System Engineering and Analysis 1
(System Definitions and Concepts)

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Tsinghua University
Department of Industrial Engineering

Agenda

- Welcome
- Introduction of the instructor, TA
- Syllabus, **Grading**, Assignment, Exam, etc
- System Definition and Concept

Instructor: Nan Tu PhD

BS. Xi'an Jiaotong University, China

Manufacturing Engineer, 1990 – 1993 Yunnan, China

Adv. Manufacturing Engineer, 1996 – 1998 Seagate Technology, Inc. USA

Research Assistant, 1998 – 2001 University of Minnesota

MS, PhD, University of Minnesota, USA 2002

Visiting Scholar / Researcher, 2004 Microsoft Research Asia

Lecturer, 2004 Tsinghua University

Various startup activities

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Office: 6277-2426

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Teaching Assistant: 王培

Responsibilities:

- Home work and project questions
- Communicate with team leaders
- Help with grading

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Dorm Phone: 5153-3637

Class Rules

- Attendance (you are **expected** in each class)
- Participation (I **encourage** class discussion)
- Cell phone:- **turn off or use vibration**
- Ethics (you are expect to produce your **own** work)
- **Electronic** version home work (no paper, no late assignment accepted, no exceptions)
- **Group Project** (make your own contribution, final report will include a task and contributor list. No free riders)

System Engineering Syllabus

Who, when, where

Schedule

Grading

- Exam - 30%,
- Homework / Reading assignments- 20% (please submit the electronic version to 网络学堂, No paper version accepted)
- Project- **50%** (work with teams, 6 person at each team, include manager, writer, researcher, designer, data collector, etc)

Please refer to the handout

System Engineering Class

- Multidisciplinary approach
- **Concepts, principles, practices** of systems engineering

1: Process of **bringing systems into being**

- definition of need
- requirements analysis,
- functional analysis and allocation,
- design synthesis,
- design evaluation ,
- system validation.

2: Process of **improving the existing systems**

- effectiveness,
- output quality,
- ownership cost,
- and user satisfaction.

What Do Engineers Do?

- Engineers help to **design and manufacture** just about everything
  - Skyscrapers, computer chips
  - Cars, space shuttles
  - Candies to tissue papers

- Big **Four Engineering Principles**
  - Chemical Engineering
  - Civil Engineering
  - Electrical and Computer Engineering
  - Mechanical Engineering

Other Engineering Disciplines

- Aeronautical and Aerospace Engineering
- Agricultural Engineering
- Biomedical Engineering
- Environmental Engineering
- **Industrial Engineering**
- Materials Engineering
- Mining Engineering
- Nuclear Engineering
- Petroleum Engineering
- **Systems Engineering**

http://www.intel.com/education/design/resources/what_engineers_do.htm

What do Industrial Engineers do?

- Industrial engineers make things **work better**, more safely, and more economically.
- Improve **Efficiency**
- **Reduce** Waste

- Industrial engineering principle has been applied to many disciplines

http://www.iienet.org

What do System Engineers do?

- Responsible for bringing all the pieces of an engineering project **together** and making them work harmoniously
- Interdisciplinary approach to a project
- From concept to production to operation
- Consider both the business and technical needs of a project.

http://www.intel.com/education/design/resources/what_engineers_do.htm

Who Practice System Engineering?

- Design Engineer
- Project Engineer
- Manufacturing Engineer
- Quality Engineer
- Purchasing Engineer
- Process Engineer
- Software Engineer
- **System Engineer**
- **Industrial Engineer**
- Project Manager
  - And many more

7 Steps of System Engineering

1. State the problem
2. Investigate alternatives
3. Model the system
4. Integrate
5. Launch the system
6. Assess performance
7. Re-evaluation

The Purpose of Systems Engineering

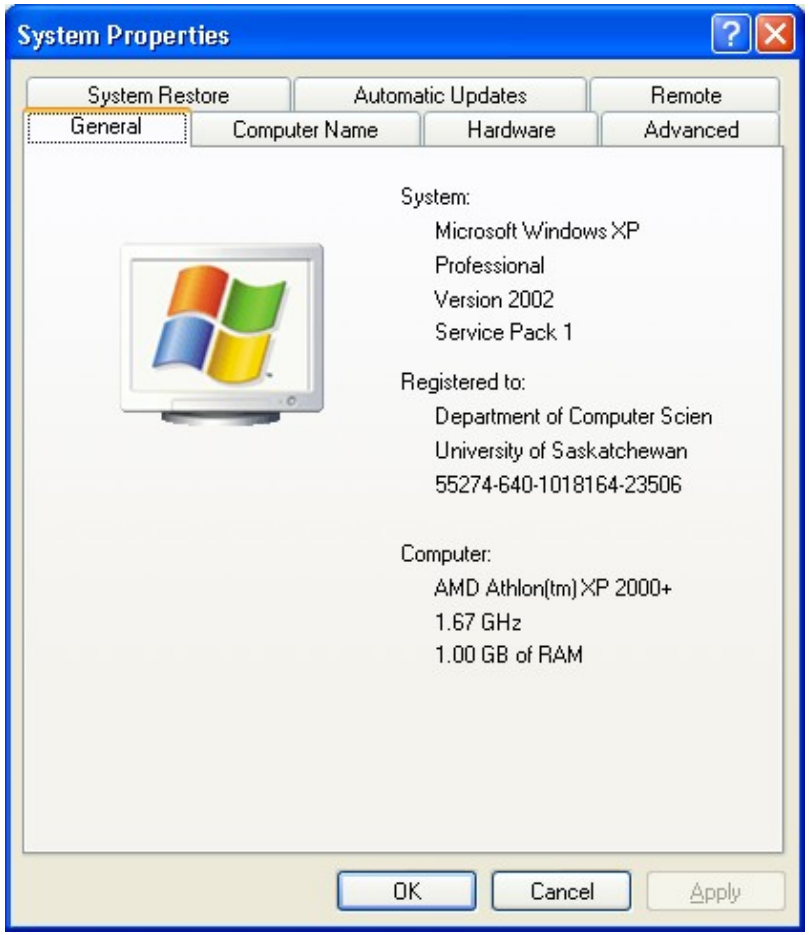
Reduction in **system acquisition** time

Reduce risk

Reduce **total-life-cycle** cost

- design, development, production and / or construction, system operation and support, retirement and disposal

What is a system?



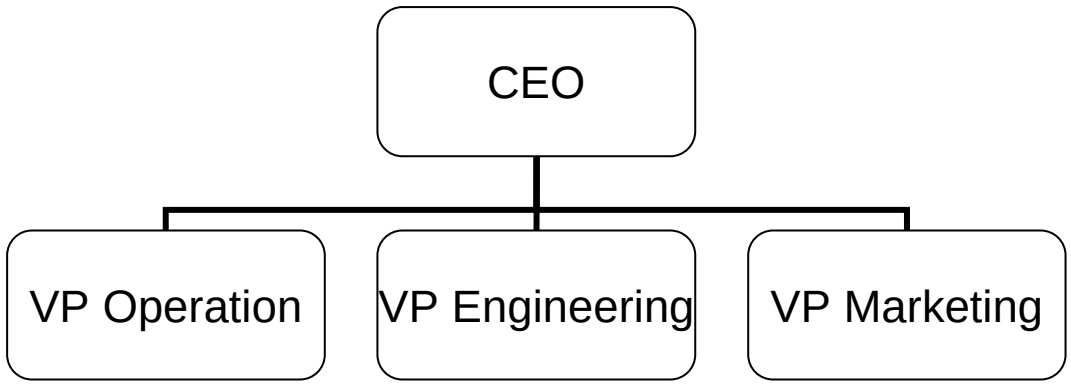
PC Computer System Property

- A regularly **interacting** or interdependent group of items forming a unified whole as a group of device or artificial objects or an organisation forming a network esp. for distributing something or serving as common purpose (**Webster Dictionary**)

- A **set of connected items** or devices which operate together (**Cambridge Dictionary**)

System Definitions and Concepts

- Components (Interconnected)
- Attributes (property of components)
- Relationships (links)



An organization system

Relationships

- Exists between **two components** only
- Formed out of imminent qualities of the components
- Connection of components is **direct**

System Examples

Highway Networks / Systems

Manufacturing Systems (Human, machine, capital)

- Question, what kind of manufacturing are moving to China? Hint, labor, capital, capacity

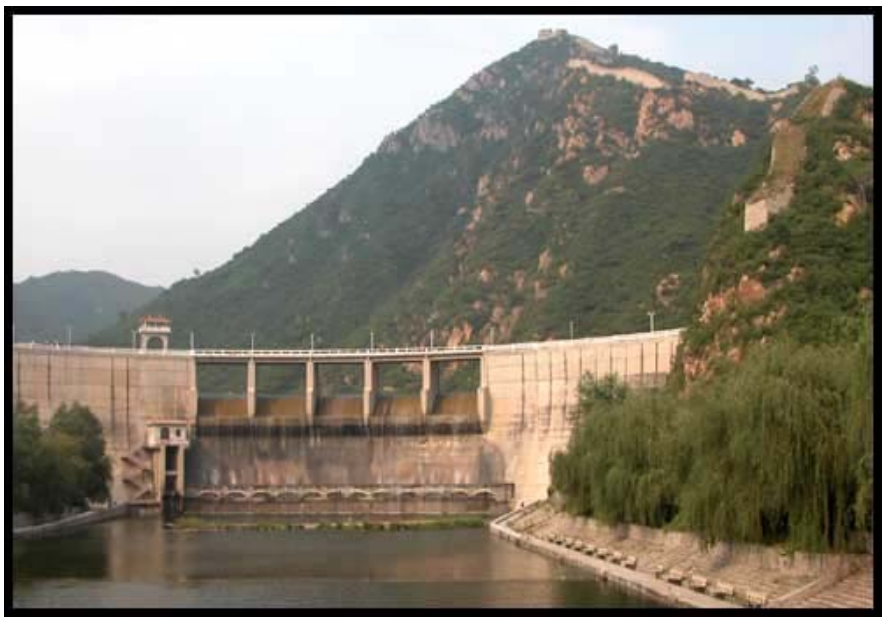
Social Systems

- Relationships, Social Network, GuanXi

Software Systems

- Microsoft everywhere ☺

Classification of Systems

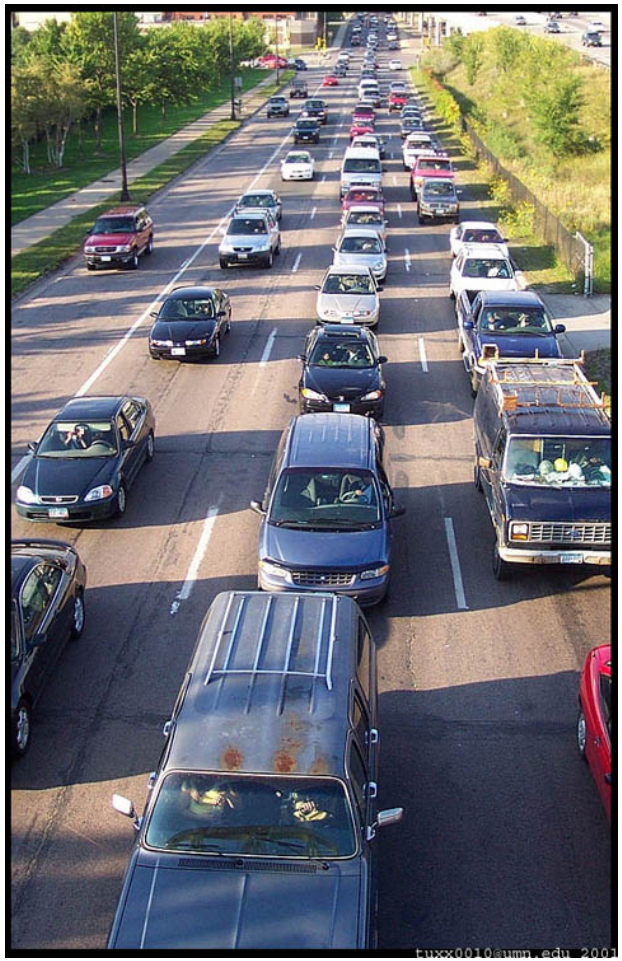


Human-Made Systems

- Natural and **Human-Made** systems
  - Grand Canyon vs. Three Gorges Dam
- Physical and **Conceptual** systems
  - China vs. Map of China
- Static and **Dynamic** Systems
  - Classroom vs. a Class
- Closed and **Open** Systems
  - A pond vs. the sea

Grand Canyon, Arizona, USA

- **277** Miles (**446 KM**) Long
- 10 Miles (16 KM) Wide
- 1 Mile **(1.6 km) deep**
- **Carved** by the Colorado River
- Erosion Rate : 50 ft / one million years



American Highway System

Authorization of the Interstate Highway System: On June 29, 1956, Federal Aid-Highway Act,

- Completed by **1980s**
- 42,500 miles
- No intersection, no traffic light
- 55,000 bridges
- Cost: **$329 Billion** in 1996 dollars

http://www.publicpurpose.com/freeway1.htm

Transport System	Market Share	Mileage Share
Interstate	**23.0%**	**1.1%**
All Other Roads	76.4%	98.2%
Passenger Rail	0.6%	0.7%

California 101: The Most Scenic Highway in the US

US Highway impact on the Economy

- Less expensive
- Travel time reliability
- Broadening geographical range
- Improve inter-regional access
- Improve safety and quality of life
- ……

http://www.publicpurpose.com/freeway1.htm

Manufacturing System

One of the oldest business in the world

Three revolutions in human history:

- Agricultural
- Industrial
- Informational

Each revolution produces its own riches.

•Industrial age riches are made from the manufacturing and its related business, like: Ford (car), Rockefeller (oil),

•New economy riches are in software and internet area, Gates (software), Yang (internet)

Trends in China

•The manufacturing base of the world for the next 15 years

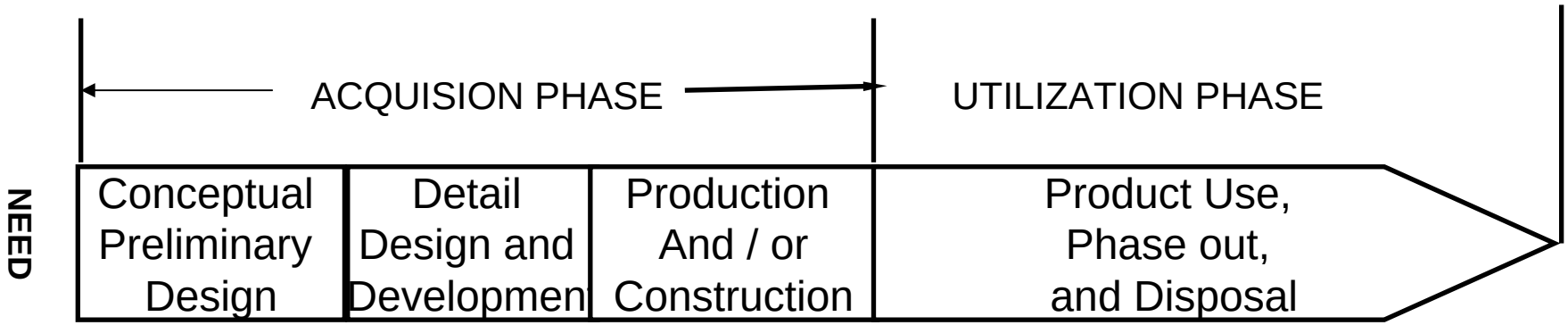
•Growing middle class

•Urbanization

The System Engineering Tasks

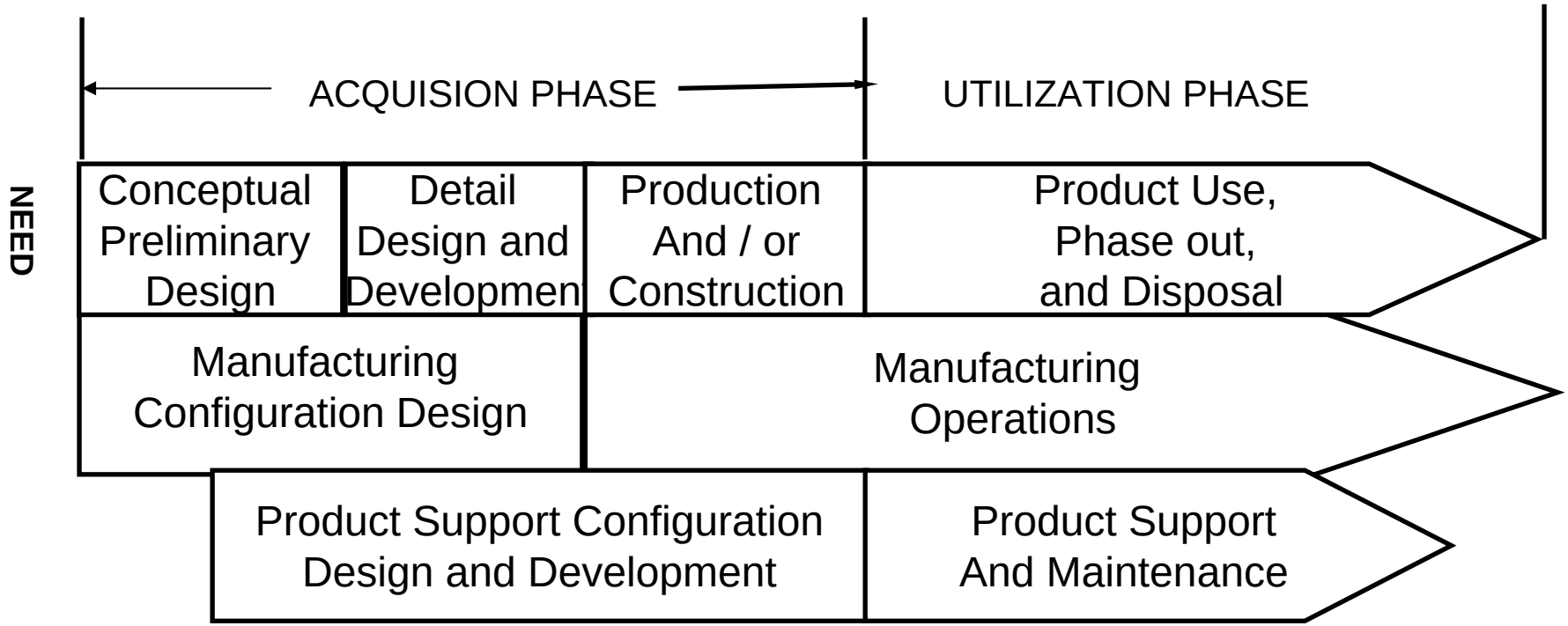
State the problem	**Design the system**	**Produce documentation**
Understand customer needs	Sensitivity analysis	Lead teams
Discover requirements	Assess & manage risk	Assess performance
Validate requirements	Reliability analysis	Prescribe tests
Investigate alternatives	integrate system components	Conduct reviews
Define quantitative measures	Design & manage interfaces	Verify requirements
Model the system	Execute configuration management	Perform total system test
Functional decomposition	Project management	Re-evaluate & improve quality

System Engineering Life Cycle



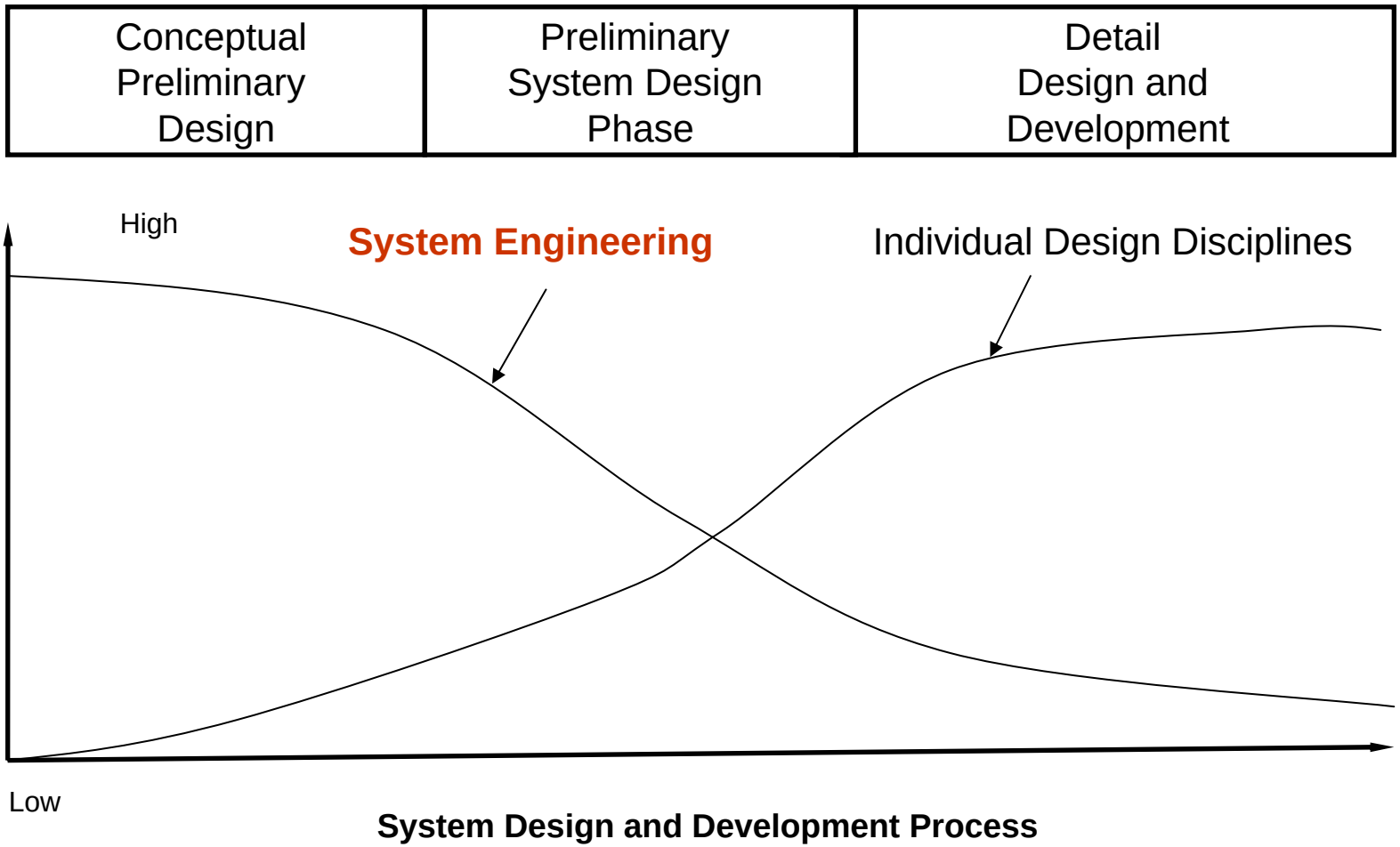
The Product Life Cycle

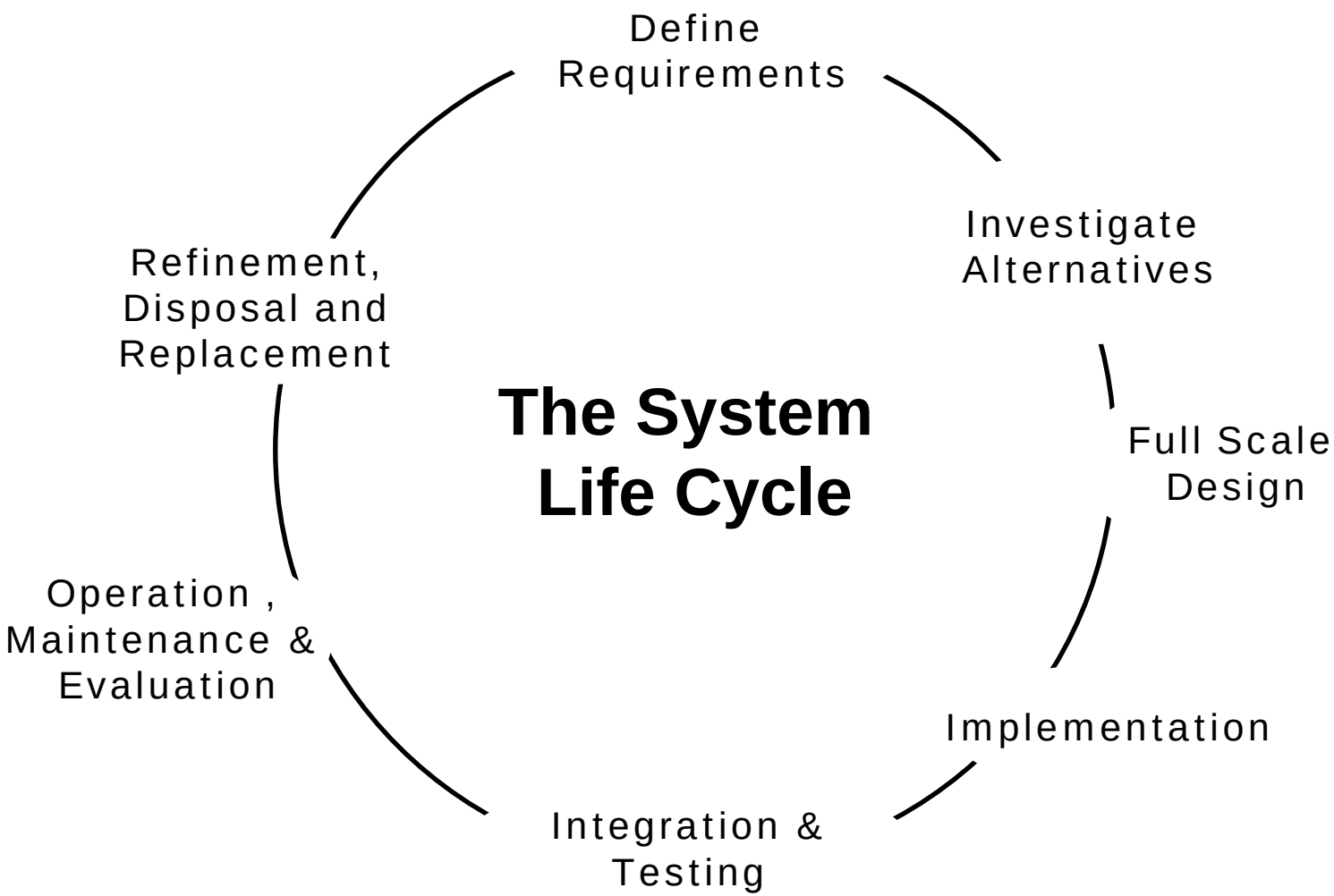
Product, Manufacturing, and Support Life Cycle

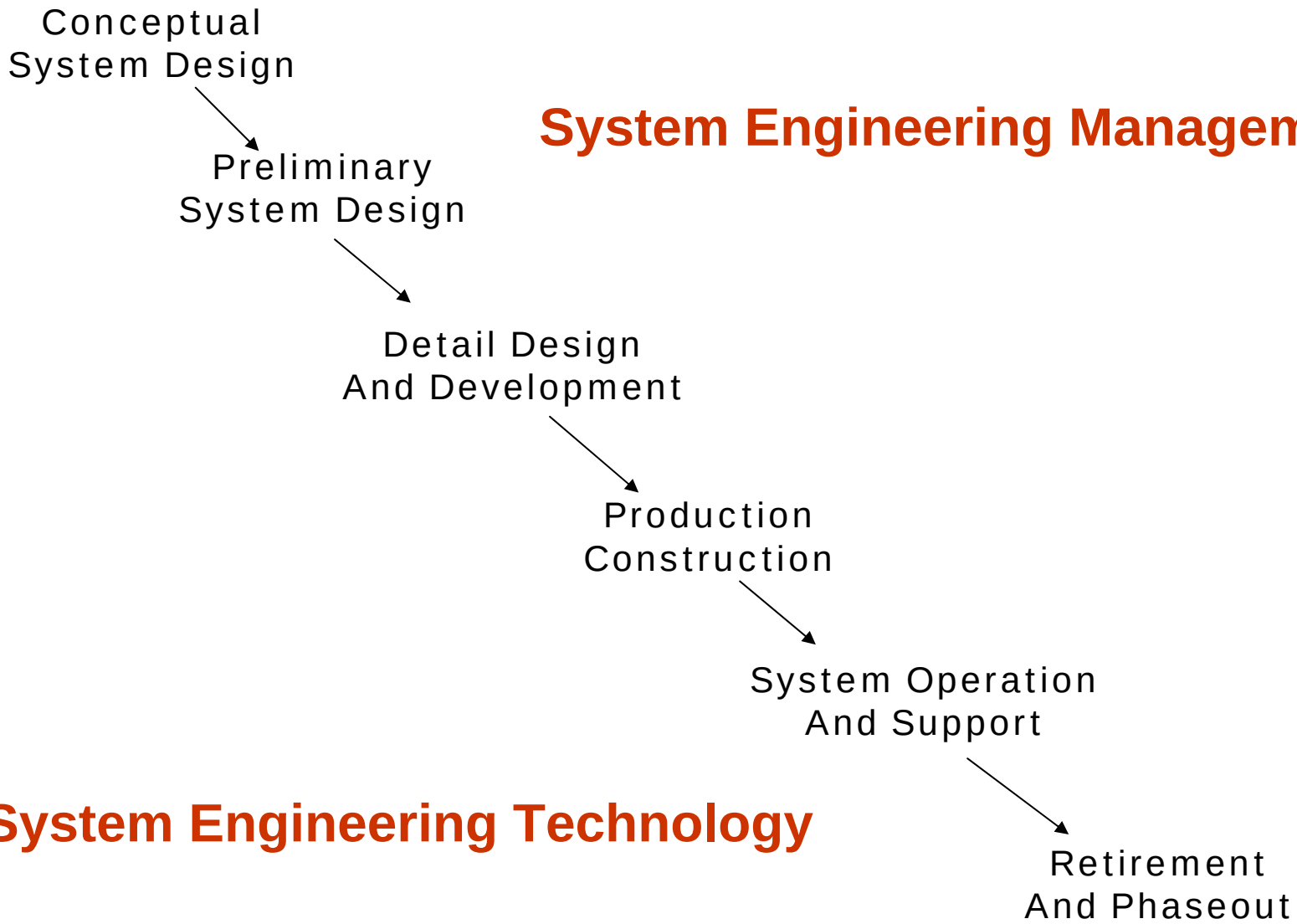


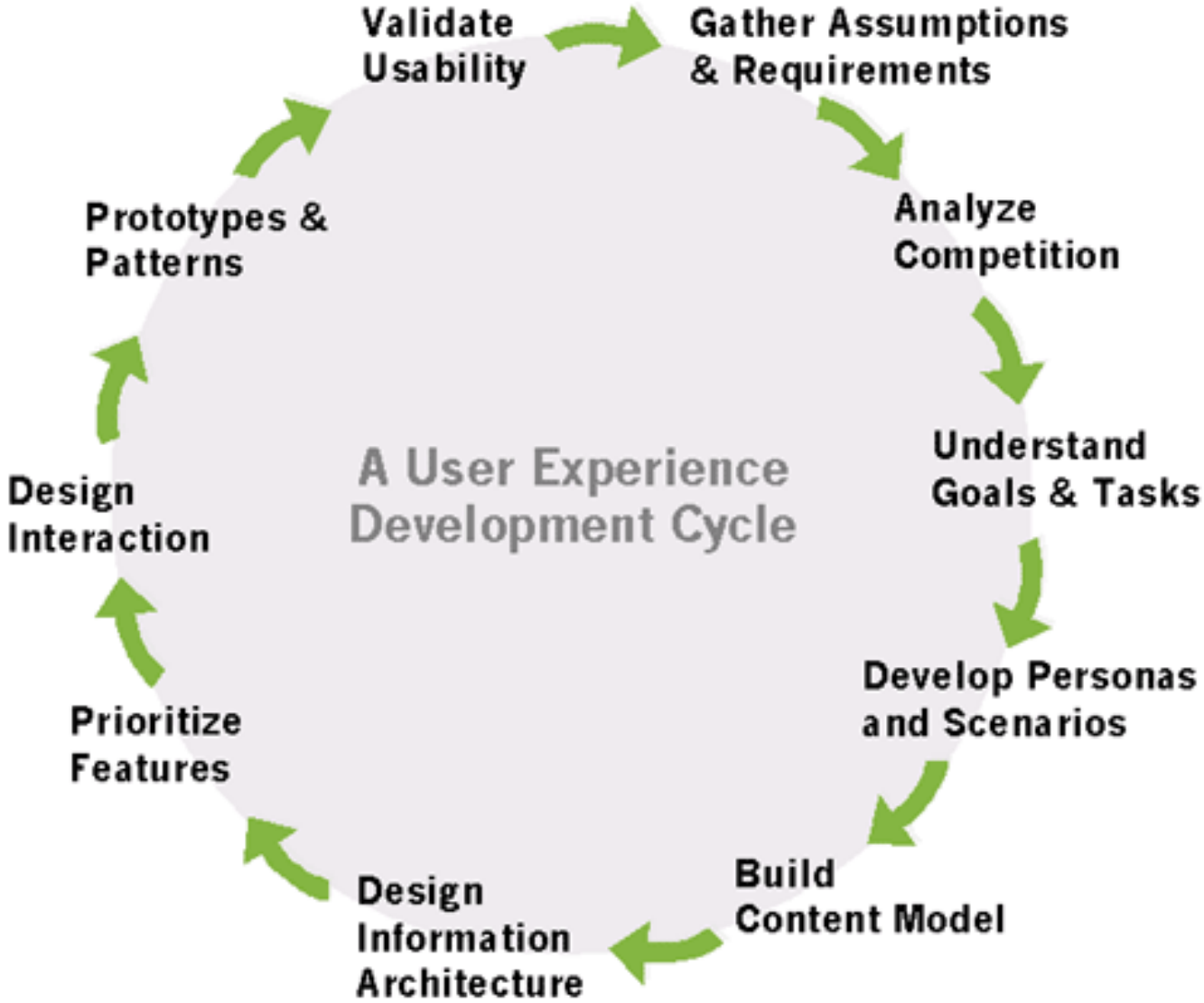
The Product, manufacturing and support life cycle

System Engineering Influence




Define Requirements
Investigate Alternatives
Full Scale Design
Implementation
Integration & Testing
Operation , Maintenance & Evaluation
Refinement, Disposal and Replacement
The System Life Cycle


Conceptual
System Design
Preliminary
System Design
Detail Design
And Development
Production
Construction
System Operation
And Support
Retirement
And Phaseout
System Engineering Management
System Engineering Technology


A User Experience
Development Cycle
Validate
Usability
Gather Assumptions
& Requirements
Analyze
Competition
Understand
Goals & Tasks
Develop Personas
and Scenarios
Build
Content Model
Design
Information
Architecture
Prioritize
Features
Design
Interaction
Prototypes &
Patterns

The System Life Cycle

- The system **life cycles** for a large office building and a roll of film will be different.
  - An office building will be used **continuously and modified** frequently as tenants change through its life cycle.
  - A roll of film will be in storage most of its life, rarely handled or modified, and used only once.

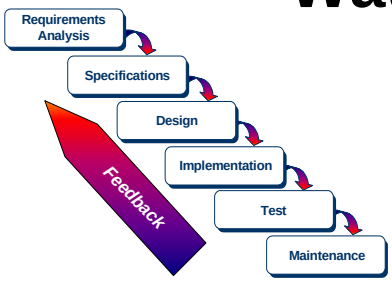
Top - Down vs. Bottom - up

- **Traditional** engineering design: bottom up approach
  - Start with a set of **known elements**
  - Iterative design
- **System** engineering design: top – down
  - Start with **requirements** (always satisfied)

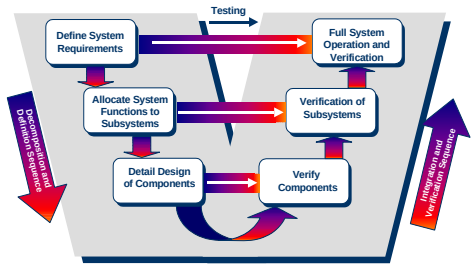
- **Class discussion**: what are the difference between these two approaches?
  - Hint: Use examples to illustrate
  - Which one is more effectives? Why?

System Process Models

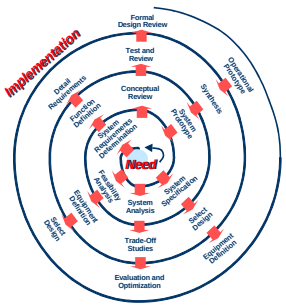
Waterfall



Vee

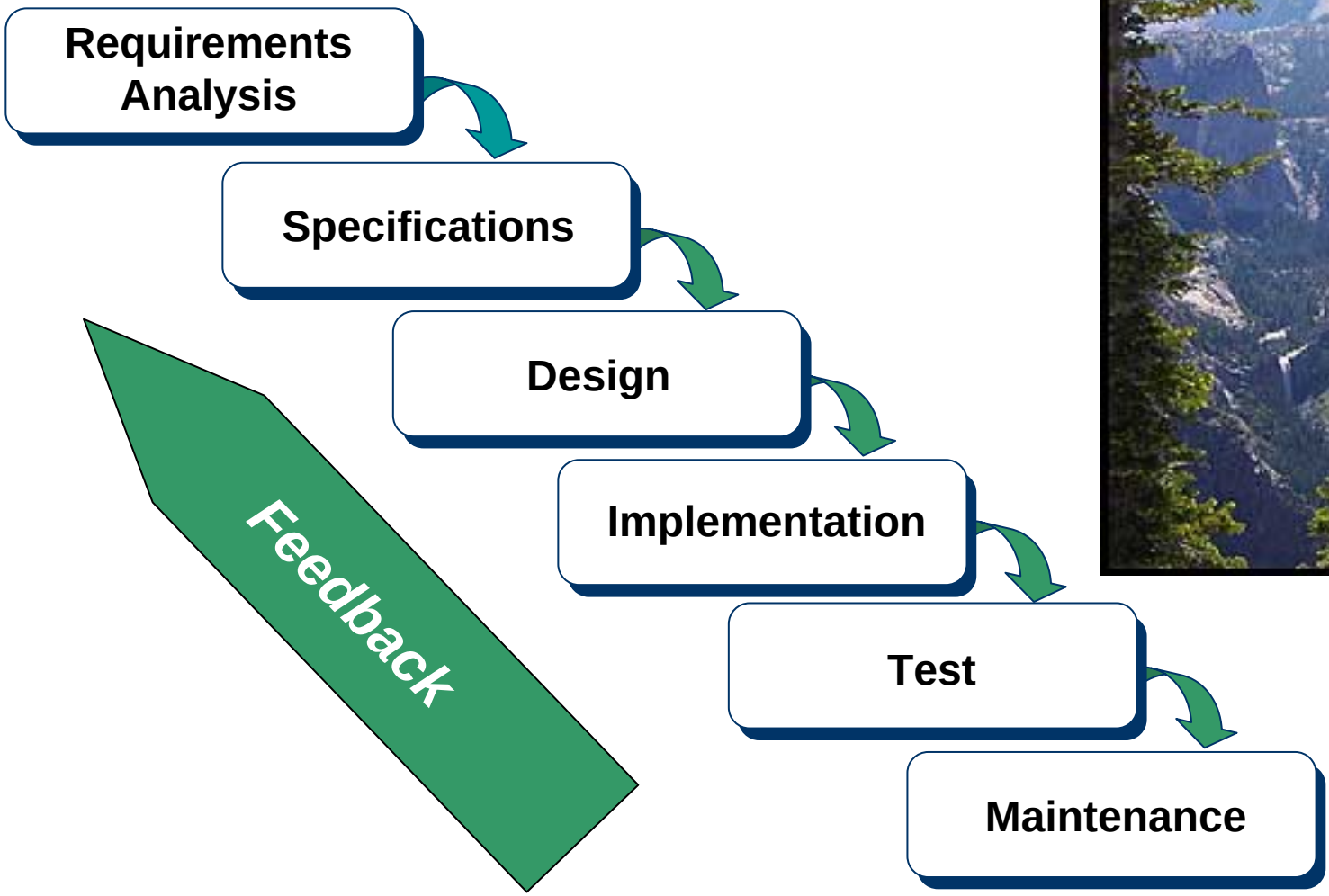


Spiral

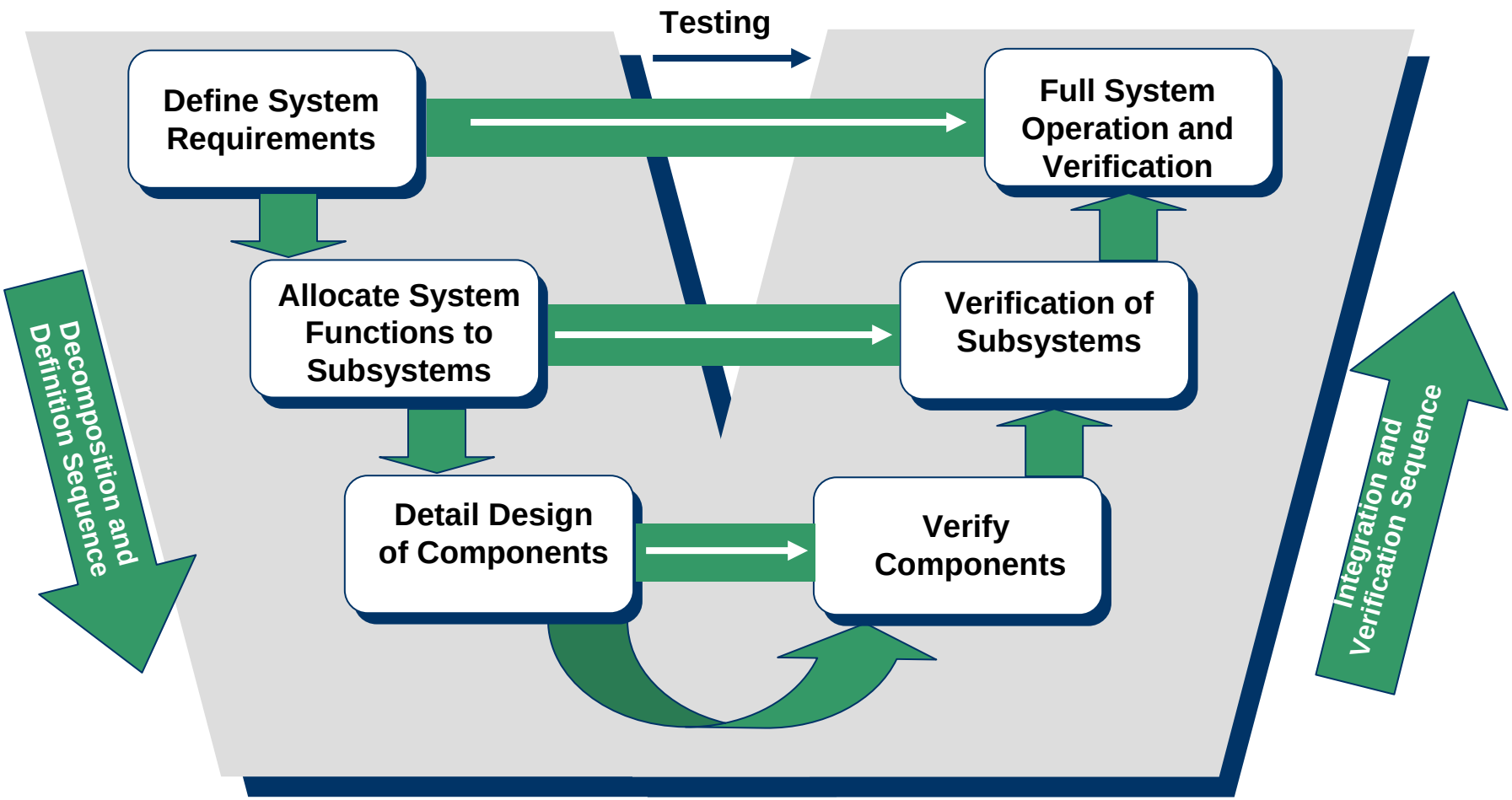


Others

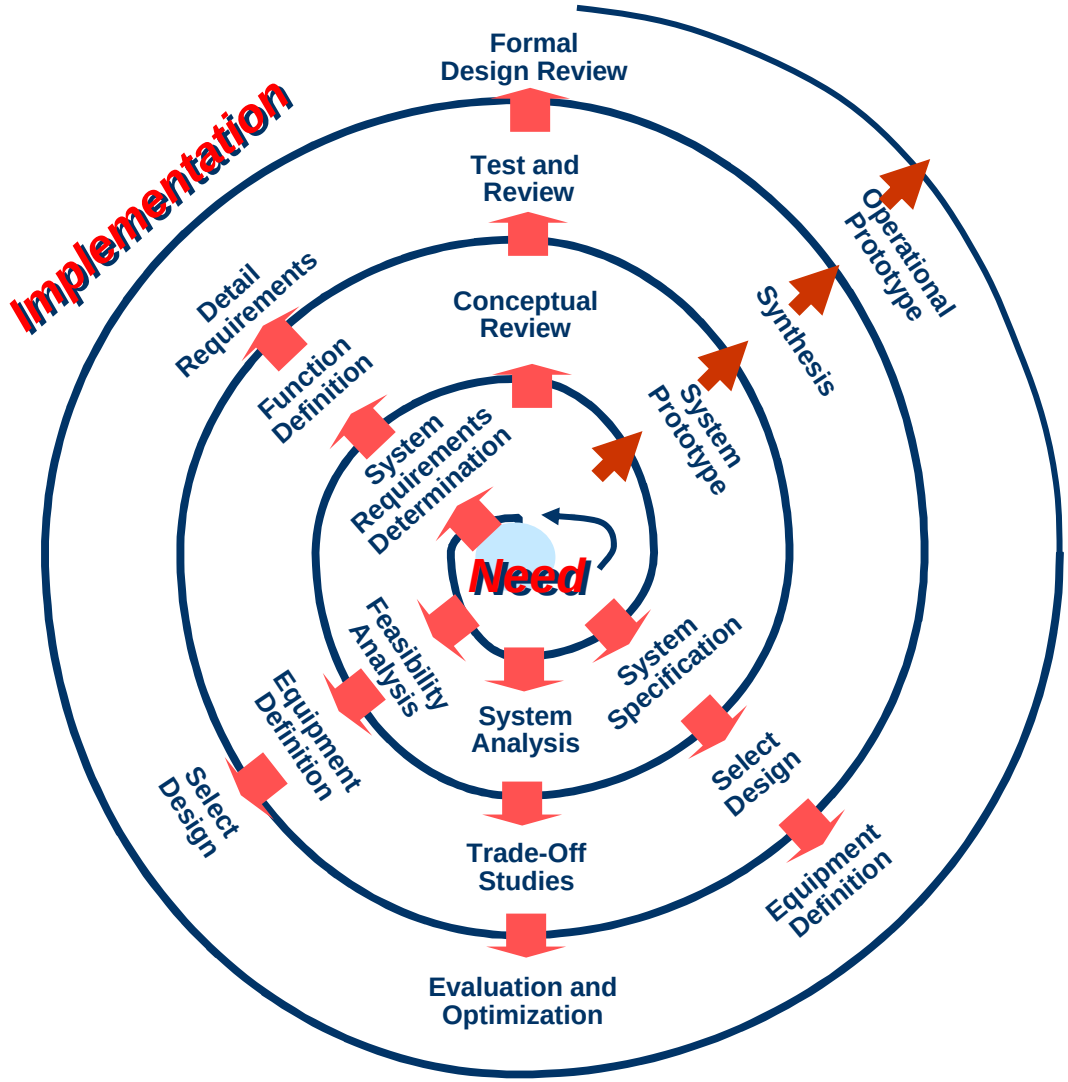
Waterfall Process Model



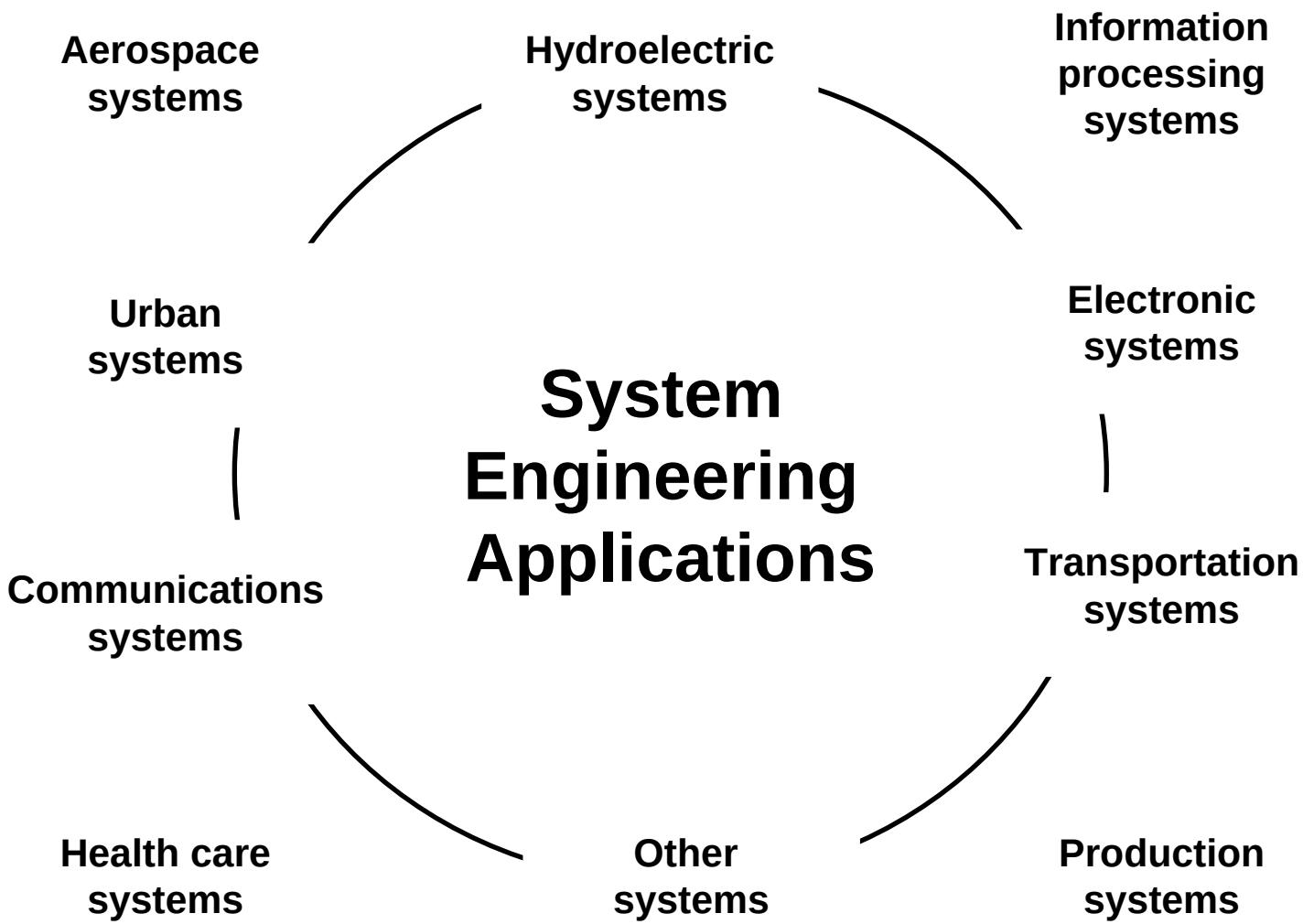
“Vee” Process Model



Spiral Process Model



Application for Systems Engineering



Class Discussion

- What are some of the **differences (or similarities)** between “System Engineering” and some of the more traditional disciplines such as aero, electrical, or mechanical?

- What does it mean by saying “**Life Cycle**”?, “**Cost”**? Why is it important in the decision making process?

Home Work

Reading: What is System Engineering?

Please each write a 300 words summary of the above article. Due before the next class.