Cultural Differences in Systems Engineering: What They Are, What They Aren't, and How to Measure Them

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Abstract

Despite frequent use of the term culture in contemporary engineering practice, there is currently no reliable way of understanding what constitutes true shared beliefs and meanings that impact how groups of Systems Engineers spread across multiple departments and countries work together. This paper develops a framework to address that gap and measure cultural variation in Systems Engineering contexts. Drawing from the field of cultural anthropology, we demonstrate methods to empirically measure cultural consensus and divergence related to fostering collaboration, understanding business success or failure, and identifying characteristics of effective cross-functional teams. The discussion identifies substantive content of what real organizational cultures are, where they are different, and where they overlap. That quantified content feeds culture as a rigorous element of organizational strategy into global alignment and process excellence or six sigma initiatives targeted at changing team behavior. The result is a framework for conducting rigorous, empirical investigations to truly understand the human dimensions that are critical to effective Systems Engineering practice. We discuss areas this approach applies to global process alignment and team effectiveness.

Introduction

The exercise of business in increasingly diverse locations throughout the world has led to the general trend known as globalization. Beyond simply conducting business transactions, companies have become more involved in joint ventures, acquisitions, partnerships, and mergers national cross national and cultural boundaries. Many corporations have located divisions or plants in countries outside their primary nation of incorporation.

This clearly presents a challenge to contemporary managers: managing businesses and projects across national boundaries with a diverse, sometimes conflicting set of cultures among the workforce. The difficulty associated with this task is embodied in the statistics associated with multicultural ventures gathered by the Chartered Institute of Personal Development. One study from 2003 found that a mere five percent (5%) of performance differences among companies can be explained by differences in strategy. Up to thirty percent (30%) of performance differences can be attributed to cultural differences. Several recent studies have found that as many as seventy-five percent (75%) of international mergers or acquisitions fail due to cultural differences (Benady 2003). New product introduction can fail due, among other things, to limited understanding of the target market and its unique cultural nuances (Pilling 2003).

These issues highlight the importance of cultural implications in modern business. This is underscored when one considers the variety of cultures present even within organizations operating in seemingly homogeneous conditions such as purely domestic ventures. Consider the following text from the website for the 2009 INCOSE International Symposium (Engineering 2009):

> The theme for INCOSE / APCOSE 2009 is East meets West: The Human Dimension to Systems Engineering, highlighting the dramatic expansion in the scope of contemporary Systems Engineering where the human cognitive dimension is becoming an integral part in the Systems Engineering processes. Future systems, where the machines are designed around the man, will benefit from Systems Engineering best practices and processes. System Engineering methodologies have been successfully applied to designing large-scale complex engineering projects that are multi-disciplinary in nature.

If Systems Engineering is to truly understand its human dimensions, its practitioners must be equipped with methods and frameworks that provide rigorous ways to understand the integral cognitive dimensions within its processes.

The rest of the paper proceeds as follows. We summarize current methods used by organizational behavior scholars to describe the problem space that cross-cultural interaction poses for today's organizations. We then discuss the weaknesses in current methods, and discuss an alternative drawing from cultural consensus analysis in anthropology. We discuss examples of empirically identified, yet unexpected patterns of agreement related to collaboration, business success and failure, and effective integrated product development teams. These examples provide a framework to conduct rigorous, empirical investigation in several different areas of concern to the Systems Engineering community. We close by proposing uses of this approach to Systems Engineering process alignment and team effectiveness.

Common Methods to Identify Organizational Cultures

Table 1 – Hofstede's Axes of Cultural Comparison

Axis	**Description**
Power Distance	Effective distance (operational difference) between members of the same organization at different hierarchical levels
Individualism	Extent to which an individual functions as a sole unit, compared to the tendency to function as a member of a group
Uncertainty Avoidance	Relative propensity to avoid risk associated with unknown characteristics or conditions
Masculinity	Tendency of the organization to function according to stereotypical masculine behavior standards
Term of View	Planning horizon

Hofstede's studies of national culture and its manifestations in organizational cultures and operations are often cited in reflections on international and global business (Hofstede 1984, 1998). Hofstede offers a theory of national culture and its impact on the individuals that work in an organization. The theory is based on survey data taken from forty international divisions of

International Business Machines, Inc. (IBM) in the late 1960s and early 1970s. The survey data were previously obtained by IBM for other reasons internal to the organization. Hofstede used a statistical approach to classifying and comparing the national cultures portrayed in the employees' responses. Table 1 summarizes the five axes that he suggested could be used to classify national and organizational cultures.

Table 2 – Schwartz's Value Types

Type	**Description**
Power	Social status or prestige, control or dominance over people and resources
Achievement	Personal success through demonstrating competence according to social standards
Hedonism	Pleasure and sensuous gratification for oneself
Stimulation	Excitement, novelty, and challenges in life
Universalism	Understanding, appreciation, tolerance, and protection for the welfare of all people and for nature
Benevolence	Preservation and enhancement of the welfare of people with whom one is in frequent personal contact
Tradition	Respect for, commitment to, and acceptance of the customs and ideas that traditional culture or religion impose on the self
Conformity	Restraint of actions, inclinations, and impulses likely to upset or harm others and to violate social expectations or norms
Security	Safety, harmony, and stability of society, of relationships and of the self

Schwartz (Schwartz 1994) contended that Hofstede's axes of cultural variation was too general. He attempted to characterize cultural differences using a more individual measure (values) and with greater resolution of behavior (more values). Table 2 summarizes Schwartz's proposed enhancements to Hofstede's national culture model. It uses fifty-six specific values categorized into ten value types to offer increased flexibility, resolution, and arguably accuracy for one trying to construct or interpret a model of an organization's culture.

The Basic Problem

A common approach to understanding cultural diversity in organizations is premised on the idea of *surface level diversity* – that is, that visible traits like gender, organizational boundary, and functional group membership are the primary source of beliefs and behavior that people call culture. Indeed, many core texts on culture in engineering organizations (Schein 1992, Schein 1996) use this premise. It assumes that there is a difference between three cultures called "Engineering," "Operations," and "Management." However, this approach has risk because it is an arbitrary unitization, meaning units of analysis are arbitrarily defined and have no verifiable relationship to the true sources of difference or agreement (Caulkins 2001).

This is a danger for multinational working because the validity of surface level diversity traits as the variable that defines cultural consensus or disagreement becomes increasingly suspect. Consider, for example, that a Caucasian male with an American accent and a UK passport travels to Asia to make a presentation in his third language about organizational trends in a country where he has lived for less than half his life. Identifying the surface level diversity trait that defines this person's "culture" is problematic.

This is not just a metaphysical concern. We know the standard team sequence of Forming, Storming, Norming, and Performing (Tuckman 1965, Tuckman and Jensen 1977). Phrases like "we want to create a global working culture" carry the assumptions of consensus related to surface level diversity. If those boundaries are truly arbitrary, then the team has no systematic way to understand what it is they truly agree about, what they truly disagree about, and what their protocols for working together are going to be. The result is that the transition from Storming to Norming will be ad hoc, or that there will be significant cycling between Storming and Norming. Either case delays the team's transition to the Performing stage. When this delay occurs on schedule constrained programs, the organization will incur significant lost time and labor costs for this delay.

A Solution Framework

The criticism in the previous section is that relating Surface Level Diversity to identifying cultural boundaries is a tautological process. Differences are first defined by the researcher using surface level diversity traits. Collected data are then categorized according to these assumed differences. There is no attempt to validate the assumption that the assigned labels accurately measure the cultural boundaries of the group being studied. This criticism is supported by both anthropological (Handwerker 2002, Pelto and Pelto 1975) and organizational behavior (Bunderson 2003, Carpenter, et al. 2004) research, which shows that surface-level diversity can be a poor predictor of team dynamics and belief consensus. Identifying the actual characteristics that influence intracultural diversity, as well as providing valid measurement techniques for cultural phenomena in organizations would significantly improve the construct of organizational culture and facilitate improved decision-making.

There is a strong social science research heritage that measures variables like stress, ethnicity, health, economic development, and religious commitment (Bernard 2002, Dressler and Bindon 2000, McCutcheon 1987). As with multivariate process control in engineering, the assumption in these research areas is that while the variable of interest cannot be directly observed, it can be systematically studied by looking at co-variation among a larger set of variables that can be observed. The interdependence among these observable variables is a result of their common tie to the underlying construct.

Anthropological research extends this approach from looking for similarities among *variables*, to looking for similarities among *people*. *Cultural Consensus Analysis* provides a quantitative method to identify, measure, and analyze shared meaning systems and the variables that influence them (Handwerker 2001, 2002, Romney, et al. 1986, 1988). Culture thus becomes a multidimensional construct that can be measured by identifying correlated ideas and behaviors among a group of people. This increases its *construct validity* (Bernard 2002:54-55), meaning that there is a high degree of agreement between a set of observations and the proposed construct those observations claim to measure. It highlights, and allows data-driven discussions about, two characteristics of organizational culture:

1. The culture that specific people use to live their lives constitutes an evolving configuration of cognition, emotion, and behavior <u>unique to themselves</u>; and
2. Cultures consist of evolving configurations of cognition, emotion, and behavior at the <u>intersection</u> of individually unique cultural sets.

Furthermore, it allows reconciliation of two apparently contradictory observations:

1. Individuals vary, make choices, and exert control over their lives, and
2. Individuals find themselves constrained by recurrent patterns with the properties of superorganic wholes.

The Cultural Consensus Analysis Method

The heritage of Cultural Consensus Analysis comes from cultural anthropology, although the mathematical method is widely used in Organizational Behavior. The analytical background is that even when written rules don't exist, groups of people use structured, systematic ways to understand and engage their world (Borgatti 1994, 1998, Handwerker 2001). The approach has been used extensively in a number of cognitive science domains, including healthcare, linguistics, ecology, and human-computer interaction. It has recently been applied to measuring knowledge in organizations (Borgatti and Carboni 2007, Caulkins 2004, Collins 2003, 2007, 2009).

Table 3 – Forms of Qualitative and Quantitative Data Analysis

	Qualitative Data	Quantitative Data
Qualitative Analysis	A - Interpretive studies of text and interviews	B - Identify themes and patterns from statistical data
Quantitative Analysis	C - Identify structure from observed behaviors / texts / interviews	D - Numerical analysis of numerical data

Table 3 identifies a four cell matrix of possibilities for qualitative and quantitative analysis of data. The heritage of Six Sigma and other process improvement initiatives is to collect quantitative data, conduct quantitative analysis, and use the results to correct defects or identify improvements (Cells B and D). Most knowledge management efforts try to take expertise, which is recognized as qualitatively observed, and move it into Cell D. Cultural consensus analysis provides an alternative by evaluating data in Cell B. The approach accepts the qualitative nature of expertise, informal knowledge, and questions without single "correct" answers. It also provides rigorous statistical methods to identify the underlying structure of this knowledge. An overview of Cultural Consensus Analysis is given below (Romney, et al. 1988, Smith, et al. 2004).

Let Participant 1's cultural knowledge be the probability of producing a "culturally correct" answer (Figure 1) that they either know or guess correctly. Participant 1's answers to a set of statements about a particular domain create a response vector defining their knowledge about that domain. Within a given group, two participants share cultural knowledge to the degree that they respond to each statement in the same way. This agreement can be captured as a matrix that measures the similarity of responses among each participant.

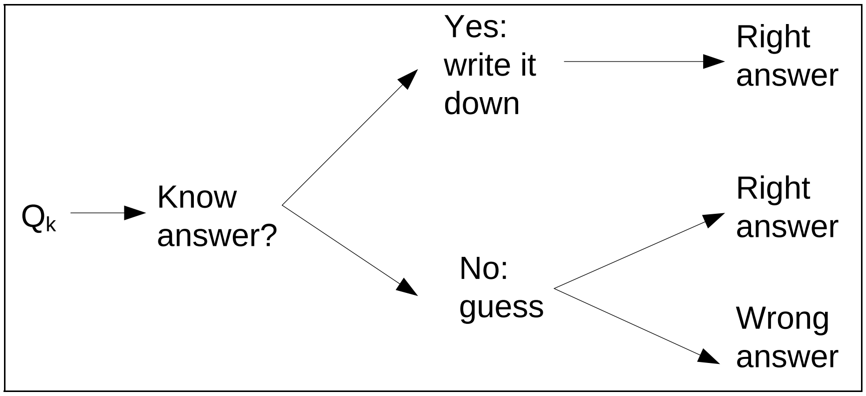

Figure 1 – Basic Response Model for Measuring Cultural Knowledge

The variance in the matrix represents the variation in cultural knowledge for the group. It can be measured analytically using a number of numerical methods, including least squares factor analysis, principal components analysis, and the minimum residual method. Several rules exist to identify cultural groups and shared knowledge among the participants based on the eigenvalue and factor values of the matrix (Handwerker 2002, Jackson 2003).

Cultural Consensus Analysis Case Studies in Organizations

Unlike the surface level diversity assumptions in common organizational culture discussions, Cultural Consensus Analysis (CCA) contains no assumption about the axes of comparison or boundaries of cultural agreement. The approach maintains a foundational assumption that cultural boundaries are to be teased out of data empirically. The inherent value in this approach is the organic manner in which the cultural experts assist with defining of the boundaries and measures of culture.

CCA provides an empirical basis to explore the cultural processes of consensus-building, factionalism, deterioration of consensus, and cultural drift. These insights can be used to support standard six sigma or process alignment initiatives in which many Systems Engineers engage in global enterprises. This can be done in several ways. First, it is possible to measure Cultural Consensus – that is, to identify that a group of individuals agree on the relationships between a set of items in a given domain. Second, it is possible to measure Cultural Diversity – that is, to identify multiple conflicting or overlapping views of item relationships for the same domain. Third, it is possible to identify Fragmented Cultures – that is, to identify that no shared agreement exists for the items in a domain. Finally, it is possible to identify Prototypical Cultures – that is, to identify agreement that is forming in a particular direction, but which is not yet firm. The next section uses three case studies to illustrate these insights.

Improving Collaboration: Modeling Effective Parent/Teacher Relationships

The first case study examines cultural models of effective relationships between parents and teachers. The common goal in this relationship is the education of children. The goal was to determine characteristics of an effective parent-teacher working relationship, and understand the various levels of parental involvement children's education (Handwerker 2002).

The CCA results showed that the high surface level diversity in terms of ethnicity among the participants (e.g. Puerto Rican, Caucasian, Chinese American and African American) did not clearly demarcate different beliefs about an effective parent / teacher relationship. Instead the results identified two clear cultures relative to parent/teacher relationships. The first culture perceived responsibility for factors of successful education as being shared between parent and teacher. The second perceived distinct and separate responsibilities for the parents and teachers. By identifying the false assumption of ethnically demarcated cultures, CCA helped focus the intervention on the substantive issues at stake – the discussions required to identify roles and distribution of work or cooperation between parents and teachers.

Guiding Entrepreneurs: Understanding Business Success and Failure

The second case study examines knowledge that business advisors in the "Silicon Glen" region of central Scotland between Glasgow and Edinburgh have about what makes entrepreneurs' efforts succeed or fail (Caulkins 2004). The study was done for a group of advisors who evaluate new business ideas ranging from taxi cab companies and specialty market gardeners to computer software and hardware businesses with international customers. The goal was to understand the degree to which knowledge about successful businesses was shared by advisors who worked with similar organizations, different organizations, or whether the knowledge was not shared at all. To what degree is this knowledge really shared among business advisers – do they know the same things about success?

The unexpected finding of consensus in this case was that business advisors who worked for a variety of different organizations, including local government, academic institutions, and private organizations, had a shared cultural model about what constituted success in Scotland's Silicon Glen. By disproving the assumption that people who advise different types of organizations would disagree with each other, the consensus model focused discussion on the substantive issue of how to succeed in Silicon Glen's specific context.

The CCA results identified a single shared model for the content and the relative importance of the forms of small-business success. The model contained four key themes. First, the model identified essential elements of a successful business model (e.g. being reliable, enjoying one's work, having adequate finances, learning from past mistakes) over which managers have high control. Second, the model identified items dependent on the response of the market, and which the managers do not control (increasing market demand). Third, the model identified being able to fine-tune a business (utilizing employee skills, increasing profit margin). Fourth, the model identified characteristics dependent on the previous elements (sourcing locally, involving employees in running the business, establishing a multigenerational business). Finally, the model identified social duties to the community that result from business success. An economically successful business must become embedded in the social relations of its local community.

The CCA model provided two broad generalizations. First, it emphasized types of success directly related to business performance over which the entrepreneur can have some control (e.g., being reliable and developing a customer base). The least salient items in the model pertained to secondary issues, which were outcomes or results of the primary business activities and other extrinsic factors. A second generalization, flowing from the first, was that the successes in the lower rankings are dependent or contingent on the items above them. The items at the top of the rankings were likely to be the causes, means, or enabling conditions of the successes at the bottom of the rankings.

Verifying Training Programs: Improving Integrated Product Development Teams

The third case study examines effective Integrated Product Development (IPD) teams at a small engineering company (Smallcomp). Smallcomp implemented IPD teams (Hjort, et al. 1991) to facilitate cross-disciplinary communication among its Engineering and Operations functions, particularly during preliminary design. Smallcomp conducted a survey to solicit employee feedback on the effectiveness of its IPD teams. The managers who created the survey had three expectations. First, they expected members of the Engineering department to agree with each other and disagree with the Operations department about IPD teams at Smallcomp. Second, they expected members of the Operations department to agree with each other and disagree with the Engineering department about IPD teams at Smallcomp. Finally, due to these differences of opinion, they expected separate training packages to be necessary for the Engineering and Operations departments based on the survey results.

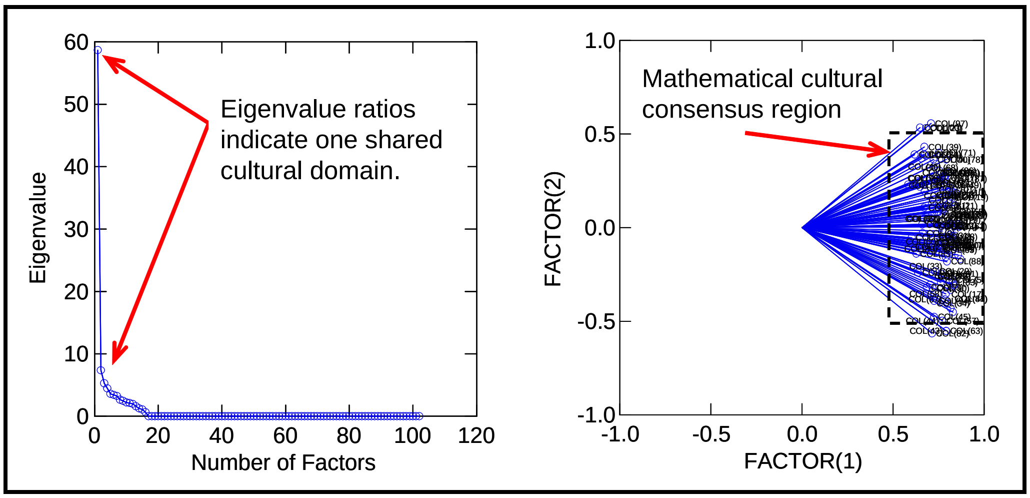

Figure 2: IPD Survey Cultural Consensus Analysis

Figure 2 shows a single domain of cultural consensus about effective IPD teams (Collins 2007). In other words, members of the Engineering and Operations departments did not disagree with each other about IPD teams at Smallcomp. Based on this analysis, Smallcomp was able to save the resources it planned for separate training packages. Furthermore, beyond the initial plan for general training about the awareness of how IPD teams should work, the results provided substantive guidelines for improving the effectiveness of Smallcomp's IPD teams. Table 4 ranks the survey questions along four dimensions (e.g. question 1 was highest on dimension 1, question 10 was highest on dimensions 2 and 3, question 15 was lowest on dimensions 2 and 3). The first two dimensions (Dim1 and Dim2) show themes that IPD implementation depends on task definition (reducing values on Dimension 2) and training (increasing values on Dimension 1). The last two dimensions (3 and 4) show themes that IPD implementation depends on empowerment and internal consensus. Empowerment to implement IPD teams is high when training is adequate (question 5) and roles are clear (question 14). It is low when there is limited management and team lead support (questions 7 and 11). Consensus to implement IPD teams is high when there is shared commitment to the concept (question 10). It is low when resources are not available (question 6) or the task dependencies are unclear (question 15).

Table 4 – IPD Survey Multidimensional Scaling Analysis (Kruskal Stress = 0.17)

			Rank on MDS Scale			
			Dim 1	Dim 2	Dim 3	Dim 4
Question	Question Text	Response*	We Agree	Definition	Consensus	Empowerment
1	IPD is the best process for rapid development of new products.	Yes	1	8	5	15
12	There is a strong sense of ownership of performance, schedule, and cost on the IPD teams	Yes	2	6	3	12
11	Project engineers and IPD team leaders support the IPD approach	Yes	3	10	8	14
7	Sr. Management supports and reinforces the IPD process	Yes	4	12	10	13
9	Functional managers buy into the IPD approach.	Maybe	5	2	2	8
4	IPD teams understand the product strategy and value proposition for their projects	Maybe	6	9	9	11
2	Smallcomp procedures for Product Design and Development Process and IPD Team Structure, clearly define the IPD process.	Maybe	7	13	13	10
3	There is strong support (communications, coordination, and commitment) for the IPD process at the working level.	Maybe	8	4	4	7
15	Many tasks are not clearly identifiable with an IPD team, and the interdependences of the tasks results in wasted time	Yes	9	15	15	9
10	All groups: Manufacturing, Engineering, Supply Chain, Planning, Quality, etc. support the IPD process	Maybe	10	1	1	5
8	The terminology and definitions for IPD are consistent	Maybe	11	11	12	6
14	Roles and Responsibilities are clearly understood	No	12	5	6	3
13	Compared to other divisions at Multinat, IPD teams function well at Smallcomp	No	13	3	7	2
6	IPD will not work effectively because it will always require too many resources to dedicate to the teams.	No	14	14	14	4
5	Training on IPD is adequate	No	15	7	11	1

*: Yes > 60% response; 40% < Maybe < 60%; No < 40% response

Dimension 1: We Agree		**Dimension 3: Consensus**	
High	This is true	High	This is a good idea
Low	This is not true	Low	Practical implementation at Smallcomp
Dimension 2: IPD Process Definition		**Dimension 4: Empowerment**	
High	Common understanding	High	Clear training
Low	Mgmt support; process clarity	Low	Mgmt support, general ownership

Applying Cultural Consensus Analysis in Systems Engineering

The previous examples show that Cultural Consensus Analysis identifies the substantive content of what real communities are, where they are different, and where they overlap. In particular, it builds on recent anthropological work around the notion of Cultural Consonance (Dressler and Bindon 2000, Dressler, et al. 2004) – the degree of agreement between what *should* be and what *is*. However, rather than dealing with states in a manufacturing process, it is possible to empirically measure cultural beliefs that influence several areas of concern to Systems Engineering organizations.

For example, the task of transferring best practices greatly depends on the representativeness of the sample of participants, the process architects' understanding of day-to-day activities, and their ability to identify themes from e-mail, teleconferences, or working group meetings. The approach in this paper to verify and refine those inferred themes, schema, or cultural models. This technique can be used to describe identity profiles for control systems engineers in multiple countries. Scenarios can be used to document claimed identity (what we do well at our site) and attributed identity (what group X does or wants us to do) and to discover similarities and differences across national or functional group (Systems / Hardware / Software / Supply Chain) boundaries. Possible scenarios that could be used for Control System Engineers working on aerospace engine systems are discussed elsewhere in these conference proceedings (Atherton and Collins 2009).

As a second example, this paper emphasizes cultural variation, or clines, rather than boundaries. Different geographic locations of a global company are sites for the performance of division best and worst practices. Many of these practices may be shared across socially constructed boundaries such as geographic site, development program, and functional area. CCA provides a tool to explore areas of greater or lesser sharing of cultural models that the practices are characteristic of a given location. By measuring consensus in each site about typical practices, it is possible to compare the culturally correct profiles of responses between each of the sites, revealing incremental changes, or clines, from site to site. These clines reveal opportunities for targeted interventions from programs such as process excellence and product lines.

Finally, some problems in sharing work and best practices within multinational companies recur because of unexpected value differences between engineers, managers, and process architects. The method in this paper identifies distinct groups with important value differences and similarities. An analysis of these value differences suggests specific and pragmatic interventions to improve cross-functional team performance for a given project. The three case studies in Section 6 all identify this type of application for CCA.

Cultural Consensus Analysis as a Tool for Organizational Control

That quantified content feeds culture as a rigorous element of organizational strategy and process excellence or six sigma initiatives targeted at changing team behavior. In six sigma terms, this is the difference between current versus the future state. In fact, conducting cultural consensus analysis lends itself very well to a DMAIC or DMADV approach.

<u>DEFINE</u>: Identify the group of interest, and conduct interviews to determine the items that define a particular domain of concern. This paper used collaboration, business success, and effective cross-functional teams as examples. We recognize there are numerous other domains of interest for Systems Engineering organizations.

<u>MEASURE</u>: Based on the interviews, develop a survey that tests cultural knowledge of individuals in the identified group. This can be done with questions that elicit a rank order of items (e.g. a 1 to 5 scale), or that elicit relationships between items (e.g. a paired comparison, triad, or pile sort test) (Borgatti 1998, Weller and Romney 1988).

<u>ANALYZE</u>: Use statistical software such as ANTHROPAC (Borgatti 1996) or SYSTAT (Wilkinson 1997) to test for cultural consensus. This will evaluate cultural consensus (what the group *should* do), cultural competence (how well individuals *conform* to the consensus), and cultural consonance (the difference between consensus and competence).

<u>INTERVENE / CONTROL</u> (for DMAIC): Develop an intervention to improve specific areas of cultural competence or consonance. For example, results from evaluating expertise in a Systems Engineering group could identify specific training for both new and current employees (Collins 2007).

<u>DEFINE / VERIFY</u> (for DMADV): If the cultural consensus analysis identifies unexpected patterns of agreement, then it is necessary to redefine the problem at stake. The case study at Smallcomp prevented a costly training program that would have targeted a non-existent

set of organizational differences. It identified areas of concern for both the Engineering and the Operations department by shifting attention away from perceived organizational boundaries and focusing on areas of common concern related to improving task definition, executing empowerment, and increasing internal consensus.

Findings and Implications

Despite frequent use of the term culture in contemporary engineering practice, there is currently no reliable way of understanding what constitutes true shared beliefs and meanings that impact how groups of Systems Engineers spread across multiple departments and countries work together. The fact that some companies successfully do this while others incur significant costs without accomplishing their goals identifies a conceptual and methodological gap in Systems Engineering practice. This paper seeks to address that gap by providing a concept of culture that helps deconstruct assumptions that shared beliefs correspond to shared surface level diversity traits. It provides an empirical basis to explore cultural processes of consensus-building, factionalism, deterioration of consensus and cultural drift in long term and/or multi-site studies, all of which are important in global Systems Engineering enterprises. This makes cultural variation an issue of empirical investigation. It quantifies cultural variability within an organization that might otherwise remain hidden. This requires continuous verification and validation of which differences truly exist, and which differences drive divergent behavior. That can only be accomplished by moving beyond the generalizations of Hofstede and others to develop a rigorous understanding of the specific context at stake.

The focus on V&V fits within the Systems Engineering framework, and also addresses the business reality of constantly shifting patterns of agreement among collaborating organizations. Treating cultural variation empirically using a V&V approach moves organizational change discussions away from speculating about mental states, which aren't measurable. Instead, it identifies concrete behaviors and environmental conditions that can form the basis of directed interventions. That distinction between mental states and observable behavior has been identified at length in empirical studies about improving engineering safety by understanding how operators truly use their equipment instead of how human factors experts believe they should (Collins 2007, Roberts, et al. 1980, Van der Schaaf and Kanse 2004).

Cultural Consensus Analysis provides a framework to conduct rigorous, empirical investigation in several different areas of concern to the Systems Engineering community. This provides insights that enhance a less empirical analysis which a manager might base on Table 1 or Table 2. Furthermore, it identifies substantive content of what real organizational cultures are, where they are different, and where they overlap. That quantified content feeds culture as a rigorous element of organizational strategy into global alignment and process excellence or six sigma initiatives targeted at changing team behavior. The result is a framework for conducting rigorous, empirical investigations to truly understand the human dimensions that are critical to effective Systems Engineering practice.

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