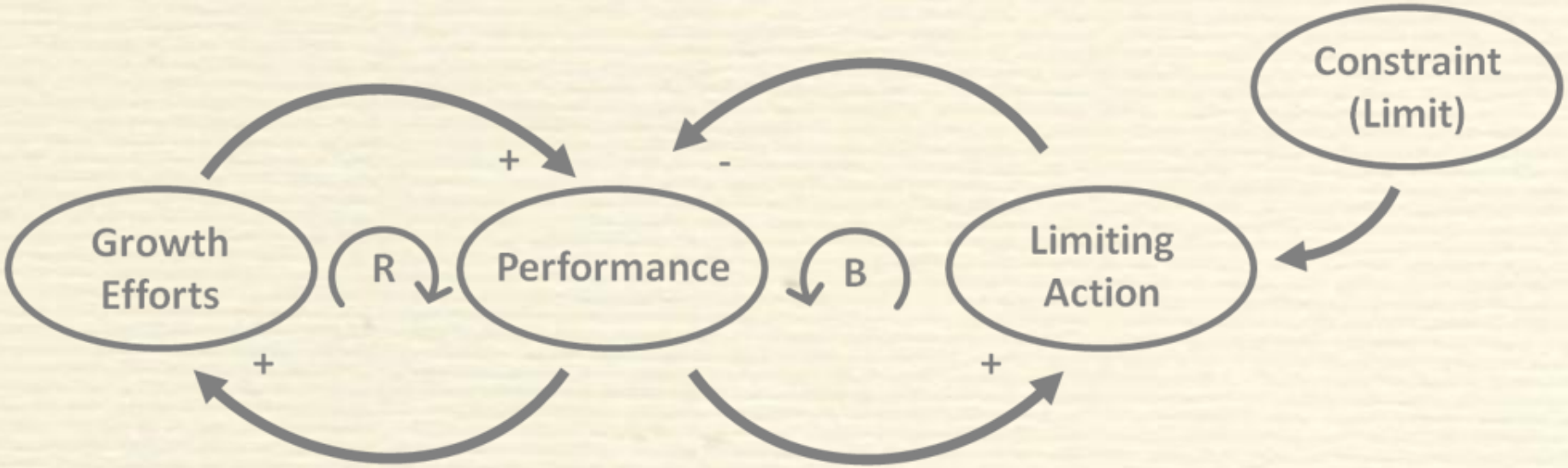

Causal Loop Diagrams in Quality

24 October 2018 (22B)

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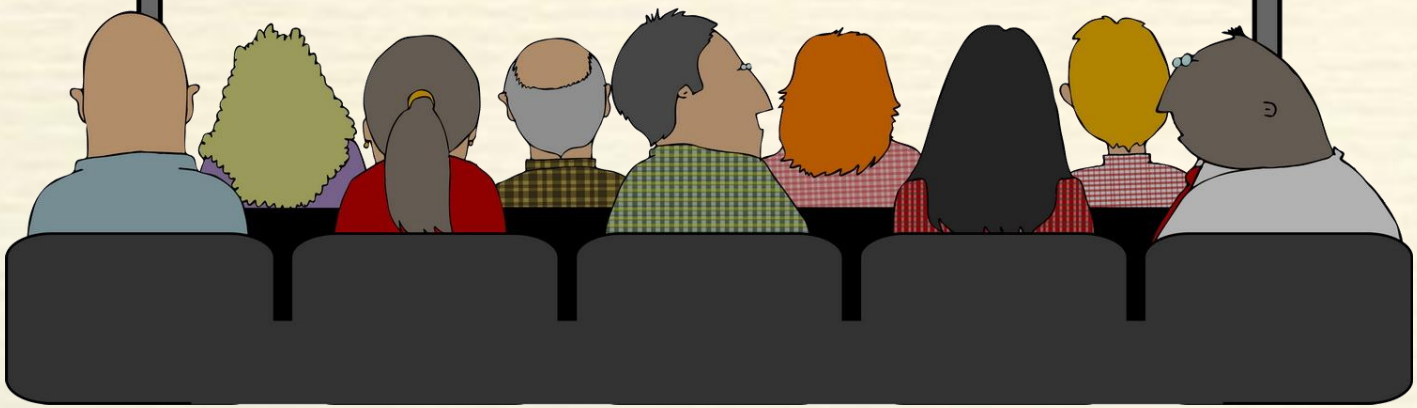
Greetings and Introduction



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Overview

GOAL:

Introduce Causal Loop Diagrams as Quality Tools

TOPICS:

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

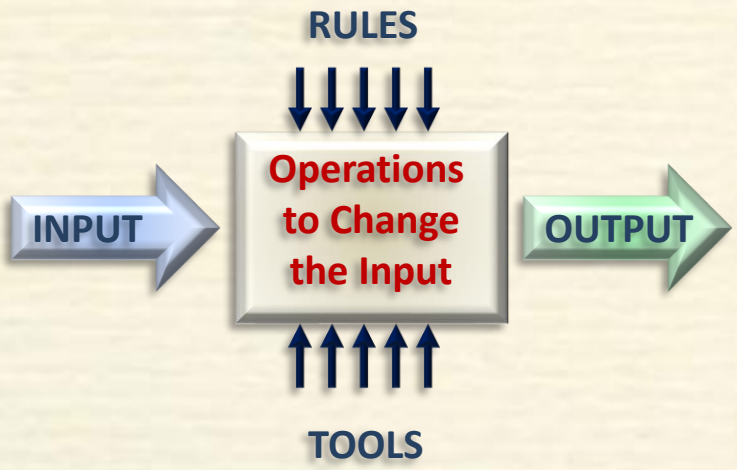
Process Mentality

A "Process Mentality" is essential to Enterprise Effectiveness

- ISO 9001:2015
- Six Sigma
- Lean Manufacturing
- Project Management
- Business Management

Processes

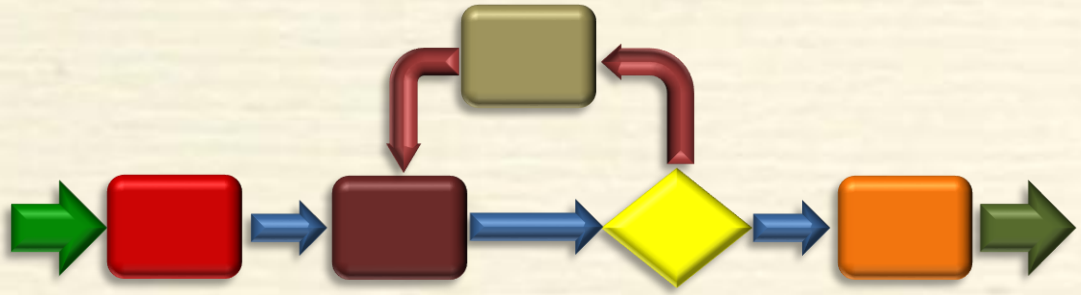
- Just what is a process ??
- A process basically consists of:
  - Inputs and Outputs / Vendors and Customers
  - Rules and Tools
  - Measures of Performance



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

Process Descriptions & Analysis

- Process Flow Charts



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

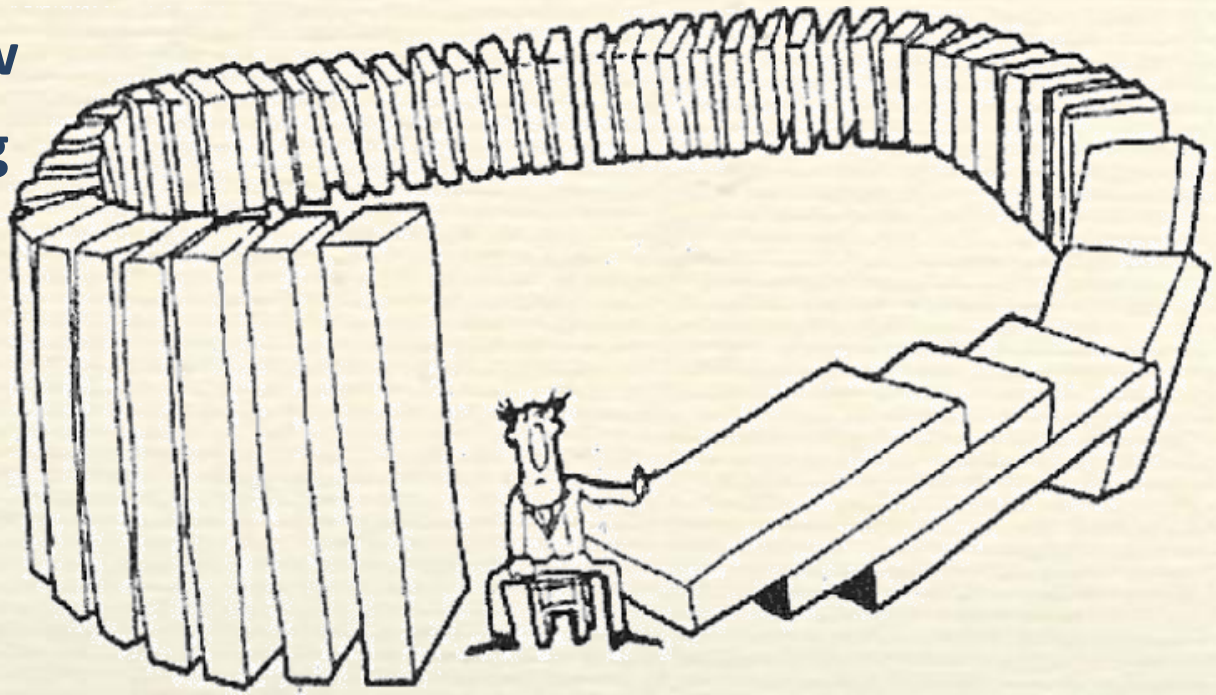
Real World Processes

- **Process Design is generally Product/Service-Centric:**
  - Single-Pass Perspective
  - Focus on Product/Service-Specific Activities & Events
  - Metrics usually relate performance to specific process features
- **Real World Processes are ongoing and pervasive:**
  - Repeated / Continuous Operation
  - Processes in an Enterprise tend to become interconnected/intertwined
- **In 'The Big Picture' things are complex and get complicated quickly:**
  - Can lead to narrow focus and sub-optimization
  - Frequently difficult to interconnect processes analytically

A "Systems Mentality" is needed for multiple processes

Real World Process Dynamics

- **Information Paths**
  - Information Feedback travels outside of the process
  - Instructions/Directives come from surprising directions
- **Time Delays**
  - Information flow
  - Decision-making
  - Systemic



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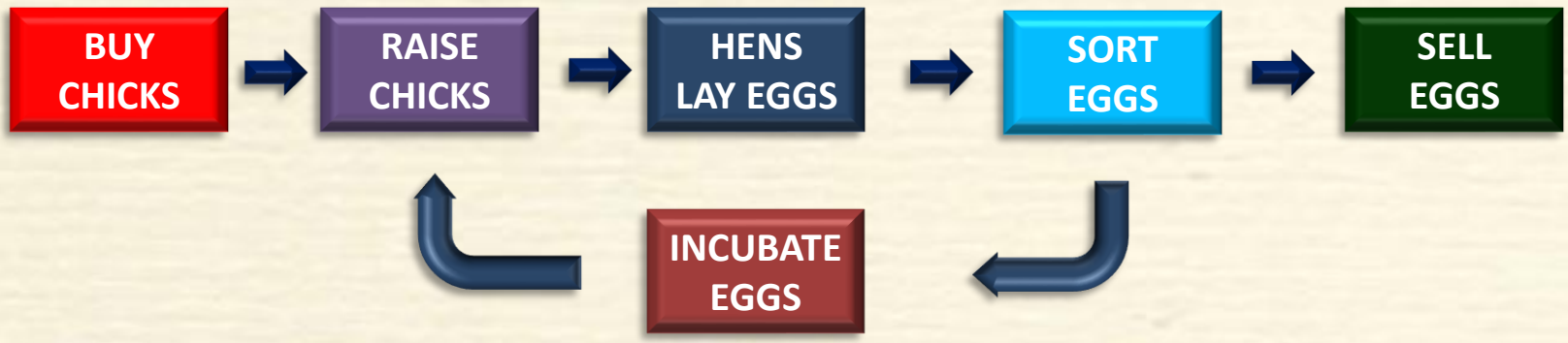
Causal Loop Diagrams – A View of the Real World

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

- Visualizing interactions among separate parts of a system:
  - Different Locations
  - Different Times
  - Different Functions
  - Different and seemingly unrelated processes
- Exploring previously hidden cause-and-effect relationships
- Developing models for dynamic behavior of a system…
- Foundational tool of Systems Thinking

CAUSAL LOOP DIAGRAMS
- AN EXAMPLE -

Chicken Farming – The Process

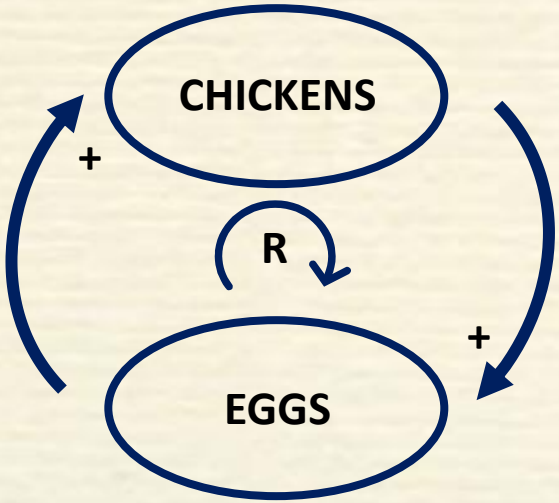


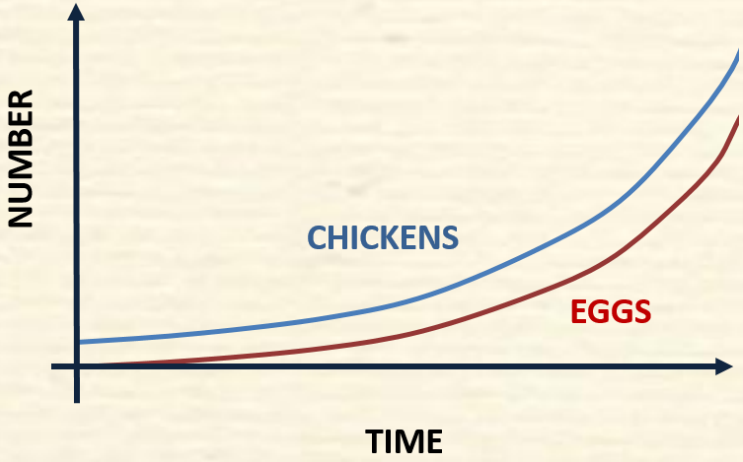
- Straightforward process – the chickens do the "heavy lifting"
- Operating metrics are very simple

Chickens & Eggs & Causal Loops

The Story:

A farmer buys a number of chickens. For the foreseeable future, there are no limitations on food, water, or space. What can we expect for the behavior of the population of the flock??



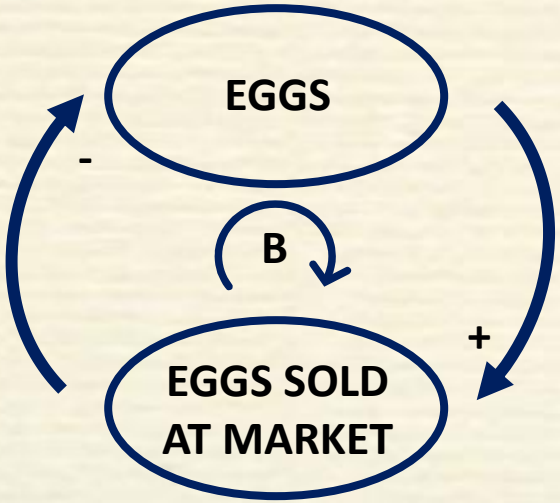


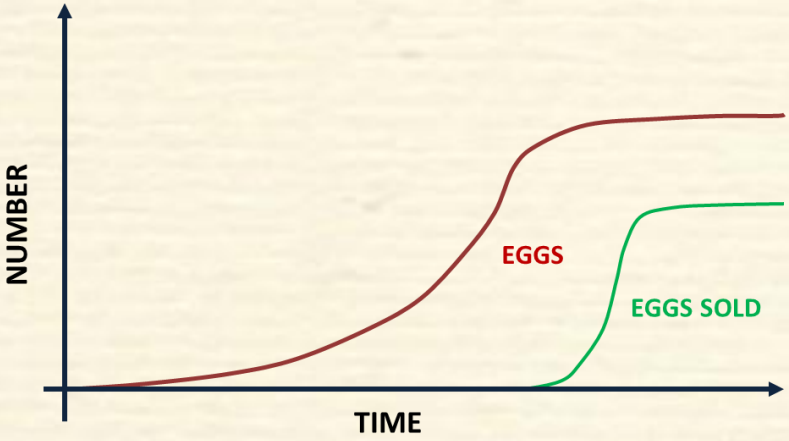
Reinforcing Loop – Growth (or Decay) Processes

Chickens & Eggs & Causal Loops (*continued*)

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??



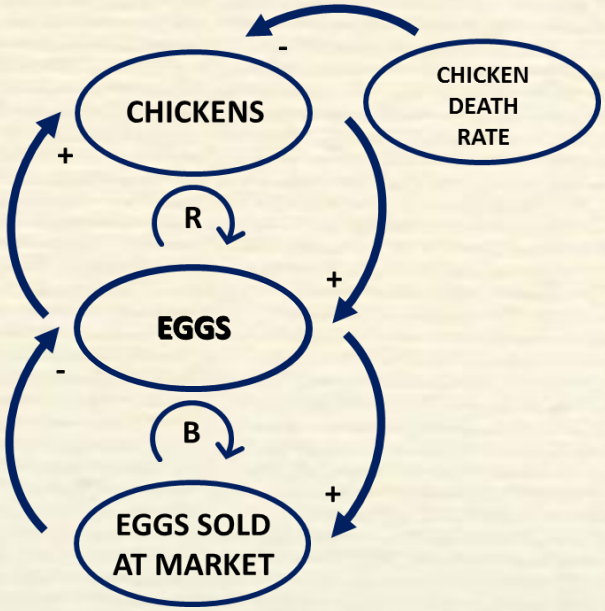


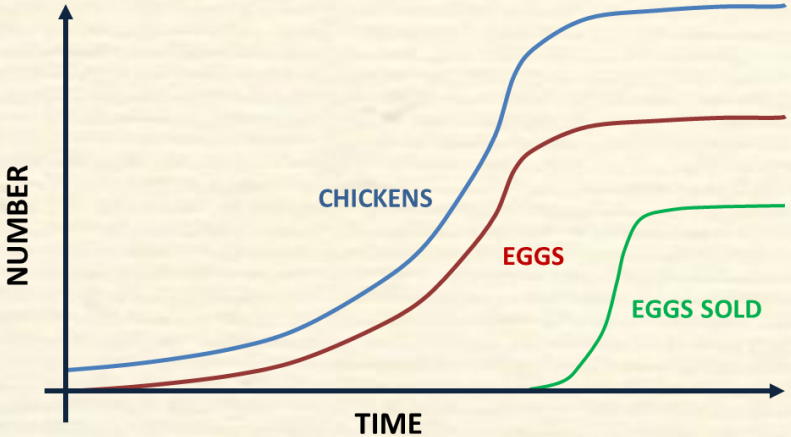
Balancing Loop - "Goal Seeking" Processes

Chickens & Eggs & Causal Loops (*continued*)

The Story (continued):

Since the number of eggs on hand affects the number of chickens, the marketing scheme will similarly affect the chicken population. And, chickens do not live forever. What can we now expect for the behavior of the population of the flock??





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

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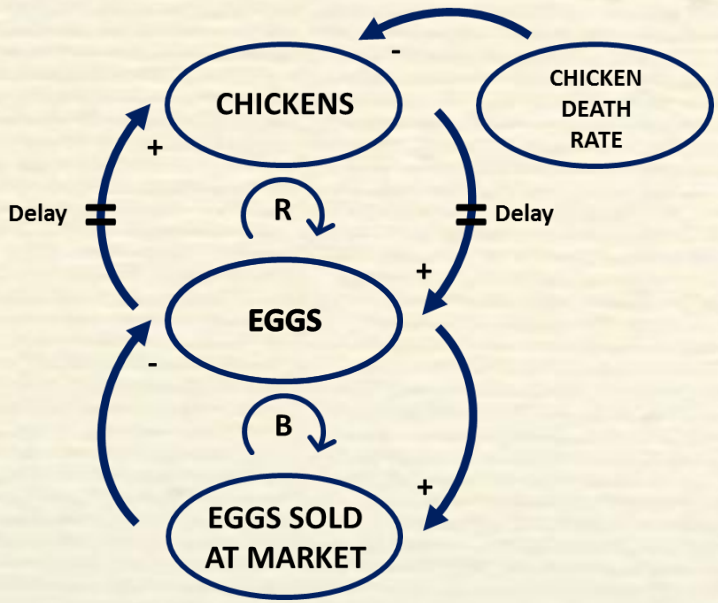
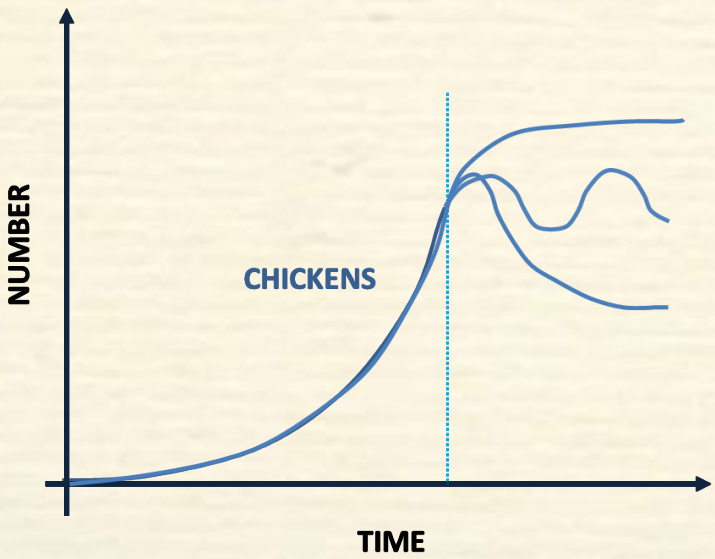
Chickens & Eggs & Causal Loops (*continued*)

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. What effect can these delays have on the behavior of the population of the flock??



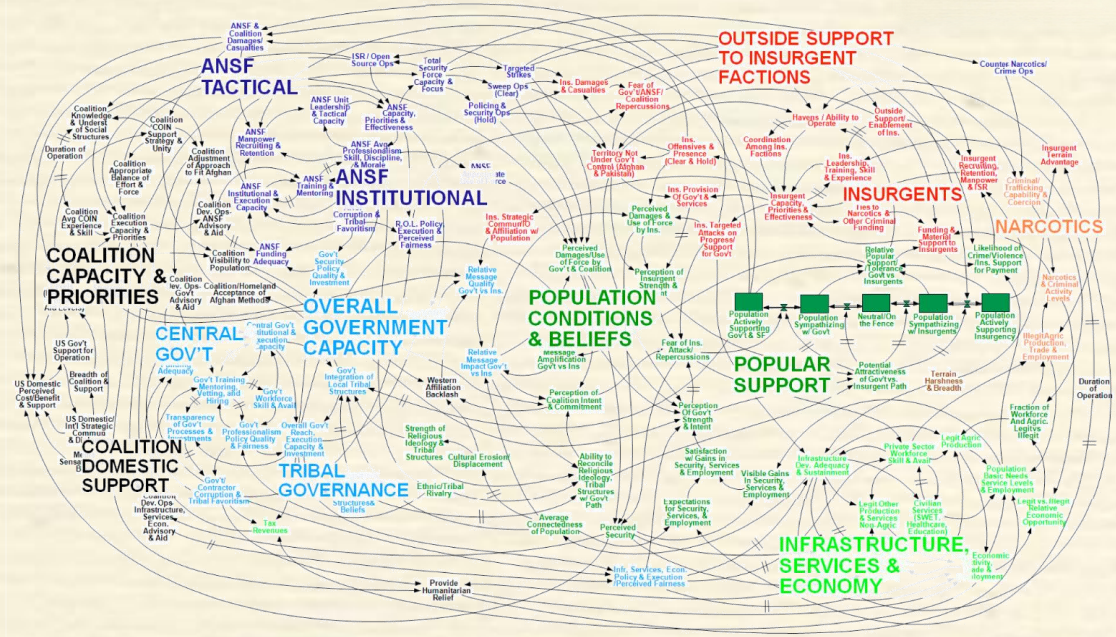


Chickens & Eggs & Causal Loops Discussion

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

Practices to Avoid

TMI – The spaghetti diagram



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

Trying to 'Boil the Ocean'…

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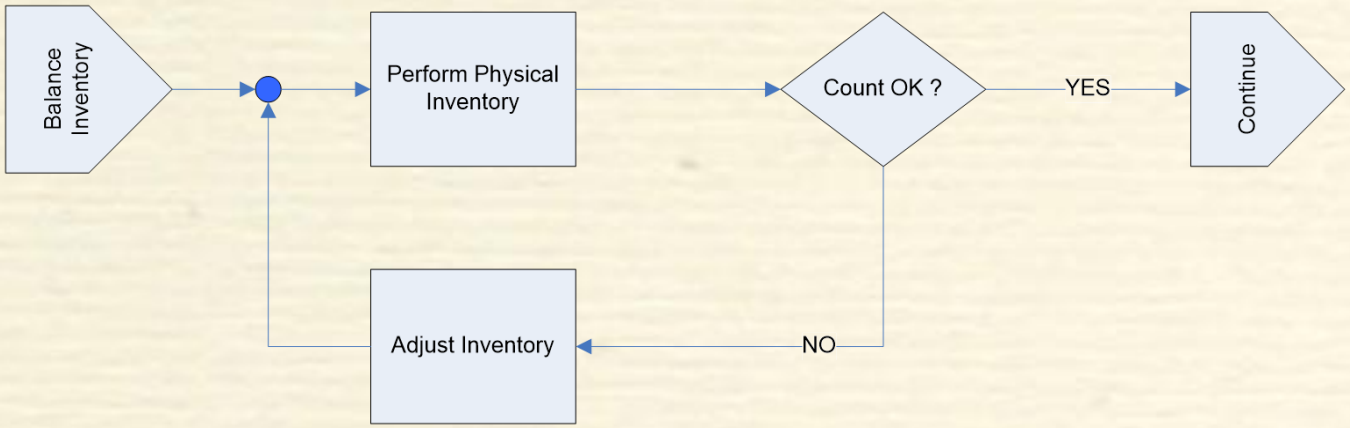
Building Causal Loop Diagrams

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 <u>nouns</u> or <u>noun phrases</u>
   - Use 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

Causal Loop Diagram Examples

Inventory Balancing Process



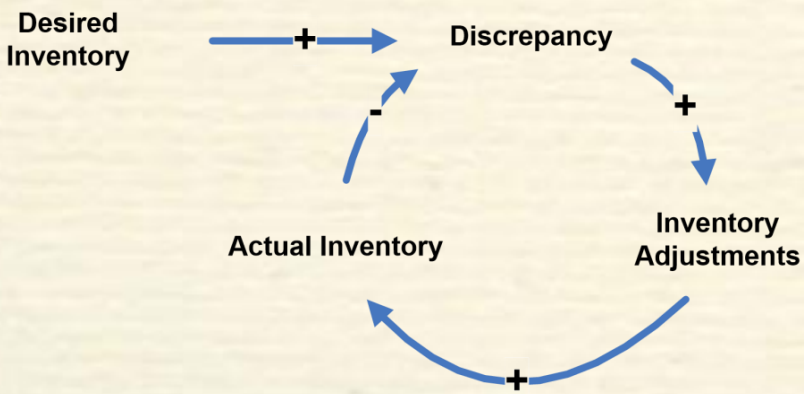
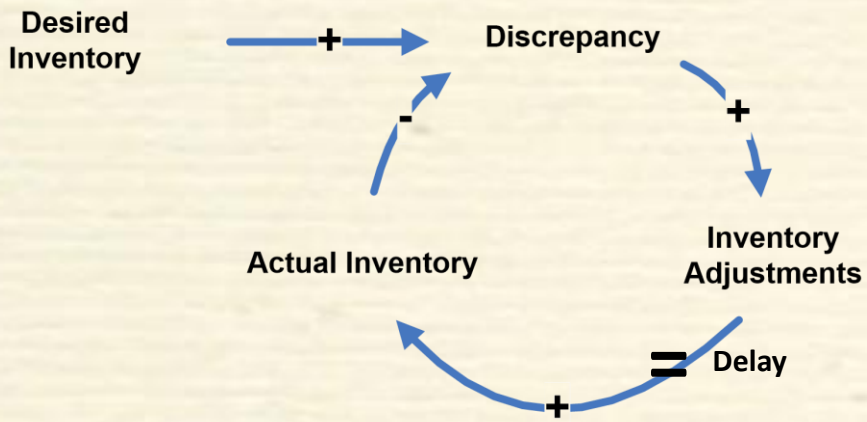


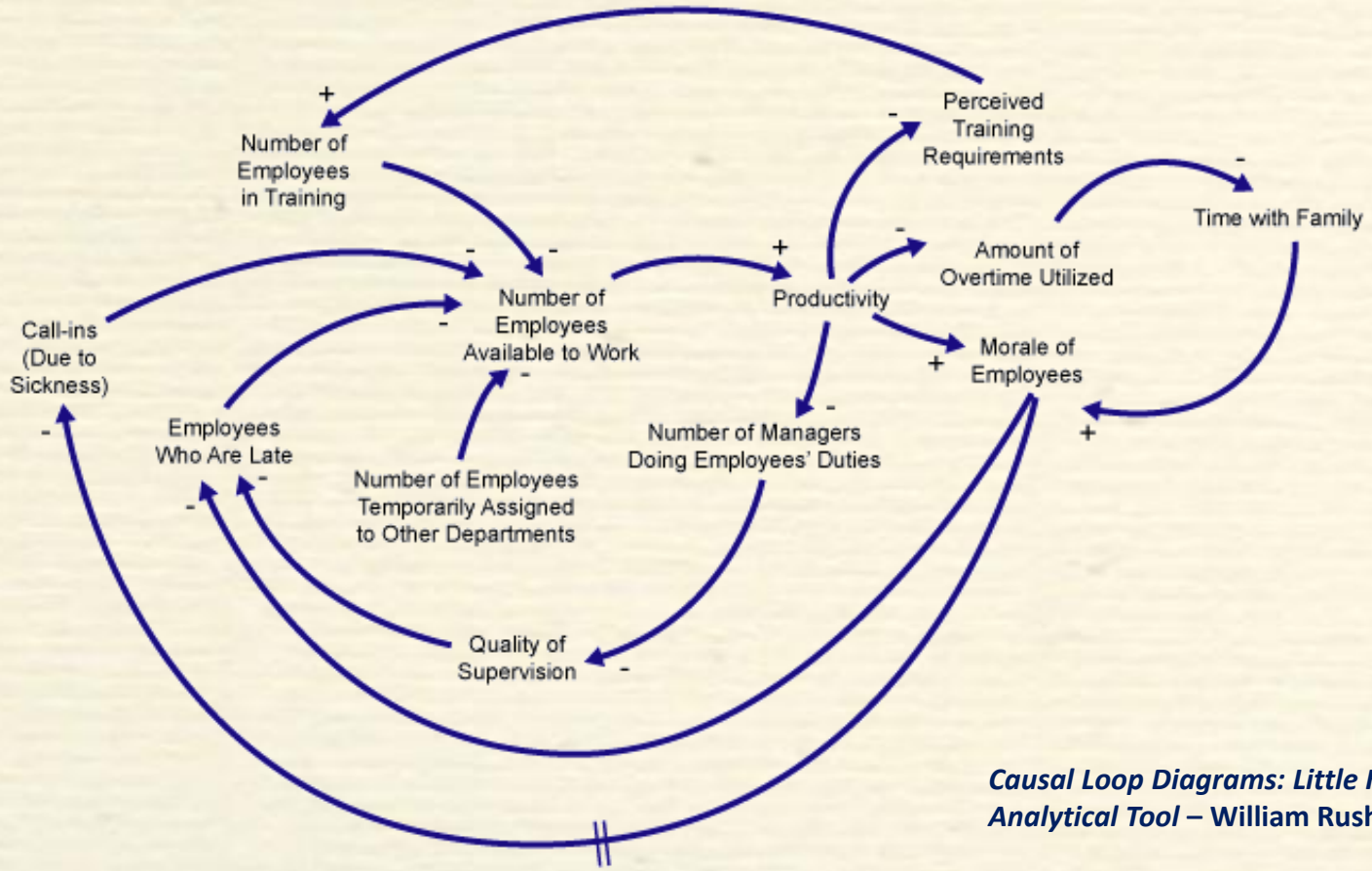
Illustration of a simple but typical Industrial Process by a Causal Loop Diagram

Effects of Delays on Inventory Balancing



- What happens when there is a delay to Actual Inventory Numbers???
  - Undershoot / Overshoot
  - Oscillation
- What are the Business Impacts???
  - Cash Flow impact
  - Production capability reduced

Productivity & Employee Absence



Causal Loop Diagrams: Little Known Analytical Tool **– William Rushing**

- **Causal Loop Diagrams in Six Sigma Projects**
- **Reveals high leverage target areas**

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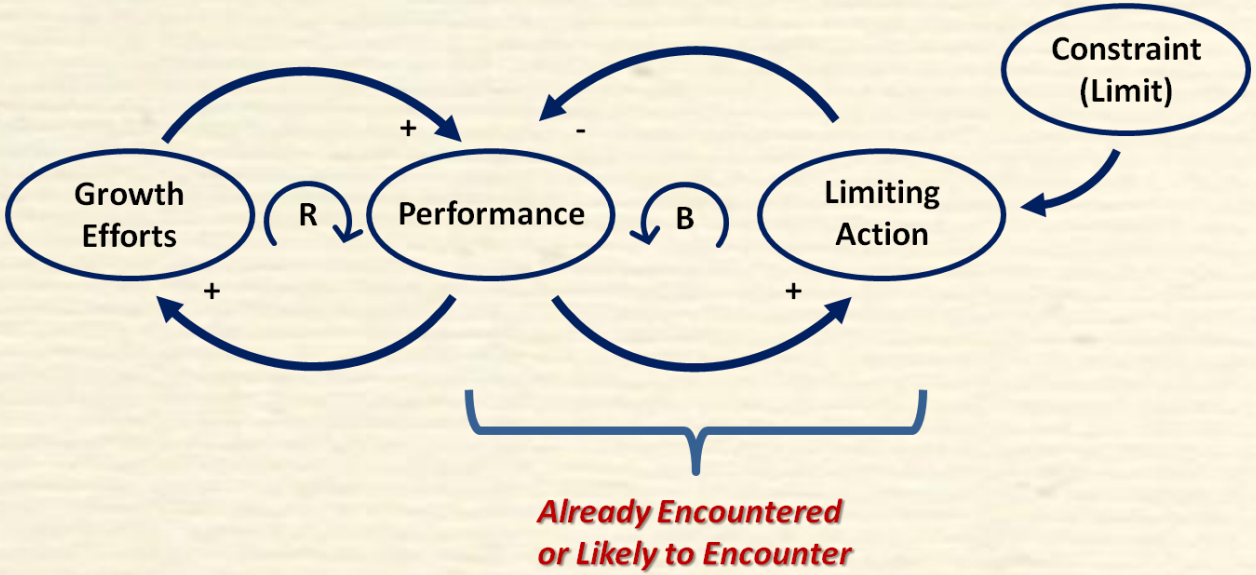
Limits to Success

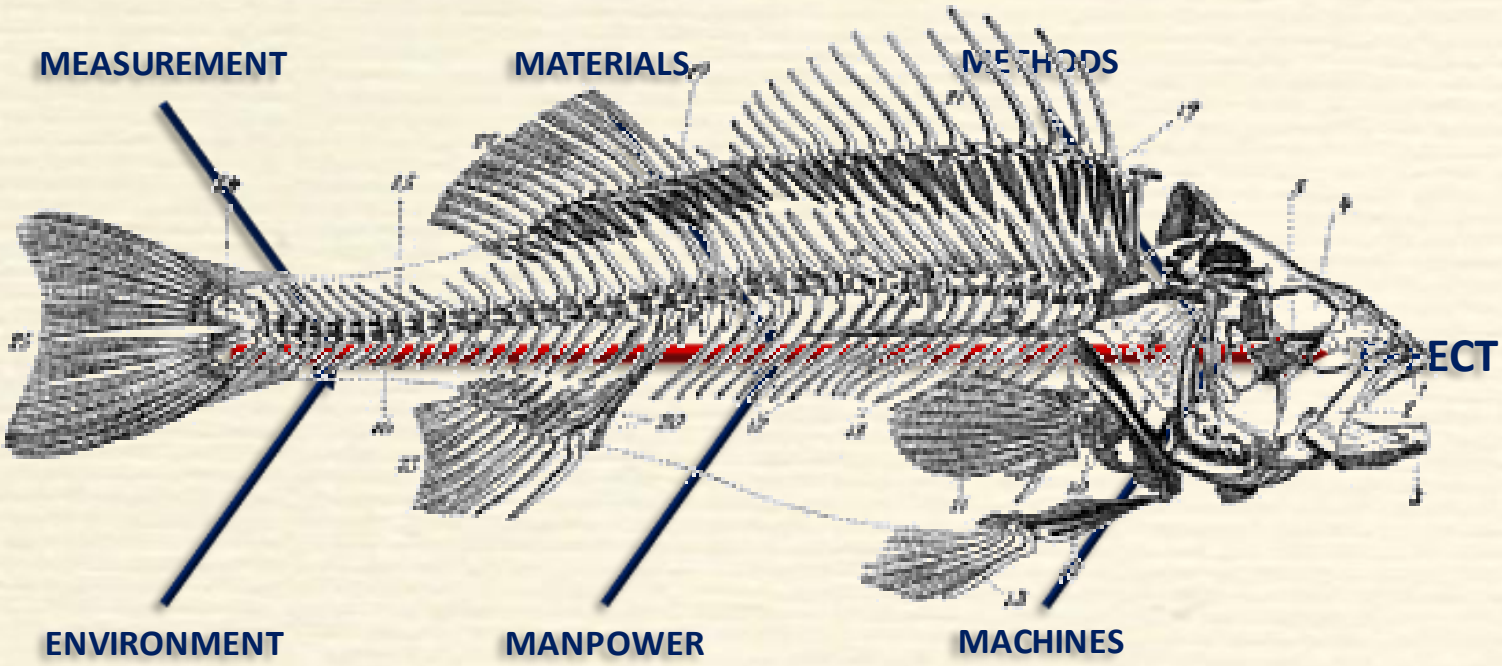
"Everything Starts Small, Then It Grows, but Not Forever."



- **The distinction between a Constraint and a Limiting Action is critical:**
  Manufacturing Capacity is a constraint; a resulting limiting action can be a reduction in Quality or Delivery Rate

Causal Loop Diagrams & Other Quality Tools

Cause and Effect Analysis



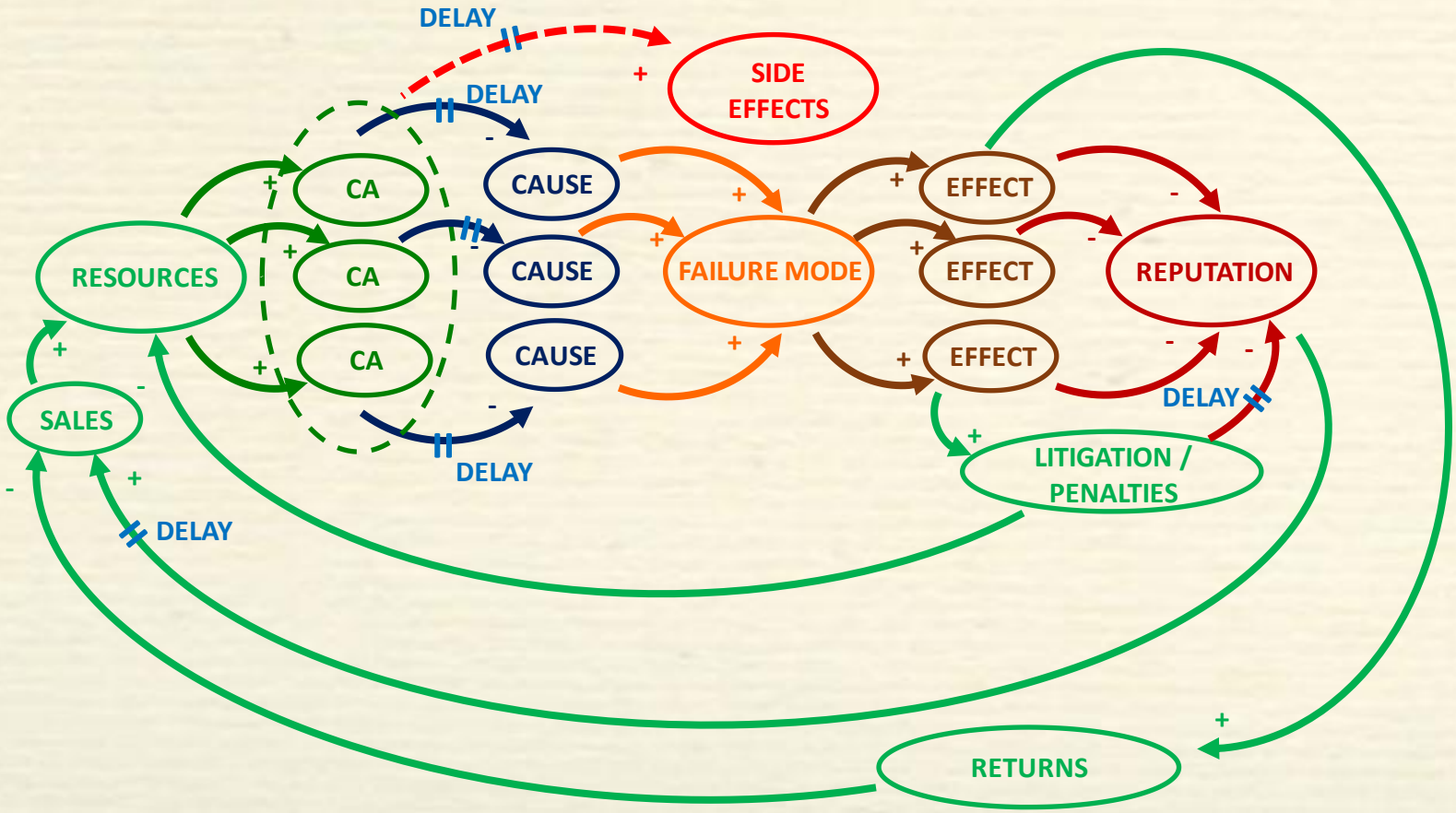
- Things start off fairly simple, then…
- Reality strikes !!!
- And things get complex fairly quickly

Causal Loops & Cause and Effect

- Identify which Causes Have the Highest Impact (Leverage)
  - Moving 'Upstream' in a Causal Chain
  - Data Required?
  - Are there Reinforcing or Balancing Feedback Loops?
- Identify which Causes may Create "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?

FMEA's and Systems Thinking

- **Complex Process / Product / Service FMEA's are likewise Complex**



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Six Sigma and Systems Thinking

Six Sigma:

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

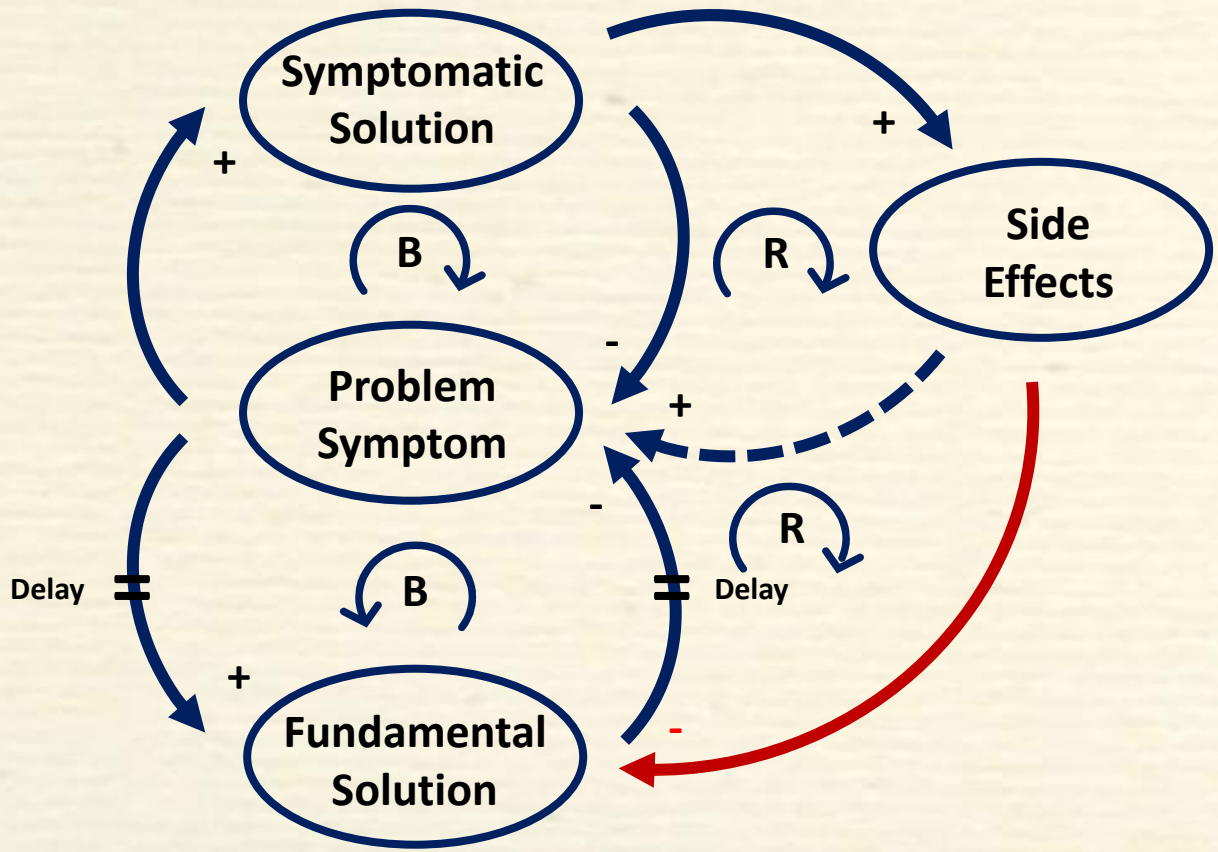
The Systems Archetypes

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**

Corrective Action (Shifting the Burden)



- Symptomatic Solutions ("Fire Fighting") have 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 it's too difficult, so let's put on a bandaid instead.***
- **Key Strategy:**
  - Identify the addictive behavior to the symptomatic solution
  - Commit to implementing the fundamental solution

Summary

- Causal Loop Diagrams permit visualizing:
  - Process Dynamics
  - Interrelationship of loosely coupled Processes
  - Systems of Processes with emphasis on different variables
- 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

Next Steps

- Try using the Causal Loop Approach for a few simple issues
- Investigate cross-functional influences in your processes
- Explore Systems Thinking – Society for Organization Learning
- Explore System Dynamics – System Dynamics Society
- Find an opportunity to play “The Beer Game”
- Have fun exploring

Questions ???

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- *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
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- *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/

THANK YOU !!!

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"Any Enterprise will Profit from a little Systems Thinking..."

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