Understanding Social Networks- A Key Requirement for System Engineers

Mr. Karl Selke
Systems Engineering Analyst

Evidence Based Research, Inc
1595 Spring Hill Road Suite 250
Vienna VA 22182 (703)-893-6800
selke@ebrinc.com

Agenda

- Introduction
- Wicked Problems
- Understanding Social Networks
- Social Network Analysis Process
- Concluding Thoughts

Introduction

- My motivation: Preliminary research for an Army Small Business Innovative Research Solicitation
  - *Social Networks and Organizations* (2003) by Martin Kilduff and Wenpin Tsai
  - *Social Network Analysis: Methods and Applications* (1994) by Wasserman and Faust
- My question: Is quantification and visualization of the maze of social interactions important for project success?
- My underlying assertion: Technical success, enabled by good systems engineering, should be accompanied by successful engineering of the social network in which the project exists.
- My underlying mission: Utilize computational social sciences' approaches for anticipating and managing the complexity, inherent in diverse, potentially conflicting stakeholders, project teams, and project managers.

The social network matters and the following is merely a simple articulation of the problem and a potential solution.

The Importance of “Wicked Problem” on Systems Engineering

Every textbook of system engineering starts with an enumeration of these phases: “understand the problems or the mission,” “gather information,” “work out solution,” or the like. For wicked problems, however, this type of Schema will not work.[1]

- Rittel and Webber’s paper introduced the concept of “wicked” problems to explain why scientific approaches and methods for solving societal problems are inherently flawed.
- As systems engineers have turned proper prior planning into a science, this raises the question as to the distribution of “wickedness” faced by systems engineers and if so, whether the field of systems engineering has adequately prepared system engineers to address them.

[1] Rittel and Weber, *Dilemmas in a General Theory of Planning* (1973)

The social network matters and the following is merely a simple articulation of the problem and a potential solution.

Properties of Wicked Problems

The ten properties are as follows:

1. There is no definitive formulation of a wicked problem.
2. Wicked problems have no stopping rule.
3. Solutions to wicked problems are not true-or-false, but good-or-bad.
4. There is no immediate and no ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.
6. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another problem.
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem’s resolution.
10. The Planner has no right to be wrong.[1]

[1] For further articulation of these properties, one can refer to Rittle and Webber, *Dilemmas in a General Theory of Planning* (1973).

One can define “wickedness” as the extent to which one or more of these properties are dominant.

“Wicked” System Engineering Problems

Establish good relationships and open communications between systems engineers and stakeholders. This is helpful when negotiations begin to refine and clarify the set of requirements.[1]

- In general, project managers and systems engineers work to meet project performance requirements within planned schedule and cost.
- There are a set of observable reasons that are asserted to be the most common rationales for why project objectives are not met.
  - Inadequate articulation of requirements
  - Poor planning
  - Inadequate technical skills and continuity
  - Lack of teamwork
  - Poor communications and coordination
  - Insufficient monitoring of progress
  - Inferior corporate support[2]

[1] INCOSE Systems Engineering Handbook

[2] Howard Eisner, *Essentials of Project and Systems Engineering Management* (2002) page 9

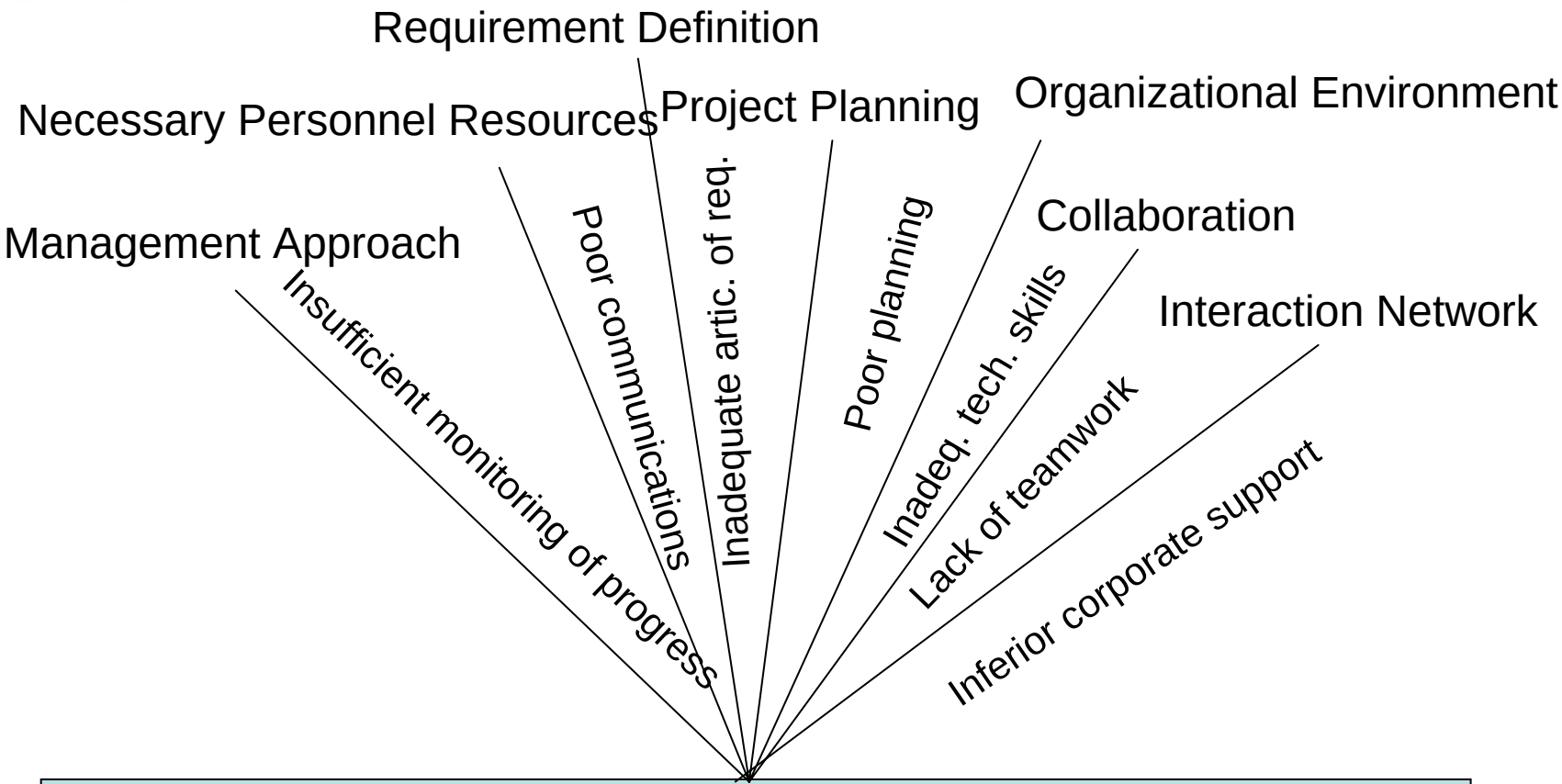
It is more useful to view these rationales as problem areas.

Problem Areas

- Requirement Definition- customer defined requirements for the system.
- Project Planning- initial project plan, personnel plans, and subsequent updates over time.
- Necessary Personnel Resources- required technical staff
- Collaboration- ability for personnel to function as a “team”
- Interaction Network- propagation and instantiation of guidance or orders
- Management Approach- leadership’s guiding principles of interaction with personnel
- Organizational Environments- external (to the project team) networks containing all the external factors that are relevant to the project.

Underlying each of these problem areas are complex interactions amongst the internal project personnel, external project personnel, customers, and stakeholders.

“Wicked” Engineering Management Problems- continued



Given that the problems are heavily correlated to the outcomes of social interactions, it suggests that these problems may have “wicked” aspects.

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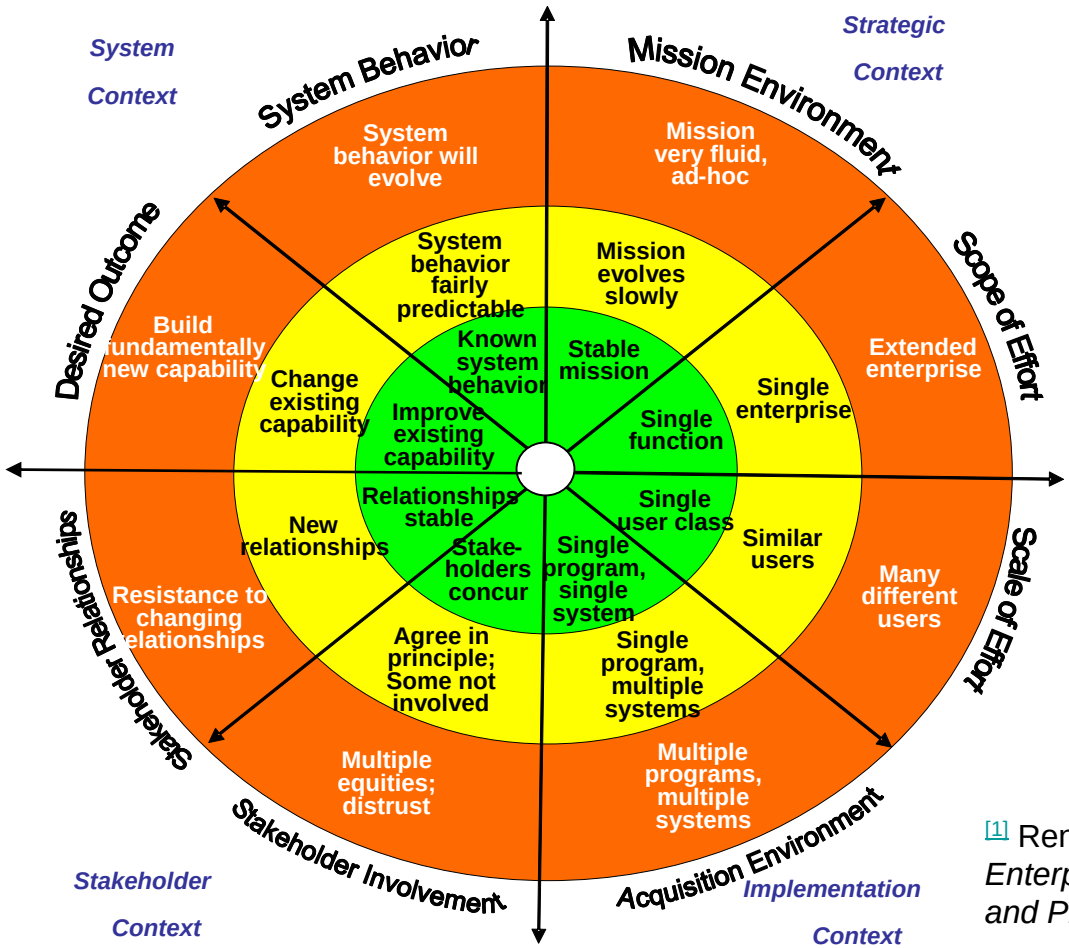
[1] For further articulation of these properties, one can refer to Rittle and Webber, *Dilemmas in a General Theory of Planning* (1973).

Property 7 can dominant the interaction of customers and systems developers

Growing Complexity of Social Interactions

Enterprise Systems Engineering Profiler[1]



[1] Renee Stevens, *Engineering Enterprise Systems: Challenges and Prospects*

Unfortunately for systems engineering, understanding the situation (or the social complexity) is the wicked problem.

Understanding Social Networks

System Thinking

- "The systems engineering perspective is based on systems thinking. Systems thinking occurs through discovery, learning, diagnosis, and dialog that lead to sensing, modeling, and talking about the real-world to better understand, define, and work with systems."[1]
- *Systems Thinking* is an important component of systems engineering—it may actually be the defining characteristic that separate great engineers from good engineers.

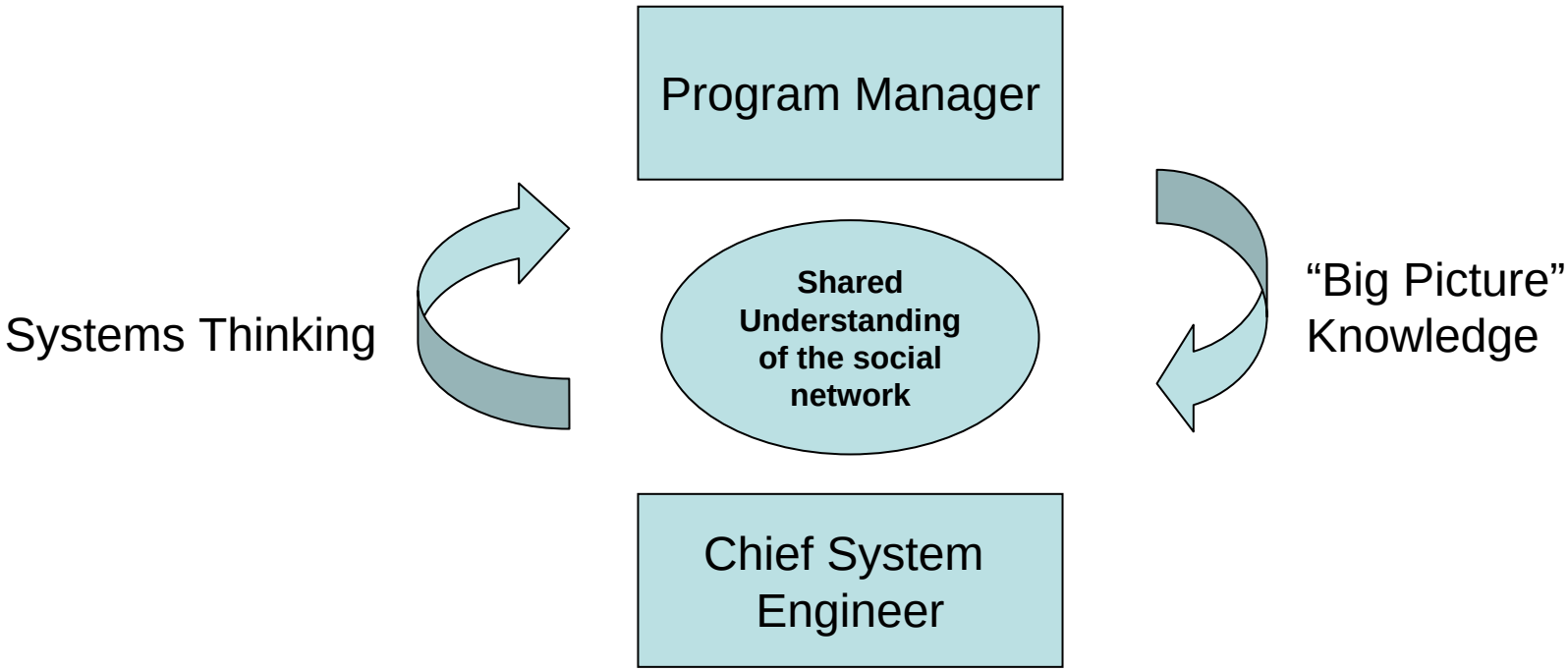
"Big Picture"Knowledge

- "Big Picture" Knowledge is simply the knowledge of the internal and external environment including communities of interest, processes, and specific players.
- Big Picture Knowledge is a necessary component of effective program management.

[1] INCOSE Systems Engineering Handbook

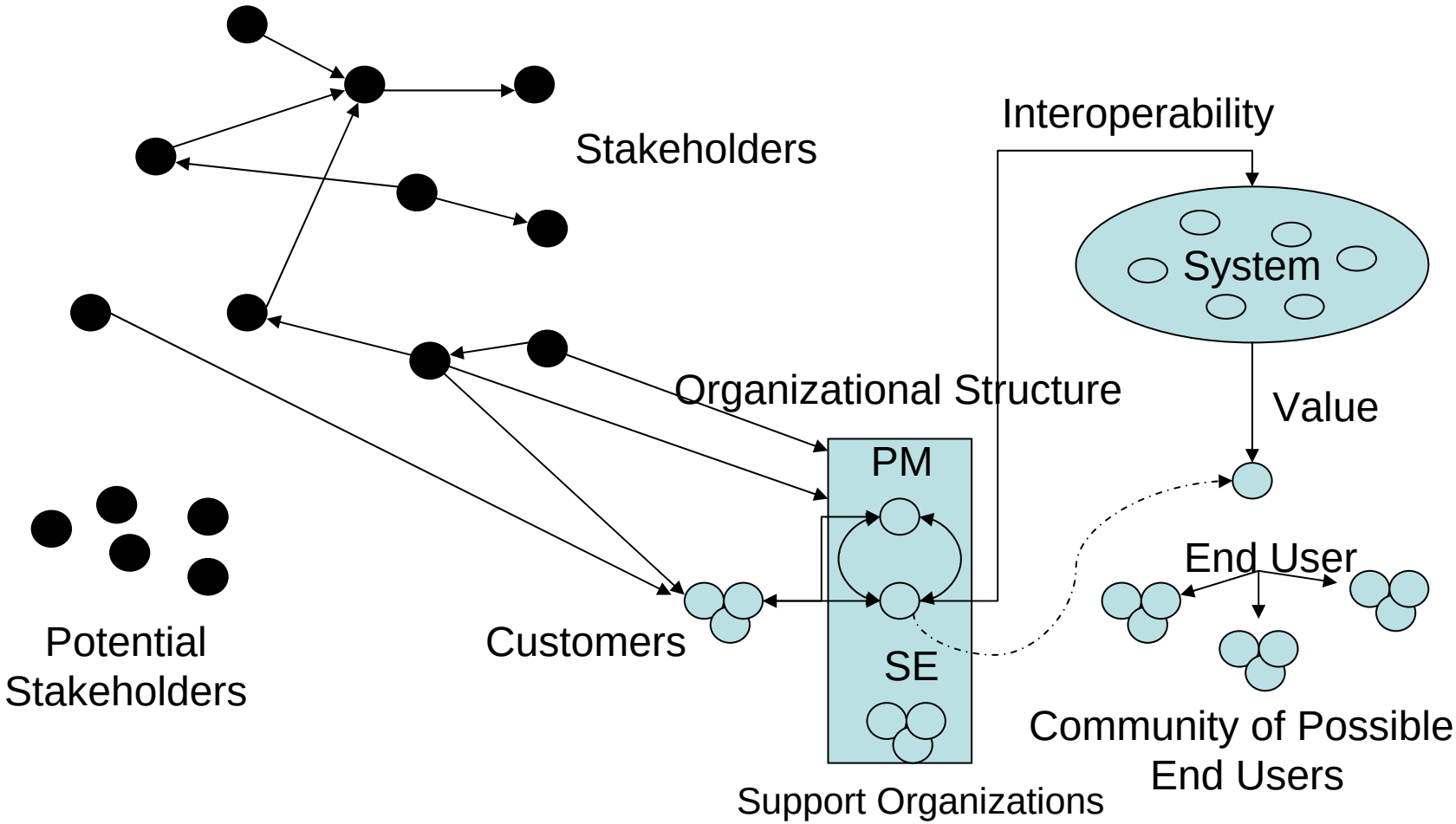
Is there a collaboration mechanism that combines "gray beard" knowledge of the big picture with the systems thinking capability of systems engineers?

Collaboration Mechanism



This interaction between the suave business knowledge program manager and the experienced systems thinker as the chief systems engineer may mitigate "wickedness."

Players Comprising the Social Network



Is it possible to institutionalize knowledge of the social network?

Brief Description of Social Network Analysis

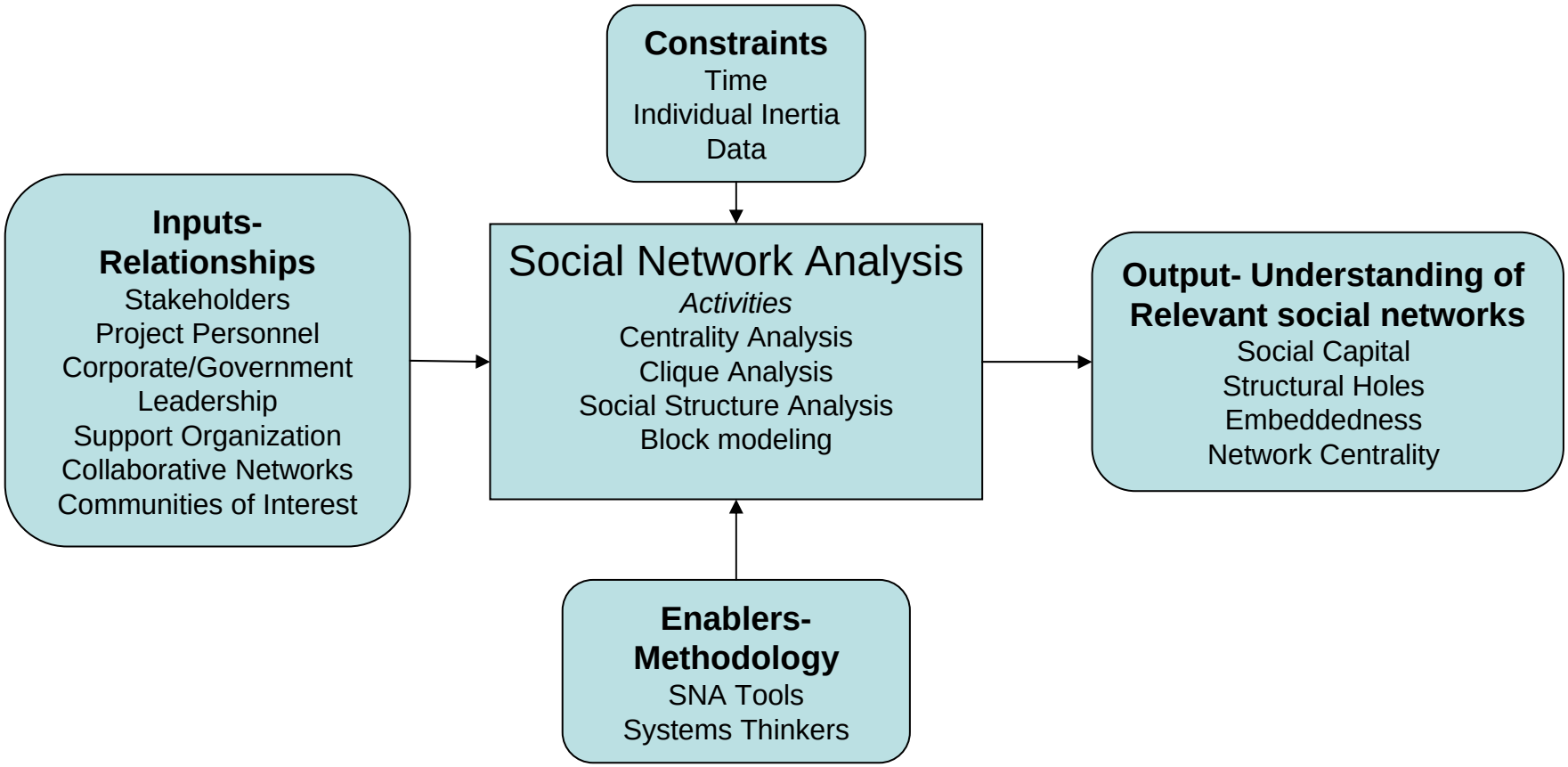
- "Social network analysis is based on an assumption of the importance of relationships among interacting units. The social network perspective encompasses theories, models, and applications that are expressed in terms of relational concepts or processes."[1]
- Social network analysis should not be outside the capability of a systems engineer, but rather its benefits would fold nicely into mission engineering—a core component of systems engineering.
  - Mission engineering is that often overlooked aspect in which the system developers ask the 'big picture' question: "why is this system being developed?"[2]
  - Social network analysis makes the question more fundamental: "Why is this system being developed and who is important to its sustained success?"
- "The purpose of social network analysis is to provide insightful information and inferences on the organization and structural properties of a network, given its nodes and relations."[3]

[1] Wasserman and Faust, Social Network Analysis: Methods and Applications (1994) page 10

[2] *Howard Eisner, Essentials of Project and Systems Engineering Management (2002) page 195*

[3] Dr. Cioffi-Revilla and Dr. Sean Obrien, Computational Analysis in US Foreign and Defense Policy (2007)

Social Network Analysis Process



Continuous process where individuals, organizations, and relationships should be systematically identified, processed, and refined into actionable information

Social Network Analysis Process- Inputs

- The inputs for this process are the data and information describing the individuals, organizations, and relationships comprising both the internal and external system engineering and management environment.
  - The nature of the data can include everything from friendship ties and organization memberships to personality.
  - This data often resides with numerous individuals; however, the project manager will likely have a solid foundation.
  - The data can be collected in several ways including roster type surveys, egocentric data from interviewing available people, archival data such as employee records based on the barriers of access.[1]
- Depending on the scope of the project, the following entities may be relevant:
  - Stakeholders including customers
  - Project Personnel
  - Corporate/Government Leadership
  - Support Organizations
  - Collaborative Networks (fellow systems engineers, project managers, etc)
  - Communities of Interest (similar projects, cutting-edge technical expertise)[1]

[1] Howard Eisner, *Essentials of Project and Systems Engineering Management* (2002) page 9-30
[1] Wasserman and Faust, *Social Network Analysis: Methods and Applications* (1994) page 28-66

Social Network Analysis Process- Constraints

- There is a strong argument that advocates progress over process which would stringently reject additional action items for systems engineers to accomplish.
  - The time pressure for project managers and system engineers is often overwhelming.
  - There may also be reluctance amongst system engineers to capture and codify individual and relationship data as part of the system engineering process, but rather let the data reside in their own mental models.
  - Thus, both time pressure and individual inertia will constrain this process.
- Data collection and a systematic examination into the social network to prevent the eschewing of project success by key stakeholders present several challenges such as personally sensitive information.

Social Network Analysis Process- Enablers

- Social network analysis as a component of the broader field of computational social science has spawned a great deal of research in the past ten years.
  - This has yielded social network software packages such as UCINET and visualization software such as KrackPlot and Netdraw (there are a good many more tools).[1]
- The automation of certain types of analysis such as deducing centrality of an individual greatly empowers social network appliers rather than only academics.
- There are current initiatives in the Department of Defense seeking to utilize social network analysis related to modeling the performance of joint, interagency, multi-organizational, and multinational organizations.
- Another enabler is the systems thinkers, particularly the graybeard contractors, who have spent forty years in the business and have deep understandings of the social networks.

[1] See Wasserman and Faust or Kilduff and Tsai for more information concerning tools.

Social Network Analysis Process- Analysis

The network of relationships within which we are embedded may have important consequences for the success or failure of our projects. Evidence suggests that the types of networks we form around ourselves affect everything from our health, to our career success, to our very identities.[1]

- There are numerous activities that can be done within the field of social network analysis that could be useful for systems engineers.
  - Centrality Analysis: Analyzes the data based on several indices to determine the degree to which the network is centered around a few key individuals.
  - Clique Analysis: Determines how many, what kind, and other clique related information that may be useful to the analyst.
  - Social Structure Analysis: Provides a delineation of structural features not observable by inspection.
  - Blockmodeling: Aims to discover groups in which there are no or limited connections.[2]
- The traditional approach for performing this type of analysis is to trust the insights of the retiring graybeards in whom past experience has grown wisdom and connections.

[1] Kilduff and Tsai, *Social Networks and Organizations* (2003) page 2.
[2] Kilduff and Tsai, *Social Networks and Organizations* (2003)

The potential knowledge gleaned from these activities can provide actionable information to project managers and systems engineers to provide assurance for project success given technical success.

Social Network Analysis Process- Output

- The analysis provides an increasing understanding of the social network in which the project exists.
- Social network analysis yields actionable information vital for decision-making.
- Four useful features of social network analysis:
  - Social Capital
  - Embeddedness
  - Network Centrality
  - Structural Holes.

Output- Understanding Social Networks: Social Capital

All leadership is influence – John C. Maxwell, Injoy, Inc.

- Social capital can be defined as “the benefits that accrue to the collectivity as a result of the maintenance of positive relations between different groups, organizational units, or hierarchical levels. At the individual level, this concept can be defined as the potential resources inherent in an actor’s set of social ties.”[1]
- Echoing this concept, Clark Aldrich in *Simulations and the Future of Learning* writes that “there is a currency that all people earn and spend called personal influence.”[2]
- Unfortunately, not all program managers and systems engineers have strong social networks that yield large amounts of influence.
- Social network analysis can be combined into the project’s personnel plan to intelligently spend your team’s social capital and your own personal influence paying special attention to the dynamics which could lead to unintended consequences.

[1] Kilduff and Tsai, *Social Networks and Organizations* (2003) page 28

[2] (2004) page 161

Output-Understanding Social Networks: Network Centrality

Richard knew that if the quality program was going to get anyplace in the organization he would have to place on the support of the princes and to dance past the kings – David T. Kearns[1]

- Network centrality is certainly implicit when discussing social capital, embeddedness, and structural holes.
- Actors can be central in the network from a variety of different perspectives such as popularity, go-between ties, or proximity to popular individuals.
  - Ascertaining this can be very informative because an actor with a high centrality level is in "direct contact or is adjacent to many other actors."
  - "This actor should then begin to be recognized by others as a major channel of relational information, indeed, a crucial cog in the network, occupying a central location."[2]

[1] *Prophets in the Dark: How Xerox Reinvented Itself and Beat Back the Japanese* page 278.

[2] Wasserman and Faust, *Social Network Analysis: Methods and Applications* (1994) page 178-179

Output- Understanding Social Networks: Embeddedness

In Washington, as elsewhere, power does not always follow organizational charts; a person's title does not necessarily reflect the power that he or she has.[1]

- The concept of embeddedness purports the notion that work-related transactions tend to overlap with patterns of social relations.
  - This is very similar to the "Good Old Boy System"
  - This has broad consequences in information flow and collaboration in the professional environment.
- Discovering individuals' or groups' past interactions early can often mitigate issues.
  - For example, there is a clear benefit to knowing that a scientist on your project has had very unfavorable interactions with a potential emergent stakeholder who could toss a wrench in the next phase of the project.
  - This prior knowledge empowers you to stave off potentially damaging issues. Carefully examining the stakeholders for friendship-enabled work transactions can guide the crafting of marketing proposals and requirements.[2]

[1] Hedrick Smith, *The Power Game: How Washington Works* page xxii

[2] Kilduff and Tsai, *Social Networks and Organizations* (2003) page 26-34

Output- Understanding Social Networks: Structural Holes

Sometimes those who refuse to cooperate actually have valuable knowledge or abilities; they may even be indispensable to your success.[1]

- The concept of structural holes is simply explained as the absence or severe shortage of ties between groups in a network.
- This is also the area in which systems engineers can leverage when doing requirement analysis and definition with the stakeholders, including customers.
- Identifying structural holes yields the benefits of increasing collaboration by furthering information sharing and dissemination.
- It may be that by connecting two otherwise stovepiped groups, the systems engineer can create more stable requirements as groups converge to a shared situational awareness (of course the opposite could easily be the case).[2]

[1] Eliza G.C. Collins and Mary Anne Devanna, *The New Portable MBA* page 33

[2] Kilduff and Tsai, *Social Networks and Organizations* (2003) page 26-34

Conclusion

If I had eight hours to chop down a tree, I'd spend six sharpening my ax. – Abraham Lincoln

- The current systems engineering practices are not sufficient in situations where the social context dominates the environment.
- Unfortunately, the trend in systems engineering is driving towards the need to anticipate and manage issues arising from diverse and competing constituencies in a complex environment.
- An important element for successful systems engineering is the incorporation of social network analysis into the systems engineering process and in effect, using this information to engineer social success in addition to technical success.

It is time to formalize what successful systems engineers have been doing guided by their intuition and in an ad hoc manner.

Additional Slides

Requirement Definition

- As previously mentioned by only simple inspection, the seven problem areas seem to have a strong social focus. These reasons are a product of the social interaction of the individuals involved. Hence, it is possible to correlate the problem areas in systems engineering with the properties of wicked problems.
- Relevant correlations: Requirement articulation
  - Property 1: There is no definitive formulation of a wicked problem.
  - Property 7: Every wicked problem is essentially unique
  - Property 6: Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan
  - Property 8: Every wicked problem can be considered to be a symptom of another problem
  - Property 5: Every solution to a wicked problem is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly

A problem area may actually indicate the presence of a “wicked” or social aspect of system development and implementation.