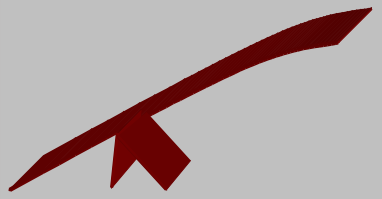
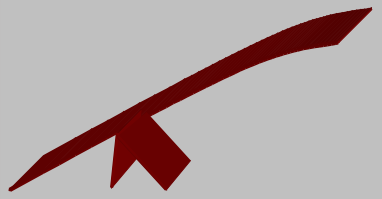


Engineering Systems Thinking



Systems Thinking

- Systems Thinking is a discipline for seeing the whole
- Systems Thinking is a framework for seeing interrelationships and repeated events rather than things
- Systems Thinking is seeing patterns of change rather than static snapshots
- Systems Thinking embodies the idea that the interrelationships among parts relative to a common purpose of a system are what is important

The Fifth Discipline

- According to Peter Senge, systems thinking is the fifth discipline "and is the catalyst and cornerstone of the learning organization that enables success through the other four disciplines":
  - Personal mastery through proficiency and commitment to lifelong learning
  - Shared mental models of the organization's markets and competitors
  - Shared vision for the future of the organization
  - Team learning

Peter Senge, The Fifth Discipline: The Art and Practice of the Learning Organization, Doubleday, New York, 1990

Laws of the Fifth Discipline

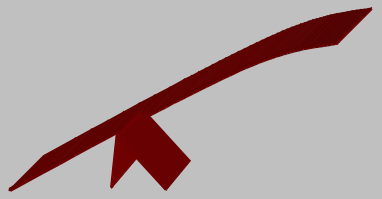
- Contemporary and future problems often come about because of what were presumed to be past solutions
- For every action, there is a reaction
- Short-term improvements often lead to long-term difficulties
- The easy solution may be no solution at all
- The solution may be worse than the problem
- Quick solutions, especially at the level of symptoms, often lead to more problems than existed initially

Laws of the Fifth Discipline - 2

- Cause and effect are not necessarily closely related, either in time or in space
  - Sometimes solutions implemented here and now will have impacts far away at a much later time
- The actions that will produce the most effective results are not necessarily obvious at first glance
- Low cost and high effectiveness do not have to be subject to compensatory trade-offs over all time

Laws of the Fifth Discipline - 3

- The entirety of an issue is often more than the simple aggregation of the components of the issue
- The entire system, comprised of the organization and its environment, must be considered together



Laws of Engineering Systems Thinking

- In all of the project's phases/stages, and along the system's life, the systems engineer has to take into account:
  - The customer's organization vision, goals, and tasks
  - The customer's requirements and preferences
  - The problem to be solved by the system and the customer's needs
- The whole has to be seen as well as the interaction between the system's elements
  - Iterative or recursive thinking must replace the traditional linear thinking

Laws of Engineering Systems Thinking - 2

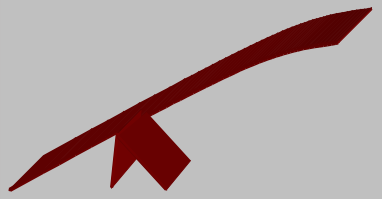
- Consider that every action also could have implications in another place or at another time
- One should always look for the synergy and the relative advantages from the integration of sub-systems
- The solution is not always an engineering one – remember to always take into account
  - Business and economic costs
  - Reuse or utilization of products and infrastructure already developed
  - Organizational, managerial, political, and personal considerations

Laws of Engineering Systems Thinking - 3

- The systems engineer should consider as many different perspectives as possible
- Always take into account:
  - Electrical considerations
  - Mechanical considerations
  - Optical considerations
  - Manufacturing considerations
  - Environmental considerations
  - Quality assurance considerations
  - Quality factors such as reliability, availability, maintainability, expandability, testability

Laws of Engineering Systems Thinking - 4

- Evaluate future logistic requirements in all development phases
  - Spare parts
  - Maintenance infrastructure
  - Support
  - Service
  - Maintenance levels
  - Technical documentation



Laws of Engineering Systems Thinking - 5

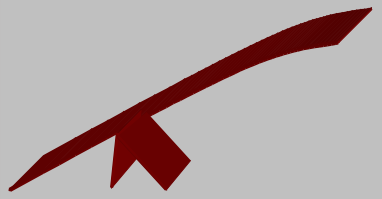
- When a need arises to carry out a modification to the system always take into account:
  - The engineering and non-engineering implications
  - The effects on the form, fit, and function
  - The system's response to the changes
  - The needs, difficulties, and attitudes of those who must live with the modification
- Each problem may have more than one possible working solution
  - All possible alternatives should be examined and compared to each other by quantitative and qualitative measurements

Laws of Engineering Systems Thinking - 6

- Engineering design is not necessarily maximal
  - At every stage, engineering trade-offs and cost-effectiveness should be considered
- In case of a system's failure, repeated structures and patterns should be looked for and analyzed
- Look for the changes that might introduce significant improvements by minimum effort
- Pay attention to and take into account slow or gradual processes

Laws of Engineering Systems Thinking - 7

- Avoid adapting a known solution for the current problem – it might not be suitable
- Take into account development risks
- It is impossible to run a project without:
  - Control
  - Configuration management
  - Milestones
  - Management
  - Scheduling methods

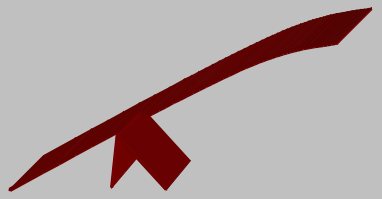


Laws of Engineering Systems Thinking - 8

- The end user must be considered as a major part of the system
  - At each stage the human element must be considered
- The engineering design is a top-down design for which the bottom-up approach is preferable
- Integration and tests are bottom-up
- At every stage, systematic design considerations should be used
- Engineering systems thinking requires the use of simulations

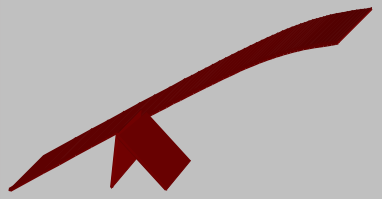
Laws of Engineering Systems Thinking - 9

- Engineering systems thinking requires the integration of expertise from different disciplines
- Engineering systems thinking, by its very nature, requires the examination of different perspectives, calling for teamwork to cover those perspectives
- Try to anticipate the future at every stage
  - The life expectancy of a system could end after 10 years or less



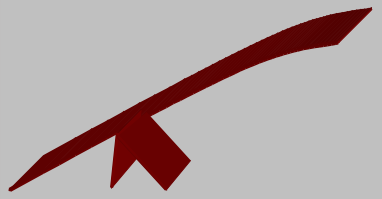
Laws of Engineering Systems Thinking - 10

- Selecting partners and subcontractors will be critical – do not enter into a partnership unless the partner is willing to share your risks as well as your successes and profits
- Make sure that the selection of a software development tool is usable and supportable or changeable throughout the life of the system
- When selecting components for production, take the shelf life into account
- Do not reduce the development price in a tender offer if there is no guarantee of the serial production budgets



Laws of Engineering Systems Thinking - 11

- Always examine the external threats against the system
  - Electromagnetic interference
  - Environmental conditions
- Engineering systems thinking includes probability and statistics both when defining the systems specifications and when determining the project targets such as cost and performance
- Limit the responsibility assigned to an external factor since this increases the dependency on it



Summary

- One of the most prominent problems observed in software and software / systems organizations today is the lack of engineering discipline - cited by managers at all levels
- The CMM was developed to encourage organizations to develop processes to guide its software development
- The CMMI integrated Software CMM and Systems Engineering CMM and put the "engineering" back into process
- Engineering Systems Thinking has again been recognized as an important asset for building systems