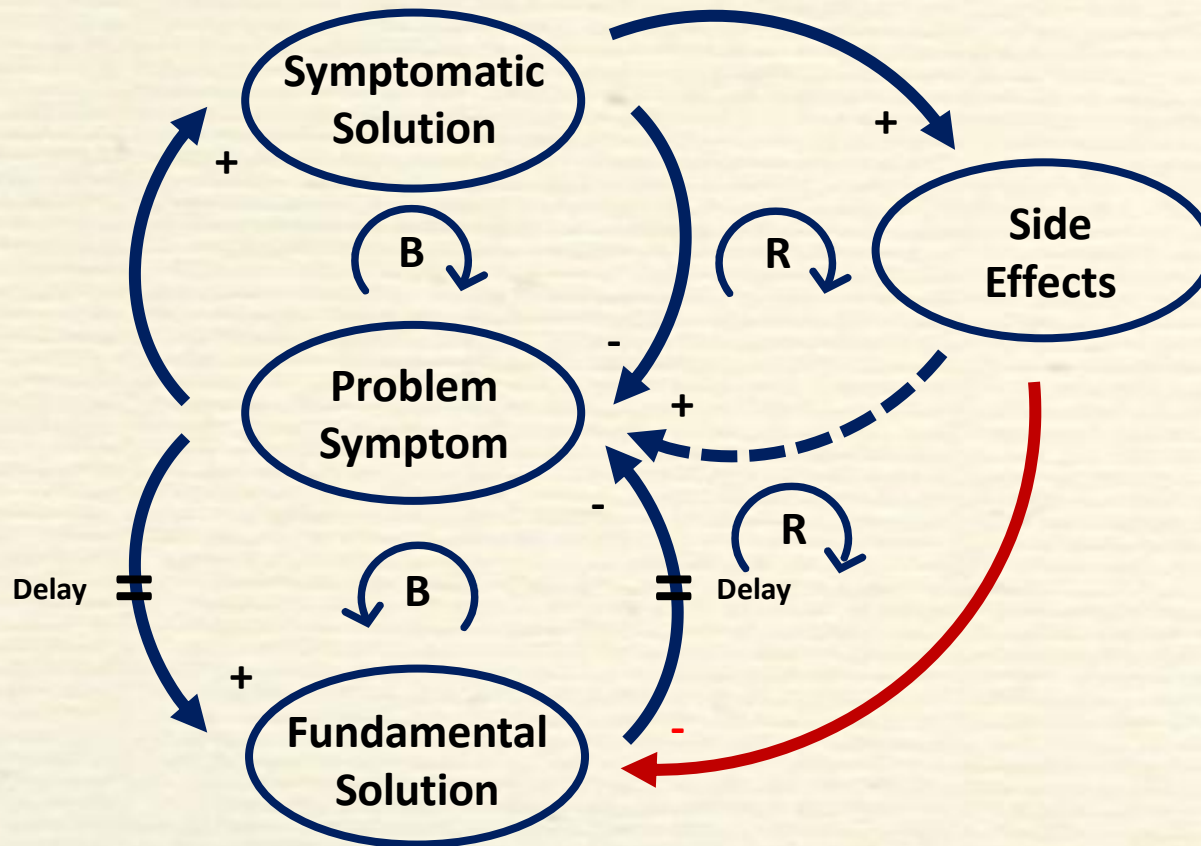
**7. Drifting Goals**

**8. Escalation**

**9. Accidental Adversaries**

**10. Attractiveness Principle**

# Shifting the Burden (C/A's)



**Symptomatic Solutions (“Fire Fighting”) create their own problems**

# Shifting the Burden Summary

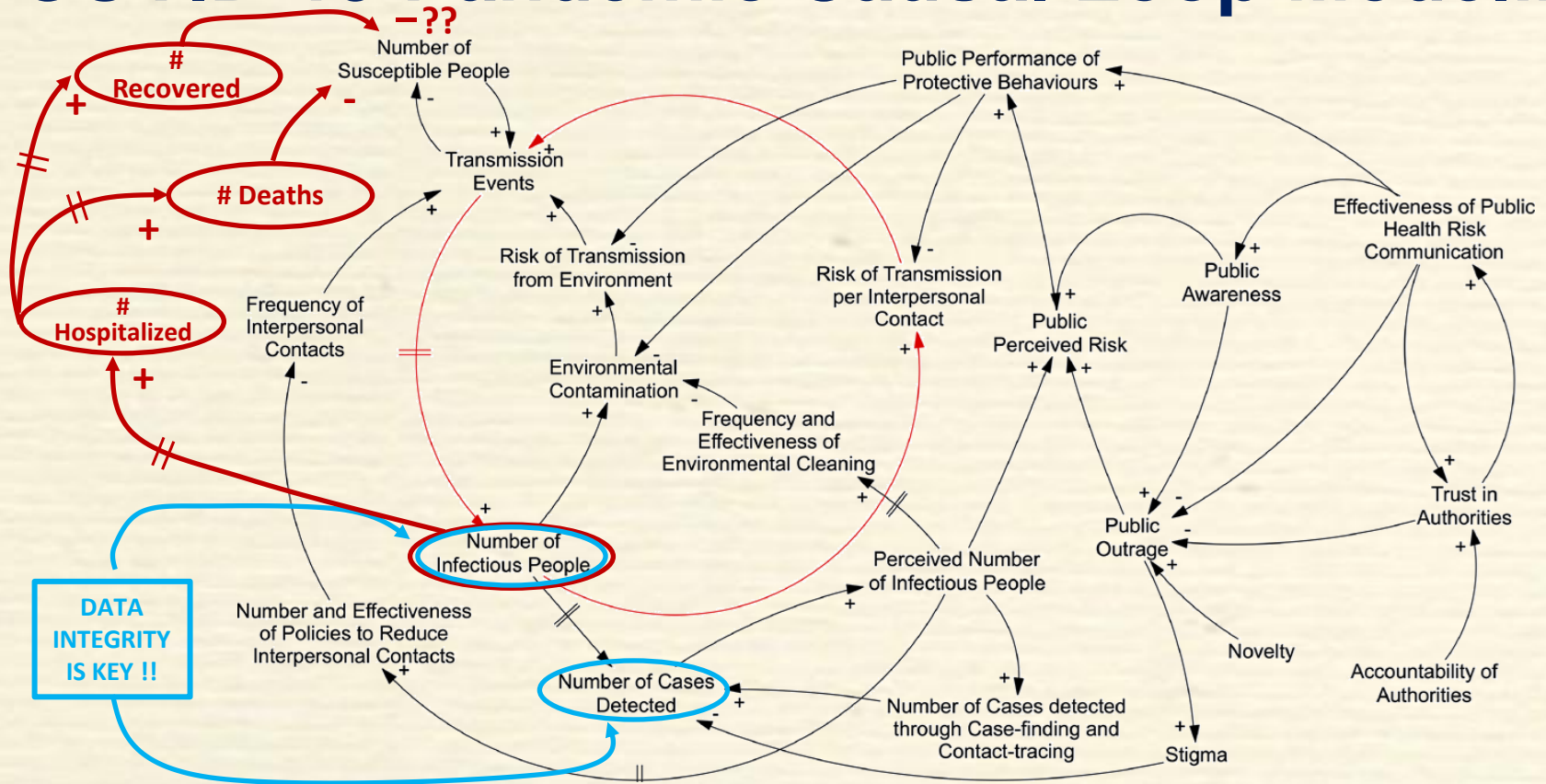
- **Description:**
  - Fundamental solution known
  - Unwilling or unable to implement fundamental solution
  - Implement symptomatic solution and live with side-effects
- **Mental Model:**

*We know what needs to be done, but:*

  1. It will take too long to implement.
  2. It's too difficult.
  3. Let's put a bandaid on it instead.
- **Key Strategy:**
  - Identify the addictive behavior to the symptomatic solution
  - Commit to implementing the fundamental solution

# CAUSAL LOOP DIAGRAMS AND THE COVID-19 PANDEMIC

# COVID-19 Pandemic Causal Loop Modeling



[A systems approach to preventing and responding to COVID-19](#)  
Bradley, Mansouri, Kee, Garcia – 3/27/2020

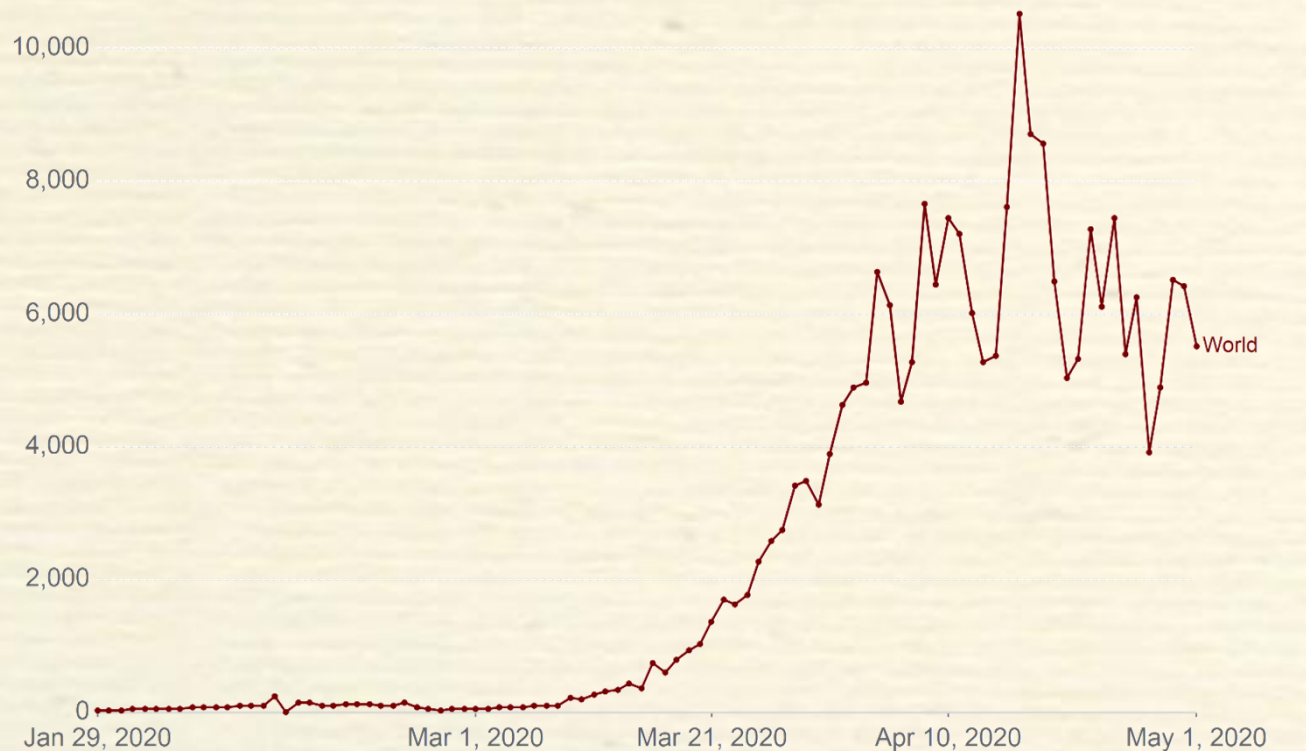
- How accurate is the testing? How many people are being tested?
- There are significant delays in hospitalization, recovery and morbidity
- Immunity through infection and recovery had not been verified yet



# COVID-19 Daily Death Count

## Daily confirmed COVID-19 deaths

Limited testing and challenges in the attribution of the cause of death means that the number of confirmed deaths may not be an accurate count of the true number of deaths from COVID-19.



Source: European CDC – Situation Update Worldwide – Last updated 1st May, 11:30 (London time) OurWorldInData.org/coronavirus • CC BY

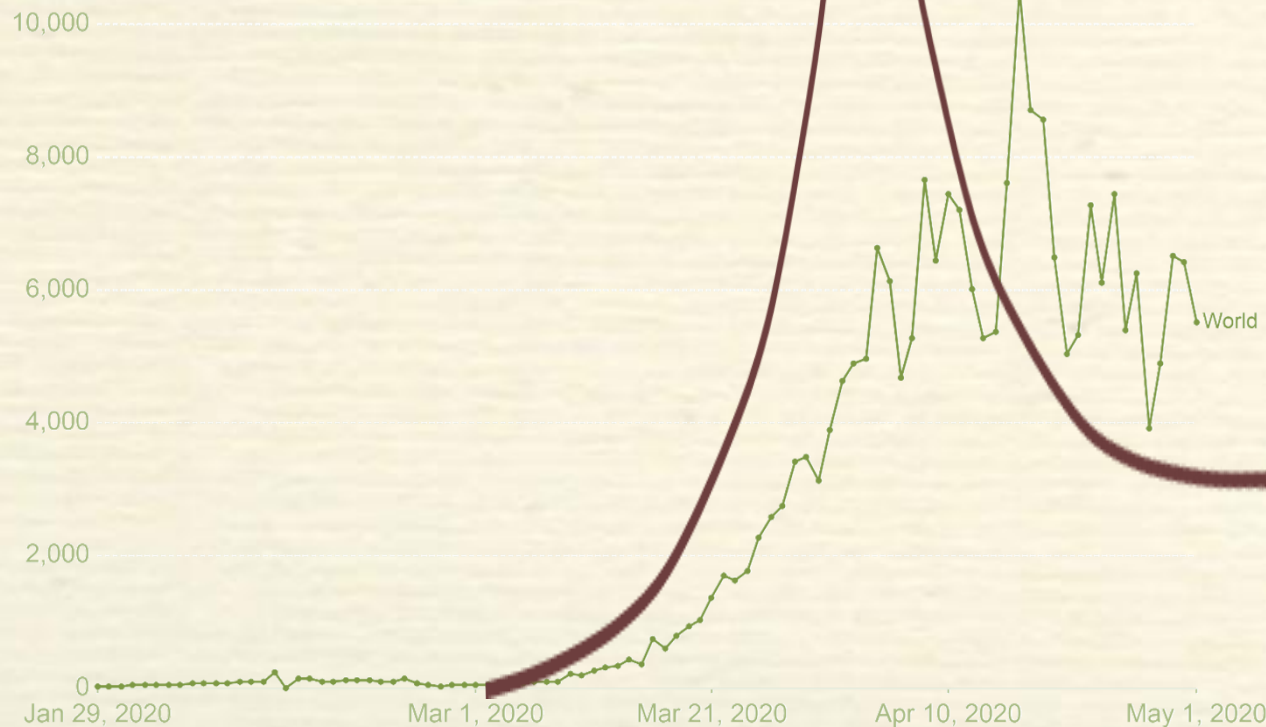
<https://ourworldindata.org/grapher/daily-deaths-covid-19?time=2020-01-29..>

# COVID-19 Daily Death Count

## Daily confirmed COVID-19 deaths

Limited testing and challenges in the attribution of the cause of death means that the number of confirmed deaths may not be an accurate count of the true number of deaths from COVID-19.

Our World  
in Data



Source: European CDC – Situation Update Worldwide – Last updated 1st May, 11:30 (London time) OurWorldInData.org/coronavirus • CC BY

## POSSIBLE DEATH COUNT WITHOUT PROTECTIVE BEHAVIORS

# Summary

- **Causal Loop Diagrams permit visualizing Process Dynamics**
- **Causal Loop Diagrams permit qualitative testing of dynamic behavior of complex systems**
- **The addition of Causal Loop Diagrams to the Quality Toolbox can:**
  - **Improve cross-functional communications**
  - **Identify high leverage points for Improvement efforts**
  - **Provide a “sniff-test” for process operation and integration proposals**

# Conclusions – Take Away Points

- **We’ve learned how to construct Causal Loop Diagrams for simple processes**
- **We better understand the advantages of Systems Thinking for managing complex issues**
- **We’ve seen how to avoid common “unintended consequences” in dynamic systems**

# Next Steps

- **Try using the Causal Loop Approach for a few simple issues**
- **Investigate cross-functional influences in your processes**
- **Expand your models by learning about Stocks & Flows**
- **Explore Systems Thinking – Society for Organization Learning**
- **Explore System Dynamics – System Dynamics Society**
- **Find an opportunity to play “The Beer Game”**
- **Have fun exploring – See the References in the closing slide**



*Questions ???*



ASQ

Excellence Through Quality™



Merrimack Valley  
Section  
Excellence Through Quality™

תודה  
Dankie Gracias شكراً  
Спасибо Merci Takk  
Köszönjük Terima kasih  
Grazie Dziękujemy Děkojame  
Ďakujeme Vielen Dank Paldies  
Kiitos Täname teid 谢谢  
**Thank You** Tak  
感谢您 Obrigado Teşekkür Ederiz  
Σας Ευχαριστούμ 감사합니다  
ขอบคุณ  
Bedankt Děkujeme vám  
ありがとうございます  
Tack

**Andy Moysenko**

ASQ Certified Manager of Quality/OE

Office: +1-978-251-0906

[Andy.Moysenko@advyse.com](mailto:Andy.Moysenko@advyse.com)



Systems thinking for a Systems world...

[www.advyse.com](http://www.advyse.com)

*Business Process Integration*

# References – Leave Business Card

## Websites:

- The Systems Thinker (formerly Pegasus Communications): <https://thesystemsthinker.com/>
  - <https://thesystemsthinker.com/introduction-to-systems-thinking/>
  - <https://thesystemsthinker.com/guidelines-for-drawing-causal-loop-diagrams-2/>
  - <https://thesystemsthinker.com/causal-loop-construction-the-basics/>
- System Dynamics Society: <http://www.systemdynamics.org/>
- Society for Organizational Learning: <https://www.solonline.org/>
- Great Video – 1<sup>st</sup> Graders Using CLD's: <https://www.youtube.com/watch?v=LEVypGV-3xA>

## Texts:

- *The Fifth Discipline*, Peter Senge
- *The Fifth Discipline Fieldbook*, Peter Senge
- *Introduction to Systems Thinking*, Daniel H. Kim (The Systems Thinker, formerly Pegasus Communications)
- *Business Dynamics: Systems Thinking and Modeling for a Complex World*, John Sterman --- Systems Thinking through System Dynamics – Graduate Level Text
- *System Dynamics Introduction, Chapter 1, System Behavior and Causal Loop Diagrams*, <http://www.public.asu.edu/~kirkwood/sysdyn/SDIntro/ch-1.pdf>

## Articles:

- *Causal Loop Diagrams: Little Known Analytical Tool*, William Rushing (<http://www.isixsigma.com/tools-templates/cause-effect/causal-loop-diagrams-little-known-analytical-tool/>)
- *360 Degree Process Mapping with Causal Loop Diagrams*, <https://www.linkedin.com/pulse/360-degree-process-mapping-causal-loop-diagrams-steven-h-jones-mba?trk=hp-feed-article-title-like>
- *Fine-Tuning Your Causal Loop Diagrams—Part I & II*. <https://thesystemsthinker.com/fine-tuning-your-causal-loop-diagrams-part-i/> and <https://thesystemsthinker.com/fine-tuning-your-causal-loop-diagrams-part-ii/>