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Complexity Science for Security and Stability Operations

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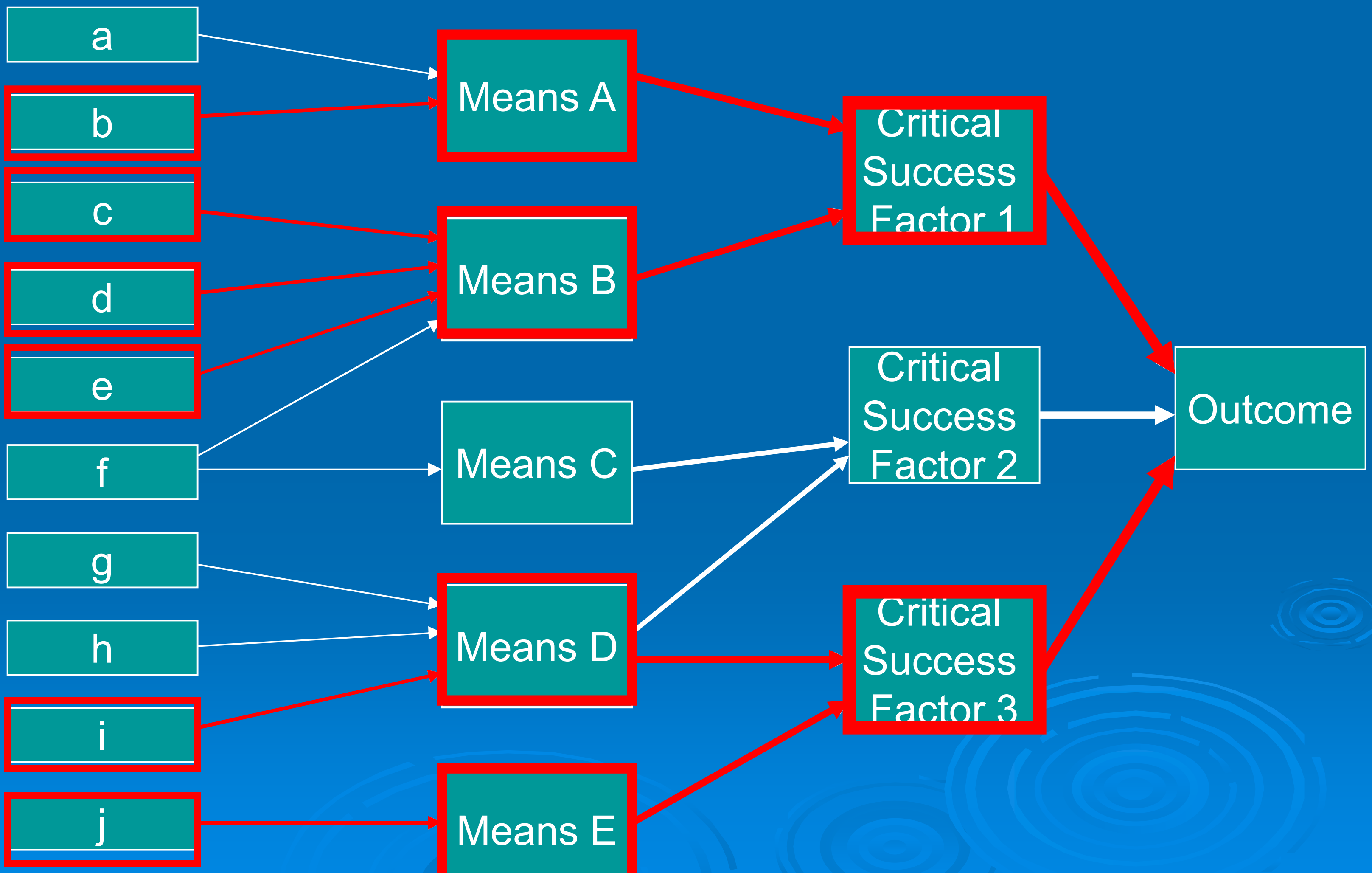
Objectives for Today

- Identify Weaknesses in Current Planning Approaches
- Understand the Nature of Complex Problems and Be Able to Identify Them
- Gain Familiarity with the Types of Tools and Approaches Available for Complex Problems
- Look at Security and Stability Operations as a Complex Problem
- Learn the Basics of One Tool for Addressing Complex Problems: System Dynamics

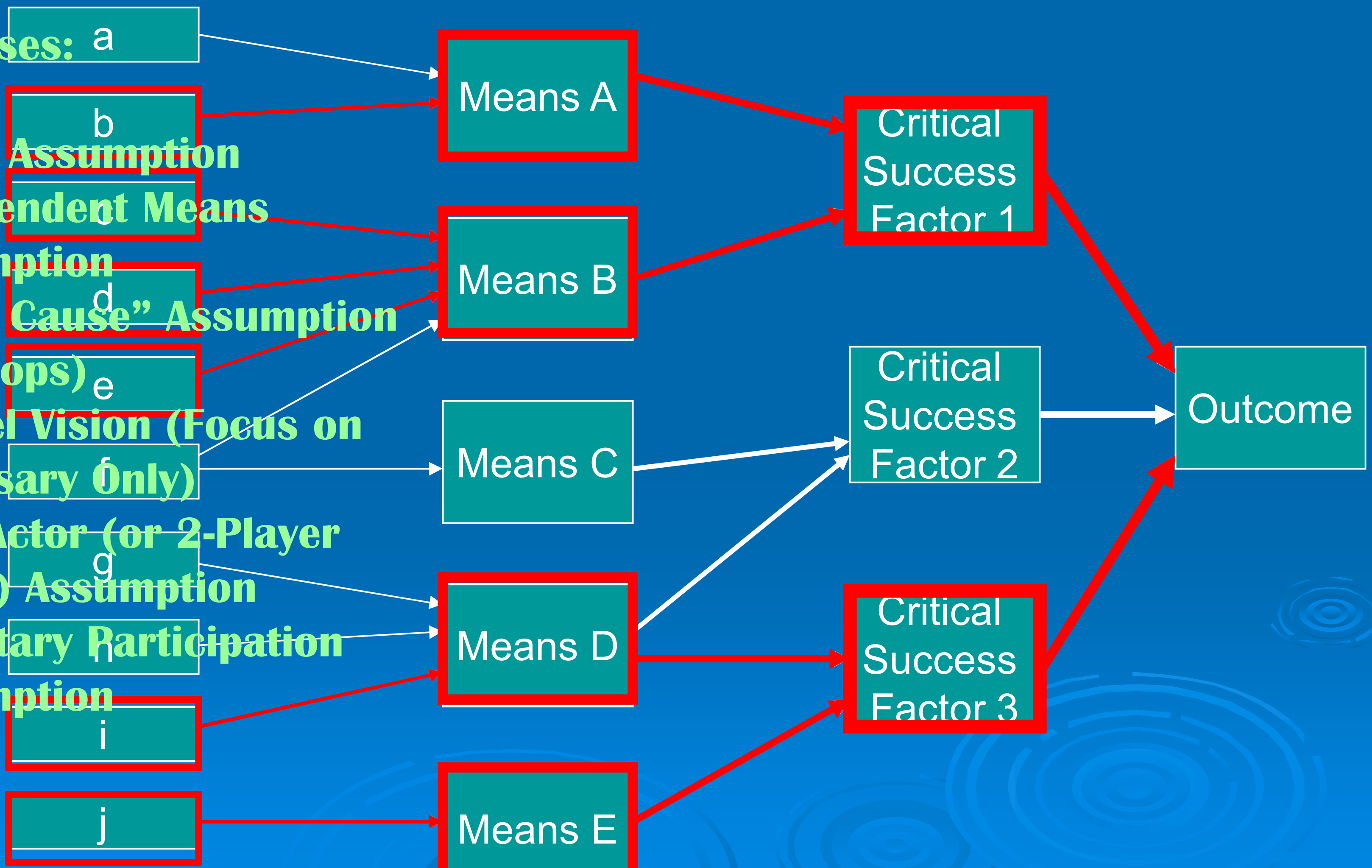
"Linear" or "Left-to-Right" Planning



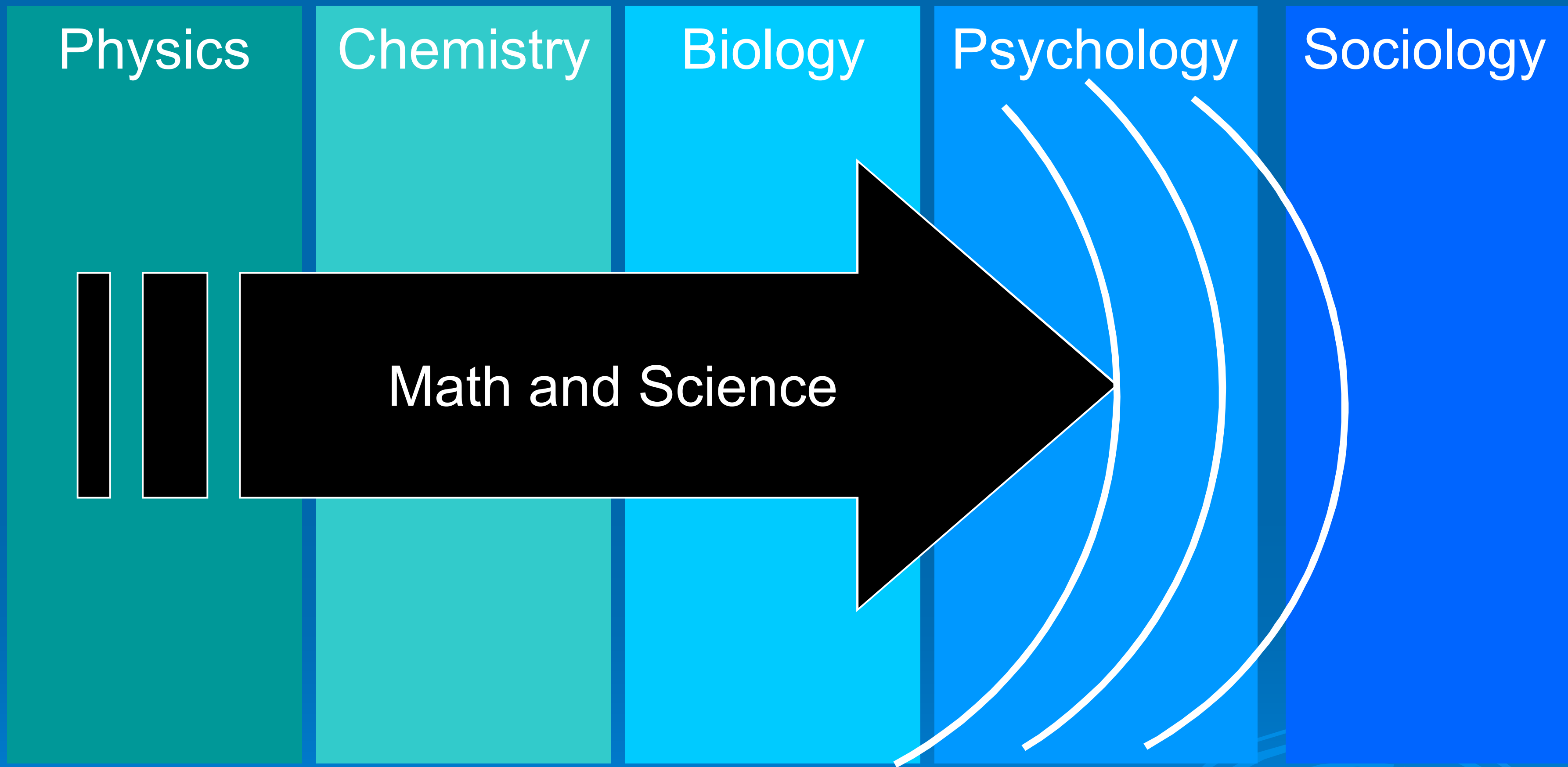
“Linear” or “Left-to-Right” Planning

Weaknesses:

1. **Static Assumption**
2. **Independent Means Assumption**
3. **“Root Cause” Assumption (no loops)**
4. **Tunnel Vision (Focus on Adversary Only)**
5. **Solo Actor (or 2-Player Game) Assumption**
6. **Voluntary Participation Assumption**



Science Reaches a Limit



Problem sets have been discovered without governing mathematical equations or solutions

Characteristics of Complex Systems

- No Definitive Description or Optimal State
- Sensitive to Initial Conditions (History)
- Causes and Effects are Elusive
  - Non-Linear
  - Many interdependent variables (feedback loops)
  - Delays and Distances
- Multi-Minded
  - Systems Adapt
  - Individuals Optimize Locally

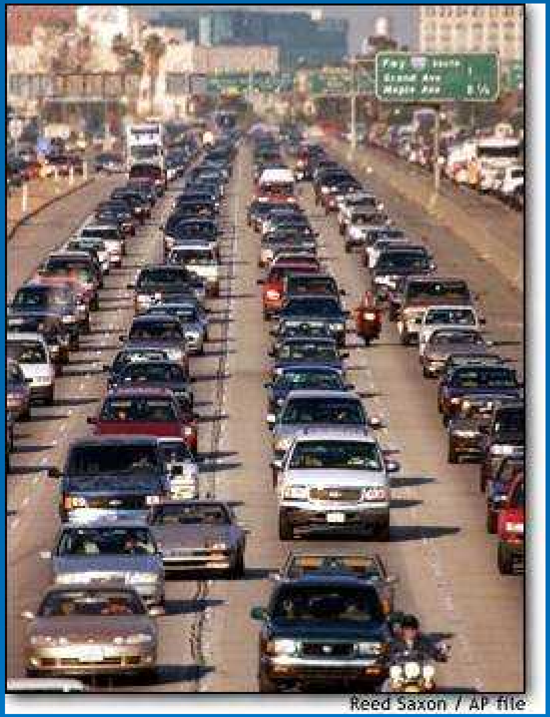
Wicked Problems Have No Definitive Description or Optimal State

- Traffic is:
  - A quality-of-life problem
  - An environmental problem
  - A safety problem
  - A transportation problem
  - A symptom of urbanization
  - A productivity (economic) problem
  - A symptom of poor mass transit systems
  - A symptom of poor acceptance and implementation of telecommuting
- Formulating the problem involves putting on blinders that:
  - Eliminate vast areas of possible solution space
  - Limit the data and information that the problem solver sees
  - Lead you to alienate many actors in the system

Complex Systems Are Sensitive to Initial Conditions

- Values about transportation and cars
- Habitual routes
- Common speeds and rules of the road
- Where the houses and factories are now
- Where a single stalled vehicle is
- Etc.

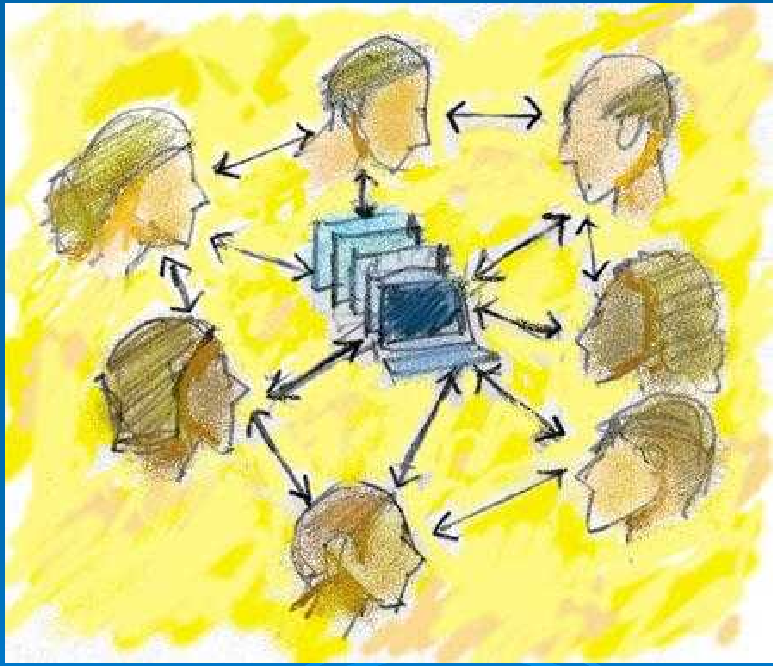
Causes and Effects are Elusive



- Humans always have a cause-effect hypothesis (i.e., we generally don't know our ignorance)
- Our minds do not effectively grasp delays, distances, non-linear effects, and diverse perspectives—even within very simple systems
- Complex systems do not yield their secrets to many analytical and mathematical techniques
- There ARE techniques and methods that can dramatically improve understanding and decisionmaking.

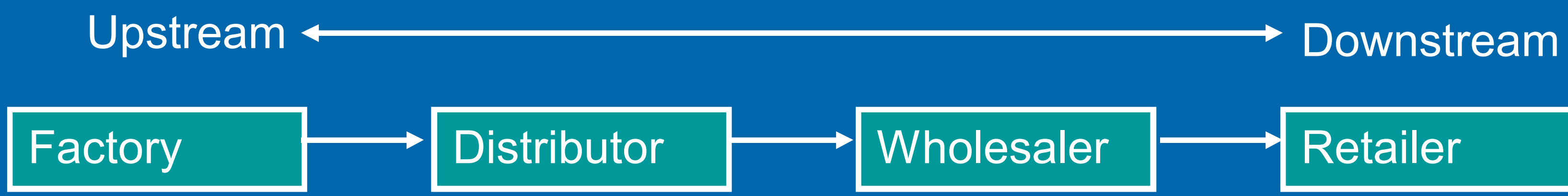
Wicked Problems Involve Multi-Minded Systems

- Multiminded systems have VERY different characteristics than controlled or effective hierarchical systems
- Leveraging multimindness is powerful
- Opposing the energy of a multiminded system is problematic at best
- Need to learn to influence systems we can't fully or even substantially sense, understand, or control.



Beer Distribution Game

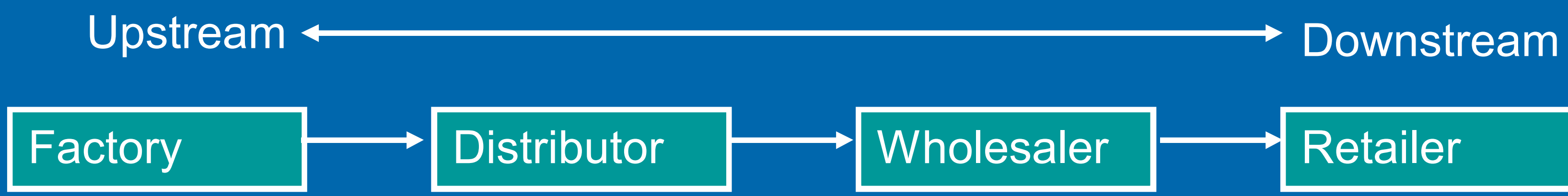
A very simple complex system



- You will play one of these roles in a four-person simulation
- Your object is to minimize your costs. There are only two costs:
  - An inventory holding cost of $1.00 per case is charged on your holdings each turn
  - A backorder cost of $2.00 per case per turn is charged for unfilled orders

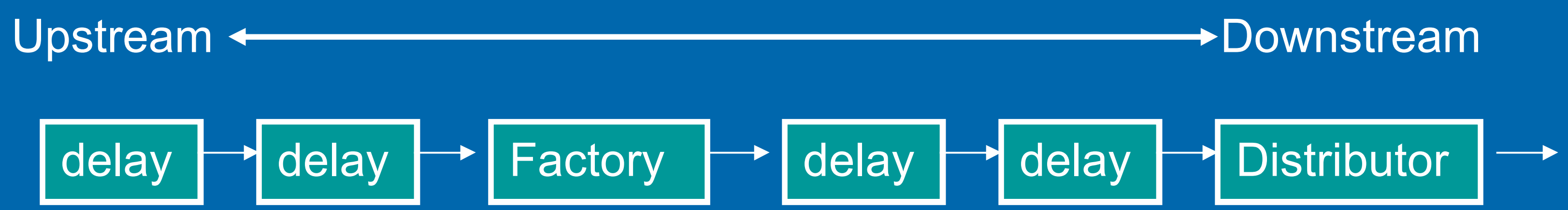
Beer Distribution Game

A very simple complex system



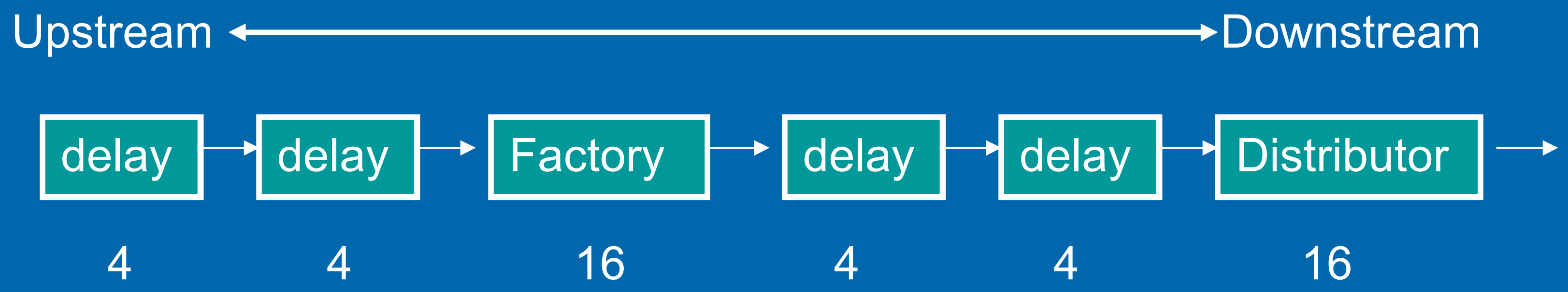
- Each period, or turn, you will be able to see how many cases of beer you have, how many have just been ordered from you by the player downstream and what is due to arrive in the next two turns from upstream.
- You will then decide how many cases of beer to order from upstream in the supply chain and how many to ship downstream.
- You may not ship more beer in any turn than the sum of the current order and the backorder from your downstream customer.

Beer Distribution Game



- It takes three periods, or turns, for cases of beer to move from one player to the next. For example, if the factory decides to ship beer during the third period, the beer travels between the factory and the distributor during the fourth and fifth periods and is available for use by the distributor for the sixth period.

Beer Distribution Game



- The game begins with each player having sixteen cases of beer and with four cases of beer at every step in the pipeline.
- No talking to your supply chain partners

Procedure for Game

- When the monitor announces a new period, click on "return to decision form" and then click on the refresh button.
- Check the top right of the screen to be sure the new period number is displayed. If not, refresh again.
- Decide how many cases of beer to ship downstream:
  - "Current Demand" is the most recent (from the previous period) order from downstream.
  - "Backorder" is the total number of cases ordered by the player downstream in previous periods <u>that have gone unfilled to date</u>
  - "On Hand" is the number of cases of beer you have now. You cannot ship more than you have.
  - You may not ship more cases of beer than the sum of Current Demand and Backorder. If you can ship this total, you will minimize your costs and not incur any backorder charges this period.

Procedure for Game, Cont.

- Decide how many cases of beer to order from upstream:
  - "Due next period" shows the number of cases of beer that will be added to your inventory ("on hand") next turn
  - "Due in two periods" shows the number of cases of beer that will be added to your inventory in two turns
  - Select a number to order that you think will minimize your future backorder and inventory costs (i.e., meet the demand you anticipate)
- When you have made your shipping and ordering decisions, click on the decision button.
- You may return to the decision form and change your mind until the monitor advances to the next period.
- If you fail to enter a decision in time, your station will ship and order no beer that period.
- When the monitor announces a new period, repeat the procedure, starting with clicking on "return to decision form, and refreshing the screen.

Beer Distribution Game—Additional Terms

- **Current Shipment** –the amount you decide to ship this period. This field will display your current decision if you return to the decision screen.
- **Current Order Release** –The number of cases of beer you decide to order from upstream this period. This field will display your current decision if you return to the decision screen.
- **Inventory Cost** –Cumulative cost (total over all the periods so far) of inventory at $1.00 per case per period
- **Backorder Cost** –Cumulative cost (total over all the periods so far) of backorders at $2.00 per case per period
- **Total Cost** –Inventory cost + backorder cost. The object of the game is to minimize the total cost for your station.

On to the Game!

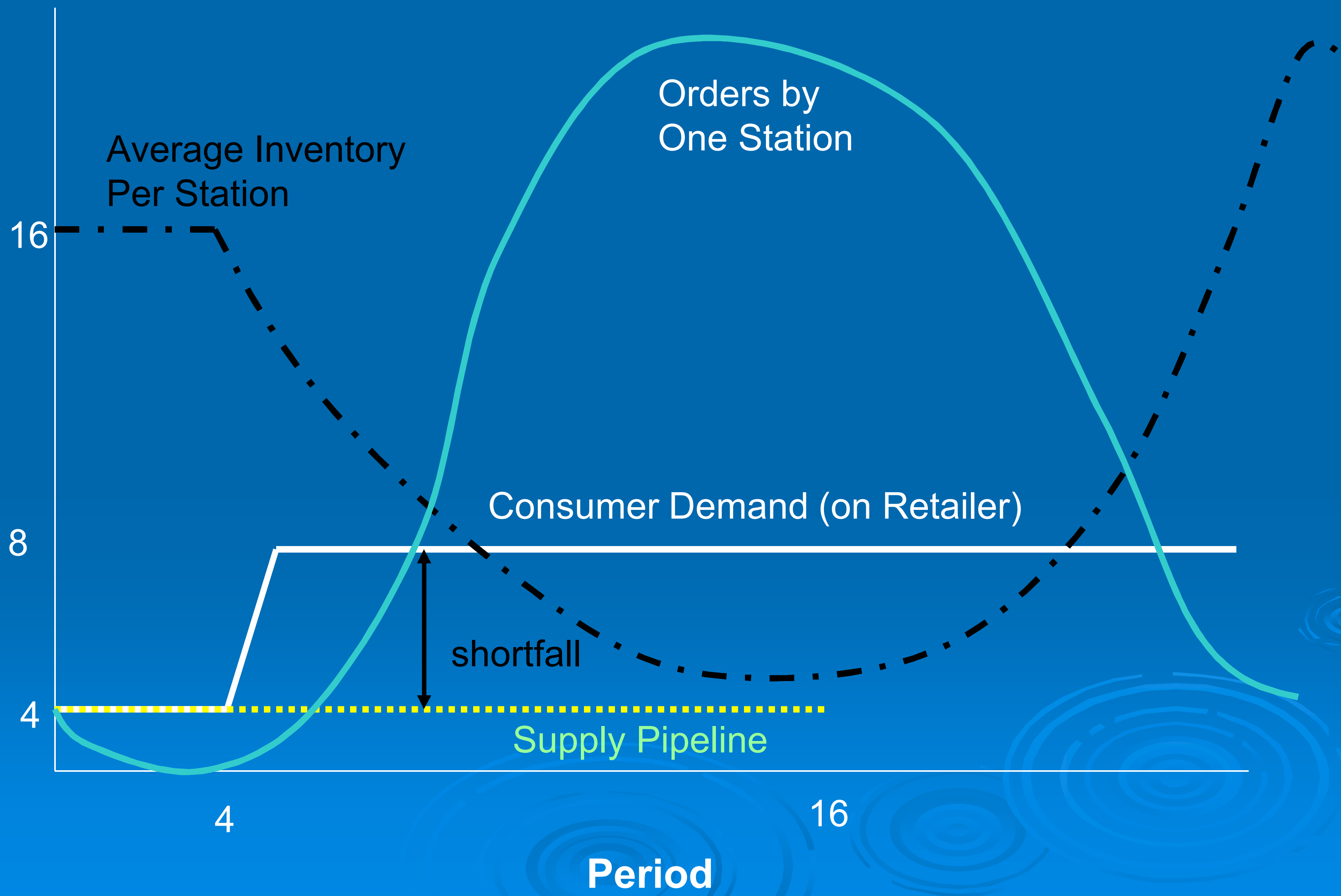
Debrief

What do you think happened to customer demand (orders from the retailer) during the game?

Debrief Continued

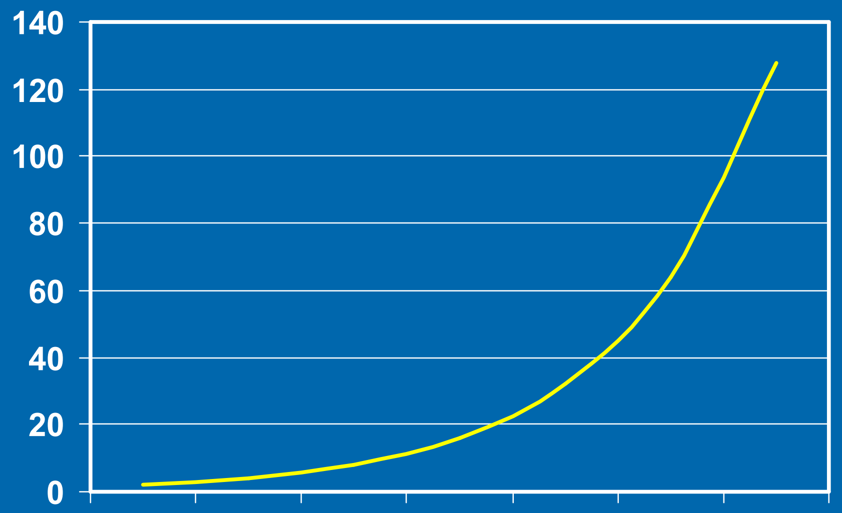
- Were you frustrated with other players? What do you or did you think they were doing?

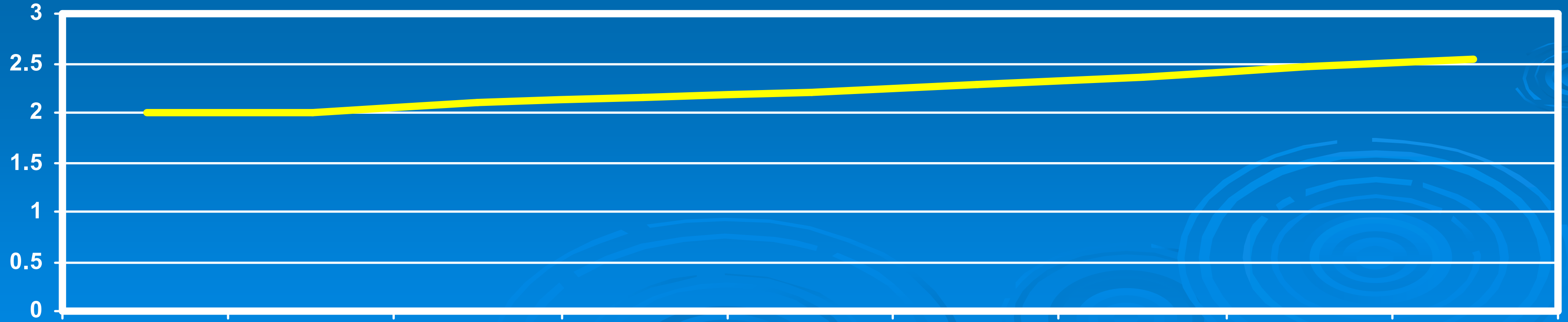
The Bullwhip Effect



Bullwhips in SSTR

- Lasting changes in complex systems are the result of exponential growth due to a reinforcing feedback loop (more on this later)
- But the beginning periods of exponential growth look flat:





Debrief Continued

- Delays really do get us confused
- Where you sit and what you need determine how you see things. There are other valid definitions of the problem
- Multi-minded systems behave very differently from centrally controlled systems
- Multi-minded is not all bad

What could you do as just one actor in the beer distribution game to make outcomes better without trying to control or redesign the system?

How can you leverage the energy of the system, rather than oppose it?

Lessons from Beer Distribution Game

- We need to think about how others will react by putting ourselves in their role before we decide what to do
- Even when people are trying to be sensible and rational, complexity happens
- We CAN understand a lot about these systems and it is not "all relative," "all random," or hopeless—just a very different game.

My Observations of Military Organizations Working in Complex Problems

- Good awareness of the need to understand cultural differences
- Good understanding of the importance of "hearts and minds" in SSTR
- Nonetheless, the military ends up:
  - Assuming it understands the problem;
  - Looking for simple, single causes and fixes;
  - Using rather homogenous teams;
  - Limiting its actions mostly to what it can count (measures of performance and measures of effect); and
  - Doing one-time planning, not continuous adaptation.

Military Influence Models Are Insufficient

- Bombing campaign and and bomb damage assessment (BDA)
  - Select Target ► Deliver Bomb ► Destroy Target
- Classic World War I and II Psychological Operations
  - Single unified enemy with a military and a homefront—Purpose of operations is to demoralize the enemy or prepare the battlefield
  - Select Message ► Deliver Message ► Demoralize Enemy

Civilian Influence Models Are Also Insufficient

- Advertising
  - Product is fixed. We just need to find the right message to get you to buy it.
  - Select Target ► Deliver Message ► Target Buys Product
- Elections
  - Only two or three sides
  - Short-term contest
  - Select Target ► Deliver Message ► Targets Vote for Us

Why Are These Approaches are Ineffective in SSTR?

Because these assumptions are invalid for most SSTR problems!!

- Static Assumption
- Independent Means Assumption
- "Root Cause" Assumption (no loops)
- Tunnel Vision Assumption (Focus on Adversary Only)
- Solo Actor (or 2-Player Game) Assumption
- Voluntary Participation Assumption

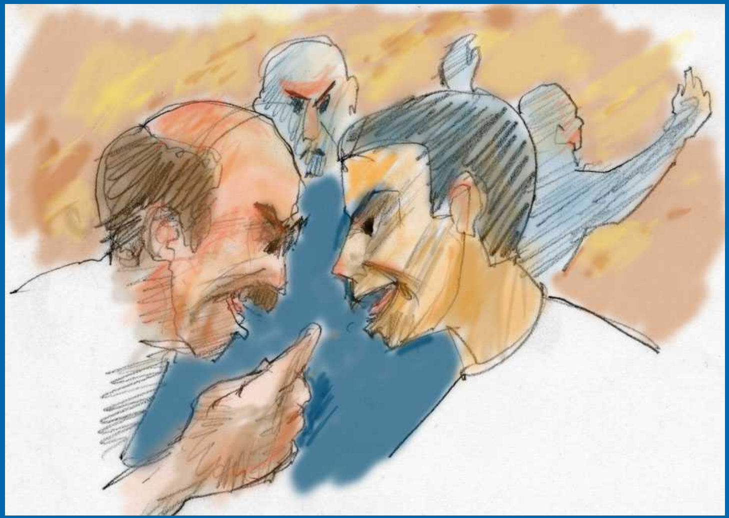
Step One: Recognize Complexity

Step Two: Accept Complexity

- Each problem at each moment is unique
- Every problem definition eliminates other valid definitions and limits the solution space
- You will never understand the whole system; Complexity cannot be studied or analyzed away.
- Studying and experimenting with the problem changes the problem
- Success changes the game (what works today will often not work tomorrow)
- You cannot control or stabilize the system
- You can anticipate outcomes but not predict them definitively

Step Three: Organize for Success

- Create a diverse team, including different:
  - Perspectives on the system and from within the system
  - Professions, academic backgrounds, genders, races, ages, religions, thinking styles, etc.
- Create an environment where those many voices are welcome



- **Identify several different formulations of the problem**
- Deliberately **put yourselves in "different shoes"**
- **Plan for continuous data collection, analysis, decision-making, and action. Organize to make rapid decisions, even with limited data, and to adapt to changes quickly**

Step Four: Use an Orderly, Rational Approach Based on the Scientific Method

1. Observe, gather data, and describe the problem
2. Formulate an hypothesis
3. Make a prediction (If . . . Then . . .)
4. Test the hypothesis
5. Update description and hypothesis

A scientific approach can't take out the complexity. It can ensure that the actions you take are rational given your assumptions and knowledge. More importantly, it can ensure that you know what you don't know, change your assumptions and problem definition when these are disproved, and that you learn as you go.

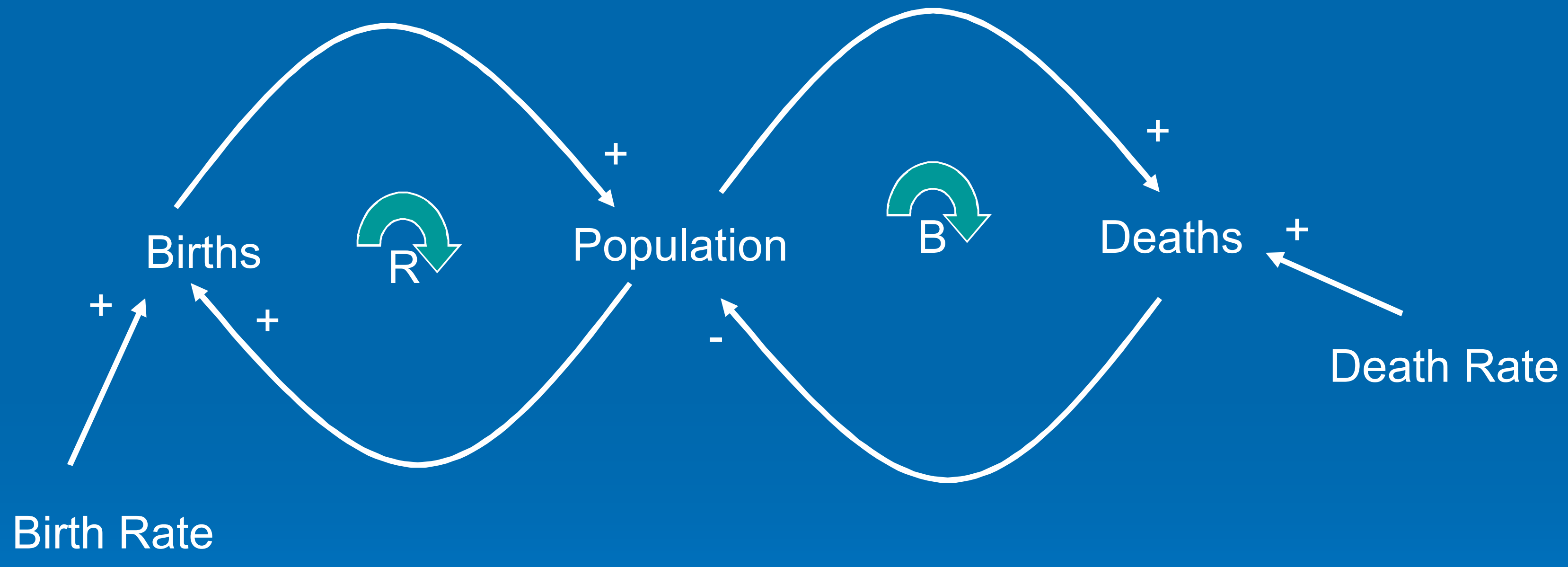
Step Five: Use Appropriate Tools

- Red Teams
- Gaming
- Modeling and Simulation
  - Agent-Based Models (simulates multi-mindedness)
  - Systems Dynamics Models
- Dialogue Mapping
- Social Network Analysis
- Informatics and Correlation Analysis
- “Pinging” and Experiments

General Principles for Working Complex Problems

- Continually gather information, revalidate assumptions, and consider alternate hypotheses
- Find ways to collect artificial or low-cost experience and test hypotheses
- Look for underlying structures, causes and motivations (an art, not a science)
- Always look at a problem from multiple frames
- Leverage the energy in the system; don’t oppose it
- Be ready to adapt even when you are successful
- Dynamic stability is more robust than controlled, or static, stability—a little chaos is good!
- Focus on the people more than the technology, the facts, or the stuff

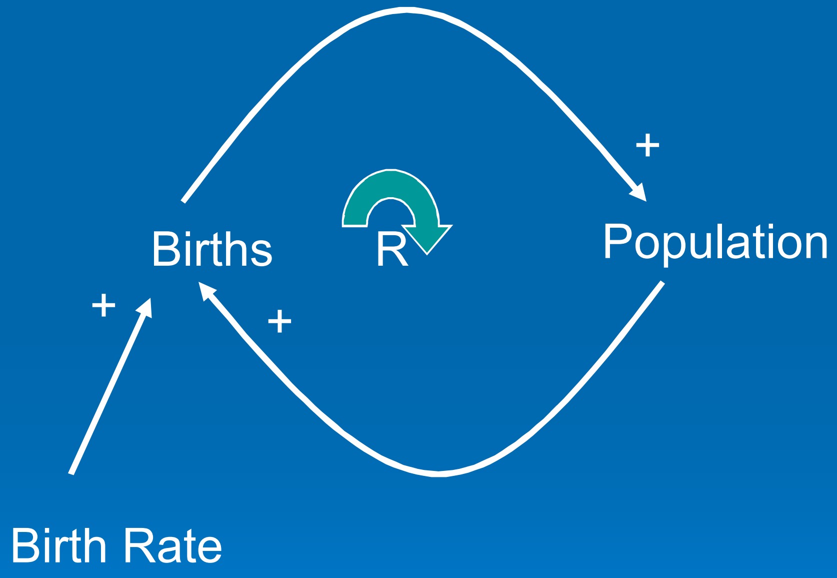
One Complexity Tool: Causal Loop Diagrams

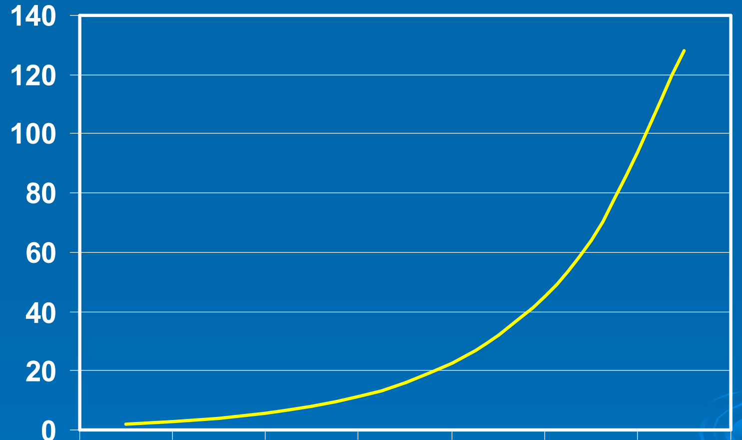


R = Reinforcing (growing)

B = Balancing (controlling)

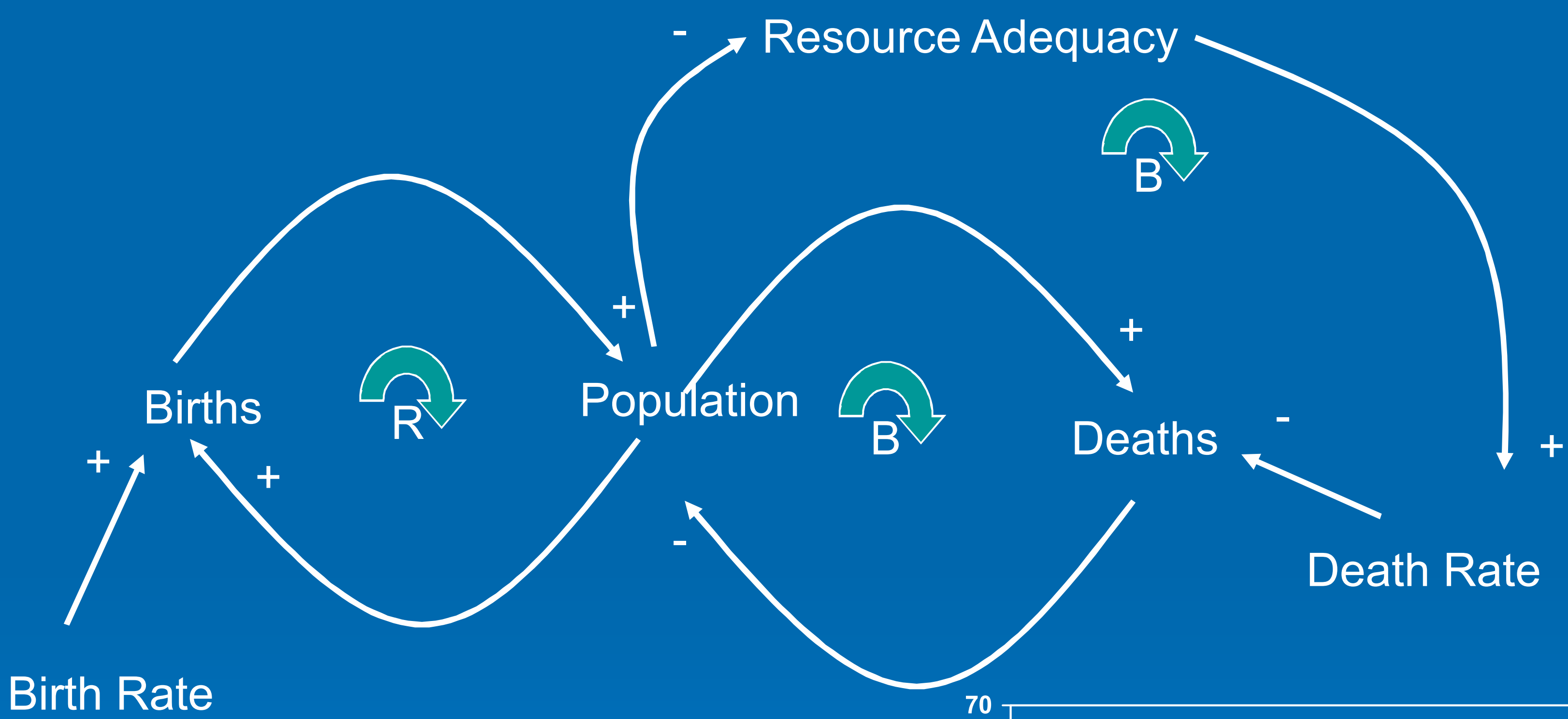
A Reinforcing Loop Will Create Exponential Growth

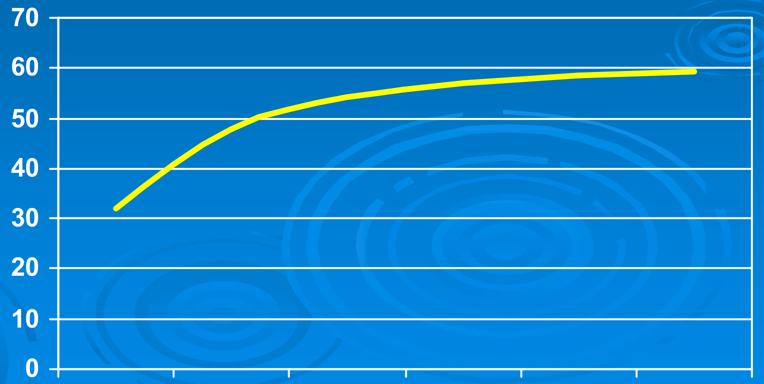




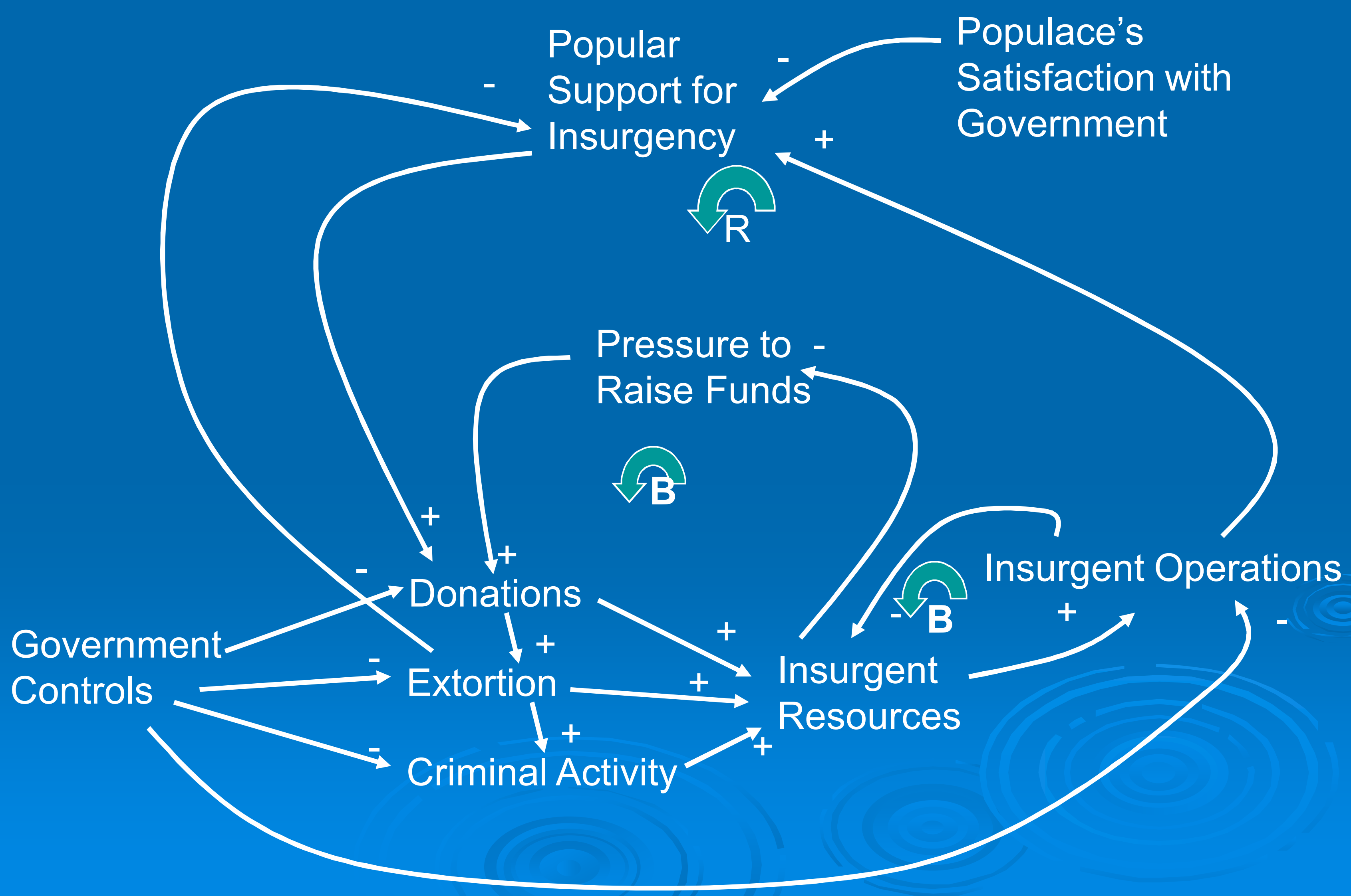
R = Reinforcing (growing)

Capacity Always Limits Growth





A Counterinsurgency Example



What We Gain With Complex Thinking

- This simple model keeps us thinking about how the whole system works and what is motivating the government, the insurgents and the populace
- When we contemplate an action, we have to think about how each player will react and how the dynamics will change.
- We also have to think about how each player will adapt to our actions and what new dynamics will arise
- In this way we think beyond the immediate consequences and we are better prepared for their next move and our counter-move

Questions and Comments?

Backup Slides

Maslow's Hierarchy of Needs