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# Complexity Science for Security and Stability Operations

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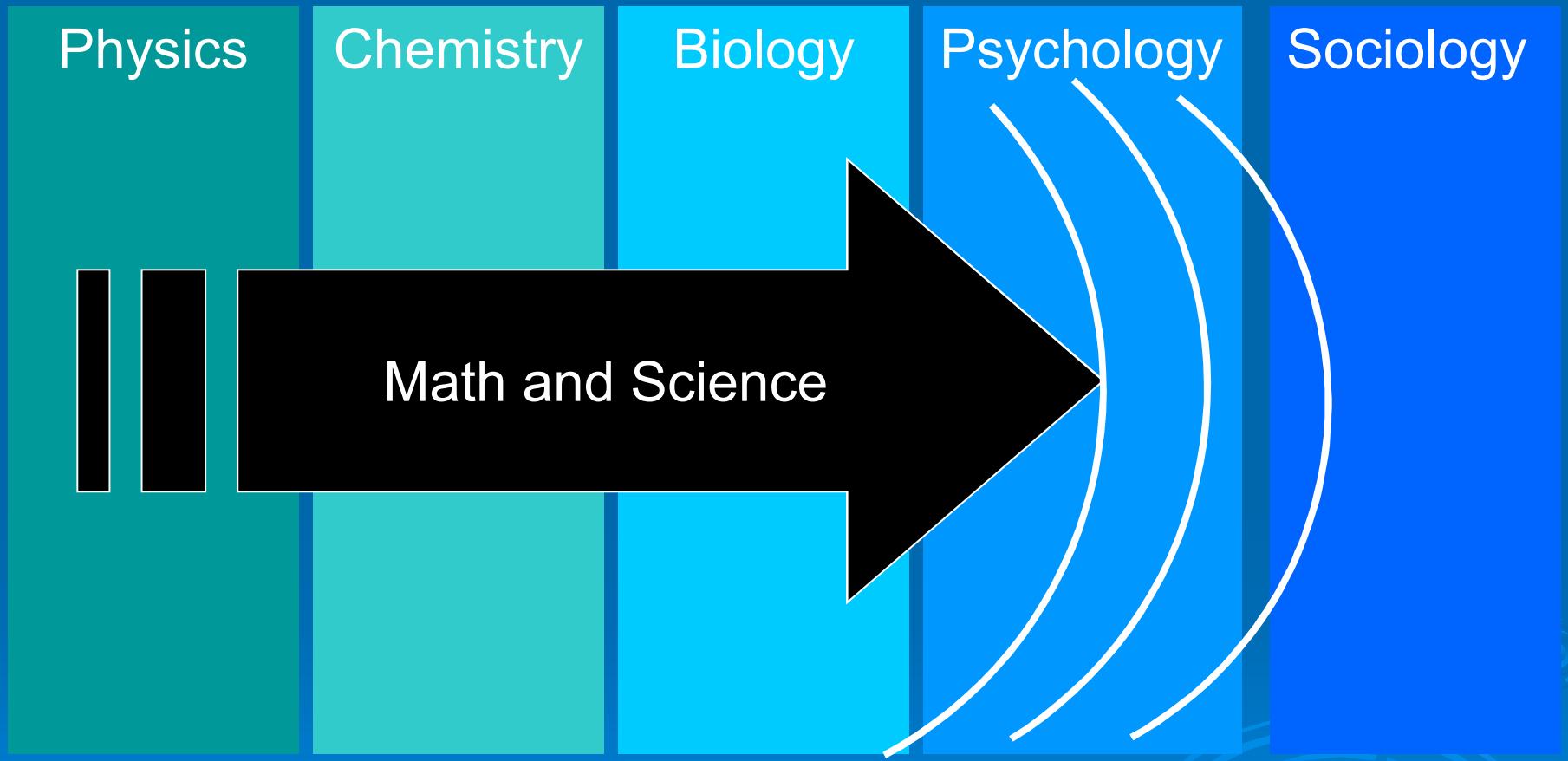
# Objectives for Today

- 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

# Science Reaches a Limit




Problem sets are discovered without closed form solutions or deterministic laws

# Characteristics of Complex Systems

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

# Causes and Effects are Elusive

- It's not just cars that cause traffic
  - Locations of homes, workplaces, stores and attractions;
  - Cost of travel
  - Hours and times of work
  - Weather and construction
  - New roads cause growth which causes traffic
  - Alleviation of traffic shortens trips which leads people to take more trips and causes traffic

# Complex Systems Have No Definitive Description or Optimal State

- Traffic is:
  - A quality of life problem
  - An environmental problem
  - A productivity problem
  - A safety problem
  - A transportation problem
  - A symptom of poor acceptance and implementation of telecommuting
  - A symptom of urbanization
  - A symptom of poor mass transit systems

# Complex Systems Are Multi-Minded

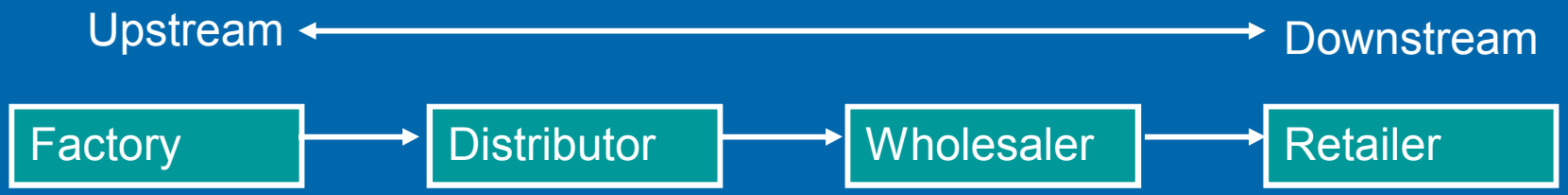
- Each person and each driver will adapt to changes and optimize locally, changing:
  - Routes
  - Jobs
  - Homes
  - Transportation modes
  - Habits
  - AND PERCEPTIONS AND VALUES

# 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.

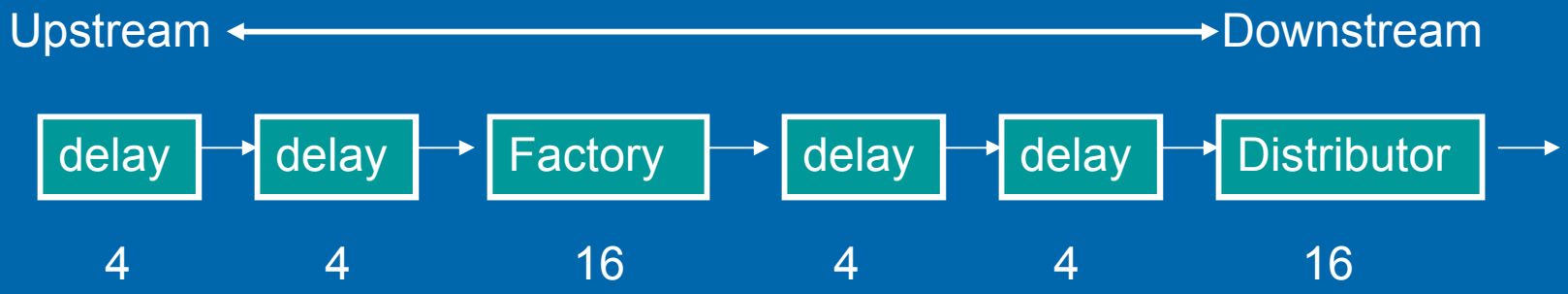
# Beer Distribution Game

## 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 charged on your holdings each turn
  - A backorder cost charged for orders that you can't fill
- Each period, or turn, you will be able to see how many cases of beer you have, how many have been ordered from the player downstream and what has just arrived from the player upstream. You will then decide how many cases of beer to order from "upstream" in the supply chain and how many to ship downstream.
- NO TALKING

# 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.
- 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.
- Similarly, it takes one turn for orders to become visible to the player upstream. For example, if the Distributor orders eight cases of beer in the first period, the Factory will see the order in the second period.

# Beer Distribution Game--Terms

- **Current Demand** —the amount requested in the most recent order from downstream
- **Backorder** –the demand that has not been met
- **Current Shipment** –the amount you decide to ship this period
- **On Hand** –the current amount of beer you have. This is the maximum you can ship this period.
- **Due Next Period** –The number of cases of beer that will arrive next period.
- **Due in Two Periods** –The number of cases of beer that will arrive in two periods.

# Beer Distribution Game--Terms

- **Current Order Release** –The number of cases of beer you decide to order from upstream this period.
- **Inventory Cost** –Cumulative cost (total over all the periods so far) of inventory
- **Backorder Cost** –Cumulative cost (total over all the periods so far) of backorders
- **Total Cost** –Inventory cost + backorder cost. The object of the game is to minimize the total cost for your station.

# Lessons from Beer Distribution Game

- Where you sit and what you need determine how you see things.  There are other valid definitions of the problem
- Delays really do get us confused
- Multi-minded systems behave very differently from centrally controlled systems;
- 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”.

# My Observations of US Military 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.

# Weak Military Metaphors for Influencing People

- 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

# Weak Civilian Metaphors for Influencing People

- 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 These Approaches are Ineffective in SSTR

- Problem is defined very narrowly and only from the military perspective
- Problem definition eliminates many possible solutions
- Solution assumes people are all the same and are the same even under different conditions
- SSTR requires long-term, deep influence, not quick fixes and surface influences
- Influence activities have unintended consequences
- The problem changes and we don't notice
- Others are exerting influence too, but we largely ignore this
- We are part of the system of influence, but we ignore this

# Maslow's Hierarchy of Needs

# **Step One:** Accept the 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
- Studying and experimenting with the problem changes the problem (like Heisenberg)
- 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 Two:** Organize for Success

- Create a diverse team
  - Interdisciplinary
  - Different perspectives on the system and from within the system
  - Race, age, religion, 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 Three:** 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.

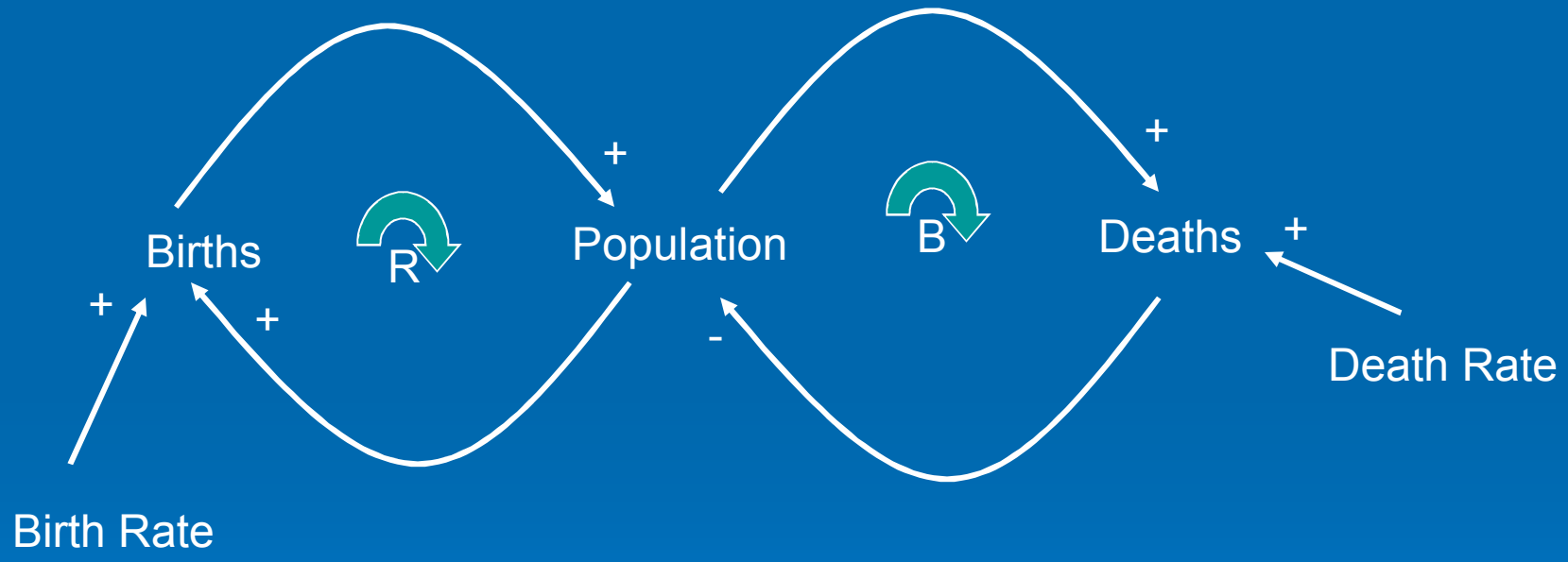
# **Step Four:** Use Appropriate Tools

- 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; and
- Focus on the people more than the technology or the stuff

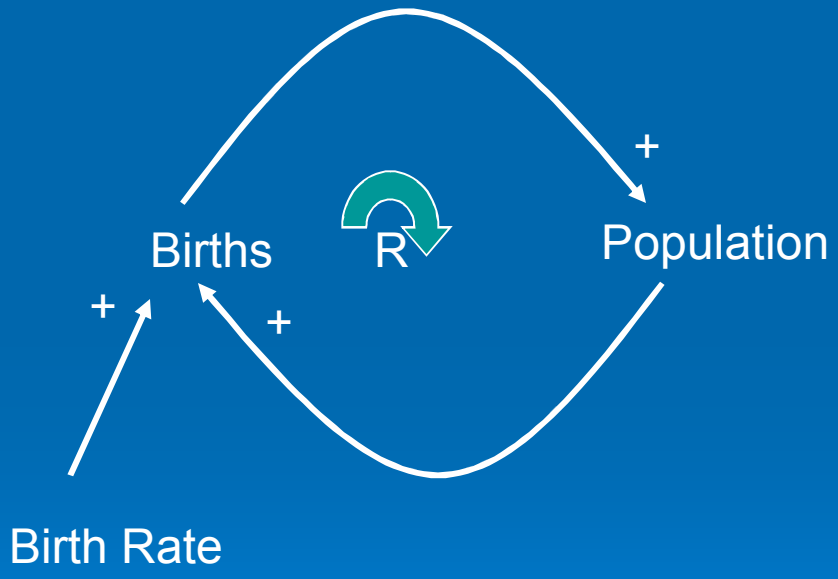
# One Complexity Tool: Causal Loop Diagrams

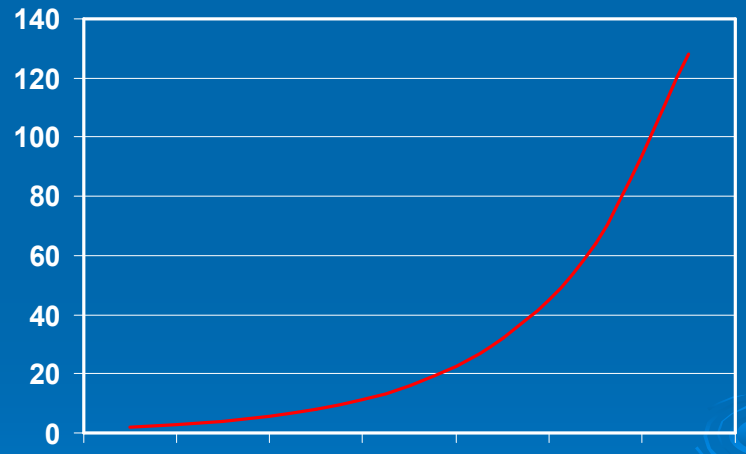



R = Reinforcing (growing)

B = Balancing (controlling)

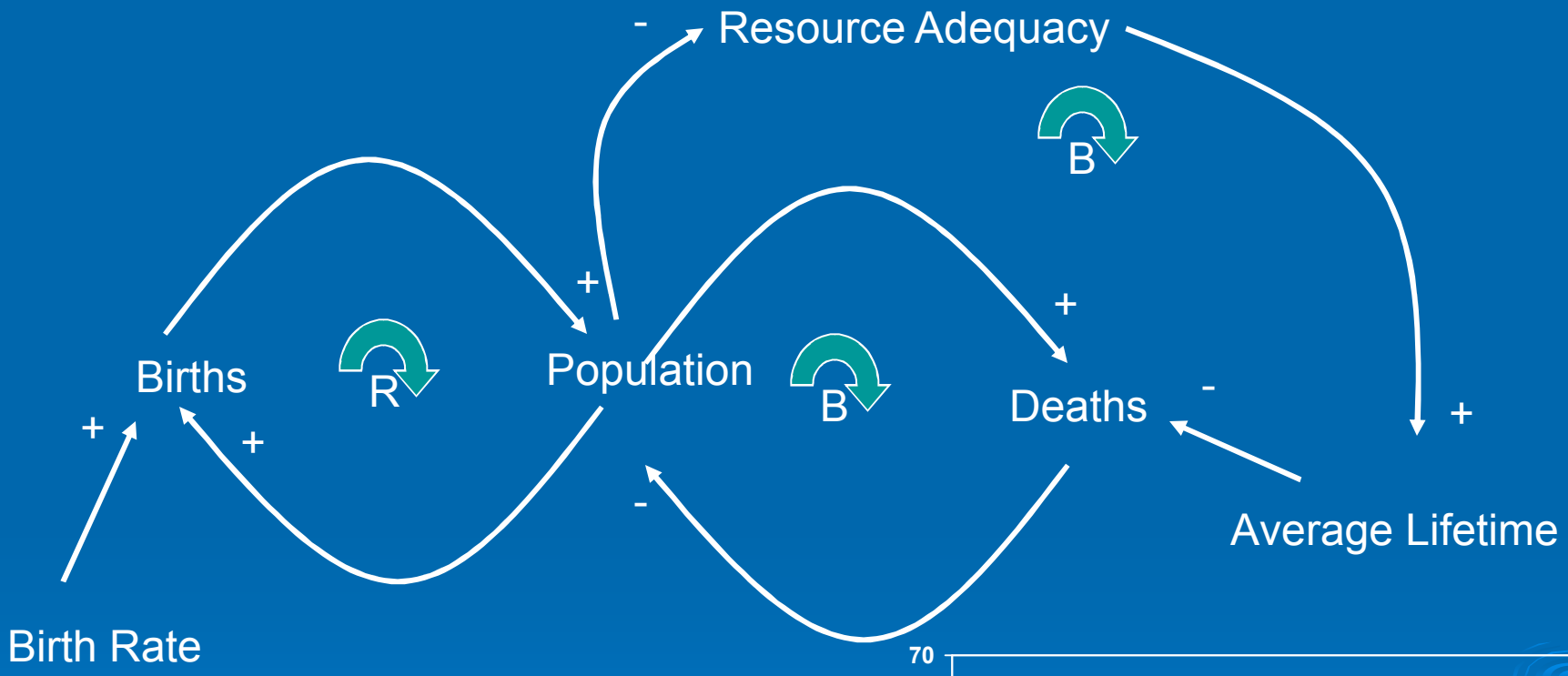
# A Reinforcing Loop Will Create Exponential Growth

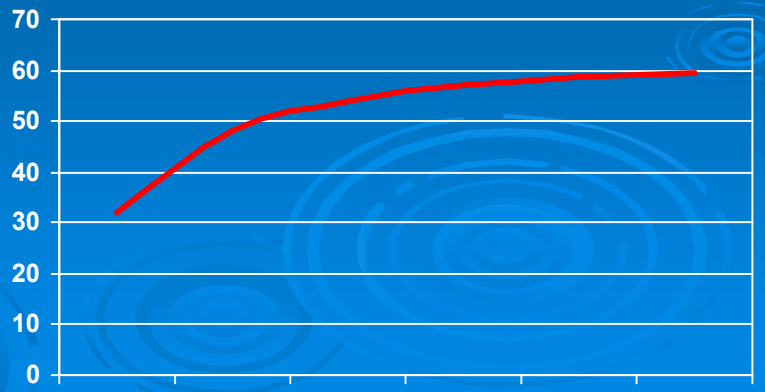


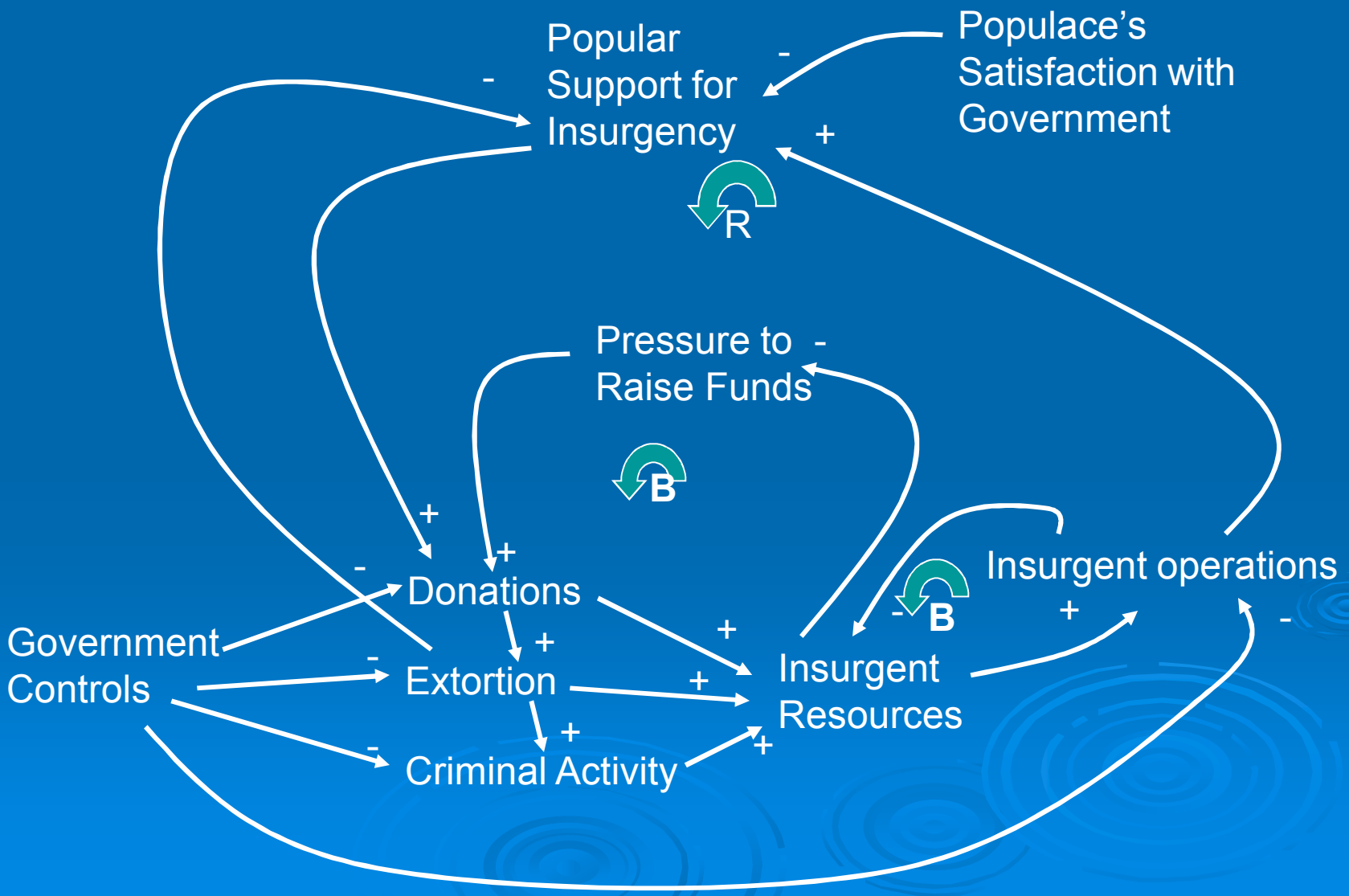

R = Reinforcing (growing)

# 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?

- 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
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