

Lecture #18

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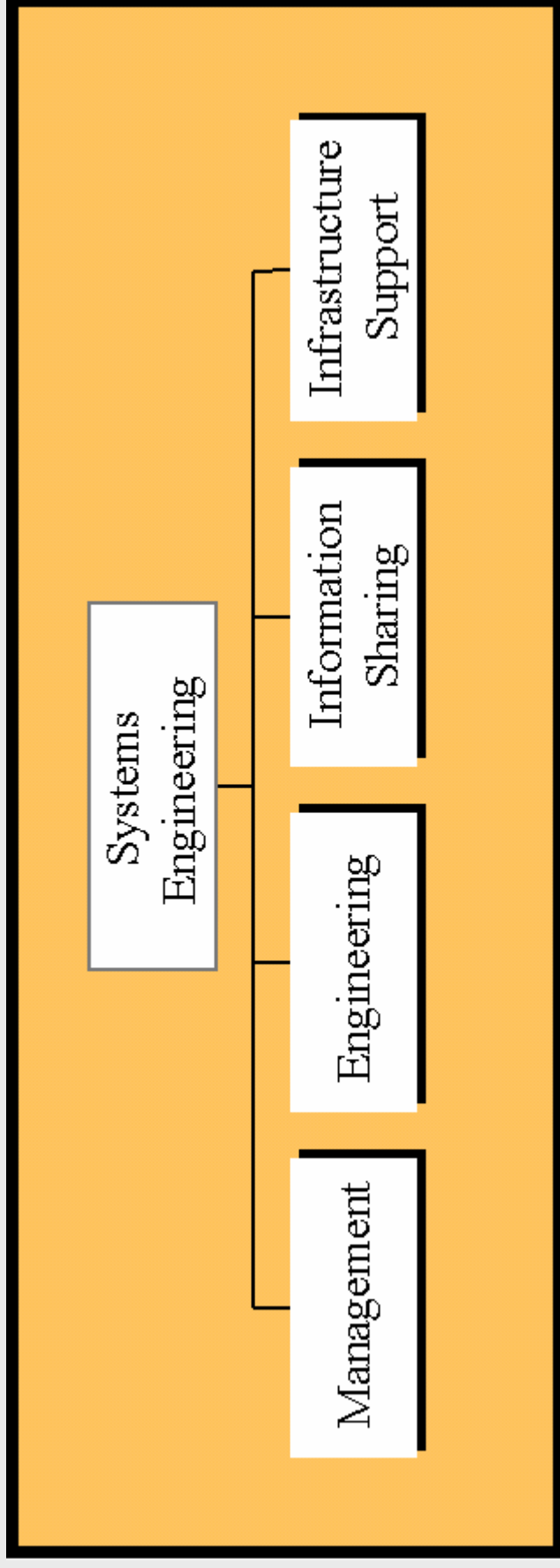
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From last time...

❖ SE is an interdisciplinary approach and means to enable realization of successful systems

□ It is very quantitative including tradeoff, optimization, selection, and integration of techniques/products from various engineering disciplines

SE Tools Taxonomy - Top Level



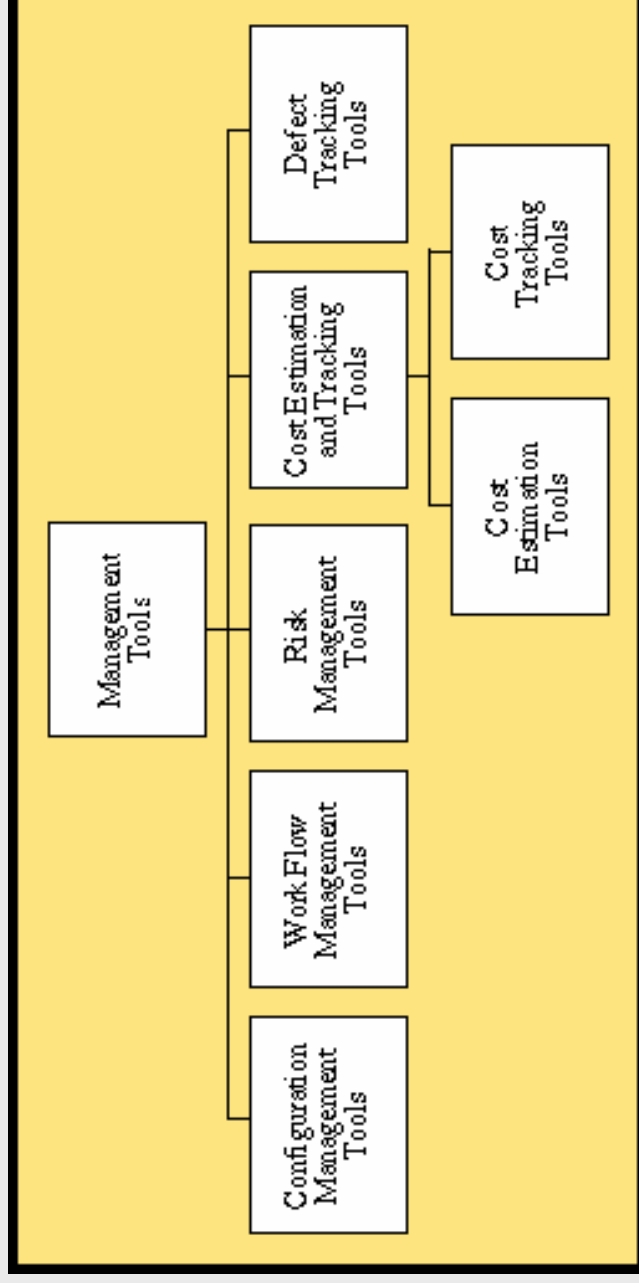
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Management Tools



- ❖ **Configuration Management: managing system baselines, both products of the engineering process and the tools used to create those products/ services. Version control, baseline control, change history, check-in/check-out control, change and archiving capabilities of both process and product/service.**

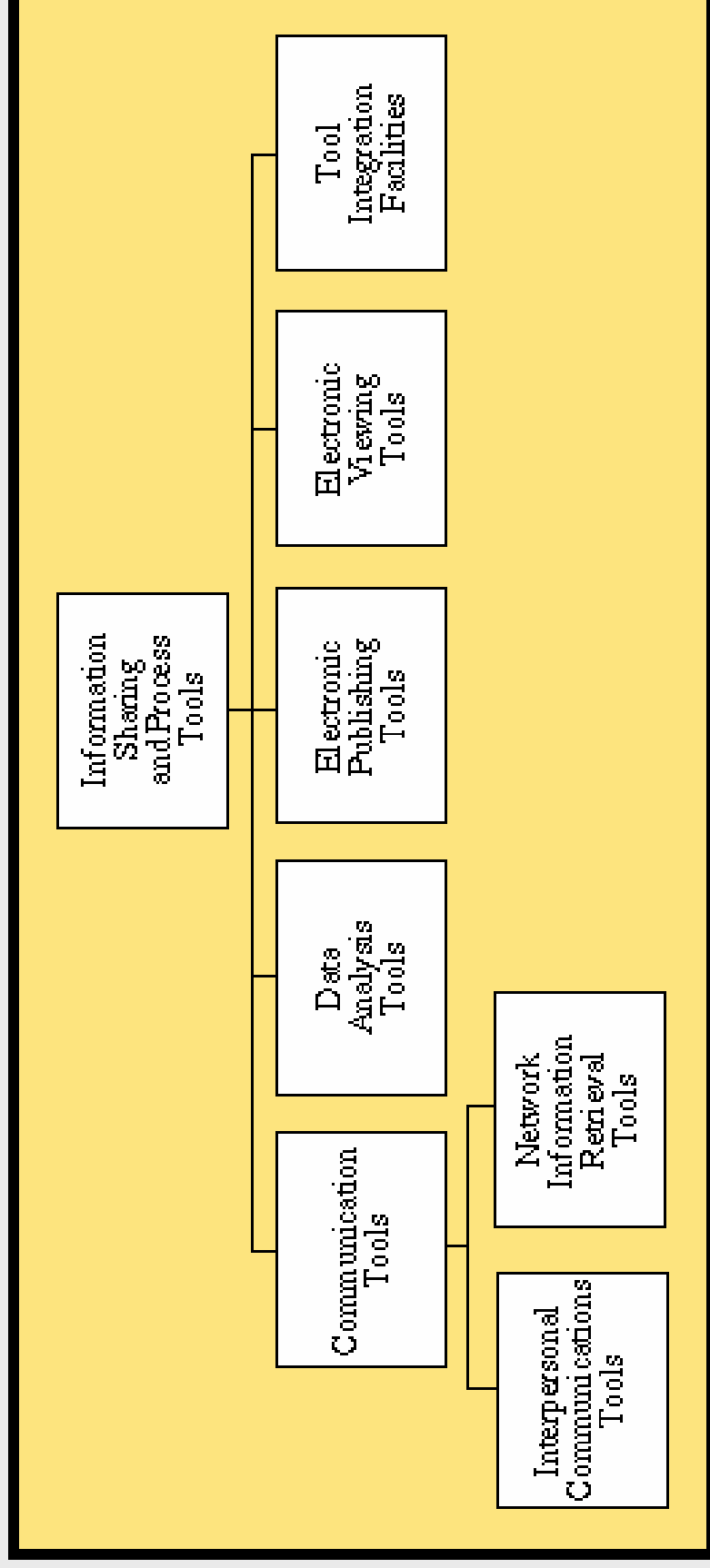
Management Tools

- ❖ **Work Flow Management tools:** used to define and schedule tasks, and make work assignments. Monitor progress, task prioritization, and support task review/approval. Identify resource loads and critical paths. Automation can help enforce the Integrated Product Development Process through the use of pre-defined workflow models.
- ❖ **Risk Management tools** support qualitative risk identification and quantitative risk analysis and visualization. Manage technical, cost, and schedule risks. Supports management decisions, identifies risk prioritized by program impact, and generates risk mitigation plans.

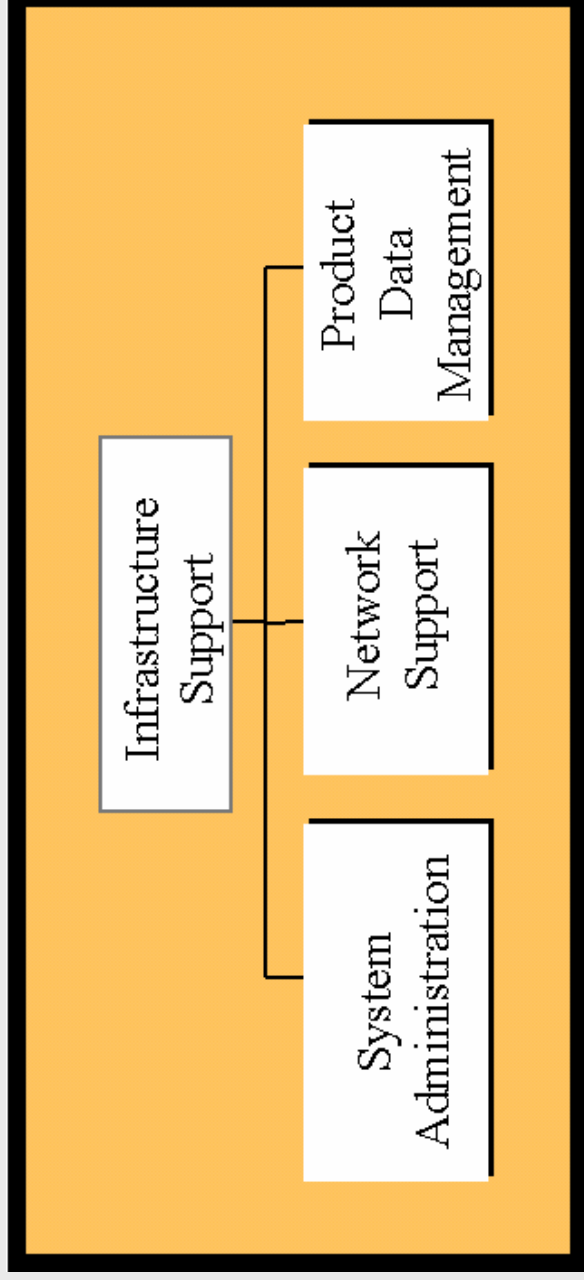
Management Tools

- ❖ **Cost Estimation and Tracking tools:** estimate the cost of tasks and roll costs into total project cost. Track the cost of the project during development and interface with the organization's financial recording and reporting system.
- ❖ **Defect Tracking tools:** used to record system defects and change requests found in product testing and in the field. Track defect details.

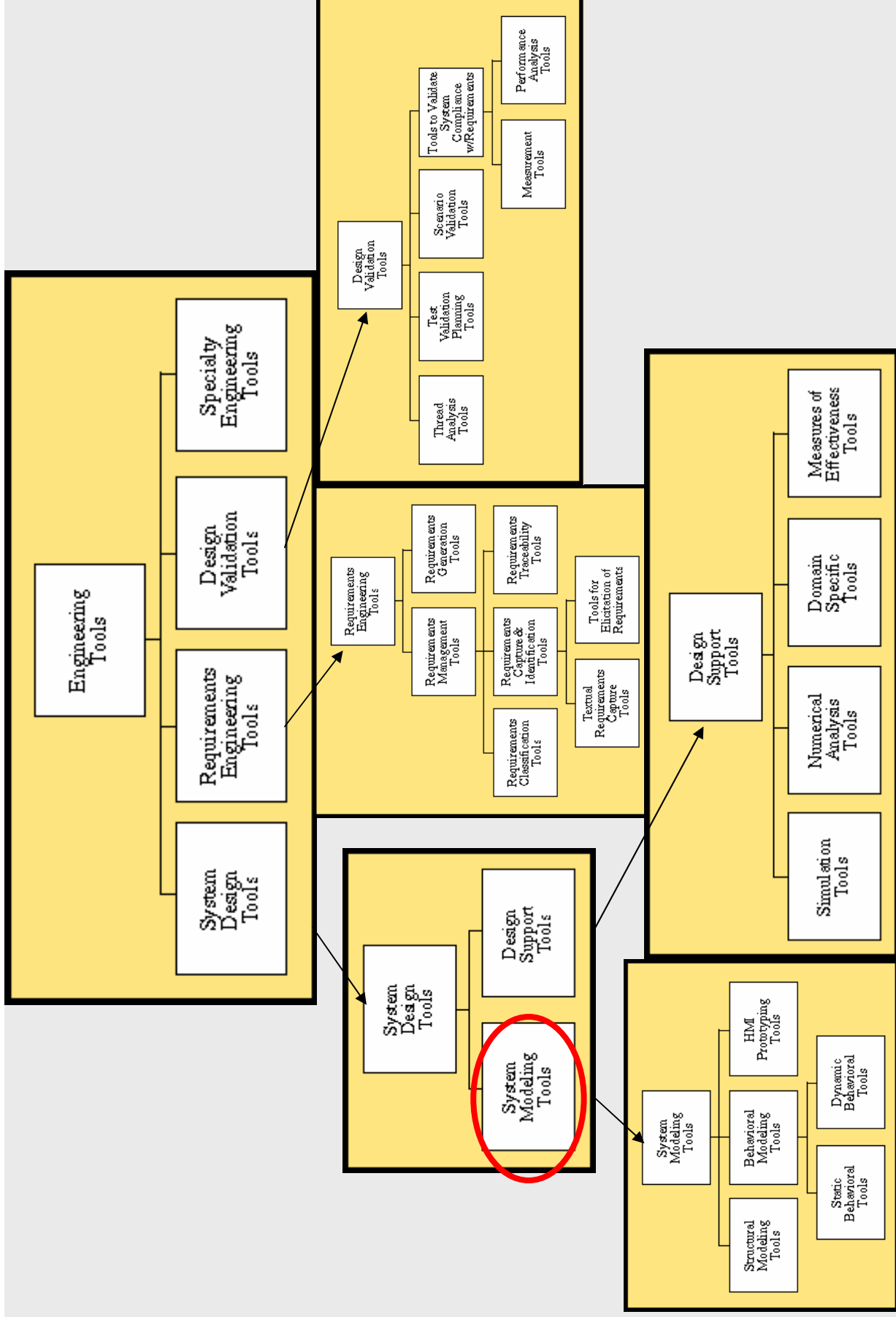
Information Sharing Tools



Infrastructure Support Tools



- ❖ Tools that assist in the administration of computer-based systems.
- ❖ Network Support Tools assist in the documentation, maintenance and performance analysis of computer-based networks.



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System Modeling Tools

- ❖ Behavioral Modeling falls into two categories, static and dynamic –model the functional capabilities of a system and its response to events.
 - ❑ Static Behavior Modeling – static description of system behavior. Static implies that the model may represent dynamic behavior, but it is not executable. Examples of static behavioral models are Functional Flow Block Diagrams and State Transition Diagrams
 - ❑ Dynamic Behavior Modeling – dynamic description of system behavior. These models are executable through simulation and prototyping
- ❖ Prototyping techniques are used to develop or verify Human Machine Interface (HMI) design by modeling the interaction of operators or users with the system. Describe input/output screens, to depict parts of the system, and animate these presentations.

System Modeling – an important tool

❖ After overview of SE tools – evident that “modeling” is a crucial element.



**Simulation Models
to Analyze Complex
Traffic Systems**

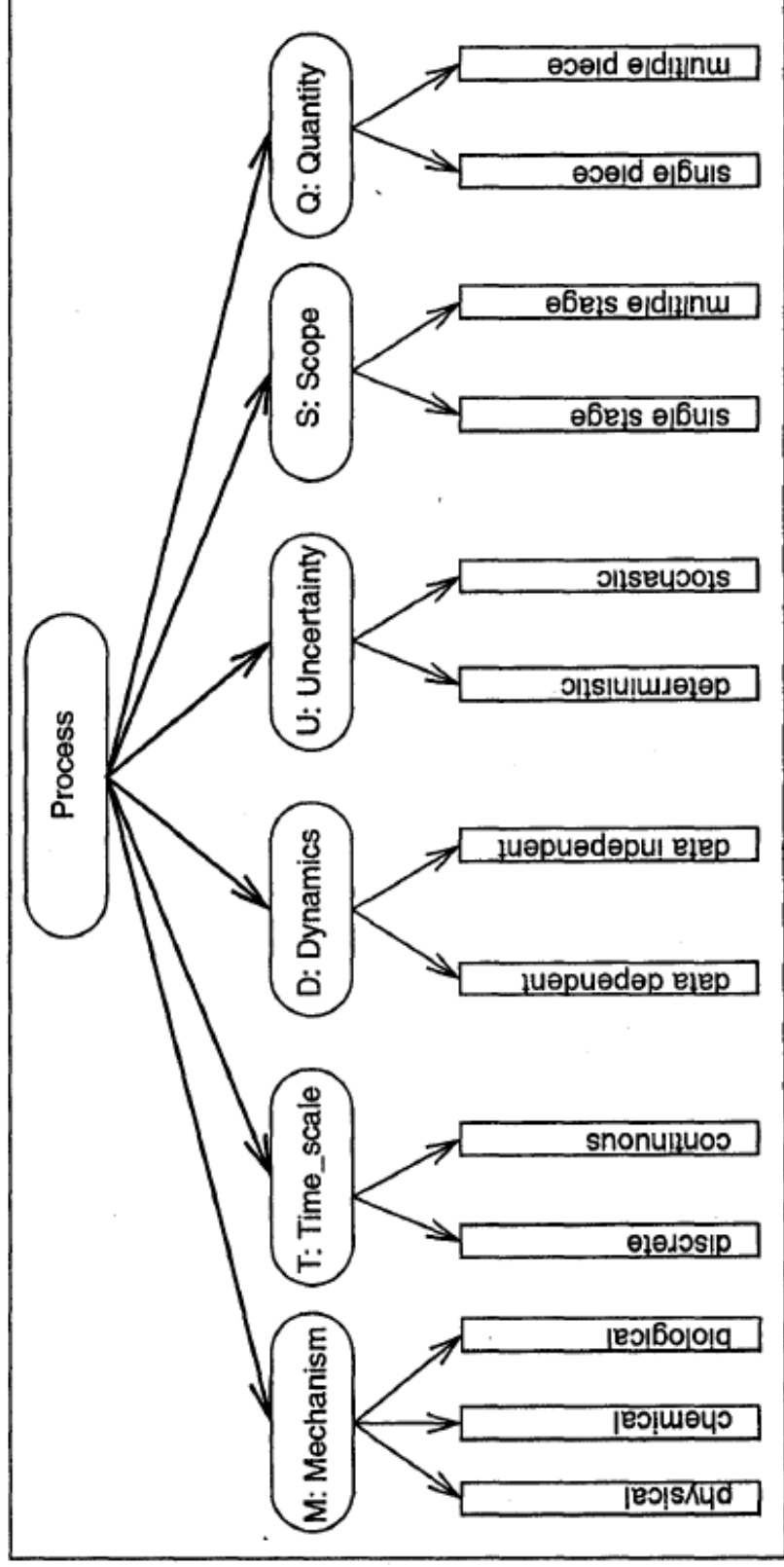
Modeling

- ❖ The modeling step seeks to relate the inputs and outputs of a system. This step is complicated because of the variety of tools and methods that exist.
- ❖ 1st approach – first principles
- ❖ 2nd approach – work with data

Process Structure

- ❖ Given the variety in modeling tools and methods, some organizing structure is needed.
- ❖ Based on common characteristics, an appropriate classification system for processes may help decision-makers understand the nature of a process

Process Classification System



Xue, Filipovic, Pandit and Sutherland, 2000

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Classification Criteria

❖ Mechanism

- ❑ Different processes rely on different mechanisms

❖ Time-scale

- ❑ Processes can be viewed as operating discretely or continuously based on the interests of the modeler

❖ Dynamics

- ❑ Static vs. dynamic

Classification Criteria

❖ Uncertainty

- ❑ Deterministic vs. stochastic

❖ Scope

- ❑ How much do we wish to describe
- ❑ Single vs. multi-stage system

❖ Quantity (duration)

- ❑ Long term – many outcomes
- ❑ Short term – single outcome

Criteria

- ❖ Most of the criteria – adopt some perspective. Perspective ultimately impacts type of models developed.
- ❖ Remember: viewpoint of modeler is subjective since processes/ systems tend to lie somewhere in between endpoints associated with each criterion.

Modeling Methods

❖ Modeling methods for processes can be broken down into two categories:

- ❑ Analytical
- ❑ Data-based (empirical)

Analytical Models

- ❖ They are developed based on natural laws (e.g., physics and chemistry).
- ❖ To develop an AM requires a fundamental understanding of the underlying mechanisms in the process
- ❖ Model forms: algebraic eqs., differential eqs., difference eqs., etc.

Time-Scale Criterion

- ❖ It should be noted that data are almost always collected discretely (i.e., sampled data), leading to models of discrete form.
- ❖ If desired, and appropriate, these models can be converted into continuous time form.

Quantity Criterion

- ❖ It is noted that some situations may require additional variables/dimensionality – handled by:
 - ❑ Ignoring the additional dimensions
 - ❑ Applying statistical methods
 - ❑ Accounting for the added dimensions in the model

Uncertainty Criterion

❖ When a high level of uncertainty is present, model fitting methods must be employed to synch the models to the data

❑ Least squares

Which criteria are left?

❖ Dynamics

- ❑ Static
- ❑ Dynamic

❖ Scope

- ❑ Process
- ❑ System description

❖ So, 4 possible combinations and 4 principal model forms emerge

1. Simple Function Model

- ❖ Static/single-stage.
- ❖ This model relates its output to a set of inputs through a function f
 - $Y = f(x_1, x_2, \dots, x_m; b_1, b_2, \dots, b_n)$
- ❖ A special case of the SFM is the input-output model
 - $Y = B_0 + BX$

2. Time Dependent Function Model

- ❖ Dynamic/single-stage process.
- ❖ Relates current value of response to past values of the response and process inputs.
- ❖ For continuous systems – differential eqs. to describe behavior; with focus on data-driven models, a difference equation model form is adopted:

$$\square Y_k = g(Y_{k-1}, Y_{k-2}, \dots, Y_{k-n}; X_{1,k}, \dots, X_{i,k-n}; \Phi_j)$$

$$\square M_k = 1.01M_{k-1} + D_k$$

2. Time Dependent Function Model

❖ Models are often developed based on historical input and output data from a process (time series). For such cases, uncertainty is generally a consideration and least squares methods are typically employed to estimate the model parameters

3. Discrete Event Simulation Model

- ❖ For a static/multi-stage situation several interconnected processes are considered
- ❖ Modeling emphasis placed on behavior of system, rather than on details associated with individual processes.
- ❖ The processes can be viewed as discrete events.

- ❑ SLAM

- ❑ Monte Carlo

4. Continuous System Simulation Model

- ❖ Useful for describing systems in which interest is placed on both time behavior of individual process and system itself
- ❖ State of the system – represented by variables that change over time.
- ❖ Constructed by developing equations for a set of state variables whose dynamic behavior simulates the real system.

- ❑ ACSL
- ❑ Matlab/Simulink

ServiceModel

❖ **ServiceModel**: simulation software for evaluating, planning, or designing service systems. Computer-based model of system – test variety of scenarios to find the best. Animation & graphical outputs for visualizing and understanding system behavior.

❑ **Typical applications of ServiceModel include:**

- Financial Services
- Logistics
- Business Reengineering