Principles of Sociology in Systems Engineering

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Outline

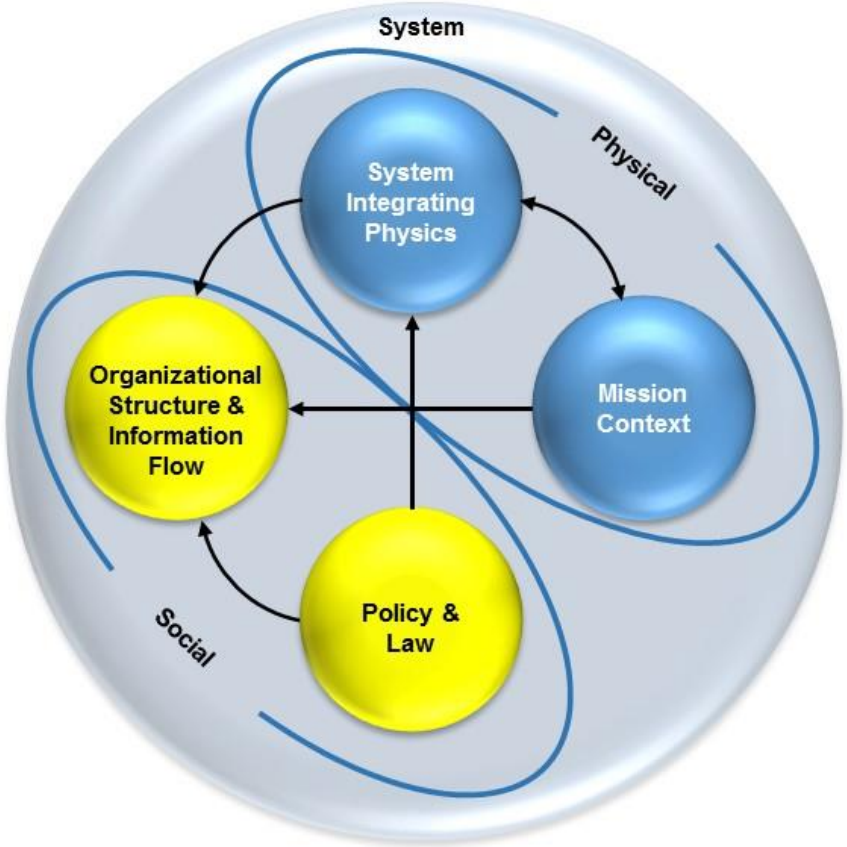
- **Understanding Systems Engineering**
  - Framework
  - Definition
- **Sociological Concepts in Systems Engineering**
- **Conclusion**

Understanding Systems Engineering

- **Definition – System Engineering is the engineering discipline which integrates the system functions, system environment, and the engineering disciplines necessary to produce and/or operate an elegant system.**
  - Elegant System - A system that is robust in application, fully meeting specified and adumbrated intent, is well structured, and is graceful in operation.

Primary Focus

- System Design and Integration
  - Identify system couplings and interactions
  - Identify system uncertainties and sensitivities
  - Identify emergent properties
  - Manage the effectiveness of the system
- Engineering Discipline Integration
  - Manage flow of information for system development and/or operations
  - Maintain system activities within budget and schedule



Supporting Activities

- Process application and execution

Sociological Concepts in Systems Engineering

- **Opportunity Structures**
  - Provide opportunity to mature ideas
    - Task teams, working groups, communities of practice, etc.
- **Social Role Sets**
  - Individuals have a set of roles for their position
- **Consistent use of Terminology is important for Communication within the Organization**
- **Specification of Ignorance is important in the advancement of the understanding of the system**
- **Socially Expected Durations will exist about the project**
- **Both Manifest and Latent Social Functions exist in the organization**
- **Social Adaptation**
  - Helps to avoid putting people in to social dysfunction or complete social anomie
    - Conformity
    - Innovation
    - Ritualism
    - Retreatism
    - Rebellion
- **Cultural Subsets will form**
  - i.e., disciplines can be a subset within the organization
  - Insider and Outsider attitudes can form
    - Be Aware of the Self-Fulfilling Prophecy, Social Polarization
- **Reconsiderations Process (i.e., Reclama Process)**
  - Provides ability to manage social ambivalence
  - Must be able to recognize social beliefs that may be contributing to the disagreement

Opportunity Structures

- **Pathways within the organization that support the accomplishment of social goals**
  - Important for success in meeting objectives of the organization
    - Successful design
    - Efficient decision making
    - Making schedule
    - Staying within budget
  - Systems Engineering
    - Ensure pathways exist at the system level for success of the system development or system operations
      - Address recognized barriers to success or difficult pathways with line and project management
      - Focus on information flow through the organization, not personnel or project issues
    - Provide opportunity to vet new ideas or alternative approaches
      - Informal discussions and meeting forums
      - Board structures are NOT vetting forums
        - » They are filtering forums, down selecting all possible options to a single approach
        - » Vetting must occur before initiating formal meeting processes

Role-Sets

- **A Role-Set is a set of roles that individuals have within the organization.**
- **Potential Systems Engineering Roles include**
  - System Expert
    - In system interactions, system function, system operations, etc.
  - System Analyst
  - Discipline Integrator
  - Team Leader
    - Study teams, task teams, etc.
  - Advisor
    - To project manager and chief engineer
  - Employee
    - To line management
- **Role-Sets are not different roles conducted by one individual but a set of roles that an individual has in different settings**
  - Systems Engineer is always a system expert even when meeting with line management as an employee

System Terminology

- **Terminology is important for clear flow of information through the organization**
  - Each engineering discipline has a specific set of terminology
    - What does ω represent?
  - Focus is on translating discipline terminology, not trying to change it

- **System Engineering should have a consistent terminology**
  - What is a component?

- **Mathematics provides a common language construct between disciplines and facilitates information flow through the organization**
  - Codifies meaning of certain representations
  - Provides basis for translation of terminology between different engineering disciplines

Specification of Ignorance

- **All great scientific discoveries were made be first acknowledging what is not understood or known, i.e., specifying ignorance about a phenomena**
  - "the express recognition of what is not yet known but needs to be known to lay the foundation for still more knowledge" (Merton, 1996, pp. 51-56)
  - We must recognize what is not known about the system behavior, performance, schedule, budget in order to look for solutions that satisfy the intent for the system
  - Fosters system analysis as a key element of system engineering in understanding the sensitivities and uncertainties about the system
  - Fosters search for unknown unknowns
  - The organization will not spend effort on system characteristics it believes to be understood

Socially Expected Durations

- **People within the organization have expectations on the duration of a given project or task**
- **Structural or institutionally defined (socially prescribed) expectations**
  - Formal system schedules and timelines
- **Collectively expected**
  - Socially defined expectations about the time the activity or task should take
  - Difficult to write down and generally not written down
  - Exists within the social structure, not in project documentation and schedules
  - Can vary among different engineering disciplines within the organization
  - Issues arises when there are large disconnects with what is socially expected and what is structurally defined
    - Systems Engineer must be aware of these disconnects as they indicate problems with the project schedule or problems with the organization understanding how the project schedule is intended to be achieved
- **Patterned temporal expectations**
  - Experienced based
  - Contracting, business processes, reorganizations, etc.
- **Drives behavior within the organization**

Cultural Subsets and Manifest and Latent Social Functions

- **Cultural Subsets**
  - Each engineering and project discipline as a unique culture
    - Based on 100's of years of history in their discipline and translated through academic instruction
- **Manifest and Latent Social Functions**
  - Manifest Social Functions
    - Are "objective consequences contributing to the adjustment or adaptation of the social system which are intended and recognized by participants in the social system" (Merton, 1996, pp. 87-95).
      - Project Norms, Organizational Norms
  - Latent Social Functions
    - Are "those [social functions] which are neither intended nor recognized." (Merton, 1996, pp. 87-95)
      - Organizational bias against a solution or approach may be of this form

Social Adaptation

- **Conformity**
  - People generally try to conform to the social system
- **Innovation**
  - Conflicts within the social structure can lead to innovations seeking new paths, new opportunity structures, within the system
  - Going out of board, skipping a level of management, etc.
- **Ritualism**
  - Conflicts within the social structure leading to disinterest resulting in ritualistic behavior (just doing what I have always done regardless of project goals)
- **Retreatism**
  - Conflicts within the social structure leading disengagement with the project.
  - Conflict should be addressed within project structure. Individual may also be better suited in another project or task.
- **Rebellion**
  - Conflicts within the social structure leading to rebellious actions. Intentional disruption of project activities or data.
  - Disgruntled employee

Social Ambivalence

- **"Inherent in the social position"**
  - Government employee relationships with contractors
    - government ethics demands disinterest while social etiquette requires personal interest.
- **"A conflict of interests or values"**
  - Matrix organizations can have this where the norms of the matrix organization conflict with those of the line organization
    - Matrix organization keeps information within the matrix while line organization values openness
- **"Conflict between roles associated with a particular" position**
  - Conflict between the disciplines culture and the project culture
- **"Contradictory cultural values"**
  - Emphasis on high reliability can conflict with emphasis on innovation
- **"The disjunction between culturally prescribed aspirations and socially structured avenues for realizing these aspirations"**
  - Disjointed opportunity structure. For example a quick change to the design is necessary for success but the decision structure does not allow a quick decision
- **That which "develops among people who have lived in two or more societies and so have become oriented to differing set of cultural values"**
  - Social values in current project which conflict with values in past projects that lead to success

Social Dysfunctions, Social Anomie, and Reclama Path

- **Social Dysfunctions result in instability of the organization or project structure**
  - Important to identify and address with project and line management
  - Innovative approaches, changing traditional approaches can be disruptive to the social structure of the organization and lead to resistance
    - Some organizations will fail rather than change

- **Social Anomie**
  - When a person drops out of the social system within the organization completely
  - Leads to rebellious behavior; criminal activity
  - Disgruntled employee can lead to this

- **Reclama Path**
  - Essential for the project
  - Provides a pathway for people in socially ambivalent situations to resolve the contradictions
  - Must be separate from project culture to recognize cultural bias in the project response and provide an impartial review of the situation
  - Mitigates system failure paths that are otherwise not recognized or addressed

Social Groups and Self-Fulfilling Prophecy

- **Social Groups**
  - Social groups will form within the project
  - Discipline cultures already exist
  - Information about the system resides in the social structure not just in the design documentation and models
    - This knowledge is passed through mentoring and experience within the culture
  - These different cultures can be a source of conflicts
    - Terminology, emphasis or approach basis
- **Social Polarization**
  - Needs to be avoided within the organization
  - Leads to challenging motives rather than technical discussions
- **Self-Fulfilling Prophecy**
  - A biased view of a group or groups
  - Not matter what a group does, it is always interpreted as fulfilling the belief that another group has about it
    - Not rationale, no technical basis
- **Systems Engineering should work with line management and project management to resolve these information flow barriers**

Unintended Consequences

- **Unintended Consequences are the result of human mistakes.**
  - Physics do not fail, we do not recognize the consequences.

- **Based on sociology, followed the work of Robert K. Merton in classifying unintended consequences.**
  - "The Unanticipated Consequences of Social Action", 1936

- **Classification**
  - Ignorance (limited knowledge of the problem)
  - Historical Precedent (confirmation bias)
  - Error (mistakes in calculations, working from habit)
  - Short Sightedness (imperious immediacy of interest, focusing on near term and ignoring long term consequences)
  - Cultural Values (cultural bias in what can and cannot happen)
  - Self Defeating Prophecy (by stating the hypothesis you induce a set of conditions that prevent the hypothesis outcome)

Conclusion

- **Systems Engineering has a focus to integrate the various system disciplines to develop or operate the system**
  - Each discipline has a unique culture
- **The principles of sociology are necessary tools to help the systems engineer integrate the disciplines**
- **Discussed the key aspects of the principles of sociology related to systems engineering**