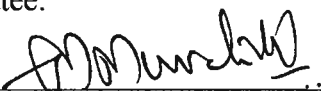


INSTANT LEARNING FOR CRISIS RESPONSE

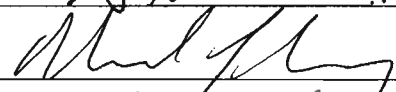
by

Martin Suydam
A Project
Submitted to the
Graduate Faculty
of
George Mason University
In Partial Fulfillment of
The Requirements for the degree
of
Engineer Degree


Committee:



Dr. M. Venigalla, Project Director



Dr. M. Casey, Committee Member



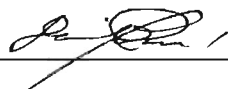
Dr. A. Flannery, Committee Member



Dr. C. Monk, Committee Member



Dr. M. Bronzini, Department Chair



Dr. Daniel Menascé, Associate Dean for
Research and Graduate Studies



Dr. Lloyd J. Griffiths, Dean, The Volgenau
School of Information Technology and
Engineering

Date: June 19, 2008

Summer Semester 2008
George Mason University
Fairfax, VA

Instant Learning For Crisis Response

A project submitted in partial fulfillment of the requirements for the degree
of Engineer Degree at George Mason University

By

Martin Suydam
Master of Science
Arizona State University 1968
Bachelor of Science
Norwich University, 1965

Director: Dr. M. Venigalla
Department of Civil, Environmental, and Infrastructure Engineering

Summer Semester 2008
George Mason University
Fairfax, VA

TABLE OF CONTENTS

	Page
LIST OF TABLES	iv
LIST OF FIGURES	v
ABSTRACT	vi
Chapter 1 Introduction	1
Accomplishments:	2
Methodology:	3
Summary:	9
Chapter 2 State-of-the-Art Technology and Market Assessment	10
Introduction:	10
Recent Developments and Trends:	11
Scalable Vector Graphics:	14
Project Design – Technical Basis Assumptions:	17
Summary:	18
Chapter 3 Cognitive Theory and Visual Learning Basis	19
Introduction:	19
Need:	21
Feasibility:	22
Usefulness:	32
Summary and Conclusion:	36
Chapter 4 Target System Implementation using NetRequest™	38
Introduction:	38
NetRequest™:	40
Database:	42
Icons and Spatial Information:	44
Summary:	50
Chapter 5 Preliminary Test Protocol for Evaluation of “Instant Learning” Effectiveness	51
Introduction:	51
Icon Discovery, Creation, Evaluation, and Selection Process:	52
Design Guide:	52
Icon Design Methodology	64
REACTICON:	76
Summary:	84
Chapter 6 Prototype System Implementation (Future Work)	86
Introduction:	86
Plan and Schedule:	87

Task Descriptions:	88
Summary:.....	89
Chapter 7 Conclusions	90
Introduction:	90
Observations:	90
Accomplishments	91
Conclusions:	92
Endnotes.....	93

LIST OF TABLES

Table	Page
Table 2-1 Project-Relevant SVG Advantages.....	16
Table 3-1 Model of Perceptual Processing.....	26
Table 5-1 Icon Design Guidelines.....	56
Table 5-3 Statistical Methods for Use in Icon Evaluation.....	68

LIST OF FIGURES

Figure	Page
Figure 1-1 NetRequest™ Existing/Potential Additional User Interfaces	8
Figure 2-1 NetRequest™ User Interface	14
Figure 2-2 Simple Example of SVG Source and Display Rendering	15
Figure 3-1 Human Sensory Input Potential (Adapted from Norretranders)	28
Figure 3-2 Cognitive Theory of Multimedia Learning	29
Figure 3-3 Visual Reference Models	31
Figure 3-4 Pre-Attentive Features	32
Figure 3-5 Icon Characteristics - Cognition and Learning Priorities	36
Figure 4-1 NetRequest™ Sample Display	42
Figure 4-2 NetRequest™ E-R Diagram	43
Figure 4-3. FGDC Symbology Methodology	45
Figure 4-4 NFPA 170 Standard for Fire Safety Symbols	45
Figure 4-5. NFPA 170 Symbols Converted to SVG	47
Figure 4-6. CAFM Emergency Response Interface for Facility Shutoffs	49
Figure 4-7. CAFM Emergency Management Response Interface Icons	50
Figure 5-1 Icon Discovery, Creation, Evaluation, and Selection Process	52
Figure 5-2 Test Case Icons	54
Figure 5-3 Sample Access Data for Case 1	70
Figure 5-4 Sample Access Data for Case 1, IM Data Pivot Table	71
Figure 5-5 Spreadsheet Tutorial for Rank Ordering and Mean Rank Computation	72
Figure 5-6 Torgerson's Law of Categorical Judgment	74
Figure 5-7. Torgeson's Rank Order Methodology – Computation Process	75
Figure 5-8 REACTICON Password Entry	77
Figure 5-9 REACTICON Navigation Entry Page	77
Figure 5-10 REACTICON Tool Functions Entry Page	78
Figure 5-11 REACTICON Tool Functions Entry Page	79
Figure 5-12a REACTICON Design Guide Page – Pull-down Menu Selection	80
Figure 5-12b REACTICON Design Guide Page – Criteria Selection	80
Figure 5-13 REACTICON Icon Library	81
Figure 5-14 REACTICON Input/Create Icon	82
Figure 5-15a REACTICON Icon Evaluation	83
Figure 5-15b REACTICON Icon Evaluation with Context Pop-up	84
Figure 5-16 REACTICON EM Icons	85
Figure 5-17 REACTICON Author Contact Information	85

ABSTRACT

INSTANT LEARNING FOR CRISIS RESPONSE

Martin Suydam

George Mason University, 2008

Project Director: Dr. Mohan Venigalla

Important to effective use of graphic portrayals of data and information is the science of communicating effectively with symbols. In general, today's practice of icon design is more art than true science. While attractiveness of symbols has merit, there exists a real discipline void in connecting human sensory (may be more than visual) and cognitive processes to easy-to-comprehend symbols.

The primary objective of this project is to develop a scientific methodology and the tools necessary for effective icon design, evaluation, selection, and implementation.

This project is considered as a foundation stage upon which future research will be based. The purpose was to establish the methodology for creation of icons for required and essential messages in emergency management visual displays. The use of the latest technology developments in Computer-Aided Facility Management (CAFM) was used as

a platform for demonstration and evaluation. It is likely that solutions for navigation within facility structures will likely require use of CAFM to be effective.

While demonstration of CAFM application produced useful results, the process methodology developed for icon creation, evaluation, and use is more important than any initial group of icon products created.

Future work will involve the proof of scientific icon identification and recognition theory in the context of Emergency Management needs. That challenge is distilled to the following questions: “Is it possible and practicable to develop icons producing consistent messages with little, or, better yet, no, learning? If these icon messages can effectively and efficiently be created, can they be easily transmitted, received, and effectively/reliably acted upon”.

This project involves development/adaptation of many enabling-technology innovations in Computer-Aided Facility Management (CAFM) that would permit wireless deployment of spatial data technology for data access and navigation within facility structures. While robust, enabling-communications, both wireless and web-based, was considered essential environment for successful satisfying Emergency Management responder needs, mechanisms to ensure reduction in communication burden were

considered essential. The communication burden is considered both in terms of the load placed on the communication transport system and the human reception and cognitive decoding aspects. These aspects can be measured in terms of file sizes required and speeds and accuracy of human response.

A major development component to minimizing the communication burden was accomplished by exploiting Scalable Vector Graphics (SVG) technology for CAFM implementation where rendering of equivalent graphics can be reduced in size by a factor of 1,000. Integration and demonstration CAFM-SVG was viewed as a major challenge and was accomplished.

Key Words: Icon. SVG Icon, Icon Design Guidelines, Instant Learning, CAFM, Emergency Management

Chapter 1 Introduction

This Engineering Degree project provides background, state of the art review, a methodology, results, and tools for follow-on research for developing solutions to information delivery within building structures under crisis conditions. The primary objective of this effort was to establish a scientific basis for information delivery and icon creation. This project becomes the basis for future work, introduced in Chapter 6 of this report.

This effort includes development of the following components: 1) theory, concepts and practical application; 2) customer information requirements; 3) the working tools for information delivery, utilization, and scientific evaluation; 4) assessment for scalability and market exploitation; and 5) research to utilize, implement, and validate tools developed in preceding 4 topics.

While many benefits are likely to be derived from this project, the scope of the effort is limited to development of methodology for data delivery and identification of tools.

Target user of this effort is the “1st Responder” of organizations charged with the Emergency Management roles. These users face unique and demanding information needs in sensory-deprived environments and where immediacy and little-to-no learning is required for the individual to comprehend and react. It is intended that the results of research will form a basis for systematic icon development in the next generation of web-

delivered, Geospatial Information Systems (GIS), and Computer-Aided Facility Management (CAFM) information applications.

This report is organized into the following chapters (if viewed electronically, chapter headings and subject headings within chapters are bookmarked for quick access):

- 1) [Introduction](#)
- 2) [State-of-the-Art Technology and Market Assessment](#)
- 3) [Cognitive Theory and Visual Learning Basis](#)
- 4) [Target System Implementation using NetRequest™](#)
- 5) [Preliminary test protocol for evaluation of “instant learning” effectiveness](#)
- 6) [Prototype System Implementation](#)

This chapter is organized as follows: 1) [Introduction](#), 2) [Accomplishments](#) 3) [Methodology](#), and 4) [Summary](#)

Accomplishments: This project developed a scientific methodology (design, evaluation, selection, and implementation) and the tools necessary for creation, acceptance, and/or adaptation of special icons that would be used in crisis situations. These crisis situations are characterized by a need for attention-getting, cognitive recognition, and appropriate reaction response. The tools created are all managed through a web-based portal, REACTICON (Rational Emergency Action Computerized Tool for Interactive

Collaborative Operational Networking), that is housed on an Active Server Pages (ASP) server. The research to develop the methodology led to creation and exploitation of Scalable Vector Graphics icons and the systems to deploy information rapidly and efficiently. New icons were integrated and deployed into a new commercial Computer-Aided Facility Management (CAFM) software application that was inspired by this effort.

Methodology: The framework for research consisted of the following elements:

- 1) Literature Review – review of recent publications and conference materials in the following discipline areas: brain theory, neuroscience, visualization, iconography, learning, and human factors engineering.
- 2) Development/adaptation of tools to organize, manage and deliver required information – analysis and conclusions on latest and future trends in software, networking, and user-interface that will allow more efficient/effective information delivery and enable the practical exploitation of the theoretical science.
- 3) Identification of methods to demonstrate concept and proof-of-principle for instant/multiple-message icon delivery – combination of research and a “hands-on” product approach to address a “real world” need to evaluate and anticipate issues related to wireless network graphics/data delivery of what has been heretofore “heavy” integrated CAD and data information for location intelligence implementation inside buildings/facilities.

The enabling technologies and developed/produced the tools, protocols, and technology interfaces for evaluation were assembled in this project. Utilization and adaptation of Commercial-Off-The-Shelf (COTS) tools and technology was a priority. Software applications and their use in the project are as follows:

- MS Access – database design, deployment, and management (e.g., storage, reporting)
- MS Visio – Scalable Vector Graphics SVG image rendering; database design; software engineering design/UML tools
- Corel Draw X3 - Scalable Vector Graphics SVG image rendering
- Adobe Illustrator Creative Suite® 3 - Scalable Vector Graphics SVG image rendering
- MS Expression Web – website(s) and database interface with Active Server Protocol (.asp)
- JavaScript - active webpage functionality
- Java – applets for security interfaces and user-server interface
- NetRequest™ – SVG Computer Aided Facility Management (CAFM) tool, still in beta testing, for information deployment and user interface

This effort began with an intention to develop/adapt the latest innovations in CAFM for use in wireless deployment of spatial data technology, primarily in a web-based

environment for Emergency Management purposes. Effective Scalable Vector Graphics (SVG) technology implementation was viewed as a major challenge.

During proposal development and early project research the scope broadened to include many other enabler technologies. Working with a development team and securing access to the latest CAFM SVG, NetRequest™ was achieved early. While NetRequest™ is still only in a beta version, it is sufficiently mature to satisfy the needs for a deployment test bed. Feasibility of web-communicated spatial data (oriented on facilities) communications that can be rapidly updated and managed was demonstrated and assured. The challenges then shifted to the emerging science of cognitive intelligence to integrate the best means to effectively transfer knowledge with minimum requirements for learning/training.

While the project domain is oriented civil engineering applications, many aspects of information technology and software engineering were required, such as:

- SVG artifact creation, use, and deployment
- ASP server/pages setup
- Tomcat server setup and management
- networking (both wired and wireless)
- database creation and update in networked environment
- software performance testing
- communication protocols

The planned focus of future work is the proof of latest scientific icon identification and recognition theory in the context of Emergency Management needs. That challenge is distilled to the following questions:

- Is it possible and practicable to develop icons producing consistent messages with little, or, better yet, no, learning?
- If these icon messages can effectively and efficiently be created, can be easily transmitted, received, and effectively/reliably acted upon, a host of derivative questions follow:
 - What is the core message?
 - What other useful/helpful messages can be transmitted?
 - What is the method of attracting attention?
 - What are the issues of prior learning, bias, cultural influences?

While discussed in greater detail later in this report, at this point it should be sufficient to understand that NetRequest™ forms a practical and deployable enabling technology for this project.

NetRequest™ has been developed and is currently undergoing its first large-scale, school system deployment. Its primary purpose, however, is to meet the needs of facility managers in day-to-day operations, such as: inventory management, repair and maintenance activities, and facility planning.

To accomplish the goals of meeting the needs of 1st responder target market CAFM-like displays and data content are essential. Yet not all the CAFM capability represented by NetRequest™ will be required, and thus, portions of data, not required, will not have to be transmitted.

This kind of “select out” capability is standard for CAFM applications.

While not part of this initial effort, it is believed there will be a need to development additional methodologies and application tools, as depicted in Figure 1-1, to ensure NetRequest™, or similar application, can be deployed effectively to the user community, particularly for navigation/communication within structures. As the 1st responder community becomes involved in the follow-on effort and their needs become meshed with emerging technical innovation, the following activities will likely need to be addressed:

- ✓ GPS interface to: internal locating devices, protocols and interfaces, and display hardware for real-time “location intelligence”
- ✓ Internal- and external-structure interface: Protocols for location registration, communications, and displays
- ✓ Inside structure navigation –protocols and methodologies for 2D (plan view navigation by floor level) and 3D (building elevation) navigation.

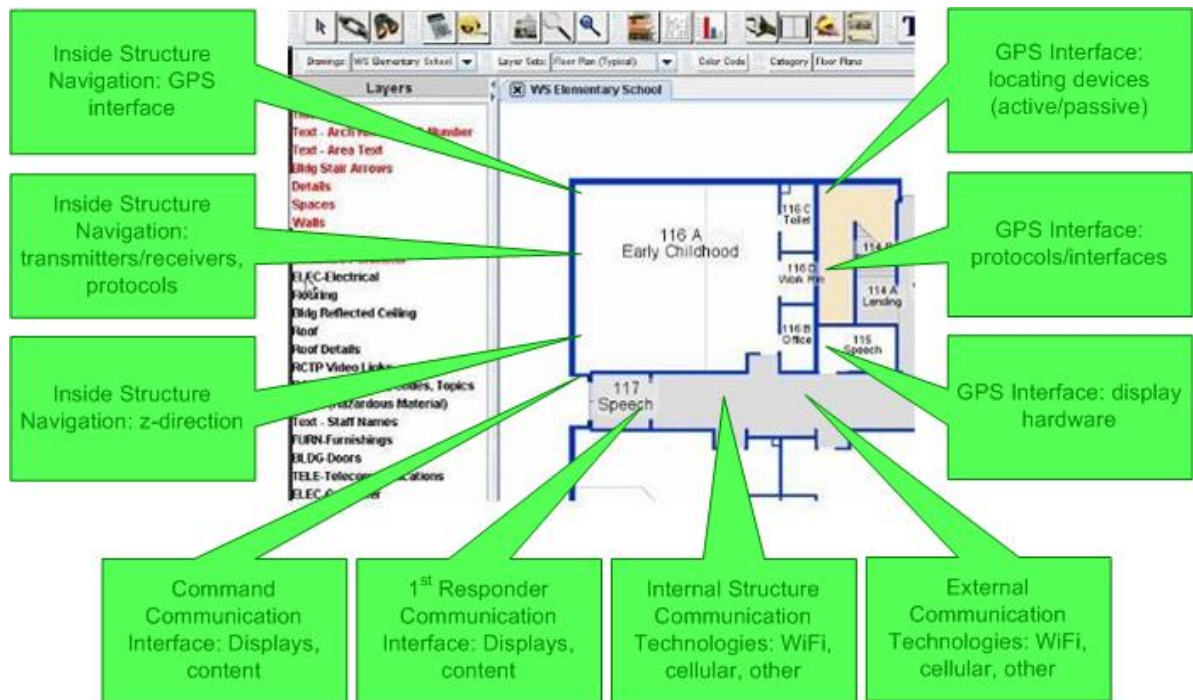


Figure 1-1 NetRequest™ Existing/Potential Additional User Interfaces

The planned future work objective is to produce validated EM icons along with design/implementation guidelines.

As important and as easily understood as that goal might be, there are many enablers required to achieve acceptance and use. Perhaps of greatest importance is a general recognition by users that an individual icon could transmit multiple messages very reliably. Selling of the concept goes beyond a report. Icons must be incorporated in tools that users are likely to use and provide substantial utility to those users.

Information Technology development progresses at such a rate that it is difficult to predict what, once developed, might survive an almost immediate obsolescence. That threat is magnified by a growing desire, on the part of developers of user interface, to create icons that duplicate appearance of actual objects (e.g., a fire extinguisher).

These issues shape the plan for future work to: 1) utilize leap-ahead applications to organize and deliver information in an Internet and Wi-Fi-dominated communication regime, 2) work closely with technical experts both in field of Emergency Management and Information Technology, 3) have a solid protocol for evaluating icon-message creation and use, and 4) be able to develop a constituency of disciples that would be part of development and testing.

It is believed that this research has assembled the necessary enablers to allow for a successful prosecution of future planned work.

Summary: This project effort: 1) recognizes, accommodates, and rationalizes competing technology forces; legacy system implications, and personal preferences; 2) validates the “best solutions”, provides a scientific basis for “instant learning” in terms of latest research in cognitive learning, psychology, cognitive computing, computer displays, graphics, networks, and databases; and 3) produces working tools to ensure scientific rigor to assessment process.

Chapter 2 State-of-the-Art Technology and Market Assessment

This chapter is organized into the following sections, if viewed electronically, chapter headings are bookmarked for quick access:

- 1) [Introduction](#)
- 2) [Recent Developments and Trends](#)
- 3) [Scalable Vector Graphics](#)
- 4) [Project Design – Technical Basis Assumptions](#)
- 5) [Summary](#)

Introduction:

While graphic display information technology has matured rapidly, spatial-decision support systems of which GIS (map-oriented) and CAFM (facility-oriented) have had a slow evolution. With Internet-enabled technology, GIS is rapidly becoming an effective tool set for planning and analysis. To the contrary the CAFM market has evolved slowly since its inception in the early 1990's. The CAFM market, along with the software providers shrunk in the late 1990's-early 2000 period. To a large extent these systems were CAD-based and were burdened by their inability to distribute information. In addition, the market has remained largely with facility managers and has not gained

broader organization subscribership or use. The result is that most CAFM installations today are relegated to desktop personal productivity or, at best, client-server asset management tools.

Rapid and effective distribution and update of data, not just pictures, via the Internet and through non-wired technology is the next step CAFM evolution. The applications to implement this aspect are in development and test now. Once Internet distribution and update is assured and robust, extending the information access and dissemination inside of buildings, including real-time location intelligence of first-responders, will provide not only a toolset to manage facilities, but to be used in times of crisis.

Recent Developments and Trends:

The Internet and the technologies that interface and work through it will cause a transformation of CAFM. Software and system providers are attempting to adapt their legacy systems to the new communication paradigm, but with difficulty. CAD, in all its forms, and with its “data mass,” makes the transition more difficult.

In the winter-spring 2006-2007 time period, national news, spawned by the Walter Reed Army Medical Center building condition problems, focused a revisit of building condition assessment tools, including CAFM. Many alternatives, assessments, reports, and decisions are being generated, leveraged by politics, to improve condition assessment practice and supporting information systems.

For example, conversations with staff at Veterans Administration and the Department of Defense, established certain “preconditions” to implement change to existing information/ management systems, as follows:

- ✓ Systems must interface with Maximo™ (a Computerized Maintenance Management System – CMMS)
- ✓ Data ownership and management are issues – Government entities will want to control.
- ✓ Building Information Model (BIM) tools will be used.
- ✓ The National Institute of Building Sciences (NIBS) is the building community's authoritative national source of knowledge and advice on matters of building regulation, science and technology.
- ✓ Industry Foundation Classes (IFC) file data protocols will be adhered to for purposes of interoperability

While these guidelines are reasonable and useful for today’s facility management practice with today’s information deployment technology, rapid innovation and installed capability in information technology will cause a greater demand for export and exploitation of the data in more deployable formats and mediums that are currently being used.

It doesn't take a great leap in imagination to recognize that the probability of 1st responder mission success is greatly increased if we can:

- 1) Accurately, efficiently and cost effectively render vector, not raster, images of facility floor plans,
- 2) Link that data to accurate GPS location intelligence (which can't receive inside of facilities) and somehow solve the challenge of the tracking of inside of buildings, and
- 3) Provide these individuals with "smart" tools to locate and identify hazards and other important areas/things/situations, all in an obscure and threatening atmosphere.

As part of the development of this project, this investigator, worked closely with the development team for a new product, NetRequest™ (still in development) as the test application for this effort. NetRequest™ exploits innovative technology in terms of Scalable Vector Graphics (SVG) and data integration with a unique deployment scheme not found in the GIS/CAFM market today. Vector based objects and all text objects are converted into SVG, and thus, can easily be zoomed without distortion of graphics quality/fidelity. A sample of the facility plan, user interface is shown in figure 2-1.

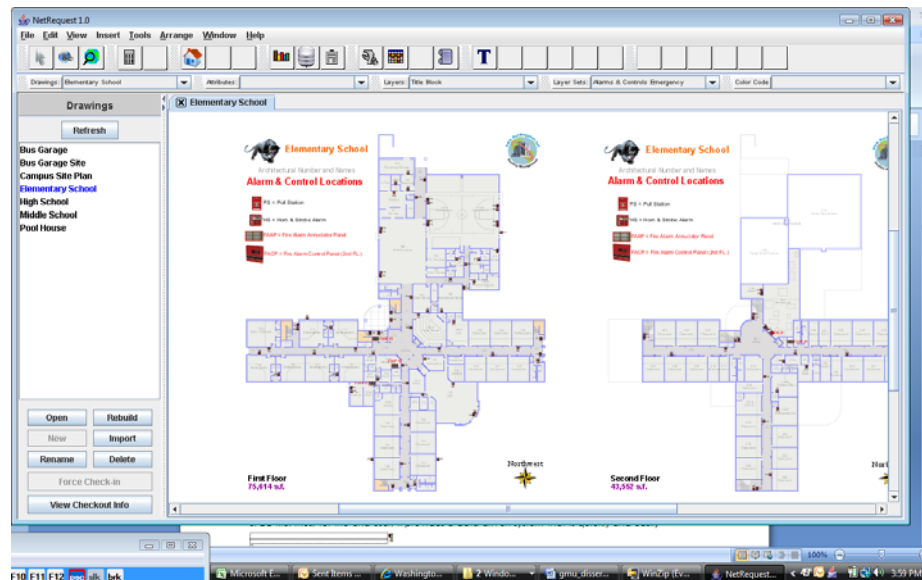


Figure 2-1 NetRequest™ User Interface

Scalable Vector Graphics: SVG is a vector graphics format that is expected to become the major graphic format for web-delivered images. SVG is written in XML (Extensible Markup Language), and is a formatting language that has the capability to draw simple or complex shapes on displays with simple, plain text code. SVG generates much smaller files than an equivalent GIF or JPEG file. Thus, for the end user, it provides a data driven system that is quickly and easily scalable, can readily zoom, and loads much faster in a web browser. SVG allows designers to create complex shapes and combinations of vector and bitmapped graphics.

While the completion of this project does not hinge on use of SVG, SVG use in NetRequest™ for data/information deployment does, and thus, the project's practical implementation is dependent on a succession of these technical decisions. Regardless, no deployment solution is sufficiently restrictive that alternatives couldn't be adapted prior to beginning future work.

To gain an appreciation for SVG and the source code that produces the graphics, the outer walls of the graphic in Figure 2-1 are created using the SVG content with various colors substituted as a visual reference aid as shown in Figure 2-2.

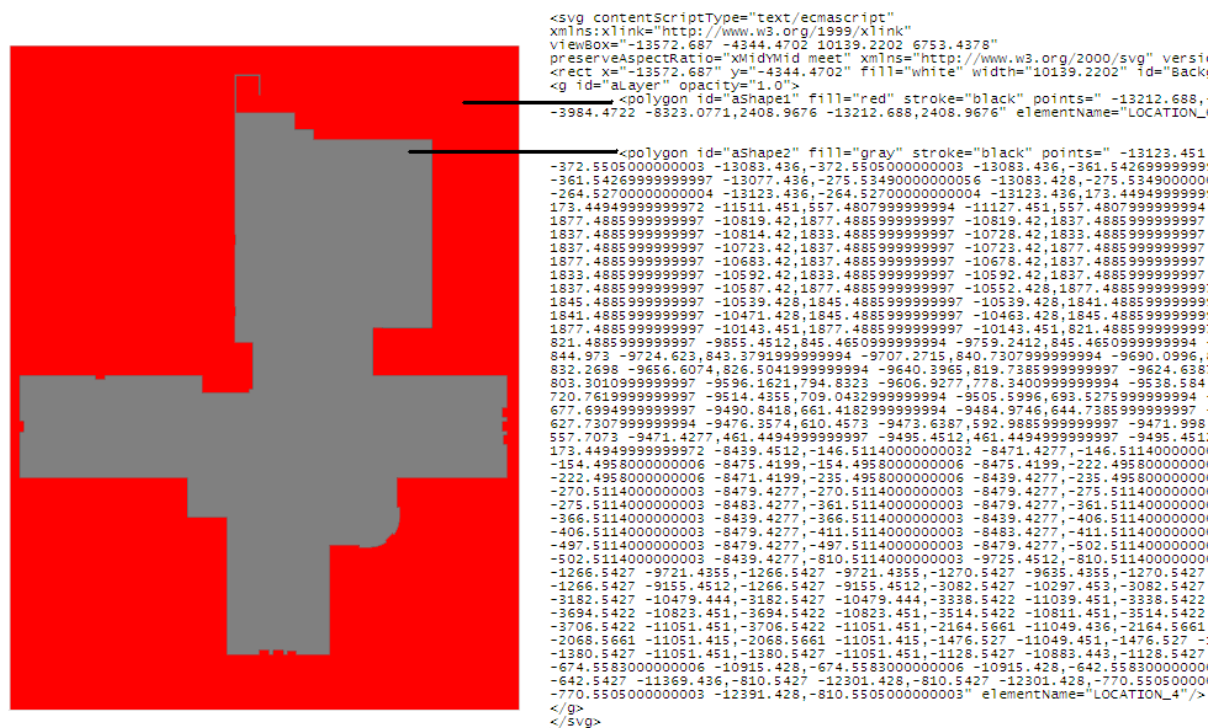


Figure 2-2 Simple Example of SVG Source and Display Rendering

Table 2-1 catalogs advantages of SVG and offers supporting rationale for believing that SVG is the correct graphic tool for deployment of these types of graphics for the applications intended in this project. The only disadvantage could be the “newness” of SVG and risk that something newer/different will become available.

Table 2-1 Project-Relevant SVG Advantages

Category	SVG Advantage to Other Graphic (mostly Raster) Forms
Rich Content	Pan and zoom without pixilation at any magnification, font styles, enhanced color palette and color control with > 16 million colors, and rich page-layouts, with boxes of text containing HTML paragraphs, lists, images, etc.
Integration	Produces graphics and audio that can reside entirely within a Web or other document formats.
Backward Compatibility	SVG graphics can include other graphic formats (e.g., GIF, JPEG, PNG, other SVG files), and audio files.
Progressive Rendering	Has the advantage that it can start rendering meaningful graphics as received, thus allowing user to start interaction immediately, as opposed to an image that is indecipherable until completely loaded.
Maintainability	When properly created, easy to modify, particularly in cases such as text in graphics, assigning geometrical properties, or modifying style elements and attributes.
Edit/Update	SVG graphics are text, thus, any text editor can be used for authoring. However, graphic development tools (e.g., Corel Draw) make the process easier and are readily available and affordable.
Time/Space Efficiency	Usually much smaller than comparable a raster graphic since there is no need to track the large number of bits of information. Potential for thousands of icons required in a CAFM display this advantage becomes a significant where bandwidth may be restricted.
Metadata	Graphics can be expressed as text, thus, an index of graphical components can be created. Using standard metadata frameworks, search engines can create diagram content indexes.
Dynamic Interactivity	SVG can respond to user actions with highlighting, tool tips, special effects, animation, and real-time changes to surrounding HTML text and animation along simple paths, fading, and other effects.
Archive/Search	Essential graphic information (e.g., size, color, etc.) is expressed within the graphic itself. Where drawing instructions include in plain text, it is selectable/ searchable.
Interoperable / Extensible	SVG is an XML application, interoperable with other Web standards and extensible.

Project Design – Technical Basis Assumptions: This project represents the convergence of many technical, business, and market assessment decisions for the selection/development of software and tools, and thus, form critical assumptions for this effort. Critical assumptions are:

1. A web-form of graphics/data delivery will be the most effective communication mode for application to 1st Responders.
2. CAFM technology is the appropriate platform/conduit for portrayal of Emergency Management displays/data.
3. The implementation of facility data (CAFM) is cost effective for public and private enterprise
4. Wi-Fi and communication protocols will continue to improve in robustness (speed and richness of data), but not to limits that would render solutions developed in this project non-viable.
5. The “market” can tolerate icon standardization guidelines for icons
6. Selection of an evaluation methodology and development of a web-based evaluation tool using Active Server Protocol (ASP) with MS Access 2007 relational database will be usable by users and software not be outdated in near-term.
7. Evaluators using tools developed will find web-based evaluation tools convenient and easy-to-use.

The first four assumptions led to the selection of NetRequest™ (described in Chapter 4) as a test platform for advanced CAFM applications. The remaining three assumptions led to the development of REACTICON, a data collection and management tool developed as part of this project (described in more detail in Chapter 5 of this report). The concept for REACTICON development and use was derived from a tool, IDEA Icon¹, developed during a 10-year research effort, by Battelle, under contract to the Federal Highway Administration (FHA). That product of that effort was to produce guidelines (still in draft) for in-vehicle display icons.

Summary: The combination of: maturity of commercially available enabling software and hardware products, 2) satisfactory development of next generation CAFM applications, and 3) cataloging of needs of 1st Responder requirements and current information capabilities are all well understood and provide an enabling basis for continued development.

Chapter 3 Cognitive Theory and Visual Learning Basis

This chapter is organized into the following sections (chapter headings, if viewed electronically, are bookmarked for quick access):

- 1) [Introduction](#)
- 2) [Need](#)
- 3) [Feasibility](#)
- 4) [Usefulness](#)
- 5) [Summary & Conclusion](#)

Introduction: The research for this proposal probed the need, feasibility, and usefulness for developing an “instant learning” capability primarily through exploitation of icons in spatially displayed data (e.g., electronic floor plans).

Intuitively, “instant learning” should have significant value. It is problematic whether true “instant learning” is achievable, since this would imply humans are born with “pre-programmed” learning and behavior. However, setting such a goal, and exploring how close to it, in terms of minimal training is possible, formed the basis for this part of the research.

For this project “instant learning” is interpreted as the ability of a human to receive input from any of the senses, subconsciously and rapidly process the input, and be able to respond appropriately. While “instant learning” may be too restrictive a goal, the research could surface icon candidates that are very easily learned, and thus, may be sufficient.

If the concepts related to “instant learning” could be validated, then the research would be extended to catalog high potential avenues of focused study and develop the means to evaluate and demonstrate capability.

The project and its research design started from a perspective of cataloging modern scientific theory on the brain and integrating relevant recent technology developments in²:

- ✓ Neurosciences – neurophysiology, brain modeling
- ✓ Cognitive sciences – psychology, reasoning
- ✓ Computer sciences – Artificial Intelligence (AI), simulation & modeling
- ✓ Control theory – mechanisms and control
- ✓ Game theory – decision making, cost/benefit analysis
- ✓ Robotics – perception, world modeling, behavior
- ✓ Visualization – computer graphics, video games

Within the scope of this project it would be very difficult to explore all the above areas thoroughly, however, from the outset, it was believed that science related to visualization (e.g., graphics, icons, etc.) should show the greatest promise to achieve “instant learning” objectives. However, other elements of the above listed disciplines were also explored and contributed as either alternatives or complements.

The research effort included reviews of latest journals, conference proceedings, textbooks, and one-to-one discussions (both verbal and through email) with experts in this field. The observations are summarized as follows: 1) concept of “instant learning” appears to be original, yet, not achieved, to date, 2) there is a current need/requirement, 3) state-of-the-art enabling technology has recently become available, and 4) the science of creating icons, to date, has been more “intuitive”, than scientific.

Considering these observations, the research was structured with a human-centered (not computers, robots, etc.) approach building on a scientific basis of a number of theories for intelligent adaptive systems, cognition and cognitive systems engineering, human-computer-human dialog management, and visualization.

Need: From a Geospatial Information System (GIS) perspective, a paper presented at the 2004 Digital Government Conference, authors stated that: “Current geospatial information technologies ... fail to support group work and have typically been designed

without scientific understanding of how groups (or groups of groups) work in crisis management to collect, process, and use geospatial information.” Thus, “...there is a need to develop advanced geospatial technology to support both same-place and distributed, dialogue-enabled, collaborative crisis management activities.”³ The need is recognized and documented to develop better tools for learning and communicating, in the GIS-Emergency Management area. While CAFM is not GIS, it is a logical extension of GIS navigation, where there is a need for location intelligence at the level inside of building structures.

Research, to date, suggests confirmation of the contention of Ware that: “In general, the science of visualization is still in its infancy. There is much about visualization and visual communication that is more craft than science.”⁴

Feasibility: One of the tasks of the project was to: 1) understand the human learning process, and 2) identify the information conduits that will exploit the processing capabilities of the brain consistent with state-of-the-art information technology delivery mechanisms. With this basis the effort could produce methodology and tools for evaluation. The future work could develop and/or accept and validate standard icon(s). Standard icons could be accepted with adequate justification and assessment of limitations and benefits. Scientifically designed icons should be capable of conveying multiple messages, without user overload and with little or no learning required.

Recent advances in computing science and technologies, such as functional magnetic resonance imaging (fMRI), coupled with interest in creating “real intelligence”, as opposed to “artificial intelligence”, improve understanding of cognitive processes at an ever increasing rate.

It is not possible within the scope of this project to catalog the structure, processes, and interactions of the human brain. However, there is serious work underway for development of next-generation computing, to emulate brain function (reception, processing, and learning), that has already yielded a significant body of knowledge. New understanding of the communication processes within the brain, in parallel with development in computing science cognitive learning, should produce a new paradigm for learning. A few illustrative numbers can make a point. The human brain consists of approximately 100 billion (1×10^{11}) cells, each capable of interaction with between 10 and 100,000 (1×10^5) cells, creating a network of approximately 1 quadrillion (1×10^{15}) connections. Some scientists would argue that the brain circuitry is an all-to-all (each cell connected to all other cells) neural microcircuit. And yet, it has been recently argued (Hawkins) that the brain solves all problems, and learns, in under 100 steps. Very simple computer programs are usually greater than 100 steps. Once better understanding of these capabilities and processes is achieved, we may get closer to the “instant learning” objective. Until that level of understanding is achieved, we will have to resort to logic and process that is understandable and probably best organized with current computing science terms.

Multicasting (the delivery of information to a group of destinations simultaneously using the most efficient strategy to deliver the messages over each link of the network only once, creating copies only when the links to the destinations split.): Viewed as a network, the human brain simultaneously multicasts 10^{11} messages that have an average of 10^4 recipients each. Each of these $10^{11} \times 10^4 = 10^{15}$ destinations receives a new binary digit – spike or no spike - once every 2.5 ms, which is the effective spike width – and another 2.5 ms later another petabit (1×10^{15}) that depends on the outcome of processing the previous one has been multicast. The brain does not simply use store-and-forward routing as does the Internet.⁵

In terms of learning and other cognitive behaviors, there is growing evidence in understanding what might be termed a “local cortical circuit” (LCC). From Mountcastle⁶, we have been shown there is substantial uniformity of cell organization and connectivity across neocortical areas.

These explorations form a knowledge base that might be best summarized as “cloudy”. The complexity is great, but there is still much to discover. Compounding this uncertainty, there are other unresolved questions⁷, such as:

- 1) What are differences in animal “fast learning” versus neural nets?
- 2) Are learning causal relations deterministic or statistical?

- 3) Is statistical learning over-emphasized?
- 4) What are the principles governing the processing, segregation, & integration of information streams (e.g., color, form, “what” & “where”)?
- 5) Is there a common ground between perception and human concept formation?
- 6) How is information coded (e.g., firing rates, spike timing, place coding, synchrony and phase-locking)?
- 7) What representations are really used by the brain?
- 8) What are the relevant aspects of the “binding problem”; self-awareness & consciousness?
- 9) What is the availability of tools to probe circuit dynamics?

Now, having painted the picture the things we don’t know, the following catalogs those things of which we are relatively certain.

An adaptation of a “Model of Perceptual Processing”, by Ware, is portrayed in Table 3-1 again using computing science metaphors for the “Type Processing”⁸. This model provides a “system context” for the development of icons that will be oriented on exploiting the processing elements that could be the most beneficial for “instant learning”.

Table 3-1 Model of Perceptual Processing

Phase	Type Processing	Purpose	Characteristics
1	Parallel	Extract low-level properties of a visual scene	<ul style="list-style-type: none"> • Rapid parallel processing • Extraction of features, orientation, color, texture, and movement patterns • Transitory nature of information, which is briefly held in an iconic store • Bottom-up, data—driven model of processing
2	Serial	Pattern Perception	<ul style="list-style-type: none"> • Slow serial processing • Involvement of both working memory and long-term memory • More emphasis on arbitrary aspects of symbols • In a state of flux, a combination of bottom-up feature processing and top-down attention mechanisms. • Different pathways for object recognition and visually guided motion.
3	Sequential, Goal-driven	Visual Search	<ul style="list-style-type: none"> • Visual search Strategies • Construction of visual queries • Visual working memory can only hold a few objects at a time

The priority preference for design, given the characteristics of perceptual processing, is for:

- 1) Stage 1, low-level properties of the visual scene that can exploit the “rapid parallel processing” characteristics, and then,
- 2) Stage 2, Pattern Perception.
- 3) Stage 3, to the extent feasible, Sequential Goal Directed Processing will be considered, but only as a last choice.

While the primary emphasis of this project is oriented to visualization, other aspects of “multimedia” were considered. Within the context of multimedia, the following are considered elements associated with message delivery: 1) devices (e.g., delivery media),

2) representational formats (e.g., presentation modes), and 3) sensory modalities, e.g., visual, audio, and processing capability/capacity.⁹

The term, “bandwidth” is a measure of transaction sending/receiving/processing/action-response measured in bits per second (bps). Figure 3-1, provides a comparative basis to measure how much information can enter through human senses. To produce an estimate of information throughput we can tally the number of receptors, e.g., how many sensitive points the eye/skin/tongue, each sensory organ possesses, calculate nerve connections to send signals to the brain, and lastly the number of signals each connection sends a second. The numbers are huge.

Clearly the optical channel has the greatest reception bandwidth. The human brain can receive 11 Mbps of information, of which 10 Mbps from the optic nerve alone. However, experience indicates that the human brain is able to process far less (e.g., “processing capability/capacity”), and further, even less in terms of action response (e.g., Skeletal 32%, Hand 26%, Language 23%, and Facial 19%).

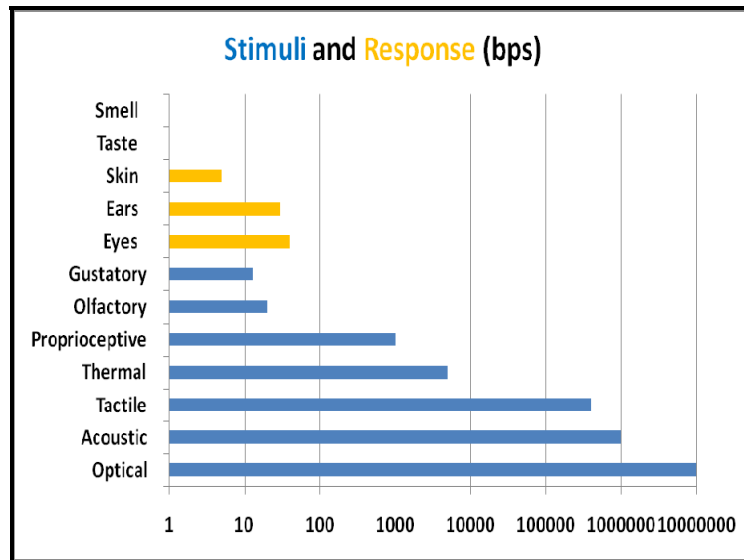


Figure 3-1 Human Sensory Input Potential (Adapted from Norretranders)¹⁰

The conscious brain (processor, connections, memory) can only act on input (data reduction and response) of about 10 bps – with a net synchronous information flow of about 20 bps. For example, the process of reducing a visual impression to the conscious recognition of something well-known (e.g., a person’s face) requires about 0.5 seconds -- actual thought is a very slow, inefficient process. Thus, while there is great sensor capability (all senses combined ~12 Mbps), “instant learning” requires emphasis on mechanisms for better data gathering and efficient/effective processing. If efficient channeling of processing can be influenced, then “instant learning” may be achievable. It is the subconscious brain where the real work is done – the conscious brain is more for organizing.

Three relevant assumptions for design, based on cognitive multimedia learning work by Mayer, are: 1) humans possess separate channels for processing auditory and visual information, 2) humans are limited in process capacity/channel, and 3) humans engage in active learning by attending to relevant incoming information, organizing selected information into coherent mental representations, and integrating those representations with other knowledge.

Figure 3-2 is an adaptation of a model suggested by Mayer to identify channel interfaces, given the foregoing assumptions. This model suggests a complementary audio path to the visual process. This observation could suggest an audio (in lieu of text component) to icons.

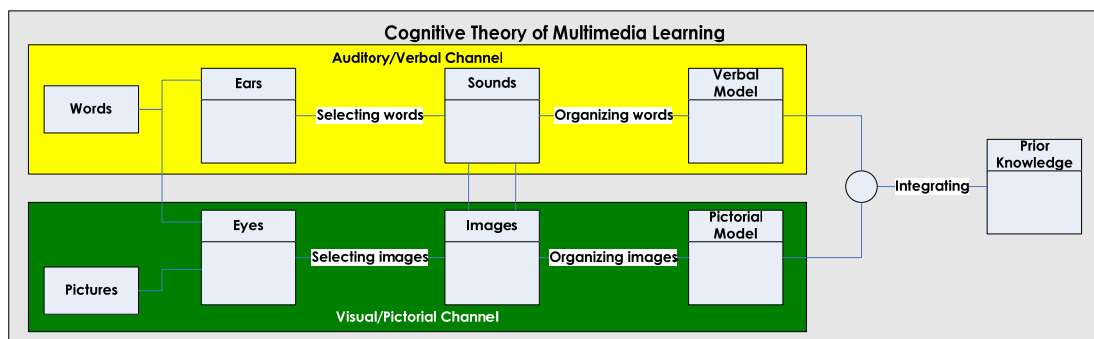


Figure 3-2 Cognitive Theory of Multimedia Learning¹¹

Complementing the concepts of Mayer, separately, Woods¹² has proposed three visual reference models (Propositional, Analogical, and Resemblance) portrayed in Figure 3-3. Mayer recommends using analogical frameworks as the foundation of the information stream with annotation by propositions and icons. Mayer observes: “Analogical reference produces economies of processing in problem solving by reducing memory, referencing and computational demands. If A represents S analogically, then relationships within S are represented in A without being explicitly named in A. Thus, modifying a diagram also and automatically changes the relationship between the modified object and all other objects in the picture. The effects or consequences of the change do not have to be calculated; they can be directly observed.” “... To analyze how a graphic represents, try to substitute words for the graphic. Can you replace the graphic with a single word or two? What is lost in this substitution? Are there many relations captured in the graphic which require lengthy exposition in words? If there is no more information about the referent in the graphic than in the words, then the graphic is likely to refer propositionally (but check to see if the categorization is iconic). If to re-represent the graphic in words requires a lengthy linguistic string, then it is fair to suspect that the graphic refers analogically.”

These concepts form a scientific foundation for development of the preferred icon-oriented solution set.

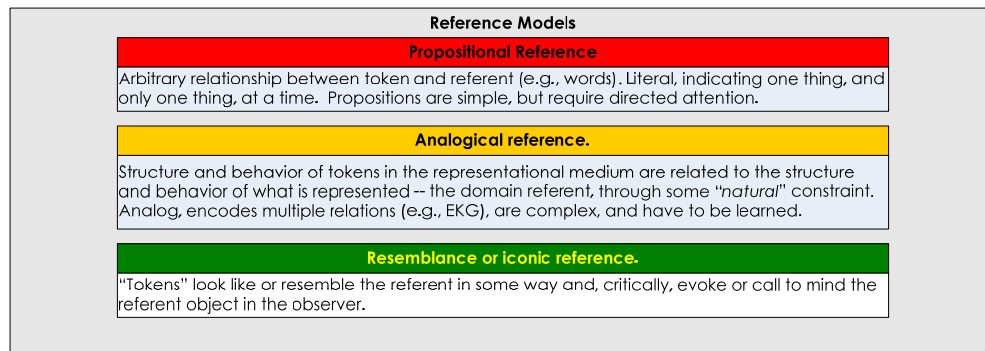


Figure 3-3 Visual Reference Models¹³

Current methodologies for GIS/CAFM information display use a combination of all these reference models, although the simple icon (resemblance or iconic reference) is mostly used. Each type has use/merits. The goal, however, ought to capture the best of each in icon design.

Since icons are a common method for the type of communication desired in computer generated user interfaces, we start from what are accepted standards and tools.

The icon "chunks" information into a symbol that, in turn, can deliver more easily processed information to the subconscious. Symbols can help us remember masses of information, even though we can keep only seven things in our minds at once. Symbols are Trojan horses by which we smuggle bits into our consciousness. "Our memories are limited by the number of units or symbols we must master, and not by the amount of

information that these symbols represent..."¹⁴ To the extent, the icon can exploit senses other than visual (e.g., sound, smell, touch) opportunities ought to be explored.

Icon elements should be constructed to take advantage of efficiency and effectiveness of pre-attentive processing. Ware organizes pre-attentive process features that are captured in the following table (figure 3-4):

Form	Color	Motion	Spatial Position
✓ Line Orientation	✓ Hue	✓ Flicker	✓ 2D Position
✓ Line Length	✓ Intensity	✓ Direction of	✓ Stereoscopic Depth
✓ Line Width		✓ Motion	✓ Convex/concave
✓ Line Co-linearity			shape from shading
✓ Size			
✓ Curvature			
✓ Spatial Grouping			
✓ Blur			
✓ Added Marks			
✓ Numerosity			

Figure 3-4 Pre-Attentive Features¹⁵

Usefulness: To date, the creation of user interfaces for GIS/CAFM-related applications, as with many machine-human interfaces in current use, has been, in general, more art than science. The following points characterize relevant observations:

- In general there are rules for how a display should look (e.g., contrast, visual placement, etc.), but the development of icons has been more one of "...does it

look like the thing I'm trying to represent..." and does it occlude information that I don't want hidden..."?

- Many display interfaces end up using a variety of visual elements and attributes, e.g., hues, shapes, shading, lines, curves, numbers and words, a representation (propositional reference) of a simple expression in language or signs, usually with one message.
- Often, displays overload the information stream forcing the user to go to more complex process to collect and process data.
- Some icons exploit short text language cues, often in English, presuming that English is a universal language.
- Over-reliance on a propositional reference can result in additional processing effort and cause the user to have to navigate to further collect information.

Beyond these acknowledged theories, new concepts on cognitive learning theory offer promise. The following summarizes key points made at a milestone conference, sponsored by IBM on cognitive computing in 2006 with presentations by many of the world's experts in learning and cognition science, as follows:

- Nobelist Gerald Edelman¹¹⁶, cognition is achieved result of a stream of consciousness which is part of his concept on "global brain theory". In simple terms, he relates the concept using a quote from Henry James: "How do I know what I think until I see what I said..." If this report is viewed electronically, this

link takes reader to a complete video presentation by Edelman

<http://www.almaden.ibm.com/institute/resources/2006/Disk1.avi>.

Edelman concludes with these key observations:

- 1) Extensive generalization in object recognition can occur without the need for language
 - 2) The world is an unlabeled place.
 - 3) Brain order shows biologically significant variance.
 - 4) Perception is adaptive and context-sensitive.
 - 5) Motion is an essential element in perception.
 - 6) Perceptual categorization and generalization are fundamental
- Jeff Hawkins, Palm/Numanta and author of the popular book On Intelligence presented his concept on: “Hierarchical Temporal Memory: Theory and Implementation”. If this report is viewed electronically, this [link](http://www.almaden.ibm.com/institute/resources/2006/Disk1.avi) (<http://www.almaden.ibm.com/institute/resources/2006/Disk1.avi>) takes reader to complete video presentation by Hawkins.

As innovative and interesting as his theories/conclusions is the fact that Hawkins, a computer scientist, innovator, author, and entrepreneur, kept the audience of cognitive scientists, often probing and argumentative, interested and agreeing with his concepts. Using his knowledge of computing science and his 20-year study of the brain (with the goal of revolutionizing computing to emulate “real intelligence”), Hawkins believes:

- 1) there is a common cortical algorithm,
- 2) there are brain hierarchical storing sequences of a pattern – inputs (beliefs) going up – predictions going down – each node stores sequences (stabilizes) – shared representations – causes (persistent and recurring spatial and temporal patterns), and
- 3) training is accomplished only through movement (image movement) in time (coincidence and sequence). Further, Hawkins believes there are yet-to-be-understood issues with working memory (prefrontal cortex) and its role in mediating the process.

These presentations represent a state-of-the-science and are useful considerations as the focus addresses concepts for “instant learning” design methodologies.

In summary, to achieve icon usefulness, we want icons to be designed to convey easily-understood, with single or multiple messages, without having the user exert more energy seeking and processing additional information.

Figure 3-5 is a composite graphic developed by this investigator combining the information from the previous two figures and is limited to pre-attentive elements (figure 3-4). It portrays ranges of cognitive reception/processing and learning with subjectively produced numbers to denote merit (5 high-to-0 low) to characteristics that: 1) will require no/little learning and 2) are processed largely in the pre-attentive cognitive domain. All elements have a pre-attentive characteristic, and thus, are good/ useable for icon design.

Those elements that require less learning may be preferred. Those elements requiring attentive cognition may be least desirable.

Category	Feature	Cognition		Learning		
		Pre-attentive	Attentive	Innate (None Req'd)	Cultural	Instructional
Form	Line Orientation, length, width, collinearity	5	1	0	0	1
	Size	5	1	0	0	1
	Curvature	5	1	0	0	1
	Spatial Grouping	5	1	0	0	1
	Blur	5	1	5	0	0
	Numerosity	5	1	5	0	0
	Added Marks	5	1	0	1	1
Color	Hue	5	1	5	0	0
	Intensity	5	1	5	0	0
Motion	Flicker	5	1	5	0	0
	Direction of Motion	5	1	5	0	0
Spatial Position	2D Position	5	0	5	0	0
	Stereoscopic Depth	5	0	5	0	0
	Convex/concave shape from shading	5	0	5	0	0
Key	Value to "instant learning"					
0	None					
1	Limited					
5	Significant					

Figure 3-5 Icon Characteristics - Cognition and Learning Priorities

Summary and Conclusion: This catalog of theory produces a design process that starts with the goal of achieving: “How can we adapt the user interface to enhance human

learning (cognition)?” Believing that the visual channel has the greatest bandwidth and may be the easiest to manage, we still must contend with the whole visual-brain process integration-recognition-recall-response flow. Thus, the design will be oriented on working with the following priorities through:

- ✓ Quick and accurate recognition of a message is necessary (e.g., blinking, color, texture, shape, text)
- ✓ Displays using visual or spatial concepts (e.g., augmented symbology)
- ✓ Enhancing visual search process
- ✓ Compromises in amount of display space (icon size/scaling)
- ✓ Utilization of existing symbology (e.g., diamonds for incidents, valve symbol for shutoff, etc.) and other cues (e.g., red for hazard) that have a generally accepted meaning.

Chapter 4 Target System Implementation using NetRequest™

This chapter is organized into the following sections (if viewed electronically, chapter headings are bookmarked for quick access):

- 1) [Introduction](#)
- 2) [NetRequest™](#)
- 3) [Database](#)
- 4) [Icons and Spatial Information](#)
- 5) [Summary](#)

Introduction: To establish a bridge between theory and practical application and rapidly demonstrate practical capability, this investigator chose to narrow the target test population to address public schools sector emergency response needs. The public school sector has been a high priority for emergency response/management in the last several years and considerable planning has been accomplished to provide a valid basis for needs assessment. The local Fairfax County Public Schools System is advanced in its use and understanding of GIS and CAFM technologies and has indicated willingness to support this effort.

Despite the restricted scope of schools for this project, it is believed that these new visualization elements, e.g., theory, protocols, and tools, will be readily scalable and transferable to other domains.

This chapter documents current understanding of the science of developing icons through a review of technical and “popular” publications (both printed and web-based). In addition, the chapter includes supporting research involving non-documented sources and interviews with technical and management staff of public and commercial organizations involved in use of state-of-the-art technology solutions within the context of the overall project (e.g., CAFM, Emergency Management/Preparedness, GIS, “Lightweight-interactive Graphics”, Visualization, Wireless Networking). Of particular significance is the assistance provided by: ESRI (Vienna, VA-based GIS software developer), Towson State University, Center for GIS (and their EMMA program team), Advanced Planning Technologies (a LaCrosse, Wisconsin-based software developer specializing in Schools-oriented Computer-Aided Facility Management and developer of NetRequest™), and Group 1 Solutions, Inc. (Chicago-based technology firm that provides software tools that enable fire departments to have access to electronic pre-plan files through in-vehicle displays and computers). Group1 Solutions, Inc. has completed an assessment of preplanning processes utilized by fire departments in the Northern Virginia region that included a technology assessment of 15 Northern Virginia jurisdictions for a region-wide program to allow jurisdictions to share preplan information over a wireless or other electronic network. The results of this interview process not only established the technical basis

for this project, but also, in some cases, evolved into the development of business relationships among the various parties.

NetRequest™: NetRequest™, under development since 2005 (beta as of 03/08), by Advanced Planning Technologies (<http://www.apt-cafm.com/>), La Crosse, Wisconsin, exploits innovative technology in terms of Scalable Vector Graphics (SVG) and data integration with a unique deployment scheme not found in the CAFM market today. NetRequest™ is intended for implementation as: 1) a stand-alone application, 2) a local network linked with other ODBC-compliant (Open Data Base Connectivity) applications, or 3) a system maintained on remote servers and accessed via the Internet. A recent (3/27/08) video demonstration can be viewed at the following link (UserID: msuydam@gmu.edu, password: s328339):

<http://webcon.gmu.edu/p70503207/>

Regardless of its deployment method, NetRequest™ allows users (e.g., managers, staff, customers) to have ready and rapid local network or Internet access to facility information through rapidly accessed easy-to-understand, spatial displays

NetRequest™ incorporates SVG graphics and data management technology, CAD, Reporting, Blueprint and Specification Document Viewing, Work Orders into a complete Facility Management System in a convenient, networked package. The system allows users to:

- View floor, roof or site plans with the capability of making changes over a local network, or the Internet by storing the NetRequest™ project on a web

server. This allows easy access plans with information linked in; direct access to CAD drawings and information without the need to re-publish/distribute the drawings when changes are made.

- Transfer and accept drawings with other CAD application.
- Manage libraries of scanned images of detailed blueprints or technical manuals with one click on the NetRequest™ toolbar.

Planned for next version release is a fully functioning Computerized Maintenance Management System (CMMS) for work orders, preventive maintenance and asset inventory is tightly integrated into the graphical format and interface with map and GIS formats for “drill-down” functionality.

While not intended for deployment in emergency management operations, NetRequest™ possesses all the necessary data and display structure to be easily adapted.

A sample facility (school) display (graphic with toolbar) is shown in figure 4-1.

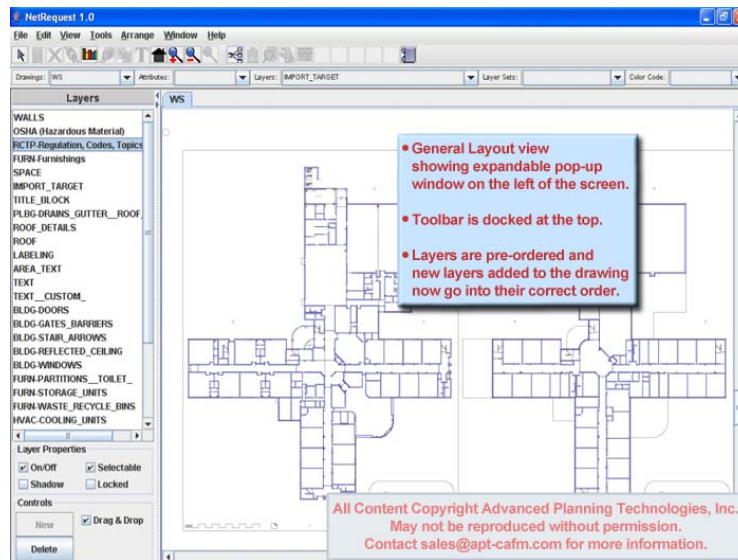


Figure 4-1 NetRequest™ Sample Display¹⁷

Database: The Entity-Relationship diagram for the current version (beta) of NetRequest™ is as shown in Figure 4-2, next page. If this report is viewed in electronic format and the user has MS Visio 2007, the diagram may be open by a simple double-click. While the creation of the E-R diagram was primarily for planning and design purposes of this project, the purpose of the figure is to highlight the extent of data that is managed (and potentially transmitted) through this application. A “layer” for Emergency Management represents a small fraction of the data, and thus, transmission of information would not necessarily (although it could easily) swap/transfer all information. Current EM-related data contained within certain datasets is noted with red background. NetRequest™, however, can easily accommodate the addition of existing datasets and/or new datasets.

Figure 42. OnRequestWebRequest
ER Diagram -Current - Schools Related Portion only
Thursday, December 16, 2021

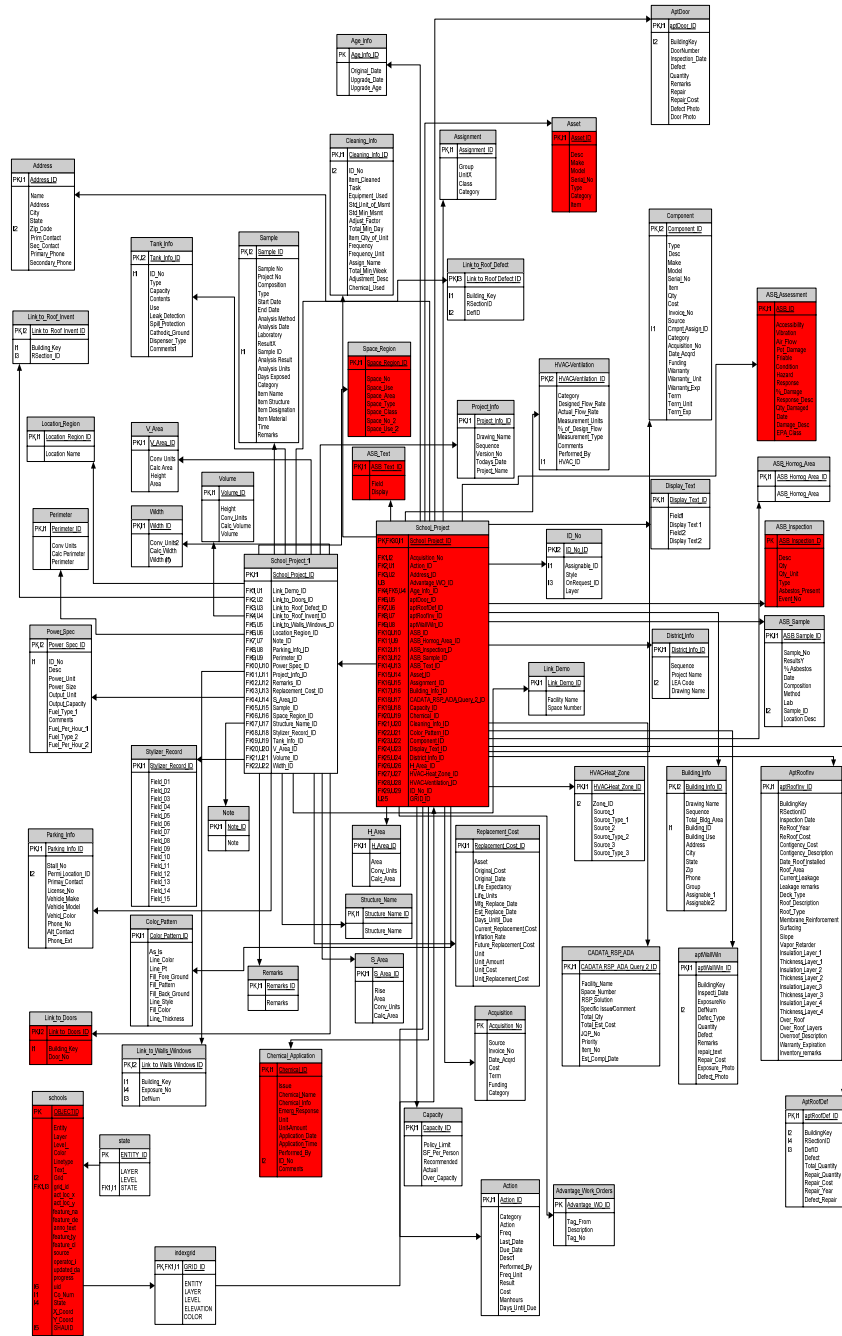


Figure 4-2 NetRequest™ E-R Diagram

Icons and Spatial Information: It is well documented that visual icons can activate logical information rapidly and effectively, however, it is only effective when the icon-information link is strong.

Symbol set design is critical, once learned, it is hard to reverse. Existing symbology can help as much as it can inhibit innovation, and will likely pose a major hurdle to creativeness for this project. There are many symbol sets in use today with a wide variety of proponents. Some sets are well developed while others are personal and/or simply artistic.

In the period following the September 11, 2001 attacks, the Federal Geographic Data Committee (FGDC) Homeland Security Working Group was tasked to develop a standard set of symbols for use by the Emergency Management and First Responder communities at all levels of need (i.e. National, State, Local and Incident). Federal, state, and local agencies worked together under the auspices of the FGDC's Homeland Security Working Group, to develop the proposed symbology. These symbols, however, are oriented to GIS-map-level information and are not necessarily for use within structures. However, the methodology for development of the symbols (includes shapes and border changes) could be applied to symbols used within a building/structure.

Figure 4-3, below, represents examples of basic shape/color/border methodology used to develop the FGDC symbols, with examples.





Symbol Category	Example Symbol Shape	Damage/Operational level Border colors
Incident		No levels
Natural Events		No levels
Operations		<p>Level 1 – Green – single line; Fully operational/open.</p> <p>Level 2 – Blue – double line; Operational, but filled to capacity or otherwise closed.</p> <p>Level 3 – Orange – double line; 4 filled dashes; Operational, but partially damaged or partially incapacitated.</p> <p>Level 4 – Red – double line; alternating dashes; Destroyed or Totally incapacitated</p>
Infrastructure		See levels described in "Operations"

Figure 4-3. FGDC Symbolology Methodology

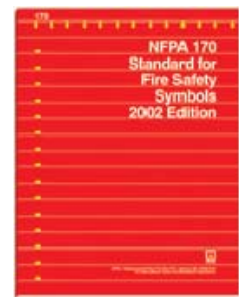


Figure 4-4 NFPA 170 Standard for Fire Safety Symbols

The scope of the FGDC symbols standard is currently limited to point symbols for map displays rather than in-facility displays and associated symbols. However, the science, comprehensiveness or research, and logic for the creation of symbols are solid and useful for application to this project.

In general, due to the need for consistency in Emergency Management, all EM icons should use either the four-sided diamond (Incident example, above) or circle shape (Operations example, above). Default border colors should be green (level 1) or black, if only black/white/gray displays are available. Few of the current sets of “artistically created” icon sets reviewed for EM possess such simple discipline.

There are other standards published by Associations, e.g., National Fire Protection Association Standard, that present uniform symbols for use by the general public and national organizations (e.g., fire service), as well as for architectural and engineering drawings, insurance diagrams, fire fighting operations, and pre-incident planning sketches.

The NFPA 170 is supported by automated stencil sets (available at the following link: <http://www.shapesource.com/scripts/prodView.asp?idproduct=111>). A set was purchased for this project compatible with MS Visio. Figure 4-5 identifies the icon and associated SVG source code for a fire extinguisher icon transferred from the stencil set in MS Visio 2007 and saved as a .SVG file, Note: this conversion to SVG cannot be accomplished with earlier releases of Visio.

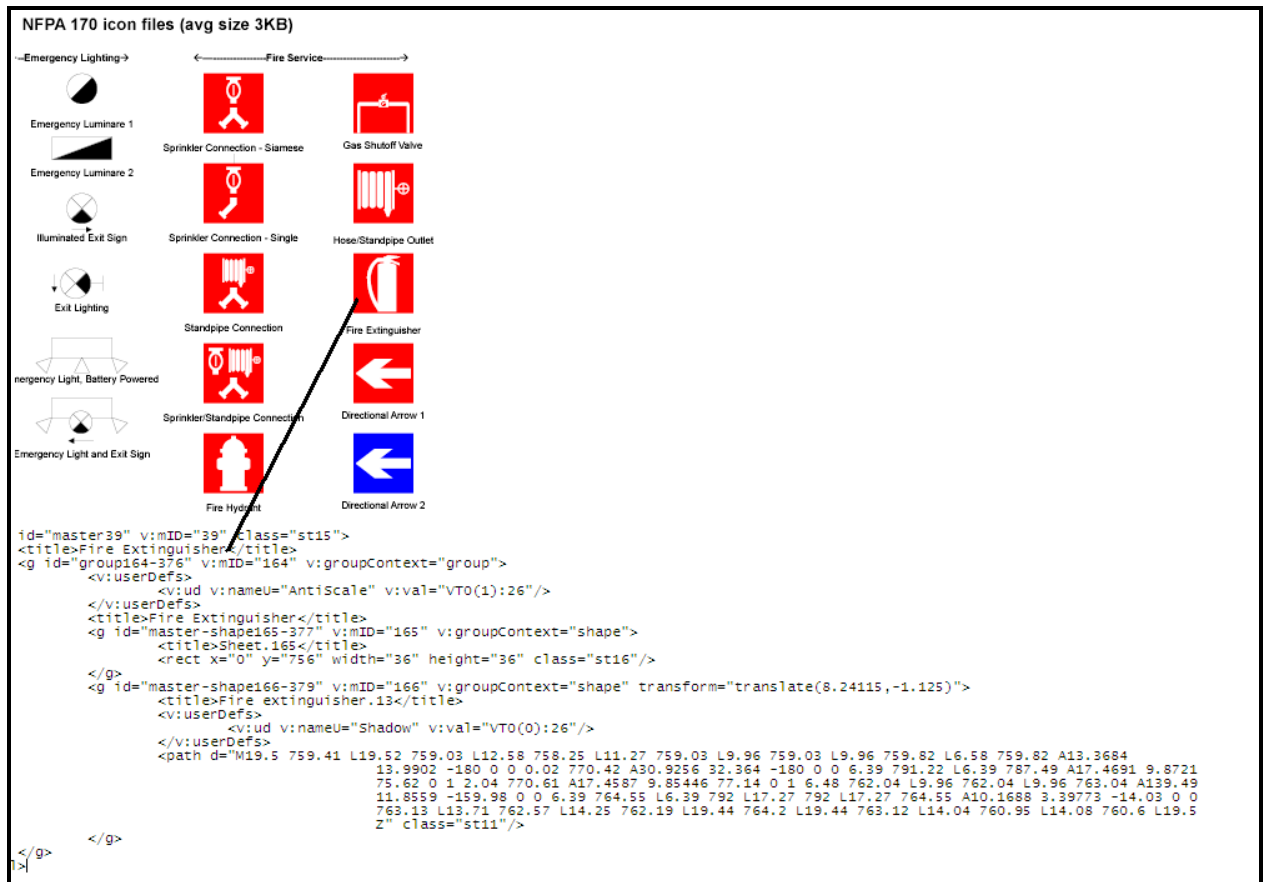


Figure 4-5. NFPA 170 Symbols Converted to SVG

There are also icons used by CAFM providers. A discussion with the principal developer¹⁸ for one of the CAFM applications that has specialized in Emergency Management and Schools provides a simple explanation of the current design basis, as follows:

“I used the NFPA 170 and the NFPA 99B for reference. A couple of the symbols from the 170 were used, but there are many more that I have not created yet.

When I create icons/symbols, I review AIA, Graphic Standards, ANSI, OSHA, NFPA, and EPA Standards. If any of these symbols differ, but still have the same meaning, I then try and come up with a better symbol that would be generically understood. This helps to keep the common user in mind without having the knowledge of all the professional areas.

An example of this is a plumber may not know all the electrical symbols. A fireman may not know all of the HVAC symbols. A janitor may not know the Fire or Telecommunication symbols or a policeman may not understand all points of entry besides the doors. There are many fields of professionalism involved in a building. I try and simplify the entire professions that are related to facilities and their symbols to create a common understanding so any individual may understand what is going on.”

Figure 4-6, below, is an example of the current “iconology”¹⁹ for emergency shutoff information provided through a current commercially implemented CAFM-GIS interface. While various standards are used, the “art” of icon development might be characterized as simply a matter of design that represents something meaningful in a small geographic space that may be linked to text and/or visual information, usually through a mouse-click or touch screen.

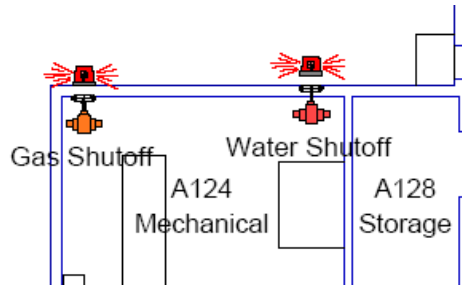


Figure 4-6. CAFM Emergency Response Interface for Facility Shutoffs

Figure 4-7, left-hand column, catalogs a set of candidate Emergency Management icon categories based on the needs for currently implemented for schools. A category may contain one or more specific icons. The right-hand columns of the table identify some other suggested/potential needs for EM icons.

Current CAFM Emergency Management Icons	Other Priority Icon Needs	
<ul style="list-style-type: none"> • ADA (American Disabilities Act) • Air Handling • Asbestos • Biohazards • Confined Space • Emergency Plans/Manuals locations • Entrances • Emergency Shutoffs • Fire Alarms, Detection • Fighting Equipment • Evaluation Routes • Flammable Materials • Lighting (including backup) • Shelters (e.g., Tornado) and Safe Rooms • Supply Conduits (air, electricity, water, etc.) 	<ul style="list-style-type: none"> • Check Areas • Earthquake Safe Harbor Areas • Fire Hydrant Locations • GPM Flow Rates • Flood Safe Harbor Areas • Gas & Electrical Lines • Lock and Key Information • Lockbox Locations • Safe Harbor Areas • Safety rooms • Sprinkler Areas/Zones 	<ul style="list-style-type: none"> • Standpipe Locations • Security Lighting • Security Cameras • Security Stations • Chemical Location • Structural Composition • Tornado shelter • Underground Tanks • Valuable property • Vent locations

Figure 4-7. CAFM Emergency Management Response Interface Icons

Summary: All the enabling technologies to produce candidate icons and demonstrate effectiveness feasibility with users are completed and available. The knowledge of requirements and practical science has been assembled and cataloged and is ready to enter into discussion with test user groups.

Chapter 5 Preliminary Test Protocol for Evaluation of “Instant Learning” Effectiveness

This chapter is organized into the following sections (if viewed electronically, chapter headings are bookmarked for quick access):

- 1) [Introduction](#)
- 2) [Icon Discovery, Creation, Evaluation, and Selection Process](#)
- 3) [Design Guide](#)
- 4) [Icon Design Methodology](#)
- 5) [Validation Methodology](#)
- 6) [REACTICON](#)
- 7) [Summary](#)

Introduction: The literature research led to a recent study by Battelle, “Vehicle Display Icons and Other Information Elements” oriented to traffic signs and in vehicle displays, producing a scientific basis and well disciplined methodology for evaluation and design of icon-type artifacts. The final report of that study included an MS Access-based desktop computer tool, IconIDEA, to catalog icon evaluation. This concept was adapted for this project. The tool created is a server-based evaluation and reference tool set, REACTICON (Rational Emergency Action Computerized Tool for Interactive Collaborative Operational Networking) to be utilized in future work.

Icon Discovery, Creation, Evaluation, and Selection Process: Figure 5.1 outlines the process of evaluation. It outlines the activities from determination of EM messages to icon acceptance. An HTML version, including detailed links, is contained in the REACTICON tool, presented in a subsequent section.

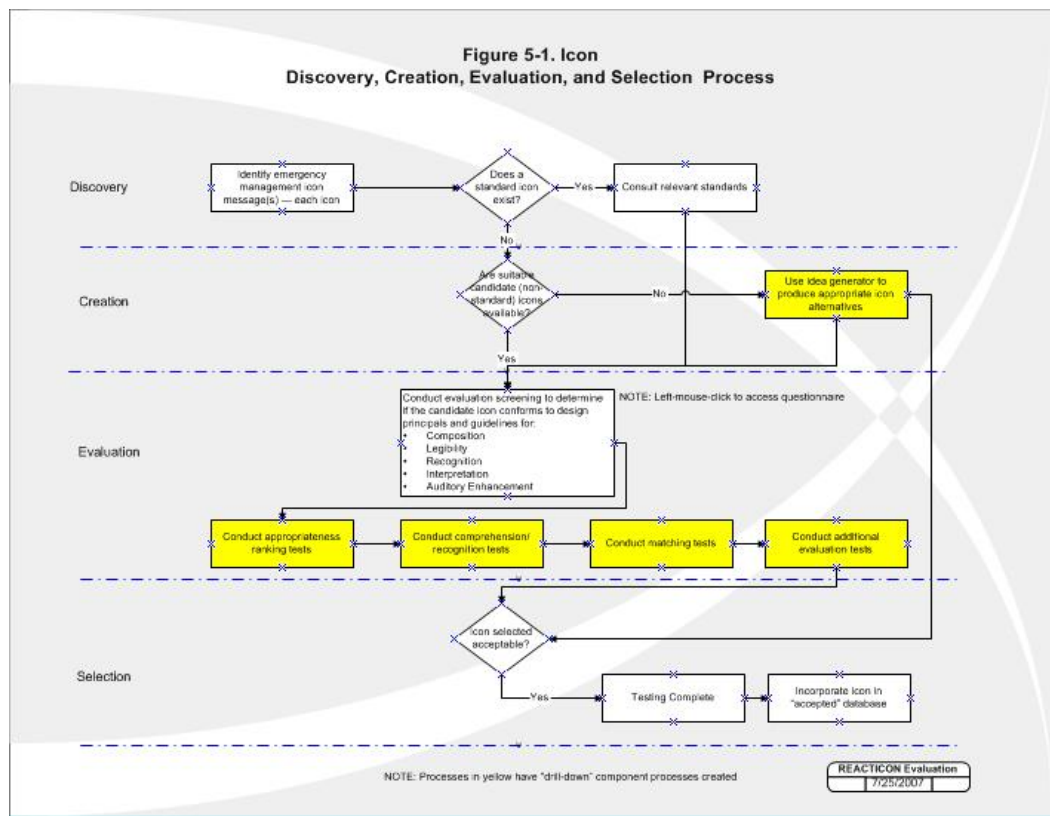


Figure 5-1 Icon Discovery, Creation, Evaluation, and Selection Process

Design Guide: Because of the usefulness of the guidelines and the scientific data in the “Vehicle Display Icons and Other Information Elements” report, the charts on following pages, Tables 5-1 (Icon Design Guidelines) and 5-2 (Icon Design Criteria), were created

to provide a summary and reference guide. These tables distill and adapt, for purposes of this study, 75 pages of the 241 page Volume 1 report. The other details may be useful reference, but are not considered necessary for this project. The Design Issues for each category examined are simple, profound, and offer fundamental “truths” about icon design. The Design Guidelines are a useful “primer” establishing a simple frame of reference for use and application of icons. The Icon Design Criteria provide a solid benchmark for evaluation and validation and are integrated into the Design module of REACTICON, discussed in the next section.

The original guidelines material has been generalized beyond the original user identifications (e.g., vehicle operators/drivers), and otherwise, substantially modified/adapted for the applications intended in this project.

In addition, the Design Guide becomes the primary instructional tool for “judges” in the evaluation process.

The criteria are measured against the satisfaction of meeting target message(s). Messages may communicate:

- beware, this is a escape door, it is blocked going down
- caution, keep as far away as possible
- leave immediately, death is imminent.
- important, good, this is a _____, this is for life saving,
- change for good, change for bad
- direction indicated...to safety...to danger?
- injured person, alive

To develop, explore, and examine the issues of messaging and evaluation of data collection plan and techniques, a test case was assembled for icon candidates. For this test case the icon had the simple objective of transmitting the following messages: stop, avoid area, danger, biohazard material present.

Five candidate icons were created employing various standard elements and graphics as shown in Figure 5.2, Test Case Icons. The images shown were extracted from context view displays in NetRequest™.



Figure 5-2 Test Case Icons

Each graphic center component of the icons is currently employed by one or more current display systems for essentially the test message purpose. It is expected that continued experimentation, will provide more insight into icon design.

Experimentation with this icon set during this project produced many changes to the collection system, icon design process, and data extraction and manipulation. Important considerations that posed some technical challenge included the ability to make icons

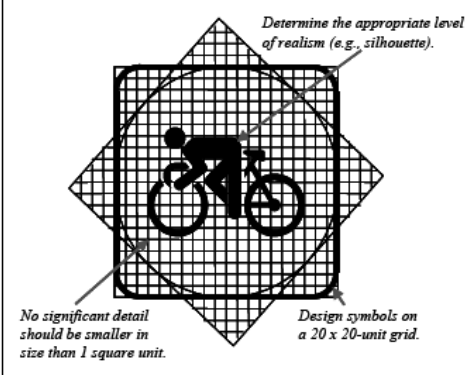
capable of blinking, flexible sizing, and transparency in order to create user alert while ensuring minimal occlusion of the base drawing information.

Table 5-1 Icon Design Guidelines²⁰

Subject	Design Guideline
Guidelines	
General Development Process for In-Vehicle Icons	General design principles for the design of in-vehicle icons provide important information that will increase the effectiveness and utility of icons. However, they represent only a necessary first step, and cannot take the place of empirically assessing the utility of a particular icon. In particular, such principles cannot always consider issues such as the driving context, different user groups of icons, or driver workload in selecting icons. That is, using general design principles alone cannot assess "specific effectiveness with the potential user group". Without research, icon development becomes little more than an intuitive approximation of what constitutes a good design, and lacks the confidence that can be obtained by empirical validation.
When to Use Icons	<p>Use icons when:</p> <ul style="list-style-type: none"> • Quick and accurate recognition of a message is necessary (e.g., warnings). • Displaying visual or spatial concepts (e.g., augmented signage). • The driver will be performing a visual search of alternatives (e.g., motorist services information). • The amount of space on the display is limited and presenting the information textually will take up more space than is available. • One already exists and has a generally accepted meaning.
Ways to Use Icons	<ul style="list-style-type: none"> • Attention: Verifying process proceeds according to plan and directing attention to deviations. Icons that provide cautions and warnings • Interpretation: Identifying a status or scanning potential alternatives. Icons that highlight changes in system state • Selection: Comparing alternatives, determining the effect each will have on the end goal, and choosing one to meet those goals. Icons for trip planning and route selection. • Action: Selecting system functions and timing tasks to achieve an end goal. Icons that label controls and identify system features
Icon Comprehension	
Legibility	<ul style="list-style-type: none"> • Determining the appropriate luminance uniformity in an icon; • Determining the appropriate contrast in an icon; • Determining the appropriate size of icon components; • Designing effective text labels, and the effects of color on icon legibility.
Recognition	<ul style="list-style-type: none"> • Level of realism, level of detail; perceptual principles of icon design; • Flash rate; • Design of prohibitive symbols; • User acceptance of general versus specific icons.
Interpretation	<ul style="list-style-type: none"> • Enhancing icon interpretation with text labels; • Composition of text labels; • Conveying the effect of actions with icon; • Identifying icons as part of a group; • Conveying system status with icons; • Enhancing icon interpretation with color; • Conveying urgency with icons; • Enhancing icon interpretation with shape.

Table 5-2 Icon Design Criteria²¹

Parameter	Criteria
Composition of an Icon	
Border	<ul style="list-style-type: none"> • Use to show the extent of an icon (beginning and end).
Background	<ul style="list-style-type: none"> • Don't cover more than half the available area with objects. • Avoid patterns in the background. • Put the image clearly in front of the background. • Place objects in the center and the background around the periphery. • Use unsaturated, cool colors for the background, and saturated, warm colors for the foreground image. • Keep the background static; if anything blinks or moves, the viewer perceives it as a foreground image. • Limit the background image to a simple rendition of a recognizable, concrete object.
Element	<ul style="list-style-type: none"> • Use commonly accepted or standardized elements when possible.
Symbol (shapes)	<ul style="list-style-type: none"> • Circles should be used for presenting prohibition or mandatory information. • Triangles or diamonds should be used to present warning or cautionary information. • Squares or triangles should be used to present general information, instructions, or safe condition information.
Text Label	<ul style="list-style-type: none"> • Use only when necessary, especially when the icon is concept-related or arbitrary. • Keep text to no more than two-three words.
Determining the Appropriate Luminance Uniformity within an Icon	<ul style="list-style-type: none"> • Provide no more than 33 percent element non-uniformity (within an individual element or segment).
Determining the Appropriate Contrast within an Icon	<ul style="list-style-type: none"> • 3:1 Minimum symbol contrast • 7:1 Preferred symbol contrast
Determining the Appropriate Size of Icon Components	<ul style="list-style-type: none"> • The visual angle of symbols contained within an icon: <ul style="list-style-type: none"> - optimum visual angle = 1.43 degrees (85 arcmin.) - minimum visual angle = 0.69 degrees (41 arcmin.) • The visual angle of text labels contained within an icon: <ul style="list-style-type: none"> - optimum visual angle = 0.40 degrees (24 arcmin.) - minimum visual angle = 0.27 degrees (16 arcmin.)
Designing Effective Text Labels	<ul style="list-style-type: none"> • Text labels should be brief, no more than 2-3 words. • The type should be at least 0.27 degrees of visual angle (16 arcmin.); 0.40 degrees (24 arcmin.), maximum. • Use a clear and simple sans serif typeface such as Helvetica. • Avoid using boldface, italics, underlining, or differences of color to emphasize words. • The space between lines should be at least 1/30 the line length. • Use both uppercase and lowercase letters rather than all of one or the other. • Character width-to-height ratios should be 0.6:1 - 1:1 (width: height). • Wider characters should be used as criticality increases. • If text must be compressed, compress the space between characters rather than the characters (1). • Use initial capital letters for multiword labels not incorporated in the symbol.

The Effects of Color on Icon Legibility	<ul style="list-style-type: none"> Any reasonably visible color may be used to create icons as long as guidelines for symbol height and contrast are followed and population stereotypes are not ignored. However, highly saturated blue (i.e., approximately 450 nanometers) should be avoided. If colored lines are shown against a colored background, the color contrast between the elements should be a minimum of 100 E (CIE Yu'v') distances.
Recognition	
Level of Realism	<ul style="list-style-type: none"> For general or abstract concepts, less detailed symbols such as caricatures or silhouettes are most appropriate. When several symbols have the same general shape or profile, detail is necessary to make them distinct from one another. In this case, they may be best portrayed using a simplified drawing. For small, familiar symbols with a distinct profile use an outline. However, when the symbol is too thin to be recognized in this format, a silhouette is preferred.
Level of Detail	<ul style="list-style-type: none"> Design symbols on a 20 x 20 unit grid, making sure that no significant detail is smaller in size than 1 square unit. Lines and other continuous aspects of the symbol do not need to span one grid square. Significant details within a symbol should subtend, at a minimum, 3 degrees of visual angle. Line thickness for a significant detail should subtend, at a minimum, 2 degrees of visual angle.
Perceptual Principles of Icon Design	<ul style="list-style-type: none"> Figure/ground relationship: Emphasize a clear, stable, and solid relationship between the elements of the symbol and its background Figure edges: Relatively solid shapes are better than thin or dotted-line edges unless the element in question depicts action or movement Closure: Use closed figures without discontinuous lines, outlines, or disjointed elements that can result in a fragmented figure Simplicity: Icons should be simple with only the necessary detail included; removal of these details should result in low recognition Unity: All parts of the symbol should be enclosed 
Flash Rate	<ul style="list-style-type: none"> Flashing lights or icons should be reserved only for emergencies, because they have the potential to distract the driver. Flash rates should be 3-10 per second (although 4 is best) with equal light/dark intervals. Flash duration should be at least 0.05 second. Only one signal should flash at a time. The background should be steady when using flashing signals. Flash rates should not be used as a visual coding method as only 2 levels can be discriminated on an absolute basis under optimum conditions.
Design of Prohibition Symbols	<ul style="list-style-type: none"> Care should be taken not to obscure small details of the symbol with the slash or cross. When necessary, the symbol's placement or orientation may need to be changed. Modification of the slash may also be necessary to ensure the display of all important features. See the points below for alternative methods for indicating prohibition. Use full-length, solid slashes rather than partial or transparent ones. Slashes that appear in front of or behind the pictorial are preferred.

	<ul style="list-style-type: none"> • Use a standard circle and 30°–60° slash to indicate prohibition. The circle and slash should be colored red for saliency. • Use pictorials that do not contain too many small details small details are likely to be obscured by the circle or slash, making the pictorial ambiguous. • Avoid using pictorials that show a negative consequence
User Acceptance of General versus Specific Icons	<ul style="list-style-type: none"> • To minimize user memory requirements and system complexity, general icons should be used as long as they do not negatively impact user acceptance or performance. Well-designed general icons will be acceptable to most users under most use circumstances • The exception to this seems to be safety-related messages (e.g., collision avoidance icons). For safety-related messages, specific icons will provide higher levels of user acceptance than do general icons.
Interpretation	
Enhancing Icon Interpretation with Text Labels	<ul style="list-style-type: none"> • Text labels should be considered when: <ul style="list-style-type: none"> - Icons are abstract and have no conventional or broadly understood meaning. - The icon represents a message that is particularly important or warns of a particularly hazardous situation. - The driver can safely spend one to three seconds interpreting the icon. - The task is complex. • Keep text labels concise (two to three words) and use them sparingly. Text labels reduce the space available for the icon, making them less interpretable.
Composition of Text Labels	<ul style="list-style-type: none"> • Use explicit icon descriptions. Explicit text labels improve comprehension and are perceived as conveying a more salient notification than non-explicit labels. In addition, precise descriptions allow the driver to judge when or where a situation will occur and thus aid in response preparation. • Use nontechnical, common vocabulary. Users will not know how to respond to a warning if they do not understand the text verbiage.
Conveying the Effect of Actions with Icons	<ul style="list-style-type: none"> • Show consequences of action with arrows, speed lines, or the ghosting of images. • Use sequence of images to convey simple transformations. • Consider animated icons for pre-action (e.g., driving) applications to show complex multistep consequences. • Because of the distracting nature of animated icons, they should be used only rarely and with great caution.
Identifying Icons as Part of a Group	<ul style="list-style-type: none"> • Group icons based on the tasks that the user performs, rather than the architecture of the system. • Put related icons close together, especially those that are almost the same and those that are opposite. • If an icon fits into more than one group, duplicate it for each group. • As a last resort, label groups of icons or individual icons. • Put groups into separate boxes or windows. • Put borders or extra space between groups of icons. • Use a common color for background or icon elements to distinguish groups. • Within a group of icons, use similar style, level of realism, and level of detail. • Combine, transform, and include elements from other icons in the same group.
Conveying System Status with Icons	<ul style="list-style-type: none"> • Use a uniform decrease in contrast or a change of solid to dashed lines to convey on/off or active/inactive change. • Use an easily recognizable element and project changes upon it to convey system status that is described by multiple categories. • Represent status changes associated with changes in magnitude by increasing the number or size of well differentiated icon elements, rather than changing color or contrast. • Consider using text or numbers to represent changes of magnitude or categories.

Enhancing Icon Interpretation with Color	<ul style="list-style-type: none"> • Use color coding only when well-established conventions exist, such as temperature, dangerous situations, and permissiveness. • Use the color red to indicate highly urgent messages, yellow to indicate cautionary information, and green to indicate normal operations or safe conditions. • For temperature, use red for hot and blue for cold. • Arbitrary codes using color to convey meaning are likely to induce errors. • Color, such as red, can be used to enhance the relative salience of icons. Therefore, color choices should be made with respect to the relationship between messages (relative urgency of messages) and the relationship between messages and the background upon which they are presented. • Small spots of intense saturated color can convey information effectively. This requires a conservative use of these colors and the use of less saturated colors for backgrounds. • Use shades of gray, rather than color, for showing quantity.
Conveying Urgency with Icons	<ul style="list-style-type: none"> • To increase the perceived urgency of an icon: <ul style="list-style-type: none"> - Increase font size of text labels to identify icons of greater urgency. - Increase white space around label. - Use red lettering or red background. - Increase line weight of border. - Use blinking or flashing to draw attention to icon. - Increase relative size of the high urgency icon. - Always position urgent warnings within 30 degrees of the operator's normal line of sight. - Pair with an auditory cue. - Show consequence of not responding. - Do not use blue or green coloration, as those convey low urgency. • For time critical situations, such as collision avoidance, icons should be positioned so that they attract the user's attention to the appropriate part of the vehicle or environment.
Enhancing Icon Interpretation with Shape	<ul style="list-style-type: none"> • Icons shaped like standard traffic signs convey the respective hazard level of the message. • Use octagon-shaped icon borders for high hazard conditions or situations. • Use diamond or inverted triangle-shaped icon borders for medium hazard conditions or situations. • Use circle, square or rectangular-shaped icon borders for low hazard conditions or situations.
Auditory	
Augmenting Icons with Auditory Information	<ul style="list-style-type: none"> • Use the auditory modality for presenting high priority alerts and warnings; present additional contextual information visually. • Use auditory prompts when a previously static visual display changes. • Use auditory prompts when high priority information is automatically displayed. • Use a combination of visual and auditory prompts to repeating low complexity messages.

Determining the Appropriate Auditory Signal	<ul style="list-style-type: none"> • Use simple tones and auditory icons when an immediate response is required. • Earcons should be used when it is important for the driver to know that pieces of information are related. • Auditory icons are effective for use in collision-warning applications (i.e., horn or skidding tires). • Use speech messages when: <ul style="list-style-type: none"> - a high degree of message flexibility is required. - a high degree of message detail is required. - the meaning of tones or other sounds may be forgotten under stress. - the auditory message deals with a future point in time for which there must be some preparation (i.e., time or distance to turn). • Speech message displays should not be used for time-critical tasks.
Design of Simple Tones	<ul style="list-style-type: none"> • Appropriate loudness levels are 15-25 decibels (dB) above the predicted masked threshold. • Auditory warning signals should be less than 30 dB above the masked threshold to minimize operator annoyance and the disruption of communication. • The pitch of warning sounds should be between 150 and 1000 Hertz (Hz). • Continuous tones should be avoided because they are usually high pitched and aversive, prevent communication if they are loud, and are easy to habituate because they never change. • When more than one tone is used: <ul style="list-style-type: none"> - Avoid tones with the same on/off ratio. - Avoid tones that share the same temporal pattern. - Avoid tones that begin in the same way (i.e., with a long tone). • No more than 6 simple tones should be used.
Design of Complex Tones	<ul style="list-style-type: none"> • The amplitude envelope of the initial pulse should include a 20 millisecond (ms) onset to reduce startle effects. • The pulse should be composed of multiple frequency components, such as formants or harmonics, to mitigate masking due to background noise. • The temporal pattern of auditory signals should be as distinct as possible. Otherwise confusion is likely, even if the spectral content is substantially different.
Design of Earcons	<ul style="list-style-type: none"> • Use synthesized musical timbres that are subjectively easy to tell apart (i.e., organ and brass). • Do not use pitch alone to distinguish between tones unless there are very significant differences. Some suggested ranges for pitch are max: 5 kHz and min: 125 Hz–150 Hz. • Use tones that are three or more octaves apart. • Make the rhythm as different as possible. Putting a different number of notes in each rhythm is effective. • Some suggested ranges for intensity are max: 20 dB above threshold and min: 10 dB above threshold. • When playing combinations of multiple earcons, a gap of 0.1 second should be between them so that the user can tell where one finishes and another starts.

Design of Auditory Icons	<ul style="list-style-type: none"> • By definition, auditory icons must be identifiable as having relevance or conveying some inherent meaning. <ul style="list-style-type: none"> - Iconic auditory icons sound like the object or action they represent (e.g., the sound of a crash to indicate a collision warning). - Metaphorical auditory icons sound like some element of the object or action they represent (e.g., the sound of children to indicate a school crossing). - Symbolic auditory icons rely on social convention for meaning (e.g., the sound of a siren to indicate an ambulance approaching). • Auditory icons should be detectable 10 to 20 dB above the masked threshold. • No more than six auditory icons should be used in an auditory icon set. • Auditory icons should strive to attract the attention of the driver without generating a startle reaction. Special attention should be paid to the perceived urgency associated with different candidate auditory icons.
Design of Speech Messages	<ul style="list-style-type: none"> • If speech must be used in a time-critical application (i.e., warning), the message should be kept to a single word or a short phrase with the fewest number of syllables possible. • Messages that are not urgent or for which a response may be delayed can be a maximum of seven units of information in the fewest number of words possible. If the information cannot be presented in a short sentence, the most important information should be presented at the beginning and/or the end of the message. • Navigation instructions should be limited to three or four information units (i.e., "Accident ahead, merge right" or "Turn right in ½ mile"). • Do not try to make the voice sound too human. A machine should have a machine voice to cue its identity when it speaks. • Provide a means for repeating speech messages. • Provide a redundant visual presentation of the information being presented orally.
Perceived Urgency of Auditory Signals	<ul style="list-style-type: none"> • To increase the perceived urgency: <ul style="list-style-type: none"> - Use faster auditory signals. - Use regular rhythms. - Use a greater number of units (4). - Use auditory signals that speed up. - Use high fundamental frequencies. - Use a large pitch range. - Use a random pitch contour. - Use an atonal musical structure. • To decrease the perceived urgency: <ul style="list-style-type: none"> - Use slower auditory signals. - Use irregular rhythms. - Use a fewer number of units. - Use auditory signals that slow down. - Use low fundamental frequencies. - Use a small pitch range. - Use a down or up pitch contour. - Use a resolved musical structure.

General Design Guidelines for Automatic Speech Recognition Systems	<ul style="list-style-type: none"> • For IVIS applications, ASR devices should be used to aid complex tasks that involve high visual, cognitive, or manual requirements. • Vocabulary sets for ASR devices should: reflect natural language conventions as much as possible, avoid similar-sounding words or phrases, and be small enough so that drivers can recall command words rapidly and with few or no errors. • The microphone for an ASR device should be located on the forward portion of the vehicle headliner, right in front of the driver. • Drivers should be provided with immediate feedback (e.g., error correction, input confirmation) of the recognition results or the system's response to the speech input. Changes in the visual display itself provide a good form of feedback, but require driver head or eye movements to verify. Although any feedback will improve the driver's performance with the system, size limits on IVIS displays in the in-vehicle environment, as well as concerns about visual overload, suggest that auditory feedback should be used.
Timing of Auditory Navigation Information	<ul style="list-style-type: none"> • For maneuvers defined as leaving the current route (i.e., turning onto a side road), the timing of the auditory guidance instruction can be based on the equations provided below. • It may be advisable to implement the equation for "preferred maximum distance." An instruction given slightly too early is preferable to one given too late. • Instructions are "stacked" (given during a single message), when the distance between two subsequent maneuvers is less than the minimum preferred distance for that speed,
Perceived Annoyance of Auditory Signals	<ul style="list-style-type: none"> • For signals to be perceived as appropriate, highly urgent sounds should be used for highly critical situations. • For signals to be perceived as appropriate, low annoyance sounds should be used for benign situations. • Sound characteristics of pulse duration, burst density, sound type, and speed all increase perceived urgency more than perceived annoyance.

Icon Design Methodology

The intent of this project is to exploit advances in communication and cognitive science to enhance probability that a user receiving input from a display source will immediately understand the message(s) and know how to respond. This is embodied in a concept of "instant learning" wherein the transmission of message(s) through computer-generated displays (visual and audio) that would (preferences are shown in priority): 1) not require any prior instruction/learning (e.g., conceived of as being part of the human DNA), 2) require only very basic knowledge gained by infant children, and 3) require only basic cultural learned behaviors such as a red signal stop, amber signal slow/yield, and green signal clear or OK.

The elements of process of communication are generally defined as a model consisting of: Sender +Message +Encoding +Channel(s) +Receiver +Decoding +Feedback +Noise +Context. The interpretation of "instant learning", given this context, must consider all these components. How well the solutions comply and/or accommodate each component will determine whether an "instantly learned" icon message(s) is successful or not.

For the creation of the test case icons, it was concluded that: some form of flashing was essential for message alerting, but that flashing must not detract nor distract user and could not hide contextual detail information of facility drawing space. This required development of a means to adapt the SVG source code to accommodate that flashing without encumbering the icon with various display tools such as applets or other

embedded players. The design then becomes a matter of how much of the graphic would flash. Once the icon image is created in SVG the source is adapted for color and flash behavior then saved in compressed form. Compression resulted in an additional 20% less storage per icon.

Icon sizes need to be scalable and should minimize concealment of background display information. Considering icons must be deployed on varied display sizes, such as laptops and PDAs, the normal icon design area of 40 pixels by 40 pixels was selected for this project. If the icon background is not relevant to message(s) and can be made transparent, it should be.

The case study exploration of defining "instant messages" and icons was sufficient to demonstrate many of the issues that will be encountered when the deliberate task is undertaken. For example, if the message of "biohazard" is selected with a goal of alerting a user to a serious hazard and its type, the various library sources selected earlier were of only small help. "Googling" using keywords of "icon" and "biohazard" produced many sources for symbology, but, it appeared, most were based on "art", not science. The case study created 5 icon alternatives for evaluation.

Creating icons (icon in .gif, .jpeg, and .svg). The scale of icon size and the value of svg can be summed up simply with the following comparison for the same icon: 1) .gif 1,382,772 bytes, 2) ".svg" 1,791 bytes, 3) ".svgz" (compressed) 549 bytes. Several different applications were tested for icon creation. A goal was to use a COTS product. Initially MS Visio 2007 appeared to satisfy requirements (e.g., simply geometric figures were easily drawn and saved to ".svg" or ".svgz"). MS Visio also accepted image

graphics files and could incorporate into an SVG object, however, the image was not converted to vector format, and thus, little advantage was gained. Both Corel Draw X3 and Adobe Illustrator CS3 were used, primarily to gain advantage of their "trace" drawing features that allow a raster image to be converted to vector format. Corel Draw X3 was slow and appeared more cumbersome to use than Adobe Illustrator. In the end, Adobe Illustrator was considered the easier-to-use, more flexible application.

Validation Methodology:

Process - The proposed evaluation process and the techniques for evaluation are described in this section. These statistical methods were adapted, with considerable modification, from the "Vehicle Display Icons and Other Information Elements", Volume I study, previously cited. While many statistical evaluation schemes were considered, those selected have been accepted practice and are standard for use in similar icon-recognition studies.

The overall validation plan is to utilize 50 knowledgeable emergency response managers and first line responders in collaboration with facilities management personnel from Fairfax County and Fairfax County Public Schools in the scientific evaluation of candidate icons. Evaluators will have the opportunity to work with the prototype NetRequest™ system as part of the process. It is believed that creating a realistic environment for evaluation in a facility context may generate ideas and will result in a more valid evaluation of icons. It is envisioned that participants would be involved in a one day workshop that would include training and evaluation of priority icons. Follow-on evaluations would be conducted online without additional training and minimal

distraction from assigned duties. The target of 50 evaluators would provide sufficient statistical basis for validation. However, it is expected a “pilot” evaluation team would consist of 10 evaluators.

An evaluator will be provided the candidate icon slate prior to beginning each icon evaluation. Practice sessions prior to actual evaluation will acquaint the judge with icon alternatives and offer basis for comparison, even though each icon is separately evaluated against the complete criteria set. Results will be collected in an MS Access Database of REACTICON and will be used to rank order and summarize inputs.

While REACTICON is designed to provide evaluation detail, based on the design guidelines, in the end, icon selection becomes a ranking and selection process among alternative candidates. The evaluation detail, however, will provide not only a disciplined method for evaluators, but will allow consistent evaluator input to redesign, should that be desired or necessary.

Statistical Methods - Table 5-3 is a summary of the statistical methods planned for use. Each of the methods is summarized in separate paragraphs within this section. The methods, that together form the proposed validation protocol alternatives, were selected based on: simplicity/ease of use, and relevance in evaluation of stimuli on human subjects. More extensive treatment of computations and scientific justification is

available in Federal Highway Administration Tutorials or online at:

<http://www.tfhrc.gov/safety/pubs/03065/09.htm>.

Table 5-3 Statistical Methods for Use in Icon Evaluation

	Method	Outcome	Computational Complexity
1	Rank Ordering and Mean Rank computation of icon evaluations	Composite ranking of icons	Simple; to be accomplished within REACTICON
2	Choice Score Method for interval-scale value computation for the stimuli	Provides an indication of relative differences between the stimuli	Simple; requires a series of simple computations to be accomplished within REACTICON
3	Torgerson's Categorical Scaling Method for interval-scale values for the stimuli using	Provides an indication of relative differences between the stimuli on an interval scale	Simple; requires a series of simple computations to be accomplished within REACTICON
4	Test of Significance	Provides evidence for concluding, with a specified risk of error, that there are or are not real differences between the stimuli	Complex; utilize COTS statistical software packages

The methods in Table 5-3 are alternative tools to test variability of differences in evaluator rating for icon groups (stimuli). Each method is summarized below with maximum use of graphics and embedded objects (e.g., MS Excel) that will assist design integration of algorithms into REACTICON. In addition to a general rank ordering, the outputs of each of these methods can provide relative difference scaling among individual icon candidates.

The next section of this chapter will describe the REACTICON tool developed in this project intended for use in collecting, processing, and archiving data. The statistical

computational algorithms have not been built into REACTICON, but are intended to future work.

Rank Ordering and Mean Rank Computation – Data is collected from independent web-based, evaluation forms through REACTICON. Criteria are evaluated on a scale of: 0 = "N/A", and 1 = "not at all" to 9 = "best/very much/excellent". In many cases a particular criteria may not be relevant, thus, the default selection "0" becomes the rating. Brief comments by judges are cataloged with each data submission and are intended for reference and anecdotal citation after-the-fact, not to influence or caveat quantitative scoring.

A sample dataset is presented in table 5-3 for 5 icon candidates (icons 1A, 1B, 1C, 1D, and 1E). These data were obtained from 5 individual inputs (44 data values/icon).

Security Warning: Certain content in the database has been disabled. Options...

ID	icon	Remote_com	message	IM	C1	C2	C3	C4	C5	L1	L2	L3	L4	L5	R1	R2	R3	R4
1	1A	69.143.138.168	Biohazard	4	10	10	8	10	1	4	10	1	1	10	10	10	10	10
2	1B	69.143.138.168	Biohazard	4	10	10	7	7	1	10	10	10	1	10	7	10	10	10
3	1C	69.143.138.168	Stop; Danger	5	4	10	7	6	1	6	6	10	1	7	8	5	10	10
4	1D	69.143.138.168	Biohazard	5	10	10	10	5	1	7	7	10	1	8	6	6	6	10
5	1E	69.143.138.168	No "instant" message	5	10	10	8	7	1	9	9	9	1	9	6	8	10	10
6	1A	69.143.138.169	Biohazard	4	10	10	8	10	1	4	10	1	1	10	10	10	10	10
7	1B	69.143.138.169	Biohazard	4	10	10	7	7	1	10	10	10	1	10	7	10	10	10
8	1C	69.143.138.169	None of the above	0	4	10	7	6	1	6	6	10	1	7	8	5	10	10
9	1D	69.143.138.169	Biohazard	5	10	10	10	5	1	7	7	10	1	8	6	6	6	10
10	1E	69.143.138.169	Stop	5	10	10	8	7	1	9	9	9	1	9	6	8	10	10
11	1A	69.143.138.170	Biohazard	4	10	10	8	10	1	4	10	1	1	10	10	10	10	10
12	1B	69.143.138.170	Biohazard	4	10	10	7	7	1	10	10	10	1	10	7	10	10	10
13	1C	69.143.138.170	Danger	5	4	10	7	6	1	6	6	10	1	7	8	5	10	10
14	1D	69.143.138.170	Biohazard	5	10	10	10	5	1	7	7	10	1	8	6	6	6	10
15	1E	69.143.138.170	Stop; Danger	5	10	10	8	7	1	9	9	9	1	9	6	8	10	10
16	1A	69.143.138.171	Biohazard	4	10	10	8	10	1	4	10	1	1	10	10	10	10	10
17	1B	69.143.138.171	Biohazard	4	10	10	7	7	1	10	10	10	1	10	7	10	10	10
18	1C	69.143.138.171	Stop; Danger	5	4	10	7	6	1	6	6	10	1	7	8	5	10	10
19	1D	69.143.138.171	Biohazard	5	10	10	10	5	1	7	7	10	1	8	6	6	6	10
20	1E	69.143.138.171	None of the above	0	10	10	8	7	1	9	9	9	1	9	6	8	10	10
21	1A	69.143.138.172	Biohazard	4	10	10	8	10	1	4	10	1	1	10	10	10	10	10
22	1B	69.143.138.172	Biohazard	4	10	10	7	7	1	10	10	10	1	10	7	10	10	10

Record: 6 of 25 | No Filter | Search

Figure 5-3 Sample Access Data for Case 1

The data is easily managed for analysis and display with MS Access 2007. For example, Figure 5-4 is a Pivot Chart of ratings, by rater, identified by separate IP addresses, for evaluation of the “instant message” function of the icon.

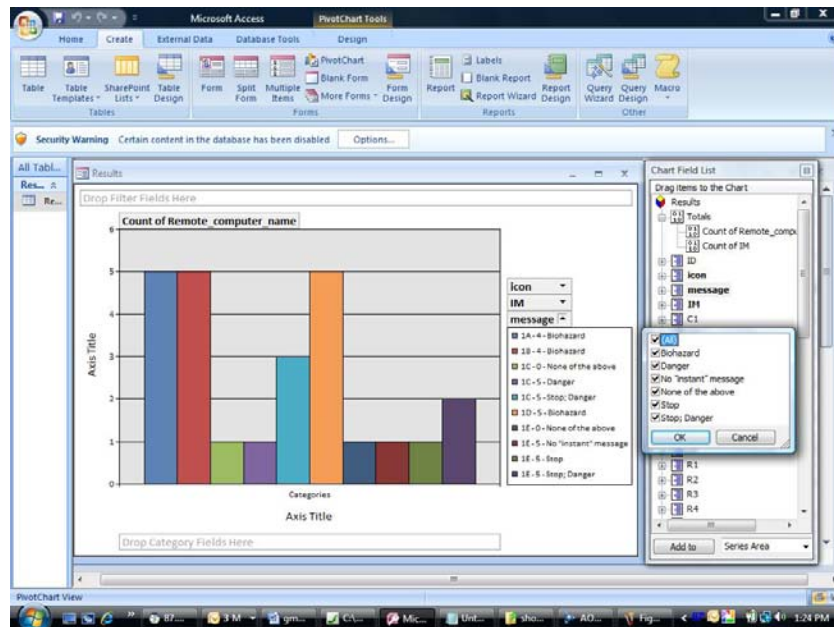


Figure 5-4 Sample Access Data for Case 1, IM Data Pivot Table

The process of evaluation will analyze data both graphically and statistically and rank order icons for a specific message or message set. For example, if 5 icons are compared, the icons are assigned ranks of 1-5, with “5” representing the highest ranked icon in terms of appropriateness.

Note: Figure 5-5 is an embedded MS Excel object, if it is viewed electronically, it can be opened and illustrative situations can be easily input/calculated to understand process and sensitivity.

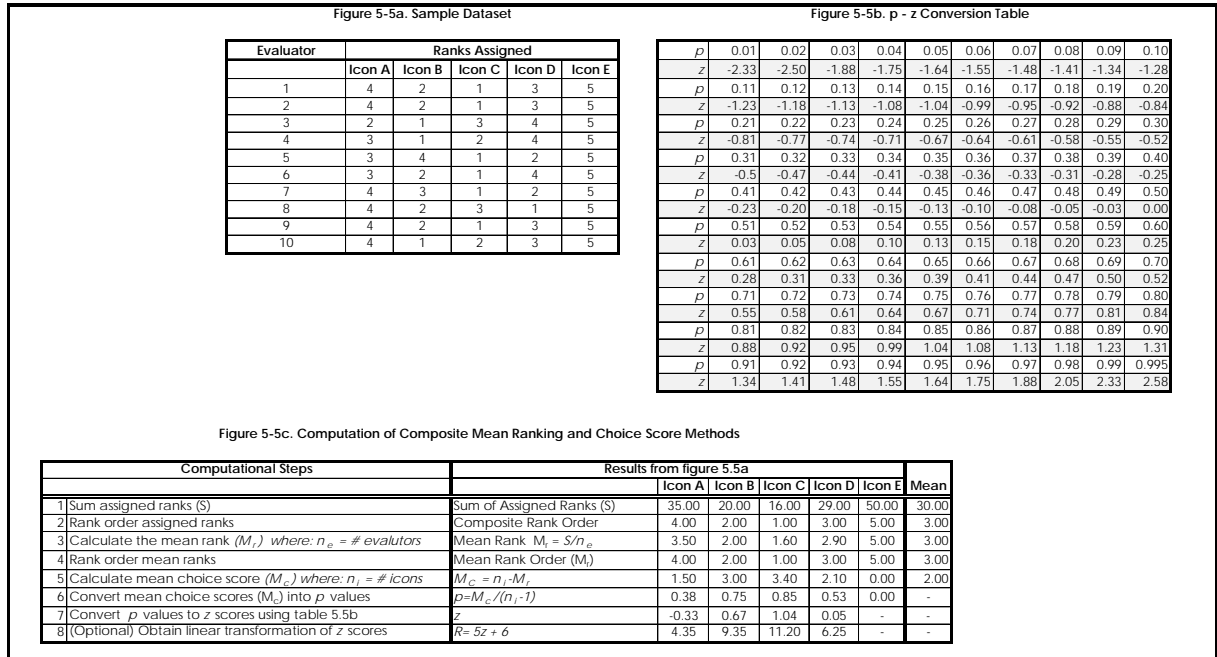


Figure 5-5 Spreadsheet Tutorial for Rank Ordering and Mean Rank Computation

Mean Order from Assigned Ranking - A composite ranking is obtained from a computation of the sums of the rank values assigned to each icon (steps 1-2, Figure 5-5c). The order of the magnitudes of the sums will indicate an ordering of icon appropriateness, with the highest sum corresponding to the icon judged as the best. For example, for the raw data of table 5-5a, we obtain the sums presented in table 5-5b, which indicate the following composite rank order from the best-to-least appropriate icon: E, A, D, B, and C.

The mean rank for each icon is the result of dividing the sum of the ranks assigned to that icon by the number of evaluators (step 3, Figure 5-5c) This produces an ordering of E, A, D, B, and C for this example. In general, mean ranks will be consistent with composite ranks in both order and often spacing. Neither index value should be considered an absolute value-of-merit, since each is derived from rank ordering.

Choice Score Method – This is a scaling procedure²² that converts rank orders to choice frequencies, then to p values, and finally to z scores (unit normal deviates, Figure 5-5b). The z scores obtained represent scale values for the stimuli on a psychological scale with equal intervals on the assumption that the rankings are normally distributed (steps 5-8, Figure 5-5c).

Torgerson's Categorical Scaling Method – This is a scaling procedure based on Torgerson's Law of Categorical Judgment.²³ The discussion below is only a summary, sufficient to provide computational basis and illustration of the method.

Figure 5.7, with several component sections, is an embedded MS Excel Worksheet. If is viewed electronically, the Worksheet can be opened and illustrative situations can be easily input/calculated to understand process and sensitivity. These MS Excel objects were designed not only for illustration, but to test and verify algorithms to be utilized in REACTICON.

The complete form of the law is as shown in figure 5-6.

$$t_g - s_j = x_{jg} (\sigma_j^2 + \sigma_g^2 - 2r_{jg} \sigma_j \sigma_g)^{1/2} \quad (j = 1, 2, \dots, n; g = 1, 2, \dots, m)$$

where

n = number of stimuli

$m+1$ = number of categories

s_j = scale value of stimulus j

t_g = mean location of the g th category boundary

σ_j = discriminial dispersion of stimulus j

σ_g = dispersion of the g th category boundary

r_{jg} = correlation between momentary values
associated with stimuli j and category
boundary g

x_{jg} = unit normal deviate corresponding to the
proportion of times stimulus j is sorted
below boundary g

In the solution procedure, it is assumed that σ_j are
 σ_g constant, and r_{jg} is constant for all
values of j and g .

Figure 5-6 Torgerson's Law of Categorical Judgment

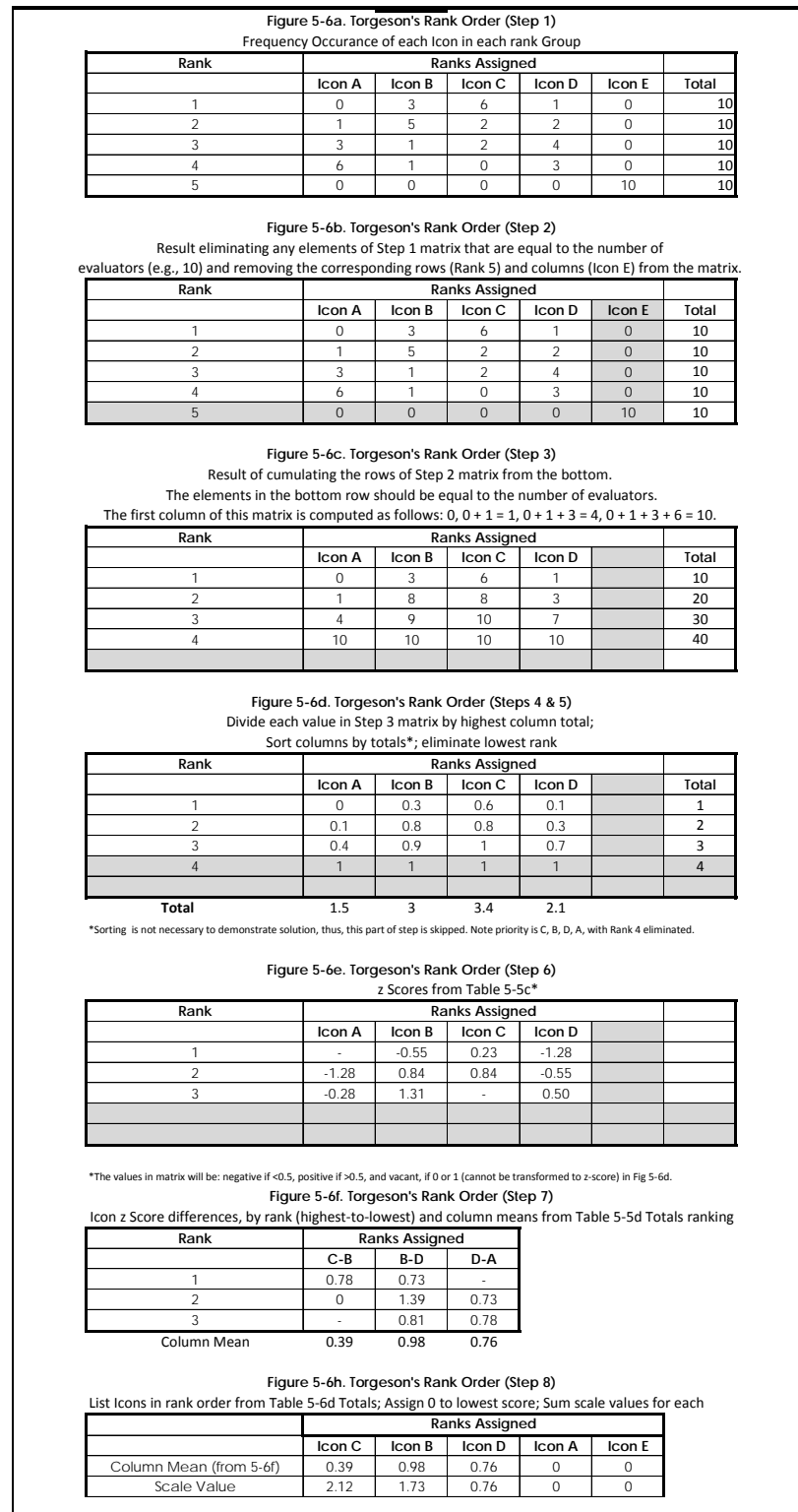


Figure 5-7. Torgeson's Rank Order Methodology – Computation Process

Test of Significance -A final evaluation tool, test of significance, if warranted, may be used to assess whether differences in observations, with a specified risk of error, is meaningful, or the result of chance factors. Using rank order data as a test of significance, based on Friedman Rank Sums could be employed. The test compares icon summary scores to a criterion value that is based on maximum summary values. There are commercially available software packages for this test.

Summary -- While many statistical evaluation schemes were considered, those selected (Rank Order/Mean Rank, Choice Ordering, Torgerson's Categorical Scaling, and Test of Significance) have been accepted practice and standard for use in similar icon-recognition studies and were selected based on: 1) simplicity/ease of use, and 2) relevance of stimuli on human subjects. These methods, taken together form the proposed validation protocol alternatives.

REACTICON: To ensure a systematic process would be used to collect and evaluate “judged” inputs in the icon creation/evaluation process a server-based instructional; icon creation-portal; survey and evaluation tool, REACTICON was created. The acronym REACTICON (Rational Emergency Action Computerized Tool for Interactive Collaborative Operational Networking) was chosen, since it not only provided instant recognition of the tool's purpose and might even, at quick look, be interpreted as “reaction”.

Entry to REACTICON is through an encrypted, java applet, password interface as shown below (if this page is viewed electronically, “CTRL+Click” on the Figure 5-8 image takes the user to this site):



Figure 5-8 REACTICON Password Entry
<http://www.wcdigitalspace.com/suydam/>



Figure 5-9 REACTICON Navigation Entry
Page

For preliminary development purposes only one UserID and password were created (REACTICON UserID: mjs password: reacticon), however the system is capable of accommodating many UserID/passwords.

The main navigation “home” page is as shown in Figure 5-9. The page contains a brief explanation for purpose and use of the website and contains the following links (discussed with succeeding figures in this section): Tool Functions, Icon Design Guide, Icon Library, Input/Create Icon, Icon Evaluation, EM Icons, and Contact. The graphic is a screen capture of a NetRequest™ school facility.

The Tool Functions entry page is portrayed Figure 5-10. It contains screen capture images linked to detail REACTICON architecture and evaluation process instructional graphics. Users would probably only need to view once to become familiar with this material for use and navigation of the tool.

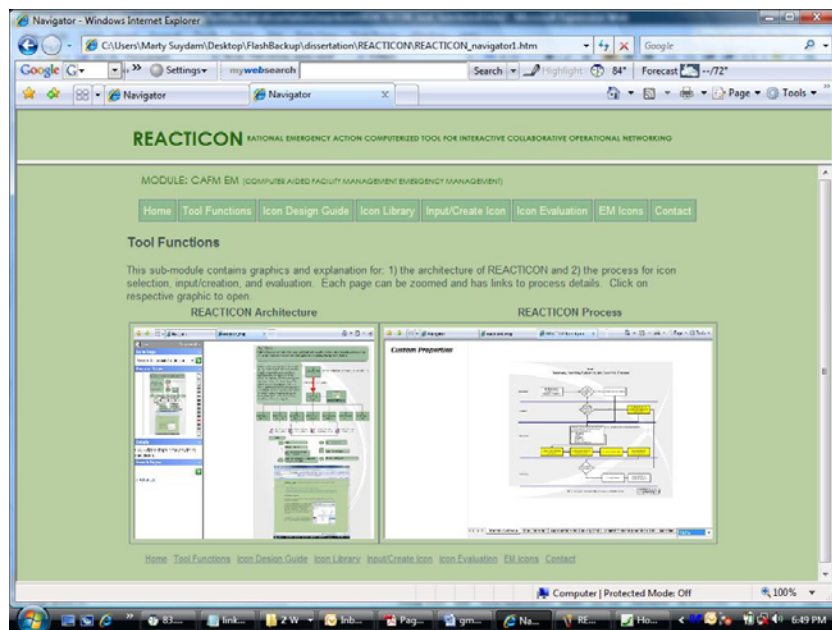


Figure 5-10 REACTICON Tool Functions Entry Page

Access to each of the architecture/process diagrams is accomplished by clicking on the image. The top-level REACTICON Process page (right-hand figure) is the same as the graphic presented earlier as Figure 5-1, at the beginning of this section, and, is thus, not duplicated here. The display also contains links to detailed process views for those processes shown in yellow and has a zoom feature. The architecture of REACTICON is shown in Figure 5-11 in below.

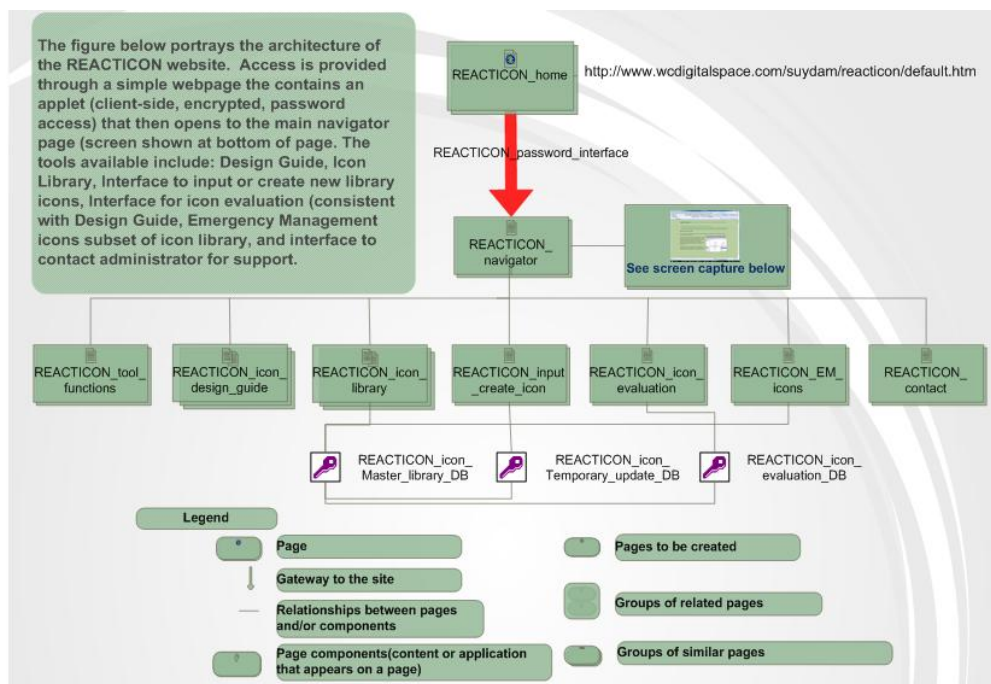


Figure 5-11 REACTICON Tool Functions Entry Page

The Design Guide utilizes a pull-down menu for selection of the individual parameter guides. Bulleted criteria are displayed separately for each of the 35 guideline parameters. The resulting display from a pull-down menu selection, grouped by criteria categories of: Composition, Legibility, Recognition, Interpretation, and Auditory, is portrayed in figures 5-12a and 5-12b.

It is expected that this part of REACTICON will be the primary instructional and reference tool for users/"judges" as they prepare for and conduct evaluation. Interactive evaluation pages, presented later, have quick reference links to each guide, should reinforcement or quick checking be necessary.



Figure 5-12a REACTICON Design Guide Page – Pull-down Menu Selection

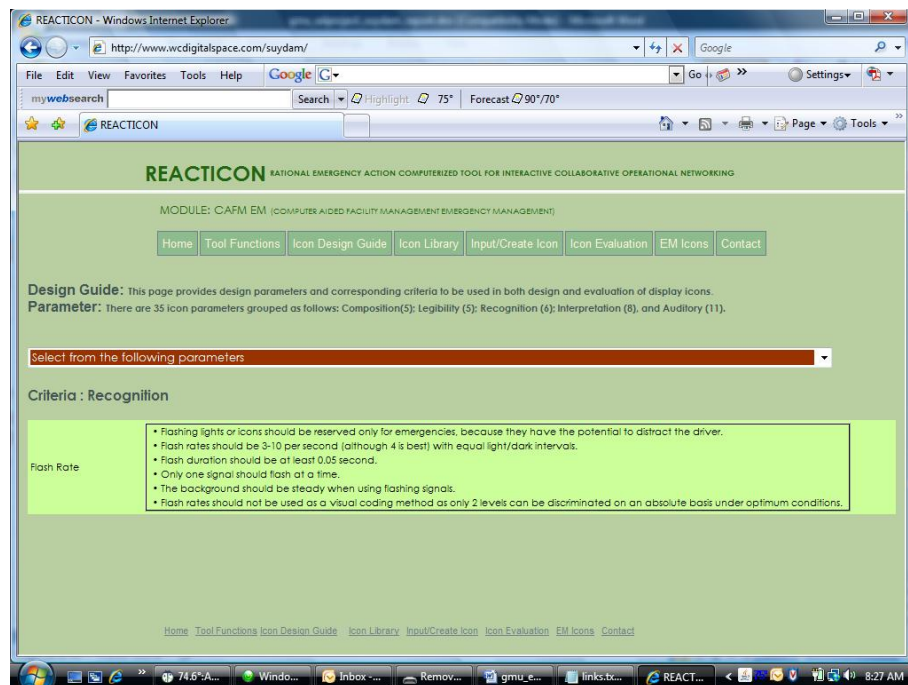


Figure 5-12b REACTICON Design Guide Page – Criteria Selection

The Icon Library entry page is portrayed Figure 5-13. This page provides explanation of contents and introduces separate reference links to existing icon palettes. These icon sets, are in general commercial use today and are considered, at a minimum, as alternative candidates in the “instant learning” process evaluation. There is no intent to catalog all relevant icons in use today since most are based on “art” rather than “science”. Those selected for inclusion in the library have reasonable authoritative endorsement.

There are many icon “standards” and switching to something new will require substantial user benefit and justification. The focus of this effort on CAFM Emergency Management is sufficiently narrowed in scope (user community and application) and new, in terms of technical innovation and implementation, that it should have an opportunity to succeed.

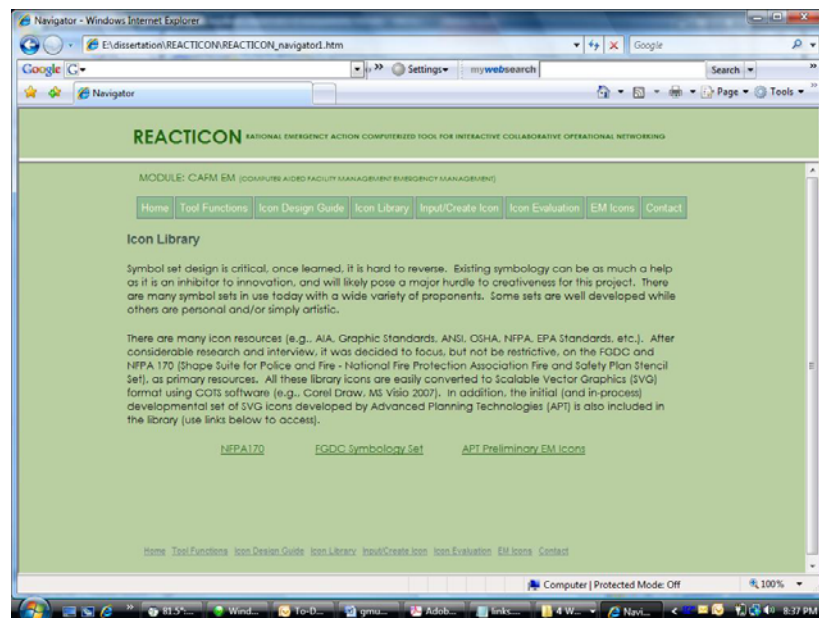


Figure 5-13 REACTICON Icon Library

The Input/Create Icon entry page is portrayed Figure 5-14. This site provides icon authors a consistent access and input tool with the intent of ensuring the same design criteria used by judges are adequately considered when a candidate icon is created.

The screenshot shows a web browser window titled "C:\Users\Marty Suydam\Desktop\FashBackup\dissertation\REACTICON\REACTICON_icon_selection\REACT - Windows Internet Explorer". The address bar shows the local file path. The page content is titled "MODULE: CAFM EM (COMPUTER AIDED FACILITY MANAGEMENT EMERGENCY MANAGEMENT)". Below the title is a navigation bar with links: Home, Tool Functions, Icon Design Guide, Icon Library, Input/Create Icon (active), Icon Evaluation, EM Icons, and Contact.

The main content area is divided into two sections. On the left is a table for evaluating icons based on various criteria. The table has 10 columns (1-10) and 16 rows of criteria. Each cell contains a radio button for selection. The criteria listed are:

Icon Name:	1	2	3	4	5	6	7	8	9	10
C1: Border	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C2: Background	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C3: Element	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C4: Symbol(Shapes)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C5: Text Label	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L1: Luminance Uniformity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L2: Contrast	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L3: Size	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L4: Text Labels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L5: Color	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R1: Realism	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R2: Detail	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R3: Perceptual Principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R4: Flash Rate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R5: Prohibition Symbols	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R6: General vs Specific Icons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Below the table is a "Comments" text area with "Submit" and "Clear" buttons. On the right side of the main content area is a "File Upload" section with the text "Upload file by drag-and-drop into window below." and a "Drop files here" box.

The bottom status bar shows "Applet Rad Upload Lite started" and "Computer | Protected Mode: Off". The taskbar at the very bottom shows various open applications and the system clock at 3:52 PM.

Figure 5-14 REACTICON Input/Create Icon

The file upload drag-and-drop tool is a Java Applet that provides file transfer without requirement for separate FTP tool or application.

The Icon Evaluation Component Functional Requirements are structured to:

- easily solicit and collect focused, knowledge-based data;
- provide rich, quantitative data;
- easily transform data and produce results for rank order consistent with statistical methods used in other similar evaluations; and
- provide an easy-to-use interface for managers, administrators, and users/judges

The evaluation module meets those goals.

The Icon Evaluation entry page is portrayed Figure 5-15a and Figure 5-15b displaying floating context pop-up with zoom capability.

MODULE: CAFM EM (COMPUTER AIDED FACILITY MANAGEMENT EMERGENCY MANAGEMENT)

Home Tool Functions Icon Design Guide Icon Library Input/Create Icon Icon Evaluation EM Icons Contact Icon A Icon B Icon C Icon D Icon E

Icon Name: 1A Message: Select most appropriate "instant" message

Criteria: 0 = "N/A" and 1 = "not at all" to 9 = "best/very much/excellent"

Evaluation Criteria	0	1	2	3	4	5	6	7	8	9
IM1: Instant Reading Message?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C1: Border	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C2: Background	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C3: Element	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C4: Symbol/Shape(s)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C5: Text Label	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L1: Luminance Uniformity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L2: Contrast	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L3: Size	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L4: Text Labels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
L5: Color	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R1: Realism	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R2: Detail	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R3: Perceptual Principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R4: Flash Rate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R5: Prohibition Symbols	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
R6: General vs Specific Icons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IM2: Interpretation w/Text Labels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IM3: Composition of Text Labels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IM4: Conveying Actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IM5: Icons as Part of a Group	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IM6: System Status	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IM7: Interpretation with Color	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IM8: Conveying Urgency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IM9: Interpretation w/Shape	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A1: Auditory Info Augment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A2: Appropriate Auditory Signal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A3: Simple Tones	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A4: Complex Tones	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A5: Echoes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A6: Auditory Icons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A7: Speech Messages	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A8: Urgency of Auditory Signals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A9: Auto. Speech Recognition	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A10: Navigation Info Timing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A11: Annoyance of Aud. Signals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Submit Clear

Figure 5-15a REACTICON Icon Evaluation

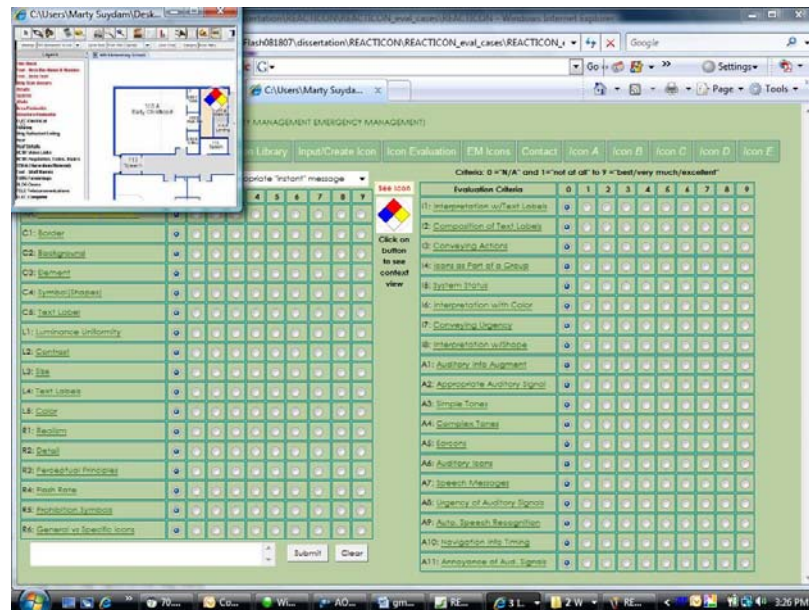


Figure 5-15b REACTICON Icon Evaluation with Context Pop-up

The EM Icons entry page is portrayed Figure 5-16. At present this is more of a “placeholder” than an active page. Future work will include an expansion of this part of the site. The Contact page is portrayed Figure 5-17.

Summary: REACTICON was created to ensure a systematic process would be used to collect and evaluate “judged” inputs in the icon creation/evaluation process a server-based instructional; icon creation-portal; survey and evaluation tool.

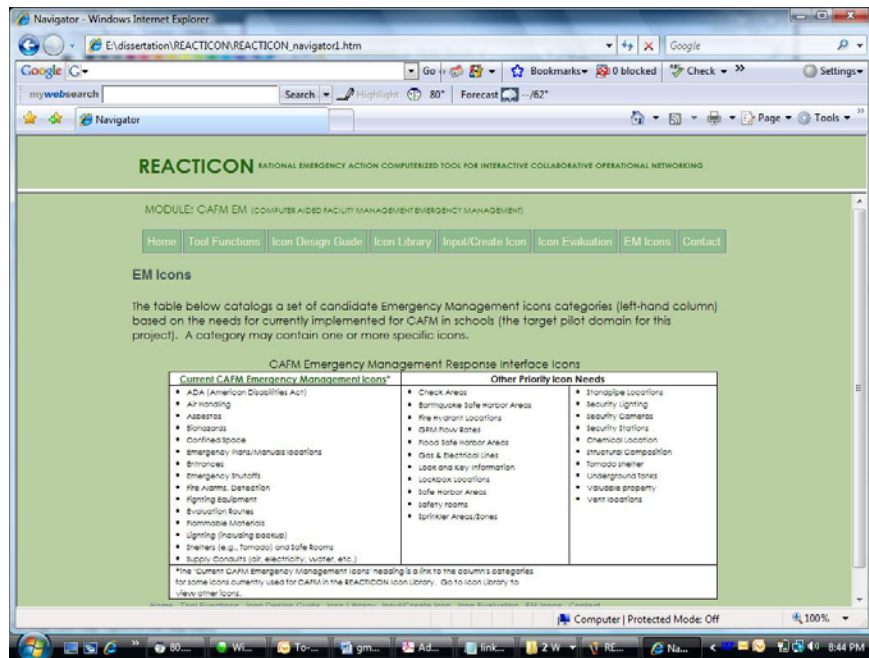


Figure 5-16 REACTICON EM Icons

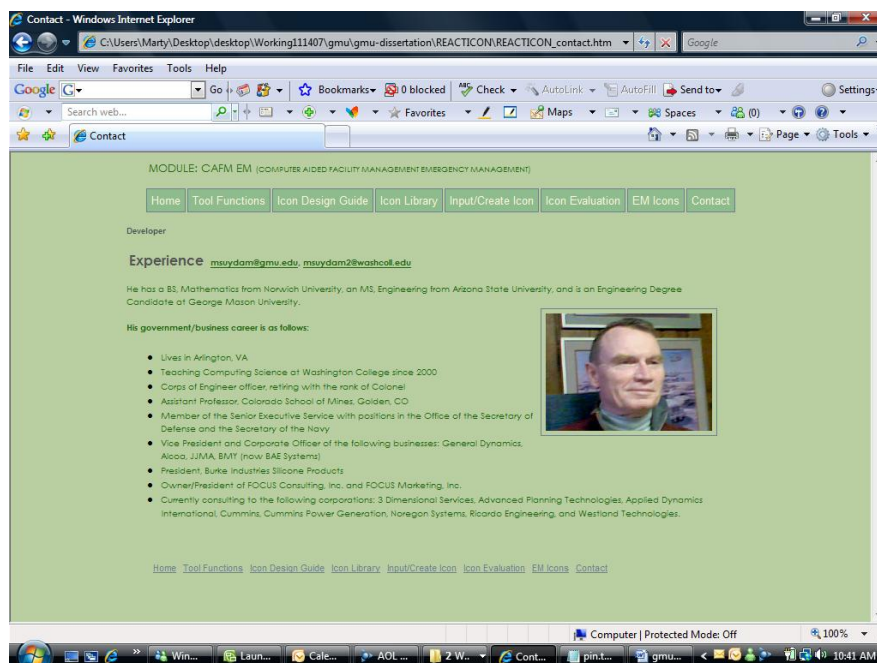


Figure 5-17 REACTICON Author Contact Information

Chapter 6 Prototype System Implementation (Future Work)

This chapter is organized into the following sections (if viewed electronically, chapter headings are bookmarked for quick access):

- 1) [Introduction](#)
- 2) [Plan and Schedule](#)
- 3) [Task Descriptions](#)
- 4) [Summary](#)

Introduction: This project confirms the logic and validity of the proposed project objectives. It also provides the tools, technological and methodological, necessary for development and evaluation of EM icons and the mechanism for realistic Internet-enabled delivery.

The next step in the follow-on work is to: 1) propose and receive commitment to support this project (REACTICON + NetRequest™) to a local County Public School system (e.g., Fairfax), and implement a pilot CAFM project with sufficient “real world” users that would demonstrate effectiveness of both a Internet-delivered CAFM capability and the sensory tools to make significant improvement to any system currently available.

Information Technology continues to change and improve rapidly. Since many of today's state-of-the-art, deployed systems, when tested against requirements for Internet information deployment and use (including WiFi), are likely to be obsolete by the time of full-system implementation, “instant obsolescence” is a threat to any Information Technology development effort. However, the scope of planned future work, while rigorously structured, contains sufficient flexibility, so that results should be resistant to these issues.

Despite careful planning, any future work must maintain cognizance of new developments and allow potential for incorporation and/or rejection of obsolescence and innovation. For example, it is believed that an integration of real-time GPS interface will be necessary to fully realize the objectives of meaningful location intelligence and aid in deployment of “instant learning” mechanisms within structures. Location finding is a significant aspect for determining effectiveness of communications to 1st Responders. Recent trade and public reporting on cellular telephone location capability offers significant opportunity. As such, this is included as an additional task within planned future work, beyond the implementation and validation of the REACTICON and NetRequest™ tools.

Plan and Schedule: Planned future work envisions a 9-month effort that is a combination of project proposal and commitment, project development, and validation.

Initial contacts have been established with key individuals in nearby counties to George Mason University (e.g., Fairfax, Loudon) who have need, interest, and responsibility for implementation of CAFM and other spatial decision support functions. A majority of the work is planned to be accomplished during the summer 2008, when schedules for school systems are a more relaxed and this investigator's work schedule has more flexibility. There appears to be sufficient interest and motivation for involvement.

Collaboration with Advanced Planning Technologies (APT) continues and, by agreement we mutually provide supporting efforts in the development, marketing, and exploitation of NetRequest. That relationship is expected to persist long beyond current work.

Task Descriptions: The major tasks envisioned for future work are summarized below:

Project Implementation – This effort will involve “selling” a local facilities organization of County (e.g., Fairfax, Loudon) Public Schools for participation in project. Creating a NetRequest pilot project, to demonstrate Internet-delivered CAFM is considered a requirement to establish the enabling base for motivating various parties to participate in evaluation. APT has indicated willingness to establish such a demonstration project and all of the surrounding county school systems have some form of last-generation CAFM in use. Conversion of existing drawing and data packages will be cost-effective to provide motivation for all parties.

Research - EM Icon Creation – this task involves: 1) identification and vetting of messages for priority EM icons. This will be achieved through meetings by this investigator with school system staff and management responsible for EM operations; and 2) creation of alternative icons for each message or message package set. It is expected this task may continue in parallel with succeeding tasks as new ideas, concepts emerge.

Research - Individual EM Icon Evaluation – This task involves: 1) establishing evaluation protocols and schedules, 2) instructing “judges” on tools (REACTICON), and 3) accomplishing evaluation. While a broad base and number of evaluators is desirable, if a cadre of 5-7 EM, CAFM and security-trained professionals could be made available, this aspect should be possible. Again, success in this task and any following tasks is dependent on success in predecessor tasks.

Research - Context EM Icon Evaluation – This task involves: 1) utilizing the pilot NetRequest™ school project (at least one facility), 2) training user staff on its operation, 3) developing protocol of testing, and 4) validating utility. The same evaluator resources involved in the immediate predecessor task would be employed in this task.

Summary: While any future work is likely to take different paths determined by new research discoveries and the impacts of changes in technology, the aforementioned tasks provide a general guide.

Chapter 7 Conclusions

Introduction:

This chapter summarizes the key observations and conclusions from this Engineering Project. The project had the objective of exploring the feasibility for developing instant learning capability that could be employed in situations where time-to-learn is difficult and/or impossible.

Observations:

Important to effective use of graphic portrayals of data and information is the science of communicating effectively with symbols. In general, today's practice of icon design is more art than true science. While attractiveness of symbols has merit, there exists a real discipline void in connecting human sensory (may be more than visual) and cognitive processes to easy-to-comprehend symbols. This research was targeted at filling that void.

The project effort recognizes, accommodates, and rationalizes competing technology forces; legacy system implications, and personal preferences; 2) validates the "best solutions", 3) provides a scientific basis for "instant learning" in terms of latest research

in cognitive learning, psychology, cognitive computing, computer displays, graphics, networks, and databases; and 4) produces working tools to ensure scientific rigor to assessment process.

Accomplishments: This project developed a scientific methodology (design, evaluation, selection, and implementation) for delivering complex CAD data to hand-held devices in an efficient manner. The effort also identified the tools necessary for creation, acceptance, and/or adaptation of special icons that would be used in crisis situations. These crisis situations are characterized by a need for attention-getting, cognitive recognition, and appropriate reaction response. The tools created are all managed through a web-based portal, REACTICON (Rational Emergency Action Computerized Tool for Interactive Collaborative Operational Networking), that is housed on an Active Server Pages (ASP) server. The research to develop the methodology led to creation and exploitation of Scalable Vector Graphics icons and the systems to deploy information rapidly and efficiently. New icons were integrated and deployed into a new commercial Computer-Aided Facility Management (CAFM) software application that was inspired by this effort.

This new application is a leap-ahead, enabling-technology that would permit wireless deployment of spatial data/decision technology for data access and navigation within facility structures. While robust, enabling-communications, both wireless and web-based, are considered essential for satisfying Emergency Management responder needs,

mechanisms to ensure reduction in communication burden are, likewise, considered essential. The communication burden is considered both in terms of the load placed on the communication transport system and the human reception and cognitive decoding aspects. These aspects can be measured in terms of file sizes required and speeds and accuracy of human response.

It is not only the rapid and effective transmission of information, but its instant conversion to useful/actionable information, that is important.

Conclusions:

Not only is the development and exploitation of instant learning mechanisms feasible, but it is needed and useful. The development of a disciplined methodology for creation, evaluation, validation, and demonstration of this capability could fill a gap that is widening, rather than narrowing. The greater the bandwidth and processing capability the greater is the desire to push information. In the normal day-to-day context it is hard to sort out what is meaningful, useful, or just noise. In life threatening situations it is not how many messages can be delivered in the shortest amount of time, but what are the essential messages and will the receiver be aware and understand – instantly?

Endnotes

-
- ¹ Campbell, J. L., Richman, J. B., Carney, C., and Lee, J. D., In-Vehicle Display Icons and Other Information Elements Volume I: Guidelines, Battelle Human Factors Transportation Center
 - ² James Albus (NIST), Presentation "Understanding the Mechanisms of the Mind", Almaden Institute, May 2006
 - ³ Alan M MacEachren, Guoray Cai, Sven Fuhrmann, Michael McNeese, Rajeev Sharma; GeoCollaborative Crisis Management (GCCM), Project Highlights Abstract, Proceedings, 5th Annual NSF Digital Government Conference, Los Angeles, CA, May 23-26, 2004; NSF (EIA-0306845)
 - ⁴ Ware, Colin, Information Visualization, 2e, 2004, pg 17
 - ⁵ Toby Berger, University of Virginia: The Four C's of Neuroinformation Theory: Coding, Computing, Control and Cognition, Almaden Institute, May 10-11, 2006 at an IBM sponsored conference on Cognitive Computing.
 - ⁶ Vernon Mountcastle (1978), "An Organizing Principle for Cerebral Function: The Unit Model and the Distributed System", The Mindful Brain (Gerald M. Edelman and Vernon B. Mountcastle, eds.) Cambridge, MA: MIT Press.
 - ⁷ Ralph Linsker (IBM), The "local cortical circuit" (LCC), Panel, Almaden Institute, May 10-11, 2006 at an IBM sponsored conference on Cognitive Computing.
 - ⁸ Ware, Colin, Information Visualization, 2e, 2004, pgs 20-22
 - ⁹ Mayer, Richard E., Multi-media Learning, Cambridge University Press, 2002, pg 5
 - ¹⁰ Carr, Daniel B.; Graphic Design Principles For Promoting Human Understanding Of Data and Models, IT875 SS2005 Classnotes, George Mason University, pg 42
 - ¹¹ Mayer, Richard E., Multi-media Learning, Cambridge University Press, 2002, pg 46-48
 - ¹² Woods, David, Patterning Views, draft paper 8/14/03 pgs 6-9
 - ¹³ Woods, David, Patterning Views, draft paper 8/14/03 pgs 8-9 (graphic developed from text discussion)
 - ¹⁴ Norretranders, Tor, The User Illusion, Viking, 1998, pg 132
 - ¹⁵ Ware, Colin, Information Visualization, pg 17 (bottom of page)
 - ¹⁵ Gerald Edelman, The Neurosciences Institute: From Brain Dynamics to Consciousness: A Prelude to the Future of Brain-Based Devices, Almaden Institute, May 10-11, 2006 at an IBM sponsored conference on Cognitive Computing.
 - ¹⁷ Advanced Planning Technologies website: <http://www.apl-cafm.com/nrdemo01.html>
 - ¹⁸ Email exchange with T. Grosskopf, Technical Director, Advanced Planning Technologies, 5/2/05
 - ¹⁹ 'Iconology' means the same as 'Iconography', which is: 'the art of representing or illustrating by pictures, figures, images, etc.'
 - ²⁰ Campbell, J. L., Richman, J. B., Carney, C., and Lee, J. D., In-Vehicle Display Icons and Other Information Elements Volume I: Guidelines, Battelle Human Factors Transportation Center Pages 2-2 to 2-9
 - ²¹ Campbell, J. L., Richman, J. B., Carney, C., and Lee, J. D., In-Vehicle Display Icons and Other Information Elements Volume I: Guidelines, Battelle Human Factors Transportation Center Pages 2-10 to 6-23
 - ²² Engen, T. (1971). Psychophysics: Scaling methods. In J. W. Kling and L. A. Riggs (Eds.), *Woodworth and Schlosberg's experimental psychology* (3rd. ed.) (pp. 47-86). New York: Holt, Rinehart, & Winston, Inc.
 - ²³ Torgerson, W. S. (1962). Theory and Methods of Scaling. New York: J. Wiley & Sons, Inc.

CURRICULUM VITAE

Martin Suydam graduated from Norwich University with a Bachelor of Science in Mathematics in 1965 and from Arizona State University with a Master of Science in Civil Engineering in 1968. He served 31 years, active and reserve, in the US Army Corps of Engineers, retiring as a Colonel. He has been a member of the US Government Senior Executive Service and a corporate officer of several corporations. He currently teaches full time in the Mathematics and Computing Science Department of Washington College, Chestertown, Maryland.