

THE DESIGNER'S SITUATION AWARENESS TOOLKIT: SUPPORT FOR USER-CENTERED DESIGN

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Designing systems to support SA involves three phases: an analysis of SA requirements, the application of SA-oriented design principles, and the measurement of SA during design evaluation. The Designer's Situation Awareness Toolkit (DeSAT) provides support to the designer for each phase of this process through both tutorials and application specific tools. The tutorials cover the Goal Directed Task Analysis (GDTA) methodology for delineating SA requirements, SA oriented design principles, and the Situation Awareness Global Assessment Technique (SAGAT) methodology. The application specific tools include a tool for documenting GDTAs, a Checklist tool to assist designers in evaluating how well a design concept has met the relevant SA requirements, a Design Guidance application, and a tool for creating and administering SAGAT queries (Super SAGAT). Through these tools, DeSAT provides a comprehensive approach for improving the designer's ability to create designs based on sound SA oriented design principles.

INTRODUCTION

The key to enabling users to cope with the plethora of data characteristic of today's "information age" is to design systems that support the user in building and maintaining a high level of situation awareness (SA). Current technologies often do not support operators as they seek to develop SA; consequently operations are left vulnerable to error. Problems with SA have been found to be a major contributor to incidents and accidents. For example, problems with SA were found to be the leading causal factor in a review of military aviation mishaps (Hartel, Smith, & Prince, 1991). In another study of accidents among major air carriers, 88% of those involving human error could be attributed to problems with situation awareness (Endsley, 1995b). A similar review of errors in other domains (such as air traffic control or nuclear power) shows that this problem is not limited to aviation, but is faced by complex systems in a variety of domains.

Successfully enhancing SA through system design requires that designers understand how to combine and present the vast amounts of data available in order to support the user's ability to develop SA. As true SA only exists in the mind of the human operator, presenting large amounts of data will do no good unless it is successfully transmitted, absorbed and assimilated in a timely manner by the person to form situation awareness.

One of the key benefits of looking at situation awareness is that it tells the designer how all the available data needs to be combined in order to facilitate user understanding. Instead of loading the user down with 100 pieces of miscellaneous data provided in haphazard fashion, situation awareness requirements provide guidance as to what the user's real comprehension and projection needs are. By evaluating the SA requirements, system designers can determine the best approach for bringing those 100 pieces of data together to form meaningful information and to create groupings of data that can be easily absorbed and assimilated in time critical situations.

In the past, the responsibility for correctly integrating all the relevant information fell on the user. This task left them overloaded and susceptible to missing critical factors. Thus, providing systems that support the SA process is essential meeting a critical challenge in today's complex environments. Meeting this challenge requires a structured approach that incorporates SA considerations into the design process, including determining SA requirements, designing for SA enhancement, and measuring SA in design evaluation. The Designer's Situation Awareness Toolkit (DeSAT) was created to support designers in effectively addressing these three aspects of the design cycle. Figure 1 shows how DeSAT will support each phase of the SA-oriented design process to provide significant aid to the designer within the system design process. Each of the three major subcomponents of DeSAT will be discussed separately, although they are all functionally linked and support each other.

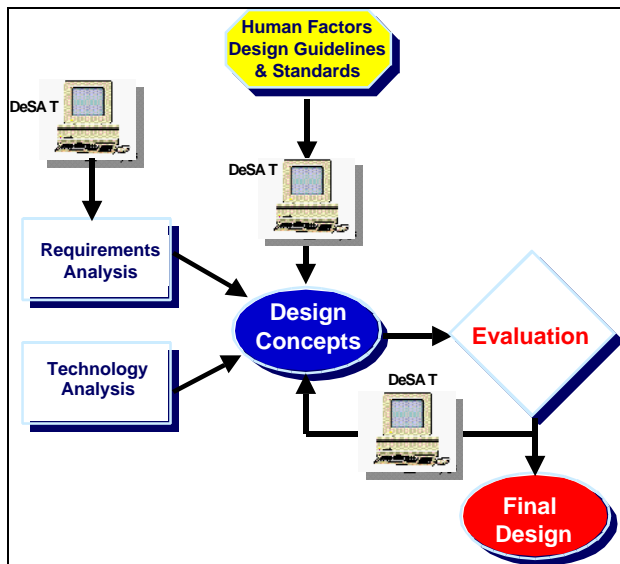


Figure 1: DeSAT and the system design process

SA Requirements Analysis. As a first step, DeSAT guides the designer through the identification of situation awareness requirements for the application being considered. In order to create effective designs, the designer must understand what information (as opposed to data!) the individual operators need as well as what information their teammates need for a particular mission. An awareness of the operator's own state as well as the state of their teammates, the systems, and the current operational situation all contribute to the operator's overall SA.

SA Design Guidelines. Most significantly, however, DeSAT does not simply provide a tool for documenting these SA requirements, but provides a significant advantage in tying these requirements to the design process. Today's designers find a significant gap between the requirements analyses they create and the translation of those requirements into design realities. DeSAT's role is to help bridge this gap. The development of a system design for successfully providing the multitude of SA requirements that exist in complex systems is a significant challenge. DeSAT features design guidance to assist designers through this process.

SA Measurement. Finally there are many concepts and technologies that are currently being developed and touted as enhancing SA. Prototyping and simulation of new technologies, new displays and new automation concepts are extremely important for evaluating the actual effects of proposed concepts within the context of the task domain. The Situation Awareness Global Assessment Technique (SAGAT) has been successfully used to provide this information by directly and objectively measuring operator SA in evaluating avionics concepts, display designs, and interface technologies (Endsley, 1995a). The SAGAT portion of DeSAT, called SuperSAGAT, supports designers in systematically evaluating their design concepts. SuperSAGAT allows designers to easily customize SAGAT queries for their particular domain, based on the SA requirements analysis for that domain.

SA REQUIREMENTS ANALYSIS

The SA requirements analysis component of DeSAT consist of a tutorial describing how to delineate SA requirements, a tool to help document these requirements, and a tool for assessing if all of the SA requirements have been incorporated into the design.

GDTA Tutorial

The Goal Directed Task Analysis (GDTA) addresses the need for delineating user SA requirements as part of the design process. The GDTA is a form of cognitive task analysis that delineates the user's goals, relevant decisions, and associated SA requirements for a particular domain. This tutorial walks the user through why a GDTA is

needed, how to construct a GDTA, and what techniques will help ensure successful data collection and organization. Basic principles and techniques are described and examples provided regarding the use of the technique to ascertain SA requirements from subject matter experts (Figure 2).

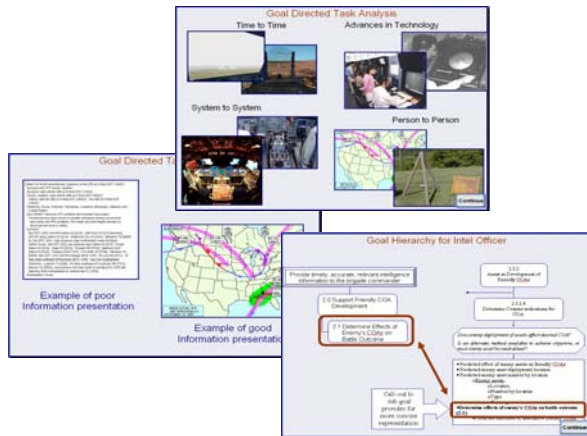


Figure 2: Screenshots from the GDTA Tutorial

GDTA Tool

Using the Goal Directed Task Analysis approach provides a consistent way to document the full range of SA requirements as they relate to specific decisions and goals in a particular domain. Using a standard format for documenting these elements facilitates the knowledge elicitation during interviews with subject matter experts and supports communication of these requirements between designers during concept development. This tool was designed specifically for documenting GDTAs and supports the designer in quickly creating graphic representations of the GDTA (Figure 3).

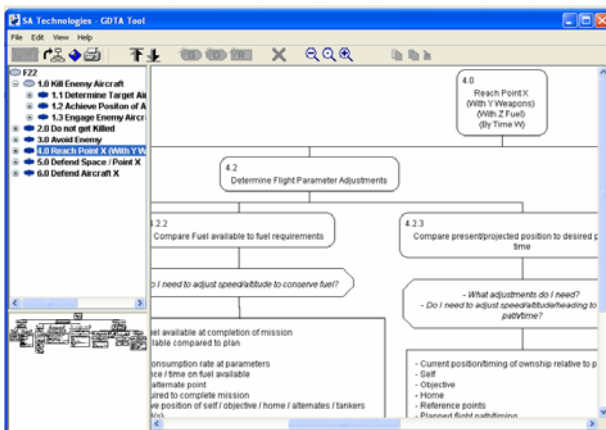


Figure 3: GDTA Tool

GDTA Checklist Tool

The GDTA checklist tool assists designers in evaluating a concept to ensure that the design meets all the users' SA requirements (Figure 4). Drawing from a GDTA previously entered in the database via the GDTA tool, this tool presents the user with a list of goals from which the user can select one or more goals to evaluate. Once a goal or set of goals has been selected for analysis, the tool presents the user with the associated decisions and SA requirements. The user can then use this list as a checklist to determine if any SA requirements have not been accounted for in the design concept. After the user has worked through the checklist, the tool provides a summary of what SA requirements have been omitted relative to each goal.

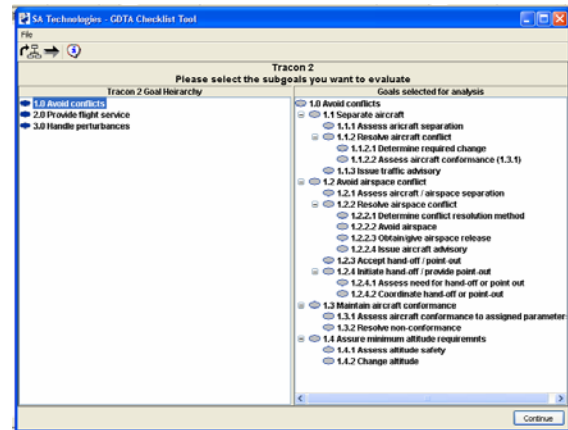


Figure 4: GDTA Checklist Tool

SA DESIGN GUIDELINES

The SA Design Guidelines portion of DeSAT includes a tutorial and a guidelines application tool. Both tools are designed to support designers in applying SA oriented design principles to the design process.

SA Oriented Design Tutorial

The SA Oriented Design tutorial delineates 50 design principles relevant to designing systems to support SA. This tutorial provides basic background information and a detailed explanation of the relevant design principles for users who may have little or no background in this area (Figure 5). It is divided into 3 modules for ease of use. The first module covers general SA oriented design issues and issues related to managing uncertainty. The

second module covers issues related to complexity and alarms. The third module covers issues related to automation and supporting SA in team operations.



Figure 5: Screenshots from the Design Guidelines Tutorial

Design Guidelines Tool

The Design Guidelines tool provides the designer with SA Oriented Design guidance (Figure 6). Based on existing theories of SA, available empirical evidence, and existing guidelines in the fields of human-computer interaction and human factors, a taxonomy was created describing issues relevant to designing systems to support SA. This taxonomy provided the structure for further developing design guidance for supporting designers in creating systems that effectively support SA. Using the taxonomy as an organizing feature, this tool allows users to quickly select a topic and view relevant questions, design guidance, design issues, testing issues, examples, and the references from which the guidance was aggregated. Topics include general SA principles, as well as guidelines for designing to support SA through visual displays, auditory displays, alarms and alerts, controls, automation, team operations, managing uncertainty, and managing complexity.

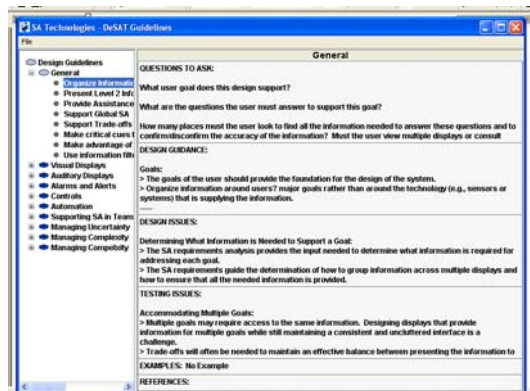


Figure 6: Design Guidelines Tool

SA MEASUREMENT

The SA measurement part of DeSAT includes two tools. The first is a tutorial describing the SAGAT methodology. The second is SuperSAGAT, an easy to use tool for creating and administering SAGAT queries.

SAGAT Tutorial

The Situation Awareness Global Assessment Technique (SAGAT) tutorial presents a technique for objectively assessing user SA (Figure 7). This tutorial describes the basic principles behind SAGAT and how to administer SAGAT to participants during an experiment. Further, it explains how to analyze SAGAT data to obtain an evaluation of user's SA, both at a high level and with respect to individual aspects of the system.

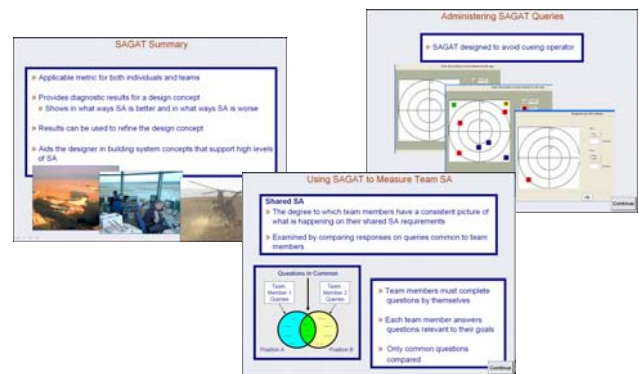


Figure 7: Screenshots from the SAGAT Tutorial

SuperSAGAT

The ability to effectively measure the impact of a design on user's SA is an essential element of SA-Oriented Design. One proven approach to objectively measuring SA is the Situation Awareness Global Assessment Technique (SAGAT) (Endsley, 1995a). SAGAT provides an unbiased assessment of a person's SA by directly querying them regarding their current knowledge of the various elements in an environment and comparing their responses to the actual state of the environment. The SAGAT methodology involves freezing a man-in-the-loop simulation at random points in time, removing information from the participant's display, and administering a battery of queries to the participant. These queries are developed based on a thorough analysis of the

participant’s SA requirements. Although these queries can be administered via pencil-paper, collecting the data on a computer reduces the time and effort required to analyze the data. The drawback to computerized data collection is that creating a program to run the queries can be time consuming and difficult.

To ease this difficulty, SuperSAGAT was developed to allow the user to quickly and easily create and administer SAGAT queries. The data collected with this computer based tool is stored in a file that can easily be retrieved and formatted for statistical analysis. This program has three components: SAGAT Designer (Figure 8), SAGAT Compiler (Figure 9), and SAGAT FileAdapter. SAGAT Designer allows users to create a series of SAGAT queries; SAGAT Compiler administers the queries to the participant; and SAGAT FileAdapter assists the user in linking image files to the program when the program has been transferred from one operating system to another.

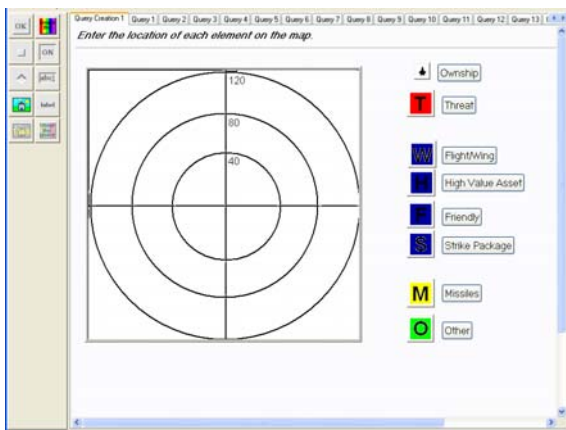


Figure 8: Screenshot from SAGATDesigner

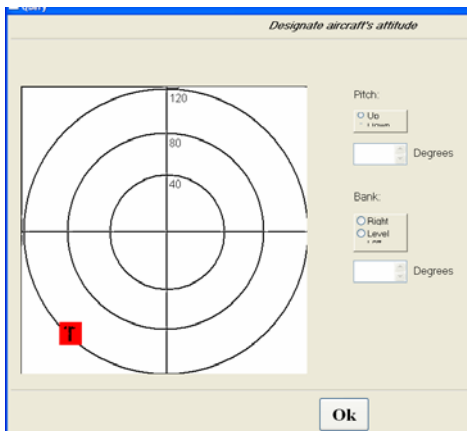


Figure 9: SAGATCompiler

SUMMARY

The Designer’s Situation Awareness Toolkit provides a unique set of tools to assist designers in creating systems that effectively support the user’s ability to build and maintain an adequate level of SA. DeSAT provides support to the designer for each phase of the SA oriented design process through both tutorials and application specific tools (Figure 10). Further, by stocking the GDTA tool and SuperSAGAT with existing versions for select domains, the designer is provided with a foundation that can be adapted as needed for other domains. By supporting the designer during each phase of the SA Oriented Design process, DeSAT provides a unique tool for developing human centered systems by providing a comprehensive approach for improving the designer’s ability to create designs based on sound SA oriented design principles.

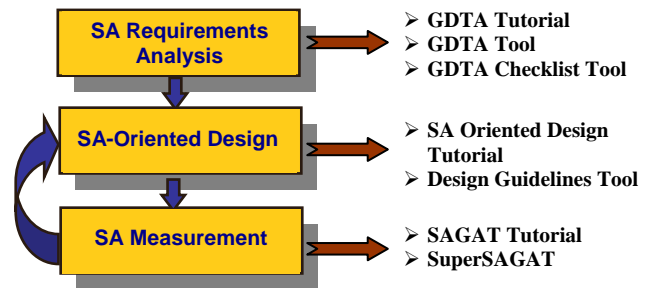


Figure 10: DeSAT and the SA Oriented Design Approach

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ACKNOWLEDGEMENTS

This work was supported by NASA Langley Research Center (#NAS1-02069).