PRACTICAL APPLICATION OF SOCIOLOGY IN SYSTEMS ENGINEERING

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Outline

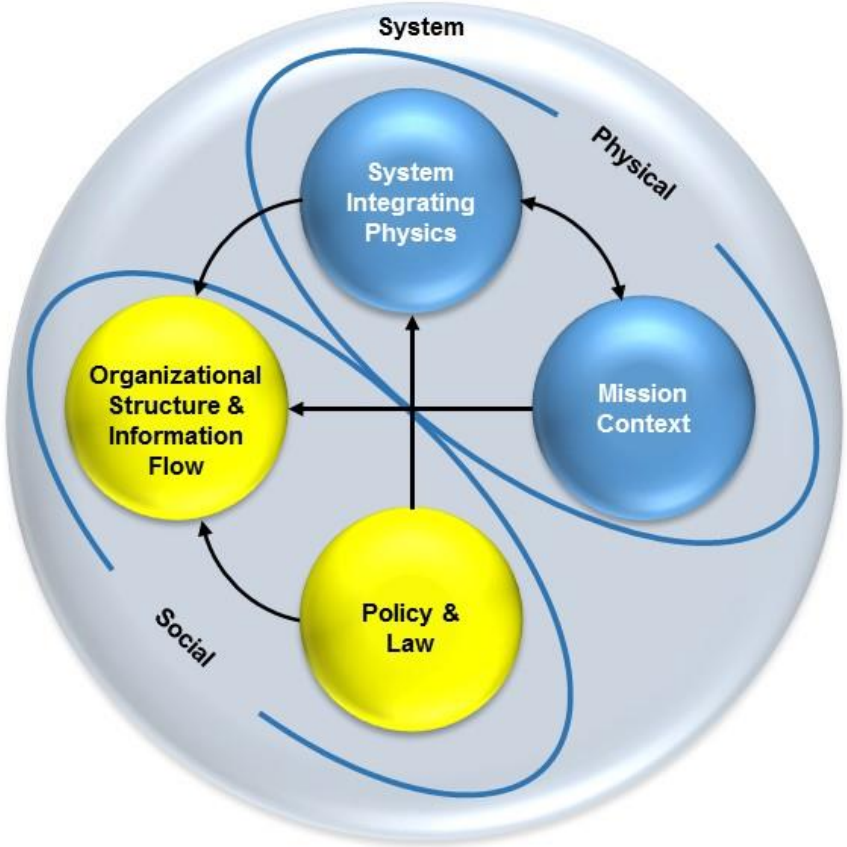
- **Understanding Systems Engineering**
  - Framework
  - Definition
- **Sociological Concepts in Systems Engineering**
- **Conclusion**

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

- **Specification of Ignorance is important in the advancement of the understanding of the system**
- **Socially Expected Durations will exist about the project**
- **Consistent use of Terminology is important for Communication within the Organization**
- **Opportunity Structures**
  - Provide opportunity to mature ideas
    - Task teams, working groups, communities of practice, etc.
- **Organizational Culture and Cultural Subsets**
  - 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
- **Accumulation of Advantage and Disadvantage**
- **Social Adaptation, Ambivalence, and Dysfunction**
- **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

Specification of Ignorance

- **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**
  - System Analysis and Test
    - Forms a basis for the areas of investigation, analysis, and test that should occur in order to learn what is presently not known.
  - System Risks
    - Strong driver to the specification of system risks where uncertainties are specified and dealt with. Risk definition starts with the specification of ignorance on a subject(s).
  - System Sensitivities and Uncertainties
    - System performance
    - System margins
    - System sensitivities
    - System environments
    - System interactions
- **Organizational bias can be found in areas where the organization believes there are no unknowns without mathematical basis**

Socially Expected Durations and Terminology

- **People within the organization have expectations on the duration of a given project or task**
  - Unease results when events are longer or shorter than social expectation
    - Systems Engineer needs to recognize the disconnect indicating
      - Problems with project schedule (e.g., overly optimistic)
      - Lack of understanding in the organization on new approaches which change schedule basis
    - System Engineer should address any schedule issues and provide rationale and explanation of new approaches affecting the schedule
      - Planned renegotiation process where the social structure is adjusted to new approaches
        - » Incremental process rather than singular response
- **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
    - Discipline terminology is good and useful within the discipline (maintains consistency, continuity in the discipline)
    - Consider external stakeholders understanding when translating terminology for up and out communication

Opportunity Structures

- **Pathways within the organization that support the accomplishment of social goals**
  - Provide opportunity to vet new ideas or alternative approaches in a peer review forum
    - Informal discussions and meeting forums
      - Informal working groups
      - Task teams
      - Communities of Practice
      - Design team meetings
        - » Integrated Product Teams do this well
    - Can have meeting topic and an agenda, but not decision making meeting
      - Developing a recommendation can be an objective
      - Maturing several ideas can also be an objective
    - Agile Systems Engineering and Agile Software Development do this well
    - Forums where all different viewpoints are invited and encouraged to participate in the discussion
      - Diverse opinions are important to solid vetting
      - Segmented meetings (one meeting per approach) are not good vetting 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
  - Work with line and project management to encourage vetting forms at the system level and for each of the disciplines

Organizational Culture

- **Cultural Lenses**
  - Individual
    - Roles and Role-Sets within the organization on an individual basis
  - Group
    - Languages (technical) and statuses (e.g., criteria for SME designation)
  - Organizational
    - Organizational structure (the organization chart) and culture
- **Culture defines beliefs, assumptions, and behavioral expectations**
  - Difficult for an individual to change (source of social ambivalence)
- **Two basic types of organizational culture**
  - Anticipative
    - Looks for what may happen and how to respond
  - Resilient
    - Stable and unmoving to change
  - Important for systems engineer to understand
    - Asking a resilient organization to change is very challenging and may not be possible
    - Asking an anticipative organization to be stable is very challenging and may not be possible
- **Organizational culture can drift over time**
  - Normalization of Deviance
    - Accepting of anomalies as normal behavior
    - Large system risk

Organizational Culture (continued)

- **Middle management is the keeper of organizational culture**
  - First and second level line management
  - Chief Engineers
  - Discipline Lead Engineers
  - Project Subsystem Managers
- **Middle Management is important to advocate adoption of new ideas and approaches**
  - Will drive for the change if supportive of the new idea or approach
  - Will stop the change if not supportive of the new idea or approach
- **Systems Engineer should be attentive to small problems indicating issues in the complex organizational social system**
  - Indicators of perhaps larger social issues within the organization
  - Attempting to simplify or abstract the social structure leads to a lack of understanding of the social interactions and hindrances to information flow
  - Root cause is both localize and systemic
    - Both aspects exist and need to be addressed in the organizational system

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
  - These are normal and good aspects of the organization in general
  - Can have specific issues in a given context that may need to be addressed with line management and project management
- **Insider Outsider Behavior**
  - This is a significant information flow barrier
  - Occurs when one group believes their perspective can only be understood by people within their social group (i.e., discipline) – Insiders
    - Has 'private' information not shared about the system since others are not believed to be capable to understand it properly
  - All other groups are viewed as Outsiders
- **Biased Information Sharing**
  - Is a conservative approach to sharing of 'margin' in the system
  - Information is slowly shared as group becomes comfortable that they will not suffer loss by sharing

Cultural Subsets (continued) and Accumulation of Advantage and Disadvantage

- Policy shifts
  - Project policy can be shifted to the disciplines policy
    - Subtle
    - Can lead to information distortion
- Groupthink
  - Individual seek psychological safety and do not share dissenting opinions
  - Can lead to information distortion and errors in system development or operation
  - Hidden information exists within the Groupthink context

- **Accumulation of Advantage and Disadvantage**
  - The assigning of more tasks to successful groups and less tasks to less successful groups
  - Leads to an imbalance in work load
    - Impact to system schedule and budget
  - System Engineer should ensure a balance exists within the organization
    - Address imbalances with project management and line management
    - Organizational units which are highly successful should not be over subscribed
    - Organizational units which are less effective should be provided necessary skills, training, experience, leadership to improve

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 Ambivalence and the "Pinch"

- **Individuals facing a social structure conflict where an expectation to succeed is blocked by the social structure are in a "pinch"**
  - Increased tension in meetings and discussions on how to proceed with a need in the system development.
  - Stress levels become visible as the pinch increases.
  - Sources of this anxiety based stress include
    - Impression that freedom to pursue a course of action has been restricted,
    - Responsibility has been removed or replaced,
    - Resources are reallocated between groups,
    - System needs, goals, and objectives (NGO) are shifting which change the importance of certain approaches or disciplines
  - Planned renegotiation is effective in addressing these social conflicts
    - Find and agree to alternative paths or goals for the task
      - Maintain the success of the system as an outcome
    - This is an organizational approach
      - Needs line management and project management support
  - System Engineer must be cognizant of these situations and ensure they are being addressed by line and project management
    - Significantly affect information flow through the organization

Social Dysfunctions 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

- **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

Conclusion

- **Systems Engineering has a focus to integrate the various system disciplines to develop or operate the system**
  - Each discipline has a unique culture
- **Sociology provides necessary tools to help the systems engineer integrate the disciplines**
- **Discussed the key aspects of the practice of sociology in systems engineering**