SYSTEM THINKING DAN SYSTEM DYNAMIC

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Sesi 3
Systems Thinking Dan System Dynamics

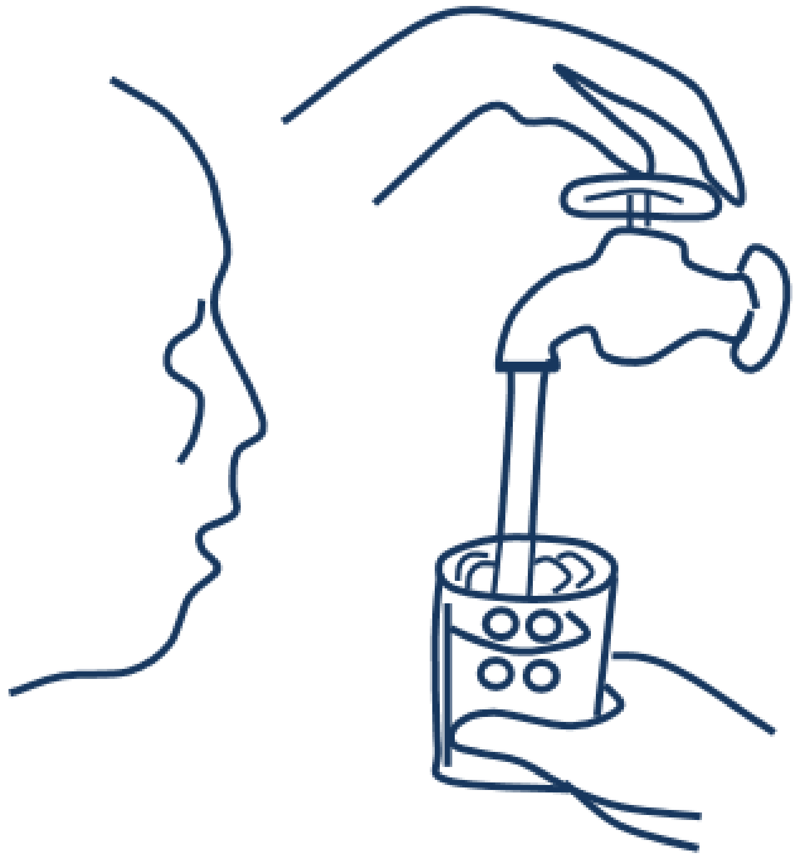
Outcomes

Pada akhir sesi ini, peserta dapat:

- mengenali hubungan sebab akibat;
- memahami metodologi pemodelan *system dynamics*.

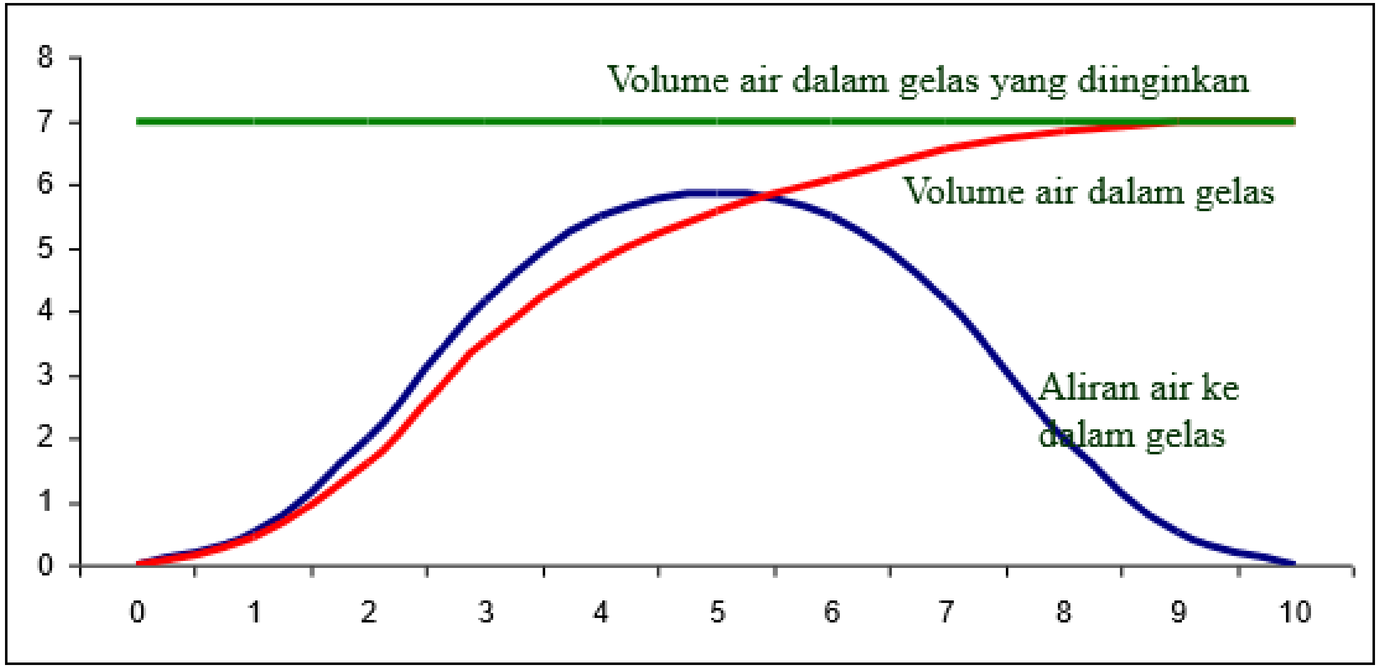
Contoh : Pengisian air ke dalam gelas sampai penuh.

(Sumber: “The Fifth Discipline”, Peter M. Senge, 1990)



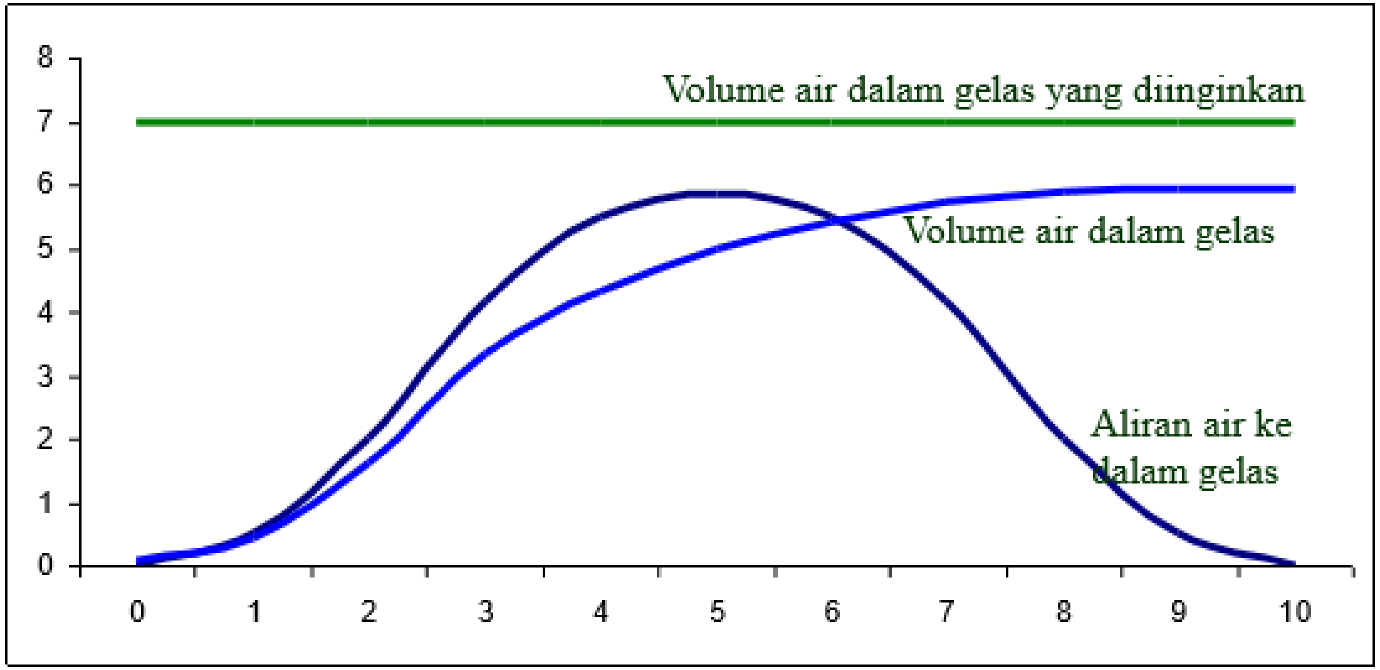
Kemungkinan Perilaku

A. Jika sumber air mencukupi

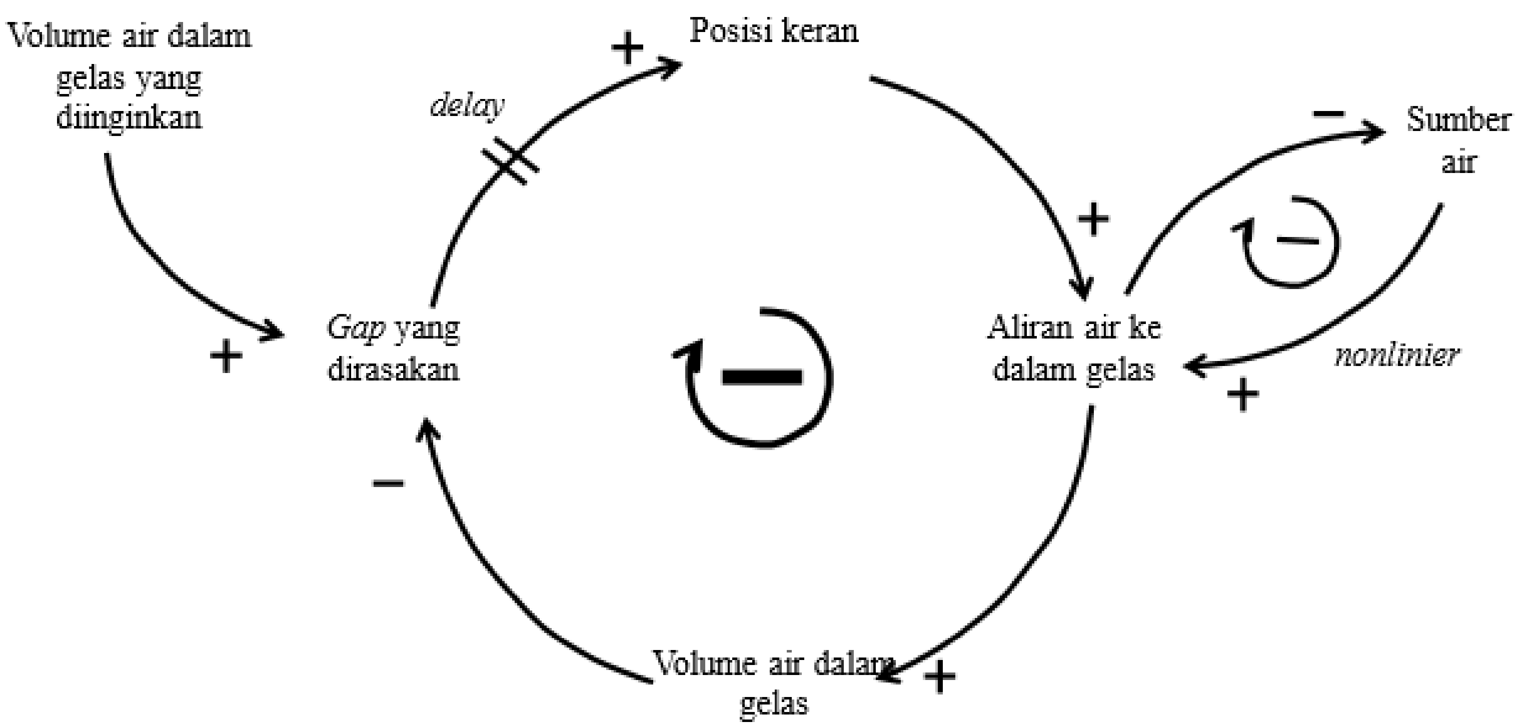


Kemungkinan Perilaku

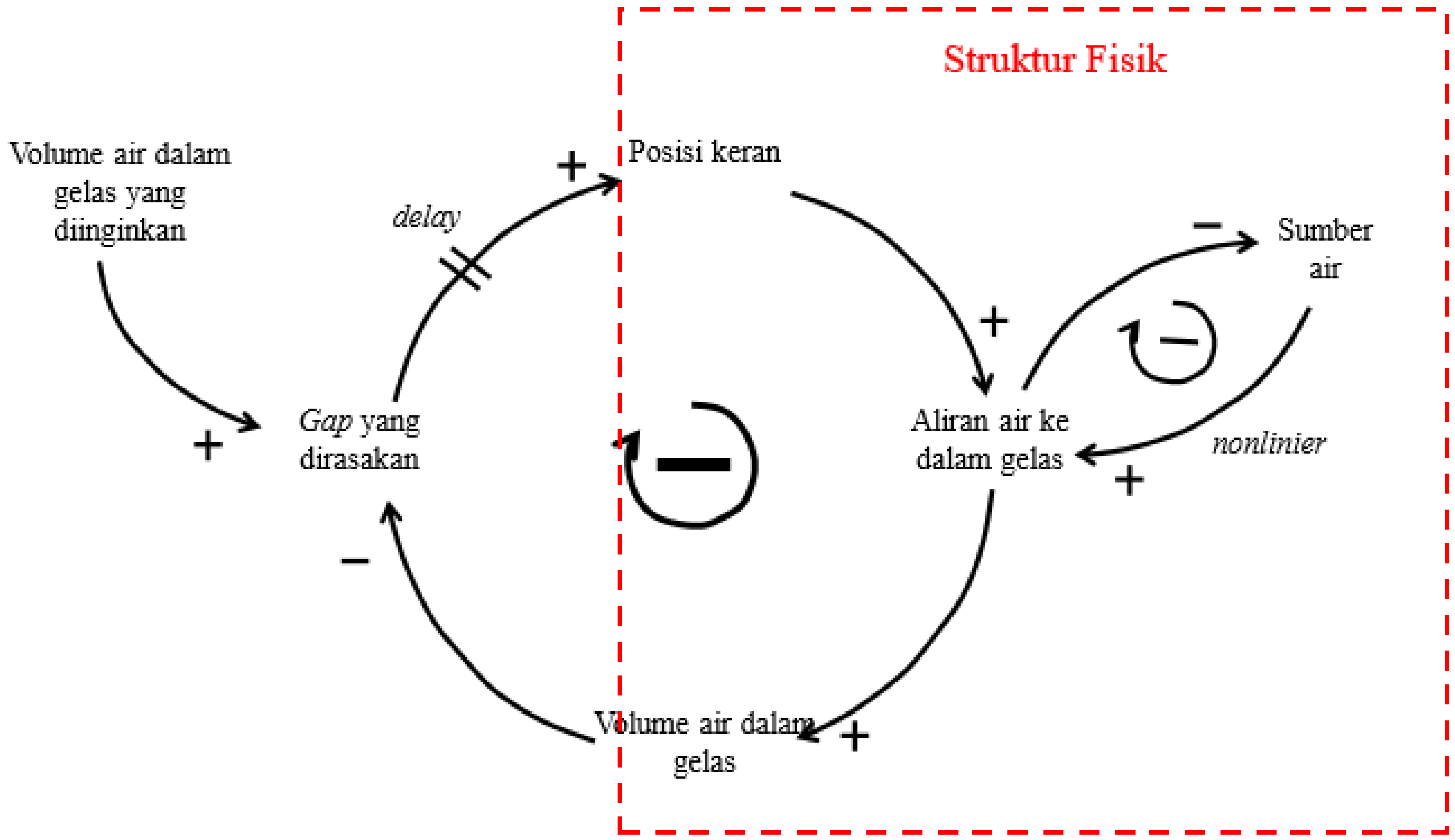
B. Jika sumber air terbatas



Struktur Fenomena



Struktur Fenomena



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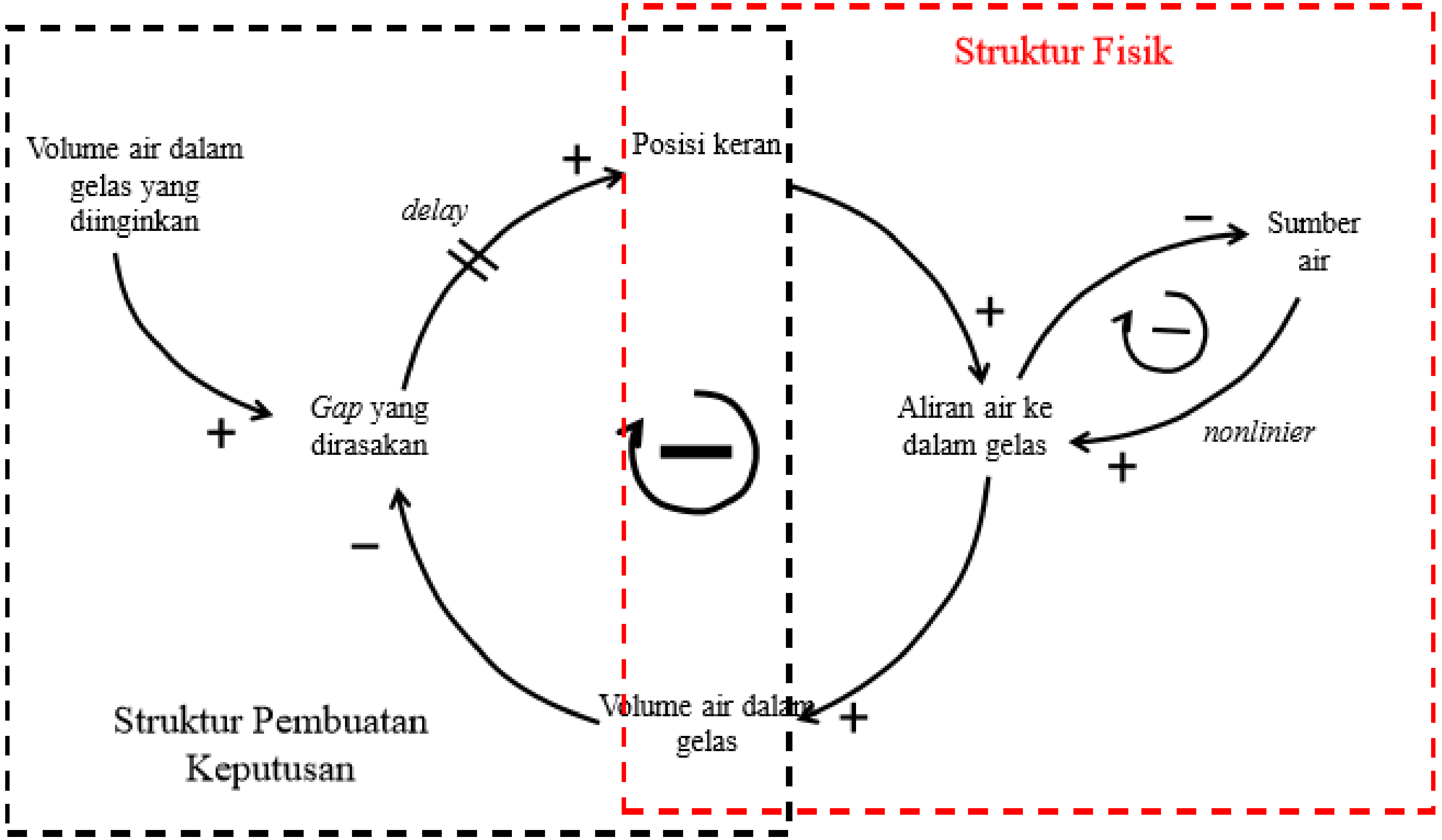

Metodologi Pemodelan

Systems Thinking dan *System Dynamics*

Struktur ➡ Perilaku

- **unsur pembentuk**
- **pola keterkaitan antar unsur :**

(1) *feedback* (*causal loop*)

(2) *stock* (*level*) dan *flow* (*rate*)

(3) *delay*

(4) *nonlinearity*

(ontological: *the ways reality itself could be*)

Pendekatan Struktural

Systems Thinking

System Dynamics

System Dynamics Methodology

A. Source: System Dynamics Home Page.htm

3.1 System Dynamics Methodology

- System dynamics is a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems.
- In fact it has been used to address practically every sort of feedback system.
- While the word system has been applied to all sorts of situations, feedback is differentiating descriptor here.
- Feedback refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects.
- One cannot study the link between X and Y and, independently, the link between Y and X and predict how the system behave. Only the study of the whole system as a feedback system will lead to correct results.

3.2 What is the relationship of Systems Thinking to System Dynamics?

- Systems thinking looks at the same type of problems from the same perspective as does system dynamics.
- The two techniques share the same causal loop mapping techniques.
- System dynamics takes the additional step of constructing computer simulation models to confirm that the structure hypothesized can lead to the observed behavior and to test the effects of alternative policies on key variables over time.

B. Richardson, George P. & Alexander L. Pugh III (1981), *Introduction to System Dynamics Modeling with Dynamo*, MIT Press/Wright-Allen series in system dynamics.

OVERVIEW OF THE SYSTEM DYNAMICS APPROACH

- The system dynamics approach to complex problems focuses on feedback processes.
  - It takes the philosophical position that feedback structures are responsible for the changes we experience over time.
  - The premise is that ***dynamic behavior is consequence of system structure*** and will become meaningful and powerful.
  - At this point, it may be treated as a postulate, or perhaps as a conjecture yet to be demonstrated.
- As both a cause and a consequence of the feedback perspective, the system dynamics approach tends to look ***within*** a system for the sources of its problem behavior.
  - Problems are not seen as being caused by external agents outside the system.

- Inventories are not assumed to oscillate merely because consumers periodically vary their orders.
  - A ball does not bounce merely because someone drops it.
  - A pendulum does not oscillate merely because it was displaced from the vertical.
  - The system dynamicist prefers to take the point of view that these systems behave as they do for reasons ***internal*** to each system.
  - A ball bounces and a pendulum oscillates because there is something about their internal structure that gives them the tendency to bounce or oscillate.
- In practice, this internal point of view results in models of feedback system that bring external agents inside the system.
  - Customers orders become endogenous to a production system, part of the feedback structure of the system.
  - Orders affect production; production affects orders.
  - Part and parcel with the notion of feedback, the endogenous point of view helps to characterize the system dynamics approach.

- The are roughly seven stages in approaching a problem from the system dynamics perspective:
  (1) problem identification and definition;
  (2) system conceptualization;
  (3) model formulation;
  (4) analysis of model behavior;
  (5) model evaluation;
  (6) policy analysis; and
  (7) model use or implementation.

- The process begins and ends with understandings of a system and its problems, so it forms a loop, not a linear progression.
  - Figure 1 shows these stages and the likely progression through them, together with some arrows that represent the cycling, iterative nature of the process.
  - At a number of stages along the way one's understanding of the system and the problem are enhanced by the modeling process, and that increased understanding further aids the modeling effort.
- Figure 1 shows that final policy recommendations from a system dynamics study come not merely from manipulations with the formal model but also from the additional understandings one gains about the real system by iterations at a number of stages in the modeling process.
  - Done properly, a system dynamics study should produce policy recommendations that can be presented, explained, and defended without resorting to the formal model.
  - The model is a means to an end, and that end is understanding.

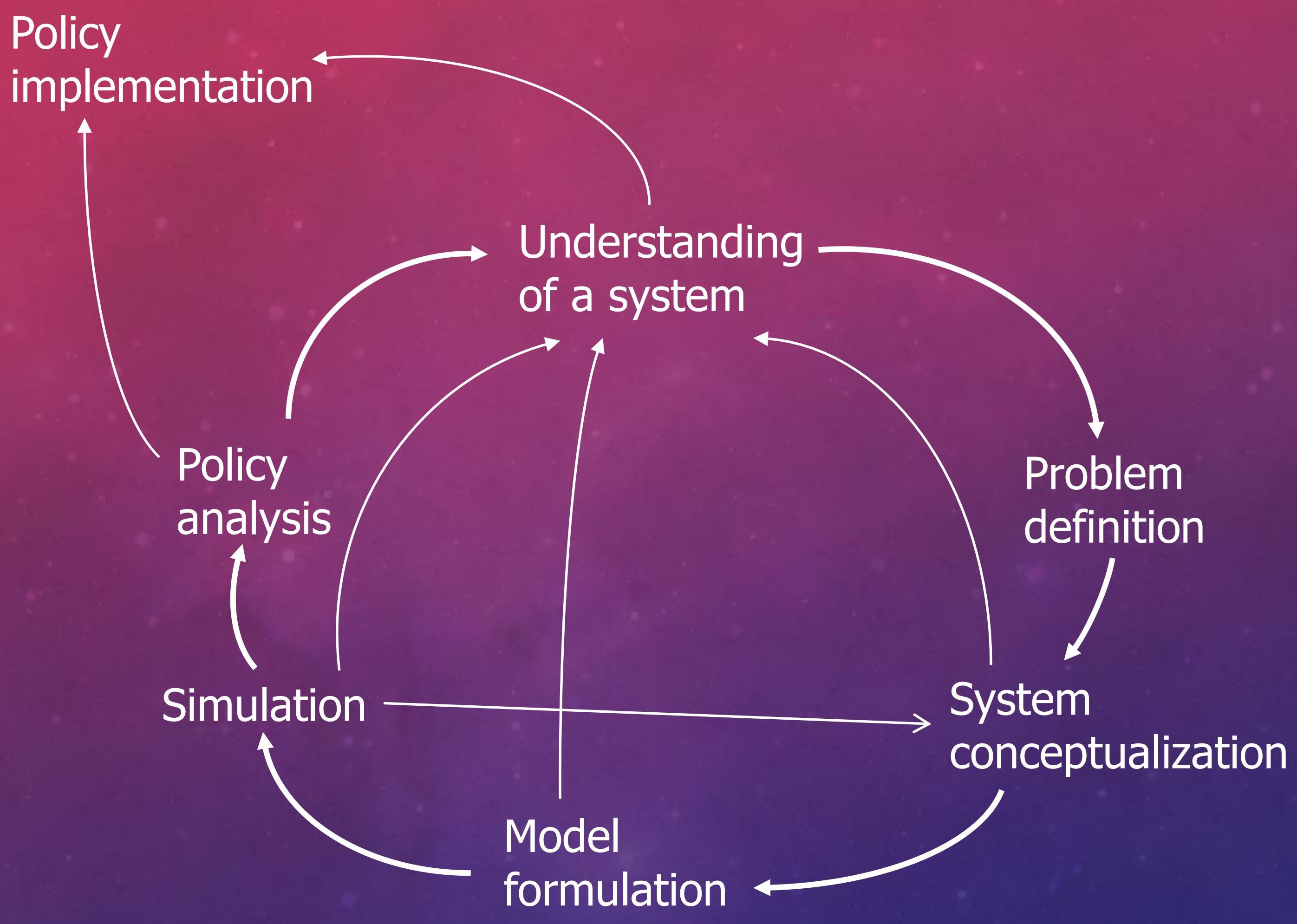

Figure 1 Overview of the system dynamics modeling approach

GUIDELINES FOR CAUSAL-LOOP DIAGRAMS

- The apparent simplicity of causal-loop diagram is deceptive. It is easy for would-be modelers to go astray with them.
  - The following suggestion may help to prevent the more common difficulties.

1. Think of variables in causal-loop diagrams as quantities that can rise or fall, grow or decline, or be up or down.

But do not worry if you can not readily think of existing measures of them.

Corollaries:

(a) Use nouns or noun phrases in causal-loop diagrams, not verbs. The actions are in the arrows (see Figure 2).

(b) Be sure it is clear what is means to say a variable increases or decreases. (Not "attitude toward crime", but "tolerance for crime".)

(c) Do not use causal-links to mean "and then….."

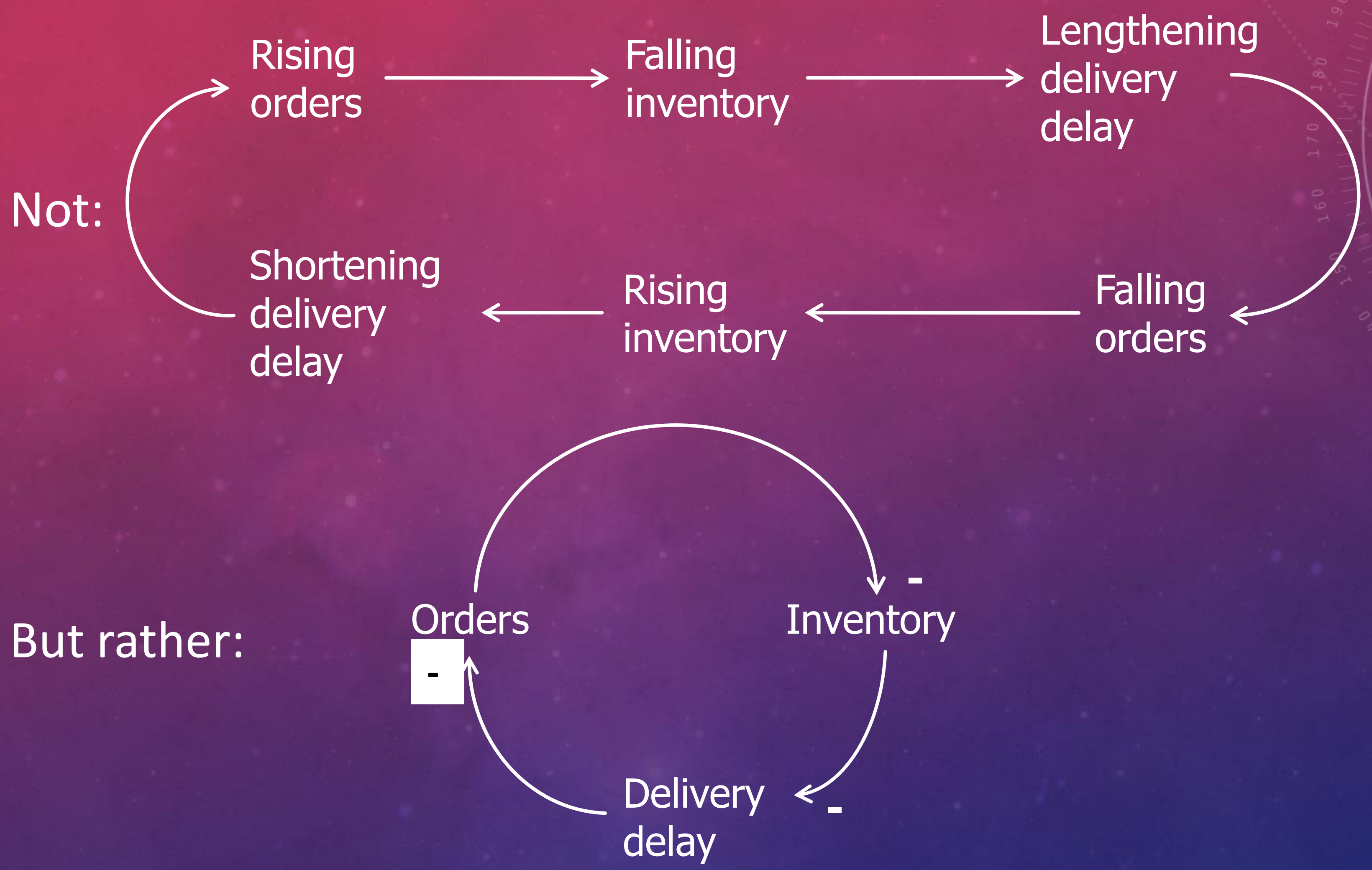

FIGURE 2 LOOPS ILLUSTRATING THAT THE ACTION IN CAUSAL-LOOP DIAGRAM IS BEST LEFT TO THE ARROWS

2. Identify the units of the variables in causal-loop diagram, if possible. If necessary, invent some: some psychological variables might have to be thought of in "stress units" or "pressure units", for example. Units help to focus the meaning of a phrase in a diagram.

3. Phrase most variables positively ("emotional state" rather than "depression". It is hard to understand what it to say "depression increases" when testing link and loop polarities.

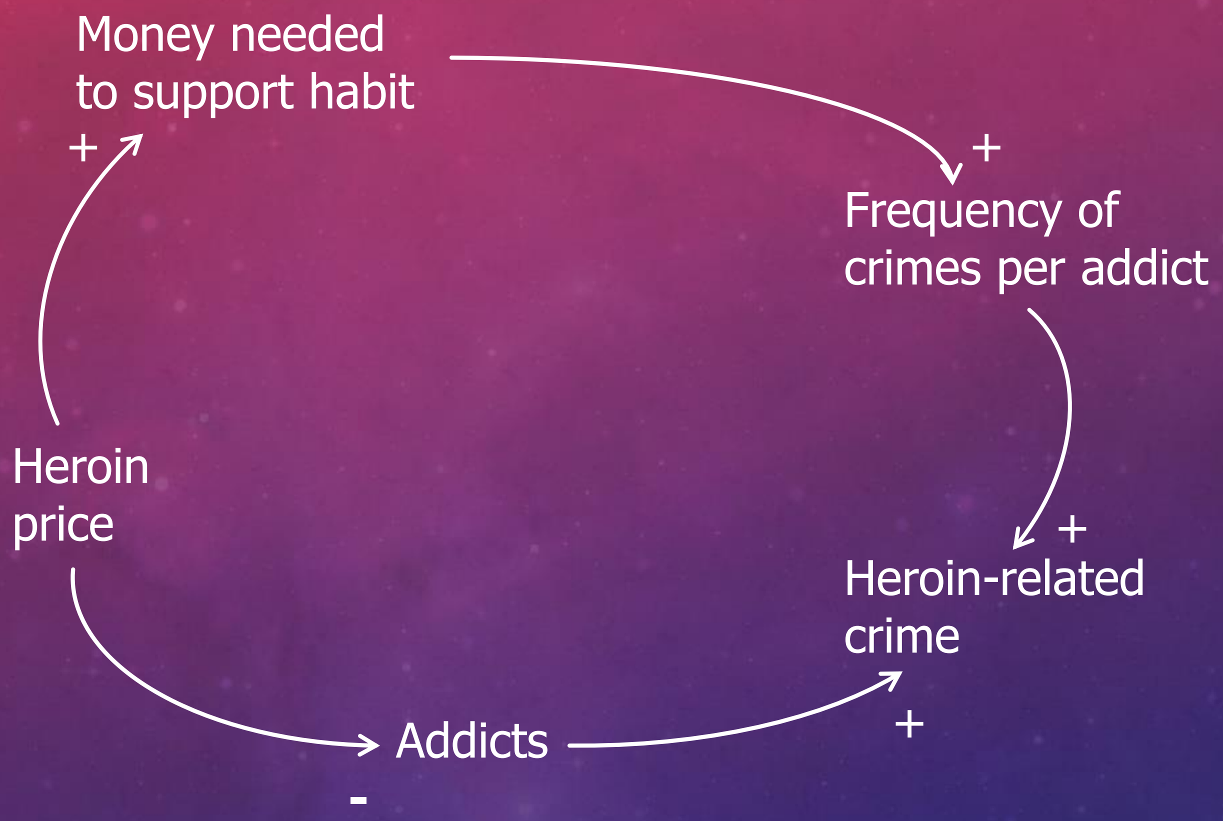

FIGURE 3 LINKS RELATING HEROIN PRICE AND CRIME

4. If a link needs explanation, disaggregate it – make it a sequence of links. For example, a study of heroin- related crime claimed a positive link from heroin price to heroin-related crime. The link is clear if disaggregated as in Figure 3 into the sequence of positive links from heroin price to money required per addict, frequency of crimes per addict, and finally heroin-related crime. Some might feel a high price deters addict and so lowers the number of addicts as it well might, but that is another link (see Figure 3).

5. Beware of interpreting open loops as feedback loops. Figure 3, for example, does not show a feedback loop.