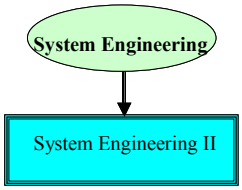
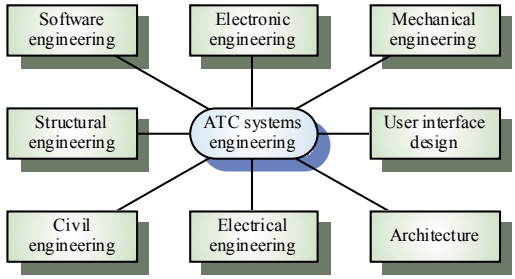
Next lecture : The System



Inter-disciplinary involvement



Foundational questions

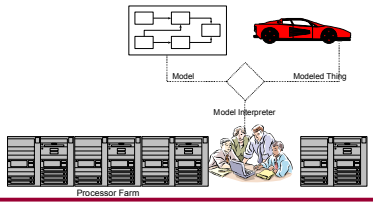
- What are the foundational ideas that link Systems Engineering to other fields in the Arts and Sciences?
  - How is systems engineering related to the broader area of systems sciences, complexity, and language?
- If we aim to utilize systems engineering in diverse areas not traditional to SE origins, how must these be conceptually mapped, and with what impact?

Foundational questions

- What conceptual road maps of simplified foundational ideas can be used to more easily or effectively understand, perform, manage, or conform to current, complex, or specific SE methodologies, standards, and processes?
- What principles are needed to apply systems engineering to more complex problems than the design of traditional systems; e.g.,
  - As in the engineering of globally optimized families of configurable systems (product lines)?
  - Or the engineering of high intelligence systems?

Model-based systems engineering

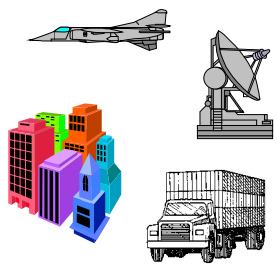
- Model-based systems engineering is an emerging approach to systems engineering:
  - See www.incose.org
- Uses explicit models where previously informal, intuitive, natural language prose (e.g., English) of documents was used



The Systems Challenge

The Man-Made World Is Increasingly Populated by ***Systems***

- Transportation, Energy & Power Systems
- Manufacturing, Construction Systems
- Telecommunication Networks
- Man-Made Biological & Health Care Systems
- Facility, Properties
- Business Processes
- Other Man-Made and Natural Systems



The Systems Challenge

These Systems Are Becoming More Complex

- Under pressure of demand & competition
- Enabled by progress in technology
- Becoming more complex at exponentially growing rates

The Systems Challenge

The Growth Of Systems Complexity Eventually Can Outpace Human Ability To:

- Describe
- Predict
- Manage
- Monitor
- Configure
- Evolve
- Understand
- Install
- Operate
- Repair
- Maintain
- Account For
- Communicate About
- Design and Implement
- Manufacture
- Diagnose
- Control
- Maintain Security Of

Those Systems . . .

The Systems Challenge

. . . At Least Within Reasonable:

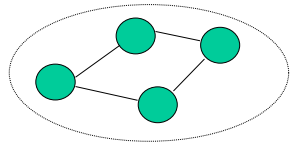
- Time
- Cost
- Effort
- Sense of Security from Risk

Incose : **Faster, Better and Cheaper**

For a meal : **must NOT result in MacDonald Hamburger !!**

Systems may be any technology

- Mechanical
- Electronic
- Software
- Chemical
- Thermodynamic
- Human organizations
- Biological



Not everything that has parts is a *system*

- For components to "interact", there must be an idea of "state" and relationship between states of components:
  - Two components interact if the state of at least one is impacted by the interaction having occurred
  - A book, a piece of music, or a photograph have their own components, but not direct interactions between them
- This view distinguishes the engineering view of systems from "systems" in some other fields.

Example system

- System: Semi-trailer truck hauling freight
- Components: engine, power train, suspension, lubrication system, fuel system, braking system, electrical system, cab, trailer, navigation system, communication system, software modules
- Relationships: physical containment, power dependency, control interaction, mechanical connection, thermal interaction

Physical and Logical Systems

- A Logical System is equivalent to a functional role.
- Physical Systems may be assigned responsibilities to perform roles that are Logical Systems.
- What plays the role of Engine System in a gas-fired generator?
- What plays the role of Engine System in a hybrid automobile?

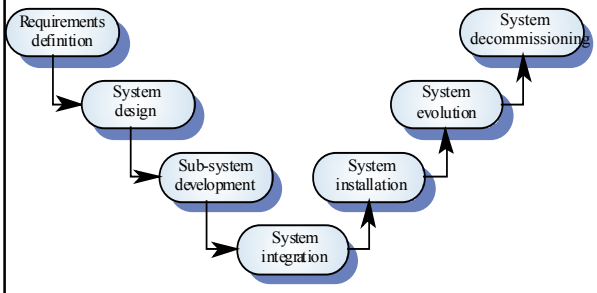
- Example of Logical System:
  - Engine System: An Engine System converts atmospheric air and chemical fuel into rotating mechanical power for use by other machine subsystems.

- Examples of Physical Systems:
  - Toyota Camry Model XLE Automobile
  - Caterpillar Model 3406 Diesel Engine
  - Program Module 1750

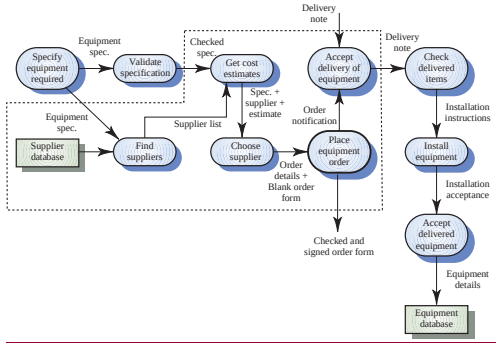
Services

- A Service is:
  - a feature of a system
  - what system users consume
  - something that can be measured and be subject to a service level agreement

The system engineering process



An example of SE process (Procurement)



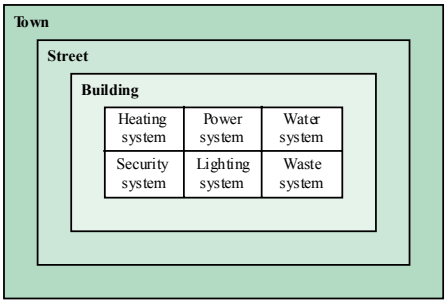
Software and systems engineering

- Proportion of software in systems is increasing. Software-driven general purpose electronics is replacing special-purpose systems
- Problems of systems engineering are similar to problems of software engineering
- Software is (unfortunately) seen as a problem in systems engineering. Many large system projects have been delayed because of software problems

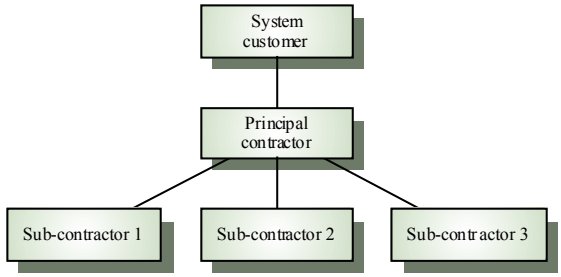
Systems and their environment

- Systems are not independent but exist in an environment
- System뭘 function may be to change its environment
- Environment affects the functioning of the system e.g. system may require electrical supply from its environment
- Organizational as well as physical environment may be important

System hierarchies

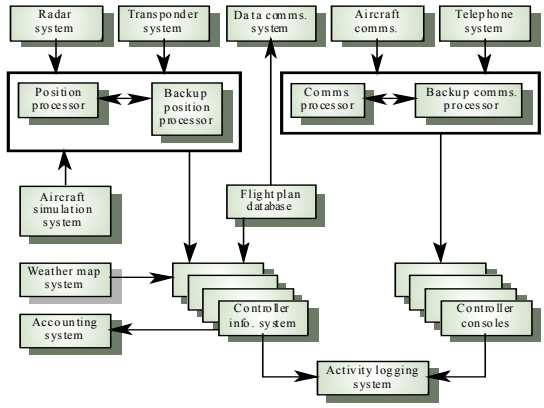


Contractor/Sub-contractor model



System architecture modelling

- An architectural model presents an abstract view of the sub-systems making up a system
- May include major information flows between sub-systems
- Usually presented as a block diagram
- May identify different types of functional component in the model



Human factors

- All systems have human users and are used in a social and organisational context
- An appropriate user interface is essential for effective system operation
- Human factors are often the most important factor in determining the success or otherwise of a system

Other human factors

- Changes to work processes in the system environment
  - May be resisted by users if jobs are lost
- De-skilling of users
  - May be resented by professionals
- Changes to organisation power structure
  - Managers don뭔 like to lose control
- Work changes
  - Some changes to work practice may be unacceptable

Conclusion

- **Systems engineering is hard!**
- There will never be an easy answer to the problems of complex system development
- Software engineers do not have all the answers but are often better at taking a systems viewpoint
- **Disciplines need to recognise each others** strengths and actively rather than reluctantly cooperate in the systems engineering process

Next lecture : SE Standards