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# Socio-technical Systems

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# Objectives

- To explain what a socio-technical system is and the distinction between this and a computer-based system
- To introduce the concept of emergent system properties such as reliability and security
- To explain system engineering and system procurement processes
- To explain why the organizational context of a system affects its design and use
- To discuss legacy systems and why these are critical to many businesses

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# Topics covered

- Emergent system properties
- Systems engineering
- Organizations, people and computer systems
- Legacy systems

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# What is a system?

- A purposeful collection of inter-related components working together to achieve some common objective.
- A system may include software, mechanical, electrical and electronic hardware and be operated by people.
- System components are dependent on other system components
- The properties and behaviour of system components are inextricably intermingled

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# System categories

- Technical computer-based systems
  - Systems that include hardware and software but where the operators and operational processes are not normally considered to be part of the system. The system is not self-aware.
- Socio-technical systems
  - Systems that include technical systems but also operational processes and people who use and interact with the technical system. Socio-technical systems are governed by organizational policies and rules.

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# Socio-technical system characteristics

- Emergent properties
  - Properties of the system of a whole that depend on the system components and their relationships.
- Non-deterministic
  - They do not always produce the same output when presented with the same input because the systems' behavior is partially dependent on human operators.
- Complex relationships with organizational objectives
  - The extent to which the system supports organizational objectives does not just depend on the system itself.

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# Emergent properties

- Properties of the system as a whole rather than properties that can be derived from the properties of components of a system
- Emergent properties are a consequence of the relationships between system components
- They can therefore only be assessed and measured once the components have been integrated into a system

# Examples of emergent properties

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<b>Property</b>	<b>Description</b>
Volume	The volume of a system (the total space occupied) varies depending on how the component assemblies are arranged and connected.
Reliability	System reliability depends on component reliability but unexpected interactions can cause new types of failure and therefore affect the reliability of the system.
Security	The security of the system (its ability to resist attack) is a complex property that cannot be easily measured. Attacks may be devised that were not anticipated by the system designers and so may defeat built-in safeguards.
Repairability	This property reflects how easy it is to fix a problem with the system once it has been discovered. It depends on being able to diagnose the problem, access the components that are faulty and modify or replace these components.
Usability	This property reflects how easy it is to use the system. It depends on the technical system components, its operators and its operating environment.

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# Types of emergent property

- Functional emergent properties
  - These appear when all the parts of a system work together to achieve some objective. For example, a bicycle has the functional property of being a transportation device once it has been assembled from its components.
- Non-functional emergent properties
  - Examples are reliability, performance, safety, and security. These relate to the behavior of the system in its operational environment. They are often critical for computer-based systems as failure to achieve some minimal defined level in these properties may make the system unusable.

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# System reliability engineering

- Because of component inter-dependencies, faults can be propagated through the system.
- System failures often occur because of unforeseen inter-relationships between components.
- It is probably impossible to anticipate all possible component relationships.
- Ex: Influences on reliability
  - *Hardware reliability*: What is the probability of a hardware component failing and how long does it take to repair that component?
  - *Software reliability*: How likely is it that a software component will produce an incorrect output. Software failure is usually distinct from hardware failure in that software does not wear out.
  - *Operator reliability*: How likely is it that the operator of a system will make an error?

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# Reliability relationships

- Hardware failure can generate spurious signals that are outside the range of inputs expected by the software.
- Software errors can cause alarms to be activated which cause operator stress and lead to operator errors.
- The environment in which a system is installed can affect its reliability.

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# The 'shall-not' properties

- Properties such as performance and reliability can be measured.
- However, some properties are properties that the system should not exhibit
- Safety - the system should not behave in an unsafe way;
- Security - the system should not permit unauthorized use.
- Measuring or assessing these properties is very hard.

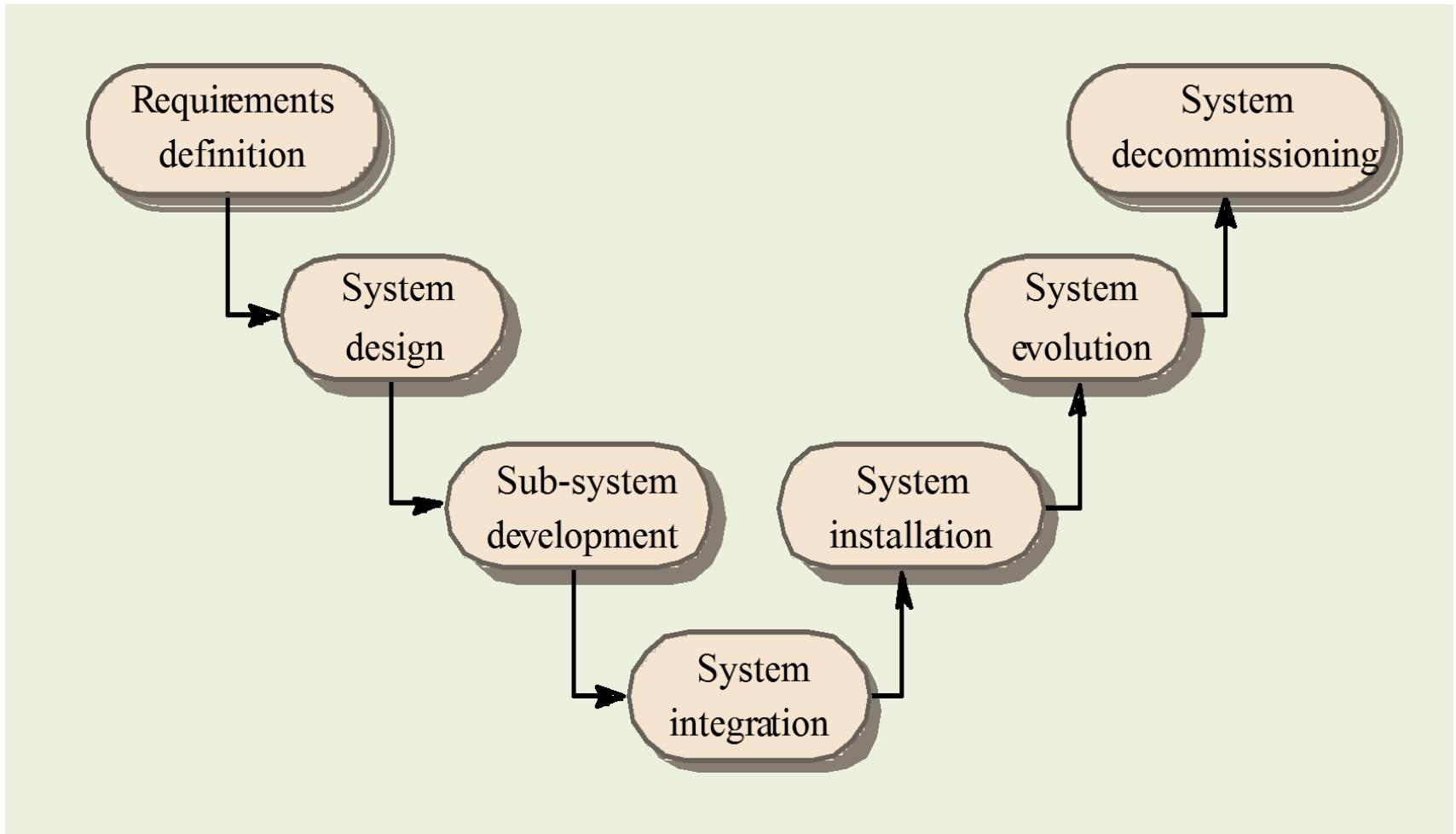


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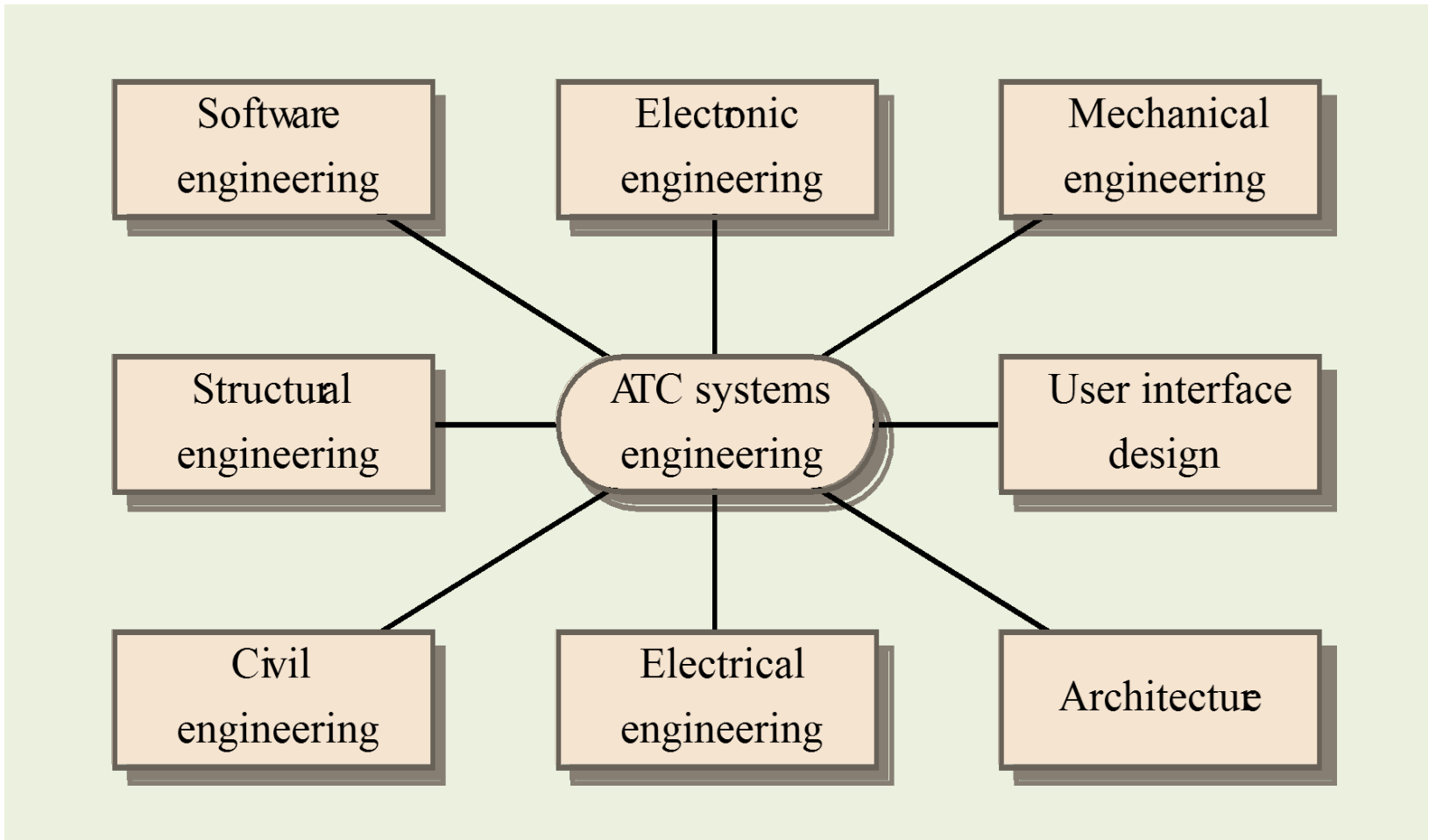
# Systems engineering

- Specifying, designing, implementing, validating, deploying and maintaining socio-technical systems.
- Concerned with the services provided by the system, constraints on its construction and operation and the ways in which it is used.
- The system engineering process
  - Usually follows a 'waterfall' model because of the need for parallel development of different parts of the system
  - Little scope for iteration between phases because hardware changes are very expensive. Software may have to compensate for hardware problems.
  - Inevitably involves engineers from different disciplines who must work together
  - Much scope for misunderstanding here. Different disciplines use a different vocabulary and much negotiation is required. Engineers may have personal agendas to fulfill.

# The systems engineering process



# Inter-disciplinary involvement







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# Organisations/people/systems

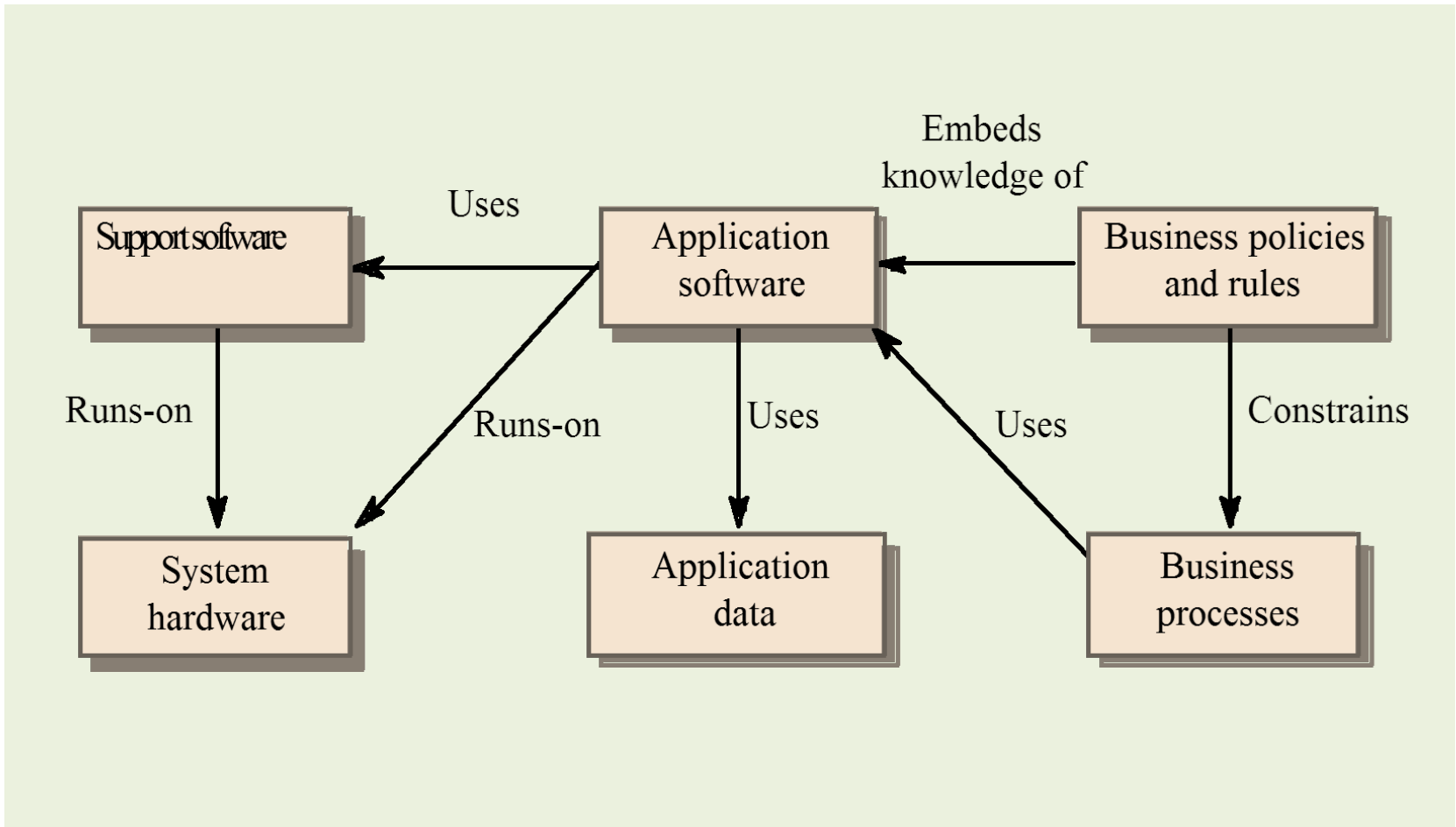
- Socio-technical systems are organizational systems intended to help deliver some organizational or business goal.
- If you do not understand the organizational environment where a system is used, the system is less likely to meet the real needs of the business and its users.
- Human and organisational factors affecting system designs.
  - *Process changes*
    - Does the system require changes to the work processes in the environment?
  - *Job changes*
    - Does the system de-skill the users in an environment or cause them to change the way they work?
  - *Organisational changes*
    - Does the system change the political power structure in an organisation?



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# Legacy systems

- Socio-technical systems that have been developed using old or obsolete technology.
- Crucial to the operation of a business and it is often too risky to discard these systems
  - Bank customer accounting system;
  - Aircraft maintenance system.
- Legacy systems constrain new business processes and consume a high proportion of company budgets.

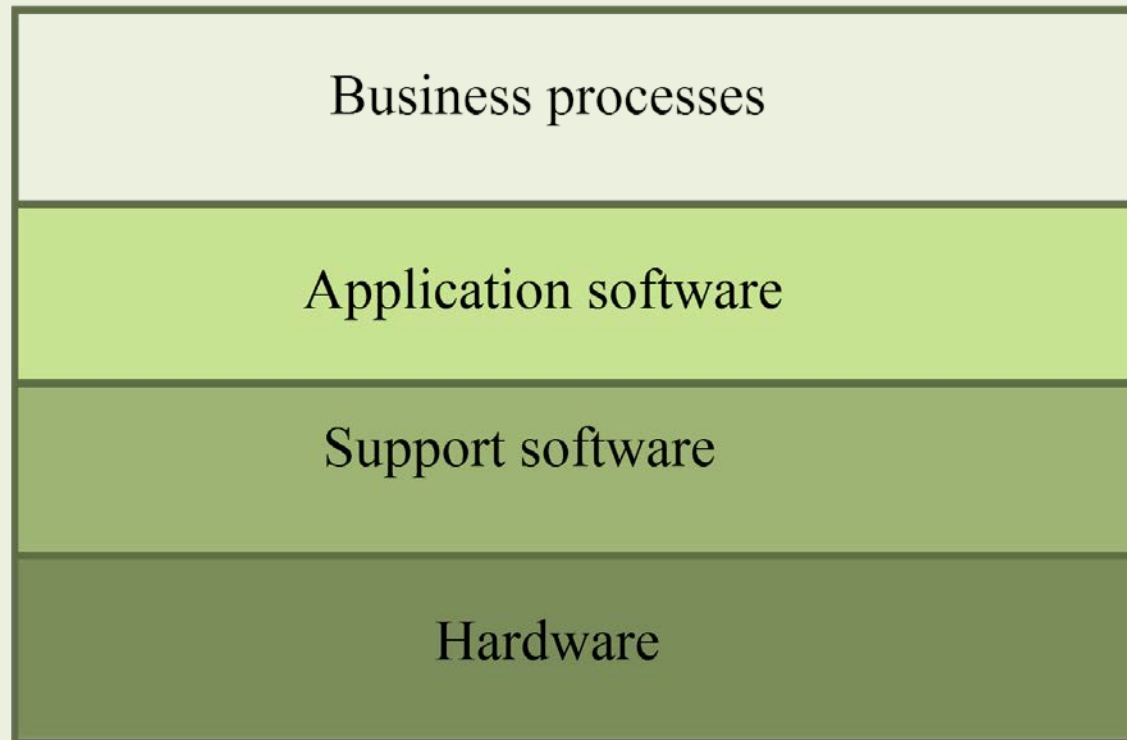


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# Legacy system components

- Hardware - may be obsolete mainframe hardware.
- Support software - may rely on support software from suppliers who are no longer in business.
- Application software - may be written in obsolete programming languages.
- Application data - often incomplete and inconsistent.
- Business processes - may be constrained by software structure and functionality.
- Business policies and rules - may be implicit and embedded in the system software.

## Socio-technical system



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# Key points

- Socio-technical systems include computer hardware, software and people and are designed to meet some business goal.
- Emergent properties are properties that are characteristic of the system as a whole and not its component parts.
- The systems engineering process includes specification, design, development, integration and testing. System integration is particularly critical.
- Human and organizational factors have a significant effect on the operation of socio-technical systems.
- There are complex interactions between the processes of system procurement, development and operation.
- A legacy system is an old system that continues to provide essential services.
- Legacy systems include business processes, application software, support software and system hardware.