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PRACTICAL APPLICATION OF SOCIOLOGY IN SYSTEMS ENGINEERING

Michael D. Watson, Ph.D.*
James G. Andrews, Ph.D.
Jeri Cassel Eckley
NASA Marshall Space Flight Center

Michael L. Culver
Aetos Systems Inc

***michael.d.watson@nasa.gov**

Abstract
Systems engineering involves both the integration of the system and the integration of the disciplines which develop and operate the system. Integrating the disciplines is a sociological effort to bring together different groups, who often have different terminology, to achieve a common goal, the system. The focus for the systems engineer is information flow through the organization, between the disciplines, to ensure the system is developed and operated will all relevant information informing system decisions. The practical application of the sociology in systems engineering brings in various organizational development concepts including the principles of planned renegotiation and the application of principles to address information barriers created by organizational culture. Concepts such as specification of ignorance, consistent terminology, opportunity structures, role-sets, and the reclama (reconsideration) process are all important sociological approaches that help address the organizational social structure (culture). In bringing the disciplines together, the systems engineer must also be wary of social ambivalence, social anomie, social dysfunction, and insider-outsider behavior. Unintended consequences can result when these social issues are present. These issues can occur when localized subcultures shift from the overarching organizational culture, or when the organizational culture prevents achievement of system goals. These sociological principles provide the systems engineer with key approaches to manage the information flow through the organization as the disciplines are integrated and share their information and provides key sociological barriers to information flow through the organization. This paper will discuss the practical application of sociological principles to systems engineering.

Keywords
Systems engineering, system integration, discipline integration, specification of ignorance, social ambivalence, social anomie, social dysfunction, insider-outsider behavior, organizational culture

Introduction
Discipline Integration is a critical activity of the systems engineer. Information about the system resides in the organization, and information about the system can be filtered or changed as information passes between disciplines. This brings into play several practices from sociology.

The organization is an integration of the disciplines which develop, manufacture, and operate the system. The organization itself is a complex system, which is put in place to develop a complex system. Systems engineering is focused on the development of elegant systems. Elegant systems are robust in application, fully meeting specified and adumbrated intent, are well structured, and are graceful in operation. The relationship between the system being developed and the organization is a key factor in system elegance that results from the development process and the execution of the manufacturing and operations of the system. Because of these relationships, the systems engineer has a special interest in the organizational structure and relationships.

The organizational structure and relationships are primarily the responsibility of the line organization and the program manager. They establish and manage the various disciplines or branches within the organization. These relationships form the medium through which the system information flows during the development and operation of the system and are vital to the success of the system. The systems engineer must recognize and understand the

information flow that occurs through the organization to ensure an elegant system development and operation. The systems engineer should work closely with the program or project manager ensuring the organizational structure is properly understood, blind spots and information choke points identified, and efficient forms of program organization within the line organization (e.g., design team structure, co-location, intra-organization communication, decision board structure) are considered. The systems engineer, taking into account how information flows through the organization, should recommend an efficient organizational structure and decision board structure to the program or project manager.

Difficulties and inefficiencies within the organization information flow and the board structure change flow can result in unintended consequences. Mitigation of these unintended consequences starts with a complete understanding of the organization structure and information flow.

The application of sociological principles is a key aspect of systems engineering who integrate various discipline activities and information to produce elegant systems. The application of these principles to systems engineering are discussed in this paper.

Systems Engineering of Elegant Systems: Discipline Integration

Integrating the disciplines through the organizational structure and ensuring clear and complete communication between the disciplines brings in several aspects of sociology, organizational theory, information theory, and cognitive science. The applications for each of these is typically different between development organizations and operational organizations. This section discusses the integration of the disciplines in both the development and operations life cycle phases.

Engineering an Elegant Organization during Development

Development organizations are intended to generate specific design information, coordinate the information with other disciplines within the organization, and integrate it into an elegant system.

Sociology provides many functions that exist within the organization. Opportunity structures provide an opportunity for the disciplines to mature their ideas and resolve questions and unexpected responses prior to carrying these through the decision board process. The systems engineer provides for these in the organizational structure and information flow process through the formation of informal status meetings, task teams, working groups, communities of practice, etc. as appropriate for the organizational culture and specific system development.

The decision-making process uses these opportunity structures. Different opportunity structures can be used for different decisions. The key is in having the correct knowledge involved in the informal and formal decision making so that a quality decision is made. Information theory shows the importance of proper knowledge in order to make a decision on a specific subject or question. Information theory also provides important guidance in the establishment of decision boards, the membership of these boards, and the relationship of delegated boards. The key is to establish a system that allows information to flow through the decision-making process with minimal uncertainty of the topics, discussions, and results in the organization.

Reconsideration paths are a key sociological mitigation for those within the organization who encounter a social ambivalence on a specific system decision or topic. These boards should not be made up of participants in the development organizational culture, but the board members should be able to discern the sociological as well as the technical forces contributing to the perceived conflict in the system. This helps mitigate social responses that can lead to system design activities or decisions moving outside the organizational structure or attempting to bypass certain decision-making steps.

The systems engineer should be aware that information may reside in the organization, but be unidentifiable in the design. A design that does not close may be due to margin in the design but only identifiable by a discipline. Before action is taken to significantly change the system, the systems engineer should engage in un-biased information sharing with the affected disciplines to determine if there are factors (e.g., margin) which the discipline organization can change to support an improved design. The basic approach is to ask questions about conservative estimates, uncertainty margins, and actual factors of safety that may indicate design margin not otherwise identified. This may be an iterative negotiation process where disciplines slowly release margins as their confidence in the system design grows (Austin-Breneman, Yu, & Yang, 2014; Austin-Breneman, Yu, & Yang, 2015; Austin-Breneman, Yu, & Yang, 2015).

Engineering an Elegant Organization during Operations

Operations organizations are intended to coordinate specific actions about a system based on a *detailed understanding* of the system's behaviors and responses defined during the system development. The discipline integration approaches are similar to those discussed with development organizations.

These operational organizations take many forms. Customer service operations organizations need the ability to matrix into the engineering teams for defined questions or issues. High reliability organizations (such as those encountered in electrical plant operations, ship crews, or spacecraft operations teams) can have a more hierarchical structure which flattens during critical operations events to address high *risk factors* in a timely and successful manner. Systems engineering must recognize the organizational constructs, how the engineering team integrates with these operations organizations, and how to ensure the correct *information flows* to the operations teams.

Sociological Principles in Practice

Sociology provides the basis for many important activities and organizational structures in a system development or operations organization. The systems engineer works in concert with both project management and line management. The systems engineers focus is on the coherent flow of information through the organization. Sociological factors play a large role in information flow and can lead to information flow gaps, barriers, or short circuits through or around the organization. The systems engineering must be aware of the sociological factors in order to ensure the information needed for the system development and operations is in the system design or operational procedures and approaches.

Specification of Ignorance

Developers and operators need to understand what they do not know. The specification of ignorance is a social process where one is acknowledging not everything is understood. This forms a basis for the areas of investigation, analysis, and test that should occur in order to learn what is presently not known. This is also a 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).

Systems engineers should identify what the unknowns are about the system. This can come in a variety of forms including system performance, system margins, system sensitivities, system environments, system interactions, etc. This provides important guidance for system analysis, discipline analysis, and development testing to determine the unknown system characteristics. The systems engineer should also be aware of sociological bias that lead to statements that there are no unknowns. This can lead to serious unintended consequences in system capabilities, schedule, and budget.

Socially Expected Durations

The participants in the system development or operation will have an expectation for how long an activity should endure. When these expectations are not met, unease can develop in the organization which can lead to social ambivalence. The systems engineer must recognize what the socially expected durations are for the various system activities. Where new approaches, methods, or structures (e.g., reorganization or realignments) are applied in the organization, it is important that these changes are explained and rationale provided to form a basis to change the expectation and mitigate unease developing in the organization. Project managers, organizational line managers, or chief engineers can help in explaining the changes to the organization.

The systems engineer should ensure that the appropriate authority (project management, line management, chief engineer, systems engineer) explain the rationale and what their new expectations for project duration will be. This is a form of planned renegotiation (Sherwood, J.J., & Glidewell, J.C., 1975) that provides for adjustments in the social structure of the project and avoiding potential causes of social ambivalence. Specifically, changing schedules can produce pressure on individuals in the organization which lead to ambivalent situations; situations where assigned goals appear to be blocked or unattainable in the new time schedule provided (either shorter or longer).

Consistent Terminology

The systems engineer has to understand all of the contributing disciplines to the system development or operation. It is important, at the system level, to use consistent terminology to aid in clear communication.

The systems engineer is not responsible for changing discipline terminology but translating terminology to ensure communication is clear and consistent. Discipline specific terminology is good and useful within the discipline and should not be discouraged. Communication between disciplines and at the system level should use consistent terminology. This can be derived from discipline terms, especially when more than one discipline uses and understands the term in the same way. Creation of new terms is not the goal; translation of terms is the goal. This will be strongly driven by the type of system being developed or operated. Communication with external groups such as stakeholders, corporate management, and government agency leadership should also be taken into account when translating and establishing a consistent terminology.

Opportunity Structures

Opportunity structures are crucial to the successful development and operation of an elegant system. Opportunity structures provide a peer review forum to express, explore, and vet new ideas and approaches in the system development or operation. A key characteristic of these structures is that they are not decision-making structures. Formal decision-making structures such as decision boards are not opportunity structures and are not intended for introduction of new ideas in the midst of a decision. These formal structures depend on the exploration of ideas occurring in opportunity structures before a decision is brought to the decision-making body.

Opportunity structures can have many forms. Communities of Practice (CoP) provide an excellent manner for practitioners to share new ideas and perspective, gain feedback and critique, and improve on their idea (or abandon an idea shown not to be valid). Design team meetings, in some forms Integrated Product Team (IPT) meetings, provide another excellent forum for these types of ideas. It is fine to have an agenda for specific meetings and even a specific topic(s) for discussion; however, these should not be decision-making meetings (note that developing a recommendation can still be the objective in an opportunity structure). Agile software and agile system approaches have these types of structures embedded in their daily and weekly team meetings and provide good approaches for some types of systems. Working groups, task teams, status meetings, and other similar type structures also provide this when they are not used in a decision-making capacity.

A key aspect of opportunity structures is providing a forum for everyone with different perspectives on the same topic to contribute to the discussion. Segmented meetings, where different ideas are considered separately are not an opportunity structure and appear more as a decisional meeting. To vet ideas fully, it is important to include a diverse group of thinking by contributors on the topic and those impacted by the topic.

The systems engineer should work with project management and line management to ensure opportunity structures are available at both the discipline or subsystem level and at the system level. Having these open expression forums is essential for the avoidance of unintended consequences (by providing an opportunity to recognize these consequences) and development of approaches that provide for an elegant system approach.

Organizational Culture and Cultural Subsets

There are three lenses from which to view social structure: individual, group, and organizational. (Page & Page, 2008). The individual view deals with roles (i.e., role sets) of individuals within the organization. The group view deals with languages and status (i.e., disciplines can have their own technical language and can be viewed as a group). The organizational view looks at organizational structure and culture (i.e., project and organizational norms). Sociology deals with all three of these views in various forms. This section deals with the organizational view and the group view (as it defines a cultural subset).

There are both manifest and latent social forces at work in the organization. Manifest social forces are visible and direct. Latent social forces are invisible and indirect (Turner, 1978). Most of what is addressed in this section are the more visible, manifest social forces. These are visible in policy statements, written norms, and behaviors in meetings and discipline interactions.

Beliefs, assumptions, and behavioral expectations are defined by the culture. Therefore, expecting individuals to act differently than their discipline subculture values is difficult and may not be possible. The systems engineer seeks to relate to individuals within the subcultures in a way that is valued by that discipline. Like the technical system, the social system (or culture) can be a source of high performance and competitive advantage if it is healthy, or a source of risk if it is unhealthy.

Culture can be either anticipative (looking for what may happen next and how to respond) or resilient (stable and unmoving to change) (Roberto, 2009). And, once culture has become ingrained in an organization (that is, accepted as "the way we do things here"), it can be very difficult to change; and change from anticipative to resilient or vice versa can be challenging. The specific culture form is important to understand for the systems engineer.

Organizational culture can also drift over time, become accepting of anomalies or unknown areas of the system. There can be incremental descents into poor decisions if not addressed. The concept of normalization of deviance (Vaughan, 1996), the acceptance of system or organizational behavior that deviates from previous behavior, is an example of cultural drift. This is a risk to the system functioning properly and to fulfilling system needs, goals, and objectives. Being able to specify ignorance and address it, not accept it, is a crucial aspect of systems engineering (Roberto, 2009).

Senior management shapes processes and organizational structure through reinforcement of rewards, status, resources allocations, and compensation. These influences are meant to engage individuals within the organization to contributing behaviors to system success. Systems engineers can recommend individuals, disciplines, and sub-teams for recognition using the reinforcement means. Systems engineering recognition should focus on open and honest

flow of information through the system contributing to the systems success, even if the information challenges some beliefs held by the culture.

Middle management tends to hold the organizational culture in place. They are charged with stability and they are rewarded based on the cultural values of the organization (Christensen, 2003). Middle managers can be project subsystem leads or chief engineers, organizational unit managers, and discipline leads or managers. Thus a good indicator of organizational culture is to look at this level of management within the organization and project and what they actually value. This level of management is important for adoption of new ideas or approaches. Technical experts push ideas to middle managers for sponsorship. If middle management adopts the ideas then the organizational structure will drive the project strategy and management will push the idea to senior executives (e.g., department managers, project managers, project chief engineers) for sponsorship and decision. (Cannon-Bowers & Salas, 1998) Note also that communication flow through managers is more formal and can lead to poor information transfer and misunderstandings between disciplines (Roberto, 2009). There needs to be informal communication among peers (i.e., opportunity structures) with input and concurrence by managers.

The complexity of the system needs to be embraced rather than looking to simplify the understanding of interactions (hides information). There are ambiguous threats to the system and organization that afford time to respond if identified and not hidden in the social structure. Sensitive information needs to be free to share with decision makers. Opportunity structures can help frame these presentations more carefully. Small problems provide a causal chain in the organizational structure that may indicate larger problems. Looking for blame is localized and often misses the broader systemic problems that may exist in the organization. (Roberto, M. A., 2009) Root cause has a specific initiator. Root cause also has a systemic facilitator or transfer medium. Both exist compatibly to produce failures in complex systems and complex organizations.

Cultural subsets will exist in any complex organization, are natural, and can be based on a variety of cultural factors. In an engineering context, engineering disciplines form cultural subsets. The systems engineer should be aware that these exist and help to mitigate any actions that impede information flow through the system. This may involve discussions with project management and line management to help deal with any insider activities (i.e., activities where a group believes they are the only ones who can understand certain facts or information and act to withhold access to this from those outside the group). These types of actions can lead to failure of the organization and therefore a failure of the system (or result in an inelegant system at best); in extreme cases where social ambivalence and dysfunction sets in, these extreme difficulties lead to a disruption in information flow within the organization and failure of the system.

Insider behavior, where organizations withhold 'private' information and share more generally known information is a serious information flow block. Organizations can also withhold information as a form of leverage or power information for fear of failure or loss of control (Roberto, 2009). Biased Information Sharing is a form of information leveraging and filtering where the organization is ensuring that it can be successful with its system functions (Austin-Breneman, Yu, & Yang, 2014). However, this can also be a risk to the system where it can force unnecessary design changes (due to more margin being held in the design than is needed and can be supported). A data clearinghouse could be established (some model based systems engineering approaches attempt to do this) but the risk is added hierarchical complexity in the information flow. Peer to peer information flow is crucial, especially in complex organizational structures to ensure information is flowing as needed.

At the discipline level there can be a shift from project policy to local discipline policy (termed practical drift). These policy shifts are typically not explicitly communicated (Snook, 2000). The systems engineer should ensure transparency in information transfer and avoid information silos that can form from local policy differences. The systems engineer should ensure that there are clear processes for transfer of system information between the disciplines and that the discipline teams understand these. Note, that these differences can lead to a socially ambivalent situation as discussed below.

Groupthink (Janis, 1982) can occur in trade study teams, working groups, disciplines, subsystems, at the project level, etc. Individuals can choose psychological safety and not express counter or dissenting opinions (fear to speak up), a serious block in information flow which causes a serious filtering of information flow and can lead to a shift or non-assignment of accountability. This results in hidden information and a lack of responsibility to resolve issues. Groupthink is also dangerous in changing or renegotiation events and leads to a failure to address or adapt to the changes needed for system success. Adding diverse thinkers as members, brining in outside experts, and cross discipline teams may help counter groupthink tendencies. Moreover, systems engineers participating in teams that appear to be operating in groupthink should openly encourage individual discussion and solicit different opinions from the team members. The systems engineer needs to recognize groupthink and raise important social conditions or system challenges.

The systems engineer should recognize and seek to understand these cultures. This understanding provides a key element to communicating with the different subcultures (e.g., disciplines, departments, divisions) within the organization in an effective manner. The intent of systems engineering is not to change the discipline subcultures but to effectively integrate the discipline subcultures.

Accumulation of Advantage and Disadvantage

Sociologically, when an organizational group is highly successful they are rewarded with access to more resources and greater opportunity for future success. The opposite is also true. When an organizational group is viewed as not being effective (which socially can be real or perceived) then their resources and opportunities are reduced. An elegant system requires that the correct engineering be done to meet the system goals. The systems engineer must ensure that an appropriate balance is maintained for the organizational effort for the specific system. Organizational units which struggle must be provided with necessary corrections (which can be skills, tools, computer time, fabrication priority, materials, skills, or leadership) to enable them to provide the needed and appropriate effort for the system. Highly successful organizational units should not be given unnecessary resources that do not improve the engineering for the system. The balance of engineering to achieve an elegant system is a focus of the systems engineer.

Social Ambivalence

Sociological ambivalence is an "incompatible normative expectation of attitudes, beliefs, and behavior assigned to a social status (i.e., position) or a set of statuses in a society". An ambivalence can be created if a discipline or position within the organization is confronted with conflicting norms. This condition can pose a threat to the system's success. There are six (6) types of sociological ambivalence (quotes in this list are taken from (Merton, 1996, pp. 123-131):

1. "Inherent in the social position"
   Government employee relationships with contractors are an example where government ethics demands disinterest while social etiquette requires personal interest. There are many examples of these types of cases in the literature (Roberto, 2009).

2. "A conflict of interests or values"
   These may arise when a person is a member of two different organizations such as in a matrix organizational structure or when a person is working two projects. If the normative values are different the person can become socially ambivalent. For example, when one project norm is to do what it takes to solve a problem conflicts with the time agreed to spend on another project. A conflict in time priority arises where one cannot satisfy both norms. These can also arise between organizational values and values from a person's life outside the organization.

3. "Conflict between roles associated with a particular" position
   These are conflicts in cultural norms that occur inherent to a given job position. These can occur in discipline integration where a representative to the system team may find oneself in conflict between norms of the system team and norms of their discipline team. Another example may be in procurement, balancing the norms of the procurement office with that of what the program views as necessary for success.

4. "Contradictory cultural values"
   These can be a risk to the system and occur when different cultural values collide. For example, an emphasis on high reliability can conflict with the need to focus only on events or situations seen as credible. High reliability is sensitive to even low probability events and requires the organization to address situations that the organization may not believe are possible. This can lead to severe tension and conflict in the organization as the organizational cultural beliefs collide with the new high reliability project culture.

5. "The disjunction between culturally prescribed aspirations and socially structured avenues for realizing these aspirations"
   This illustrates a disconnect between social expectations and the structure to achieve these expectations. An example is when a quick change is needed in the system design or operation and the organizational structure does not support a quick assessment and implementation of the change. The engineer is faced with either allowing a larger impact to the system later or moving ahead of approval with a change. Systems engineering is to ensure that the decision-making structures are efficient and that mechanisms are in place for the types of disjunctions in this example.

6. That which "develops among people who have lived in two or more societies and so have become oriented to differing set of cultural values"
   This occurs when an engineer worked in different disciplines or supported projects with very different cultural values. The varying cultural values experienced can lead to ambivalence to cultural values in the current system that conflict or contradict what has been successful in the engineer's past. This can lead to a strong disinterest in the social structure of the system development or operation. These types of issues should be brought to line management or project management (at the appropriate level) to address. It is important that the members of the organization have an agreed to set of values or sociological dysfunction can develop within the sociological structure of the organization.

Sociological ambivalence can lead to a failure to deal with or possibly to acknowledge conditions that affect system reliability and success. Systems engineering must be aware of these conditions when they occur in the organization and seek to find a new balance for the norms. This may involve the precedence of conflicting norms elevating one as more prominent to resolve a conflict or finding a common understanding that balances the norms, and addressing the concerns that may be suppressed in the ambivalent situation.

An extreme sociologically ambivalent context leads to sociological anomie. In this case an individual in the culture can become normless or rootless (Merton, 1996, pp. 132-152). A no win situation has been perceived where an individual moves outside the organizational structure and opposes the organizational norms to achieve what the sociological culture calls for and the organizational structure is preventing. This imbalance occurs when the emphasis on success-goals of the system are much greater than the emphasis on the institutional means to achieve these goals. There are five (5) types of individual adaptations to the social structure disjunctions.

1. Conformity
   Most people seek to conform to the cultural norms and the social structure to achieve these norms. They will try to stay within these bounds as they work in the organization. This can lead to failure to achieve assignments as individuals seek to conform to the social structure.

2. Innovation
   Individuals caught in a conflict between the cultural norms and social structure may try to create a new path through the social structure. This typically involves violating some minor cultural norm or organizational constraint to resolve the conflict (or organizational pinch) that they are in. An example may be in skipping a level in the chain of command or bypassing an approval cycle to move forward. There are many more creative ways that people may find to move forward in satisfying a cultural norm that the social structure is not facilitating. Social structure in this case would include the formal approval cycle (e.g., decision making boards). The systems engineer needs to recognize when information is moving outside the project structure and seek to address the perceived barriers that are leading to this deviation.

3. Ritualism
   In some cases, the frustration in conflicts can lead to an abandonment or reduction in importance to achieving a cultural norm leading to a ritualistic following of the organizational structure processes. This can be dangerous to the system as ambivalence has developed and conflicts in the system design or operation may not be identified as discussed above. This often leads to a failure to accomplish goals as the social structure is given precedence.

4. Retreatism
   Occasionally an individual will retreat from both the cultural norms and the organizational structure. A person who is in such an ambivalent situation simply withdraws from significant participation in the system development or design. When this occurs, the person should seek a different position in the project or with another project where the conflict they have encountered does not exist. These cases should be discussed with line management or project management at an appropriate level. Systems engineering is focused on the success of the system. When these deep sociological conflicts develop, line management is primarily responsible to help the individual deal with the conflict. Systems engineering is responsible to ensure the conflict does not indicate an issue in organizational culture values or structure that needs to be addressed.

5. Rebellion
   This is the most radical of the responses to sociological anomie situations. Rebellion is a strong form of social dysfunction attempting to bring about a new social structure within the organization. This can occur in cases

were an organization views the success of the system based on different values than are required for the system in application. This can occur when a traditional organization attempts to adapt to a disruptive technological approach. As discussed above, this may mean the organization is not suited to the system development or operation. Disgruntled employees can fall into this type of social response.

Dealing with these various levels of social ambivalence, the systems engineer has to deal with the pinch that leads to the ambivalence. Disruptions to the social structure leads to uncertainty in what the actual organizational expectations are for accomplishing a task. Individually this can lead to anxiety. Organizationally this also opens the door for potential renegotiation of social expectations (i.e., a process change is possible) based on new understandings of what is necessary for a successful system. Note that this is also accompanied by social resistance to change which can be strong. This social resistance seeks to keep the social structure the same and needs to be managed with line management and project management to help correct the ambivalent situation. Middle management, who are changed with maintaining organizational stability, are often sources of resistance to organizational change (Christensen, 2003). The anxiety response can be a driving force for the methods discussed below:

- Innovate by renegotiating expectations within the social structure
- Retreat from the situation, terminating efforts toward the task
- Ritualism by returning to the previous social structure expectations which leads to a failure of the task. This may be seen through an apology to not be able to do the task (i.e., returning to the previous social structure expectation) or some other means of expressing an understanding of the problem with an inability to deal with the obstacles to address the task. If the return to previous expectations (a closed response to change) is not feasible for the system progress, the organization and system can fail.

If the social ambivalence is not addressed, it can lead to repetitive and more intense disruptions of the organizational relationships. The previous disruptions feed the intensity of future disruptions. The systems engineer needs to be aware of this cycle and work with project and line management to address the imbalance in the organizational structure. Staying on the status quo (i.e., being inflexible), and not addressing the imbalance in the organization, can lead to significant organizational, project, and system failures (Sherwood & Glidewell, 1975).

One possible avenue for dealing with these organizational imbalances which social ambivalence indicates, is to plan to renegotiate social expectations and arrangements as a part of the system development or operations activity. This is a form of reclama process (discussed more below) and allows the organization to adjust to unforeseen needs in the system development and operation as the organization gains a better understanding of the system and the approaches to successfully develop an elegant system. When an imbalance occurs, the organization can use this renegotiation process to develop a more fitting balance for the system. This relieves the anxiety produced by a socially ambivalent circumstance and allows the organization to flex and accommodate the system needs. A more stable renegotiation is allowed through this planning. As the organization experiences this response to imbalances, the planned renegotiation process acts as a stabilizing force in the social expectations for the project (Sherwood & Glidewell, 1975).

One of the signs of a socially ambivalent situation is sometimes referred to as a ‘pinch’ (Sherwood & Glidewell, 1975). As individuals begin to feel a pinch, an organizational disruption is developing. Signs of a pinch are 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 the impression that freedom to pursue a course of action has been restricted, responsibility has been removed or replaced, resources are reallocated between groups, and system needs, goals, and objectives (NGO) are shifting which change the importance of certain approaches or disciplines. These are all social stresses that need to be managed in conjunction with project management and line management. The systems engineer should be aware that these factors will cause stress in the organization and individuals and seek to restore a balance based on the needs of the successful elegant system development or operation.

Social Dysfunction

Social dysfunction is “any process that undermines the stability of survival of a social system” (Merton, 1996, pp. 96-100). Systems engineering helps to mitigate dysfunctions that can cause information about the system to be suppressed or inaccurately communicated. These dysfunctions are a risk factor for the system and can greatly affect the ability of an organization to accomplish a given system design or operation. Note, that innovative approaches to accomplishing a system can be very disruptive to an organizations sociological values. This can mean that a given organizational culture is not able to develop the system which embodies values contrary to what the organization has come to believe as most important. Innovative system approaches often entail the formation of an entirely new organizational structure

and culture with a different view on what is most significant in the system. Examples can be found in various industries including the computer industry (mainframe vs networked workstations), heavy equipment industry (steam driven systems vs hydraulic systems), medical practice, etc. (Christensen, 2003) Another current example in United States culture is automation of previously manual operations (i.e., anxiety toward drone applications).

Reconsideration Process

The reconsideration process, or reclama process, is a crucial sociological mitigation forum within the organizational structure. The systems engineer ensures that project management or line management has established a process for appeal or reconsideration of decisions about the system, organization, or project structure. This provides those who find themselves in a socially ambivalent situation (i.e., given an objective to achieve and find the organizational structure does not support accomplishment of that objective) to have an avenue to address the ambivalent situation. The reconsideration process should be able to recognize and handle organizational biases that exist and may be leading to unrecognized and unintended consequences. Thus, the reconsideration process provides an avenue to mitigate unintended consequences in decisions about the system, project structure, and organization.

Summary

Systems engineering involves the application of sociological principles in integrating the disciplines within an organization for the development or operation of a system. The sytems engineer is focused on the flow of information about the system through the organization rather than on the management of the organization (the line managers responsibility) or management of the project (the project manager's responsibility). The systems engineer should work with line management and project management to understand the system information flow to help address gaps, blocks, or other disruptions in the information flow. The systems engineer should establish opportunity structures to provide a mechanism to vet ideas before they are introdcuced into a decision making process. Specification of ignorance is a key aspect in a successful system development. Knowing what is not known is essential to addressing and resolving system issues. It is important to ensure a consistent system terminology is used, translating and not changing, discipline based terminology. Socically expected durations are important to manage. Activites or events which occur much longer or shorter than socially expected can cause distress within the organization and uncertainty about whether the activity or event is being considered seriously by management. Systems engineers mainly focus on manifest social functions, though latent social functions also exist (and are more difficult to identify). Ensuring resources are allocated based on need for the system and not based on the social views of a team are important to a successful system. Social ambivalence should be avoided in the functioning of the organization. This involves being aware when organizational expectations are not supported by the organizational structure. Serious social issues can arise including anomie and dysfunction if these organizational disconnects are not addressed. The reclama process can help aleviate some of these situations when they arise. Understanding these social principles equips the systems engineer to recognize information between disciplines in the organizations and disruptions to this information flow. Applying these sociological principles enables the systems engineer to manage the information flow throughout the organization and is essential to a successful system.

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About the Author(s)

Michael D. Watson received his Ph.D. in Electrical and Computer Engineering (2005) from the University of Alabama in Huntsville. He graduated with a BSEE from the University of Kentucky (1987) and MSE in Electrical and Computer Engineering (1996) from UAH. He is leading the NASA Systems Engineering Research Consortium responsible for definition of elegant product focused systems engineering. He has served as the Space Launch System (SLS) Lead Discipline Engineer for Operations Engineering. He started his career with NASA developing International Space Station (ISS) operations capabilities. He also worked to develop remote operations support capabilities for the Spacelab Program in the United States, Europe, and Japan. He subsequently served as Chief of the Optics Branch responsible for the fabrication of large x-ray telescope mirrors, diffractive optics, and telescope systems. He served as Chief of the Integrated Systems Health Management (ISHM) and Sensors Branch focusing on launch vehicle abort systems.

James G. Andrews received his PhD in Psychology from the University of Tennessee, Knoxville, Tennessee (1977). Jim was Senior Consultant at The Stanford Associates, The Transition Management Group-Outplacement International, the JM Perry Corporation and Principle Consultant at Right Management. Jim was Vice President of Organization Development and Human Resources for Salestar telecommunications intelligence company, and Rusher, Loscavio, Lopresto a national retained executive search firm. Jim was Lieutenant Commander in the U.S. Navy serving at the Naval Regional Medical Center in Oakland, CA as staff psychologist. He was a Group leader at the Meyer Friedman Institute for Coronary Artery Disease and Type-A Behavior change. He is a past President of the American Association for Training and Development, Golden Gate Chapter, San Francisco, and a past Chair of the Northern California Human Resource Association. Jim currently leads the Organization and Leadership Development Office at Marshall Space Flight Center, NASA.

Michael Culver holds a BSIE from Auburn University (1971). He currently serves as an Organization Development Specialist and Deputy Program Manager with the ASRI/Aetos Team at Marshall Space Flight Center. Since 1980, the focus of his work has been helping create competitive advantage through organizational effectiveness. His expertise includes organization development, strategic planning, work redesign, labor-management partnering, leadership development, change management, continuous improvement, and training design and delivery. He has served in external and internal consulting roles in government, corporate, manufacturing, and academic settings. While at MSFC, he was selected as a Launch Honoree for STS-103, and he has received a Silver Snoopy, a Director's Commendation, two Exceptional Public Service Medals, and several team awards. His certifications include Situational Leadership I and II, the Myers-Briggs Type Indicator, and the Birkman Method. He is a seasoned organization development professional, and his clients see him as practical, caring and results-oriented.

Jeri Cassel Eckley is pursuing a Ph.D. in Industrial/Organizational Psychology from Capella University. She holds a Bachelor of Arts in Psychology from the University of North Alabama (2002) and a Master of Arts in Applied Psychology, from the University of Alabama at Huntsville (2005). She serves as an Organization Development (OD) Specialist for NASA's Marshall Space Flight Center. In this role, she serves as trusted advisor and consultant in OD, change management, and Lean Six Sigma, as well as leads Marshall's Lean Six Sigma program. She started

at Marshall in 2007 with Will Technology as an analyst. She then worked as an analyst for a subsidiary of Blue Cross Blue Shield of Tennessee. She retunred to Marshall as OD Specialist in 2012. Jeri is a certified Lean Six Sigma Master Black Belt, as well as certified in Myers-Briggs Type Indicator, the Birkman Method, and Environment Matters 360 Feedback.