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A Facilitator Method for Upstream Design Activities with Diverse Stakeholders ; CU-CS-785-95

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ABSTRACT

This paper presents a method that can be used for the elicitation and specification of requirements and high-level design. It supports stakeholder-based modeling, rapid feasibility feedback to marketing, and the interpersonal dynamics that are necessary to develop a product. The method centers on the role of the facilitator*, an independent agent whose purpose is to build the Integrated System Model (ISM). The ISM is the product of merging the independent system views from all stakeholders at any given abstraction level. Formulation of this method was based on the real-world experience of developing a complex, high-technology medical product with critical time-to-market pressures. It has proven to be a practical approach to the evolution of requirements definition and provides a necessary link to the marketing aspect of a product.*

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1 Introduction

This paper presents an experience in which requirements engineering is done in a very adverse environment. From the experience, a method called the *Facilitator Method* is derived. The term "facilitator" is used because the analyst acts as an independent, neutral agent that facilitates diverse stakeholders actively developing the system model. For this and many other industrial projects, requirements definition, requirements specification, and design activities are performed in a continuum rather than as clearly demarcated subprocesses. The full definition and specification of a product require the collaboration and contribution of many people and is done based on precedence. The history of the technology and the history of the people developing the product determine what the product looks like. A product is designed based on a combination of prototypes, i.e., an existing product line for the company, what exists in the market, and what is in the heads of the development staff and customers. Using these people to the fullest extent possible during requirements definition is one goal of the facilitator method.

The facilitator method addresses specifically marketing concerns and project planning needs. Information that helps determine market feasibility is solicited from stakeholders as the system definition evolves. The model maintains focus on the risk of not meeting the market requirements for the product, including features, cost, and time-to-market. The method allows marketing feedback and decisions to be made at each abstraction or conceptual level of the requirements and design definition. The leveling approach, when combined with market feasibility information allows losses to be minimized, incremental investment decisions, and effective concurrent design efforts. This leveling approach is common to most analysis methods.

Another aspect of the facilitator method is that it attempts to address the human factors element of getting project requirements and a design definition accomplished. Diverse stakeholders present a challenge to achieving a single definition that is comprehensive and understood by all stakeholders. Each stakeholder embodies a tradition, a set of priorities or interests, specific training, and very often a language different from that of the others. The stakeholders require a medium of exchange and a neutral mechanism for achieving a common understanding [1]. Often communicating face-to-face in a roundtable fashion hides elements of the diversity that exist. Without a means to anchor the discussions that type of communication is ineffective. With a concrete, neutral mechanism in which the stakeholders are invested, the communication is definitive and real progress can be made.

Leite and Freeman laid the foundations for using viewpoint resolution as a means to validate and formulate a more complete picture of requirements during the elicitation process [2]. Viewpoint resolution in their paper was a process of soliciting a mental position or viewpoint from significant actors in a project. The discrepancies between viewpoints were evaluated and eventually integrated into a single solution or view. They did preliminary controlled studies that demonstrated that using differing viewpoints enhanced the requirements elicitation process. They did not address the issue of scaling their method for larger projects, in particular the fact that it would take significant resources and time to do a large project in the way they proposed.

The facilitator method presented in this paper uses a modified form of viewpoint resolution to achieve requirements definition quickly for large projects. Viewpoint resolution as introduced by Leite and Freeman is different from the method described here in a number of ways. For one, the facilitator method does not specifically use formal rule-based models and multiple analysts. The stakeholders, rather than the analyst, become responsible for representing their viewpoints by graphical means and supporting it with annotated data. For another, the generation of a model happens at the same time the elicitation process is occurring, unlike the Leite and Freeman method. This speeds up the development process when the scale of the project is increased and many diverse stakeholders are involved. Finally, the facilitator method is a more dynamic process of merging viewpoints and defining requirements as completely as practical at any one point in time. It deals with the fluidity of contingencies, politics, interpersonal dynamics, and the evolving nature of viewpoints.

This remainder of this paper describes a case study that served as the seed for the facilitator method and then describes the method in detail. We conclude with a look at future work.

2 Case Study

The experience presented in this paper happened over a period of fourteen months. The product was a complex, high-technology medical system. The overriding requirement was meeting the time-to-market deadline. The product sold for over one-million dollars each and the investment capital was very high. The company had bought out a small 25-person firm that made chemical research systems using the application technology that was to be applied to the medical product. The new product was substantially different from the existing one, but a prototype was built based on the chemical research system that existed in the previous company.

The company grew quickly and at the time of first shipment of the beta-test product there were over 250 employees. Many people were brought together very quickly from diverse backgrounds. Those who were experienced in the application area had worked for one of about five existing companies in the market. Many of those people were scientist in physics or chemistry. Most of the engineers had little to no familiarity with the application area and were also brought together from a diverse set of training and experiences. All the people involved were highly skilled, including the medical technicians (who acted as surrogate customers), the production staff, marketing and the service technicians. Since the company was being formed at the same time that the product was being defined, many of the required processes were not in place and were built as the development went along. In addition, since it was a medical product, FDA approval was critical.

Once the proof-of-concept prototype had been built, the results were demonstrated at an annual medical trade show. The company then launched into full-scale engineering of the product that was going to be introduced at the next show. At the time work on the actual product began, the company was quite fragmented and engineers were unproductive because they did not have any good specification from which to work. The only things that existed were preliminary marketing documents that described the product in terms that would sell to a customer. The scientists as a collective understood the very complex application, but did not know how to specify it for the engineers. The engineers struggled to learn the application area, but it was very complex and they felt pressured by the time-to-market requirement. Most of the managers were scientist as were the

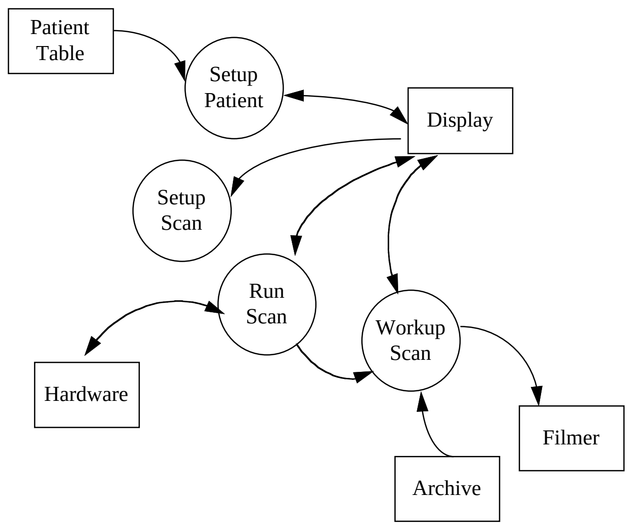

Figure 1: Initial Viewpoint of Surrogate Customer.

people that had to do the application programming. These application programmers had to have a system upon which to layer their software. The key to moving forward was to begin to get the system defined in a way that the engineers could build from, one step removed from the application area.

2.1 Product Development Process

At the beginning of the project, many ineffective meetings took place and the frustration level was very high. Eventually, an analyst (one of the authors, R. Gonzales) met with the stakeholders, the unofficial technical leaders from each group, and sketched out with them independent models of how they saw the system. They used data-flow diagrams with real-time extensions. Figures 1 and 2 show simplified example diagrams given by two representative stakeholders. In the figures, rectangles represent elements outside the system, circles represent transformation of data, and arrows are the data flows themselves. As the modeling proceeded, the data-flow technique was introduced to the stakeholders, but they often strayed away from the notation.

After several models were created from the individual stakeholders, they were combined and made into an integrated system model. This merged viewpoint is illustrated in Figure 3. The merged view reflects the views captured in figures 1 and 2 together with the views of other stake-

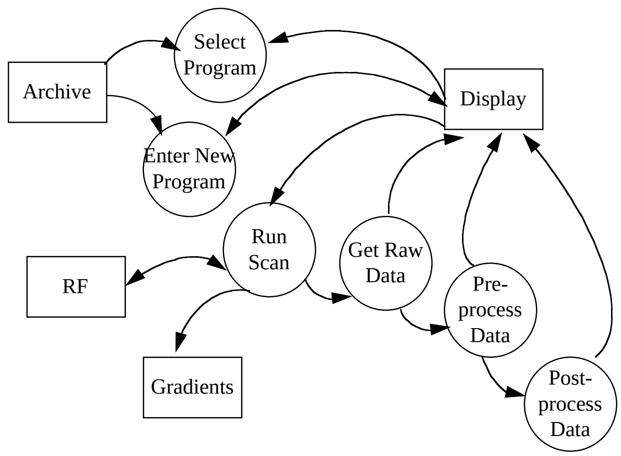

Figure 2: Initial Viewpoint of Application Scientist.

holders. (Merging is discussed in more detail below.) The system model was then distributed and communication between the stakeholders began to take place. As the model was iterated, it became clear to the stakeholders which areas needed to be defined first and which areas would become critical paths. The same process was followed for each of the critical areas, except that the stakeholders changed. The areas that posed greatest risk were those areas where the most diverse set of stakeholders existed. Once the modeling had been done for these critical areas, the system model changed and the model that emerged was one that the stakeholders were content with at the system level.

While the edict to be ready with a product in a year remained in place, there was still some latitude in what would actually be delivered in the product. Moreover, the development staff could request additional resources. Information about how long it would take to develop each of the components in the system was sought in the same manner as before, namely separately from each stakeholder. By asking for specifics on resources and time, further definition was required by the stakeholders. Of course, this had an effect on the system model. The results of this process were a new model at the system level, a model for three of the most critical areas of the system, and a time-line. In the process, the marketing staff and management were forced to make some compromises on what would be shipped and the technical staff prioritized the various parts that

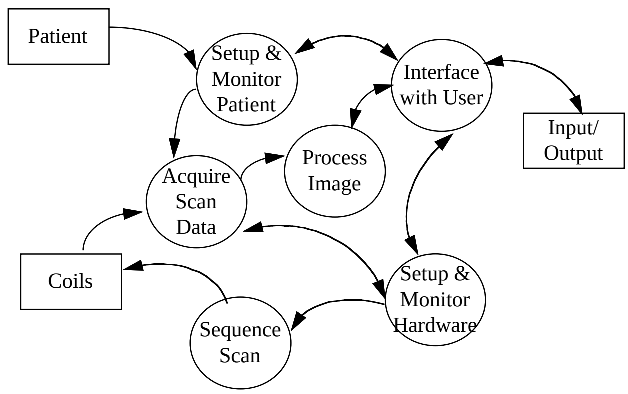

Figure 3: Merged Viewpoints from Multiple Stakeholders.

needed to be built so that the minimum system could be delivered.

Several months into the development of the system it was recognized that a key component was not going to be available in time for the application scientists to perform the development needed on the actual system. At that point an existing component used in the prototype was made to fit into the new system and development continued. This was the only significant problem that was encountered. The data necessary for FDA approval was taken before the product was shipped. The beta-test system was shipped just before the show and results from the new system were demonstrated at the show. Some of features of the product were not quite competitive, but it had other distinctive features that set it apart. The fact that the company was at the show with a real product made it a contender. This was the goal of the company.

2.2 Lessons Learned

This was a high-pressure experience and during development there was never a moment that product shipment was certain. In an ideal world, one might observe that the schedule requirements were not reasonable. It was, however, realistic in that highly competitive market, and similar market pressures do exist for other products. While the analyst in this case study was rather experienced, the standard methods that were available for her to use were too inefficient. This was an extreme case, but generally the real-world still cannot afford the time most standard methods require because they rely primarily on the analyst for the modeling and, as a result, require the analyst to become an expert in very complex areas. The analyst in this example acted as a model refiner because there was no time to understand adequately the application area. The alternative would have been to require everyone in the company to become an analyst. Scientists and medical technicians, along with many others, resist learning a complex analysis method especially when they are under pressure. This is not surprising since they are highly trained and their concerns were in areas other than systems analysis. While evolving the system model, strict adherence to a modeling notation impeded communication. Most of the stakeholders naturally were able to draw a visual representation for a system, and flexibility was a necessity, since the stakeholders were actively doing the modeling. Of course, it may be possible over time for all the stakeholders in a single company to adopt, without lengthy training, a single rich notation. In fact, during this case study, some of the people did use the notation presented to them by the analyst.

Many existing modeling techniques do not take into account the people issues involved in developing complex products. Working with the caliber of people that existed in this project was extremely tricky. They were considered experts, but had diverse experiences, with opinions that were quite entrenched and had to be convinced when alternate views were presented. They were often impatient with the engineers, wanting them to "just go away and build the machine". Bridging the gap in this situation required the analyst to be a neutral party and to work hard to adequately represent the concerns of all the stakeholders. People began to circumvent the requirements process when they did not feel adequately involved and when it appeared to be taking too long. Equal opportunity for contribution to a system model was necessary. Lengthy face-to-face communication with very diverse people was not an efficient use of time. Many times during face-to-face meetings the more technical people of the group dominated the discussion. This lead to divergent conversations with a result that most of the people were left frustrated. Having a system model in which all of the stakeholders were invested anchored the communication, and meetings were held only as necessary between subsets of stakeholders.

3 The Facilitator Method

The neutral model described in the previous section is called an *Integrated System Model* (ISM) in this method. The analyst role in the example is termed a *facilitator*. A skilled facilitator is able to rapidly iterate to an ISM that is useful for determining requirements by using the prototypes that exist in the company, the market, and the knowledge of the experienced stakeholders. There are two parts or perspectives to the ISM, a graphical system model perspective and an annotated project-related commitment perspective. Unlike the method used by Leite and Freeman, where perspectives were taken in parallel to formulate each viewpoint and then combined with other viewpoints, the graphical perspective is taken then combined with graphical perspectives held by other stakeholders (Figure 4). After agreement on the graphical perspective has been achieved, the second perspective, the commitment perspective, is solicited and acts to validate the first perspective. By resolving the perspectives in series, the facilitator method capitalizes on the strength of what has already been

Figure 4: Process Diagram for Facilitator Method.

agreed to by the stakeholders.

The facilitator begins the process by soliciting a block diagram of the system from each of the stakeholders. This block diagram does not have to use any specific notation. The block diagram is based on whatever preliminary marketing information or statement of need that is available. Some of the stakeholders may require assistance in developing this first-cut diagram, but even if assistance is rendered, it is important that the block diagram is owned by the stakeholder. Equal opportunity for unbiased input is critical at this stage. Complete system requirements from each stakeholder are not the concern so much as representing all the elements that are important to the particular stakeholder.

The individual viewpoints on the system are then merged by the facilitator. The technique used in the example project was that of grouping and leveling based on structured analysis methods. In particular, the facilitator first examines the various viewpoints, looking for patterns. This involves trying to find the largest scope that defines what is being called "the system" by defining the boundary between what is inside the system and what is outside the system. The facilitator then forms logical groups of functions into components and subsystems, usually based on communication.

The outcome of merging should be the graphical portion of an ISM. The ISM does not have to be in any specific graphical notation, but a notation should be used that is adequate to describe the entire system and that can be understood by all the stakeholders. Using a notation that is too full of dichotomies and vocabulary can impede communication among the stakeholders at this level. For example, in the case study, many of the specialized notation for the structured analysis real-time extensions confused the stakeholders and had to be compromised.

The ISM is then given back to the stakeholders for iterative refinement and discussion. At this point many issues will arise and a sort of synergy of thought will occur. What one stakeholder has included will spark another stakeholder, and the diagram will undergo tremendous amounts of change. The key is that the communication is all anchored to the ISM. Issues are resolved in a series of face-to-face meetings that include subsets of the stakeholders with or without the facilitator. Once the issues are resolved to the satisfaction of the parties involved, a modified ISM is given to the facilitator. In the project described, about three weeks were required for the building of the original graphical ISM and two weeks for feedback to be returned to the facilitator. This time was reduced as the process was used more. It is then the responsibility of the facilitator to turn the next version of the ISM around to the stakeholders quickly. The iteration continues until the ISM more or less stabilizes. This happened within about four to six iterations in the case study.

The facilitator then asks for specific information on each component of the ISM again from each stakeholder. Since this information is more specific, each stakeholder will not be able to supply all of it. The information is text and includes specific attributes of each component, resources that will be required to design, test and produce each component, and time required for each phase of development. Again, the reliance here is on past projects and systems that have been developed and on the experience that the stakeholders possess. Estimation techniques and consulting with the group that the stakeholder represents may be required to get the detail necessary. The reason to ask for this project-related information at this early stage is to make explicit all assumptions and areas that are not yet well defined or understood. People pay close attention when commitments need to be made. This is a so-called "truth-generating mechanism" [1]. When the data from the stakeholders are taken in aggregate, they reveal what is not known about the system, areas of discrepancy, and risk areas. The facilitator takes the information and forms as complete a picture as possible from the data given. If huge discrepancies occur—e.g., someone says it will take two weeks to test and another says it will take six months—it may be necessary for the facilitator to meet with a subset of the stakeholders. Again, the merged data are presented to all the stakeholders and the communication sparks fly. This communication is based on something concrete and specific that will anchor the face-to-face meetings that take place. The graphical ISM is subject to change at this point as more things become apparent to the group of stakeholders. In this way, the second perspective validates the graphical model that was achieved previously. The feedback in the form of a modified graphical ISM and edited annotation information is given to the facilitator for the next iteration.

A complete picture of the annotated information may not be possible without further leveling of the ISM. The facilitator uses all the information given so far and creates a first cut of the next level of the ISM. At this point, stakeholders may change for each specific component that is leveled. This supports the first-level phenomena experienced by many people who have been involved in using methods like structured analysis. This phenomenon happens when any one group of people will only go down a couple of levels until the level that they are concerned with is resolved. For example, the user interaction portion of a system, once taken down a level, may require someone more experienced in user interfaces and may not require the radio frequency (RF) engineer to be involved. These decisions can be made and the process can continue with new sets of stakeholders for the various components in the system. The priority in this process is to get a completed ISM at the highest level. Components that are well defined and do not have holes can be put aside or further development can continue concurrently at a lower priority. Once the graphical model and the annotated information are complete at the highest level, concurrent engineering efforts can begin in earnest. However, the use of a facilitator may continue until the stakeholders are more homogeneous and less technically diverse.

The outcome of this process is a multi-level ISM with the necessary project information achieved rapidly by collaboration and consensus. The dependency is on the stakeholders and not the analyst. A more comprehensive set of requirements can be developed quicker by using the people and their combined experience in a synergistic fashion. The critical information that is provided assists marketing and management to determine the feasibility of the product being developed. Trade-offs can be made and priorities can be established in light of this marketing information. Risk areas can be defined and mitigated. Engineering and production efforts can be based on these decisions, and a viable product is more likely.

3.1 The Facilitator's Role

The term facilitator may be ambiguous. It was chosen instead of "neutral-intervenor", "mediator", or "arbitrator" because of its ambiguity. The role requires definition, but there was no convenient term to use for the role defined in this process. The primary role of the facilitator is to build the ISM based on information given by the stakeholders. The definition given by Hall for the various third party roles is that

> "A facilitator helps with the logistics in the proceedings of meetings. A mediator guides or helps people come to a voluntary agreement. An arbitrator tries to understand the issues on all sides and then imposes an agreement, as a judge." [1]

The facilitator in this process does a little of each of these. However, their primary role is providing the ISM. The ISM should embody the proceedings of meetings held by the stakeholders. One of the logistics that the facilitator handles is managing the iteration loops. The facilitator in this process should be well trained in system design.

The fact that there are diverse stakeholders and many issues that need to be resolved rapidly makes developing requirements and high-level design definition an "integrative bargaining problem" [1]. The facilitator reduces this "integrative bargaining problem" to a "distributive bargaining problem" [1] at which point the facilitator is no longer necessary. It may take multiple facilitators to achieve this, because as the abstraction levels become more specific, facilitators with different specialties may be necessary. To accomplish this reduction, the facilitator sets up a dynamic mechanism to resolve potentially conflicting views of the system or subsystem. These conflicting views are a rich source of information. This dynamic mechanism starts with a sort of bidding about what the system looks like. These multiple views are transformed into a neutral model. Yet, each stakeholder's concerns are not overridden or forgotten in the process of face-to-face meetings.

It is necessary that the facilitator be independent from any of the stakeholder organizations. One common error that is made is that this role is in essence filled by the project manager who belongs to one of the engineering organizations. The requirements document that results is very biased toward the engineering stakeholders with the marketing, users, and customers left figuring out what it means in the terms they care about. The production and quality staff are left subservient to whatever the engineers devise. In the case study, the facilitator was made a neutral party. This was very helpful, since there were many times when she had to suggest a solution that was not in keeping with the biases of the engineering managers.

The marketing focus is a grounding in the reality that the product that is being produced has to sell. The goal is to negotiate what is physically possible and what is marketably possible. There may not be a margin of overlap, but it is up to the facilitator working with the stakeholders to quickly figure out whether or not there is. Figure 5 shows that if there is an overlap, it is not static. Therefore, market feasibility for any one product defined by a set of requirements is not static. The sense of urgency in achieving requirements definition quickly is one of the elements that is missing in many requirements elicitation methods. The window of opportunity for any potential product shrinks as time passes and risks increase. If there is an overlap, then a solution that comes with an acceptable risk must be developed as quickly as possible. The facilitator process makes risk areas apparent because it shows discrepancies in how stakeholders view the system. It is up to the facilitator to flag the risk areas and pursue them with the appropriate management and staff. Depending on the situation and the company, this may be done by assigning a team to mitigate a specific risk area or re-negotiating requirements with marketing, whatever is necessary to get the job done.

4 Conclusions and Future Work

The facilitator method outlined in this paper is a practical, systematic approach of using experienced stakeholders to achieve requirements definition rapidly. It is based primarily on the experience presented in Section 2. The need for speed in defining requirements for a product is paramount given most marketing environments. The use of a facilitator, rather than a formal analyst, speeds up the process of developing a system model that can be used for requirements specification. This can be achieved with some, but effectively little, impact on completeness, using

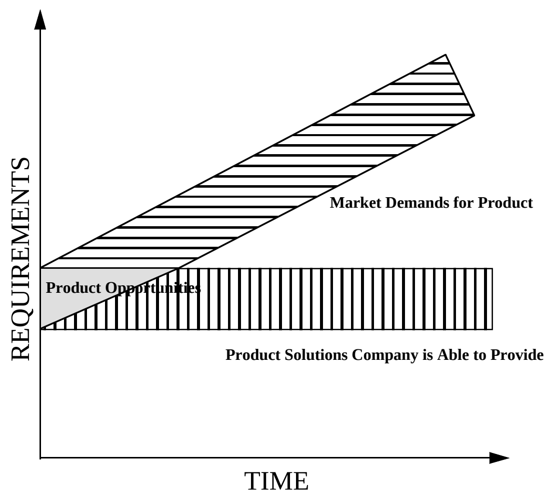

Figure 5: Non-static Market Feasibility for Any Single Product Defined by Requirements.

viewpoint resolution [2] as modified for this method. The use of a commitment perspective helps validate the graphical model perspective of the ISM and it provides the measure by which a project should be evaluated. This method can be scaled to small projects but is most effective for large, complex projects such as the case study described in this paper.

This method needs to be tested on controlled projects to determine how much training a facilitator would require in addition to a standard systems engineering background. The interaction and potential problems that can occur with an ineffective facilitator needs to be investigated further. The facilitator could potentially become a bottleneck, but no more so than a project leader, a product manager, or someone in a similar systems role. Controlled studies would be useful in determining what impediments a facilitator would have to overcome to be effective. In the case study, it was determined that ownership of the ISM by all of the stakeholders is critical. The facilitator is key in fostering this ownership. Specific ways a facilitator can cultivate this ownership is an area that would require controlled studies.

The type of graphical notation used primarily at the highest levels of abstraction needs further investigation. A notation that is natural for people from diverse disciplines would be most useful. Block diagrams of different flavors seemed to be a common method of communicating by most of the stakeholders in the case study. The marketing staff drew block diagrams as did the scientists and production people. Some questions still remain: how much information is communicated in common block diagrams and how rich does a notation have to be to achieve the level of understanding required for the facilitator method to be effective? Another aspect of the graphical notation is the use of specialized tools. The goal would be for the stakeholders to use whatever graphical editor is most convenient for them to use. Given the diversity of the stakeholders for a large project, a tool that is too restrictive can cause a stakeholder to be less effective. The cost of investing in a tool, especially in terms of time, should not be an obstacle to using the facilitator method.

The specific information that needs to be annotated in the commitment perspective is another area that needs further investigation. This information could potentially vary from company to company and between abstraction levels for a single project. This information should allow the determination of product feasibility—i.e., is there an overlap between what the market requires and what the developers can realistically produce? The annotated information must flag risk areas and provide a means to validate the graphical model perspective of the ISM.

REFERENCES

[1] L. Hall. *Negotiation: Strategies for Mutual Gain.* Sage Publishing, Newbury Park, California, 1993.

[2] J. Leite and P. Freeman. Requirements Validation Through Viewpoint Resolution. *IEEE Transactions on Software Engineering*, 17(12):1253–1269, December 1991.