HUMAN INFORMATION PROCESSING STYLES AND THE INFORMATION SYSTEMS ARCHITECT IN THE PSC SYSTEMEERING MODEL

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INTRODUCTION

In the Nordic countries the term systemeering refers to the comprehensive set of activities associated with building an information system. This term has been adopted to focus attention on the broader, human and organization oriented concerns in the development of systematized information and data for users in organizations.

One version of the systemeering philosophy developed at the Institute of Data Processing Science at the University of Oulu is called the PSC systemeering model. These initials stand for three different systemeering types and for three of four main phases in the systems life cycle: pragmatic, semantic and constructive. These terms are derived from a general systems theory framework.

In the first section of this paper, we introduce the structure and dynamic functioning of the model. Attention focuses on the definition of primary roles and the communication needs among these roles in the systems development process. Then in the second section of the paper, the PSC life cycle is compared to traditional and evolutionary views of this process.

The primacy of the user in information systems development is a basic tenet of the Nordic approach to the life cycle. However the main objective in the PSC systemeering model is to balance the specific and often contradictory interests of the different groups concerned with systems development. To help insure harmony and coordination in the development process, the role of an information systems architect (ISA) has been developed. The third section of the paper explores the idea of the ISA position.

In the four phases of the development process, the systems architect position goes beyond the bounds of the traditional systems analyst. The scope of this position's responsibility is analogous to that of the building architect in a physical project except that in information systems product is a more complicated combination of material and nonmaterial factors than a building.

The work of the ISA can be understood in terms of human information processing (HIP) style. Four styles of processing range on a spectrum from left hemisphere to right hemisphere oriented skills. These are introduced in the fourth section of the paper. The styles that an ISA should exercise in PSC systemeering imply a breadth and depth of coordinating and harmonizing skills that argue for placing users in the architect role in systems development. In the absence of an adequate educational curriculum for the preparation of systems architects, assigning users to this role provides a viable alternative.

We feel curricula should be developed to educate ISA. The generally more narrow orientation of technical systems staff usually precludes their being able to move freely among the different HIP styles required in the main phases of the PSC process. Present United States academic programs provide more limited educational opportunities than are required for the ISA perspective. The last two sections of the paper discuss the meaning of HIP styles in the PSC main phases and the important skills of the ISA in the development process.

Roles in the PSC Systemeering Process

In the PSC systemeering model each main phase is concerned with certain decision problems. Solving these problems yield a set of models at successively lower levels of abstraction for each main phase (Kerola, 1979). The highest level of abstraction is pragmatic (P), the second semantic (S) and the third constructive (C). Each main phase supports a class of decision makers and is accomplished by appropriate experts called systemeers. The hierarchical order of the model implies a basic structure among the roles that is illustrated in Figure 1, The joint efforts of the people occupying these roles are briefly described in the following paragraphs.

In the pragmatic main phase, the information system is studied in terms of its influence on the environment and the influence of the environment on the information system. All three phases consist of a design and test cycle. In the P main phase, alternatives for an information systems solution are evaluated using a criterion of the net value of the effectiveness versus all the costs incurred during the life cycle. At this broad level the evaluation is qualitatively oriented. Effectiveness is a multidimensional criterion taking into account such factors as economic, social, technical, communicational, ecological and managerial components. The models selected for the proposed system at this level establish the solution space for moving into the S main phase.

The development of alternative solutions is refined in the semantic main phase as the focus turns to an evaluation of the information content produced by the system in terms of users' needs. This refinement takes the laternative chosen in the P main phase and develops alternatives at the next lower level of information systems definition. The design and test criteria in this phase are more tangible than in the P phase. For instance we can evaluate alternative information sets in terms of informativeness, accessibility and adaptability. These factors can in turn be stated as more explicit criteria for measurement. Using the lowest level criteria in this decision framework, the S level decision maker estimates net value based on cumulative user satisfaction expressed as a function of these criteria less the costs of providing that level of satisfation.

At the third constructive level of information systems development, the design and test responsibilities determine the structure and performers for the system. This identifies the man and/or machine components that will accomplish each function required in the information system to satisfy the information needs identified in the S main phase. At this level the decision criteria shift to the more

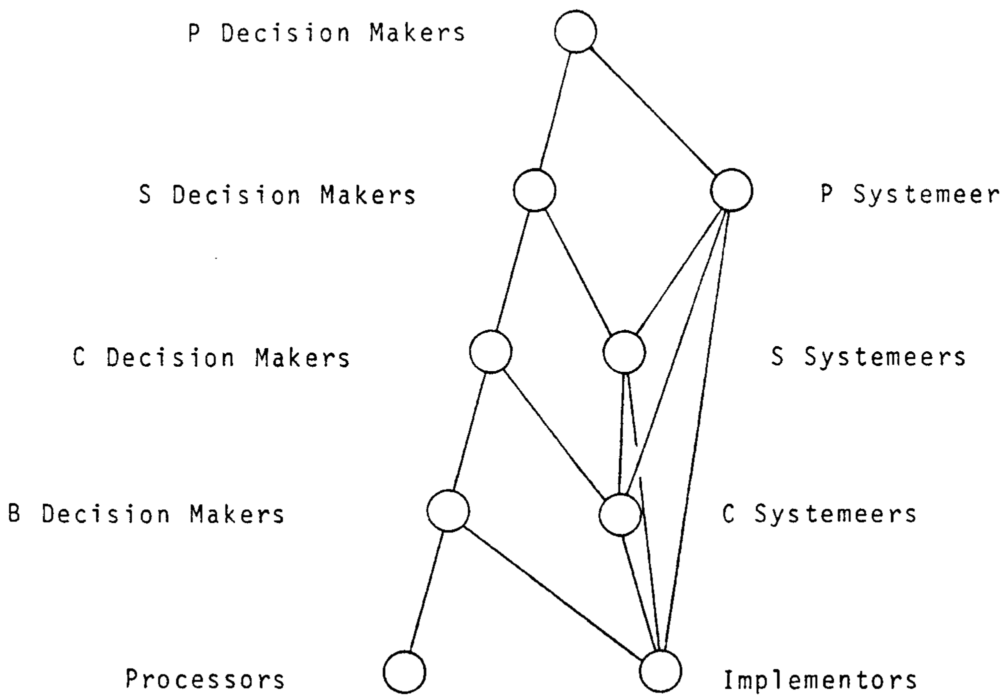

Figure 1 - Roles and Their Hierarchical Relationship in th
PSC Systemeering Process

quantitative efficiency factors. For instance at the most general C level evaluation, the application can be designed and tested in terms of the sum of design and implementation costs, operations costs and maintenance costs. These factors and their lower level expression provide the basis for selecting a C level solution that achieves maximum efficiency for the total cumulative costs of the proposed information system during its life cycle.

For this presentation the fourth implementation (B) main phase is not emphasized. This life cycle actively is reasonable well developed in the literature and in practice. The levels of decision above this phase in the pragmatic, semantic and constructive phases are less well developed. The emphasis on the more qualitative and user oriented criteria in the earlier and upper three levels presents a greater challenge to the development of strategies and techniques for assisting in their accomplishment. At the P and S levels the inherent primacy of the user is apparent in the criteria for alternative selection.

In the PSC model of the life cycle, the design resulting from a given phase is analyzed in a preliminary fashion using later phase criteria to determine the feasibility of the given design. For instance for the P main phase, the S, C and B level implementations are tentatively developed by the systemeers to see if the P level result is feasible in terms of the highest S, C and B criteria. After completing all four levels of design in the P main phase, then the proposed information system is tested in reverse order. The solution proposed in the P main phase is tested at the B, C, S and P levels respectively. This highlights the iterative top down design and bottom up test that is built into each phase of the PSC life cycle.

Carrying the example one phase further, the solution developed in the S main phase is implemented in general terms at the C and B levels. The resulting S level solution is tested successively in terms of B, C, S and P level criteria. This strategy indicates the two dimensional character of the PSC model. For the P, S, C B phases through time, there are P, S, C and B levels of design and test within each. This feature provides a robust approach to information systems development.

Comparison of Life Cycle Approaches

The PSC systemeering approach can be contrasted with the more traditional and with the evolutionary systems development processes. A composite of the traditional view of systems development phases has been defined as (Taggard, 1980):

> Situation Review - Identification of the problem or opportunity that presents a challenge to the user.
>
> Requirements Identification - Determination of the information outputs that will alleviate the problem or capitalize on the opportunity.
>
> Physical Design - Specification of the input, process and storage modules that are required to produce the indicated outputs.
>
> Program Preparation - Preparation of the instructions for the machine components of the information system.
>
> Procedure Preparation - Preparation of the instructions for the people components of the information system.
>
> System Conversion - Parallel or direct cutover from the current to the new capability developed to replace it.
>
> Utilization - The ongoing use and maintenance of the information system to serve the purpose for which it was developed.

Lucas has proposed an evolutionary approach to systems development in combination with "creative design" strategies (1978). This view assumes user initiated systems to which the systems department responds with prototype outputs to serve as a basis for mutual discussion of the user need. This stimulates ideas for other outputs. In this way the user and systems personnel engage in a collaborative problem-solving dialogue. This dialogue is characterized by a series of design, program and test cycles. As the system evolves to an acceptable level of user support, the user gradually assumes full responsibility for his or her application. Even when the application has matured, new ideas for further development emerge but at a slower rate. In this approach there is no final product or "finished" application. It is always an ongoing development efforts.

The traditional, evolutionary and PSC models of the systems development life cycle can be compared and contrasted. The three versions of the life cycle are summarized in Figure 2. The phases of the traditional model appear in the left column. These terms are taken from the phase definitions above. The five phases of the evolutionary model appear in the middle of the figure. The inception and initial groping phases correspond in part to situation review. But part of the intention of these two phases precedes what is normally encompassed in situation review. However because of its experimental nature, some aspects of the first three traditional phases are covered by the evolutionary model. Mutual progress covers the situation review through procedure preparation phases. Finally conversion and maturity correspond approximately to the systems conversion and utilization phases respectively.

The distinctive feature of the PSC model is the coverage of <u>all</u> traditional phases in each phase of this approach. The P, S and C phases all involve the program preparation through utilization phase on an experimental basis. This feature of the Lucas approach is built into the PSC model. The comparison also highlights the greater emphasis placed on the early systems development phases in the PSC approach. The rationale for this heavier relative investment is that more conscious decisions in earlier phases reduce the investment required to converge on the B level solution.

The additional investment in the earlier phases is compensated for by reduced resource demands in the C, B and utilization main phases. The top down systematic reduction in uncertainty for the design and test of the information system following the PSC model results in little or no net increase in the total development cost with a significant potential saving in user frustration. Users will more likely obtain an information system that will adequately respond to the problems and/or opportunities they are confronted with. This comparison suggests the greater sophistication of the PSC model in light of the traditional and the evolutionary models. To coordinate and integrate the work in

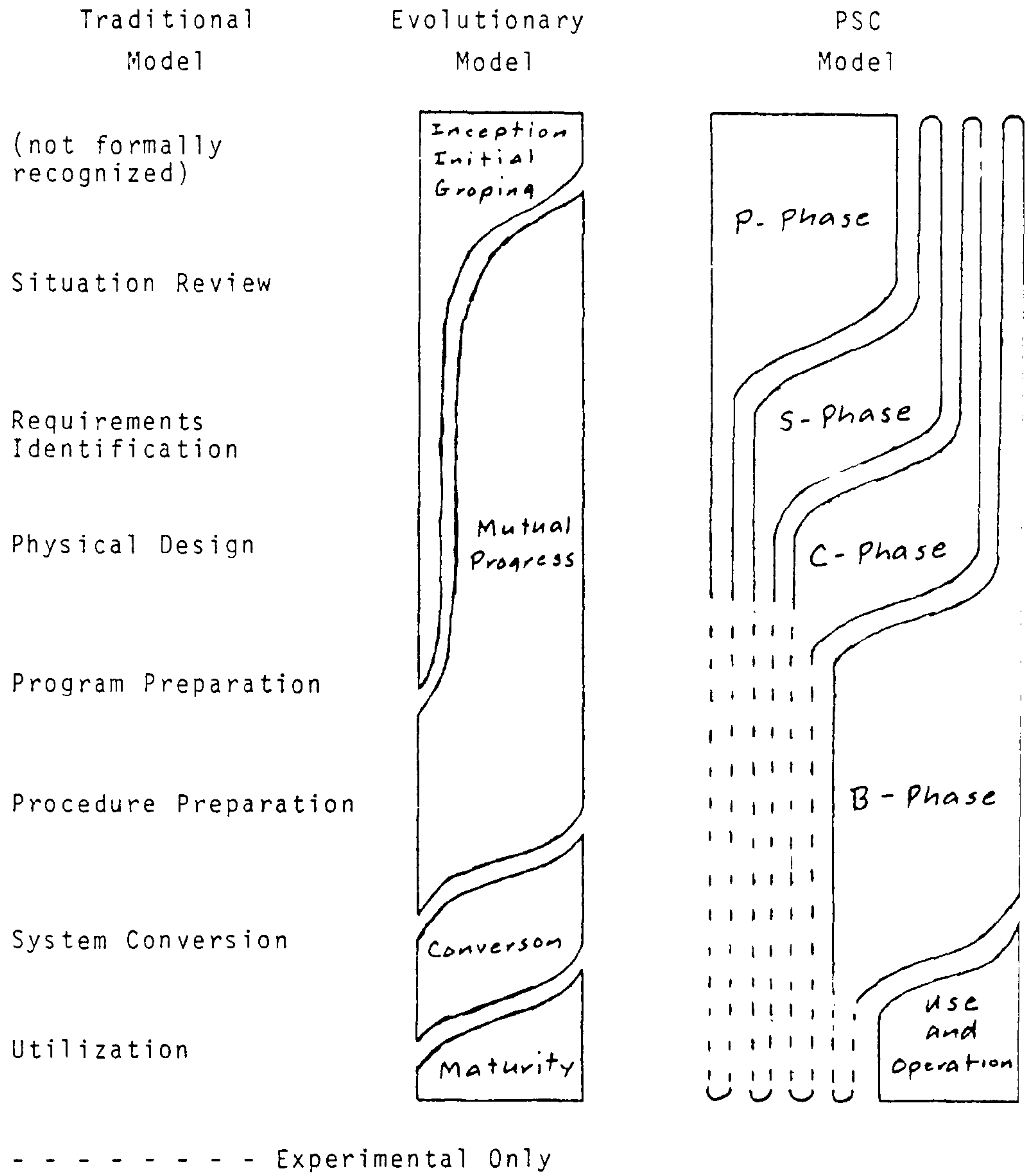

Figure 2 - Comparison of Life Cycle Models

the PSC approach requires a position that is more sophisticated than traditional systems positions.

The Information Systems Architect

To complement the PSC systemeering view of the life cycle, we need a distinctive title to identify the integrating and coordinating role across phases and among levels of decision makers in the PSC strategy. The traditional data processing position titles do not indicate the scope of this systems responsibility. The ACM Curriculum Committee recommended the redefinition of the systems analyst position as two specialists: information analyst and systems designer (Ashenhurst, 1972). This recognizes the need to clearly distinguish the activities of the S main phase and the C main phase in systems development respectively. However this differentiation does not encompass the decision roles associated with the P main phase. From an integrated viewpoint this most important phase deserves specific recognition in information systems responsibility.

This deficiency in responsibility definition for systems development is remedied by recognizing the position of an information systems architect. This position's scope of responsibility encompasses that of the information analyst and the systems designer as well as extends explicitly to the P level design decisions that consider the relationship between the information system and its environment.

The individual that fills this position can be either a data systems staff person, a member of a user group or a specifically trained expert. The rationale for an ISA curriculum has been described by Koskela, Nuutinen and Iivari (1980). Comparing a data systems staff to a user assignment, an argument can be made that the ISA role should be filled by a user to avoid the narrow viewpoint that often accompanies technical competence. On the other hand one can argue that the user may be technically incapable of discharging the architect's responsibility. In our view it is generally easier to provide the nontechnical person with adequate technical support than it is to broaden the often narrow viewpoint of a technical person.

On balance we weigh the argument in favor of the user as the ISA until individuals with specific education in the area are available. This person can be selected from among the principal users of the information system. The individual should represent the user groups and also have an appreciation of the technical aspects of systems development. Assuming user primacy, as we do, the first criterion is more important than the latter. If the person is weak in technical matters, we can provide advice and counsel from the data systems staff.

Human Information Processing Styles

The work of the ISA in the PSC life cycle can be enhanced through an understanding and application of differences and similarities in information processing styles interpreted in terms of hemispheric specialization (Taggart and Robey, 1980). Processing style refers to the ways that people perceive and make judgements with information. Using personality types developed by Carl Jung, we can identify a person as sensing (S) or intuitive (N) in their perception and as thinking (T) or feeling (F) in their judgement (Jung, 1971). Selecting one dominant mode of perceiving and one dominant mode of judgement, we have four typical styles for human information processing: ST, NT, SF and NF. Preferences in brain utilization can be associated with these four styles.

An understanding of left and right hemisphere processing specialization has developed out of work done with split brain patients who have been surgically treated for a severe form of epilepsy (Ornstein, 1977). Experiments with these individuals after their surgery indicates the distinctive processing characteristics of the two hemispheres of our brain. While the left hemisphere is a logical, sequential processor, the right proceeds nonlogically and simultaneously. Where the left is causal and analytic in its perception and judgement of situations, the right is acausal and holistic. The left hemisphere has a structured processing orientation while the right has a nonstructured outlook. These skills complement each other to provide an integrated processing style for individuals that have developed an ability to exercise the range of right and left hemisphere skills.

The sensing/thinking (ST) person focuses on facts using an impersonal analysis method of handling things. STs have a tendency to be practical and matter-of-fact and objects. This dominant style can be associated with the logical, sequential characteristics of left hemisphere processing. An intuitive/thinking (NT) person that leans to left dominance with a degree of right hemisphere skill will focus attention on possibilities and use impersonal analysis for handling things. NTs tend to be logical and ingenious and to express their abilities in theoretical and technical developments.

Then the sensing/feeling (SF) person who leans toward right hemisphere dominance with some skill in left hemisphere style has a facts focus of attention and uses personal warmth for handling things. They have a tendency to be sympathetic and friendly and express their abilities in practical help and service for people. Finally the right hemisphere dominant intuitive/feeling (NF) person has a possibilities focus of attention and handles things with personal warmth. They have a tendency to be enthusiastic and insightful and to express their abilities in understanding and communicating with people.

This framework offers insight into the personal information approach of the ISA. The architect's awareness of his or her own processing style dominance will highlight situations where a style is required that is a weakness for the architect. A special effort can then be made by the architect to activate the latent style to meet the decision needs of that situation.

In addition to this awareness, the framework helps the ISA appreciate the dynamics of the interpersonal relationships among users and other participants in the development process. One technique that we are experimenting with uses a survey instrument to classify individuals into one of the four processing styles. With a knowledge of the participants' processing styles, the ISA achieves a better understanding of user information needs as well as the internal information needs of the development process. This facilitates the handling of the coordination and communication problems that are the responsibility of the ISA in PSC systems development.

Processing Style in the PSC Main Phases

The primary processing style implied in each main phase varies. In general as we move from the pragmatic main phase through the semantic to the constructive main phase, the emphasis shifts from evaluation in terms of effectiveness to evaluation in terms of efficiency. The information perception and judgement processes for these evaluations vary from a right to a left hemisphere orientation. This means that as the ISA coordinates each phase he or she should consciously adapt individual and group style as successive decision stages are encountered.

For example in evaluating the effectiveness of an information system, the intuitive perception/feeling judgement (NF) approach will be most productive. These broad decisions rely on impressions more than facts. Impressions are derived intuitively from the context of the information system, and NF skills are most helpful for the ISA in these decisions. The architect must focus on possibilities and handle the situation with personal warmth. Users will be the primary contacts for inputs to the evaluation. Approaching them in a personable fashion will more likely elicit the possibilities that are so important in selecting a P level systems alternative. The ability to understand and communicate with different people is more important in the P main phase than in any other phase of the systems development process. An enthusiastic and insightful architect makes the difference in successful identification and evaluation of alternatives.

In the B main phase of implementation a sensing perception/ thinking judgement (ST) style is more productive in making decisions. Here the tendency to be practical and matter of fact is an appropriate orientation for making information system implementation decisions. The architect expresses his or her abilities as technical skills with facts and objects. In this as in the other phases, the architect has a coordinating role since the different systemeers perform the actual tasks of the B main phase. It is essential that the architect provide this coordination to insure the realization of the design features chosen in the previous three main phases of the process.

In between P and B main phases, the semantic and the constructive main phases are best served by the intermediate styles of the sensing perception/feeling judgment (SF) and intuitive perception/thinking judgement (NT) respectively. For the evaluation of information content in the S main phase, the SF style which focuses on facts with a personal warmth that considers the information user provides an appropriate blend of right and left hemisphere orientations. The tendency to be sympathetic and friendly and to express one's abilities in practical help and services for people supports the careful consideration of user information needs in the S main phase.

Then in the structure and performer selection evaluation of the C main phase, the skills of the NT systems architect offer the most effective orientation. This mode focuses on the possibilities of performers to accomplish information system tasks while handling the selection with impersonal analysis. The tendency to be logical and ingenious and to express abilities in theoretical and technical developments increases the probability that the most appropriate choice of performers will be made.

Coordination in the PSC Process

The variety of activities and people encompassed in the PSC approach to the development of an information system implies the need for high degree of coordination and integration. These responsibilities go beyond what the traditional view suggests for project management. In addition to the recognized responsibilities of planning, scheduling and control of the life cycle activities, the need for coordination and integration stands out due to the number of elements involved and their relationships. At each level in the process, decision makers select the information system alternative for that phase: P level decision makers, S level decision makers, C level decision makers and B level decision makers. In addition to the people who select the system alternatives for that level of development are the people that carry out the tasks in each phase.

The work responsibilities in the PSC systemeering process are performed by the systemeers identified in Figure 1. This position title identifies all of the roles that are associated with accomplishing the tasks of the PSC process. The traditional positions mentioned earlier perform some of the specific systemeering tasks. The positions of information analyst, systems designer and programmer are associated respectively with the S, C and B levels of systemeering. The current position typology does not identify a systemeer for P level task performance.

The complexity of the process and the number of roles involved in its accomplishment requires highly skilled coordination that can be provided by the ISA position as defined here. In terms of HIP style, the architect and the PSC group need to have the flexibility to adopt anyone of the four styles as appropriate to the level and phase of the PSC process. Individuals that are left or right dominant in their style would not be as successful in the ISA position as a person with an integrated processing style. As a whole the PSC group should also express an integrated style.

In selecting candidates to fill the ISA position in an organization, the user groups offer a more fertile ground for finding people since technical personnel are more likely to express the left dominant characteristic of data processing professionals. In coordinating higher level tasks, the left dominant style may be counterproductive as the association of the NF to ST styles with the four levels P through B has shown. Survey instruments are available to classify an individual into a style category. With a person's HIP style profiles, their skill as an ISA coordinator and integrator can be assessed in broad terms.

A summary statement of the skill requirements for the ISA is project management capability with an integrated information processing style. This person should have the experience to manage the planning, scheduling and control responsibilities for the systems project and the breadth of style to successfully interact with the different decision makers and systemeers at all four levels of the PSC process. In this role the ISA can be compared to the central hub in a hierarchical communication network. The hub communicates with and coordinates the communications among the other individuals in the process. This responsibility demands a person with managerial skill and the breadth of perspective that an integrated HIP style brings to a situation. As coordinator the architect needs to express the skills of an NF, SF, NT or ST processing style as the situation requires. Such people are rare in our organizations. We need to identify and cultivate them for these major positions of responsibility in organizations that desire to move ahead in the development of truly effective and efficient information systems.

SUMMARY

Information systems development for the 1980s requires greater attention than ever to the concerns of the user. This concern should be expressed as an integral part of the development life cycle. In contrast to typical United States practice, the Nordic countries assume user primacy as a basic tenet in their systems development strategies. The PSC systemeering model presents a representative version of this emphasis. The phases of the process are coordinated and integrated by an ISA who has a broader perspective than the typical information analyst or systems designer.

The architect works from a framework that recognizes a variety of HIP styles for the people participating in the PSC process. The styles range on a spectrum from a sensing/thinking (ST) person with left hemisphere decision characteristics to the intuitive/feeling (NF) person with a right hemisphere style. An awareness of and a flexibility in using these styles enables the architect to competently discharge the coordination responsibilities implicit in a user oriented PSC approach to information systems development.

The use of HIP style in the PSC systemeering model by the ISA yields a more effective and efficient information systems product. The system users will more likely receive information outputs that meet their needs and the PSC participants will make a more valuable contribution to the development process. Following the ideas suggested here sets the stage for a humanistic systemeering methodology.

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