Socio-technical Systems

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 organisational context of a system affects its design and use
- To discuss legacy systems and why these are critical to many businesses

Topics covered

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

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.

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.
- 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 organisational policies and rules.

    They are designed to help the organisation to meet some broad goal.

Socio-technical system characteristics

- Emergent properties
  - Properties of the system as a whole that depend on the system components and their relationships. The success or failure of a system is often dependent on these emergent properties.
- Non-deterministic
  - They do not always produce the same output when presented with the same input because the systems's behaviour is partially dependent on human operators.

Emergent properties

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

Examples of emergent properties

Property	Description
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.

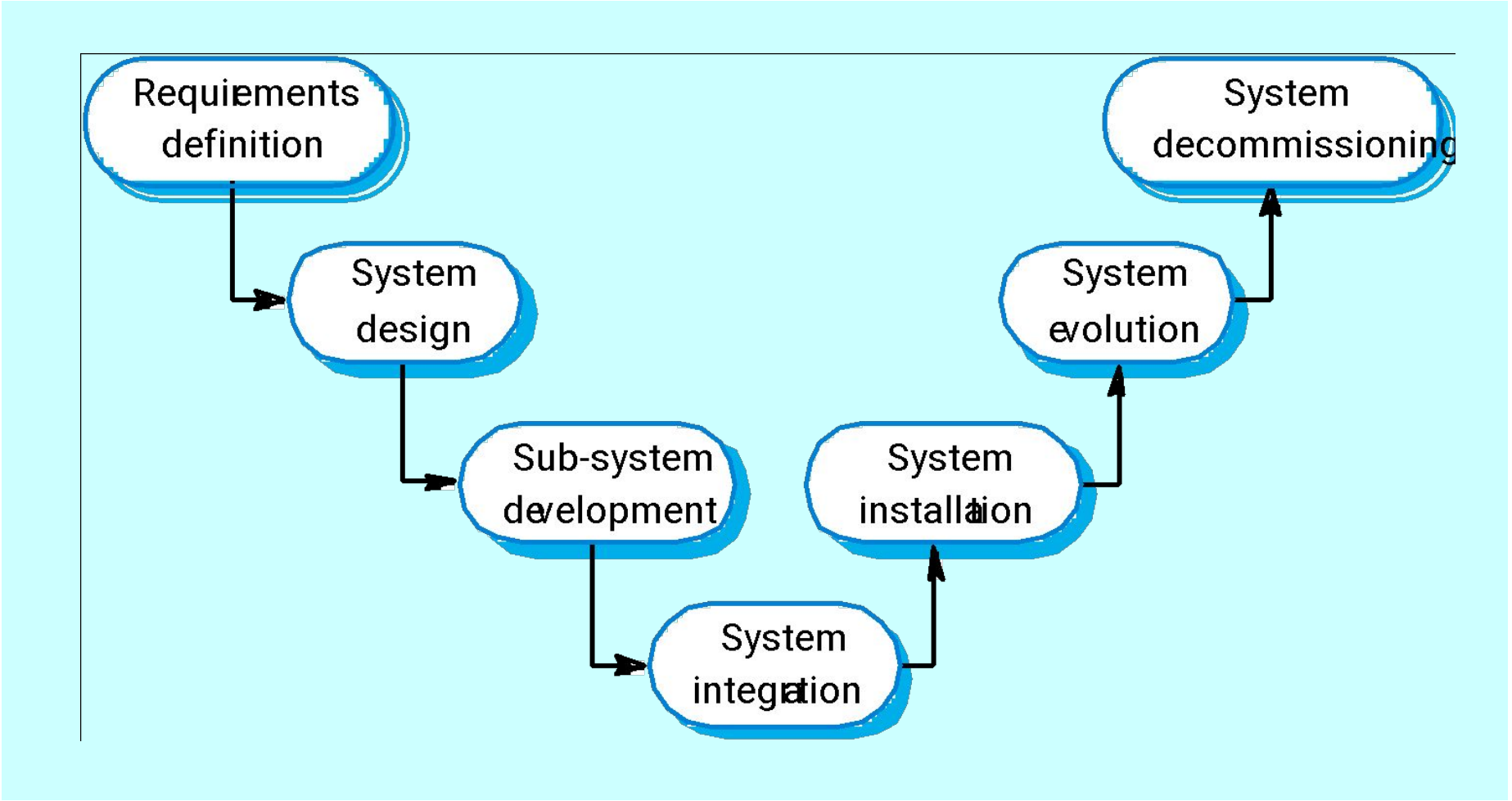
Types of emergent property

- Functional 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 behaviour 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.

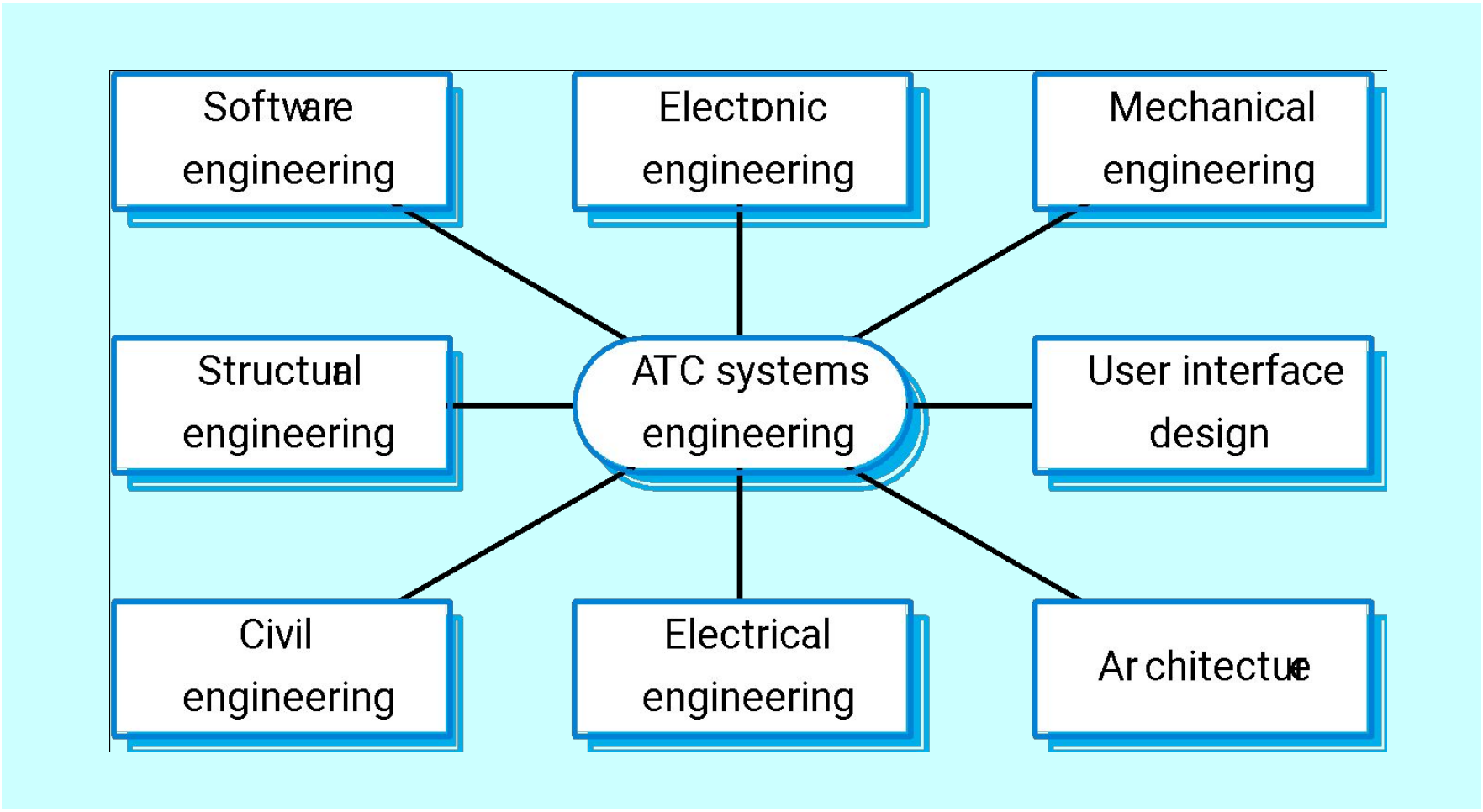
Systems engineering

- 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 systems engineering process



Inter-disciplinary involvement



- Systems engineering is an interdisciplinary activity involving many teams from various backgrounds. Figure shows some of the disciplines that may be involved in the system engineering team for an air traffic control system that uses radars and other sensors to determine aircraft position.

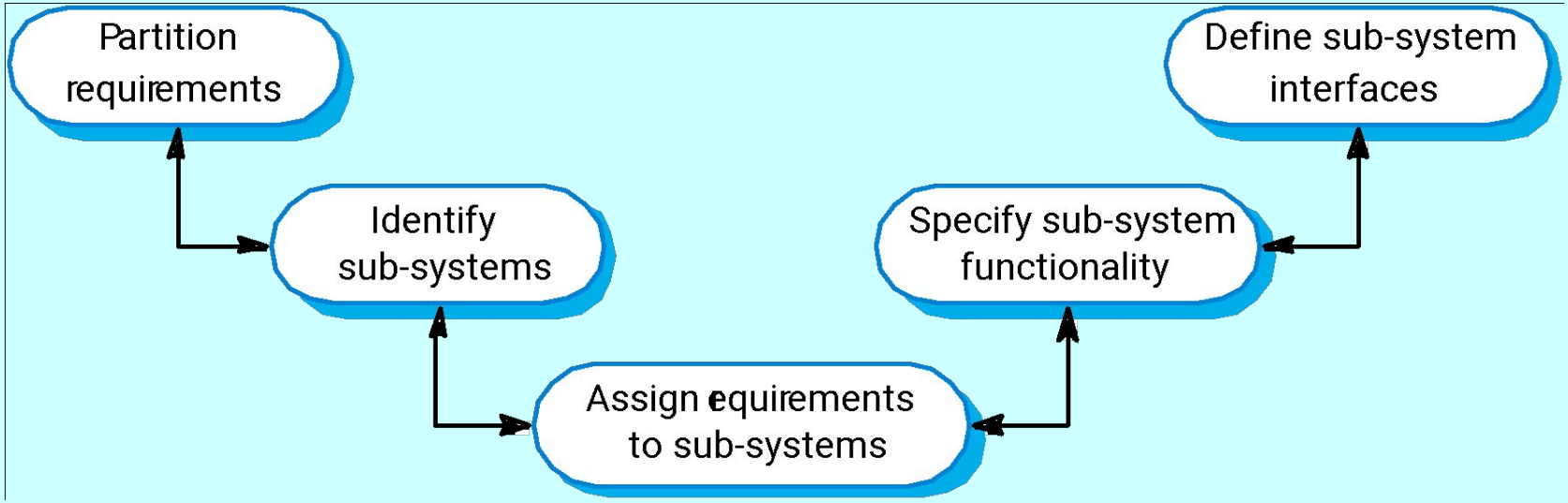
System requirements definition

- Three types of requirement defined at this stage
  - Abstract functional requirements. System functions are defined in an abstract way;
  - System properties. Non-functional requirements for the system in general are defined;
  - Undesirable characteristics. Unacceptable system behaviour is specified.
- Should also define overall organisational objectives for the system.

The system design process

- System design is concerned with how the system functionality is to be provided by the components of the system.
- Partition requirements
  - Organise requirements into related groups.
- Identify sub-systems
  - Identify a set of sub-systems which collectively can meet the system requirements.
- Assign requirements to sub-systems
  - Causes particular problems when COTS are integrated.
- Specify sub-system functionality.
- Define sub-system interfaces
  - Critical activity for parallel sub-system development.

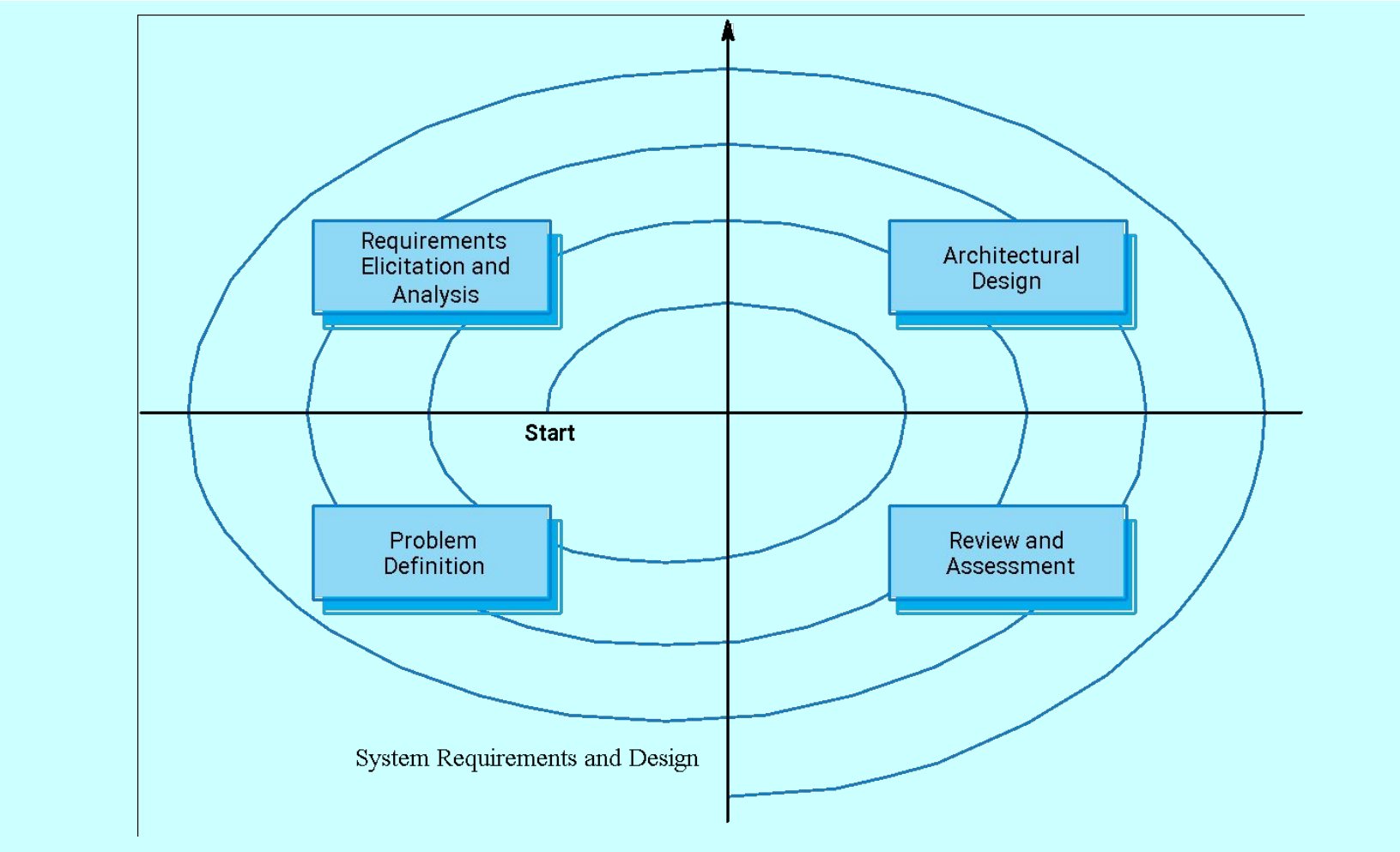
The system design process



Requirements and design

- Requirements engineering and system design are inextricably linked.
- Initial design may be necessary to structure the requirements.
- As you do design, you learn more about the requirements.

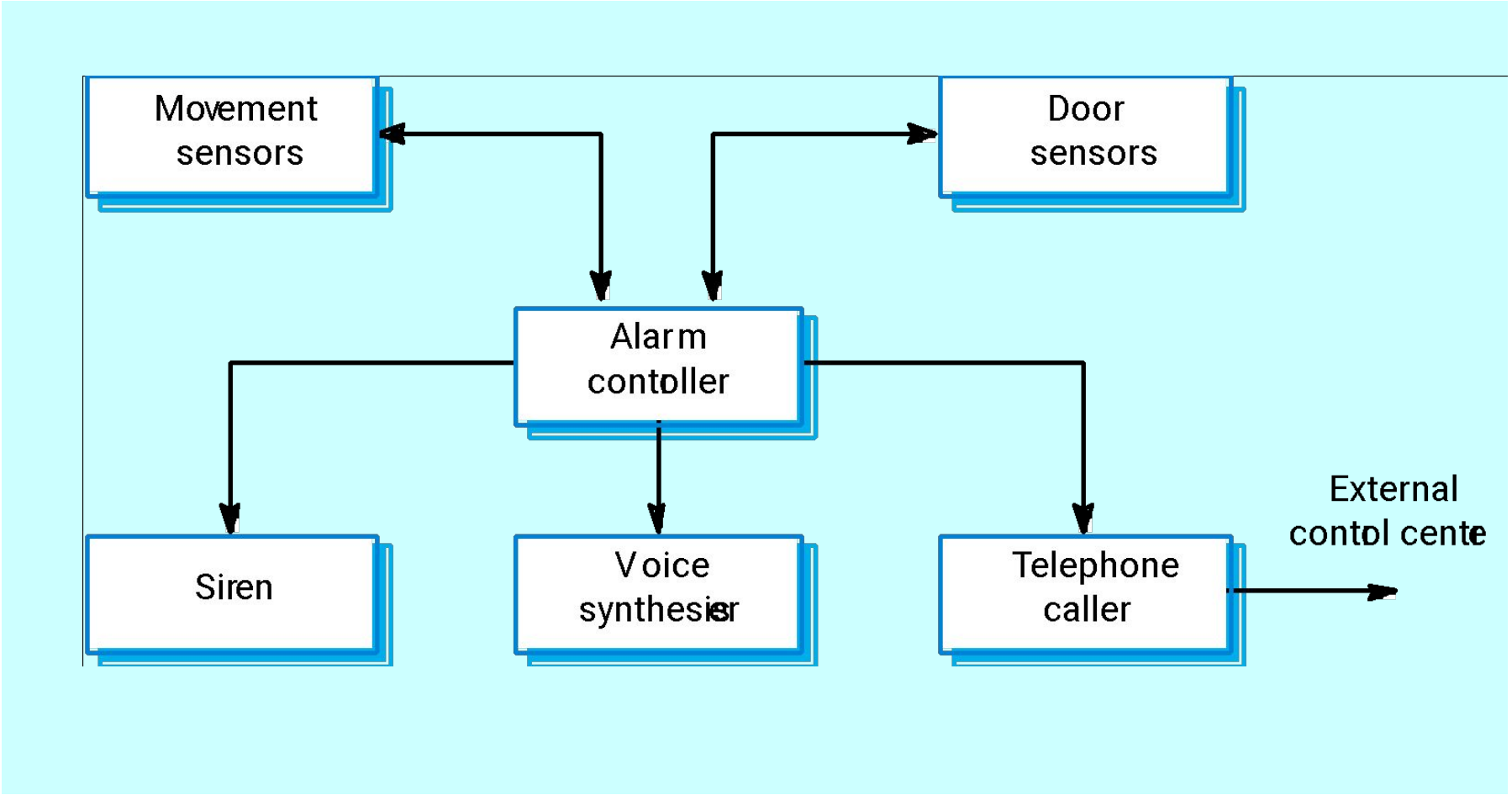
Spiral model of requirements/design



System modelling

- An architectural model presents an abstract view of the sub-systems making up a system
- May include major information flows between sub-systems
- The system architecture may be presented as a block diagram showing the major sub-systems and the inter connection between the sub systems.
- May identify different types of functional component in the model
- Burglar alarm system shows the decomposition of an intruder alarm

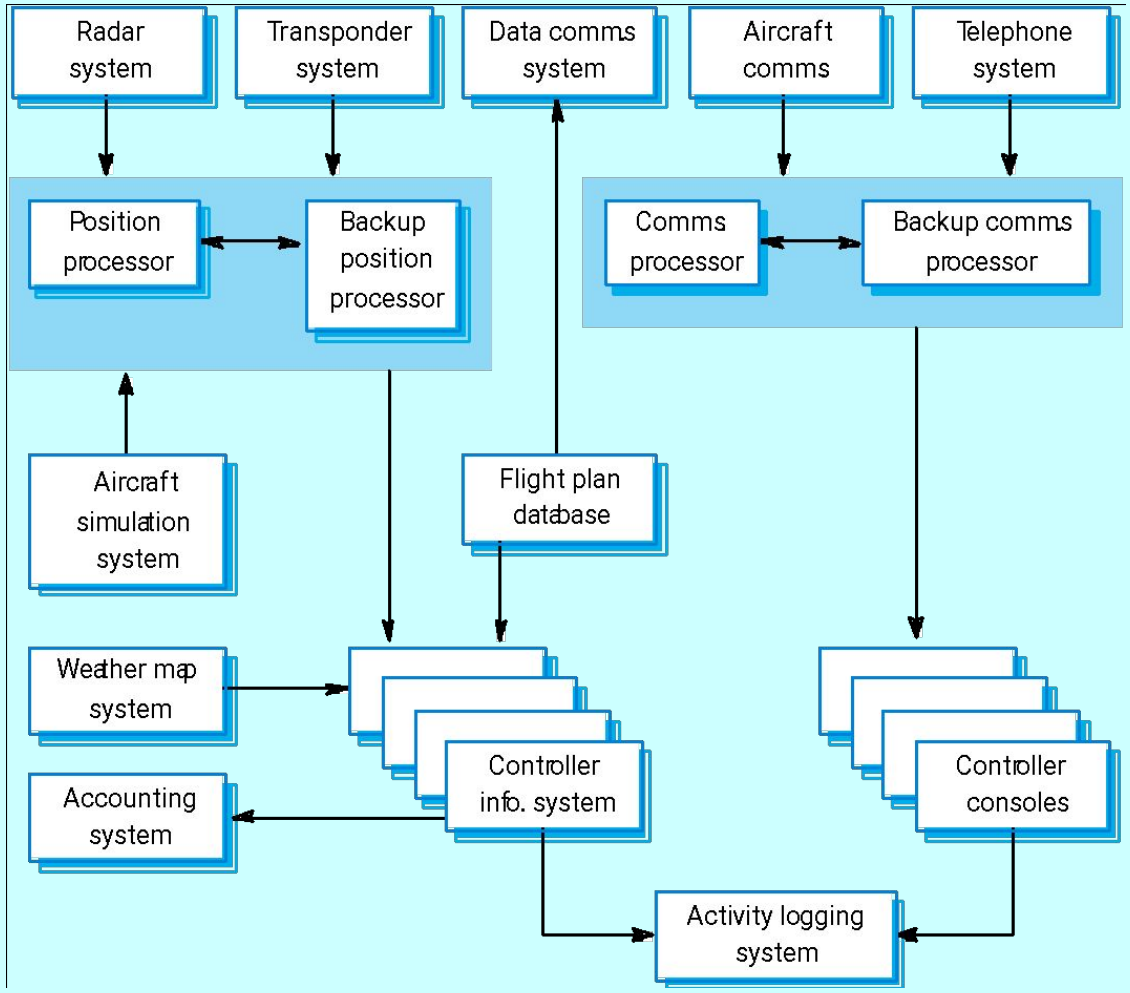
Burglar alarm system



Sub-system description

Sub-system	Description
Movement sensors	Detects movement in the rooms monitored by the system
Door sensors	Detects door opening in the external doors of the building
Alarm controller	Controls the operation of the system
Siren	Emits an audible warning when an intruder is suspected
Voice synthesizer	Synthesizes a voice message giving the location of the suspected intruder
Telephone caller	Makes external calls to notify security, the police, etc.

ATC system architecture



Sub-system development

- It involves implementation of sub-systems identified during system design.
- It starts another system engineering process for each individual sub-system.
- All sub-systems are developed from scratch.
- May involve some COTS (Commercial Off-the-Shelf) systems procurement. It is much cheaper than building from scratch.

System integration

- The process of putting hardware, software and people together to make a system.
- Should be tackled incrementally so that sub-systems are integrated one at a time.
- Interface problems between sub-systems are usually found at this stage.
- Sub-system faults that are a consequence of invalid assumption about other sub-system are often revealed during integration.

System installation

- After completion, the system has to be installed in the customer's environment
  - Environmental assumptions may be incorrect;
  - System may have to coexist with alternative systems for some time;
  - May be physical installation problems (e.g. cabling problems);
  - Operator training has to be identified.

System evolution

- Large systems have a long lifetime. They must evolve to meet changing requirements.
- Evolution is inherently costly
  - Changes must be analysed from a technical and business perspective;
  - Sub-systems interact so unanticipated problems can arise;
  - There is rarely a rationale for original design decisions;
  - System structure is corrupted as changes are made to it.

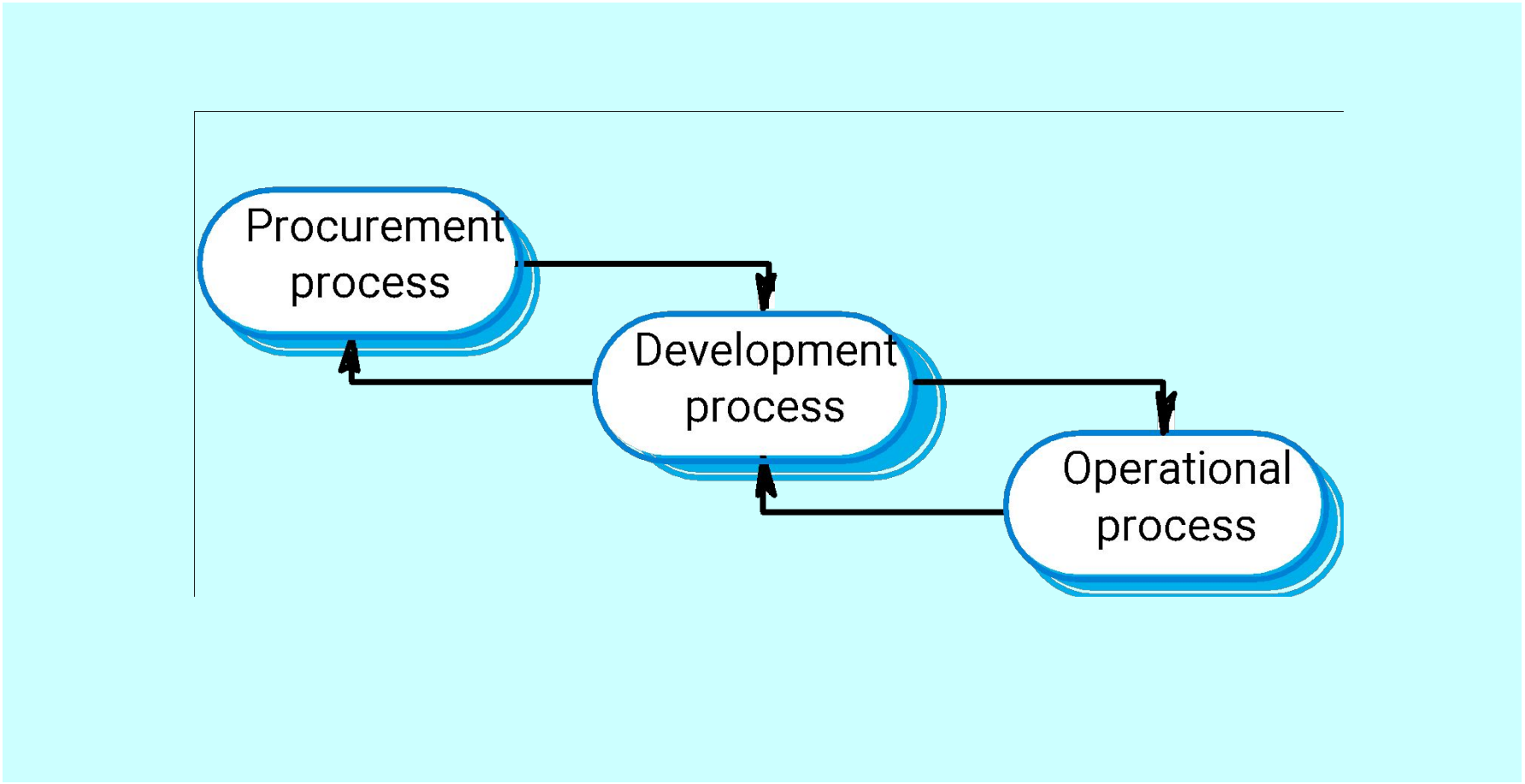
System decommissioning

- Taking the system out of service after its useful lifetime.
- May require removal of materials (e.g. dangerous chemicals) which pollute the environment
  - Should be planned for in the system design by encapsulation.
- May require data to be restructured and converted to be used in some other system.

Organisational processes

- The processes of systems engineering overlap and interact with organisational procurement processes.
- Operational processes are the processes involved in using the system for its intended purpose. For new systems, these have to be defined as part of the system design.
- Operational processes should be designed to be flexible and should not force operations to be done in a particular way. It is important that human operators can use their initiative if problems arise.

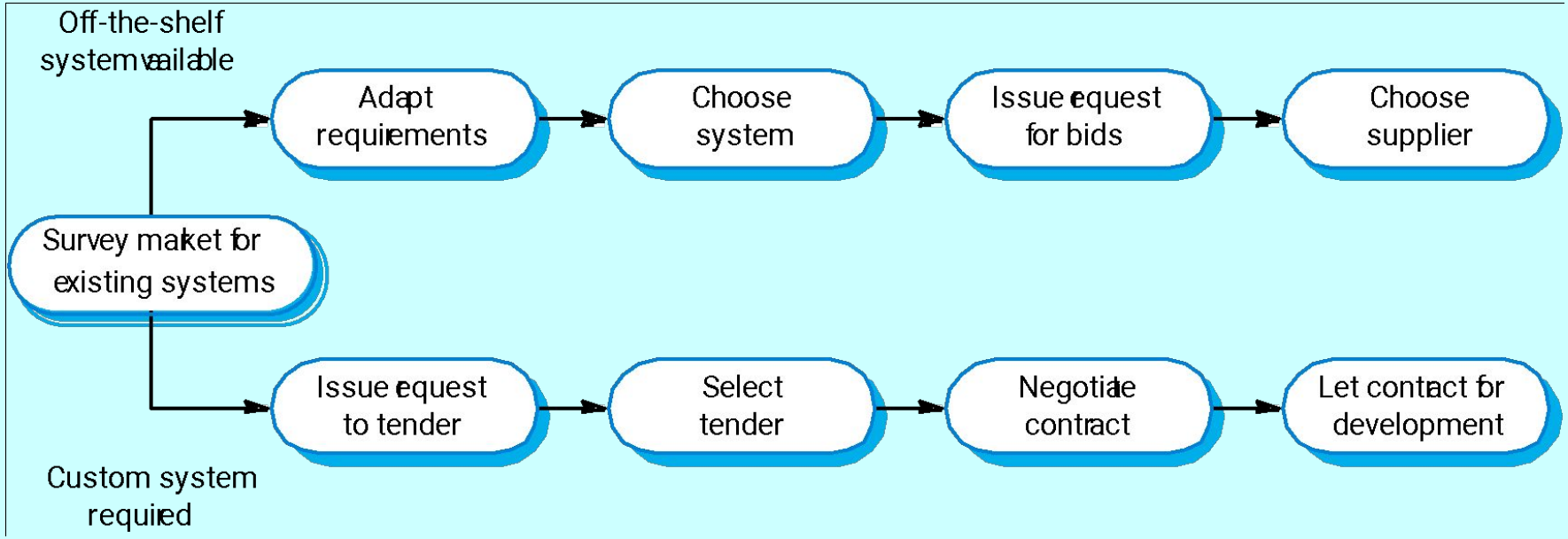
Procurement/development processes



System procurement

- Acquiring a system for an organization to meet some need
- Some system specification and architectural design is usually necessary before procurement
  - You need a specification to let a contract for system development
  - The specification may allow you to buy a commercial off-the-shelf (COTS) system. Almost always cheaper than developing a system from scratch
- Large complex systems usually consist of a mix of off the shelf and specially designed components. The procurement processes for these different types of component are usually different.

The system procurement process



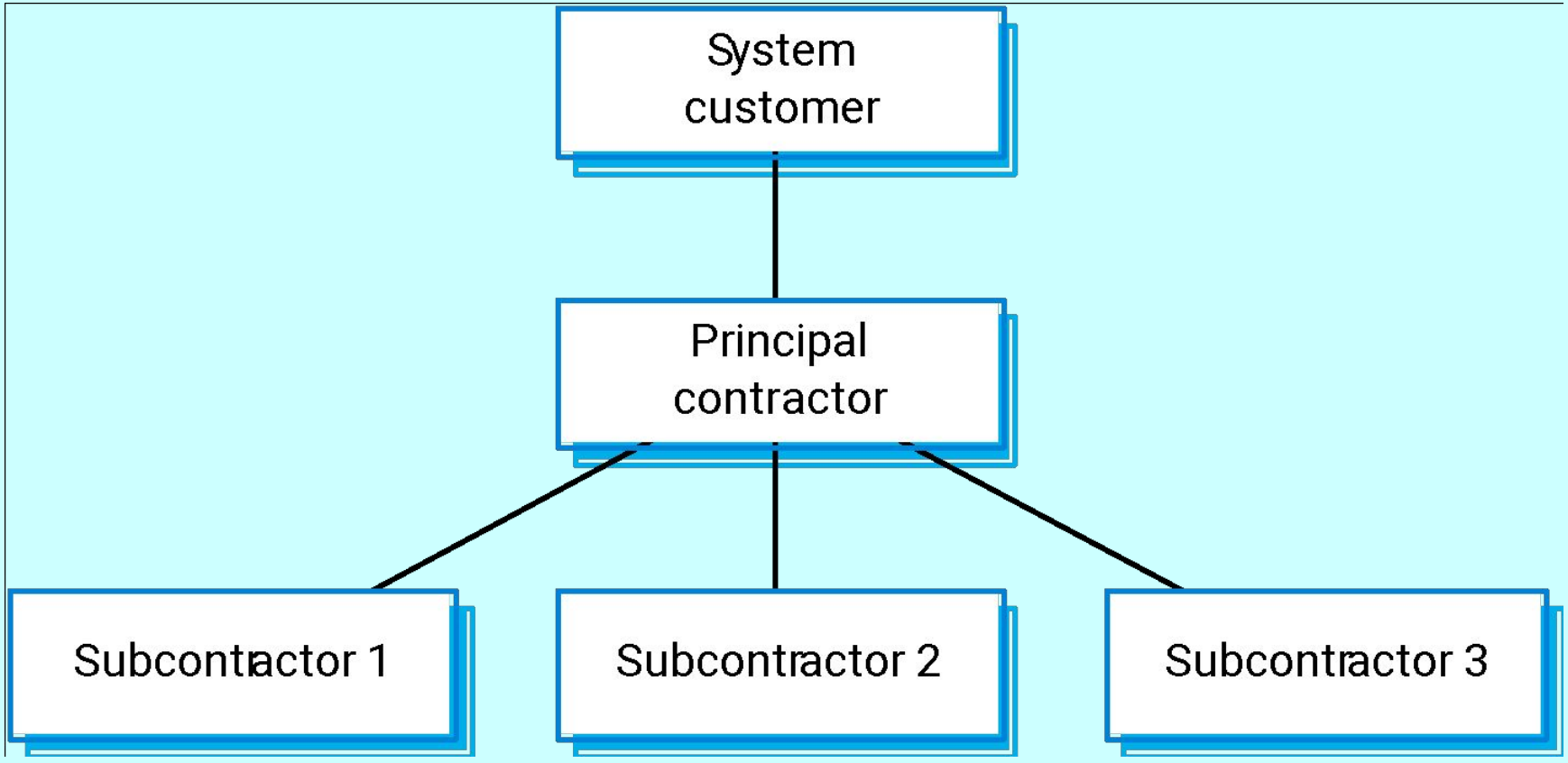
Procurement issues

- Requirements may have to be modified to match the capabilities of off-the-shelf components.
- The requirements specification may be part of the contract for the development of the system.
- There is usually a contract negotiation period to agree changes after the contractor to build a system has been selected.

Contractors and sub-contractors

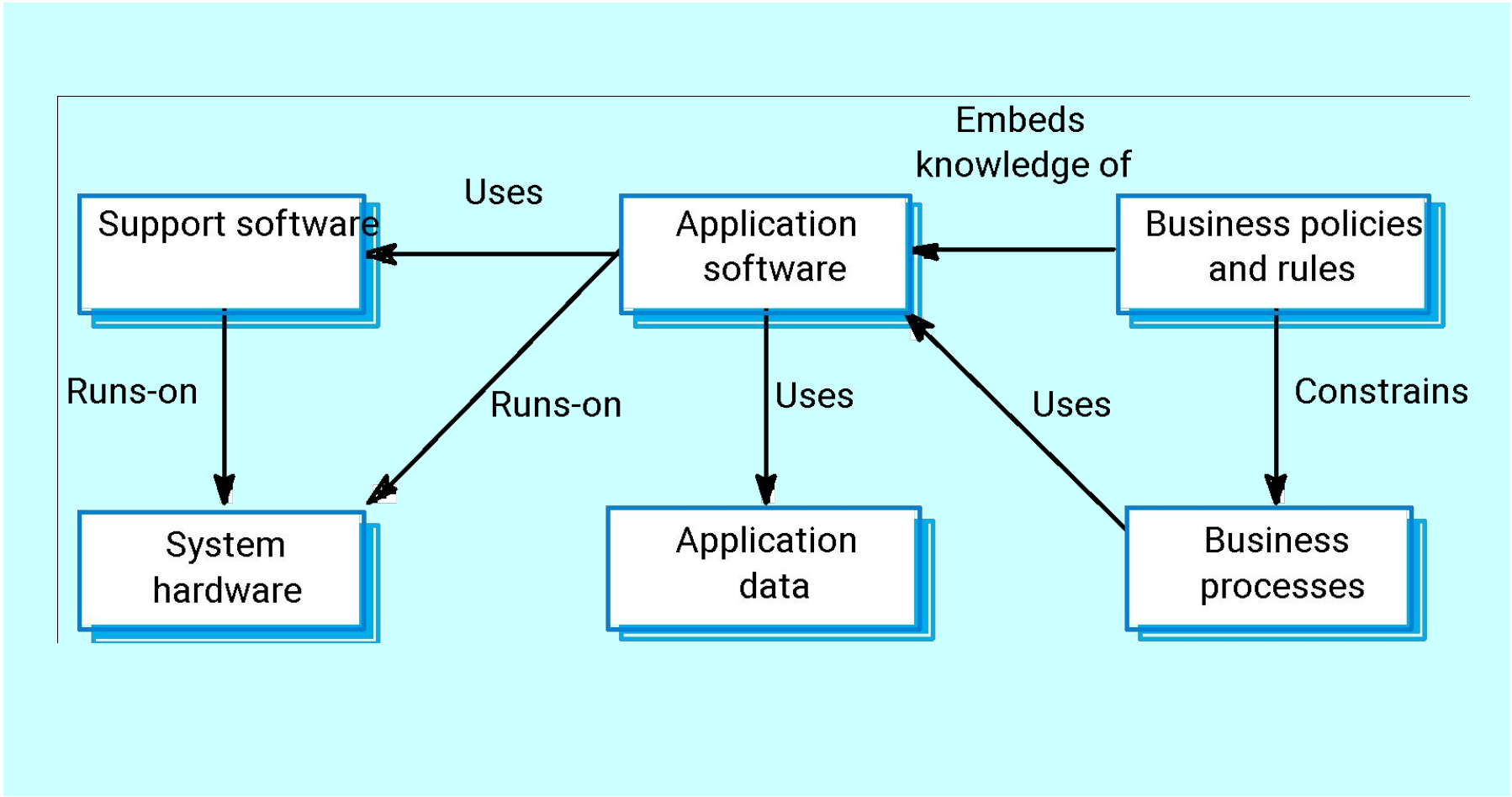
- The procurement of large hardware/software systems is usually based around some principal contractor.
- Sub-contracts are issued to other suppliers to supply parts of the system.
- Customer liases with the principal contractor and does not deal directly with sub-contractors.

Contractor/Sub-contractor model



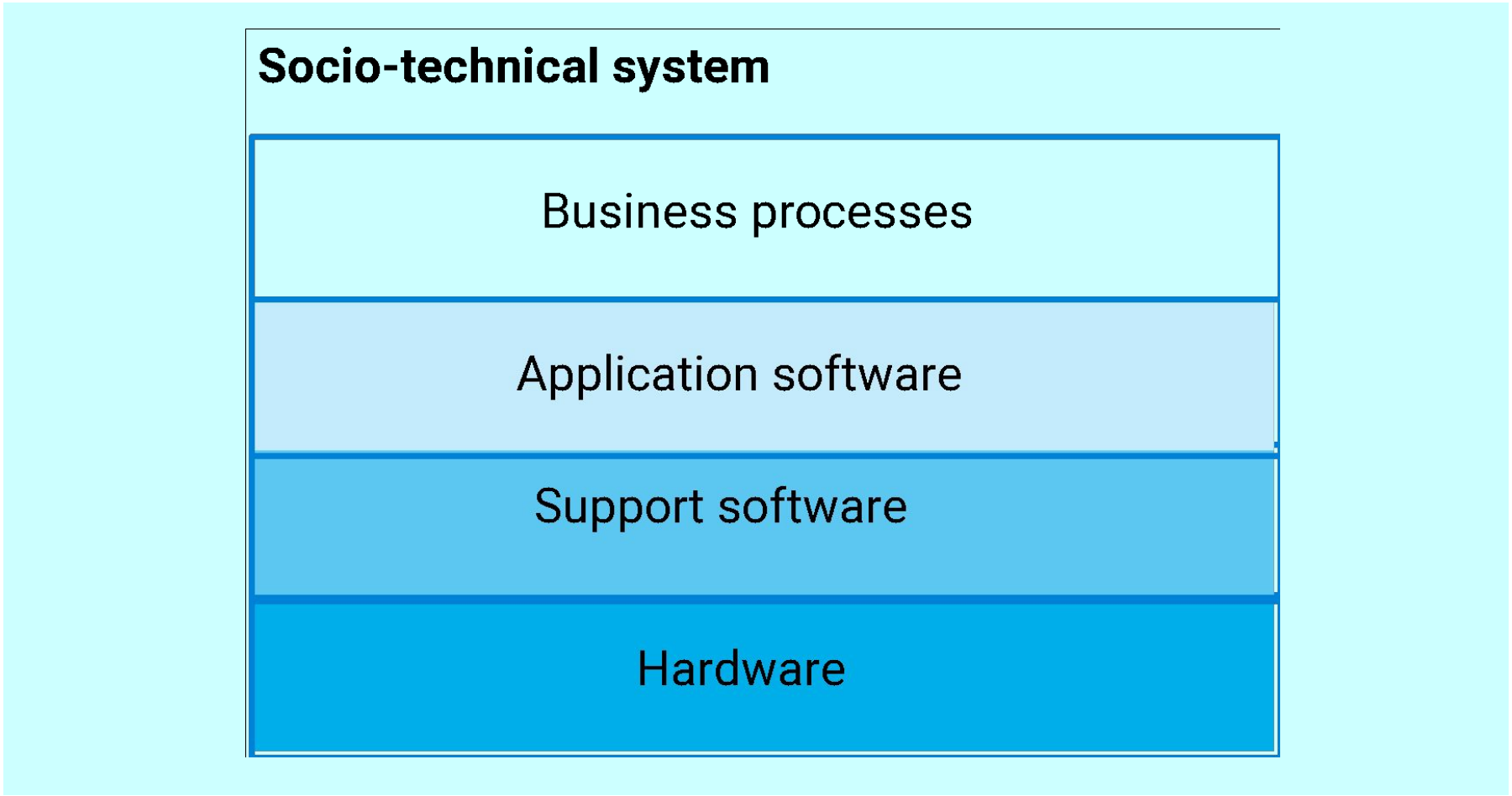
Legacy systems

- Socio-technical systems that have been developed using old or obsolete technology.
- Existing systems which must be maintained are sometimes called legacy systems.
- 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.


Embeds
knowledge of
Uses
Support software
Application
software
Business policies
and rules
Runs-on
Runs-on
Uses
Uses
Constrains
System
hardware
Application
data
Business
processes

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
Business processes
Application software
Support software
Hardware

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.

Key points

- Human and organisational 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.