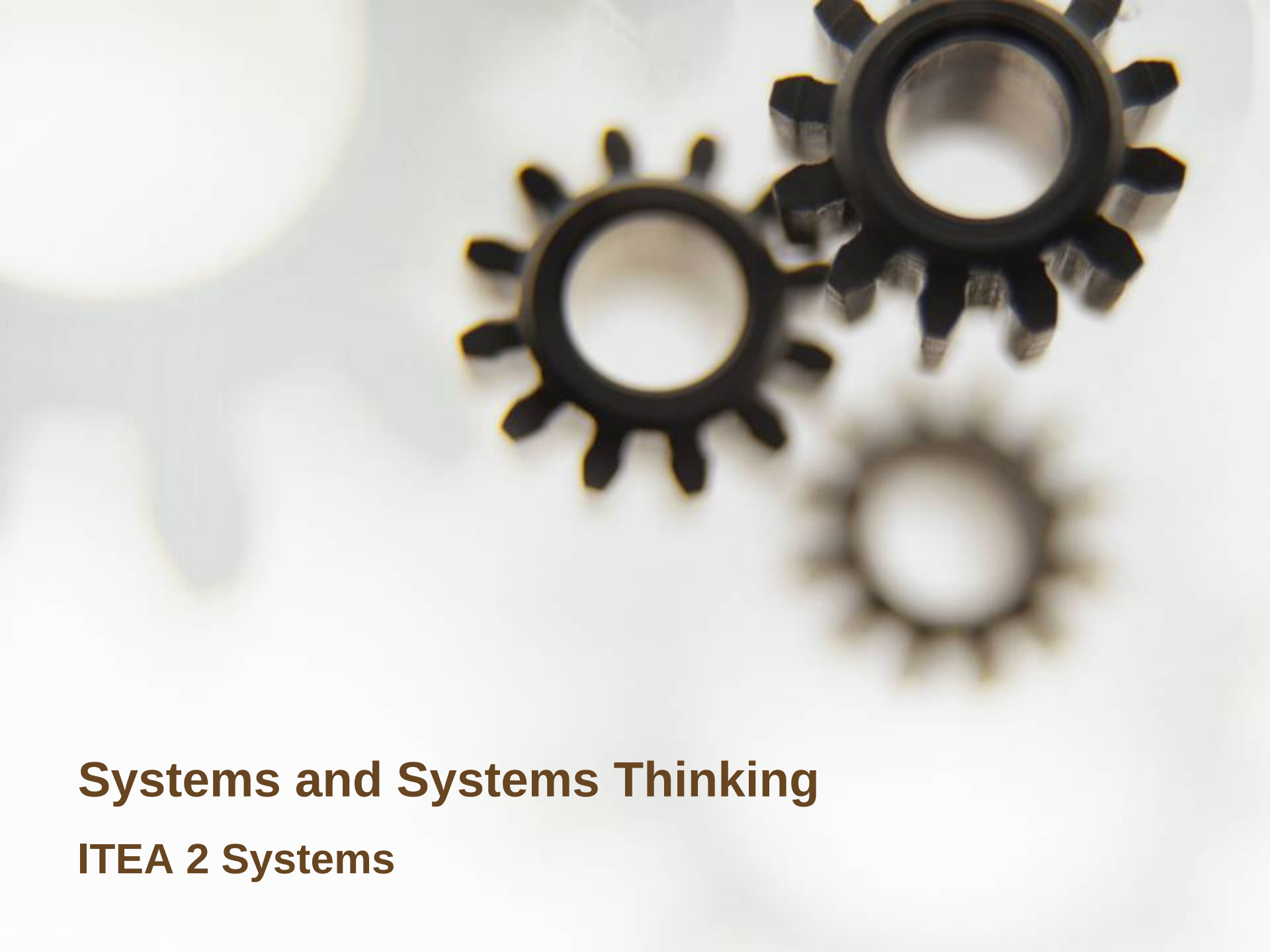


Systems and Systems Thinking

ITEA 2 Systems

Outcomes

In this lesson, you will go beyond the basic core concept of systems, and go into more depth, extending the topic to include systems thinking. In this presentation you will learn…

- Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. (ITEA 2-W)
- Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. (ITEA 2-X)
- The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. (ITEA 2-Y)
- Technological systems include input, processes, output, and at times, feedback. (ITEA 2-M)
- Complex systems have many layers of controls and feedback loops. (ITEA 2-FF)

Simple Systems and Complex Systems

A **system** is an arrangement (pattern, design) of parts which interact with each other within the system's boundaries (form, structure, organization) to function as a whole. The nature (purpose, operation) of the whole is always different from, and more than, the sum of its unassembled collection of parts.

A **complex system** is a system whose properties are not fully explained by an understanding of its component parts. Complex systems consist of a large number of mutually interacting and interwoven parts, entities or agents. Complex systems have many layers of controls and feedback loops.

Examples of Complex Systems

An example of a complex system is a traffic control system. If a traffic light fails at a major intersection, it can snarl traffic and cause all kinds of problems for motorists. The police will usually intervene and direct traffic until the traffic control experts can restore the system to normal operation.

The traffic light is a component of a larger complex traffic control system. Parts of a complex system can fail without harm to the entire system.

Electricity is vital for most everyday activities. From the moment you flip the first switch each morning, you are connecting to a huge complex system — a network of people, electric lines, and generating equipment. Electric power lines transport electricity at low costs across great distances by taking advantage of the ability to transform the voltage using power transformers. If these transformers fail then the electric to homes and businesses shuts down and you experience **systems failure**.

Systems Failure

Complex systems have many layers of controls and feedback loops to provide information. Controls do not always succeed or work perfectly.

The more parts and connections in a system, the more likely it is that something may not work properly and **system failure** occurs. Human intervention may be necessary at some point.

Integrated Systems

Systems are the building blocks of technology. Smaller systems are combined and embedded into larger systems. This is true of technological systems, as well as social and environmental systems.

A farm is an example of an **integrated system** of both living (the farmer, crops, animals, weeds, insects) and non-living (the tractor, barn, house, machinery, fertilizer) subsystems.

For example, a tractor is a vehicular system comprised of many mechanical, electrical, electronic (non-living) sub-systems for propulsion, steering, lighting, seating, etc. The boundaries of each sub-system "**interface**" (connect) with one or more of the others. Successful interfacing of sub-systems is “**systems integration**".

Systems also appear in many aspects of daily life, such as solar systems, political systems, civil systems, and technological systems.

The tractor, and the farm itself, are "**open systems**“ because they need fuel and maintenance from outside sources in order to function.






Interaction between systems

The tractor can be considered as part of an off-highway transportation system as well as part of an agricultural production system. Each of these systems in turn is part of a hierarchy of larger, interactive, transportation, production, economic, social, political, ecological, and energy systems on a local, regional, national and global scale.

Open and Closed Systems

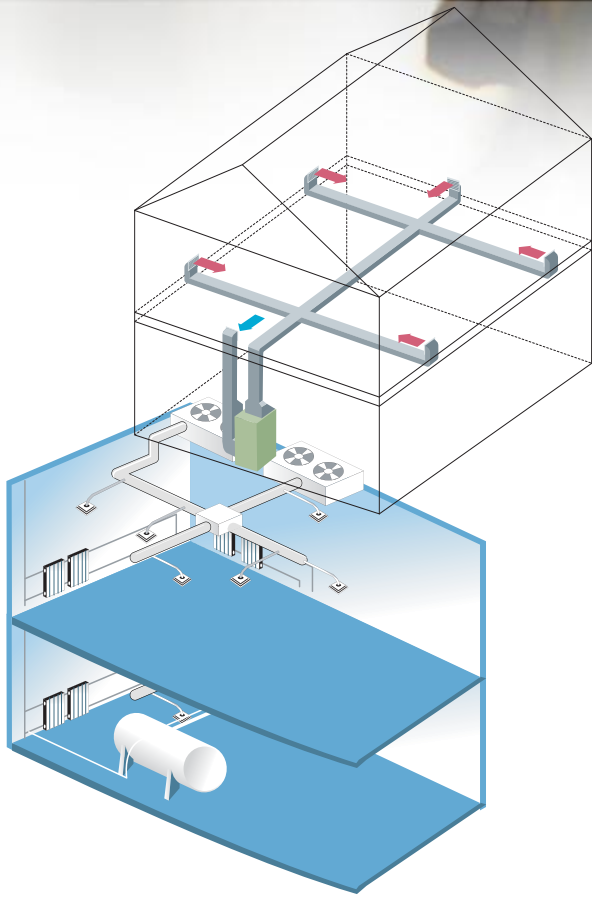
The heating/cooling system in your home is a **closed system** because it is a system which is isolated, having no interaction with an environment — a system whose behavior is entirely explainable from within.

What is the difference between an open-loop and a closed-loop system?

An **open-loop system** has no feedback and requires human intervention, while a **closed-loop system** uses feedback from a control mechanism.

Examples:

Open-Loop	Closed-Loop
Clothes Dryer	ATM Machine
Microwave Oven	Alarm System
Television	Diabetes Blood Test
Electric Toothbrush	Toll Road
Toilet	Airport Security
Digital Camera	Product Bar Code



Open-Loop System

An open-loop system is a control system that has no means for comparing the output (the results of the operation of any system) with input (something put into a system, such as resources, in order to achieve a result) for control purposes. Control of open-loop systems often requires human intervention. An example of an open-loop system is a microwave oven that requires a person to determine if the food has been heated to the required temperature.

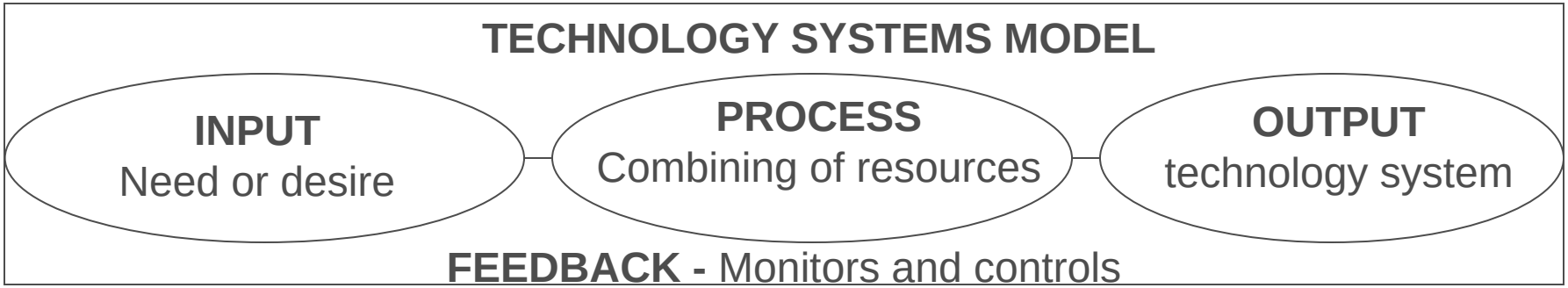
Closed-loop Systems

A closed-loop system is a control system that uses feedback from the output (the results of the operation of any system) to control the input (something put into a system, such as resources, in order to achieve a result). An example of an closed-loop system is a heating system in a home, which has a thermostat to provide feedback when it needs to be turned on and off.

Technological Systems

Technological systems include input, processes, output, and at times, feedback.

- The **input** consists of the resources that flow into a technological system.
- The **process** is a systematic sequence of actions that combines resources to produce an output — encoding, reproducing, designing, or propagating, for example.
- The **output** is the end result, which can have either a positive or negative impact.
- The **feedback** is information used to monitor or control a system.



Feedback

A system often includes a component that permits revising or refining the system when the feedback information suggests such action. For example, the fuel level indicator of a car is a feedback system that lets the user know when the system needs additional fuel.

The **stability** of a technological system is influenced by all the components in the system, especially those in the **feedback loop**. Cruise control in an automobile, for example, automatically detects and controls the speed of the car. Some delay in feedback or in functioning can cause a cycle to develop in a system.

System Size and Complexity

COMPLEXITY OF TECHNOLOGY SYSTEM

Simple

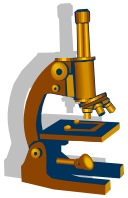
Complicated

Small

Large

PENCIL

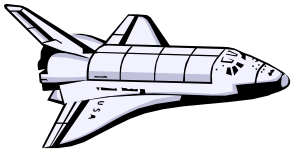
SCISSORS



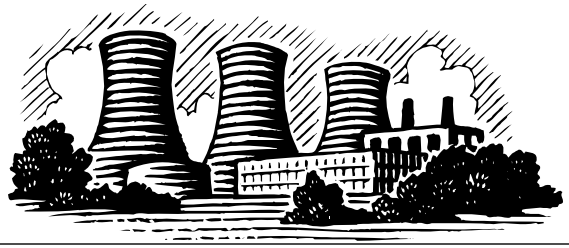
MICROSCOPE

COMPUTER

FIRE ENGINE



SPACE SHUTTLE



NUCLEAR POWER PLANT

A technology system may be very simple or very complex. It may be very small or very large.

Note: Not all large systems are complex (ex: canal) and not all small systems are simple (ex: cell phone).

Systems Thinking

Systems thinking involves considering how every part of a system relates to other systems for a common purpose. Systems are used in a number of different ways in technology.

The tractor can be considered as part of an off-highway transportation system as well as part of an agricultural production system. Each of these systems in turn is part of a hierarchy of larger, interactive, transportation, production, economic, social, political, ecological, and energy systems on a local, regional, national and global scale.

There are networks within networks, systems within systems, various parts of which are physically, chemically and/or socially interrelated in an endless ever-changing (dynamic) web of matter and energy from the smallest atom to the largest galaxy to the universe itself.

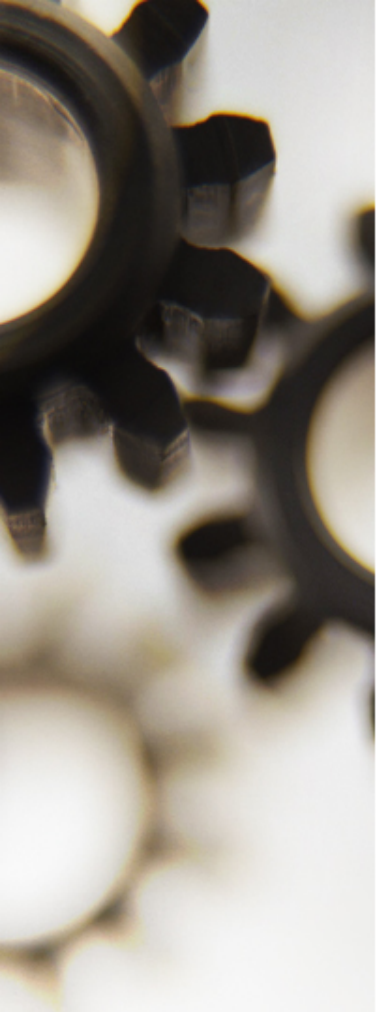
The human body is a perfect example of a very complex system. You can have a cold, a headache, a pulled muscle or a broken bone yet you can still function. Failure of individual parts of a system to work normally does not always affect the entire complex system.

Life on earth can be thought of as a complex web of interconnected natural and human-made systems. Our own human bodies and brains are individual sub-systems within networks of larger biological, economic and socio-political systems without which we couldn't exist.

Systems and Systems Thinking

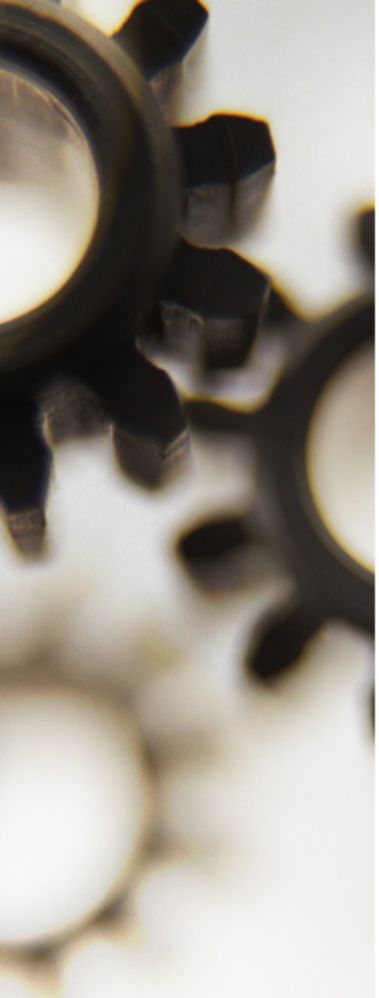
Systems thinking applies logic and creativity with appropriate compromises to complex real-life problems. It uses simulation and mathematical modeling to identify conflicting considerations before the entire system is developed.

Analyzing a system is done in terms of its individual parts or in terms of the whole system and how it interacts with or relates to other systems. For example, discussing a computer system may involve the particular parts of a single computer, or it may include the entire computer network. In contrast, discussing the solar system may involve listing the planets, stars, and other celestial bodies, or it may be discussed by comparing our solar system to other solar systems in the universe.



Systems and Systems Thinking: Summary

- A system is a group of interrelated components designed collectively to achieve a desired goal. Systems can be open-loop or closed-loop
- Control of open-loop systems often requires human intervention
- A closed-loop system is a control system that uses feedback from the output to control the input
- Systems thinking involves considering how every part of a system relates to others for a common purpose
- Technological systems include input, processes, output, and at times, feedback
- A technology system is a combination of materials, devices, structures, information and energy working together to solve problems and extend human capabilities
- Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems
- Analyzing a system is done in terms of its individual parts or in terms of the whole system and how it interacts with or relates to other systems
- Systems also appear in many aspects of daily life, such as solar systems, political systems, civil systems, and technological systems
- Systems, which are building blocks of technology, are embedded within larger technological, social and environmental systems
- Life on earth can be thought of as a complex web of interconnected natural and human-made systems



Complex Systems and Systems Failure Summary

- A complex system is a system whose properties are not fully explained by an understanding of its component parts
- Complex systems consist of a large number of mutually interacting and interwoven parts, entities or agents
- The more parts and connections in a complex system, the more likely it is that something may not work properly
- Complex systems can be either open-loop or closed-loop
- Human intervention may be necessary at some point to correct malfunctions in a complex system