Revealing Cost Drivers for Systems Integration and Interoperability Through Q Methodology

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Abstract

Organizations are increasingly seeking to enhance performance and efficiency and establish new capabilities by integrating previously developed software systems. As organizations undertake the integration of multiple software systems, they often have little idea of how much it will cost or how long it will take. Little research has been performed to date on how cost drivers for integration differ from traditional single-system initiatives. This paper outlines a major research effort undertaken by the DOD, SEI and UNC to identify the non-SLOC based cost drivers of systems integration and interoperability. The paper then turns to a discussion of the potential role that "operant subjectivity" analysis may provide for expanding our understanding of the latent cost drivers that are often associated with integration and interoperability. We then illustrate the results of a study of public sector CIO's where Q Methodology was employed to isolate the system needs of local government agencies. The findings suggest that Q Methodology may prove helpful in isolating many of the non-technical latent cost factors associated with system integration and interoperability.

Revealing Cost Drivers for Systems Integration and Interoperability

Through Q Methodology

There is little debate that technological integration and interoperability (I&I) provides a significant support mechanism for leveraging the benefits that joint capabilities afford today's organizations. And much is being done to overcome the deleterious effects that silo based systems have on organizational performance. Despite the potential advances that can be derived from I&I efforts, the benefits are not easily achieved. In a study of 131 public and private sector CIO's, Brown (2004) found that, when asked to rate the difficulties encountered with I&I on a scale of one to ten, 70 percent of the sample rated I&I difficulty in the moderate to high range. Research findings tend to agree that many of the difficulties encountered in I&I are not technical in nature. Instead, researchers and practitioners alike are beginning to reveal that many of the difficulties associated with integration and interoperability are largely programmatic [Morris et al. 04]. Areas such as leadership, willingness to change, willingness to share power, and inability to establish shared understanding often undermine I&I efforts [Brown, 2004].

Recognizing the potential joint capability benefits that I&I can provide, the DoD has explicitly mandated that all systems be certified interoperable and all future development efforts be designed for integration (see the Chairman of the Joint Chiefs of Staff Manual 3170.01, Operation of the Joint Capabilities Integration and Development System, DoDI 5000.2, and Operation of the Defense Acquisition System, 2003). Yet the ability to provide validated analytical tools and method for developing joint resource plans, programs, and budgets from a capabilities-based perspective is largely under developed. As a consequence, in an attempt to isolate many of non-technical issues associated with I&I, a three-year research effort has been undertaken by the DOD, SEI, and UNC. In short, the research seeks to discover new methods and models for ensuring successful cross-organizational system integration, not only at the system level, but also at the organizational/policy level. This more expansive area of investigation is necessary because recent research reveals that organizational and policy factors are often the source of interoperability problems realized at the system of systems level.

Integration and interoperability efforts, by definition, involve collaborative efforts among independent organizations. What delineates integration and interoperability programmatic efforts from single system efforts is the fact that the stakeholders derive from multiple disciplines across multiple organizations. Often termed multi-agent systems, or complex adaptive systems, their performance levels are often a function of their ability to develop joint solutions that meet both individual and collective needs. They are composed of multiple independent parts that must behave in an optimal manner both at the individual and collective levels. In essence, they seek systems that allow both independence and interdependence simultaneously.

Specifically, in the design of integration and interoperability efforts, the DOD employs a framework that encourages designers, developers, and program managers to assess resource needs according to seven dimensions: doctrine, operations, training, materiels, leadership, personnel, and facilities. From a practical perspective, resource investments will be divided among these seven competing needs. Anecdotal evidence suggests that the doctrine, operations, training, leadership, personnel, and facilities (aka DOTLPF) dimensions are often sacrificed for materiels. In a non-interoperable / non-integrative systems development environment DOTLPF sacrifices may be relatively easy to absorb. But in an I&I environment, the collaboration that needs to occur to ensure that the interfaces behave properly is likely to have a significant impact on the DOTLPF's of each of the participating organizations.

Given that the stakeholders derive from multiple organizations, I&I efforts require unusually high levels of coordination and cooperation. Conflicting goals pose an especially serious problem in the I&I environment because the collective DOTLPF needs often conflict with the individual DOTLPF needs. The efforts are also complicated by the fact that, since the participants derive from multiple organizations, they lack a central leadership function that assumes stakeholder responsibility and accountability for sacrificing individual DOTLPF goals to reach a collective DOTLPF need (for example, the difficulty of establishing consensus on data standards). The lack of a central leadership role also forces the relationship into a collaborative arrangement where commitment cannot be mandated. Instead successful collaboration typically rests on interpersonal skills. Moreover, collaboration difficulties are often compounded by the stark fact that the costs and benefits of these types of efforts are rarely symmetrical across the participants. Hence, these efforts are at high risk for conflict and relatively immune to many of the traditional conflict resolution methodologies. The default solutions, i.e. establish central leadership and mandate standards, are infeasible because the relationships are often a mixture of public and private entities.

Unfortunately, many of the difficulties that are encountered in I&I are hard to predict and not easily observed at the start of the project when the resources are allocated. Thus, accounting for the late-rising latent resource demands is a major concern of the DoD. We believe that many of the I&I cost drivers are tacit or latent in nature; they are intangible, subjective, and contingent. Moreover, we believe that many of the cost drivers are buried in the syntactical and semantic differences in how each agency or service represents a system. Thus, many of the resources that will be required to "build the I&I bridge" will be inexplicable at the start when resources are allocated. The study of I&I is fundamentally a study of how to establish and maintain relationships for the purposes of benefiting from joint capabilities. We propose that the study of these relationships from an "operant subjectivity" frame of reference may allow the ability to detect early in the System Development Life Cycle (SDLC) the latent implicit, subjective, contingent, and inexplicable costs that typically arise late in the process and threaten the I&I effort.

I&I and Operant Subjectivity

This research model proposes to use an operant subjectivity approach, Q methodology, as the primary analytical tool to explore the social network influences of I&I cost and risk estimation. The long-range goal is to correlate a set of social network patterns (Factors in Q methodology) with historical project performance – with the expectation that the findings can be generalized to predict future performance. Before explaining the model a short discussion of "operant subjectivity" is required.

An agent is said to behave operantly if it is modifying its behavior in response to environmental consequences. The operantly behaving agent is constantly exploring the consequences of its own actions in the pursuit of optimality. Operant behaviors are exhibited in I&I efforts and influence the overall collaboration and cooperation efforts of the group. Group behaviors, and their resulting performance levels, are modified by individual motivations, abilities, roles, and situational contingencies. For example, most of the physically measurable artifacts associated with software cost estimation - e.g. SLOC, architectural views, specifications, and standards – are external to the operant and while providing these artifacts may alter the operant's *potential performance*, they do not in and of themselves improve performance. They only impact *actual performance* when they become a functional part of the operant's perspective [Brown 2003]. Subjective measures of the operant's internalization of these artifacts may contain keys to predicting their impacts and ways to measure the effectiveness of mitigation strategies.

Methodologies that focus on operant subjectivity allow researchers to isolate how these behaviors are manifested. The subjective component of the method allows analysts to tap individual perceptions of relevant issues. Given the assumption that the relationships of the group (network patterns) influence final outcomes, subjective measures are likely to play a significant role in achieving I&I outcomes. Thus, we believe Q may prove instrumental in understanding and predicting the overall performance of a group's I&I initiative. The following section provides a short illustration of Q Methodology. The closing paragraphs define our research model and how Q will be employed.

Q Methodology Background

Q methodology was invented in 1935 by British physicist-psychologist William Stephenson (1953) and is most often associated with quantitative analysis due to its involvement with factor analysis. Statistical procedures aside, however, what Stephenson was interested in providing was a way to reveal the subjectivity involved in any situation -- e.g., in perceptions of risk, appraisal of costs, perspectives on user requirements, opinions on training. It is life as lived from the *standpoint* of the person living it that Q methodology attempts to capture and ultimately measure. It is a method that allows researchers to examine the subjective perceptions of individuals on any number of topics. It also allows the ability to find commonalities and differences in subjective perceptions across a sample group. In short, Q-methodology is a research technique that allows the researcher to 1) identify, understand, and categorize individual perceptions and opinions, and 2) cluster the perceptions in like groups.

The real utility of Q-methodology lies in uncovering these opinion/perception clusters. Once identified, they can be targeted for follow-up activities such as further research or programmatic activities. It is the combination of 1) qualitative and 2) quantitative research techniques that allows the researchers to identify individuals who share common opinions. Q is often employed in areas such as:

1. identifying important internal and external constituencies
2. defining participant viewpoints and perceptions
3. providing sharper insight into preferred management directions

4. identifying criteria that are important to clusters of individuals
5. examining areas of friction, consensus and conflict, and
6. isolating gaps in shared understanding (Steelman and Maguire).

The qualitative aspect of Q-methodology is grounded in its ability to emphasize the *how* and *why* people think the way they do. The primary goal is to uncover different patterns of thought *not to count* how many people think the way they do (Valenta and Wigger, 1997). And the quantitative aspect involves using factor analytic techniques (specifically Principle Components Analysis) as a means for grouping like-minded individuals.

In short, Q-Methodology provides analysts with "a systematic and rigorously quantitative means for examining human subjectivity" (McKeown and Thomas, 1988). Q-Methodology constructs typologies of different perspectives based on subjective viewpoints. In terms of systems development, Q-methodology may be useful for

- Understanding, and mitigating pockets of resistance in system adoption,
- Targeting and tailoring system features, training needs, or security requirements,
- Isolating data standards requirements for system integration,
- Tailoring system performance measures and metrics,
- Understanding system risk elements, or
- Tailoring checklists and criteria for understanding cost, schedule, and sizing estimates.

A Primer on Q Methodology

Q can be used to observe operant subjectivity at multiple units of analysis. Intrasubjective studies attempt to assess how an individual's different opinion constructs might cluster together. An individual may be asked to reveal their perceptions on a variety of different constructs, and when examined in total, the findings may reveal similarity patterns. For example, a programmer may be studied to determine his or her preferences for different software programming methodologies under various conditions. In this case the study is intrasubjective because the researcher is studying a single individual to determine if preferences cluster around one or more common themes. These studies may be single dimensional, but are often multidimensional in nature as the researcher tends to be attempting to determine how preferences cluster around multiple dimensions or constructs. Conversely, intersubjective studies focus on how groups of people cluster on one or more constructs. These studies may also be single or multidimensional. The point being, if one was only concerned about how various traits clustered together, they would be employing traditional factor analysis (R based) methods. Alternatively, Q is concerned about clustering like-minded perceptions and hence whether the study is single dimensional or multidimensional it is always framed around subjective perceptions. The methodology involves three distinct stages of activities: Establishing the Q-sample, Administering the Q-Sort, and Factor Analyzing the Q-Sorts.

Stage 1: Establishing the Q-sample.

Establishing the Q-Sample involves identifying the survey items (not the participants), or statements, that will be used to identify individual perceptions. Because the survey items are perceptual in nature, they tend to reflect subjective statements pertaining to the particular research area of interest. (Later, during the Q-Sort procedure, the participants will be asked to rank order these survey items according to their individual level of agreement.) This collection of items is not restricted to words but has been known to include paintings, art-work, photographs, or even musical selections (Brown). While the actual items can take several different forms the scale the participants sort the items on remains fixed. For example, a participant may be asked to sort each of the survey items on a –5 to +5 scale on whether they agree with the statement "the software process would benefit more from additional investments in QA than additional investments in system design."

The survey items (or statements) that compile the concourse can be derived in a number of ways. Typically, the items are collected through personal interviews and focus groups. Focus group discussions will often reveal the multiplicity of subjective perceptions and allow the researcher to design specific survey items that drill down into these particular attitudes. Other sources for the survey items may include journal publications or news paper articles. The primary point is that the collection of items in the concourse should reflect the range of the perceptions on the particular topic of interest. In many cases, researchers will pilot test the concourse to verify its validity. Because participants are asked to sort the statements in a particular manner (see Stage 2), most Q-Samples consist of either 30 or 60 items. After the Q Sample is constructed, each item in the sample is numbered for data recording purposes.

It should be noted that the goal of the Q-Sample is to provide, in miniature, a comprehensive portrayal of the larger process being modeled (Brown, 1993). To ensure content validity, sample statements are usually reviewed by domain experts and tested in one or more pilot studies. In terms of comprehensiveness and representativeness of any given Q Sample, the design of the instrument is performed as carefully as participant selection is conducted for survey studies. Hence, some researchers prefer to develop a larger set of items and then pull a random sample of 30 or 60 items to administer.

Because Q Methodology does not seek to make claims to larger untapped populations, it is less concerned with participant sampling techniques. There is often the assumption that the participants are the total population. Since the focus is on capturing the wide array of perceptions, the rigor that is often associated with identifying the participant sample is actually placed on Stage 1 in identifying the survey items. The outcome of the Q-Sample Stage should be attainment of a comprehensive, balanced, and representative set of survey items. Once the Q Sample has been designed it is released for "sorting."

Stage 2: Administering the Q-Sort

Stage 2 involves administering the Q-Sort or collecting participant perceptions. When administering the Q-Sort, participants are often given a sheet with specific sorting instructions called a *condition of instruction*, and an answer sheet to record the rank ordering (see figure 1). In this stage, participants are asked to sort the opinion statements into a predefined set of categories, ranging from "Most Agree" to "Most Disagree." As noted in figure 1, the answer form that participants use to sort the survey items forces the Q-Sort into the shape of a normal distribution. There are fewer statements that can be placed at either of the ends and more are allowed to go into the middle, or neutral, zone of the scale.

The Q-Sample is administered to each participant and his or her individual rank-ordered statements are then recorded and collected. The resulting data matrix will reflect the participant's sorting arrangements in the column with the survey item statement along the row. The ranking level of each item is then entered into the data matrix to allow factor analysis. Because each item is measured according to the individual's perception, and on the same scale, the individual's specific array can be correlated with the array's of the other participants. The data can then be analyzed with a variety of statistical tools (see Stage 3). The outcomes of this stage should be a data matrix of the participants rank ordering of each of the survey items in the Q Sample. Given that respondents, or participants, array their perceptions in a forced matrix reflecting a normal distribution curve, participants can be correlated and grouped according to their level of agreement or similarity – the goal of the next stage.

Stage 3: Analyzing the Q-Sorts

Data analysis in Q-Methodology typically involves the sequential application of three sets of statistical procedures: correlation, factor analysis, and the computation of factor scores. The discussion below speaks briefly to each of these issues. Readers are encouraged to examine the citations provided below to develop a deeper understanding of these specific statistical tools. It should be noted that while the steps are discussed below, most statistical software generates these procedures automatically. Hence the discussion is meant to explain what is occurring, not to provide a concrete list of instructions.

The first step that occurs in analyzing the data is to generate a correlation matrix of the participants. As Brown (1971) has shown, it makes no difference whether the coefficients in the correlation matrix are Pearson's *r*, Spearman's *rho,* or any other commonly employed nonparametric measure of association. As a practical matter, the factoring process commences once a matrix of Q-Sort correlations is provided.

According to a variety of research findings, it makes little difference whether the specific factoring routine is principal components, centroid, or any other available method. Regardless of the precise procedures employed, the resultant factor structures appear to differ little from one another in any appreciable respects (Thomas and McKeown, 1998). By convention, Principle Components Analysis with a Varimax Rotation is the most common routine employed (For detailed elaboration see Adcock, 1954; Harman, 1976; or Brown, 1980). Hence the case examined below will focus on analyzing Q-Sorts using PCA with the Varimax method of orthogonal rotation.

Factor loadings are in effect correlation coefficients: They indicate the extent to which each Q-Sort (i.e. participant) is similar or dissimilar to the composite factor array. In most research applications, factor interpretation proceeds on the basis of factor loadings. In Q, on the other hand, interpretations are based on factor scores. In Q-Methodology the presence of several orthogonal (independent) factors is evidence of different points of view in the participant-sample. An individual's positive loading on a factor indicates his or her shared subjectivity with others on that factor; negative loadings, on the other hand, are signs of rejection of the factor's perspective (Thomas and McKeown, 1988). The following case illustrates the analysis and interpretation of a group of city and county chief executive officers to understand the types of IT assistance that they perceived would be most helpful to local governments.

Q Methodology: An Application

The study began by holding a focus group discussion to identify relevant Q Sample Items. Based on discussion and dialog, 33 items were derived, and thus composed the Q Sample (see Table 1).

The Q Sample was administered and the CEO's were asked to sort the items in terms of their level of agreement on a -4 to +4 scale. All participants sorted their responses according to a "forced" normal distribution curve. Table 2 illustrates the Q Sort for Respondent 2 (R2). As demonstrated in the Sort, R2 ranked Items 1 (data policies) and 28 (process improvement) as the areas requiring the greatest attention. Conversely, Items 5 and 6 (changes in business related standard operating procedures and changes in IT related standard operating procedures) as requiring the least attention. The data for all 13 CEO's were collected and entered in a data matrix (table 3). In keeping with the Q methodology process, individual respondents were listed along the column and Q sample items along the row.

The next step was to obtain the correlation matrix of the Q Sorts (table 4). As noted in the table, R1 correlates with R5 in the amount of .51, and a quick perusal down the column shows a weak correlation with R3 (.34) and R4 (.32). R3, on the other hand, shows a fairly moderate correlation with R4 (.69), R5 (.49), and R7 (.46). It should be noted that Q Sort correlations are rarely of any interest in and of themselves and typically represent only a phase through which the data pass on the way to being factor analyzed (Brown, et al. 1999).

Once the correlation matrix is obtained, the factor analysis process begins, an unrotated factor matrix is computed and Eigenvalues identified. The factor loadings are in effect correlation coefficients: they indicate the extent to which each Q Sort is similar or dissimilar to the composite factor array for that type. By convention, factors with Eigenvalues greater than 1.00 are considered significant; those with Eigenvalues of lesser value are considered too weak to warrant serious attention. For this size sample, factor loadings in excess of .45 are considered significant ($p<.01$). Referring to Table 5 Factor 1, the loadings of R1 (.54), R3 (.79), R4 (.77), R5 (.71), R7 (.53), and R9 (.62) means that the Q Sorts for these people share a common perspective, or are highly correlated.

The Eignevalue of 3.73 is considered significant and thus, Factor 1 appears to represent a common viewpoint held by a number of the respondents. The Eigenvalues for Factors 2, 3, and 4 are also significant (2.3, 1.4, and 1.3, respectively). While Factor 5 appears to demonstrate borderline significance (Eigenvalue = 1.06), perusing the columns one will note that since only two respondents (R1 and R13) were loaded significantly, the factor did not constitute a large enough group to merit further examination. Hence four factors were identified for further analysis.

In Q, interpretations are based on factor arrays and factor scores rather than loadings which are typically used in factor analysis based on categorical variables. After controlling for the weighting of each of the factor loadings, a composite Q Sort, termed the Array) can be uncovered for each of the Factors. As shown in Table 7, these Factor Arrays reflect an overall Q Sample for the respondents in total. Based on these Factor arrays, we can then identify the distinguishing statements (Items) that are associated with each Factor. Thus we can begin to see the pattern of thoughts that arises specific to each of the four groups.

Referring back to Table 6, Respondents 3, 7, and 10 make up Factor 1. As illustrated in table 8, Factor 1 identifies that the grouping shared strong opinions on the need for assistance in “understanding and defining security legislation” and “achieving added value” from their systems. Note that theses two items received a +4 on the Q Sort. The respondents were also similar in their thinking in that they did not perceive “data policies,” “disaster recovery,” or “returns-on-investment” as areas for needed assistance.

Turning our attention to Table 9, Respondents 1,3,4, and 6 illustrate the need for assistance in “standard operating procedures for IT and business related practices” that impact system efforts. They also hang together in their impressions of the need for assistance with achieving transparency and accountability gains from systems. They are in agreement, *albeit not concerned*, with needing assistance in cost savings, added value, or citizen engagement.

Respondents 2, 11, and 12 form a similar pattern of thinking on the need for assistance with “engineering documents,” “data sharing,” “the ethical use of systems,” and “test program reviews” (table 10). “Emerging privacy legislation” is not an area that is deemed important for assistance.

Finally, Factor 4 is distinguished by the need for assistance in “training” and “return-on-investment strategies” related to IT systems. These respondents (5,7,8,9, and 13) saw little need for assistance in standard operating procedures or prototyping. Table 12 shows the Q Sample Items that did not distinguish any of the factors. It should be noted that this does not imply that none of the respondents deemed these areas as necessary for assistance, rather that their thinking on the subjects did not distinguish them from the others.

In sum, the analysis revealed four patterns of thought: one that stressed security and added value (Factor 1), one that stressed process issues (Factor 2) , one that valued technical support (Factor 3), and one that was concerned with training and investment (Factor 4). Note that in the analysis, we are less concerned with which respondents fall where, and more concerned with the overall pattern of opinions that emerge. Q's strength is in revealing the dominant patterns and clusters of opinions that surface within a group from the group's perspective.

Conclusion

Q Methodology is a method for exploring dominant perceptions or patterns of thought. In essence, it is a method that can help to capture and reflect the richness and complexity of various points of view. It is used primarily to identify groups with conflicting values, preferences, and opinions to better understand the context of actions. It is also often used to identify potential areas for research or action. For the purposes of our research, the application of the Q-sorts across multiple I&I programs will produce a pool of Factors that will be correlated with schedule, budget, and quality indicators of performance
At a minimum, we expect the identification of differentiating Factors will be beneficial to the software community. Continued analysis will allow us to ascertain clues to risk mitigation strategies, pointers to areas worthy of more detailed research, and a mechanism to systematically investigate operant subjectivity.

Our long range goal is to produce a set of concourses that when administered to a newly formed program team, perhaps at different points in the lifecycle, will produce Factors that are predictive of subsequent project performance. We believe this is a unique application of Q methodology and presents the software engineering community with an opportunity to leverage knowledge from a different domain that will shed light on aspects of software development that heretofore went untapped.

Figure 1: Q Sort Answer Sheet								
Most Disagree								Most Agree
-4	-3	-2	-1	0	+1	+2	+3	+4

Table 1: Q Sample Items	
Item #	In my opinion local governments need the most help in establishing and understanding:
1	data policies
2	emerging privacy legislation
3	emerging security legislation
4	ethical use of sfw, techology, and data
5	changes in business related standard operating procedures
6	changes in IT related standard operating procedures
7	ADA requirements
8	data sharing
9	prototyping new software solutions
10	technical requirements definition
11	code inspections
12	test program reviews
13	screen design, format, and layout
14	disaster recovery
15	engineering documents
16	technical documentation
17	training investments
18	ROI strategies
19	Quality Assurance
20	risk management

21	estimating cost and schedule
22	communications and team building
23	visioning/strategic planning and goal alignment
24	contracting and outsourcing
25	auditing and post-mortems
26	productivity changes
27	cost savings
28	process improvement
29	added value
30	leveraging organizational information and knowledge
31	developing feasible and reliable metrics
32	citizen engagement
33	transparency and accountability

Table 2: Q Sort for Respondent 2

-4	-3	-2	-1	0	+1	+2	+3	+4
5	15	9	19	3	7	2	17	1
6	25	10	22	4	21	14	23	28
	31	11	26	12	24	33	18	
		16	29	13	27	8		
			32	20	30			

Table 3: Q Sort by Respondent

Item	1	2	3	4	5	6	7	8	9	10	11	12	13
1	-2	4	3	-1	4	3	2	4	4	4	3	0	4
2	-1	2	-3	0	-2	-3	-3	-1	-2	-1	2	-1	-4
3	-2	0	0	-3	2	-3	-3	-1	-2	-1	1	4	-4
4	-1	0	3	2	1	-4	0	-2	2	-4	1	-2	-3
5	-1	-4	0	3	4	2	4	2	3	3	-1	0	-3
6	-1	-4	0	0	3	2	3	3	0	4	-2	0	-3
7	0	1	-4	-1	2	-1	-4	-3	-1	-3	-3	-1	-2
8	-1	2	4	4	3	2	0	0	2	-2	-1	0	1
9	2	-2	2	2	2	4	3	0	1	1	-3	2	0
10	-2	-2	-1	1	2	1	1	1	-4	1	-1	1	-1
11	-2	-2	-3	-3	0	-3	-1	1	-3	0	-3	-1	0
12	-3	0	1	-2	1	2	-1	0	0	-1	-2	-2	-2

13	-3	0	-1	-1	1	-2	-4	-3	-4	-2	-4	1	-2
14	-3	2	-1	1	1	3	-3	-3	0	1	0	-3	0
15	-4	-3	4	-1	0	4	-2	-2	-1	0	-2	-4	1
16	-4	-2	-1	0	1	3	-2	-2	-1	0	0	-3	0
17	0	3	-2	-2	-3	-2	2	1	2	-1	1	-3	3
18	1	3	1	1	3	1	1	0	1	-1	3	-4	2
19	1	-1	0	2	0	0	1	1	-1	1	2	2	3
20	1	0	0	-2	0	-2	0	0	0	1	0	0	2
21	0	1	1	0	0	0	0	2	0	0	2	1	2
22	1	-1	2	3	0	-2	0	2	3	0	1	3	2
23	2	3	2	1	-1	1	3	4	4	3	4	2	3
24	4	1	-2	0	-4	1	2	3	0	-3	3	1	0
25	0	-3	1	-3	-4	0	0	-4	-1	0	0	0	-2
26	3	-1	0	1	-1	0	-1	1	1	-2	4	3	1
27	3	1	2	-2	-3	1	2	0	-3	-2	2	2	4
28	4	4	-1	4	-1	0	4	3	1	2	1	1	-1
29	0	-1	1	-4	-1	-1	-1	-1	-2	-3	0	4	1
30	2	1	-2	3	-2	0	-1	-1	2	2	0	-1	-1
31	1	-3	-2	-4	-3	-4	-2	-2	-2	2	-1	-2	0
32	0	-1	3	-1	-2	-1	1	-4	3	-4	-1	3	1
33	2	2	-3	2	-2	-1	-2	-1	1	3	-2	-1	-1

Table 4: Correlation Matrix Between Sorts

SORTS	1	2	3	4	5	6	7	8	9	10	11	12	13
1 r1	100	29	34	32	51	23	27	23	14	1	13	31	-3
2 r2	29	100	7	20	15	23	-49	-7	-23	-9	26	38	-15
3 r3	34	7	100	69	49	34	46	4	32	22	35	35	33
4 r4	32	20	69	100	37	47	35	25	46	24	8	22	34
5 r5	51	15	49	37	100	24	27	33	35	0	40	23	28
6 r6	23	23	34	47	24	100	2	-4	-1	-13	-11	32	6
7 r7	27	-49	46	35	27	2	100	28	44	40	-12	-15	28
8 r8	23	-7	4	25	33	-4	28	100	47	-9	-6	-4	33
9 r9	14	-23	32	46	35	-1	44	47	100	20	18	-1	44
10 r10	1	-9	22	24	0	-13	40	-9	20	100	20	-16	9
11 r11	13	26	35	8	40	-11	-12	-6	18	20	100	38	37
12 r12	31	38	35	22	23	32	-15	-4	-1	-16	38	100	23
13 r13	-3	-15	33	34	28	6	28	33	44	9	37	23	100

Note: Decimals to two places omitted

Table 5: Unrotated Factor Loadings

SORTS	Factors 1	2	3	4	5	6	7	8
1 r1	0.5426	0.2893	-0.3061	-0.1161	0.5690	-0.1729	0.2301	0.0080
2 r2	0.1000	0.7930	0.0314	-0.0216	0.2049	0.4741	0.0322	0.0536
3 r3	0.7975	0.0910	-0.0245	0.3505	-0.0821	-0.1689	-0.0914	-0.1712
4 r4	0.7767	0.0401	-0.2650	0.2174	-0.2016	0.3568	-0.0172	-0.1199
5 r5	0.7152	0.1459	0.0232	-0.2443	0.2944	-0.2050	-0.4195	0.1424
6 r6	0.3731	0.4166	-0.5484	0.1631	-0.4020	-0.0046	-0.1690	0.2243
7 r7	0.5382	-0.6394	-0.2230	0.2097	0.1339	-0.2727	0.1583	0.0677
8 r8	0.4119	-0.3223	-0.1397	-0.6877	0.0908	0.2724	0.1562	0.1525
9 r9	0.6241	-0.4545	0.1129	-0.2267	-0.0730	0.2306	-0.0739	-0.3979
10 r10	0.2503	-0.3609	0.2595	0.6549	0.2832	0.3112	0.1487	0.2223
11 r11	0.4066	0.3035	0.7821	0.0344	0.1238	-0.0660	-0.1543	-0.0002
12 r12	0.3906	0.6377	0.1741	-0.0493	-0.2238	-0.2336	0.4577	-0.1239
13 r13	0.5619	-0.2160	0.4139	-0.2067	-0.4724	-0.0300	0.1149	0.3137
Eigenvalues	3.7395	2.3121	1.4293	1.3139	1.0617	0.8109	0.5907	0.4665
% expl.Var.	29	18	11	10	8	6	5	4

Table 6: Factor Matrix with an X Indicating a Defining Sort

	Loadings			
QSORT	1	2	3	4
1 r1	-0.1029	0.6442X	0.1156	0.2153
2 r2	-0.3271	0.3842	0.5380	-0.3102
3 r3	0.5105	0.6165	0.2706	0.2320
4 r4	0.3629	0.7102X	0.0588	0.2879
5 r5	0.0005	0.4702	0.3222	0.5178
6 r6	-0.0582	0.7818X	-0.0382	-0.1549
7 r7	0.5853	0.2367	-0.3969	0.4858
8 r8	-0.2864	0.1088	-0.1682	0.8024X
9 r9	0.2711	0.0995	-0.0066	0.7595X
10 r10	0.8270X	-0.0594	0.0357	-0.0223
11 r11	0.2244	-0.0869	0.8794X	0.1973
12 r12	-0.1428	0.4107	0.6344X	-0.0173
13 r13	0.2315	-0.0202	0.3412	0.6372X
% expl.Var.	14	20	15	19

Table 7: Factor Q-Sort Values for Each Statement

No.	Statement	No.	Factor Arrays 1	2	3	4
1	data policies	1	-1	4	3	4
2	emerging privacy legislation	2	-2	-1	-4	1
3	emerging security legislation	3	4	-2	-1	-1
4	ethical use of sfw, techology, and data	4	-2	-2	2	0
5	changes in business related SOP	5	-1	3	0	-4
6	changes in IT related SOP	6	-1	3	0	-4
7	ADA requirements	7	-2	-3	-4	-1
8	data sharing	8	-1	1	4	1
9	prototyping new software solutions	9	2	1	3	-3
10	technical requirements definition	10	1	1	-1	-2
11	code inspections	11	-2	0	-4	-3
12	test program reviews	12	-2	-2	2	-1
13	screen design, format, and layout	13	1	-3	-2	-3
14	disaster recovery	14	-3	0	-1	1
15	engineering documents	15	-4	-1	4	-2
16	technical documentation	16	-3	-1	-1	-1
17	training investments	17	-3	-1	-2	3
18	ROI strategies	18	-4	0	1	3
19	Quality Assurance	19	2	2	0	1
20	risk management	20	-1	1	-1	1
21	estimating cost and schedule	21	1	1	1	2
22	communications and team building	22	3	2	1	0
23	visioning/strategic planning and goal alignment	23	2	4	2	4
24	contracting and outsourcing	24	1	0	-2	2
25	auditing and post-mortems	25	-1	-3	1	-2
26	productivity changes	26	3	0	0	2
27	cost savings	27	2	-2	2	3
28	process improvement	28	1	3	-1	2
29	added value	29	4	-4	1	0
30	leveraging organizational information and knowledge	30	-2	2	-2	0
31	developing feasible and reliable metrics	31	-2	-1	-3	-2
32	citizen engagement	32	3	-4	3	-1

33	transparency and accountability	33	-2	2	-3	0

Table 8: Distinguishing Statements for Factor 1
Both the Factor Q-Sort Value and the Normalized Score are Shown.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
3	emerging security legislation	3	4	1.78*	-2	-0.85	-1	-0.38	-1	-0.29
29	added value	29	4	1.78*	-4	-1.51	1	0.25	0	-0.16
13	screen design, format, and layout	13	1	0.43	-3	-1.20	-2	-0.69	-3	-1.10
1	data policies	1	-1	-0.03*	4	1.68	3	1.52	4	2.06
14	disaster recovery	14	-3	-1.39	0	-0.13	-1	-0.15	1	0.47
18	ROI strategies	18	-4	-1.84*	0	-0.09	1	0.47	3	1.58

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Table 9: Distinguishing Statements for Factor 2
Both the Factor Q-Sort Value and the Normalized Score are Shown.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
6	changes in IT related SOP	6	-1	-0.03	3	1.64*	0	0.16	-4	-1.79
5	changes in business related SOP	5	-1	-0.03	3	1.61*	0	0.16	-4	-1.58
33	transparency and accountability	33	-2	-0.48	2	0.91	-3	-1.41	0	-0.07
27	cost savings	27	2	0.88	-2	-0.78*	2	0.89	3	1.11
29	added value	29	4	1.78	-4	-1.51*	1	0.25	0	-0.16
32	citizen engagement	32	3	1.33	-4	-1.91*	3	1.09	-1	-0.37

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Table 10: Distinguishing Statements for Factor 3
Both the Factor Q-Sort Value and the Normalized Score are Shown.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
15	engineering documents	15	-4	-1.84	-1	-0.49	4	2.05*	-2	-1.07
8	data sharing	8	-1	-0.03	1	0.07	4	1.83*	1	0.38
4	ethical use of sfw, techology, and data	4	-2	-0.93	-2	-1.11	2	0.76	0	-0.18
12	test program reviews	12	-2	-0.93	-2	-0.52	2	0.58	-1	-0.68
2	emerging privacy legislation	2	-2	-0.48	-1	-0.42	-4	-1.63	1	0.41

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Table 11: Distinguishing Statements for Factor 4
Both the Factor Q-Sort Value and the Normalized Score are Shown.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
18	ROI strategies	18	-4	-1.84	0	-0.09	1	0.47	3	1.58
17	training investments	17	-3	-1.39	-1	-0.33	-2	-1.10	3	1.28*
32	citizen engagement	32	3	1.33	-4	-1.91	3	1.09	-1	-0.37*
9	prototyping new software solutions	9	2	0.88	1	0.57	3	1.21	-3	-1.15*
5	changes in business related SOP	5	-1	-0.03	3	1.61	0	0.16	-4	-1.58*
6	changes in IT related SOP	6	-1	-0.03	3	1.64	0	0.16	-4	-1.79*

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Table 12: Items That Do Not Distinguish Between ANY Pair of Factors.

All Listed Statements are Non-Significant at P>.01, and Those Flagged With an * are also Non-Significant at P>.05.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
16	technical documentation	16	-3	-1.39	-1	-0.35	-1	-0.15	-1	-0.52
19*	Quality Assurance	19	2	0.88	2	0.76	0	-0.05	1	0.50
20*	risk management	20	-1	-0.03	1	0.01	-1	-0.27	1	0.21
21*	estimating cost and schedule	21	1	0.43	1	0.40	1	0.36	2	0.87
22	communications and team building	22	3	1.33	2	0.83	1	0.56	0	0.17
23	visioning/strategic planning and goal alignment	23	2	0.88	4	1.70	2	0.89	4	1.90
31	developing feasible and reliable metrics	31	-2	-0.93	-1	-0.39	-3	-1.32	-2	-0.98

Glossary of Terminology

Concourse – the volume of subjective communicability on any topic, e.g., about what it is like to live in poverty, what it means to be empowered, etc.

Composite Statement Arrays
Q-Sample – the rigorously constructed set of questions that represent the concourse
Q-Sort – the ordered, zero sum rankings of the Q-sample into a predefined distribution across a Likert scale
Condition of Instruction – the condition or conditions under which subjects are instructed to perform their Q sorts
Factor – clusters of respondents who have ranked the statements in the Q-Sample in essentially the same fashion. Explanations of factors are advanced in terms of commonly shared attitudes or perspectives.
Factor Loadings - Correlation between the original variables and the factors, and the key to understanding the nature of a particular factor. Squared factor loadings indicate what percentage of the variance in an original variable is explained by a factor.
Factor matrix -Table displaying the factor loadings of all variables on each factor.
Factor rotation - Process of manipulation or adjusting the factor axes to achieve a simpler and pragmatically more meaningful factor solution.
Factor score - Composite measure created for each observation on each factor extracted in the factor analysis. The factor weights are used in conjunction with the original variable values to calculate each observation's score. The factor scores are standardized to according to a z-score.

Relevant Web Sites

Q Methodology Network -- **http://listserv.kent.edu/archives/q-method.html**

Q A Method for Modern Research - **http://www.qmethod.org/**

Q Sort - **http://www.q-sort.com/**

QMethod page - **http://www.rz.unibw-muenchen.de/~p41bsmk/qmethod/**

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