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# A Use-Case Model for a Knowledge Management System to Facilitate Disaster Relief Operations

Eileen Eudy
*Nova Southeastern University*, eileen.eudy@gmail.com

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By

Eileen Eudy

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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We hereby certify that this dissertation, submitted by Eileen F. Eudy., conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

Sumitra Mukherjee, Ph.D. — Date
Chairperson of Dissertation Committee

Maxine S. Cohen, Ph.D. — Date
Dissertation Committee Member

William L Haffner, Ph.D. — Date
Dissertation Committee Member

Approved:

Edward Lieblein, Ph.D. — Date
Dean, Graduate School of Computer and Information Sciences

Graduate School of Computer and Information Sciences
Nova Southeastern University

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There are numerous disaster relief agencies poised to respond to disasters; however, coordinating the activities of these diverse and dispersed entities and capitalizing on their knowledge assets can be a challenge. All of these agencies are dedicated to serving survivors of disasters, but they at times lack the coordination necessary to respond efficiently. The Virginia Voluntary Organizations Active in Disaster (VOAD) is an umbrella organization of existing agencies dedicated to working closely with other organizations to improve service and minimize duplication during disaster operations. To better cope with disasters, the Virginia VOAD needs to develop knowledge management strategies to coordinate its resources. The goal of this study was to design a use-case model of a web-based knowledge management system to support state and local level disaster recovery planning and operations in the aftermath of a disaster. The focus of this study was to support the disaster field office (DFO) operations. The use-case methodology outlined in the Rational Unified Process and supported by the Unified Modeling Language notation provided the means of systematically discovering and documenting system requirements. The resulting model provides a framework for a knowledge management system that has been adapted to the disaster recovery domain. Evaluation and validation of the model has shown this to be a viable concept. It is anticipated that this model could serve as the basis for developing a prototype knowledge management system that may also be adapted to similar state and local VOAD chapters around the country.

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# Chapter 1

# Introduction

## Problem Statement and Goal

### *Problem Statement*

The problem investigated in this study is the difficulty that disaster relief volunteers encounter with communication and coordination during post disaster operations. Specifically, it examined the requirements of individuals who operate in disaster field offices (DFO) and need access to knowledge resources to coordinate the activities of a range of disaster relief organizations and state agencies.

Disasters come in many forms and levels of magnitude and can strike at inopportune times and places. There are numerous agencies poised to deal with disasters; however, coordinating the activities of these diverse and dispersed entities and capitalizing on their knowledge assets can be a challenge. These agencies range from national organizations such as the Red Cross to regional organizations such as food banks and small private or civic organizations such as church based agencies.

All of these agencies are dedicated to serving survivors of disasters, but they at times lack the coordination necessary to respond efficiently. Decision makers who have ready access to timely, accurate information that is appropriately shared can save more lives and minimize damage; unfortunately, decisions are often based on inadequate information (Morentz, 1999). Providing the right information in a timely manner in the aftermath of a disaster is key to mitigating suffering and managing resources effectively (Tierney, Lindell, & Perry, 2001).

Organizations like the Voluntary Organizations Active in Disaster (VOAD) recognize the importance of coordination between relief agencies. VOAD is made up of various disaster relief organizations that strive to work together cooperatively. The state or local VOAD's role is to plan for disaster and provide training so its members can respond in a coherent manner (Kim, 2002). Organizations need to have up-to-date plans that are readily accessible to deal with contingency situations (Eklund, 2001). However, due to the diversity of disaster relief organizations and geographic separation of state and local agencies this can be a daunting task.

Access to organizational knowledge resources by volunteers temporarily located at disaster sites can be problematic. Stephen Terveer, former president of the Virginia VOAD, noted significant problems in coordination and communication within his organization. He indicated that the organization needs to collaborate, cooperate, and communicate effectively to fulfill their disaster relief tasking. Presently, the Virginia VOAD lacks the means to adequately support disaster field office (DFO) operations (Terveer, 2001).

To better cope with disasters, the Virginia VOAD needs to develop knowledge management strategies to coordinate its resources. Information technology can be an important tool to link elements of a community together (Romm & Taylor, 2001). Virginia VOAD DFO volunteers need timely access to the organization's knowledge resources to effectively collaborate with member agencies operating as virtual teams.

Producing an effective knowledge management system first requires constructing a model to capture the system requirements. One technique for model development outlined in the Rational Unified Process (Kruchten, 2000) is use-case modeling. According to Conallen (2003), "use cases are a powerful technique for capturing and expressing detailed system behavior (p.173)." Use cases combine a textual description with the notation tools found in the Unified Modeling Language (UML) to detail the interaction and dialogue between system users and the system (Conallen, 2003). Several development processes that use UML advocate that the system development should start with use-case modeling to define the functional requirements of the system (Eriksson & Penker, 2000).

There are potential benefits in using use-case modeling that are shared among different domains including both business orientated for-profit organizations and non-profit organizations such as disaster relief organizations. All of these domains require that the stakeholders share a common mental model of the organization. It is essential to develop a shared mental model of the organization and its environment to benefit from new insights and to develop real consensus (Marshall, 1999). The use-case method can facilitate developing such a common mental model. Additionally, use-case modeling creates value by describing what the system will do and revealing the scope of the system and its purpose. It stimulates discussion about the system and becomes a communication device between the different stakeholders on the project often among people with no special training in system development (Cockburn, 2001).

Use-case modeling has been used successfully in areas such as software development (Booch, 1999) and business modeling (Eriksson & Penker, 2000). This modeling approach assists team-based software development by anchoring user requirements (Booch, 2000). Marshall (1999) discusses use-case techniques in terms of business engineering and the strategic potential of technology. Use-case modeling has proven useful in depicting a high level view of business processes within organizations.

Although there are similarities between for-profit organizations and non-profit organizations, the domain of disaster relief operations differs from business-orientated environments in terms of the motivation, goals, and behaviors of its stakeholders (Tierney et al., 2001). Disaster relief organizations operate in an environment not driven by conventional competitive business forces. While use-case modeling has proven applicability in the business arena, this has not been documented for non-profit disaster relief organizations. An objective of this research was to demonstrate that use-case modeling can be adapted to the non-profit, ad hoc environment in which disaster relief organizations operate. This research highlighted the unique attributes associated with disaster relief organizations and it is hoped that the Virginia VOAD model will serve as a template that can be revised and customized to accommodate local requirements of other disaster relief organizations.

### *Goal*

The goal of this study was to design a use-case model of a knowledge management system to support state and local level disaster recovery planning and operations in the aftermath of a disaster. This model outlines a knowledge management system, accessible via an Internet web site; the purpose of which is to assist disaster relief volunteers at disaster field offices. It is anticipated that this model could serve as the basis for developing a prototype knowledge management system that may also be adapted to similar state and local chapters around the country.

The desired outcome of this research was to:

1. Define the knowledge management requirements to support disaster field office (DFO) operations for disaster relief organizations
2. Design a knowledge management system model based on design objectives
3. Evaluate and validate the knowledge management system model

The knowledge management system model meets the following three system objectives. It will:

1. Foster a community of practice to enable a cross flow of communication
2. Be accessible and relevant to users and stakeholders operating in varied contexts and roles
3. Be designed to meet organizational needs and constraints

**Relevance and Significance**

Getting the right information to the right people in a timely manner is essential to disaster relief operations. This is dependent upon establishing a shared understanding and integration of knowledge across disparate member agencies. In the case of the Virginia Voluntary Organizations Active in Disaster (VOAD), an umbrella organization made up of various disaster relief organizations, this is complicated by the virtual nature of the organization. An effective knowledge management system needs to support members of this virtual community who operate in dispersed geographic locations to allow them to learn from, contribute to, and collectively build upon the community's knowledge. Virtual organizations face even greater challenges in communicating and coordinating their activities and managing the knowledge of team members than their traditional counterparts (Lucca, Sharda, & Weiser, 2000). One way to provide access to the knowledge assets of the various organizations is through use of online web-based tools. Disaster relief operations are complex and further study needs to be done to ensure timely and efficient response to disasters.

The goal of disaster relief is to conduct operations in a timely and organized fashion. Virginia Governor Mark Warner has recognized this and formed a panel of government, law enforcement, business leaders, and voluntary organizations to evaluate the State's emergency response and recovery systems and recommend how they can be improved (Bergman, 2002; Qualls, 2003). Coordination, communication, and access to knowledge-based resources will be important factors in disaster response.

According to Rogers (1995) having a wide range of members who are cognizant of collaboration tools and opportunities may be a critical aspect of effective information exchange. Swan, Newell, and Robertson (2000) contend that knowledge management should not simply exploit knowledge. It depends on shared understanding and the integration of knowledge across disparate social communities. This is complicated even further due to the "virtual" nature of the Virginia VOAD.

Bieber et al (2002) outlined an architecture for a community knowledge evolution system called Collaborative Knowledge Evolution Support System (CKESS) designed to support members of a virtual community to learn from, contribute to, and collectively build upon the community's knowledge and improve many member tasks. Their research centers on educational communities and professional societies but they stress that their proposed knowledge support system could enhance other virtual communities as well. The designers of CKESS encourage further research in other environments that could include non-profit organizations such as Virginia VOAD.

Brazelton and Gorry (2003) describe a knowledge sharing system called Electronic Community of Teachers (ECOT) that serves as a virtual community of practice. One of the factors they point out is although technology may provide tools to communicate and coordinate, getting users to participate in effective ways is critical to the system's success. The system design includes email, discussion areas and work spaces, individual and group calendars, chat rooms and asynchronous forums. By using the Internet and collaborative technology they have created the conditions for a knowledge sharing community to emerge. They suggest that electronic communities that support collaborative learning would be beneficial for governmental or social services agencies where lack of coordination and integration of services are detrimental to clients.

Hiltz and Fjermestad (2001) suggested further research needs to be done to determine what system features and characteristics of technology are useful to support online discussion and teamwork. Shao, Lee, and Liao (2000) state "Empirical studies are needed to investigate practical design and implementation issues of virtual organizations" (p.6). It would appear intuitive that effective communication and collaboration is a requirement for success. However, determining the elements of the supporting architecture to achieve these objectives requires a deliberate and considered approach.

The use-case methodology outlined in the Rational Unified Process (Kruchten, 2000) and supported by the Unified Modeling Language notation provides the means of systematically discovering and documenting system requirements. Although this methodology has yet to be demonstrated in the disaster relief domain it has been proven effective in other domains to include web-based environments (Conallen, 2003). A web-based presence can foster communication and collaboration among geographically dispersed members of an organization.

"Connecting" people so they can solve problems together is the cornerstone of disaster relief operations. Turoff (2002) explains that crisis situations bring diverse individuals from many different organizations together and they must be able to freely exchange information, delegate authority, and conduct oversight. Wybo and Lonka (2002) point out that the field of emergency management has unique attributes and circumstances. They note the difficulty in grasping the complexity of emergency management and accessing the tacit knowledge of practitioners. A timely and efficient response to emergencies can shorten the length of the emergency phase and provide needed assistance to survivors (Burkholder & Toole, 1995).

Lesser and Prusak (2001) discuss the consequences of corporate downsizing and the loss of valuable workers when force reductions occur. This drain of knowledgeable workers can have a very negative strategic impact on organizations. In the past, few organizations had any systematic way to identify an individual's specific knowledge or tap their ability to share that knowledge prior to their departure from the company. As a result, the remaining workers faced with new duties became frustrated and unproductive. Lahti, Darr, and Krebs (2002) describe the challenges organizations face that use a nontraditional workforce and the problems of getting a dynamic workforce up to speed. They address the socialization policy, the formal knowledge transfer, and the informal knowledge transfer using social networks.

Lesser and Prusak (2001) cited research showing that social networks that foster knowledge sharing play a critical role in helping people identify, share, and work with corporate knowledge. These networks provide identification of experts, referrals for those seeking answers, and knowledge transfer among groups. Consequently, companies have begun to devote time and resources into enhancing the ability to create, share, and use both individual and collective expertise to improve productivity, organizational effectiveness, and innovative capacity. Many public and private sector organizations are investigating and implementing knowledge management projects to locate expertise, foster communities of practice, and utilize collaborative technologies (Lesser & Prusak, 2001). Disaster relief organizations such as the Virginia VOAD suffer from a high turnover of volunteer staff (Terveer, 2002). Often times those called upon to work in the disaster field office (DFO) have little or no formal training or experience prior to the onset of the disaster and they rely heavily on the advice and assistance of others.

Getting the right people to communicate at the right time is essential to disaster recovery operations. This is dependent upon having access to organizational knowledge. Wybo (2002) cites the low level of information integration in the emergency response community and calls the need for knowledge management "crucial." He stresses a cross-disciplined approach and states that engineers and planners can learn from behavioral scientists with researchers being guided by the issues of workers at the scene. He points out that those workers responding to emergency situations in the field can benefit from new academic theory and technology.

Tierney, Lindell, and Perry (2001) state that an issue that has not been addressed systematically involves the capability and potential of emergency management organizations to employ new technologies. They express skepticism about the idea that technology will provide a panacea for emergency management problems. Nevertheless, they note the Internet is increasingly being viewed as a means both for disseminating information and coordinating organizational and community activities when disaster strikes and therefore it warrants "in-depth study."

Dispersed virtual teams need to develop an organized and structured knowledge management system to bring people together to distribute and enhance the expertise of the group (Liebowitz & Beckman, 1998). Additional research should be conducted on coordination issues in emergency management to ascertain how the public, private, and non-profit agencies can better cooperate in responding to disasters (McEntire, 2002). Therefore, designing a use-case model depicting organizational interactions and requirements will further our understanding of how disaster relief organizations can benefit from knowledge management systems.

## Barriers and Issues

The Virginia Voluntary Organizations Active in Disaster (VOAD) is a relatively new organization that was created in the early 1990's. Over the years, Virginia VOAD eventually evolved into a mature organization that now has a goal, objectives, and operating procedures. By its very nature, it is an ad hoc organization that maintains a skeletal structure until called upon to respond to a disaster.

While Virginia VOAD has responded to a number of disasters over the years, the terrorist activity of September 11, 2001 was a watershed. As a result, Virginia Governor Mark Warner has called upon volunteer organizations such as Virginia VOAD to take a more active role in State recovery operations (Office of the Governor, 2002). Additionally, the State of Virginia has identified Virginia VOAD to participate directly in State level disaster relief operations outlining specific Virginia VOAD responsibilities in the Virginia Emergency Operations Plan for the State Emergency Operations Center (Virginia Emergency Operations Center, n.d.). This new role has significantly increased the range and breadth of Virginia VOAD involvement and has highlighted the need for a knowledge management system for field operations.

An integral element of Virginia VOAD's responsibilities involves having representation in the field during disaster recovery operations. The individuals charged with manning the disaster field office (DFO) play a pivotal role in coordinating and directing the efforts of the various disaster relief organizations that make up Virginia VOAD. However, this requires an extensive knowledge of the operations and resources of many diverse organizations. Unfortunately, the individuals staffing the DFO are volunteers who may not be able to be identified in advance of the disaster and may have limited training in DFO situations. These issues have been identified by Virginia VOAD as problems (Terveer, 2001). Thus, it is imperative that there be a knowledge management tool available to assist the DFO volunteers.

A challenge to providing a knowledge management system for disaster relief workers involves planning for access to the system in the event communications are disrupted as the result of a disaster. This is mitigated in two ways for the system considered in this study. First, the intent of this knowledge management system is to support volunteers at the DFO locations during the recovery phase of disaster relief operations. This phase follows the initial response phase and is focused on meeting the long term needs of disaster victims. By design, the location of the DFO is selected so as to be as geographically close to the disaster site as possible while still having access to communications and facilities to support the DFO (FEMA, 1997). Secondly, in the event communications were unexpectedly disrupted and the DFO had to relocate, the knowledge management system would maintain its integrity and availability because the information is resident on a web-based server geographically removed from the disaster area. After relocation, access would be possible via any computer with Internet capability and web browser software.

Recent advances in technology have made development and deployment of a knowledge management system a realistic goal. The Internet offers flexible, ubiquitous options with mobile and "on the edge" architectures using web-based technology. A range of knowledge management options are now available that allow access to both explicit and tacit organizational knowledge using both synchronous and asynchronous applications.

Along with new opportunities, there are a number of factors and limitations that must be considered. For example, the design of the knowledge management system needs to feature a user interface that is simple and “user friendly.” Also, the web site must accommodate slow computer connections to service low end users. This may limit the use of some applications.

In addition, cost and maintenance of the system are prime considerations. The Virginia VOAD has a modest budget with limited technical support although it has had success in procuring grants to fund projects. Therefore, the system design must take the procurement and operational limitations of the system into consideration. Poon and Wagner (2001) cite availability of resources as a critical success factor for knowledge management systems.

Inter-organizational alliances often have difficulty promoting a collaborative work culture (Winer & Ray, 1994). The issues of security, privacy, and protection of proprietary information complicate the flow of information. These factors were taken into account during design of the model.

The current level of organizational maturity of the Virginia VOAD and its expanded mission responsibilities at the State level as a result of recent terrorist activities have generated the need for a more robust and comprehensive response to future disasters. Recent information systems developments along with the emergence of the Internet in a mainstream capacity have opened the door to new opportunities and options.
Although there are various factors involving cost, maintenance, training, design and usability that need to be taken into account, this is the opportune time to develop a use-case model for a knowledge management system to facilitate disaster relief operations.

**Research Questions**

The research questions were:

1. What are the types of information that disaster relief workers need when operating in a disaster field office (DFO)?
2. What are the functional and non-functional requirements for a web-based knowledge management system for disaster relief field operations?

**Limitations of the Study**

The Virginia Voluntary Organizations Activein Disaster (VOAD) is a loosely coupled organization. As its name suggests, it is made up of a collection of non-profit agencies whose purpose is to assist disaster victims when disaster strikes. These agencies are very disparate organizations comprised of individuals who do not interact on a continuing basis. Members spend the vast majority of their time resident in their parent organizations. Their participation in VOAD is part time and subordinate to their responsibility to their parent organization.

This lack of primary identification with VOAD was considered in the selection of candidates to be study participants for requirements gathering and system validation. In light of this, a group of 10 key personnel consisting of current members of the executive committee and past Virginia VOAD presidents were asked to serve as the formative and summative body. These participants were selected because they represent the most knowledgeable, experienced and committed Virginia VOAD members.

At the present time, there are some legal restrictions on the release of software used by the State of Virginia. This includes the Action Tracking System (ATS) software used by the Virginia Department of Emergency Management. The ATS was included in the model but implementation of this software in a prototype and follow-on system is prohibited at this time. While the ATS was included as an element in the model, this software is only peripheral to the system design and failure to incorporate it into a prototype will not have a significant impact on the system. This is a limitation unique to the Virginia VOAD. However, there are limitations inherent in the Privacy Act that restrict release of some information concerning how federal/state authorities are supporting disaster victims (Hoffman, 2003). This is a limitation that will affect all the state VOADs.

The state VOADs fall under the auspices of the National VOAD (www.nvoad.org) that establishes the conditions for membership as well as outlining the structure, activities and scope of the state VOADs. The National VOAD lists 52 state/territorial members and these organizations adhere to common bylaws and share information via newsletters, listserves, and conferences. Nevertheless, all the state VOADs are not carbon copies of each other and the knowledge management model developed for this study will require a degree of adaptation to be relevant for a particular state VOAD.

**Definition of Terms**

Communities of Practice – These consist of self-organizing groups whose members interact via networks sharing common interests and who may live or work in dispersed geographical settings. These communities have a number of characteristics in common that include similar work activities, common backgrounds and shared stories, contexts and values (Millen, Fontaine, & Muller, 2002).

<u>Disaster Field Office</u> - Once a major disaster declaration has been made the Federal Emergency Management Agency will set up a disaster field office (DFO) located as close to the disaster site as practical to help coordinate overall disaster response and recovery. This serves as the headquarters for federal staff and will include state and local government staff as well as voluntary organizations to include VOAD (FEMA, 1997).

<u>Explicit knowledge</u> – This is knowledge that can be codified and captured in artifacts such as documents, standard operating procedures or other accessible formats (Grover & Davenport, 2001).

<u>FEMA</u> – The Federal Emergency Management Agency with tasking that includes responding to declared disasters (FEMA, 1997).

<u>Knowledge Management</u> – This is the tools, technologies, practices and incentives that an organization employs to "know what it knows." This knowledge is available to the users who need it when they need it (Ahmed, Kok, & Loh, 2002).

<u>NVOAD</u> – The national level organization of Voluntary Organizations Active in Disaster that provides education, outreach, communication, and coordinated planning of member VOAD organizations (NVOAD, 2003).

<u>Primary Actor</u> – This is a stakeholder of the system that calls on the system to deliver one of its services (Kruchten, 2000).

<u>Rational Unified Process</u> – This is a process framework that can be adapted to the needs of the user organization. It is a use-case driven approach where the use cases defined for the system serve as the foundation and continuity for the follow-on development process (Kruchten, 2000).

State of Virginia – Although Virginia is technically a "Commonwealth", for purposes of this study it will be referred to as a "State."

Stakeholder – This is someone or something that has a vested interest in the behavior of a use case (Kruchten, 2000).

Tacit knowledge – This is knowledge that is embedded within individuals and cannot be easily expressed or communicated (Grover & Davenport, 2001).

Unified Modeling Language - UML is primarily a set of notations that provides a visual foundation for using an object-orientated modeling approach. The UML diagrams can be very useful in understanding or conceptualizing a problem, solving the problem, and implementing or realizing the solution. UML helps to define systems by addressing the behavioral, structural and architectural aspects of the system and visually displaying these relationships (Fowler & Scott, 2000).

Use Cases – This is a set of scenarios tied together by a common user goal. The use case considers the behavioral aspects of the system reflecting the user's concerns and requirements. The use cases defined for the system serve as the foundation and continuity for the follow-on development process (Cockburn, 2001).

VEOC – A Virtual Emergency Operations Center may include the functions of information gathering and assessment, warning, coordination and reporting that can be done on a distributed basis without the requirement of being present at a physical facility by having a presence on the Internet. This term has also been used to describe the Virginia Emergency Operations Center that is referred to in this study as the State Emergency Operations Center (Davis, 2002).

VDEM – The Virginia Department of Emergency Management is located in Richmond, Virginia and coordinates the State Emergency Operations Center (EOC) that is part of a permanent ongoing operation supporting the State of Virginia (VDEM, 2002).

Virginia VOAD – Voluntary Organizations Active in Disaster is an umbrella organization of existing agencies where each member organization maintains its own identity working closely with other organizations to improve service and minimize duplication. It has been described as an organization made up of organizations. These include the Red Cross, regional foodbanks, civic and church groups among others. As such, it is essentially a virtual organization that relies on the resources of its member agencies to respond in disaster relief (VOAD, 1998).

**Summary**

Disasters come in many forms and levels of magnitude and can strike at inopportune times and places. There are numerous agencies poised to deal with disasters; however, coordinating the activities of these diverse and dispersed entities and capitalizing on their knowledge assets can be a challenge. These agencies range from national organizations such as the Red Cross to regional organizations such as food banks and small private or civic organizations such as church based agencies. All of these agencies are dedicated to serving survivors of disasters, but they at times lack the coordination necessary to respond efficiently. Providing the right information in a timely manner in the aftermath of a disaster is essential to mitigating suffering and managing resources effectively.

The Virginia Voluntary Organizations Active in Disaster (VOAD) is an umbrella organization of existing agencies dedicated to working closely with other organizations to improve service and minimize duplication during disaster operations. To better cope with disasters, the Virginia VOAD needs to develop knowledge management strategies to coordinate its resources. Information technology can be an important tool to link elements of a community together. Virginia VOAD DFO volunteers need timely access to the organization's knowledge resources to effectively collaborate with member agencies operating as virtual teams.

The goal of this study was to design a use-case model of a web-based knowledge management system with supporting documentation to support state and local level disaster recovery planning and operations in the aftermath of a disaster. It is anticipated that this model could serve as the basis for developing a prototype knowledge management system that may also be adapted to similar state and local chapters around the country.

The use-case methodology outlined in the Rational Unified Process and supported by the Unified Modeling Language notation provided the means of systematically discovering and documenting system requirements. Although this methodology has yet to be demonstrated in the disaster relief domain it has been proven effective in other domains to include web-based environments. A web-based presence can foster communication and collaboration among geographically dispersed members of an organization.

The current level of organizational maturity of the Virginia VOAD and its expanded mission responsibilities at the state level as a result of recent terrorist activities have generated the need for a more robust and comprehensive response to future disasters. Recent information systems developments along with the emergence of the Internet in a mainstream capacity have opened the door to new opportunities and options. Although there are various factors involving cost, maintenance, training, design and usability that need to be taken into account, this is the opportune time to develop a use-case model for a knowledge management system to facilitate disaster relief operations.

# Chapter 2

# Review of the Literature

## The History, Theory and Research Literature Specific to the Topic

In constructing a knowledge management model for disaster relief operations a number of aspects must be analyzed. The first of these involves understanding the Virginia Voluntary Organizations Active in Disaster (VOAD) and how this organization functions, particularly, with regard to disaster field office (DFO) operations. Second, the requirements of the disaster relief community in the context of the broad domain of knowledge management need to be defined. In this study, the area of disaster relief is examined with particular emphasis on studying similar research efforts and systems that have been implemented to support information gathering, coordination and decision support. Third, knowledge management can encompass a wide-ranging spectrum of how knowledge can be "managed" and this definition needs to be narrowed and defined to fit the disaster relief domain. Fourth, modeling methodology is investigated to determine the appropriate approach with regard to developing the knowledge management model for disaster relief operations. Finally, technology and design issues are considered. Thus, to begin one must first have an understanding of the organization that forms the basis of this study, namely, the Virginia Voluntary Organizations Active in Disaster (VOAD).

*Virginia Voluntary Organizations Active in Disaster (VOAD)*

The Virginia VOAD is one of 52 state and territorial VOAD organizations that come under the jurisdiction of the National VOAD organization whose purpose and objectives include fostering more effective service to people affected by disaster through communication, coordination, cooperation, and collaboration (NVOAD, 2003). Each state VOAD is somewhat unique in its composition of member agencies but all serve the purpose of striving to increase efficiency and effectiveness of disaster relief recovery through coordinating the actions of these member agencies. In addition, the state VOADS work closely with both federal and state government agencies during post disaster operations (FEMA, 2000).

The Virginia VOAD was established in the early 1990's and currently has over two dozen member agencies. These include organizations such as the Red Cross, regional foodbanks, civic and church groups. It is an umbrella organization of existing agencies where each member organization maintains its own identity and works closely with other organizations to improve service and minimize duplication of effort and waste (VOAD, 1998). It has been described as an organization made up of organizations. As such, it is essentially a virtual organization that relies on the resources of its member agencies to respond in disaster situations. It accomplishes its mission by fostering (VOAD, 1998):

- Cooperation: Creating a climate for cooperation and providing a channel for sharing information and planning
- Communication: Disseminating information through news releases and notices, a directory of participating agencies, case study, and critiques

- Education: Providing training, encouraging increased awareness, and sharing information related to public policies that affect disaster response

Unfortunately, problems with communication and information sharing have been highlighted as ongoing issues during recent semi-annual Virginia VOAD meetings (Oldman, 2000; Terveer, 2001, 2002). This has been particularly prevalent during operations at disaster field office (DF0) locations. Lack of information available to the VOAD representative and well as turnover of VOAD personnel to staff the position were cited as contributing factors (Terveer, 2002). In order to comprehend the problem at the VOAD, it is necessary to understand how the VOAD and DFO fit into the larger disaster relief domain.

In the aftermath of a disaster but prior to a national declaration of the emergency, the Virginia VOAD may also be called on to have a representative in the State Emergency Operations Center (EOC) located in Richmond, Virginia. Prior to activation of the DFO (normally situated geographically close to the disaster site) this is where the VOAD representative will report to and operate from if required. The DFO (when activated) is established in conjunction with state recovery operations (FEMA, 1997). The State Emergency Operations Center (EOC) is part of a permanent, ongoing operation administered by the Virginia Department of Emergency Management headquartered in Richmond, Virginia. The State of Virginia will also have representation at the DFO (when activated) with the presence of a State Coordinating Officer working with federal and local officials. At elevated alert levels, the Virginia VOAD will maintain a liaison with the State EOC and may have a representative report to the State EOC if necessary (VDEM, 2002). This is in addition to the VOAD representation at the DFO. Needless to say, close coordination between the VOAD representatives at the State EOC and the DFO is imperative. The VOAD representative functions in the State EOC as part of the Human Services Branch. This is depicted in Figure 1.

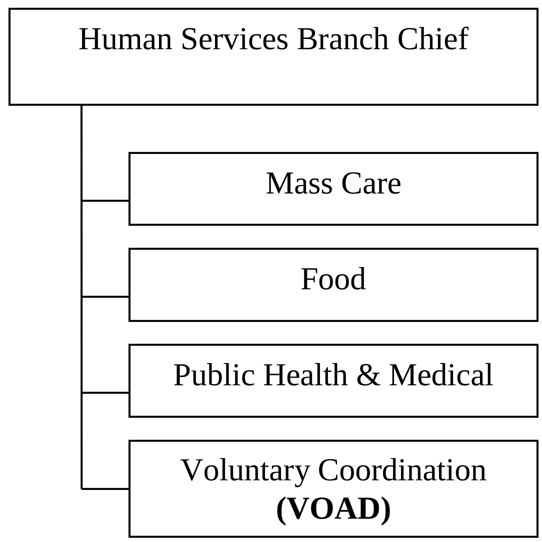


Figure 1. VOAD representation in the Human Services Branch of the State EOC

Once a major disaster declaration has been made the Federal Emergency Management Agency (FEMA) will set up a disaster field office (DFO) to help coordinate overall disaster response and recovery. This will serve as the headquarters for federal staff and will include state and local government staff as well as voluntary organizations to include VOAD. Factors that are considered in choosing a location include wanting to be as geographically close to the affected site as possible while also considering suitable office space and communications availability.

The DFO serves as the operating site for the responding agencies and is established under the joint auspices of the Federal Coordinating Officer (FCO), appointed by the

FEMA Director, and the State Coordinating Officer (SCO), appointed by the governor (Hoffman, 2003). Identifying needs and channeling information generally flows from local to state to federal agencies and these agencies establish working relationships to deal with the situation (FEMA, 1997). Local information drives federal support (Hoffman, 2003). Each situation (disaster) is unique and information and feedback flow is fluid and situation dependant. This is depicted in Figure 2.

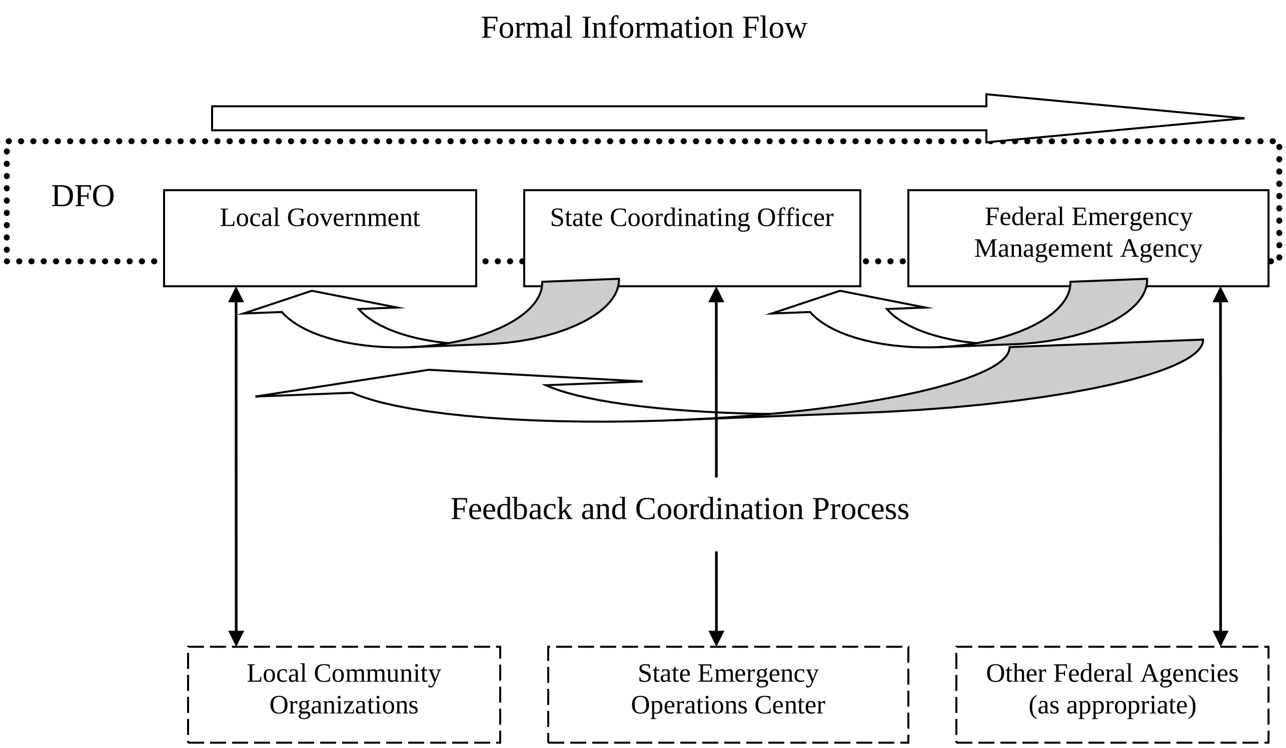


Figure 2. Local, State, and Federal Coordination at the DFO

Working together with local, state and federal agencies the VOAD is tasked to support unmet needs that include sheltering, mobile and fixed feeding, repair and reconstruction of homes, clean-up, counseling, storage and distribution of bulk food, clothing and household goods, child care, pet care and other services (VDEM, 2002). The VOAD works closely with the state elements of the DFO serving as a liaison and coordinating agent between the member agencies of VOAD. The VOAD representative works with the State Coordinating Officer in the DFO as depicted in Figure 3.

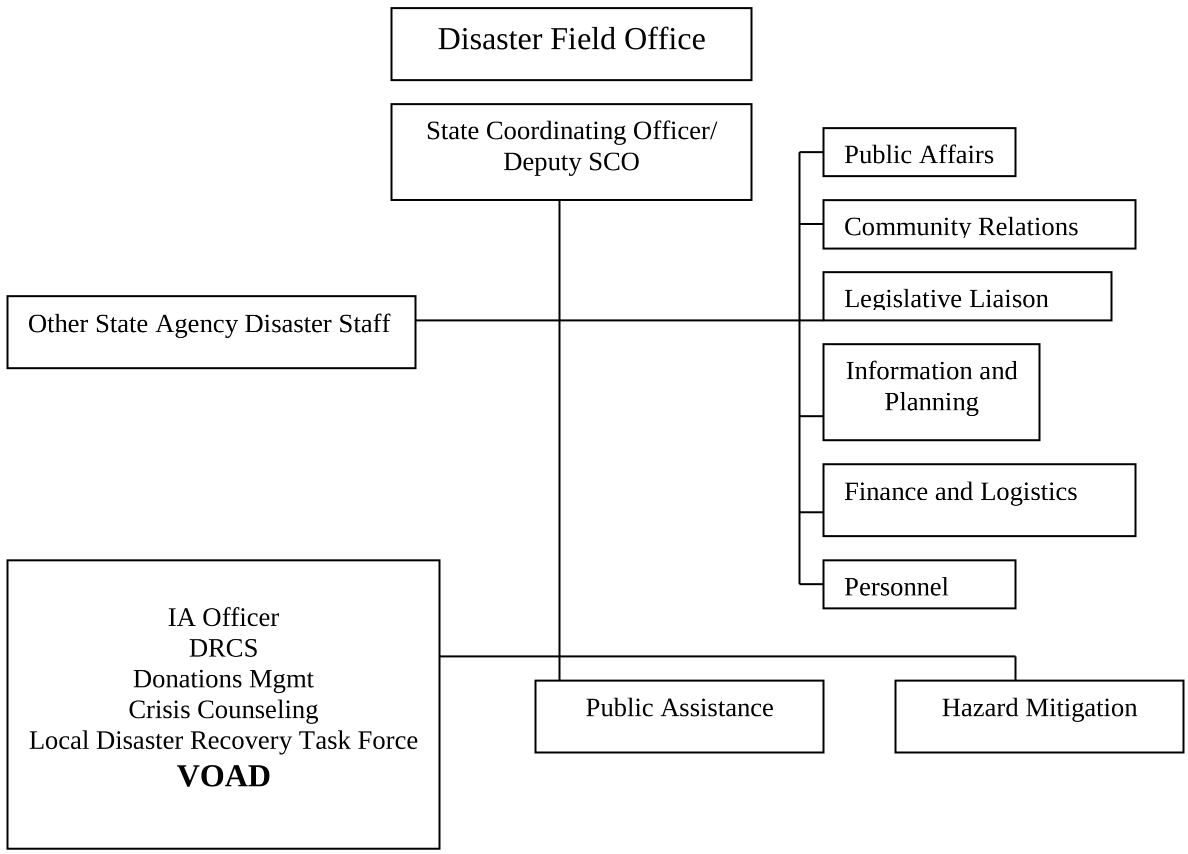


Figure 3. VOAD representation with the State Coordination Officer

The DFO VOAD volunteer is also required to link member organizations with local emergency managers, local voluntary agencies, and state and federal agencies that are providing assistance as well as collecting, compiling and reporting information on the status of activities and resources of Virginia VOAD member organizations (VDEM, 2002). This is a tall order for a part time volunteer who may be new to the process. Without the proper access to the organization's knowledge resources this individual may quickly become overwhelmed. The problems discussed during the Virginia VOAD meetings point to problems with communication and information sharing at disaster field office (DF0) locations. The lack of information available to the VOAD representative and well as the low experience levels resulting from the turnover of VOAD personnel can be alleviated with access to a knowledge management system that taps into the expertise embedded in the organization.

*Disaster Relief Operations*

The cornerstone to disaster relief operations is "connecting" people so they can solve problems together. Turoff (2002) explains that crisis situations bring many and diverse individuals from different organizations together and they must be able to freely exchange information, delegate authority, and conduct oversight. Additionally, this must be accomplished without the burden of information overload. He states that establishing and supporting confidence in decision making is essential to coherent operations. This is accomplished through supplying the best possible up-to-date information to decision-makers whose actions directly influence lives and resources. However, as Wybo and Lonka (2002) point out there is a relatively low integration of information technology in the field of emergency management and, first and foremost, we need to gain a proper understanding of the information requirements. They note the difficulty in grasping the complexity of emergency management and accessing the tacit knowledge of practitioners.

There are a number of criteria that must be considered in the design of a knowledge management system to support emergency management of disaster relief operations. These include user friendly interfaces and a real-time capability for the system (Ikeda, Beroggi, & Wallace, 2001). System designers must understand user capabilities and familiarity with the system and make the interface as intuitive as possible (Lindell, Sanderson, & Hwang, 2002). Also, the exact series of events in a disaster are hard to predict. However, a timely and efficient response to emergencies can shorten the length of the emergency phase and provide needed assistance to survivors (Burkholder & Toole, 1995).

Additional significant criteria that researchers have noted in emergency management operations are access to accurate and comprehensive information. Iakovou and Douligeris (2001) found this to be of critical importance in coping with hurricane disasters. They describe the development of an emergency management system called Information Management System for Hurricane disasters (IMASH). This system is an "intelligent integrated dynamic" information management tool that provides comprehensive data and is accessible through the World Wide Web. It employs the intelligence of a decision support system and supports a range of hurricane disaster related activities that include pre-strike, activities during, and post-strike activities. It can be dynamically augmented to include new data and models. One aspect that would enhance IMASH would be the inclusion of a knowledge management capability to capture explicit and tacit knowledge.

Under the auspices of the Office of Emergency Preparedness in the Executive Office of the President a system was developed called Emergency Management Information Systems and Reference Index (EMISARI). It consisted of a computerized system that allowed participants to engage in a collaborative Delphi process via a computer network to exercise coordinated response to crisis situations. The system designers recognized that emergency situations were, by nature, unpredictable and fluid. The purpose of the system was to allow a distributed group of people to track and coordinate their activities. The system enabled event notification and discussion threads as well as the ability to tailor reports dynamically (Turoff, 2002).

Other advanced information systems have proven effective in capturing and consolidating information and knowledge. Kompetenzverbund Resiko und Sicherheitswissenschlaften (KOVERS) is an integrated support system designed to assist emergency management personnel during nuclear and chemical accidents involving fixed installations or transportation activities as well as satellite impact parameters. It has a high degree of integration with existing commercial maps to give it geographic information system (GIS) capabilities combined with complex computational features (Gheorghe & Vamanu, 2001). Integration with GIS and simulation modeling are also features of Configurable Evacuation Management and Planning Simulator (CEMPS) which supports nuclear planning and management (Silva, 2002). Another system is IDA. IDA is an intelligent decision advisor that incorporates a generic agent model and object-based conceptualization for large-scale industrial and territorial emergencies. It includes the properties of an information-based agent and a knowledge-managed agent. The knowledge-managed agent is designed to suggest an action or plan after every new significant event in the domain. (Gadomski, Bologna, Costanzo, Perini, & Shaerf, 2001).

While sophisticated systems can be useful in providing information and managing knowledge, the very sophistication of these systems can be a drawback. Local emergency management authorities in Auckland, New Zealand have a number of challenges in managing a variety of hazards that could result in significant damage. They found that there were management concerns about the collection, storage, interpretation, and dissemination of information as well as the way information was used to influence decisions about management risks. In short, having complex, cumbersome systems was a drawback. They cited examples of issues that include information that was known by council staff but not disseminated, inconsistency of hazard information, lack of knowledge of information systems, and inappropriate systems. One of their key conclusions was the need to set up a system that was as simple as possible to encourage its use (Pardy & Daly, 2001).

Providing adequate training will also benefit users of a system. Britton (2001) cited best practices and relevant education and training as important parts of an emergency management strategy. He suggested creating opportunities to link person-to-person, specialist-to-specialist, agency-to-agency, and sector-to-sector as the paramount role for the Australian Ministry for Emergency Management. A comprehensive training strategy is essential to the effective use of an emergency management system (Jenvald, Morin, & Kincaid, 2001). This training must not only focus on individual skills but also intra and inter-agency competency.

Paton and Jackson (2002) outlined the dynamic and evolving conditions, role uncertainty and situational constraints that characterize the disaster response environment relating these factors to the importance of developing training techniques. They stressed the importance of management capabilities in the context of dealing with delegation, communication, decision making, and inter-agency coordination. In order to use collective expertise effectively, one must understand the complex inter-organizational relationships that emerge during disaster recovery operations. However, one constraint in developing this capability is the rarity and unpredictability of disasters which limits the opportunities to gain depth and breadth of experience in disaster recovery operations. They discussed the creation of Assessment Centres to provide a training venue for exercises and simulations. They concluded training enhanced team performance and contributed to shared mental models that accommodate information availability and participants' diverse backgrounds, needs, interests, and goals. Decision effectiveness is a function of the level of integration and the extent to which the participants share a mental model of the response environment (Paton & Jackson, 2002).

Stumpf (2001, May/June) described a concept called Unified Command. This Incident Command System is a computer-mediated system that outlines authorities and responsibilities during incidents. Through this system, command or staff roles are assigned and participants share equally in the development of overall objectives and management of the incident. The Unified Command concept highlights the growing need for multi-agency and multifunctional involvement in incidents and notes the difficulty agencies have in working together. These include different emergency response organizational structures, lack of reliable incident information, inadequate and incompatible communications, lack of structure for coordinated planning between agencies, and unclear lines of authority (Stumpf, 2001).

McEntire (2002) pointed out that coordination is a major challenge among individuals, groups, and agencies involved in responding to the aftermath of disasters. Multi-organizational operations call for collaborative problem solving to overcome the difficulties encountered among the agencies that respond to disaster. This was illustrated by the tornado that occurred in Fort Worth, Texas in March of 2000. He observed that the involvement of numerous public, private, and non-profit agencies required both intra- and inter-organizational coordination. A disaster field office (DFO) was established to meet the challenges posed during the immediate and long-term recovery periods that included donations management and disaster assistance. He noted a number of constraining and contributing factors. Factors constraining a coordinated effort included:

- Information was sometimes incomplete or inaccurate with either not enough or too much information available
- Lack of initial communication between field personnel
- Failure of communications systems resulting in lack of coordination
- Responding agencies overstepping their authority

Factors contributing to a coordinated response included:

- The city had held training sessions to build response capacity and help participants understand field operations
- Networking and cooperation that led to knowing participants personally was important
- Experience in previous incidents was very valuable

- Technology, correctly applied, played an important role and proved to be a valuable asset in coordinating the disaster response tasking
- Promoting a "big picture" perspective enhanced cooperation and coordination

In the aftermath of the destruction of the World Trade Center and damage to downtown Manhattan on September 11, 2001, the city of New York relied on an emergency management system called Eteam. This system was based on Lotus Domino and allowed more than 1,700 workers from 200 federal, state, and local agencies in New York to communicate with each other, keep information up to date, and make decisions for both the initial rescue effort and the follow-on cleanup and recovery activities. This system was instrumental in managing workers and coordinating the logistics of bringing in equipment and emergency supplies. The web-based collaboration software was used to create and access infrastructure reports and produce and update incident reports. It was also used to submit and process requests for blankets, boots, construction equipment, and other resources vital to the recovery and reconstruction of the downtown area. At ground zero, the rescue workers accessed the Eteam system via wireless network cards in laptop computers and transmitted updates remotely to the command center. The system allowed participating agencies to all be "on the same page" and make decisions using the same reports (Lunt, 2001).

Logistics operations are often the cornerstone to saving lives and expediting the recovery phase of disasters. Nevertheless, matching the requirements with available resources is not an easy task and necessitates considerable coordination (Bradley et al., 2002). Software can help manage workflow challenges, expedite response, and avoid duplication of effort. Green (2001) discussed the Virginia Department of Emergency

Management software called the Action Tracking System that allows state agencies to access key data relevant to the mission. Developed "in-house" this software is an information sharing tool designed to provide clear visibility for task assignment and status.

Emergency management software is increasingly offering options to work in a web-based online environment (Green, 2001). This has led to the employment of Virtual Emergency Operations Centers (VEOC). Although this concept is evolving, a definition of a VEOC may include the functions of information gathering and assessment, warning, coordination, and reporting that can be done on a distributed basis without the requirement of being present at a physical facility by having a presence on the Internet (Green, 2000). A VEOC allows direction and control of resources, manages processes and methodologies, assigns and tracks tasks, and communicates real-time information serving as a center for information management (Davis, 2002). Green (2001) cited an example of a VEOC. In Virginia, one volunteer organization, the Virtual Emergency Operations Center (VEOC) operates an emergency operations center supporting other agencies using web-based architecture. The VEOC collects and analyses information, provides warning and notifications, and distributes tailored information products. It is managed using an incident command system, and integrating established emergency operations plans and procedures.

Davis (2002) notes that the military has embraced the VEOC concept in its command and control initiatives and the private sector is following their lead. Companies such as Cisco and AT&T use commercial off-the-shelf VEOC software to limit company vulnerability and provide continuity and knowledge transfer. Green (2001) suggests the following components for a VEOC:

- Use of software to communicate internally and externally in a management context
- Remote access to information
- Access to Internet sites to gather additional information
- Dissemination of information
- Linking dispersed individuals to perform functions and duties remotely

Researchers have raised questions about the vulnerability of Internet based emergency operations centers in disasters, in particular, due to their dependence on connectivity via communications links (Green, 2001; Wybo & Lonka, 2002). However, Davis (2002) points out that new developments in telecommunications, such as wireless networks and hand held devices have created significant solutions for overcoming inherent VEOC connectivity problems. Wireless and mobile networks are being used in diverse areas that include disaster recovery (Malladi & Agrawal, 2002). One of the technologies described on the Disaster! Finder Web site hosted by NASA is PowerWatch. This application uses a combination of Internet, pagers, cell phones, voicemail, fax, Blackberry, and PDA to contact personnel and allow personnel to obtain additional critical information about a crisis (Einaudi, 2003). One of the strengths of the web-based system is that even though accessibility may be temporarily limited, distributed computer- based emergency operations center architecture has the potential to re-establish a situation picture rapidly once when connectivity is enabled (Green, 2001).

There are a variety of information systems that provide coordination and decision aids to emergency managers. However, a difficult challenge that has not been adequately addressed is that of understanding the basic inter-relationship and functioning of local disaster relief organizations and what benefits they may obtain from knowledge management systems. One can begin by defining the capabilities and functions of knowledge management systems.

*Knowledge Management*

Perhaps the first step in understanding knowledge management is to define the term *knowledge*. Drucker (1989) defines knowledge as " information that changes something or somebody, either by becoming grounds for action, or by making an individual (or an institution) capable of different or more effective action" (p. 14). Knowledge can be a powerful element in influencing events either on an individual or organizational level. But how do we get to the stage of creating this element?

Galup, Dattero, and Hicks (2002) categorize it in terms of the three related concepts of data, information and knowledge. *Data* is a set of facts about events that is both discrete and objective. Standing alone it is static until the user adds meaning or value at which time it becomes *information*. This derivative process continues in the creation of *knowledge*. When information is viewed in context together with an understanding of how to use it, information becomes knowledge. According to Davenport, DeLong, and Beers (1999), "Knowledge is information combined with experience, context, interpretation, and reflection. It is a high-value form of information that is ready to apply to decisions and actions" (p.89). A characteristic that distinguishes an organization's knowledge from its information assets is how knowledge is constructed. Collaborative problem solving, conversations, and teamwork generate a significant proportion of the knowledge assets of an organization (Tiwana, 2002). Liebowitz (1999) states knowledge management is the process of creating value from an organization's intangible assets.

The concept of knowledge can be further defined in terms of explicit or tacit knowledge. Explicit knowledge can be codified and captured in artifacts such as documents, standard operating procedures, or other accessible formats. Tacit knowledge, on the other hand, is embedded within individuals and cannot be easily expressed or communicated. Both types of knowledge have value to an organization but Western firms have focused largely on capturing and exploiting explicit knowledge (Grover & Davenport, 2001).

Mack, Ravin, and Byrd (2001) define knowledge management as the tools, technologies, practices and incentives that an organization employs to "know what it knows." It is important this knowledge is available to the users who need it when they need it. They define the knowledge management cycle as a process in which solving a problem leads to new knowledge (initially tacit) that is made explicit when experiences are documented, distributed, and shared. This cycle continues when explicit knowledge is applied to a new problem creating tacit knowledge and potentially initiating a new knowledge management cycle. Nonaka and Takeuchi (1995) describe creating a "knowledge spiral" in an organization where knowledge is transferred from one member to another. Initially the first member's tacit knowledge is transformed into explicit knowledge. This is then passed on to the other member of the organization who internalizes it and converts it into tacit knowledge.

Fahey and Prusak (1998) see tacit knowledge as a crucial and very valuable asset of the organization and view an overwhelming focus on explicit (as opposed to tacit) knowledge as one of the "deadly sins" of knowledge management. Typically, employees possess knowledge pertinent to the organization's core competence in the form of tacit knowledge and their departure represents a significant loss to the organization. Individual knowledge is difficult to pass on and reuse throughout the organization (Wei, Hu, & Chen, 2002). In the dynamic, unpredictabl,e and fluid emergency management environment, tacit knowledge is an important element of successful performance because it allows individuals to adapt to and shape the environment (Paton & Jackson, 2002). Wybo and Lonka (2002) conclude that the use of tacit knowledge is prevalent in the domain of emergency management.

Even though corporations have unprecedented access to data, all too often, that data is not transformed into a form that can be used to aid business decisions (Davenport, Harris, & DeLong, 2001). The mounds of data collected can be overwhelming but they still need to develop the capability to aggregate, analyze, and use date to achieve real business value and make informed, confident decisions. Lack of investment in tools such as decision support systems, executive information systems, online analytic processing, and data mining is not the problem. The market for these systems is growing at an average rate of more than 50 percent (Davenport et al., 2001).

Indeed, the role of information systems has evolved over the past decade. How to measure the success of these systems to support knowledge management has been an area of interest to researchers. DeLone and McLean (2002) proposed a taxonomy and interactive model called the D & M IS Success Model as a framework for conceptualizing a successful information system. Information quality, system quality, and service quality were prime factors contributing to system use, user satisfaction and, ultimately, net benefits of the system.

The problem is that organizations have not progressed through the stages of data to information to knowledge and leveraged this process into concrete results. Many organizations have missed the most important step in the data transformation process, that of the human component necessary to interpret data and formulate actions. DenHertog and Huizenga (2000) discuss Knowledge Centers where knowledge is concentrated in a number of places. This concept involves specific knowledge domains in a “center” where frequent informal and formal exchanges take place. Many organizations have ignored the organizational, cultural, and strategic changes and are finding that the glamour of technology is no substitute for the human element (Davenport et al., 2001).

Organizations must develop a “learning organization” culture to capitalize on the knowledge resources embedded within the organization. Garvin (1998) cites five activities that learning organizations are skilled at accomplishing:

- Problem solving in a systematic manner
- Being free to experiment with new approaches
- Using their experience and past history as a learning experience
- Learning from others experience and best practices
- Being able to transfer knowledge efficiently and effectively throughout the organization as appropriate

A knowledge strategy must take into account that social capital is multidimensional and includes attributes such as culture, trust, anticipated reciprocity, context, and informal networks. Short (2000) discussed the importance of these attributes as well as four management approaches:

- Harvesting. This is the most common and recognizable approach to knowledge management. Examples of this approach include best practices and lessons learned and online article collections which represent attempts to collect artifacts and use them in conjunction with a specific issue in the future. A challenge is to not only identify these elements but to also codify them in a meaningful way to allow users ease of navigating and finding targeted material. Another issue is the willingness of end users to contribute information or artifacts and then access and exploit those artifacts in a productive way. Harvesting is often the first step organizations take in developing knowledge management systems.
- Hunting. Organizations sometimes collect and store data, information or other knowledge artifacts in a repository for future use but a key is effective discovery from these repositories. Data warehouses and competitive intelligence gathering are two examples where the value of these collections comes from further exploration of content. The benefit derived from this approach relies more on serendipity than on the focused harvesting technique that one would use in a best practices database.
- Harnessing. Effective knowledge management encompasses another dimension of deliberate activities that may be characterized as “the age of connection.” An example is how British Petroleum used desktop videoconferencing to solve a drill

rig compressor problem in Latin America by connecting staff in Italy and Alaska. There were no databases or repositories used to solve the problem. It was done by connecting "knowers" to each other and to a problem with the aim to exploit what the knowers know. Effective harnessing approaches assume that significant knowledge and expertise exists among participants. Also, this knowledge and expertise is highly tacit and thus not readily captured and accessible from a database. Other important factors are a cultural willingness to collaboratively solve problems, a means to map "who knows what" and a wide access to such a map.

- Hypothesizing. This involves a technique called scenario planning that is an approach to manage uncertainty and increase the richness of decisions that are made. This technique is not aimed at predicting the future but rather aims to develop alternative scenarios of the future. Identified known and unknown data points at a given time form the basis for the decision support oriented concept that allows the development of an operational strategy. Royal Dutch Shell used this approach to identify early warning indicators for the oil markets. This approach can incorporate brainstorming sessions that involve participants with diverse backgrounds using a concept called requisite variety that is a central principle of scenario planning. The term hypothesizing describes connecting-to-explore approaches to knowledge management.

Srinantaiah (2000) explains that an important issue to be addressed with regard to tacit knowledge is that it includes not only the actions, expertise, and ideas of staff personnel but also the values and emotions of human beings. Constructive results depend on how workers communicate, collaborate, and interact in communities of practice within the institution as well as outside the institution. To make knowledge management effective, bringing explicit knowledge and tacit knowledge together in an integrated infrastructure is absolutely essential. The type of infrastructure is dependent on a number of factors. These include the organization's complexity, its available resources for supporting knowledge management, and the organization's goals and objectives. The infrastructure may include simple or sophisticated information technology. Other key issues include top management support, social capital, trust relationships, mentoring, benchmarking, training, and employee development (Srikantaiah, 2000).

Burnett, Brookes-Rooney, & Keogh (2002) point out that although knowledge is commonly being created, shared, and maintained across organizations, there is a dearth of supporting infrastructure or processes for the effective management of knowledge gained from a wide range of initiatives. They describe a system called Stretch Performance Network (SPN). This system was set up by oil and gas industry companies to act as an "honest broker" in providing a knowledge repository and forum to disseminate best practices. Organizations are becoming cognizant of the fact that their intangible knowledge assets provide the lynchpin to their success. These organizations are striving to identify and manage their knowledge resources more effectively by implementing a range of efforts addressing behavioral, process, and technological issues. A key aspect of this strategy is capturing the benefits derived from the sharing of knowledge, not only intra-organizational but inter-organizational.

Companies including BP and Schlumberger have implemented staff "yellow pages" identifying contact details and areas of expertise. The effective transfer of lessons learned from projects may prevent time and money from being wasted through re-learning within other areas of the organization. Burnett, Brookes-Rooney, & Keogh (2002) highlight clarifying tacit knowledge as a primary challenge. One of the strengths of the SPN system was the recognition of the synergy between individual and organizational knowledge. An important aspect was the issue of transferring learning and knowledge between companies as well as within them. Different types of media to transfer knowledge included electronic formats such as web pages and emails (Burnett, Brookes-Rooney, & Keogh, 2002).

Davenport, DeLong, and Beers (1999) studied 31 projects in 24 companies and identified eight key characteristics of successful projects. The top ranked factors were a knowledge-oriented culture, creating an effective organizational infrastructure, procuring the right motivational tools, and cultivating support from senior management. They pointed out that, often times in knowledge management, knowledge is treated as an 'it' and set apart from the people who create and use the knowledge.

How to use information is a primary challenge for managers and this has been compounded by the dispersed nature of organizational knowledge. Becker (2001) suggests four strategies to deal with this situation. The first is to "substitute knowledge by access to knowledge" and create "information channels" along the lines of social relationships through which knowledge is acquired. The second strategy solves the knowledge gaps created by the dispersed nature of knowledge by developing the capability to "complete incomplete knowledge." In this instance, organizational learning is central to detecting and filling the gaps. The third strategy proposes decomposing organizational units into smaller ones and delegating tasks to sub-units therefore increasing specialization and “economizing” on the transmission of information and knowledge. Finally, the fourth strategy is to compensate for coordination problems by designing institutions with appropriate coordination mechanisms. This strategy recognizes that tacit knowledge cannot be transferred easily and communities of practice play an important role in information transfer.

Millen, Fontaine, and Muller (2002) state that there has been increasing interest within large organizations in the development and support of communities of practice. These communities have a number of characteristics in common that include similar work activities, common backgrounds and shared stories, contexts, and values. Benefits have accrued from fostering these entities. This has included enhancing collaboration, improving social interaction, increasing productivity, and greater organizational performance. Increasingly, the online venue that includes web spaces, email, discussion forums, and synchronous chats has largely replaced face-to-face exchanges for these communities. These technology tools lend themselves to the creation of virtual environments or “spaces” where people interact in synchronous and asynchronous timeframes.

The knowledge creation process is by extension a social process, embedded in a particular set of relationships present among individuals, teams, and organizations (Nonaka & Nishiguchi, 2001). De Michelis (2001) describes knowledge creation in terms of a “space” where members convene and interact. He contends that knowledge does not require the support of large information bases and sophisticated information processing and retrieval systems. He highlights the point that the function of information and communication technology is to create a space that supports, with continuity, openness, and multiplicity, the awareness of its users with respect to their continuously changing context.

The emergence of virtual spaces has contributed to the growth of virtual teams and virtual organizations. Critical components of knowledge management include developing cross-functional teams to facilitate knowledge exchange, integration, and innovation (Burton-Jones, 1999). An important issue in this environment is to understand what skill sets are needed to work effectively. Larsen and McInerney (2002) found that the ability to work in teams was essential but this was complicated by the fact that groups are often formed on an ad hoc basis to respond to uncertain needs or situations. This relationship is often fleeting and temporary and demands that workers contend with rapid change. This requires high levels of trust and cooperation. Enhancing communication through the use of all alternative media was one solution to the problems associated with geographical dispersion (Larsen & McInerney, 2002).

Bieber, Hiltz, Stohr et al (2002) define a virtual community as "anyone actively interested in, or associated with, a group formed around a particular domain of interest" (p.1). They describe an architecture for a community knowledge evolution system called Collaborative Knowledge Evolution Support System (CKESS). This includes computer-mediated communications, community process support, decision support, advanced hypermedia features, and conceptual knowledge structures. It would serve as a continuously growing and evolving repository of the community's knowledge enriching individual competence.

A way of conceptualizing the capture of information is through knowledge mapping. Vail (1999) describes a knowledge map as a visual display of captured information and relationships that allows for the communication and learning of knowledge. It permits observers with different backgrounds to obtain information at various levels of detail. This can provide a hierarchical-based display with summary-level knowledge and relationships and can serve as links to more detailed knowledge sources. The map serves as a continually evolving corporate memory that encapsulates and integrates the important knowledge of an organization. It promotes learning through the navigation and interrogation of the information in the map as well as the creation of new knowledge through the discovery of new relationships. Linkages can be expanded electronically to other sources and repositories of detailed internal and external knowledge in text, story, picture, numerical, model, or multimedia forms.

According to Kemp, Nidiffer, Rose, Small, & Stankosky (2001) in today's business arena a company's value is largely measured by its capability to exploit knowledge and leverage it into net worth. To do this an organization must create an environment for knowledge creation, utilization, and sharing. An important aspect of the value equation is providing innovative support for information access and member collaboration. Technology is one of the elements that form the basis for this support. They conclude that establishing a web based portal with such features as intelligent search and support for communities of practice would provide advantageous functionality. An effective user interface and concept-based search capability were also important considerations. Criteria for selecting features for the portal were based on need, cost, and feasibility.

Although non-profit organizations may not measure their "net worth" using the same metrics as for-profit companies they are, nevertheless, compelled to provide "value" for their clients. The lessons learned by Kemp et al. (2001) in developing a web portal based knowledge management system are largely applicable and include establishing:

- Clear goals where knowledge requirements are prioritized and policies, systems, and infrastructure are designed to satisfy user needs
- Strong sponsorship at the executive level
- Realistic expectations that reflect the situation
- A balance of technology with other critical elements such as leadership, organizational structure, and learning
- Taking an iterative approach with continual system evolution

According to Mack, Ravin, and Byrd (2001), knowledge portals provide easy and timely access to information and support mobility and collaboration with a single point access. The expanding knowledge workplace is characterized by gathering, organizing, analyzing, creating, and synthesizing information and expertise. However, the ubiquitous mobile and pervasive computing environments present challenges to web based portal designs. For example, bandwidth and device limitations must be considered and accommodated. Mack, Ravin, and Byrd suggest the co-evolution of three research initiatives will drive the emerging knowledge workplace. These are an evolving understanding of how knowledge management systems help to accomplish tasks, technical innovation in component technologies, and innovation in application integration linking tasks and technology.

Competence has to be learned and accumulated over time. Loss of knowledgeable workers can have a devastating effect on an organization (Lesser & Prusak, 2001). In addition, there is a risk of re-inventing the wheel unless information is captured and available for others in the organization to use. The goal should be to transfer the experiences and knowledge of individuals in a way and in a form that can be readily shared and communicated to others in the organization (Bessant, 2000). NASA has formed a Knowledge Management Team as one of their knowledge management initiatives within their organization. They recognize this as a way to improve practices and processes, enhance employee capabilities, and improve customer service. In addition, the Social Security Administration reports that its SSA intranet called PRIDE (Project Resource guIDE) is a successful project that allows subject matter experts to share best practices (Liebowitz, 2002). Web-based technologies enable innovative ways to disseminate knowledge and lessons learned but it is important that these technologies are introduced using sound methodology (Jenvald et al., 2001).

Not all knowledge management projects prove to be productive. Braganza and Mollenkramer (2002) discuss the experience of PharmaCorp with their failed knowledge management system. This was centered in PharmaCorp's Alpha Project which was a global initiative that began with great promise. However, at the end of three years it was deemed a failure despite the positive support from executive commitment, availability of funding and associated resources, and participation by competent people. Braganza and Mollenkramer highlight the following as the chief lessons learned:

1. Center knowledge management on business processes and manage knowledge across communities of practice.
2. Natural groups of activities should provide the basis to contextualize knowledge. Specific elements of knowledge must be appropriately weighted and this must be within a clear context.

3. There was too much emphasis on explicit knowledge and tacit knowledge was often neglected.
4. Tacit and explicit knowledge management requirements should be determined by the users. They should be able to contribute their ideas and provide input to shape the environment and improve their activities with feedback.
5. Don't let external consultants control the development. The people in the organization must "own" the system and manage the system development.

Alvesson and Karreman (2001) state that knowledge is an entity that is inherently difficult to manage due to its ambiguous, unspecified, and dynamic nature. Knowledge is intrinsically related to meaning, understanding, and process. What knowledge management does is connect people so they can think together (DenHertog & Huizenga, 2000). Learning and understanding during and after a crisis are important elements of the response process (Turoff, 2002). However, to create a successful knowledge management system we must first understand how stakeholders interact with the system and be able to define their requirements.

*Modeling*

Before investing time and resources in developing a knowledge management system it is prudent to take a systematic and disciplined approach to analyzing the entity relationships and requirements of the organization. One option is to develop a model to document the essential elements and provide a synchronized view of the environment. Although the model will likely lend itself to follow-on decisions involving technology choices, it is a higher level artifact. The model should remain robust, stable, and relevant, while the specific technologies may change over time, as appropriate (Luan & Serban, 2002).

No model can ever be a precise representation of reality and even the simplest organization has so many internal and external interrelationships that are constantly changing that the model depiction will never be "finished" (DeGues, 1994). Nevertheless, modeling sets the stage for understanding the dynamics of the organization or system. Rehfeldt and Turowski (2000) describe a distributed knowledge management environment that focuses on decentralized and virtual organizations that encompass multiple companies. Their approach integrates information and knowledge creating tools into next generation business models characterized by electronic collaboration.

Analysis of knowledge processes in organizations may reveal complex relationships. Kanfer et al. (2000) note that current research indicates a critical conflict between knowledge process in groups and the technologies intended to provide support for them. They suggest there is a tension between embedded and mobile knowledge arising from the interrelationships between knowledge shared among elements, communications technology, and the group context. They use a multi-model approach for studying this tension.

There are a number of options available to choose from when deciding on a formal modeling strategy. Model builders using system dynamics rely on multiple, diverse streams of information to create and calibrate model structure and incorporate quantitative data, written records, and information contained within the mental models of key actors in the system (Vennix, Anderson, Richardson, & Rohrbaugh, 1992). Another option is to use Petri Nets to define relationships among elements and depict the internal logic of the coordination components (Raposo, Cruz, Adriano, & Magalhaes, 2001). However, one modeling technique that has gained wide acceptance is use-case modeling (Cockburn, 2001).

Use-case development incorporated within the framework of the Rational Unified Process (RUP) plays a pivotal role in process workflows especially requirements definition and is key to business modeling (Eriksson & Penker, 2000; Kruchten, 2000). Although originally used as a software engineering process, RUP is a process framework that can be adapted to the needs of the user organization. It is a use-case driven approach where the use cases defined for the system serve as the foundation and continuity for the follow-on development process (Kruchten, 2000).

The use case considers the behavioral aspects of the system reflecting the user's concerns and requirements (Saleh, 2002). The core of the Unified Modeling Language (UML) includes use cases to model requirements and classes and objects to model system structure. Fowler and Scott (2000) define a use case as "a set of scenarios tied together by a common user goal " (p.40). They explain that there is flexibility in describing the contents of a use case with sections the designer can add or omit depending on the requirements. They also point out a possible pitfall with use cases. By focusing on the interaction between user and the system, the designer can overlook opportunities to examine ways to change a business process (when this may be the best solution to the problem). Although use cases are written in a textual format their utility can be enhanced with visual representation using UML (Fowler & Scott, 2000).

The UML is a de-facto modeling language used in the software industry and adopted by the Object Management Group in 1997 (Booch, 1999). However, it can be adapted to modeling more than just software and can provide a higher view of systems. It can be used for visualizing, specifying, constructing, and documenting software systems and the elements of a system in general to include describing business processes (Eriksson & Penker, 2000). The UML is primarily a set of notations that provides a visual foundation for using an object-orientated modeling approach. It does not require a specific development process but lends itself to a pragmatic, iterative, and comprehensive strategy for systems development of different types of systems, domains, and methods (Alhir, 1998). The UML diagrams can be very useful in understanding or conceptualizing a problem, solving the problem, and implementing, or realizing the solution. UML helps to define systems by addressing the behavioral, structural, and architectural aspects of the system and visually displaying these relationships.

Marshall (1999) demonstrated the use of UML in modeling an enterprise using a strategic model hierarchy of purpose, processes, entities, and organization. He presented a higher level view of system components and how they interact inside and outside the organization. This high level use of UML to model systems can be applied in diverse environments. Saleh (2002) described the use of UML for the documentation of various aspects and views of electronic commerce systems. UML was also used to create a modeling environment for a manufacturing plant life-cycle model improving the efficiency, manipulation, and utilization of the plant life-cycle models (Gabbar, Shimada, & Suzuki, 2002). UML has also shown its utility by its integration with other specification methods such as Linear Algebra and Sets Theory (LAST), a formal method for business software requirements specification (Almendros-Jimenez & Gonzalez-

Jimenez, 2002), and Specification and Description Language a standard used by the International Telecommunication Union (Andersson, Ek, & Landin, 2001).

*Technology and Infrastructure Design Issues*

Technology experts view knowledge management with systems analysis, design, and implementation in mind. Their approach may emphasis one or several of the following areas: knowledge storage and access; “push” and “pull approaches; network architecture options; customer satisfaction metrics; organizational culture; telecommunication opportunities and limitations; application software packages; and cost recovery (Srikantaiah, 2000). Simply because people are connected electronically does not guarantee that collaboration will result. Careful examination of the necessary components of a system is needed. Enhanced productivity will result from better availability of information and improved collaborative support (Lucca et al., 2000).

Selvin and Buckingham-Shum (2002) discuss a concept called Rapid Knowledge Construction (RKC) that was introduced as a project called Compendium. This is an approach that combines document management (in a repository) with real-time communication resulting in the ability to create knowledge content. It can be either formal or informal in nature and is characterized by a rapid and real-time condition. This is achieved by combining collaborative hypermedia, group facilitation techniques, and an analytical methodology. This technology could be instrumental in helping capture knowledge for reuse within and across communities of practice. Compendium illustrates a number of challenges for the application of knowledge management technologies

(Selvin & Buckingham-Shum, 2002):

- Customization for different use contexts as in the form of templates and metadata
- Integration of formal and informal communication
- Integration of prescribed and ad hoc representations depending on constraints
- Validation and cross-referencing of the repository
- Conversion of organizational documents/emails into a hypertext database
- Conversion of hypertext databases into document formats such as text and process diagrams

Marwick (2001) defines knowledge as both the experience and understanding of people and the information artifacts, such as documents and reports that are available from internal and external sources. However, providing access to this knowledge can be problematic. Technology tools can play an important role in overcoming the barriers of time and space. One such tool is groupware that provides a "synthetic environment" often called a virtual space where participants can share certain kinds of experience. Participants can conduct meetings, have discussions and share documents.

A richer kind of shared experience is offered by applications that support real-time online meetings that include conferencing, synchronous communication and chat. In addition, portals and the incorporation of meta-data allow easier access to stored information. However, knowledge management solutions are typically not effective with the deployment of a technology alone. Overcoming technological limitations is less important than understanding the organizational culture and changing people's behavior (Marwick, 2001).

Lucca, Sharda, and Weiser (2000, Spring) also recognize the importance of cultural change to accept new technologies such as electronic collaboration and knowledge sharing programs. When implementing change, it is very important to have the support and dedication of key stakeholders. They point out that without coaching or training the new technology will not be fully utilized. They conclude that effective knowledge management is "critical" to the success of virtual organizations. Some of the applications they highlight include email as one of the earliest, simplest, and most successful groupware tools. Other key technologies include both synchronous and asynchronous communication such as conferencing and discussion threads. Also, more sophisticated applications such as expert or knowledge-based systems may be appropriate.

For knowledge management to be a success the organization must incorporate mechanisms and incentives for relatively effortless cooperation. Lewis (2002) states that the right set of conditions such as a sense of urgency, the right design, and a continuously updated knowledge management system can significantly increase system usage. He describes the on-demand two-tier architecture design of the Knowledge Today system used at the U.S. military's Joint Forces Command in Norfolk, VA. The first tier structures the organization's documents, reports, white papers, brainstorming sessions, and emails. Also, the first tier locates and identifies the staff's expertise and affinities to allow the organization's tacit knowledge to be tapped. This supports the organization's goals of empowerment, developing a vision, and establishing urgency. The second tier is very accessible and visible to users and is collaborative in nature. It is designed to afford easy access to the material and talent that others have previously identified and categorized in the background. The portal or entry points to the system reside in the second tier.

Organizations must not only possess the right information, they must also allow user friendly access to it with tools such as site search engines (Kemp et al., 2001). However, users often report a poor quality of results from site searches (Hearst, 2000). Hearst et al. (2002, April) note that while 76% of firms rated the search function as "extremely important" for their web site, only 24% rated their particular web search capability as "extremely useful." Good user interface plays an important role in user satisfaction. Users should not have to focus on the mechanisms and technology of the search system. Exposing metadata in the interface and making use of hyperlinks should be tightly integrated for access to content within web sites (Hearst et al., 2002). Hearst (2000) also suggests creating a specialized interface that takes the structure of the information on the site into account. This will help reveal the context in which the search hit occurred and focus on the type of information rather than the content domain.

Salisbury and Plass (2001) describe a web-based knowledge management system used by the U.S. Department of Energy based on a theoretical foundation they call the Collaborative Cognition Model. It proposes that learning can take place in one individual, be captured, and made available to another individual in an organization. Their approach was to treat the system as if it were a living and adapting organism revealing complex and changing requirements. The system focuses on communication features that allow users to grow and share knowledge. They found that a search capability was an important tool as was having access to online reference material. Other key features included a "points of contact" email capability, a frequently asked questions list, a threaded discussion capability, and a means to organize and store case studies and real time experiences.

Individuals can customize the information gathering process by exploiting push and pull technologies. These information delivery systems can provide an “intelligent” method of targeting personalized needs and allowing users access to meaningful information (Kendall & Kendall, 1999). Technology is evolving to efficiently disseminate time-varying web data. Bhide, Deolasee, Katkar, Panchbudhe, and Ramamritham (2002) combine push and pull based techniques to achieve the best features of both approaches for the efficient and scalable utilization of server and network resources. Podnar, Hauswirth, and Jazayeri (2002, April) discuss information services that rely on content delivery in mobile communications. They describe an efficient and flexible content dissemination service with an architecture based on a publish/subscribe (P/S) paradigm. This supports many-to-many interaction of loosely-coupled entities that can interact asynchronously to exchange messages.

The telecommunications piece of the system architecture puzzle must also be considered. Bandwidth limitations are a factor in considering a web-based knowledge management system. Slow download times can inhibit user interaction. This can be especially pertinent in the mobile computing environment. The 802.11a and 802.11g standards at 54 MPS will help alleviate the slow connection problem (Kapp, 2002). In addition, the trend towards increased network bandwidth and faster servers with more storage capacity will let companies embrace voice and video features into the knowledge management infrastructure (Lawton, 2001).

Lawton (2001) described another trend that had unfortunate consequences for organizations. Many organizations implemented knowledge management systems without properly considering deployment methodology and this was instrumental in the failure of 50 to 60 percent of knowledge management projects. He explains that knowledge management is not a single technology but a collection of various technologies that can be tailored but must be coupled with methodologies designed to meet user needs. The purpose is to categorize knowledge and direct it to workers but one of the main reasons knowledge management systems have failed is that organizations have not thoroughly determined their goals before implementing projects. This has been tied to inadequate attention to strategic priorities (Lawton, 2001).

There are a number of vendors offering knowledge management products and these applications are evolving. Along with opportunities, there are issues that have emerged as challenges and obstacles. These include security weaknesses that enable hackers to gain access to a system, unwillingness of employees to regularly enter and update information, and a lack of industry standards that is fragmenting deployment of knowledge management products (Lawton, 2001). This inhibits an organization's ability to create a comprehensive architecture that allows managed data flow and integration of a cross section of plug-in application tools.

King, Marks, and McCoy (2002) emphasize that knowledge management primarily involves new applications based on existing infrastructure. These applications include:

- Knowledge repositories that permit the retrieval of explicit technical and management information

- Best practices and lessons learned systems that allow the retrieval of information extracted from previous projects
- Expert networks comprising networks of individuals identified for their professional expertise who are electronically accessible by others with questions related to that expertise
- Communities of practice that consist of self-organizing groups whose members interact via networks sharing common interests and who may live or work in dispersed geographical settings

Additional challenges confront organizations that are composed of loosely coupled entities. Provant is an organization that is considered to be a “company of companies” consisting of 20 companies mainly in the training industry. Souder (2001) outlined Provant’s efforts to develop synergy and productivity among its companies through a comprehensive knowledge management strategy. They defined knowledge management as a collection of tools ranging from mentoring and team self-assessments to sophisticated databases emphasizing that a knowledge management system should consist of a variety of tools to meet unique situations. Continuous learning is stressed and supported via a Knowledge Nucleus comprised of information in the form of information objects, references, definitions, rules, procedures, processes, organizational knowledge, and internal and external sources of information. In light of the structure of the company, they found that duplication of effort was an issue and tools were needed to share status reports and document actions. Tools were also needed to share best practices, provide contact information, and present an integrated appearance to customers (Souder, 2001).

**Summary of What is Known and Unknown About the Topic**

There has been extensive research conducted in the domains of disaster recovery, knowledge management, and modeling. This research has expanded the body of knowledge in each of these individual fields. However, there is much to be learned about how these domains intersect and how they relate to non-profit organizations such as the Virginia Voluntary Organizations Active in Disaster (VOAD).

What is known is that a crisis brings numerous and diverse individuals and organizations together and these entities need to exchange information, delegate authority, and conduct oversight (Turoff, 2002). However, there is a relatively low level of information technology integration (Wybo & Lonka, 2002) and the rarity of disasters make it difficult to gain and maintain a solid experience base to ensure an integrated approach to disaster recovery situations (Paton & Jackson, 2002). Organizations like the VOAD lack access to information and its volunteers have low experience levels. Promoting a “big picture” perspective can enhance cooperation and coordination (McEntire, 2002). Cooperation and coordination is essential to efficient and effective response in the aftermath of disasters.

Knowledge management systems can enhance coordination and collaboration both within and between organizations (to include more informal communities of practice). Organizations can benefit through access to explicit and tacit knowledge. They must develop a “learning organization” approach to capitalize on knowledge resources embedded in the organization (Garvin, 1998) and need the tools, understanding of the organization, (Davenport et al., 1999) and communities of practice (Millen et al., 2002) to be successful.

The Rational Unified Process and Unified Modeling Language have been shown to be useful modeling methodologies for systems development (Kruchten, 2000). This is a de facto standard in the software industry (Booch, 1999) that has been successfully adapted to the enterprise business modeling level (Eriksson & Penker, 2000). In particular, use case methodology can be very effective in reflecting user's concerns and requirements (Saleh, 2002).

Although much is known about the individual domains of disaster relief, knowledge management, and modeling there is still much to be learned about how these domains interact. The disaster relief domain has a number of unique characteristics and attributes and would benefit from further research and analysis in the area of knowledge management (Tierney et al., 2001; Wybo & Lonka, 2002). While systems have been implemented to support emergency management operations, none have specifically addressed the needs of disaster field office (DFO) operations for disaster relief organizations such as the Virginia Voluntary Organizations Active in Disaster (VOAD).

## The Contributions This Study Will Make to the Field

This study seeks to combine the elements of three main areas to solve the problem of providing knowledge management resources to disaster relief volunteers located at disaster field offices during the recovery phase of a disaster. These three areas are disaster relief operations, knowledge management, and use-case modeling. The literature review has resulted in valuable insight into the nature of disaster relief operations, the concept of knowledge management as well as practical applications, and guidance on the methodology of use-case modeling.

The examples in the literature that discuss knowledge management systems used in the disaster relief domain provide a useful framework and noteworthy lessons learned. Many of these lessons learned are germane to the problem that is the subject of this study. However, these systems are not appropriate to solve the problem discussed in this study.

Considerable research has been done on the value and applicability of knowledge management. The field of knowledge management encompasses a wide-ranging spectrum of how knowledge can be “managed” but knowledge management needs to be viewed in the context of how it will be used. This study narrows and defines the concept of knowledge management to fit the disaster relief domain.

The literature cites numerous examples of successful use-case modeling. Although originally developed to support software development, this study demonstrates that use-case methodology can also be applied at a higher level of system development. This study tailors the process of using the Rational Unified Process (RUP) and use-case modeling with the Unified Modeling Language (UML) notation to capture the requirements for a knowledge management system specific to disaster relief operations.

In summary, this research contributes to this field of study in three ways. First, it explains how a virtual organization such as the Virginia VOAD can benefit from a knowledge management system. Secondly, it adds to the literature on the applicability of using the RUP, use-case methodology, and UML to model a knowledge management system for non-profit disaster recovery operations. Finally, provides a template that can be adapted for other disaster relief organizations in developing a knowledge management system.

# Chapter 3

# Methodology

## Research Methods Employed

The Rational Unified Process (RUP) provided guidance for developing the use-case model that was graphically depicted using the Unified Modeling Language (UML). Interviews and survey questionnaires provided information from key personnel as the formative body and the summative body. This also served to evaluate and validate the model. The methodology was adapted to fit the disaster relief domain by making adjustments to RUP and the use-case methodology. Artifacts produced were a Requirements Definition Document (RDD) that included the Vision document, set of use cases, and architecture description.

### *Rational Unified Process*

A mature organization that employs a well-defined process can develop systems in a repeatable and predictable way. The Rational Unified Process (RUP) provides such a process methodology for developers. Originally conceived to facilitate software development, it has been extended to provide a process framework that can be adapted and extended to meet the requirements of diverse organizations (Kantor, 2001; Kruchten, 2000). The adopting organization can modify, adjust, and expand the process framework. It can be tailored to meet the needs, characteristics, and constraints of its organization, culture, and domain (Kruchten, 2000). This methodology was tailored to meet the needs of this study. The phases and workflows of the RUP provide a high level overview of artifact development and risk management. RUP is requirements management intensive. RUP comprises four primary modeling components (Kruchten, 2000):

1. Workers (also known as Roles). Constitute the "who." Defines the behavior and responsibilities of an individual or group working as a team. The behavior is expressed in terms of activities. The responsibilities are expressed in relation to artifacts created by the worker.
2. Activities. Consists of the "how." A unit of work that an individual is asked to perform. Activity steps to develop use cases include:

- find actors
- find use cases
- describe how actors and use cases interact
- package use cases and actors
- present the use-case model in use-case diagrams
- develop a survey of the use-case model
- evaluate the results

3. Artifacts. Makes up the "what." This is a piece of information that is produced, modified, or used by a process. These are the tangible products of the project and may include any of the following:

- A model such as the use-case model
- A model element
- A document such as a business case or software architecture
- Source code

- Executables

4. Workflows. Determines the "when." It is a sequence of activities that produces a result of observable value. An example of a workflow is illustrated in figure 4.

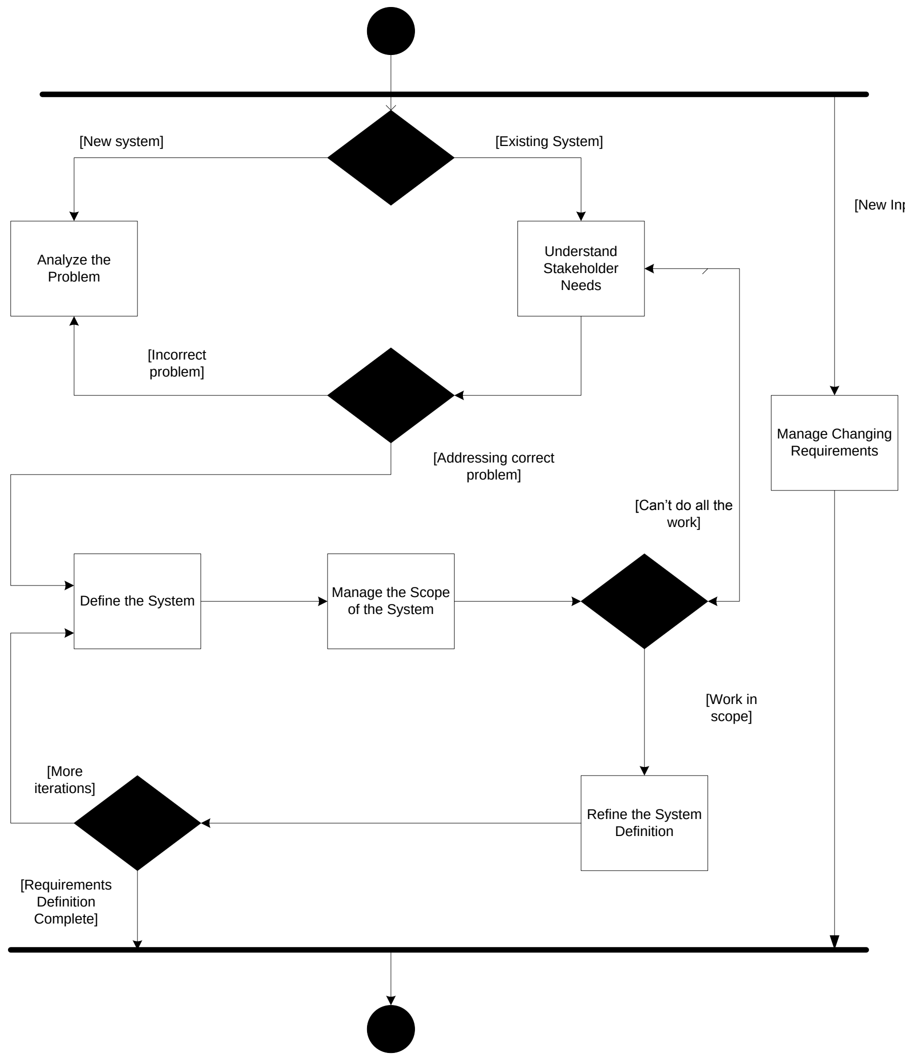


Figure 4. Sample workflow diagram[1]

[1] From *The Rational Unified Process-An Introduction* (p. 164) by Philippe Kruchten, 2000, Upper Saddle River, N.J.: Addison-Wesley. Copyright 2000 by Addison-Wesley. Reprinted with permission.

In accordance with RUP methodology, the first step involved collecting the stakeholder requests. This was done via interviews and validating system criteria. The system criteria and support from the literature were used to determine the system objectives. These system objectives were used to develop a RDD document that portrayed a set of key stakeholder and user needs and the high level features of the system. The system features express services the system is required to provide to meet stakeholder needs. The RDD provides a high level, comprehensive overview of the system model and is a source for expressing the expectations of the stakeholders. It is written from the user's perspective focusing on the essential elements of the system and acceptable levels of quality. It specifies operational capacities, user profiles, and inter-operational interfaces with entities outside the system boundary, where applicable (Kruchten, 2000). Documentation is an important facet of RUP (Priestly & Utt, 2000) that allows visibility to the system stakeholders.

There is a return on investment factor that will be considered based on cost and expected value that will effect the decision as to which features to include in the RDD document. These requirements are captured in the use-case model and other supplementary specifications, which include those requirements and other system information. Cockburn (2001) has suggested a format for consolidating and expressing the requirements definition (see appendix F).

RUP incorporates an iterative approach that fosters risk mitigation. It provides the ability to make tactical changes to the project based on user feedback. This feedback was accomplished by using survey questionnaires. Additionally, RUP supports reuse of components and results in a very robust architecture that allows errors to be detected early on and corrected with the development process itself improved and refined along the way (Kruchten, 2000). The iterative process is organized in phases that consist of a number of iterations (Utt & Mathews, 1999). Each phase is concluded by a major milestone. The four phases are (Kruchten, 2000):

- Inception. This is the basic idea that specifies the end-product vision and defines the scope of the project. This phase ends with the lifecycle objective milestone.
- Elaboration. This phase involves planning the key activities and determining the required resources. It also specifies system features and architecture design. This phase ends with the lifecycle architecture milestone.
- Construction. This entails building the product and evolving the vision, the architecture, and the plans until the product (the completed vision) is ready to be delivered to the users. This phase ends with the initial operational capability milestone.
- Transition. This involves manufacturing, delivering, training, supporting, and maintaining the product. This phase ends with the product release milestone.

Inception and elaboration are the first two phases. These are the two phases that are included in this study. During the inception phase the business rationale for the project was determined and the scope, objectives, and basic requirements of the project were delimited. This included specifying the Vision (Alhir, 1998). During the elaboration phase the researcher conducted research, collected detailed requirements, and did high-level analysis for the architecture. Capturing use cases is one of the primary tasks of the elaboration phase (Fowler & Scott, 2000).

Kruchten (2000) concludes that RUP is an architecture centric process. Architecture is about structure, organization, and behavior. It is concerned with the fit of the system in both an operational (end user) and developmental (the originating organization) context. In addition, it can also address the "soft" issues such as style and aesthetics. These were considerations in the development of the architecture description artifact for this study. The purpose of architecture is to (Kruchten, 2000):

- Understand what the system does
- Understand how it works
- Be able to work on one piece of the system in a modular context
- Extend the system
- Reuse part of the system in building another system

Use-case development incorporated within the framework of RUP plays a pivotal role in process workflows especially requirements definition and is key to business modeling (Eriksson & Penker, 2000; Kruchten, 2000). Utilized as a process framework, RUP can be adapted to the needs of the user organization. It is a use-case driven approach where the use cases defined for the system serve as the foundation and continuity for the follow-on development process (Phillips & Kemp, 2002). Use cases emerge when developers concentrate on the value that a system provides to an actor and they group the sequences of actions that a system takes to provide those results of value. This technique was used by the researcher in this study. In analysis and design, use cases are the bridge that unites requirements and design activities and act as the common language for communication between the users and system developers (Kruchten, 2000).

Only the most complex, mission critical applications require the depth and rigor of the entire RUP. An alternative solution adopted by some organizations has been to attempt to define more streamlined or light-weight processes that emphasize simpler applications. There is evidence that these processes may be more efficient and suitable for small to medium projects (Kantor, 2001). The artifacts and methodology for this study was tailored to meet the unique circumstances of this study. Methods such as RUP should be considered as suggestions and recommendations that organize and facilitate the process rather than rigid and unbending rules (Alhir, 1998). RUP does not dictate that all artifacts and all activities be mandated or every project (Filho, 2002). In addition, the RUP is easily extended because the information development process has a great deal in common with the software development process driving user information architecture, design, development, and delivery (Utt & Mathews, 1999).

*Use-Case Development*

Cockburn (2001) describes a use case as capturing a contract between the stakeholders of a system about its behavior. Stakeholders can be company members, customers, vendors, government regulatory agencies or any entity that has an interest in the project. In this study, stakeholders include relief agencies, disaster victims, local/state/federal agencies, and others. The primary actor can be the user of the system or even another computer program that interacts with the system. Stakeholders or primary actors initiate an interaction with the system with the intent to accomplish a goal. Different sequences of behavior or scenarios can occur resulting in a system response. The use case serves to gather information on the different scenarios and clarify the user interaction (Eriksson &

Penker, 2000). Use cases are particularly well suited to capture requirements (Bittner, Spence, & Jacobson, 2003).

An intrinsic value of use cases is the ability to communicate the sequence of events among the interested parties in the system development (Kruchten, 2000). Use cases are commonly described in text form but can also be depicted graphically. This study incorporated both textual and graphical representation of use cases. Use cases serve as a means of communication among team members and are especially useful in stimulating discussion among people with no special training (Cockburn, 2001). This is relevant to this study because the study participants have little or no background or experience in systems development. The use-case method is intended to be flexible with documentation artifacts and appropriate levels of technical detail generated as required for the specific development environment (Cockburn, 2001).

A well-written use case consists of easily comprehendible sentences that describe a situation in which an actor achieves a result or passes information to another actor (Fowler & Scott, 2000). The scenario depicted in the use case should be easily understandable to even a novice reader. The use-case methodology is flexible and adaptable to different situations. These were important goals of the study. A use case can be used to (Cockburn, 2001):

- describe a business's work process
- provide a forum to focus discussion about a proposed system's requirements (without including the requirements description)
- form the basis of the functional requirements for a system
- document the system design

- support the work of a small, close-knit group or a large or distributed group

It should be noted that use cases are only part of the total requirements definition documented for a system. Use cases will not represent all the requirements but only outline the behavioral portion, that element where the actor interacts with the system. There are other aspects of the system such as technology, glossary, human, political, legal, etc. that will be addressed in other portions of the requirements definition (see appendix F).

Use cases are effective because they convey a coherent picture and tell the ‘story’ of how the system will behave (Alhir, 1998). This will allow the users to react early to fine-tune or reject the stories. The use cases first create value when they identify user goals that the system will support. This depicts what the system will do and describes the scope and purpose of the system providing a common understanding between the different stakeholders on the project. Another important aspect of use-case development is brainstorming all the things that could go wrong in the scenario and discovering how the system should respond.

The use case can exist in different formats. They can be “dressed up” in a use-case template that may include such categories as Primary Actor, Goal in Context, Scope, Level, Stakeholders and Interests, Precondition, Minimum Guarantees, Success Guarantees, Trigger, Main Success Scenario, Extensions, and other categories as needed. Conversely, they may be “casual” and described in a simple story-like form as sentences in a paragraph. Both are acceptable and selected based on the project situation (Cockburn, 2001). The use-case technique for this study will be aligned with the casual category of use-case development to be more meaningful to the users and stakeholders participating in the development process. There is variation permitted in how the contents of use cases are described. The Unified Modeling Language does not specify any standard (Fowler & Scott, 2000).

The services that are projected for the system and will be captured by the use cases can be referred to as the functional scope (Eriksson & Penker, 2000). A higher level of precision in describing system behavior can be accomplished with use-case briefs. The use-case brief generally consists of a two-to-six sentence description of use-case behavior in succinct format. If a project team has exceptionally good internal communication and continual coordination with users these use-case briefs may be all they need to keep on track with requirements. This assumes the team is also using discussions, prototypes and frequently delivered increments (Cockburn, 2001).

A use case may contain more than one scenario but there is always one main scenario (Conallen, 2003). This was a key element of the use cases captured in this study. The core of the use case is the "main success scenario." This describes the typical scenario in which the primary actor's goal is achieved and all the stakeholders' interests are satisfied. This is the ideal solution where they "all live happily ever after." It consists of the following elements (Cockburn, 2001):

- A condition under which the scenario runs.
- A goal to achieve. (This is the stated goal as it is met to satisfy the stakeholders.)
- A set of action steps. (These form the body of the scenario and consistently follow scenario rules.)
- An end condition. (This is goal achievement when the main success scenario is completed.)

- A possible set of extensions written as scenario fragments.

Although use cases generally begin as a text based description of the scenario, they are enhanced by the visual and graphical qualities of the Unified Modeling Language (UML). The old adage that a picture is worth a thousand words is demonstrated by the value that UML adds to the documentation of use cases. Design is all about seeing the key issues in the development of a system (Fowler & Scott, 2000). Using UML to complement the scenario descriptions in use cases will help users and developers obtain a clearer understanding of proposed system capability.

*Unified Modeling Language*

The Unified Modeling Language (UML) is a modeling language for specifying, visualizing, constructing, and documenting the artifacts of a system intensive process that applies to many different types of systems, domains, and methods or processes (Alhir, 1998). It defines a notation and a metamodel that aids designers in seeing key issues in the development process. The notation is a graphical representation or syntax of the modeling language. A metamodel is a diagram that defines the notation. UML's object oriented perspective will allow for both flexibility and a disciplined development approach. Using UML helps project participants including users and developers to acquire an overall view of the system (Booch, 1999). UML may be applied in the context of problem solving and the application of knowledge (Alhir, 1998).

Kruchten (2000) describes a model as a simplification of reality that completely describes a system from a particular perspective. Using UML, the developer is able to visualize, specify, construct, and document the structure and behavior of the system.

Visual modeling can help manage complexity and conceal or expose detail as required. However, the UML is a modeling language not a method and as such does not formulate process. It complements the process framework of a methodology such as the Rational Unified Process with its notational and metamodel capabilities by recording the analysis and design decisions (Fowler & Scott, 2000). The UML enables and promotes a use-case driven, architecture centric, iterative, and incremental process (Alhir, 1998).

The UML offers many options in terms of how activities and relationships are documented and displayed. According to Alhir (1998) the UML defines the types of diagrams (see Figure 5).

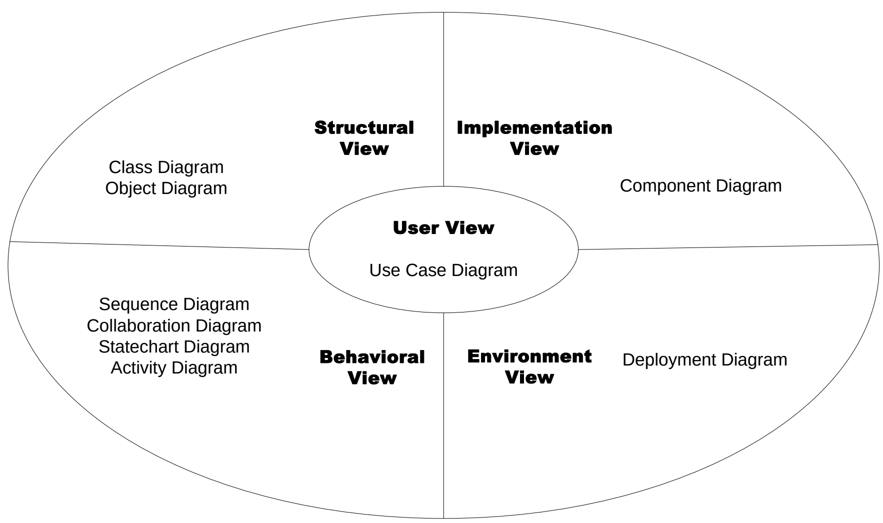


Figure 5. Unified Modeling Language diagrams[2]

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[2] From *UML in a Nutshell* by Sinan Si Alhir, 1998, Sebastopol, CA: O'Reilly & Associates. Copyright 1998 by O'Reilly & Associates. Reprinted with permission.

They all show different views of the system but have the underlying purpose of communicating certain concepts clearly. UML is meant to capture the knowledge and semantics represented by the diagrams. The user view looks at the problem and solution from the point of view of those individuals who are the focus of the problem and for whom the solution is being worked. This was the focus of this study. The user view is useful in supporting the problem owners (in this case the VOAD volunteers at the DFO) by presenting their goals and objectives as well as their requirements.

Establishing unambiguous communication with users and domain experts is central to developing knowledge management systems. One technique to enhance this communication is to incorporate use cases in the design process. This is the approach that was taken in this study. An individual use case is a snapshot of one part of the overall system. The sum of all use cases is the external picture of the system and explains what the system will do providing an essential understanding what the users want (Fowler & Scott, 2000). The combination of use-case diagrams and their supporting documentation is known as a use-case model (Alhir, 1998).

In this study, high level use-case diagrams were used to describe the functionality of the system. One of the primary purposes of a use case is to facilitate communication between users and developers, therefore, it should reflect only the essential aspects of a process (Marshall, 1999). These diagrams contain the following elements (Alhir, 1998):

- Actors. These represent the users of the system (consisting of human and non-human entities)
- Use cases. Represent functionality or services that the system provides to users

The use-case diagrams illustrate the key functionality of the system as perceived by the actors through the interaction that takes place between the actors and the system (Eriksson & Penker, 2000). The notation and syntax to depict the use cases in this study are in accordance with the UML style rules outlined by Ambler (2003).

*Interview Procedures and Design of Survey Instruments*

The Nova Southeastern University Institutional Review Board granted approval to conduct this study. Interviews and survey questionnaires were used to gather information and feedback for the development of the artifacts that were produced for this study. Artifacts include a Requirements Definition Document (RDD) comprised of a Vision document, a use-case model, and a high level architecture description. These artifacts are discussed in more detail in a following section.

Fowler and Scott (2000) recommend using interviews with users for the purpose of gathering use cases. Interviews are among the most useful means of understanding the stakeholders' perspective (Bittner et al., 2003). Ten key personnel from the Virginia VOAD were interviewed. These peoplel were past presidents of VOAD and current members of the executive committee. Each individual had at least three years experience in disaster relief operations and had been affiliated with the Virginia VOAD for at least two years. Overall, they represent those in the organization with the highest experience levels and closest involvement in the organization. The 10 key personnel served as the formative and summative body for the study.

The interviews were conducted via telephone using a structured format. Telephone interviews are suited for structured interviews (Sekaran, 2000). A predetermined set of questions guided the interview (see appendix A). Prior to the interviews, the researcher personally met each of the interviewees during the semi-annual meetings of the Virginia VOAD held in Fall of 2002 and Spring of 2003. In addition, the researcher discussed the purpose and goals of this study with the general membership of VOAD who attended these meetings. Establishing trust relationships with study participants is an important element in the process (Sekaran, 2000).

After the interviews were completed the researcher distilled criteria objectives from the interviews. Evaluation criteria are system properties that help the users and stakeholders make a decision by capturing the performance, quality, or availability of the system. The evaluation process can also assess a system's non-technical criteria to include dependability and functionality (Bockle et al., 1996).

The 10 key personnel were sent these criteria for their feedback and comments (see appendix B) via the first of two survey instruments. According to Kruchten (2000) questionnaires are appropriate to support the Rational Unified Process in gathering information to develop use cases. This is an effective way to collect pertinent information and feedback from users (Bittner et al., 2003). The survey used a five-point Likert scale and data collected was analyzed using various descriptive statistical techniques. The criteria and background information obtained from the interviews and first survey questionnaire, along with a survey of the literature, formed the system objectives. These provided the basis for the RDD, Vision document, use-case development, and architecture description.

The second questionnaire was sent to the 10 key personnel acting as the summative body. This survey consisted of a series of questions (see appendix C) soliciting feedback on the Vision document, use cases, and architecture description as summarized in the

RDD. This survey instrument was adapted from a concept developed by Boloix and Robillard (1995) based on the goal-question-metric paradigm. Evaluation is considered within the context of a goal-centered view to compare pre-established objectives to actual results. It serves to define evaluation objectives for each factor and dimension of the framework and to establish questions for each factor category. For the purpose of this study, the goal-question-metric paradigm has been restricted to the user's environment category focusing on the compliance, usability, and contribution attributes.

*Application to the Disaster Relief Domain*

The origins of the Rational Unified Process (RUP), use-cases, and the Unified Modeling Language (UML) are in software design and development (Booch, 1999). However, it became apparent that the concepts and process elements of this methodology could be adapted to a wider domain that included business oriented environments. It has been shown to be effective in modeling higher-level business processes in organizations (Cockburn, 2001). However, the literature has centered on documenting use-case development projects describing relationships involving customers and commercial transactions, supply chain interactions, and other for-profit activities. For the most part the focus has been on generating income for the organization or providing services to support customer, vendor, and other business relationships. The purpose of this study is to extend the application of use-case modeling to the domain of the non-profit disaster relief environment.

Eriksson and Penker (2000) discuss business modeling with UML and suggest this can be extended to nonprofit activities. They describe a good architecture as having the following characteristics:

- Captures the business as accurately as possible. Defines an architecture that is realistic and feasible
- Views the key processes at an appropriate level of abstraction
- Represents a consensus among the stakeholders
- Adapts easily to change and expansion
- Easily understood and fosters communication

The researcher used these principles to develop the use-case model and supporting documentation. Even though the Virginia VOAD operates in a domain different from conventional commercial business there are parallels that will support the use of RUP, use-case, and UML methodology. Both domains rely on business rules and business processes (although these may be more loosely documented and codified for the VOAD) and operate in a customer-centered environment.

The RUP, use-case, and UML methodology were tailored appropriately for the VOAD domain. In view of the organizational needs, artifact audience, and overall project mission the full RUP process was not used but was adapted to this project. RUP does not mandate that all artifacts and activities be followed for every project but allows for customizing (Filho, 2002). Consequently, the artifacts produced to support this project were adapted to the disaster relief domain.

*Artifacts Produced*

The goal of the study was to produce a use-case model for a knowledge management system to facilitate disaster relief operations. To provide the users and stakeholders with a comprehensive view of the model, supporting documents consisting of a Requirements Definition Document (RDD) that is comprised of the Vision document, set of use cases, and architecture description were produced. The intent of these documents is to clarify the requirements, purpose, and scope of the project and to suggest a way forward for further development.

The first artifact was the RDD overview. This is a comprehensive tool used to summarize the Vision, use cases, and architecture description to provide the users and stakeholders with an overview of the project. While not specified in RUP as a process artifact, the researcher found that the RDD overview proved useful to the VOAD community whose mambers generally have very limited systems development expertise. This is in line with the philosophy of RUP which allows for customizing (Filho, 2002). Cockburn (2001) proposes a format for expressing system requirements that covers the main topics and issues pertinent to this study (see appendix F). This format was adapted to suit the disaster relief domain and the needs of this study. In particular, the sections in Chapter 5 (see appendix F) on business rules were revised to accommodate a non-business environment and a section addressing funding and maintenance was added. Also, in Chapter 6 (see appendix F) the sections on human backup, legal, political, and organizational issues addressed concerns unique to the disaster relief domain.

Part 1 of the RDD is the Vision document. The purpose of the Vision document is to (Bittner et al., 2003):

- actively involve stakeholders in project
- assess whether progress has been made
- manage project scope

- validate project decisions
- bring new developers or stakeholders into the project
- have effective communication among stakeholders

The Vision document is a primary means of communication among project participants that expresses the focus, stakeholder needs, goals and objectives, user environment, target platforms, and features of the product being built. It provides (Bittner et al., 2003):

- a high level basis for the more detailed requirements
- input to the project approval process
- a means for eliciting initial feedback
- a means to establish the scope and priority for product features

It is key to producing a result that meets the stakeholders' needs and gathers information on the following questions (Probasco, 2000, p.4):

- What are the key terms? (Glossary)
- What problem are we trying to solve? (Problem Statement)
- Who are the stakeholders? Who are the users? What are their needs?
- What are the product features?
- What are the functional requirements? (description of use cases)
- What are the non-functional requirements?
- What are the design constraints?

These are included in the framework proposed by Bittner, Spence and Jacobson (2003) (see appendix D). While this template provides a good foundation and starting point for the Vision document it had to be adapted and amended to reflect the needs of the disaster relief domain. For example, the focus on market forces and business opportunities was reconfigured to conform to the context of the non-profit and ad hoc environment of the Virginia VOAD.

Part 2 of the RDD is the set of use cases. The broad requirements of a business process and actor's roles and interactions with the system may be elicited and documented with use cases (Marshall, 1999). Use cases are unique in helping teams understand the value the system must provide for the stakeholders and build consensus about what the system must deliver (Bittner et al., 2003). Initial input for use-case development for this study came from interviews with key personnel. Since this will be a relatively small system, seven use cases were generated. A small system may be expressed by as few as a half-dozen use cases that involve two or three actors (Kruchten, 2000). The textual use-case descriptions were complemented with UML use-case diagrams in accordance with the UML style rules outlined by Ambler (2003).

Part 3 of the RDD is the architecture description. This has a high level business process orientation that allows the users to see what the system will look like. The use-case model is meant to be "technology independent" and thus not tied or restricted by the state of technology as it exists today. It is hoped that the model will remain robust to take advantage of future technology advances and remain extensible. However, for the practical purposes of allowing the users and stakeholders a realistic view of how the model can be implemented, the high level architecture proposes software components that could be incorporated to build a prototype. The risk analysis factors outlined by Schneider, Winters, and Jacobson (2001) provide guidance on important factors to consider (see appendix E). Since it is unlikely funding will be available for custom designed software the proposed architecture will take advantage of commercial off the shelf, shareware, and freeware components.

## Specific Procedures Employed

### *Research Outcome*

1. Define the knowledge management requirements to support disaster field office (DFO) operations for disaster relief organizations
2. Design a knowledge management system model based on design objectives
3. Evaluate and validate the knowledge management system model

### *Research Questions*

1. What are the types of information that disaster relief workers need when operating in a disaster field office (DFO)?
2. What are the functional and non-functional requirements for a web-based knowledge management system for disaster relief field operations?

### *Overview of Procedures*

The model was developed using the Rational Unified Process (RUP). Although often used in software development, RUP is also helpful in depicting a higher level view of an organization through use-case development (Kruchten, 2000). The scope of this project corresponded to the *inception* and *elaboration phases* of the RUP and concluded prior to construction of a prototype. In view of the organizational needs, artifact audience, and overall project mission the full RUP process was not used but was adapted to this project.

RUP does not mandate that all artifacts and activities be followed for every project but allows for customizing (Filho, 2002). In the software development community there is broad consensus that methods should be tailored to the actual needs of the development context (Fitzgerald, Russo, & O'Kane, 2003).

Artifacts that were produced included a RDD comprised of a Vision document, a set of use cases, and an architecture description. Microsoft Visio 2002 was used to depict the Unified Modeling Language notation of the use cases. StatPac (Walonick, 2003) was used for statistical analysis of the survey questionnaires. The result was a use-case based model providing a user-centered view of the knowledge management system.

The methodology was designed as an eleven step procedure consisting of the following:

1. Review documentation
2. Interview key personnel
3. Compile list of criteria
4. Validate criteria (survey questionnaire #1) – formative review
5. Determine system design objectives
6. Produce Vision document
7. Develop use cases
8. Determine architecture description
9. Produce Requirements Definition Document (RDD)
10. Validate the use-case model (survey questionnaire #2) - summative review
11. Revise the model

*Procedure Steps*

1. Document Review

--Action:  Review documents pertaining to the Virginia VOAD to include minutes of past Virginia VOAD meetings and literature pertinent to the field of study.

--Rationale:  This provided history and background on the problems associated with disaster field office (DFO) operations that have been discussed at past Virginia VOAD meetings.  It also provided an overview of relevant literature concerning disaster recovery, knowledge management, and modeling techniques such as RUP and UML.

--Result:  This gave the researcher a better understanding of the nature and background of the problem and the Virginia VOAD organization as well as an overview of related research in the field of study.

2. Key Personnel Interview – Formative Development

--Action:  Interview 10 key Virginia VOAD personnel from various Virginia VOAD member agencies who served as the formative body.  The researcher conducted structured interviews with both open-ended and closed-ended questions.  The questionnaire at appendix A guided the interview.

--Rationale:  The individuals who are interviewed represented various agencies in VOAD to include national and regional level agencies as well as church/civic oriented agencies. As a group, these individuals represented the most knowledgeable and experienced members of the Virginia VOAD.  Interviewing these individuals expanded the researcher's knowledge of the organization as a whole and, in particular, disaster field office operations, and stakeholder requirements.

--Result: The interviews provided the basis for determining the system criteria for the use-case model. The interviews also provided background and details for the Vision document, set of use cases, and system architecture description.

3. <u>Criteria List</u>

--Action: Analyze the 10 interviews and determine 8 to 10 basic criteria to use to develop the use-case model.

--Rationale: This discovered the functional and non-functional requirements for the system.

--Result: This list provided the basis for survey # 1 (see appendix B).

4. <u>Criteria Validation- Formative</u>

--Action: Send the 10 key personnel survey #1 (see appendix B) to assess the content and construct validity of the criteria (Bockle et al., 1996; Sekaran, 2000).

--Rationale: The 10 key personnel served as a formative body to validate the criteria. This was an important step in the iterative process to validate the functional and non-functional requirements for the system by soliciting feedback from the key personnel.

--Result: Formative body validation of the criteria for the model.

5. <u>Determine System Design Objectives</u>

--Action: Develop system design objectives. These was based on prior research of the literature and the result of the analysis of survey #1 (see appendix B) that provided feedback from key personnel on the criteria for the model.

--Rationale: The system design objectives provided the foundation for high level system requirements. Developing system design objectives has been shown to be an effective way to summarize system requirements for a knowledge management system (Kwan & Balasubramanian, 2003).

--Result: The objectives served as the basis for developing the RDD and its components.

6. Vision Document

--Action: Produce the Vision document based on the results of the interviews with key personnel, review of VOAD documentation, and system objectives. The format outlined by Bittner, Spence, and Jacobson (2003) at appendix D served as a guideline.

--Rationale: The Vision document captures the "essence" of the requirements workflow in RUP (Probasco, 2000) by analyzing the problem, understanding stakeholders' needs, defining the system, and managing requirements.

--Result: The Vision document was the key artifact created at the end of the inception phase of the RUP process (Kruchten, 2000).

7. Use Case Development

--Action: Develop the use cases and use the Unified Modeling Language to depict the use-case notation.

--Rationale: This expanded and defined the requirements of the system. The use cases documented user/system interaction to obtain an understanding of the events and magnitude of the system and graphically depict the functional requirements. This listed all use cases and actors that can be identified at this stage (Kruchten, 2000; Schneider et al., 2001).

--Result: This supported the objectives of the elaboration phase of RUP and provided the basis for the use-case summary submitted to the summative body.

8. Architecture Description

--Action: Determine the high-level architecture components.

--Rationale: The model is meant to be independent of any specific technology solution and, therefore, it would remain relevant and open to future technology developments. However, specifying the system's architecture, identifying its components, and delineating its boundaries will help users evaluate the system (Bockle et al., 1996) and show a possible application of the model.

--Result: A high-level architecture description that allowed the VOAD general membership to envision the next step in the process that would lead to the development of a prototype.

9. Requirements Definition Document (RDD)

--Action: Produce the Requirements Definition Document.

--Rationale: This document consists of an overview, a summary of the use cases, functional and non-functional requirements, the Vision document, and a high-level software architecture description. The RDD served as a comprehensive document for the key personnel to review as a summative body to evaluate the model.

--Result: This supported the outcome of the elaboration phase of the RUP whose goals include (Kruchten, 2000, p.70):

- A use-case model (at least 80% complete) in which all use cases have been identified, all actors have been identified, and most use-case descriptions have been developed
- Supplementary requirements that capture the nonfunctional requirements and any requirements that are not associated with a specific use case

10. Validate Use-Case Model - Summative Review

--Action: Send the RDD and its components (Vision document, use cases, and high level architecture) to the key personnel along with a survey questionnaire (survey #2) designed to elicit feed back on the model (appendix C).

--Rationale: The RDD drives the architectural and planning decisions as per the RUP process (Kruchten, 2000). The survey questionnaire was based on the goal-question-metric paradigm as it relates to the environment or user's perspective (Boloix & Robillard, 1995).

--Result: Evaluation of the model and elicitation of feed back comments. This was the summative evaluation of the model.

11. Revise the Model

--Action: Analyze the results of feedback from survey #2.

--Rationale: Incorporates user feedback to revise the model as appropriate.

--Result: Changes were made to the use-case model. This completed construction of the model.

**Formats for Presenting Results**

The following steps were taken to present the results:

1. A list of criteria generated from the interviews along with a survey questionnaire (see appendix B) was sent to the 10 key personnel.
2. After the survey questionnaire was returned, the results were analyzed using the StatPac statistical package. Each question was analyzed for mean and standard deviation. The results were compiled in table format (see chapter 4, table 1).
3. The RDD and its components were prepared and sent to the key personnel along with the second survey questionnaire (see appendix C).
4. After the survey questionnaire was returned, the results were analyzed using the StatPac statistical package. Each question was analyzed for mean and standard deviation. The results were compiled in table format (see chapter 4, table 2).

**Projected Outcomes**

The following were projected outcomes of the study:

- The key personnel selected as part of the interview group and formative body would have the background and experience needed to provide feedback for development of the use cases.
- The use-case methodology could be extended from the business environment to the domain of the non-profit, ad hoc, virtual environment.

- The researcher would get sufficient response from the interviews and surveys.
- The result of the interviews would yield a list of valid system criterion that along with a review of the literature would produce a set of system objectives.
- The Vision document, use cases, and architecture description would reflect user requirements and be validated by the key personnel.
- The model would support the system objectives.

**Resource Requirements**

The following resources were used for the development of the project:

1. Key personnel from Virginia VOAD to include national and state agencies, as well as food bank and religious organizations who participated in one-on-one interviews with the researcher and responded to survey #1 and survey #2.
2. Microsoft Visio Pro 2002 was used for the UML notation for the model.
3. StatPac statistical analysis software was used for data analysis.

**Reliability and Validity**

*Criteria Establishment*

a. Procedure Steps #1 and #2 provided the knowledge base upon which to establish the criteria and follow-on development of the system artifacts.

b. This was done by conducting a survey of the literature and interviewing experienced personnel in the VOAD organization (see appendix A).

c. This established the functional and non-functional requirements that were expressed as criteria objectives in Procedure Step #3.

*Criteria Validation*

a. In Procedure Step # 4, the 10 person formative body was sent survey # 1 to assess the content and construct validity of the criteria.

b. The key personnel were asked to evaluate the content validity of each of the criterion by answering the question (see appendix B):

> Please evaluate the listed criteria. Do you think each criterion accurately depicts a valid user requirement for the proposed system? Rank your answers to each question on the survey using the 1-5 scale.

c. Mean scores and standard deviation for each of the criterion were calculated. These scores were analyzed to determine agreement/disagreement with the proposed criteria.

d. The key personnel were then asked to evaluate the construct validity of the criteria by answering the question (see appendix B):

> Please evaluate the criteria as a whole in the context of the entire project. How well do you think the criteria represent the needs of the operators in disaster field office (DFO) operations? Rank your answer to the question using the 1-5 scale.

e. Mean scores and standard deviation for the construct validity were calculated to determine if the key personnel agreed or disagreed that the criteria represents the needs of the operators in disaster field office (DFO) operations.

*Model Establishment*

a. The system criteria (derived from the interviews) and the review of the literature provided the basis for development of the system objectives in Procedure Step #5.

b. In Procedure Step #6 the Vision document was produced.

c. In Procedure Step #7, the use cases were developed.

d. In Procedure Step #8, the architecture description was produced.

e. In Procedure Step #9, a RDD was produced. This consisted of an overview, summary of the use cases, the Vision, and a high-level architecture description. The RDD was sent to the general membership to review as a summative body to evaluate the model.

*Model Validation*

a. This was done via survey questionnaire #2 (see appendix C) in Procedure Step #10. This was sent to the 10 key personnel serving as the summative body.

b. Mean scores and standard deviation were calculated for each survey question. Individual comments to each question were analyzed.

c. Results of survey #2 were analyzed in relation to the design objectives.

**Summary**

The Rational Unified Process (RUP) provided guidance for developing the use-case model that was graphically depicted using the Unified Modeling Language. In accordance with the latitude afforded by RUP and the unique nature of the disaster relief domain, the methodology was adapted to fit the disaster relief domain by making adjustments to RUP and the use-case methodology. Artifacts produced were a RDD comprised of a Vision document, set of use cases, and an architecture description. Interviews and survey questionnaires were used the gather information. The VOAD key personnel served as the formative body and summative providing feedback via survey #1 and survey #2. After statistical analysis of the survey questionnaires, the result for each question was compiled in a table along with a narrative summary of feedback comments. The results was analyzed and compared to the system design objectives to ascertain if the design objectives have been met.

# Chapter 4

# Results

## Overview

The methodology employed in this study was based on an adaptation of the Rational Unified Process (RUP) using Unified Modeling Language (UML) notation. It consisted of an eleven step process. This included a literature review of research in the domains of knowledge management, modeling, disaster recovery, and emergency management and documentation specific to the Virginia Voluntary Organizations Active in Disaster (VOAD). It also included interviews of key personnel in VOAD as well as formative and summative surveys to formulate and validate system criteria and system objectives. These system criteria and objectives are reflected in the resulting model which is described in the Requirements Definition Document (RDD) and the related artifacts of the Vision document, use cases and architecture description (see appendix G).

Review of VOAD meeting minutes from 2001 and 2002 revealed the problem that formed the basis for this study. This was the difficulty that disaster relief volunteers encounter with communication and coordination during post disaster operations. Specifically, it focuses on individuals who operate in disaster field offices (DFO) and need access to knowledge resources to coordinate the activities of a range of disaster relief organizations and work with state and federal agencies.

With the problem identified, the follow-on steps in the process to collect and analyze data were accomplished. This produced the project objectives and the use-case model. This is described in more detail in the following sections.

**Data Analysis**

*Interviews*

Ten key personnel of the Virginia VOAD who were former presidents of the VOAD organization and/or current members of the executive committee were interviewed. They represented a cross section of the VOAD organization and were members of the organization who had both a comprehensive knowledge base and commitment to the organization. The interviews consisted of a structured format with both open-ended and closed-ended questions. The questionnaire (at appendix A), derived from RUP methodology as outlined by Probasco (2000), guided the interviews. Analysis of the interviews found recurring themes and concerns associated with each of the questions. This confirmed the purpose and responsibilities of individuals at the disaster field office (DFO) as outlined in VOAD and FEMA documentation as well as the problems and challenges these individuals face. The interviews also served to identify the stakeholders and users and explain how these parties interact and what categories of knowledge they require. The interviewees discussed the kinds of activities VOAD personnel conducted and made suggestions for applications to support these activities. The discussions also outlined functional and non-functional requirements as well as potential design constraints. The results of the analysis of the interviews were distilled into a list of 10 system criteria. These system criteria were incorporated into survey #1 (appendix B).

*Survey #1*

Survey #1 containing the 10 system criteria derived from the interviews was sent to the 10 key VOAD personnel via postal mail for their evaluation and comment. There was also a question included in the survey to assess the content and construct validity of the criteria (Bockle et al., 1996; Sekaran, 2000). A copy of the survey can be found in appendix B. The 10 personnel served as a formative body to validate the criteria.

Nine of the ten surveys were returned. All of the returned surveys were completed according to the instructions. Respondents were asked to rate each of the 10 system criteria. Each of the criteria was evaluated using a five point Likert scale.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Each question was analyzed to determine mean and standard deviation. The statistical application used was .

The formula to find the mean is:

$$\bar{x} = \frac{1}{N} \sum_{j=1}^{N} x_j$$

where N is the number of data points in the data set, and $x_j$ is the $j^{th}$ data point.

The formula find the standard deviation is:

$$S = \sqrt{\frac{1}{N-1} \sum_{j=1}^{N} (x_j - \bar{x})^2}$$

In addition, some respondents had additional comments on specific system criterion. The analysis of each item is shown in table 1. Additional comments can also be found in table 1.

**Table 1**. Analysis of model criteria

A. Evaluation of individual criterion:

| # | Statement | Mean | Standard Deviation |
|---|---|---|---|
| 1 | Should be user friendly with quick loading capability and intuitive interfaces | 4.89 | .33 |
| 2 | Provide features to enable communication between members | 4.78 | .44 |
| 3 | Allow public access (to a public information section) and member access (to restricted information) | 4.78 | .44 |
| 4 | Include security features to protect private information | 5 | .00 |
| 5 | Incorporate access to external applications such as the (Virtual Emergency Operations Center and Action Tracking System) | 4.22 | .73 |
| 6 | Include links to VOAD member and outside agencies | 4.56 | .88 |
| 7 | Include access to a reference library | 4.22 | .97 |
| 8 | Provide disaster relief information for DFO volunteers | 4.56 | 1.01 |
| 9 | System should be used as a training asset | 4.78 | .44 |
| 10 | System should be inexpensive and easy to maintain | 4.78 | .44 |

B. Evaluation of construct validity of criteria:

| Statement | Mean | Standard deviation |
|---|---|---|
| Please evaluate the criteria as a whole in the context of the entire project. How well do you think the criteria represent the needs of the operators in disaster field office (DFO) operations? | 4.78. | .44 |

C. Summary of survey participant comments:

| Criteria # | Comments |
|---|---|
| 1 | No comments |
| 2 | Four commented that there may be too many features listed. Of these, one stated chat was not required; two stated threaded conversation capability was not needed. |
| 3 | Three expressed concern about public access to the web site. |
| 4 | No comments |
| 5 | Three stated access to the Action Tracking System was not likely in the near future. One said system should be security protected. One advised against duplication of effort. |
| 6 | One stated emphasis should be on those “active” in the event. |
| 7 | One expressed concern for privacy requirements stating that some documents should be for internal use only. One said this criterion should not be a top priority due to cost concerns. |
| 8 | One expressed the need for more planning for volunteers. One said local contact information should be maintained at the DFO. |
| 9 | Two said training should be tailored in an appropriate manner for VOAD. |
| 10 | One said that costs would probably be a paramount concern. |
| Construct Validity | One said it should be clear what systems are for what people. One said it represented most of the volunteer’s needs. One said it should also apply to those working at the disaster site. |

Analysis of the mean and standard deviation for each criterion indicates strong agreement overall with the proposed system criteria. The mean score for each criterion was above four. Additionally, nine of the ten criterion were within one standard deviation. For question #8 the standard deviation was 1.01 with only one respondent scoring the criterion below four. There were concerns expressed in the form of written comments. The most significant theme was the issue of security and protection of privacy. Additional comments addressed the need for simplicity; avoiding duplication of effort; considering cost, and; appropriate use of the system for training. The results of survey #1 combined with the literature review determined the system objectives.

*Formulation of Design Objectives*

At this point in the study there appeared to be a convergence between the feedback obtained from the study participants and findings in the literature. Three design objectives emerged to characterize the requirements for the knowledge management to support disaster recovery operations for the VOAD organization. System design objectives were mapped to the system criteria as represented in survey #1.

Objective 1. *A knowledge management system should foster a community of practice to enable a cross flow of communication*

King, Marks and McCoy (2002) describe communities of practice as networks of self-organizing groups sharing common interests who may geographically separated. This aptly describes disaster recovery organizations who often operate ”in the field” close to the disaster site and need to share information and coordinate activities with other dispersed agencies. Turoff (2002) explains that crisis situations bring many and diverse individuals from different organizations together and they must be able to freely exchange information, delegate authority, and conduct oversight. He states that establishing and supporting confidence in decision making is essential to coherent operations. This is accomplished through supplying quality up-to-date information to decision makers. Decision effectiveness is a function of the level of integration and the extent to which the participants share a mental model of the response environment (Paton & Jackson, 2002). Providing the tools to enhance the sharing of knowledge resident in communities of practice through better communication can help create this shared mental model.

Nonaka and Takeuchi (1995) describe creating a “knowledge spiral” in an organization where knowledge is transferred from one member to another. Initially, the first member’s tacit knowledge is transformed into explicit knowledge. This is then passed on to other members of the organization who internalize it and convert it into tacit knowledge. In the dynamic, unpredictable, and fluid emergency management environment tacit knowledge is an important element of successful performance because it allows individuals to adapt to and shape the environment (Paton & Jackson, 2002). Wybo and Lonka (2002) conclude that the use of tacit knowledge is prevalent in the domain of emergency management. A knowledge management system can support the cross flow of both tacit and explicit knowledge. Links to both internal and external information sources can provide opportunities to exploit both tacit and explicit knowledge.

McEntire (2002) pointed out that coordination is a major challenge among individuals, groups, and agencies involved in responding to the aftermath of disasters. Multi-organizational operations call for collaborative problem solving to overcome the difficulties encountered among the agencies that respond to disaster. This was illustrated by the tornado that occurred in Fort Worth, Texas in March of 2000. He observed that the involvement of numerous public, private, and non-profit agencies required both intra- and inter-organizational coordination. Stumpf (2001, May/June) highlights the growing need for multi-agency and multifunctional involvement with incidents and notes the difficulty agencies have in working together.

The concept of communities of practice has wide application. Millen, Fontaine, and Muller (2002) state that there has been increasing interest within large organizations in the development and support of communities of practice. These communities have a number of characteristics in common that include similar work activities, common backgrounds and shared stories, contexts, and values. Benefits have accrued from fostering these capabilities that include enhancing collaboration, improving social interaction, increasing productivity, and greater organizational performance (Millen et al., 2002). The individuals who comprise these communities of practice need effective and efficient ways to communicate in order to share their knowledge, experience, and insights. This can be facilitated through knowledge management. Souder (2001) found that duplication of effort in an organization can be an issue and tools are needed to share status reports and document actions as well as sharing best practices and providing contact information. Providing access to external information sources and applications that contain relevant information can benefit the entire community of practice.

In the aftermath of the destruction of the World Trade Center and damage to downtown Manhattan on September 11, 2001, the city of New York relied on an emergency management system called Eteam. This system was based on Lotus Domino and allowed workers from federal, state, and local agencies in New York to communicate with each other, keep information up to date, and make decisions. This system was instrumental in managing workers and coordinating the logistics of bringing in equipment and emergency supplies. The web-based collaboration software was used to create and access infrastructure reports and produce and update incident reports. The system allowed participating agencies to all be "on the same page" and make decisions using the same reports (Lunt, 2001).

Increasingly, the online venue that includes web spaces, email, discussion forums, and synchronous chats has replaced face-to-face exchanges for communities of practice. These technology tools lend themselves to the creation of virtual environments or "spaces" where people interact in synchronous and asynchronous timeframes (Nonaka, Konno, & Toyama, 2001). Malhotra (1998) discusses incorporating flexible technologies and systems that support, enable, and empower communities of practice composed of informal and semi-formal networks of individuals based on shared concerns and interests. Providing innovative support for information access and member collaboration is highlighted as an increasingly important element for knowledge management and its implications for communities of practice (Kemp et al., 2001). Brazelton and Gorry (2003) propose creating the conditions for a knowledge sharing community to emerge suggesting that electronic communities could enhance governmental or social services agencies where lack of coordination and integration of services negatively impacts clients.

Summary: Providing innovative support that enables communities of practice to share information and effectively collaborate has become a driving force in industry, government, and academic domains (Kemp et al., 2001). There is growing recognition of the value of knowledge resident within the members of organizations and communities. A knowledge management system can capitalize on the intellectual and experiential knowledge embedded in communities of practice by allowing a cross flow of information between entities.

Objective 1 supports the following system criteria (found in table 1-section A):

a. #2 – Provide features to enable communication between members

b. #5 – Incorporate access to external applications ( such as the Virtual Emergency Operations Center and Action Tracking System)

c. #6 – Include links to VOAD member and outside agencies

Objective 2. *A knowledge management system should be accessible and relevant to users and stakeholders operating in varied contexts and roles*

In diverse organizations there will be a variety of users and stakeholders and these individuals will be operating in different contexts. To accommodate this diversity, a knowledge management system should be easy to use and convenient to access. A web-based approach lends itself to fulfill these requirements due to the pervasive nature of the Internet and public familiarity with web browsing tools. In addition, the system needs to be relevant for users by providing useful and timely information tailored to the context of the individual user.

The system should take into account the range of potential users with regard to their experience levels and computing/communication resources. It should include user friendly interfaces and a real-time capability for the system (Ikeda et al., 2001). System designers must understand user capabilities and familiarity with the system and make the interface as intuitive as possible (Lindell et al., 2002). Standards for web site design are being refined. The IEEE web site engineering and management standard suggests methods to better engineer web sites for maintenance, access, and usability (Isaak, 2002). Shneiderman (1998) proposes using the Object-Action Interface model to build a logical and effective web site. It uses a hierarchical decomposition of objects and actions in the task and interface domains and can serve as a guide to web site designers. Web technologies such as hyper text markup language (HTML) support user friendly interfaces to remote web applications (Ito & Tanaka, 2003).

The system should also be accessible from a time and space perspective. Having the knowledge management system accessible via the Internet allows geographically dispersed users the flexibility to "connect" to information anytime, anywhere. Web technology is also being adapted to numerous devices thereby boosting productivity and contributing to the pervasive computing environment (Dimitrova, 2000). Enhanced productivity will result from better availability of information and improved collaborative support (Lucca et al., 2000). The goal should be to transfer the experiences and knowledge of individuals in a way and in a form that can be readily shared and communicated to others in the organization (Bessant, 2000). In the disaster recovery environment organizations often have personnel that are dispersed and need to be agile to react to unique circumstances. Having organizational knowledge available via the Internet lets these people tap into the organization's knowledge base providing they have a connection to the web server where the web site is located. The growing ubiquitous and pervasive nature of the Internet accommodates this need. For example, web applications are increasingly being incorporated into mobile wireless systems. New approaches to upgrading wireless web browsing performance by using thin client architecture are showing improved speed and resiliency over lossy local area networks (Yang, Nieh, Krishnappa, Mohla, & Sajadpour, 2003).

The system should be available to different groups to service their unique needs. Different groups may have their own shared frame of reference and participants playing different roles may need different information (Zack, 1993). Web sites can be designed to differentiate among users and stakeholders by allowing selected access to parts of the site. Access is determined by user identification and password use. A web-based design can differentiate public and restricted access. Web site designers have tools available to customize sites to allow public access to some information and restricted or protected access to other areas of the site to meet the needs of the organization (Joshi, Aref, Ghafoor, & Spafford, 2001). This must take into account that stakeholders will be operating within different environments to meet specific needs.

In addition to being easily accessible and available, a knowledge management system should contain relevant information tailored to the contextual framework of its users. Knowledge repositories should be integrated into the workflow of organizational processes and take into account that each community has different knowledge requirements and therefore defines context by their own frame of reference (Kwan & Balasubramanian, 2003). Stein and Zwass (1995) differentiate between the terms semantic knowledge and episodic knowledge. They define semantic knowledge as organizational practices that have been captured and codified in accessible manuals and standard operating procedures. Grover and Davenport (2001) discuss capturing knowledge in knowledge repositories for later and broader access by others within an organization. These repositories can include best practices, lessons learned, competitive intelligence for planning purposes, and learning histories or records of experience. In contrast, episodic knowledge is generated based on contextually based solutions derived from real-time solutions to unique problems. This episodic knowledge is vital to the success of the organization and is dependent on an evolving semantic base of knowledge.

Salisbury and Plass (2001) describe a web based knowledge management system used by the U.S. Department of Energy based on a theoretical foundation they call the Collaborative Cognition Model. This model proposes that learning can take place in one individual, be captured, and made available to another individual in an organization. Their approach was to treat the system as if it were a living and adapting organism revealing complex and changing requirements. The system focuses on communication features that allow users to grow and share knowledge. They found that a search capability was an important tool as was having access to online reference material. Other key features included a "points of contact" email capability, a frequently asked questions list, a threaded discussion capability, and a means to organize and store case studies and real time experiences.

Summary: The disaster relief environment must accommodate the needs of a diverse community. A knowledge management system to support this community must be user friendly and flexible to accommodate various user/stakeholder needs. In addition, it must be readily available and contain relevant information to support a fluid environment consisting of users and stakeholders in various contexts and roles.

Objective 2 supports the following system criteria (found in table 1-section A):

a. #1 – Should be user friendly with quick loading capability and intuitive interfaces

b. #3 – Allow public access (to a public information section) and member access (to restricted information)

c. #7 – Include access to a reference library

d. #8 – Provide disaster relief information for DFO volunteers

Objective 3. *A knowledge management system should be designed to meet organizational needs and constraints*

Wybo and Lonka (2002) point out there is a relatively low integration of information technology in the field of emergency management and, first and foremost, we need to gain a proper understanding of the information requirements. Coupled with this are the constraints and limitations that are applicable to the organization. Issues such as security, training, cost, and maintenance need to be considered. The success or failure of the knowledge management system will be tied to fulfilling organizational needs and operating within the boundaries of its constraints.

Along with opportunities, there are issues that have emerged as challenges and obstacles. These include security weaknesses that enable hackers to gain access to a system (Lawton, 2001). Ensuring knowledge security is listed as one of the top 10 important issues in knowledge management (King et al., 2002). Completely securing a computer is extremely difficult and reliance on the Internet can make an organization vulnerable to attack and compromise of information (Bashir et al., 2001). There is a prevailing need for information security on the Internet that includes access control and communication security services (Joshi et al., 2001).

Another challenge is ensuring users are comfortable using a new system. Lucca, Sharda, and Weiser (2000, Spring) recognize the importance of cultural change to accept new technologies such as electronic collaboration and knowledge sharing programs. When implementing change it is very important to have the support and dedication of key stakeholders. They point out that without coaching or training the new technology will not be fully utilized. Providing adequate training will benefit users of a system. Jenvald, Morin and Kincaid (2001) found that a comprehensive training strategy is essential to the effective use of an emergency management system and participation in emergency response exercises produced valuable lessons learned. Britton (2001) cited best practices and relevant education and training as important parts of an emergency management strategy

Additionally, important considerations for non-profit organizations with limited budgets are that the system be low cost and easy to maintain. The system must be designed within the boundaries of the organization’s financial capabilities. Dalcher (2001) noted the pitfalls and implications of failing to properly evaluate these factors stressing that financial pressures and resource constraints must be thoroughly considered in project design. Comprehensive system life cycle costs need to be evaluated. In addition to system procurement, system management and maintenance may also be affected by resource and personnel limitations and need to be taken into consideration during system requirements and design planning.

Having a dedicated information technology staff may not be an option for all organizations such as a non-profit organization that may rely on volunteers to manage the system. Therefore, the system should be easy to maintain. There are a number of factors that support ease of development and maintenance. First, web based architecture provides the flexibility for site maintenance and administration to be location independent. Second, commercial off the shelf (COTS) applications are available to facilitate site functionality. The use of COTS products can lead to faster development, reduced effort, and lower cost (Torchiano, Jaccheri, Sorensen, & Wang, 2002). Third, cost effective web site hosting from commercial sources is also an option. Numerous commercial web site hosting companies offer wide-ranging options. These can be located using Internet search engines (www.google.com).

Summary: If a knowledge management system is to be successful, the design must take into consideration the priorities and constraints of the organization. Issues such as security, training, cost, and maintenance must be addressed. These must be aligned to the organizations requirements and goals.

Objective 3 supports the following system criteria (found in table 1-section A):

a. # 4 - Include security features to protect private information

b. # 9 - System should be used as a training asset

c. # 10 - System should be inexpensive and easy to maintain

These three system design objectives formed the basis for further development of the model and provided the foundation for the high level system architecture. Developing system design objectives has been shown to be an effective way to summarize system requirements for an knowledge management system (Kwan & Balasubramanian, 2003). These system objectives, along with information obtained from the key personnel interviews and VOAD literature research, provided the basis for producing the project artifacts. The project artifacts were the Requirements Definition Document (RDD) that included the Vision document, use cases, and high level system architecture. These can be found in appendix G. The RDD along with survey #2 were sent to the project participants serving as the summative body.

*Survey #2*

Survey #2 contained nine questions that were sent to the 10 key VOAD personnel via postal mail for their evaluation and comment. There were three questions associated with each part of the Requirements Definition Document.

- Part 1 is the Vision document
- Part 2 is the use cases
- Part 3 is the high level system architecture

The survey questionnaire was based on the goal-question-metric paradigm as it relates to the environment or user's perspective (Boloix & Robillard, 1995). Evaluation was considered within the context of a goal-centered view to compare pre-established objectives to actual results. It served to define evaluation objectives for each element and dimension of the framework and to establish questions for each category. For the purpose of this study, the goal-question-metric paradigm has been restricted to the user's environment category focusing on the compliance, usability, and contribution attributes. A copy of the survey can be found in appendix C.

The 10 key personnel served as a summative body to validate the system artifacts. Eight of the ten surveys were returned. All of the returned surveys were completed according to the instructions. Respondents were asked to rate each of the nine questions using a five point Likert scale.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Each question was analyzed to determine mean and standard deviation. The formulas for calculating mean and standard deviation were the same as used for survey #1. The statistical application was StatPac (Walonick, 2003). In addition, some respondents had additional comments on specific system criterion. The analysis of each item, as well as the additional comments, is shown in table 2.

**Table 2**. Analysis of system artifacts

A. Evaluation of individual questions in survey #2

| # | Question | Mean | Standard Deviation |
|---|---|---|---|
| 1 | Do you think the vision is in compliance with the mission and goals of VOAD? | 4.75 | .46 |
| 2 | Do you think the vision provides useful information to support development of a Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? | 4.63 | .52 |
| 3 | Do you think the vision provides accurate information to support development of a Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? | 4.25 | .71 |
| 4 | Do you think the use cases are in compliance with the mission and goals of VOAD? | 4.75 | .46 |
| 5 | Do you think the use cases provide useful information to support development of a Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? | 4.63 | .52 |
| 6 | Do you think the use cases provide accurate information to support development of a Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? | 4.5 | .76 |
| 7 | Do you think the proposed architecture is in compliance with the mission and goals of VOAD? | 4.88 | .35 |
| 8 | Do you think the proposed architecture provides a useful Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? | 4.75 | .46 |
| 9 | Do you think the proposed architecture accurately supports the requirements of Disaster Field Office (DFO) operations? | 4.88 | .35 |

B. Summary of survey participant comments:

| Question # | Comments* |
|---|---|
| 1 | Ease of use and accessibility is key |
| 2 | Maintenance of data is critical; Concern over possible lack of computer availability |
| 3 | Accuracy will depend on sources and data entry process; Maintenance of data is critical; Hardware and software compatibility should be considered |
| 4 | Agencies should designate personnel to update the system |
| 5 | Access to the system should be limited to set time frames |
| 6 | Access to the DFO is closely controlled and walk-in access for disaster victims is unlikely; Donations management is the toughest component. |
| 7 | Concerns about unresolved issues of staffing for system admin and maintenance, Level of volunteer skills may be an issue; Support and access to funding are issues |
| 8 | No comments |
| 9 | Impressed by content and format of RDD, clearly lays groundwork for system development of a useful and useable tool for state and local VOADS; Weakness lies with who will maintain the system long term and cooperation from member agencies |

* Each of these statements represents individual comments

Analysis of the mean and standard deviation for each criterion indicates strong agreement overall with the nine questions evaluating each part of the RDD (Vision document, use cases, system architecture). The mean score for each criterion was above four. Additionally, responses to all nine questions were within one standard deviation. There were concerns expressed in the form of written comments, however, no trend was detected indicating a significant dissatisfaction or perceived weakness with the model.

Some comments were repeated from survey #1. Common to survey #1 and survey #2 were comments concerning the issues of security and costs. This is not unexpected from an organization that operates in the public interest and is a non-profit entity with limited funding. A hands-on demonstration of a prototype that incorporates the security features described in the model will address this concern in a practical way. In addition, the next stage of development of a prototype will provide more details of costs involved; however, the RDD does propose minimizing costs by incorporating commercial off the shelf and free software.

It is also useful to discuss comments that did not reoccur between survey #1 and survey #2. Comments that were made in survey #1 (that were not mentioned in survey #2) include:

- concern that there may be too many features included in the system
- the need to explain “what systems are for what people”
- concern over duplication of effort

Survey #1 provided limited information to address these issues. Subsequently, these issues were covered in more detail in the RDD. Functionality of the system, relationships to other web applications and human computer interaction issues were explained in the text and graphically depicted using diagrams and the Unified Modeling Language (UML) notation. This appears to have resolved these concerns.

Comments also addressed issues related to compatibility, user friendliness, and maintenance. Because the intent of the architecture description was to provide a high level view, specific hardware and software solutions dealing with compatibility were not delineated. However, the RDD does suggest the maximum use of commercial off the shelf and non-proprietary options. Comments also included statements about user friendliness that concern ease of use, accessibility, and concern over the skill levels of volunteers. The RDD addresses these issues by proposing use of Internet access and using familiar web based interfaces and applications commonly used in home and business environments. A significant concern that was highlighted a number of times in the survey was the need for long-term planning for maintenance of the system. As discussed in the RDD, this is a policy question that will have to be determined by the VOAD executive committee.

Comments were also made about availability of computer resources and member agency support in using the system. Although these comments are outside the boundaries of the model, they are worthy of discussion. These include concern over possible lack of computer availability at the DFO in the aftermath of a disaster. This issue was not in the scope of model but the researcher's personal experience in working at the DFO in Henrico County in Virginia (after hurricane Isabel in September through November of 2003) showed government agency support for computer resources at the DFO was available when required. Another concern that was outside the boundaries of this study involved cultural and political issues surrounding member agency support of the system.

The question was whether the member agencies would actively support and participate in using and updating the system. The degree to which organizations such as VOAD that are made up of loosely aligned, non-profit agencies will embrace such a system is worthy of further study.

## Findings

### *Effectiveness of Methodology*

Although originally used as a software engineering process, the Rational Unified Process (RUP) is a process framework that was successfully adapted to the needs of this study to capture system requirements and provide the framework for constructing a model for a knowledge management system. It is a use-case driven approach where the use-cases defined for the system serve as the foundation and continuity for the follow-on development process (Kruchten, 2000). The use case considers the behavioral aspects of the system reflecting the user's concerns and requirements (Saleh, 2002). This was the approach adopted in this study and it proved effective in capturing the system requirements and serving to communicate the model's features and functionality to the formative and summative body.

Although use cases are written in a textual format their utility can be enhanced with visual representation using Unified Modeling Language (UML) (Fowler & Scott, 2000). The UML is primarily a set of notations that provides a visual foundation for using an object-orientated modeling approach. It does not require a specific development process but lends itself to a pragmatic, iterative, and comprehensive strategy for systems development of different types of systems, domains, and methods (Alhir, 1998). It was very useful in this study by allowing the users to visualize the interaction of use-cases via a graphical representation. UML helped to define the system by addressing the behavioral, structural, and architectural aspects of the system and visually displaying these relationships.

RUP and UML provided effective structure and notation to fulfill methodology requirements for the project. It was successfully adapted to the non-profit disaster recovery domain. The building block approach that was delineated in the eleven steps of the methodology used in this study (as described in chapter 3) resulted in establishing the requirements for the project. The subsequent model accurately reflects these requirements as indicated by survey #2.

*Conclusions of Data Analysis*

The system criteria that resulted from the initial interviews of key VOAD personnel listed the functional and non-functional requirements for the system that was the subject of this study. These criteria were evaluated individually as a result of survey #1 and the results indicated that the members of the formative body were in agreement that these were valid criteria. While there were individual comments that indicated not all the respondents agreed completely with each criterion, there was not a significant pattern to invalidate any of the individual criterion. Additionally, the purpose of the final question of the survey was to ascertain the construct validity of the system criteria. The survey results indicated this was valid.

The literature review and the result of the survey #1 formed the basis of the system objectives and subsequently the creation of the Requirements Definition Document

(RDD) consisting of three parts. The Vision document was Part 1. The set of use cases was Part 2. The high level system architecture was Part 3. Each of the parts included a list of evaluation questions that collectively constituted survey #2. The results of survey #2 indicated general agreement with the model. Individual comments highlighted changes that needed to be made to the use cases. As a result of the analysis of the feedback comments, the use-case model was modified as follows:

- Use case # 1 – Delete the disaster victim behavior of "walk-in" to the DFO. Maintain the behaviors of calling the DFO and communicating via a web site connection.
- Use case # 6 – Behavior should reflect that the update will be by agency designated personnel.
- Use case # 7 – Add time frame criteria to automatically terminate user access after a designated period of time.

*How System Objectives were met*

The system objectives provided the foundation for development of the model. The system objectives led to the production of the RDD (found at appendix G) that consisted of the Vision document, set of use cases, and system architecture. A summary of the use cases, compiled as use-case briefs, is presented in table 3. According to Cockburn (2001), the use case brief is an abbreviated description of use-case behavior used to portray what is going on in the use case. Here it is used to show how the use cases relate to the system objectives. More detail on the use cases can be found at appendix G. The following illustrates how the system objectives are integrated into the RDD and reflected in the model.

Objective 1. *A knowledge management system should foster a community of practice to enable a cross flow of communication*

Vision Document. The Virginia VOAD currently has over two dozen member agencies. It is an umbrella organization of existing agencies that include among others the American Red Cross, Salvation Army, regional food banks, and faith based organizations. Each member organization works closely with other organizations to improve service and minimize duplication of effort and waste. According to the VOAD "Plan of Organization" (1998) it fosters:

- Cooperation: Creating a climate for cooperation and providing a channel for sharing information and planning.
- Communication: Disseminating information through news releases and notices, a directory of participating agencies, case studies, and critiques.
- Education: Providing training, encouraging increased awareness, and sharing information related to public policies that affect disaster response.

The knowledge management system, as outlined in the Vision document, provides tools to help create and cultivate the community of practice that forms in the aftermath of a disaster under the auspices of the VOAD.

Use case. The use cases illustrate the cross flow of information that supports a community of practice. The goals of the use cases (as depicted in table 3) include seek assistance; find information; establish a synchronous and asynchronous collaboration environment, and; enter and update requests. Both explicit and tacit knowledge are addressed in use cases. The model also takes into account both internal and external sources of information.

Architecture. The high level architecture proposal includes a number of tools that support knowledge exchange between members of the community of practice. These tools include web navigation, email, chat, threaded discussion, and search engine capabilities. This is a flexible array of options enabling communication in both a synchronous and asynchronous environment. This concept also incorporates the listserve capability that has been used successfully by VOAD in past disasters. Additionally, links to the Virtual Emergency Operations Center and the Action Tracking System (used by the State of Virginia) and external tools such as teleconferencing complement the system to create an effective and coordinated working environment.

Objective 2. *A knowledge management system should be accessible and relevant to users and stakeholders operating in varied contexts and roles*

Vision Document. The needs of a number of users and stakeholders need to be considered. The VOAD volunteers at the disaster field offices (DFO) and the State Emergency Operations Center in Richmond are primary users but there are others who will be involved. This includes local, state, and federal representatives at the DFO and well as member agencies of VOAD. In addition, it includes the victims of disaster and the general public seeking information and points of contact to seek or give assistance. These actors are identified in the Vision document as well as the overall factors considered in developing the system to include capabilities, assumptions, dependencies, and alternatives.

Use case. The use cases identify the users and stakeholders according to the role they play and the context in which they will interact with the system. The use cases recognize that the different actors (or users) will have different goals (see table 3). The system design allows access to applications and files according to need to know. It is meant to be flexible and available twenty four hours a day, seven days a week with access to a variety of information sources.

Architecture. The web-based foundation allows access from any geographic location with Internet availability. In addition, design parameters include that the system be user friendly, intuitive, and utilize common web tools for navigation and web site search. The site will contain explicit and tacit disaster relief information for disaster field office (DFO) volunteers to include access to a reference library of information as well as contacts for problem solving. It will be based on a two tier concept that allows general access to publicly available information and members only access to the area that contains private information.

Objective 3. *A knowledge management system should be designed to meet organizational needs and constraints*

Vision Document. All organizations operate under certain constraints and limitations. This is certainly the case with non-profit organizations. The success or failure of the knowledge management system is tied to fulfilling organizational needs and operating within the boundaries of its constraints. In the case of the VOAD organization, the

Vision document highlighted security, training, maintenance, and cost as key issues that needed to be addressed in the design of the system.

Use case. As depicted in the use cases, access to information will be restricted based on a need to know and other applicable criteria. The system administrator will allow access to private information based on policies established by the VOAD executive committee. The use cases outline the steps that are required to be completed successfully for access to the restricted area in the model. As illustrated in the use cases, appropriate personnel can access explicit and tacit information. While this would be used during the recovery phase of a disaster, the system can also be made available to designated individuals for training purposes, for example, during exercises.

Architecture. The design takes into account the need for security provisions that includes the requirement to adhere to federal, state, and local rules and regulations (i.e. the Privacy Act). The web-based framework is flexible and accessible by a variety of platforms and commercial off the shelf software. Therefore, it does not require proprietary hardware or software, thus, keeping costs down. It is designed to be cost effective and easy to maintain. The model does not mandate specific technology but is open to embrace new innovations and the evolving requirements of the organization.

**Table 3**. Use-Case Briefs

| Actor | Goal | Brief |
|---|---|---|
| Disaster Victim | Contact the DFO to seek assistance | Disaster victim can access information via the Internet or call the DFO. They can view information on web page and navigate to other hyperlinks in public area of site. They can email appropriate authorities listed on the site. |
| VOAD DFO Volunteer | Inexperienced personnel can access explicit and tacit information | Volunteer will enter the web site via the public area. They can access information on the public area via hyperlinks. They may also have access the restricted area provided they have a valid userID and password. Depending on their privileges entry to the restricted area allows access the explicit (i.e. documents) and tacit (i.e. applications to allow consult with others) information. |
| General Public | Provide information and points of contact to the general public | Entry to the web site is via access to the public area available through the URL address. They can view information and navigate to other pages in the public area of the site via hyperlinks. They can email appropriate authorities listed on the site or use links on the page to link to member agency sites for additional information (i.e. to make donations). |
| VOAD DFO Volunteer | Establish a synchronous collaboration environment with VOAD members or stakeholders | From the Public Area the VOAD volunteer can enter the Restricted Area.* This can include access to applications such as chat, videoconferencing, and other real-time collaboration tools. |
| VOAD DFO Volunteer | Establish an asynchronous collaboration environment with VOAD members or stakeholders | From the Public Area the VOAD volunteer can enter the Restricted Area.* This will include access to applications such as email, threaded discussion, and other non real-time collaboration tools. |
| VOAD Volunteers and VOAD Agencies | Enter and update requests for assistance | From the Public Area the VOAD volunteer can enter the Restricted Area.* VOAD volunteers and designated members of VOAD agencies can view, change, add content to the activities log IAW their assigned privileges. |
| System Administrator | Manage system access and site administration | He/she will manage userID and password access to site and ensure compliance with organizational policies and procedures. |

* From the Public Area the VOAD volunteer will click on the “members only” hyperlink. They will then be prompted for a userID and password. If this is authenticated, they will now have access to the information resident in the Restricted Area with the privileges associated with their userID.

**Summary of Results**

The methodology was derived from the Rational Unified Process and incorporating the Unified Modeling Language proved effective in discovering user requirements for the system and shaping the model. The interviews of the key VOAD personnel provided the background and substance for developing the system criteria that determined key functional and non-functional requirements. These system criteria were included in survey #1 and sent to the key personnel for rating and comment. Survey #1 was analyzed using means and standard deviations. The results supported the proposed system criteria and the comments indicated a particular concern with security and privacy. The results of the survey combined with the review of the literature were used to formulate the system objectives. These objectives stressed fostering a community of practice, enabling the system to be relevant and accessible to users and stakeholders, and ensuring the system design met organizational needs and constraints. The system objectives formed the basis of the Requirements Definition Document (RDD) and its components (Vision document, use cases, and high level architecture). The RDD was sent to the key personnel for their evaluation with survey #2. Survey #2 was analyzed using means and standard deviations. The results supported the RDD and its component parts. Changes were made to the use cases based on the feedback from survey #2. Analysis of the RDD found that the Vision document, use cases, and architecture supported the system objectives.

# Chapter 5

# Conclusions, Implications, Recommendations, and Summary

## Conclusions

### *Methodology and Results Achieved*

The purpose of this study was to develop a use-case based model of a knowledge management system to support disaster relief operations. The Rational Unified Process (RUP) using Unified Modeling Language (UML) was successfully adapted to provide the methodology necessary to construct the model. Each element of the process including literature review, interviews, and surveys supported data collection.

A building block approach was employed. First background information was gathered through interviews with key personnel in the Virginia Voluntary Organizations Active in Disaster (VOAD) organization and a review of VOAD documentation. This was used to construct a list of system criteria. These criteria were validated by the key VOAD personnel via survey #1 (see appendix A). Analysis of survey #1 showed survey participant agreement with the 10 system criteria and supported the construct validity of the survey. The results of survey #1 combined with a review of the literature led to development of the three system objectives:

1. A knowledge management system should foster a community of practice to enable a cross flow of communication
2. A knowledge management system should be accessible and relevant to users and stakeholders operating in varied contexts and roles

3. A knowledge management system should be designed to meet organizational needs and constraints

These objectives, along with previous research, provided the basis for creation of the Requirements Definition Document (RDD) that included the Vision document, use cases, and high level system architecture. Survey #2 (see appendix B) sent to the VOAD key personnel validated the RDD. Analysis of Survey #2 showed survey participant agreement with the nine survey questions. As a result of feedback from the survey, three use cases were amended. Analysis of the system objectives and the RDD concluded that the system objectives were met.

*Analysis of Outcome and Research Questions*

The desired outcome of this research was to:

- Define the knowledge management requirements to support disaster field office (DFO) operations for disaster relief organizations
- Design a knowledge management system model based on design objectives
- Evaluate and validate the knowledge management system model

The desired outcome was achieved by adapting the RUP methodology and depicting the results using the UML notation. Requirements were gathered and validated using the eleven step approach (outlined in chapter three). The system objectives that were formulated formed the basis for the design of the knowledge management system. This design was evaluated and validated using feedback from the formative and summative bodies via survey #1 and survey #2.

As a result of the study that included interviews, review of the literature, and feedback from key personnel in the Virginia Voluntary Organizations Active in Disaster (VOAD) organization, the following research questions were answered:

1. What are the types of information that disaster relief workers need when operating in a disaster field office (DFO)?
2. What are the functional and non-functional requirements for a web-based knowledge management system for disaster relief field operations?

*Weaknesses and Strengths*

There were weakness and strengths with regard to the participation in the study. A weakness in the study is that there were only 10 key VOAD personnel involved in the formative and summative bodies. However, these are also the individuals who are highly knowledgeable and experienced in the VOAD organization and in the disaster recovery domain. In addition, they represented a diverse cross section of disaster relief organizations. Thus, although it was a small group of participants, the fact that they were very appropriate participants was a strong point in the study.

Serendipity also played a role in the environment that surrounded this study. On September 18, 2003, hurricane Isabel came roaring through Virginia and touched all the lives of those participating in the study. The hurricane caused extensive damage to parts of Virginia, particularly southeastern Virginia, and the Virginia VOAD was activated to deal with the disaster recovery phase. While this study started out utilizing only historical data, after September 18, 2003 the researcher became personally involved by observing actual field conditions at the disaster field office (DFO) operations in Henrico

County, north of Richmond, Virginia. A limitation of this study is the inability to formally include the experience gained from this event; however, the events that followed Isabel did drive valuable discussion and lend credence to the findings of this study.

## Implications

It is anticipated that this model will lead to production of a prototype for a knowledge management system to facilitate disaster relief operations for organizations that operate in the disaster relief domain. In the short term, it is hoped that the model will be used to create a system that will improve communication and access to the Virginia VOAD organization's knowledge resources. Although the immediate focus of this study was on the Virginia VOAD, the long term objective of the study is to outline a process using the Rational Unified Process (RUP), use-case modeling, and the Unified Modeling Language (UML) that can serve as a template for other disaster relief organizations and that can be tailored for other organizations unique requirements.

There can be practical applications of a web-based knowledge management system for disaster recovery operations. These include distance learning through online access that would support training for disaster recovery operations. Another benefit might be expanding the opportunity for exercise participation for VOAD members who are geographically located throughout the State of Virginia. In addition, it is hoped an online system will provide potential volunteers with the capability to learn more about the organization and encourage more volunteer participation. It could also provide a forum to increase public awareness of the VOAD organization. From a systemic point of view, a web-based design can consolidate various disaster recovery tools and provide links necessary for comprehensive coordination.

Development of a model for a knowledge management system for disaster relief operations is the first step towards building a prototype system. It is anticipated this system could provide both synchronous and asynchronous tools to enhance communication and coordination during the disaster recovery phase. Therefore, designing a use-case model for a knowledge management system to support disaster relief operations will benefit the Virginia VOAD organization and ultimately the victims of disasters.

The domain of disaster recovery operations can be difficult due to the unpredictability of events and the fluid and dynamic nature of operations when an event does occur. However, enabling disaster recovery personnel to access organizational and/or community of practice based knowledge will enhance recovery operations. The implications for further research may concern how to tailor knowledge management systems to other specific disaster and emergency management situations.

## Recommendations

Further research is recommended in three areas. The first is to take the model and continue development to produce a prototype. This would move the RUP from the Inception and Elaboration phases to the Construction and Transition Phases and provide a "hands-on" product to evaluate.

The second area for additional study is to explore the applicability of developing knowledge management systems to support the other three stages of disaster relief. This study focuses on the recovery stage. However, the stages that precede the recovery stage are mitigation, preparation, and response (FEMA, 1999). These stages may also benefit from the use of knowledge management systems.

Finally, there are many cultural issues associated with disaster relief organizations such as VOAD. The characteristics and influences of a virtual organization, communities of practice, and the importance of face-to-face contacts on building trust in the disaster relief domain are important issues that have been alluded to in this study but are beyond its scope. Networking and cooperation that leads to knowing participants on a personal basis has been identified as important (McEntire, 2002). A knowledge management system is limited in establishing personal relationships. Trust is important and "having contextual insight" in team members lives such as personal familiarity results in a higher level of trust, enabling improved communication (Lucca et al., 2000). These are areas that need additional research.

It is recommended that disaster recovery organizations such as the Virginia VOAD continue to exploit the opportunities that information systems provide for information sharing and communication. As technology advances, organizations must rethink how they can take advantage of these advances and incorporate them into their operating procedures. A primary goal of disaster recovery organizations is to deliver goods and services to disaster survivors as quickly and efficiently as possible. Access to information and organizational knowledge is a cornerstone to achieving this goal.

## Summary

### *Description of the Problem*

This study examined the difficulty that disaster relief volunteers encounter with communication and coordination during post disaster operations. Specifically, it analyzed the requirements of individuals who operate in disaster field offices (DFO) and need access to knowledge resources to coordinate the activities of a range of disaster relief organizations and state agencies.

Disasters come in many forms and levels of magnitude and can strike at inopportune times and places. There are numerous agencies poised to deal with disasters; however, coordinating the activities of these diverse and dispersed entities and capitalizing on their knowledge assets can be a challenge. These agencies range from national organizations such as the Red Cross to regional organizations such as food banks and small private or civic organizations such as church based agencies.

All of these agencies are dedicated to serving survivors of disasters, but they at times lack the coordination necessary to respond efficiently. Decision makers who have ready access to timely, accurate information that is appropriately shared can save more lives and minimize damage. Unfortunately, decisions are often based on inadequate information (Morentz, 1999). Providing the right information in a timely manner in the aftermath of a disaster is key to mitigating suffering and managing resources effectively (Tierney et al., 2001).

Organizations like the Voluntary Organizations Active in Disaster (VOAD) recognize the importance of coordination between relief agencies. VOAD is made up of various disaster relief organizations that strive to work together cooperatively. The state or local

VOAD's role is to plan for disaster and provide training so its members can respond in a coherent manner. However, due to the diversity of disaster relief organizations and the geographic separation of state and local agencies this can be a daunting task.

Access to organizational knowledge resources by volunteers temporarily located at disaster sites can be problematic. Stephen Terveer, former president of the Virginia VOAD, noted significant problems in coordination and communication within his organization. He indicated that the organization needs to collaborate, cooperate, and communicate effectively to fulfill their disaster relief tasking. Presently, the Virginia VOAD lacks the means to adequately support disaster field office (DFO) operations (Terveer, 2001).

To better cope with disasters, the Virginia VOAD needs to develop knowledge management strategies to coordinate its resources. Information technology can be an important tool to link elements of a community together (Romm & Taylor, 2001). Virginia VOAD DFO volunteers need timely access to the organization's knowledge resources to effectively collaborate with member agencies operating as virtual teams.

*Characteristics of the System*

The Virginia Voluntary Organizations Active in Disaster (VOAD) is a relatively new organization that came into being in the early 1990's. By its very nature, it is an ad hoc organization that maintains a skeletal structure until called upon to respond to a disaster. The State of Virginia has identified Virginia VOAD to participate directly in state level disaster relief operations outlining specific Virginia VOAD responsibilities. This has significantly increased the range and breadth of Virginia VOAD involvement and has highlighted the need for a knowledge management system for field operations.

An integral element of Virginia VOAD's responsibilities involves having representation in the field during disaster recovery operations. The individuals charged with manning the disaster field office (DFO) play a pivotal role in coordinating and directing the efforts of the various disaster relief organizations that make up Virginia VOAD. However, this requires an extensive knowledge of the operations and resources of many diverse organizations. Unfortunately, the individuals staffing the DFO are volunteers who may not be able to be identified in advance of the disaster and may have limited training in DFO situations. Thus, it is imperative that there be a knowledge management tool available to assist the DFO volunteers.

Recent advances in technology have made development and deployment of a knowledge management system a realistic goal. The Internet offers flexible, ubiquitous options with mobile and "on the edge" architectures using web-based technology. A range of knowledge management options are now available that allow access to both explicit and tacit organizational knowledge using both synchronous and asynchronous applications.

Along with new opportunities, there are a number of factors and limitations that must be considered. For example, the design of the knowledge management system should have a user interface that is simple and “user friendly” and the web site should accommodate slow computer connections. This may limit the use of some applications. Also, security, cost and maintenance of the system are prime considerations. The Virginia VOAD has a modest budget with limited technical support. Therefore, the system design must take the procurement and operational limitations of the system into consideration. Additionally, unique challenges and difficulties associated with loosely structured organizations need to be addressed. Inter-organizational alliances often have difficulty promoting a collaborative work culture (Winer & Ray, 1994).

The current level of organizational maturity of the Virginia VOAD and its expanded mission responsibilities at the state level as a result of recent terrorist activities have generated the need for a more robust and comprehensive response to future disasters. Recent information systems developments along with the emergence of the Internet in a mainstream capacity have opened the door to new opportunities and options. Although there are various factors involving security, cost, maintenance, training, design, and usability that need to be taken into account, this is the opportune time to develop a use-case model for a knowledge management system to facilitate disaster relief operations.

*Approach*

Producing an effective knowledge management system first requires constructing a model to capture the system requirements. One technique for model development outlined in the Rational Unified Process (RUP) (Kruchten, 2000) is use-case modeling. According to Conallen (2003), "use cases are a powerful technique for capturing and expressing detailed system behavior" (p.173). Use cases combine a textual description with the notation tools found in the UML to detail the interaction and dialogue between system users and the system (Conallen, 2003). Several development processes that use UML advocate that the system development should start with use-case modeling to define the functional requirements of the system (Eriksson & Penker, 2000). The use-case method can facilitate developing a common mental model. Additionally, use-case modeling creates value by describing what the system will do and revealing the scope of the system and its purpose. It stimulates discussion about the system and becomes a communication device between the different stakeholders on the project often among people with no special training in system development (Cockburn, 2001).

The object of this research was to demonstrate that use-case modeling can be adapted to the non-profit, ad hoc environment in which disaster relief organizations operate. This research highlighted the unique attributes associated with disaster relief organizations. It is hoped that the Virginia VOAD model will serve as a template that can be revised and customized to accommodate local requirements of other disaster relief organizations.

The RUP provided guidance for developing the use-case model that was graphically depicted using the UML. In accordance with the latitude afforded by RUP and the unique nature of the disaster relief domain, the methodology was adapted to fit the disaster relief domain by making adjustments to RUP and the use-case methodology. Artifacts produced were a Requirements Definition Document that included a Vision document, set of use cases, and architecture description. Interviews and survey questionnaires were used to gather information. VOAD key personnel served as the formative and summative body providing feedback via survey questionnaires #1 and #2. After statistical analysis of the survey questionnaires, the results for each question were compiled along with a narrative summary of feedback comments. The results were analyzed and compared to the system design objectives to ascertain if the design objectives have been met. It was found that the system objectives were met.

*Application of the Study*

It is anticipated that development of this model for a knowledge management system to facilitate disaster relief operations will enhance recovery operations for organizations such as VOAD that operate in the disaster relief domain. In particular, it is hoped that the model will be used as a starting point to create a system that will improve communication and access to the organization's knowledge resources. Development of a prototype would be the next step in advancing the model. Although the focus of this study was on the Virginia VOAD, the purpose of the study was to outline a process using the RUP, use-case modeling, and the UML that can be adapted to other disaster relief organizations and to serve as a template. Additionally, it is hoped this concept can be extended beyond disaster recovery into the disaster response, mitigation, and preparation phases of the disaster event cycle.

*Goal*

The goal of this study was to design a use-case model of a knowledge management system to support state and local level disaster recovery planning and operations in the aftermath of a disaster. The goal was achieved. This model outlines a knowledge management system, accessible via an Internet web site; the purpose of which is to assist disaster relief volunteers at disaster field offices. It is anticipated that this model could serve as the basis for developing a prototype knowledge management system that may also be adapted to similar state and local chapters around the country.

# Appendix A

## Key Personnel Interview Questions

- *What are the key terms*?
    - How would you define the purpose and responsibilities of the disaster field office (DFO) operations?
- *What problem are we trying to solve*?
    - What do you see as the problems and challenges the individual (s) who staff the DFO face in terms of access to needed information?
- *Who are the stakeholders? Who are the users? What are their needs*?
    - Who do you view as stakeholders in the system?
    - Who will be the users?
    - How do the DFO individual(s) interact with the stakeholders and other users?
    - What categories of knowledge do they need access to?
- *What are the model features and functional requirements*?
    - What kinds of applications would be needed to support DFO individual(s)?
    - What kinds of activities (i.e. interactive chat, collaboration, access to documents and points of contact etc.) would enhance DFO individual(s) capabilities?
- *What are the non-functional requirements*?
    - Do you see any restrictions concerning cost?
    - Do you see any restrictions for operations from disaster locations?
    - Are there are concerns about training or user proficiency?
- *What are the design constraints*?
    - Is complexity of the system a concern?
    - Are there additional issues concerning the user interface?

*Interview questions are derived from the *Vision* as described by Probasco (2000)

# Appendix B

## Survey Questionnaire #1 - Criteria Objectives

A. Please evaluate each of the 10 criterion listed below to determine if each criterion accurately depicts a valid user requirement for the proposed system. Rank your answers to each question by circling one of the numbers on the 1-5 scale. If you wish, you may also include comments.

1. The system should be user friendly with quick loading capability and intuitive interfaces.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________

2. The system should provide features to enable communication between members (i.e. email, chat, threaded conversation, chat, information on conference calling, etc.).

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________

3. The system should be designed to allow limited public access (to a public information section) and full member access (to the restricted information area).

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

4. The system should include security features to protect private information.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

5. The system should incorporate access to VEOC (Virtual Emergency Operations Center) and state applications (such as the Action Tracking System and the VEOC web site situation reports).

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

6. The system should include external links to VOAD member and outside agencies.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

7. The system should provide access to a reference library (to include VOAD documents, lessons learned, memorandums of understanding, FEMA and State documents, etc.).

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

8. The system should provide access to disaster specific information for DFO volunteers (i.e. directions to DFO site, local contacts and phone numbers, orientation information etc.).

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

9. The system should be used as a training asset.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

10. The system should be inexpensive and easy to maintain.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

B. Please evaluate the 10 criteria as a whole in the context of the entire project.

Rank your answer by circling one of the numbers on the 1-5 scale. If you wish, you may also include comments.

1. The 10 criteria listed above represent the needs of the volunteers in the disaster field office (DFO) operations.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:_______________________________________________

# Appendix C

## Survey Questionnaire #2 – Model Evaluation *

1. Do you think the Vision is in compliance with the mission and goals of VOAD? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

2. Do you think the Vision provides useful information to support development of a Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

3. Do you think the Vision provides accurate information to support development of a Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

4. Do you think the use cases are in compliance with the mission and goals of VOAD? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

5. Do you think the use cases provide useful information to support development of a Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

6. Do you think the use cases provide accurate information to support development of a Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

7. Do you think the proposed architecture is in compliance with the mission and goals of VOAD? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

8. Do you think the proposed architecture provides a <u>useful</u> Knowledge Management System (KMS) to support Disaster Field Office (DFO) operations for VOAD? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

9. Do you think the proposed architecture <u>accurately</u> supports the requirements of Disaster Field Office (DFO) operations? (Circle the appropriate number)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | | Neither Agree Nor Disagree | | Strongly Agree |

Comments:________________________________________________

* Questionnaire is adapted from the goal-question-metric paradigm described by Boloix and Robillard (1995)

# Appendix D

## Vision Document Template

| Section Title | Contents |
|---|---|
| Positioning | The business opportunity<br>The problem statement<br>Market demographics (market forces that drive product decisions)<br>User environment |
| Stakeholders and Users | Identifying the actors with an interest in the system |
| Key Stakeholder and User Needs | Requirements and functionality expressed by actors to include background and justification |
| Product Overview | High level view of capabilities, assumptions, dependencies (to other programs), and alternatives to the development |
| Features | High level capabilities (services or qualities of the system) that are necessary to deliver benefits to users and satisfy user needs |
| Other Product Requirements | Any other high level requirements that can not be captured as product features. This includes any constraints on development and any requirements the product places on its operating environment |

(Bittner et al., 2003)

# Appendix E

## Risk Analysis Factors

1. The technologies the system is dependent on
2. Market trends that influence the system
3. Number of expected users
4. Future trends it is dependent on
5. Expected duration of some functionality
6. Legacy systems to interface with
7. Elements maintained outside the organization
8. Lack of user acceptance
9. Dependence on technology that changes
10. Users not experienced enough
11. Lack of connectivity
12. System scope and boundaries (things inside and outside the system)

(Schneider et al., 2001)

# Appendix F

## A Requirements Outline

**Chapter 1. Purpose and Scope**

1a. What is the overall scope and goal?

1b. Stakeholders (Who cares)?

1c. What is in scope, what is out of scope?

**Chapter 2. Terms Used/Glossary**

**Chapter 3. The Use Cases**

2a. The primary actors and their general goals

2b. The business use cases (operational concepts)

2c. The system use cases

**Chapter 4. The Technology Used**

4a. What technology requirements are there for this system?

4b. What systems will this system interface with, with what requirements?

**Chapter 5. Other Requirements**

5a. Development process

Q1. Who are the project participants?

Q2. What values will be reflected (simple, soon, fast, or flexible)?

Q3. What feedback or project visibility do the users and sponsors want?

Q4. What can we buy, what must we build, what is our competition?

Q5. What other process requirements are there (testing, installation, etc.)?

Q6. What dependencies does the project operate under?

5b. Business rules

5c. Performance

5d. Operations, security, documentation

5e. Use and usability

5g. Unresolved or deferred

**Chapter 6. Human Backup, Legal, Political, Organizational Issues**

Q1. What is the human backup to system operation?

Q2. What legal and what political requirements are there?

Q3. What are the human consequences of completing the system?

Q4. What are the training requirements?

Q5. What assumptions, dependencies are there on the human environment?

(Cockburn, 2001)

# Appendix G

## Requirements Definition Document

Part 1 – Vision Document

Part 2 – Use Cases

Part 3 – High level System Architecture

# Requirements Definition Document

## Purpose and Scope

The purpose of this study was to determine the requirements of VOAD volunteers operating in the disaster field office (DFO) during the recovery phase in the aftermath of a disaster. This led to the development of a model for an information system to support these requirements. The model takes into account the individuals and agencies that have an interest or "stake" in the system and describes the system's functionality.

This Requirements Definition Document is subdivided into three parts:

Part 1: Vision Document - Details the vision or overall concept of the system
Part 2: Use Case Summary – Describes scenarios of how users will interact with the system
Part 3: Architecture Description – Gives an overview of the system's components and functionality

## Terms Used/Glossary

Action Tracking System – Messaging system developed and used by the VDEM managed State Emergency Operations Center to coordinate and track status of actions.

Applications – Either individual software programs or systems designed to support particular functionality.

Asynchronous – Not real time. This allows the user to access information at a time that is convenient for them. For example, someone can read their email when they choose to open it.

Chat - This software application allows an individual to converse (either by typing words or verbally) with other individual (s) in real time (also called synchronous).

Disaster Field Office (DFO) - Once a major disaster declaration has been made the Federal Emergency Management Agency will set up a disaster field office (DFO) located as close to the disaster site as practical to help coordinate overall disaster response and recovery. This serves as the headquarters for federal staff and will include state and local government staff as well as voluntary organizations to include VOAD (FEMA, 1997).

Explicit knowledge – This is knowledge that can be written down and included in artifacts such as documents, standard operating procedures or other accessible formats (Grover & Davenport, 2001).

Interface – (For the purposes of this study) it is the means for humans to interact with the computer. It is the screen, web site design, and the application logic that the individuals will use to access the system.

Knowledge Management – The tools, technologies, practices, and incentives that an organization employs to "know what it knows." This knowledge is available to the users who need it when they need it.

Privacy Act – A federal law that requires individual privacy be safeguarded.

Public Area – The area of the system that can be freely accessed by the general public.

Restricted Area – The area of the system that is reserved for VOAD members and selected others that requires an authenticated userID and password for access.

Stakeholder – Someone or something that has a vested interest in the behavior of a use case.

Synchronous – Real time. This allows the user to interact with another individual(s) for immediate feedback. Examples would be chat or teleconferencing.

System – This is the projected product generated from the model.

Tacit knowledge – This is knowledge that is embedded within individuals and cannot be easily expressed or communicated.

Teleconferencing – Establishing communication with numerous individuals via audio telephone contact.

Tier One and Two – The web-based online system will be divided into two areas. Tier One allows access for the general public. Tier Two requires special authorization for access and will be limited to VOAD and associated members.

Use Cases – This is a set of scenarios tied together by a common user goal. The use case considers the behavioral aspects of the system reflecting the user's concerns and requirements. The use cases defined for the system serve as the foundation and continuity for the follow-on development process.

User – Individuals or entities that interact with the system.

UserID and password – These are special identifiers that are administered by the system administrator to control access to the Restricted Area. Users will determine their own passwords.

VEOC – A Virtual Emergency Operations Center may include the functions of information gathering and assessment, warning, coordination, and reporting that can be done on a distributed basis without the requirement of being present at a physical facility by having a presence on the Internet (http://members.tripod.com/~Richmond_ESM/usscdisaster.html). This term has also been used to describe the VDEM managed Virginia Emergency Operations Center that is referred to in this study as the State Emergency Operations Center.

VDEM – The Virginia Department of Emergency Management is located in Richmond, Virginia and coordinates the State Emergency Operations Center (EOC) that is part of a permanent ongoing operation supporting the State of Virginia.

Vision document - Expresses the focus, stakeholder needs, goals and objectives, user environment, and features of the proposed information system.

Web-based – Accessible via the Internet and uses commonly available World Wide Web technologies.

Web navigation – Accessing information on a web site via hyperlinks (point and click).

## The Use Cases

Use cases are a set of scenarios that consider the behavioral aspects of the system reflecting the user's concerns and requirements. Basically, they describe how the system will be used. These are included in Part 2.

## The Technology Used

The technology considered will be compatible with user needs as outlined in the use cases. The intent is to use available technology that is either free or embedded in standard systems (i.e. Adobe Reader, word processing application etc.). The technology issues are discussed in Part 1, Sections 4 & 5 and in more detail in Part 3.

## Other Requirements

Development process. Part 1 Section 3 discusses the key stakeholder and user needs and includes an explanation of the methodology and phases used to develop the model for the system that is the subject of this study. Part 1 Section 4 outlines the capabilities and assumptions for system development as well as the dependencies and alternatives to development.

Operational rules – The system must conform to the formal rules of the Virginia VOAD to include the VOAD Plan of Organization (1998) and the informal organizational culture. VOAD is an umbrella organization made up of various agencies where each member agency is independent. Also, the system must comply with state/federal DFO directives and guidance and be compatible with National VOAD guidelines.

System characteristics. Performance, operations, security, cost, and usability are addressed in Part 1 and Part 3.

Unresolved or deferred issues. It should be kept in mind that the model is a proposal, in effect, a "wish list" of desired features and functionality. Elements have been included in the model that currently may not be feasible to implement. For example, there are legal issues that need to be resolved such as links to proprietary software (i.e. the Action Tracking System) and privacy restrictions.

**Human, Legal, Political, Organizational Issues**

Human. Disasters typically do not create an ideal operating environment. The nature of disasters is disruption. Therefore, VOAD volunteers must be flexible and they have demonstrated this capability in the past. It follows that any system to support VOAD volunteers must also be flexible to user needs.

Legal. The system must operate within the confines of legal requirements to include copyright restrictions and protection of privacy.

Political/Organizational. In keeping with the limited financial resources of the Virginia VOAD, the system must be low/or no cost and be easy to use with minimal training required. Also, policy issues need to be worked out at the VOAD executive committee level to include questions as to how the system would be developed, accessed, and maintained.

# Part 1 - Vision Document

## Section 1 – Introduction

*Why have a Vision document?*

Purpose. The Vision document is a primary means of communication among project participants that expresses the focus, stakeholder needs, goals and objectives, user environment, and features of the proposed information system. It allows those involved in the project:

- input to the project approval process
- a means for eliciting initial feedback
- a means to establish the scope and priority for product features

*What is the reason for this study?*

Problem Statement and Goal. The problem to be investigated in this study is the difficulty that disaster relief volunteers encounter with communication and coordination during post disaster operations. Specifically, it examines the requirements of individuals who operate in disaster field offices (DFO) and need access to knowledge resources to coordinate VOAD activities. The goal of this study is to design a model of an information system to support VOAD disaster recovery planning and operations in the aftermath of a disaster. It is anticipated that this model could serve as the basis for developing a prototype knowledge management system that may also be adapted to similar state and local chapters around the country.

*How will the proposed system benefit VOAD?*

User Environment. The Virginia VOAD currently has over two dozen member agencies. It is an umbrella organization of existing agencies where each member organization maintains its own identity and works closely with other organizations to improve service and minimize duplication of effort and waste. According to the VOAD "Plan of Organization" (1998) it fosters:

- Cooperation: Creating a climate for cooperation and providing a channel for sharing information and planning
- Communication: Disseminating information through news releases and notices, a directory of participating agencies, case studies and critiques
- Education: Providing training, encouraging increased awareness and sharing information related to public policies that affect disaster response

It is hoped that the system under consideration in this study will assist the Virginia VOAD in achieving these goals.

**Section 2 - Stakeholders and Users**

*Who has an interest in this project?*

There are a number of individuals and agencies that have a "stake" in this project. The VOAD volunteers at the disaster field offices (DFO) and possibly located at the State Emergency Operations Center in Richmond would be prime users but there are others who would be peripherally involved. This would include local, state, and federal representatives at the DFO and well as member agencies of VOAD. In addition, it would include the victims of disaster and the general public seeking information and points of contact to seek or give assistance.

**Section 3 - Key Stakeholder and User Needs**

*Who are the key participants and what do they need?*

Background and Justification. An integral element of Virginia VOAD's responsibilities involves having representation in the field during disaster recovery operations. The VOAD individuals charged with manning the disaster field office (DFO) play a pivotal role in coordinating and directing the efforts of the various disaster relief organizations that make up Virginia VOAD. However, this requires an extensive knowledge of the operations and resources of many diverse organizations. There are some individuals associated with the Virginia VOAD who serve at the DFO who have this extensive knowledge and experience. However, some the individuals who may be called on to staff the DFO are volunteers who may not be able to be identified in advance of the disaster and may have limited training in DFO situations. These issues have been identified as problems by Virginia VOAD in their semi-annual meeting minutes. Thus, it is hoped that having an information system that can help the inexperienced individuals collaborate and have access to organizational knowledge will benefit VOAD.

*How is this study being conducted?*

Methodology. The study is being conducted in a phased approach:

- Phase One – Review past minutes of Virginia VOAD meetings and research work previously done on similar projects.
- Phase Two - Conduct interviews of key personnel of VOAD to gain background and perspective on the area of study.
- Phase Three – Distill interview comments into system criteria. Send out survey #1 to key personnel for comment.
- Phase Four – Analyze survey #1 result and incorporate research and interview comments to determine system objectives and produce the Requirements Definition Document (Vision document, use cases, architecture description).
- Phase Five – Send survey #2 to key personnel for comment on documents produced in Phase Four.

- Phase Six – Analyze survey #2. Make appropriate changes and present results to Virginia VOAD executive committee for review and further action.

**Section 4 – Product Overview**

*What are the overall factors to be considered in developing this system?*

Capabilities – The system would be web site based via the Internet and therefore, accessible at any location with Internet access. It would provide a central point for access to information (i.e. documents, reports, email etc). It would also provide tools to communicate and collaborate (i.e. with fellow agencies and experienced members of VOAD). The basic design premise is that it would be flexible and adaptable to unique situation needs. It would provide two tier access. While the general public would have access to the public portion of the web site (Tier One) there would also be a portion of the system restricted to authorized VOAD members (Tier Two). (The architecture description document on page 13 provides more detail of system features).

Assumptions – It is assumed that computer equipment and VOAD personnel will available at the DFO. It is also assumed that the VOAD volunteers will have minimal computer literacy skills (i.e. to log on and use a mouse etc.) or access to help in the DFO. Finally, it is assumed the system will be able to be developed at low cost/no cost using volunteer contributions.

Dependencies - The system will require that computers have Internet access (minimum of dial-up access). Part of the system will consist of links to external web sites. It will be dependent on those site owners to keep their sites current.

Alternatives to Development – The alternative is to maintain the status quo and not have an information system. VOAD has been blessed with hard working and dedicated personnel who have been the mainstay of VOAD support. These few individuals possess a wealth of experience and knowledge. However, VOAD is critically dependent on the expertise of these few individuals who may not be able to maintain a presence in the DFO during a prolonged recovery period in the aftermath of a disaster.

**Section 5 – Features**

*What are the general features of the system and the limitations?*

Services and Quality of System – The web site must be designed to be simple and easy to navigate with a logical user interface. It must also be able to accommodate slow Internet connections, load quickly and have high availability and quick response time.

Limitations – Any information system will not take the place of face-to-face interactions and building personal relationships. These relationships are vitally important to VOAD operations and must be fostered through other means. Additionally, the circumstances of the disaster location or environmental factors such as disruption in communications may degrade system access.

**Section 6 – Other Product Requirements**

*What are other issues that VOAD needs to take into account?*

Cost Issues – Cost is a very important factor in the design of the proposed system. The Virginia VOAD is a non-profit organization with very limited financial resources. The assumption is that funding will not come from current internal resources. The system should be designed to incorporate as many free elements as possible (i.e. software) and any additional funding be sought from outside sources (private contributions, grants etc.).

Maintenance Issues - The system should be designed to be simple to maintain. It is assumed it will be maintained by a VOAD volunteer. Maintenance and updates procedures will be determined by the Virginia VOAD executive committee or its designee.

Security Considerations – Because personal information may be resident in the system, protecting individual privacy is a key issue. Information must be safeguarded in accordance with the Privacy Act and other applicable local, state, and federal laws and regulations. The portion of the system containing personal information must be restricted to authorized personnel and access controlled with user ID and password protection.

# Part 2 – Use Case Summary

*What are use cases?*

Use cases are a set of scenarios that consider the behavioral aspects of the system reflecting the user's concerns and requirements. The use cases defined for the system serve as the foundation and continuity for the follow-on development process.

These use cases are a summary of how users are expected to interact with the system.

**Use Case #1 ***
Title: Seek Assistance
Primary User: Disaster Victim
Stakeholder(s): VOAD Volunteer, Local/State/Federal DFO Staff
Scenario: During the disaster recovery period the disaster victim seeks assistance. The most likely scenario is that the victim will call the DFO or walk-in for face–to-face interaction.

Provided connectivity is available, the disaster victim can also access information via the VOAD web site. Entry to the web site is via the Public Area. He/she can then view information on the web page and navigate to other hyperlinks available in Public Area. He/she can activate the email application to contact appropriate authorities. Disaster victim will not have access privileges to Restricted Area.

**Use Case #2**
Title: Find Information
Primary User: VOAD DFO Volunteer
Stakeholder(s): Disaster Victim, VOAD Agencies
Scenario: The experience level of the VOAD volunteer located at the DFO may vary considerably. While there are very experienced individuals who serve in this position, there are also likely to be very inexperienced volunteers as well. Thus, the needs of the VOAD volunteer will vary.

To find information on the web site the VOAD volunteer will enter the site via the Public Area. He/she can then view information on the web page and navigate to other hyperlinks available in Public Area. To enter the Restricted Area, he/she will click the "members only" hyperlink. They will then be prompted for a userID and password. If this is authenticated, they will now have access to the information resident in the Restricted Area with the privileges associated with their userID. This will include access to explicit (i.e. documents) and tacit (i.e. someone to consult with) information.

***** Use case #1 amended IAW survey #2 to exclude disaster victim behavior of "walk-in" to DFO

**Use Case #3**

Title: Find Information
Primary User: General Public
Stakeholder(s): VOAD Agencies, Disaster Victim
Scenario: One of the goals of the Virginia VOAD is to inform the public about the existence and mission of the VOAD. This is currently being done via printed media. The web site would extend this to the Internet and provide a means of contact with the VOAD and member agencies.

In the aftermath of a disaster people reach out to help the victims. The web site can provide a means to do this for the general public. Entry the web site is via the Public Area. He/she can view information on the web page and navigate to other hyperlinks available in Public Area. He/she can activate the email application to contact appropriate authorities. The site can also provide hyperlinks to member agencies for donation management and other functions. The general public will not have access privileges to Restricted Area.

**Use Case #4**

Title: Establish Synchronous Collaboration Environment
Primary User: VOAD DFO Volunteer
Stakeholder(s): VOAD Agencies, VOAD Volunteer (Richmond) if applicable
Scenario: The VOAD volunteer may need to contact one or more VOAD members or stakeholders to discuss how to assist disaster victims or update participants on the status of a situation.

Entry to the site is via the Public Area. To enter the Restricted Area, the VOAD volunteer will click the "members only" hyperlink. He/she will then be prompted for a userID and password. If this is authenticated, they will now have access to the information resident in the Restricted Area with the privileges associated with their userID. This will include access to applications such as chat, videoconferencing, and other real-time collaboration applications (as available). This allows initiation of the synchronous collaboration environment. This can also be accomplished via teleconferencing (available outside the system).

**Use Case #5**

Title: Establish Asynchronous Collaboration Environment
Primary User: VOAD DFO Volunteer
Stakeholder(s): VOAD Agencies, VOAD Volunteer (Richmond) if applicable
Scenario: The VOAD volunteer may need to contact one or more VOAD members or stakeholders to discuss how to assist disaster victims or update participants on the status of a situation.

Entry to the site is via the Public Area. To enter the Restricted Area, the VOAD volunteer will click the "members only" hyperlink. He/she will then be prompted for a userID and password. If this is authenticated, they will now have access to the information resident in the Restricted Area with the privileges associated with their userID. This will include access to applications such as email, threaded discussion, and other non real-time collaboration applications (as available). This allows initiation of the asynchronous collaboration environment.

**Use Case #6 ***
Title: Enter and Update Requests
Primary User: VOAD DFO Volunteer, VOAD Agencies
Stakeholder(s): Disaster Victims
Scenario: Requests for assistance posted by the VOAD volunteer and directed to the VOAD member agencies need to be updated to show the status of actions. This involves coordination between the VOAD DFO volunteer and VOAD member agencies. The intent is not to duplicate services resident on external sites such as the Virtual Emergency Operation Center http://members.tripod.com/~Richmond_ESM/usscdisaster.html or the State of Virginia Action Tracking System.

Entry to the site is via the Public Area. To enter the Restricted Area, the VOAD volunteer or VOAD member agency representative will click the "members only" hyperlink. He/she will then be prompted for a userID and password. If this is authenticated, they will now have access to the information resident in the Restricted Area with the privileges associated with their userID. Access will be in accordance with the permissions set by the system administrator to view, change, add content etc.

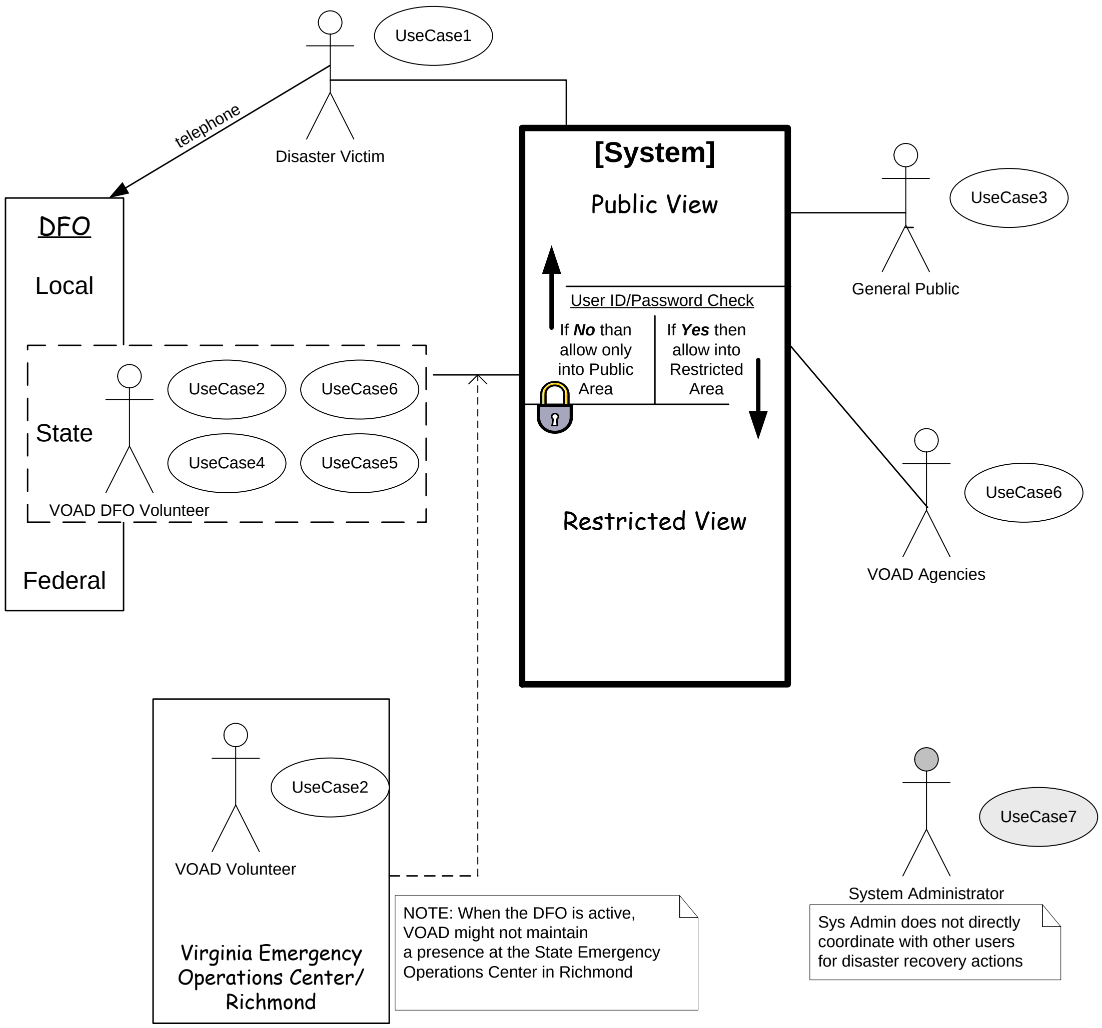
**Use Case #7 ****
Title: Manage System Access
Primary User: System Administrator
Stakeholder(s): VOAD Organization, Disaster Victims
Scenario: Local, state, and federal laws and regulations mandate that certain elements of personal information be safeguarded. The Privacy Act is one example that illustrates this requirement. Thus, access to personal information must be controlled. This information will be resident in the Restricted Area.

System administrator will be provided with list of individuals who will be granted access to the Restricted Area. He/she will assign userID and initial passwords and set up system permissions to comply with the appropriate level of access (the files/folders each individual can access and actions they can take i.e. read/write/change). To enter the Restricted Area, the VOAD volunteer or VOAD member agency representative will click the "members only" hyperlink found in the Public Area. He/she will then be prompted for a userID and password. Upon initial login the user (VOAD organization member) will change the password in accordance with system administration instructions. Upon subsequent login to the Restricted Area VOAD member will use established userID and personal password.

* Use case #6 amended IAW survey #2 to indicate updates will be accomplished by agency designated personnel

**Use case #7 amended IAW survey #2 to indicate system administrator will put time limit on user privileges

Figure 1- Use Case Summary



# Part 3 - Architecture Description

## Section 1 – Overview

Goal of the Model – To depict an information system (see figure 2) and how it can be used to enhance VOAD operations at the DFO. Provide a basis for discussion and further evaluation.

How the Model Can Be Applied, The next step would be the development of a prototype that can be tested and evaluated to provide iterative feedback.

## Section 2 - Rationale for Proposed Architecture

VOAD Identified Problems - The problem is the difficulty that disaster relief volunteers encounter with communication and coordination during post disaster operations. Specifically, it addresses the requirements of individuals who operate in disaster field offices (DFO) and need access to knowledge resources to coordinate VOAD activities.

Review of the Literature – Research done in the area of disaster relief operations documents the need for tools to assist in disaster response and recovery. Various systems have been built as decision support systems but have tended to be complex, expensive, and tailored to specific emergency situations. The VOAD requirement is for a simple, inexpensive, and flexible system that requires minimal training.

## Section 3 - Scope and Boundaries

What the System Will Do – It will provide two tier access (first level for general public information – second tier for authorized VOAD members only), and contain a repository of information (i.e. reference documents, lessons learned etc.) that includes a search engine component, synchronous and asynchronous communication, and tools for collaboration.

What the System Won't Do - It won't provide answers to all situations as each disaster is unique. Also, and very significantly, it doesn't develop personal relationships so important in the disaster recovery environment. These must be developed outside the scope of the system. In addition, this study does not include other alternatives such as using ham radio operators, postal mail etc.

## Section 4 - Description of Components

Web-Based Environment- It will be accessible with a standard web browser (i.e. Internet Explorer, Mozilla). The web site will be available through any Internet Service Provider. It will use standard web technologies (i.e. FTP, HTML) and be developed with commercial web site software (i.e. Macromedia Dreamweaver, Microsoft Front Page).

Hardware- It will be platform independent, accessible via desktop, laptop or hand held PDA and hosted on a web server (geographically separate from disaster site).

Software- It will be based on client/server architecture, “windows” based, utilize free software where possible or that commonly included on a computer supporting a windows environment and be compatible with commercial off-the-shelf products like Microsoft, Adobe etc.

Discussion of the Model - The model is graphically depicted in Figure 2. See the glossary in RDD for more detailed definition of terms.

The system is composed of two tiers. Tier One is the public area and Tier Two is the restricted area.

Tier One:

- Includes the first contact with the user interface. This is accessed through an Internet connection to the web site via a web browser
- Functions as a first point of contact for the general public and as an initial entry point to the site for VOAD members
- Includes web applications to allow for web site navigation on the site (hyperlinks) and links for email to selected VOAD members
- Content can include general information about the Virginia VOAD, contacts for information and assistance, and links to member agencies for donation management etc.
- From this tier, members will gain access to Tier Two provided they have entered a valid user ID and password

Tier Two:

- Following validation of the user ID and password VOAD members will enter Tier Two
- This tier is subdivided into two parts: Explicit and Tacit
    - Explicit will contain a knowledge repository that can include historical documents (i.e. VOAD organization documents, meeting minutes, lessons learned etc.) and event specific information (items posted relevant to the current disaster).
    - Tacit will contain a synchronous element that will allow for a real-time communication with partners (i.e. using instant messenger chat, video teleconferencing etc.) and an asynchronous element that allows for non-real time communication (i.e. email, threaded discussion, points of contact etc.).
- Included in this tier are applications to allow for web site navigation, email, listserve, chat, threaded discussion and a search engine to permit a key word search of the site (i.e. a search on the word “pet” could bring up information and points of contact on caring for pets in the aftermath of a disaster)
- Outside of the System but working in parallel are additional Explicit and Tacit applications (noted in dotted boxes). Explicit include links to external web sites that include the Virginia Department of Emergency Management (VDEM) Action

Tracking System (currently unavailable for legal reasons) and the Virginia Emergency Operations Center (http://members.tripod.com/~Richmond_ESM/usscdisaster.html). Tacit systems include the VDEM sponsored teleconferencing capability and on site face-to-face coordination.

**Section 5 - User Issues**

User Profile – User experience will vary both in terms of level of computer literacy and expertise working disaster recovery operations in VOAD. Some individuals will be very experienced in both respects. However, the system will be designed to accommodate those individuals with minimum computer experience and minimum knowledge of VOAD operations.

Risk Factors – Risk factors include the fact that user experience may be low, the system may not be accepted by users, and there may be an unanticipated large number of users (i.e. the general public) trying to access the site simultaneously. However, these factors are considered relatively low risk and will be taken into account by the system design. Additionally, there is the risk of lack of a telephone connection at the DFO (for dial-up to the Internet). However, according to FEMA guidelines when the DFO location is selected communication requirements are considered.

Training Considerations – The system can be included in the periodic training exercises conducted by outside agencies. An advantage of a web-based system accessible via the Internet is that the system is available to trainees at dispersed geographical locations. Additionally, a tutorial that is available online as part of the system could help meet training requirements.

**Section 6 - System Life Cycle Issues**

Requirements Definition – The methodology used is discussed in Part 1 – Section 3.

Maintenance – The system will be administrated and maintained by a VOAD volunteer. It is anticipated that the Virginia VOAD executive committee will be the supervisory authority. Procedures will need to be developed to determine how the system is updated and who will have authority to make changes. Simplicity and ease of use will be overriding considerations for maintenance and administration.

Testing – Due to the Ad Hoc nature of VOAD it is impractical to conduct a formal test program for the system. Nevertheless, there would be opportunity to test the system during the periodic exercises.

**Section 7 - System Vulnerabilities**

System vulnerabilities include lack of connectivity (communication lines down) and equipment availability (lack of access to a computer or the web server being unavailable).

**Section 8 - Elements Maintained Outside the Organization**

The system is self contained but does include links to external web sites that contain relevant information (such as the Virtual Emergency Operations Center http://members.tripod.com/~Richmond_ESM/usscdisaster.html and VDEM Action Tracking System). This is outside the scope of the system and these sites are updated and maintained by those owners.

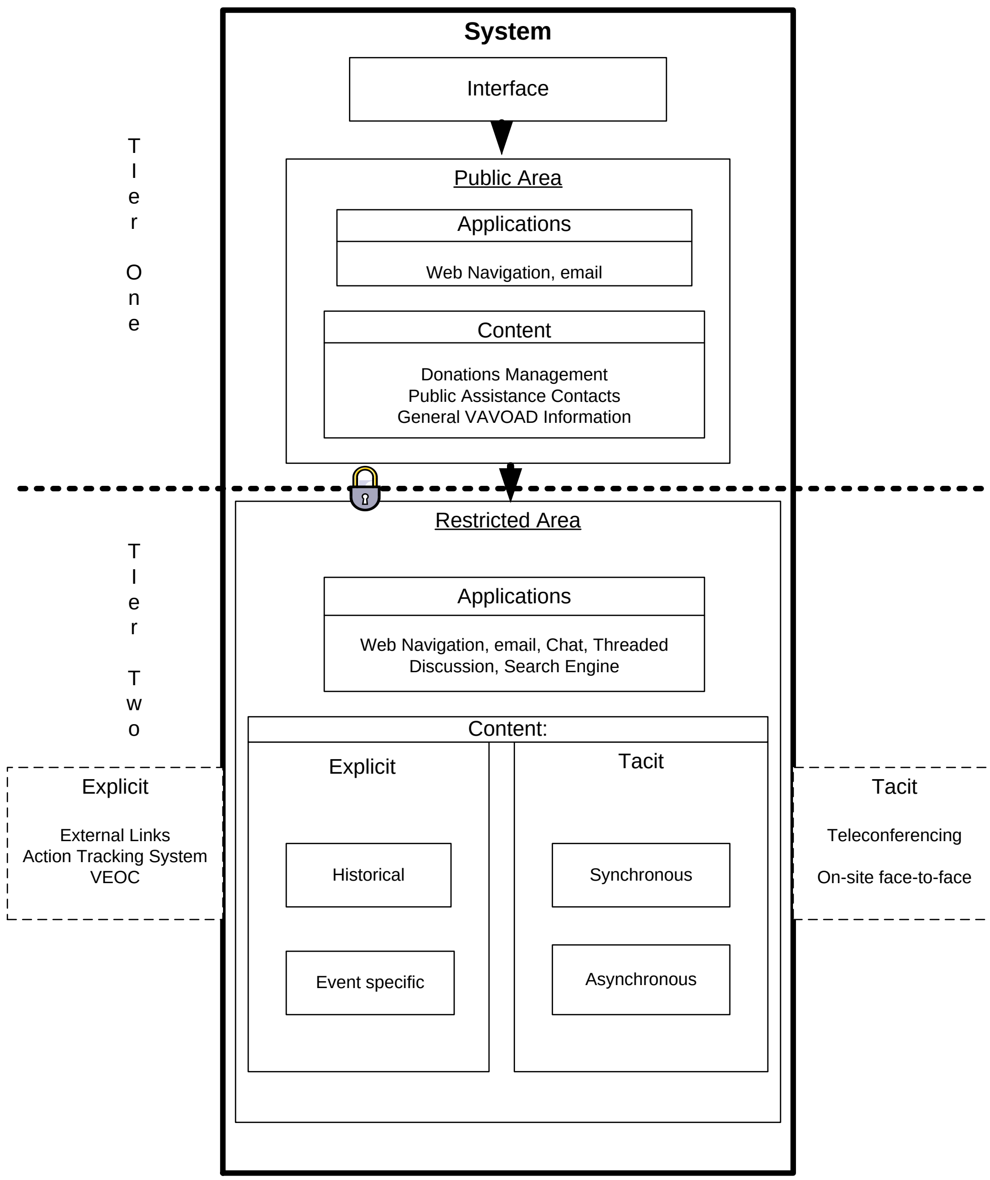
**Section 9 - Evolution of Technology**

Dependencies – The model is purposely designed to avoid being dependent on a specific vendor product or technology. Open standards will be used to the maximum extent possible and commercial off-the-shelf products included keeping costs to a minimum.

Expected Duration of Functionality – Key to the design is to remain flexible and agile to emerging technology opportunities. The model is not tied to specific technology but designed on a modular basis to capitalize on future commercial off-the-shelf enhancements.

Future Trends – The current concept assumes the VOAD volunteer at the DFO will access the system via a computer located at the DFO. However, future usage may include mobile, wireless access via wireless hotspots, 3G cellular, or satellite connectivity exploiting the developments in technology convergence.

Figure 2 - Schematic of Architecture Description



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